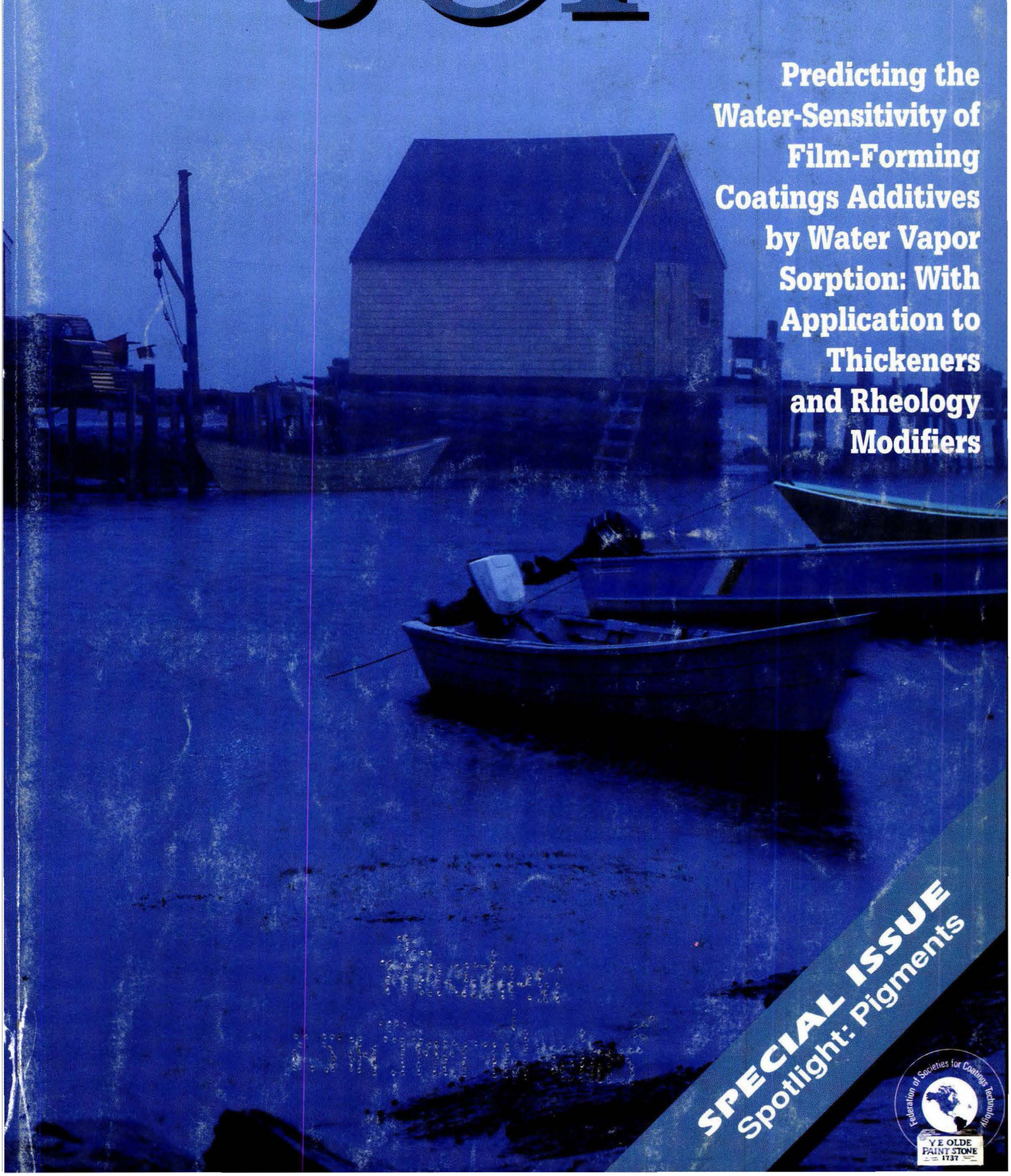
March 1996

JCT

JOURNAL OF COATINGS TECHNOLOGY



Predicting the Water-Sensitivity of Film-Forming Coatings Additives by Water Vapor Sorption: With Application to Thickeners and Rheology Modifiers

SPECIAL ISSUE
Spotlight: Pigments

Federation of Societies for Coatings Technology
YE OLDE PAINT STONE 1737

Official Newsletter of the Federation of Societies for Coatings Technology March 1996

The PaintStone

FSCT Strategic Planning Report

FSCT Board of Directors Meets to Discuss Future; Proposals to be Reviewed by Constituent Societies

In an historic session, the Federation Board of Directors met over two days in February to review the results of three years of Strategic Planning discussions. Centering on the topics of Membership, Organizational Restructure, and Common Interest Groups, the Board reached consensus on proposals which, if implemented, will significantly change the direction of the organization's activities and the manner in which the Federation is governed.

The proposals will be reviewed by the Federation's 26 Constituent Societies over March and April and the Societies' comments will be considered by the full Board at its meeting on May 5 during Spring Week in Seattle.

Highlighting the meeting was a full day session devoted to brainstorming where hundreds of ideas on the topics were developed. Prioritizing reduced these to several dozen categories and the major concepts of the proposals were debated during the second day. After making some concessions and adjustments the Board reached an overwhelming consensus on the proposals.

Strategic Planning Proposals

In addressing the issues raised in the White Paper (*see accompanying story*), the Board prepared proposals in three critical areas: Membership; Organizational Structure; and Common Interest Groups.

Membership —

One of the key areas under consideration was that of revamping the way in which new members are recruited. The present system of Society-based member acquisition and the process of having two readings prior to acceptance was seen as outdated. Membership approval is lengthy, sometimes taking many months, and severely hampers promotional efforts. The proposals call for a more centralized membership system which accommodates local membership processing.

The Board reasoned that by centralizing the promotional efforts in coordination with local Society recruitment programming, and by allowing for direct membership approval at the national level, membership growth would be greatly stimulated and would encourage membership increases by the Societies.

Logistically, prospective members could apply directly to the FSCT, with headquarters approving applications, collecting the appropriate dues and submitting names and the Society dues to the local constituents. Membership classifications would remain as they currently are (although the topic of "Associate vs. Active" was raised there was no consensus on the question of a single classification).

Annual membership renewals could be done by direct invoicing at the national level, and Federation headquarters could also maintain Society membership rosters; although these areas were proposed on an optional basis to the Societies.

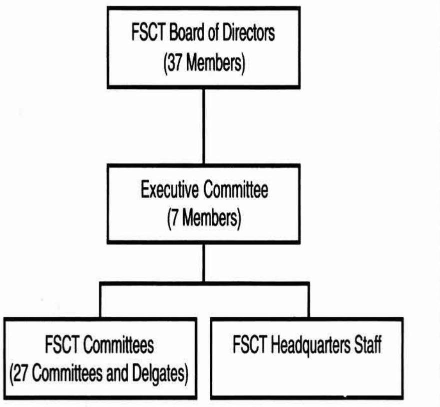
Necessary would be a common membership year for all Societies and the FSCT. Currently, individual Societies have a variety of membership years ranging from May-April to September-August.

The proposal also calls for the development of a coordinated, targeted promotional program which would clearly define the benefits of membership. Underlying the proposal is the continued improvement and expansion of membership services as well as technical programs.

Organizational Structure —

Another key issue was that of the current manner in which the Federation is governed. The present structure (a 37-member Board of Directors that meets twice annually, a seven-member Executive Committee, and 27 national committees and delegates) was seen as too cumbersome. Proposed

Current Organizational Structure



was a smaller Board that would meet more frequently and be better able to respond on a more timely basis to opportunities and challenges.

Proposed was a Board of 12-15 members, consisting of the three Officers, an FSCT Past-President member, and 8-11 Society Representatives, meeting at least four times per year, either in person or via conference calls. The Board would be the governing body of the FSCT; the Executive Committee was seen as redundant and would be eliminated.

The proposal also calls for the creation of a Council of Society Representatives who would elect the Officers and the Societies' representatives on the Board. Unclear was how the representatives would be selected and it was decided to allow the Council to determine this process.

The Federation's national committees would be reduced in number to six: Bylaws, Finance, Professional Development (which would include appropriate sub-committees such as education, corrosion, manufacturing, etc.), Educational Coordinating (which would work directly with the Societies in support of local educational programs and activities), Publications, and a single Awards committee, rather than a separate committee for each award. Limited term task forces would be used for specific issues where appropriate.

In a measure to simplify and make more timely needed revisions and additions to the Federation's Bylaws and Standing Rules, it was proposed that these be streamlined and made more flexible.

Common Interest Groups —

Due to changing technologies and the variety of areas in which coatings technology applies, it was proposed that the Federation create opportunities for individuals who are interested in specific segments or areas of the industry. These Common Interest Groups (or CIGs) will be organized as self-sustaining groups of individuals pursuing a common interest and conforming to a minimum set of standards as established by the FSCT Board of Directors. CIG activity will recapture and enhance the technical drive and enthusiasm of Federation and Society members and will provide an international forum for specific focused topics of interest.

Local Societies will be encouraged to exploit the interests of CIGs in their own areas; however, CIGs will be a Federation level activity and will not be geographically based.

(Continued on page 2A)

Summary of Strategic Planning Proposals

MEMBERSHIP:

Concern —

That an individual's access to membership in the Societies and the Federation is stifled by the current process. The Federation is not allowed to recruit members nationally, thereby limiting opportunities for growth.

Proposals—

1) Although retaining all current membership classifications (Active, Associate, Retired, Educator/ Student) —To minimize the requirements needed for membership.

2) To allow FSCT nationally to recruit and accept new members and to assign these members to Societies.

3) To adopt a Federation-wide membership year by all Societies to coordinate rosters and dues invoicing.

4) To allow Federation headquarters to invoice and collect individual annual membership dues and to maintain Society membership rosters. This will be done on an optional basis determined by each Society.

5) To increase and improve programs and services and to develop targeted membership promotional programs.

ORGANIZATIONAL RESTRUCTURE:

Concern —

That the current structure of the FSCT's governing bodies and the present system to revise Bylaws and Standing Rules do not allow for timely response to opportunities and threats that affect the future of the organization.

Proposals —

1) To reduce the size of the Board of Directors to 12-15 individuals, which would include the three Officers, an FSCT Past-President, and 8-11 Society Representatives; the Board would meet at least four times annually.

2) To create a Council of Society Representatives that would meet annually to elect Federation Officers and Regional Society Representation on the Board, and to discuss items of importance for Board consideration.

3) To eliminate, as extraneous, the Executive Committee.

4) To reduce the number of Federation Committees.

5) To streamline the process for revision of Bylaws and Standing Rules.

COMMON INTEREST GROUPS:

Concern —

That the growth of coatings technology has created numerous opportunities to create educational programs in areas other than currently provided by the FSCT or others. Interests in specific areas of coatings technology cross regional boundaries, which limit activity and growth of the FSCT and Societies.

Proposals —

1) To create Common Interest Groups, organized as self-sustaining groups of individuals pursuing a common interest and conforming to a minimum set of standards as established by the FSCT Board of Directors.

2) That CIGs be Federation level activities that are non-geographically based.

3) That a CIG have a three-year provisional status prior to eligibility for "active" status by the FSCT Board, and be subject to periodic review by the Board.

4) That members of active CIGs must be members of the FSCT and Societies.

State of the FSCT: A Case for Change

The following "white paper" was prepared by an ad hoc committee of Federation Board Members who met to review the results of prior meetings on Federation Strategic Planning. The paper was distributed to Constituent Society Officers and Board Representatives for their consideration prior to a special meeting of the Board. Meeting on February 24-25, the Board discussed the issues and opportunities presented in the paper and prepared proposals on implementation of the plan for Society review and comment.

Overview

Throughout its 74-year history the Federation of Societies for Coatings Technology has remained fundamentally the same: an organization composed of Constituent Societies established in various regions to provide for the technical needs of their memberships. Especially in its early days and until recent years, the FSCT has performed well, operating as an umbrella organization for its Constituents, coordinating activities and providing information essential to its members. As the industry's status quo changed little, so did the FSCT.

However, beginning in the early 1970's changes started occurring at a faster pace. Increasing advances in technology, the lead issue, VOC, and other regulatory matters quickly became a priority in the industry's day-to-day affairs, and impacted the continued progress of manufacturers if not their continued existence. Companies which were for years solvent, well-managed entities underwent significant changes in coping with regulations and the increased competition which they drove.

Over the same period our Society has changed even more drastically. In some regards, time is now a more important currency than dollars. Volunteerism, a driving force in any industry organization, has suffered significant decreases. Our companies are expecting more from us and we expect more from our service organizations, like the FSCT.

In 1992 the Federation, recognizing these changes in our industry and in our daily lives, began a series of discussions among its leaders, committees, and members to determine if the FSCT is responding adequately to these changes and, if not, what needed to be done in the future to provide value and services to its members.

Out of these discussions came a number of key issues which indicate that the FSCT needs to "re-formulate" itself if it is to continue to be viewed as a meaningful, valuable resource to its membership.

Issues

Internationalization — The rapidly growing trend in overseas competition and in supplying raw materials and services indicates that the FSCT will need to respond accordingly, providing both services and programs on the international level and cooperating with sister technical organizations in other countries to expand its base.

Industry Competition — Corporate consolidation and acquisition have driven a rise in competitiveness and greatly reduced the potential to maintain a strong, effective volunteer membership. As the number of manufacturers grow fewer, so do the size and activity of the Constituent Societies which effects their role in the operation of the FSCT. Increased competition has made some companies reluctant to support employees' activities in local Societies for fear of "sharing information."

The FSCT has also faced increased competition from for-profit service companies in the areas of publications, journals, and trade shows, especially in the international area. The failure of FSCT to respond quickly to these challenges has weakened its ability to be as effective as it may be in providing services.

Increased Technological Focus — As employers demand more of their employees, the demand for technological information is accelerating, not only in the traditional areas of liquid coatings, but also in the growing areas of alternative technologies, such as powder coatings, low energy cure coatings, etc. The needs of the technologist in these specialized areas are not now being adequately addressed by the FSCT or other major industry organizations.

Employer / Employee Loyalty — With consolidation and the accompanying emphasis on the corporate "bottom line," an increasing number of companies are reluctant to expend resources on R&D, centralizing research facilities or relying instead on their suppliers to provide information on technical advances and formulation options. The coatings technologist, therefore, is required to develop an increased sense of "professionalism" which will not only increase his worth to a current employer, but will also make him more desirable in the marketplace. The FSCT, as the major resource of educational tools for the coatings technologist, should lead the way in providing for the professional development of its members.

External Threats — Both at the national and local levels, the FSCT and its Constituent Societies have felt pressure from the National Paint & Coatings Association, its member companies and its local PCAs to use resources in the area of regulatory affairs. These challenges, faced by the FSCT and its Societies, diminish membership and support and, as seen in southern California, have greatly affected the manner in which the local Societies operate. Although the FSCT continues to address areas of cooperation with the NPCA, there is no denying that these recent efforts to deny support to the FSCT, its activities, and its membership in have placed the future of the FSCT and its Societies in jeopardy if they do not meet the needs of their members.

Organizational Structure — The Federation, as it is currently structured, does not allow for adequate and timely response to internal and external threats and opportunities. While the environment in which the FSCT operates has changed, the FSCT, as well as its Societies, has not. Beyond the visible value of the monthly JCT, the FSCT's offering of services and products has been devoted to a limited segment of the industry. It has not expanded to encompass the needs of emerging technologies. So too, Societies have maintained their basic format and activities. Continued poor attendance at Society meetings and difficulty by many Societies in securing officers and committees indicate that problems exist that must be faced.

Limiting the FSCT's growth is the way in which it operates. Considerable redundancies exist; a large bureaucratic structure inhibits growth, responds slowly to change, and requires considerable resources. It is seen that the responsibilities of several FSCT committees overlap, causing confu-

Summary of FSCT Strategic Planning Meetings

November 1992 — Meeting of Officers, Executive Committee, Committee Chairs, Staff in workshop to discuss strengths, weaknesses and gauge future of FSCT and industry

December 1993 — Survey conducted of attendees and exhibitors at 1993 Annual Meeting, Atlanta.

October 1994 — Meeting of FSCT Officers and Planning Committee to review plan.

December 1994 — Meeting of Task Force (Officers, Past-Presidents, Planning Committee) to involve past FSCT leadership and to formulate action plan to communicate strategic plan to Societies.

January - May 1995 — Officers and Past-Presidents met with all Societies' Executive Committees to review plan and to acquire feedback for consideration.

May 1995 — Reviewed Strategic Plan at FSCT Board of Directors Meeting. Received affirmative vote on goals and objectives of plan.

September 1995 — FSCT Officers met to develop implementation plan.

October 1995 — Reviewed implementation plans with Board at Fall Meeting. Received approval to continue implementation discussions.

December 1995 — Task Force (Officers, Board Members-at-Large, Staff) met to review September, 1995 plan and develop further.

February 1996 — Special Board Meeting to discuss implementation of strategic plan.

Other — Throughout the process many committees, including Professional Development, Technical Advisory, Annual Meeting Program, and CIEF have discussed their activities in relation to FSCT future direction. Their thoughts and suggestions have been considered in the total planning process.

Federation of Societies for
Coatings Technology
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sion and duplication of effort. This is also seen in the operation of the Executive Committee and Board of Directors. The need to respond quickly, as noted above, is greatly constrained. For example, an increase in the annual FSCT membership dues of $5.00 required almost two years of discussion and votes.

Acquiring and retaining membership is outdated. Member recruitment activities are spread among local Societies, increasing redundancy of effort and limiting the potential for growth. While it is recognized that the Societies should maintain control of their membership, there is seen a need to provide member services beyond the local Societies. Membership in some Societies now requires months to attain. This is limits the value of membership and severely inhibits growth. The FSCT does not now have the ability to offer direct membership, e.g., at conventions, trade shows, symposia, etc., which prevents the potential for increased Society membership.

Opportunities

The above issues indicate that problems now exist in the operation and structure of the FSCT. They also indicate that opportunities exist to redirect resources and to restructure the organization to meet the current and future needs of its members and the industry at large.

Due to consolidation, internationalization, and diversification of technical disciplines, the technologist of the future will be a well-trained professional whose greatest asset will be skills which can be brought to bear on the problems manufacturers will encounter. Needed to attain this state will be membership in a national organization which can present the required educational opportunities. The FSCT will be this organization.

However, to bring this about the FSCT will have to change its basic structure, its manner of operation, and the type and scope of its activities. The FSCT of the future will be focused on the development of the individual, offering numerous opportunities for local, national and international advancement in the professional development of its members. To accomplish this several areas need to be addressed.

COMMON INTEREST GROUPS (CIGs) — The development, organization, and support of common interest groups (CIGs) in various technical disciplines should be a priority. CIGs are a means of the most direct and valuable use of resources which will gain immediate benefit to our members, providing focused training and educational activities in technical areas not currently under the FSCT umbrella. In their most basic form CIGs cross local Society boundaries, revitalizing both the FSCT and giving Societies numerous opportunities to enhance programming and activities.

ACTIVITIES — The development of new programs, publications and services and the way in which they are delivered to the membership should be examined, with a heavy focus on technical training, utilizing short courses, publications, and electronic transfer of information. There is a great need to create programs which enhance the technical competency of our members and the competitiveness of our industry.

The establishment of a strong International Coatings Expo and Conference in 1996 is a start, providing a forum for all aspects of the industry to participate in training and educational programs and a means for the supplier industry to promote its products and services. The ICE should be used as a base for the expansion and enhancement of programs and the promotion of membership growth.

MEMBERSHIP — As noted above, the current method of accepting new members has not changed fundamentally since the inception of the FSCT. It is recognized that the current policy requiring a new member to be voted on (most Societies still require two readings) is archaic. Today's Society demands an easier means to become a member. If CIGs are to be successful, open and centralized membership to the FSCT is a necessity. New membership classifications and the current Society/FSCT membership structure should be reconsidered.

OPERATIONAL STRUCTURE — In addition to needed changes in its membership structure, the Federation needs to consider revising the structure of its Board and committees if it is to be an effective and valuable organization in the future. The current structure is cumbersome, redundant and expensive to operate and focuses more on the Societies as individual entities rather than the organization as a whole. It is also slow to react to and address the opportunities and challenges being faced by the organization.

Considered should be a smaller Board of Directors, able to meet more frequently and which could consider in depth the various internal and external aspects of the total organization, including proposed changes to programs, services, finances.

The Federation's various committees should be reviewed for their appropriateness and value, providing a more streamlined way for members to still interact nationally while minimizing the demands on their time and the resources of the FSCT. Committees, as a whole, should conform their activities to meet with the mission of the FSCT.

Summary

To be competitive in a rapidly changing environment and to meet the needs of a membership which requires enhanced technical and professional development opportunities, the FSCT needs to consider fundamental changes in its structure, operation and activities.

- The creation of common interest groups would create a driving force in providing focal point for service and programs.
- The generation of programs and publications through our international liaisons would make the FSCT a valuable partner in the international coatings community.
- A centralized membership structure would create needed opportunities for growth and eliminate redundancies.
- Streamlining the basic operational structure for both committees and the organization will be an essential component of a Federation which can respond quickly in the future to challenges and opportunities.

We truly believe that if the status quo is maintained the FSCT and its Constituent Societies can exist in a limited fashion for the foreseeable future. However, we will be continually responding to external threats, have no real growth in programs and services, with a constituency that sees little value in Federation membership. Long-range the organization will become a non-factor in the future of the industry and its technical personnel, surrendering its mission to the for-profit segment and abdicating any voice in the direction of educational programs.

With change comes opportunities. The issues discussed here are real and the Federation's response is critical to its future.

AD HOC COMMITTEE ON STRATEGIC PLAN IMPLEMENTATION
JANUARY 2, 1996

FSCT Board of Directors Meets to Discuss Future

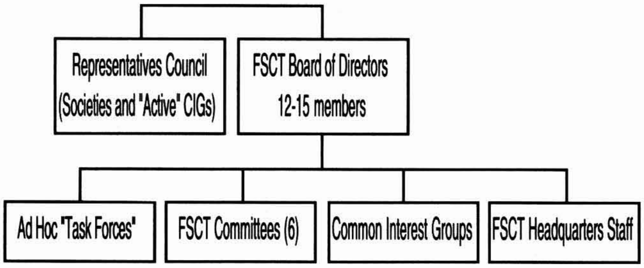
(Continued from page 1A)

The proposal calls for a three-year "provisional" term for a new CIG, which can acquire an "Active" status following Board approval. Petitions to create a new CIG must have 50 signatures and include a mission statement, define the scope and goals of the CIG, and have a specific request for seed funding.

Regarding membership criteria, the proposal allows that members of active CIGs must also be members of the FSCT and the Societies. Active CIGs will report to the Board of Directors and will be reviewed periodically.

The foregoing proposals cover only some of the topics addressed in a series of discussions involving many individuals over the past three years (*see "Summary of Strategic Planning Meetings"*). They do, however, represent the areas felt to be at the core of the future direction of the FSCT. The leadership of the Federation urges the full consideration of the proposals by the Societies and their membership. To assist the Societies and the FSCT, please provide your comments on the proposals on the form provided and fax to FSCT Headquarters. Your comments will be forwarded to your Society President and Representative.

Proposed Organizational Structure



FSCT Member Comments on FSCT Strategic Plan Proposals

FAX To FSCT Headquarters — 610-940-0292

FSCT Members:

Please provide us with your comments and thoughts on the Board proposals regarding Strategic Planning for the future direction and operation of the FSCT. Your comments will be forwarded to your Society's leadership for consideration in their discussion. Thank you.

Membership:

Organization:

CIGs:

Name (Optional)

Society

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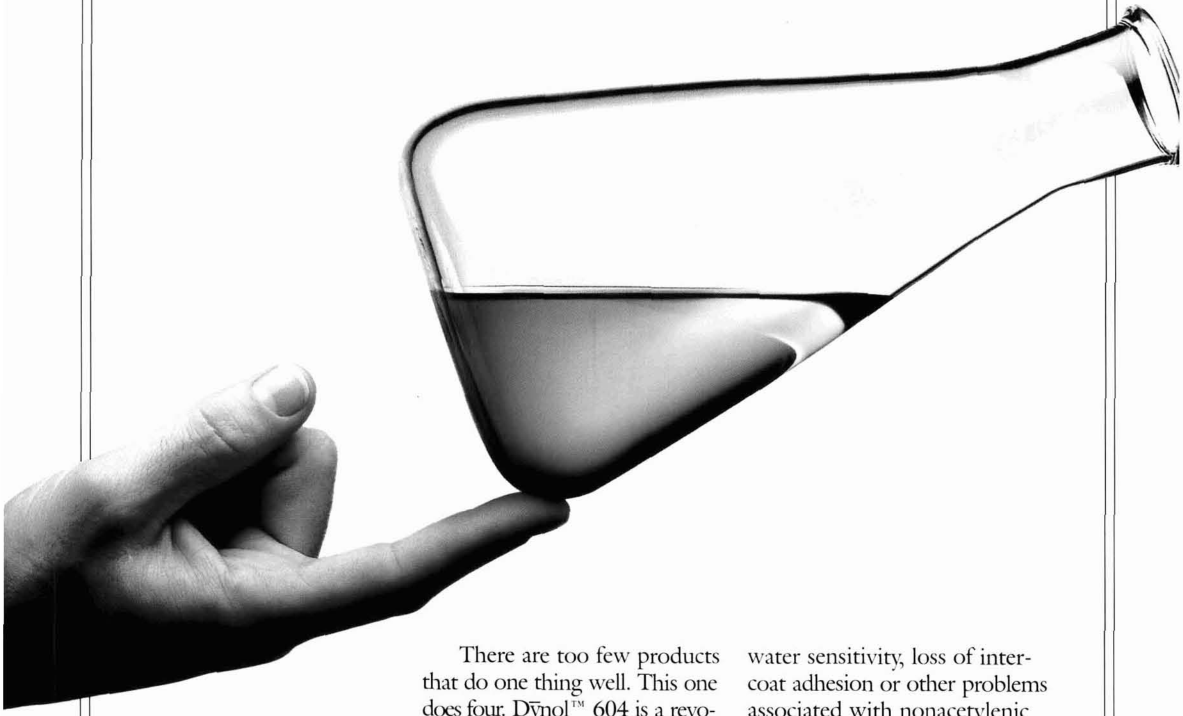

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Guide for Authors

JCT
Journal of Coatings Technology

GENERAL

The Journal of Coatings Technology is published monthly by the Federation of Societies for Coatings Technology for its membership of approximately 7,000 in 26 Constituent Societies in the United States, Canada, Great Britain, and Mexico. The Journal is devoted to the advancement of knowledge in the science and technology of surface coatings, the materials comprising such coatings, and their use and performance.

The Editors invite submission of original research papers, review papers, and papers under the special headings *Open Forum* and *Back to Basics*, and *Letters to the Editor*. All manuscripts will be assumed to be previously unpublished writing of the authors, not under consideration for publication elsewhere. When review papers contain tables or graphs from copyrighted articles, the authors will be required to obtain permission for use from the copyright holders. When the organization with which the authors are affiliated requires clearance of publications, authors are expected to obtain such clearance before submission of the manuscript. Papers presented to associations other than the Federation must be released by written communication before they can be considered for publication in the Journal of Coatings Technology. Authors are obligated to reveal any exceptions to these conditions at the time a manuscript is submitted.

The Journal of Coatings Technology has first right to the publication of papers presented at the International Coatings Technology Conference of the Federation and at local regional meetings or symposia of the Constituent Societies.

Papers in which proprietary products or processes are promoted for commercial purposes are specifically nonacceptable for publication.

SUBMISSION OF MANUSCRIPTS...

...for the Journal

Four complete copies should be sent to the Editor, Journal of Coatings Technology, 492 Norristown Rd., Blue Bell, PA 19422. The cover letter should address copyright, clearance, and release issues discussed above and should specify paper category: *Original Research*, *Reviews*, *Open Forum*, or *Back to Basics*.

Letters to the Editor: The Journal will consider for publication all correspondence relevant to the coatings industry and to the contents of the Journal. When a letter concerns an article appearing in the Journal, the original author is usually given an opportunity to reply.

...by Constituent Societies For International Coatings Technology Conference Presentation

Ten complete copies of the manuscript are required for committee review. The set of copies should be addressed to Mike Bell, Director of Educational Services, FSCT, 492 Norristown Rd., Blue Bell, PA 19422.

...for Roon Foundation Award Competition

Ten complete copies of the manuscript are required, and should be submitted to Mike Bell at the address previously listed.(For complete details, see "Roon Awards" section of the Journal in the January 1995 issue.)

MANUSCRIPT PREPARATION

In general, authors are advised to use the "Handbook for Authors" published by the American Chemical Society as a guide to the preparation of manuscripts (ACS, 1155 Sixteenth St., Washington, D.C. 20036). Another excellent reference work is "How to Write and Publish a Scientific Paper," by Robert A. Day (ISI Press, 3501 Market St., University City Science Center, Philadelphia, PA 19104).

Authors are encouraged to consider submissions in several categories and to prepare their manuscripts accordingly. The categories are:

Original Research Papers: The main technical content of the Journal of Coatings Technology will continue to be original research papers. Editors support the trend in scientific writing to a direct, less formal style that permits limited use of personal pronouns to avoid repititious or awkward use of passive voice.

Review Papers: Papers that organize and compare data from numerous sources to provide new insights and unified concepts are solicted. Reviews that show how advances from other fields can beneficially be applied to coatings are also desired. Reviews that consist mainly of computer searches with little attempt to integrate or critically evaluate are not solicited.

Open Forum: Topics for this category may be nontechnical in nature, dealing with any aspect of the coatings industry. The subject may be approached informally. Editors encourage submission of manuscripts that constructively address industry problems and their solutions.

Back to Basics: Papers that provide useful guides to Federation members in carrying out their work are solicited. Topics in this category are technical but focus on the "how to" of coatings technology. Useful calculations for coatings formulation and procedures that make a paint test more reproducible are examples of suitable topics. Process and production topics, i.e., paint manufacture, will also be reviewed in the *Back to Basics* category.

If a submitted paper consists of the text of a presentation made previously to a monthly or special meeting of a Society for Coatings Technology, or to another technical group, the name of the organization and the date of the presentation should be given. If someone other than the author of the paper made the presentation, this information, too, should be noted. Papers originally composed for oral presentation will have to be revised or rewritten by the author to conform to the style described in this guide.

Manuscripts should be typed with double spacing on one side of $8^1/2$ x 11 inch (22 x 28 cm) paper, with at least one-inch (2.5 cm) margins on all four sides. All paragraphs should be indented five spaces, and all pages should be numbered at the top center, or upper right corner.

Title

The title should be as brief and informative as possible. Selection of titles that are key word-indexable is a helpful and recommended practice.

Authors' Biographies and Photographs

Give complete names, company or institutional affiliations, and brief biographical sketches of all authors. If available, submit a 5 x 7 inch (13 x 18 cm) black-and-white photograph with glossy or smooth high sheen surface, for each author. See later section on photographs for further details.

Abstracts

A 75 -100 word abstract must be part of the manuscript, and should be a concise description of the key findings or teachings of the work described in the paper. The abstract should not repeat the title or include reference numbers, nor should it duplicate the Conclusion or Summary.

Text

Main headings and sub-headings should be used to improve readability, and to break up typographical monotony. The text should *not* be presented as an alphanumeric outline.

The main headings usually should be INTRODUCTION, EXPERIMENTAL, RESULTS AND DISCUSSION, and SUMMARY or CONCLUSIONS. Sub-headings will be specific to the subject.

Only as much review as is necessary should be given to provide an introduction to the subject; the main burden for extensive background should be placed on the list of references.

Standard scientific and technical terminology should be used to convey clear and unambiguous meaning, but the use of technical jargon or slang should be avoided. Authors should bear in mind that the Journal has an international audience, for many of whom English is a second, not native, language. Use of regional idioms or colloquialisms should be avoided. The use of obscure abbreviations is also discouraged. When appropriate, abbreviations should be made in parenthesis immediately following first mention of the term in the text, and then used alone whenever necessary.

Recent issues of the Journal should be consulted for desired style and technical level.

Metric System

Metric system units should be used wherever applicable with the equivalent English units shown afterwords in parentheses. The ASTM Metric Practice Guide, E 380-72 (American Society for Testing and Materials, 1916 Race St., Philadelphia, PA 19103) is a convenient reference.

Tables, Graphs, and Drawings

Tables, rather than descriptive text, should be used only when they are genuinely helpful. They should be proportioned in accordance with the height and width limitations of the Journal's pages. Each table should be typed on a separate sheet, rather than included in the text, and appended to the manuscript. Each table should be numbered and have a descriptive caption. Tables should be referenced in the text (e.g., "See *Table* 1").

In numerical data in tables, numbers less than one should have a zero before the decimal point.

Graphs should be on good quality white or nonphotographic blue-lined $8^1/2$ x 11 inch paper. Each graph should be drawn on a separate sheet, numbered, and the captions listed on a *copy* of the original graph. Graph captions and legends should also be typed on a separate sheet from original for typesetting.

Drawings should conform to the guidelines given for Graphs and should be proportioned to fit the height-to-width ratio of the Journal's pages and columns.

Photographs

All photographs should be sharp, clear, black-and-white prints no larger than 8 x 10 inches in size. Photos should be clearly labeled on the reverse side, taking care not to mar the image.

Color prints and slides are unacceptable.

When illustrations are secured from an outside source, the source must be identified and the Editor assured that permission to reprint has been granted.

Nomenclature

Whenever possible, generic names should be used in preference to trade names. When trade names must be used to avoid ambiguity, and the name is a registered trademark, the symbol R, in a circle or parentheses, should be given immediately following, and the manufacturer listed as a footnote. In general, trade names should be used only in footnotes or in an appendix, rather than in the text.

If special nomenclature is used, include a nomenclature table giving definitions and dimensions for all terms.

Nomenclature of chemical compounds should conform to the style of *Chemical Abstracts* and the IUPAC rules. For oligomeric or polymeric materials, characteristics such as molecular weight, polydispersity, functional group content, etc. should be provided.

Equations

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The paper should be concluded with a summary which is intelligible without reference to the main text. The summary may be more complete than the abstract, listing conclusions drawn from the text. A well written summary can serve to inspire the busy reader to turn back to the paper, to read it thoroughly.

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(1) Pascal, R.H. and Reig, F.L., "Pigment Colors and Surfactant Selection," *Official* Digest, 36, No. 475 (Part 1), 839 (1964).

(2) Davidson, H.R., "Use and Misuse of Computers in Color Control," Journal of Coatings Technology, 54, No. 691, 55 (1982).

(3) Stephen, H.G., "Hydrogen Bonding—Key to Dispersion?," *J. Oil & Colour Chemists' Assoc.*, 65, No. 5, 191 (1982).

(4) Patton, T. (Ed.), *Pigment Handbook*, Vol. 1, John Wiley & Sons, Inc., New York, 1973.

(5) Henderson, W.A. Jr. and Singh, B. (to American Cyanamid Co.), U.S. Patent 4,361,518 (Nov. 30, 1982).

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COMMENT

Here Comes the International Coatings Technology Conference!

A change is on the horizon that will provide immediate benefits to the performance of many industry participants. The change is going to bring top quality information on the latest innovations taking place in the coatings industry and training materials to improve skills. This change is the Federation of Societies for Coatings Technology's 1996 International Coatings Technology Conference, with the theme "Insights and Innovations."

The new conference has been designed to provide focused and timely information to the attendees. Each program has been developed with a set of clearly defined learning objectives. At the same time, the program committee has worked long and hard to secure top quality instructors for each program. The committee has also worked to communicate the learning objectives with the instructors to ensure that these individuals are aware of the expectations of the attendees.

The three-day conference has been created with both one- and two-day programs. Leading off the event will be a pre-convention series of six one-day programs on Tuesday, October 22, 1996, the day before the start of the International Coatings Expo (ICE—formerly Paint Industries' Show). The topics are: Surfactant Chemistry; Technical Presentations; Technical Writing; Design of Experiments; Spray Applications; and Technology Assessment. Of special note are the Spray Applications course, which will be held at Binks Manufacturing Company, in Franklin Park, IL, and the Technology Assessment program, presented as an Executive Forum, including a special dinner on Monday evening.

On Wednesday, the two-day programs begin. The topics for these will be: Substrates and Coatings; Characterization; Polymer Chemistry; and a course dealing with the Basics of Coatings Chemistry. Each of these programs will be conducted by expert instructors delivering the information you need.

As an added benefit, all conference attendees will be entitled to complimentary attendance at the ICE as part of the seminar registration fee, and ample time will be allotted for all participants to visit the show floor. As an extra incentive, special rates are available for those who register for the full three-day conference and for groups of three or more from the same company.

Mark your calendars now to make sure you don't miss the most insightful and innovative event to come along in the coatings industry for quite some time. Attendance in all sessions is limited, so make sure you sign up for the International Coatings Technology Conference as soon as the brochure hits your desk!

Michael G. Bell
Director of Educational Services

Technical Abstracts

Translations provided by: Spanish—Jesús Camacho, of Instituto Mexicano de Tecnicos en Pinturas y Tintas.

Predicting the Water-Sensitivity of Film-Forming Coatings Additives by Water Vapor Sorption: With Application to Thickeners and Rheology Modifiers—G.D. Shay, K.R. Olesen and J.L. Stallings

JCT, Vol. 68, No. 854, 51 (Mar. 1996)

Although present in relatively low concentrations, additives such as thickeners, rheology modifiers, dispersants, and surfactants can contribute to the water sensitivity of coatings due to their inherent affinity for moisture. Because of the number of additives often present and the variable response possible within different formulations, a method was sought to examine the moisture affinity of individual additives in the absence of other coating components. A simple gravimetric procedure with high sensitivity and good repeatability was developed based on water vapor sorption (WVS). In this paper, the technique is applied to a variety of commercial thickeners and rheology modifiers commonly employed in waterborne coatings. Although alkali-swellable emulsions of the conventional (ASE) and associative (HASE) varieties are generally considered to be more water sensitive than nonionic thickener types, these carboxyl functional polymers in their acid form actually showed much lower moisture affinities. WVS for the anionic ASE and HASE thickeners was a function of polymer composition, type of counter ion, base volatility, dry time, and the state

Prediciendo la Sensitividad de Aditivos Formadores de Pelicula de Recubrimentos por Sorpción de Vapor de Agua: con Aplicación a los Espesantes y Modificicadores de Reología—G.D. Shay, K.R. Olesen, y J.L. Stallings

Aunque se presentan relativamente en bajas concentraciones, aditivos tales como espesantes, modificadores de reología, dispersantes y surfactantes pueden contribuir a la sensitividad de agua de recubrimietos debido a su inherente afinidad por la húmedad. Debido a que un número de aditivos presenta de manera regular este fenómeno y la posible respuesta variable dentro de las diferentes formulaciones, un método fué buscado para examinar la afinidad por la húmedad de aditivos individuales en ausencia de otros componentes de recubrimientos. Un procedimiento gravimétrico simple con gran sensitividad y reproducible fué desarrollado basado en la sorpción de vapor de agua (SVA). En este trabajo, la técnica es aplicada a una variedad de espesantes comerciales y modificadores reológicos comunmente empleados en recubrimientos base agua. Sin embargo, emulsiones alkali-dilatables de la (ASE) convencinal y variedades de (HASE) son generalmente consideradas para ser más sensitivas al agua que tipos de espesantes no-ionicos, estos polímeros funcional carboxilo en su forma ácida mostraron mucho menores afinidades por la húmedad. La SVA para la ASE anionica y espesantes HASE fué una función de composición de polimero, tipo de conteo d ión, volatilidad base, tiempo de secado y el estado de neutralización anterior a la prueba de conducción.

Cure Behavior of Silicone-Epoxies and Urethane Modified Acrylates in Interpenetrating Polymer Networks—The Detroit Society for Coatings Technology

JCT, Vol. 68, No. 854, 65 (Mar. 1996)

In an attempt to improve the toughness and flexibility of poly(epoxy-urethane-acrylic), interpenetrating polymer network (IPN) coatings conventional bisphenol A type epoxy was replaced with silicone containing epoxy. By comparing silicone epoxy containing samples with bisphenol A controls, the effect of siloxane modification on the properties of the materials thus formed were tested.

The coatings were formulated to typical automotive primer conditions (in the absence of any pigments) and tested for solvent resistance, lap shear strength, impact resistance, and thermal stability. The formation of IPNs was established by changes in the thermal behavior of the coatings as well as by the synergistic effects noted in the physical and mechanical properties achieved in the formulated coatings.

In formation of the silicone modified IPNs, however, it was noted that cure response was diminished versus control. Therefore, we undertook a cure study to determine the effects of catalysts and trifunctional acrylates on the resultant properties in the IPN coatings. This paper describes the chemistries and formulations utilized in attaining the aforementioned properties.

El Comportamiento de Cura de Epoxi-Silicona y Acrilatos de Uretano Modificados en Redes de Polímeros Interpenetrables—The Detroit Society for Coatings Technology

En un intento para mejorar la dureza y la flexibilidad de recubrimientos de redes de polímeros interpenetrables (IPN) de poli(epoxi-uretano-acrilico) epóxico convencinal tipo bisfenol A fue reemplazado con siliconafueron probado conteniendo epóxico. Por comparación de epoxi sicona conteniendo muestras con controles de bisfenol A, el efecto de la modificación de siloxano sobre las propiedades de los materiales de este modo fueron probadas.

Los recubrimientos fueron formulados para condiciones típicas de primarios automotivos (en ausencia de algunos pigmentos) y probados para resistencia al solvente, esfuerzo cortante, resistencia al impacto y estabilidad térmica. La formación de IPNs fue establecida por cambios en el comportamiento térmico de los recubrimientos así como por los efectos sinergísticos que se observaron en las propiedades físicas y mecánicas obtenidas en los recubrimientos formulados.

En la formación de IPNs de silicona modificadas, sin embargo, se observo que la respuesta de cura disminuyó con respecto al control. Por esto se comenzó un estudio de cura para determinar los efectos de catalízador y acrilatos trifuncionales en las propiedades resultantes de los recubrimientos de IPN. Este estudio describe los reactivos químicos y las formulaciones utilizadas para lograr alcanzar las propiedades arriba mencionadas.

Novel Inorganic/Organic Coatings Based on Linseed Oil and Sunflower Oil with Sol-Gel Precursors—S.J. Tuman and M.D. Soucek

JCT, Vol. 68, No. 854, 73 (Mar. 1996)

New inorganic/organic hybrid coatings have been prepared utilizing linseed oil and sunflower oil as an organic phase and two sol-gel precursors [titanium (IV) *i*-propoxide, titanium (di-*i*-propoxide) bis(acetyl-acetonate)] as an inorganic phase. The ultimate goal is to develop a primer that will provide better adhesion and corrosion protection for metal substrates with minimal environmental impact. Coatings with a range of sol-gel precursor to drying oil ratios have been studied. Various coatings properties such as adhesion, hardness, impact resistance, and flexibility were observed as a function of sol-gel precursor content. In addition, the tensile properties and thermo-oxidative stabilities were also investigated. During processing, the sol-gel precursors appear to accelerate the drying of the coatings. Higher sol-gel precursor content increased both tensile strength and tensile modulus but decreased flexibility and strain-at-break. The thermo-oxidative stability was similar to drying oil coatings cured with driers.

Modernos Recubrimientos Orgánicos/Inorgánicos Basados en Aceite de Linaza y Aceite Girasol con Precursores Sol-Gel—S.J. Tuman y M.D. Soucek

Han sido preparados nuevos recubrimientos inorgánicos/orgánicos utilizando aceite de linaza y aceite de girasol como una fase orgánica y dos precursores sol-gel (i-propóxido de titanio (IV), (di-i-propóxido)bis(acetil-acetonato) de Titanio) como una fase inorgánica. El objectivo final es desarrollar un primario que proporcione mejor adhesión y protección contra la corrosión para sustratos de metal con un impacto ambiental mínimo. Han sido estudiados recubrimientos con un rango de precursor sol-gel para razones de aceítes de secado. Algunas propiedades de recubrimientos tales como adhesión, dureza, resistencia al impacto y flexibilidad fueron observados como una función del contenido de precursor sol-gel. También fueron investigadas la propiedades de tensión y las estabilidades termo-oxidativas. Durante el proceso, los precursores sol-gel aceleraron el secado de los recubrimientos. Un mayor contenido de precursor sol-gel incremento tanto la resistencia como el módulo de tensión pero la flexibilidad y la resistencia a la deformación disminuyeron. La estabilidad oxidativa fué similar a la de recubrimientos base solvente de secado al aire curados con secadores.

Microencapsulation of Isocyanates. Characterization and Storage Stability of Microcapsules in a Polyester α,ϖ-ol—E. Quérat, L. Tighzert and J.-Pierre Pascault

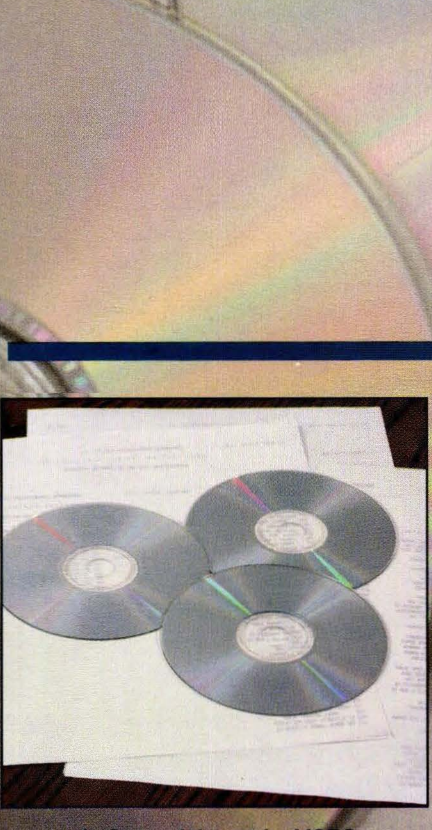
JCT, Vol. 68, No. 854, 83 (Mar. 1996)

The microencapsulation of toluene 2,4-diisocyanate dimer (di-TDI) was accomplished by interfacial polycondensation with ethylene diamine in cyclohexane and in a polycaprolactone; the influence of different parameters was discussed.

The microcapsules obtained were characterized according to morphology and NCO content. Their behavior in two polycaprolactones was studied. The reaction between NCO and OH groups took place only after the isocyanate melting when encapsulation was well done. The stability of microcapsules stored in polycaprolactones at room temperature and 40°C was also examined.

Microencapsulación de Isocianatos. Caracterización y Estabilidad de Almacenamiento de Microcapsulas en un Poliéster—E. Quérat, L. Tighzert y J.-P. Pascault

La microencapsulación del dimero 2,4-diisocianato tolueno (di-TDI) fué llevada a cabo por policondensación interfacial con etilen-diamina en ciclohexano y dentro de una policaprolactona, además se discutío la influencia de diferentes parámetros. Fueron caracterizadas las microcapsulas obtenidas acorde a su morfología y contenido de NCO. Fue estudiado su comportamiento en dos policaprolactonas. La reacción entre NCO y grupos OH tomo lugar solamente después de la fusión del isocianato cuando la encapsulación término totalmente. También fue examinada la estabilidad de microcapsulas almacenadas a temperatura ambiente y 40°C.



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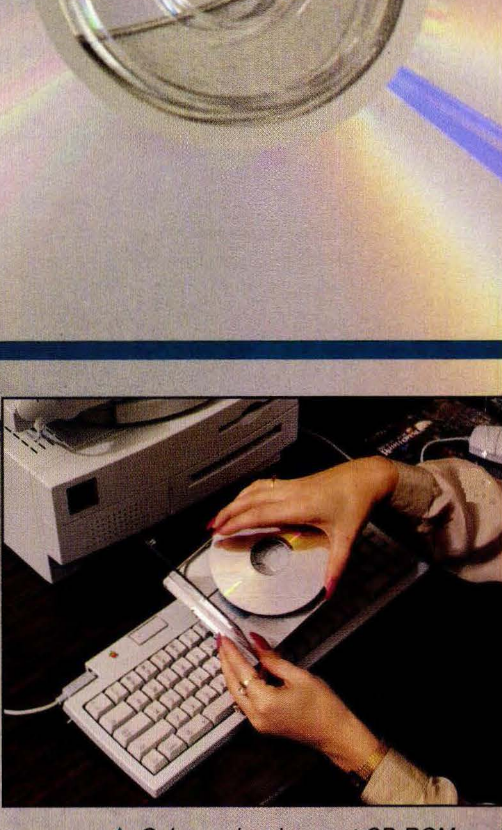

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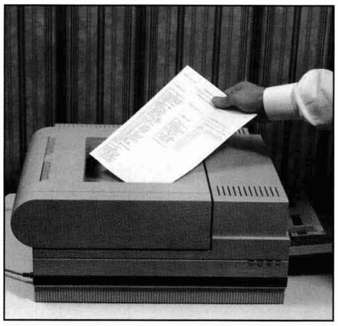

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X-Rite, Inc.

Yamada America, Inc.

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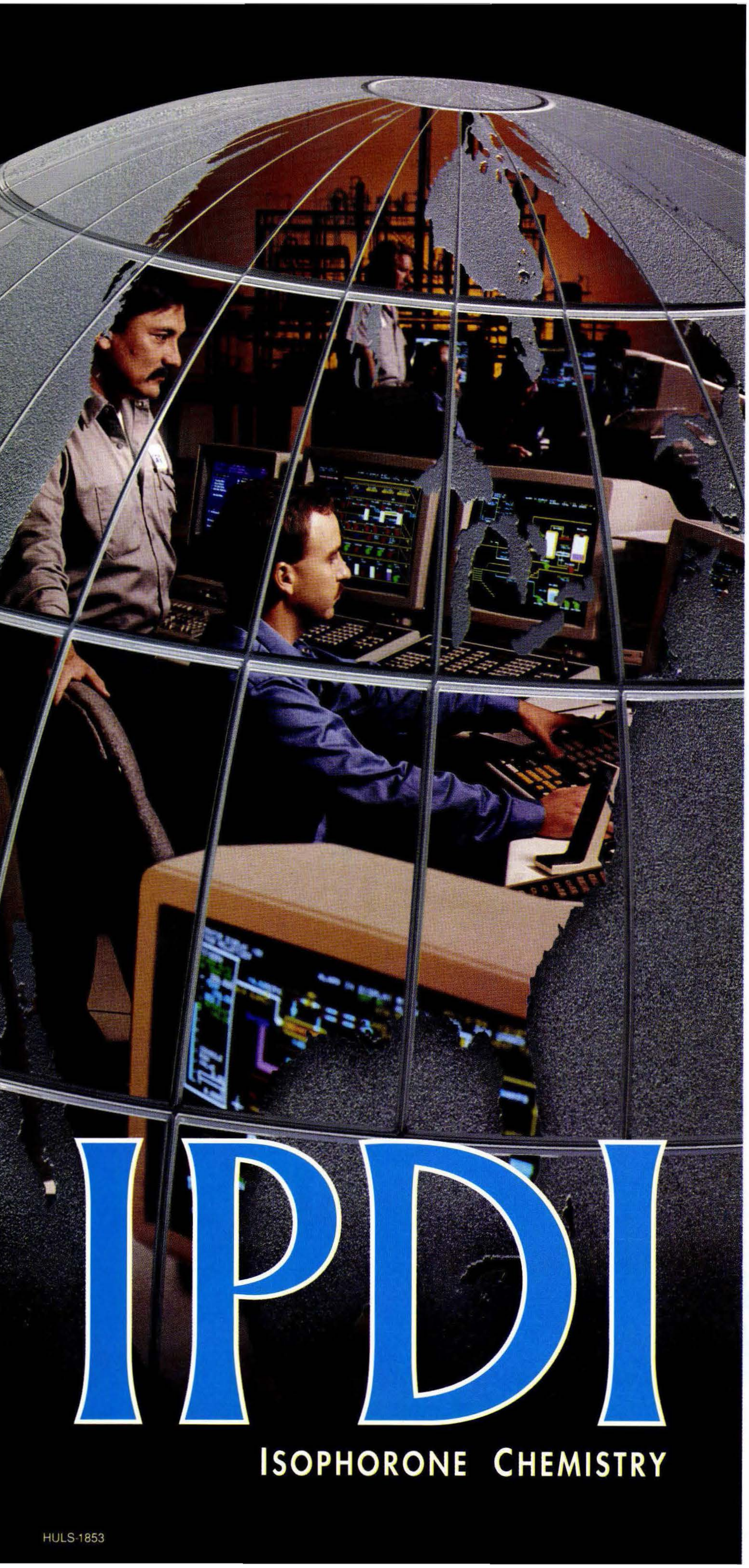
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SPOTLIGHT ON

PIGMENTS

What is a Spotlight?

Introduced in this issue, the JCT 'Spotlight' focuses on a critical area of the coatings industry. Insights into trends, opportunities, and challenges that impact this area will be provided in targeted articles and interviews.

Providing a valuable reference tool, the Spotlight also highlights the companies and products that supply essential services, materials, or equipment to the industry. The company and product guides included in the Spotlight were compiled from responses by individual companies responses to a mail survey.

The inclusion of companies and products in this guide should not be construed as an endorsement by the JCT or the Federation of Societies for Coatings Technology. JCT makes every effort to ensure that the information is accurate, but is not responsible for errors or omissions.

Future '96 Spotlights

April -------- Environmental Services and Equipment
June -------------------- Mixing and Dispersing
July -------------------------------- Additives
August -------------------- Production & Safety
September ---------------------------- Resins
December ------------ Lab Apparatus & Equipment

To participate in future Spotlights, contact JCT, 492 Norristown Rd., Blue Bell, PA 19422; (610) 940-0777.

PIGMENT SPOTLIGHT: a roundtable discussion

In the recently published FSCT Coatings Encyclopedic Dictionary, *pigments are defined as "finely ground, natural or synthetic, inorganic or organic, insoluble dispersed particles which, when dispersed in a liquid vehicle to make paint, may provide, in addition to color, many of the essential properties of a paint—opacity, hardness, durability, and corrosion resistance."*

In this Roundtable Discussion, representatives from suppliers of various types of pigments for the coatings market provide insight into the opportunities, influences, and challenges that impact the development and manufacture of these essential materials.

JCT: ***In your opinion, what recent progress has been made to improve the quality of pigments in the marketplace?***

Roland Valin: A lot of progress has been made in products designed to help coatings manufacturers comply with VOC regulations. Several of them have come out of our own plants, in fact. We've manufactured organic pigments to replace the leaded pigment of the past especially in the traffic coatings area where, for a long time, it's been 100% lead based pigments. Now in the U.S., at least, there has been a switch, and projections are that, for 1996, 75-80% will be organic pigments.

Other areas we have focused on . . . have been pigments to improve the rheological properties of coatings, thereby reducing the need for solvents containing VOCs. Also, (there has been) work to improve opacity to replace some of the former inorganic heavy metal type pigments that provide a lot of opacity for the coatings manufacturer. We've done a lot of that work along the lines of organic pigments as well, for example, with some of our new naphthol reds.

Peter Lewis: As people have moved more towards lower VOCs into high solid, it's become critical that the pigments we offer be low rheology.

Also, the widespread introduction of SPC for quality control has had a major impact on the quality of the products that we put into the warehouse. First, in terms of color control—more and more quality control labs have color computers; since we have the technology to measure, you can use those measurements to go back and constantly improve. Second, we have support from senior management that quality is second only to safety and that has filtered down from the top right through the organization.

James Kassner: There continue to be advances in high tech analytical instrumentation used in process development. This is an area that has had a significant impact on the quality of pigments we are bringing to the marketplace. The other area is . . . in the development of modern process control computers which we use in our facilities to guide manufacturing. This has had impact both from the standpoint of quality and also in helping us hold our line on costs. We've made investments in both of those technologies and, as a result, we can produce pigments with tighter specifications.

George Patrick: We are also doing more in terms of SPC on processes. Being involved with ISO 9001 quality systems has helped us focus on how our processes operate and maintain controls so we can produce materials that have better quality associated with them. If you can better understand and control the process with these methods, you bring products to the marketplace that represent the best that we can produce.

The technology portion of this question (and I'm talking primarily about automotive area), we could direct toward the . . . technology of putting solid state treatments on pigments surface . . . and to have those pigments be used both in waterborne and solvent systems. The surface treatments have definitely provided the quality necessary for those polymer systems. The treatments are there and are

Roundtable Participants

M. Jay Austin
Vice President/General Manager
Halox Pigments
Hammond Group, Inc.

James Kassner
Vice President, Coatings and Inks
Specialty Products Business Unit
Industrial Chemicals Division
Bayer Corp.

Peter Lewis
Industry Manager, Pigments
Sun Chemical Corp.

used to help improve rheological properties in solvent systems, and they are also acceptable for use in waterborne systems.

Jay Austin: The viewpoint I'm going to express is that of a corrosion inhibitive pigment producer whose primary interest in the marketplace is in the area of protective coatings. I think that probably the most significant improvement in quality is the one that has been forced on our entire industry through the quality demands of our customers. Now the marketplace is being supplied with overall products that are more consistent, better quality than, say, where we were five years ago.

Also, there is a move in the marketplace away from just going with the cheapest priced product and a move towards the products that will supply the most consistency, the best quality, in order to produce the most consistent end product. The quality movement has been the biggest factor in the improvement of corrosion inhibitive pigment quality in the marketplace over the last five years.

JK: Speaking from the inorganic pigment area, regarding iron oxide, we have worked on advances that pertain to heat resistance primarily in regard to yellow and black iron oxide and we have worked on flocculation issues in the form of treated red iron oxide.

Another focus is to develop better rheological yellows with a spherical particle shape rather than the usual needle shaped particle. The advantage is lower viscosity and applicability to high solid systems . . . This is an example of the application of understanding chemistry and physics and using modern analytical tools to do that.

JCT: ***What are the needs of your customers that will drive technology towards future improvements?***

JA: Well, I think that the environmental concerns of our industry are going to continue to drive everyone's technology. In our end of the market, certainly VOC and waste disposal concerns and, to a slightly lesser extent, employee health concerns are driving our customers. From our standpoint, they drive the resins technology and, in turn, the resin technology drives the pigment technology because we are constantly trying to develop new pigments that perform and do the job of corrosion resistance and the continuing supply of new resins. So, when the government establishes new environmental regulations, the resin suppliers develop new resins to help the customer meet those (regulations) and we in turn have to develop products that are going to work in those resins to at least maintain the quality of the end coating, to what the new formulation is supposed to be replacing. It's a never ending circle.

PL: Customers require value in use. They aren't looking for a new blue or a new green (however, they are looking for a new yellow . . .). They want high quality and they want attractive economics. The industry as a whole has a thing about toxicity—they want nontoxic or low toxic products as evidenced by the move to replace cadmium. They've moved to replace lead chromes . . . and I think we'll see it become a reality before the turn of the century. The move towards nontoxic pigments from both an environmental and a personnel standpoint is very key.

RV: Yes. The largest single need is going to be environmental compliance for years to come because there is still so much more to be done to overcome the initial shock of not using the heavy metal based pigments. That has certainly created a challenge for pigment and coatings manufacturers given the traditional price difference between heavy metal and organic pigments. Now, how do you overcome that kind of situation? We've done it by improving the color strength of our organic pigments and thereby turned the cost difference around. If we can make a pigment three times stronger, the difference in cost is offset significantly.

JK: There are several things that come together here. One is "just in time" emphasis and, generally, the pressure from our customers for cost control. The production has to be more consistent, but at a lower cost. The benefit as we see it is that, in order to accomplish this, we have to have closer cooperation with our customers, to really understand what their needs are in order to serve them.

George Patrick
Business Center Director,
Automotive Finishes
Ciba Pigments

Roland Valin
Market Development Manager, Colors
Engelhard Corp.

One area in which we have shown improvement is mainly due to process computers and the fact that we are now using statistical process control techniques. We have been able to tighten the specs of our products. Now we also supply certificates of analysis on each shipment that give each customer an overview what can be expected with the quality of that shipment as far as coloristic characteristics, tinting strength, dispersability, pH, and so on. Generally, (customers) expect more from us and we are trying to meet their requirements.

GP: People are asking for color space that has what we call "value added" benefits. The technology we see developing . . . is utilizing solid solution chemistry to make very transparent pigments in a wide range of hues, such as bronze, copper, to shade reds.

In speaking from the perspective of customers in the automotive area, a major drive in the pigment area continues to be VOC but our technology requirements would be providing pigments with specific surface treatments that work in water and solvents and providing workability of those systems.

We are also developing technology for powder coatings in the automotive area, but also for other industrial applications. Powder has its place as a low VOC material for paint and therefore, that technology requires that we look at opportunities to have our pigments work in powder coatings systems.

We also see all the pressures of the marketplace with significant requests for cost reductions and how can we bring cost reductions and value added opportunities with our pigments. I think some of the new chemistries offer that potential.

RV: The unmet needs are still about the cost/performance ratio, but that cost still relates back to the environmental compliance question.

In that respect, I'd like to offer the philosophy that we've adopted here. We're seriously trying to 'right-fit' pigments to the end user—the coatings manufacturer. We're trying to find a way to provide a performance level that is needed without over-engineering it to the point where costs go up along with the changeover. Over the years many manufacturers . . . have made tremendous strides in the ultra high technology, high performance pigments. They have supplied a lot of tremendous products to the market, but most of them have come at a tremendous cost. That's difficult for a coatings manufacturer to have to swallow.

PL: Finally, there is a move in decorative (coatings) to extend durability. I think you'll start to see more colors being used within the home than have been used in the past as more and more people are personalizing the fronts and the interiors of their homes and are using color to do it. If you can tell the homeowner, we'll sell you this gallon of paint, it will last five years on your house, and you'll only have to paint your house every five years as opposed to this (less-expensive) gallon which will only last three years, the consumer will choose the five-year product because they know how much it costs to paint a house. As a result, we are seeing the demand for increased durability in the decorative systems.

> ***"We see all the pressures of the marketplace with significant requests for cost reductions"*** — GP

JCT: What other trends do you see in the pigments area of the industry?

GP: Customers want to consolidate the number of pigments they are using so that they cover a larger color space to help them reduce inventories and provide them with more formulation flexibility.

PL: Improved material handling is crucial to customers. What they want to see are limited numbers of packages, bulk sacks, things like that—anything that makes it easier for them to handle the product when it hits the docks.

GP: I'm sure you've heard about globalization of manufacturing around the world. There are also requests for the suppliers in the pigments base to be global to support the coatings industry in the various regions around the world. Some are further along in their global character, especially in the automotive industry, but there are other companies in the industrial markets and in the refinish markets that have their niches worldwide as well. So, they want to have products with the same quality, with the same types available, supported in the various regions around the world. We make sure that the products are positioned in the various countries, that there is a local source, and that there is technical support . . . You have to have the infrastructure in order to be able to execute appropriately and be able to serve them. You can't serve them from another continent.

Lastly, there is significant downsizing with corporations which requires more technical support from pigment suppliers. In the companies we call on, manpower continues to be reduced. Since the companies have their own priorities, there are specific things we have to assume more responsibility for, now and into the future.

JCT: What are the most significant technological challenges that pigment manufacturers face today? Are there economically viable solutions?

JK: The biggest challenge is the effort to globalize systems. Many of our customers are global in their view and this has put pressure on adopting systems that have standard finishes all around the world. The major automobile manufacturers with their emphasis on QS 9000 are leading the push towards more stringent worldwide specifications.

The demands are a little paradoxical. There is a drive toward simplicity on one hand, but it also means that the products have to be a little more robust and that is a more complex requirement. The challenge that we face is that suppliers have to be worldwide and offer competitive products that work is a wide range of systems. These systems vary from customer to customer and from country to country, so it's a really complex solution. Robustness of products is something that is of extreme value.

PL: One situation we're seeing, and this is in terms of automotive and industrial as opposed to decorative, is systems moving from solvent to water based. Increasingly our customers are saying we need a pigment that looks the same in water as it did in solvent. This is very challenging as they are two entirely different systems: they wet differently, they disperse differently, one is ionic, one is non-ionic. Customers want to buy one pigment to do both jobs. It's easy to ask for, but it isn't easy to accomplish.

Again, rheology is still a criteria. In order to reduce VOC, rheology becomes a critical point, as does the appearance at different viewing angles.

In addition, replacing lead-containing yellows is a real technical challenge to the industry. There is nothing more economical than lead chrome. It costs around a dollar a pound, it's durable, it's predictable . . . People have been using these pigments for 40 years and are comfortable with them. Now, all of a sudden, they have to get rid of them and there's nothing that's a real replacement—everything is a compromise . . . between the stability of the pigment and the cost of the pigment. Equally, a lot of the chromes were used in baking enamels so we're looking for yellows that have high heat stability with the bake resistance of chromes. They're just not around for anything like the price of the chromes.

Industry is being told to "get the lead out" but they're not being told how. I'm sure the coatings customer, the person who's been buying the paint, isn't going to be very sympathetic to the paint maker who says, "I've got to replace a pigment that costs me $1 a pound with one that costs in excess of $15 to $20 a pound." Especially when it's not 20 times stronger, it's only three times stronger. So, you have a no-win situation.

Solutions aren't economically viable until consumers place a value on nontoxicity. How do you place a value on the good that . . . the additional $5.00 for a gallon of paint does for the environment?

> ***"Industry is being told to 'get the lead out' but they're not being told how"*** — PL

GP: There is a challenge for improved durability requirements. That is a significant challenge. Also, the challenges in our organization are to meet environmental guidelines for the processes that we use with our pigments, both in development and manufacturing, to provide for recycling and reduced emissions. Anything we do to bring pigments to the marketplace must have these considerations in place or else our pigments won't be viable to be put into the manufacturing operations.

JA: I think there are probably two major areas that our customers would really like to have. Products that are more versatile in their nature, meaning that they're easier to formulate with and that work in a greater variety of resin systems. The other is the challenge of developing products that are closer to meeting chromate performance both in their economic viability and also in their effectiveness.

> ***"The quality movement has been the biggest factor in the improvement of corrosion inhibitive pigment quality in the marketplace over the last five years"*** — *JA*

JCT: Has your company experienced problems in terms of making improvement to products while still holding costs?

JA: The traditional corrosion inhibitors, mainly lead-based, chromate-based, and zinc phosphate products, have always been considered commodity items and the marketplace was very competitive. As the industry has moved away from these commodity inhibitors and moved on the development of specialty products around specialty technologies, specialty manufacturing techniques and chemistries, it has been a real challenge to develop products that *are* economically viable and that people can accept the cost of. For example, red lead still sells for 60 cents a pound. Most nontoxic inhibitors are a dollar or more. Purchasing agents have a tendency to just look at how much a material costs per pound and not that you're changing technologies and that you are spending many R&D dollars changing to those new technologies.

JK: In addition, as with all modern technology, there's been an acceleration of system development. The cycle time for new products gets shorter and the supplier needs to keep pace with that. This means that there is a constant pressure to try to update your products and, in order to be successful, a constant pressure to stay really close to your customer and understand at what pace and how fast he is changing.

Again, in order to . . . facilitate the process, there has to be close cooperation and communication between the pigment supplier and their customer. The customers, for their part, scrutinize their suppliers and look for people who can provide that kind of support. We try to bring them economically viable solutions.

JCT: How is the marketplace for pigments changing geographically? Where are the growth markets?

JK: Globalization is key. Our opportunities lie with our existing customer base and they are global customers and we are trying to stay at pace with them and what their needs are. It's not a case of identifying a place and saying that's where we need to be. We listen to our customers and try to understand where they see themselves going in a global market.

Demands are for products that go across borders. You have to make sure you are serving their interests. In terms of their expansion, particularly automotive driven, they seem to be looking at countries that have good labor cost profiles and still have sufficient infrastructure to support the automotive industry.

Regarding inorganic pigments, we have seen the outlets in the United States shifting for inorganics. The coatings market used to be the largest segment for iron oxide pigments and that has slowly and steadily shifted toward pigment application for the construction industry to color concrete products. This takes us in the direction of a product application split as it exists in Europe.

Changes in requirements are also coming from industry consolidation with the amount of smaller and mid-size companies that are being bought by the larger market leaders in the industries. That shifts pigment approval processes that might have been in Europe and are now consolidated in those larger companies in the U.S, and vice versa. Then you have merging companies with different technical requirements and also different pigments being used. Certainly what they attempt to do is to consolidate all of their requirements, which is an interesting challenge for us as the pigment supplier.

RV: We see it changing geographically. From the coatings side, it's difficult to say the base is expanding; it is 'conglomerating.' The volume doesn't change as much as the number of customers, but the market is changing without a doubt. There is growing demand in the Asia-Pacific, South America, Mexico and it is moving away from the U.S. —although the U.S. is the biggest, most powerful purchasing market for us. We're looking all over the world to see where opportunities are.

PL: Yes; it's a qualified yes. You're seeing major changes in the automotive area as they are becoming truly multinational. What's happening to the pigment suppliers to these people is that we're being asked, 'can you supply the same standard' and the answer really has to be yes. It's a rhetorical question. We've got to use this blue, or this red, or this green through the company; can you supply the same standard to Germany as you can to Mexico as you can to the U.S.? That's what we're being asked.

> ***"The light at the end of the tunnel is nothing more than the train carrying newer and tougher regulations."***—PL

The difficulties arise when systems are so different. A company in Italy may be using an alkyd melamine system, when their counterpart in the U.S. is using an acrylic system and products don't perform the same in the two systems.

In terms of where the market is growing, we see growth in Latin American countries, particularly in Mexico, followed by Brazil and Argentina. Then the Middle East, and certain Third World Countries, like Africa, China, and India. We've seen Eastern Bloc blossom. But often they don't have the dollars to purchase what the county needs.

JA: We see growth slowing down in the both the North American marketplace (outside of Mexico), and in Europe. . . . We are seeing much more interest and growth coming out of Southeast Asia and South America. We are hearing of more Third World emerging areas. It's quite interesting in dealing with the Third World countries in that they are going from technology that is 50 or 60 years old and they are moving right up to current technology.

JCT: ***Do you see them as future competitors?***

JA: We see them as future customers. They want to emerge and compete in the world marketplace and the world marketplace is one of nontoxic-containing protective coatings. So they are moving, as an example, from old red lead linseed oil technology to some very sophisticated water-based technologies or high solids technologies that are based on nontoxic corrosion inhibitors. It is a quantum leap for them. They are not going through the stages as the United States or Europe has undergone in the last 25 years, as regulations every two or three years have dictated the change in technology. What the Third World is doing is jumping over 50 years and coming right up to current day technology.

JCT: ***Current concern for employee health and environmental protection has affected many areas of the coatings industry. How do you see this concern impacting on pigment manufacture in the short-term and long-term goals of your company?***

RV: We are focusing on organics, without a doubt. Our focus on organic pigments is such that we start off making environmentally friendly products.

PL: Certainly there is a major impact with health and environmental safety issues. We also feel that the end is never in sight. The light at the end of the tunnel is really nothing more than the train carrying newer and tougher regulations. One of the things that occurs, since I've been in industry, is that the equipment that people have can now measure at such low levels that whatever level they can measure almost automatically becomes the level you need to achieve. Whereas those working with analytical equipment might have been content to measure at parts per million, now, with changes in technology and improvements in equipment, they can measure parts per billion. So, since we can measure it—why not make that our limit? We tend to lose sight of the objective. Because it's measurable doesn't mean that's what we require in order to exist.

There are problems in defining what is be accomplished. Are (the regulators) trying to put companies our of business? are they trying to protect the workforce? or are they just trying to put logic and universality in what we do?

Safety is the paramount concern within our company, the second is quality. We're also seeing what is bound to develop as we progress toward the 21st Century and that's this "cradle to grave" mentality in terms of packaging . . . You own the package. You send the pigment out, and the package is disposed of or sent back to you. It's your package and you are responsible for it . . . I think we're going to see innovations in terms of packaging to allow packages to have longer life than they currently do in order to minimize the amount of packaging.

One thing that happens is that capital that at one time has been earmarked for expansion gets diverted to issues of environmental nature, things like report keeping—you almost have to dedicate a person to keeping records to show the necessary agencies.

I think you're going to see greater focus on issues like labeling, shipping, and containers for shipping and this affects goals in the amount of money you have to spend. Some of it has to be diverted toward taking care of the environmental issues.

GP: Well, I can say categorically that Ciba is committed to environmental issues involving pigment manufacturing, particularly when we talk about the U.S. and it's true of our global manufacturing base. For example, we are putting $140 million dollars worth of investment in a new plant and approximately $40 million of that is involved in environmental issues and $100 million would be in building a new facility, and modernizing our quinacridones —you can see the balance of investment required in the marketplace.

This investment speaks for what is required in putting in a manufacturing facility these days. I think the modernization is an example that will provide for a 90% reduction in air emission and 70% reduction in water. Those are the kinds of changes that show the commitment of the industry in general to stay within these guidelines.

JA: In the short term I don't see much more of an effect (short term being the next two or three years). Long term, I think the push is going to continue for products to be more and more and more nontoxic in their nature. Twenty-five years ago when the move started away from what we have traditionally called toxic pigments, such as lead chromates, the only concern was that a product be lead free, chromate free, and it was considered nontoxic. Now, in many areas barium is considered a problem, where 20 years ago, barium wasn't discussed. Now, other metals, such as aluminum, strontium, and zinc are having concerns raised against them. Possibly these may become major issues in our industry in the not too distant future.

A lot of it is going to depend on how the regulatory climate develops. I think it's going to be very interesting to see what the regulatory climate is going to be and how it develops after the next election. The next election may play a big role in a lot of companies' long term and short term planning. We'll see what really shakes out in the regulatory arena and how many dollars are going to be there to push the regulatory machine.

JK: This is a great concern to us at Bayer. We have made significant investments to address these issues in our plant structure. We accept this as an obligation. Bayer is an early member of the Responsible Care Program and is a subscriber to the Responsible Care Program . . . We have made significant investment to make sure that we not only comply with the regulations, but stay ahead of them as corporate citizens.

With inorganics, (in terms of) the iron oxides, mixed metal oxides, and chrome oxides we sell, we have current research and marketing on different forms of delivering pigments to make them more environmentally friendly. In terms of lower dusting, for instance, we and our competitors are doing research in supplying pigments in granulated form rather than in powder that is dusty. We are looking at ways of packaging the pigment to make it easier for our customer to use, to make (the pigments) more environmentally friendly.

On the organic side, much of our research and development efforts are directed toward waterborne systems.

What is the challenge for us is the fact that we are operating in general multidivisional plant sites. We are trying to maximize the reduction of waste streams and making use of those waste streams internally. Whatever would have to go out and be disposed of is minimized. The first thing in that regard is to avoid the generation of waste. We accept that one of our internal goals of our process chemistry is to develop processes that do not generate environmental issues to begin with.

JA: There's an aspect that's very unique to our side of the industry as opposed to a lot of the others when you talk about the impact of regulations and that is what effect that has on reformulation of protective coatings. When a regulation is handed down, its first impact is usually on the resins supplier. The resin supplier tries to develop a new resin that helps to meet that new regulation and they do most of their development work in the laboratory based on accelerated testing. In turn, then, it passes down to us, the corrosion-inhibitive supplier, to develop or to formulate around that resin, to optimize it, to meet the protective coatings needs—not just the regulatory needs but also the performance needs—of our customers and their end use customers.

We in turn depend very much on accelerated testing technology. Unfortunately the paint industry, from a protective coatings standpoint, is still very much wrapped up in measuring performance by salt spray. We have done so much work over the last 10 years that shows that salt spray is an unreliable test method for predicting and developing protective coatings. Yet, the industry is in a cycle of using salt spray because that is what everyone recognizes. We're in a vicious cycle that at some point the industry is going to have to break out of, but it's going to take some research, and a fair amount of cooperative work between regulators, specification writers, raw materials suppliers, paint companies, and their customers to develop new, reliable test methods.

> ***"The challenge that we face is that suppliers have to be worldwide and offer competitive products that work in a wide range of systems"*** — JK

Right now, we are spending a lot of time developing coatings that work well in salt spray but there's no guarantee that these new coatings are going to be viable replacements. I see this issue as being a major industry problem that needs to be addressed. Recognition should be given to the work that the Federation Corrosion Committee has done to try to educate people in this and also the excellent work that the Steel Structures Painting Council has been doing. But as much as both of those organizations have done . . . there's still a lot of education left to be done. ◆

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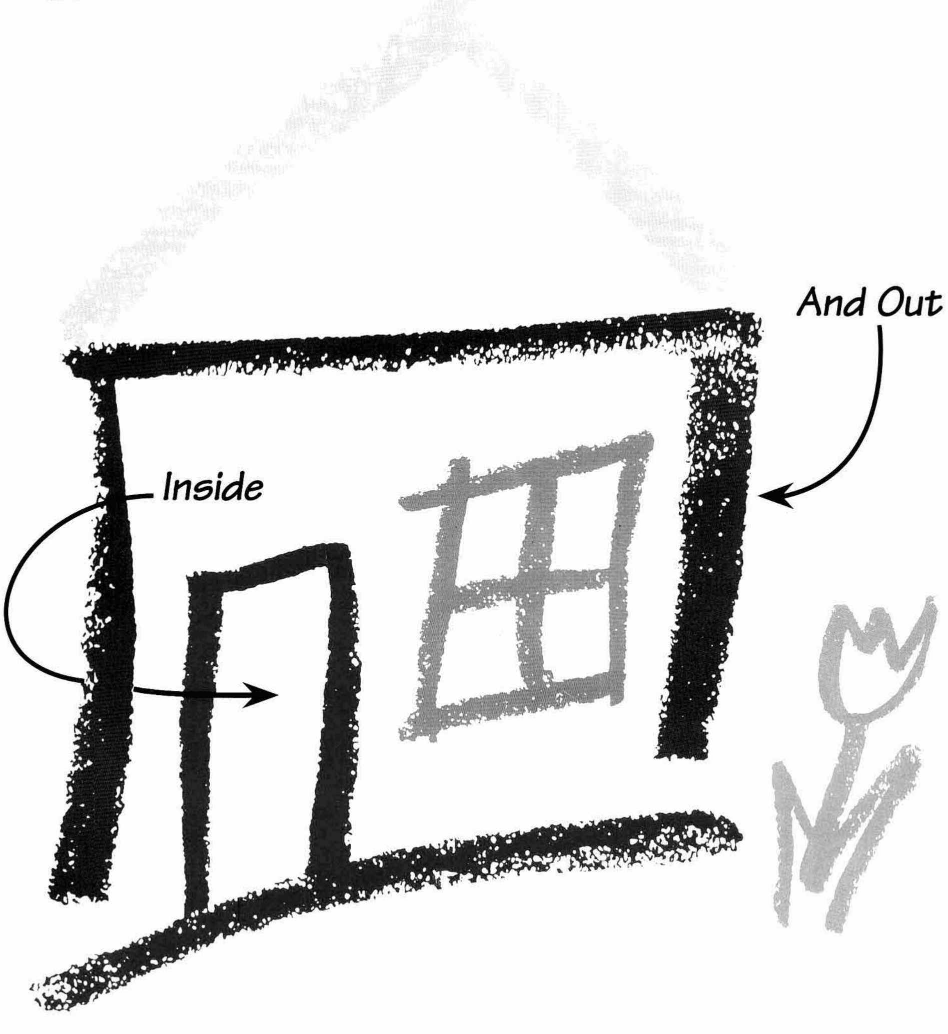
PIGMENT SPOTLIGHT: source guide

	BLACK/BROWN/GRAY	BLUE	CORROSION-INHIBITING	DYES	EXTENDERS	GREEN	IRON OXIDE	METALLIC FLAKES AND POWDERED	OTHER	PIGMENT DISPERSIONS (AQUEOUS)	PIGMENT DISPERSIONS (NON-AQUEOUS)	RED	WHITE	YELLOW/ ORANGE
ABCO Enterprises	X									X				
Alcan-Toyo America								X						
Alcoa Indus. Chem.					X									
American Chemet												X	X	
American Colors										X	X			
Apollo Colors		X								X		X		X
Atomergic Chemetals		X			X	X						X		X
BAYER CORP.	X	X	X	X		X	X			X		X	X	X
Buckman Labs.			X											
BURGESS PIGMENT					X									
Cabot Corp.					X									
CDI Dispersions										X	X			
Celite Corp.					X									
Cerdec Corp.	X	X				X						X		X
Ciba Pigments		X		X					X	X		X		X
Clariant Corp.		X		X		X				X		X		X
Color Corp.										X	X			
Columbia River Carb.					X									
Columbian Chemicals	X													
Cookson Pigments	X	X	X			X						X		X
CR Minerals Corp.					X									
Daicolor-Pope, Inc.		X		X	X	X			X	X		X	X	X
Daniel Products										X	X			
Day-Glo Color Corp.				X					X	X	X			
Degussa														
Dominion Color Corp.			X									X		X
Dry Branch Kaolin					X									
DuPont													X	
Dynamic Color Sol.	X	X			X	X	X						X	
Eagle Zinc Co.			X										X	X
Ebonex Corp.	X									X				
EM Industries	X									X				
Engelhard Corp.	X	X			X	X				X		X		X
Ferro Corp., Colors	X	X				X								X

	BLACK/BROWN/GRAY	BLUE	CORROSION-INHIBITING	DYES	EXTENDERS	GREEN	IRON OXIDE	METALLIC FLAKES AND POWDERED	OTHER	PIGMENT DISPERSIONS (AQUEOUS)	PIGMENT DISPERSIONS (NON-AQUEOUS)	RED	WHITE	YELLOW/ ORANGE
Floridin Co.					X									
Grace Davison			X		X									
HALOX PIGMENTS			X											
Halstab			X										X	
Harcros Pigments	X				X	X	X							
Heucotech Ltd.	X	X	X			X	X			X		X		X
Hoechst Celanese	X	X				X			X	X		X		X
Hoover Color Corp.	X					X	X							
J.M Huber Corp.					X									
HÜLS AMERICA										X	X			
Ishihara Corporation													X	X
Kemira Pigments													X	
KERR-McGEE													X	
Keystone Aniline Corp.	X	X		X		X			X			X		X
Kikuchi Color & Chem.														X
Kronos, Inc.													X	
Lansco Colors	X	X	X		X	X	X	X				X	X	X
Lawter International									X					
Luzenac America					X									
Malvern Minerals Co.					X									
Mapico Inc.							X							
MD-Both Industries								X						
Meadowbrook Co.			X					X						
The Mearl Corp.					X									
Mineral Pigments	X	X	X			X	X							X
Ming-Zu Chemical				X										
Mississippi Lime					X									
National Chemical		X	X			X			X	X		X	X	X
OMYA Inc.					X									
Peer Chemical		X				X						X		X
Penn Color, Inc.										X	X			
PQ Corporation					X									
Pyosa S.A. de C.V.		X	X	X		X				X		X		X
Reichhold/RBH										X	X			

PIGMENT SPOTLIGHT: source guide

	BLACK/BROWN/GRAY	BLUE	CORROSION-INHIBITING	DYES	EXTENDERS	GREEN	IRON OXIDE	METALLIC FLAKES AND POWDERED	OTHER	PIGMENT DISPERSIONS (AQUEOUS)	PIGMENT DISPERSIONS (NON-AQUEOUS)	RED	WHITE	YELLOW/ ORANGE
Rheox, Inc.			X											
Sartomer Company		X				X						X		X
Sherwin-Williams			X											
Silberline								X						
Silvertown Prod. Inc.										X	X			
Sino-American					X				X				X	X
Specialty Minerals					X									
Sun Chemical		X				X				X		X		X
Swansea Minerals	X		X		X		X							
Toyo Ink America		X				X					X	X		X
Tulco, Inc.					X									
United Mineral & Chem.		X	X		X	X			X			X	X	X
U.S. Aluminum, Inc.								X						
U.S. Bronze Powders								X						
R.T. VANDERBILT					X									
Wabash Gilsonite	X													
Wayne Pigment Corp.			X						X					X
Wilkinson Kaolin					X									
Zinc Corporation			X					X					X	X


And Out
Inside

PIGMENT SPOTLIGHT: supplier listing

ABCO Enterprises, Inc.
3450 Eagle Dr.
Allegan, MI 49010
Phone: (616) 673-5822
FAX: (616) 673-6005
Black/Brown/Gray Pigments
Pigment Dispersions (Aqueous)

Alcan-Toyo America, Inc.
1717 N. Naper Blvd., Ste. 201
Naperville, IL 60563-8838
Phone: (708) 505-2169
FAX: (708) 505-2176
Metallic Flakes and Powdered Pigments

Alcoa Industrial Chemicals
P.O. Box 300
Bauxite, AR 72011
Phone: (501) 776-4717
FAX: (501) 776-4904
Extender Pigments

American Chemet
400 Lake Cook Rd.
Deerfield, IL 60015
Phone: (847) 948-0800
FAX: (847) 948-0811
Red Pigments
White Pigments

American Colors, Inc.
160 E. Market St.
Sandusky, OH 44870
Phone: (419) 621-4000
FAX: (419) 625-3979
Pigment Dispersions (Aqueous)
Pigment Dispersions (Non-Aqueous)

Apollo Colors Inc.
3000 Dundee Rd., Ste. 415
Northbrook, IL 60062
Phone: (847) 564-9190
FAX: (847) 564-9296
Blue Pigments
Pigment Dispersions (Aqueous)
Red Pigments
Yellow and Orange Pigments

Atomergic Chemetals Corp.
222 Sherwood Ave.
Farmingdale, NY 11735-1718
Phone: (516) 694-9000
FAX: (516) 694-9177
Blue Pigments
Extender Pigments
Green Pigments
Red Pigments
Yellow and Orange Pigments

BAYER CORPORATION
100 Bayer Rd., Bldg. 14
Pittsburgh, PA 15205
Phone: (412) 777-2597
FAX: (412) 777-7840
Black/Brown/Gray Pigments
Blue Pigments
Corrosion-Inhibiting Pigments
Dyes
Green Pigments
Iron Oxide Pigments
Pigment Dispersions (Aqueous)
Red Pigments
White Pigments
Yellow and Orange Pigments

Buckman Laboratories, Inc.
1256 N. McLean Blvd.
Memphis, TN 38108
Phone: (800) 282-5626
FAX: (901) 726-5970
Corrosion-Inhibiting Pigments

BURGESS PIGMENT COMPANY
P.O. Box 349
Sandersville, GA 31082
Phone: (912) 552-2544
FAX: (912) 552-1772
Extender Pigments

Cabot Corp.
CAB-O-SIL Div.
700 E. US Highway 36
Tuscola, IL 61953
Phone: (217) 253-3370
FAX: (217) 253-4334
Extender Pigments

CDI Dispersions
27 Haynes Ave.
Newark, NJ 07114
Phone: (201) 824-1806
FAX: (201) 824-3947
Pigment Dispersions (Aqueous)
Pigment Dispersions (Non-Aqueous)

Celite Corp.
c/o World Minerals Inc.
P.O. Box 519
Lompoc, CA 93438-0519
Phone: (805) 737-2436
FAX: (805) 735-5699
Extender Pigments

Cerdec Corporation
West Wylie Ave.
Washington, PA 15301
Phone: (412) 223-5900
FAX: (412)229-5388
Black/Brown/Gray Pigments
Blue Pigments
Green Pigments
Red Pigments
Yellow and Orange Pigments

Ciba Pigments
205 S. James St.
Newport, DE 19804
Phone: (800) 326-0048
FAX: (302) 996-2990
Blue Pigments
Dyes
Other Pigments
Pigment Dispersions (Aqueous)
Red Pigments
Yellow and Orange Pigments

Clariant Corp.
4000 Monroe Rd.
Charlotte, NC 28205
Phone: (800) 334-2823
FAX: (704) 377-1064
Blue Pigments
Dyes
Green Pigments
Pigment Dispersions (Aqueous)
Red Pigments
Yellow and Orange Pigments

Color Corporation of America
1215 Nelson Blvd.
Rockford, IL 61104
Phone: (815) 987-3777
FAX: (815) 964-0559
Pigment Dispersions (Aqueous)
Pigment Dispersions (Non-Aqueous)

Columbia River Carbonates
300 N. Pekin Rd.
P.O. Box D
Woodland, WA 98074
Phone: (360) 225-6505
FAX: (360) 225-5087
Extender Pigments

Columbian Chemicals Co.
1600 Parkwood Circle, Ste. 400
Atlanta, GA 30339
Phone: (770) 953-7806
FAX: (770) 951-5742
Black/Brown/Gray Pigments

Cookson Pigments, Inc.
256 Vanderpool St.
Newark, NJ 07114
Phone: (800) 932-0761
FAX: (201) 242-7274
Black/Brown/Gray Pigments
Blue Pigments
Corrosion-Inhibiting Pigments
Green Pigments
Red Pigments
Yellow and Orange Pigments

CR Minerals Corp.
14142 Denver West Pky., Ste. 101
Golden, CO 80401
Phone: (303) 278-1706
FAX: (303) 278-7729
Extender Pigments

Daicolor-Pope, Inc.
40 Webro Rd.
Clifton, NJ 07012
Phone: (800) 631-8387
FAX: (201) 777-4198
Blue Pigments
Dyes
Extender Pigments
Green Pigments
Other Pigments
Pigment Dispersions (Aqueous)
Red Pigments
White Pigments
Yellow and Orange Pigments

PIGMENT SPOTLIGHT: supplier listing

Daniel Products Co., Inc.
400 Claremont Ave.
Jersey City, NJ 07304
Phone: (201) 432-0800
FAX: (201) 432-0266
    Pigment Dispersions (Aqueous)
    Pigment Dispersions (Non-Aqueous)

Day-Glo Color Corp.
4515 St. Clair Ave.
Cleveland, OH 44103
Phone: (216) 391-7070
FAX: (216) 391-7751
    Dyes
    Other Pigments
    Pigment Dispersions (Aqueous)
    Pigment Dispersions (Non-Aqueous)

Dominion Colour Corp.
1800 Ironstone Manor, Unit #2
Pickering, Ont., L1W 3J9
Canada
Phone: (905) 837-4000
FAX: (905) 837-2859
    Corrosion-Inhibiting Pigments
    Red Pigments
    Yellow and Orange Pigments

Dry Branch Kaolin Co.
Route 1, Box 468-D
Dry Branch, GA 31020
Phone: (912) 750-3500
FAX: (912) 746-0217
    Extender Pigments

DuPont Co.
White Pigments & Mineral Products
1007 Market St., B14374
Wilmington, DE 19898
Phone: (302) 774-0542
FAX: (302) 773-4181
    White Pigments

Dynamic Color Solutions
2024 S. Lenox St.
Milwaukee, WI 53207
Phone: (414) 769-2850
Fax: (414) 769-2585
    Black/Brown/Gray Pigments
    Blue Pigments
    Extender Pigments
    Green Pigments
    Iron Oxide Pigments
    White Pigments

Eagle Zinc Co.
30 Rockefeller Plaza
New York, NY 10112
Phone: (212) 582-0420
FAX: (212) 582-3412
    Corrosion-Inhibiting Pigments
    White Pigments
    Yellow and Orange Pigments

Ebonex Corp.
P.O. Box 3247
Melvindale, MI 48122
Phone: (313) 388-0060
Fax: (313) 388-6475
    Black/Brown/Gray Pigments
    Pigment Dispersions (Aqueous)

EM Industries, Inc.
7 Skyline Dr.
Hawthorne, NY 10532
Phone: (914) 592-4660
FAX: (914) 592-9469
    Black/Brown/Gray Pigments
    Other Pigments
    Powder Coating Pigments

Engelhard Corp.
Pigments & Additives Group
101 Wood Ave.
Iselin, NJ 08830
Phone: (908) 205-7144
FAX: (908) 321-0250
    Black/Brown/Gray Pigments
    Blue Pigments
    Extender Pigments
    Green Pigments
    Pigment Dispersions (Aqueous)
    Red Pigments
    Yellow and Orange Pigments

Ferro Corp.
4150 E. 56th St.
P.O. Box 6550
Cleveland, OH 44101
Phone: (216) 641-8580
FAX: (216) 641-8831
    Black/Brown/Gray Pigments
    Blue Pigments
    Green Pigments
    Yellow and Orange Pigments

Floridin Co.
1101 N. Madison St.
Quincy, FL 32351
Phone: (904) 627-7688
FAX: (904) 875-1757
    Extender Pigments
Grace Davison
P.O. Box 2117
Baltimore, MD 21203-2117
Phone: (410) 659-9000
FAX: (410) 659-9213
    Corrosion-Inhibiting Pigments
    Extender Pigments

HALOX PIGMENTS
Hammond Group, Inc.
1326 Summer St.
Hammond, IN 46320
Phone: (219) 933-1560
FAX: (219) 933-1570
    Corrosion-Inhibiting Pigments

Halstab
Hammond Group, Inc.
3100 Michigan St.
Hammond, IN 46323
Phone: (219) 844-3980
FAX: (219) 844-7287
    Corrosion-Inhibiting Pigments
    White Pigments

Harcros Pigments, Inc.
11 Executive Dr., Ste. 1
Fairview Heights, IL 62208
Phone: (800) 323-7796
FAX: (618) 628-1029
    Black/Brown/Gray Pigments
    Extender Pigments
    Green Pigments
    Iron Oxide Pigments

Heucotech Ltd.
99 Newbold Rd.
Fairless Hills, PA 19030
Phone: (215) 736-0712
FAX: (215) 736-0652
    Black/Brown/Gray Pigments
    Blue Pigments
    Corrosion-Inhibiting Pigments
    Green Pigments
    Iron Oxide Pigments
    Pigment Dispersions (Aqueous)
    Red Pigments
    Yellow and Orange Pigments

Hoechst Celanese Corp.
500 Washington St.
Coventry, RI 02893
Phone: (401) 823-2215
FAX: (401) 823-2350
    Black/Brown/Gray Pigments
    Blue Pigments
    Green Pigments
    Other Pigments
    Pigment Dispersions (Aqueous)
    Red Pigments
    Yellow and Orange Pigments

Hoover Color Corp.
P.O. Box 218
Hiwassee, VA 24347
Phone: (540) 980-7233
FAX: (540) 980-8781
    Black/Brown/Gray Pigments
    Green Pigments
    Iron Oxide Pigments

J.M. Huber Corp.
Engineered Minerals Div.
4940 Peachtree Industrial Blvd.,
Ste. 340
Norcross, GA 30071
Phone: (770) 441-1301
FAX: (770) 368-9908
    Extender Pigments

HÜLS AMERICA INC.
220 Davidson Ave.
Somerset, NJ 08854
Phone: (800) FOR-HULS
FAX: (908) 560-6386
Pigment Dispersions (Aqueous)
Pigment Dispersions (Non-Aqueous)

Ishihara Corp. (U.S.A)
600 Montgomery St.
San Francisco, CA 94111
Phone: (415) 421-8207
FAX: (415) 397-5403
White Pigments
Yellow and Orange Pigments

Kemira Pigments, Inc.
One Kemira Rd.
Savannah, GA 31402
Phone: (912) 652-1000
FAX: (912) 652-1181
White Pigments

KERR-McGEE CHEMICAL CORP.
P.O. Box 25861
Oklahoma City, OK 73125
Phone: (405) 775-5021
FAX: (405) 775-5027
White Pigments

Keystone Aniline Corp.
2501 W. Fulton St.
Chicago, IL 60612
Phone: (312) 666-2015
FAX: (312) 666-8530
Black/Brown/Gray Pigments
Blue Pigments
Dyes
Green Pigments
Other Pigments
Red Pigments
Yellow and Orange Pigments

Kikuchi Color & Chemicals Corp.
19 East 5th St.
Paterson, NJ 07524
Phone: (201) 278-0206
FAX: (201) 742-0166
Yellow and Orange Pigments

Kronos, Inc.
P.O. Box 4272
Houston, TX 77210
Phone: (713) 423-5054
FAX: (713) 423-3258
White Pigments

Lansco Colors
(Landers-Segal Color Co., Inc. & Smithchem Div.)
90 Dayton Ave.
Passaic, NJ 07055
Phone: (201) 779-5001
FAX: (201) 779-8948
Black/Brown/Gray Pigments
Blue Pigments
Corrosion-Inhibiting Pigments
Extender Pigments
Green Pigments
Iron Oxide Pigments
Metallic Flakes and Powdered Pigments
Red Pigments
White Pigments
Yellow and Orange Pigments

Lawter International, Inc.
990 Skokie Blvd.
Northbrook, IL 60062
Phone (847) 498-4700
FAX: (847) 498-0066
Other Pigments

Luzenac America
8985 E. Nichols Ave.
Englewood, CO 80112
Phone (303) 643-0487
FAX: (303) 799-8926
Extender Pigments

Malvern Minerals Company
220 Runyon St.
P.O. Box 1238
Hot Springs, AR 71901
Phone: (501) 623-8893
FAX: (501) 623-5113
Extender Pigments

Mapico, Inc.
11116 S. Towne Sq., Ste. 101
St. Louis, MO 63123
Phone: (314) 845-2010
FAX: (314) 845-3570
Iron Oxide Pigments

MD-Both Industries
40 Nickerson Rd.
Ashland, MA 01721
Phone: (508) 881-4100
FAX: (508) 881-1656
Metallic Flakes and Powdered Pigments

Meadowbrook Company
30 Rockefeller Plaza
New York, NY 10112
Phone: (212) 582-0420
FAX: (212) 582-3412
Corrosion-Inhibiting Pigments
Metallic Flakes and Powdered Pigments

The Mearl Corp.
P.O. Box 390, Highway 172 S.
Hartwell, GA 30643
Phone (706) 376-3174
FAX: (706) 376-3044
Extender Pigments

Mineral Pigments Corp.
12116 Conway Rd.
Beltsville, MD 20705
Phone: (301) 210-3400
FAX: (301) 210-4967
Black/Brown/Gray Pigments
Blue Pigments
Corrosion-Inhibiting Pigments
Green Pigments
Iron Oxide Pigments
Yellow and Orange Pigments

Ming-Zu Chemical Industries
1578 Barclay Blvd.
Buffalo Grove, IL 60089
Phone: (847) 419-1083
FAX: (847) 419-1082
Dyes

Mississippi Lime Co.
P.O. Box 2247
Alton, IL 62002-2247
Phone: (618) 465-7741
FAX: (618) 465-7786
Extender Pigments

National Industrial Chemical Co.
600 W. 52nd St.
Chicago, IL 60609
Phone: (312) 924-3700
FAX: (312) 924-7760
Blue Pigments
Corrosion-Inhibiting Pigments
Green Pigments
Other Pigments
Pigment Dispersions (Aqueous)
Red Pigments
White Pigments
Yellow and Orange Pigments

Omya Inc.
61 Main St.
Proctor, VT 05765
Phone: (802) 459-3311
FAX: (802) 459-2125
Extender Pigments

Peer Chemical Corp.
1552 S. Abbott Dr.
Wheeling, IL 60090
Phone: (847) 459-5347
FAX: (847) 459-5340
Blue Pigments
Green Pigments
Red Pigments
Yellow and Orange Pigments

Penn Color Inc.
400 Old Dublin Pike
Doylestown, PA 18901
Phone: (215) 345-6550
FAX: (215) 345-0270
Pigment Dispersions (Aqueous)
Pigment Dispersions (Non-Aqueous)

PQ Corp.
P.O. Box 840
Valley Forge, PA 19402-0840
Phone: (610) 651-4317
FAX: (610) 251-4060
Extender Pigments

PIGMENT SPOTLIGHT: supplier listing

Pyosa S.A. de C.V.
Ave. Industrias #1200 Pte.
Monterrey, NL, Mexico 64000
Mexico
Phone: (52) (8) 331-2600
FAX: (52) (8) 331-4632
Blue Pigments
Corrosion-Inhibiting Pigments
Dyes
Green Pigments
Pigment Dispersions (Aqueous)
Red Pigments
Yellow and Orange Pigments

Reichhold-RBH Pigment Dispersions
CN 2006 L5 Factory Lane
Bound Brook, NJ 08805
Phone: (908) 356-1800
FAX: (908) 356-8369
Pigment Dispersions (Aqueous)
Pigment Dispersions (Non-Aqueous)

Rheox, Inc.
P.O. Box 700
Hightstown, NJ 08520
Phone: (609) 443-2500
FAX: (609) 443-2422
Corrosion-Inhibiting Pigments

Sartomer Company, Inc.
502 Thomas Jones Way
Exton, PA 19341
Phone: (610) 363-4100
FAX: (610) 363-4170
Blue Pigments
Green Pigments
Red Pigments
Yellow and Orange Pigments

Sherwin-Williams Chemicals
101 Prospect Ave., NW
Cleveland, OH 44115
Phone: (216) 566-1294
FAX: (216) 566-1876
Corrosion-Inhibiting Pigments

Silberline Mfg. Co., Inc.
Lincoln Dr.
Tamaqua, PA 18252
Phone: (800) 348-4824
FAX: (717) 668-0197
Metallic Flakes and Powdered Pigments

Silvertown Products, Inc.
DBA Allo Colouring
P.O. Box 443
Ontario, CA 91762
Phone: (909) 986-7061
FAX: (909) 391-1094
Pigment Dispersions (Aqueous)
Pigment Dispersions (Non-Aqueous)

Sino-American Pigments Systems, Inc.
1936 University Ave., Ste. 330
Berkeley, CA 94704-1024
Phone: (510) 848-8890
FAX: (510) 848-8889
Extender Pigments
Other Pigments
White Pigments
Yellow and Orange Pigments

Specialty Minerals Inc.
640 N. 13th St.
Easton, PA 18042
Phone: (610) 250-3039
FAX: (610) 250-3344
Extender Pigments

Sun Chemical Corporation
5020 Spring Grove Ave.
Cincinnati, OH 45232-1988
Phone: (513) 681-5950
FAX: (513) 632-1537
Blue Pigments
Green Pigments
Pigment Dispersions (Aqueous)
Red Pigments
Yellow and Orange Pigment

Swansea Minerals, Inc.
6360 E. Rose Circle Dr.
Scottsdale, AZ 85251
Phone: (602) 994-9964
FAX: (602) 941-2423
Black/Brown/Gray Pigments
Corrosion-Inhibiting Pigments
Extender Pigments
Iron Oxide Pigments

Toyo Ink America, Inc.
910 Sylvan Ave.
Englewood Cliffs, NJ 07632
Phone: (201) 568-8660
FAX: (201) 569-2455
Blue Pigments
Green Pigments
Pigment Dispersion (Non-Aqueous)
Red Pigments
Yellow and Orange Pigments

Tulco, Inc.
9 Bishop Rd.
Ayer, MA 01432
Phone: (508) 772-4412
FAX: (508) 772-1751
Extender Pigments

United Mineral & Chemical Corp.
1100 Valley Brook Ave.
Lyndhurst, NJ 07071
Phone: (201) 507-3300
FAX: (201) 507-1506
Blue Pigments
Corrosion-Inhibiting Pigments
Extender Pigments
Other Pigments
Red Pigments
White Pigments
Yellow and Orange Pigments

U.S. Aluminum, Inc.
408 Route 202
P.O. Box 2190
Flemington, NJ 08822-2190
Phone: (908) 782-5454
FAX: (908) 782-3489
Metallic Flakes and Powdered Pigments

U.S. Bronze Powders, Inc.
408 Route 202
P.O. Box 31
Flemington, NJ 08822-0031
Phone: (908) 782-5454
FAX: (908) 782-3489
Metallic Flakes and Powdered Pigments

R.T. VANDERBILT CO.
30 Winfield St.
Norwalk, CT 06856
Phone: (203) 853-1400
FAX: (203) 853-1452
Extender Pigments

Wabash Gilsonite Blends
707 E. Fayette Ave.
P.O. Box 368
Effingham, IL 62401
Phone: (217) 342-9755
FAX: (217) 342-9827
Black/Brown/Gray Pigments

Wayne Pigment Corp.
306 N. Milwaukee St.
Milwaukee, WI 53202
Phone: (414) 225-2400
FAX: (414) 225-2410
Corrosion-Inhibiting Pigments
Other Pigments
Yellow and Orange Pigments

Wilkinson Kaolin Associates, Ltd.
831 Milledgeville Rd.
P.O. Box 306
Gordon, GA 31031
Phone: (912) 628-5301
FAX: (912) 628-3231
Extender Pigments

Zinc Corporation of America
300 Frankfort Rd.
Monaca, PA 15061-2295
Phone: (412) 773-2208
FAX: (412) 773-2217
Corrosion-Inhibiting Pigments
Metallic Flakes and Powdered Pigments
White Pigments
Yellow and Orange Pigments

PIGMENT SPOTLIGHT: product listing

Black/Brown/Gray Pigments

Brown and Gray Pigments

Bayer Corporation
Engelhard Corp.
Hoechst Celanese Corp.
Hoover Color Corp.

Carbon Black

ABCO Enterprises, Inc.
Bayer Corporation
Columbian Chemicals Co.
Dynamic Color Solutions
Harcros Pigments, Inc.
Keystone Aniline Corp.
Landers-Segal Color Co., Inc.
Mineral Pigments Corp.

Complex Inorganic Color Pigments

Bayer Corporation
Cerdec Corp.
Engelhard Corp.
Ferro Corp., Color Div.
Heucotech Ltd.
Hoover Color Corp.
Landers-Segal Color Co., Inc.

Drop and Bone Blacks

ABCO Enterprises, Inc.
Ebonex Corp.
Hoover Color Corp.

Lampblack

Dynamic Color Solutions
Hoover Color Corp.
Landers-Segal Color Co., Inc.

Miscellaneous Black Pigments

Bayer Corporation
Cookson Pigments, Inc.
Dynamic Color Solutions
EM Industries, Inc.
Engelhard Corp.
Harcros Pigments Inc.
Wabash Gilsonite Blends, Inc.

Blue Pigments

Blue, Purple and Violet PMA & PTA Toners/Lakes

Heucotech Ltd.
Peer Chemical Corp.

Complex Inorganic Color Pigments

Bayer Corporation
Cerdec Corp.
Engelhard Corp.
Ferro Corp., Color Div.
Heucotech Ltd.
Landers-Segal Color Co., Inc.

Indanthrone Blue

Ciba Pigments
Keystone Aniline Corp.

Iron Blue

Daicolor-Pope, Inc.
Keystone Aniline Corp.
Landers-Segal Color Co., Inc.
Mineral Pigments corp.
Pyosa S.A. de C.V.

Miscellaneous Blue, Purple and Violet

Ciba Pigments
Hoechst Celanese Corp.
Landers-Segal Color Co., Inc.
Peer Chemical Corp.
Toyo Ink America, Inc.

Phthalocyanine Blue

Apollo Colors
Atomergic Chemetals Corp.
Bayer Corp.
Ciba Pigments
Clariant Corp.
Cookson Pigments, Inc.
Daicolor-Pope, Inc.
Engelhard Corp.
Heucotech Ltd.
Hoechst Celanese Corp.
Keystone Aniline Corp.
Landers-Segal Color Co., Inc.
National Industrial Chemical
Peer Chemical Corp.
Pyosa S.A. de C.V.
Sartomer Co., Inc.
Sun Chemical Corp., Pigments Div.
Toyo Ink American Inc.
United Mineral & Chemical Corp.

Ultramarine

Atomergic Chemetals Corp.
Dynamic Color Solutions
Ferro Corp., Color
Landers-Segal Color Co., Inc.
United Mineral & Chemical Corp.

Corrosion-Inhibiting Pigments

Miscellaneous Corrosion-Inhibiting Pigments

Buckman Laboratories, Inc.
Dominion Colour Corp.
Eagle Zinc Co.
Grace Davison
Halox Pigments
Halstab
Heucotech Ltd.
Landers-Segal Color Co., Inc.
Mineral Pigments
National Industrial Chemical
Rheox, Inc.
Sherwin-Williams Chemicals
Swansea Minerals, Inc.
United Mineral & Chemical Corp.
Wayne Pigment Corp.

Red Lead/Litharge/Blue Lead

Pyosa S.A. de C.V.

Zinc Dust and Flakes

Meadowbrook Co.
Zinc Corp. of America

Zinc Yellow Pigments

Cookson Pigments, Inc.
Landers-Segal Color Co., Inc.
Mineral Pigments Corp.
National Industrial Chemical
Pyosa S.A. de C.V.
United Mineral & Chemical Corp.
Wayne Pigment Corp.

Dyes

Miscellaneous Dyes

Bayer Corporation
Daicolor-Pope, Inc.
Day-Glo Color Corp.
Keystone Aniline Corp.
Ming-Zu Chemical Industries
Pyosa S.A. de C.V.

Organic

Bayer Corporation
Clariant Corp.
Daicolor-Pope, Inc.
Keystone Aniline Corp.
Pyosa S.A. de C.V.

Solvent-Soluble

Bayer Corporation
Ciba Pigments
Clariant Corp.
Daicolor-Pope, Inc.
Keystone Aniline Corp.
Ming-Zu Chemical Industries
Pyosa S.A. de C.V.

Water-Soluble

Bayer Corporation
Clariant Corp.
Daicolor-Pope, Inc.
Keystone Aniline Corp.

Extender Pigments

Aluminum Trihydrate
Alcoa Industrial Chemicals
J.M. Huber Corp.
Landers-Segal Color Co., Inc.

Barium Sulfate (Barytes, Blanc Fixc)
Harcros Pigments, Inc.
J.M. Huber Corp.
Landers-Segal Color Co., Inc.

Barium Sulfate
Atomergic Chemetals Corp.
Daicolor-Pope, Inc.
Harcros Pigments, Inc.
Landers-Segal Color Co., Inc.
Sino-American Pigment Systems

Bentonite
Landers-Segal Color Co., Inc.

Calcium Carbonate
Columbia River Carbonates
Dynamic Color Solutions
J.M. Huber Corp.
Mississippi Lime Co.
Omya, Inc.
Specialty Minerals, Inc.
United Mineral & Chemical Corp.

China Clay and Aluminum Silicate
Burgess Pigment Co.
Dry Branch Kaolin Co.
Engelhard Corp.
J.M. Huber Corp.
Landers-Segal Color Co., Inc.
Wilkinson Kaolin Associates, Ltd.

Fillers
Burgess Pigment Co.
CR Minerals Corp.
Engelhard Corp.
Floridin Co.
J.M. Huber Corp.
Landers-Segal Color Co., Inc.
Luzenac America
Mississippi Lime Co.
PQ Corp./Potters Industries
R.T. Vanderbilt Co., Inc.

Mica
The Mearl Corp.
Landers-Segal Color Co., Inc.

Miscellaneous Extenders
Burgess Pigment Co.
Engelhard Corp.
Floridin Co.
J.M. Huber Corp.
Landers-Segal Color Co., Inc.
Luzenac America
Malvern Minerals Co.
PQ Corp./Potter Industries
Specialty Minerals, Inc.
Swansea Minerals, Inc.
R.T. Vanderbilt Co., Inc.

Silica-Amorphous-Naturally Occurring
CR Minerals Corp.
Landers-Segal Color Co., Inc.

Silica-Amorphous-Synthetic
Cabot Corp.
Dry Branch Kaolin Co.
Grace Davison
Tulco Inc.

Silica-Quartz and Diatomaceous
Celite Corp.
CR Minerals Corp.
Landers-Segal Color Co., Inc.
Malvern Minerals Co.

Talc or Magnesium Silicate
Landers-Segal Color Co., Inc.
Luzenac America
Specialty Minerals Inc.
R.T. Vanderbilt Co., Inc.

Green Pigments

Chrome Green
National Industrial Chemical
Pyosa S.A. de C.V.

Chromium Oxide
Atomergic Chemetals Corp.
Bayer Corporation
Dynamic Color Solutions
Engelhard Corp.
Harcros Pigments Inc.
Hoover Color Corp.
Landers-Segal Color Co., Inc.
Mineral Pigments Corp.

Complex Inorganic Color Pigments
Bayer Corporation
Cerdec Corp.
Engelhard Corp.
Ferro Corp., Color Div.
Heucotech Ltd.
Landers-Segal Color Co., Inc.

Green PMA & PTA Toners/Lakes
Heucotech Ltd.
Peer Chemical Corp.

Hydrated Chromium Oxide
Harcros Pigments Inc.

Miscellaneous Green Pigments
Engelhard Corp.
Peer Chemical Corp.

Phthalocyanine Green
Atomergic Chemetals Corp.
Bayer Corporation
Clariant Corp.
Cookson Pigments, Inc.
Daicolor-Pope, Inc.
Dynamic Color Solutions
Engelhard Corp.
Heucotech Ltd.
Hoechst Celanese Corp.
Keystone AnilineCorp.
Landers-Segal Color Co., Inc.
National Industrial Chemical
Peer Chemical Corp.
Pyosa S.A. de C.V.
Sartomer Co., Inc.
Sun Chemical Corp., Pigments Div.
Toyo Ink America, Inc.
United Mineral & Chemical Corp.

Iron Oxide Pigments

Black Iron Oxide
Bayer Corporation
Dynamic Color Solutions
Harcros Pigments, Inc.
Heucotech Ltd.
Hoover Color Corp.
Landers-Segal Color Co., Inc.
Mapico Inc.
Mineral Pigments Corp.
Swansea Minerals, Inc.

Burnt Sienna
Hoover Color Corp.
Landers-Segal Color Co., Inc.
Mineral Pigments Corp.

Burnt Umber
Dynamic Color Solutions
Harcros Pigments Inc.
Hoover Color Corp.
Landers-Segal Color Co., Inc.
Mineral Pigments Corp.

Indian Red
Hoover Color Corp.
Landers-Segal Color Co., Inc.

Metallic Brown
Harcros Pigments, Inc.
Hoover Color Corp.
Landers-Segal Color Co., Inc.

Mineral Black
Dynamic Color Solutions
Harcros Pigments, Inc.
Hoover Color Corp.

PIGMENT SPOTLIGHT: product listing

Ochre
Dynamic Color Solutions
Hoover Color Corp.
Landers-Segal Color Co., Inc.
Mineral Pigments Corp.

Raw Sienna
Hoover Color Corp.
Landers-Segal Color Co., Inc.
Mineral Pigments Corp.

Raw Umber
Harcros Pigments, Inc.
Hoover Color Corp.
Landers-Segal Color Co., Inc.
Mineral Pigments Corp.

Red and Brown Iron Oxide — Natural
Dynamic Color Solutions
Harcros Pigments, Inc.
Hoover Color Corp.
Landers-Segal Color Co., Inc.
Mineral Pigments Corp.

Red and Brown Iron Oxide — Synthetic
Bayer Corporation
Dynamic Color Solutions
Harcros Pigments, Inc.
Hoover Color Corp.
Landers-Segal Color Co., Inc.
Mineral Pigments Corp.

Spanish Type Oxide
Hoover Color Corp.
Landers-Segal Color Co., Inc.
Mineral Pigments Corp.

Van Dyke Brown
Hoover Color Corp.
Landers-Segal Color Co., Inc.
Mineral Pigments Corp.

Yellow Iron Oxide—Synthetic
Bayer Corporation
Dynamic Color Solutions
Harcros Pigments, Inc.
Hoover Color Corp.
Landers-Segal Color Co., Inc.
Mapico Inc.
Mineral Pigments Corp.

Metallic Flakes and Powdered Pigments

Aluminum Pastes—Leafing
Alcan-Toyo America, Inc.
Landers-Segal Color Co., Inc.
MD-Both Industries
Silberline Manufacturing Co., Inc.
U.S. Aluminum, Inc.

Aluminum Pastes—Nonleafing
Alcan-Toyo America, Inc.
Landers-Segal Color Co., Inc.
MD-Both Industries
Silberline Manufacturing Co., Inc.
U.S. Aluminum, Inc.

Aluminum Powders—Leafing
Alcan-Toyo America, Inc.
MD-Both Industries
U.S. Aluminum, Inc.

Aluminum Powders—Nonleafing
Alcan-Toyo America, Inc.
MD-Both Industries
U.S. Aluminum, Inc.

Gold Bronze Powders
MD-Both Industries
United States Bronze Powders, Inc.

Other Metallic Flakes
United States Bronze Powders, Inc.

Zinc Dust and Flakes
Meadowbrook Co.
U.S. Aluminum, Inc.
Zinc Corp. of America

Other Pigments

Iridescent
Daicolor-Pope, Inc.
EM Industries, Inc.

Luminescent and Fluorescent
Day-Glo Color Corp.
Keystone Aniline Corp.
Hoechst Celanese Corp.
Lawter International
Sino-American Pigment Systems
United Minerals & Chemical Corp.

Miscellaneous Other Pigments
Apollo Colors
Ciba Pigments
EM Industries
Floridin Co.
Grace Davison
Keystone Aniline Corp.
National Industrial Chemical
United Mineral & Chemical Corp.
Wayne Pigment Corp.

Pearlescent
EM Industries, Inc.

Pigment Dispersions (Aqueous)

Color Concentrates
American Colors, Inc.
Bayer Corporation
CDI Dispersions
Clariant Corp.
Color Corp. of America
Day-Glo Color Corp.
Engelhard Corp.
Heucotech Ltd.
Hüls America Inc.
National Industrial Chemical
Penn Color, Inc.
Reichhold Chemicals, Inc.
Silvertown Products, Inc.
Sun Chemical Corp., Pigments Div.

Machine Colorants
Color Corp. of America
Day-Glo Color Corp.
Engelhard Corp.
Hoechst Celanese Corp.
Hüls America Inc.
National Industrial Chemical

Press Cakes
Apollo Colors
Bayer Corporation
Clariant Corp.
Daicolor-Pope, Inc.
Engelhard Corp.
National Industrial Chemical
Pyosa S.A. de C.V.
Sun Chemical Corp., Pigments Div.

Solvent-Soluble Dyes
Ciba Pigments
Clariant Corp.

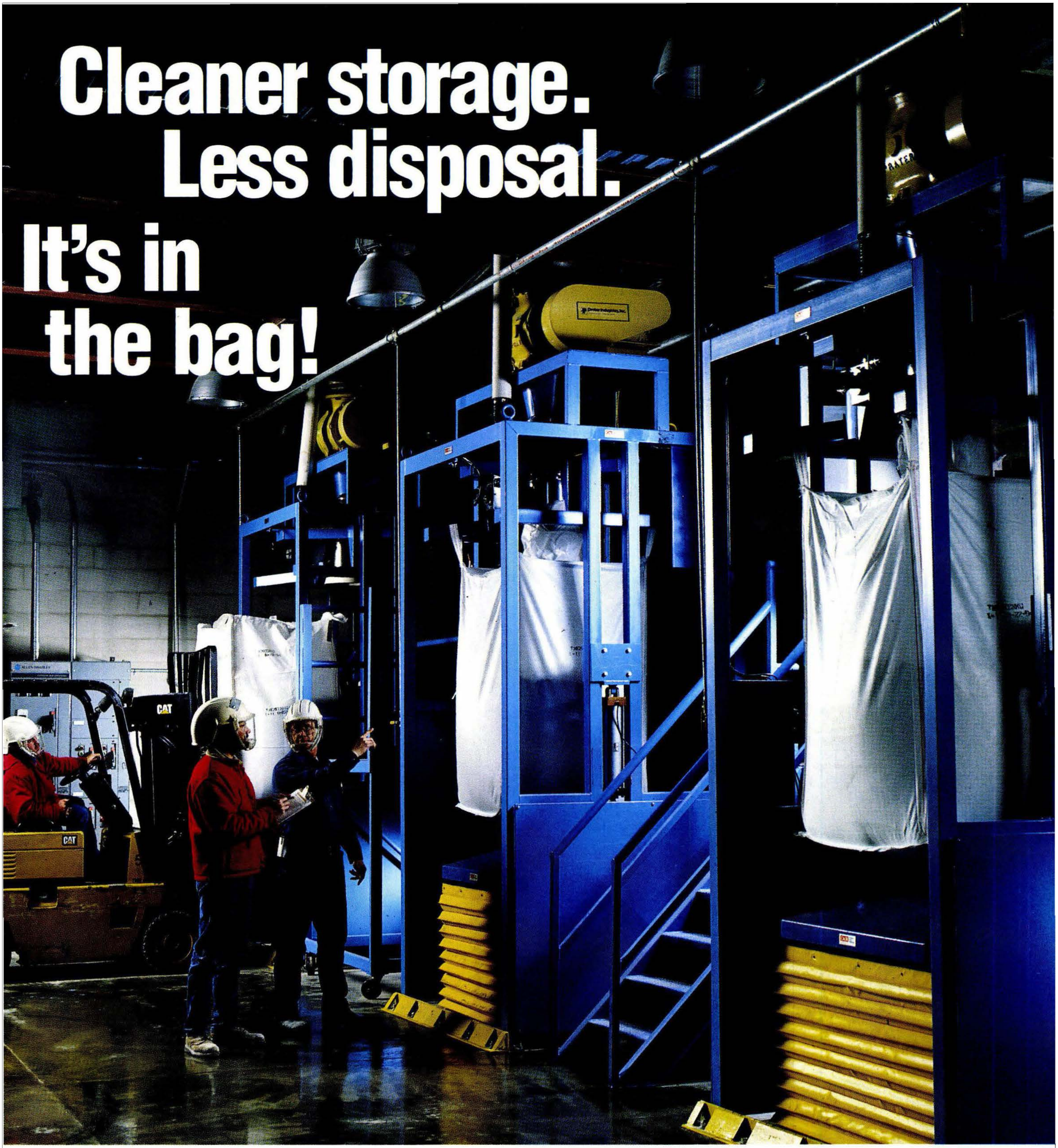
Tube Colorants
Color Corp. of America

Water-Soluble
ABCO Enterprises, Inc.
American Colors, Inc.
Hüls America Inc.
National Industrial Chemical
Penn Color, Inc.
Reichhold Chemicals, Inc.

Pigment Dispersions (Non-Aqueous)

Acrylic Vehicle Pigment Dispersion
American Colors, Inc.
CDI Dispersions
Daniel Products Co., Inc.
Day-Glo Color Corp.
Hüls America Inc.
Penn Color, Inc.
Reichhold Chemicals, Inc.
Toyo Ink America, Inc.

Alkyd Vehicle Pigment Dispersion
American Colors, Inc.
CDI Dispersions


Cleaner storage.
Less disposal.
It's in
the bag!

Color Corp. of America
Daniel Products Co., Inc.
Day-Glo Color Corp.
Hüls America Inc.
Penn Color, Inc.
Reichhold Chemicals, Inc.
Toyo Ink America, Inc.

Nitrocellulose Vehicle Pigment Dispersion

Penn Color, Inc.
Reichhold Chemicals, Inc.
Toyo Ink America, Inc.

Polyester Vehicle Pigment Dispersion

American Colors, Inc.
CDI Dispersions
Day-Glo Color Corp.
Penn Color, Inc.
Toyo Ink America, Inc.

Universal Solvent Vehicle Dispersion

American Colors, Inc.
CDI Dispersions
Color Corp. of America
Daniel Products Co., Inc.
Day-Glo Color Corp.
Hüls America Inc.
Penn Color, Inc.
Silvertown, Products, Inc.

Red Pigments

Alizarine or Madder Lake

Heucotech Ltd.
Keystone Aniline Corp.

Arylide Red and Maroon

Hoechst Celanese Corp.
Keystone Aniline Corp.

BON Red and Maroon

Bayer Corporation
Ciba Pigments
Cookson Pigments, Inc.
Dominion Colour Corp.
Engelhard Corp.
Hoechst Celanese Corp.
Keystone Aniline Corp.
National Industrial Chemical
Peer Chemical Corp.
Pyosa S.A. de C.V.
Sun Chemical Corp., Pigments Div.
United Minerals & Chemical Corp.

Cadmium Red

Atomergic Chemetals Corp.
Cerdec Corp.
Engelhard Corp.
Keystone Aniline Corp.
Sartomer Co., Inc.
United Mineral & Chemical Corp.

Cadmium-Mercury Red, Maroon and Orange

Atomergic Chemetals Corp.
Sartomer Co., Inc.
United Minerals & Chemical Corp.

Cuprous Oxide

American Chemet Corporation

Lithol Rubine

Apollo Colors
Bayer Corporation
Dominion Colour Corp.
Engelhard Corp.
Heucotech Ltd.
Keystone Aniline Corp.
Landers-Segal Color Co., Inc.
National Industrial Chemical
Peer Chemical Corp.
Pyosa S.A. de C.V.
Sun Chemical Corp., Pigments Div.
Toyo Ink America, Inc.
United Mineral & Chemical Corp.

Metallized Azo Red

Cookson Pigments, Inc.
Dominion Colour Corp.
Hoechst Celanese Corp.
Keystone Aniline Corp.
Sun Chemical Corp., Pigments Div.
Toyo Ink America, Inc.

Miscellaneous Red and Maroon Toners/Lakes

Ciba Pigments
Daicolor-Pope, Inc.
Dominion Colour Corp.
Heucotech Ltd.
Hoechst Celanese Corp.
Pyosa S.A. de C.V.
Sun Chemical Corp., Pigments Div.
United Mineral & Chemical Corp.

Naphthol Red

Ciba Pigments
Clariant Corp.
Cookson Pigments, Inc.
Daicolor-Pope, Inc.
Dominion Colour Corp.
Engelhard Corp.
Heucotech Ltd.
Hoechst Celanese Corp.
Landers-Segal Color Co., Inc.
National Indsutrial Chemical
Peer Chemical Corp.
Pyosa S.A. de C.V.
Sun Chemical Corp., Pigments Div.
Toyo Ink America, Inc.
United Mineral & Chemical Corp.

Para Red, Chlorinated Paranitraniline Toner

Engelhard Corp.
National Industrial Chemical

Pigment Scarlet

Ciba Pigments
Clariant Corp.
Engelhard Corp.
Sun Chemical Corp., Pigments Div.
United Mineral & Chemical Corp.

Pyrazolone Red and Maroon

Engelhard Corp.
Keystone Aniline Corp.
Pyosa S.A. de C.V.
Sun Chemical Corp., Pigments Div.

Quinacridone Pigment

Bayer Corporation
Ciba Pigments
Cookson Pigments, Inc.
Daicolor-Pope, Inc.
Hoechst Celanese Corp.
Keystone Aniline Corp.
Landers-Segal Color Co., Inc.
Sun Chemical Corp., Pigments Div.

Red Lake C

Apollo Colors
Ciba Pigments
Daicolor-Pope, Inc.
Dominion Colour Corp.
Engelhard Corp.
Heucotech Ltd.
Hoechst Celanse Corp.
Keystone Aniline Corp.
Landers-Segal Color Co., Inc.
Peer Chemical Corp.
Pyosa S.A. de C.V.
Sun Chemical Corp., Pigments Div.
Toyo Ink America, Inc.
United Mineral & Chemical Corp.

Rhodamine

Keystone Aniline Corp.
Sun Chemical Corp., Pigments Div.

Sodium Lithol, Calcium Lithol, and Barium Lithol Tone

Dominion Colour Corp.
Engelhard Corp.
Heucotech Ltd.
National Industrial Chemical
Pyosa S.A. de C.V.
Sun Chemical Corp., Pigments Div.
Toyo Ink America, Inc.
United Mineral & Chemical Corp.

Toluidine Red

Atomergic Chemetals Corp.
Dominion Colour Corp.
Engelhard Corp.
Hoechst Celanese Corp.
Landers-Segal Color Co., Inc.
Pyosa S.A. de C.V.
Sun Chemical Corp., Pigments Div.
United Mineral & Chemical Corp.

White Pigments

Antimony Oxide
Sino-American Pigment Systems
United Mineral & Chemical Corp.

Titanium Dioxide-Anatase
Bayer Corporation
Ishihara Corp. (USA)
Kemira Pigments, Inc.
Kronos, Inc.
Sino-American Pigment Systems
United Mineral & Chemical Corp.

Titanium Dioxide-Rutile
Bayer Corporation
Daicolor-Pope, Inc.
DuPont
Dynamic Color Solutions
Ishihara Corp. (USA)
Kemira Pigments, Inc.
Kerr-McGee Chemical Corp.
Kronos, Inc.
Landers-Segal Color Co., Inc.
United Mineral & Chemical Corp.

White Lead
Halstab, Div. of Hammond Group, Inc.
Landers-Segal Color Co., Inc.
National Industrial Chemical

Zinc Oxide
Bayer Corporation
American Chemet Corporation
Eagle Zinc Co.
Landers-Segal Color Co., Inc.
National Industrial Chemical
Zinc Corp. of America

Zinc Sulfide
Landers-Segal Color Co., Inc.
Sino-American Pigment Systems

Yellow and Orange Pigments

Cadmium Yellow and Orange
Atomergic Chemetals Corp.
Cerdec Corp.
Engelhard Corp.
Sartomer Co., Inc.
United Mineral & Chemical Corp.

Chrome Orange
Cookson Pigments, Inc.
Dominion Colour Corp.
Engelhard Corp.
National Industrial Chemical
Pyosa S.A. de C.V.

Chrome Yellow
Cookson Pigments, Inc.
Dominion Colour Corp.
Engelhard Corp.
Kikuchi Color & Chemicals Corp.
Pyosa S.A. de C.V.
Mineral Pigments Corp.
National Industrial Chemical
Pyosa S.A. de C.V.
Wayne Pigment Corp.

Complex Inorganic Color Pigments
Bayer Corporation
Cerdec Corp.
Ciba Pigments
Engelhard Corp.
Ferro Corp., Color Div.
Heucotech Ltd.
Ishihara Corp. (USA)
Landers-Segal Color Co., Inc.
National Industrial Chemical

Diarylide Orange Toner
Ciba Pigments
Clariant Corp.
Dominion Colour Corp.
Engelhard Corp.
Hoechst Celanese Corp.
Landers-Segal Color Co., Inc.
National Industrial Chemical
Peer Chemical Corp.
Pyosa S.A. de C.V.
Sun Chemical Corp., Pigments Div.
United Mineral & Chemical Corp.

Diarylide Yellow Toner
Apollo Colors
Ciba Pigments
Clariant Corp.
Daicolor-Pope, Inc.
Dominion Colour Corp.
Engelhard Corp.
Heucotech Ltd.
Hoechst Celanese Corp.
National Indsutrial Chemical
Peer Chemical Corp.
Pyosa S.A. de C.V.
Sino-American Pigment Systems
Sun Chemical Corp., Pigments Div.
Toyo Ink America, Inc.
United Mineral & Chemical Corp.

Hansa Yellow
Cookson Pigments, Inc.
Dominion Colour Corp.
Engelhard Corp.
Heucotech Ltd.
Hoechst Celanese Corp.
Landers-Segal Color Co., Inc.
National Industrial Chemical
Peer Chemical Corp.
Pyosa S.A. de C.V.
Sino-American Pigment Systems
Sun Chemical Corp., Pigment Div.
United Mineral & Chemical Corp.

Metallized Azo Yellow
Clariant Corp.
Cookson Pigments, Inc.
Dominion Colour Corp.
Engelhard Corp.
Hoechst Celanese Corp.
Keystone Aniline Corp.
Sino-American Pigment Systems

Miscellaneous Yellow and Orange Toners/Lakes
Ciba Pigments
Clariant Corp.
Daicolor-Pope, Inc.
Dominion Colour Corp.
Engelhard Corp.
Heucotech Ltd.
Hoechst Celanese Corp.
Peer Chemical Corp.
United Mineral & Chemical Corp.

Miscellaneous Yellow Pigments
Bayer Corporation
Ciba Pigments
Dominion Colour Corp.
Engelhard Corp.
Heucotech Ltd.
Keystone Aniline Corp.
National Industrial Chemical
Peer Chemical Corp.
Pyosa S.A. de C.V.
Sino-American Pigment Systems
Toyo Ink America, Inc.
United Mineral & Chemical Corp.

Molybdate Orange
Cookson Pigments, Inc.
Dominion Colour Corp.
Engelhard Corp.
Landers-Segal Color Co., Inc.
National Industrial Chemical
Pyosa S.A. de C.V.
Wayne Pigment Corp.

Zinc Oxide, Orthonitraniline Orange, Dinitraniline Orange
Eagle Zinc Co.
Engelhard Corp.
Hoechst Celanese Corp.
Landers-Segal Color Co., Inc.
National Industrial Chemical
Pyosa S.A. de C.V.
United Mineral & Chemical Corp.
Zinc Corp. of America

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Adjunct Professor, Chemistry
Indiana University, South Bend

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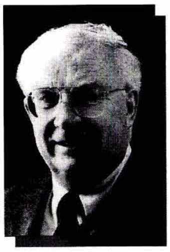
Prof. John K. Gillham, of Princeton University, To Receive 1996 Roy W. Tess Award in Coatings

The 1996 Roy W. Tess Award in Coatings will be presented to Prof. John K. Gillham, of Princeton University. The presentation of the award bestowed by the Polymeric Materials: Science and Engineering division of the American Chemical Society (ACS), will be made during the 212th meeting of ACS on August 25-29, in Orlando, FL.


J.K. Gillham

The Roy W. Tess Award recognizes outstanding contributions in the fields of coatings science, technology, and engineering. Prof. Gillham will be acknowledged for his research group's significant achievements in a variety of coatings-related areas, including the development of the torsional braid analyzer (TBA), from which he instigated the commercial development of automated dynamic mechanical analysis instruments through Plastics Analysis Instruments Inc. Other areas of achievement are: the invention of a nondrag optical rotatory transducer using a pair of polarizers; the conception and subsequent development of "Time-Temperature-Transportation (TTT) Cure Diagrams"; studies of the anomalous isothermal properties versus extent of cure which led directly to the "Conversion-Temperature-Property (T_gTP) Diagram"; development of a complete kinetic model to describe the transformation from reactive liquid to glass (Roon Award 1989): and "development of T_g versus conversion" relationships for thermosetting systems.

Prof. Gillham's work in the measurement and integrated understanding of the cure and properties of thermosetting polymeric systems has been of widespread importance. He has been recognized by international awards, including two first-place Roon Awards—in 1983 and 1989—presented by FSCT; the 1978 ACS Award in Chemistry of Plastics and Coatings; the 1978 North American Thermal Analysis Society Award; the 1980 Doolittle Award, presented by the ORPL (now PMSE) Division of ACS; and the 1988 Society of Plastics Engineering International Research Award.

The profound and widespread influence of Prof. Gillham's work was underscored by his inclusion in Prof. Raymond A. Seymour's 1984 "Polymer Science Pioneers" series in *Polymer News*. He has frequently been introduced as "Mr. Thermoset" and a review of his group's research has been published in *Trends in Polymer Science*, Volume 2, Number 12, pages 406-419, December 1994.

Prof. Gillham has been credited with over 150 journal articles, various book chapters, and numerous invited presentations. He has firmly established himself as one of the seminal thinkers in the field of coatings science, and the body of his work—created over the length of his distinguished career—has marked him as a key innovator in the coatings industry.

Prof. Gillham received his B.A. in 1953 and M.A. in 1957 from Cambridge University, and his Ph.D. in Chemistry from McGill University in 1959.

He began his career in the coatings industry with American Cyanamid. In 1965, he joined the faculty of Princeton University as a member of the Polymer Materials Program of the Department of Chemical Engineering. Prof. Gillham's professional activities have included serving on two committees of the National Materials Advisory Board (NMAB); participation in the American Chemical Society (past-chair of the Plastic Analysis Division, and International Award Committee member); and chairing the 1983 Gordon Research Conference on Thermosetting Polymers.

The Powder Coating Institute Awards Scholarships Totaling $24,000 To Five Colleges and Universities

The Powder Coating Institute, Alexandria, VA, has bestowed scholarship funds to five colleges and universities for the efforts they have made in promoting academic programs, educational opportunities, and research projects relating to the powder coatings industry. The funds, totaling $24,000 were set up to benefit industrial finishing and polymer science students and curricula and academic programs related to powder coatings.

The following colleges and universities were recent recipients:

California Polytechnic State University, San Luis Obispo, CA—Under its polymers and coatings concentration, Cal Poly will support two students for work expanding its powder coatings capabilities and increasing the impact of powder coatings in its laboratory curriculum;

Eastern Michigan University, Ypsilanti, MI—Scholarships will be distributed to polymers and coating technology majors who have a "B" or better academic record and have completed at least 30 hours toward their degree;

Lima Technical College, Lima, OH—Scholarships will be awarded to finishing students in its industrial finishing technology program, which places particular emphasis on powder coating and electrocoating;

University of Missouri-Rolla, Rolla, MO—Two undergraduate fellowships and two graduate summer fellowships for powder coating research will be established with PCI scholarship funds, set up under The UMR Coatings Institute. The graduate summer fellowships will be awarded for doing a research project on powder coatings; and

The University of Southern Mississippi, Hattiesburg, MS—Sponsors of the annual Waterborne, High-Solids, Powder Coatings Symposium in New Orleans, LA, USM will offer scholarships for one school year to two undergraduate students, who will perform work on current and proposed research being conducted by USM.

Union Carbide To Acquire Brazilian Manufacturer

Union Carbide Corp., Danbury, CT, has revealed plans to acquire Companhia Alcoolquimica Nacional (CAN), a Brazilian manufacturer of vinyl acetate monomer. CAN operates an 80,000 metric tons-per-year vinyl acetate production facility in the Nordeste region of Brazil.

Union Carbide has entered into an agreement with Rhodia S.A., a Brazilian company and subsidiary of Rhône-Poulenc, to purchase all the shares of CAN held by Rhodia.

Harrisons & Crosfield plc Acquires Daniel Products Co.

Harrisons & Crosfield plc has announced the acquisition of Daniel Products Co., Inc., Jersey City, NJ.

Daniel Products supplies dispersions, pigments, and other additives for paints and coatings, inks, adhesives, and related materials.

Harrisons & Crosfield is a supplier of pigments and driers to the coatings and plastics industries.

New EPA AIM Draft Receives Support from NPCA Members

Members of the National Paint and Coatings Association's (NPCA), Washington, D.C., Architectural and Industrial Maintenance (AIM) Steering Committee and Architectural Coatings Committee voted in favor of NPCA's offering its support of the U.S. Environmental Agency's (EPA) proposed AIM rule. In November 1995, EPA released a new draft framework for a proposed national AIM coatings rule, which is substantially based on a model AIM rule suggested by NPCA.

In conjunction with its proposal, EPA asked industry to participate in a post-rule study to determine whether there is any justification or need for further regulatory action beyond 1996. NPCA's Board of Directors has endorsed NPCA's participation in the study contingent on the development of an acceptable study protocol.

The new AIM draft accepts NPCA's recommendation that the rule establish only one 1996 table of standards consistent with industry-recommended limits for VOC content. In consideration of industry's participation in the study, EPA has agreed to withdraw and not propose its table of standards for the year 2000.

EPA plans to publish the rule on an expedited schedule in order to allow industry time to prepare for compliance and to avoid conflicting state AIM regulations. Although the proposal is not identical to NPCA's model rule, NPCA will make every attempt to resolve concerns raised by members, as well as any remaining differences, during the upcoming rulemaking process.

The post-rule VOC study, which should be finalized over the next three months, would be jointly managed and funded by EPA and the coatings industry and would likely begin after the effective compliance date of the AIM rule. The national rule and subsequent joint industry/government study should provide NPCA with an opportunity to obtain uniform regulations throughout the country while evaluating the scientific, technological, and economic questions surrounding the issue of future VOC control in AIM coatings.

Engelhard Increases Manufacturing Capacity For Its Organic Color Pigments Facility in Louisville

Engelhard Corp., Iselin, NJ, has announced the completion of a \$2 million expansion to the manufacturing capacity for organic color pigments at its Louisville, KY, site. The increase is approximately 35%.

The Louisville plant expansion is the most recent in a series of steps Engelhard has taken to respond to customers' demands. Recently, the company has introduced new organics to the Harshaw™ color line, including RX 1290, an enhanced Yellow 62, and RX 3170, an enhanced yellow shade Red 170.

December Construction Activity Declines Six Percent; 1995 Total Increases One Percent to \$298.8 Billion

According to a report released by the F.W. Dodge Division of The McGraw-Hill Companies, New York, NY, the rate of new construction starts fell six percent in December.

Despite the year-end slowdown, total construction contracts for 1995 advanced to \$298.8 billion, an increase of one percent over 1994. The modest 1995 gain follows three years in which the dollar volume of construction activity climbed eight to nine percent per year.

December's data lowered the Dodge Index to 107 (1987=100), down from November's revised reading of 114 and marking the fourth consecutive monthly decline since the Index reached its 1995 high of 123 in August.

The report further revealed that nonresidential building in December dropped six percent. For 1995, nonresidential construction advanced nine percent to \$110.1 billion, marking another year of strong improvement following the 14% gain.

Residential construction slipped one percent in December, with a 16% drop for multifamily housing outweighing a one percent single family gain. Overall, residential construction dropped six percent to \$126.0 billion in 1995.

Nonbuilding construction plunged 14% in December, as the various public works categories and utilities showed across-the-board declines. For 1995, nonbuilding construction grew two percent to \$62.8 billion.

Over the 12 months of 1995, total construction in the South Central region led the nation with five percent increase, followed by the South Atlantic with a two percent gain and the Midwest with a one percent gain. Both the Northeast and West showed year-to-year declines of one percent for total construction.

Atlas Electric Devices Details New Organizational Structure

As a result of the acquisition of Xenotest GmbH and DSET Laboratories by Atlas Electric Devices Co., Chicago, IL, a new organizational structure has been developed.

To accommodate the new business structure, a name change will take place. The Atlas Family of Companies title will be changed to Atlas Material Testing Solutions. In addition, the seven subsidiaries and divisions will be organized into three service/production groups: Atlas Test Instruments Group, Atlas Weathering Services Group, and Atlas Engineered Products Group.

The Atlas Test Instruments Group supplies laboratory instruments for performing weathering, lightfastness, fire science, polymer evaluation, corrosion resistance, laundering, dyeing, and UV exposure tests, as well as textile testing instruments.

Outdoor and laboratory materials testing services are provided by the Atlas Weathering Services Group.

Atlas Engineered Products Group provides large-scale solar simulation chambers and lighting systems.

Facility Expansion Announced By Fusion UV Curing Systems

A major facility expansion is underway at Fusion UV Curing Systems, a subsidiary of Fusion Systems Corp., Gaithersburg, MD.

The company's Fusion Semiconductor Systems subsidiary will expand into the space currently occupied by Fusion UV Curing. The new space will be used for increasing efforts, as well as increasing production capacity. Upon completion, total square footage will increase by over 60%.

ISO Certification

Hüls America Inc., Somerset, NJ, has been awarded ISO 9002 certification for its Silanes and Silicones Semiworks Unit based in Mobile, AL.

ISO 9001-1994 certification was achieved by **Phillips Paint Products,** Winnipeg, Manitoba, Canada.

Advanced Chemical Co., Warwick, RI, has been approved for ISO 9002 registration.

ISO 9002-1994 registration has been awarded to **Anachemia Solvents,** Mississauga, Ontario, Canada.

Regulatory Update March 1996

This digest of current regulatory activity pertinent to the coatings industry is published to inform readers of actions which could affect them and their firms, and is designed to provide sufficient data to enable those interested to seek additional information. Material is supplied by National Paint and Coatings Association, Washington, D.C. The Regulatory Update is made available as a service to FSCT members, to assist them in making independent inquiries about matters of particular interest to them. Although all reasonable steps have been taken to ensure the reliability of the Regulatory Update, the FSCT cannot guarantee its completeness or accuracy.

Environmental Protection Agency
January 29, 1996—61 FR 2722
Toxic Chemical Release Reporting; Community Right-to-Know; Additional Time to Report
Action: Time extensions for submission of reports.

According to this notice, the Environmental Protection Agency is extending the deadline for facilities to submit Toxic Release Inventory (TRI) reports for the calendar year 1995 from July 1 until August 1, 1996. TRI reports are required under Section 313 of the Emergency Planning and Community Right-to-Know Act. Due to the recent government shut downs and inclement weather, EPA has been delayed in developing and distributing the reporting package for 1995, which includes extensive materials and guidance for preparing TRI reports. This extension will allow facilities an extra month to properly prepare and submit their reports.

For specific information on the deadline extension, contact Maria Doa, EPA, (202) 260-9592; e-mail, doa.maria@epamail.epa.gov. For more information on the Emergency Planning and Community Right-to-Know Act, contact the EPCRA Hotline, 1-800-535-0202.

Environmental Protection Agency
January 30, 1996—61 FR 3031
Accidental Release Prevention Requirements; Risk Management Programs Under Section 112(r) (7) of the Clean Air Act as Amended; Draft Guidances
Action: Notice of availability

The Environmental Protection Agency has developed and issued draft guidance documents, including model risk management plans, to assist stationary sources in the creation of risk management programs. The draft document, "Offsite Consequence Assessment," is designed to help sources comply with offsite consequence requirements without specific expertise or access to computer-based modeling tools. A draft "Risk Management Data Elements" guidance details the type of information that would be submitted by each source as its risk management plan, including data on worst case and alternative releases for toxics.

To order copies of these documents, please fax requests to the Emergency Planning and Community Right-to-Know Hotline at (703) 412-3333. Copies of these draft guidance documents may also be obtained through EPA's Technology Transfer Network bulletin board at (919) 541-5742, or through the World Wide Web, at http://earthl.epa.gpv/ceppo.

For more information on "Offsite Consequence Assessment," contact Craig Matthiessen, EPA, (202) 260-9781. For further information on "Risk Management Data Elements," contact Lyse Helsing, EPA, (202) 260-6128.

Environmental Protection Agency
February 9, 1996—61 FR 4903
Hazardous Waste Treatment, Storage and Disposal Facilities and Hazardous Waste Generators; Organic Air Emission Standards for Tanks, Surface Impoundments, and Containers
Action: Final rule; technical amendment

The Environmental Protection Agency has issued technical amendments to its final rule, published December 6, 1994, which regulates organic air emissions from hazardous waste tanks, containers, and surface impoundments. These standards are applicable to owners and operators of hazardous waste treatment, storage, and disposal facilities subject to RCRA subtitle C permitting requirements and to certain hazardous waste generators accumulating waste in on-site tanks and containers. This action, which will go into effect on June 6, 1996, makes clarifying amendments in the regulatory text and preamble.

The clarifications include the definitions of "waste stabilization" and "point of origination" under the rule, as well as specifying test methods allowed for waste determinations and sampling batch processes. In addition, the corrections address the issue of agitation in tanks by stating that tanks must be equipped with organic emission controls if there is a visible turbulent flow at the surface of the waste.

Copies of the technical amendments are available on EPA's Clean-up Information Bulletin Board at (301) 589-8366, under the file name "RCRACLAR.ZIP." For further information, contact the RCRA Hotline, (800) 424-9346 or Michele Aston, EPA, (919) 541-2363.

Environmental Protection Agency
February 9, 1996—61 FR 4902
National Emission Standards for Hazardous Air Pollutants (NESHAP) for Source Categories: Aerospace Manufacturing and Rework Facilities
Notice: Final rule, correction.

The Environmental Protection Agency has issued a correction to its final rule for NESHAP for aerospace manufacturing and rework facilities that was promulgated on September 1, 1995 (60 FR 45948). Under the original regulation, affected facilities were required to submit an initial notification by December 30, 1995. However, the final rule should have indicated that the notification was to be submitted within two years of the effective data of the final standard. Therefore, the date for submittal of an initial notification to the agency is September 1, 1997.

For more information about this correction, contact James Szykman, EPA, (919) 541-2452.

Environmental Protection Agency
February 9, 1996—61 FR 5248
Technical Correction: Final National Pollutant Discharge Elimination System Storm Water Multi-Sector General Permit for Industrial Activities
Action: Corrections; technical amendments; and deadline extensions for applicants under the storm water multi-section general permit.

EPA has issued a notice extending the deadlines for submittal of a Notice of Intent (NOI) to be covered by the multi-sector general permit (MSGP) to March 29, 1996, and the development and implementation of storm water pollution prevention plans (SWPPP) to September 25, 1996. The extensions are designed to provide additional time for applicants to review MSGP requirements and to decide whether they wish to seek coverage under the MSGP or the applicable baseline general permit. In addition, this rule also corrects specific errors and omissions in the text of the final rule, published on September 29, 1995.

For more information on the deadline extension, contact Marily Fonseca, EPA, (202) 260-0592.

Federal Government Remains Open As Congress and President Agree to Funding Resolution—On January 26, just hours before the current budget resolution, providing funding for the federal government would have expired, President Clinton signed yet another stopgap spending bill (HR 2880), averting a third partial shutdown of the government. The new measure funds Cabinet departments and other agencies whose 1996 budgets have not been approved through March 15. The resolution also cuts funding for several of President Clinton's initiatives, including the AmeriCorps National Service program.

Apparently reacting to polls that showed that the American public blamed them for the current budget crisis, House and Senate Republicans abandoned their tactic of shutting down the government and instead worked to create this temporary funding measure. In the meantime, the National Governor's Association has developed a bipartisan plan for overhauling welfare and Medicaid that was greeted with cautious optimism by both Congress and the Clinton administration and which may be used as a basis for continuing budget negotiations. Pending resolution of the budget issue, Congress will have to continue extending stopgap funding legislation in order to keep the federal government running.

Additionally, President Clinton sent a brief outline of his 1997 fiscal budget to Congress on February 5, as he is required to do by law. The outline closely resembled his earlier balanced budget plan, which Republicans rejected in January. The President has indicated that he will submit a much more detailed plan in March, but this delay will limit the time Congress has to work on 1997 appropriations.

The following is an update of legislation of interest to industry:

The Superfund Reform Act of 1995—HR 2500 (Oxley R-OH) Markup of this bill by the House Commerce Committee is expected sometime in early March. Concern in Congress is mounting about the provisions in the measure which would provide a limited repeal of retroactive liability. Legislators cannot find a way to finance this section without shifting costs to taxpayers, a problem that has stalled consideration of a similar bill in the Senate. It is expected that this provision may be revised during the full committee markup and addressed later in 1997. After reviewing the bill, the Congressional Budget Office has announced that the current version would create a budget shortfall of $400 million by 2000, leading House Democratic leaders to call for an end to efforts to pass broad superfund reforms this session. However, House Speaker Newt Gingrich has listed superfund reauthorization as a priority for Congress this year.

Clean Water Act Reauthorization—HR 961 (Shuster R-PA). In May, the House approved HR 961, a bill to reauthorize the Clean Water Act. However, opposition in the Senate to certain provisions in the bill, as well as the Republican party's concern with appearing "anti-environmental" to the general public, has stalled consideration of the bill.

Senator John Chafee (R-RI), Chairman of the Environment and Public Works Committee, has stated that he believes the Clean Water Act does not need comprehensive reform and favors a much more moderate version of the House bill. Senate staff is currently in the process of resolving differences over wetlands issues and is expected to begin working shortly on their own reauthorization legislation, which would include provisions for the storm water program, the state revolving loan fund, watershed planning, and regulatory reform.

Comprehensive Regulatory Reform—S. 343 (Dole R-KS). This bill would require regulatory agencies to conduct cost-benefit analyses and risk assessments for major regulations. In July 1995, S. 343 was stalled in the Senate when it failed to pass three cloture votes. At that point, Senator Dole withdrew the bill from the floor. Since that time, however, several Senators have continued to work on more moderate draft legislation, based on S. 343, that could be supported by both Republicans and Democrats, but an official bill has not yet been introduced.

RCRA Disposal Bill Passed—On January 31, HR 2036, the Land Disposal Program Flexibility Act, was approved by the House by a vote of 402-19. Under this bill, solid waste that is no longer considered hazardous and can be disposed of in a surface impoundment or underground injection well is not subject to hazardous waste treatment and disposal regulation under the Resource Conservation and Recovery Act (RCRA). The legislation will now be sent to the Senate Environment and Public Works Committee for consideration. Both EPA and White House officials have offered endorsements of this bill.

President Signs Bill to Extend Use of Fiber Drum Packaging—President Clinton has signed legislation (HR 2539, Public Law 104-88) which directs the Research and Special Program Administration to extend the transition period for the use of fiber drum packaging for the transport of hazardous materials. The language was part of a larger bill which dissolved the Interstate Commerce Commission. According to the provisions, transporters of certain liquid hazardous materials who use open head fiber drums will have until September 30, 1997 to phase out their use. Originally, open head fiber drums were to be phased out after September 30, 1996, due to the amended hazardous materials transportation performance packaging standards.

States Proposed Legislation and Regulations

Alabama

Air Quality (Regulation)—A final regulation of the Alabama Department of Environmental Management (DEM) changes the definition of volatile organic compounds (VOCs) to correspond to the federal Environmental Protection Agency (EPA) definition. The rule was effective January 5, 1996. Contact Ron Gore, DEM, (334) 271-7861.

Hazardous Waste (Regulation)—The Alabama DEM has adopted a final rule which incorporates changes made to federal EPA organic air emission standards for tanks, surface impoundments, and containers. In addition, 58 additional specific chemicals are added to the list of commercial chemical products that are considered hazardous waste when discarded. The rule became effective January 12, 1996. Contact Office of General Counsel, DEM, (205) 271-7726.

Arizona

Hazardous Waste (Proposed Regulation)—A proposed regulation of the Arizona Department of Environmental Quality (DEQ) would incorporate by reference amendments to federal hazardous waste management standards. The proposal would set forth standards to reduce organic air emissions from hazardous waste management facilities and update provisions regarding testing and monitoring activities. Contact Lynn Keeling, DEQ, (602) 207-2223.

The Arizona DEQ has adopted a regulation which incorporates changes to federal hazardous waste standards into the state hazardous waste program. The rule was effective December 7, 1995. Contact Lynn Keeling, DEQ, (602) 207-2223.

Lead—AZ S. 1351 (Buster) establishes a committee of legislators and others to study lead-based paint issues and recommend a regulatory program. The bill was introduced on January 30 and referred to the Senate Committee on Health.

Spray Paint Restrictions/Graffiti—AZ H. 2489 (Foster) states that it is illegal to sell or give an aerosol spray paint container or an indelible felt marker with a tip more than 1/2-inch wide to a person younger than 18. Merchants must keep these goods locked up, and owners of walls or buildings with graffiti must clean it up or face having the city do it and receiving the bill. The bill, introduced on February 1, was sent to the House Committee on Judiciary.

Arkansas

Hazardous Waste (Regulation)—A final regulation of the Arkansas Department of Pollution Control and Ecology (DPCE) incorporates federal EPA hazardous waste regulations and amends control requirements of volatile organic vapor emissions from hazardous wastes stored in containers, tanks, and surface impoundments. The rule was effective September 1, 1995. Contact Tom Ezell, DPCE, (501) 682-0876.

California

Air Quality (Regulation)—The California Air Resources (CARB) has adopted regulations limiting the amount of VOCs contained in aerosol coating products and amends the regulations which authorize alternative control plans for consumer products to include aerosol coating products. The rule became effective January 8, 1996. Contact Robert C. Jenne, CARB, (916) 322-2884.

The Sacramento Metropolitan Air Quality Management District (SMAQMD) has proposed a rule which would reduce emissions of VOCs by businesses engaged in the coating of wood products, by requiring the use of lower VOC coatings and more efficient application of the coatings, or by the addition of equipment to capture and destroy the VOC emissions prior to their release into the atmosphere. Contact Phil Stafford, SMAQMD, (916) 386-7032.

Household Hazardous Waste—CA S. 176 (Alquist) specifies that the information on safer substitutes under a household hazardous substance information program be competent and reliable information, and prohibits any state or local agency from providing information on household hazardous substances or safer substitutes for products that contain hazardous substances, unless the information is competent and reliable. The bill failed to pass the Senate by January 31 and is therefore considered dead for the rest of the legislative session.

Lead—CA S. 329 (Bustamente) requires the identification of high-risk children for lead poisoning and establishes procedures for lead abatement activities. The bill died pursuant to certain articles in the constitution on January 31.

CA A. 1195 (Morrissey) requires the Department of Health Services (DHS) to consider only documented evidence of potential occupational lead poisoning in this state. The bill would also reduce the fees for employers, exempting employers who demonstrate that fewer than 100 pounds of lead is present in the place of employment from the fees. The legislation passed the Assembly on January 31 and was sent to the Senate.

Colorado

Air Quality (Regulation)—A final rule of the Colorado Department of Public Health and Environment (DPHE) incorporates by reference federal maximum achievable control technology (MACT) requirements for epoxy resin producers, halogenated solvent degreasers, and magnetic tape manufacturers. The rule became effective January 31, 1996. Contact Air Quality Control Commission, DPHE, (303) 692-3100.

The Colorado DPHE has proposed a rule which would adopt by reference federal MACT standards for industrial process cooling towers and secondary lead smelting operations. Contact Air Quality Control Commission, DPHE, (303) 692-3100.

A proposed rule of the Colorado DPHE would revise air pollutant emission notice APEN reporting requirements for stationary sources, clarify the authority to impose fees for fugitive emissions, and add new APEN exemptions. A hearing is scheduled for March 21, 1996, and comments are due on that same day. Contact Air Quality Control Commission, DPHE, (303) 692-2000.

Hazardous Waste (Regulation)—An emergency regulation of the Colorado Department of Public Health and Environment (DPHE) amends hazardous waste management regulations to incorporate federal EPA amendments that postpone until June 6, 1996 the effective date for organic air emissions standards for surface impoundments, tanks, and containers. The rule went into effect on November 28, 1995. Contact Karen Osthus, DPHE, (303) 692-3321.

The Colorado DPHE has proposed a rule which would incorporate federal EPA amendments governing universal waste into state hazardous waste management regulations. Contact Karen Osthus, DPHE, (303) 692-3321.

Connecticut

Lead (Regulation)—A final rule of the Connecticut Department of Housing (DOH) adopts regulations to provide financial assistance for the abatement of lead-based paint. The rule was effective October 19, 1995. Contact Eyvonne Parker, DOH, (203) 566-2494.

Delaware

Hazardous Waste (Regulation)—A notice issued by the Delaware Department of Natural Resources (DNR) announces the issuance of an order in reference to the management of extremely hazardous substances which changes the registration for processes registered in the program from annually to every three years and incorporates a revised fee structure. The order was dated December 24, 1995. Contact Robert Barrish, DNR, (302) 323-4524.

Florida

Air Quality (Proposed Regulation)—A proposed regulation of the Florida Department of Environmental Protection (DEP) would revise general requirements for stationary sources by (1) clarifying permit effective dates and exemptions; (2) limiting VOC-containing coatings for 6 gallons per day; (3) indicating that annual reports are not required for facilities operating under a Title V general permit; (4) establishing reporting thresholds for hazardous air pollutants; and (5) adopting by reference general permit notification forms for new sources. Contact Michael Hewett, DEP, (904) 488-0114.

The Florida DEP has proposed a rule which would amend regulations in reference to operating permits for major sources of air pollution. Among other things, the regulation would clarify Title V application requirements and delete provisions that make exemptions from permitting automatically available to units or activities within Title V sources. Contact Michael Hewett, DEP, (904) 488-0114.

Final rules of the Florida DEP amend regulations regarding stationary sources of air pollution. The rules incorporate federal EPA changes to the definition of VOCs, clarify the definition of "affected pollutant," and add exemptions for certain sources. Contact Michael Hewett, DEP, (904) 488-0114.

The Florida DEP has proposed a regulation which would amend regulations regarding air pollution control. Among other things, the proposal would add ambient air quality standards, set forth procedures for the designation and redesignation of attainment and non-attainment areas, and incorporate by reference federal ambient air quality standards. Contact Jeanne Carver, DEP, (904) 488-0114.

Proposed rules of the Florida DEP would amend general provisions for stationary sources by adding procedures for emissions unit reclassification; eliminating unnecessary or redundant provisions regarding emissions estimates, air quality models, and enhanced monitoring; and consolidating provisions regulating preconstruction review of stationary sources. Contact Jeanne Carver, DEP, (904) 488-0114.

Water Quality—FL. H. (Tedder) removes the application of the tax for water quality to solvent mixtures. The legislation is currently being considered by the House Committee on Finance and Taxation and Appropriations.

The Florida DEP adopted a final rule which eliminates procedural provisions governing the advance disposal fee program. The rule became effective December 27, 1995. Contact Betsy Hewitt, DEP, (904) 921-9638.

Georgia

Hazardous Waste (Regulation)—A final rule of the Georgia Department of Natural Resources (DNR) amends regulations to comply with certain requirements of the federal Resource Conservation and Recovery Act (RCRA) and adds 58 specific chemicals to the list of commercial chemical products that are considered hazardous waste when discarded. The rule became effective December 28, 1995. Contact Bill Mundy, DNR, (404) 656-7802.

Lead—GA H. 1436 (Thomas) provides that it shall be illegal to rent, let, or lease a lease a residential dwelling it any portion is painted with lead-based paint and requires tenants to post notice of the possible presence of lead-based paint. The bill was amended and released on February 1 from the House Committee on Special Judiciary.

GA S. 554 (Henson and Madden) provides that implementation of certain lead paint abatement certification programs shall be contingent upon the promulgation of certain federal regulations. The bill passed the Senate and was sent to the House Committee on Natural Resources and Environment where it was released and reported favorably on February 8.

Hawaii

Spray Paint Restrictions—HI H. 2747 (Arakaki) bans the sale of certain indelible markers and certain types of spray paint cans. The bill was referred to the House Committee on Judiciary on January 22.

Idaho

Air Quality (Proposed Regulation)—The Idaho Department of Health and Welfare (DHW) has proposed a rule which would remove total suspended particulates as a category of regulated criteria pollutants, incorporate by reference federal MACT standards, and eliminate acetone and methyl siloxanes from the definition of VOCs. Contact Tim Teater, DHW, (208) 373-0502.

Illinois

Air Quality (Proposed Regulations)—Proposed rules of the Illinois Pollution Control Board (PCB) would amend organic material emission standards and limitations for certain areas, clarifying recordkeeping and reporting requirements for coating operations. Contact Dorothy Gunn, PCB, (312) 814-6931.

Water Quality (Proposed Regulation)—The Illinois Pollution Control Board (PCB) has proposed a rule which would amend regulations to incorporate federal national pollutant discharge elimination system (NPDES) permitting requirements affecting toxicity testing procedures for publicly owned treatment works. Contact Dorothy Gunn, PCB, (312) 814-6931.

Indiana

Air Quality (Proposed Regulation)—The Indiana Department of Environmental Management (DEM) has announced its intention to adopt regulations which would incorporate by reference amendments to federal conformity standards aligning the timing of sanctions under the Clean Air Act for failure to submit a required state implementation plan (SIP). Contact Office of Air Management, DEM, (317) 233-5684.

Automotive Refinishing—In S. 458 (Wheeler) requires a contractor who engages in the business of automotive painting using hazardous substances or an individual who is engaged as a professional painter to be licensure. It provides that the Department of Labor (DOL) shall regulate the licensure of hazardous painting contractors and professional painters. Introduced on January 10, the bill was referred to the Senate Committee on Public Policy.

Kansas

Air Quality (Proposed Regulation)—A proposed rule of the Kansas Department of Health and Environment (DHE) would repeal air quality regulations governing ambient air quality standards which would thereby affect performance standards for metal coil surface coating operations. The rule would also repeal underground storage tank standards which are duplicative due to the incorporation by reference of federal national emission standards for hazardous air pollutants (NESHAPs). A hearing is scheduled for March 15, 1996 and comments are due on this same date. Contact DHE, (913) 296-1547.

Kentucky

Lead—KY S. 182 (Neal) defines "lead-hazard abatement." It also requires (1) all persons who perform or offer to perform lead-hazard detection or abatement services to be certified; (2) the Department of Health Services (DHS) to create and administer the certification program and promulgate administrative regulations to establish the training and testing requirements for certification; and (3) a permit for every lead-hazard abatement service performed. The bill was introduced on February 1 and referred to the Senate Committee on Health and Welfare.

Louisiana

Air Quality (Notice)—The Louisiana Department of Environmental Quality (DEQ) has issued a notice regarding regulations that have been submitted as a component of the state implementation plan. Among other things, the notice identifies the facilities that are exempt from fugitive emission control requirements and clarifies when written approval is not needed for sources to get an exemption. Contact Office of Air Quality and Radiation Protection, DEQ, (504) 765-0399.

The Louisiana DEQ has adopted a final rule which adds acetone to the list of compounds that are exempted from the definition of VOCs. The rule became effective on December 20, 1995. Contact Patsy Deaville, DEQ, (504) 765-0399.

Hazardous Waste (Regulation)—A final regulation of the Louisiana Department of Environmental Quality (DEQ) requires certification of waste analysis and minimization plans to be done by professional engineers and removes the option of certification by certified hazardous materials managers. The rule was effective December 20, 1995. Contact Patsy Deaville, DEQ, (504) 765-0399.

Maryland

Air Quality (Proposed Regulation Withdrawn)—A proposed regulation of the Maryland Department of the Environment (DOE) that would have adopted regulations for VOC control equipment has been withdrawn. Among other things, the regulation would have required a source of VOC emissions to operate only when its control device was operating properly and to develop a maintenance plan. The withdrawal date was December 11, 1995. Contact Deanna Miles-Brown, DOE, (410) 631-3173.

Lead—MD H. 61 (Arnick) alters (1) the definition of "abatement" related to lead-containing substances; (2) the scope of properties subject to accreditation requirements; and (3) the scope of exceptions to accreditation required to be adopted by regulation. Introduced on January 10, the bill was referred to the House Committee on Environmental Matters.

MD S. 549 (Derr) exempts affected property in which a child under six years old does not reside from provisions of law requiring the reduction of lead risk in housing by October 1, 1999. Introduced on February 2, the legislation was sent to the Senate Committee on Judicial Proceedings.

MD H. 237 (Hubbard) provides for the establishment of a lead poisoning screening program and a lead poisoning outreach and education programs. The bill was introduced on January 19 and sent to the House Committee on Environmental Matters.

Minnesota

Air Quality (Proposed Regulation)—A proposed rule of the Minnesota Pollution Control Agency (PCA) would adopt NESHAPs for source categories. In order to enforce the source categories, the proposal would also incorporate the federal standards into state law. Contact Sherryl Livingston, PCA, (612) 296-7832.

Lead—MN S. 2104 (Stevens) delays the prohibition on the use of lead in products until July 1, 1998 for substances used to mark road, highway, or bridge pavement. The bill, introduced on January 22, was reported favorably out of the Senate Committee on Transportation and Public Transit on February 9 and sent to the Senate Committee on Environment and Natural Resources.

MN S. 1931 (Pariseau and Samuelson) removes unfunded lead mandates including property owner plan requirements; requirements to identify known prior addresses of children or pregnant women with elevated blood lead levels; and relocation requirements during lead hazard reductions. The bill would also repeal the lead-safe housing certification program and abatement or lead hazard reduction plan requirements. Introduced on January 16, the bill was referred to the Senate Committee on Health Care.

Toxics-in-Products—MN S. 2077 (Stevens), identical to S. 2382, repeals the law prohibiting the introduction of specified toxics into inks, dyes, pigments, paints, or fungicides sold in the state. The legislation was introduced on January 22, amended by the Senate Committee on Environment and Natural Resources, and reported favorably out of Committee on February 9.

MN H. 2014 (Workman) repeals the Toxics-in-Products Law prohibiting the distribution of certain materials (including paints) containing lead, cadmium, mercury, or hexavalent chromium. The bill was introduced on January 16 and referred to the House Committee on Environment and Natural Resources.

Mississippi

Graffiti—MS H. 753 (Scott) relates to graffiti; prohibits and provides penalties. On February 6, the bill was amended and released from the House Committee on Judiciary.

Missouri

Air Quality—MO H. 1227 (Harlan) allows state clean air guidelines to be stricter than federal. The bill was introduced on January 23 and referred to the House Committee on Energy and Environment.

Hazardous Waste (Notice)—The Missouri Department of Natural Resources (DNR) has announced the adoption of the state hazardous waste management plan which addresses the future of the hazardous waste program, general projections about the budget, and existing laws and rules for the program. Contact Division of Environmental Quality, DNR, (314) 751-3176.

Storm Water—MO H. 1312 (Tate) permits additional funds for storm water control. The bill is currently being considered by the House Committee on Budget.

Montana

Hazardous Waste (Proposed Regulation)—A proposed regulation of the Montana Department of Environmental Quality (DEQ) would incorporate by reference federal hazardous waste management standards to maintain consistency and ensure that the state still has the primary authority of administration and enforcement. Contact Mark Stahly, DEQ, (406) 444-3742.

Highway Transportation (Regulation)—The Montana Department of Justice (DOJ) has adopted a regulation which makes motor carrier safety and hazardous material transportation standards consistent with federal standards and interstate and intrastate provisions. The rule was effective December 22, 1995. Contact Curt Rissman, Montana Highway Patrol, (406) 444-3780.

Nevada

Water Quality (Regulation)—The Nevada State Environmental Commission (SEC) adopted a rule pertaining to toxic material standards applicable to designated waters. The rule updates supply standards to comply with current federal maximum contaminant levels for various metals, including barium, cadmium, chromium, selenium, and silver. The rule went into effect on November 29, 1995. Contact David Cowperthwaite, SEC, (702) 687-4670.

New Hampshire

Air Quality (Proposed Regulation)—A proposed rule of the New Hampshire Department of Environmental Services (DES) would readopt with amendments regulations that implement air quality standards for several types of pollutants emitted in or transported into the state. Contact Susan Jones, DES, (603) 271-7874.

New Jersey

Lead—NJ A. 1277 (Collins) provides financial assistance for lead abatement work and authorizes the Economic Development Authority (EDA) to issue bonds for that purpose. The bill was introduced on January 11 and sent to the Assembly Committee on Agriculture and Waste Management.

Spray Paint Restrictions—NJ A 1417 (Garcia) prohibits the sale, transportation, and possession of certain spray paints and indelible markers. The legislation was introduced on February 5 and referred to the Assembly Committee on Law and Public Safety.

Toxics-in-Packaging—NJ A. 1169 (Cohen and Murphy) amends the "Toxic Packaging Reduction Act." The bill was introduced on January 11 and referred to the Assembly Committee on Agriculture and Waste Management.

New Mexico

Lead—NM S.J.M. 20 (Duran and Carraro) relates to the creation of a specialty license for residential lead-based paint abatement. The legislation was introduced on January 18 and referred to the Senate Committees on Rules and Conservation.

Water Quality (Regulation)—A final rule of the New Mexico Water Quality Control Committee (WQCC) amends regulations pertaining to ground and surface water protection, setting forth standards for the prevention and abatement of water pollution. The rule was effective December 1, 1995. Contact Marcy Leavitt, WQCC, (505) 827-2918.

New York

Flammable Paint—NY A. 8711 (Wright) prohibits use of non-waterbase or flammable paint in any public or private dwelling unit. If said paint is found by public housing authority, it shall be removed within 30 days and replaced with waterbase or non-flammable paint. The bill was introduced on February 5 and referred to the Assembly Committee on Health.

Spray Paint Restrictions/Graffiti—NY S. 5896 (Gonzalez) prohibits (1) the sale of spray paint cans unless the design of the can or the spray technology is modified in some way to limit the portability of the spray paint can; (2) prohibits the sale of indelible markers which have a writing surface of three-eighths of an inch or wider; and (3) imposes a fine of eight hundred dollars for the first offense and one thousand dollars for each subsequent offense. Introduced on January 22, the bill was referred to the Senate Committee on Consumer Protection.

Lead—NY S. 5808 (Markowitz and Abate) imposes a $100 surcharge on any building code violation related to lead paint and creates a lead paint education program within the Department of Health (DOH) to be funded by such surcharge. The bill was introduced on January 16 and sent to the Senate Committee on Health.

Toxic Substances—NY A. 3970 (DiNapoli) requires certain facilities to report releases of toxic chemicals on a toxic chemical release form so as to provide information to government agencies and the public about the nature and extent of such releases and the commissioner to maintain a computer database of a toxic chemical inventory. The legislation passed the Assembly on January 31 and was referred to the Senate Committee on Environmental Conservation.

Ohio

Air Quality (Proposed Regulation)—The Ohio Environmental Protection Agency (OEPA) has proposed a rule which would establish procedures for permits to install new sources, define limitations for proposed new sources of air pollution, and include federal standards for new source review for major stationary sources in attainment and non-attainment area. Contact Tami Saunders, OEPA, (614) 644-3689.

Oklahoma

Glass Coatings—OK H. 2383 (Siekel) relates to motor vehicles and restrictions on use of glass coating materials on windshields and windows. Introduced on February 5, the legislation was referred to the House Committee on Public Safety.

Hazardous Waste (Proposed Regulation)—The Oklahoma Department of Environmental Quality (DEQ) has proposed a regulation which would adopt by reference federal universal waste standards and implement a regulatory framework for a modified hazardous waste collection and management system. Contact Catherine Sharp, DEQ, (405) 271-1169.

Oregon

Air Quality (Regulation)—A final rule of the Oregon Department of Environmental Quality (DEQ) revises the definition of VOCs to reflect the federal EPA's delisting of acetone and expected delisting of perchloroethylene. The rule was effective December 6, 1995. Contact Susan Greco, DEQ, (503) 229-5213.

Pennsylvania

Spray Paint Ban—Philadelphia, Bill No. 30 (DiCicco, Fernandez, Verna, and Kenney) seeks to ban the retail sale and possession of non-water soluble spray paint and indelible markers. The bill was introduced on February 8.

Rhode Island

Automobile Refinishing—RI H. 7622 (Faria) relates to the sale of motor vehicle paints. Introduced on January 23, the bill was referred to the House Committee on Corporations.

Spray Paint Restrictions—RI S. 2837 (Palazzo) relates to spray paint control. The bill was introduced on February 6 and sent to the Senate Committee on Judiciary.

RI H. 8691 (McCauley) relates to spray paint can access to minors. Introduced on February 6, the legislation was referred to the House Committee on Judiciary.

South Carolina

Occupational Safety and Health (Regulation)—A final rule of the South Carolina Department of Labor, Licensing, and Regulation (DLLR) adopts federal amendments to standards for fall protection, personal protective and life saving equipment, and logging operations in order to be consistent with federal OSHA standards. Contact DLLR, (803) 734-9612.

South Dakota

Transportation—SD H. 1159 (Weber) permits the Department of Transportation (DOT) to require reflector or luminescent paint on railroad cars. The bill was introduced on January 17 and referred to the House Committee on Transportation.

Tennessee

Air Quality (Proposed Regulation)—The Tennessee Department of Environment and Conservation (DEC) has proposed a regulation which would amend source emissions by requiring source owners or operators to report all three hour averages in excess of the applicable emission standards or all 24-hour averages in units of the applicable standard. Contact Malcolm Butler, DEC, (615) 532-0660.

Automotive Refinishing (Regulation)—A final rule of the Tennessee DEC adopts regulations to add VOC emission requirements for motor vehicle and mobile equipment refinishing operations. The rule affects certain counties with potential emissions in excess of 15 pounds of VOCs per day. The rule was effective January 17, 1996. Contact Malcolm Butler, DEC, (615) 532-0600.

Solid Waste (Proposed Regulation)—The Tennessee DEC has proposed a rule to adopt regulations in reference to solid waste processing and disposal which would revise the definition of "special waste," require certification of waste annually, set forth permitting exemptions, and modify requirements for certain facilities and landfills. Contact Division of Solid Waste Management, DEC, (615) 532-0103.

TN S. 2180 (Gilbert) makes substantive changes in solid waste statutes including (1) setting tipping fees beginning at $0.85 per ton on July 1, 1996 to go into the state solid waste fund; (2) putting transport of waste under sway of commissioner; (3) redefining landfill; (4) separating the definitions of recovered materials (recycling) from solid waste processing; (5) changing provisions of municipal solid waste authorities; and (6) establishing a pilot program for household hazardous waste. The legislation was referred to the Senate Committee on Environment, Conservation, and Tourism on January 22.

Texas

Air Quality (Regulation)—A final rule of the Texas Natural Resource Conservation Commission (TNRCC) amends regulations regarding multiple air contaminant sources or properties that attempt to be treated as a single property for the purpose of controlling emissions. The rule was effective January 9, 1996. Contact TNRCC, (512) 239-1966.

Highway Transportation (Proposed Regulation)—The Texas Department of Public Safety (DPS) has proposed a rule which would adopt regulations in reference to hazardous materials transportation incorporating by reference federal motor carrier safety provisions. Contact John West, DPS, (512) 424-2890.

Lead (Proposed Regulation)—The Texas Department of Health (DOH) has proposed a regulation which would control and minimize public exposure to lead from lead-based paint activities in target housing. Among other things, the proposal would set the requirements for accreditation and certification of those involved in lead-based paint abatement and establish standards for safe lead-based paint activities. Contact David Lacker, DOH, (512) 834-6600.

Utah

Automotive Refinishing (Proposed Regulation)—A proposed rule of the Utah Department of Environmental Quality (DEQ) would give automotive refinishing shops an alternative to following the notice of intent process in order to streamline the permit process. The proposal would also specify the requirements that must be met by each paint booth, require registration forms to be submitted by the facilities, require the use of a paint-arresting filter, and outline the techniques to minimize the use of solvent. Contact Jan Miller, DEQ, (801) 536-4042.

Hazardous Waste (Proposed Regulation)—Proposed regulations of the Utah Department of Environmental Quality (DEQ) would amend the identification and listing of hazardous waste, incorporating by reference amendments to federal hazardous waste generator requirements. The proposal would clarify the wastes that would be classified as universal wastes. Contact Susan Toronto, DEQ, (801) 538-6776.

Vermont

Lead—VT H. 778 (Committee on Health & Welfare) creates a program to prevent lead paint poisoning in children in rental housing and child care facilities. The bill was introduced on February 2.

Solid Waste—VT H. 415 (Rose) proposes to repeal the prohibition on the disposal in landfills of solidified water-based paint. On January 31, the legislation was released from the House Committee on Natural Resources and Energy as amended.

Virginia

Air Quality—VA H. 1512 (Stump) prohibits state agencies from entering into any agreement related to the transport of ozone if the proposed agreement contains stationary source emission requirements exceedings (1) the reasonable available control technology standard; or (2) the nitrogen oxide standard contained in the Clean Air Act. On February 7, the bill passed the House and was referred to the Senate.

The Virginia Air Pollution Control Board (APCB) has issued notices announcing their intention to revise standards for the control and abatement of air pollution pursuant to Title V of the Federal Clean Air Act. The proposals would also meet federal requirements for new source review permit programs and state operating permit programs. Contact Kathleen Sands, DEQ, (804) 762-4413.

Lead—VA S.J.M. 70 (Lambert) continues the study of the abatement of lead-based paint and monitors the implementation of the lead certification program. The bill was released from the Senate Committee on Rules on February 7.

Solid Waste—VA H. 885 (Van Yahres) allows a permitted solid waste facility that devotes a specific storage area to household hazardous waste to store such waste for up to one year. The legislation passed the House and was sent to the Senate on February 7.

Water Quality—VA S. 480 (Gartlan) requires persons responsible for discharging prohibited wastes into or upon state waters, storm drain systems or lands to report such discharges to either the State Waste Control Board (SWCB), the Director of the DEQ, or the local emergency services coordinator, and the appropriate federal authorities. The bill passed the Senate and was referred to the House on February 9.

Washington

Occupational Safety and Health—WA H. 2654 (Clements) provides that no citations may be issued if the employer demonstrates that they maintain a written accident prevention program, safety rules that are adequate, hold safety meetings, take measures to discover violations of safety rules and disciplines violators, and provides employees with training and equipment in compliance with standards. On January 31, the legislation was released from the House Committee on Commerce and Labor.

WA S. 6676 (Hochstatter) provides that no citation may be issued under statute if the employer demonstrates that the employees of the employer were provided with training and equipment in compliance with standards and the employer maintains a written accident prevention program in compliance with standards. The legislation was introduced on January 23 and referred to the Senate Committee on Labor, Commerce and Trade.

Wisconsin

Air Quality (Proposed Regulation)—A proposed regulation of the Wisconsin Department of Natural Resources (DNR) would exempt acetone from the definition of VOCs, revise eligibility for variances from reasonable available control technology requirements, and update air pollution control provisions. Contact Robert Park, DNR, (608) 266-1054.

Wyoming

Labeling—WY S. 28 (Committee on Joint Agriculture) repeals the provision regulating the labeling and regulation of paint. On February 5, the legislation was prefiled.

Cleveland Society's 39th Technical Symposium To Focus on Formulating, Manufacturing Paints

The 39th Annual Manufacturing and Technical Symposium of the Cleveland Society is scheduled for April 24-25 at the John S. Knight Center, in Akron, OH. The Symposium is themed "Formulating, Manufacturing & Painting the Future."

Currently, 16 experts in coatings and manufacturing are scheduled to deliver the following presentations:

"Scaleup—Moving from the Lab to the Plant"—Chris Carmichael, of PPG Industries Inc.;

"Acrylic Styrene Latex in Anticorrosive Paints"—Alan Smith, of BASF Corp.;

"Reducing HAPs Emissions Using Solvent Substitution"—Ron Stout, of Eastman Chemical Co.;

"The Importance of Dispersion"—John R. Sneeringer, of Premier Mill Co.;

"Novel Crosslinking Agents for Powder Coatings"—Shelby F. Thames, of The University of Southern Mississippi;

"High-Solids Coatings Formulations"—M. Emami, of McWhorter Technologies;

"The Role of Ionic Functional Monomers in Emulsion Polymerization"—Chester E. Ramey, of The Lubrizol Corp.;

"Quality Assurance—How Statistics and Planning Can Help"—John Staines and Kevin Reid, of Orr & Boss;

"The A,B,C's of Color and Gloss"—Kevin Loughrey, of BYK-Gardner USA;

"The Use of Spherical Extenders in VOC Compliant Coatings"—Ben Carlozzo, of Mameco International;

"Navigating the Hazardous Waste Maze"—Phillip T. Schaefer and Jamie McNeil, of Ross Environmental Services;

"Considerations for the Scaleup of Laboratory Dispersion Process"—John Pope, of BYK-Gardner USA;

"Electrocoat—Charging into the New Millennium"—R. Edward Bish, of Jamestown Paint Co.;

"UV/EB Curing in Coatings Applications"—William K. Goss, of UCB Chemicals Corp., Radcure Business Unit;

"Transportation—What You Don't Know Could Kill You"—Joseph Fyd, of CCX Transportation; and

"Colloidal Engineering Strategies for Control of Coating Quality"—Donald L. Feke, of Case Western Reserve University.

In addition to the technical program, an outing to the Cleveland Rock 'n Roll Hall of Fame is planned.

The two-day registration fee is $295, which includes lunches, breaks, and the trip to the Hall of Fame.

For additional information, contact Roy A. Glover, The Mahoning Paint Corp., P.O. Box 1282, Youngstown, OH 44501; (216) 744-2139.

(See registration form on page 49.)

ChinaCoat '96 Scheduled for May 28-31 in Guangzhou

To address the needs of the growing Chinese coatings industry, the first international coatings exhibition "ChinaCoat 96" is slated for May 28-31, 1996 at the China Foreign Trade Centre, Guangzhou, P.R. China.

This event will feature exhibits from the chemical, fine chemical, raw material, manufacturing plant and technology, quality and control instruments for the paint, coatings, and printing ink industry.

For more information, contact Raymond Ho, Sinostar International Ltd. 1501 Connaught Commercial Bldg., 185 Wanchai Rd., Wanchai, Hong Kong.

NYSCT/MNYPCA Coatings Course to Begin in March

The New York Society for Coatings Technology, in conjunction with the Metropolitan New York Paint and Coatings Association is sponsoring a course on "Rheology of Coatings." This course will cover physical principles, viscometry, sagging and settling, dispersion and stabilization of pigments, surface tension, and application defects.

"Rheology of Coatings" will be conducted on the campus of Fairleigh Dickinson University, in Hackensack, NJ, beginning on March 27, 1996. The course prerequisite is a successful completion of a course in physics or physical chemistry in high school or college.

The fee for the course is $275 and includes the course text book and other course related material. For more information contact Mildred Leonard, NYSCT/MNYPCA Office, 520 Westfield Ave., Elizabeth, NJ 07208; (908) 354-3200.

Pacific Northwest Society's Spring Symposium Held In Conjunction with FSCT Spring Week in May

The Pacific Northwest Society for Coatings Technology's 49th Annual Spring Symposium will be held on May 2-4, 1996 at the DoubleTree Suites Hotel, Seattle, WA. The Symposium will be held in conjunction with FSCT Spring Week, which will take place on May 3-5.

The technical portion of the symposium will feature the following presentations:

"Waterborne Acrylic Stains for Wood"—Robert Krasnansky, of Rohm & Haas;

"Surfactant Free Acrylic Latexes for Waterproofing Wood"—Ray Southwell, of Specialty Polymers;

"Organic Pigments for Heavy Metal Free Coatings-Solvent & Waterborne Systems"—Romesh Kumar, of Hoechst Celanese;

"New Acrylic Emulsion Technologies for Industrial Wood Finishes"—Charles C. Shearer, of Zeneca Resins;

"OSB Board"—Louisiana Pacific;

"Masonite"—Weyerhauser Co.;

"Masonary"—Hardy Board;

"Wood Siding"—Cedar Products;

"New Waterborne Water Repellents"—Victoria Scarborough, of Thompson & Formby;

"Novel, VOC Compliant Wood Preservative Coatings with Outstanding Penetrating Properties"—Eeva-Liisa Kuusisto, of Troy Chemical Co.; and

"Fast Drying, Ultra-Low VOC, Two-Component Waterborne Polyurethane Coatings for the Wood Industry"—Christine A. Renk, of Bayer Corp.

FSCT Spring Week will begin with the Incoming Society Officers Meeting on May 4. The Board of Directors Meeting will be held on May 5.

For more information on the PNWSCT Spring Symposium, contact Beverly Spears, Tarr Inc., 4510 B St., N.W., Ste. B, Auburn, WA 98001; (206) 859-2979. To obtain information on FSCT Spring Week, contact Tori Graves, FSCT, 492 Norristown Rd., Blue Bell, PA 19422; (610) 940-0777.

(See registration form on page 47)

OCCA's Bristol Section to Address Wood Coatings

The Bristol section of the Oil & Colour Chemist's Association (OCCA) is presenting the program "Environmentally Friendly Wood Preservatives and Coatings." Slated for April 18, at the University of The West of England, Bristol, Avon, the symposium discuss wood protection with the emphasis on how environmental legislation is affecting and controlling the direction of development in this field.

The symposium will cover wood, its makeup and decay; parameters and principles applied in formulating the protective systems used; and long-term protective performance.

Eight papers are scheduled to be presented and will cover the following topics:

Keynote Lecture—"Characteristics of Wood as a Substrate for Exterior Coatings"—Roy Miller, of Building Research Establishment;

"Timber Decay"—Janice Carey, of Building Research Establishment;

"Water-Based Preservatives and Low Build Coatings for Wood"—Justine Warringham, of Cuprinol;

"Use of Biocides and Fungicides in Wood Coatings and Preservatives"—John Gillatt, of Thor Chemicals;

"New Fast Drying High-Solids Latexes for Waterborne Wood Coatings"—David Cornwell, of Zeneca Resins;

"High-Solids for Decorative Wood Care"—Steve Rees, of Cray Valley;

"Water-Based Coatings for Protection of Exterior Wood"—Bent Samuelson, of Rohm and Haas; and

"Long Life Durable Coatings for Wood/Joinery Coatings"—Hans Fridh, of Akzo Nobel.

The symposium is designed for those who wish to keep up-to-date with current trends, as well as those who have recently entered the industry, and also for end users in the timber industry who wish to broaden their knowledge, gaining an understanding of what makes individual coatings and preservatives carry out the job intended.

The registration fee for the one-day symposium is £176.25. For additional information, contact Yvonne Waterman, OCCA, Priory House, 967 Harrow Rd., Wembley, HA0 2SF.

AVS Issues Call for Papers

The American Vacuum Society (AVS), New York, NY, is seeking papers for its 43rd National Symposium slated for October 14-18, 1996 at the Pennsylvania Convention Center, in Philadelphia, PA. Papers are now being solicited as follows:

Topical Conferences—Flat panel displays (FPD); micro-electromechanical systems (MEMS); and magnetic surfaces, interfaces, and nanostructures.

Technical Groups—Manufacturing science and technology; electrochemistry and fluid/solid interfaces; and biomaterial interfaces.

Eight Traditional Technical Divisions—Applied surface science, nanometer-scale science and technology; surface science, vacuum metallurgy; electronic materials and processing; plasma science and technology; thin film; and vacuum technology.

The deadline for abstracts is May 10. For additional information contact Angela Mulligan, AVS, 120 Wall St., 32nd Floor, New York, NY 1005.

"Corrosion and Its Control by Protective Coatings" Topic of Lehigh University Course on May 20-24

Lehigh University, Bethlehem, PA, will conduct the week-long course "Corrosion and Its Control by Protective Coatings," May 20-24 on the Bethlehem campus. The course will concentrate on the control of corrosion through the use of metallic and organic coatings. The topics to be discussed are as follows:

Monday, May 20

Fundamentals of electrochemistry, metallurgy, and polymer science of importance to corrosion; electrochemical theory of corrosion; Pourbaix diagram; and passivity.

Tuesday, May 21

Localized corrosion; atmospheric corrosion; degradation of metals by combined mechanical and chemical effects; measuring rates of corrosion; and control of corrosion.

Wednesday, May 22

Corrosion control by organic coatings; methods of application of coatings; generic classes of coatings; mechanisms of loss of protection; phosphating and other conversion coatings processes; morphology of organic coatings; nature of the interface between coating and metal; charge motion through coatings; nature of ions in coatings; and inhibition of corrosion of coated metals.

Thursday, May 23

Corrosion control by metallic and cementitious coatings; methods of applying coatings; properties of various metallic coatings; principles as related to galvanized steel, tin plate, gold coatings on copper; metals on polymers; corrosion of metals in concrete; and composite materials and corrosion processes.

Friday, May 24

Methods of monitoring corrosion; high temperature corrosion; coatings for high temperature applications; review and integration of course; and an open forum.

The fee for the course is $1095 and includes lecture notes, discussion questions, continental breakfast, coffee breaks, and social hours.

For more information, contact Richard D. Granata, Lehigh University, Sinclair Lab., 7 ASA Dr., Bethlehem, PA 18015.

Chicago Society To Establish Coatings Library and Coatings Laboratory at DePaul University

In commemoration of the 75th Anniversary of the Chicago Society for Coatings Technology (CSCT), a Coatings Laboratory and Coatings Library will be established at the DePaul University Chemistry Department, Rosemont, IL.

The CSCT is soliciting donations for specific pieces of equipment that the faculty at DePaul requests, as well as donations of good, usable surplus equipment that your company may have. Appropriate plaques will be attached to the donated equipment, noting the contributor, an honorary or memorial inscription, and the occasion of the CSCT 75th Anniversary. A donor plaque will also be prepared for display at DePaul.

The Coatings Library will be housed at DePaul with access for CSCT members as well as students and faculty of DePaul. Donations of books on coatings technology as well as monies to purchase new books are welcome. A bookplate will be inserted into each book in the Library indicating the individual or company making the donation, an inscription "in honor of..." or "in memory of...", and the occasion of the CSCT's 75th Anniversary.

For further information, contact Richard E. Max, Zarco Industrial Finishes, 3115 W. 36th St., Chicago, IL 60632.

Pacific Northwest Society for Coatings Technology Presents

49th Annual Spring Symposium

May 2-4, 1996

Double Tree Suites Hotel
Seattle, WA

Registration Application

Please Print (for badge)

Name____

Significant Other's Name ______________________________

Company____

Address____

City__________________ State/Province __________________ Postal Code____________

Phone Number ______________________ Fax:______________________

Registration Fees

Full-time registration Registration fee includes technical sessions, luncheon, and Saturday evening banquet and entertainment.	$100.00 ($115.00 after April 15th)	________
One-day registration	$75.00	________
Half-day registration	$55.00	________
Thursday Evening Social Includes transportation, Murder Mystery Dinner and production.	$75.00 ($85.00 after April 15th)	________
Thursday Golf Outing Includes green fee, cart, lunch, and gifts and prizes.	$60.00	________
Significant Other's registration Includes Saturday evening banquet and entertainment and a tour of Seattle and lunch.	$65.00 ($75.00 after April 15)	________
	Total U.S. $	________
	Do you plan on attending the Saturday Evening Banquet?	________

Make checks payable (in U.S. funds) to: **PNWSCT**

Please mail registration to: PNWSCT, 4510 B St.,N.W., Ste. B, Auburn, WA 98001.

For additional information, contact: Bev Spears at (206) 859-2979

"Driving Technology to Meet New Challenges" Is Topic Of the Detroit Society's 21st Annual FOCUS Conference

The Detroit Society's 21st Annual FOCUS Conference is slated for April 16, 1996, at the Michigan State University Management Education Center, Troy, MI. The theme of the Conference is "Driving Technology to Meet New Challenges."

The Conference will once again feature a two-track format with 14experts in the field of coatings technology scheduled to deliver the following presentations:

Keynote Speaker—"Where Have We Been? Where Are We Going?"—John McElroy, of Automotive Industries;

"Novel Acrylic Cure Polyester Coatings Resin Technology"—Eric D. Dumain, of Reichhold Chemicals, Inc.;

"A New Development in Surface Defect Control for Aqueous Coatings"—Mesach Ojunga-Andrew, of Monsanto Chemical Co.;

"Approaches to Formulating Industrial Coatings"—John C. Ballard, of Burgess Pigment Co.;

"Pretreating Aluminum in Mixed Metal Automotive Body Applications"—John C. Hess, of Chrysler Corp.;

"Determining Powder Coatings Cure Rates: Evaluating Coatings Performance by DSC"—James R. Allaway, SC Johnson;

"The Canadian Environmental Protection Act: Regulations and Programs Pertaining to Paints and Coatings"—Gordon Stringer, of Environment Canada;

"Creeping Requirements or Unchallenged Assumptions: A Case of Suntan Lotion Attack"—Ruben Balangue, of Prince Corp.;

"Supersurfactants for the Coatings Industry"—Chang Jho, of Ciba-Geigy Corp.;

"Ultra Low Viscosity Oxazolidine and Aldimine-Based Reactive Diluents for High-Solids Polyurethane Coatings"—Thomas L. Johnson, of ANGUS Chemical Co.;

"Problem Solving in the Coatings Industry Using FTIR Spectroscopy"—Manoj K. Gupta, of BASF Corp.;

"Applications of Aldimine/Isocyanate Chemistry in High-Solids Automotive Coatings"—Sharon D. Hicks, of Bayer Corp.;

"Modern Paste Formulation and its Effect on Media Mill Performance"—Mark L. Drukenbrod, of CB Mills;

"High Performance, High MW Polymeric Dispersants for Aqueous and Nonaqueous Automotive and Industrial Coatings"—Robert E. Van Doren, of RHEOX, Inc.; and

"Advanced Methods for Evaluation Electrostatic Painting of Plastics"—F.M. Migda, of Ford Motor Co.

The Conference is designed for formulators, end-users, raw material and equipment suppliers, and educators and students.

For additional information, contact Rosemary Brady, Akzo Nobel Coatings, Inc., 1845 Maxwell St., P.O. Box 7062, Troy, MI 48007-7062; (810) 637-8565.

Atlas Electric Devices Releases Schedule for 1996 Workshops and Weathering School

Atlas Electric Devices Co., Chicago, IL, has released the 1996 schedule for its Weather-Ometer® Workshop. This two-day, in-depth training course for operators of Atlas Ci35 and Ci65 Weather-Ometer and Fade-Ometer® laboratory accelerated exposure instruments will be held on May 15-17, August 21-23, and November 13-15, in Chicago at the Holiday Inn O'Hare.

Attendees will learn how to perform operation, calibration, and maintenance on fully operational instruments in the classroom. In addition, the class agenda includes instruction periods for emphasized focus on special systems, such as air temperature control, humidity control, the xenon lamp, and the blower controller.

The tuition for the course is $825 and includes a get acquainted welcoming reception, continental breakfast, lunch, and refreshment for both days and all materials.

In addition, the 1996 Atlas School for Natural and Accelerated Weathering (ASNAW) will be held on May 14-17 at Don Shula's Hotel and Golf Club, in Miami, FL.

The school is designed to teach the fundamentals of natural and accelerated weathering of materials. The course covers the individual and synergistic effects of various climatological elements on the degradation of materials. Test design and techniques of natural and accelerated weathering are discussed in addition to material evaluation, correlation of results, and conformance to required government and industry test specification.

Engineers, product managers, quality control personnel, and others responsible for materials formulation and test design who need to stay abreast of the latest technological and scientific developments in the field will benefit from this course.

The fee to attend the ASNAW school is $875 and covers a welcoming reception, course materials, instruction, refreshments, and meals.

To register for either of these events, contact Allen Short, Atlas Electric Devices Co., 4114 N. Ravenswood Ave., Chicago, IL 60613.

Louisville SCT and PCA Host Spring Symposium

The Louisville Society for Coatings Technology in conjunction with the Louisville Paint and Coatings Association will again be holding its Spring Symposium "Spectrum of Coatings Science" on April 17, at the Executive West Hotel, Louisville, KY.

The program for the one-day event includes:

"Manufacture of the Major Types of Colored Organic Pigments Used in the Coatings Industry"—Peter A. Lewis, of Sun Chemical Corp.;

"Interior Solvent Free Acrylic Binders"—Gregory Monaghan, of Rohm & Haas Co.;

"Mechanism of Dispersion"—Malcolm H. MacKay, of Union Process, Inc.;

"New Developments in Zero VOC High Performance, High Molecular Weight Polymeric Dispersants for Waterborne Coatings"—Robert E. Van Doren, of RHEOX, Inc.;

"Controlled Stress or Controlled Strain, Which to Use?"—Abel Gaspar Rosas, of Paar Physica USA, Inc.;

"New Photoreactive Hindered Amine Technology"—Joseph R. Webster, of Clariant Corp.;

"Film Formation Mechanism of Two-Component Waterborne Polyurethane Coatings"—Charles R. Hegedus, of Air Products & Chemicals; and

"Toward Solventless Liquid Coatings"—Frank N. Jones, of Eastern Michigan University.

The advance registration fee for the Symposium is $65. For more information, contact Ilona Duvall, Red Spot Paint & Varnish, P.O. Box 418, Evansville, IN 47703-0418; (812) 467-2337.

Emulsion Polymerization Course Slated for August

"Advances in Emulsion Polymerization and Latex Technology," an in-depth study of the synthesis, characterization, and properties of high polymer latexes, will be held on August 19-23, 1996, in Davos, Switzerland.

For additional information, contact Gary W. Poehlein, School of Chemical Engineering, Georgia Institute of Technology, Atlanta, GA 30332-0100.

Cleveland Society for Coatings Technology

39th Annual Manufacturing & Technical Symposium

"Formulating, Manufacturing & Painting the Future"

What:

39th Annual Manufacturing & Technical Symposium of the Cleveland Society for Coatings Technology where leaders in the coatings and manufacturing fields will present topics on: E-coat, UV/EB, high solids, water technologies, color, dispersing techniques, hazardous transportation, scaling up, HAPs . . . and much more.

When & Where:

April 24 & 25, 1996, at the John S. Knight Center, in Akron, OH.

Speakers from:

University of Southern Mississippi; Ross Environmental; BYK-Gardner; Case Western Reserve University; CCX Transport; BASF; PPG Industries Inc.; McWhorter Technologies; Eastman Chemical; Lubrizol Corp.; Jamestown Paint; UCB Radcure; Premier Mills; Mameco International; and Orr & Boss

Who Should Attend?

Anyone in the industry who wishes to gain a comprehensive understanding of its products and trends. Personnel from the lab, manufacturing and shipping will all benefit from these highly respected leaders in their fields.

Conference Application

Please Print

Name______________________________

Company______________________________

Address______________________________

City______________________________

State ______________________________

Zip Code______________________________

Phone Number ______________________________

Fax______________________________

FSCT Society Affiliation______________________________

Conference Rates

$295 — Two day (includes: lunches, breaks, and trip to Rock N Roll Hall of Fame on the 24th)

$195 — One day (includes: lunch and breaks)

$30 — Late registration fee

All attendees will receive a copy of the proceedings.

Make checks payable to: Cleveland Society for Coatings Technology

Mail registration and check to: Jim Miller, J. Miller & Associates, 3057 Kent Rd., Silverlake, OH 44224, (216) 688-5761.

Application deadline is April 12, 1996

Note: A special evening has been arranged for the two-day registrants to travel on the night of May 24th, via coach, up to Cleveland's Rock N Roll Hall of Fame. A boxed dinner will be included with the package. Departure time is at 5:15 pm from Quaker Hilton—return time is around 9:00 pm.

Announcing . . .

1996
Pan-American Coatings Expo

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Federation of Societies for Coatings Technology

Instituto Mexicano de Téchnicos en Pinturas y Tintas

August 15-17, 1996

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Sheraton Maria Isabel Hotel
Mexico City

For more information, contact
Federation of Societies for Coatings Technology
492 Norristown Road • Blue Bell, Pennsylvania 19422-2350
(610) 940-0777 • Fax: (610) 940-0292

Predicting the Water-Sensitivity of Film-Forming Coatings Additives by Water Vapor Sorption: With Application to Thickeners and Rheology Modifiers

Gregory D. Shay, Keith R. Olesen, and Jeanne L. Stallings—The Union Carbide Corp.*

Although present in relatively low concentrations, additives such as thickeners, rheology modifiers, dispersants, and surfactants can contribute to the water sensitivity of coatings due to their inherent affinity for moisture. Because of the number of additives often present and the variable response possible within different formulations, a method was sought to examine the moisture affinity of individual additives in the absence of other coating components. A simple gravimetric procedure with high sensitivity and good repeatability was developed based on water vapor sorption (WVS). In this paper, the technique is applied to a variety of commercial thickeners and rheology modifiers commonly employed in waterborne coatings. Although alkali-swellable emulsions of the conventional (ASE) and associative (HASE) varieties are generally considered to be more water sensitive than nonionic thickener types, these carboxyl functional polymers in their acid form actually showed much lower moisture affinities. WVS for the anionic ASE and HASE thickeners was a function of polymer composition, type of counter ion, base volatility, dry time, and the state of neutralization prior to conducting the test.

INTRODUCTION

An important criteria for modern day coatings is that they have good "water-resistance" or "low water-sensitivity." This is more challenging with coatings based on waterborne and latex binders, since some of the components used to prepare the binders and those added to the finished coatings are water-soluble or water-dispersible. For architectural finishes, water-sensitivity is often defined in terms of the coating's scrub resistance. For exterior finishes, blister resistance is important and rated in actual outdoor test fence exposures. Some of the important measures of water sensitivity for these and other coatings applications are listed in *Table* 1.

A formulator often has little guidance in the selection of aqueous coatings additives with regard to their potential contribution to water sensitivity. This is particularly true for rheology modifiers, thickeners, dispersants, and surfactants. If the moisture affinity of these and other components could be independently quantified, formulating for reduced water sensitivity might be facilitated by appropriate selection.

The use of paint films to quantify the water-sensitivity contribution of individual coating additives is a formidable task. This is because there are usually several additives in a given coating formulation which confound any attempt for independent examination. In addition, the possibility for variable response within different coatings matrixes exists which could be a function of additive concentration, the type and amount of other components present (including binder and pigments), interaction with those components, distribution within the coating matrix, degree of flocculation, and the additives effects on dispersion, coating hardness, and film coalescence. For these reasons, the primary objective of the work presented here was to develop a suitable method for quantifying the water-sensitivity of individual coatings additives with respect to affinity for moisture in the absence of other coating components. Further objectives were that the method should be uncomplicated, so that any coating lab, large or small, would be able to conduct the test procedure without special equipment requirements, that it have high sensitivity, and that it have good repeatability. A final objective was to generate an initial base of water sensitivity data for a broad variety of commercial thickeners used in coatings with some rationalization of the results obtained.

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*UCAR Emulsion Systems, 410 Gregson Dr., Cary, NC 27511.

Table 1—Some Primary Measures of Water-Sensitivity by Type of Coating

Coating Type	Measure of Water-Sensitivity
Interior architectural	Scrubs, wet abrasion
Exterior architectural	Blistering, flaking, peeling
Industrial and automotive	Corrosion, blistering
Furniture coatings	Blushing, water spotting
Adhesive coatings	Adhesion, tensile properties
Barrier coatings	Vapor transmission

CONCEPTS/THEORY

Causes of Water-Sensitivity

A key fundamental assumption in the development of a method to quantify the water sensitivity of coating additives is that "the relative water sensitivity of a coating is largely a function of its ability to attract or repel moisture." The greater a coating's affinity for moisture, the more moisture will be absorbed into that coating, eventually resulting in some type of failure (e.g., loss of adhesion, low scrubs, blushing, corrosion, blistering, etc). To illustrate the extent to which failures may occur, extreme examples of blistering on exposure to moisture of coatings containing water-sensitive components are shown in *Figures* 1 and 2 over metal and wood substrates. It is also reasonable to assume that the attraction for moisture is somewhat additive. If many of the components present are water sensitive, large amounts of water will be absorbed in a short period of time, and rapid failure is probable. If only one component is water-sensitive, it may or may not be a problem depending on the degree of water sensitivity (i.e., affinity for moisture) for that component and its concentration in the formulation. A recent theory proposed by Bassett[1] is that each coating has a "hydrophilic budget" with respect to the presence of a given water sensitive component. When the concentration of that component exceeds the budget, coating failures occur. This model is further expanded to include all of the water sensitive components within a coating where the hydrophilic budget is presumably some function of the number of hydrophilic components present, the concentrations of those components, and their respective moisture affinities. Being the primary ingredients in most coatings, the relative hydrophilicity contribution of hydrophobic components (e.g., latex binders and some pigments) is obviously a major factor in the development of a comprehensive model.

Among the coating components which are generally considered water sensitive are surfactants, dispersants, thickeners, and rheology modifiers. Since the terms rheology modifier and thickener are often used interchangeably, particularly with respect to the associative products, they will collectively be referred to as just thickeners hereafter. Virtually all of the thickeners, most of the dispersants, and some of the surfactants used in coatings are polymeric or oligomeric film-formers. In practical applications, some of these polymeric additives are deemed to be less water sensitive than others and have fallen into favor either by promotion or based on an extensive history of testing. Paradigms also exist regarding the relative performance of polymer classes. For example, conventional wisdom suggests that nonionic polymers should be less water sensitive than anionics, and that low molecular weight materials should be more water sensitive than those of higher molecular weight. Some of these concepts will be tested in the examination of thickeners for moisture affinity by the test method developed.

Moisture Affinity Methods

A variety of methods have been applied to determine the absorption (or just sorption) of moisture into polymer films[2-6] and coatings.[7-18] Two practical methods commonly employed involve gravimetric determinations. The first is by the direct immersion of a coating film (free form or on a coupon substrate) of known dimensions in water. The film is then removed from the water after a fixed period of time, blotted to remove surface moisture, and subsequently weighed to determine moisture uptake. This method works reasonably well for most clear and pigmented coatings with good film integrity, but it has severe limitations for the examination of most film-forming coatings additives. For example, if the additive is a water-soluble polymer, of which many thickeners and dispersants are, the polymer will simply dissolve, and no determination of sorption can be made. Some materials also become tacky making blotting problematic and resultant weighings imprecise. A more adaptive technique and the one chosen for our work is based on water-vapor sorption (WVS)—the ab-

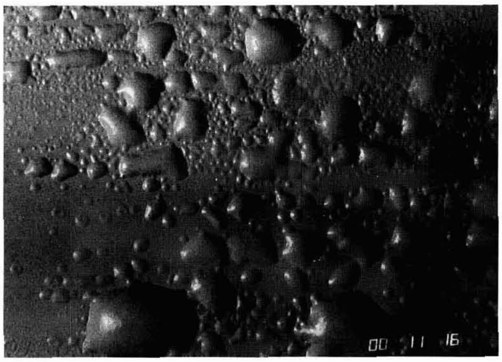

Figure 1—Severe blistering on a metal substrate upon exposure of coating to warm water vapor.

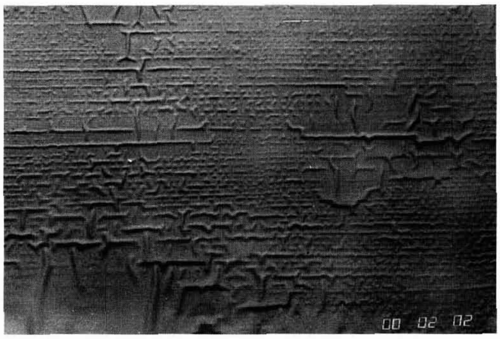

Figure 2—Severe blistering on a wood substrate on exposure of coating to overnight rain.

sorption of moisture from the gas phase with permeation into the film sample specimen. With the development of proper technique as described later, the disadvantages associated with direct immersion were avoided.

Water Vapor Sorption Theory

The mechanism of absorption of water into hydrophilic polymers was explained by Flory.[19] Diffusion is the process by which matter is transported from one part of a system to another as a result of random molecular motions. For the purposes of our study, the substance being transported is water, and the transport is from the gaseous vapor state with absorption into a polymer film. It is well known that the sorption curve for a plane sheet (e.g., thin film) is described by a relationship between the amount of substance sorbed M_t in the specimen and the square root of time t divided by the specimen thickness b. For films following Fick's law, the sorption curve shows a linear increase in the initial stage of water uptake followed by a saturation plateau as depicted in *Figure* 3. From this relationship, the diffusion constant D for the polymer may be approximated.

The detailed mathematics of diffusion have been derived for a variety of geometric conditions and constraints.[20,21] For the case of Fickian diffusion into a wide thin sheet from both sides, the mass M_t of water absorbed in time t is related to the mass absorbed at saturation M_s by equation (1).

$$\frac{M_t}{M_s} = 1 - \sum_{n=0}^{\infty} \frac{8}{(2n+1)^2 \pi^2} e^{-D(2n+1)^2 \pi^2 t/b^2} \qquad (1)$$

Here it is assumed that the film thickness b is very small relative to other dimensions so that diffusion is limited to penetration through the b dimension from both sides. To arrive at this solution, the concentration of water or water vapor must be constant at the film surfaces during the diffusion process.

For exposures of short duration t, equation (1) can be replaced by the approximate following expression:

$$\frac{M_t}{M_s} = 4\left(\frac{Dt}{b^2}\right)^{1/2} \times \left[\pi^{-1/2} + 2\sum_{n=0}^{\infty}(-1)^n \operatorname{ierfc}\left(\frac{nb}{2\sqrt{Dt}}\right)\right] \qquad (2)$$

A further approximation may be used to obtain the diffusion coefficient D with a systematic error[15] of less than one percent when M_t/M_s is less than 0.6.

$$\frac{M_t}{M_s} \approx 4\left(\frac{Dt}{\pi b^2}\right)^{1/2} \quad \text{or} \quad \frac{M_t}{M_s} \approx \frac{4}{\sqrt{\pi}} D^{1/2} \frac{t^{1/2}}{b} \qquad (3)$$

Equations (1-3) define the symmetrical relationships and also apply to when there is an impermeable barrier at one film surface (i.e., when a film is coated on or otherwise is intimately in contact with an impermeable substrate such that sorption can only occur in one direction). This latter situation is used advantageously for the method development described later.

The partition coefficient K [see equation (4)] is another useful parameter which reflects the saturation level of moisture attainable for a given polymer.[5] K is defined as the volume fraction of water contained in a unit volume of sorbed polymer at saturation where W_s and W_d are the specimen weights at equilibrium saturation and dry, respectively, and ρ_w and ρ_p are the density of water and dry polymer, respectively.

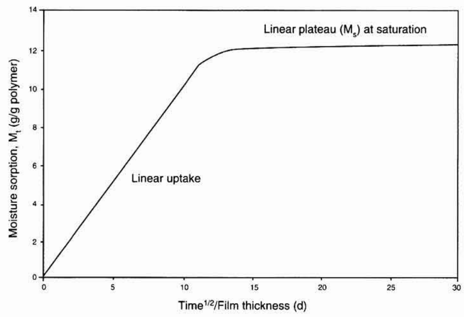

Figure 3—Example of Fickian moisture sorption in a thin sheet.

$$K = \frac{W_s - W_d}{\rho_w} \Big/ \left(\frac{W_s - W_d}{\rho_w} + \frac{W_d}{\rho_p}\right) \qquad (4)$$

EXPERIMENTAL DETAILS

Test Method

Water vapor sorption is often conducted on rigid films and fibers of known dimensions. Although many thickeners are good film-formers at room temperature, some require cosolvents or elevated temperatures for coalescence. Still others are waxy solids on drying with distinct melting points, and others are supplied as powders that must first be hydrated for coalescence. In nearly all cases, however, continuous films of constant weight and dimensions were obtained using the tech-

Table 2—Classification of Coatings Thickeners Tested

Conventional Thickeners	
Alkali-swellable/soluble emulsions	ASE
Conventional cellulosics (CC)	
Hydroxyethyl cellulose	HEC
Ethyl hydroxyethyl cellulose	EHEC
Hydroxypropyl methyl cellulose	HPMC
Sodium carboxymethyl cellulose	CMC
Synthetic biopolymers	SBP
Associative Thickeners	
Hydrophobe modified cellulosics (HMC)	
Hydrophobe modified hydroxyethyl cellulose	HMHEC
Hydrophobe modified ethyl hydroxyethyl celluose	HMEHEC
Hydrophobe Modified Nonionic Synthetics (HNS)	
Hydrophobe modified ethoxylate urethane	HEUR
Hydrophobe modified ethoxylate nonurethane	HENN
Hydrophobe modified alkali-swellable/soluble emulsion (HASE)	
Hydrophobe modified theoxylate ester ASE	HEEASE
Hydrophobe modified ethoxylate urethane ASE	HEURASE

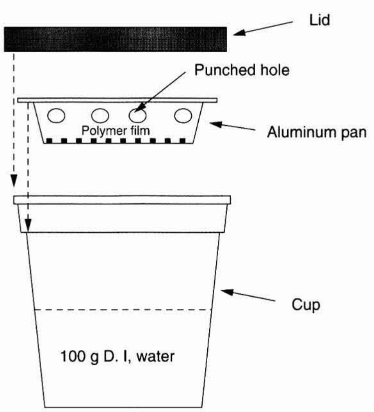

Figure 4—Water vapor sorption cell arrangement.

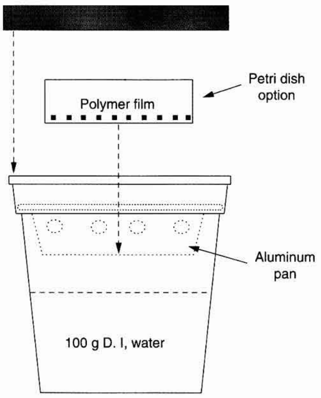

Figure 5—Water vapor sorption cell with optional plastic petri dish.

nique described. With this procedure, the films were readily adaptable to examination by WVS with diffusion from one side through the thickness (b) dimension. Edge effect was also eliminated with an edge barrier.

To easily obtain films of uniform diameter and weight, the viscous solutions or low viscosity dispersions of the commercial thickeners being tested were simply weighed on an analytical balance into disposable aluminum pans (Fisher Cat. No. 8-732-5C), or optionally into disposable plastic petri dishes (Fisher Cat. No. 8-757-13A). Disposable plastic syringes were used for injection of the samples. Adjusting for the predetermined solids content of each thickener, the wet amount of liquid injected into each pan was computed to give a constant dry weight of polymer (e.g., 0.50 ± 0.02 g) weighed to four decimal places. With the bottom interior diameter of the dish fixed (58 mm for the aluminum pans and 52 mm for the petri dishes) and the weight of dry sample constant, the dry film thickness of each sample was also approximately constant assuming similar polymer densities. For a 0.50 g dry sample, film thickness was about 0.158 mm (6.2 mils) in the aluminum pan and 0.196 mm (7.7 mils) in the petri dishes with an assumed polymer density of 1.2 g/cm^3.

A convection oven was used to dry each set of samples being tested to constant weight at either 50°C for four days in petri dishes or pans, or more conveniently at 95°C for 24 hr in the aluminum pans. Care was taken to place the dishes and pans on a level surface for uniform distribution and film thickness. The conditions cited for drying were necessary to obtain thoroughly dry samples and to remove any organic solvent which is commonly present in the nonionic synthetic associative thickeners. Except for the some cellulosic thickeners at the higher drying temperature, little or no degradation of the samples was apparent under the conditions cited. Only the aluminum pans could be used at the higher drying temperature due to deformation of the petri dishes above 50°C.

After drying, the samples were weighed immediately and each placed into separate humidity cells consisting of an impermeable polypropylene cup and mated polyethylene snap cap (Fisher brand, multi-purpose containers, disposable 8 oz, cat. no. 11-840G). In the bottom of each container was placed 100 ml of deionized water. With this particular container and the specified aluminum dish, a neat fit was obtained with the rim of the dish resting on a ridge within the cup approximately 12 mm above the water line (see cell arrangements, *Figure* 4). To facilitate transfer of water vapor to the specimen film, eight holes measuring 7 mm in diameter were punched around the upper perimeter of each dish prior to any weighings. When in place, the container lids provided tight seals, and due to the compact vapor space dimensions, the cells became rapidly saturated with water vapor to effectively provide 100% relative humidity. To obtain accurate weighings on removal of the aluminum pans from the cells, the undersides were inspected for accumulation of any condensation and blotted dry. At no time did condensation appear on interior pan surfaces.

Figure 6—Photo of open sorption cell with aluminum pan.

When the optional petri dish was used for the sample (cell arrangement, *Figure* 5), a punched aluminum pan was first placed into the cell merely as a support for the petri dish and to permit vapor diffusion to the sample (see photographic view of open cell and support in *Figure* 6). The advantage of this latter arrangement is that condensation did not collect on the underside of the petri dishes as it occasionally did with the aluminum pans, and weighings could be made without blotting.

To obtain moisture sorption isotherms, the aluminum pans or petri dishes were periodically removed from the cells and weighed (typically at one day, three days, seven days, two weeks, and one month). Moisture sorption at time t is defined as the weight of water taken up per unit weight of dry polymer. This is often expressed as the grams water taken up (sorbed) per gram of dry polymer or simply as a percentage which is used hereafter [see equation (5)].

$$M_t = (\text{g water uptake at time t/g dry polymer}) \times 100\% \quad (5)$$

For routine determinations and product comparisons, a single point measurement at either one day, three days, or seven days was more convenient and sufficient for characterization in the initial phase of water uptake prior to saturation.

Materials

The additives tested in this evaluation were commercial thickeners and rheology modifiers from a wide range of conventional (nonassociative) and associative varieties.[22-27] Conventional products included alkali-swellable emulsions, cellulosic polymers, and synthetic biopolymers. The associative products included one or more representative products from each major class and subclass within the classification scheme[28] shown in *Table* 2. The actual products tested are compiled in *Tables* 3a and b.

With few exceptions, all thickeners were tested as supplied including the alkali-swellable emulsions. Although the alkali-swellable emulsions of the conventional (ASE) and associative (HASE) products must be neutralized in actual practice to be used as thickeners, they were initially tested in the unneutralized state on the widely held assumption that volatile bases commonly used for neutralization leave the film on drying[29]—this assumption is later examined for validity. The unneutralized form typically at 25-30% solids was also necessitated in most cases to obtain sufficient film weight for testing. When neutralized, most of these polymers are extremely viscous, and only samples of low solids content can conveniently be prepared which did not permit sufficient film thickness for sorption testing. For powdered samples such as the cellulosics and synthetic biopolymers, adequate film formation was obtained by prehydrating the samples in the aluminum pans or petri dishes with the addition of 8 g water for 24 hr prior to drying. Solids content for samples as supplied or diluted were obtained using standard microwave or convection oven gravimetric procedures.

RESULTS AND DISCUSSION

General Observations

Three thickeners from different classifications (HASE—UCAR® Polyphobe® 9823; HEUR—Acrysol® RM-825; and

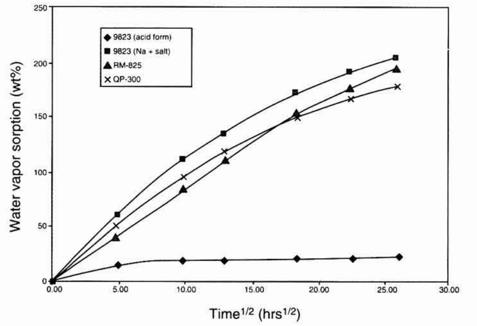

Figure 7—Moisture sorption curves for four different thickeners at 23.0°C—film weight 0.50 g dried 24 hr at 95°C.

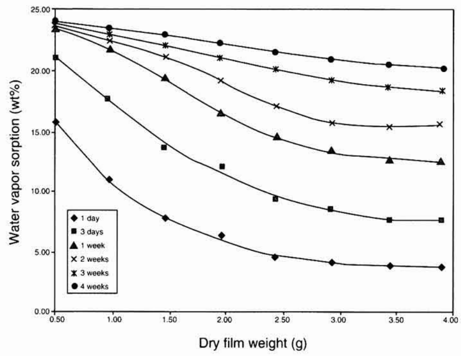

Figure 8—Effect of film weight on moisture sorption of unneutralized HASE thickener 9823 at 23.0°C—film dried 24 hr at 95°C.

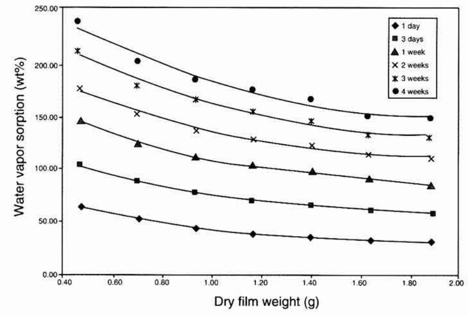

Figure 9—Effect of film weight on moisture sorption at 23.0°C of HASE thickener 9823 neutralized with NaOH—films dried 24 hr at 95°C.

Table 3a—Thickeners Evaluated for Water Vapor Sorption

Supplier Code[a]	Tradename	Product Code	Class	Subclass
11	UCAR Thickener	146	ASE	—
10	Acrysol	ASE-60	ASE	—
10	Acrysol	ASE-108	ASE	—
1	Viscolex	HV-30	ASE	—
3	Bermocoll	E351	CC	EHEC
3	Bermocoll	E481	CC	EHEC
2	Natrosol	250 MBR	CC	HEC
2	Natrosol	250 HBR	CC	HEC
11	Cellosize	QP300	CC	HEC
11	Cellosize	ER 4400	CC	HEC
11	Cellosize	ER 52M	CC	HEC
11	Cellosize	QP100MH	CC	HEC
5	Methocel	J5MS	CC	HPMC
5	Methocel	J75	CC	HPMC
2	CMC-T	7MT	CC	CMC
2	CMC-T	7M31T	CC	CMC
7	—	K1A112	CC	SBP-RG[b]
7	—	K1A96	CC	SBP-WG[b]
7	Kelzan	XG[b]	CC	SBP-Xg[b]
9	Rheolate	1	HASE	HEEASE
1	Rheovis	CR	HASE	HEEASE
1	Rheovis	CR3	HASE	HEEASE
1	Rheovis	CRX	HASE	HEEASE
8	Alcogum	PT-33	HASE	HEEASE
10	Acrysol	RM-5	HASE	HEEASE
10	Acrysol	RM-6	HASE	HEEASE
10	Acrysol	TT-615	HASE	HEEASE
10	Acrysol	TT-935	HASE	HEEASE
10	Acrysol	TT-950	HASE	HEEASE
11	UCAR Polyphobe	101	HASE	HEURASE
11	UCAR Polyphobe	102	HASE	HEURASE
11	UCAR Polyphobe	103	HASE	HEURASE

(a) See Appendix.
(b) RG = Rhansam gum, WG = Whelan gum, XG = Xanthan gum.

Table 3b—Thickeners Evaluated for Water Vapor Sorption

Supplier Code[a]	Tradename	Product Code	Thickener Class	Thickener Subclass
11	UCAR Polyphobe	104	HASE	HEURASE
11	UCAR Polyphobe	107	HASE	HEURASE
11	UCAR Polyphobe	114	HASE	HEURASE
11	UCAR Polyphobe	9823	HASE	HEURASE
11	UCAR Polyphobe	106HE	HASE	HEURASE
4	RHEO	2000	HASE	HEURASE
4	RHEO	2100	HASE	HEURASE
4	RHEO	3000	HASE	HEURASE
9	Rheolate	255	HMN	HEUR
9	Rheolate	278	HMN	HEUR
4	—	BR-100	HMN	HEUR
6	—	DSX-1514	HMN	HEUR
6	—	DSX-1550	HMN	HEUR
3	Bermodol	PUR 2100	HMN	HEUR
3	Bermodol	PUR 2130	HMN	HEUR
10	Acrysol	RM-1020	HMN	HEUR
10	Acrysol	RM-2020	HMN	HEUR
10	Acrysol	RM-8	HMN	HEUR
10	Acrysol	RM-825	HMN	HEUR
10	Acrysol	RM-830	HMN	HEUR
10	Acrysol	RM-870	HMN	HEUR
10	Acrysol	SCT-200	HMN	HEUR
10	Acrysol	SCT-275	HMN	HEUR
9	Rheolate	300	HMN	HENN
9	Rheolate	350	HMN	HENN
6	—	DSC 2000	HMN	HENN
3	Bermocoll	EHM100	HMC	HMHEC
2	Natrosol	FPS PLUS 330	HMC	HMHEC
2	Natrosol	FPF PLUS 430	HMC	HMHEC
2	Natrosol	PLUS 330	HMC	HMHEC
2	Natrosol	PLUS 430	HMC	HMHEC
11	Cellosize	SG-100	HMC	HMHEC

(a) See Appendix.

HEC—Cellosize QP-300) were chosen to examine the efficacy of the WVS test method. Because of its exceptional film forming characteristics and relatively low viscosity on neutralization, the HASE polymer in both unneutralized (acid form) and neutralized (Na^+ salt form) was selected to determine variability in WVS due to the effects of film weight and temperature. For each of these studies, triplicate samples of polymer were dried in aluminum pans for 24 hr at 90°C. The WVS cells were placed in a controlled temperature chamber with sorption determinations made periodically over a period of up to four weeks. In the thickener comparison study, dry film weight was constant at 0.50 g with WVS conducted at 23.0°C (see *Figure* 7). In the film weight study, dry film weights were varied from 0.50 to 4.0 g with WVS conducted at a constant temperature of 23.0°C (see *Figures* 8 and 9). In the temperature study, dry film weight was held constant at 0.50 g with temperature varied for WVS from 10.0 to 40.0°C (see *Figure* 10).

On preliminary examination, several initial observations were made: (1) moisture sorption as a function of time in the humidity cells showed significant measurable response with good repeatability obtained in as little as one day; (2) differential response between thickener types was readily observed; and (3) only one sample (unneutralized HASE) had reached equilibrium sorption at one month, and the sorption curve obtained for this sample was similar to what would be predicted for Fickian diffusion. The results obtained also suggested that testing at a fixed period (e.g., one day, three days, or one week) would be feasible for more convenient single-time-frame determinations.

Test Repeatability

The repeatability of the WVS test method using triplicate samples for the four previous polymers is shown in *Table* 4 for exposure times of one day, one week, and one month. Although the spread on triplicate samples is considered small, <5% standard deviation (SD) at all exposures, it appears that % SD increases with increasing exposure time. The % SD on other thickeners gave similar results, and testing the same polymer on different occasions also showed variability of <5% SD when a constant temperature chamber was used.

Effect of Film Weight

As predicted by diffusion theory (*Figures* 8 and 9), water vapor sorption values (M_t) at any time t were inversely related to film thickness (b). At $M_t < M_s$, thin films absorbed a higher percentage of moisture at any time t because there is less polymer absorbing a similar amount of water (i.e, the denominator is less in M_t = g water/g polymer). Even though the HASE Na^+ salt absorbed much greater quantities of moisture than its acid form, both showed an approximate doubling of WVS at one day with a reduction in film weight from 2.0 g to

Table 4—Repeatability of WVS Test Results for Triplicate Samples

Thickener		WVS 1 Day	WVS 1 Week	WVS 1 Month
HASE 9823 (acid)	Ave (%)	13.9	18.7	19.2
	SD	0.4	0.9	0.8
	% SD	2.7	5.1	4.2
HASE 9823 (Na+ salt) ..	Ave (%)	61.6	135.1	201.9
	SD	2.0	5.9	12.0
	% SD	3.2	4.4	5.9
HEUR 825	Ave (%)	38.6	110.9	191.3
	SD	0.6	2.7	7.8
	% SD	1.6	2.4	4.1
CC QP-300..................	Ave (%)	49.9	117.0	175.9
	SD	1.7	2.8	7.6
	% SD	3.5	2.4	4.3
Average	% SD	2.8	3.6	4.6

1.0 g. At one week the change in WVS for both was still similar, but the increase in WVS with the same weight reduction was less (about 50%). The results obtained suggested that maximum precision and accuracy would be obtained if dry film weights were held relatively constant when repeating a test or when comparing different products. Fortunately, control of film weight with variation of less than 10% was easily achievable in these and later WVS determinations facilitated by two factors: solids content of samples was readily determined with accuracy using conventional procedures, and wet sample weighings into the WVS pans of ± 0.05 g were also easily obtainable. For samples with high-solids contents of about 50%, variation in M_t of about ±5% was realized. If diluted, these and samples of lower supplied solids permitted even less variation in M_t.

Effect of Temperature

Although more difficult to obtain film uniformity, thinner films were considered desirable since they attained saturation equilibrium more quickly. A low film weight was also necessary for thickeners supplied at or diluted to low solids content (i.e., the maximum wet sample accommodated in the aluminum pans was about 20 g with holes punched, which limited the dry film weight possible). On visual inspection, the lowest film weight providing uniform and complete coverage of the pan surface for most samples was about 0.5 g dry (approximate film thickness of 0.16 mm or 6.2 mils). This weight was selected for determining the effect of temperature on WVS using HASE (UCAR Polyphobe 9823) thickener at 10% solids content.

In this study samples were dried as before, but single point WVS determinations were made at three days only. *Figure* 10 shows that sorption was a linear function of temperature for both the acid form and Na^+ salt form of the HASE rheology modifier tested. The higher sorption obtained with increasing temperature was primarily due to an increase in vapor pressure which can be computed from the well-known Clausius-Clapeyron equation where P is the vapor pressure of the liquid (water in this case) and ΔH_{vap} is the enthalpy of vaporization at temperature T [see equation (6)].

$$\ln P = -\frac{\overline{\Delta H_{vap}}}{RT} + \text{constant} \qquad (6)$$

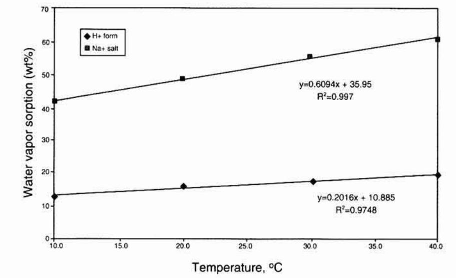

Figure 10—Effect of temperature on moisture sorption for 0.500 g dry samples of HASE thickener 9823 in three days—dried 24 hr at 95°C.

From the results obtained, it was concluded that the WVS test ideally should be conducted at constant temperature. Because the temperature effect was not large, however, reasonably good results might be expected in an open lab at ambient temperature. Support for this conclusion comes from the equations derived for sorption versus temperature in *Figure* 10, where a variation in room temperature of 23 ± 3°C would produce a error in sorption of only ± 3.6%.

Comparative WVS Thickener Evaluations

On preliminary examination of other thickeners at 0.5 g dry film weight, some gave excellent substrate coverage (par-

GREGORY D. SHAY graduated from North Dakota State University in 1971 with an M.S. Degree in Polymers and Coatings Chemistry. His first 20 years of employment were with two major paint companies, The Sherwin-Williams Co. and DeSoto Inc. where he managed synthesis and application programs for architectural and industrial latexes. He most recently joined Union Carbide Corporation in 1990 and is currently Technology Manager of Thickeners and Rheology Modifiers in the UCAR Emulsion Systems business unit. He holds nearly 20 patents in emulsion polymers and thickeners, and is the author of several technical publications.

KEITH R. OLESEN received a B.S. Degree in Chemistry from the University of Guelph, in Guelph, Canada, in 1991 and is currently completing his M.S. Degree in Chemistry, specializing in Polymer Chemistry from the University of Waterloo, in Waterloo, Canada. Mr. Olesen was formerly employed by National Starch and Chemical's Canadian subsidiary Nacan Products Limited where he was involved in the synthesis and applications testing of emulsion polymers for use in architectural coatings. He joined UCAR Emulsion Systems business unit in 1994 and is currently a Senior Chemist in the charge of synthesis and applications testing of UCAR Polyphobe thickeners and rheology modifiers in Cary, NC.

JEANNE L. STALLINGS received a B.S. Degree in Biology from the University of North Carolina, in Chapel Hill, NC, in 1992. She joined the UCAR Emulsion Systems business unit in 1993 and is currently a Research Associate in the applications section of the thickeners and rheology modifiers group in Cary.

Table 5—Bases Used to Prepare 10 wt% Aqueous Solutions of HEURASE 9822 Thickener at pH 8.0

Neutralizing Base	Figure Designation	Base Strength	Base Volatility	Equivalent Weight	% of Theor. Base Used for pH 8.00
Ammonium hydroxide	NH_4OH	weak	yes	35.0	126
Sodium hydroxide	NaOH	strong	no	40.0	101
Potassium hydroxide	KOH	strong	no	56.1	97
Ammonium carbonate	$(NH4)_2CO_3$	weak	yes	48.0	348
Sodium carbonate	Na_2CO_3	weak	no	53.0	126
Potassium carbonate	K_2CO_3	weak	no	69.1	147
2-Amino-2-methyl-1-propanol	AMP	weak	yes	89.1	104
Tris(hydroxymethyl)aminomethane	Tris Amino	weak	yes	121.1	129
Tetraethyl ammonium hydroxide	TEAH	strong	yes	147.0	100

ticularly HASE types), while others did not. Variations in film formation, surface tension, substrate wetting, and film shrinkage on drying may have been factors. Because of this, a higher dry film weight of 1.3 g was chosen for a more comprehensive thickener evaluation where complete coverage was obtained for nearly all samples tested. After drying in petri dishes to a precomputed film weight of 1.3 g for four days at 60°C, sorption determinations on approximately 64 different thickeners were conducted over a period of 28 days using the previously described cell arrangement. WVS results for the thickeners tested are compiled in *Figures* 11-13. At this film weight, the film thickness for samples was computed to be approximately 0.41 mm (16 mils) with an assumed polymer density of 1.2 g/cm^3. Experimental results for WVS on most of the thickeners tested showed linear or near linear increases for M_t as a function of $t^{1/2}$ which is characteristic of Fickian diffusion in the linear region prior to saturation. At this film weight, however, none of the samples reached equilibrium saturation M_s in the 28-day time interval.

With both associative and nonassociative thickeners included, a most interesting result was obtained on grouping the thickeners tested into five primary classifications where data for all members in each class were averaged together (*Figure* 14). In their unneutralized state as tested, the alkali-swellable thickeners (ASE and HASE) absorbed much less moisture than did the cellulosics (CC and HMC) or nonionics (HEUR and HENN) thickeners. The order for increasing sorption at later times t was ASE < HASE << HNS < CC HMHEC. The ASE and HASE polymers also appear to be approaching equilibrium in two weeks at M_t about 20%. This suggests that the commonly held notion "that alkali-swellable thickeners are more sensitive than nonionics" is not valid at low degrees of ionization. Important assumptions are that a volatile base is used for the neutralization of the ASE or HASE polymer, and that some or all of the base leaves the film on drying before the time frame of water sensitivity assessment.

The aforementioned finding would seem reasonable when one considers the physical nature of the polymers. All of the nonionic thickeners tested, including the cellulosic and synthetic species, were water-soluble polymers as supplied. Since they are chemically unchanged when incorporated into a coating, they remain water-soluble or sensitive after the paint film has dried even though the polymer is now within an insoluble binder/pigment matrix. The ASE and HASE thickeners, on the other hand, are the only polymers tested which are made by emulsion polymerization. To produce a stable latex by this process, the polymers formed must, by definition, be water-insoluble. Otherwise, the polymer particles formed would simply dissolve. Only on neutralization with a suitable base do the ASE and HASE polymers become water-soluble and function as thickeners or rheology modifiers. If the base used is volatile (e.g., ammonia or aminomethyl propanol, etc.), it eventually leaves the film, and the ASE and HASE polymers theoretically revert back to their insoluble form, and hence, should impart less water sensitivity (see *Figure* 15). If a nonvolatile base is used (e.g., KOH, NaOH, Na_2CO_3, etc.) quite a different result would be expected (high moisture affinity) and was obtained previously when WVS was conducted on the Na^+ salt of a HASE polymer compared with its unneutralized latex form.

Effect of Neutralizing Agents with ASE/HASE

It is a generally accepted opinion of coating formulators that volatile bases eventually leave a paint film on drying. Formulating literature suggests that ammonia leaves a latex based coating in only about one day, and less volatile aminoalcohols may take up to a week. This occurs even though the latex binder, and any ASE or HASE thickeners present contain carboxyl groups, which are neutralized by the base to form ammonium polymer salts. Since the neutralization is that of a weak base with a weak acid, the state of ionization is tenuous, and equilibrium is easily shifted by volatilization of the base.

To demonstrate the loss of ammonia from a highly carboxylated thickener, FTIR spectra were obtained on a film of an ammonium hydroxide neutralized HASE polymer (UCAR Polyphobe 107) deposited on a zinc selenide ATR crystal. A 0.0027 mm film was deposited from a 0.75% aqueous solution of the thickener at pH 9.0. On drying at room temperature with periodic examination by FTIR, the disappearance of carboxyl salt (wavenumber 1550) and simultaneous appearance of free carboxyl (wavenumber 1700) was readily apparent as shown in *Figure* 16. Complete loss of ammonia was evident in less than 24 hr.

As discussed previously, all ASE and HASE thickeners were first examined by WVS in their unneutralized latex form. The untested assumption was that if a volatile base were used for the neutralization, the solubilized polymer would become insoluble again on evaporation of base and should then have a similar moisture affinity. If observed, any slight difference in WVS would most likely be attributable to differences in film formation, from a latex in the former case and from true solution in the latter.

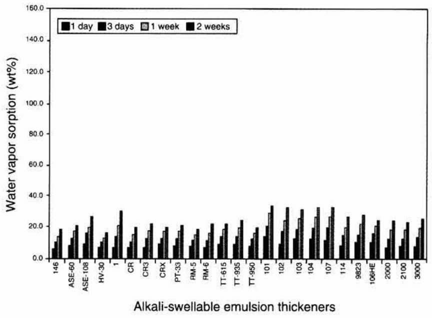

Figure 11—Moisture sorption at 23.0°C for conventional (ASE) and associative (HASE) alkali-swellable emulsion thickeners—1.30 g, dried 24 hr at 95°C.

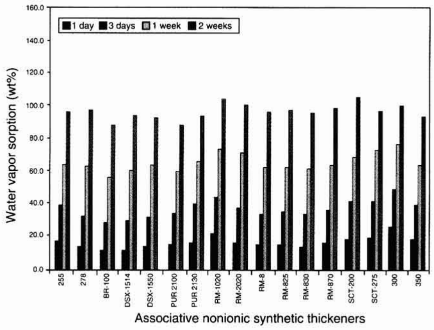

Figure 12—Moisture sorption at 23.0°C for hydrophobe modified nonionic synthetic thickeners (HNS)—1.30 g, dried 24 hr at 95°C.

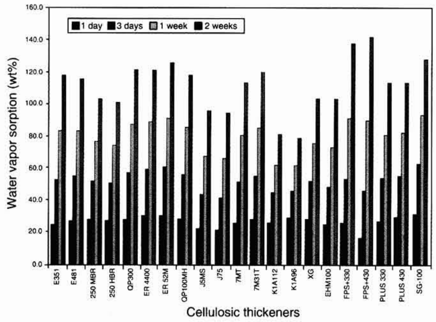

Figure 13—Moisture sorption at 23.0°C for conventional (CC) and associative (HMC) cellulosic thickeners—1.30 g, dried 24 hr at 95°C.

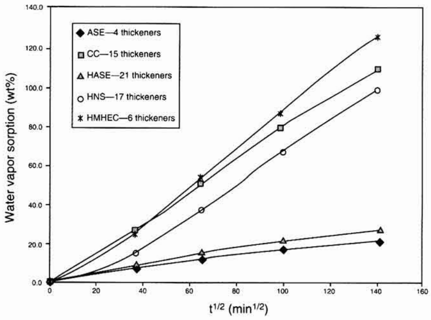

Figure 14—Composition moisture sorption curves at 23.0°C for five major classes of thickeners—1.30 g, dried 24 hr at 95°C.

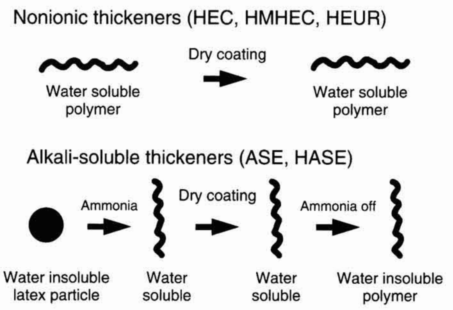

Figure 15—Theoretical water sensitivity comparison of nonionic thickeners with anionic alkali-swellable emulsion thickeners in a coating before and after drying.

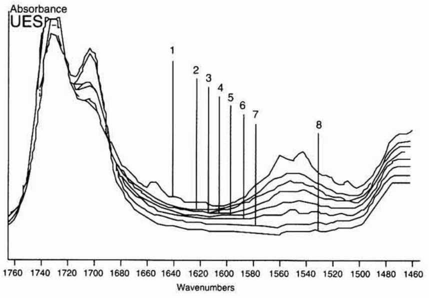

Figure 16—FTIR specta for volatilization of ammonia from film of thickener 107 at 23°C (1 = 10 min, 2 = 20 min, 3 = 45 min, 4 = 1.5 hr, 5 = 4 hr, 6 = 12 hr, 7 = 24 hr, 8 = 1 week).

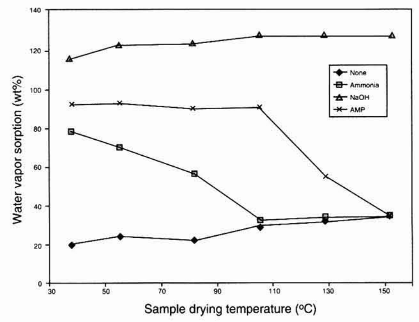

Figure 17—Effect of neutralizing agent and film drying temperature on moisture sorption of HASE thickener 9823 at 23.0°C—film weight 0.50 g dried for 24 hr at six different temperatures.

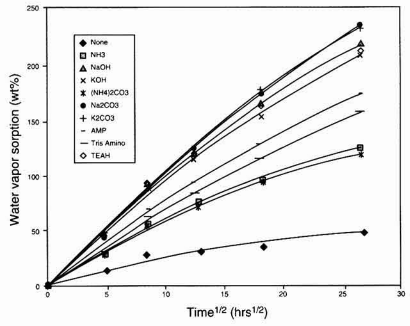

Figure 18—Moisture sorption curves at 23.0°C for various bases used to neutralize 10% aqueous solution of HASE thickener 9823 to pH 8.0—dry film weight 0.50 g dried 24 hr at 60°C with partial elimination of volatile bases.

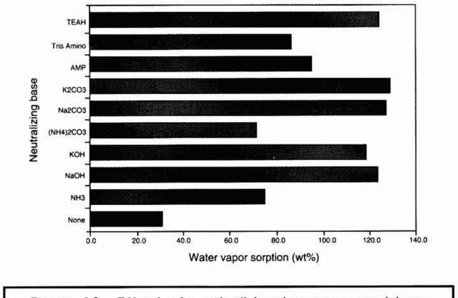

Figure 19—Effect of neutralizing bases on moisture sorption of thickener 9823 for one week at 23.0°C—dry film weight 0.50 g dried 24 hr at 60°C with partial elimination of volatile bases.

So far, it has been demonstrated by FTIR that ammonia leaves the film of a HASE polymer under ambient conditions. What is left untested is a prediction that WVS on a film from neutralized HASE polymer should be similar to that of the film cast from the same unneutralized HASE latex after a volatile base leaves the film. To examine this notion, films of ammonia neutralized HASE polymer were dried at successively elevated temperatures to accelerate liberation of the base. HASE films neutralized with 2-amino-2-methyl-1-propanol (AMP) and NaOH were also examined under the same conditions along with an unneutralized polymer control. The results of WVA conducted on the samples are shown in *Figure* 17. Liberation of ammonia and AMP base in this figure is suggested by the gradual reduction in M_t, and as predicted, the WVS is the same as the unneutralized polymer when all base apparently has been eliminated. The polymer neutralized with NaOH, on the other hand, retains the Na^+ ion regardless of drying conditions, and WVS remains high and relatively constant.

In one additional study, a variety of neutralizing bases shown in *Table* 5 were used to prepare aqueous solutions of the HASE (UCAR Polyprobe 9823) polymer at pH 8.0. WVS was then conducted on 0.50 g cast from these solutions (see *Figures* 18 and 19) using drying conditions of four days at 60°C which only partially removed volatile base where present. All samples containing sodium or potassium ion showed similar high WVS values, while the ammonia and amine neutralized samples were lower to varying degrees as expected.

Degree of Neutralization with ASE/HASE

From *Figures* 18 and 19, it is apparent that WVS is some function of the amount of base left in the HASE thickener film on drying. To examine this more thoroughly, 10% aqueous dispersions ($pH < 6$) and solutions ($pH > 6$) of the HASE (UCAR Polyprobe 9823) polymer used previously were prepared at increasing degrees of neutralization from 0 to 120% with NaOH base. The relationship obtained for pH as a function of theoretical % neutralization is shown in *Figure* 20. Since the Na^+ cation is not volatile, WVS determinations were expected to be some function of the carboxyl salt concentration. *Figure* 21 shows a positive, approximately linear, relationship between the degree of neutralization and moisture sorption. Even beyond 100% neutralization, the Na^+ ion appears to increase the affinity for moisture. *Figure* 22 shows the effect on WVS for films cast from these same aqueous dispersions and solutions as a function of pH. WVS rises rapidly between pH 6 and 7.

Estimation of Diffusion and Partition Coefficients

As mentioned, none of the 64 thickeners tested at the 1.3 g dry film weight reached saturation sorption M_s during the 28-day test period. Since most of the polymers examined were highly water soluble, a conclusion that sorption to infinite dilution was more likely than sorption to finite saturation seems reasonable. However, this did not appear to be the case for ASE/HASE polymers in unneutralized form. At the lower film weight of 0.5 g, one of the four polymers tested earlier (HASE—UCAR Polyprobe 9823) did reach equilibrium saturation in only a few days. Using equation (3) and the data obtained in *Figure* 23, it was possible to compute the approximate diffusion coefficient D for this relatively water-insoluble

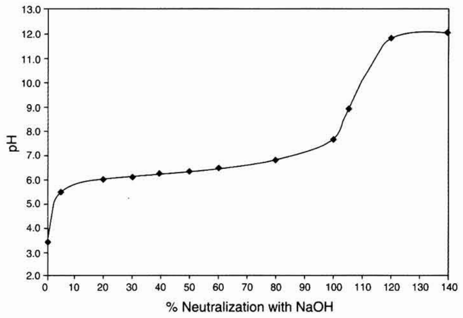

Figure 20—pH as a function of theoretical % neutralization for dispersions and solutions of 9823 HASE thickener.

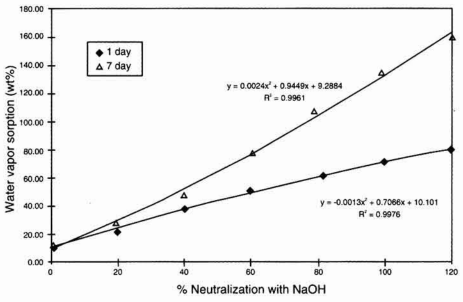

Figure 21—Effect of % neutralization of HASE thickener 9823 with NaOH on moisture sorption at 23.0°C—dry film weight 0.5 g dried 24 hr at 95°C.

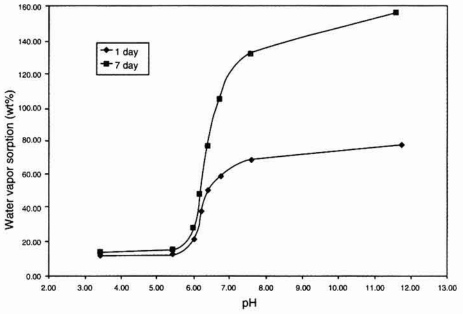

Figure 22—Effect of HASE thickener 9823 solution pH on moisture sorption at 23.0°C—dry film weight 0.5 g dried 24 hr at 95°C.

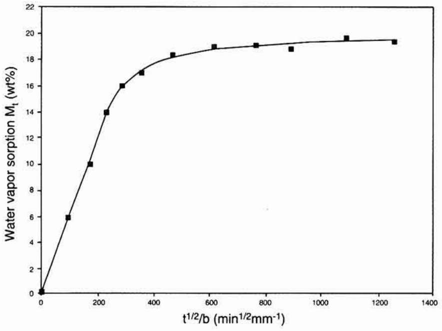

Figure 23—Moisture sorption curve at 23.0°C for unnetrualized HASE thickener 9823 (dry film weight 0.50 g, film thickness b approximately 0.41 mm).

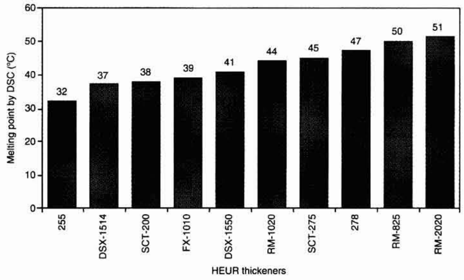

Figure 24—Thickener (HEUR) with melting points.

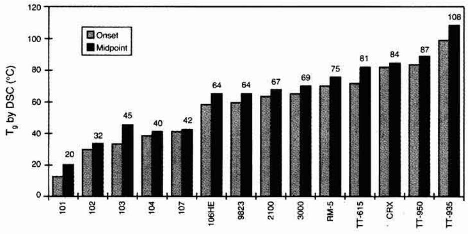

Figure 25—Thickener (HASE) with glass transition temperatures.

Figure 26—Moisture sorption cell using optional petri dish. Blisters in film are visible after one day at 23.0°C due to high WVS.

polymer (D = 3.02×10^{-10} cm^2 sec^{-1}) where M_s was 19.05 g/g dry polymer, and the average film thickness b was 0.0158 cm. Using equation (4), the partition coefficient K was also obtained (K = 0.187) where densities for water and polymer were 1.00 g/cm^3 and 1.21 g/cm^3, respectively. In more practical terms, 18.7% of the sorbed polymer was water by volume at saturation.

Molecular Weight

For a given polymer type, WVS did not appear to be a function of molecular weight. This conclusion is drawn primarily from the cellulosic polymers tested (see *Table* 6). The two percent solution viscosities of the five sets of cellulosic thickeners compiled in this table reflect increasing molecular weight within each set. From the WVS compiled in *Table* 6, it is apparent that effect of MW is minimal. This result is what would be expected for polymers of relatively high molecular weight below the glass transition temperature (T_g) where chain and segment mobility is limited.

Other Film Properties

On visual inspection, the film forming properties of the thickeners tested for WVS varied considerably, but usually not to the degree where WVS would be affected due to edge effect from shrinkage, cracks, or holes. These latter problems were mostly avoided by careful drying of the samples at elevated temperatures below the boiling point of water and any other volatiles present. However, because some films were still imperfect, accuracy of the WVS determination was less certain in those cases. In general, film integrity was of the order ASE/HASE > HEUR/HENN (HNS) > cellulosics. At the extremes, some of the cellulosic thickeners were opaque and showed shrinkage with occasional cracks or defects, while most of the alkali-swellable thickeners formed clear continuous films. The nonionic synthetics thickeners (HNS) were somewhat intermediate forming continuous films which were usually opaque with a waxy or crystalline appearance. On drying and removal from an oven, the HNS polymers were often liquids, and on cooling, they solidified into waxy films. DSC conducted on several of the alkali-swellable and HNS polymers showed that the ASE/HASE have T_gs, and the HNS, being of much lower molecular weight, have true melting points (see *Figures* 24 and 25).

Another noteworthy observation made was that some of the films having a combination of good film integrity and high moisture sorption actually formed blisters in the WVS cells, often in as little as one day. *Figure* 26 shows an example of this using the optional petri dish as the film substrate where blisters are readily visible. Occasionally, individual blisters were as large as half the dish surface area. On longer exposure times, the blisters would usually collapse presumably due to continued plasticization of the films with water. Besides the various film defects previously mentioned, the presence of blisters would be another source of error in WVS determinations. The degree of error is expected to be slight, but is presently unknown.

SUMMARY AND CONCLUSIONS

A relatively simple yet sensitive method was developed based on water vapor sorption (WVS) to individually examine the moisture affinity of film forming water-soluble and water-insoluble coatings additives. Except for the requirement of an oven and analytical balance, the technique used only readily obtainable, low-cost disposable components for moisture cell construction. In this study, a broad spectrum of thickeners was initially examined to determine the efficacy of the procedure and to quantify the relative moisture affinity of the polymers tested. The following are some of the more significant conclusions obtained:

(1) The method was applicable to nearly all thickeners tested, and significant measurable response with good repeatability was obtained at ambient temperature in as little as 24 hr;

(2) Control of film weight and to a lesser degree, temperature, were desirable for improved accuracy of test results;

(3) A high degree of WVS differentiation was obtained between thickener samples (as much as 10X depending on the test time frame);

(4) The acid form of the ASE and HASE thickeners showed much lower WVS than other thickener types. Being

Table 6—2% Solution Viscosities of Cellulosic Thickeners

Product Code	Product Type Supplier Code	Midrange Viscosity 2% Solution	WVS 2 Weeks
QP300	HEC - 11	275	121
ER4400	HEC - 11	5,000	121
ER52M	HEC - 11	50,000	126
QP100M	HEC - 11	110,000	118
250MBR	HEC - 2	5,500	103
250MBR	HEC - 2	28,000	101
E351	EHEC - 3	5,000	118
E481	EHEC - 3	80,000	116
7MT	CMC - 2	350	114
7M31T	CMC - 2	1,650	116
J5MS	HPMC - 5	5,000	96
J75	HPMC - 5	75,000	94

water-insoluble in this state, equilibrium saturation was obtained permitting estimation of diffusion coefficients. By definition, most of the other polymers were highly water-soluble tending toward infinite dilution rather than equilibrium saturation;

(5) The general order of moisture affinity obtained was alkali-swellable (acid form) << nonionic synthetics (HNS) < cellulosics ≅ alkali-swellable (salt form);

(6) The moisture affinity of alkali-swellable polymers increased linearly with increasing degrees of neutralization. Nonvolatile bases (e.g., Na^+ and K^+ ions) at full neutralization gave high moisture affinity similar to the cellulosic thickeners regardless of dry time or drying temperature. Volatile bases gave variable response of lower degree depending on the amount of base remaining in film; and

(7) When a volatile base such as NH_3 or aminoalcohol was used to neutralize ASE and HASE thickeners and sufficiently dried to remove all of the base, very low WVS was obtained similar to that of the acid emulsion form of the same polymers.

Although no attempt has been made in this study to correlate WVS with actual coating performance, this is a natural extension and the ultimate objective of this work. However, a foundation has been provided for examining the moisture affinity of virtually all film forming components present in a coating including most thickeners, rheology modifiers, dispersants, and latex binders. The method may even lend itself to examination of formulated coatings. The results obtained suggest that with proper formulating technique, the alkali-swellable thickeners could ultimately provide the lowest degree of water sensitivity in coatings.

ACKNOWLEDGMENTS

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References

(1) Bassett, D.R., internal Union Carbide communication, 1994.

(2) Hunt, O.L., Huff, R.B., and Spencer, H.G., "Sorption of Water Vapor by Hydrophilic Polymers," *Official* DIGEST, 35, No. 547, 113 (1963).

(3) Xu, J.R. and Balik, C.M., "Measurement of Diffusivities of Small Molecules in Polymers Using FTIR-ATR," *Appl. Spectroscopy*, 42, No. 8, 1543 (1988).

(4) Morris, D.R. and Sun, X., "Water-Sorption and Transport Properties of Nafion 117H," *J. Appl. Polymer Sci.*, 50, 1445 (1993).

(5) Kojima, Y. et al., "Sorption of Water in Nylon 6-Clay Hybrid," *J. Appl. Polymer Sci.*, 49, 1259 (1993).

(6) Belluci, F. and Nicodemo, "Water Transport in Organic Coatings," *Corrosion*, 49, No. 3, 235 (1993).

(7) Kittelberger, W.W. and Elm, A.C., "Water Immersion Testing of Metal Protective Paints," *Ind. Eng. Chem.*, 38, 695 (1946).

(8) Browne, F.L., "Swelling of Paint Films in Water, II. Absorption and Volumetric Swelling of Bound and Free Films Before and After Weathering," *J. of Forest Prods. Res. Soc.*, 4, 391 (1954).

(9) Holtzman, K.A., "Water Vapor Transport in Adherent Organic Coatings," JOURNAL OF COATINGS TECHNOLOGY, 43, No. 554, 47 (1971).

(10) Yaseen and Funke, W., "Effect of Temperature on Water Absorption and Permeation Properties of Coatings," *J. Oil and Colour Chemists' Assoc.*, 61, 284 (1978).

(11) D'Alkaine, C.V., Garcia, C., and Gomez, D., "Epoxy-Chromate Coatings: Electric and Membrane Results," *J. Oil and Colour Chemists' Assoc.*, 63, 23 (1980).

(12) Corti, H. and Fernadex-Prini, R., "Protective Organic Coatings: Membrane Properties and Performance," *Prog. Org. Coat.*, 10, p. 5 (1982).

(13) Thomas, N.L., "The Barrier Properties of Paint Coatings," *Prog. Org. Coat.*, 19, 101 (1991).

(14) Walter, G.W., "The Application of Impedance Methods to Study the Effects of Water Uptake and Chloride Ion Concentration on the Degradation of Paint Films-II. Free Films and Attached/Free Film Comparisons," *Corrosion Sci.*, 32, No. 10, 1085 (1991).

(15) Bucknall, C.B. et al., "Water Absorption and Disc Cracking in Urethane-Methacrylate Resins," *J. Appl. Polymer Sci.*, 52, 457 (1994).

(16) Nguyen, T., Bentz, D., and Byrd, W.E., "A Study of Water at the Organic Coating/Substrate Interface," JOURNAL OF COATINGS TECHNOLOGY, 66, No. 834, 39 (1994).

(17) Balik, C.M. and Xu, J.R., "Simultaneous Measurement of Water Diffusion, Swelling, and Calcium Carbonate Removal in a Latex Paint Using FTIR-ATR," *J. of Appl. Polymer Sci.*, 52, 975 (1994).

(18) Nguyen, T., Bentz, D., and Byrd, E., "Method of Measuring Water Diffusion in a Coating Applied to a Substrate," JOURNAL OF COATINGS TECHNOLOGY, 67, No. 844, 37 (1995).

(19) Flory, P.J., *Principles of Polymer Chemistry*, Cornell University Press, Ithaca, NY, 1953.

(20) Crank, J., *The Mathematics of Diffusion*, Second Edition, Clarendon Press, Oxford, 1975.

(21) Shewmon, P.G., *Diffusion in Solids*, McGraw-Hill, New York, 1963.

(22) Karunasena, A., Brown, R.G., and Glass, J.E., "Hydrophobically Modified Ethoxylated Urethane Architecture," in *Polymers in Aqueous Media*, ACS Advances in Chemistry Series No. 223, Glass, J.E. (Ed.), 495, 1989.

(23) Shay, G.D., "Alkali-Swellable and Alkali-Soluble Thickener Technology," in *Polymers in Aqueous Media*, ACS Advances in Chemistry Series No. 223, Glass, J.E. (Ed.), 457 (1989).

(24) Schaller, E.J. and Sperry, P.R., "Associative Thickeners," Chapter 4 in *Handbook of Coatings Additives*, Vol. 2, Cable, L.J. (Ed.), Marcel Decker, 105, 1993.

(25) Glass, J.E., Schultz, D.N., and Zukoski, C.F., "Polymers as Rheology Modifiers: An Overview," in *Polymers as Rheology Modifiers*, ACS Advances in Chemistry Series, No. 462, Schulz, D.N. and Glass, J.E. (Eds.) 2, 1991.

(26) Shay, G.D., "Thickeners and Rheology Modifiers," Chapter 30 in *ASTM Paint and Coatings Testing Manual: 14th Edition of the Gardner Sward Handbook*, Koleske, J.V. (Ed.), ASTM Manual Series MNL 17, 268, 1995.

(27) *Handbook of Water-Soluble Gums and Resins*, Davidson, R.L. (Ed.), McGraw-Hill Book Co., 1980.

(28) Shay, G.D., Bassett, D.R., and Rex, J.D., "A New Class of Alkali-Swellable Associative Thickeners," *J. Oil and Colour Chemists' Assoc., Surf. Coat. Int.*, 76, No. 11, 446 (Nov. 1993).

(29) LeSota, S., Lewandowski, E.W., and Schaller, E.J., "Hydrophobically Modified Alkali-Soluble Emulsions as Thickeners for Exterior Latex Paints," JOURNAL OF COATINGS TECHNOLOGY, *61*, No. 777, 135 (1989).

Appendix

List of thickener and rheology modifier suppliers for *Tables* 3a and b:

Reference No.	Supplier Company
1	Allied Colloids, Coatings and Specialties Div.
2	Aqualon Co.
3	Berol Nobel, Nobel Industries
4	Coatex, S.A.
5	Dow Chemical U.S.A., Specialty Chemicals Dept.
6	Henkel Corp., Coating Chemicals
7	Kelco, Division of Merek & Co., Inc.
8	National Starch and Chemical Co., Alco Chemical Div.
9	RHEOX, Inc.
10	Rohm and Haas Co.
11	Union Carbide Corp.

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S.B.P. SPIRITS
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Cure Behavior of Silicone-Epoxies and Urethane Modified Acrylates in Interpenetrating Polymer Networks

The Detroit Society for Coatings Technology
L. Price,* R.A. Ryntz, K.C. Frisch, H.X. Xiao, V.E. Gunn,
R. van den Heuvel, K.G.P. Baars, and H.A. van den Reijen

In an attempt to improve the toughness and flexibility of poly(epoxy-urethane-acrylic), interpenetrating polymer network (IPN) coatings conventional bisphenol A type epoxy was replaced with silicone containing epoxy. By comparing silicone epoxy containing samples with bisphenol A controls, the effect of siloxane modification on the properties of the materials thus formed were tested.

The coatings were formulated to typical automotive primer conditions (in the absence of any pigments) and tested for solvent resistance, lap shear strength, impact resistance, and thermal stability. The formation of IPNs was established by changes in the thermal behavior of the coatings as well as by the synergistic effects noted in the physical and mechanical properties achieved in the formulated coatings.

In formation of the silicone modified IPNs, however, it was noted that cure response was diminished versus control. Therefore, we undertook a cure study to determine the effects of catalysts and trifunctional acrylates on the resultant properties in the IPN coatings. This paper describes the chemistries and formulations utilized in attaining the aforementioned properties.

INTRODUCTION

An interpenetrating polymer network (IPN) can be defined as a blend of two polymeric networks in which at least one of the networks has been synthesized and/or crosslinked in the immediate presence of the other.[1] Instead of covalent bonds or grafts, the two independent networks are held together by permanent interpenetrating entanglements. Formation of IPNs is the only way of intimately combining crosslinked polymers with the resulting mixtures exhibiting, at worst, only limited phase separation. If both polymers are crosslinked, they are crosslinked separately and both networks exert a unique control over the size, shape, and composition of the phase domains. Because most IPNs phase separate, molecular interpenetration may be restricted by macromolecular interpenetration. True molecular interpenetation is thought to take place only at the phase boundaries.

The properties of an IPN depend on the properties of the components, the phase morphology, and the interactions between the phases. The morphology of phase domains strongly influences the physical and mechanical behavior of the material. It is controlled by the chemical compatibility of the polymers, the interfacial tension, the crosslink density of the network, the polymerization method, and the IPN composition.[2] A degree of compatibility is brought about by the IPN formation, because the polymers are interlocked in a three-dimensional structure, resulting in phase domains which are generally smaller than those obtained by mechanical blending techniques. Compatibility can be indicated by clarity and a single or "shifted" glass transition temperature (T_g). On the condition that the refractive indexes of the two polymers do not match, clarity usually indicates very small or nonexistent phase domains. Provided that the glass transitions of the homopolymers are different and that the T_g of the mixture is intermediate between the two, a "shift" or even the occurrence of a single T_g is indicative of molecular mixing.

IPNs can be distinguished from other multi-component polymer materials, such as polymer blends, blocks, and grafts, in two ways (assuming that adequate interpenetration occurs within the network): (1) an IPN swells but does not dissolve in solvents; and (2) creep and flow are suppressed.

Synthesis of IPNs is possible in a variety of ways. The sequential IPN begins with the synthesis of a crosslinked polymer 1 from monomer 1 (*Figure* 1a). Monomer 2, with its own crosslinker and initiator, are swollen into polymer 1 and polymerized in-situ.

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*Person to whom correspondence should be sent: Akzo Nobel Coatings, Inc., 1845 Maxwell St., Troy, MI 48007-7002.

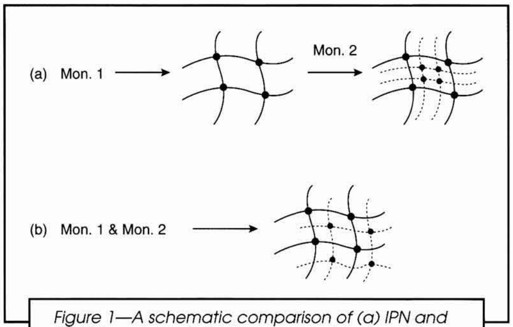


Figure 1—A schematic comparison of (a) IPN and (b) SIN synthesis. Solid line represents network 1, dotted line network 2.

Simultaneous IPNs, or SINs, begin with a mutual solution of both monomers and their respective crosslinkers (*Figure* 1b) which are polymerized simultaneously by noninterfering modes, such as polyaddition and free-radical polymerization.

When only one of the polymers is crosslinked the product is called a semi-IPN. While grafts between networks I and II may occur to greater and lesser extents, the IPN topology may be said to exist if the deliberately introduced crosslinks outnumber the accidentally introduced ones.

The first person to describe an IPN type structure was Jonas Aylsworth in 1914, although he did not use the term "interpenetrating polymer network" (he did not even use the term "polymer"). The particular topology, however, was lost to science and rediscovered several times.

In 1941, Straudinger and Hutchinson applied for patents in Great Britain. They had made a homo-IPN of poly(methyl methacrylate) (PMMA). In their patent they stated: "When the original crosslinked poly(methyl methacrylate) mass is immersed in the liquid monomer, it swells and absorbs considerable quantities of monomer, increasing in volume up to tenfold or even more, depending on the degree of crosslinking, the temperature, the nature of the material present, and on whether the absorption is allowed to proceed to saturation. The product at this stage is a gel and is heated to polymerize the absorbed monomer. During polymerization, shrinkage takes place as in the case of the noncrosslinked polymer, but here the shrinkage is, surprisingly, uniform and does not result in the formation of strains or voids." The patent was issued in the U.S. in 1951 for the manufacture of smooth-surface transparent plastics.

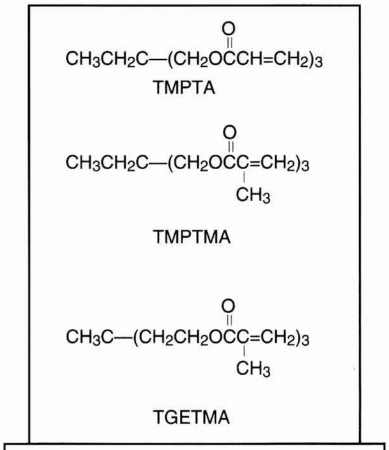
The first to use the term "interpenetrating polymer network" was John Millar in 1961 with the introduction of poly(styrene)/poly(styrene) IPNs as models for ion-exchange resin matrixes.

Today, about ten academic institutions and numerous industries, e.g., Petrarch, LNP, Allied, etc., are working in the arena of IPNs. Numerous applications have been found for IPNs, including toughened plastics, noise- and vibration-damping equipment, electrical insulation, removable nail polish, and coatings. There are approximately 75 patents which expose the use of IPNs and closely related materials.

The use of IPNs in automotive coating applications has been studied[3-6] with the intent to attain synergy in the properties of each individual component. For example, in an epoxy-based coating applied over steel, one would expect to achieve good corrosion resistance and toughness. Urethane acrylate based coatings should impart mar and scratch resistance as well as toughness. Silicone modification should add better weathering characteristics as well as lowering the surface tension within the IPN network to aide in better interpenetration.

Several researchers have studied the effects of siloxane modification of IPNs. Ma[7] modified poly(urethane) elastomers with poly(siloxanes) to form semi-IPNs and compatibilized the matrix with a urethane-phenylmethylsiloxane block copolymer. The morphological and mechanical properties of the blends as a function of compatibilizer are presented. Hourston[8] and Geetha,[9] studied the effects of dimethylsiloxanes on polyether-polyurethane IPN physicomechanical properties and the subsequent morpholoy. Mr. He et al.[10] studied the effects of various catalysts on the in-situ sequential synthesis of a dimethylsiloxane/poly(methylmethacrylate) IPN. The effect of epoxy incorporation into siloxane interpenetrating polymer networks was examined by Foscante[11] and Rizk.[12] The general conclusions drawn by the researchers described previously stated that the degree of interpenetration achieved in the IPNs was interrelated to the physical and mechanical properties afforded. Generally, by selecting the correct ratio of IPN components and the appropriate catalyst (thus cure speed), the solvent resistance, impact, toughness, and other mechanical properties were improved through the incorporation of siloxanes.

The initial studies of IPN-based automotive coatings comprised the synthesis and formulation of poly(epoxy-urethane-acrylates).[4] These novel binders were formulated as automotive primers without corrosion inhibiting pigments. The resultant coatings were evaluated for impact and solvent resistance, lap shear and tensile strengths, gravelometer chip resistance, and corrosion resistance. The IPN-based primers afforded corrosion protection and solvent resistance comparable to conventional primers containing corrosion inhibitors. Although the lap shear and tensile strengths along with the impact and chip resistance were adequate for traditional



$$CH_3CH_2C\text{—}(CH_2O\overset{\overset{O}{\|}}{C}CH{=}CH_2)_3$$

TMPTA

$$CH_3CH_2C\text{—}(CH_2O\overset{\overset{O}{\|}}{C}\underset{\underset{CH_3}{|}}{C}{=}CH_2)_3$$

TMPTMA

$$CH_3C\text{—}(CH_2CH_2O\overset{\overset{O}{\|}}{C}\underset{\underset{CH_3}{|}}{C}{=}CH_2)_3$$

TGETMA

Figure 2—Chemical structures of TMPTA, TMPTMA, and TGETMA acrylics.

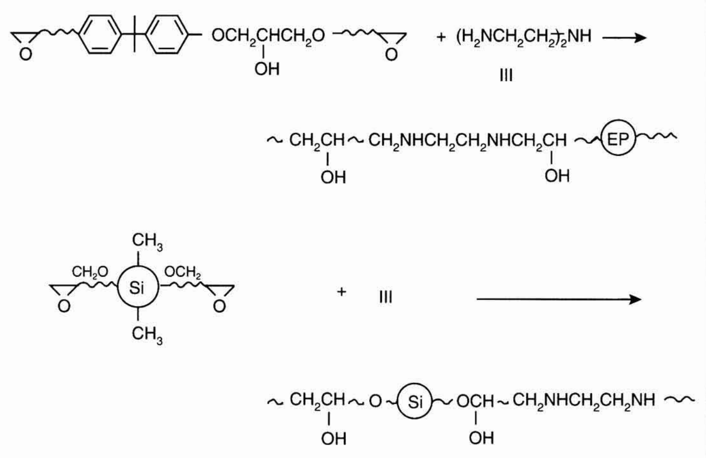


Figure 3—Reaction of epoxy (silicone-epoxy) with diethylenetriamine.

primers, the values were too low for true chip resistant primer applications.

The next step, then, was to improve the toughness, and, therefore, the impact and chip resistance of these coatings without sacrificing the flexibility of the system. This was initially attempted through the use of siloxane modification of the epoxy component as a model system, cured with traditional and siloxane modified amines.[5] Optimized formulations of the siloxane modified epoxy/amine systems afforded improvements in thermal stability, flexibility, elongation, and impact and chip resistance.

The cure properties of the urethane-acrylate component were optimized by introduction of suitable peroxide initiators in the urethane-acrylate model systems. Attempts to improve the solvent resistance, taken as a measure of cure or crosslink density, evolved around increasing the crosslink density of the urethane-acrylate without sacrificing flexibility. This was accomplished through the incorporation of low molecular weight tri-functional acrylates. The crosslinking agents employed (*Figure* 2) were trimethylolpropane triacrylate (TMPTA), trimethylolpropane trimethacrylate (TMPTMA), and triglycolethane trimethyacrylate (TGETMA).

Encouraged by the results of these experiments, the next task at hand was to incorporate the siloxane modified epoxy component into the poly(epoxy-urethane-acrylate) IPNs. A low molecular weight epoxide was utilized in combination with the high molecular weight siloxane modified epoxy to afford a balance of flexibility and adhesive strength when cured with conventional amines. In addition, several catalysts were reviewed for potential improvements in cure response. The final segment of this research, described herein, involves the evaluation of several ratios of the siloxane modified epoxy-amine/urethane acrylate to determine which will afford the optimum balance of properties.

The IPNs described are prepared from the concomitant, noninterfering polyaddition of Epon® 1001F epoxy and/or the silylepoxide EXP-36-X-20 or EXP-38-X-20 with diethylenetriamine (*Figure* 3) and the free radical polymerization of the acrylic functional urethane modified macromonomer. The macromonomer is prepared from the reaction of the isocyanate functional prepolymer (*Figure* 4) with a predetermined amount of hydroxyethyl methacrylate (*Figure* 5). The synthesis of the prepolymer was accomplished by the reaction of polycaprolactone triol (Tone 301) with H$_{12}$MDI and is hereafter referred to as a urethane modified acrylate (URMAC) prepolymer.

EXPERIMENTAL

In previous studies[13] on IPN primers based on silicone-epoxy resins and urethane modified acrylates, a starting formulation for further IPN studies was developed based on solvent resistance testing of the resultant coating:

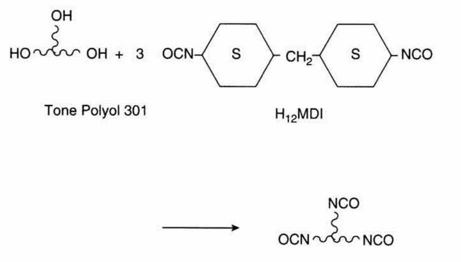


Figure 4—Preparation of isocyanate terminated macromonomer.

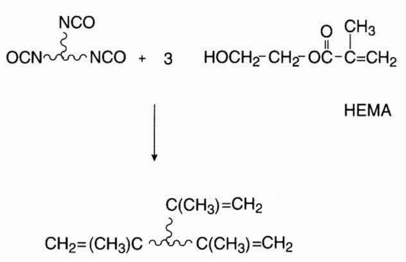


Figure 5—Preparation of methacrylate functional macromonomer (URMAC).

Table 1—Raw Materials

Designation	Chemical Composition	Source
Tone polyol 301	Polycaprolactone triol M_w = 300; Eq. wt. = 100	Union Carbide
H_{12}MDI	4,4-Methylene-bis(cyclohexyl-isocyanate) M_w = 262; Eq. wt. = 131	Mobay Corp.
HEMA	Hydroxyethylmethacrylate M_w = Eq. wt. = 130	Rohm & Haas
T-12	Dibutyltin dilaurate	Mobay Corp.
Epon 1001F	Bisphenol A/epichlorohydrin based epoxy resin Eq. wt. = 535	Shell Chemical Co.
EXP-36-X-20	Epoxy functional silicone solution Eq. wt. = 2847 (based on a 22.38% solution)	Genesee Polymer Co.
EXP-38-X-20	Epoxy functional silicone solution Eq. wt. = 5180 (based on a 21.00% solution)	Genesee Polymer Co.
DETA	Diethylenetriamine Eq. wt. = 20.6	Fisher Scientific
TMPTA	Trimethylolpropane triacrylate	Sartomer
TMPTMA	Trimethylolpropane trimethacrylate	Sartomer
Lupersol 11	75% t-Butylperoxypivilate in odorless mineral spirts	Lucidol Div. Pennwalt
MEK	Methylethylketone	Fisher Scientific

Table 2—Composition of Samples

The following solutions were used to prepare the samples:

URMAC[a] + 2% L11
URMAC + 16.3 % TMPTMA + 2% L11
URMAC + 16.3% TMPTA + 2% L11

(a) solid contents of the used URMAC: 31.0%.

All ratios and weight percentages were based on the solid contents of the solutions.

The tested samples had the following compositions:

IPN 1: Epon 1001F/DETA + URMAC/TMPTMA/L11
1. Epon/URMAC : 100/0
2. Epon/URMAC : 80/20
3. Epon/URMAC : 60/40
4. Epon/URMAC : 50/50
5. Epon/URMAC : 40/60
6. Epon/URMAC : 20/80
7. Epon/URMAC : 0/100

IPN 2: EXP-36-X20/DETA + URMAC/TMPTMA/L11
1. EXP-36/URMAC : 100/0
2. EXP-36/URMAC : 80/20
3. EXP-36/URMAC : 60/40
4. EXP-36/URMAC : 50/50
5. EXP-36/URMAC : 40/60
6. EXP-36/URMAC : 20/80
7. EXP-36/URMAC : 0/100

IPN 3: Epon 1001F/DETA + URMAC/L11
1. Epon/URMAC : 100/0
2. Epon/URMAC : 60/40
3. Epon/URMAC : 40/60
4. Epon/URMAC : 0/100

IPN 4: EXP-36-X20/DETA + URMAC/L11
1. EXP-36/URMAC : 100/0
2. EXP-36/URMAC : 80/20
3. EXP-36/URMAC : 60/40
4. EXP-36/URMAC : 40/60
5. EXP-36/URMAC : 20/80
6. EXP-36/URMAC : 0/100

IPN 5: Epon 100IF/DETA + URMAC/TMPTA/L11
1. Epon/URMAC : 100/0
2. Epon/URMAC : 80/20
3. Epon/URMAC : 60/40
4. Epon/URMAC : 40/60
5. Epon/URMAC : 0/100

IPN 6: EXP-36-X20/DETA + URMAC
1. EXP-36/URMAC : 100/0
2. EXP-36/URMAC : 80/20
3. EXP-36/URMAC : 60/40
4. EXP-36/URMAC : 40/60
5. EXP-36/URMAC : 20/80
6. EXP-36/URMAC : 0/100

IPN 7: EXP-38-X20/DETA + URMAC/L11
1. EXP-38/URMAC : 100/0
2. EXP-38/URMAC : 80/20
3. EXP-38/URMAC : 60/40
4. EXP-38/URMAC : 50/50
5. EXP-38/URMAC : 40/60
6. EXP-38/URMAC : 20/80
7. EXP-38/URMAC : 0/100

IPN 8: EXP-38-X20/DETA + URMAC/TMPTA/L11
1. EXP-38/URMAC : 100/0
2. EXP-38/URMAC : 80/20
3. EXP-38/URMAC : 60/40
4. EXP-38/URMAC : 50/50
5. EXP-38/URMAC : 40/60
6. EXP-38/URMAC : 20/80
7. EXP-38/URMAC : 0/100

Table 3—Surfactant Effects on Wetting Behavior

Surfactant	Applicability
Siponic L-4	3.5
Q2-5211 S.W.A	3.5
Surfonic N-101	4
Surfonic N-31.5	3.5
Abex 18 S	3.5
No surfactant	3.5

Table 4—Effect of Surfactant Level of Wetting

Surfactant	Percentage	Applicability
Surfonic N-101	0.5	4.5
	1	5
Surfonic N-31.5	0.5	3
	1	4
Siponic L-4	0.5	4.5
	1	3.5

—the best initiator for the urethane modified acrylate (URMAC) system was Lupersol 11 (L11, 95% t-butylperoxypivalate in odorless mineral spirits).

—the optimal amount of L11 was 2%, based on weight solids.

—the best trifunctional acrylate(s) in the URMAC system was TMPTMA or TMPTA at levels of 16.3 wt% based on resin solids.

—the best URMAC system was based on Tone 301 (versus a higher molecular weight Tone 300).

—the use of catalysts for the epoxy system had a negligible effect on cure and was therefore omitted.

All chemicals utilized in this research are listed in *Table* 1 and were used as received from the supplier.

Preparation of the Prepolymer

In a reaction kettle equipped with a nitrogen inlet, mechanical stirrer, and heating mantle, a calculated quantity of H_{12}MDI and two drops of stannous octoate (T12) catalyst were added to 95.8 g of dried Tone 301 polyol. The reaction mixture was heated slowly until the reaction started, which was marked by the sudden increase of temperature. The reaction was then controlled by cooling, until the temperature started to drop again. Heating was resumed to bring and keep the temperature of the reaction mixture at 80°C. The progress of the reaction was frequently measured by titration of the free NCO. After completion of the first step of the reaction (as determined by a titration* for the theoretical molar amount of free NCO), a calculated amount of HEMA was added. The reaction was allowed to proceed for two hours at 80°C. Solvent, methyl ethyl ketone (MEK) was then added to create the URMAC system with a weight percentage of 69%.

Preparation of the IPN Samples

Samples of various compositions were made based on the prepared URMAC system and different epoxy systems. Both the conventional bisphenol A epoxy (Epon 1001F) and silicone containing epoxies (EXP-36-X-20 and EXP-38-X-20, glycidyl epoxies of dimethyl siloxanes) were utilized. The difference between the two silicone containing epoxies is the molecular weight: the molecular weight of EXP-38-X-20 is higher. The amine utilized for the epoxy cure was DETA. The URMAC network was formed both in the presence and absence of TMPTMA or TMPTA. Lupersol 11 was utilized at a

Table 5—Solvent Resistance of IPN Coatings

Sample	Amount of MEK Rubs	Sample	Amount of MEK-Rubs
IPN 1-1	>100	IPN 5-1	>100
IPN 1-2	>100	IPN 5-2	>100
IPN 1-3	>100	IPN 5-3	>100
IPN 1-4	>100	IPN 5-4	>100
IPN 1-5	>100	IPN 5-5	>100
IPN 1-6	>100	IPN 6-1	60
IPN 1-7	>100	IPN 6-2	>100
IPN 2-1	60	IPN 6-3	90
IPN 2-2	25	IPN 6-4	5
IPN 2-3	50	IPN 6-5	>100
IPN 2-4	40	IPN 6-6	>100
IPN 2-5	30	IPN 7-1	>100
IPN 2-6	15	IPN 7-2	>100
IPN 2-7	>100	IPN 7-3	40
IPN 3-1	>100	IPN 7-4	35
IPN 3-2	>100	IPN 7-5	35
IPN 3-3	>100	IPN 7-6	5
IPN 3-4	>100	IPN 7-7	>100
IPN 4-1	60	IPN 8-1	>100
IPN 4-2	10	IPN 8-2	>100
IPN 4-3	20	IPN 8-3	>100
IPN 4-4	10	IPN 8-4	>100
IPN 4-5	15	IPN 8-5	>100
IPN 4-6	>100	IPN 8-6	>100
		IPN 8-7	>100

Table 6—Impact Strengths of IPN Coatings

Sample	Lap Shear Strength (psi)	Sample	Lap Shear Strength (psi)
IPN 1-1	577	IPN 5-1	577
IPN 1-2	906	IPN 5-2	598
IPN 1-3	247	IPN 5-3	230
IPN 1-4	—	IPN 5-4	198
IPN 1-5	—	IPN 5-5	166
IPN 1-6	76	IPN 6-1	128
IPN 1-7	194	IPN 6-2	122
IPN 2-1	128	IPN 6-3	168
IPN 2-2	213	IPN 6-4	288
IPN 2-3	153	IPN 6-5	162
IPN 2-4	169	IPN 6-6	166
IPN 2-5	247	IPN 7-1	210
IPN 2-6	320	IPN 7-2	345
IPN 2-7	194	IPN 7-3	744
IPN 3-1	577	IPN 7-4	432
IPN 3-2	538	IPN 7-5	381
IPN 3-3	699	IPN 7-6	636
IPN 3-4	178	IPN 7-7	178
IPN 4-1	128	IPN 8-1	210
IPN 4-2	279	IPN 8-2	—
IPN 4-3	415	IPN 8-3	—
IPN 4-4	525	IPN 8-4	707
IPN 4-5	246	IPN 8-5	435
IPN 4-6	178	IPN 8-6	212
		IPN 8-7	166

---

*The disappearance of free NCO was followed by adding a known aliquot of dibutylamine in toluene solution to a predetermined amount of prepolymer. The solution was diluted with 50 mL of 2-propanol to prevent the solution from becoming too turbid upon the addition of hydrochloric acid (HCl). Three drops of bromophenol blue indicator was added to the solution and the total mixture was backtitrated with 0.196 N HCl until the color of the mixture changed from blue to yellow.

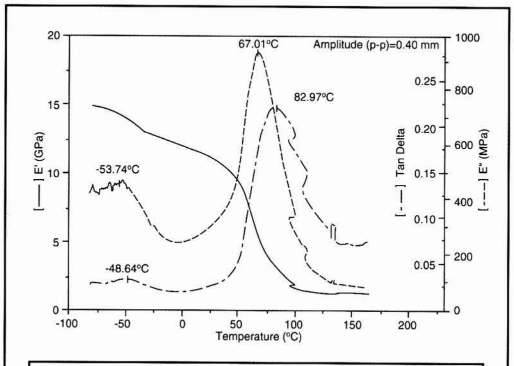


Figure 6—DMA of IPN 8-4.

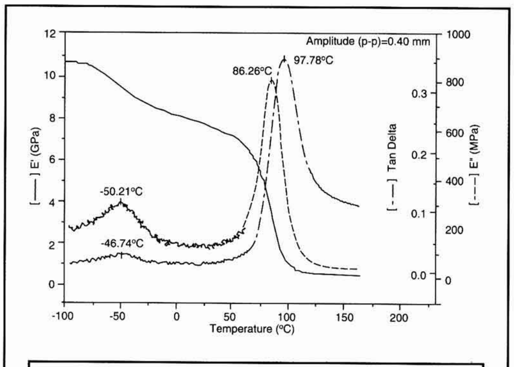


Figure 7—DMA of IPN 5-2.

two percent by weight level as initiator for the URMAC system. The compositions of the prepared samples are listed in *Table* 2.

Wetting

In order to improve the wetting of the URMAC/EPOXY mixture, additional surfactants were tested. The following surfactants were screened: Dow Corning Q2-5211; Surfonic N-101; Siponic L-4; Surfonic N-31.5; Abex 18S; and no surfactant.

The percentage of each surfactant added to the final IPN formulation was 1.5 wt% based on resin solids. The coatings were applied to metal panels (Q-Panel, cold-rolled steel) and dried for approximately two hours at 125°C. The effect of the various surfactants on the improvement in wetting of the metal panel with the coating is listed in *Table* 3. The applicability of the coating to the substrate was determined by visually examining the panels for "fisheyes" and uniformity of the coating on the panel. The "applicability" rating criteria is based on a number from 1-5, where 1 represents poor wetting and 5 represents excellent wetting. Based on the surfactants that provided the best "applicability," a screening of the level utilized was undertaken. The level of surfactant was varied from 0.5 to 1.0% based on the total resin solids in the coating formulation. Results are given in *Table* 4.

Preparation of the Coatings

Prior to the preparation of the coatings, special attention was given to the curing conditions, since they appeared to influence the quality of the coatings afforded. A cure time of

Table 7—Impact Strengths of IPN Coatings

Sample	Direct Impact Strength (lb/in.)	Reverse Impact Strengh (lb/in.)
IPN 1-1	>160	>160
IPN 1-2	>160	>160
IPN 1-3	>160	>160
IPN 1-4	>160	>160
IPN 1-5	>160	>160
IPN 1-6	30	20
IPN 1-7	<10	<10
IPN 2-1	>160	>160
IPN 2-2	>160	60
IPN 2-3	130	100
IPN 2-4	140	60
IPN 2-5	>160	60
IPN 2-6	30	<10
IPN 2-7	<10	<10
IPN 3-1	>160	>160
IPN 3-2	>160	>160
IPN 3-3	>160	>160
IPN 3-4	30	< 20
IPN 4-1	>160	>160
IPN 4-2	>160	140
IPN 4-3	>160	60
IPN 4-4	100	10
IPN 4-5	30	<10
IPN 4-6	30	<20

Sample	Direct Impact Stregnth (lb/in.)	Reverse Impact Strength (lb/in.)
IPN 5-1	>160	>160
IPN 5-2	>160	>160
IPN 5-3	>160	>160
IPN 5-4	>160	>160
IPN 5-5	15	<10
IPN 6-1	>160	>160
IPN 6-2	>160	50
IPN 6-3	>160	90
IPN 6-4	60	<15
IPN 6-5	40	<10
IPN 6-6	15	<15
IPN 7-1	>160	>160
IPN 7-2	>160	>160
IPN 7-3	>160	>160
IPN 7-4	>160	>160
IPN 7-5	>160	>160
IPN 7-6	15	15
IPN 7-7	30	<20
IPN 8-1	>160	>160
IPN 8-2	>160	>160
IPN 8-3	>160	>160
IPN 8-4	>160	>160
IPN 8-5	>160	50
IPN 8-6	100	20
IPN 8-7	15	<10

one hour at 130°C was utilized to afford acceptable crosslink density as measured by solvent resistance testing. The coated panels were made by drawing a film of the samples on cold-rolled steel and curing in a gas-fired oven for the predescribed bake conditions.

Testing of the Coatings

In order to get an indication of the solvent resistance, the coatings were rubbed with a piece of cheesecloth soaked in MEK. The number of MEK double rubs until the appearance of visible damage was measured. When the coating was yet undamaged after 100 MEK double rubs, the rubbing was stopped. Solvent resistance ratings are listed in *Table* 5.

Lap Shear Tests

The lap shear strengths were measured on a computer controlled Instron with 3 × 0.5 in. steel plates lapped 0.5 in. from their edges, according to ASTM D 3163-73. The steel plates were precleaned with acetone prior to applying the coating. The crosshead speed of the Instron was 0.1 in./mm. All samples were dried for three hours at room temperature and then one hour at 130°C in a vacuum oven to assure no air or solvent entrapment. Lap shear strength results on a variety of formulated IPN coatings are listed in *Table* 6.

Impact Strength Tests

The Gardner impact resistance tests were performed on coatings with a thickness of 40-60 µm. Both direct and reverse impact strengths were measured. The coatings were cured for three hours at room temperature and then one hour at 130°C in a vacuum oven. Values for both direct and reverse impact strengths of the formulated IPN coatings on cold-rolled steel panels are listed in *Table* 7.

Thermal Stability Tests

A DuPont Model 951 thermal gravimetric analyzer was utilized to determine the thermal stability of the samples. All samples were dried for three hours at room temperature and for one hour at 130°C in a vacuum oven. Only coatings with good solvent resistance, high lap shear strength, and high impact strength were tested. All samples were weighed to approximately 10 mg and were heated from room temperature to 600°C at a rate of 20°C/min. Resultant values for the aforementioned coatings are given in *Table* 8.

Dynamic Mechanical Analysis

A DuPont Model 983 dynamic mechanical analyzer was used to compare two samples: one containing silicone and the other without silicone. The following curing schedule was utilized:

- — 45 hr at room temperature
- — 2 hr at room temperature in a vacuum oven
- — 3 hr at 50°C in a vacuum oven
- — 1 hr at 90°C in a vacuum oven
- — 1 hr at 130°C in a vacuum oven

The curing process was carried out to avoid air entrapment in the relatively thick samples (approximately 1 mm). The samples were heated from –100°C to 150°C at a rate of 5°C/min. The T_g was determined from the maximum in the tan δ curve (*Table* 9).

Table 8—Thermal Stability of IPN Coatings

	Temperature (°C) at a Weight Loss of				
Sample	**2%**	**5%**	**10%**	**25%**	**50%**
IPN 1-2	277	300	334	389	434
IPN 3-3	264	285	310	350	387
IPN 5-2	253	277	311	384	421
IPN 8-4	257	276	317	353	423

	Percentage of Retained Weight at the Following Temperatures (°C)					
Sample	**100**	**200**	**300**	**400**	**500**	**600**
IPN 1-2	100.0	100.0	95.0	70.0	8.8	6.4
IPN 3-3	100.0	99.9	91.6	43.9	1.8	0.0
IPN 5-2	100.0	100.0	91.8	69.2	11.0	7.6
IPN 8-4	100.0	100.0	93.2	57.9	21.2	14.8

RESULTS AND DISCUSSION

The IPN formulations were based on varying weight percentages of URMAC to Epon 1001 or siliconized epoxy (EXP-36 or EXP-38)/DETA (at a ratio of 1/4 epoxy of DETA) with and without added trifunctional acrylate (at 16.3 wt%) (*Table* 2). Free radical initiator (Lupersol 11) was added at a level of 2 wt% to aid in the crosslinking. The solids content of all formulated samples was 31 wt% in ethyl acetate.

The ability of the formulated coatings to effectively wet out a metal panel and form a uniform film was addressed via the use of surfactants (*Tables* 3 and 4). Of the silicone and nonsilicone type surfactants tested, the nonsilicone type performed most efficiently. Surfonic N-101 at a level of 1 wt% based on total resin solids, afforded the maximized wetting efficiency. All coatings formulated, therefore, contained 1 wt% of this surfactant.

The crosslink density, and, therefore, the cure response of the formulated coatings was examined through the ability of the coating to withstand MEK solvent rubs (*Table* 5). When comparing samples containing TMPTA to those without, it appears that the TMPTMA aids in crosslink density (samples IPN 2 vs. IPN 4). The TMPTA trifunctional acrylate was more effective at increasing solvent resistance than the TMPTMA (IPN 6 vs. IPN 2). The use of siliconized epoxy appears to detract from overall solvent resistance (IPNs 2, 4, 6, 7, and 8 vs. IPNs 1, 3, and 5), although the higher molecular weight silicone epoxy afforded acceptable solvent resistance when cured in the presence of TMPTA. The siliconized epoxy of higher molecular weight has more sites for crosslinking which may account for the increased solvent resistance. Siliconized epoxy use, although detracting from solvent resis-

Table 9—Glass Transition Temperatures of Selected IPNs by DMA

Sample	T_g (°C), Based on tan δ
IPN 5-2	98
IPN 8-4	83

tance versus the nonsiliconized epoxy, can be made solvent resistant through the use of tri-functional acrylate in the URMAC crosslinking reaction.

Adhesion of the formulated IPN coatings was measured through lap shear and is shown in *Table* 6. Overall, the nonsiliconized epoxy/URMAC system with TMPTMA (IPN 1) afforded the best adhesion to the metal substrate when formulated at an 80/20 epoxy/URMAC ratio (IPN 1-2). The TMPTMA containing nonsiliconized epoxy IPN (IPN 1) afforded higher adhesion values than the non TMPTA IPN (IPN 5) which were in turn higher than those nonsiliconized IPNs containing no trifunctional acrylate (IPN 3). The higher molecular weight siliconized-epoxy IPNs (IPNs 7 and 8) yielded better performance than the lower molecular weight siliconized-epoxy IPNs (IPNs 4 and 5). It is important to note, however, that each IPN formulation yields a maximum in lap shear strength at varying ratios of epoxy/URMAC which exceed those values for the separate components that comprise the matrix. This is probably due to increased degree of interpenetration and IPN formation in the corresponding network. Maximized values are indicative of increased apparent "crosslink density" through interpenetration. Each IPN would achieve its maximized properties at varying weight percentages of Part A (epoxy) to Part B (URMAC) based on compatibilities and the ability to interpenetrate. It is not unexpected, therefore, that the siliconized epoxies yield increased performance at different weight ratios of Part A/Part B over the nonsiliconized epoxies based on variances in compatibilities. For instance, IPN 5 (nonsiliconized epoxy) achieves maximized performance at an 80/20 ratio (IPNs 5-2) of Part A/Part B whereas IPN 7 reaches ultimate interpenetration and, therefore, maximum lap shear strength at a 60/40 ratio (IPNs 7-3).

Impact strength (*Table* 7) of the IPNs seemed to reflect on the level of epoxy, whether siliconized or not, in the IPN. Generally, the higher the level of epoxy in the IPN, the higher the impact strength of the system. The incorporation of low molecular weight silicon in the epoxy portion of the IPN detracted more from the reverse impact strengths than the direct, where little variation was noted. Higher molecular weight siliconized epoxies (IPNs 7 and 8) afforded impact strengths comparable to those achieved with nonsiliconized analogues (IPNs 1, 3, and 5). Increasing the crosslink density through the addition of trifunctional acrylics (IPNs 1, 2, 5, 6, and 8) did little to afford higher impact strength. These results are parallel to those attained in the lap shear studies. The direct correlation particularly plays out in the reverse impact strength, where poorer adhesion would result in premature failure upon impact through loss of adhesion from the steel substrate.

Several IPNs that had a good balance of physical properties were selected for further study by determination of thermal stability (IPNs 1-2, 3-3, 5-2, and 8-4) and dynamic mechanical properties (IPNs 5-2 and 8-4).

Thermal stability of the IPNs was increased through silicon incorporation (*Table* 8). At 500°C the siliconized IPN labeled 8-4 retained 21.2% of its weight versus 2-11% for the nonsiliconized versions (IPNs 1, 3, and 5). This is not unexpected since silicon is generally known to increase thermal stability in organic coatings.

The results of glass transition measurements, as measured through dynamic mechanical analysis, although performed on only two samples (*Table* 9), indicate that silicon incorporation into the IPN did little to increase the brittleness of the matrix. Because the T_g of the siliconized epoxy based IPN (sample 8-4) is 83°C (*Figure* 6) the sample at room temperature behaves as a glass. It is not surprising, therefore, that impact strength would suffer as a consequence. As explained previously, the decreased impact performance can translate to decreased apparent lap shear strength due to premature failure in adhesion upon embrittlement. The nonsiliconized IPN sample labelled 5-2 has a higher T_g (98°C) (*Figure* 7) but affords higher lap shear strengths. This must be due to better initial adhesion of the coating to the cold-rolled steel which in turn translates to better lap shear strength before embrittlement failures.

The results of this study indicate that incorporation of silicon into an IPN matrix through modification of the epoxy portion of an epoxy/URMAC IPN performs the following tasks versus the nonsiliconized version: lowers solvent resistance overall unless additional crosslinking through the use of a trifunctional acrylate is incorporated into the URMAC portion of the IPN; decreases effective reverse impact performance of the coating; no significant change in the glass transition temperature; and increases thermal stability.

Overall, the properties of the higher molecular weight siliconized epoxy when formulated with trifunctional acrylate present in the URMAC portion of the IPN, afforded acceptable properties for use as chip resistant automotive primer. Because of the increased thermal stability of this sample versus the nonsiliconized control, this IPN may prove useful in high heat areas such as frontal engine hood components.

References

(1) Sperling, L.H., *Interpenetrating Polymer Networks and Related Materials*, Plenum Press, New York, 1981.

(2) Klempner, D. and Frisch, K.C., *Advances in Interpenetrating Polymer Networks*, Technomic Publishing Co., Inc., Lancaster, PA, 1991.

(3) Detroit Society for Coatings Technology, "Poly(Epoxy-Urethane-Acrylic) Interpenetrating Polymer Networks (IPNs) for Primer Applications," JOURNAL OF COATINGS TECHNOLOGY, *61*, No. 772, 61 (1989).

(4) Detroit Society for Coatings Technology, "Poly(Epoxy-Urethane-Acrylic) Interpenetrating Polymer Networks (IPNs) for Primer Applications. II," JOURNAL OF COATINGS TECHNOLOGY, 62, No. 785, 63 (1990).

(5) Detroit Society for Coatings Technology, "Effect of Siloxane Modification on the Physical Attributes of an Automotive Coating," JOURNAL OF COATINGS TECHNOLOGY, 64, No. 813, 83 (1992).

(6) Tehranisa, M., Ryntz, R.A., Xiao, H.X., Kordomenos, P.I., and Frisch, K.C., "Urethane Acrylic Interpenetrating Polymer Networks (IPNs) for Coatings Appliations," JOURNAL OF COATINGS TECHNOLOGY, 59, No. 746, 43 (1987).

(7) Ma, J., Yi, S., Zhang, Z., and Yao, K., *Proc. Int. Conf. Petrochem. Process*, 3, 1437 (1991).

(8) Hourston, D.J. and Zarandouz, M., *Advanced Interpenetrating Polymer Networks*, *Vol.* 2, 101, Klempner, D. and Frisch, K.C. (Eds.), Technomic Publishing Co., Inc., Lancaster, PA, 1990.

(9) Geetha, J., *Polymer Sci. Symp. Proc. Polym. '91*, Vol. 2, 882, Sivaram, S. (Ed.), Tata McGraw-Hill, New Delhi, India, 1991.

(10) He, X.W., Widmaier, J.M., Herz, J.E., and Meyer, G.C., *Polymer*, 33 (4), 866 (1992).

(11) Foscante, R.E., Martinich, P.J., Law, G.H.K., and Gysegem, A.P., PCT Int. Appl. 8,000,847 (1980).

(12) Rizk, S.D., Shah, N.B., and Powers, J.W., Eur. Pat. Appl. EP230666 (1987).

(13) Detroit Society for Coatings Technology, "The Effect of Siloxane Modification on the Physical Attributes of an Automotive Coating II: Studies on Interpenetrating Polymer Networks (IPNs) Based on Silicone Epoxy Resins and Urethane Acrylates," presented at the Federation of Societies for Coatings Technology Annual Meeting, Atlanta, GA, October 1993.

Novel Inorganic/Organic Coatings Based on Linseed Oil and Sunflower Oil with Sol-Gel Precursors

Scott J. Tuman and Mark D. Soucek*—North Dakota State University

New inorganic/organic hybrid coatings have been prepared utilizing linseed oil and sunflower oil as an organic phase and two sol-gel precursors [titanium (IV) i-propoxide, titanium (di-i-propoxide) bis(acetyl-acetonate)] as an inorganic phase. The ultimate goal is to develop a primer that will provide better adhesion and corrosion protection for metal substrates with minimal environmental impact. Coatings with a range of sol-gel precursor to drying oil ratios have been studied. Various coatings properties such as adhesion, hardness, impact resistance, and flexibility were observed as a function of sol-gel precursor content. In addition, the tensile properties and thermo-oxidative stabilities were also investigated. During processing, the sol-gel precursors appear to accelerate the drying of the coatings. Higher sol-gel precursor content increased both tensile strength and tensile modulus but decreased flexibility and strain-at-break. The thermo-oxidative stability was similar to drying oil coatings cured with driers.

INTRODUCTION

Seed oils have traditionally been used as drying oils and as raw materials for uralkyds and alkyd resins.[1] Naturally occurring seed oils are triglycerides consisting of a mixture of saturated, oleic, linoleic, and linolenic fatty acids. In order for a seed oil to be classified as a "drying oil," the drying index [drying index = % linoleic acid + 2 (% linolenic acid)] must be greater than 70. A "semi-drying oil" must have a drying index in the range of 65-70.[2] Linseed oil and sunflower oil are categorized as a drying oil and semi-drying oil, respectively. *Figure* 1 shows an example of a triglyceride containing an oleic, linoleic, and linolenic fatty acid.

The term drying oil is used to describe oils in which the unsaturated fatty acid residues crosslink via an auto-oxidative reach to form a varnish.[3] Some of the initiation, propagation, and termination mechanisms of this process are illustrated in *Scheme* 1. In the initiation step, naturally present hydroperoxides decompose to form free radicals. Propagation then proceeds by abstraction of hydrogen atoms on the methylene groups between double bonds. This results in free radicals such as 1. Free radical 1 reacts with oxygen to form peroxy free radical 2. The peroxy free radicals can regenerate free radicals like 1 by abstracting hydrogen atoms from other methylene groups between double bonds. Crosslinking proceeds by radical-radical termination reactions. These combinations may consist of C–C bonds 3, ether bonds 4, or peroxide bonds 5. Metal catalysts known as driers can be added to accelerate the drying process.[4] The metal catalysts promote the formation of peroxide radicals which initiate the auto-oxidative process.

Previously, numerous attempts have been made to develop novel inorganic/organic composites. The primary objective of these studies was to attain unique properties surpassing those of the inorganic and organic components. One successful method developed in the past decade involves in-situ polycondensation of metal alkoxides in organic polymer matrixes via the sol-gel process.[5-8] The sol-gel process allows low temperature synthesis of ceramic materials, while yielding a high purity and high homogeneity microphase. Some of the hydrolysis, condensation, and gelation mechanism of this curing process are illustrated in *Scheme* 2. Initial hydrolysis of the metal oxides occurs when an inorganic molecule 6 reacts with water to form a partially hydrolyzed complex 7 or 8. The curing process continues as molecules with varying degrees of hydrolysis react via polycondensation 9 and 10. Ultimately, the polycondensation results in three-dimensional mixed metal oxide/hydroxide/alkoxide clusters 11.

In the preparation of pure, thin, ceramic coatings it is crucial to control diffusion of volatile components to avoid fracture due to shrinkage during the curing process. The rate of glass formation can be varied by the addition of acid catalysts.[9] At high temperatures, the clusters can react further to form ceramic metal oxides. The sol-gel process is also used extensively in making binders for zinc silicate primers for corrosion protection of steel. Tetraethylorthosilicate $[Si(OEt)_4]$

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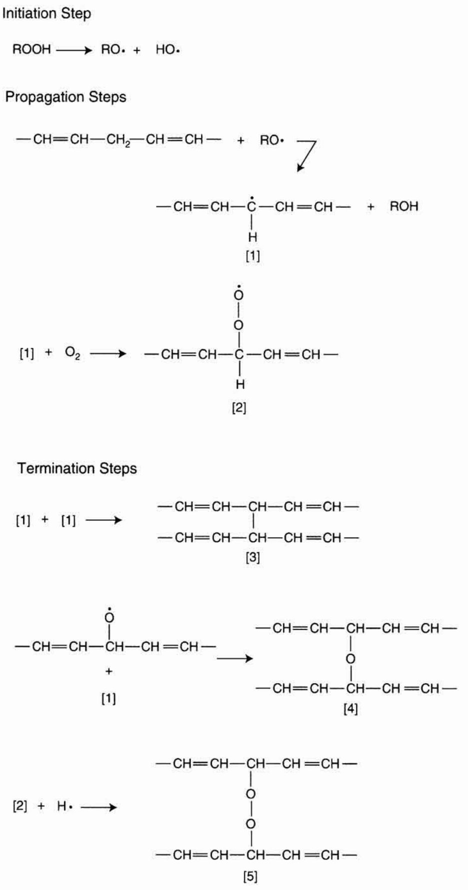
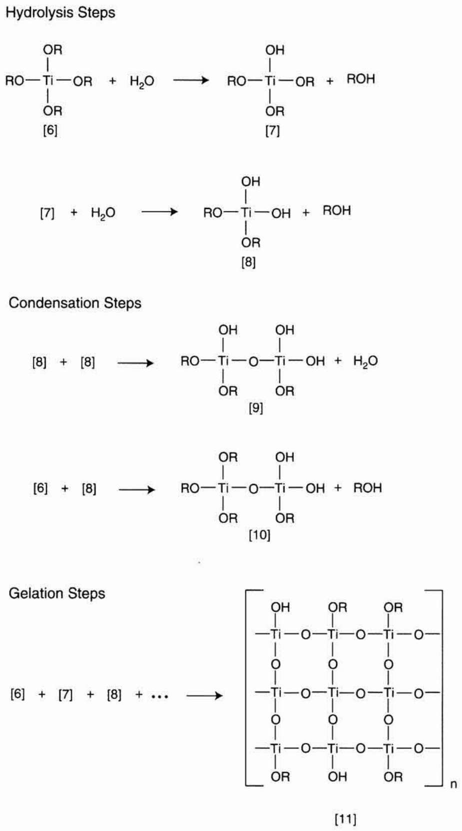
*Department of Polymers & Coatings, Fargo, ND 58105.



Scheme 1—Auto-oxidation curing process of drying oils including initiation, propagation, and termination steps.



Scheme 2—Sol-gel curing process including hydrolysis, condensation, and gelation steps.

(TEOS) hydrolyzes in the presence of water. The result is a partially polymerized film of polysilicic acid. Ethyl alcohol helps maintain package stability. Upon application, the ethyl alcohol evaporates and water from the atmosphere completes the hydrolysis.

Sugama et al.[10-13] have investigated corrosion-protective coatings for aluminum substrates based on preceramic polymetallosiloxane (PMS). Thin PMS coatings prepared by dipping Al into sol solution provided significant protection for Al against NaCl-induced corrosion. They summarized the important factors governing good protective performance as follows: (1) an increase in metal–O–Si linkages with increased treatment temperature; (2) a low degree of water wettability and spreadability; and (3) a specific microstructure geometry, in which the cluster units consisting of symmetrically grown fractal polymer branches were linked together.[13] Titanates are an example of coupling agents which are used in a new class of nonchromate/corrosion-resistant primers to align preferentially at the metal surface or metal-polymer interface.[14] The titanate acts as a barrier phase and an adhesion promotor. The bond between the metal and the titanate reduces the rate of anodic dissolution of the metal.[15-16]

In this work, sol-gel precursors [Ti(O*i*-Pr)$_4$ or Ti(O*i*-Pr)$_2$(acac)$_2$] were incorporated into a linseed oil or sunflower oil coating. The seed oil was mixed with a metal alkoxide utilizing an approach similar to Mark[5] and Imai.[7] The resulting inorganic/organic hybrid coatings cured via concomitant reactions in the inorganic and organic phases. The chemical composition of the coatings was varied in a systematic fashion by altering the sol-gel precursor to seed oil ratio. The coatings were compared in terms of adhesion, hardness, impact resistance, flexibility, tensile properties, and thermo-oxidative stability.

EXPERIMENTAL

Materials

The nomenclature which was developed to represent the hybrid systems in this study is shown in *Scheme* 3. The first term designates on which drying oil the coating is based. The second term defines which (if any) sol-gel precursor is included in the coating or the type of drier included in the coating. The number in parentheses immediately following the second term quantifies the initial weight fraction of this component relative to the drying oil content.

The linseed oil used in these experiments was obtained from Frost Paint and Oil Corp. The sunflower oil was obtained from National Sun Industries. The drier catalyst was obtained from Hüls America Inc. The titanium (IV) *i*-propoxide (TIP, Strem Chemicals) and titanium (di-*i*-propoxide) bis(acetyl-acetonate) (TIA, Strem Chemicals) were obtained from commercial sources as noted. All starting materials were used as received.

The drying oil fatty acid compositions of linseed oil and sunflower oil were obtained from a DB-23 J&W Scientific gas chromatographer. The column was 30 m in length and 0.25 mm in diameter. A helium carrier was used and the run temperature was 220°C.

Coating Preparation

A resin solution of each sample was prepared by mixing the appropriate quantity of drying oil and sol-gel precursor or drier. The resin solution was stirred with a magnetic stir bar for 10-15 min. A coating was then cast with a doctor blade at 130-150 μm thickness. The wet coatings were held in a dust-free drying chamber at room temperature for 48 hr. This allowed the isopropanol present in the sol-gel precursor solution and other impurities to volatilize from the coatings before curing. Coatings were cast on 0.6 mm thick aluminum panels for evaluation of mechanical coatings properties and on 12 in. × 12 in. Pyrex glass plates for removal and testing of physical properties.

The cure cycle of the coatings was as follows: one hour at 130°C, one hour at 180°C, and three hour at 210°C. The coatings were slowly cooled to room temperature. The coatings on glass substrates were then soaked in deionized water for 48 hr. Upon removal, the dry coatings were 70-90 μm thick.

Examples: LIN–Zr(0.5)
SUN–TIA(25)
LIN–TIP(10)

Where:	
LIN	linseed oil-based film
SUN	Sunflower oil-based film
Zr(0.5)	0.5 wt% zirconium with respect to drying oil content
TIA(25)	25 wt% titanium (di-i-propoxide) bis(acetyl-acetonate) with respect to drying content
TIP(10)	10 wt% titanium (IV) i-propoxide with respect to drying oil content

Scheme 3—Nomenclature describing the compositions of the hybrid films.

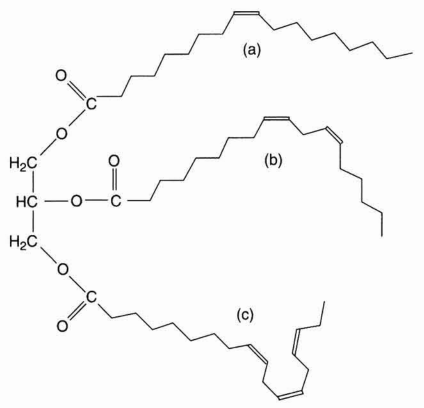


Figure 1—Idealized triglyceride structure containing; (a) oleic fatty acid; (b) linoleic fatty acid; and (c) linolenic fatty acid.

Coating Evaluation

Tensile measurements were made on dog-bone-shaped specimens with thickness of 70-90 μm and width of 12 mm at the center. The initial gauge length was 4-5 cm. The testing was performed on an Instron universal tester (model 1000) at a strain rate of 2 mm/min. More than five samples were tested for each composition and average values were reported.

Dynamic thermogravimetric analysis (TGA) was performed on a DuPont 951 thermogravimetric analyzer with thermal analyst 2000 software. Typical sample weights for TGA measurements were 8-10 mg. Tests were performed in an air atmosphere. The dynamic samples were heated from 100°C to 500°C at a rate of 20°C/min. Differential scanning calorimetry (DSC) was performed in a DuPont 910 differential scanning calorimeter with thermal analyst 2000 software. The DSC tests were run at a rate of 10°C/min.

Mechanical coating tests were performed according to ASTM standards. Pencil hardness was measured according to ASTM D 3363. Conical mandrel flexibility was measured according to ASTM D 522. Crosshatch adhesion was measured according to ASTM D 3359. Reverse impact resistance was measured according to ASTM D 2794-84 using a Paul N. Gardner Co. Model 172 impact tester. Dry coating thickness was measured using a General Electric micrometer.

Table 1—Drying Oil Fatty Acid Compositions (wt%) of Linseed Oil and Sunflower Oil

Drying Oil	Saturated	Oleic	Linoleic	Linolenic
Linseed	10	22	16	52
Sunflower	12	17	70	—

Table 2—Mechanical Properties of Inorganic/Organic Hybrid Coatings

Coating Composition	Dry Film Thickness	Pencil Hardness	Rev. Impact Resistance	Conical Mand. Flexibility	X-Hatch Adhesion
		Linseed Oil			
Pure linseed oil	70 µm	3B	40 ft-lb	1/8 in. dia	100%
LIN - TIA(5)	79 µm	4H	18 ft-lb	1/8 in. dia	100%
LIN - TIA(10)	88 µm	6H	12 ft-lb	1/4 in. dia	95%
LIN - TIA(15)	86 µm	7H	8 ft-lb	1/2 in. dia	95%
LIN - TIA(20)	90 µm	9H	2 ft-lb	1/2 in. dia	100%
LIN - TIA(25)	85 µm	9H	2 ft-lb	3/4 in. dia	100%
LIN - TIP(5)	75 µm	3H	10 ft-lb	1/4 in. dia	90%
LIN - TIP(10)	82 µm	7H	4 ft-lb	1/4 in. dia	80%
LIN - TIP(15)	91 µm	9H	2 ft-lb	1/2 in. dia	65%
LIN - TIP(20)	84 µm	9H	2 ft-lb	1/2 in. dia	65%
LIN - TIP(25)	78 µm	9H	2 ft-lb	1/2 in. dia	70%
		Sunflower Oil			
Pure sunflower oil	78 µm	4B	55 ft-lb	1.8 in. dia	100%
SUN - TIA(5)	87 µm	4H	14 ft-lb	1/8 in. dia	100%
SUN - TIA(10)	83 µm	6H	8 ft-lb	1/4 in. dia	100%
SUN - TIA(15)	72 µm	6H	8 ft-lb	1/2 in. dia	100%
SUN - TIA(20)	70 µm	7H	2 ft-lb	3/4 in. dia	100%
SUN - TIA(25)	78 µm	9H	2 ft-lb	3/4 in. dia	100%
SUN - TIP(5)	78 µm	5H	8 ft-lb	1/8 in. dia	90%
SUN - TIP(10)	73 µm	7H	5 ft-lb	1/4 in. dia	85%
SUN - TIP(15)	81 µm	9H	2 ft-lb	1/4 in. dia	75%
SUN - TIP(20)	83 µm	9H	2 ft-lb	1/2 in. dia	65%
SUN - TIP(25)	75 µm	9H	2 ft-lb	3/4 in. dia	65%

RESULTS AND DISCUSSION

The primary objective of this study was to develop the first generation of inorganic/organic hybrid coatings using drying oils and sol-gel precursors. It is hoped that the combination of these two different types of materials will yield coatings that have a unique balance of properties. Our long-term goal is to develop low-VOC, chromate-free, corrosion-resistant primers for metal substrates. In this preliminary study, the effects of the sol-gel precursor content have been investigated in terms of the mechanical and physical properties of these coatings. The results of the fatty acid assays of the linseed oil and sunflower oil used in this study are shown in *Table* 1. The linseed oil has a drying index of 120 and the sunflower oil has a drying index of 70. The linseed oil was chosen for its high concentration of linolenic acid. For comparison, the sunflower oil was chosen for its high linoleic acid content and its lack of linolenic acid.

Hybrid inorganic/organic coatings with a range of 5 to 50 wt% sol-gel precursor were prepared but only samples with up to 25 wt% sol-gel precursor could be evaluated quantitatively. Coatings with greater than 25 wt% sol-gel precursor were extremely brittle and proved exceedingly difficult to remove from the substrate. In addition, coatings of pure linseed oil

Table 3—Mechanical Properties of Drying Oil Coatings Cured with Driers

Coating Composition	Dry Film Thickness	Pencil Hardness	Rev. Impact Resistance	Conical Mand. Flexibility	X-Hatch Adhesion
		Linseed Oil			
Pure linseed oil	70 µm	3B	40 ft-lb	1/8 in. dia	100%
LIN - Zr(0.5)	82 µm	3H	35 ft-lb	1/8 in. dia	100%
LIN - Zr(1.0)	73 µm	5H	25 ft-lb	1/8 in. dia	95%
LIN - Zr(1.5)	85 µm	5H	15 ft-lb	1/4 in. dia	100%
LIN - Zr(2.0)	79 µm	6H	15 ft-lb	1/4 in. dia	100%
LIN - Zr(2.5)	82 µm	6H	2 ft-lb	1/4 in. dia	100%
		Sunflower Oil			
Pure sunflower oil	78 µm	4B	55 ft-lb	1.8 in. dia	100%
SUN - Zr(0.5)	71 µm	3H	15 ft-lb	1/8 in. dia	100%
SUN - Zr(1.0)	82 µm	4H	9 ft-lb	1/8 in. dia	100%
SUN - Zr(1.5)	78 µm	4H	5 ft-lb	1/8 in. dia	100%
SUN - Zr(2.0)	87 µm	5H	2 ft-lb	1/4 in. dia	100%
SUN - Zr(2.5)	86 µm	5H	2 ft-lb	1/4 in. dia	100%

and pure sunflower oil were prepared and analyzed as a baseline. Also, drying oil coatings cured with a range of zirconium drier content (0.5-2.5 wt%) were prepared and analyzed. Coatings cured with various combinations of through and top driers yielded results similar to those cured only with zirconium drier. Therefore, only zirconium drier was used in this study.

The cure cycle was derived from thermal analysis data. *Figure* 2 illustrates a differential scanning calorimetry (DSC) curve for pure linseed oil. The exothermic peak from 110° to 190°C illustrates the temperature range during which the drying oil undergoes extensive crosslinking. Initially, the coatings are held in a dust-free drying chamber for 48 hr to expel solvents and impurities. This procedure resulted in a tacky coating and limited flow upon exposure to elevated temperatures. In the first segment of the cure cycle, the temperature was ramped gradually to 130°C and held constant for one hour. This segment increased the peroxide concentration and propagated crosslinking of the drying oil. In the second segment, the temperature is ramped gradually to 180°C and held constant for one hour. This segment increased the crosslink density. In the third segment, the temperature was ramped gradually to 210°C and held constant for three hours. This segment ensured extensive crosslinking and increased the reaction of the sol-gel precursor. To ensure relevant comparisons, all samples were cured via the same cure cycle.

Table 2 shows the mechanical coating properties of linseed oil-based and sunflower oil-based coatings as a function of sol-gel precursor content. The pencil hardness significantly increased with increasing sol-gel precursor concentration. The lowest pencil hardness values were obtained with pure linseed oil coatings [3B] and pure sunflower oil coatings [4B]. The highest pencil hardness value for the linseed oil-based coatings was 9H and was obtained with 20-25 wt% $Ti(Oi\text{-}Pr)_2(acac)_2$ and 15-25 wt% $Ti(Oi\text{-}Pr)_4$. Similarly, the highest value for the sunflower oil-based coatings was 9H and was obtained with 25 wt% $Ti(Oi\text{-}Pr)_2(acac)_2$ and 15-25 wt% $Ti(Oi\text{-}Pr)_4$. Overall, inclusion of sol-gel precursors decreased the reverse impact resistance in comparison to pure linseed oil and sunflower oil coatings. Concentrations greater than 10 wt% sol-gel precursor resulted in poor impact resistance. Likewise, the conical mandrel flexibility decreased as the sol-gel precursor concentration was increased. The crosshatch adhesion of the linseed oil-based coatings and sunflower oil-based coatings containing $Ti(Oi\text{-}Pr)_2(acac)_2$ was excellent [100%]. The crosshatch adhesion of the linseed oil-based [70-90%] and sunflower oil-based [65-90%] coatings containing $Ti(Oi\text{-}Pr)_4$ was inferior to the crosshatch adhesion of the hybrid coatings containing $Ti(Oi\text{-}Pr)_2(acac)_2$.

The mechanical coating properties of linseed oil and sunflower oil coatings cured with a range of 0 to 2.5 wt% zirconium drier are shown in *Table* 3. The pencil hardness increased with increasing drier concentration. This was not surprising since the inclusion of a drier promotes crosslinking. The metal salt catalyzes hydroperoxide decomposition resulting in higher concentrations of free radicals.[4] This accelerates the initiation step in *Scheme* 1. It is interesting to note that the pencil hardness values of the drying oil coatings cured with driers were not as high as the hybrid coatings. The reverse impact resistance and conical mandrel flexibility decreased with increasing drier concentration. These trends were expected since the crosslink density increases with increasing drier concentration. As the crosslink density in-

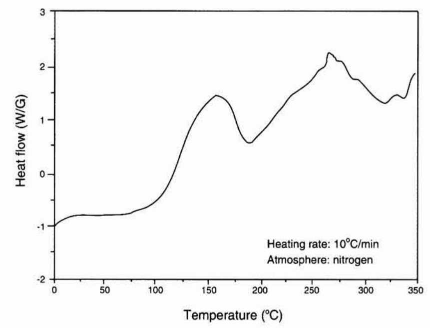


Figure 2—Differential scanning calorimetry (DSC) curve for the curing process of linseed oil.

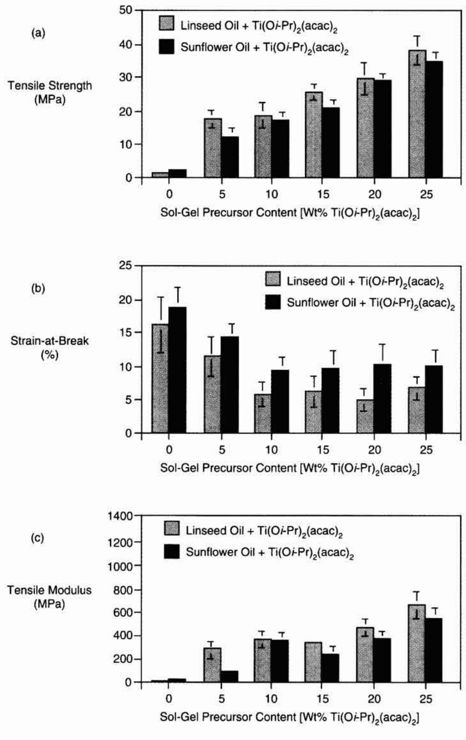


Figure 3—Tensile properties of linseed oil and sunflower oil coatings with a range of $Ti(Oi\text{–}Pr_2(acac)_2$ sol-gel precursor content (a) tensile strength versus sol-gel precursor content; (b) strain-at-break versus sol-gel precursor content; and (c) tensile modulus versus sol-gel precursor content.

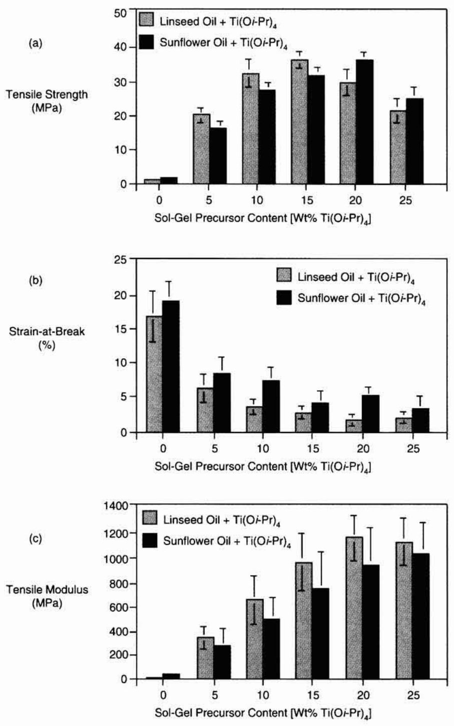


Figure 4— Tensile properties of linseed oil and sunflower oil coatings with a range of Ti(Oi–Pr$_4$ sol-gel precursor content (a) tensile strength versus sol-gel precursor content; (b) strain-at-break versus sol-gel precursor content; and (c) tensile modulus versus sol-gel precursor content.

creases, the coating will become more rigid and a rigid coating will not withstand impact nor allow extension.

Figure 3 shows the tensile strength, strain-at-break, and tensile modulus of linseed oil-based and sunflower oil-based coatings as a function of Ti(O*i*-Pr)$_2$(acac)$_2$ content. As an overall trend, the tensile strength increased with increasing Ti(O*i*-Pr)$_2$(acac)$_2$ concentration. Consequently, the highest tensile strengths of both the linseed oil [38.7 MPa] and sunflower oil [34.7 MPa] coatings were obtained when the sol-gel precursor content was maximized at 25 wt%. Compositions greater than 25 wt% Ti(O*i*-Pr)$_2$(acac)$_2$ yielded brittle coatings that could not be removed from the substrate. The strain-at-break initially decreased with increasing Ti(O*i*-Pr)$_2$(acac)$_2$ concentration and then remained relatively constant from 10 to 25 wt% for both the linseed oil-based [6%] and sunflower oil-based [10%] coatings. The tensile modulus values showed a general increase as the Ti(O*i*-Pr)$_2$(acac)$_2$ concentration was increased. The highest tensile modulus value was observed at 25 wt% Ti(O*i*-Pr)$_2$(acac)$_2$ for both the linseed oil-based [680 MPa] and sunflower oil-based [570 MPa] coatings.

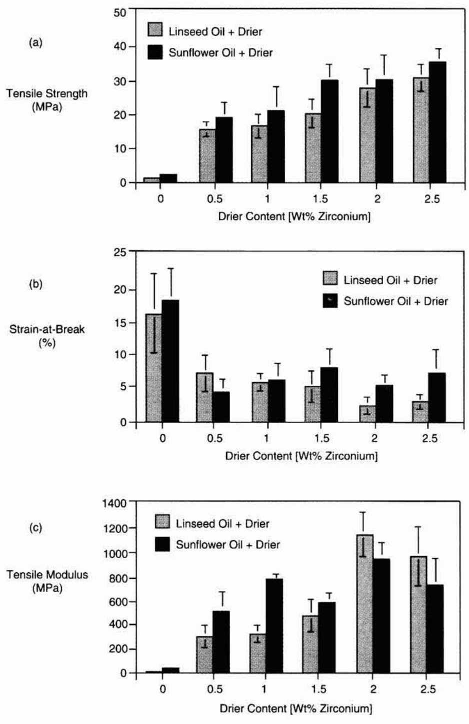


Figure 5—Tensile properties of linseed oil and sunflower oil coatings cured with a range of zirconium drier content (tensile strength versus drier content; (b) strain-at-break versus drier content; and (c) tensile modulus versus drier content.

Figure 4 shows the tensile strength, strain-at-break, and tensile modulus of linseed oil-based and sunflower oil-based coatings as a function of Ti(O*i*-Pr)$_4$ content. The tensile strength initially increased with increasing Ti(O*i*-Pr)$_4$ concentration and then decreased at high concentrations of the sol-gel precursor. The highest tensile strength value of the linseed oil-based coatings was 35.9 MPa at 15 wt% Ti(O*i*-Pr)$_4$. The highest tensile strength value of the sunflower oil-based coatings was 36.2 MPa at 20 wt% Ti(O*i*-Pr)$_4$. At compositions greater than 15 wt% Ti(O*i*-Pr)$_4$, the hybrid coatings were brittle and sustained numerous cracks and nicks upon removal from the substrate. When subjected to stress, these coatings cracked easily, starting at the imperfections. The strain-at-break decreased with increasing Ti(O*i*-Pr)$_4$ concentration. The Ti(O*i*-Pr)$_4$ strain-at-break values were lower than analogous hybrid coatings containing Ti(O*i*-Pr)$_2$(acac)$_2$. The tensile modulus values increased with increasing Ti(O*i*-Pr)$_4$ concentration and the highest value of 1200 MPa was obtained with linseed oil and 20 wt% Ti(O*i*-Pr)$_4$. The highest tensile modulus value of the sunflower oil-based coatings was

Table 4—Dynamic Thermogravimetric Analysis Data of Inorganic/Organic Hybrid Coatings

	Weight Loss Percentage			
Coating Composition	**5%**	**10%**	**25%**	**50%**
	Linseed Oil			
Linseed oil	303°C	330°C	358°C	426°C
LIN - TIA(5)	301°C	325°C	370°C	442°C
LIN - TIA(10)	295°C	318°C	387°C	447°C
LIN - TIA(15)	296°C	316°C	390°C	460°C
LIN - TIA(20)	292°C	316°C	394°C	470°C
LIN - TIA(25)	290°C	318°C	395°C	474°C
LIN - TIP(5)	301°C	318°C	371°C	444°C
LIN - TIP(10)	297°C	327°C	382°C	451°C
LIN - TIP(15)	294°C	325°C	367°C	457°C
LIN - TIP(20)	296°C	332°C	375°C	461°C
LIN - TIP(25)	291°C	322°C	390°C	455°C
	Sunflower Oil			
Sunflower Oil	311°C	334°C	388°C	434°C
SUN - TIA(5)	304°C	320°C	367°C	441°C
SUN - TIA(10)	294°C	317°C	355°C	449°C
SUN - TIA(15)	296°C	320°C	380°C	455°C
SUN - TIA(20)	292°C	314°C	375°C	458°C
SUN - TIA(25)	291°C	314°C	378°C	459°C
SUN - TIP(5)	297°C	320°C	374°C	447°C
SUN - TIP(10)	295°C	317°C	377°C	455°C
SUN - TIP(15)	299°C	328°C	401°C	447°C
SUN - TIP(20)	292°C	323°C	397°C	456°C
SUN - TIP(25)	304°C	328°C	393°C	437°C

1050 MPa at 25 wt% $Ti(O\textit{i}\text{-}Pr)_4$. In addition, the tensile modulus values of all the hybrid coatings containing $Ti(O\textit{i}\text{-}Pr)_4$ were 150 to 200% higher than analogous hybrid coatings containing $Ti(O\textit{i}\text{-}Pr)_2(acac)_2$.

The tensile strength, strain-at-break, and tensile modulus of linseed oil and sunflower oil coatings cured with a range of 0 to 2.5 wt% zirconium drier are shown in *Figure* 5. The tensile strength and tensile modulus increased while the strain-at-break decreased with increasing drier concentration. As mentioned previously, the drier increases the crosslink density of drying oil coatings. There are similarities in the trends observed in *Figures* 3-5. Since titanates catalyze the auto-oxidation of drying oils,[1] the trends in *Figures* 3 and 4 are probably caused, at least partially, by changes in crosslink density.

Dynamic thermogravimetric analysis (TGA) data for the inorganic/organic hybrid coatings are shown in *Table* 4. There are many reactions that may contribute to the decomposition and resulting weight loss of the inorganic/organic hybrid coatings. The auto-oxidation curing process of the drying oils, illustrated in *Scheme* 1, is reversible. At elevated temperatures, the crosslinks will decompose to free radicals and the presence of free radicals causes decomposition. The sol-gel precursor contains ligands which are expelled and subsequently volatilized during all three steps of the sol-gel curing process illustrated in *Scheme* 2. The sol-gel curing process is advanced at high temperatures resulting in volatilized small molecules. The sol-gel precursor may accelerate the decomposition of the crosslinked organic phase since it appears to accelerate the auto-oxidative curing process. The TGA data for linseed oil and sunflower oil coatings having a range of 0 to 2.5 wt% zirconium drier are shown in *Table* 5. At elevated temperatures, decomposition is catalyzed by the metal drier. The thermo-oxidative stability trends in *Table* 5 are similar to the trends of the hybrid coatings in *Table* 4.

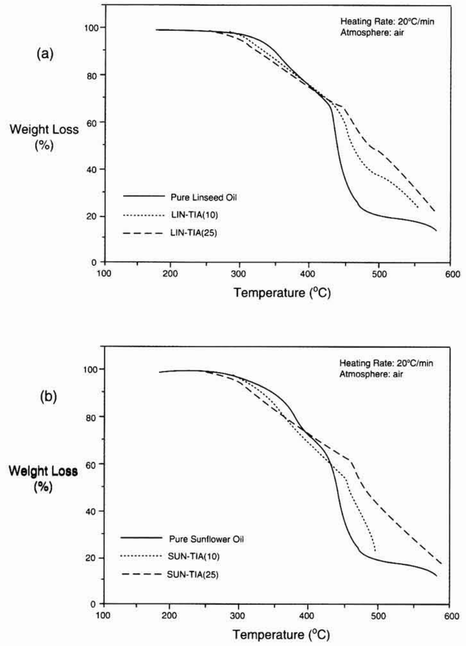


Figure 6—Dynamic thermogravimetric analysis curves (a) linseed oil with Ti(Oi–Pr$_2$(acac)$_2$; and (b) sunflower oil coatings with Ti(Oi–Pr$_2$(acac)$_2$ sol-gel precursor.

Representative dynamic TGA curves for linseed oil-based and sunflower oil-based coatings with $Ti(O\textit{i}\text{-}Pr)_2(acac)_2$ are shown in *Figure* 6. As shown in *Figure* 7, the initial weight loss

Table 5—Dynamic Thermogravimetric Analysis Data of Linseed Oil and Sunflower Oil Coatings with Zirconium Drier

	Weight Loss Percentage			
Coating Composition	**5%**	**10%**	**25%**	**50%**
	Linseed Oil			
Linseed oil	303°C	330°C	358°C	426°C
LIN - Zr(0.5)	304°C	334°C	372°C	441°C
LIN - Zr(1.0)	306°C	337°C	391°C	454°C
LIN - Zr(1.5)	306°C	336°C	375°C	442°C
LIN - Zr(2.0)	290°C	324°C	361°C	448°C
LIN - Zr(2.5)	284°C	310°C	353°C	443°C
	Sunflower Oil			
Sunflower oil	331°C	334°C	388°C	434°C
SUN - Zr(0.5)	299°C	326°C	368°C	442°C
SUN - Zr(1.0)	296°C	317°C	362°C	453°C
SUN - Zr(1.5)	302°C	321°C	371°C	457°C
SUN - Zr(2.0)	291°C	315°C	366°C	461°C
SUN - Zr(2.5)	293°C	317°C	367°C	464°C

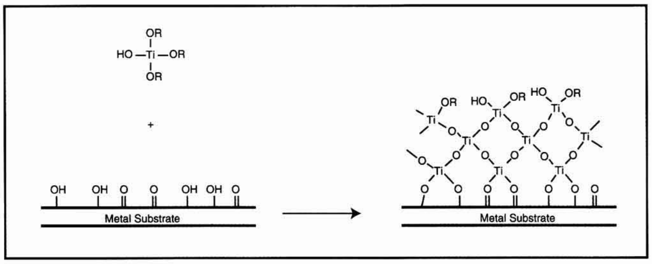


Figure 7—Proposed anti-corrosion barrier interactions of the sol-gel precursor with a metal substrate.

of the coatings was in the 260-300°C range and progressed almost linearly to 400-450°C where a transition occurred. At this transition, the slope increased, after which the curves were approximately linear once again. From *Figure* 6 and *Table* 5, it appears that the initial decomposition of the coatings was accelerated by the presence of the sol-gel precursor. The temperatures required to produce 5 and 10% weight loss decreased slightly with increasing sol-gel precursor content. There were no discernible trends in the TGA data in *Table* 4 for 25 and 50% weight loss. There is a crossover of the curves in *Figure* 6 in the region from 25 to 50% weight loss (375-450°C). At temperatures above 450°C the inclusion of the sol-gel precursor enhanced the thermo-oxidative stability of the hybrid coatings.

The results in *Figures* 3 and 4 illustrate that tensile strength and tensile modulus increased while strain-at-break decreased with increasing sol-gel precursor concentration. Two factors may be responsible for this effect. One factor is that the sol-gel precursor forms a three-dimensional mixed metal oxide/hydroxide/alkoxide micro-phase via polycondensation. This reaction, illustrated in *Scheme* 2, yields rigid pre-ceramic clusters. These rigid clusters would significantly increase the tensile strength and tensile modulus and decrease the strain-at-break. The second factor contributing to these trends is the change in crosslink density of the organic phase. Unfortunately, a useful comparison cannot be made among the catalysis efficiencies of zirconium drier, $\mathrm{Ti(O\mathit{i}{-}Pr)_2(acac)_2}$ and $\mathrm{Ti(O\mathit{i}{-}Pr)_4}$, because there is more than one factor contributing to the changes in physical and mechanical properties.

Alternatively, a useful comparison can be made between the mechanical properties of the linseed oil-based and sunflower oil-based coatings. The tensile strength and tensile modulus of linseed oil-based coatings were consistently higher than analogous sunflower oil-based coatings while the strain-at-break was lower. As shown in *Table* 1, linseed oil has a much higher composition of linolenic acid. As seen in *Figure* 1, a higher concentration of linolenic fatty acids results in a higher abundance of methylene groups between double bonds. Methylene groups between double bonds are very susceptible to proton abstraction, resulting in free radicals. This is a critical step in the auto-oxidative curing process of drying oils, illustrated in *Scheme* 1. Therefore, the crosslink density of linseed oil-based coatings should be higher than analogous sunflower oil-based coatings.

Among the coatings analyzed thus far, the best balance of properties was achieved with linseed oil hybrid coatings containing 10 wt% $\mathrm{Ti(O\mathit{i}{-}Pr)_2(acac)_2}$ sol-gel precursor. LIN–TIA (10) coatings had relatively high tensile strengths [19 MPa] and tensile moduli [386 MPa] while retaining a reasonably high strain-at-break [5.9%] and reverse impact resistance [12 ft-lb]. These results showed that LIN–TIA (10) coatings have a good balance between strength and flexibility. The thermo-oxidative stability of LIN– TIA (10) was similar to drying oil coatings cured with driers. The other hybrid coatings containing 10 wt% sol-gel precursor [SUN–TIA (10), LIN–TIP (10), SUN– TIP (10)] also showed good balance of properties. However, these coatings were lacking in one aspect or another in comparison to LIN–TIA (10).

Once established, the cure cycle was held constant to ensure a meaningful comparison of the data. It is important to note that even at ambient temperature, these samples can cure into continuous coatings. However, an aggressive cure cycle was chosen to accelerate the cure of the inorganic/organic hybrid coatings. An ongoing study involves optimization of the cure cycle. In further work, $\mathrm{Zr(O\mathit{n}{-}Bu)_4}$, $\mathrm{Si(OEt)_4}$, and $\mathrm{Zn(OR)_2}$ sol-gel precursors will be incorporated into drying oil systems. Acid or base catalysts can be included to control the rate of consideration of the sol-gel precursors. Our ultimate goal is to develop a primer that will provide better adhesion and corrosion protection for metal substrates with minimal environmental impact. It is anticipated that the sol-gel component of the coating will react with the metal substrate as shown in *Figure* 7, protecting it from corrosion similarly to previously reported titanates which act as a barrier phase and as adhesion promoters.[15]

CONCLUSION

- Continuous, strong coatings can be made with linseed oil or sunflower oil and 5-25 wt% $\mathrm{Ti(O\mathit{i}{-}Pr)_2(acac)_2}$ sol-gel precursor.

SCOTT J. TUMAN is a graduate student in the Department of Polymers and Coatings at North Dakota State University. His research involves the study of morphology and mechanical and physical properties inorganic/organic hybrid coatings. He has worked as an intern with 3M Company at the 3M Center in St. Paul, Minnesota. He has a B.S. in Mechanical Engineering with a specialization in Polymers and Coatings from NDSU. (Mr. Tuman has since graduated from NDSU with an M.S. Degree in Polymers and Coatings and is presently employed with 3M Company, in St. Paul.)

MARK D. SOUCEK is an Assistant Professor in the Department of Polymers and Coatings at North Dakota State University. His research interests include high performance polymers, inorganic/organic hybrid coatings, UV coatings, and cyclo-aliphatic epoxide crosslinked (acrylic) latex coatings. Previously, Dr. Soucek was a National Research Council postdoctoral Fellow working in the Polymeric Materials Branch of NASA Langley Research Center. He received a B.S. in Chemistry from Eastern Illinois University, an M.S. Degree in Organic Chemistry from Illinois State University, and a Ph.D in Inorganic Chemistry from the University of Texas at Austin in 1990.

- Continuous, strong coatings can be made with linseed oil or sunflower oil and 5-20 wt% $Ti(Oi\text{–}Pr)_4$ sol-gel precursor.

- The inclusion of sol-gel precursors $[Ti(Oi\text{–}Pr)_2(acac)_2, Ti(Oi\text{–}Pr)_4]$ significantly increased the tensile strength, tensile modulus, and hardness but decreased flexibility and impact resistance of linseed oil and sunflower oil coatings.

- The inclusion of sol-gel precursors $[Ti(Oi\text{–}Pr)_2(acac)_2, Ti(Oi\text{–}Pr)_4]$ slightly decreased the thermo-oxidative stability of linseed oil and sunflower oil coatings at elevated temperatures (260-300°C).

- The best balance between strength and flexibility was achieved with linseed oil-based hybrid coatings containing 10 wt% $Ti(Oi\text{–}Pr)_2(acac)_2$ sol-gel precursor.

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References

(1) Wicks, Z.W., Jones, F.N., and Pappas, P.S., *Organic Coatings Science and Technology, Volume 1, Film Formation, Component, and Appearance*, SPE Monograph Series, John Wiley & Sons, New York, 1992.
(2) Holmberg, K., *High Solid Alkyd Resins*, Marcel Dekker, New York, 1987.
(3) Formo, M.W., "Drying Oils," in *Bailey's Industrial Oil and Fat Products Vol. 1*, Swern, D. (Ed.), John Wiley & Sons, Inc., New York, 1979.
(4) Bellettiere, S.J. and Mahoney, D.M., "Multi-Metallic Complexes: The Next Generation of Driers," JOURNAL OF COATINGS TECHNOLOGY, 59, No. 752, 101 (1987).
(5) (a) Wang, S., and Mark, J.E., *Macromolecular Reports*, 31, 253, 1994; (b) Wang, S., Ahmad, Z. and Mark, J.E., *Macromolecular Reports*, 31, 411, 1994; (c) Zhao, M.X., Ning, Y.P., and Mark, J.E., *Adv. Compos. Mater.*, 891, 1992; and (d) Wang, S., Ahmad, Z., and Mark, J.E., *Chem. Mater.*, 6, 943, 1994.
(6) (a) Surivet, F., Lam, T., Pascault, J.P., and Pham, Q.T., *Macromolecules*, 25, 4309, 1992; (b) Surivet, F., Lam, T.M., Pascault, J.P., and Mai, C., *Macromolecules*, 25, 5742, 1992; and (c) Kaddami, H., Surivet, F., Gerard, J.F., Lam, T.M., and Pascault, J.P., *J. Inorg. Organomet. Polymer*, 4, 183, 1994.
(7) Iyoku, Y., Kakimoto, M., and Imai, Y., *High Perform. Polymer*, 6, 43, 1994; (b) Iyoku, Y., Kakimoto, M., and Imai, Y., *High Perform. Polymer*, 6, 53, 1994; (c) Morikawa, A., Yamaguchi, H., Kakimoto, M., and Imai, Y., *Chem. Mater.*, 6, 913, 1994; and (d) Iyoku, Y., Kakimoto, M., and Imai, Y., *High Perform. Polymer*, 6, 95, 1994.
(8) (a) Rodrigues, D.E. and Wilkes, G.L., *Inorg. Organomet. Polymer*, 3, 197, 1993; (b) Tamami, B., Betrabet, C., and Wilkes, G.L., *Polymer Bull.*, 30, 39, 1993; (c) Huang, H., Glaser, R.H., Brennan, A.B., Rodrigues, D., and Wilkes, G.L., in *Ultrastructure Processing of Advanced Materials*, Uhlmann, D.R. and Ulrich, D.R. (Eds.), John Wiley & Sons, Inc., New York, 1992; (d) Rodrigues, D.E., Brennan, A.B., Betrabet, C., Wang, B., and Wilkes, G.L., *Chem. Mater.*, 4, 1437, 1992; (e) Brennan, A.B., Wang, B., Rodrigues, D.E., and Wilkes, G.L., *J. Inorg. Organomet. Polymer*, 1, 167, 1991; (f) Wang, B., Wilkes, G.L., Smith, C.D., and McGrath, J.E., *Polymer Commum.*, 32, 400, 1991; (g) Rodrigues, D.E. and Wilkes, G.L., *Mat. Res. Soc. Symp. Proc.*, 189, 441, 1991; (h) Wang, B., Wilkes, J.C., Hedrick, S.C., Liptak, S.C., and McGrath, J.E., *Macromolecules*, 24, 3449, 1991; (i) Wang, B. and Wilkes, G.L., *J. Polymer Sci., Part A: Polymer Chem.*, 29, 905, 1991; (j) Brennan, A.B. and Wilkes, G.L., *Polymer*, 32, 733, 1991; (k) Glaser, R.H., and Wilkes, G.L., *Polymer Bulletin*, 22, 527, 1989; (l) Wilkes, G.L., Brennan, A.B., Huang, H.H., Rodrigues, D., and Wang, B., *Mat. Res. Soc. Symp. Proc.*, 171, 15, 1990; and (m) Huang, H.H., Orler, B., and Wilkes, G.L., *Polymer Bull.*, 14, 557, 1985.
(9) Brinker, C.J. and Scherer, G.W., *Sol-Gel Science*, Academic Press, New York, 1990.
(10) Sugama, T., Kukacka, L.E., and Carciello, N., *Prog. Org. Coat.*, 18, 173 (1990).
(11) Sugama, T., Carciello, N., and Taylor, C., *J. Non-Cryst. Solids*, 134, 58 (1991).
(12) Sugama, T. and Taylor, C., *J. Mater. Sci.*, 27, 1723 (1992).
(13) Sugama, T., Fair, J.R., and Reed, A.O., "Polymetallosiloxane Coatings Derived from Two-Step, Acid-Base Catalyzed Sol Precursors for Corrosion Protection of Aluminum Subtrates," JOURNAL OF COATINGS TECHNOLOGY, 65, No. 826, 27 (1993).
(14) van Ooij, W.J., in *Organic CoatingP: Science and Technology, Vol. 6*, Parfitt, G.D. and Patsis, A.V. (Eds.), Marcel Dekker, New York (1984).
(15) Monte, J.S. and Sugerman, G., *ACS Dev. Org. Coat. Plast. Chem.*, 43, 158, 1980.
(16) Wiendand, H. and Ostertag, W., *Farbe und Lack*, 88, 183, 1982.

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Microencapsulation of Isocyanates. Characterization and Storage Stability of Microcapsules in a Polyester α,ϖ-ol

Evelyne Quérat, Lan Tighzert* and Jean-Pierre Pascault—
Laboratorie des Matériaux Macromoléculaires

The microencapsulation of toluene 2,4-diisocyanate dimer (di-TDI) was accomplished by interfacial polycondensation with ethylene diamine in cyclohexane and in a polycaprolactone; the influence of different parameters was discussed.

The microcapsules obtained were characterized according to morphology and NCO content. Their behavior in two polycaprolactones was studied. The reaction between NCO and OH groups took place only after the isocyanate melting when encapsulation was well done. The stability of microcapsules stored in polycaprolactones at room temperature and 40°C was also examined.

INTRODUCTION

The crosslinking reaction between multifuctional isocyanates and –OH, –SH, or –NHR terminated prepolymers is the basic chemical reaction occurring in polyurethane adhesives, coatings casting resins, etc. Although it is a fast reaction, there are some disadvantages to the systems due to the presence of isocyanate groups in the mixture. The toxicity of the isocyanate, its high reactivity, and its moisture sensitivity that lead to the formation of CO_2 are the drawbacks of isocyanate use. Therefore, it is not possible to formulate storage stable heat curable one-component adhesives or water-based coatings with a mixture containing free isocyanate groups. Industrial applications often require one-component systems. They can be prepared by using blocked polyisocyanates, which are stable at room temperature. Upon heating, the blocking agent is cleaved off, and the polyisocyanate undergoes addition with reactive hydrogen atoms that produce a thermally stable final product.[1,2] Such a system depends on the type of blocking agent used. In paint systems this agent evaporates and must be separated from the exhaust air, or it can act as a plastifier in the final material and affect its mechanical properties.

The microencapsulation described here has a direct interest in the suppression of these disadvantages. Hitherto, very little literature has been published on the surface modification of polyisocyanates that are solid at room temperature. Fine particles of solid polyisocyanates can be unactivated by a microencapsulation process.[3] Then, the core compound can be released at a desired time and temperature or with a controlled rate. In the latter case, the shell acts as a porous membrane.[4]

Microencapsulation was initially introduced by Green and Schleicher in the 1950s to produce pressure-sensitive dye microcapsules for the manufacture of carbonless copying paper.[5] The microencapsulation can be carried out by different processes such as chemical, physicochemical, and mechanical processes.[6] Chemical processes include radical polymerization in emulsion and interfacial polycondensation.[7,8] In encapsulation by interfacial polycondensation, the shell morphology depends on the reactivity of two monomers and their reaction kinetics. Further, the microcapsule size depends on the reaction temperature, the stirring rate, and the form of the stirring blade. The presence of surface active agents also influences the capsule formation.[9]

Microcapsules may be produced through physical processes like coacervation, evaporation of solvent, and polymer-polymer immiscibility.[6,10] Spray-drying and spray-congealing[11] result in microcapsules as well.

In this report, the microencapsulation of the toluene 2,4-diisocyanate dimer by the interfacial polycondensation with diamine for the purpose of preparation of a one-component system that could be cured at an elevated temperature is studied.

EXPERIMENTAL

Materials

The toluene 2,4-diisocyanate dimer (di-TDI), crystalline powder of diameter 10-50 μm was Desmodur TT (provided by Bayer). Its melting point is 156°C. The isocyanate equivalent

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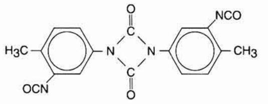
*URA CNRS n° 507, Institut National des Sciences Appliquées de Lyon - Bâtiment 403 30, Avenue Albert Einstein, 69621 Villeurbanne Cedex, France.

Table 1—Results of Microencapsulations

Sample[a]	Amine Concentration mol/mol NCO	Time (min) - Stirring Rate (rpm)	Isocyanate Conversion α_{NCO} (%)	Amine Conversion α_{NH2} (%)
E1	0.1	120-300	5.8	58
E2	0.1	240-300	6.5	65
E3	0.1	3-3000 115-240	7.1	71
E4	0.1	3-3000 240-300	8.5	85
E5	0.05	3-3000 120-240	4.7	94
E6	0.02	3-3000 120-240	1.75	87
E7	0.15	3-3000 120-240	8.6	57
E8	0.15	3-3000 240-240	10.2	68.3
E9	0.1	2-3000 120-240	4.4	44

(a) E1 to E8 were synthesized in cyclohexane and these syntheses are named external synthesis. E9 was synthesized in polyprolactone 500, this synthesis is named in-situ synthesis.

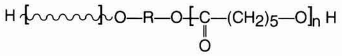
weight is 174 g, without the splitting of uretidione ring. The chemical structure of di-TDI is the following:



The encapsulating agent ethylene diamine or EDA (T_{ev} = 116°C, molar mass = 60.1 g) was purchased from Fluka and used as an encapsulation agent. It was distilled before use.

Polycaprolactone PCL 500 and PCL 1000, which are OH terminated saturated polyesters, were purchased from Solvay Interox under tradename CAPA 200 (molar mass 535) and CAPA 210 (molar mass 993), respectively. PCL 500 has an hydroxyl index of 210 mg KOH/g, and its melting point is about 20°C. PCL 1000 hydroxyl index is 113 mg KOH/g, and its melting point is in the range of 30-40°C. These two OH terminated polycaprolactones were dried under vacuum at 70°C during one or two hours in order to eliminate all traces of humidity that can react with NCO groups.

Polycaprolactone chemical formula given by Solvay is shown in the following.



$$H\{\sim\sim\sim\sim\}\!\sim O—R—O\!\left[\underset{\underset{O}{\|}}{C}—(CH_2)_5—O\right]_n H$$

Synthesis

External Synthesis: According to a procedure described in reference 12, 10 g of di-TDI (0.0575 mol, of free NCO) were dispersed in 30 g of anhydrous cyclohexane (nonsolvent) with an Ultra-Turrax T50 (IKA Labortechnik-Germany) at 3,000 rpm for three minutes and at room temperature, 0.173 g of ethylene diamine (5.75 × 10^{-3} mol of NH_2) were introduced at this stirring rate for two minutes. Then the whole system was stirred with another stirrer at 300 rpm, under nitrogen, at room temperature for two to three hours. At the

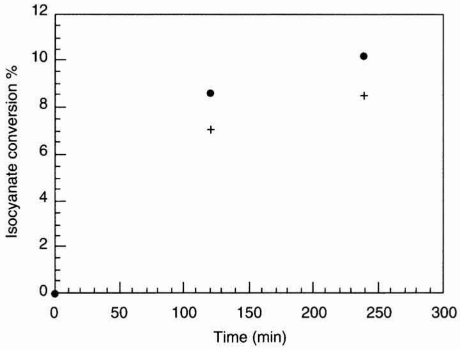


Figure 1—Isocyanate conversion versus time (+) 0.1 and (•) 0.15 mol NH_2/mol NCO.

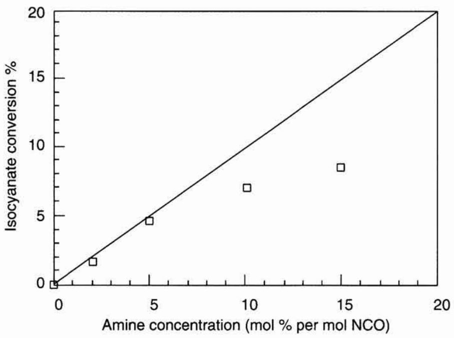


Figure 2—Isocyanate conversion versus introduced amine amount after two hours of reaction.

end, the microcapsules were isolated by filtration and washed with cyclohexane. They were dried under vacuum at 30-40°C for 10-20 hr.

In-Situ Synthesis: The microencapsulation was also conducted in PCL 500. First, 25 g of di-TDI were dispersed in 72.8 g of PCL 500 at 3,000 rpm for 2 min. Then the reactor was immersed in a cooling bath to avoid a temperature higher than 30°C. After that, the ethylene diamine (0.431 g, i.e., 10 mol % per di-TDI) was added under agitation at 300 rpm. The reaction went on for four hours under N_2. The reactive mixture of the in-situ synthesis contained three types of reactive groups NCO, OH, and NH_2 that were used according to the following equation:

$$[NCO]_{di-TDI} = [OH] + [NH_2] \qquad (1)$$

The total NCO concentration is 4-NCO/mol of di-TDI.

Analysis

Chemical Titration: The chemical titration was used to determine the amine consumption during the microencapsulation. The residual amine was extracted from the reactive mixture with water, which is a good solvent for ethylene diamine. The cyclohexane phase and microcapsules were washed with water until pH = 7. The residual amine was determined by titration with HCl 0.5 N or 0.1 N using a green color indicator of bromocresol. It is worth noting that the microcapsules washed with water will not be used later for the dispersion in polyol phase. The amine amount reacted during the microencapsulation process was calculated according to:

$$\alpha_{NH_2}(\%) = \frac{[NH_2]_i - V_{HCl}\, N_{HCl}}{[NH_2]_i} \times 100 \qquad (2)$$

where $[NH_2]_i$ is the initial number of mol of NH_2 groups, V_{HCl} is the volume of HCl of 0.5 or 0.1 N necessary to the titration.

DSC Analysis: The differential scanning calorimetry (DSC) thermograms were obtained under argon in a Mettler TA3000 apparatus. Samples of 10-20 mg were tested in crimped aluminum pans. Indium was used as standard. The heating rate was 10 K.min^{-1}.

Microscopy: The sample (powder or dispersion) was placed between glass plates and is observed with a Carl Zeiss optical microscope. For scanning electron microscopy (SEM) observation, the powder was dispersed in cyclohexane and put on a glass plate. The cyclohexane evaporates, and the sample metallized with gold was analyzed under a JEOL 840A microscope.

RESULTS AND DISCUSSION

Influence of Different Parameters of Reaction on the Microencapsulation Process

Different tests of microencapsulation were carried out in cyclohexane, except one in polycaprolactone 500. Several concentrations of ethylene diamine (0.02-0.15 mol NH_2/mol NCO) were used. The amine conversions were obtained by chemical titration and from these results the isocyanate conversions were calculated by difference. All results are summarized in *Table* 1.

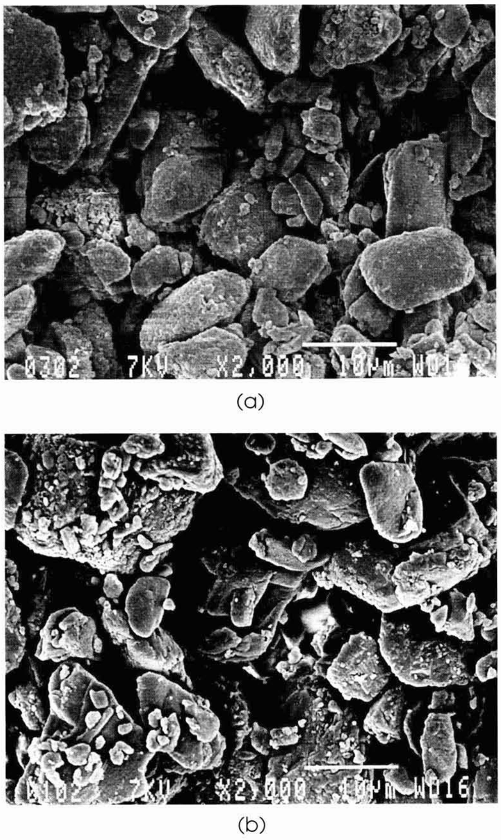


Figure 3—(a) Micrographs of di-TDI; and (b) microcapsules E5 (X2000).

We can see easily that the stirring with Ultra-Turrax during three minutes improves the isocyanate and amine conversions. In fact, in the case of E_2, α_{NCO}, and α_{NH2} are equal to 6.5 and 65%, respectively. They increase to 8.5 and 85% in the case of E4, an increase of about 20-30%. The Ultra-Turrax apparatus ensures a good dispersion of fine particles. Thus, the specific surface of di-TDI will be important to react with amine. Stirring at only 300 rpm gives some agglomerates.

Not only the stirring by Ultra-Turrax influences the microencapsulation but also the reaction time. Effectively, α_{NCO} and α_{NH2} increase from E1 to E4 (*Table* 1). This is available for either E7 or E8. *Figure* 1 shows the isocyanate conversion versus time which would stabilize beyond 240 min for both concentrations 0.1 and 0.15 mol NH_2/mol NCO. There is only a slight difference between the values of α_{NCO} at 120 min and those at 240 min. Thus, we can think that above 240 min, α_{NCO} reaches a plateau. The reached plateau depends on the specific surface of particles and on the nature of the capsule shell. When the polyurea shell is formed, the

Table 2—Isocyanate Equivalent Weight for Some Microcapsules

Samples	Isocyanate Conversion (%)	Without Splitting of Uretidione E (g)	Splitting of Uretidione E(g)
Pure di-TDI	0	174	87
E4 (10% EDA) washed with water	8.5	192.9	91.6
E5 (5% EDA) washed with water	4.7	184.1	89.8
E4 (10% EDA) washed with cyclohexane	10	196.7	93.2
E5 (5% EDA) washed with cyclohexane	5	184.7	90

kinetics are controlled by the diffusion of monomers through the shell-core interface. The activity in this region depends on reactivity of monomers and on the physical properties of the first oligomers which were formed previously.[13]

Figure 2 shows the influence of the introduced amine amount, α_{NH2} increases initially with increasing amine concentration. A plateau is reached towards 0.1 mol NH_2/mol NCO. Moreover, the deviation from the theoretical line (complete reaction) increases slightly with increasing amine concentration. We can approach a maximum consumption of amine at the interface. Blum[14] has shown by chemical titration that only 2 mol% of a polyamide α,ϖ-diamine were consumed in the encapsulation of di-TDI. This value is clearly lower to our values. This difference can be attributed to different experimental parameters and to the nature of the amine (reactivity, hindrance).

Finally, the microencapsulation in PCL 500 leads to a decrease in α_{NH2}. If we compare samples E3 and E9, α_{NH2} decreases from 71 to 44%. We can think that the following different parameters can influence the reaction between NCO groups and EDA. The solubility of EDA is probably higher in PCL than in cyclohexane and the viscosity of PCL is higher than that of cyclohexane. These factors can reduce the reaction rate between NCO at the surface of di-TDI particles and NH_2. The diffusion through the interface depends also on the swelling of the shell by the encapsulating medium. Moreover, there is no reaction between OH groups of PCL 500 and NH_2 groups of EDA.

Characterization of Microcapsules

The microcapsules were obtained as a white powder. The surface analyses were difficult because of the low conversion of NCO (<10%) at the surface of di-TDI particles. We may have a formation of a thin polyurea shell, which is probably not continuous because of the irregular morphology of the initial di-TDI particles. We have tried to characterize the chemical structure surface of microcapsules by diffuse reflectance infrared Fourier transform spectrometry, but we observed no difference between the initial di-TDI particles and encapsulated di-TDI particles, because of the low mass fraction of the shell (2% b.w.).

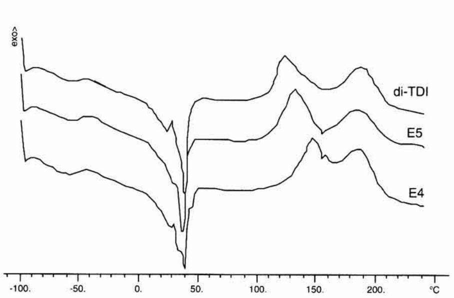
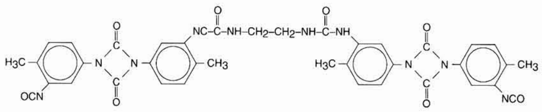


Figure 4—DSC thermograms of pure di-TDI, microcapsules E4 and E5 dispersed in PCL 1000 at time t=0.

The initial and encapsulated di-TDI particles were analyzed by optical and scanning electron microscopies. The micrographs are given in *Figures* 3a and b. The initial di-TDI particles show a heterogeneous morphology with a dispersed granulometry (*Figure* 3a). We observed a smooth, porous, and irregular surface. The particles are not spherical, but they are probably in flake form. The morphology of encapsulated di-TDI (E5) remains almost unchanged (*Figure* 3b). With either optical microscopy or scanning electron microscopy, we cannot characterize the porosity or surface of the microcapsule shell. But for the almost spherical particles, these techniques give a diameter varying between some microns and 30 microns; the average value is about 10 μm.

For the mixing with polycaprolactone, we must calculate the isocyanate equivalent weight of microcapsules. The reaction between di-TDI and ethylene diamine leads to the formation of a urea shell. The NCO functions are in excess with respect to NH_2 functions. Thus we can consider that the oligomer of smallest molar mass that can be formed during the microencapsulation process is the following:



The uretidione group is a blocked source of isocyanate groups which are released by the splitting of uretidione group near the melting point of di-TDI (156°C).[14,15] So the isocyanate equivalent has been calculated in two possible cases.

1. Calculation of NCO equivalent without uretidione splitting:

$$E=\frac{E_{dimer}+xE_{NH_2}}{(1-x)} \qquad (3)$$

Table 3—Melting Enthalpies and Melting Temperature of Pure di-TDI and Encapsulated di-TDI

Samples	ΔH_m (J/g)	$T_{m\ onset}$ (°C)
di-TDI	119.8	156
E5	110	152
E4	112	150.5

where

E_{dimer} is NCO equivalent of di-TDI unsplitted, equal to 174 g
E_{NH2} is NH_2 equivalent of ethylene diamine, equal to 30 g
x is the molar conversion of NH_2 per mol of NCO ($x=\alpha_{NCO}$)

2. Calculation of NCO equivalent with uretidione splitting:

At elevated temperatures, if all of uretidione rings are splitted giving two NCO groups, NCO equivalent will be:

$$E = \frac{2\,E_{TDI} + x(E_{NH_2}/2)}{(2-x)} \qquad (4)$$

where

E_{TDI} is NCO equivalent of toluene diisocyanate (87g)
E_{NH2} and x have the same meaning as in case 1

For the mixing with species that is reactive in isocyanates, e.g., a polyol, if the reaction between NCO and OH takes place at low temperatures (under 156°C), equation (3) is applied because in this range of temperature the uretidione ring remains unbroken. Otherwise, at temperatures higher than 156°C, equation (4) must be taken into account because of the uretidione dissociation giving two NCO groups. The characteristics of obtained material depend on the ratio NCO/OH. The excess or default of each function leads to a decrease in thermal and mechanical properties.

Table 2 summarizes the NCO equivalent values for different samples. Microcapsules used for the dispersions in polycaprolactone were washed with cyclohexane after their synthesis, but it does not eliminate residual EDA. These residual NH_2 groups are consumed when the system is reactivated at high temperature so in that case, x must represent the initial ratio of NH_2 per mol of NCO, in equations (3) and (4).

The DSC thermogram of pure di-TDI shows a melting point at 156°C. A scan to 250°C provokes 100% of mass loss, the TDI evaporates at 250°C. The melting temperature of encapsulated di-TDI decreases, the lowest value is obtained for E4 (α_{NCO} = 8.5%) with respect to E5 (α_{NCO} = 4.7%) (*Table* 3). The microencapsulation also leads to a decreasing melting enthalpy, but the relatively low difference has not been quantified and did not vary logically with the amine ratio.

Behavior and Reactivity of Microcapsules in Polycaprolactone

The microcapsules obtained from the syntheses in cyclohexane were dispersed in polycaprolactone, PCL 500 and PCL 1000. The reactive mixtures were carried out with stoichiometric ratio, for example, 0.93 g of E4 (E = 93.2 g/mol, NCO in case of uretidione dissociation) and 4.96 g of PCL 1000 (E = 496 g/mol OH). These reactive mixtures were stored at room temperature when PCL 500 ($T_m \approx 23$°C) was used. The mixture prepared with PCL 1000 was stored at 40°C in an oven due to its higher melting temperature ($T_m \approx 40$°C). In both cases we have liquid mixtures.

Figure 4 shows different features of DSC thermograms obtained from pure di-TDI, microcapsules E4 and E5 in PCL 1000. These analyses were conducted immediately after the mixing of the two components. The thermograms show several transformations from –100°C to 250°C. We can see clearly the glass transition temperature of PCL 1000 at –80°C, then the crystallization at –40°C followed by its melting

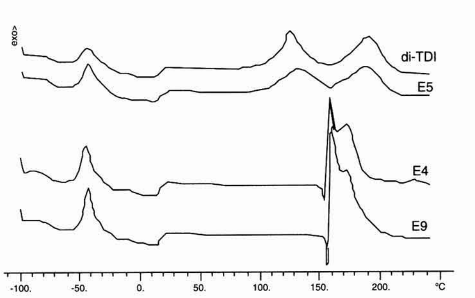


Figure 5—DSC thermograms of pure di-TDI, microcapsules E4, E5, and E9 dispersed in PCL 500 at time t=0.

Table 4—NCO Conversion of Different Systems in PCL 500 at Room Temperature and in PCL 1000 at 40°C With or Without Catalyst, After 200 hr of Storage

Systems	α_{NCO} in PCL 500	α_{NCO} in PCL 1000	α_{NCO} in PCL 1000 with 0.01% b.w. of DBDL Sn
di-TDI	0.3	0.40	0.44
E4 (48 hr)	≈0	0.15	
E4 (22 days)	0.05		0.1
E5	0.15	0.25	0.38
E9	0.1		

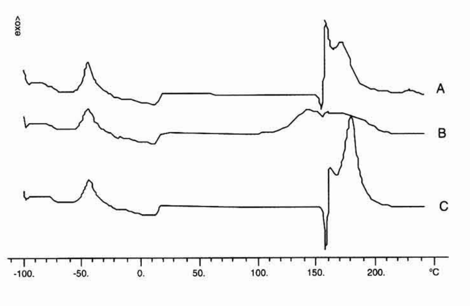


Figure 6—DSC thermograms of microcapsules E4 dispersed in PCL 500 at time t = 0. (A) E4 48 hr after their synthesis; (B) E4 22 days after their synthesis; (C) E4 22 days after their synthesis with three percent EDA added (mol NH_2/mol NCO).

between 0 and 50°C. The first exotherm (between 110 and 140°C) corresponds to the reaction between OH and free NCO. The second exotherm (between 170 and 220°C) corresponds to the reaction of uretidione ring.[15] Moreover, an endotherm is seen about 157°C, derived from the melting of di-TDI inside the microcapsules (*Figure* 4).

The unactivation of the particle surface of di-TDI leads to a shift of the first exotherm to higher temperatures, 126°C for the pure di-TDI, 133°C for E5 (0.05 mol NH_2/mol NCO), and 149°C for E4 (0.1 mol NH_2/mol NCO). Therefore, the reaction of the microcapsules takes place at higher temperatures, but it evolves before the fusion of the contents in the microcapsules at 157°C. The melting enthalpy is about 3 J/g, that corresponds to three percent of the value measured for pure di-TDI. Thus, we can suggest two explanations. The first is that the melting enthalpy is partially masked by the exotherm derived from OH and free NCO reaction. The second one is that the polyurea shell is porous. During the temperature scan, there is a slow diffusion of di-TDI through the shell and consequently its dissolution in PCL phase. According to the latter hypothesis, the little endotherm peak could correspond to the melting of residual encapsulated di-TDI. This second explanation is more probable than the first one since the thermogram features of E4 and E5 look like that of pure di-TDI (*Figure* 4).

Figure 5 shows different thermogram features of pure di-TDI, E4, E5, and E9 in PCL 500. There are two quite different behaviors for the three kinds of microcapsules. E5 gives the same thermogram as E5 and E4 in PCL 1000 (*Figure* 4). But E4 gives another curve, the reaction between OH and free NCO (first exotherm) takes place only after the capsule melting at 157°C. This result means that the polyurea shell forms a good barrier to protect the di-TDI particles. The reaction between free NCO, uretidione ring, and OH takes place only after the melting of di-TDI inside the microcapsules. This is an ideal behavior. Moreover, E5 in PCL 500 does not have the same behavior as E4, this is probably due to the lower isocyanate conversion during the microencapsulation process (*Figure* 5). α_{NCO} is equal to 4.7 and 8.5% for E5 and E4, respectively (*Table* 1).

Effect of Residual EDA

Our experiments have shown an effect of residual ethylene diamine stored with the microcapsules after the synthesis. *Figure* 6 illustrates this result. The microcapsules E4 stored 48 hr after their synthesis and then mixed in PCL 500 results in ideal behavior (*Figure* 6a). When the microcapsules are 22 days old, they give the thermogram 6b a similar curve as that obtained in PCL 1000. The reaction begins before the capsule melting (*Figure* 4). The addition of three percent EDA (mol NH_2/mol NCO) during the dispersion of E4 aged 22 days in PCL 500, reinforces again the polyurea shell (*Figure* 6c). So residual EDA stored with microcapsules synthesized in cyclohexane can react with NCO in a post-reaction in the polycaprolactone, due to the swelling of the polyurea shell in the polycaprolactone; hence, the diffusion of isocyanate across the polyurea shell is favored to react with EDA. Whereas, during the storage of the capsules, residual EDA can be deactivated by oxidation reaction or can evaporate.

The microcapsules E4 give two different thermograms in PCL 1000 (*Figure* 4) and in PCL 500 as high in PCL 500 than

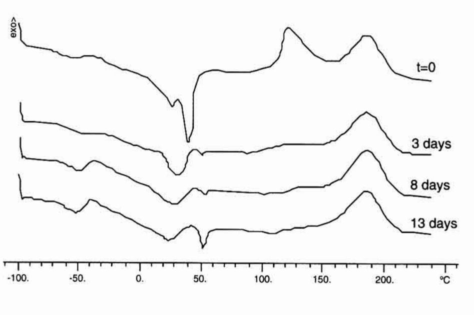


Figure 7—DSC thermograms of di-TDI in PCL 1000 stored at 40°C.

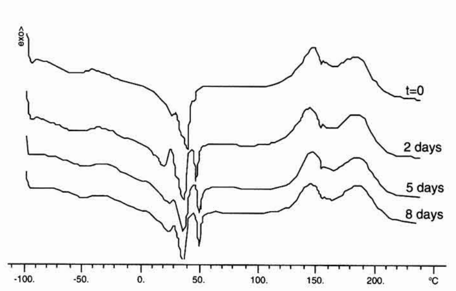


Figure 8—DSC thermograms of E4 in PCL 1000 stored at 40°C.

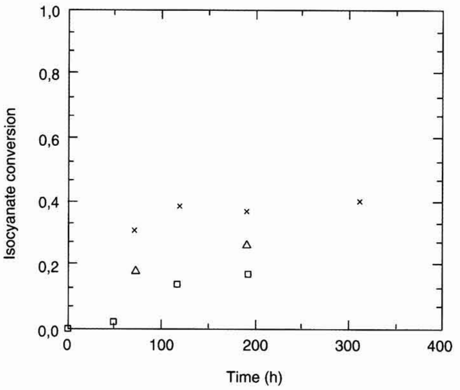


Figure 9—Isocyanate conversion versus time of the dispersions in PCL 1000 at 40°C (x) di-TDI, (Δ) E5, (□) E4.

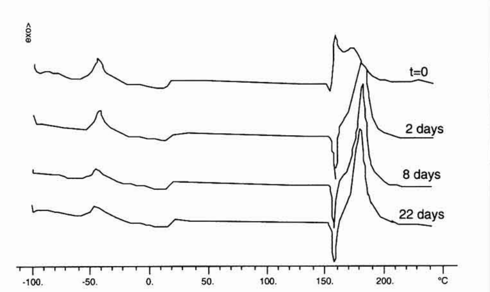


Figure 10—DSC thermograms of E4 aged 48 hr stored in PCL 500 at 25°C.

in PCL 1000, therefore, the residual amine concentration is higher in PCL 500. Second, the mixing of microcapsules and PCL takes place at room temperature and at 40°C for PCL 500 and PCL 1000, respectively.

Stability of Microcapsules in Polycaprolactones

The stability of the one-component systems (microcapsules mixed in PCL) during the storage was evaluated by DSC analysis. The conversion of the reaction between NCO and OH was calculated by

$$x = 1 - \frac{\Delta H_r}{\Delta H_t} \qquad (5)$$

where ΔH_r is the residual enthalphy

ΔH_t is the total enthalpy obtained by integration of both exotherms, ΔH_t = 61 kJ/mol NCO

Figure 7 shows the evolution of the mixture di-TDI/PCL 1000 during storage at 40°C. The first exotherm peak at 120°C corresponding to the reaction of OH and free NCO of di-TDI decreases with storage time.[15] While the second exotherm at 170°C, related to the reaction between uretidione ring with OH, remains almost unchanged. Globally, the system is unstable and isocyanate conversion tends towards 0.5. The melting peak of PCL 1000 changes with storage time; it is normal because reaction occurs but apparently larger size crystals are formed and melt at higher temperature (endotherm at 50°C).

In the case of E4, the melting peak of PCL 1000 presents the same change as previously. But the first exotherm decreases slightly (*Figure* 8). Similar DSC responses were obtained with the microcapsules E5 but the system was not completely stable.

Figure 9 shows the comparison between pure di-TDI, E4 and E5. After eight days of storage in PCL 1000 at 40°C, the isocyanate conversion reaches the values of 0.40, 0.23, and 0.16 for di-TDI powder, E5 and E4 microcapsules, respectively. During the storage only the reaction of NCO at the capsule surface is possible.

In the PCL 500 at room temperature, the di-TDI has the same behavior as in the PCL 1000. The isocyanate conversion is 0.40% after 12 days. As seen previously, the microcapsules E4 gave different features of DSC curves, depending on the ratio of residual ethylene diamine in the reactive medium. *Figures* 10 and 11 illustrate the thermograms obtained with E4 aged 48 hr and 22 days, respectively. Both figures show that all thermograms have the same feature as that at t = 0. Microcapsules E4 aged 48 hr maintain an ideal behavior, moreover the melting peak appears not clearly after two days of storage, the polyurea shell was reinforced by the reaction of residual ethylene diamine (*Figure* 10).

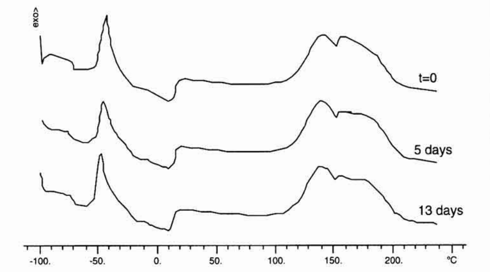


Figure 11—DSC thermograms of E4 aged 22 days stored in PCL 500 at 25°C.

Microcapsules E4 aged 22 days does not have the same ideal behavior (*Figure* 11), but it gives good stability in PCL 500 like E4 aged 48 hr. The isocyanate conversion is only 0.03 after 13 days (*Figure* 13).

As for microcapsules E9 synthesized in-situ (in PCL 500), they give an ideal behavior after 4 hr of storage at 25°C. Then, the melting endotherm disappears after 22 days and the exotherm begins at 135°C (*Figure* 12). The exotherm is displaced at low temperature during storage but the mixture remains relatively stable. Compared to the microcapsules E4, the polyurea shell formed in the polycaprolactone (E9) does not have the same physical properties, the permeability is different at high temperature but the stability at room temperature is similar.

Figure 13 shows the isocyanate conversion of di-TDI, microcapsules E4, E5, and E9 in PCL 500 at room temperature. E4 is more stable than E9 and E5. However, the α_{NCO} versus time is lower in PCL 500 than in PCL 1000. Storage at 40°C slightly increases the permeability of microcapsules.

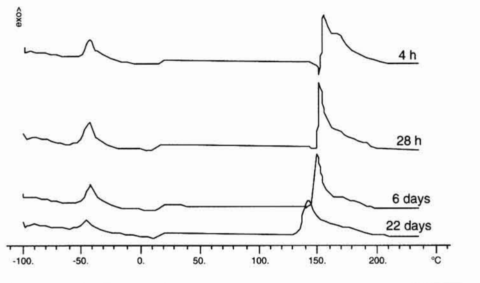


Figure 12—DSC thermograms of E9 synthesized in PCL 500 at 25°C.

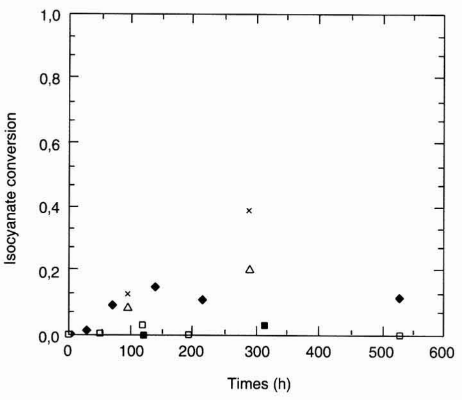


Figure 13—Isocyanate conversion versus time of the dispersions in PCL 500 at room temperature (x) di-TDI, (Δ) E5, (□) E4 aged 48 hr, (■) E4 aged 22 days, (◆) E9.

Table 4 summarizes the NCO conversion of several systems during the storage in PCL 500 and PCL 1000 at room temperature and at 40°C, respectively. The catalyst dibutyl tin dilaurate (DBDLSn) frequently used to catalyze the reaction OH/NCO was added in PCL 1000. We observed a decreasing temperature of the first exotherm, 100°C instead of 125°C in the case of di-TDI. When the isocyanate is not very well encapsulated, for example E5, in the presence of DBDLSn, the NCO conversion is close to that of di-TDI, α_{NCO} equal to 0.38 instead of 0.44. Moreover with E5, α_{NCO} increases from 0.15 (in PCL 500 at room temperature) to 0.25 (in PCL 1000 at 40°C) and finally it reaches the values of 0.38 by the action of catalyst.

After 200 hr of storage, E4 (aged 22 days) shows a very good stability, α_{NCO} is only 0.05 in PCL 500 and $\alpha_{NCO} = 0.1$ in PCL 1000 at 40°C, even in the presence of DBDLSn. E9 also shows a satisfactory behavior ($\alpha_{NCO} = 0.1$ in PCL 500). However, E4 is the capsule the most stable among the whole of studied capsules.

CONCLUSION

The microencapsulation of toluene 2,4-diisocyanate dimer was carried out in cyclohexane and in a polycaprolactone PCL 500, according to the process of interfacial polycondensation with ethylene diamine. The microencapsulation was improved by stirring with an Ultra-Turrax apparatus, because of a good dispersion of the initial isocyanate particles. It was also improved by increasing the reaction time and amine concentration.

An ideal behavior, i.e., reaction after diisocyanate dimer melting was obtained with 10% by mol of ethylene diamine. If the shell is porous or permeable, the reaction NCO/OH can begin before the microcapsule melting, due to diffusion of reactants through the interface. A supplementary adding of amine can reinforce the polyurea shell.

The storage stability of toluene 2,4-diisocyanate dimer powder and its various microcapsules were compared. The microcapsules showed a good stability in polycaprolactone at room temperature and 40°C. When isocyanate was well encapsulated, addition of catalyst to the polycaprolactone did not decrease the stability.

It is desirable to obtain a good stability associated with an easy reactivation of the mixture near the melting point of the diisocyanate dimer. So the nature and the amount of the deactivating agent amine are important factors.

In conclusion, this study proposes the dispersion of encapsulated isocyanate into a species that is reactive with isocyanate, e.g., polyol, polyamine, as a one-component system that could be cured at an elevated temperature. In this scheme the isocyanate would be encapsulated and "reactively insulated" from the polyol or polyamine until the heat cure.

ACKNOWLEDGMENTS

The authors are grateful for financial support provided by Cray Valley.

References

(1) Wicks, Z., *Prog. Org. Coat.*, 9, 3 (1981).
(2) Quérat, E., Tighzert, L., and Pascault, J.P., *Die Angew. Makrom. Chem.*, 219, 185, (N_R. 3835 (1994).
(3) BASF A.G., U.S. Patent 4,888,124 (1989).
(4) Janssen, L.J.J.M., Boersma, A., and Nijenhuis, K.te., *J. Membr. Sci.*, 79, 11 (1993).
(5) Arshady, R., Pol. Eng. Sci., 29, 1746 (1989).
(6) Thies, C., "Microencapsulation," in *Encyclopedia of Polymer Science and Engineering, 2nd Ed.*, John Wiley & Sons, New York, 1987.
(7) Morgan, P.W., "Interfacial Polymerization," in *Encyclopedia of Polymer Science and Engineering, 2nd Ed.*, John Wiley & Sons, New York, 1987.
(8) Arshady, R., *J. Microencaps.*, 6, 13 (1989).
(9) Koischi, M., Fukhara, N., and Kondo, T., *Chem. Pharm. Bull.*, 17, 4, 804 (1969).
(10) Arshady, R., *Pol. Eng. and Sci.*, 30, 905 (1990).
(11) Kalle, A.G., U.S. Patent 3,409,461 (1968).
(12) BASF A.G., U.S. Patent 4,400,497 (1983).
(13) Machuga, S.C., Midge, H.L., Peanasky, J.S., Macosko, C.W., and Ranz, W.E., *AIChE*, 34, 7, 1057 (1988).
(14) Blum, R. and Schupp, H., *Prog. Org. Coat.*, 18, 275 (1990).
(15) Quérat, E., Tighzert, L., Pascault, J.P., and Dusek, K., *Polymer*, submitted for publication.

Feature Article

A Review of Radiation Curing: New Surface Control Additives

Karen Bowling—Tego Chemie Service USA
Jay Adams and Susanne Struck—Tego Chemie Service GmbH*

Radiation curing is a process whereby reactive liquids are transformed into solid crosslinked networks by exposing them to radiant energy—specifically ultraviolet light (UV) or electron beam (EB). Since its commercial introduction into the coatings industry nearly 30 years ago, radiation curing technology has benefited from an extremely steady growth rate. During the 1980s the radiation curing coatings market grew at an annual rate of 15% a year. It is expected to see nearly 10% annual growth through the year 2000, increasing the total shipment of radiation curable coatings to approximately 86 million pounds or 40,000 metric tons.[1] There are two main mechanisms that come into play with radiation curing. These are a free radical mechanism and cationic mechanism. This article and many of the review items pertain only to free radical curing of acrylates and other ethylenically unsaturated molecules.

The market segments within the coatings industry which have seen the greatest increase in radiation curing activity are paper, wood and flooring, metal, and plastics. Paper coatings include overprint varnishes for paperback books, magazines, and conventional graphics, folding cartons and packaging, lottery tickets, and business forms. UV and EB coatings for wood are used for furniture and kitchen cabinets, hardwood flooring, doors, and wood filler for particle board. Metal coatings are comprised of can printing inks and varnishes, coatings for lids and closures, coil coatings, and automotive finishes. Radiation cured systems are currently used on plastics for vinyl floor tile, credit cards, compact discs, release film, and plastic labels. These are but a few of the many examples that could be provided to show the development of the radiation curing coatings market. It is obvious that radiation curing is quickly moving away from being a niche segment of the coatings industry and towards a major growth factor in it.[2]

This increase in acceptance and usage of radiation curing was originally fueled by the environmental advantages of the technology, but in recent years it has been powered by performance merits. UV and EB curing systems are environmentally clean since they generally are 100% active and usually contain no solvent, therefore eliminating VOCs. Furthermore, the curing process does not generate any other by-products. This eliminates the need for any special exhaust or incineration equipment. Furthermore, the space required to house radiation curing equipment (UV light cabinets or electron beam unit) is much less than for the large ovens used for conventional coatings. The energy required to polymerize a UV or EB coating is much lower than that is necessary to volatilize water or solvents from conventional coatings, resulting in decreased energy costs. Performance advantages of radiation-curing systems over traditional coatings include higher gloss, scratch and abrasion resistance, unlimited substrate choice, high solvent and chemical resistance, and increased coating line speed which translates to higher productivity.

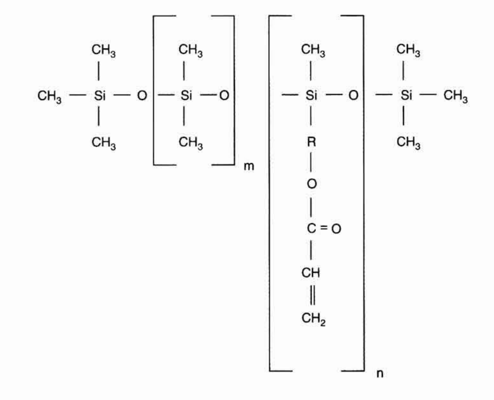
Though there are many advantages to radiation curing, it would be unwise to suggest that there are no disadvantages to this technology. Some of the disadvantages are: higher raw material costs, higher raw material viscosities, possible skin irritation by certain raw materials (low molecular weight acrylate monomers), poor adhesion to some substrates (plastic, vinyl, metal), difficult-to-control gloss (high viscosity starting materials makes flattening UV- and EB-curing coatings difficult), and higher equipment costs in the case of EB.

The chemistry and cure process for radiation-curing coatings is different from that of conventional coatings. Therefore, formulation parameters for these systems will be presented. Later, a brief description of free-radical polymerization in radiation-curing systems will be provided.

Formulation Parameters for Radiation-Curing Coatings

A complete formulation for a radiation-curing coating can be a mixture of the following:[3]

- Oligomers, which provide the final cured film with its ultimate performance properties.



Silicone Acrylate

Presented at the Waterborne, High-Solids and Powder Coatings Symposium, on February 22-24, 1995, in New Orleans, LA.

*Gerlingstr. 64, D-45139, Essen Germany.

Table 1—Monomer Selection

Property Desired	Selected Monomer
Viscosity reduction	Mono-functional: hydroxyethyl acrylate, N-vinylpyrollidone. Difunctional: hexanediol diacrylate, tripropyleneglycol diacrylate
High crosslink density	Multifunctional: trimethylolpropane triacrylate, glyceryl propoxy triacrylate, pentaerythritol triacrylate
Flexibility	Hexanediol diacrylate, tripropyleneglycol diacrylate
Adhesion	N-vinylpyrrolidone, beta-carboxyacrylate, hydroxyethyl acrylate
Cure speed	High functionality: functionality must be balanced against other desired properties

- Mono- or Multifunctional monomers, which assist in viscosity reduction as well as crosslink density of the cured film. Most commercially available monomers and oligomers for free radical radiation curing are acrylates, which are the fastest curing. Other monomers used, though to a much lesser degree, are methacrylates and allylic and vinylic compounds (styrene). The common feature of all of these materials is the ethylenic unsaturation or carbon-carbon double bond.
- Additives, which provide the desired system specific properties.
- Photoinitiator for UV systems, which transform the energy from light into free radicals initiating the polymerization process. Photoinitiators are not needed in EB-cure formulations.

Oligomer Selection

The performance properties of any UV or EB coating are determined principally by the oligomer(s) used in the formulation. Most of the commercially available oligomers used in free-radical initiated radiation curing systems are based on acrylated compounds. Oligomers are usually relatively low in molecular weight (approximately 400 to 700) and are chosen based on desired properties. The structures most commonly employed are the following:

Epoxy Acrylates—Impart very fast cure speed, hardness, chemical resistance, and lower cost to a formulation. However, these high viscosity oligomers also contribute poor exterior durability and high viscosity. Epoxy acrylates are used extensively in paper coatings where fast cure speed is essential.

Urethane Acrylates—These high viscosity compounds are known for their flexibility, toughness, good adhesion, and superior weathering. Urethane acrylates tend to be used more in high-performance coatings (i.e. for plastics).

Polyether Acrylates—Provide relatively low viscosity, flexibility, and abrasion resistance.

Polyester Acrylates—Are used mainly as reactive diluents; and are also used in wood coatings.

Acrylic Acrylates—Promote good weatherability and improved adhesion, but give soft films. Acrylic acrylates are often used in adhesive applications.

Unsaturated Polyesters—Low-cost oligomers which are also extremely slow in curing. Primary application for these oligomers is in the wood finishing industry where their slow cure speed is not a problem.[4]

Monomer Selection[5]

In radiation-curing formulations, monofunctional monomers are usually used as diluents to reduce coating viscosity. However, their presence can also have a great effect on other coating properties such as adhesion promotion or flexibility (either increase or decrease). Multifunctional monomers also serve to reduce viscosity, however, they are usually chosen based on their ability to form the crosslinks between oligomers and with other monomers in the formulation. To this end, the choice of multifunctional monomer contributes to the resulting properties of flexibility, crosslink density, and cure speed. *Table* 1 provides some examples of monomer choices to achieve specific performance characteristics.

In addition, in *Table* 2 see the differences in viscosity reduction and cure speed afforded by use of particular monomers. It is especially interesting to note the effect styrene and methacrylates have on coating cure speed.

Photoinitiator Selection for UV-Curing Systems

Before photoinitiator selection for UV-curing coatings is discussed, it is best to have a description of the curing mechanism in UV and EB coatings, specifically free-radical polymerization.

Free Radical Polymerization[6]

The free radical mechanism is the primary curing reaction. It is similar for both UV and EB systems. The difference between the two is the means by which these radicals are generated. A simplistic view of the mechanism (see *Table* 3) for UV curing is as follows:

Step 1. When the coating is exposed to UV radiation in the wavelength range of 200-400 nm the photoinitiator is excited and subsequently breaks down, forming free radicals.

Step 2. The free radicals react with double bonds in the UV-curing system to form propagating chain species. This step is crucial since it governs the rate of reaction and, therefore, the cure speed of the coating.

Steps 3-4. The final step is chain transfer and/or termination. At this point the polymerization ends as the reactive sites are terminated by large relatively less reactive chains or by dual free radical addition to the carbon-carbon double bond.

In the case of electron beam curing, the accelerated electrons themselves interact with the unsaturated groups within the oligomer/monomer system. In this case, no photoinitiator is necessary to produce reactive

Table 2—Effect of Monomer Selection on Viscosity and Cure Speed (Blend: 70% Epoxy Acrylate: 30% Monomer)

Monomer	Viscosity (m Pas)	Cure Speed (M/min/lamp)
Styrene	1000	04
Hydroxyethyl acrylate	1180	20
N-vinyl pyrrolidone	1400	25
1-6 hexanediol diacrylate	2088	65
Tripropyleneglycol diacrylate	7550	35
Trimethylolpropane trimethacrylate	10440	05
Pentaerythritol triacrylate	25000	35
Trimethylolpropane triacrylate	25400	65

Table 3—Free Radical Polymerization[7]

1. Initiation

$$R \xrightarrow{\text{UV or electrons}} R^{\circ}$$

R = photoinitiator
R° = free radical

2. Propagation

$$R^{\circ} + R_1 \longrightarrow RR^{\circ}_1$$

R_1 = polymer chain

3. Chain Transfer

$$RR^{\circ} + AH \longrightarrow RR_nH + A^{\circ}$$

R°_n = chain of n units long
AH = AH can stand for an amine, such as n-methyl diethanol amine.

4. Termination

$$R_n + R^{\circ}_m \longrightarrow R_nR_m$$

R°_m = chain terminator, chain of m units long with a free radical

species. Otherwise, the subsequent initiation, propagation, chain transfer, and termination reactions are very similar to those that occur in UV curing.

A photoinitiator can be defined as a molecule that absorbs UV light energy and is directly involved in the creation of free radicals that initiate polymerization. Usually the photoinitiator concentration is low relative to that of the oligomers and monomers, such that their presence does not negatively affect the cured film. Generally the level of photoinitiator utilized is between 1.0 and 8.0%, based on total formulation. Photoinitiators are benzoin ethers, benzyl ketals, substituted acetophenones, and benzophenone/amine combinations.[8]

There are two main classes of photoinitiators used in free radical curing: hydrogen abstraction photoinitiators and alpha cleavage photoinitiators. The primary hydrogen abstraction photoinitiators are benzophenone and its derivatives and thioxanthones. The process of hydrogen abstraction involves electron excitation of the photoinitiator from a ground state singlet to an excited triplet, followed by electron transfer to a hydrogen atom donor (e.g., amines) with the generation of free radicals.

Alpha cleavage photoinitiation involves the absorption of UV light by the photoinitiator and in the resulting excited state the intramolecular fragmentation to form the initiator species. Examples of alpha cleavage photoinitiators are benzoin ethers, benzyl ketals, and substituted acetophenones.

It should be noted that oxygen inhibits polymerization. For this reason, most EB units are inserted with nitrogen. UV systems either have additional photoinitiator or added amines to overcome the problem. There is an "oxyplex" formed between molecular oxygen and the excited photoinitiator in UV systems. In its complex form, the photoinitiator cannot function and cure speed is either markedly diminished or negated.

Additive Selection

Additives are necessary in radiation-curing coatings to provide the same types of performance properties as are required in conventional coatings. As in other coating systems, pigments, fillers, defoamers, adhesion promoters, flatting agents, wetting agents, slip additives, and stabilizers are utilized in radiation-curing formulations. Often the same additives in conventional coatings are applied in radiation-cured coatings with similar results. However, for UV-cured coatings, it is important to minimize the absorption of light by additives in the frequency range needed to initiate polymerization, so that cure is not affected.

Reactive Silicone-Based Additives

Silicone products are used extensively in the coatings industry to provide surface-active properties such as increased slip, mar and scratch resistance, substrate wetting, improved flow and leveling, and air release. These products function due to their inherent incompatibility in a coating, which allows them to migrate to the coating surface more rapidly. Though it is possible for silicone additives to be used in radiation curing systems, they are not the ideal product to address the aforementioned formulating parameters. This is due to the fact that they are not reactive in a UV or EB coating, in contrast to the oligomers, monomers, and photoinitiators in the formulation. This incompatibility and nonreactivity makes it possible for the silicone to be exuded from crosslinking film, with subsequent migration onto areas of substrate or contact areas where the presence of silicone is undesirable, simultaneously minimizing the effect of the silicone in the very place where it is needed.

To overcome migration problems and deteriorating performance over time, a new class of additives has been developed for radiation-curing systems: silicone acrylates. Combining silicone chemistry with acrylate functionality yields products that are crosslinkable, have little or no tendency towards migration, and provide improvement in flow and leveling, substrate wetting, air release, and slip and release properties as well as scratch resistance.

Within the class of silicone acrylates to be discussed, the structure of the additive determines the specific surface active properties exhibited by each product. It has been found that the ratio of siloxane to acrylate functionality in particular is critical in determining additive activity in coating applications. Product profiles are listed in *Table* 4.

From this information some general comments regarding application and activity can be made about each additive. Comparative testing results for slip and scratch resistance, release and surface tension reduction follows.

Additive 1 exhibits excellent compatibility and flow and leveling properties due to its lower siloxane content and molecular weight. It is soluble in most solvents and acrylate monomers. However, it is not soluble in water. Additive 1 is best suited as a reactive flow aid in clearcoatings and sensitive binder systems.

Additive 2 is a universal surface control additive providing very good compatibility, flow, and slip properties. It is soluble in most solvents and acrylate monomers, and also water due to the polyether modification on the molecule. It is an ideal additive to provide slip and flow properties to clear and pigmented coatings and even waterborne UV-curing systems. The composition of additive 2 is different from additives 1, 3, and 4 due to the presence of polyether moieties.

Additive 3 has excellent slip and release properties due to the PDMS (polydimethyl-

Table 4—Reactive Silicone Product Profiles

Additive	Ratio of Polydimethyl Siloxane to Acrylate	Molecular Weight	Miscellaneous
1	4:1	Lowest	—
2	10:1	—	Polyether modification
3	10:1	—	—
4	25:1	Highest	—

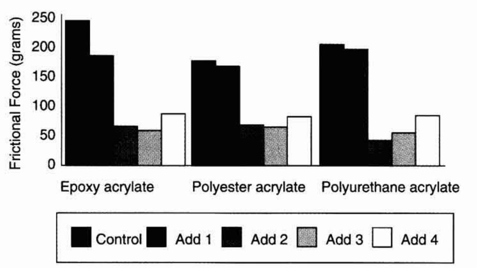


Figure 1—Scratch values in different varnishes (0.1% additive).

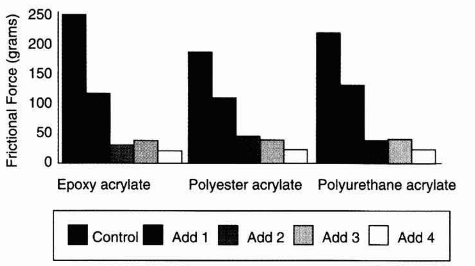


Figure 2—Scratch values in different varnishes (1.0% additive).

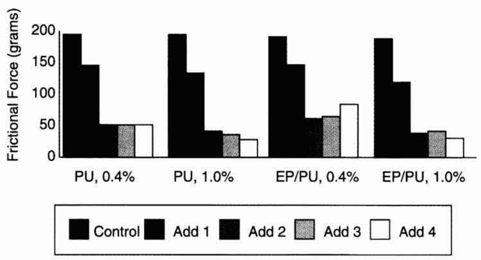


Figure 3—Scratch values in pigmented silk screen inks.

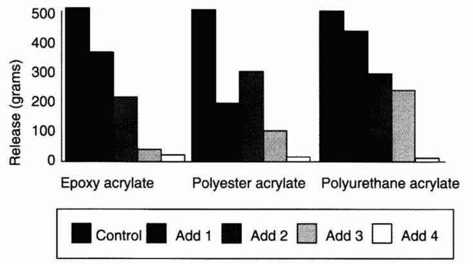


Figure 4—Release values in different varnishes (1.0% additive)

siloxane) content, which helps to orient methyl groups more readily at the surface providing a hydrodynamic lubrication. With this increased molecular weight (taking into account the differences between the molecular weights of additives 1, 3, and 4 as a series of similar compounds with additive 2 being the exception due to its composition) comes increased incompatibility: additive 3 is not soluble in acrylate monomers or water. It should be used in nonsensitive clear coatings and pigmented systems to provide slip and release properties.

Additive 4 is highest in molecular weight and siloxane content of the additives discussed and it therefore has the greatest effect on slip, release, and system compatibility. It should be used only in pigmented systems since it is not soluble in water, acrylate monomers, and some solvents.

Measurements of Slip and Scratch Properties

To measure scratch resistance, a 500-gram weight positioned on three metal tips is pulled across a coated substrate at a constant speed. The friction between the metal tips and the substrate is registered as grams-resistance. The lower the resistance, the lower the friction or scratch value and the greater the effect of the additive. The four additives were compared to scratch resistance at two different levels (0.1 and 1.0%) in three different clear varnishes based on different oligomers, epoxy acrylate, polyester acrylate, and urethane acrylate, respectively.

At 0.1%, additive 1 was not significantly better than the control at reducing the friction caused by the scratch test. However, additives 2 and 3 gave outstanding (and very similar) scratch results, with additive 4 also providing very good scratch resistance.

At one percent, additive 1 reduced the friction induced by the scratch test by roughly 50% over the control, yet it was not as effective as the other additives. In each of the clear varnishes at one percent, additive 4 was the better additive for improvement in scratch resistance, however, additives 2 and 3 were also very good.

The same trends in results was exhibited in two different silk screen inks based on a urethane acrylate and a combination of epoxy acrylate and urethane acrylate, respectively. It should be noted that although additives 2 and 3 exhibit similar scratch results due to their similar molecular weight and siloxane content, additive 2 is much more compatible in the clearcoatings, due to the presence of polyether moieties.

Measurement of Release Properties

To measure release properties, a piece of Scotch® tape is mounted to a coated panel and attached at one end to an electric force registration. As the panel is moved away from the source at a constant speed, the tape is peeled from the substrate. The adhesion force or release is registered as weight in grams. The lower the release value in grams, the greater the effectiveness of the additive. The four additives were compared for release properties at an addition level of one percent in three different clear varnishes based on different oligomers, epoxy acrylate, polyester acrylate, and urethane acrylate, respectively.

In each of the three varnishes, additive 4 provided superior release results to any of the other products, with additive 3 also providing excellent results in the epoxy acrylate coating. Neither additive 1 or 2 exhibited outstanding release values in any of the systems, although both gave better release properties results than the control.

Measurement of Static Surface Tension

The static surface tension reduction properties of each of the additives at two addition levels (0.4% and 1.0%) in an epoxy acrylate overprint varnish was measured via the du Nouy ring method. It was found that each additive had a profound effect on the surface tension, as is seen in *Table* 5.

Table 5—Static Surface Tension Reduction

Sample	Level	Surface Tension
Control	—	35 dynes/cm
Additive 1	0.4%	28.0
Additive 1	1.0%	27.0
Additive 2	0.4%	24.5
Additive 2	1.0%	23.5
Additive 3	0.4%	24.0
Additive 3	1.0%	24.0
Additive 4	0.4%	26.0
Additive 4	1.0%	25.5

From the data presented, it can be seen that structure property relationships can be used to determine the correct reactive silicone additive for a given radiation-curing system. For best compatibility and flow results in any system, plus slip and release properties in clearcoatings, the lower molecular weight and polyether-modified additives, 1 and 2, respectively, should be incorporated. For increased scratch resistance and release properties in pigmented coatings, the higher molecular weight additives, 3 and 4, should be selected.

Conclusion

Radiation curing is one of the fastest growing segments of the paint and coatings markets. Its advantages include VOC elimination, lower energy costs, increased productivity, low capital costs (UV), low equipment space requirements, and high performance coatings. To optimize the performance properties of radiation-curing coatings, additives are a necessity. To overcome migration problems and deteriorating performance over time often seen with typical silicone additives, a new class of reactive additives has been developed for radiation curing systems. These products are crosslinkable, have little or no tendency towards migration, and provide improvement in flow and leveling, substrate wetting, air release, and slip and release properties as well as scratch resistance. This new class of additive combines the positive attributes of silicone chemistry with that of radiation curing, thereby optimizing UV and EB coating performance.

REFERENCES

(1) Pernell, J.E., "U.S. Market Trends for the UV/EB Industry in the 1990s," *Proc. 1992 Radiation Curing Conference and Exposition*, pp. 801-805.

(2) RADTECH International North America, *Radiation Curing Primer I*, p. 15.

(3) Elias, P., "UV/EB Curing Technology: Making Headway in Technology and Applications," *Paint & Coatings Industry*, June 1994, p. 61-64.

(4) Golden, R. and Guarino, J., *Overview of Radiation Curing Chemistry and Application*, Radcure Specialties, Inc. (internal publication), p. 7.

(5) Golden, R. and Guarino, J., op. cit., p. 8.

(6) Aynessazian, D., "UV Inks Move Into the Light," *American Ink Maker*, July 1994, pp. 38-46.

(7) Radtech International, op. cit., p. 50.

(8) Costanza, J.R., Silveri, A.P., and Vona, J.A., "Radiation Cured Coatings," *Federation Series on Coatings Technology*, p. 11, Philadelphia, PA, 1986.

Society Reports

CHICAGO—NOVEMBER

"Reactive Diluents"

Several events have been planned to commemorate the CSCT's 75th Anniversary. The Educational Committee is planning a Lecture Module, and the Membership Committee is sponsoring an Anniversary Membership Challenge. In addition, the Technical Committee is in the process of establishing a coatings laboratory and library at DePaul University.

Chicago Society member Thomas L. Johnson, of ANGUS Chemical Co., delivered the evening's technical presentation on "REACTIVE DILUENTS FOR HIGH-SOLIDS URETHANES."

Mr. Johnson introduced a novel class of ultra low viscosity oxazolidine and aldimine compounds that offer lower system viscosity, much lower VOC, enhanced film properties, and practical RMC when used as reactive diluents. The speaker also discussed formulation parameters as well as laboratory results and weathering performance.

VICTOR WILLIS, *Publicity*

CHICAGO—FEBRUARY

"Waterborne Coatings for Wood"

The evening's speaker was David Setzke, of SC Johnson Polymers. He discussed "PROBLEMS ASSOCIATED WITH WATERBORNE COATINGS FOR WOOD."

Due to the growing need for low VOC coatings in wood finishing, Mr. Setzke stated that a great deal of interest has arisen in new film formers and additives to match properties inherent in existing high VOC systems.

According to the speaker, problems that have been encountered are microfoam, haze, and grain raising, all of which have a common root in the properties of water. The first two can be addressed to some extent by additives and the latter by wood selection and nonaqueous pre-sealers.

VICTOR WILLIS, *Publicity*

CDIC—DECEMBER

Bosses Night

President John C. Avery, of Cintech Industrial Coatings, discussed the new format for the International Coatings Expo (formerly the Paint Industries' Show).

Vice President William Jelf, of Akzo Nobel Coatings Inc., reported that the Cleveland Society is conducting a meeting on the impact of environmental regulations on the coatings industry in January.

Ohio Paint Council Representative Hugh Lowrey, of Perry & Derrick Co., reported on the status of the bill requiring a cost/benefit analysis of new regulations. He indicated that it was passed by both houses and sent to the governor for signature.

Mr. Lowrey also updated the members on the Legislative Advisory Committee's Report on Lead Abatement. He stated that even though the report recommends a tax on coatings as a way of funding recommended lead screening and abatement programs, no action is expected to be taken in the current legislature.

Pittsburgh Society member Robert S. Henderson, of Bayer Corp., spoke on "THE WEATHERABILITY OF POLYURETHANE COATINGS."

Mr. Henderson discussed the chemistry, selection, and application of polyurethane resins and their impact on weatherability in coatings. He noted that polyurethanes provide the formulator with a wide range of performance characteristics including film flexibility, solvent resistance, chemical resistance, gloss retention, hardness, and weather resistance.

According to the speaker, polyurethane chemistry is classified as either aromatic or aliphatic, solvent- or waterborne, and one- or two-component. The particular chemistry chosen is determined by the type of property desired for the final coating. Mr. Henderson cited the following examples: rail car coatings for chemical resistance, marine coatings for salt water resistance, aircraft coatings, auto clearcoats for acid etch resistance, and maintenance coatings for bridge and construction applications.

The speaker discussed polyurethane coating chemistry for one-part and two-part systems in both solvent- and waterborne solutions. Typically in the paint industry, use of an isocyanate such as TDI or MDI is reacted with a polyol to yield a PUR with an aromatic group results in a coating with good general properties. However, improved weatherability is attained starting with aliphatic isocyanates. Co-reactants are used for modified functionality.

Mr. Henderson also discussed one part PUR systems that require no mixing, had longer pot lives, provide a variety of cure relationships, require no equipment modifications for application that a two-part system would, and retain the desirable properties of the two-component system. Chemistry involves using a blocked isocyanate reacted with a polyol. The speaker recommended these systems since they yield film flexibility with good hardness, low VOC, good weatherability as well as solvent, chemical and detergent resistance.

JOHN E. IMES, *Acting Secretary*

KANSAS CITY—DECEMBER

General Membership Meeting

A moment of silence was observed for the passing of Terryl Johnson, Past-President of the Federation and Kansas City Society.

Society Representative Mark Algaier, of Hillyard Industries reported on the 1995 FSCT Annual Meeting and Paint Industries' Show, in St. Louis, MO. He also informed the members of upcoming events.

Manufacturing Committee Chair Terry Barnett, of Nazdar, stated that the Committee will be sponsoring a plant tour in the next few months. Details will be forthcoming.

Technical Committee Chair Monty Montgomery, of Tnemec Co., Inc., reported that the plans for the Joint Meeting with the St. Louis Society in June are well underway.

The meeting's speaker was Bryan Busby, a meteorologist.

CURRY SANDERS, *Secretary*

KANSAS CITY—JANUARY

General Membership Meeting

Randall Ehmer, of Walsh & Associates, Inc., reported that most of the program for the Joint Meeting with the St. Louis Society has been finalized; however, he is still seeking some volunteers.

Bill Porter, of Hillyard Industries, stated that the Manufacturing Committee is planning a plant tour for March. Mr. Porter also announced that Spouses' Night will be held March 16.

CURRY SANDERS, *Secretary*

LOS ANGELES—JANUARY

"Universal Primers"

Scott Hoffer, of Ashland Chemical Co., stated that the Spring Folic will take place on May 17 not May 19 as was printed earlier. In addition, he reported that the February meeting is "Spouses' Night."

Vice President Bud Jenkins informed the members that a seminar on "Horizontal Mill/ Pigment Premix" will be held at Cal Poly Pomona on February 16.

President Bob Skarvan, of Engineered Polymer Solutions, stated that the general membership needs to be informed of the happenings at the Board Meetings. Therefore, copies of the Board Meeting minutes will be available at the general membership meetings.

Chicago Society member Mike Wildman, of Engineered Polymer Solutions, spoke on "The Next Generation of High Performance Universal Primers ."

Mr. Wildman compared stain blocking emulsion SBE-1 and SBE-2 as well as VT alkyds, shellac, and several other emulsions. He stated that VT alkyds, acrylic emulsions, and alkyds all have advantages. However, their disadvantages cause more concern.

The speaker then showed a slide comparing the different systems in multiple coats and how they either allow the stains to penetrate through the topcoat or act as barriers and at varying degrees. Some emulsions allow the stains to keep migrating no matter how many coats you put on, while alkyds stop them easily. This also prevents stains from coming from the substrate. Sometimes, also, a primer may show stains coming through from the substrate, but the stains are trapped in the primer and do not migrate when topcoated.

According to Mr. Wildman, the requirements for a universal primer include the ability to apply it to both wood and metal, have alkyd-like stain blocking, have excellent exterior durability, have adhesion to a wide variety of previously painted substrates whether chalky or glossy, have adhesion to both ferrous and nonferrous metals, and have corrosion resistance.

Tannin bleed resistance, grain cracking resistance, and adhesion to chalky substrates are all areas that determine exterior durability, the speaker stated.

Adhesion tests were conducted over unpolished CRS, galvanized steel and on untreated aluminum. SBE-1 has good adhesion over all three, while SBE-2 has excellent adhesion. Slides showed a comparison of various systems with varying results. Corrosion testing was done in Prohesion, QUV and humidity cabinets and slides showed the differences between the systems tested.

In conclusion, Mr. Wildman said that one of the things that showed up in these tests is that the choice of extender pigments makes a big difference. In the systems tested, especially in the SBE's, calcium carbonate gave the best corrosion resistance, followed by talc, mica, and Minex, and finally by

Constituent Society Meetings and Secretaries

BALTIMORE (Third Thursday—Martin's West, Woodlawn, MD). Joseph Schilare, The Valspar Corp., 1401 Severn St., Baltimore, MD 21230 .

BIRMINGHAM (First Thursday—Strathallan Hotel, Birmingham, England). David C. Morris, PPG Industries (UK) Ltd., P.O. Box 359, Rotton Park St., Birmingham, B16 0AD, England.

CDIC (Second Monday—Location alternates between Cincinnati, Columbus, Dayton, and Indianapolis). Theresa Case, Fibreglass Evercoat Co., Inc., 6600 Cornell Rd., Cincinnati, OH 45242.

CHICAGO (First Monday—Sharko's Restaurant, Villa Park, IL). Gerry K. Noren, DSM-Desotech, Inc., 1122 St. Charles St., Elgin, IL 60120.

CLEVELAND (Third Tuesday—Monthly meeting site TBA). James Currie, Jamestown Paint Co., 108 Main St., Jamestown, PA 16134.

DALLAS (Second Thursday following first Wednesday—Dallas Medallion Hotel, Dallas, TX). Mike Templin, Hilton-Davis Co., 1696 Dickerson Dr., Arlington, TX.

DETROIT (Second Tuesday—meeting sites vary). Ray Stewart, Akzo Nobel Coatings, Inc., 1845 Maxwell St., P.O. Box 7062, Troy, MI 48007-7062.

GOLDEN GATE (Monday before third Wednesday—alternates between Francesco's in Oakland, CA, and Holiday Inn in S. San Francisco). Don Mazzone, Dowd & Guild, Inc., 14 Crow Canyon Ct., #200, San Ramon, CA 94583.

HOUSTON (Second Wednesday—Medallion Hotel, Houston, TX). Ken Mundy, Ribelin Sales, Inc., 7786 Blankenship Dr., Houston, TX 77055.

KANSAS CITY (Second Thursday—Cascone's Restaurant, Kansas City, MO). Curry Sanders, Tnemec Co., Inc., 123 N. 23rd Ave., N. Kansas City, MO 64116.

LOS ANGELES (Second Wednesday—Steven's Steakhouse, Commerce, CA). Arthur W. Lorenz, Sinclair-Ameritone Paint Corp., 6100 S. Garfield Ave., Los Angeles, CA 90040.

LOUISVILLE (Third Wednesday—Executive West Motor Hotel, Louisville, KY). Paul Baukema, Akzo Nobel Coatings, Inc., R&D Div., 4730 Crittenden Dr., P.O. Box 37230, Louisville, KY 40233.

MEXICO (Every fifteen days—Gabriel Mancera, Mexico City, Mexico). Sergio Rojas, Pinturas International, S.A. De C.V., Ganaderos 234, Col. Granjas Esmeralda, 09810 Mexico, D.F., Mexico.

MONTREAL (First Wednesday— Restaurant Le Bifthèque, St. Laurent, Quebec). Robert Benoit, KRONOS Canada Inc., 3390 Marie Victorin, Varennes, Que., J3X 1T4 Canada.

NEW ENGLAND (Third Thursday—Best Western TLC, Waltham, MA). Richard Twomey, Kronos, Inc., 68 Fisher St., Medway, MA 02053-2004.

NEW YORK (Second Tuesday—Landmark II, East Rutherford, NJ). Robert W. Schroeder, Daniel Products Co., 400 Claremont Ave., Jersey City, NJ 07304.

NORTHWESTERN (Tuesday following first Monday—Jax Cafe, Minneapolis, MN). Michael D. Coad, McWhorter Technologies, 1028 S. Third St., Minneapolis, MN 55415.

PACIFIC NORTHWEST (Portland Section—Tuesday before third Wednesday—Tony Roma's, Mall 205, Portland, OR; Seattle Section—Third Wednesday—Wyndham Gardes Hotel, Sea-Tac, WA; Vancouver Section—Thursday after third Wednesday—Abercorn Inn, Richmond, B.C.). Kenneth Wenzel, Chemical Distributors, Inc., P.O. Box 10763, Portland, OR 97210.

PHILADELPHIA (Second Thursday—DoubleTree Guest Suites, Plymouth Meeting, PA). Patricia M. Peterson, ARCO Chemical Co., 3801 West Chester Pike, Newtown Square, PA 19073-3230.

PIEDMONT (Third Wednesday—Ramada Inn Airport, Greensboro, NC). Alex Blahnik, Chemcraft Sadolin, Inc., P.O. Box 669, Walkertown, NC 27051.

PITTSBURGH (Second Monday—Montemurro's Restaurant, Sharpsburg, PA). James Giammarco, Lockhart Chemical Co., 2873 W. Hardies Rd., Gibsonia, PA 15044.

ROCKY MOUNTAIN (Monday following first Wednesday—Monthly meeting site TBA). John Elverum, Hauser Chemical Research, 5555 Airport Blvd., Boulder, CO 80301.

ST. LOUIS (Third Tuesday—The Salad Bowl Restaurant, St. Louis, MO). Robert Phelps, P.D. George Co., P.O. Box 66756, St. Louis, MO 63166.

SOUTHERN (Gulf Coast Section—third Thursday; Central Florida Section—third Thursday after first Monday; Atlanta Section—third Thursday; Memphis Section—bi-monthly on second Tuesday; and Miami Section—Tuesday prior to Central Florida Section). Eve De La Vega-Irvine, J.M. Huber Corp., One Huber Rd., Macon, GA 31298.

TORONTO (Second Monday—Speranza Restaurant & Banquet Hall Convention Centre, Brampton, Ont., Canada). Mike Molnar, CIBA Pigments, P.O. Box 2000, Mississauga, Ont., L5M 5N3 Canada.

WESTERN NEW YORK—Marko Markoff, 182 Farmingdale Rd., Cheektowaga, NY 14225.

silica, calcium silicate, and clay. Other pigmentation would be needed for salt spray resistance.

ARTHUR LORENZ, *Secretary*

MONTREAL—JANUARY

"Pigment Concentrates"

New York Society member Patrick Laine, of BYK-Chemie, spoke on "PIGMENT CONCENTRATES—SELECTION AND USE OF ADDITIVES FOR THE PRODUCTION OF HIGH QUALITY PIGMENT CONCENTRATES."

Mr. Laine stated that pigment concentrates have been used by many paint producers to facilitate and reduce the cost of production of pigmented coatings.

According to the speaker, pigment concentrates should contain a high pigment level, be stable in storage, and easy to handle. They are expected to have a wide compatibility with many different resin systems with no flocculation, flooding, and floating, or other defects.

To guarantee this, Mr. Laine stated that the proper additives have to be used in formulating the pigment concentrates. Wetting and dispersing additives are used to stabilize inorganic as well as organic pigments; reflocculation and color drift are thus avoided when the concentrates are mixed. These additives also reduce viscosity which allows a higher pigmentation level.

The speaker concluded by discussing formulation guidelines for solvent-based, glycol-based, and aqueous concentrates.

HORACE PHILIPP, *Publicity*

MONTREAL—FEBRUARY

"Anticorrosive Molybdate Pigments"

Charles Simpson, of Sherwin-Williams Chemicals, discussed at the meeting "ANTI-CORROSIVE MOLYBDATE PIGMENTS FOR PROTECTIVE COATINGS."

Mr. Simpson stated that molybdate-based corrosion inhibitors represent an important, nontoxic alternative to the use of chromium and lead-based pigments for corrosion control in coatings. The speaker reviewed the different types of anticorrosive molybdate pigments in use today along with some important applications. In the development of chromium and lead-free systems, there is a tremendous need for reliable short-term test methods for evaluating the new systems. In addition, Mr. Simpson discussed current industry research towards the adoption of improved test methods, and also the application of these in testing molybdate-based corrosion inhibitors.

In conclusion, Mr. Simpson suggested that the development of high performance nontoxic replacement systems be pursued through the application of field proven material technologies, used together with meaningful evaluation techniques.

HORACE PHILIPP, *Publicity*

NEW ENGLAND—JANUARY

"The Economy for 1996"

Society Representative Maureen Lein, of Davidson Technology Center, advised the membership of the upcoming meeting of the FSCT Board of Directors.

The evening's speaker was Robert Fry, of DuPont. He discussed "THE ECONOMY FOR 1996."

Dr. Fry predicted that after a slow start in the first quarter, 1996 should duplicate 1995's performance of 1.5% gross domestic product (GDP). To support his opinions, Dr. Fry forecasted housing starts (1.6 million) for 1996, with support for nonresidential investment of approximately $170 billion in 1996, becoming a few of the stabilizing affects on this economy.

Using overheads to support his data, Dr. Fry noted that 1994 had the greatest GDP growth in 10 years at five percent. the GDP for 1995 is looking to be approximately 2.5, and 1996 should range from 2.5 to 3.0 GDP. He also stated that pigments cost for the paint industry rose six percent, pricewise, in 1995, yet the six percent was below the cost of resins for the same period. The speaker anticipates growth of paint production in 1996 of approximately three percent over 1995.

Dr. Fry stated that inflation should continue at a range of 2.9% in 1996, and perhaps three percent in 1997. Along with this, he noted that employee benefit costs have been reduced due to health costs going down approximately three percent in the last three years.

RICHARD TWOMEY, *Secretary*

PACIFIC NORTHWEST—JANUARY

"Universal Primers"

Safety and Manufacturing Committee Chair, Valerie Braund, of General Paint Ltd., reported that a survey was sent to all manufacturing members.

Technical Committee Chair, Yoichi Seo, of Flecto Coatings Ltd., announced that a Technical Committee has been formed. The members are: Paul Andreassen, of Consolidated Coatings; Tom Wong, of Cloverdale Paint Inc.; Tom Fairley, of Calcoast Labs Canada, Inc.; and Yvon Poitras, of Mills Paint Sales Ltd.

Mr. Seo also reported that Valerie Braund will attend a meeting to establish a budget and goals for the production of a video tape.

Tom Fairley, Educational Committee Chair, stated that a coatings technology course will start at Kwantlen College of February 22.

It was announced that a student co-op program will be held and sponsors are being sought for the summer student program.

As a result of the new strategic plan, the Federation is changing the format of the annual convention. The Federation also plans to increase the awareness of the organization and has discussed the following changes: (1) formation of common interest groups (e.g., specialty coatings and construction materials); (2) centralized membership/recruiting; and (3) organizational structure.

Chicago Society member Mike Wildman, of Engineered Polymer Solutions, spoke on "THE NEXT GENERATION OF HIGH PERFORMANCE UNIVERSAL PRIMERS ."

KELVIN J. HUGET, *Secretary*

PHILADELPHIA—JANUARY

Joint Meeting with PPCA

Wayne Kraus, of Hercules Incorporated, updated the members on the status of the Eastern Training Conference slated for May.

Tom Brown, of Consultants Consortium, reviewed the upcoming Society events.

John Matthews, of Villanova University, delivered the evening's presentation on "STRATEGIES OF SUCCESSFUL U.S. INVESTORS."

According to Dr. Matthews, most forecasters predict that the gross domestic product (GDP), which is presently at 1.9% growth, would drop slightly to 1.6%.

The speaker also predicted that three-month T-bills would be slightly lower than this year's five percent and unemployment would stay the same at 5.7%. In addition, Mr. Matthews stated that the resolution of the budget debate could have considerable effect on the economy in 1996. The players in the budget debate need a "push" from their constituents to resolve the impasse.

Q. How much money in the stock market is from the mutual fund investments?

A. At present 35% of the wealth in stocks is in the mutual fund type investment.

PATRICIA M. PETERSON, *Secretary*

New FSCT Members

CHICAGO

Active

Davis, Prentiss—The Valspar Corp., Wheeling, IL.
Gesenhues, Albert M—McWhorter Technologies, Carpentersville, IL.
Jamersons, Marvin—The Valspar Corp., Wheeling.
Keck, Jody L.—The Valspar Corp., Wheeling.
Patel, Arvind J.—CFC International, Chicago Heights, IL.
Santiago, Mildred C.—The Valspar Corp., Wheeling.
Schmidt, Gary R.—North American Kestrel, Carol Stream, IL.
Synder, Marcia—The Valspar Corp., Wheeling.

Associate

Alexa, Barry A.—Emco Chemical Distributors, Schaumburg, IL.
Crossman, Fred L.—North American Kestrel, Carol Stream, IL.
Decker, David J.—Georgia Marble Co., Kennesaw, GA.
Holly, Bruce E.—Hüls America Inc., Chicago, IL.
Kowalewski, Charles M.—Zaclon Inc., Chcago.
Piske, Charles A.—Enginneered Polymer Solutions, Marengo, IL.
Waiksnoris, William J.—Allied Signal Inc., Naperville, IL.

CLEVELAND

Active

Barkey, Travis D.—Master Builders, Beachwood, OH.
Bender, Howard S.—BFGoodrich Co., Brecksville, OH.
Blaha, David A.—Continental Products, Euclid, OH.
Croll, Stuart G.—Shaker Heights, OH.
Geriak, Thomas A.—Republic Powdered Metals Inc., Medina, OH.
Lee, Richard P.—Gibson-Honana, North Canton, OH.
Sanders, Andrea—The Sherwin-Williams Co., Cleveland, OH.

Associate

Pyzoha, Thomas T.—Maroon Inc., Westlake, OH.
Witt, William J.—Hudson, OH.
Yafanaro, John—The Kish Co., Euclid, OH.

KANSAS CITY

Associate

Morgan, Teresa M.—Akzo Nobel Resins, E. St. Louis, IL.
Peterson, Davis W.—Ashland Chemical Co., Kansas City, KS.
Starling, Keith L.—ChemCentral, Olathe, KS.

LOUISVILLE

Active

Binns, Mark J.—The Valspar Corp., Louisville, KY.
Green, Charles D.—Estron Chemical Inc., Calvert City, KY.
Malloy, Dennis P.—Reynolds Metals Co., Louisville.
Oliver, Bernie D.—The Valspar Corp., Louisville.
Rosati, Joseph A.—The Sherwin-Williams Co., Richmond, KY.
Vick, William C.—Marcus Paint, Louisville.

Associate

Beasley, David M.—Hüls America Inc., Alpharetta, GA.
Gill, Thomas M.—Morton International, Louisville, KY.
McVey, Brian—World Minerals, Inc., Antioch, TN.
Overman, Janet K.—R.E. Carroll Inc., Louisville.

NEW ENGLAND

Associate

Caswell, Sherman C.—Brookfield Engineering, Stoughton, MA.
Dwyer, James L.—Lab Connections Inc., Marlborough, MA.
Penny, Debbie M.—The Truesdale Co., Brighton, MA.

NEW YORK

Associate

Krizan, Jeffrey F.—Datacolor Corp., Southbury, CT.

PACIFIC NORTHWEST

Active

Brexette, David A.—McWhorter Technologies, Portland, OR.
Courier, John P.—Specialty Products Inc., Tacoma, WA.
Franks, David A.—Miller Paint Co., Portland.
Hiscocks, Peter A.—General Paint, Vancouver, B.C.
Lo, Vernon—Imasco Minerals Inc., Vancouver.
Mominee, Robert P.—Ponderosa Paint, Boise, ID.
Simmons, Robert L.—Guardsman Products, Seattle, WA.

Associate

Charnley, John J.—Progressive Services Inc., Coquitlam, B.C.
Hagan, Jeffrey E.—Fuji Silysia Chemical, Portland, OR.
John, Ron L.—John K. Bice Co., Inc., Cathlamet, WA.
McDonough, Jim K.—Industrial Machinery Inc., Preston, WA.
Romagnoli, Aldo A. III—Fuji Silysia Chemical, Portland.
Seeman, Roy D.—Fuji Silysia Chemical, Portland.
Vandekieft, Dirk—Pacific Coast Chemical, Portland.

PITTSBURGH

Active

Anderson, Mildred R.—The Valspar Corp., Pittsburgh, PA.
Balint, Gary T.—Bayer Corp., Pittsburgh.
Cheeks, Charles N.—Kop-Coat, Pittsburgh.
Knell, Timothy A.—Cerdec Corp., Washington, PA.
Sarver, Joseph E.—Cerdec Corp., Washington.

Associate

Cugliara, Michelle L.—Lab Support, Pittsburgh, PA.
Marsh, Kenneth J.—Dar-Tech Inc., Cleveland, OH.

Society Sponsored Event

Detroit Society for Coatings Technology
presents

21st Annual FOCUS Conference

"Driving Technology to Meet New Challenges"

April 16, 1996
Michigan State University • Troy MI

For more information, contact Rosemary Brady at (810) 637-8565

Future Society Meetings

Baltimore

(Apr. 18)—"Good Tests–Bad Testing"—Saul Spindel, D/L Laboratories, Inc.

(May 16)—General Meeting and Elections.

Birmingham

(Mar. 28)—Powder Coatings: "We Might Still be Green but We Are Not Wet"—David Bate, H.B. Fuller Coatings.

(Mar. 30)—60th Anniversary Dinner Dance.

(May 2)—67th Annual General Meeting.

Chicago

(Apr. 1)—"Field Observations and Latex Chemistry"—Violete Stevens.

(May 10)—Annual Awards Banquet.

Cleveland

(Apr. 16)—Annual Meeting. "Spray Equipment Advances"—Dave Hagood, Nordson Corp; and "Acrylic-Polyurethane Hybrid Dispersion for Water Base"—Charles R. Hegedus, Air Products and Chemicals.

(May 21)—Awards/Past-President/ Spouse's Night.

Los Angeles

(Apr. 10)—"Rheological Measurements and How They Apply to the Paint and Coatings Industry"—Scott Krane, Haake Instruments.

(May 8)—"The Latest Trends in Accelerated Corrosion Testing: Prohesion, QUV and Automotive Cyclic Corrosion Testing"—Steve Grossman, Q-Panel Corp.

New York

(Apr. 9)—"The Lobbying Process: From Beginning to End"—William Pascrell, Princeton Public Affairs Group.

(May 14)—PaVac Awards Night. "Colored Organic Pigments for the Coatings Industry"—Peter Lewis, Sun Chemicals.

Pacific Northwest

(Apr.)—"Rheological Measurements and How They Apply to the Paint and Coatings Industry"—Scott Krane, Haake Instruments.

(May)—"The Latest Trends in Accelerated Corrosion Testing: Prohesion, QUV and Automotive Cyclic Corrosion Testing"—Steve Grossman, Q-Panel Corp.

Philadelphia

(Apr. 26)—Awards Night

(May 8-10)—Eastern Training Conference and Technical Seminar.

Pittsburgh

(Apr. 8)—"Coatings for Automotive Plastics"—Jack Burgman, PPG Industries, Inc.

(May13)—Society Officer Elections and Spouses' Night.

Rocky Mountain

(Apr. 8)—"Rheological Measurements and How They Apply to the Paint and Coatings Industry"—Scott Krane, Haake Instruments.

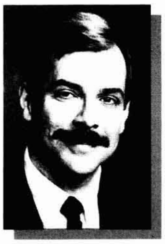
(May 6)—"The Latest Trends in Accelerated Corrosion Testing: Prohesion, QUV and Automotive Cyclic Corrosion Testing"—Steve Grossman, Q-Panel Corp.

Toronto

(Apr. 15)—Annual Technical Symposium.

(May 13)—"The Application of Science to the Examination and Conservation of Museum Objects"—Sandra Lawrence, Ontario Gallery of Art.

People in the News



K. Moody

Chicago Society member, **Keith Moody** has been appointed Senior Account Development Representative for Eastman Chemical Co., Kingsport, TN. Based in Chicago, IL, Mr. Moody will work with customer research and development personnel in the coatings industry.

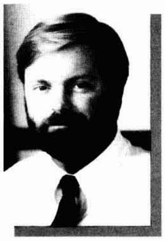
The St. Louis Society for Coatings Technology has bestowed four scholarships for the University of Missouri-Rolla Paint and Coatings Courses. The following are the recipients: **Sharon Masek,** of Carboline Co.; **Betsy Hudson,** of Carboline Co.; **Chrissa Schremp,** of Marsh Co.; and **Steve De La Roche,** of Amteco. Ms. Schremp is a member of the St. Louis Society.

ANGUS Chemical Co., Buffalo Grove, IL, has promoted **Michel J. Hourani** to Technical Director at ANGUS Chemie in Paris, France. Dr. Hourani will identify and develop technical resources in Europe to support sales and market development programs. He is a member of the Chicago Society.

UPACO Adhesives and Coatings Division of Worthen Industries, Inc., Richmond, VA, has appointed **C. Herbert Pund, III** to the position of Manufacturing Manager. Mr. Pund is a Past-President of the Baltimore Society.

Ken Brandt, of United States Paint Corp., St. Louis, MO, has assumed the title and responsibilities of Operations Manager. In this new position, Mr. Brandt will work with manufacturing, purchasing, shipping, receiving, and the environmental and health departments. He is a member of the St. Louis Society.

John Paterson has joined the staff of Charles Ross & Son Co., Hauppauge, NY, as Coatings Equipment Manager. In his new position, Mr. Paterson will manage product development and strategic planning for all applications involving the coatings industry with a focus on pigment dispersions.



J. Paterson

Dr. Joseph W. Tomecko, FSCT Past-President, Dies at 89

Dr. Joseph (Jim) W. Tomecko, well-known coatings figure and educational activist, died at the age of 89, on February 2. Dr. Tomecko was an Honorary Member of the Federation of Societies for Coatings Technology and served as President of the FSCT in 1958.

J.W. Tomecko

Born in Lipton, Saskatchewan in 1906, his career in both coatings and education began in 1932 following the receipt of B.A and M.A Degrees in Chemistry from the University of Saskatchewan. For the next eight years he was an instructor in chemistry, physics, and mathematics at the university and at Campion College, and a Professor of Chemistry at Loyola College, in Montreal. Completing post-graduate work along with his teaching assignments, he received his Ph.D. in Chemistry from McGill University in 1940.

Not limited to academic endeavors during this period, Dr. Tomecko also played professional football for two years for the Regina Roughriders and participated in the 1934 Dominion Grey Cup Final.

In 1940, he joined Canadian Industries Ltd., in Toronto, as a Chemist in the Paints Div. During a 27-year career with CIL, he rose through numerous positions including Assistant General Manager of Paints and Coated Fabrics, Assistant General Manager of the Paints Div., Educational Relations Manager, and General Manager of Exocolor, Inc. and the "Kaleidoscope" Pavilion at Expo 67 in Montreal.

After retiring from CIL in 1967, he continued his educational pursuits and returned to academic life at the University of Waterloo, which had presented him with an Honorary LL.D. Degree for his technical work and contributions to the growth of the university during his tenure with CIL. At Waterloo he became the university's first Director of the Industrial Research Institute. Two years later he got the added responsibility of being Director of the office of Research Administration. He retired from the university in 1974.

Active in numerous organizations throughout his career, he was President of the Toronto Society in 1950, of the FSCT in 1958, and was a Trustee and President (1966-69) of the Paint Research Institute.

He was made an Honorary Member of the FSCT in 1969 and had received the organization's George Baugh Heckel Award in 1966. In 1970, he presented the Keynote Address at the Federation's Annual Meeting.

In 1978, Dr. Tomecko was further honored with the appointment by The Queen as a Member of the Order of Canada.

Surviving Dr. Tomecko are two daughters, Jo-Anne Dooley, of Philadelphia, and Stephanie Gagne, of Burlington, Ont. The family requests that donations be made in his name to the Victoria Order of Nurses, 2370 Speers Rd., Oakville, Ont. L6L 5MZ, Canada.

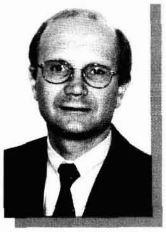
Cerdec Corporation, Drakenfeld Products, Washington, PA, has announced the following appointments: **Geoffrey A. Weinstock** was named Pigment Production Manager; **Gil Burkhart** accepted the position of Mixed Metal Oxide (MMO) Technical Sales Representative; **Joe Sarver** was named MMO Lab Manager; and **Dennis Gilmore** joined the MMO Division as Lab Technician. Mr. Sarver is a member of the Pittsburgh Society.

Hüls America Inc., Somerset, NJ, has named **Wolfgang Minnerup** as Business Controller. Mr. Minnerup will coordinate the development of the company's strategies for its business units and product lines.

Accepting the promotion of Product Manager-Grinding Media for the Specialty Ceramics Division of Ferro Corp., Cleveland, OH, is **Susan L. English**. Ms. English will be responsible for managing the grinding media, mill linings, and alumina-sand product lines in North America.

Also, **Carol C. Bernauer** was named Sales and Marketing Manager. Ms. Bernauer will be responsible for the sales activities for the five plant locations in the United States that manufacture kiln furniture, advanced structural ceramics, grinding media, wear-resistant shapes, and porous ceramics.

Elsewhere, **William H. Prior** has joined the staff of Ferro as Director, Environmental Affairs. Mr. Prior will manage and direct the company's environmental affairs.



A. Clause

Alain Clause has been named President of FATIPEC for 1995-96. FATIPEC located in Paris, France, represents nine countries and three candidate countries in Europe.

Presently, Mr. Clause is Research and Development Manager, New Products for Akzo Nobel Industrial Coatings N.V. In 1988, he was elected President of ATIPEC, the Belgian Paint and Ink Chemists Association. In addition, Mr. Clause is a member of the FATIPEC Board of Directors.

Mr. Clause was elected President of FATIPEC during the 1994 Congress. He will preside over the 23rd FATIPEC Congress, June 10-14, in Brussels, Belgium.

The Oleo/Surfactants Group of Witco Corp., Greenwich, CT, has appointed **Jeannene Ackerman,** Vice President of its Industrial Surfactants Strategic Business Unit. Ms. Ackerman will be responsible for developing market share in several of the company's industries.

In addition, **Peter T. Thomas** was named Vice President of Sales. He will direct sales efforts for the company's Oleos Surfactants Group in North America.

Hilary Himpler was named Vice President of the Laundry Products Strategic Business Unit. She was most recently Marketing Manager for Fabric Softeners.

Terry Guckes has accepted the position of Vice President of Planning and Development of OM Group, Cleveland, OH. Dr. Guckes will manage new product introductions as well as development of new business opportunities.

Ralph W. Leonard is the 1995 recipient of the Award of Merit presented by The American Society for Testing and Materials (ASTM), West Conshohocken, PA. Mr. Leonard was nominated for the award by standards-writing Committee A-5 on Metallic Coated Iron and Steel Products.

The Roof Coatings Manufacturers Association (RCMA), Rockville, MD, has announced its new officers for 1996. Elected are: President—**Jim Van Pelt**, of Grundy Industries, Inc.; Vice President—**Richard Zegelbone**, of Tropical Asphalt Products Corp.; and Treasurer—**David Mehtlan**, of American Stone-Mix, Inc.

The following were elected to the Board of Directors: **Raymond Hyer, III**, of Gardner Asphalt Corp.; **Richard Kaplan**, of Aluminum Coatings Manufacturing Co., Inc.; **David Mehtlan; Joseph Mooney, III**, of Monsey Products Co.; **Tim Nelligan**, of Henry Co.; **Lewis Ripps**, of Palmer Asphalt Co.; **Kenneth Sokoloff**, of U.S. Can Co.; **Jim Van Pelt**; and **Richard Zegelbone**.

In other RCMA news, **J. Tim Nelligan** was the recipient of the 1995 Martin A. Davis Industry Leadership Award for his outstanding service and contributions to the roof coatings industry.

William Ansell Jr., has accepted the position of Technical Manager of Air Testing Services for TolTest Inc., Plymouth, MI. Mr. Ansell brings seven years of experience in air quality testing, engineering, compliance, and management to the position.

Tom Miranda has been named the recipient of the 1996 Brewer Award. Dr. Miranda was cited for his contribution to electrocoat in the area of application of the technology.

Dr. Miranda, Past Technical Editor of the JOURNAL OF COATINGS TECHNOLOGY, is Co-editor of the *Federation Series on Coatings Technology*. In 1980 he received the FSCT George Baugh Heckel Award and in 1984 he delivered the Joseph J. Mattiello Lecture.

Dr. Miranda is a member of the Chicago Society and serves as a consultant for Consolidated Research Inc.

Chemical Leaman Tank Lines, Inc., Exton, PA, has welcomed **Philip J. Ringo** to the staff as President and Chief Executive Officer. Mr. Ringo succeeds **John Kilcullen,** who has resigned. Mr. Ringo will also serve on the company's Board of Directors.

AlliedSignal Inc., Morristown, NJ, has appointed **Gary Hansell** to the position of Vice President and General Manager of the Performance Additives business unit.

Dallam E. "Ted" Blandy has been named General Manager of the Specialty Resins Group at Colorite Polymers Division of Pure Tech International, Burlington, NJ. Mr. Blandy most recently served as Director of Marketing for PVC Commodity Resins with Occidental Chemical Corp.

The newly created position of Vice President of Environment, Health, and Safety at PPG Industries, Inc., Pittsburgh, PA, has been accepted **by David C. Cannon Jr**. Mr. Cannon's responsibilities at PPG have included legal affairs involving environmental activities, employment, and the company's coatings and chemicals businesses.

Hunter Associates Laboratory, Inc., Reston, VA, has hired **Mark S. Lachman** to join its sales team. Mr. Lachman will represent HunterLab's products and services in Connecticut, Maine, Massachusetts, New Hampshire, Northwest New Jersey, Upstate New York, Rhode Island, and Vermont.

Gilles Perrot has been promoted to the position of Chief Executive Officer, Resin Division, of Total-Chimie, Paris, France. Mr. Perrot most recently served as Chief Executive Officer of Cook Composites and Polymers (CCP), Kansas City, MO.

Replacing Mr. Perrot as Chief Executive Officer of CCP is **Werner Brück**.

Varian Associates Inc., Palo Alto, CA, has named **John D. Mills** to the position of Marketing Manager for its Chromatography Systems business unit. Mr. Mills will be responsible for marketing gas and liquid chromatography instrumentation products.

David Bishop, former President of The International Society for Measurement and Control (ISA), Research Triangle Park, NC, was recently honored by the American National Standards Institute (ANSI) with the Meritorious Service Award. In addition, ISA presented Mr. Bishop with the Standards and Practices Award as well as the ISA Fellow Award.

OBITUARIES

William Raymond Tooke Jr., a 25-plus year member of the Southern Society, passed away on October 5, 1996. He was 70 years old.

Mr. Tooke, a graduate of Georgia Tech, began his career in the school's chemical engineering experiment station. The inventor of the Tooke Paint Inspection Gage, Mr. Tooke founded his own company, Micromeritics, approximately 30 years ago.

Mr. Tooke is survived by his wife; three sons; his mother; a brother; and two grandchildren.

George Louis Zachos, a longtime member of the paint industry, died on December 3, 1995. He was 73 years old.

Mr. Zachos worked for Zac Loc Paints from 1946-59. He later worked with William Armstrong Smith & Coronado in Florida until his retirement.

Luster Pigments

Two new grades have been added to the Mearlin® Dynacolor® series of luster pigments. Dynacolor GG (green) and BB (blue) consist of an absorption colorant deposited directly on a titanium dioxide-coated mica interference pigment. The Mearl Corp. colors are nontoxic, nonmetallic powders recommended for plastic applications, general surface coatings, and printing inks.

Circle No. 30 on Reader Service Card

Surface Modifier

A new low VOC surface modifier for titanium dioxide pigment is recommended for use by titanium dioxide pigment slurry manufacturers, paint and coatings manufacturers, and titanium dioxide pigment dispersion manufacturers. Tismod 94 reportedly provides improved physical characteristics such as drying time, abrasion, scrub resistance, and hardness. The dual-action surface modifier is available from IPMC Inc.

Circle No. 31 on Reader Service Card

Biocide

Calgon Corp. has received EPA registration in California for the use of Tektamer® 38 biocide as an in-can preservative in paints, coatings, adhesives, emulsions, and slurries. The product contains no formaldehyde or heavy metals and is designed for effectiveness over a wide pH range. The biocide is compatible with many other actives.

Circle No. 32 on Reader Service Card

Corrosion Inhibitor

A modified calcium pyroborate pigment for use as a corrosion inhibitor in coatings is lead, chromate, zinc, and barium free. The white pigment may be formulated into water and solvent-based coatings for consumer, maintenance, and industrial use. Butrol 9104, as well as formulating suggestions and literature on this product, is available from Buckman Laboratories International, Inc.

Circle No. 33 on Reader Service Card

Polyester Resins

Hybrid formulations of Rucote 555 and Rucote 555 HF, new carboxyl polyesters, have been developed by Ruco Polymer Corp. These resins are engineered to yield all-purpose powder coatings that combine good overall properties with competitive costs. Reported benefits include lower temperature cure capability, low resin viscosity, and formulating versatility.

Circle No. 34 on Reader Service Card

Dispersants

ICI Surfactants has introduced a new line of proprietary polymeric dispersants, which are engineered for dispersion of a range of organic pigments in water. Hypermer® 2434, 2630, and 2678 polymer surfactants offer zero VOC and contain no alkylphenol ethoxylates. Reported benefits include stabilization, color development, and minimal viscosity drift over time.

Circle No. 35 on Reader Service Card

Formulation

PC-based software, Formu-Tools™, has been developed to help coatings formulators manage, store, and retrieve raw material and formula information and make formulation analysis calculations. The program can also calculate the amounts of ingredients required for a formulation, meeting prescribed constraints commonly used in formulation work (P/B, VOC, PVC, fixed amount, ratios). This product is available from DTW Associates, Inc.

Circle No. 36 on Reader Service Card

Paint Problem Solver

An interactive CD-ROM version of the *Paint Problem Solver*, published by the National Decorating Products Association, is available. Using computer prompts in the program, a customer can find their specific paint problem and learn its cause as well as how to solve it or avoid it on future projects. They can also generate a printout listing specific product recommendations for solving their paint problem.

Circle No. 37 on Reader Service Card

Weighting Factors

A software package provides 72 sets of tristimulus weighting factors as well as nine standard and recommended CIE illuminants: A, C, D50, D55, D75, F02, F07, and F11. A text file explains file layouts and suggests ways to read files under program control. This tristimulus weighting factors software, adjunct to ASTM Standard Practice E 308, "Computing the Colors of Objects Using the CIE System," is available from ASTM.

Circle No. 38 on Reader Service Card

Chromatography

The Perkin-Elmer Co. has introduced Turbochrom™ Results Manager (TCRM) version 1.1, the latest version of the company's optional database software package for the Turbochrom professional chromatography data handling system. TCRM stores chromatographic results data and images in a relational database, providing users with a varied selection of queries and formats for sorting, organizing, and printing information. System suitability data and method/sequence parameters can be added.

Circle No. 39 on Reader Service Card

Remote Control

Multi-Comm software from Athena Controls allows remote monitoring and control of up to 100 Athena XT series temperature or process controllers. Up to 16 controllers, connected via an RS-485 network, may be viewed on the computer screen at one time with a full-color emulation of each instrument's front panel display showing process value and setpoint in real time. Controller configuration and data analysis are facilitated by menus and pop-up windows.

Circle No. 40 on Reader Service Card

Conveyor Oven

The Grieve No. 766, featuring an 8 in. long open loading zone for access to the 42 ft. wide, 1 in. X 1in. high carbon steel conveyor belt, is a gas-fired conveyor oven currently in use for heat treating pistons. It features two independent heating zones within its overall 49 ft. processing length. This oven is built on a heavy-duty 6 in. channel steel frame, structurally reinforced and internally welded throughout.

Circle No. 41 on Reader Service Card

Air/Gas Dryer

The Sahara-Pak compressed air/gas dryer, which is capable of delivering dewpoints in the 0 to –40°F range, is designed to fit any compressor. The patented pre-piped and prewired unit uses the normally wasted heat of compression to regenerate its desiccant beds, eliminating the cost of drying air. There is no purge air lost in this Henderson Engineering Co., Inc. dryer, which uses no heaters or blowers.

Circle No. 42 on Reader Service Card

Solutions/Dispersions

Silverson Machines has developed a new system for the high-speed entraining and instant dispersing of powders into liquids. Designed to handle powders including gelling agents, gums, caseinates, and polymers, the Flashblend produces homogeneous, agglomerate-free solutions/dispersions, and will reportedly incorporate up to 33,000 lb of powder with a minimum of aeration.

Circle No. 43 on Reader Service Card

Storage Locker

The Model 30N hazardous materials storage locker has been introduced by Safety Storage, Inc. The prefabricated, relocatable steel locker is designed for single or double stacking of palletized materials or individual containers. Standard features include welded, heavy-gauge sheet and structural steel construction, a 640-gallon spill containment pump, removable steel floor grating, chemical resistant coating inside and out, and a security locking system with inside safety release.

Circle No. 44 on Reader Service Card

Low-Micron Filter

A low-micron backwashable filter is designed with low-micron capability, cleanable 316 stainless steel media, adaptability to low flow rates, a clear acrylic chamber for visual monitoring of the filter, and backwash cleaning cycle. Both manual and actuated typers are available, and automated operation is possible. Hayward Industrial Products, Inc., recommends the Hayward Model 2300 for such applications as cooling towers, reverse osmosis and distillation, and solvent systems.

Circle No. 45 on Reader Service Card

Color Control

The Instrument Systems Division of Minolta Corp. introduces a compact, lightweight benchtop spectrophotometer designed for use in a variety of color control applications. The CM-3200d features d/8 geometry and conforms to ISO, DIN, CIE d/0, ASTM t/0, and D/0 standards. This instrument is switchable between specular component included and excluded and takes light measurements in 20 nm wavelength intervals.

Circle No. 46 on Reader Service Card

Coating Analysis

Fischer Technology highlights the Fischerscope® X-ray system XDV, used for nondestructive, automated coating thickness measurement and analysis of dual and triple coatings, alloy coatings, and P% in electroless nickel coatings. True focus positioning with dual magnification optics allows measurement on a range of shapes and sizes of test specimens. Multiple focal planes allow the user to measure close to steps and recesses.

Circle No. 47 on Reader Service Card

Degreaser

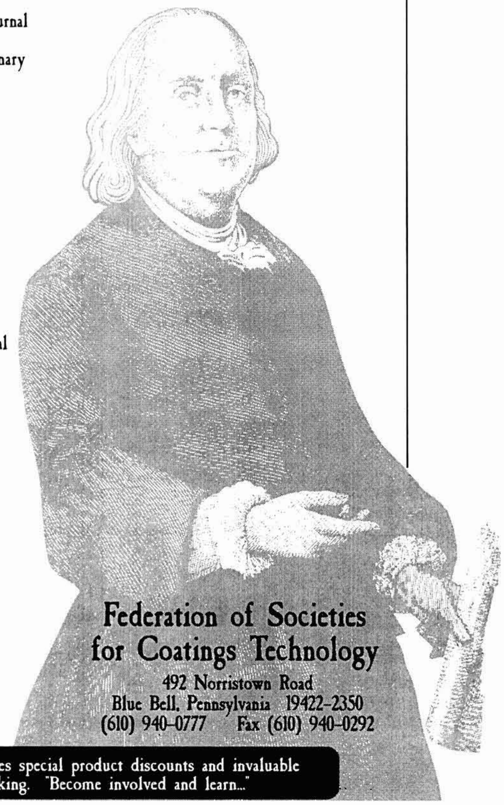
A degreaser/cleaner is developed to be nonhazardous, nontoxic, noncarcinogenic, and nonflammable. The product, available from Solvent Kleene, dissolves and emulsifies hydraulic oils, stamping oils, penetrating oils, cosmolin, greases, lubricating oils, adhesives, sealants, and fluxes. D-Greeze 1000 is suitable for use with aluminum, copper, titanium, magnesium, and stainless and carbon steels.

Circle No. 48 on Reader Service Card

Escape System

3M's five-minute escape system is designed to be lightweight for comfort and reduced fatigue, and includes a stainless steel check valve built into the inlet hose at the base of the regulator to reduce the risk of contamination. A dedicated fill port is included for refilling of the cylinder, which contains five minutes of compressed air for emergency escape. An on/off knob starts the system, and a respirator gauge displays the amount of air available.

Circle No. 49 on Reader Service Card



Calendar of Events

FEDERATION MEETINGS

For information on FSCT meetings, contact Federation of Societies for Coatings Technology, 492 Norristown Rd., Blue Bell, PA 19422 (610) 940-0777, FAX: (610) 940-0292.

1996

(May 3-5)—FSCT Spring Week. Held in conjunction with the Pacific Northwest Society's Annual Spring Symposium. Seminar on the 3rd and 4th. Incoming Society Officers Meeting on the 4th. Board of Directors Meeting on the 5th. DoubleTree Suites Hotel, Seattle, WA.

(Aug. 15-17)—Pan American Coatings Expo. Co-sponsored by Federation of Societies for Coatings Technology, ANAFAPYT, and Instituto Mexicano de Téchnicos en Pinturas y Tintas. Sheraton Maria Isabel Hotel, Mexico City, Mexico.

(Oct. 23-25)—International Coatings Expo and International Coatings Technology Conference (Formerly Annual Meeting and Paint Industries' Show). McCormick Place North, Chicago, IL.

1997

(Nov. 3-5)—International Coatings Expo and International Coatings Technology Conference (Formerly Annual Meeting and Paint Industries' Show). Georgia World Congress Center, Atlanta, GA.

SPECIAL SOCIETY MEETINGS

1996

(Mar. 27-July 10)—"Rheology of Coatings." Sponsored by the New York Society and the New York Paint and Coatings Association. Course held Wednesday evenings for 15 consecutive weeks at Fairleigh Dickinson University, Hackensack, NJ. (Mildred Leonard, NYSCT Office, 520 Westfield Ave., Elizabeth, NJ 07208; (908) 354-3200).

(Apr. 16)—FOCUS '96—"Driving Technology to Meet New Challenges." Sponsored by the Detroit Society. Michigan State University Management Center, Troy, MI. (Rosemary Brady, Akzo Nobel Coatings, Inc., 1845 Maxwell St., P.O. Box 7062, Troy, MI 48007-7062; (810) 637-8565).

(Apr. 17)—"Spectrum of Coatings Science." Sponsored by the Louisville Society. Executive West Hotel, Louisville, KY. (Ilona Duvall, Red Spot Paint & Varnish, 1107 E. Louisiana, Evansville, IN 47711; (812) 467-2337).

(Apr. 24-25)—"Formulating, Manufacturing, and Painting for the Future." 39th Manufacturing & Technical Symposium. Sponsored by the Cleveland Society. John S. Knight Center, Akron, OH. (Jim Miller, J. Miller & Associates, 3057 Kent Rd., Silver Lake, OH 44224; (216) 688-5761).

(May 2-4)—49th Annual Spring Symposium. Sponsored by the Pacific Northwest Society. DoubleTree Suites Hotel, Seattle, WA. (Beverly Spears, Tarr, Inc., 4510 B St., N.W., Auburn, WA 98001; (206) 859-2979).

(May 8-9)—Eastern Training Conference and Show. Sponsored by the Philadelphia Society for Coatings Technology. Valley Forge Convention Center, Valley Forge, PA. (Wayne Kraus, Hercules Incorporated, Research Center, 500 Hercules Rd., Wilmington, DE 19808; (302) 995-3435. Booth reservations: Sam Firestone, S.E. Firestone Associates, Inc., 101 Surrey Rd., Melrose Park, PA 19207-2931).

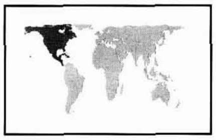
(May 8-10)—Southern Society Annual Meeting. Hyatt Regency-West Shore, Tampa, FL. (Walter R. Naughton Jr., Scott Paint Corp., P.O. Box 10218, Sarasota, FL 34278-0218; (813) 371-0015).

(June 14-15)—Joint Meeting of the St. Louis and Kansas City Societies. Holiday Inn, Lake of the Ozarks, MO. (Randall Ehmer, Walsh & Associates, Inc., 500 Railroad Ave., N. Kansas City, MO 64116; (816) 842-3014).

1997

(Feb. 18-20)—Western Coatings Societies' 23rd Biennial Symposium and Show. Sponsored by the Golden Gate, Los Angeles, Pacific Northwest, and Rocky Mountain Societies. Disneyland Hotel and Convention Center, Anaheim, CA. (Bruce Cotton, Pluess-Staufer (California), Inc., P.O. Box 825, Lucerne Valley, CA 92356; (619) 248-7306; or Ron Elliott, J.R. Elliott Enterprises, Inc., 300 Thor Pl., Brea, CA 92621; (714) 529-0711).

OTHER ORGANIZATIONS



1996—North America

(Mar. 26-29)—"Experiment Design Made Easy." Sponsored by Stat-Ease Corp. Raleigh, NC. (Rich Burnham, Stat-Ease Inc., Hennepin Square, Ste. 191, 2021 E. Hennepin Ave., Minneapolis, MN 55413-2723).

(Mar. 31-Apr. 3)—1996 Spring Convention. Sponsored by The Adhesive and Sealant Council, Inc. Hyatt Regency O'Hare, Rosemont, IL. (The Adhesive and Sealant Council, Inc., 1627 K St., N.W., Ste. 1000, Washington, D.C. 20006).

(Apr. 9)—Rheology Seminar. Sponsored by Brookfield Engineering Laboratories, Inc. Philadelphia, PA. (Brookfield Engineering Laboratories, Inc., Dept. NR-118, 240 Cushing St., Stoughton, MA 02072).

(Apr. 11)—Rheology Seminar. Sponsored by Brookfield Engineering Laboratories, Inc. Chicago, IL. (Brookfield Engineering Laboratories, Inc., Dept. NR-118, 240 Cushing St., Stoughton, MA 02072).

(Apr. 13-14)—"Eastern Education & Trade Fair." Sponsored by the National Decorating Products Association (NDPA). Sturbridge Host Hotel, Sturbridge, MA. (Teri Flotron, NDPA, 1050 N. Lindbergh Blvd., St. Louis, MO 63132-2994).

(Apr. 14-17)—The American Ceramic Society's 98th Annual Meeting and Exposition. Indiana Convention Center and RCA Dome, Indianapolis, IN. (The American Ceramic Society, 735 Ceramic Place, Westerville, OH 43081-8720).

(Apr. 15-17)—"The Fundamentals of Corrosion and Its Control." Sponsored by LaQue Corrosion Services. Holiday Inn SunSpree Resort, Wrightsville Beach, NC. (S. Darden, LaQue Corrosion Services, P.O. Box 656, Wrightsville Beach, NC 28480).

(Apr. 16-18)—1996 Annual Forum. Sponsored by The Conference on Safe Transportation of Hazardous Articles (COSTHA). Atlanta Airport Hilton and Towers, Atlanta, GA. (COSTHA, 9053 Shady Grove Ct., Gaithersburg, MD 20877).

(Apr. 16-19)—"Introduction to Coatings Science." Short course sponsored by The University of Southern Mississippi (USM), Hattiesburg, MS. (Shelby F. Thames, Director, USM, Box 10037, Hattiesburg, MS 39406).

(Apr. 22-23)—"Practical Chemistry of Polyurethanes and Diisocyanates." Seminar sponsored by Technomic Publishing Co., Program Division. Sheraton Colony Square Hotel, Atlanta, GA. (Program Division, Technomic Publishing Co., Inc., 851 New Holland Ave., Box 3535, Lancaster, PA 17604).

(Apr. 22-26)—"Basic Coatings for Sales, Marketing, and General Personnel." Short Course sponsored by University of Missouri-Rolla (UMR), Rolla, MO. (UMR Coatings Institute, 1870 Miner Circle, Rolla, MO 65409-0010).

(Apr. 22-26)—23rd International Conference on Metallurgical Coatings and Thin Films (ICMCTF '96). Sponsored by the American Vacuum Society. Town & Country Hotel, San Diego, CA. (Mary Gray, Conference Secretary, 1090 G Smallwood Dr., Ste. 502, Waldorf, MD 20603).

(Apr. 23-25)—Fabtech East. Sponsored by the Society of Manufacturing Engineers (SME). Pennsylvania Convention Center, Philadelphia, PA. (SME, One SME Drive, P.O. Box 930, Dearborn, MI 48121-0930).

(Apr. 23-25)—Rapid Prototyping and Manufacturing Conference & Exposition. Sponsored by the Society of Manufacturing Engineers (SME). Hyatt Regency Hotel, Dearborn, MI. (SME, One SME Drive, P.O. Box 930, Dearborn, MI 48121-0930).

(Apr. 23-26)—"Response Surface Methods for Process Optimization." Sponsored by Stat-Ease Inc. Minneapolis, MN. (Carol Summer, Stat-Ease Inc., Hennepin Square, Ste. 191, 2021 E. Hennepin Ave., Minneapolis, MN 55413-2723).

(Apr. 24-25)—"Advances in Polyurethane Foam Formulation." Seminar sponsored by Technomic Publishing Co., Program Division. Sheraton Colony Square Hotel, Atlanta, GA. (Program Division, Technomic Publishing Co., Inc., 851 New Holland Ave., Box 3535, Lancaster, PA 17604).

(Apr. 28-May 1)—American Oil Chemists' Society (AOCS) Meeting. Indiana Convention Center and RCA Dome, Indianapolis, IN. (AOCS Education/Meetings Dept., P.O. Box 3489, Champaign, IL 61826-3489).

(Apr. 28-May 2)—Radtech North America. Exhibition and Conference sponsored by RadTech International North America. Nashville, TN. (Christine Dionne, RadTech International North America, 60 Revere Dr., Ste. 500, Northbrook, IL 60062).

(Apr. 30-May 1)—"Thermoplastic Foams." Seminar sponsored by Technomic Publishing Co., Program Division. Sheraton Colony Square Hotel, Atlanta, GA. (Program Division, Technomic Publishing Co., Inc., 851 New Holland Ave., Box 3535, Lancaster, PA 17604).

(Apr. 30-May 2)—Automotive Finishing Conference & Exposition. Sponsored by the Society of Manufacturing Engineers (SME). Cobo Center, Detroit, MI. (SME, One SME Drive, P.O. Box 930, Dearborn, MI 48121).

(May 1-2)—"Paint Volatile Organic Compounds (VOC)." Training course sponsored by the American Society for Testing and Materials (ASTM). Cleveland, OH. (Tina Falkenstein, ASTM, 100 Barr Harbor Dr., West Conshohocken, PA 19428-2959).

(May 1-5)—46th Annual Convention of The Ceilings & Interior Systems Construction Association (CISCA). Royal York Hotel, Toronto, Ont., Canada. (CISCA, 579 W. North Ave., Ste. 301, Elmhurst, IL 60126).

(May 5-7)—1996 ISCC Annual Meeting and Joint Symposium. Sponsored by the Inter-Society Color Council. Doubletree Guest Suites Resort at Walt Disney World Village, Lake Buena Vista, FL. (Robert T. Marcus, ISCC Publicity Chairman, c/o Pantone, Inc., 590 Commerce Blvd., Carlstadt, NJ 07072-3098).

(May 5-10)—39th Annual Technical Conference of the Society of Vacuum Coaters. Adam's Mark Hotel, Philadelphia, PA. (Society of Vacuum Coaters, 440 Live Oak Loop, Albuquerque, NM 87122).

(May 6-10)—"Dispersion of Pigments and Resins in Fluid Media." Course sponsored by Kent State University, Kent, OH. (Carl J. Knauss, Director, Professional Development Institute, P.O. Box 1792, Kent, OH 44240).

(May 7)—Rheology Seminar. Sponsored by Brookfield Engineering Laboratories, Inc. Atlanta, GA. (Brookfield Engineering Laboratories, Inc., Dept. NR-118, 240 Cushing St., Stoughton, MA 02072).

(May 7-9)—"Technochem Expo." Sponsored by American Institute of Chemical Engineers. George R. Brown Convention Center, Houston, TX. (AIChE*xpress* Service Center, 345 E. 47th St., New York, NY 10017-2395).

(May 8-9)—ARMA Executive Committee Meeting and Board of Directors Meeting. Sponsored by Asphalt Roofing Manufacturers Association (ARMA). Baltimore, MD. (ARMA, 6000 Executive Blvd., Ste. 201, Rockville, MD 20852-3803).

(May 8-9)—"Surgical Tissue Adhesives." Seminar sponsored by Technomic Publishing Co., Program Division. Westin Hotel, San Francisco, CA. (Program Division, Technomic Publishing Co., Inc., 851 New Holland Ave., Box 3535, Lancaster, PA 17604).

(May 9)—Rheology Seminar. Sponsored by Brookfield Engineering Laboratories, Inc. Kansas City, MO. (Brookfield Engineering Laboratories, Inc., Dept. NR-118, 240 Cushing St., Stoughton, MA 02072).

(May 12-17)—42nd Annual Technical Meeting and Exposition of the Institute of Environmental Sciences. Radisson Twin Towers Hotel, Orlando, FL. (Institute of Environmental Sciences, 940 E. Northwest Hwy., Mt. Prospect, IL 60056).

(May 13-17)—"Physical Testing of Paints and Coatings." Short Course sponsored by University of Missouri-Rolla (UMR), Rolla, MO. (UMR Coatings Institute, 1870 Miner Circle, Rolla, MO 65409-0010).

(May 13-18)—"Interpretation of IR and Raman Spectroscopy." Short course sponsored by the Fisk Infrared Institute. Vanderbilt University, Nashville, TN. (Clara Craver, Fisk Infrared Institute, 1000 17th Ave., N., Nashville, TN 37208).

(May 14-17)—"Practical Emulsion Polymerization." Conference sponsored by Business Communications Co., Inc. Ramada Plaza, Stamford, CT. (Business Communications Co., Inc., 25 Van Zant St., Norwalk, CT 06855).

(May 15-17)—"Spray Finishing Technology Workshop." Sponsored by Bowling Green State University and ITW DeVilbiss. (Richard A. Kruppa, Bowling Green State University, College of Technology, Bowling Green, OH 43403).

(May 20-22)—"Advances in Flame Retardancy of Polymeric Materials: Applications, Materials, Industry Developments, Markets." Conference sponsored by Business Communications Co., Inc. Ramada Plaza, Stamford, CT. (Business Communications Co., Inc., 25 Van Zant St., Norwalk, CT 06855).

(May 20-24)—"Adhesion Principles and Practice for Coatings and Polymer Scientists." Short course sponsored by Kent State University, Kent, OH. (Carl J. Knauss, Director, Professional Development Institute, P.O. Box 1792, Kent, OH 44240).

(May 20-24)—"Corrosion and Its Control by Protective Coatings." Short course sponsored by Lehigh University. Bethlehem, PA. (Richard D. Granata, Lehigh University, Sinclair Lab, 7 ASA Dr., Bethlehem, PA 18015).

(May 21-23)—Eastec Advanced Productivity Exposition. Sponsored by the Society of Manufacturing Engineers (SME). Eastern States Exposition Center, West Springfield, MA. (SME, One SME Drive, P.O. Box 930, Dearborn, MI 48121-0930).

(May 21-24)—"Coatings Science for Coatings Technicians." Short course sponsored by The University of Southern Mississippi (USM), Hattiesburg, MS. (Shelby F. Thames, Director, USM, Box 10037, Hattiesburg, MS 39406).

(June 3-7)—"Applied Rheology for Industrial Chemists." Short course sponsored by Kent State University, Kent, OH. (Carl J. Knauss, Director, Professional Development Institute, P.O. Box 1792, Kent, OH 44240).

(June 3-7)—"Advances in Emulsion Polymerization and Latex Technology." Short course sponsored by Lehigh University, Bethlehem, PA. (Mohamed S. El-Aasser. Emulsion Polymers Institute, Lehigh University, 111 Research Dr., Bethlehem, PA 18015).

(June 11)—Rheology Seminar. Sponsored by Brookfield Engineering Laboratories, Inc. Providence, RI/Boston, MA. (Brookfield Engineering Laboratories, Inc., Dept. NR-118, 240 Cushing St., Stoughton, MA 02072).

(June 11-14)—"Introduction to Coatings Technology." Short course sponsored by Kent State University, Kent, OH. (Carl J. Knauss, Director, Professional Development Institute, P.O. Box 1792, Kent, OH 44240).

(June 16-19)—CPMA 66th Annual Meeting. Sponsored by the Color Pigments Manufacturers Association, Inc. (CPMA). The Greenbrier, White Sulphur Springs, WV. (CPMA, P.O. Box 20839, Alexandria, VA 22320-1839).

(June 18-21)—"Coatings Science for Coatings Chemists." Short course sponsored by The University of Southern Mississippi (USM), Hattiesburg, MS. (Shelby F. Thames, Director, USM, Box 10037, Hattiesburg, MS 39406).

(June 24-26)—"The Fundamentals of Corrosion and Its Control." Sponsored by LaQue Corrosion Services. Holiday Inn SunSpree Resort, Wrightsville Beach, NC. (S. Darden, LaQue Corrosion Services, P.O. Box 656, Wrightsville Beach, NC 28480).

(June 25-28)—"Coatings Science for Coatings Formulators." Short course sponsored by The University of Southern Mississippi (USM), Hattiesburg, MS. (Shelby F. Thames, Director, USM, Box 10037, Hattiesburg, MS 39406).

(July 14-18)—Fifth World Congress of Chemical Engineering. Sponsored by American Institute of Chemical Engineers. Marriott Hotel, San Diego, CA. (AIChE*xpress* Service Center, 345 E. 47th St., New York, NY 10017-2395).

(July 15-17)—"Basic Coatings for Sales, Marketing, and General Personnel." Short Course sponsored by University of Missouri-Rolla (UMR), Rolla, MO. (UMR Coatings Institute, 1870 Miner Circle, Rolla, MO 65409).

(July 16-19)—"Introduction to Powder Coatings Technology." Short course sponsored by The University of Southern Mississippi (USM), Hattiesburg, MS. (Shelby F. Thames, Director, USM, Box 10037, Hattiesburg, MS 39406).

(Aug. 19-22)—ARMA Fall Committee Meetings. Sponsored by Asphalt Roofing Manufacturers Association (ARMA). New Orleans, LA. (ARMA, 6000 Executive Blvd., Ste. 201, Rockville, MD 20852-3803).

(Sept. 8-12)—1996 EOS/ESD Symposium. Sponsored by the ESD Association. Lake Buena Vista, FL. (ESD Association, 7902 Turin Rd., Ste. 4, Rome, NY 13440).

(Sept. 9-13)—"The Basic Composition of Coatings." Short Course sponsored by University of Missouri-Rolla (UMR), Rolla, MO. (UMR Coatings Institute, 1870 Miner Circle, Rolla, MO 65409-0010).

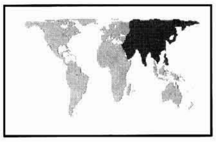
(Sept. 22-25)—1996 Manufacturers and Suppliers Workshop and Exposition. Sponsored by The American Ceramic Society. Adam's Mark Hotel, Charlotte, NC. (The American Ceramic Society, 735 Ceramic Place, Westerville, OH 43081-8720).

(Sept. 23-27)—"Introduction to Paint Formulation." Short Course sponsored by University of Missouri-Rolla (UMR), Rolla, MO. (UMR Coatings Institute, 1870 Miner Circle, Rolla, MO 65409-0010).

(Oct. 14-18)—43rd National Symposium of the American Vacuum Society. Pennsylvania Convention Center, Philadelphia, PA. (American Vacuum Society, 120 Wall St., 32nd Flr., New York, NY 10005).

(Oct. 23-25)—109th Annual Meeting of the National Paint and Coatings Association (NPCA). Palmer House (Hilton), Chicago, IL. (Cheryl Matthews, NPCA, 1500 Rhode Island Ave., N.W., Washington, D.C. 20005-5597).

1996—Asia



(May 28-31)—ChinaCoat. Exhibition sponsored by Sinostar International Ltd. Guangzhou, China. (Sinostar International Ltd., 1001 Siu Lam Bldg., 23 Luard Rd., Wanchai, Hong Kong).

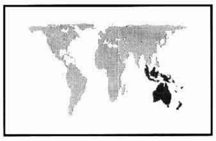
(June 5-6)—Asia-Pacific Coatings Show. Exhibition and Conference sponsored by FMJ International. Hong Kong Convention and Exhibition Centre, Hong Kong. (Mike Tarrant, FMJ International Publications Ltd., Queensway House, 2 Queensway, Redhill, Surrey RH1 1QS, England).

(June 5-8)—The International Exposition for Coatings & Paints. Sponsored by Chinese Chemical Society (CCS) and Chemical Industry and Engineering Society of China (CIESC). Shanghai Exhibition Center, Shanghai, P.R. China. (Worldwide Exhibitions Service Co., Ltd. (WES), 4/F, Bldg. 2, 1486 Nanjing Rd. (W), Shanghai 200040, P.R. China).

(June 12-13)—Korean Coatings Show '96. Exhibition and Conference sponsored by FMJ International. Hong Kong Convention and Exhibition Centre, Hong Kong. (Nicky Molloy, FMJ International Publications Ltd., Queensway House, 2 Queensway, Redhill, Surrey RH1 1QS, England).

(July 9-12)—Autofact Asia Conference. Sponsored by the Society of Manufacturing Engineers (SME). Singapore International Convention and Exhibition Center (Suntec City), Singapore. (SME, One SME Drive, P.O. Box 930, Dearborn, MI 48121-0930).

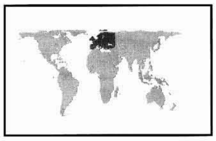
1996—Australia



(Aug. 8-11)—"Cradle to Grave, The Life Cycle of Paint Products." Sponsored by the Surface Coatings Association New Zealand (SCANZ). Plaza International Hotel, Wellington, New Zealand. (SCANZCON.96 Secretariat, P.O. Box 38 546, Wellington, NZ; 64 4 568 8993).

(Aug. 11-16)—Third International Hydrocolloids Conference. Cosponsored by the CSIRO and the Cooperative Research Centre for Industrial Plant Biopolymers. Landmark Park Royal Hotel, Potts Point, Sydney, Australia. (Gail Hawke, Third International Hydrocolloids Conference, P.O. Box N399, Grosvenor Place, Sydney, NSW 2000, Australia).

1996—Europe



(Apr. 11-12)—"Polymer Structure and Practical Properties." Seminar sponsored by Technomic Publishing AG. Hotel International, Basel, Switzerland. (Program Division, Technomic Publishing Co., Inc., 851 New Holland Ave., Box 3535, Lancaster, PA 17604).

(Apr. 15-17)—"Color Measurement and Color Control." Training course sponsored by Paint Research Association (PRA). Teddington, Middlesex, England. (Sue Benjamin, PRA, 8 Waldegrave Rd., Teddington, Middlesex TW11 8LD England).

(Apr. 18)—"Environmentally Friendly Wood Preservatives and Coatings." Sponsored by the Oil & Colour Chemist's Association (OCCA) Bristol Section. University of The West of England, Bristol. (Yvonne Waterman, OCCA, Priory House, 967 Harrow Rd., Wembley, HA0 2SF; 0181 908 1086).

(May 7-8)—"Hydrogels: Specialty Plastics for Biomedical and Pharmaceutical Applications." Seminar sponsored by Technomic Publishing AG. Basel Hilton Hotel, Basel, Switzerland. (Program Division, Technomic Publishing Co., Inc., 851 New Holland Ave., Box 3535, Lancaster, PA 17604).

(May 8-10)—"Medical Packaging Technology and Validation of the Packaging Process." Seminar sponsored by Technomic Publishing AG. Zurich Hilton Hotel, Zurich, Switzerland. (Program Division, Technomic Publishing Co., Inc., 851 New Holland Ave., Box 3535, Lancaster, PA 17604).

(May 21-22)—"Thermoforming: Process and Design." Seminar sponsored by Technomic Publishing AG. Hotel International, Basel, Switzerland. (Program Division, Technomic Publishing Co., Inc., 851 New Holland Ave., Box 3535, Lancaster, PA 17604).

(May 23-24)—"Thermoplastic Foams." Seminar sponsored by Technomic Publishing AG. Hotel International, Basel, Switzerland. (Program Division, Technomic Publishing Co., Inc., 851 New Holland Ave., Box 3535, Lancaster, PA 17604).

(May 30-31)—"Nanomaterials: Design, Preparation, Characterization, and Applications." Seminar sponsored by Technomic Publishing AG. Hotel International, Basel, Switzerland. (Program Division, Technomic Publishing Co., Inc., 851 New Holland Ave., Box 3535, Lancaster, PA 17604).

(June 3-5)—"Styrenics '96." Sponsored by Maack Business Services. Zürich, Switzerland. (Maack Business Services, Moosacherstrasse 14, CH-8804 AU/Zürich, Switzerland).

(June 4-5)—"Sealing Technology: Materials, Design, and Applications." Seminar sponsored by Technomic Publishing AG. Hotel International, Basel, Switzerland. (Program Division, Technomic Publishing Co., Inc., 851 New Holland Ave., Box 3535, Lancaster, PA 17604).

(June 10-14)—23rd FATIPEC Congress. "Performance, Environment, and Legislation: Challenges and Sources of Innovation in the Coatings Industry." Conference sponsored by the Belgian Association of Coatings Technicians. Brussels, Belgium. (Michael Kuhn, Vincentz Verlag, Postfach 6247, 30062 Hannover, Germany).

(June 11-13)—European Coatings Show '96. Exhibition and conference sponsored by Vincentz Verlag. Brussels, Belgium. (Michael Kuhn, Vincentz Verlag, Postfach 6247, 30062 Hannover, Germany).

(June 10-13)—"Science and Technology of Pigment Dispersion." Vitznau (Luzern), Switzerland. (Angelos V. Patsis, Director, Institute for Materials Science, State University of New York, New Paltz, NY 12561).

(June 17-19)—18th International Conference in Stabilization and Controlled Degradation of Polymers. Luzern, Switzerland. (Angelos V. Patsis, Director, Institute for Materials Science, State University of New York, New Paltz, NY 12561).

(June 25-26)—SURFEX '96. Sponsored by Oil & Colour Chemists' Association (OCCA). Harrogate, North Yorks, England. (Chris Pacey-Day, SURFEX Ltd., Priory House, 967 Harrow Rd., Wembley HA0 2SF, England).

(July 1-3)—Ninth International Symposium on Polymer Analysis and Characterization. Keble College, Oxford University, United Kingdom. (John Dawkins, Dept. of Chemistry, Loughborough University of Technology, Loughborough, Leicestershire, LE11 3TU, United Kingdom).

(July 1-5)—22nd International Conference in Organic Coatings—Waterborne, High-Solids, Powder Coatings. Vouliagmeni (Athens), Greece. (Angelos V. Patsis, Director, Institute for Materials Science, State University of New York, New Paltz, NY 12561).

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Humbug from Hillman

Jeff Sturm ended 1995 for me with several smiles when he sent me another copy of the "Yetter Letter." We'll start with a few examples on following directions.

The next time you have sales people together, copy this test and give one to each person.

This is a timed test, you only have three minutes.

(1) Read everything carefully before doing anything.
(2) Put your name in the upper right hand corner of this paper.
(3) Circle the word "name" in sentence 2.
(4) Draw five small squares in the upper left hand corner.
(5) Put an "X" in each square.
(6) Sign your name under the title of this paper.
(7) Now that you have finished reading everything carefully, do only sentences one and two.

(And how did YOU do?)

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Reader's Digest grouped these critical reviews:

—From a theater review: "The big trouble was the seats faced the stage."—Joey Adams

—Movie critic Richard Harrington: "The plot must have been scripted on a napkin over lunch at a fast food restaurant."—*Washington Post*

—Gene Shalit, of NBC: "Some films could only have been cast in one way—screen tests were given and the losers got the parts.

—"A book with a message not even a pigeon would carry."—*The Spectator*

—It probably would have been all right if only they had eliminated the plot."—Henry Tenenbaum

—If it's bright and sunny after two rainy days, it is probably Monday.—H.B. Brous

—The person I work for is everything you could want in an ex-boss.

—Lily Tomlin says, "I've always wanted to be somebody, but I see now I should have been more specific."

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Barbara Lauren, apparently a devotee of Bob Levey's column in the *Washington Post*, kindly saved a copy of the August 4th issue for me. In it, Levey announces the winner and innumerable runners up in his "make up a word" contest. The challenge:

The voice on the radio warns ominously of massive congestion on the inner loop of the Beltway. But that's where you happen to be and it's smooth sailing. Later the same voice swears that the lanes near Tyson's Corner are wide open. In fact it's stop and go for four miles. Such inaccurate traffic reports are called:

The winner . . . . Looplicity
Some almosts . . . . . . .Highway Rubery. Fraudcasts. Car-Null Knowledge, Carbungles, Automobull, Radio-I-So-Hope, Stupgridity, Triptease, Media-ocrity, and many others.

Barbara also recommended this story from the *ABA Journal*:

The plaintiff's witness in a personal injury trial was undergoing cross examination. The defendant's lawyer sought to establish that the witness could not have seen clearly the nighttime automobile accident.

"How far can you see at night?" the lawyer asked.

The witness paused to think it over. "I can see the moon." he said. "How far is that?"

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So Cohen decides to take a luxury cruise. He comes to the table for his first dinner with his wife. Opposite Cohen sits a friendly Frenchman, who smiles and says, "Bon Appetit." Cohen smiles and answers. "Abe Cohen." Next morning, at breakfast, the same thing happens . . . "Bon Appetit" — "Abe Cohen."

After breakfast, Cohen turns to his wife and says, "What's with this guy? Every meal he tells me his name and I tell him mine." His wife says patiently, "Abe, 'Bon Appetit' means 'Hearty Appetite' — 'Enjoy your meal'."

Learning his lesson, at dinner he smiles at the Frenchman and says, "Bon Appetit." The Frenchman answers, "Abe Cohen."

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Two single ladies set up farming in Vermont, although they knew nothing about it. Well, they decided to raise pigs. Since they had a single sow, they loaded it in a wheelbarrow and took the sow down to a farmer who had a boar. They brought the sow back home after servicing but after some time didn't see any signs of pregnancy. So they loaded the sow in the wheelbarrow and repeated the trip. . . . . . No results. So they again decided to cart the sow off again and when they went out to catch her, there she was sitting in the wheelbarrow.

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Some months ago Past Prez Clarke Boyce sent a potpourri of items, from which I, again, can give you a sampling.

—Antique store window: Come in and buy what your grandmother threw away.
—In nudist camp: We never clothe.
—In linen shop window: Towels for the whole damp family.
—Beauty Parlor: Where the talk alone is enough to curl your hair.

And, with a personal aside to M G:

—Intuition: The instinct that tells you you're right regardless of the facts.

—Herb Hillman, Humbug's Nest,
P.O. Box 135, Whitingham, VT 05361.

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