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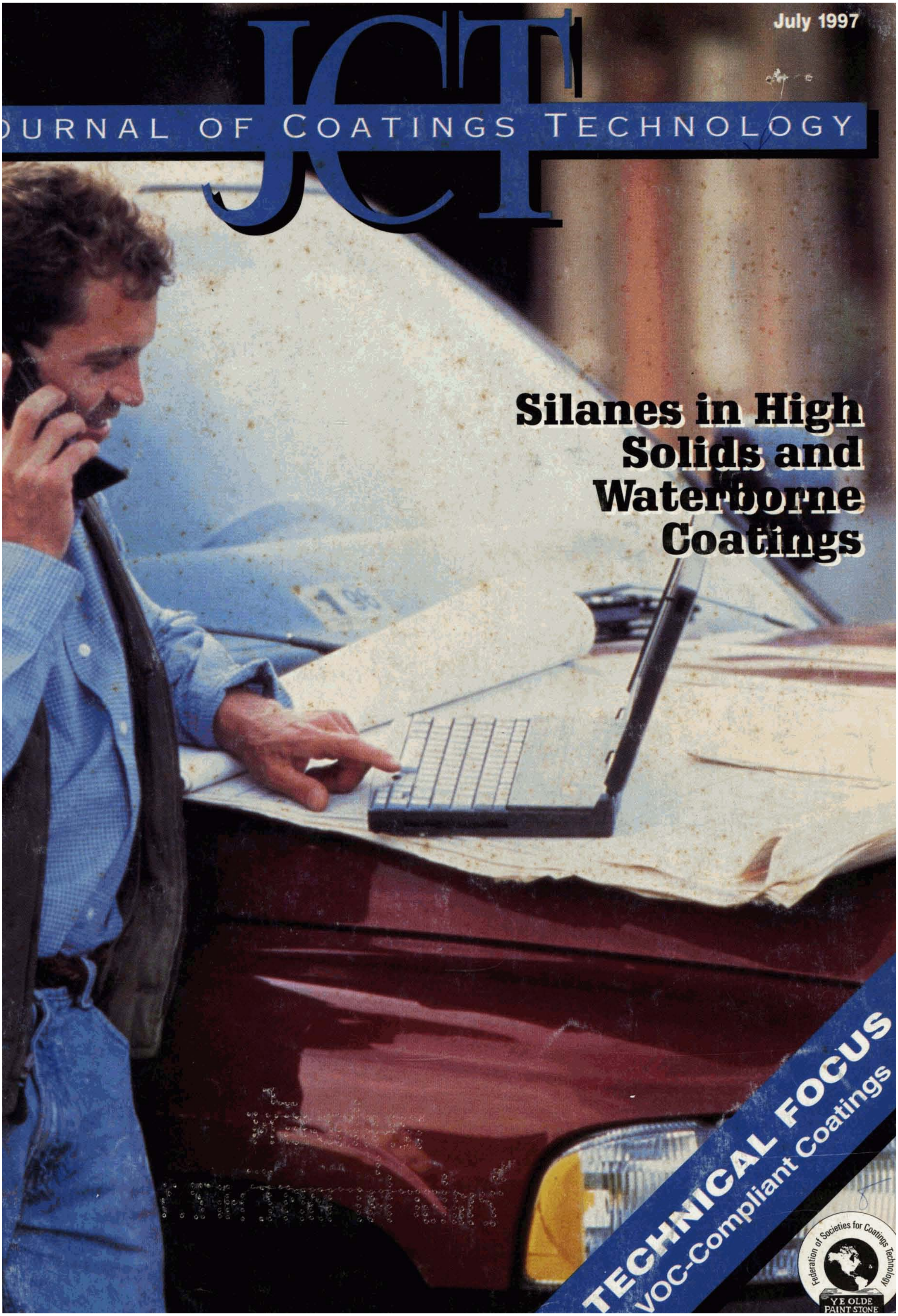

Silanes in High Solids and Waterborne Coatings

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VOC-Compliant Coatings

Federation of Societies for Coatings Technology
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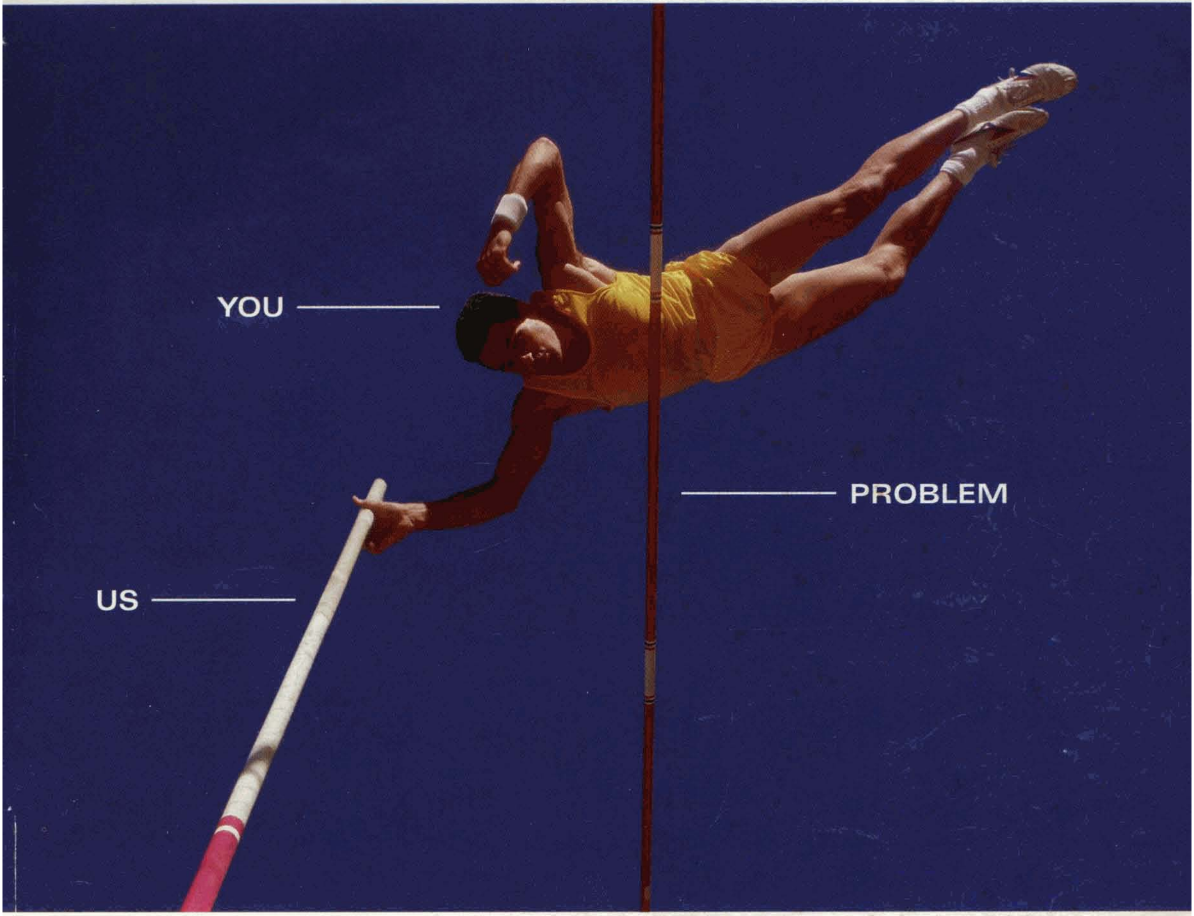
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ice
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AND TECHNOLOGY CONFERENCE

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JOURNAL OF COATINGS TECHNOLOGY

Guide for Authors

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 All manuscripts will be assumed to be previously unpublished writing of the authors, not under consideration for publication elsewhere.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 Annual Meeting 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.

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...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 Annual Meeting 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 1997 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).

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

Equations must be typed, or written clearly, with equations numbered sequentially in parentheses to the right. If Greek letters are used, write out their names in the manuscript margin at the first point of use. Place superscripts^a and subscripts$_b$ accurately. Avoid the use of superscripts in a manner that can lead to their interpretation as exponents.

Summary

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.

Acknowledgment

If used, it should follow the summary.

References

These should be listed in the numerical order in which they are cited in the text, and should be placed at the end of the manuscript. Names of authors may or may not be shown in the text with reference numbers. If possible, include titles of articles referenced in the literature. The following are examples of acceptable reference citations for periodicals, [1,2,3] books, [4] and patents.[5]

(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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Transitions

It seems that beginning with the move in Headquarters location in 1990, the Federation started looking at itself and where it stood—not just in geographical terms—but also, in relation to its members, the industry, and its future. As you have no doubt read and/or heard, during the past five years the FSCT has examined the possibilities for improvement, discussed potential avenues of action, and at the May meeting of its Board of Directors, finally, set the direction in which it is headed.

The outcome from thousands of "man-hours" spent over the past 60 months is detailed on pp. 13-18 of this issue. The proposed bylaws changes, those which passed first reading in May and those which will be given initial consideration in November, represent significant changes in the way the FSCT and its Societies recruit members, the manner in which the FSCT is governed, and with yet additional proposals on the establishment of Common Interest Groups—to be looked at next Spring—the FSCT will embark on new opportunities to inform and involve a wider audience.

Many have said, "If ain't broke, don't fix it." If taken in the context of this industry, the many changes it faces and the needs and wants of our industry members both now and in the future, may I suggest that this quaint saying be updated to: "If it seems it ain't broke, look again. Make it better!"

In this space last month, JCT Editor Pat Viola reviewed the substantial list of changes and improvements in the Journal. These aren't just cosmetic, but real enhancements brought about by a realization that change was needed. These are just some of the more visible improvements in the FSCT. Like the changes in the JCT the changes being addressed in the bylaws proposals will enable the FSCT to more effectively meet the needs of its Societies and its members.

Transitions are part of life both in business and personally; stressful, yes, but necessary for growth and fulfillment. While the FSCT is coping with the many changes taking place, both Pat Viola and I are looking forward to a transition of a personal nature. Although some may think that an announcement of this type is inappropriate for a trade journal (it's probably the first time ever that this has been done), we have relented to the many requests over the past several months: You see, we're getting married this month and we want to thank all of the members/readers who have expressed their good wishes.

Meanwhile, the FSCT looks forward to increasing the number and scope of its activities and services to its members and the industry. Please let us know your thoughts on the issues presented here, along with any suggestions you may have for improvement. Thank you.

Robert F. Ziegler
Executive Vice President

Technical Abstracts

Spanish translations provided by Jose L. Ramirez, Technical Chief, Institute Mexicano de Técnicos en Pinturas y Tintas (ANAFAPYT)

Silanes in High Solids and Waterborne Coatings—Ming J. Chen, Fred D. Osterholtz, Eric R. Pohl, Philbert E. Ramdatt, Antonio Chaves, and Valerie Bennett

JCT, Vol. 69, No. 870, 43 (July 1997)

Silanes have been used effectively in solvent-based or waterborne coatings to crosslink binder resins, increase pigment dispersion and improve end use properties, such as mar and solvent resistance and durability. A series of silylated styrene acrylic clearcoats have been prepared and studied in order to understand the chemical and physical parameters that influence the mar resistance and weathering properties of the cured coatings. It was found that the silane content affects the indentation hardness, coefficient of friction, modulus, and toughness of the cured coatings. A relationship between these coating characteristics and mar resistance is demonstrated. In water dispersed and emulsion polymer systems, silanes maximize properties, such as adhesion and solvent resistance. Silanes are incorporated into these systems via copolymerization or post addition. Recent advances in waterborne silane technologies are discussed, including methods of improving formulation stability.

Silanos en Recubrimientos de Altos Sólidos y Base Agua—M.J. Chen et al.

Los silanos han sido utilizados efectivamente en recubrimientos base solvente y base agua para vehículos de resinas reticulantes al facilitar la dispersión de pigmentos y mejorar las propiedades de uso final, como la resistencia a la abrasión, al solvente y la durabilidad. Una serie de recubrimientos trasparentes a base de acrilico - estireno - siliconados fueron preparados y estudiados con la finalidad de entender los parámetros fisícos y químicos que influyen en la resistencia a la abrasión y las propiedades de intemperismo de los recubrimientos curados.

Se encontró que el contenido de silanos afecta la dureza de penetración, el coeficiente de fricción, los módulos de fuerza y la dureza total del recubrimiento curado. Se demonstró la relación entre estas características del recubrimiento y la resistencia a la abrasión. Los sistemas de polímeros que se ofrecen en forma de emulsión o dispersados en agua maximizan las propiedades de los silanos tales como la adhesión y la resistencia a solventes. Los silanos se incorporan en estos sistemas vía copolimerización o post-adicion. Se discuten los avances recientes en la tecnologia de los silanos para sistemas base agua, y se incluyen metodos para mejorar la estabilidad de las formulaciones.

Corrosion Resistance and Dielectric Properties of an Iron Oxide Filled Epoxy Coating—N. Kouloumbi et al.

JCT, Vol. 69, No. 870, 53 (July 1997)

Polymeric composites of a bisphenol-A-epoxy resin and iron oxide filler (15% w/w) were deposited on pretreated steel specimens. The applied coatings had a thickness of 80 μm and 220 μm. The modification of the anticorrosive and dielectric characteristics of these coatings, in a corrosive environment (3.5% NaCl), were monitored by potentiodynamic polarization measurements, electrochemical impedance spectroscopy, and dielectric measurements.

Corrosion resistance of composite coatings was found to be somewhat higher than that of unfilled epoxy coatings. Coatings containing iron oxide exhibited capacitive behavior as revealed by dielectric and EIS measurements. This behavior is more pronounced in high thickness composite coatings.

Propiedades Dieléctricas y Resistencia a la Corrosión de un Recubrimiento Epóxico con Carga Rellenadora de Oxido de Oxido de Fierro—N. Kouloumbi et al.

Se aplicó sobre un probeta de acero tratado un compuesto polimérico a base de resina epóxica tipo bisfenol A y con carga rellenadora de óxido de fierro (15%). Se aplico a un espesor de película seca de 80-220 micras. La modificación que sufrieron las características dieléctricas y anticorrosivas de este recubrimiento fueron monitoreadas mediante mediciones de polarización potenciodinamica, espectroscopia de impedancia electroquímica (EIS) y la medición dieléctrica, en un ambiente corrosivo (3.5% de NaCl).

Se encontró que la resistencia a la corrosión del recubrimiento analizado es algo mayor que la de un recubrimiento epóxico tipico sin carga rellenadora. La capacidad de funcionamiento que muestra el recubrimiento que contiene el óxido de fierro se evidenció mediante mediciones dieléctricas y de espectroscopia de impedancia electroquímica. Este funcionamiento es más pronunciado a altos espesores del recubrimiento.

High Performance Coating Films Cured by Novel Penetrating Method: Anionic Resin Paints—Y. Nakayama

JCT, Vol. 69, No. 870, 61 (July 1997)

This study deals with a method of curing paint film at ambient temperature with a film-penetrative crosslinker. The method is based on the phenomenon that, after a wet coating film becomes thermoplastic, it is dipped in an aqueous solution of crosslinker. The crosslinker then penetrates into the film, and the film can be cured with the passage of dipping time.

Herein an anionic copolymer containing diacetone acrylamide was employed as the main resin and carbohydrazide as the film-penetrative crosslinker. Cured films can be prepared with a short dipping time using this method. The curing front propagates from the film surface towards the substrate surface according to the penetration of the crosslinker. Excellent films were obtained when they were dipped in a suitable crosslinker solution containing the proper organic solvents (accelerator of penetration rate) and an appropriate acid (promoter of the reaction). In particular, the adhesion after the water resistance test was excellent compared with that of the coating film obtained by the two-component coating method.

If the method is completed from both a technical and engineering standpoint, industrial paint can be cured practically at ambient temperature without bulky devices for hardening the coating films.

Curado de un Recubrimiento de Alto Desempeño Mediante el Original Método de Penetración. Pintura de Resina Anionica—Y. Nakayama

Este estudio trata de un método de curado de película de pintura a temperatura ambiente con un reticulante de penetración de película. Este método esta basado en el fenómeno de que después de que la película de recubrimiento en estado termoplástico es inmerso en una solución acuosa del reticulante, el reticulante entonces penetra dentro de la película y ésta cura conforme pasa el tiempo de inmersión.

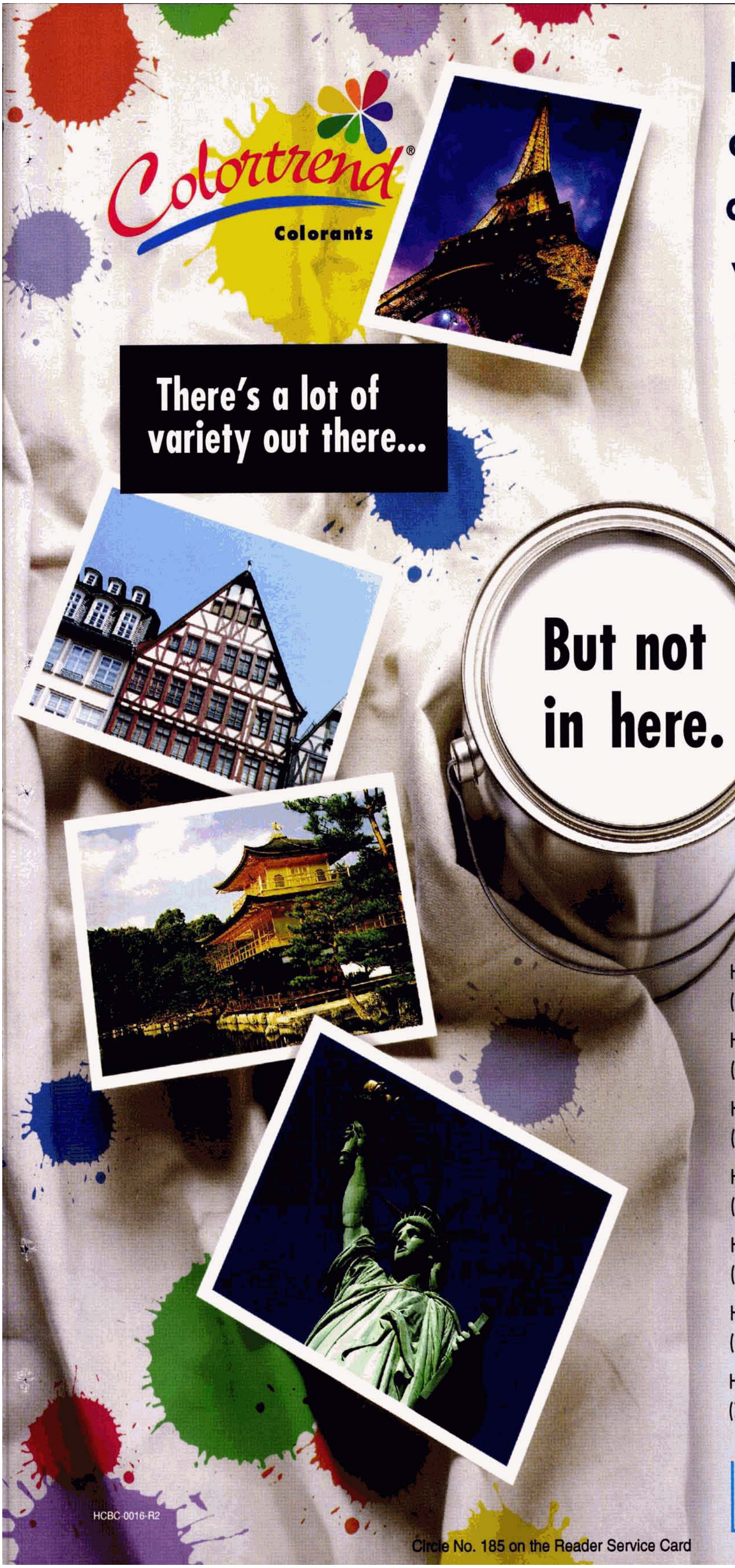
Aquí es necesario mencionar que se utilizó como resina principal un copolímero anionico conteniendo acetona acrilamida y como reticulante de penetración de película la carbohidrazida.

Pueden ser preparadas películas curadas con cortos tiempos de inmersión usando este método.

El curado se inicia desde la superficie de la pelicula y se propaga en dirección del sustrato de acuerdo a la velocidad de penetración del reticulante.

Fueron obtenidas excelentes películes las cuales fuerón inmersas en una solución adecuada de reticulante que contenga un solvente organico adecuado (acelerador de las velocidad de penetración) y un ácido apropiado (catalizador o promotor de la reacción). En especial la adhesión de la película de recubrimiento fue excelente después de la prueba resistencia al agua comparada con el resultado obtenido con la película de recubrimiento curada mediante el método normal de dos componentes.

Si el método de inmersión se completa desde el punto de vista técnico y de ingeniería, las pinturas industriales pueden ser curadas prácticamente a temperatura ambiente sin equipos voluminosos para el endurecimiento de las películas de recubrimiento.


Colortrend®
Colorants
There's a lot of variety out there...
But not in here.
HCBC-0016-R2

Proposed Amendments
to FSCT Bylaws and Standing Rules

The following amendments to the Federation Bylaws and Standing Rules passed First Reading at the May 18, 1997 meeting of the Board. They will be presented for Second and Final Reading at the Board Meeting of November 2, 1997 in Atlanta.

The Amendments provide for implementation of Strategic Planning objectives. The Bylaws Committee recommends adoption of the amendments.

Freidun Anwari,
Chair, Bylaws Committee

For Second Reading

Amendment to Remove Dues Amount from Bylaws and Add to Standing Rules

Bylaws
ARTICLE XII
Dues

Delete Sections A. through D. of ARTICLE XII:

A. Active and Associate Members

Each Constituent Society shall pay to the Federation office annual dues of twenty-five dollars ($25.00) in U.S. funds per capita for each Active and Associate Member of the Constituent Society.

B. Affiliated Members

Affiliated Members shall pay to the Federation annual dues equal to the nonmember subscription price of the Journal of Coatings Technology applying to the address of the Affiliated Member.

C. Educator and Student Members

The dues, if any, of Educator and Student Members shall be determined by the Board of Directors. (Current dues are $12.50.)

D. Retired and Society Honorary Members

Each Constituent Society shall pay to the Federation office annual dues equal to one-half the amount established for Active Member, for each Retired and Society Honorary Member of the Constituent Society.

Replace with the following:

The Board of Directors shall establish the amount of the annual dues applying to all classes of membership to be paid to the Federation.

Following Standing Rule ARTICLE SR VIII, insert:

Standing Rule
ARTICLE SR IX
Dues

A. Active and Associate Members

Each Constituent Society shall pay to the Federation office annual dues of twenty-five dollars ($25.00) in U.S. funds per capita for each Active and Associate Member of the Constituent Society.

B. Affiliated Members

Affiliated Members shall pay to the Federation annual dues equal to the nonmember subscription price of the Journal of Coatings Technology applying to the address of the Affiliated Member.

C. Educator and Student Members

Each Constituent Society shall pay to the Federation annual dues of twelve and one-half dollars ($12.50) in U.S. funds per capita for each Educator and Student Member of the Constituent Society.

D. Retired and Society Honorary Members

Each Constituent Society shall pay to the Federation office annual dues equal to one-half the amount established for Active Members, for each Retired and Society Honorary Member of the Constituent Society.

and renumber all subsequent Standing Rules

* * *

For Second Reading

(Following discussion at its May 18, 1997 meeting, the Board voted to amend the original proposal, reinstating the Members-at-Large on the Board.)

Amendment to Reduce the Size of the FSCT Board of Directors by the Elimination of the NPCA Representative Position

Bylaws
ARTICLE IV
Organization

Under ARTICLE IV, Section B. of the Bylaws, delete:

B. BOARD OF DIRECTORS

The Board of Directors shall consist of the President, President-Elect, Secretary-Treasurer, four Members-at-Large, the immediate Past-President or most recent available Past-President, two additional Past-Presidents, all of the Society Representatives, and a representative appointed by the National Paint & Coatings Association (NPCA). Active membership shall be required for all members of the Board of

Directors, except (1) the Past-President members may hold any class of membership in the Federation, and (2) the representative of the NPCA, who need not be a member of the Federation.

And replace with:

B. BOARD OF DIRECTORS

The Board of Directors shall consist of the President, President-Elect, Secretary-Treasurer, four Directors-at-Large, the immediate Past-President or most recent available Past-President, two additional Past-Presidents, and all of the Society Representatives. Active membership shall be required for all members of the Board of Directors, except the Past-President members may hold any class of membership in the Federation.

Under ARTICLE VII, Section C. of the Bylaws, delete:

(9) The NPCA Representative on the Board of Directors shall be appointed annually by the NPCA.

* * *

For Second Reading

Amendment to Change the Membership Year

Replace:

Bylaws
ARTICLE XIII
Fiscal Year

The Fiscal Year of the Federation shall end on December 31.

With:

Bylaws
ARTICLE XIII
Fiscal Year and Membership Year

The Fiscal Year of the Federation shall end on December 31. The Membership Year of the Federation and the Constituent Societies shall end on June 30.

* * *

For Second Reading

Resolution to Eliminate Elections for New Constituent Society Members

Bylaws
ARTICLE III
Constituent Societies

Delete ARTICLE III, Section E.:

E. Procedural Matters

The organizing of Constituent Societies, Constituent Society boundaries, and election to membership in Constituent Societies are subject to the provisions of the Standing Rules of the Federation.

Replace with the following:

E. Procedural Matters

The organizing of Constituent Societies, Constituent Society boundaries, and membership acceptance in Constituent Societies are subject to the provisions of the Standing Rules of the Federation.

Standing Rule
ARTICLE SRII
Membership in Constituent Societies

Rename Standing Rule ARTICLE SR II; Section C from "Method of Election to Membership" to "Method of Attaining Membership."

Delete ARTICLE SR II, Section C. (1):

(1) An applicant for Active, Associate, or Educator and Student class of membership must be proposed by a Voting Member who has verified the eligibility of said applicant for the class of membership proposed. If the application is approved by the Constituent Society Membership Committee, it shall be submitted to the membership of the Constituent Society at a regular meeting of the Society. Election to membership shall be by a two-thirds favorable vote of the Voting Members present and voting. If the applicant is elected to Society membership, both copies of the application, bearing the Constituent Society Secretary's certification of election, shall be forwarded to the Executive Vice President of the Federation who will sign the original and return it to the Society.

Replace with the following:

(1) An applicant for Active, Associate, or Educator and Student class of membership must be approved by the Constituent Society Membership Committee that verified the eligibility of said applicant for the class of membership proposed. The application, bearing the Constituent Society Secretary's certification of eligibility, shall be forwarded to the Executive Vice President of the Federation, who will sign and return it to the Society.

Delete ARTICLE SR II, Section C. (2):

(2) An applicant for Retired Membership, after recommendation by the Membership or other appropriate committee of the Constituent Society, shall be subject to election to membership by two-thirds of the Voting Members present and voting at any regular meeting of the Society. The application shall be processed in the same manner as an application for Active Membership.

Replace with the following:

(2) An applicant for Retired Membership, after recommendation by the Membership or other appropriate committee of the Constituent Society, shall be processed in the same manner as an application for Active Membership.

Delete ARTICLE SR II, Section C. (3):

(3) An application for the transfer of an Active Member or an Associate Member from one firm to another within the same Constituent Society shall be processed in the same manner as an application for Retired Membership. If the firm to which the member is transferring currently employs a member of the same class, the application need not be subject to a vote by the membership, may be certified by the Secretary, and be forwarded to the Executive Vice President of the Federation. It is expressly provided, however, that an Associate Member may not assume Active Membership in another firm by means of the transfer procedure. Any Constituent Society may require any applicant for transfer to be subject to the full procedures as if application were being made for a new membership, in accordance with such requirements as may be included in the Constituent Society By-Laws.

Replace with the following:

(3) An application for the transfer of an Active Member or an Associate Member from one firm to another within the same

Constituent Society shall be processed in the same manner as an application for Retired Membership. It is expressly provided, however, that an Associate Member may not assume Active Membership in another firm by means of the transfer procedure. Any Constituent Society may require any applicant for transfer to be subject to the full procedures as if application were being made for a new membership, in accordance with such requirements as may be included in the Constituent Society By-Laws.

+ + +

For Second Reading

Resolution to Allow the FSCT to Accept New Constituent Society Members

Following Standing Rules ARTICLE SR II, Section C. (3) add the following:

(4) An application for a new Active, Associate, Educator and Student, or Retired member can be accepted by the Federation. If the proposed member resides or is employed, or performs services within the territorial boundaries of a Constituent Society, the application will be forwarded to that Constituent Society's Membership Committee for processing in accordance with **ARTICLE SR II** Section C (1) and C (2) of the Standing Rules. The Federation will collect the appropriate Constituent Society's dues at the time of application. The Constituent Society's portion of that amount for the proposed member will be forwarded when the Federation receives the certified application back from the Society. If the application is not certified by the Constituent Society, the collected dues will be returned to the proposed member. During the processing of the application, the proposed member may exercise the same rights as an Affiliated Member. If the proposed member does not reside or is not employed, or does not perform services within the territorial boundaries of a Constituent Society, the application will be processed for Affiliated Membership in the Federation under **ARTICLE II** Section A (4) of the Bylaws.

+ + +

For Second Reading

Resolution to Allow the FSCT to Collect Constituent Society Dues

Add the following to Standing Rules ARTICLE SR II:

F. MEMBERSHIP RENEWAL

At the option of each Constituent Society, the Constituent Society's dues may be collected by the Federation. On a monthly basis, the Federation will forward a roster of Constituent Society renewals along with the collected dues, less the appropriate Federation dues. If a Constituent Society elects this option, it will be the Constituent Society's responsibility to inform the Federation in writing of any dues structure change at least 120 days prior to the date the change takes effect.

The following amendments to the Federation Bylaws and Standing Rules will be presented for First Reading at the Board Meeting of November 2, 1997 in Atlanta.

The Amendments provide for implementation of Strategic Planning objectives. The Bylaws Committee recommends adoption of the amendments.

Freidun Anwari,
Chair, Bylaws Committee

For First Reading

Resolution to Increase the Executive Committee

Under ARTICLE IV, Section B. Board of Directors (1), of the Bylaws, delete:

c. Elect the three Society Representative members of the Executive Committee.

g. Fill vacancies occurring among the elected officers, the Past-Presidents, Members-at-Large of the Board of Directors, and Society Representatives on the Executive Committee.

And replace with:

c. Elect the four Society Representative members and the Director-at-Large on the Executive Committee.

g. Fill vacancies occurring among the elected officers, the Past-Presidents, and Directors-at-Large on the Board of Directors, and the Society Representatives and Director-at-Large on the Executive Committee.

Under ARTICLE IV, Section D. Executive Committee, of the Bylaws, delete the first paragraph:

The Executive Committee shall consist of seven members: the President, President-Elect, Secretary-Treasurer, immediate Past-President or most recent available Past-President, and three Society Representatives.

And replace with:

The Executive Committee shall consist of nine members: the President, President-Elect, Secretary-Treasurer, immediate Past-President or most recent available Past-President, four Society Representatives, and a Director-at-Large.

Under ARTICLE IV, Section D. Executive Committee, of the Bylaws, delete:

(3) Quorum. A quorum shall consist of five members, at least two of whom must be officers.

And replace with:

(3) Quorum. A quorum shall consist of six members, at least two of whom must be officers.

Under ARTICLE VII, Section A. Nominations, of the Bylaws, delete:

(1) The Nominating Committee shall prepare a slate nominating the following: President-Elect; Secretary-Treasurer; Members-at-Large on the Board of Directors; Past-Presidents on the Board, except the Immediate Past-President; Society Representatives on the Executive Committee. Should the Immediate Past-President be unable to serve, the Committee shall determine the most recent available Past-President.

And replace with:

(1) The Nominating Committee shall prepare a slate nominating the following: President-Elect; Secretary-Treasurer; Directors-at-Large on the Board of Directors; Past-Presidents on the Board, except the Immediate Past-President; Society Representatives on the Executive Committee, and the Director-at-Large on the Executive Committee. Should the Immediate Past-President be unable to serve, the Committee shall determine the most recent available Past-President.

Under ARTICLE VII, Section B. Election, of the Bylaws, delete:

(2) The Board of Directors shall elect the President-Elect; Secretary-Treasurer; Members-at-Large on the Board of Directors; Past-Presidents on the Board, except the immediate Past-President; and Society Representatives on the Executive Committee.

And replace with:

(2) The Board of Directors shall elect the President-Elect; Secretary-Treasurer; Directors-at-Large on the Board of Directors; Past-Presidents on the Board, except the immediate Past-President; Society Representatives on the Executive Committee; and the Director-at-Large on the Executive Committee.

Under ARTICLE VII, section C. Terms of Office, of the Bylaws, delete:

(1) The four Members-at-Large on the Board of Directors shall be elected for two-year terms. The terms of two of the four Members-at-Large shall expire each year.

(4) The three Society Representatives on the Executive Committee shall be elected for three-year terms. The term of one of the Society Representatives shall expire each year. The term of any of the three Society Representatives shall terminate automatically upon ceasing to be a regularly qualified Society Representative.

And replace with:

(1) The four Directors-at-Large on the Board of Directors shall be elected for three-year terms. The terms of at least one of the four Directors-at-Large shall expire each year.

(4) The four Society Representatives and the Director-at-Large on the Executive Committee shall be elected for three-year terms. The term of at least one of the Society Representatives shall expire each year. The term of any of the four Society Representatives shall terminate automatically upon ceasing to be a regularly qualified Society Representative. The term of any member of the Executive Committee shall terminate automatically upon such member ceasing to be a regularly qualified member of the Board of Directors.

✢ ✢ ✢

For First Reading

Resolution to Change Duties of the Board of Directors and Executive Committee

Under ARTICLE III, Section C. Mutual Interest, of the Bylaws, delete:

C. Mutual Interest
(1) No Constituent Society shall independently take final action upon matters involving the interests or policies of the industry as a whole. Such matters, with the recommendation of the Constituent Society, shall be referred by the Constituent Society to the Federation Board of Directors.

(2) All contemplated action by Constituent Societies with regard to specifications shall be referred to the appropriate committee of the Federation.

And replace with:

C. Mutual Interest
(1) No Constituent Society shall independently take final action upon matters involving the interests or policies of the industry as a whole. Such matters, with the recommendation of the Constituent Society, shall be referred by the Constituent Society to the Executive Committee for consideration.

(2) All contemplated action by Constituent Societies with regard to specifications shall be referred to the Executive Committee for consideration.

Under ARTICLE IV, Section B. Board of Directors (1), of the Bylaws, delete:

l. Approve the site of each Federation Annual Meeting and Paint Industries' Show.

And replace:

n. Receive written reports on their activities from the Federation Officers, Committee Chairmen, and the President of the Coatings Industry Education Fund semiannually; and from Constituent Societies annually.

With:

n. Receive written reports on activities from Federation Officers, the Executive Committee (including the annual operating plan), and the President of the Coatings Industry Education Foundation semiannually; and on the activities of the Constituent Societies from the Society Representatives annually.

and reletter all lines of this section.

Under ARTICLE IV. Section D. Executive Committee (1), of the Bylaws, delete

f. Hold a minimum of two meetings each year at times and places to be designated by the President.

And replace with:

f. Hold a minimum of four meetings each year at times and places to be designated by the President.

add:

a. Act on behalf of the Board of Directors between meetings of the Board of Directors.

and reletter all lines in this section.

Under ARTICLE IV. Section D. Executive Committee, of the Bylaws, delete:

(2) Emergency Funding. Between meetings of the Executive Committee, two elected officers acting together are authorized to expend funds up to 1% of the approved budget, or an amount previously set by the Board of Directors for non-budgeted items.

And replace with:

(2) During any fiscal year, the Executive Committee is authorized to expend funds for non-budgeted items only if the total of the proposed non-budgeted expenditures, less non-budgeted related income to be received in the same fiscal year, does not exceed an amount equal to 1% of the operational budget for the year. Authorization of greater expenditures must be made by the Board of Directors.

GENERAL, of the Bylaws:
Whenever the term "Member-at-Large" or "member-at-large" (or the plural thereof) appears in the Bylaws, there shall be substituted the term "Director-at-Large" (or plural thereof).

+ + +

For First Reading

Resolution to Create an Annual Operating Plan and a Three Year Strategic Plan

Under ARTICLE IV, Section B. Board of Directors (1), of the Bylaws, add:

j. Approve an annual operating budget plan and three year strategic plan presented by the Executive Committee.

(and reletter all subsequent lines of this section.)

Under ARTICLE IV. Section C. Officers (3) Secretary-Treasurer, of the Bylaws, delete:

a. Act as custodian of the books and records of the Federation.

d. Deposit all such funds in the name of the Federation in depositories selected by the Board of Directors.

and replace:

c. Have charge and custody of, and be responsible for, all funds of the Federation, and the books and records relating to the same.

f. Serve as custodian of the corporate seal and affix the seal to all documents, the execution and delivery of which are duly authorized.

g. Record the minutes of all meetings of the members and of the Board of Directors and give all notices of such meetings in accordance with the Bylaws.

The Secretary-Treasurer shall be bonded at the Federation's expense for an amount determined by the Executive Committee. No contracts shall be entered into, nor disbursements made, without the prior approval of the Secretary-Treasurer and the President acting under the authorization by the Executive Committee.

with:

b. Be responsible for all funds of the Federation and the books and records relating to the same.

d. Serve as custodian of the corporate seal and affix, or cause to be affixed, the seal to all documents, the execution and delivery of which are duly authorized.

e. Record, or cause to be recorded, the minutes of all meetings of the members and of the Board of Directors and give, or cause to be given, all notices of such meetings in accordance with the Bylaws.

The Secretary-Treasurer shall be bonded at the Federation's expense for an amount determined by the Executive Committee.

and reletter all lines in this section.

Under ARTICLE IV, Section D. Executive Committee (1) delete:

c. Adopt the annual operating budget and authorize the expenditure of all funds in keeping with the provisions of these Bylaws, either by specific direction to the President and Secretary-Treasurer, or by limited allocation of funds to be expended at the discretion of Committees duly appointed by the President.

And replace with:

c. Develop and submit to the Board of Directors 60 days prior to the Fall Meeting of the Board of Directors at which adoption of the operating budget plan and three-year strategic plan are to be considered, a proposed annual operating budget plan and three-year strategic plan. Such plans shall be consistent with fiscal guidelines as may be developed from time to time by the Board of Directors or Executive Committee.

and reletter all subsequent lines.

+ + +

For First Reading

Resolution to Allow for the Rearrangement of Federation Committees

Under ARTICLE IV, Section E. Society Representative (1), of the Bylaws, add:

d. Serve on Federation Committees when appointed by the President.

Under ARTICLE VIII of the Bylaws, delete:

B. Standing Committees; Other Committees

The President shall appoint the following Standing Committees: Bylaws, Educational, Finance, Membership, and Publications. The President shall also appoint any other Committees which may be required to conduct the business of the Federation.

And replace with:

B. Bylaws Committee

The President shall appoint the Chair and members of the Bylaws Committee.

Add:

C. Other Committees

All other Committees which may be required to conduct the business of the Federation shall be established by the Executive Committee. The President shall appoint the Chair of each such Committee. The Chair, in turn, shall appoint the members of the Committee with the prior approval of the Executive Committee.

+ + +

(The portion of the following resolution pertaining to the revision of the Federation's Articles of Incorporation is presented here for First Reading and, if approved, application for revision will be forwarded to the Commonwealth of Pennsylvania.)

For First Reading

Resolution to Expedite the Legislative Process

Under the ARTICLES OF INCORPORATION 9, delete:

9. The Articles of Incorporation of the corporation may be altered, amended, or repealed by a three-fourth vote of the entire membership of the Board of Directors of the corporation. This action must be taken at two successive regular or special meetings of the Board of Directors. At least ninety days notice of such a proposal shall have been given before each such meeting by publication in the Journal of Coatings Technology and direct mailing to the President and Secretary of each Constituent Society and the members of the Board of Directors of the corporation. The procedure or [sic] originating, processing and considering amendments to the Articles of Incorporation shall be identical in every respect as prescribed in the Bylaws for amendment to the Bylaws.

And replace with:

9. The Articles of Incorporation of the corporation may be altered, amended, or repealed by a three fourth vote of the membership of the Board of Directors of the corporation present. This action must be taken at two successive regular or special meetings of the Board of Directors. At least 45 days notice of such a proposal shall have been given before each such meeting by publication in the Journal of Coatings Technology and direct mailing at least 60 days prior to the President and Secretary of each Constituent Society and the members of the Board of Directors of the corporation.

Under ARTICLE XV, Amendments, B. Processing of the Bylaws, delete:

(2) The Executive Vice President shall publish the report of the Bylaws Committee in the Journal of Coatings Technology, and mail it to the President and Secretary of each Constituent Society and the entire membership of the Federation Board of Directors, at least 90 days prior to the regular or special meeting of the Board at which the proposed amendments are to be considered. Following the action taken by the Board of Directors, the Executive Vice President shall publish in the Journal of Coatings Technology the texts of the resolutions adopted, and mail them to the President and Secretary of each Constituent Society and the entire membership of the Board at least 90 days prior to the next regular or special meeting of the Board called for the purpose of final vote on the proposed amendments.

And replace with:

(2) The Executive Vice President shall forward the report of the Bylaws Committee to the President and Secretary of each Constituent Society and the entire membership of the Federation Board of Directors at least 60 days prior to each such regular or special meeting of the Board at which the proposed amendments are to be considered, and shall cause to be published in the Journal of Coatings Technology such report at least 45 days prior to each such regular or special meeting of the Board at which the proposed amendments are to be considered.

Under ARTICLE XV, C. Consideration by Federation Board of Directors, of the Bylaws, delete:

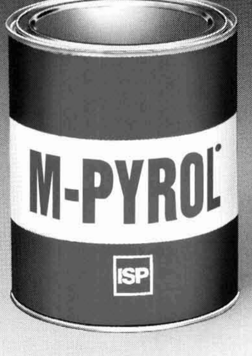
(1) Resolutions to alter, amend, or repeal these Bylaws may be considered at any two successive regular or special meetings of the Federation Board of Directors. A majority vote of all members of the Board shall be required to make any change in the text of the proposed amendments, provided that any such changes may not exceed or reduce the purpose or intent of the amendments as previously published.

(2) Resolutions to alter, amend, or repeal these Bylaws, having been subject to consideration by the Federation Board of Directors, must be approved by a two-thirds vote of the entire membership of the Board of Directors. This action must be taken at two successive regular or special meetings of the Board. The approved amendments shall become effective immediately, or at a time specified in the resolution.

And replace with:

Resolutions to alter, amend, or repeal these Bylaws, having been subject to consideration by the Bylaws Committee, must be approved by a three-fourth vote of the members of the Board present. This action must be taken at two successive regular or special meetings of the Board. The approved amendments shall become effective immediately, or at a time specified in the resolution.


Methyl Chloroform
Toluen
DMF
Ketones
Xylene
CFC-113
MEK
Trichloroethylene
Methylene Chloride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FSCT Publications Order Form

Buyer Information

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B ☐ Manufacturers of Raw Materials
C ☐ Manufacturers of Equipment and Containers
D ☐ Sales Agents for Raw Materials and Equipment
E ☐ Government Agency
F ☐ Research/Testing/Consulting
G ☐ Educational Institution/Library
H ☐ Paint Consumer/Applicator
J ☐ Other ______________________________
please specify

YOUR POSITION: Check the one block which best describes your position in your company or organization:

A ☐ Management/Administration
B ☐ Manufacturing and Engineering
C ☐ Quality Control
D ☐ Research and Development
E ☐ Technical Sales/Service
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G ☐ Consultant
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Mechanical Properties of Coatings	☐	☐	___
Automotive Coatings	☐	☐	___
Coating Film Defects	☐	☐	___
Application of Paints and Coatings	☐	☐	___
Organic Pigments, Second Edition	☐	☐	___
Inorganic Primer Pigments	☐	☐	___
Marine Coatings	☐	☐	___
Sealants and Caulks	☐	☐	___
Aerospace and Aircraft Coatings	☐	☐	___
Introduction to Coatings Technology	☐	☐	___
Cationic Radiation Curing	☐	☐	___
Rheology	☐	☐	___
Powder Coatings	☐	☐	___
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Painting of Plastics	☐	☐	___
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Methodologies for Predicting the Service Lives of Coatings Systems	☐	☐	___
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Adhesion Aspects of Polymeric Coatings	☐	☐	___

JCT: __________ (specify no. of yrs.) (annual subscrip. included w/FSCT membership)

	U.S. & Canada	Europe (Air Mail)	Other Countries
1 Year	☐ $60	☐ $90	☐ $75
2 Years	☐ $110	☐ $170	☐ $140
3 Years	☐ $170	☐ $260	☐ $220

Coatings Encyclopedic Dictionary*	☐ Soft Cover	☐ $80	☐ $105	___
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Special Update

International Coatings

In the second of a series focusing on the international coatings market, the JCT examines the Scandinavian paint industry. Information for this segment was contributed by the Federation of Scandinavian Paint and Varnish Technologists (SLF), a member with FSCT in the coatings technical organization, Coatings Societies International. The FSCT is proud to be associated with groups like SLF and the people they serve.

International Update: Scandinavia

Scandinavian Paint Industry: Its Structure and Trends

The per capita use of paint in Scandinavia is among the highest in the world. However, unlike many other markets, it is mostly concentrated in a few big companies. Over the last few years many consolidations and buy-outs have taken place that make it difficult to analyze the market and present it in a simple way. One example of such a buy-out is that of the large Danish company Sadolin. They were first purchased by the Swedish Nobel Group, with Nobel group consequently being purchased by the Dutch company Akzo. Should such companies be considered as Scandinavian or foreign? In the following discussion they have mainly been excluded, as details of these would appear in an analysis of continental European companies.

The paint industry in Scandinavia is well developed and functions at a high technical level. This is not only true for industrial customers but also for the quality-conscious do-it-yourself (DIY) customer. This may be exemplified by the very extensive use of color dispensing machines in retail sales. Such systems have been found to be very advantageous, not only for the customer who can obtain practically any desired color, but also for the retailer and paint manufacturer who can thereby reduce both storage and production costs.

Structure of the Market

As Scandinavia consists of four distinct national cultures and markets, it can be quite difficult to generalize about the Scandinavian paint industry as a whole. As there are both similarities and differences, the four paint industries, those of Denmark, Finland, Norway, and Sweden, will be discussed individually. However, the general tendencies that characterize the Scandinavian market as a whole are also presented.

Table 1 gives an overview of the market structure as it was in 1993, the last date for which we have full figures available.

What in the context of Scandinavia may be considered a large company may not, perhaps, be considered as such on a world-scale. However, among the 26 biggest manufacturers in the world, we find six from the Scandinavian countries. The figures for these for the year 1994 are given in *Table* 2.

As shown in *Table* 1, the market structures of the four Scandinavian countries are somewhat different; this will be seen from the following descriptions of the individual countries.

SLF Table 1

Company Size in U.S.$	Denmark	Norway	Sweden	Finland
Large, > 60 million	4	1	10	2
Large to medium, 30-60 million	1	—	1	1
Medium, 10-30 million	5	6	3	1
Small to medium, 5-10 million	3	4	5	3
Small, < 5 million	16	12	12	2
Total number of companies	29	23	31	9
Total employees	2205	1220	2500	1240
Production (tons)	127,382	65,500	146,400	65,800
Production per employee, approx.	58	54	58	53
Paint consumption per capita (Kg)	19.1	16.2	14.6	13.1

Denmark

The four most important Danish companies are those three given in the *Table* 2, together with Sadolin. The latter, as already stated, now belongs to the Akzo Group.

Dyrup, one of the larger producers of quality wood-protective stains in Europe, purchased Gori, a smaller Danish firm specializing in high-quality stains; they now cover about 65% of the Danish market for this type of product. They also have operations in several European countries, being especially strong in Europe.

The production and use in Scandinavia of such high-quality wood-protective stains for housing is characteristic of the Scandinavian market. As in Norway, there has long been a tradition for this type of product.

Flügger, a very successful company in the professional decorative trade, also has a large subsidiary plant in Sweden. In terms of profit, Flügger is probably one of the most successful paint firms in Scandinavia today.

Hempel specializes in marine paints, these being a well established product in a traditional shipbuilding and seafaring nation. Tikkurila has a market share of about 50%. Together with the Norwegian Jotun, they rank as No. 2 and 3 in the world.

Finland

The paint industry in Finland is mainly covered by three companies, those of Tikkurila owned by Kemira (given in the *Table* 2), Teknos-Winter, and Sadolin (now Akzo Nobel).

The entire Finnish market amounts to about 80 million liters.

Tikkurila, with operations in eight countries, produces all types of paint and varnish, ranging from decorative paints to heavy duty and industrial coatings. Their car refinishing paints are mainly exported to Russia. Tikkurila has a three percent share of the European market and is among the top 12. It is the leader in Europe in tinting systems and No. 2 worldwide.

Teknos-Winter, the largest private paint manufacturer in Finland, produces all types of paint, including powder coatings. These are also produced at Teknos-Schou, a company located in Denmark, who specializes in this type of product.

It can be seen that where the Finnish paint companies have invested outside Finland it has often been in Denmark. Tikkurila has invested strongly in the UK, in the Netherlands, and in the Baltic states. This was originally due to the wish to get a foot-hold in the EEC. However, even though Finland is now within the EEC, large investments are still taking place within Europe. This is exemplified by the investment of the Finnish chemical combine of Neste in a plant at Gent, Holland, for producing materials for resin production.

Norway

The Norwegian market is dominated by Jotun A/S, with a turnover in 1995 of about U.S.$ 700 million, 70% of which comes from abroad. It has 42 production units in more than 20 countries. Jotun has a three percent share of the European market. The company produces all types of paint.

The very extensive use of color-dispensing machines in retail sales in Scandinavia is exemplified by the case of Jotun who, together with Tikkurila in Finland, specializes in such tinting systems. In Norway there are about 1,000 paint retail shops to whom Jotun has sold some 900 systems. Jotun has sold about 1,500 systems worldwide.

Within some segments, Jotun is very well known; for example, Jotun is placed third in Europe in the production of unsaturated polyesters, fifth in the world in the production of powder coatings, and, together

SLF Table 2

Company	No. of Employees	Net Sales, U.S.$ Million
S. Dyrup & Co., Denmark	1048	214
Flügger A/S, Denmark	673	135
Hempel Marine Paints, Denmark	2250	417
Tikkurila OY, Finland	1559	270
AB Wilh. Becker, Sweden	2253	468
Jotun A/S, Norway	2820	597

with Hempel, second or third in the world in marine coatings.

Sweden

The most important companies in Sweden are AB Wilh. Becker, Klintens Sweden AB, and Nobel Paints and Adhesives (now owned by Akzo).

AB Wilh. Becker is the largest Scandinavian paint and coatings manufacturer, ranked No. 7 in Europe and having a market share of about four percent. Becker is a market leader within the coil-coating sector in Europe. It is also the largest manufacturer of artists' paints in Europe.

Sweden, compared to Denmark or Finland, boasts heavy industrial production. Volvo and Saab, Asea, and Electrolux are among the well-known firms established in Sweden. This has, of course, influenced the existence of subcontractors, among whom are paint manufacturers. For this reason, Becker has been able to become, for example, suppliers of high-quality automobile finishes.

Trends, Developments and Challenges

Financial yields of 10% and more are normal. The extensive use of dispensing machines in the DIY trade is still on the increase. While there are the advantages to both retailer and customer referred to previously, there is the disadvantage of dependence on a single supplier. Such systems can only be used with products from a specific producer who has a rather large share of the market. Market shares in Scandinavia of 50-70% occur quite frequently.

The Scandinavian paint industry has long paid particular attention to the occupational health and environmental aspects of the industry, which reflected in the current strict legislation pertaining both to the manufacture and use of paint products. The main targets of R&D have therefore been safety, health, and the environment.

Earlier the emphasis was on cost per liter. The cost per square meter of applied coating and its durability were thereafter considered as the most important factors. Today, however, the total Life Cycle Assessment (LCA) is thought to be the most relevant factor when considering the environmental impact of paint products. This assessment is no easy task, where all economic and ecological factors have to be estimated from the production of the raw materials themselves, through production and use, to the final recycling or destruction of the paint materials. In spite of the problems in such assessments, their introduction will give a common language and will also supply information for public

Federation of Scandinavian Paint and Varnish Technologists (SLF)

SLF, founded January 26, 1953, is the federation of the four Scandinavian Paint and Varnish Technologists' Associations. These associations are the Danish (441 members), the Finnish (189 members), the Norwegian (450 members), and the Swedish (650 members).

Each of these four associations has its own finances and its own set of laws which, although similar in content, do differ somewhat according to the differing local conditions and educational requirements.

Due to the large geographical extent, the Swedish Association is divided into three societies—Stockholm, Gothenburg, and Malmoe. Norway is also divided into two societies—Oslo and Bergen. Thus, for most practical purposes, such as lecture meetings and social events, SLF consists of seven separate societies.

The purpose of the supranational Federation therefore is to promote cooperation between the four Scandinavian Associations, to arrange joint inter-Scandinavian meetings, to raise the level of technical expertise and knowledge of its members, and, last but not least, to promote contact between the Scandinavian Associations and the international paint and varnish chemists' associations comprising CSI.

One of the main ongoing concerns is that of Professional Gradings. SLF is strongly promoting this service, leading, as it will, not only to higher levels of expertise among its members but also to a higher internationally accepted status for its members in the industry as a whole.

The Federation's affairs are managed by a Board and are directed by a President. The presidency is held in turn by each of the four Associations for a three-year period, rotating in the order of Sweden, Denmark, Norway, and Finland. The presidency is currently in Norway, for the period 1995 to 1997.

To ensure continuity with presidential changes, certain activities of SLF are centralized through an honorary general secretary, currently placed in Copenhagen.

The Federation regularly issues a journal, *färg och lack scandinavia*, which is sent to all members of the Scandinavian Associations. The present circulation is 2,000 of which about 1,700 go to members of SLF. The journal is managed by an editor who is responsible to the board.

An inter-Scandinavian Congress is held every three years, taking place in the country of the president who is responsible for organizing it. This is considered as an international event to which all members of CSI are invited, the language spoken is either English, or Scandinavian with simultaneous translation to English.

The main mission of SLF is in the field of education, both formal and informal, where emphasis is placed on raising the standards of technical competence at all levels within the industry.

and in-house debate regarding the environmental impact of paints.

The demand to reduce the solvent content of paint, and thereby the environmental impact, is very strong. However, it is not always absolutely true that waterborne paints are to be preferred; only a full LCA can give a rational answer. Therefore, most companies in Scandinavia have started to use LCA in their development work, and consequently ask the paint industry to give an LCA for their products.

Internationalization

Each Scandinavian country is a relatively small market area, but the product range is large. The exceptionally large market shares of the bigger paint manufacturers have resulted in a situation in which each producer makes all types of paint products. Therefore, the cost of product development has become very high. The larger companies in Scandinavia need to acquire market shares in larger markets in order to overcome the high expenses entailed in modern R&D work. Expansion outside Scandinavia is therefore necessary, and several companies are now multinational concerns situated in 20 or 30 countries, not only within Europe but over the world.

Kaare Kleive

Kaare Kleive, born in 1928, received the M.Sc. in Chemistry in 1958 at the Technical University of Graz, Austria, and began employment with Jotun A/S in Norway.

From 1964 to 1967 he was Raw Material Manager at Wilh. Becker AB, Sweden. In 1968, he started-up the Jotun Thailand Ltd. factory as its Technical Manager, and was later appointed its Managing Director. In 1974 he returned to Jotun A/S in Norway as Laboratory Manager. As appointed Senior Chemist at Jotun A/S, he also served as Technical Coordinator for Jotun's international activities, Technical Manager for export within Europe, Manager for the R&D service laboratory, and finally, Jotun Corporate Raw Material Manager.

Together with his collaborators, he has published several articles on the subject of wood protection.

Kaare Kleive has been active in the Norwegian Paint and Varnish Technologists' Association. He was elected to serve as President of the Federation of Scandinavian Paint and Varnish Technologists for the years 1995 to 1997.

Regulatory Update July 1997

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
May 16, 1997 – 62 FR 27158
Prevention of Significant Deterioration of Air Quality Program: Permit Review Procedures for Sources That May Adversely Affect Air Quality in Non-Federal Class I Areas
Action: Advance notice of proposed rulemaking

This notice requests public input on preliminary issues in clarifying the prevention of significant deterioration permit review procedures for new and modified stationary sources that may have an adverse effect on the air quality of non-federal Class I areas. Under the Clean Air Act, states may, with the approval of the Environmental Protection Agency (EPA), redesignate their lands as "Class I" areas to enhance protection of their air quality resources.

Comments on this rulemaking must be received by Aug. 14. Send comments, in duplicate, to EPA, Air Docket Section, Air Docket A-96-53, 401 M St., S.W., Washington, D.C. 20460.

For further information, contact David LaRoche, EPA, (202) 260-7652.

Department of Transportation
Federal Highway Administration
May 28, 1997 – 62 FR 28826
Safety Fitness Procedures; Safety Ratings
Action: Notice of proposed rulemaking; request for comments

The Federal Highway Administration (FHWA) has issued this proposal which would incorporate a modified Safety Fitness Rating Methodology to measure the safety fitness of motor carriers against the current standard. The agency is requesting comments on issues including accident rates and procedures for challenging ratings.

The FHWA has published an interim final rule (62 FR 28807) which incorporates the agency's current safety fitness rating methodology for motor carriers. The regulation, which went into effect May 28 and will expire on Nov. 28, 1997, is only applicable to motor carriers that are transporting hazardous materials in quantities for which vehicle placarding is required.

Comments on the proposed rule must be received by July 28. Send comments, referencing docket number MC-94-22, to the Docket Clerk, Department of Transportation Dockets, Room PL-401, 400 7th St., S.W., Washington, D.C. 20590.

For additional information, contact William Hill, Office of Motor Carrier Research and Standards, (202) 366-4009, or Charles Medalen, FHWA, (202) 366-1354.

Department of Transportation
Research and Special Programs Administration
June 2, 1997 – 62 FR 29673
Hazardous Materials: Use of Non-Specification Open-Head Fiber Drum Packagings
Action: Direct final rule

In this direct final rule, the Research and Special Programs Administration (RSPA) is announcing the end of its rulemakings relating to alternate standards for open-head fiber drums. This termination is based on recommendations that RSPA should not extend authorization for the transportation of liquid hazardous materials in open-head fiber drums that do not meet current performance-oriented packaging standards. RSPA is allowing the transportation of certain liquid hazardous materials in non-specification open-head fiber drums until Sept. 30, 1999, under certain conditions.

This final rule is effective Oct. 1, 1997, unless adverse comments are received by August 1. Send any comments to the Dockets Office, Department of Transportation, Room PL-401, 400 7th St., S.W., Washington, D.C. 20590-0001. Please reference docket number RSPA-97-2501 on all submissions.

For more information, contact Frazer Hilder, RSPA, (202) 366-4400.

Department of Labor
Occupational Safety and Health Administration
June 6, 1997 – 62 FR 31159
Supplement to California State Plan; Approval
Action: Approval; California State Standard on Hazard Communication Incorporating Proposition 65

This notice approves, subject to certain conditions, the California Hazard Communication Standard, including its incorporation of the occupational applications of the California State Drinking Water and Toxic Enforcement Act (Proposition 65). The action follows a period for public comments and a federal court challenge brought by NPCA and the Coalition of Manufacturers for the Responsible Administration of Proposition 65 Enforcement.

The following conditions apply:

(1) Employers covered by Proposition 65 may comply with the occupational requirements of that law by following Occupational Safety and Health Administration (OSHA) or California OSHA (Cal/OSHA) Hazard Communication provisions.

(2) Cal/OSHA is responsible for assuring that enforcement of its general Hazard Communication Standard and Proposition 65 results in "at least as effective" worker protection. The agency must take appropriate action to assure that court decisions in supplemental enforcement actions do not result in a less effective standard or in inconsistencies with the conditions under which the standard is approved.

(3) The state standard, including Proposition 65 in its occupational aspects, may not be enforced against out-of-state manufacturers.

This approval went into effect June 6, 1997. For further information, contact Bonnie Friedman, OSHA, (202) 219-8148.

Environmental Protection Agency
June 3, 1997 – 62 FR 30257
National Emission Standards for Hazardous Air Pollutants; Final Standards for Hazardous Air Pollutant Emissions from Wood Furniture Manufacturing Operations; Correction
Action: Final rule; correction

This action corrects errors and clarifies regulatory text in the National Emission Standards for Hazardous Air Pollutants; Final Standards for Hazardous Air Pollutant Emissions from Wood Furniture Manufacturing Operations. This final rule was published in the Dec. 7, 1995 issue of the *Federal Register* (60 FR 62930).

For additional information on this notice, contact Paul Almodovar, EPA, (919) 541-0283. Information regarding the applicability of this action can be obtained from Robert Marshall, EPA, (202) 564-7021.

EPA Sponsors P-MACT Work Groups—The Environmental Protection Agency's Coatings and Consumer Products Group is holding a series of work group meetings between May and October 1997 to discuss presumptive maximum achievable control technology (P-MACT) standards for various types of coatings manufacturing operations. The work groups cover surface coatings for large appliances, metal furniture, fabric, flatwood paneling, metal cans, metal coils, miscellaneous metal parts, and plastic parts.

The meeting dates are listed in the following: Aug. 18—Target date for a draft P-MACT for Large Appliances; Sept. 4—Large Appliances Work Group (third meeting); and Sept. 30—Target date for a final P-MACT for Large Appliances.

All of the work group sessions will be held in the Raleigh-Durham area. A conference call-in number will also be available. Please note that these dates are subject to change

Chemical Safety Alerts Issued—The Environmental Protection Agency (EPA) has issued four chemical safety alerts to warn facilities and safety officials of potential hazards that were uncovered during the course of various chemical accident investigations. The alerts include information on:

- catastrophic failure of aboveground storage tanks;
- the potential hazards of pressure valves that are improperly designed, constructed or operated;
- dangers of lightening strikes at bulk chemical facilities and processing sites; and
- fires caused by activated carbon systems.

Copies of these alerts can be obtained from the EPCRA Hotline, 1-800-424-9346.

Air Quality Update—Debate among members of Congress over EPA's proposed national air quality standards for ozone and particulate matter is becoming increasingly intense as the date that the agency plans to issue the final regulation approaches. The rule is scheduled for publication by July 19.

The new standard would lower the current concentration limit for ozone from 0.12 parts per million to only 0.08, measured over the course of an eight-hour time period. Additionally, a 2.5 micron particulate matter standard would be established.

The recently enacted Small Business Regulatory Enforcement Fairness Act grants Congress the ability to vote down regulations; informal polls of the House have indicated that critics of the proposal may have enough votes to not only reject the rule but to also withstand a Presidential veto. Support in the Senate is less certain, with the vote count currently standing at several short of the number needed to overturn a veto. In addition, dozens of congressmen, including leading Democrats, have publicly asked EPA to either reaffirm the existing standards or postpone their implementation until better scientific evidence can be established.

Senate Passes Bill To Implement CWC—On May 23, the Senate approved legislation (S. 610) which would implement the requirements of the Chemical Weapons Convention (CWC) treaty. The CWC itself was formally ratified by the Senate on April 24. It prohibits the sale, manufacture, distribution and stockpiling of chemical weapons. The treaty also provides for the inspection of domestic operations by international teams.

In general, the intent of the bill is to incorporate all the "understandings" that were negotiated by the Clinton administration and the GOP as part of the agreement to ratify the CWC. It specifically lists the schedule I, II, and III chemicals that will be regulated. Penalties for violations are also detailed; life-imprisonment or the death penalty would be imposed for the criminal use of chemical weapons. In addition, the State Department is designated as the National Authority for the treaty.

To help alleviate U.S. companies' fears concerning the theft of trade secrets, the federal government would agree to be held responsible. Companies would have five years to bring a civil suit against the government to gain compensation for the loss of proprietary information. Sanctions, including blocking of assets, would be levied against foreign companies found to have engaged in such activities.

The CWC requires two different types of inspections, "routine" and "challenge." The implementing legislation specifies certain requirements concerning inspections. Included in the measure were provisions that would (1) require inspection teams to follow certain procedures to notify facilities of upcoming inspections; (2) allow facilities to deny inspectors access until they obtain a search warrant; (3) bar EPA or OSHA employees from accompanying any inspection team; (4)

prevent any samples taken from leaving the United States; and (5) specifically define the scope of inspections.

The legislation will now be sent to the House for approval. At presstime, no schedule for action had been announced.

Right-to-Know Legislation Introduced—Legislation was introduced in both the House (H.R. 1636) and Senate (S. 769) in May which would expand community right-to-know and Toxics Release Inventory (TRI) requirements. Among other things, both bills would require facilities to submit "materials accounting" information to the government. Under the materials accounting requirement, industry would monitor and report the use of a toxic substance through every step in the manufacturing process, including the amount coming into a facility, the amount transformed into a product, the amount left over, and the amount transported off-site for disposal.

In addition, both measures include provisions that would

(1) establish new TRI reporting thresholds for releases of lead, mercury, cadmium, chromium, and certain bioaccumulative chemicals;

(2) require source reduction and toxics use reduction data to be reported under TRI;

(3) allow portions of materials accounting information to be withheld if it is a trade secret; and

(4) consolidate all annual environmental reporting requirements within three years for small business and five years for everyone else.

The House bill would also establish new standards for reporting the presence of toxic substances in consumer products. And the Senate bill, sponsored by Senator Frank Lautenberg (D-NJ), contains provisions requiring facilities that submit TRI reports to also prepare and update biennially a pollution prevention plan.

Supporters of an expansion of the TRI program hope to move these bills forward quickly, either separately or as riders to a larger bill.

OSHA Reform Bill Introduced in Senate—On May 20, Senate Republicans introduced yet another bill (S. 765) that intends to "modernize" the Occupational Safety and Health Administration (OSHA). The measure is one of several pieces of legislation introduced in this session of Congress that would significantly modify the responsibilities of the agency.

In this bill, a third party "independent audit and evaluation program" would be established that could provide safety and health consultations for employers. The organization would be comprised of certified auditors and would be separate from OSHA. Any employers who use this program would be exempted from civil safety and health violations for two years.

Additionally, the legislation would encourage employers to develop and maintain voluntary safety and health programs in their facilities. Finally, the bill would allow workers who violate occupational safety and health requirements to be fined individually if their employer is in compliance with standards.

S. 765 is currently under consideration by the Senate Committee on Labor and Human Resources, but no date has been set for further activity. Additional bills dealing with safety and health reform have been introduced in both the House and Senate.

In Brief—In a remarkable display of bipartisan cooperation, the House and Senate voted the week of May 19 by large margins to approve the 1998 fiscal year budget resolution which contains provisions to balance the budget by 2002. Final work on the resolution was completed during the first week of June. The budget agreement does not include provisions to renew the Superfund tax that expired at the end of 1995. Next, Congress will begin the formal appropriation process.

On May 15 and again on June 4, the Senate failed to end debate on legislation (S. 4) that would allow employers to offer their workers the choice between receiving compensatory time off in lieu of overtime pay for any work over 40 hours a week. The final votes were far short of the 60 votes needed to invoke cloture. Bill sponsors are considering amending the bill to clarify that workers may not be coerced into choosing time off in order to appease critics of the measure. Further action on the bill is uncertain as of this writing.

States Proposed Legislation and Regulations

ALABAMA

Air Quality (Proposed Regulation)—The Alabama Department of Environmental Management (DEM) proposed a rule (15 ALAM 173; 4/30/97) which would amend the definition of volatile organic compound (VOC); and incorporate by reference new source performance requirements and national emission standards for hazardous air pollutants. Contact Lynn Garthright, DEM, (334) 271-7700.

Lead—AL H. 680 (Johnson) authorizes the development of a program relating to indoor lead hazard reduction. The legislation was signed by the governor on May 27.

ALASKA

Occupational Safety and Health—AK S. 205 (Leman) authorizes certain qualified privileges and immunity for facilities that con-duct voluntary health and safety audits. Introduced on May 10, the bill was referred to the Senate Committee on Labor and Commerce.

CALIFORNIA

Air Quality (Regulation)—The California Air Resources Board (CARB) adopted a final regulation (97 CARR 934; 5/2/97) which revises the method of calculating 1996-97 air toxics hot spots fees. The fees will now be based on potential risk as determined by risk assessments or prioritization scores. The rule went into effect April 22. Contact Judith Tracy, CARB, (916) 322-2884.

Graffiti—CA S. 1229 (Schiff) defines vandalism to include any act that defaces property with graffiti. On June 10, the bill failed passage out of the Senate Committee on Public Safety.

Hazardous Materials Transportation (Proposed Regulation)—A proposed rule (97 CARR 1013; 5/16/97) issued by the California Highway Patrol (CHP) would incorporate by reference hazardous materials transportation requirements to conform with federal standards. Contact Steve Brown, CHP, (916) 327-3310.

Lead (Regulation)—The California Department of Health Services (DHS) issued an emergency rule (97 CARR 1038; 5/16/97) which amends requirements for occupational lead poisoning prevention program fees by adding a definition of what is considered a *de minimis* amount of lead in the workplace; and specifying that lead evaluations of workplaces must include a review of material safety data sheets. The regulation was effective May 1. Contact Charles Smith, DHS, (916) 657-0730.

Lead (Proposed Regulation)—A proposed regulation (97 CARR 1064; 5/23/97) of the California DHS would amend standards exempting employers who use a small amount of lead in the workplace from payment of the occupational lead poisoning fee. Contact Charles Smith, DHS, (916) 657-0730.

Lead (Notice)—The California Supreme Court heard oral arguments on June 6 in Sinclair vs. Board of Equalization, a lawsuit originally brought by NPCA and the California Paint Council challenging the constitutionality of lead "fees" imposed under California's Childhood Lead Poisoning Prevention Act of 1991. A decision is expected in early August. For more information, contact NPCA's David Lloyd at (202) 462-6272 or the California Paint Council at (916) 444-6034.

Occupational Safety and Health—CA S. 370 (Solis) includes painters within the category of persons for whom cancer occurring during employment is deemed an injury under the workers' compensation law. On May 22, the Senate Appropriations Committee granted reconsideration of the bill.

Proposition 65 (Notice)—The California Office of Environmental Health Hazard Assessment (OEHHA) has added nine chemicals to the list of substances known to cause cancer or reproductive toxicity, as required under Proposition 65. The chemicals are nitromethane, tetrafluoroethylene, vinyl fluoride, spironolactone, stanozolol, clarithromycin, dihydroergotamine mesylate, hydrozyurea, and oxymetholone. Contact OEHHA, (916) 322-6325.

The California OEHHA has made available the newly revised full list of chemicals regulated under Proposition 65. The revisions were effective May 1. An updated list of Proposition 65 chemicals is available from contact OEHHA, (916) 322-6325.

A final regulation (97 CARR 934; 5/2/97) of the OEHHA establishes requirements for "60-day notices" that are filed to initiate actions to enforce violations of Proposition 65. The rule became effective April 22. Contact Cynthia Oshita, OEHHA, (916) 322-2068.

Recycling—CA A. 705 (Strom-Martin) reenacts existing law until Jan. 1, 2001 which requires all state agencies to purchase recycled paint. On June 6, the measure was approved by the Assembly and sent to the Senate.

Toxic Substances—CA A. 1173 (Olberg) requires purchasers of chemical solvents to maintain records of all transactions; bill was amended to delete the requirement that copies of original sales records for sales in excess of $100 be submitted to the state biweekly. On June 3, the bill passed the Assembly and was sent to the Senate Committee on Public Safety.

COLORADO

Air Quality (Regulation)—The Colorado Air Quality Control Commission (AQCC) issued a final rule (20 COR 2; 4/10/97) which adopts federal maximum achievable control technology standards for printing and publishing, and for Groups I and IV polymers and resins. The regulation was effective April 30. Contact AQCC, (303) 692-3100.

Graffiti—CO H. 1125 (S. Williams) makes mandatory revocation of a driver's license one of the penalties for defacing property with graffiti. The governor signed the bill on June 4.

Hazardous Materials Transportation (Regulation)—A final regulation (20 COR 2; 5/10/97) of the Colorado Department of Public Safety amends procedures for hazardous materials transportation permits. The rule went into effect May 30. Contact State Patrol, (303) 239-4500.

Hazardous Waste (Proposed Regulation)—A proposed rule (20 COR 5; 5/10/97) issued by the Colorado Department of Public Health and Environment (DPHE) would revise hazardous waste management requirements concerning air emission standards for tanks, containers, and surface impoundments. Contact DPHE, (303) 692-3300.

Lead—CO S. 136 (Blickensderfer) requires the establishment of a plan to reduce elevated blood lead levels in children and to control exposure to lead-based paint hazards. The governor signed the measure on May 27.

DISTRICT OF COLUMBIA

Lead (Notice)—The Council of the District of Columbia (CDC) has issued the Lead-Based Paint Abatement and Control Act (44 DCR 2579; 5/2/97) which establishes a program to reduce and abate lead-based paint hazards. The act went into effect April 9. Contact CDC, Legislative Services Division, (202) 724-8050.

IDAHO

Air Quality (Regulation)—A final rule (1997 IDAB 34; 5/7/97) adopted by the Idaho Department of Health and Welfare (DHW) modifies air pollution control standards; updates the deadline for submitting a complete Tier I application; eliminates existing excess Tier I emission provisions; and amends permit-to-construct requirements. Contact Paula Saul, DHW, (208) 373-0418.

A final regulation (1997 IDAB 34; 5/7/97) of the Idaho Department of Health and Welfare (DHW), among other things, removes the category of total suspended particulates from regulated criteria pollutants; incorporates federal maximum achievable control technology standards; and removes acetone and methyl siloxanes from the definition of VOC. The rule went into effect July 1. Contact Paula Saul, DHW, (208) 373-0418.

Air Quality (Notice)—The Idaho DHW has negotiated a rulemaking (1997 IDAB 36; 5/7/97) which would establish maximum achievable control technology (MACT) standards for new major sources of hazardous air pollutants. Contact Paula Saul, DHW, (208) 373-0481.

Environmental Audits (Regulation)—A regulation (1997 IDAB 34; 5/7/97) adopted by the Idaho DHW defines environmental audits, sets up requirements concerning the treatment of environmental audit reports and confidential business information, and specifies data that must be included in a plan for conducting an audit. The rule went into effect July 1. Contact Paula Saul, DHW, (208) 373-0418.

ILLINOIS

Air Quality—IL H. 1386 (Hassert) extends the repeal date of the provisions providing for fast-track rulemaking pursuant to the Clean Air Act Amendments to Dec. 31, 2002. The bill passed the Senate on May 13.

IL S. 819 (Mahar) provides that sources of air pollution that are not subject to the Clean Air Act permit program and are not required to obtain an operating permit shall not be required to renew an operating permit except on the written request of the federal EPA. On May 15, the House approved the legislation.

Air Quality (Regulation)—A final regulation (21 ILR 6237; 5/23/97) of the Illinois Pollution Control Board (PCB) requires sources that manufacture, process, or import more than 25,000 pounds or use more than 10,000 pounds per year of a toxic air pollutant to submit reports listing the total emissions. The rule became effective May 12. Contact Dorothy Gunn, PCB, (312) 814-6062.

Automotive Refinishing—IL H.R. 161 (Novak and Persico) directs the state to conduct a study to determine the relative toxicity of auto body paints and finishes compared to touch-up or general purpose paints. Introduced on May 14, the legislation was referred to the House Rules Committee.

Hazardous Materials Transportation—IL S. 378 (Mahar) requires the implementation of a uniform state hazardous materials transportation registration and permit program. On June 6, the bill was sent to the governor.

Lead—IL S. 247 (Syverson) provides that only positive results of a blood lead analysis must be reported to the state within 48 hours. The legislation was sent to the governor on June 6.

INDIANA

Air Quality (Notice)—The Indiana Department of Environmental Management (DEM) has made a policy document (20 INR 2240; 5/1/97) available to the public which describes the short-term enforcement policy for air quality violations in which (1) Title V applications were not submitted on time; or (2) a state operating permit is not obtained, but the facility voluntarily identifies itself. Contact DEM, (317) 232-8603.

Automotive Refinishing (Notice)—The Indiana DEM has issued a policy document (20 INR 2233; 5/1/97) to clarify recordkeeping requirements for automotive refinishing operations. Contact Janet McCabe, DEM, (317) 233-5694.

Hazardous Waste—IN S. 478 (Simpson) provides that an industrial or manufacturing byproduct that is listed as a hazardous waste but is capable of being recycled in a process with no additional threat to health or the environment may be excluded from hazardous waste regulations. The governor signed the bill on May 13.

Lead—IN H. 1181 (Crawford) requires health care providers to conduct period blood lead testing on children between six months and six years. The legislation was signed by the governor on May 13.

IOWA

Air Quality (Regulation)—A final regulation (19 IAAB 1677; 4/9/97) adopted by the Iowa Department of Natural Resources (DNR) amends requirements for air pollution control and emission standards; incorporates revisions for organic hazardous air pollutants, source categories, and equipment leak regulations; and modifies emissions limits for hazardous air pollutants for shipbuilding and ship repair, wood furniture manufacturing, and Group IV polymers and resins. The rule went into effect May 14. Contact Anne Preziosi, DNR, (515) 281-6243.

Hazardous Materials Transportation (Proposed Regulation)—The Iowa Department of Transportation (DOT) proposed a rule (19 IAAB 1628; 4/9/97) which would incorporate amendments to federal motor carrier safety and hazardous materials transportation standards; would extend the date that open-head, fiber drums can be used to transport hazardous materials in Packing Group III until Sept. 30, 1997; simplify criteria for hazmat shipments; and strengthen requirements for hazmat packaging and the classification of materials that are poisonous by inhalation. Contact DOT, (515) 239-1639.

Labeling—IA S. 285 (Committee on Natural Resources) adds solvent-based paint to the definition of household hazardous waste (HHW); requires the implementation of an informational program regarding the use and disposal of HHW; and repeals sections relating to mounting warning labels near displays of products in retail establishments. The legislation was signed by the governor on May 26.

Lead (Proposed Regulation)—A proposed rule (19 IAAB 1627; 4/9/97) issued by the Iowa Department of Public Health (DPH) would amend certification requirements for lead abatement inspectors and workers to conform with federal standards. Contact DPH, (515) 281-5787.

Occupational Safety and Health (Regulation)—The Iowa Labor Services Department (LSD) adopted an emergency rule (19 IAAB 1766; 4/23/97) which incorporates federal occupational safety and health requirements concerning worker exposure to methylene chloride. The regulation went into effect April 23. Contact DLS, (515) 281-3606.

KENTUCKY

Occupational Safety and Health (Proposed Regulation)—The Kentucky Department of Workplace Standards (DWS) proposed a rule (23 ARKY 3929; 5/1/97) which would incorporate by reference federal requirements for eye, face, head and foot protective equipment. Contact William Ralston, DWS, (502) 564-3070.

LOUISIANA

Air Quality—LA S. 618 (Hainkel) authorizes an increase in air quality control fees. On June 3, the bill passed the House and was sent to the Senate for concurrence.

LA S. 619 (Hainkel) authorizes an increase in air quality control fees to fund a program for the prevention of accidental releases of air pollutants. The measure was approved by the House on June 3 and was sent back to the Senate for concurrence.

Hazardous Waste—LA S. 1175 (Hainkel) eliminates the collection of certain fees for hazardous waste permits, registrations, licenses or variances. The bill was sent to the governor on June 6.

Lead—LA S. 616 (Hainkel) provides for lead abatement licenses, certification and accreditation fees. On May 15, the legislation was amended on the House floor.

MAINE

Lead—ME H. 1137 (S. Jones) specifies methods of lead abatement and requires all lead abatement workers to be licensed. On May 31, the governor signed the measure.

MARYLAND

Lead—MD H. 229 (Brinkley) alters the definition of "affected property" in provisions of the insurance law relating to lead hazard coverage for rental property. The governor vetoed the bill on May 22.

MD H. 1068 (Guns) modifies a provision of law authorizing a lessee to invoke rent escrow remedies under certain circumstances if there is lead-based paint in specified residential premises. The governor signed the bill on May 22.

MD S. 669 (Baker) alters the dates by which rental dwelling units must be registered under the Lead Poisoning Prevention Program. On May 22, the legislation was signed by the governor.

MD S. 772 (Baker) modifies a provision of law authorizing a lessee to invoke rent escrow remedies under certain circumstances if there is lead-based paint in residential premises. The governor vetoed the measure on May 22.

MASSACHUSETTS

Lead—MA S. 1384 (Jajuga) directs the governor to issue a proclamation concerning lead poisoning prevention week. The bill was reported out of the Joint Committee on State Administration on June 2.

MICHIGAN

Hazardous Materials Transportation—MI S. 554 (Bennett) regulates the transportation of hazardous waste. Introduced on June 4, the bill was referred to the Senate Committee on Natural Resources and Environmental Affairs.

MINNESOTA

Hazardous Materials Transportation—MN H. 241 (Mullery) reauthorizes the uniform hazardous materials transportation registration and permit program for an additional year; and modifies provisions relating to motor carrier regulation. The legislation was signed by the governor on June 2.

Lead (Proposed Regulation)—The Minnesota Department of Health (DOH) intends to propose a rule (21 MNSR 1556; 4/28/97) which would establish standards for lead-based paint; criteria for licensure and certification of lead workers; and amend variance requirements pertaining to lead abatement and lead hazard reduction. Contact Douglas Benson, DOH, (612) 215-0881.

Toxics-in-Packaging—MN S. 900 (J. Johnson) modifies toxics-in-packaging requirements. The bill was signed by the governor on May 20.

Toxics-in-Products—MN S. 184 (Stevens) modifies the requirements of the toxics-in-products law which prohibits the sale or use of products to which heavy metals have been intentionally introduced. The bill was signed by the governor on May 30.

MISSOURI

Labeling (Proposed Regulation)—The Missouri Department of Natural Resources (DNR) issued a proposal (22 MOR 736; 4/15/97) which would rescind the effectiveness of a final regulation which amended procedures for obtaining exemptions for rigid plastic container labeling. Contact Charlene Fitch, DNR, (573) 751-5401.

NEW JERSEY

Lead (Proposed Regulation)—A proposed rule (29 NJR 2202; 5/19/97) of the New Jersey Department of Community Affairs (DCA) would amend current lead hazard evaluation and abatement standards and would incorporate by reference the "Industrial Lead Paint Removal Handbook." Contact Michael Ticktin, DCA, (609) 530-8803.

Water Quality (Regulation)—A final regulation (29 NJR 1704; 5/5/97) of the New Jersey Department of Environmental Protection (DEP) amends requirements to restructure the state pollutant discharge elimination system by simplifying the permitting process; revising provisions for storm water permitting, industrial users programs, and point source permitting; and modifying monitoring requirements. The rule went into effect May 5, 1997. Contact Janis Hoagland, DEP, (609) 292-0716.

NEW MEXICO

Hazardous Materials Transportation (Regulation)—The New Mexico Taxation and Revenue Department (TRD) adopted a final rule (8 NMR 352; 4/30/97) which establishes safety requirements for motor carriers, and standards for the transportation of hazardous materials. The regulation became effective April 30. Contact TRD, (505) 827-0939.

NEW YORK

Lead —NY S. 5319 (Smith) establishes a lead abatement licensing and certification program. The bill, which was introduced on May 14, was referred to the Senate Rules Committee.

NORTH CAROLINA

Lead—NC S. 516 (Ballance) establishes a lead-based paint hazard management program and requires any individual involved in lead abatement activities to be certified. Amendments to the bill were adopted by the Senate on June 4.

NC S. 806 (Conder and Forrester) pertains to the control of lead exposure of children. The bill passed the Senate on June 10.

OREGON

Air Quality—OR S. 946 (Committee on Livability) extends the state limitation of authority in implementing federal operating permit program requirements from Jan. 1, 1990 to Jan. 1, 2005. The House Committee on Environment and Energy released the bill on May 28 with a favorable report.

Air Quality (Proposed Regulation)—A proposed rule (36 ORRB 141; 5/1/97) issued by the Oregon Department of Environmental Quality (DEQ) would adopt the federal national emission standards for hazardous air pollutants (NESHAP) for newly constructed or reconstructed sources for which no NESHAP has been established; and would subject such sources to stringent air pollution control requirements. Contact Susan Greco, DEQ, (503) 229-5213.

The Oregon Department of Environmental Quality (DEQ) proposed a regulation (36 ORRB 142; 5/1/97) which would raise the fees charged to industrial sources subject to air contaminant discharge permit requirements by 40%. Contact Susan Greco, DEQ, (503) 229-5213.

Community Right-to-Know—OR S. 146 (Administrative Services) extends the deadline for small quantity generators of hazardous waste to submit toxics use reduction and hazardous waste reduction plans; and exempts small quantity hazardous waste generators from annual progress reporting requirements. On June 5, the bill passed the House.

Hazardous Materials Transportation (Proposed Regulation)—A proposal (36 ORRB 139; 5/1/97) of the Oregon Department of Transportation (DOT) would amend current requirements concerning the transportation of hazardous materials and waste by railroads to maintain consistency with federal standards. Contact Brenda Trump, DOT, (503) 945-5278.

The Oregon DOT proposed a regulation (36 ORRB 97; 5/1/97) which would adopt by reference federal requirements concerning hazardous materials transportation; motor carrier safety; and driver, vehicle and hazardous material out-of-service standards. The rule became effective April 1. Contact Brenda Trump, DOT, (503) 945-5278.

Hazardous Waste (Proposed Regulation)—A proposed regulation (36 ORRB 141; 5/1/97) of the Oregon Department of Environmental Quality (DEQ) would revise the compliance fee schedules for hazardous waste generators, and treatment, storage and disposal facilities. Contact Susan Greco, DEQ, (503) 229-5213.

Occupational Safety and Health (Proposed Regulation)—The Oregon Occupational Safety and Health Division (OSHD) has proposed regulations (36 ORRB 98, 101; 5/1/97) which would, among other things, incorporate by reference federal standards for the use of personal protective equipment and for group lockout or tagout. Contact Sue Joye, OSHD, (503) 378-3272.

RHODE ISLAND

Spray Paint Restrictions—RI S. 106 (Palazzo) calls for a joint public/private partnership to study technological solutions to graffiti. Provisions in the bill which would have required "graffiti-proof" containers for aerosol paint were deleted at a hearing before the House Judiciary Committee on May 29. The bill is now considered dead.

SOUTH DAKOTA

Water Quality (Proposed Regulation)—The South Dakota Department of Environment and Natural Resources (DENR) proposed a regulation (23 SDR 177; 4/14/97) which would amend surface water quality requirements, update toxic pollutant criteria and simplify the Section 401 water quality certification program. Contact DENR, (605) 773-3351.

TENNESSEE

Lead—TN S. 414 (Dixon) requires the establishment of a training/certification program to police the use of lead-based paint. The governor signed the measure on May 15.

TEXAS

Air Quality (Regulation)—The Texas Department of Environmental Quality (DEQ) adopted a final regulation which amends provisions for solvent-using and surface coatings operations concerning emission and monitoring requirements. The rule went into effect May 22. Contact Heather Evans, DEQ, (512) 239-1970.

Environmental Audits—TX H. 3459 (Chisum) allows penalties to be assessed for environmental or safety violations that were voluntarily disclosed under specific circumstances. On May 21, the measure was signed by the governor.

Lead—TX H. 729 (Van de Putte) requires lead hazard abatement workers in target housing and child-occupied facilities to be certified. The governor signed the legislation on May 27.

Lead (Notice)—The Texas Department of Health (DOH) has withdrawn a proposed rule (22 TXR 3395; 4/11/97) which would have reduced the adult elevated blood lead reporting level from 40 micrograms per deciliter of blood to 25 micrograms. The withdrawal was effective March 27. Contact DOH, (512) 458-7236.

Spray Paint Restrictions—TX S. 758 (Shapleigh) relates to the retail sale of spray paint. The governor signed the measure on June 9.

UTAH

Hazardous Materials Transportation (Proposed Regulation)—The Utah Department of Transportation (DOT) proposed a rule (97 UTSB 148; 5/15/97) which would incorporate by reference amendments to federal standards for motor carriers transporting hazardous materials and would lessen requirements for the transportation of hazardous materials that fall under "materials of trade" standards. Contact Shirleen Hancock, DOT, (801) 965-4781.

Hazardous Waste (Proposed Regulation)—A proposed regulation (97 UTSB 45; 5/15/97) of the Utah Department of Environmental Quality (DEQ) would establish standards to control organic air emissions from tanks, containers, and surface impoundments; improve the permitting process for hazardous waste storage, treatment, and disposal facilities; and would improve public access to information on hazardous waste facilities. Contact Susan Toronto, DEQ, (801) 538-6776.

VERMONT

Lead—VT S. 114 (Shumlin) reduces the burden on landlords for abatement of lead paint hazards in rental housing and child care centers. The governor signed the bill on May 28.

WASHINGTON

Occupational Safety and Health (Proposed Regulation)—The Washington Department of Labor and Industries (DLI) plans to issue a proposal (97-09 WASR 4; 5/7/97) which would incorporate federal occupational safety and health standards concerning worker exposure to methylene chloride. Contact Dan Locke, DLI, (360) 902-5524.

Methylene Chloride Rule Status—On Jan. 10, 1997, the U.S. Occupational Safety and Health Administration adopted a regulation which amended the existing requirements for employee exposure to methylene chloride. The new standard reduces the existing eight-hour time-weighted average exposure from 500 parts per million to 25. In response to this revision, a number of states are incorporating the new standard into their health and safety regulations.

The following states have proposed the incorporation of the new methylene chloride standard:Arizona, California, Connecticut, Maryland, North Carolina, Oregon, and Washington.

The following states have adopted the new methylene chloride standard: Indiana, Iowa, and Utah.

ice
INTERNATIONAL
COATINGS EXPO
NOVEMBER 3-5, 1997
ATLANTA, GA

Federation of Societies for Coatings Technology
1922
1997
75
years

ice '97
F S C T
75th Annual Meeting
International Coatings
Expo and Technology
Conference

FSCT's "ICE '97" Marks Our 75th Anniversary

Encompassing the spectrum of coatings manufacturing, the new format of the FSCT's annual convention will again feature an exhibition of over 300 supplier companies at the **International Coatings Expo, on November 3-5, 1997 at the Georgia World Congress Center, in Atlanta, GA.** Held in conjunction with the **FSCT Annual Meeting and the Technology Conference,** the Expo will present the industry's largest exhibition of suppliers. Come meet these suppliers for a face-to-face discussion of your needs and concerns. Problem-solving opportunities abound at "ICE '97"!

The FSCT's concurrent Technology Conference will provide a forum for learning at all levels of the coatings industry, from the newly hired technician to top level management. Each Course has been designed for specific areas of your organization, including lab personnel, sales and marketing staff, manufacturing, research and development, and quality assurance.

<u>Highlights of the Technology Conference include:</u>

- Two Executive Forums, covering new product development and technology management on Monday, November 3.
- Nine one-day Courses, scheduled over three days; November 3,4, and 5, allowing attendees ample time to visit the International Coatings Exposition.
- Four two-day Courses, scheduled for <u>Monday and Tuesday, November 3 and 4</u>, which again allows attendees time to visit the Exposition on November 5.
- Course attendees will be given *complimentary attendance* to the International Coatings Expo and the technical presentations given at the FSCT's Annual Meeting.
- Set of Course Materials is provided to the attendees of each Course.

Both you and your company benefit from attendance at this event. Your personal knowledge increases, which in turn improves your value within your organization, while the company stands to benefit from the new ideas and solutions you've learned by attending the conferences. The conferences also provide an opportunity for all coatings personnel to participate in the industry's premier event and learn the latest advances in the coatings industry.

ICE '97 Tentative Schedule of Events

All events are scheduled for the Georgia World Congress Center unless otherwise noted.

Sunday, November 2

Registration Services	8:00 a.m. to 5:00 p.m.

Monday, November 3

Registration Services	7:00 a.m. to 5:00 p.m.
Technology Conference	8:00 a.m. to 5:00 p.m.
Opening Session	8:30 a.m. to 10:00 a.m.
Expo Hours	10:00 a.m. to 5:00 p.m.
Annual Meeting Program	10:00 a.m. to 4:00 p.m.
Social Guests Welcome Reception	2:00 p.m. to 4:00 p.m.

Tuesday, November 4

Registration Services	7:00 a.m. to 5:00 p.m.
Technology Conference	8:00 a.m. to 5:00 p.m.
Expo Hours	9:00 a.m. to 5:00 p.m.
Social Guests Optional Tours departs from GWCC	9:30 a.m. to 3:30 p.m.
Annual Meeting Program	10:00 a.m. to 4:00 p.m.
International Reception Marriott Marquis	6:30 p.m. to 7:30 p.m.

Wednesday, November 5

Registration Services	7:30 a.m. to 12:00 p.m.
FSCT Anniversary Breakfast	8:00 a.m. to 9:30 a.m.
Technology Conference	8:00 a.m. to 5:00 p.m.
Expo Hours	9:00 a.m. to 12:00 p.m.
Annual Meeting Program	9:00 a.m. to 12:00 p.m.

INTERNATIONAL
COATINGS EXPO

NOVEMBER 3-5, 1997
ATLANTA, GA

FSCT 75th Anniversary Annual Meeting Program

Celebrating 75 years as the premier technical organization in the coatings industry, the FSCT has planned an event that will truly reflect the theme "75 Years . . . Tradition . . . Discovery . . . Opportunity." ICE '97 will provide a fascinating look back to the organization's origins. Even further, it will offer attendees insights into the coatings industry as it moves into the future—previewing innovative technologies and solutions to current challenges.

Participants of ICE '97 will have the opportunity to attend Annual Meeting technical sessions as part of their registration. Highlights of this year's technical program include:

ICE '97 Opening Session: Keynote Address by Daniel Burrus

Daniel Burrus, respected Science and Technology Forecaster, will provide the Keynote Address at the Opening Session on Monday, November 3.

Recent innovations in science and technology have provided us with a "new" set of tools to work with which will greatly increase our productivity and efficiency in all areas. Knowing what these tools are, and how to apply them creatively is rapidly becoming a matter of business survival and a key to personal gain. In his presentation, Mr. Burrus uses down-to-earth terminology, insight and humor to provide an informative, provocative and fascinating look at the impact of scientific innovations on how we will live and work in the near future.

Roon Award Competition Papers

Representing the best technical work directly related to the protective coatings industry, the Roon Award Papers describe original work of high scientific caliber, not previously presented or published. Awards for the papers are determined on the basis of originality, scientific importance, practical value, and the quality of composition.

International Papers

Reflecting the global audience of ICE '97, papers are presented from international industry experts. These papers often report on technologies which may affect the global marketplace or detail some of the latest technical advances outside of North America.

APJ/Voss Award Competition Papers

These FSCT Constituent Society papers are developed and presented by the Societies' technical committees. Their work deals with the research, development, manufacture or application of the industry's products or raw materials entering into their preparation.

Women in Coatings Roundtable

Entitled, "Coatings 2000: Women Leading into the New Century," this panel discussion will feature female leaders of the coatings industry addressing a timely topic—the role of women in the paint and coatings industry, both now and in the future.

Technical Focus Lecture

One of the most popular features of the Annual Meeting, the Technical Focus Lecture kicks off the technical portion of the Annual Meeting technical program. The Lecturer is chosen by the Chairs of several FSCT Committees, for on-going work in critical technical areas.

Mattiello Memorial Lecture

The 1997 Mattiello Lecturer is F. Louis Floyd, Vice President for Technology of Duron Paints and Wallcoverings, Baltimore, MD. The Mattiello Lecturer is an individual who has made outstanding contributions to science, technology, and engineering, related to the coatings industry. The Lecturer embodies the standards of technical accomplishment, service to the coatings industry and leadership established by Joseph J. Mattiello, who did much to expand the application of science in the decorative and protective coatings field.

Coatings Societies International to Present Medallion Honoring Technical Achievement at FSCT 75th Annual Meeting

Coatings Societies International will sponsor an award honoring outstanding technical achievement in the presentation of papers at the FSCT Annual Meeting in Atlanta, on November 3-5, 1997. This award, first presented at the XXIII FATIPEC Congress in June 1996, is given at selected annual congresses of CSI-member organizations.

In addition to the Federation of Societies for Coatings Technology, member organizations of CSI include: FATIPEC (Federation d'Association des Technicians des Peintures, Vernis, Emaux, et d'Imprimerie de l'Europe Continentale); JSCM (Japan Society of Colour Materials); OCCA (Oil & Colour Chemists' Association); SLF (Skandinaviska Lackteknikers Forbund); SCAA (Surface Coatings Association Australia); and SCANZ (Surface Coatings Association New Zealand).

The award is a polished bronze medallion, inscribed with the CSI logo. Interested parties may contact the CSI General Secretariat at the Federation of Societies for Coatings Technology, 492 Norristown, Rd., Blue Bell, PA 19422-U.S.

Coatings Technology Conference

All Courses held at Georgia World Congress Center

Sunday, November 2

Sunday Evening (Reception and Dinner)

(Included when you register for Executive Forum I & II)

Monday, November 3

Executive Forum I:

Strategically Effective New Product Development: An Enterprise-Wide Approach from Concept through Commercialization

Course Description

A one-day interactive workshop introducing participants to the "Why's" and "How's" of enterprise-wide New Product Development (NPD), fuzzy front end processes, concept generation, portfolio management, supporting systems and tools and fast development. The course is geared toward company executives and decision makers with key responsibilities for improving their organization's NPD output.

Instructors

- Paul O'Connor, Adept Group, Ltd.
- Chris Miller, Innovation Focus

Attendance Limit

30

Executive Forum II:

Advanced Topics in Technology Management

Course Description

Targeted to R&D and business executives who have strategic leadership responsibility in their organizations, this executive level workshop will introduce participants to three management topics focused on maximizing technology to achieve commercial success in the coatings industry.

Instructors

- Stephen E. Rudolph, A.D. Little
- John F. Martin, A.D. Little

Attendance Limit

30

Effective Technical and Scientific Writing Workshop

Course Description

For all levels of laboratory and R&D personnel, along with applicators and anyone with responsibility for writing memos, letters, reports, manuals, specifications and proposals on a routine basis. The session includes in-class writing exercises designed for practical application and allows time for individual instructor attention. Participants are invited to submit writing samples in advance for confidential review by the instructor.

Instructor

- Sal Iacone

Attendance Limit

25

Effective Employee Motivation Strategies

Course Description

Designed for all managers, this course will provide attendees with the necessary techniques to keep employees all pulling in the same direction for a common cause. Participants will learn the benefits of different types of motivational strategies and why some techniques work on certain people and not others. Attendees will also learn the value of incorporating these strategies into their management style.

Attendance Limit

30

Monday-Tuesday, November 3-4

(Two-Day Courses)

Introduction to Radiation Curing

Course Description

Radiation curable coatings are fast becoming an efficient method to meet the regulatory challenges facing the industry. This course is designed for formulating chemists, R&D chemists, technical directors and company decision makers in the adhesives, inks, plastics and coatings industries, and will provide details on the basics of radiation cure as a low VOC, low energy cure technology.

Instructors (Partial List)

- Latoska Price, Akzo Nobel
- Paul Gupta, Flint Ink Corp.
- Ed Jurczak, Sartomer
- Richard Stowe, Fusion
- Roy Modjewski, Akzo Nobel
- Ron Golden, UCB Radcure
- Bill Schaeffer, Sartomer

Attendance Limit

125

Methodology of Evaluating Corrosion Resistance

Course Description

This course is designed to review what corrosion is, its mechanism, methods of prevention, and a discussion of standardizing the process of testing for corrosion resistance. Attendees will learn important details of corrosion, the principles of protection, and then participate in and discuss possible methods of standardizing the evaluation process. It is designed for formulators, R & D chemists, technical service personnel and technical management.

Attendance Limit

125

Back to Basics: Resins, Pigments, Solvents & Additives

Course Description

For chemists, lab technicians, sales, marketing, and field support personnel new to the industry or with minimal experience. Participants will gain a better understanding of the basic composition of coatings and will be given tips on troubleshooting techniques to effectively formulate coatings.

Attendance Limit

125

Polymer Chemistry for the Coatings Formulator

Course Description

Provides current information on polymer chemistry for coatings formulators, R&D chemists, and sales and marketing personnel with strong technical backgrounds or interests. Attendees will realize a greater understanding of the essential concepts of polymer science and the underlying principles to determine coating performance. The course helps attendees to develop coatings using specific scientific principles as opposed to trial and error and is also relevant for ink, sealant and adhesive industry personnel.

Attendance Limit

125

Tuesday, November 4

(One-Day Courses)

Winning Technical Presentations

Course Description

For laboratory and R&D personnel at all levels, in addition to marketing and sales staff and anyone else responsible for delivering technical presentations. Attendees will learn how to develop effective visuals; proper speaking techniques and data organization; how to handle question and answer sessions; tips on transferring written information to speaking terms; and how to communicate clearly to all audiences. This program offers a combination of lecture, interaction and small group projects.

Instructor

Carter Johnson

Attendance Limit

25

Effective Negotiating Skills

Course Description

Every day, in every aspect of our lives, we are faced with negotiations. This program, designed for both technical staff and sales personnel, will provide attendees with proven techniques to enable your organization to benefit, both financially and time wise, from improved negotiations.

Attendance Limit

30

Creative Decorating

Course Description

Designed for decorators, applicators, those who develop trade sales paints, forward marketers, painting contractors, store owners, and anyone interested in do-it-yourself projects, this course will provide current information on the latest techniques being used to decorate homes and the workplace. The course will cover techniques such as stenciling, rag painting, sponge and broom painting and many other methods used to provide the current "looks" for home and office decoration.

Attendance Limit

50

Wednesday, November 5

(One-Day Courses)

Surfactant Chemistry and Application

Course Description

For R&D personnel, technicians, formulating chemists and application chemists, along with technical service personnel in the coatings and inks industries, this course will provide attendees with a better understanding of the various aspects of surfactant chemistry and its effect on the development of coatings and inks. Attendees will also develop an open thinking approach to surfactants and problem solving. This course content will include case studies and live demonstrations. Attendees are encouraged to submit questions in advance.

Instructors (Partial List)

- Bob Stevens, Dow Corning
- Steve Snow, Air Products
- Ed Orr, BYK Chemie
- Joel Schwartz, Air Products
- Fred Lewchik, BYK Chemie
- Tara Greesing, Ultra Additives

Attendance Limit

75

Industry Leadership with Product Stewardship

Course Description

This course has been developed for senior officers, hygienists, regulatory personnel, and those individuals involved in regulatory enforcement from the DOT, military, refinishing industry as well as the coatings and chemical industries. The program will give attendees a good description of the benefits of developing a Product Stewardship program and the value it has to the company. Initiatives such as Responsible Care™ and Coatings Care™ will be reviewed, and the benefits of these initiatives will be illustrated. This overview will give a basic understanding to attendees on how to install and manage such a program.

Attendance Limit

100

Responsible Care™ is a registered trademark of the Chemical Manufacturers Association.
Coatings Care™ is a registered trademark of the National Paint and Coatings Association.

Spray Applications Workshop

Course Description

Provides both experienced and novice applicators, field service personnel, specifiers and formulators with information on current and upcoming technologies as they apply to the application of coatings and finishes. Considered a "Learning Exchange Seminar," attendees will learn how to properly select, maintain and operate spray finishing equipment and to answer a variety of questions related to spray finishing.

Attendance Limit

25

Chemistry and Formulation of Powder Coatings

Course Description

Designed to provide formulators, R&D chemists, technical directors, and company decision makers with information on the basic processes of formulating powder coatings. This course will be beneficial to both newcomers to the powder coatings industry as well as give information to those companies that are considering adding powder coatings as a product line.

Attendance Limit

100

ice

INTERNATIONAL COATINGS EXPO

NOVEMBER 3-5, 1997
ATLANTA, GA

Guest Accommodations

There are 10 hotels providing convention rates for ICE '97. All have undergone extensive renovations to prepare for the Olympics held in Atlanta in 1996. Properties have been included to match every travel budget.

The Atlanta Convention Bureau's housing department is the official housing coordinator for ICE '97. To obtain a reservation for the convention, you must complete the official housing form and send it to ICE Housing. Only international attendees using a credit card may fax to 404-521-6392. The Bureau will provide an acknowledgment of all reservations. The hotel assigned will then forward a confirmation of the reservation. Please read your confirmation carefully for the hotel's cancellation policy.

The deadline for housing is **October 3**. After October 3, the Housing Bureau will place reservations on a space available basis. A deposit is required on all reservations. The deposit amount is $125 per room reservation with three exceptions: the Ritz Carlton, the Westin, and Omni at CNN, each of which requires a deposit equal to one-nights' stay. If paying by check, make the check payable to the ICE Housing Bureau. Credit card deposits will be processed 30 days prior to arrival. Before October 3, contact the Housing Bureau at 404-521-6630 with changes required. After October 3, contact the hotels directly.

The ICE Housing Bureau strives to place your reservation in the hotel of your choice. If the property desired is not available, the reservation will be placed based on the next choice available. Please be sure to indicate three choices on your form.

Rates

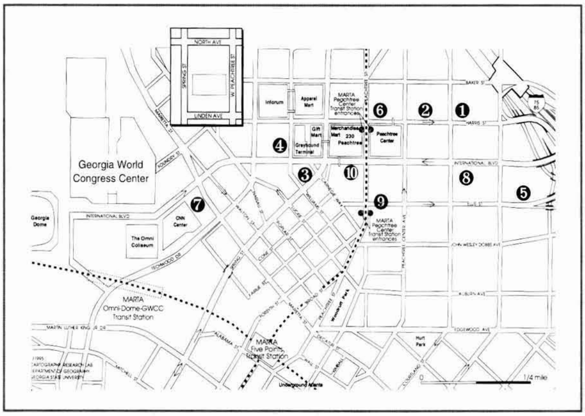
Hotel	Single	Double or Twin	1 BR Suites	2 BR Suites	X indicates Shuttle stop
FSCT Headquarters					
Atlanta Marriott Marquis*	$150	$170	$500 - $1,250	$650 - $1,400	x
Marquis level	194	214			
Atlanta Hilton and Towers	150	170			x
Hyatt Regency Atlanta	155	175	605 - 925	825 - 1,075	x
Concierge level	189	209			
Westin Peachtree Plaza	147	167			x
Concierge Level	177	197			
Radisson	91	101			x
Omni at CNN*	159	179	675 - 825	825 - 1,800	
Courtyard by Marriott	129	139			x
Best Western American	99	114			x
Concierge level	119	134			
Ritz Carlton	165	180			x
Comfort Inn	105	115			x

Key: Single = room with one occupant; Double = room with two occupants, 1 bed; Twin = room with two occupants, 2 beds; 1 bedroom suites = living room parlor and one connecting bedroom; 2 bedroom suites = living room parlor and two connecting bedrooms

*Exhibitors will be limited to a block of 10 rooms at the Marriott Marquis and the Omni at CNN. A one-bedroom suite counts as 2 rooms. A two-bedroom suite counts as 3 rooms.

KEY to HOTEL MAP

1. Atlanta Hilton and Towers
2. Atlanta Marriott Marquis
3. Best Western American Hotel
4. Comfort Inn Downtown
5. Courtyard by Marriott Downtown
6. Hyatt Regency Atlanta
7. Omni at CNN
8. Radisson Hotel Atlanta
9. Ritz Carlton Atlanta
10. Westin Peachtree Plaza Hotel



1997 Housing Application Form

Reservations must be placed with the ICE Housing Bureau to receive preferred rates. Hotels will not accept reservations directly. *Reservations must be received by **October 3, 1997.***

FEDERATION OF SOCIETIES FOR COATINGS TECHNOLOGY
ice
INTERNATIONAL COATINGS EXPO
AND TECHNOLOGY CONFERENCE

1. To Make Reservations

- Please print or type all items to ensure accuracy
- Complete each part below in detail for correct and rapid computer processing
- Form may be duplicated or supplemental room list must be attached using same format as below

MAIL or FAX

Send completed form and payment (in U.S. dollars only) to:

ICE Housing Bureau
233 Peachtree St., N.E.
Suite 2000
Atlanta, GA 30303

International Attendees may fax to 404-521-6392

Prior to October 3, all reservations, changes, and cancellations must be made with ICE Housing Bureau. After this date, these changes must be made with the hotel directly. Cancellation policies vary by hotel, please read confirmations carefully.

2. Hotel Information

Select 3 hotels of your choice to facilitate processing. Requests are given priority in the order received. First choice is assigned IF AVAILABLE. Be sure to list definite arrival and departure dates. Please use brackets to indicate those sharing a room.

1st ______________________ Rate________ 3rd ______________________ Rate________
2nd ______________________ Rate________ No. of rooms requested ________

Names of Occupants	Room Type*	Arrival	Departure
1.	☐ single ☐ dbl/dbl ☐ double		
2.	☐ single ☐ dbl/dbl ☐ double		
3.	☐ single ☐ dbl/dbl ☐ double		
4.	☐ single ☐ dbl/dbl ☐ double		
5.	☐ single ☐ dbl/dbl ☐ double		

* Room Key: single (1 person, 1 bed); double (2 people, 1 bed); double/double (2 people, 2 beds).
Requests for the Marriott Marquis and the Omni @ CNN will be limited to 10 rooms per exhibitor company.

3. Room Deposit

All rooms require a room deposit or credit card guarantee. Deposits are $125 per room for all hotels with the exception of the Omni @CNN, Westin, and Ritz Carlton. They require a one night's stay deposit. Deposits may be made by major credit card or check (U.S. dollars).

☐ Enclosed is my check payable to the ICE Housing Bureau for $ _______

Please bill my: ☐ AMEX ☐ MC ☐ Visa

Credit Card Number ______________________ Expiration Date ____________

Name of Card Holder ______________________ Signature ____________________

4. Send Confirmations to:

Contact Name: ______________________ Telephone: ____________________
Company: ______________________ FAX: ____________________
Address: ____
City/State (Province): ______________________ Zip Code (Mailing Code): ____________
Country (if other than U.S.): ______________________

♿ ______________________ requires special assistance. Please attach a written description of your needs.

ice
INTERNATIONAL COATINGS EXPO

NOVEMBER 3-5, 1997
ATLANTA, GA

Registration Information

Registration Procedures

By Mail Complete ICE '97 Registration Form and mail with payment to:

ICE Registration
P.O. Box 998
Park Ridge, IL 60068

By Fax 24 hours a day, 7 days a week
U.S. 800-952-9812
International 847-698-9245

By the Internet The FSCT's ICE '97 Registration has gone on-line. To register via the Internet, use the address: "www.coatingstech.org"

If you have any questions on how to complete the registration form, contact the ICE Registration Help Line:

U.S. 800-823-1530
International 847-384-7755

All cancellations and refund requests must be in writing and sent to ICE Registration. Cancellations received after October 26 are non-refundable.

All pre-registered attendees will receive a confirmation statement of their registration selection. Badges and materials will be available for pickup at the ICE Registration Services Area located in the Georgia World Congress Center beginning on Saturday, November 1.

Registration Rates

	~~EARLY BIRD DISCOUNTS *(Deadline is June 30, 1997)*~~		ADVANCE PRICING *(After June 30, 1997)*		CANCELLATION FEES	
	~~Member~~	~~Non-Member~~	Member	Non-Member	Before Oct. 3	After Oct. 3
ICE Expo/Annual Meeting Attendee	~~$70~~	~~$90~~	$75	$100	$25	$25
Retired Members	–	–	30	–	–	–
Students	–	–	15	15	–	–
Social Guests	–	–	40	40	–	–
Swan House Tour	–	–	60	60	–	–
Atlanta Tour	–	–	60	60	–	–
Conf. Package 1	~~225~~	~~315~~	250	350	50	100
Conf. Package 2	~~405~~	~~540~~	450	600	50	100
Conf. Package 3	~~495~~	~~675~~	550	750	50	100
Executive Forum	~~495~~	~~675~~	550	750	50	100

Registration Options

ICE Expo/Annual Meeting	Attendee receives 3-days' admittance to the Expo and to the Annual Meeting program
Conference Package 1*	Receives admittance to 1 ONE-DAY course
Conference Package 2*	Receives admittance to 2 ONE-DAY courses or 1 TWO-DAY course
Conference Package 3*	Receives admittance to 3 ONE-DAY courses or 1 TWO-DAY & 1 ONE-DAY course
Executive Forum	Receives admittance to 1 Executive Forum and 3 days admittance to the ICE Expo/ Annual Meeting

**All conference packages include admittance to the Expo and Annual Meeting Program*

Do Not Use This Form After October 3, 1997

ICE '97, PRE-REGISTRATION FORM

November 3-5, Atlanta, GA

Early-bird pricing is in effect until JUNE 30. For regular pre-registration, this form must be postmarked no later than OCTOBER 3, 1997. Form must be filled out completely for processing. A confirmation of your registration will be sent to you. ICE badges must be worn for admission to the ICE exhibits and all Technical Conference programs.

STEP 1. Industry Attendee Badge Information

FIRST NAME (Nickname)

FIRST NAME LAST NAME

COMPANY

MAILING ADDRESS (or P.O. Box)

CITY STATE/PROV.

COUNTRY (other than U.S.) POSTAL CODE

TELEPHONE NO. FAX NO.

STEP 2. Registrant Profile

Are you a first-time attendee?
1 ☐ Yes 2 ☐ No

FSCT Society Affiliation____________________

Information below must be completed for registration to be processed:

Your Company (Check one only)

31 ☐ Manufacturers of Paints, Varnishes, Lacquers
32 ☐ Manufacturers of Printing Inks
33 ☐ Manufacturers of Sealants, Caulks, Adhesives
34 ☐ Manufacturers of Powder Coatings
35 ☐ Manufacturers of Raw Materials
36 ☐ Manufacturers of Equipment and Containers
37 ☐ Sales Agents for Raw Materials and Equipment
38 ☐ Government Agency
39 ☐ Research/Testing/Consulting
40 ☐ Educational Institution
41 ☐ Paint Consumer
42 ☐ Environmental Services
43 ☐ Other ____________

Your Position (Check one only)

51 ☐ Management/Administration
52 ☐ Mfg. & Engineering
53 ☐ Quality Control
54 ☐ Research & Development
55 ☐ Technical Sales Service
56 ☐ Sales & Marketing
57 ☐ Consultant
58 ☐ Educator/Student
59 ☐ Other ____________

STEP 3. Social Guest Badge Information

FIRST NAME (Nickname)

FIRST NAME LAST NAME

CITY STATE/PROV.

COUNTRY (other than U.S.) POSTAL CODE

TELEPHONE NO.

Social Guest Registration
(Welcome Social and Expo) $40

Optional Activities *(Select only one—include selection in Step 5):*
Tues. Tour to Swan House $60
Tues. Tour of Atlanta Highlights $60

STEP 4. Conference Registration: Conference registrants must check boxes of session they wish to attend *(Not more than one box per day)*

Monday, Nov. 3	Tuesday, Nov. 4	Wednesday, Nov. 5
ONE-DAY COURSES ☐ **1** TECHNICAL WRITING ☐ **2** MOTIVATION	**ONE-DAY COURSES** ☐ **3** TECH. PRESENTATIONS ☐ **4** NEGOTIATING ☐ **5** CREATIVE DECORATING	**ONE-DAY COURSES** ☐ **6** SURFACTANT CHEM. ☐ **7** PROD. STEWARDSHIP ☐ **8** SPRAY APPLICATION ☐ **9** POWDER COATING
TWO-DAY COURSES (Nov. 3-4) ☐ **A** RADIATION CURING ☐ **B** CORROSION ☐ **C** BACK TO BASICS ☐ **D** POLYMER CHEM.	(TWO-DAY COURSES WILL BE COMPLETED ON TUESDAY)	***NOTE: Registration is limited for many courses. Provide alternate selections (put an X over appropriate choice/s):*** *one-day courses:* ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ *two-day courses:* Ⓐ Ⓑ Ⓒ Ⓓ *executive forum:* (F1) (F2)
EXECUTIVE FORUM (incl. dinner, Sun., Nov. 2) ☐ **F1** NEW PROD. DEV. ☐ **F2** TECH. MGMT.	For Office Use Only B/N ______ R ______ E ______ P ______ C______	

STEP 5. Calculate Amount

	~~EARLY BIRD DISCOUNTS (deadline June 30)~~		ADVANCE PRICING (after June 30)		
	~~FSCT member~~	~~nonmember~~	member	nonmember	amount
ICE EXPO/ANNUAL MTG. ONLY	~~$70~~	~~$90~~	$75	$100	$_____
Retired Members	—	—	$30	—	$_____
Students	—	—	$15	$15	$_____
SOCIAL GUEST Registration	—	—	$40	$40	$_____
Tues. Tour to Swan House (optional)	—	—	$60	$60	$_____
Tues. Tour of Atlanta (optional)	—	—	$60	$60	$_____
CONFERENCE & ICE EXPO:					
Conference Package 1 (1 one-day)	~~$225~~	~~$315~~	$250	$350	$_____
Conference Package 2 (1 two-day or 2 one-day)	~~$405~~	~~$540~~	$450	$600	$_____
Conference Package 3 (full conference* or 3 one-day)	~~$495~~	~~$675~~	$550	$750	$_____
EXECUTIVE FORUM	~~$495~~	~~$675~~	$550	$750	$_____
			SUBTOTAL		$_____
FSCT Industry Breakfast Tickets (number of tickets_____) $30			$30	$_____	
			TOTAL		$_____

*Full conference includes one one-day course and one two-day course

STEP 6. Method of Payment (Make check payable in U.S. Funds to FSCT)

SELECT ONE:
☐ Check enclosed
☐ MasterCard
☐ VISA
☐ American Express

Card number: ____________________

Exp. date: month _____ year _____

Cardholder's name ____________________
please print

Signature: ____________________

Amount Enclosed (from Step 5) .... $________

REGISTER TODAY!

Avoid duplication of registration: if you fax your registration, please do NOT mail it.

By Fax: **USA (800) 952-9812**
International (847) 698-9245

By Mail **send to:**
ICE Registration,
P.O. Box 998,
Park Ridge, IL 60068 USA

ICE '97 Registration Helpline **(between 9:00 am and 5:00 pm CST)**
USA (800) 823-1530
International (847) 384-7755

General Information

Social Guest Program

This year's Social Guest program includes registration to attend a welcome program featuring Decorating Trends for Your Home, on Monday, November 3, as well as admittance to the FSCT Opening Session on Monday, November 3, and three days admittance to the Expo.

Social Guest registration is offered only to the spouse or guest of the industry attendees. To register, complete the Social Guest portion of the official FSCT registration form. Advance Registration fee is $40. On-Site fee in Atlanta is $50.

Optional Tours

Social Guests have the opportunity to register for optional guided tours to be conducted on Tuesday, November 4. Two choices are offered: The Goodlife in Historic Buckhead and A Taste of the Peach. Each will run from 9 a.m. to 3 p.m.

The tours include transportation on deluxe motorcoaches, admission fees to attractions specified, and lunch. To participate Social Guests must complete the Activities portion of the Social Guests Registration Form.

Tour 1: The Good Life in Historic Buckhead features a visit to the Atlanta History Center offering participants a chance to tour the regal Swan House, the Tullie Smith House, and browse through the Atlanta History Museum. Following the morning tours, participants will travel to 103 West for a lunch at the posh Four Star restaurant. After lunch, participants will travel to Phipps Plaza and Lenox Square, two of Buckhead's favorite malls!

Due to limited availability, pre-registration is encouraged.

$60/person

Tour 2: A Taste of the Peach is a city tour highlighting the Olympic Village, the State Capitol, as well as the Historic District on Sweet Auburn Avenue. Participants will visit the Fox Theater as well as the Shops of Bennett Street. Following the morning tours, participants will travel to 103 West for a lunch at the posh Four Star restaurant.

After lunch, participants will travel to Phipps Plaza and Lenox Square, two of Buckhead's favorite malls!

Due to limited availability, pre-registration is encouraged.

$60/person

Shuttle Service

Shuttle service will be provided between the participating hotels and the Georgia World Congress Center.

Hours of Operation

Sunday, Nov. 2	8:00 a.m. to 5:00 p.m.
Monday, Nov. 3	7:00 a.m. to 6:00 p.m.
Tuesday, Nov. 4	7:30 a.m. to 6:00 p.m.
Wednesday, Nov. 5	7:30 a.m. to 3:00 p.m.

Pick-up locations and up-to-date schedule information will be posted at the Georgia World Congress Center and in the lobby of each participating hotel.

Travel Notes

The official carrier is Delta Airlines. To receive the special Delta convention rates*, you may wish to arrange your travel through the FSCT Travel Desk OR through Delta's Meeting Network.

If you book your travel through the **FSCT Travel Desk**, you will receive a chance to win round-trip transportation for two to FSCT's ICE '98 in New Orleans. To earn a chance at the drawing, you must book through the **FSCT Travel Desk at 1-800-448-FSCT and mention the ICE Show**.

Should you or your travel professional desire to make travel arrangements through the **Delta Meeting Network contact them at 1-800-241-6760** and refer to the convention file number **I-3697.**

**Certain restrictions apply.*

Airport and Ground Transportation

Hartsfield International Airport serves the Atlanta-metropolitan area. With 2,000 flights a day, it's one of the world's largest passenger terminals.

Located in Hartsfield International Airport near the baggage claim area is a station for MARTA, Atlanta's rapid transit system. MARTA provides a fast and economical transportation option to the downtown area. Call 404-848-4711 for further details. Other transportation options from the airport are shuttle service and taxis. Atlanta Airport Shuttle provides scheduled service from Hartsfield to the downtown hotels every 15 minutes from 7 a.m. to 11 p.m. One-way runs $8.00 and round-trip is $14.00. The trip takes approximately 30 minutes. Taxi service from Hartsfield operates on a flat fee: $18 for one person, $20 for two people, and $24 for three people.

Weather

Temperatures average 64°F (17.8°C) in Atlanta during early November. In the evenings expect the average to be 46°F (7.8°C).

Attire

Business attire is appropriate for all events.

Visitor details on Atlanta are available on the world wide web at "www.atlanta.com"

ICE '97 Exhibitors

(As of 7/8/97)

A.P. Dataweigh Systems
ABC Dispensing Technologies Inc.
Aceto Corp.
ACT Laboratories
Adhesives Age/Intertec Publishing
Advanced Software Designs
Air Products & Chemicals, Inc.
Akzo Nobel Resins
Alar Engineering Corp.
Allied Colloids, Inc.
AlliedSignal Inc.
Alnor Oil Co., Inc.
Ambrose Co.
ACS, Information & Services
American Paint & Coatings Journal
Amoco Chemical Co.
ANGUS Chemical Co.
Anker Labelers USA Inc.
Aqualon, A Div. of Hercules Inc.
ARCO Chemical Co.
Argus Business Media
Arizona Instrument Corp.
Ashland Chemical Co. Drew Industrial Div.
Atlas Electric Devices
Atotech USA Inc
Avestin Inc.
Avila-Agnelo Editora E Comercio Ltda- Paint & Pinturas Magazine
Barry-Wehmiller Co.
Barry-Wehmiller Packaging Systems
BASF Corp.
BatchMaster Software Corp.
Bayer Corp.
Blacoh Fluid Control, Inc
Borden Chemical, Inc.
Boss Bulk Systems, Inc.
Bowers Process Equipment Inc.
Brookfield Engineering Labs., Inc.
Buckman Laboratories, Inc.
Buhler Inc.
Bulkcon Systems USA
Burgess Pigment Co.
BYK-Chemie USA
BYK-Gardner, Inc.
Cabot Corp., CAB-O-SIL & Special Blacks Div.
Calgon Corp.
Cardolite Corp.
Cellulose Filler Factory Corp.
CEM Corp.
Chemical & Engineering News
Chemical Marketing Reporter
Chemical Week
Chemicals Incorporated
Chemir/Polytech Laboratories, Inc.
Ciba Specialty Chemicals Additives, Pigments, & Polymers Divs.
CIBA Specialty Chemicals- Fluoro Chemicals
Cimbar Performance Minerals
Clariant Corp.
Clawson Container Co.
CMI International
Coatings Magazine
Coatings World/Ink World Magazine
Color Communications, Inc.
Color Corp. of America
ColorTec Associates
Columbian Chemicals Co.
Cook Composite & Polymers (CCP)
Corob North America Div. of Taotek NA
Corrosion Control Consultants & Labs
Cortec Corp.
CR Minerals Corp.
Crosfield Co.
Cuno, Inc.
Cytec Industries Inc.
D/L Laboratories
Daniel Products Co., Inc.
Datacolor International
J. De Vree & Co. N.V.
DeFelsko Corp.
Degen Oil & Chemical Co.
Degussa Corp.
Delta Colour
University of Detroit Mercy
Disti-Kleen, Inc.
Dixie Poly-Drum Corp.
Dominion Colour Corp.
Dover Chemical Corp.
Dow Chemical Co.
Dow Corning Corp.
Draiswerke, Inc.
Dry Branch Kaolin Co.
DuPont Nylon Intermediates
DuPont Performance Chemicals
Eagle Zinc Co.
Eastern Michigan University
Ebonex Corp.
ECC International
Eiger Machinery, Inc.
Eckart America
Elf ATOCHEM North America, Inc.
EMCO (Epworth Morehouse-Cowles)
Engelhard Corp./Mearl
Engineered Polymer Solutions, Inc.
Esprit Chemical Co.
Estron Chemical, Inc.
European Coatings Journal
Exxon Chemical Co.
Federation of Societies for Coatings Technology
Filter Specialists, Inc. (FSI)
Fischer Technology Inc.
Florida Drum Co.
Fluid Management
Formation Systems, Inc.
Franklin Industrial Minerals
Fuji Silysia Chemical
H.B. Fuller Co.
G A F Filter Systmes
Gamry Instruments, Inc.
Paul N. Gardner Co., Inc.
Georgia Marble Co.
Georgia-Pacific Resins, Inc.
Gilson Co., Inc.
BFGoodrich Co. Specialty Chemicals
The Goodyear Tire & Rubber Co.
Gorman-Rupp Co.
Grace Davison
Graco, Inc.
GretagMacbeth (formely known as Macbeth)
Halox Pigments
J.W. Hanson Co., Inc.
Harcros Pigments Inc.
Henkel Corp.
HERO Industries Limited
Heucotech Ltd.
Hi-Mar Specialties, Inc.
Hilton Davis Co.
Hockmeyer Equipment Corp.
Horiba Instruments Inc.
Huls America, Inc.
HunterLab
Huntsman Corp.
ICI Surfactants
Ideal Manufacturing & Sales Corp.
IGT Reprotest Inc.
Indco, Inc.
Industrial Copolymers
Industrial Oil Products Corp.
Infinium Software (formerly Software 2000)
Inmark, Inc.
Inpra-Latina
Interfibe Corp.
International Compliance Center
International Speciality Chemicals
International Specialty Products (ISP)
ITT Marlow/ITT A-C Pump
J.M. Huber Corp. Engineered Minerals Div.
S.C. Johnson Polymer
Journal of Coatings Technology
K-T Feldspar Corp.
Kelly Chemical Corp.
Kenrich Petrochemicals, Inc.
King Industries, Inc.
Kline & Co., Inc.
KRONES, Inc.
KTA-Tator Inc.
Labelmaster
Laporte Inc./Aztec Peroxides, Inc.
Laporte Inc./Laponite Rheological Additives
Laporte Inc./Mapico
Laporte Inc./Mineral Pigments
Laporte Inc./Southern Clay Products
Lawter International
The Leneta Co.
Liquid Controls Corp.
Littleford Day Inc.
Longview Fibre Co.
The Lubrizol Corp.
3M Specialty Chemical Div.
Macbeth (see GretagMacbeth)
Mallinckrodt Inc.
Malvern Minerals Co.
Manufacturing Business Systems
Michelman, Inc.
Micro Powders, Inc.
Microfluidics International Corp.
Micromeritics
Micromet Instruments
Microview USA Inc.
Ming-Zu Chemical Industries
MiniFibers, Inc.
Minolta Corp.
Mississippi Lime Co.
University of Missouri-Rolla
Mitsubishi Chemical
Monsanto Co.
Morton International
Muetek Analytic Inc.
Myers Engineering
Nacan Products Ltd.
Nagase America Corp.
Nametre Co.
Neste OXO AB
Netzsch Incorporated
Neupak, Inc.
New Way Packaging Machinery
Norman International
North American Oxide Inc
North Dakota State University
Nyco® Minerals, Inc.
Occidental Chemical Corp.
Ohio Polychemical Co.
Olin Corp.
Omnimark Instrument Corp.
Paar Physica, USA Inc.
Paint & Coatings Industry Magazine
Paint Research Association
Pall Filtron Corp.
Parasol Systems, Inc.
Particle Sizing Systems, Inc.
Peninsula Polymers, Inc.
Pfaudler, Inc.
Phenoxy Specialties
Polar Minerals
Poly-Resyn, Inc.
PPG Industries, Inc.
PQ Corp./ Potters Industries
Premier Mill Corp.
Purity Zinc Metals
Q-Panel Lab Products
Quackenbush Co.
K.J. Quinn & Co., Inc.
Raabe Corp.
RadTech International North America
Ranbar Technology, Inc.
Readco Manufacturing, Inc.
Reichhold Chemicals, Inc.
Rexam Mulox, Inc.
Reynolds Industries, Inc.
Rheox, Inc.
Rhone-Poulenc, Inc.
Rhopoint Instrumentation Ltd.
Rohm and Haas Co.
Ronningen-Petter
Charles Ross & Son Co.
Russell Finex, Inc.
S & G Technologies
San Esters Corp.
Sartomer Co.
Schenectady International, Inc.
Schlumberger Industries
Schold Machine Co.
SEPR Ceramic Beads & Powders
Shamrock Technologies, Inc.
Shell Chemical Co.
Sherwin-Williams Chemicals
Silberline Mfg. Co., Inc.
Software 2000 (see Infinium Software)
Sonoco Industrial Containers
Southcorp Packaging USA, Inc. NAMPAC/Bennett
University of Southern Mississippi
Specialty Minerals, Inc.
Spencer Machine & Tool Co., Inc.
Spraymation, Inc.
Startex Chemical, Inc.
Steel Structures Painting Council
Stony Brook Scientific, Ltd.
Stretch-O-Seal Corp.
Summit Precision Polymers Corp.
Tech Pak, Inc.
Teemark Corp.
Tego Chemie Service USA
Testing Machines, Inc.
Thiele Engineering Co.
Thomas Scientific
Tikkurila/McWhorter/Kemira
Toyal America Inc.
Troy Corp.
U.S. Aluminum, Inc.
U.S. Zinc Corp.
UCB Chemicals Corp.
Union Carbide Corp.
Union Process Inc.
United Mineral & Chemical Corp.
United Soybean Board
VanDeMark Group
R.T. Vanderbilt Co., Inc.
Versa-Matic Pump Co.
Vianova Resins Inc.
Vorti-Siv Div. MM Industries, Inc.
Wacker Silicones Corp.
Western Equipment Co.
Wilden Pump & Engineering Co.
Witco Corp.
X-Rite, Incorporated
Zeiss Optical Systems, Inc.
Zemex Industrial Minerals
Zeneca Resins/Zeneca Biocides

Los Angeles Society and Cal Poly Pomona to Co-Sponsor Corrosion Control Conference

The first annual "Corrosion Control through Coatings Conference," co-sponsored by the Los Angeles Society for Coatings Technology and California State Polytechnic University, Pomona, CA, will be held on September 12, 1997 at the Kellogg West Conference Center, on the Cal Poly Pomona campus.

The conference will feature papers directed toward helping coatings scientists and application engineers develop successful protection strategies.

The following topics will be presented during the one-day event:

"Overview of Corrosion Control"—Robert Heidersbach, California Polytechnic State University at San Luis Obispo;

"Cyclic Corrosion Testing"—Glenn J. Bebie, Q-Panel;

"Primer Formulation"—Michael McGaugh, The Dow Chemical Co.;

"Water-Based Barrier Topcoat"—Aurelia C. Sheppard, Rohm and Haas;

"Corrosion Research Overview"—Earl Pye, California State Polytechnic University, Pomona;

"Coatings Design for Real World Application"—Norman R. Mowrer, Ameron PCD; and

"Specifications and Performance"—William B. Harper, NACE.

The conference fee is $100 for FSCT members and $250 for non-members.

For more information, contact LASCT, 11278 Los Alamitos Blvd., #104, Los Alamitos, CA 90720; Fax: (310) 594-6862 or Charles N. Millner, California State Polytechnic University, Pomona, College of Science, Bldg. 8, Rm. 310, Pomona, CA 91768; (909) 869-3678.

(See registration form on opposite page.)

Nuclear Painting Course Scheduled for Oct. 19-24

The National Board of Registration for Nuclear Safety Related Coating Engineers and Specialists (NBR), Leola, PA, will address "Nuclear Maintenance Painting Training," in a course slated for October 19-24, 1997, in Pittsburgh, PA.

Held at the facilities of KTA-Tator, Inc., the five-day course will focus on state-of-the-art materials and methods for successfully implementing a coatings maintenance program and will offer practical solutions and techniques for dealing with an anticipated new U.S. Nuclear Regulatory Commission regulatory posture toward coating maintenance in nuclear facilities.

Maintenance engineers, operations personnel, and coating work contractors involved in Class 1 nuclear coating work will benefit from this course.

The fee for the course is $1,000. Contact Dean Berger, NBR Executive Director, Box 56, Leola, PA 17540, for more information.

International Symposium:
"A Systems Approach to the Service Life Prediction of Organic Coatings"

September 14-19, 1997
The Village of Breckenridge Resort
Breckenridge, Colorado

Invited talks will cover the following topics:

→ SLP methodologies used in different industries
→ Quantitative characterization of outdoor weather variables
→ Recent fundamental mechanistic research results
→ Representation, integration, and use of SLP knowledge obtained from a variety of sources
→ Application of a systems approach to SLP: success stories

Posters in these topics are being solicited.

Registration Fee: $600 per participant (Includes most meals). Register early since the number of participants is limited.

For more information contact, Jonathan W. Martin at (301) 990-6707;
Fax: 301-990-6891 • e-mail:jonathan.martin@nist.gov

Atlas Adds Two New Courses to Its Educational Curriculum

Atlas Electric Devices Co., Chicago, IL, has announced the addition of two new Weather-Ometer® workshops to its educational curriculum. "Advanced Ci35A and Ci65A Weather-Ometer" and "Ci4000/Ci5000 Weather-Ometer" workshops will serve as a continuation and provide further instruction to the company's Weather-Ometer workshop.

The "Advanced Ci35A and Ci65A Weather-Ometer" workshop is designed to provide hands-on training in programming controllers, wiring diagram comprehension and detailed troubleshooting, as well as a step-by-step explanation of the operator's manual. This course is slated for August 15.

Designed for operators of the Ci4000 and Ci5000 Weather-Ometers, the "Ci4000/Ci5000 Weather-Ometer" workshop is a one-day course offering in-depth, hands-on training. Scheduled for November 19, this course will demonstrate operation, calibration, and maintenance to both experienced and inexperienced personnel.

The fee to attend "Advanced Ci35A and Ci65A Weather-Ometer" is $495 and includes course materials, continental breakfast, lunch, and refreshments. The registration fee for "Ci4000/Ci5000 Weather-Ometer" is $525 and includes course materials, continental breakfast, lunch, and refreshments.

For more information, contact Amy J. Benson, Atlas Electric Devices Co., 4114 N. Ravenswood Ave., Chicago, IL 60613.

LA Society & Cal Poly Pomona presents

The First Annual Corrosion Control through Coatings Conference

Presented by
The Los Angeles Society for Coatings Technology
and California State Polytechnic University, Pomona
Friday, September 12, 1997
Kellogg West Conference Center
Cal Poly Pomona, Pomona, CA

Registration Application

Please Print (for badge)

Name____

Institution____________ ____________________________

Address____

City________________ State/Province ________________ Postal Code____________

Phone:________________ Fax:________________E-Mail:________________

Registration Fees

Featured Luncheon Speaker Dr. Earl Pye

Advanced Conference registration includes lunch. The below prices are available until August 22, 1997:

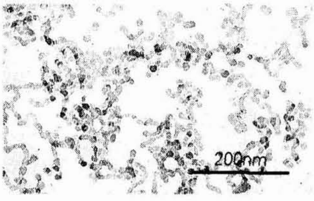
FSCT Members	$100.00	________
Non-FSCT Members	$250.00	________
Cal Poly Students	$25.00	________
	Total U.S. $	________

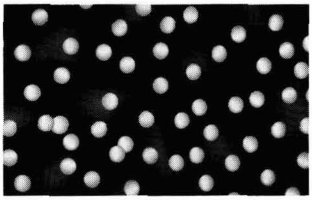
Make checks payable (in U.S. funds) to: **Cal Poly Pomona**

Please mail registration to: Charles N. Millner, Chemistry Dept., Cal Poly Pomona, College of Science, Bldg. 8, Rm. 310, Pomona, CA 91768.

For additional information, contact Dr. Millner at: Phone: (909) 869-3678; E-Mail: CNMILLNER

The conference is partially sponsored by the LASCT Continuing Education Fund





PRA Announces Schedule for Training Courses; Issues Call for Papers for Silicone Conference

The Paint Research Association (PRA), Teddington, Middlesex, United Kingdom, has released its schedule for upcoming training courses. Topics to be discussed include the following:

"Color Measurement and Color Control"—September 22-24;

"Printing Ink Technology"—October 6-8;

"Paint Technology"—October 13-16;

"What is Paint?"—October 22;

"Radiation Curing Technology"—November 3-5;

"Design of Experiments"—November 24-26;

"Paint Technology"—December 8-11.

Contact Heena Mehta, PRA, 8 Waldegrave Rd., Teddington, Middlesex TW11 8LD, United Kingdom, for more information.

In addition, PRA has issued a call for papers for the "Silicone in Coatings II" conference. Slated for March 24-26, 1998 in Disney World Village, Orlando, FL, this conference will cover all aspects of general chemistry, function types, substrates, techniques, and applications. Papers must be of high scientific and technical standards. Preference may be given to papers from end users, specifiers, formulators, and architects. Joint presentations are also welcome.

Prospective authors should submit a title and abstract (maximum of 150 words) by September 1, 1997, to Avril Henn, PRA Conference Secretary.

PRA will host "Coatings, Inks and Adhesives for Plastics and Elastomers" on October 27-29, 1997 in Milan, Italy.

The conference will provide information on the profitable cross-fertilization between widely diverse industries, application, and requirements.

In addition, a new generation of coatings for plastics, and their raw materials, showing how earlier technical hurdles have been overcome will be discussed. This event is designed for both product development managers as well as formulating scientists.

For more information contact Dip Dasgupta, Head of Information Dept., PRA, 8 Waldegrave Rd., Teddington, Middlesex TW11 8LD, United Kingdom.

HunterLab's Color Institute to Aid Color Professionals

Hunter Associates Laboratory, Inc., Reston, VA, has created the Richard S. Hunter Color Institute, which will provide commercial education and training for industrial color professionals. Named in honor of Richard S. Hunter, who created the L,a,b color system, the Institute will also offer courses and seminars in conjunction with HunterLab and other organizations.

In addition, the Institute's programs are expected to include:

- industry specific training sessions for personnel working in the coatings, chemicals, plastics, food, paint, paper, and textiles fields;
- initial or continuing education for all levels of personnel in color and appearance science;
- partnerships with various trade and professional associations to provide noncommercial educational classes to meet specific member needs;
- active membership and participation in major industrial and standards organizations;
- developing educational training aids such as video tapes and CD ROM; and
- The Richard S. Hunter Color Institute Fellow award program to encourage and recognize innovation in the field of color.

To obtain additional information, contact the Richard S. Hunter Color Institute, 11654 Plaza America Dr., Ste. 211, Reston, VA 20190.

ASTM Seeks Papers on Wear Processes in Manufacturing

The American Society for Testing and Materials (ASTM), West Conshohocken, PA, is inviting prospective authors to submit papers for ASTM's Committee G-2 on Wear and Erosion Symposium on Wear Processes in Manufacturing. The symposium will be held May 6, 1998 in Atlanta, GA, in conjunction with the May 7-8 standards development meetings of Committee G-2.

The purpose of this symposium is to provide a forum for interaction between tribologists and manufacturing scientists. Papers are, therefore, being solicited from researchers and industry people working in tribology and manufacturing on topics that integrate both tribology and manufacturing.

Prospective authors are requested to submit a title, a 250-300 word abstract, and an ASTM submittal form by July 31, 1997 to Dorothy Savini, Symposia Operations, ASTM, 100 Barr Harbor Dr., W. Conshohocken, PA 19428-2959; (610) 832-9677.

ACS: PMSE Seeks Nominations for 1998 Roy W. Tess Award in Coatings

The American Chemical Society's Division of Polymeric Materials: Science and Engineering (PMSE) is seeking nominations for the 1998 Roy W. Tess Award in Coatings.

The Tess Award recognizes significant contributions to coatings science and technology, encourages interest and progress in the field, and honors noteworthy contributors to the field.

The nomination should describe the achievements which form the basis for the nomination and should summarize the impact the nominee has had on the coatings industry, and the significance of his or her work to the public, the employer, and coatings science and technology. In addition, it would be helpful to include a discussion of the ways in which the work resulted in practical advances or influenced the work of others. The nomination may include a résumé, copies of up to five pertinent publications, and up to three seconding letters. Teaching credentials, skills and accomplishments will not be considered.

Please submit all nominations by September 1, 1997 to Dr. Robert F. Brady Jr., Code 6123, Naval Research Laboratory, Washington, D.C. 20375. Contact Dr. Brady at (202) 767-2268 or fax (202) 767-0594; e-mail: brady2@ccf.nrl.navy.mil for additional information.

New Substance Notification Program Targeted by Environment Canada as Cost Recovery Candidate

According to a report published by Environment Canada, Ottawa, Ont., the Canadian Treasury Board requires that government departments consider cost recovery for programs which confer benefits to individuals or groups. Consequently, the Departments of Environment and Health have identified the New Substances Notification Program as a candidate for cost recovery. The proposed mechanism for cost recovery under this Program is the collection of fees for notifications submitted pursuant to the New Substances Notification Regulations under the Canadian Environmental Protection Act.

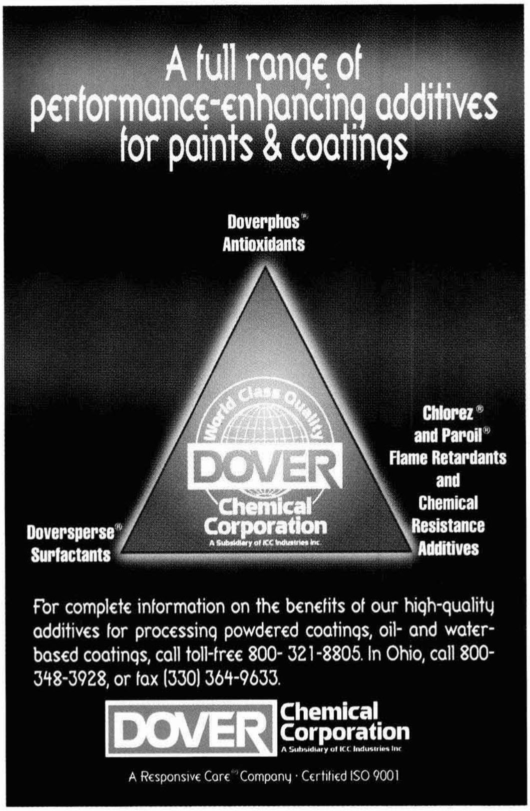
Both Departments are in the process of developing a consultation plan to permit a discussion with individual who would be subject to these proposed fees. In support of this consultation process, the Departments of Environment and Health have drafted a document entitled "Discussion Paper—Cost Recovery for the New Substances Program—Chemicals and Polymers." This document contains recommendations for implementing cost recovery in the New Substances Program in the context of chemicals and polymers. In particular, the document identifies cost recoverable activities, recommends a mechanism for recovering costs, and identifies potential fees for specific services.

All fees in the consultation document represent 100% of the costs to be recovered. This consultation process is intended to give affected parties an opportunity to comment on the proposed framework and fee structure in order to ensure that the policy is applied in an equitable manner. This process will also be used to identify the impact these fees may have on various industry sectors.

Sequa Corp. Acquires Sedgefield Specialties

Sequa Corp., Chester, SC, has purchased Sedgefield Specialties, Jamestown, NC, a specialty chemicals unit of Burlington Industries, Inc. The newly acquired business will be operated as a part of Sequa's specialty chemicals subsidiary.

The acquisition of Sedgefield adds manufacturing capacity to support Sequa's textile and emulsion polymer businesses. The Sedgefield site, which occupies more than 20 acres, also includes a 55,000 square foot technical center for the conduct of original and applications research.



OSHA Cites Three Conditions for Approval in Ruling on California's Hazard Communication Standard

A report released by the National Paint and Coatings Association (NPCA), Washington, D.C., states that the U.S. Occupational Safety and Health Administration (OSHA) approved, subject to certain conditions, California's hazard communication standard. These key conditions conform with NPCA comments on the issue, and should help clarify much of the current ambiguity in Proposition 65.

The three conditions for approval are the following:

- Employers in California can fulfill their obligations under Proposition 65 by complying with the federal or the OSHA hazard communication standard.
- Cal/OSHA, the designated occupational safety and health authority in California, must assure that the California standard continues to provide worker protection "at least as effective" as the federal standard and remains consistent with the approval conditions.
- Cal/OSHA's hazard communication standard may not be enforced against out-of-state manufacturers, because a state plan may not regulate conduct occurring outside the state.

According to Tom Graves, NPCA General Counsel, "This federal ruling will virtually eliminate the threat of bounty-hunter extortion suits against our out-of-state manufacturers for workplace warnings under OSHA law, and helps those operating plants in California to choose viable options for state and federal compliance."

OSHA's conditional approval of the hazard communication standard intends to clarify concerns about the extent the standard covers out-of-state manufacturers, importers and distributors, and outlines employer compliance provisions. It requires California OSHA to ensure that private enforcement lawsuits do not interfere with the regime in place.

BASF Seeks Sites for Monomers and Oligomers Plant

To meet the growing demands for UV-curing products throughout the NAFTA region, BASF Corp.'s Coatings Raw Materials, Charlotte, NC, has begun a comprehensive study of possible sites for a new U.S. production plant. The study follows the recent completion of BASF's domestic UV-curing applications and testing laboratory at its Charlotte Technical Center.

The study will focus on identifying the best possible plant location for the manufacture of both monomers and oligomers. UV-curing products represent an expanding market; by some estimates, North American demand for these products is growing at twice the rate of the coatings industry overall. UV-curing is recognized as a lower cost and environmentally friendlier alternative to solvent- and water-based techniques. Reduced cost per unit, improved air quality through the reduction of volatile organic compounds (VOCs), faster production rates, and reductions in required space and energy are among the appealing benefits of the UV-curing process.

Price Adjustments

Dow Chemical, Midland, MI

Product: Dowanol EB (ethylene glycol n-butyl ether)
Increase: $0.03 per pound
Effective: July 1, 1997

Product: Dowanol DB (diethylene glycol n-butyl ether)
Increase: $0.03 per pound
Effective: July 1, 1997

Product: Dowanol DM (diethylene glycol methyl ether)
Increase: $0.03 per pound
Effective: July 1, 1997

Degussa Corp., Ridgefield Park, NJ

Product: All hydrophilic fumed silica grades
Increase: 5%
Effective: July 15, 1997

Kerr-McGee Chemical Corp., Oklahoma City, OK

Product: Tronox® titanium dioxide
Increase: 7% (United Kingdom and Ireland) and 10% (European countries)
Effective: July 1, 1997

Ruco Polymer Corp., Hicksville, NY

Product: Rucoflex polyester polyols
Increase: $0.02 per pound
Effective: July 1, 1997

Product: Ethylene glycol adipates
Increase: $0.04 per pound
Effective: July 1, 1997

Nine Regional Operations to Serve KTA-Tator's Customers

KTA-Tator, Inc., Pittsburgh, PA, has formed nine nation-wide, full-service, regional operations. The corporate headquarters will remain in the Pittsburgh area, with regional headquarters located in Boston, MA (Northeast region); New York, NY (Mid-Atlantic region); Atlanta, GA (Southeast region); Pittsburgh, PA (Central region); Chicago, IL (Midwest region); Lexington, KY (Southcentral region); Seattle, WA (Northwest region); and Los Angeles, CA (Southwest region).

All regions will also offer the full complement of KTA services including coatings consulting, inspection, laboratory testing, instrument sales, environmental services, and materials engineering services.

Stochem to Distribute Vianova Resins' Products

Vianova Resins, Charlotte, NC, has appointed Stochem Inc., Brampton, Ont., as the Canadian distributor for its line of low-VOC resins.

Stochem will have distribution rights in Canada for all Vianova resins for liquid coatings. The resin line includes Beckopox epoxy resins and hardeners, Resydrol acrylic alkyd resins, Macrynal and Viacryl acrylic resins, and Daotan polyurethane dispersions. These products are used to formulate high-performance compliant coatings for substrates.

Silanes in High-Solids and Waterborne Coatings

Ming J. Chen, Fred D. Osterholtz, Eric R. Pohl, Philbert E. Ramdatt,
Antonio Chaves, and Valerie Bennett—Witco Corporation*

INTRODUCTION

Hydrolyzable organofunctional silanes (OFS) have played an important role as crosslinkers, both in silicone elastomers chemistry and in organic polymer technology.[1,2] These silylated polymers are crosslinked and cured with moisture from the air to form siloxane bonds and to give a network material. The ability of silanes added to a coating formulation to migrate to the substrate/coating interface and improve bonding is well known.[1] Generally, the substrates can be metal, mineral or plastic surfaces, glass or ceramic fibers, and fillers. The easy hydrolysis of these groups and subsequent condensation of the resulting silanols to form siloxane bonds are the chemical basis for the functional roles of coupling and crosslinking. The kinetics and fundamental aspects of alkoxy silane hydrolysis and condensation were previously reviewed.[3] Some advancements in using silanes in high-solids and waterborne coating technologies are introduced in this paper.

Silanes in High-Solids Systems

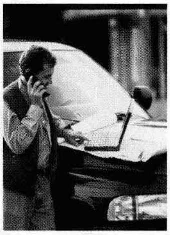
In our laboratories, we have explored the benefits of OFS crosslinking to provide mar resistance to solvent-borne acrylic automotive clearcoats. Possible mechanisms are presented in this study. The mar resistance of an organic coating defined by Corcoran is its ability to withstand scratching and scuffing actions.[4] Abrasion resistance may be defined generally as the ability of a material to withstand mechanical action, such as rubbing, scraping, or erosion.[5] Mar resistance is primarily a surface property, whereas abrasion resistance involves the body of the material as well. The following models have been proposed for abrasive wear:

Brittle Polymers: The wear volume V_w can be determined as follows[6,a,b]:

$$V_w = k_1 \, L \bullet d \bullet \tan \Theta / \pi H \tag{1}$$

Ratner has further determined the wear volume[6c]:

$$V_w - k_2 \, \mu \bullet d / H \bullet \sigma \bullet \varepsilon \tag{2}$$



Silanes have been used effectively in solvent-based or waterborne coatings to crosslink binder resins, increase pigment dispersion and improve end use properties, such as mar and solvent resistance and durability. A series of silylated styrene acrylic clearcoats have been prepared and studied in order to understand the chemical and physical parameters that influence the mar resistance and weathering properties of the cured coatings. It was found that the silane content affects the indentation hardness, coefficient of friction, modulus, and toughness of the cured coatings. A relationship between these coating characteristics and mar resistance is demonstrated. In water dispersed and emulsion polymer systems, silanes maximize properties, such as adhesion and solvent resistance. Silanes are incorporated into these systems via copolymerization or post addition. Recent advances in waterborne silane technologies are discussed, including methods of improving formulation stability.

Based on the fracture energy in the fracture of metals and brittle polymers,[6d]

$$V_w = k_3 \, (P \bullet L^{3/2} / G_{Ic} \bullet H^{3/2}) \, d \tag{3}$$

Ductile Polymers: Rice introduced the ductile fracture energy to the equation[6e]

Presented at the Waterborne, High-Solids and Powder Coatings Symposium, February 14-16, 1996, New Orleans, LA.

*777 Old Saw Mill River Rd., Tarrytown, NY 10591.

Table 1—Synthesis of Methyl Methacrylate/Butyl Acrylate/Styrene/3-Methacryloxypropyltrimethoxysilane/3-Mercaptopropyltrimethoxysilane Copolymer Resin

Ingredient	Parts by Weight
Vessel	
Butyl acetate	336
VM&P Naphtha	144
Toluene	96
Charge I	
Methyl methacrylate	896
Butyl acrylate	448
Styrene	560
3-Methacryloxypropyltrimethoxysilane	360
Charge II	
Butyl acetate	192
Di-tert-butyl peroxide	112
Charge III	
Butyl acetate	192
3-Mercaptopropyltrimethoxysilane	112

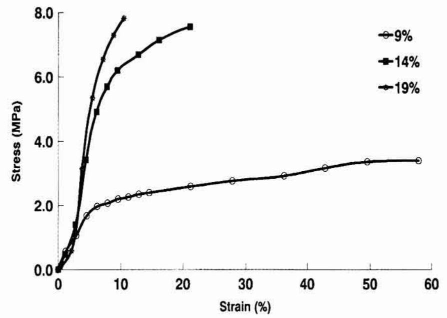


Figure 1—The stress-strain curves of cast silylated acrylic films containing 9, 14, and 19% silanes cured for 11 days. The crosshead speed was 5 in./min.

Table 2—Physico-Chemical Characteristics of Methyl Methacrylate/Butyl Acrylate/Styrene/3-Methacryloxypropyltrimethoxysilane/3-Mercaptopropyltrimethoxysilane Copolymer Resin

Property	Silylated Acrylic Resins		
Silane (wt%)	9%	14%	19%
Mp	8106	8482	8935
Mn	5219	4981	4598
Mw	7990	8379	9452
Polydispersity	1.53	1.68	2.06
Solid content	67.9%	67.3%	71.1%
Viscosity (centipoise)	3160	2405	2400
Acid number (mg KOH/g)	0.04	0.08	0.03
T_g	25.7°C	16.2°C	−22.4°C
^{29}Si solution NMR			
T^0	100.0%	100.0%	96.6%
T^1			3.4%

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[1] The weight ratio of MMA/BA/styrene/A-174/A-189/DTBP for 9, 14, and 19% silane copolymers are 45.9/18.0/22.5/4.5/4.5/4.5, 41.4/18.0/22.5/9.14/4.5/4.5 and 36.0/18.0/22.5/14.5/4.5, respectively. Methyl methacrylate was added to compensate the amount of difference. "T" represents three oxygen and one organic group tetrahedra, T = $Si(O_{1/2})_3R$. T^0 represents species when no oxygen is involved in a SiOSi bridge. T^1 represents species with one bridging oxygen.

$$V_w = k_4 \, (P \bullet L^{3/2} / J_{Ic} \bullet H^{3/2}) \, d \tag{4}$$

where $k_{n(n=1\text{-}4)}$ = wear constant, L = normal load, H = hardness, Θ = mean slopes of asperities, d = sliding distance, μ = friction coefficient, σ = breaking stress, ε = elongation at break, G_{Ic} = fracture energy, P = yield strain, J_{Ic} = ductile fracture energy.

The ideal mar resistant materials should possess somewhat contradictory properties of the hardness of brittle materials and also the toughness of ductile materials. We report here on some of the evaluations experimentally.

EXPERIMENTAL

Characteristics of Silylated Acrylic Clearcoats

The synthesis according to the literature[7] of the methyl methacrylate/butyl acrylate/styrene/3-methacryloxypropyltrimethoxysilane (Silquest® A-174)/3-mercaptopropyltrimethoxysilane (A-189) copolymers, provided resin for the formulations of automotive clear topcoats.

Into a reaction kettle equipped with a nitrogen inlet, stirrer, reflux condenser, and three metering pumps, were charged butyl acetate, VM&P naphtha, and toluene. The solvent was heated to reflux at about 119°C. At this time, three charges of solutions (charge I, II, and III) were added simultaneously through metering pumps separately over a period of two hours. After the end of the addition, another nine parts of the peroxide catalyst were added and the solution was kept at 119°C for one hour. Then, another nine parts of the peroxide catalyst were added, and the mixture was held for another 1.5 hr at reflux.

Table 1 lists the ingredients and synthesis procedure, which gave 19% of silanes by weight. By varying the weight of 3-methacryloxypropyltrimethoxysilane and compensating with methyl methacrylate, copolymers with 9 and 14% silane were also synthesized.

The physico-chemical characteristics of these copolymers, including peak molecular weight (Mp), weight-average molecular weight (Mw), number-average molecular weight (Mn), polydispersity, acid value, viscosity, solid content, glass transition temperature (T_g), and T^0 and T^1 by solution ^{29}Si NMR, were determined and listed in *Table* 2. The T_gs of the dried resins were measured by differential scanning calorimetry (DuPont 2100 DSC) under nitrogen. It was found that the T_g decreased when the silane concentration was increased.

Clearcoat free films were prepared according to a published formulation.[7] The material properties of silane interpolymer free films were determined as follows: free films were prepared in aluminum molds with mold release agent (fluorocarbon release agent dry lubricant, MS-122, by Miller-Stephenson Chemical Company) or teflon molds. The film thickness was approximately 1270 μ in thickness. The tensile properties of polymer films were carried out by an Instron series IX automated materials testing system with a 4500 series interface. The crosshead speed was tested at 5 in./min.

Coating Tests

Pencil hardness, indentation hardness (by Shore durometer "A2"), and Sward hardness were determined according to ASTM 3363-74, D 2240-86, and D 2134-66, respectively. Gloss at 20° and 60° was measured by a micro-TRI-gloss reflectometer according to ASTM D 2457. Adhesion test was carried out by use of a cross-cut paint adhesion test kit (ASTM D 2197-E86). Viscosity was conducted on a Brookfield viscometer according to ASTM D 2196-86. The percent elongation for specimens on Bonderite treated cold-rolled steel panels was determined by a conical mandrel according to ASTM D 522-88. Slip angle and coefficient of friction of various coatings were determined on a Tilt Table Lubricity Tester (from American Glass Research, Inc.) according to ASTM D 4518-87. Abrasion test was conducted by a Taber Abraser model 174, using a pair of CS-10 abrasive wheels and 500 g load (ASTM D 4060-90). Mar resistance was measured by gloss retention after abrasion for 10 cycles by an AATCC Crockmeter (from Atlas Electric Devices Company, Model CM-5) wrapped with a piece of wool.

RESULTS AND DISCUSSION

Tensile Properties, Siloxane Crosslinking, and Coating Properties

The stress-strain curves of these silylated acrylic free films are depicted in *Figure* 1. The moduli and toughness of the polymer films were increased by increasing the concentration of the silane crosslinker. The long-term siloxane crosslinking of the films prepared from the silylated clearcoats was further studied by solid state ^{29}Si NMR. Notations for the types of silicon-based tetrahedra containing oxygen and organic "R" groups are defined here. "T" represents three oxygen and one organic group tetrahedra, T - $Si(O_{1/2})_3R$. T^0 represents species when no oxygen is involved in a SiOSi bridge. T^1, T^2, and T^3 represent species with one, two, and three bridging oxygens, respectively. The concentrations of T^0, T^1, T^2, and T^3 were calculated from deconvoluted spectra. The "percent of crosslinking," defined as $(T^1+2T^2+3T^3)/3$ was calculated. The cure chemistry of the clearcoats is shown in *Figure* 2 by plotting the T^0, T^1, T^2, T^3 species and percentage of crosslinking versus the curing time. The values of percent of crosslinking at 49 days and 342 days were essentially the same (73.1% and 73.5%). The crosslinking rate of silane interpolymers becomes much slower after curing at ambient conditions for 10 days.

The coatings were drawn down on zinc phosphate treated steel panels and fully cured by exposure to 23°C and 50% RH for one week before testing the following coating properties on panels were determined. *Table* 3 lists the results. It is interesting to note that the indentation hardness data give a distinct trend, which is consistent with the mathematical models.

During preparation of silylated acrylic copolymers, 4.5% of mercaptosilane was incorporated as a chain transfer agent to control the molecular weight. Without the mercaptosilane, the viscosity of the copolymer was raised

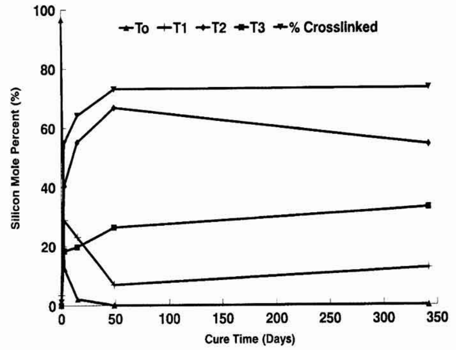

Figure 2—A plot of the siloxane crosslinking of cast silylated acrylic films containing 19% silanes, cured at ambient conditions over time and monitored by solid state ^{29}Si NMR.

Table 3—Film Properties of Silylated Acrylic Clearcoats

Test Method	Silylated Acrylic Clearcoats		
Silane (wt%)	9%	14%	19%
Pencil hardness	HB	F	HB
Gloss (20°)	83	89	85
(60°)	94	99	96
Sward hardness	30	26	27
D.O.I.	85	90	85
Shore hardness	25	49	89
Tape adhesion	0B	0B	0B
Elongation	3.7%	6.9%	3.0%
Coef. of friction	0.53	0.31	0.24
Taber abrasion index	22	19	17

The coatings were prepared on phosphate-treated panels. The abrasion test was conducted on films drawn down on E-coated panels by a Taber Abraser model 174, using a pair of CS-10 abrasive wheels and 500 g load (ASTM D 4060).

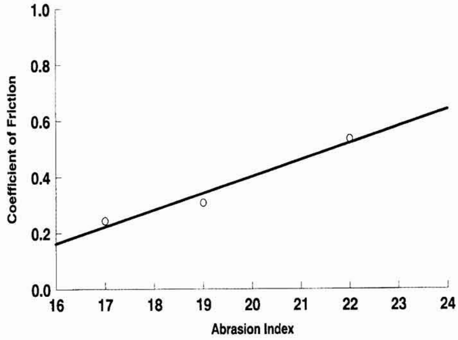

Figure 3—The effect of coefficient on friction on the mar resistance of silylated acrylic clearcoats.

Table 4—Coating Properties of Difunctional and Trifunctional Silane-Containing Styrene-Acrylic Clear Coats During QUV Aging Process[a]

	Clearcoat		
Test Method	A	B	C
Pencil Hardness			
0 weeks	2H	2H	6H
2 weeks	2H	2H	6H
4 weeks	7H	2H	6H
8 weeks	7H	4H	6H
12 weeks	7H	6H	6H
Adhesion by Tape Test			
2 weeks	2B	2B	3B
4 weeks	2B	2B	—
12 weeks	5B	5B	5B
Flexibility Test by			
2 weeks	3.8	3.7	3.5
4 weeks	3.6	4.2	3.8
8 weeks	6.1	7.1	3.3
12 weeks	12.9	12.8	11.9

(a) The accelerated weathering was carried out in a QUV apparatus (The Q-Panel Co.). Each weathering cycle consisted of a dry period (UV-B lamp 313 for 4 hr at 60°C) and a wet period (condensation for 4 hr at 40°C).

(b) A: 19% A-174/A-189 (14.5% A-174 and 4.5% A-189); B: 19% MPMDM/A-174/A-189 (4.8% MPMDM, 9.6% A-174 and 4.5% A-189); C: 14% MPMDM/A-189 (9.1% MPMDM and 4.5% A-189). Methyl methacrylate was added to compensate the amount of difference.

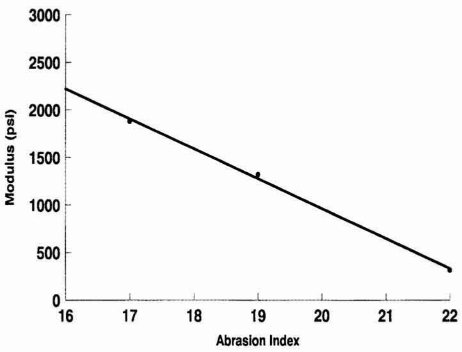

Figure 4—The effect of modulus on the mar resistance of silylated acrylic clearcoats.

Table 5—Glass Transition Temperatures of Cured Films Cast from Silylated Acrylic Clearcoats[a]

A—19% A-174/A-189; B—19% MPMDM/A-174/A-189; C—14% MPMDM/A-174/A-189

Testing	A	B	C
T_g(°C)	49.7	45.7	41.5

(a) The T_gs of the above free films of 50 mil thickness, cured at ambient conditions for 10 weeks, are determined by dynamic mechanical analysis.

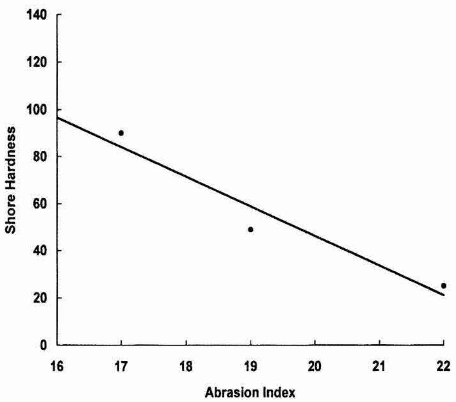

Figure 5—The effect of hardness on the mar resistance of silylated acrylic clearcoats.

Table 6—Ingredients of 4 mole% Vinyltris(isopropoxy)silane Silylated Vinyl Acrylic Latex

Latex Polymer Contents	Parts by Weight
Vinyl acetate	385.0
Butyl acrylate	65.0
Vinyltris(isopropoxy)silane	46.6
Water	438.9
Igepal CA-897	26.5
Igepal CA-630	3.0
$NaHCO_3$	2.0
Natrosol 250 MXR	2.5
$NH_4S_2O_8$	1.8
Abex EP-110	3.6
t-Butyl hydroperoxide-70	0.1
2% Sodium formaldehyde sulfoxylate	25.0
Ammonium hydroxide	to pH 7.5

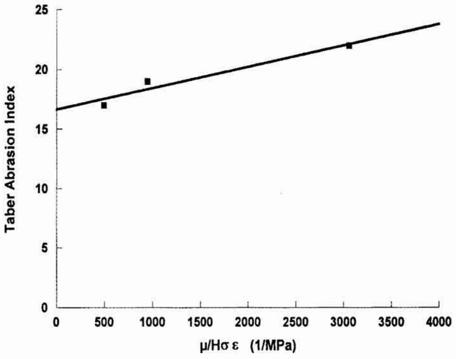

Figure 6—A plot of Taber abrasion index versus the empirical parameters $\mu/H\cdot\sigma\cdot\varepsilon$.

to one million centipoise. Therefore, a control polymer with 0% silane is not feasible.

Correlation of Modulus, Friction, and Hardness on Mar Resistance of Clearcoats

The abrasion tests show decreasing Taber abrasion with increasing silane concentration. The contributions of modulus, coefficient of friction, and hardness to abrasion and mar resistance are presented individually in *Figures* 3-5. The plots illustrate that modulus and indentation hardness are inversely correlated with the rate of abrasion, whereas the coefficient of friction has a direct correlation with the rate of abrasion. By plotting the abrasion index against the empirical parameters $\mu / H \cdot \sigma \cdot \varepsilon$, the consistency of the factors is further demonstrated in *Figure* 6.

The Influence of Difunctional Silane Ester on Clearcoats

Silylated acrylic clearcoats containing 3-methacryloxypropylmethyldimethoxysilane (MPMDM) were synthesized in the same manner. The free films were cured at 23°C and 50% RH for seven days. Comparisons on tensile curves among 14% MPMDM/A-189 (A), 14% A-174/A-189 (B) and a blend of A/B at weight ratio of 20/80 are depicted in *Figure* 7. The weathering resistance of these clearcoats studied by QUV exposure over 2,000 hr is further described in *Table* 4, and in *Figures* 8 and 9. During this study, no crack formation was found and adhesion was actually improved. The mar resistance of these coatings was maintained after accelerated aging by QUV. Samples were coated on phosphate treated steel panels. The T_gs of free films containing difunctional and trifunctional silanes are reported in *Table* 5. The incorporation of a difunctional silane ester gives benefits in controlling the mechanical properties of the coatings.

Silanes in Waterborne Systems

OFS may be incorporated in latex systems by copolymerization, grafting, physical addition, or combinations. When levels rise much above 0.25% to 0.5% by weight of solids, premature crosslinking often occurs, producing a poor quality latex. Bourne et al.[8] describes many attempts to prepare latexes containing 5 wt% and higher silane co-monomers. Masuda et al. reported using water insoluble tin catalyst in long-chain alkoxysilane silylated latexes.[9] We report suc-

Table 7—Ingredients of 6 mole% 3-Methacryloxypropyltriisopropoxysilane Acrylic Latex

Latex Polymer Contents	Parts by Weight
Portion 1	
Deionized water	479.4
Igepal CA-897	44.0
Butyl acrylate	55.0
Methyl methacrylate	120.8
Methacrylic acid	2.8
3-Methacryloxypropyltriisopropoxysilane	41.8
0.15% Ferrous sulfate	6.0
Potassium persulfate	3.0
Portion 2	
2% Sodium formaldehyde sulfoxylate	12.0
Portion 3	
Butyl acrylate	65.0
Methyl methacrylate	121.4
Methacrylic acid	2.8
3-Methacryloxypropyltrimethoxysilane	27.8
Portion 4	
2% Sodium formaldehyde sulfoxylate	12.0
Portion 5	
t-Butyl hydroperoxide-70	0.1
Portion 6	
2% Sodium formaldehyde sulfoxylate	6.0

Table 8—Film Properties of Silylated Acrylic Latexes vs. Controls Without Silane

Ingredient	A	B	C	D
Latex solids (wt%)	47	47	43	43
Latex composition (mole%)				
Butyl acrylate	26	26	32	32
Methyl methacrylate	67	67	67	67
Methacrylic acid	2	2	2	2
3-Methacryloxypropyl triisopropoxysilane	6	6	0	0
Catalyst[a]	No	Yes	No	Yes
Film Properties				
Gloss (60°)	85	83	84	83
Pencil hardness	F	H	B	HB
Tape adhesion	5B	5B	5B	5B
MEK double rubs	>400	>400	10	30

(a) Tyzor® 131 (5%) was used as the catalyst. Coatings were prepared from fresh mixtures of Tyzor catalyst and the acrylic latexes. Six percent of diethylene glycol monobutyl ether acetate was added as coalescent. Coatings were baked at 250°F for 20 min and further cured at 23°C and 50% RH for seven days.

Table 9—Film Properties of the Silylated Vinyl Acrylic Latexes vs. Controls Without Silane

Ingredient	A	B	C	D
Latex solids (wt%)	53	53	51	51
Latex composition (mole%)				
Vinyl acetate	86	86	86	86
Butyl acrylate	10	10	14	14
Vinyltris(isopropoxy)silane	4	4	0	0
Catalyst[a]	No	Yes	No	Yes
Film Properties				
Gloss (60°)	87	86	82	103
Pencil hardness	3B	B	4B	4B
Tape adhesion	5B	5B	5B	5B
MEK double rubs	17	50	19	15

(a) Tyzor 131 (5%) was used as the catalyst. The silylated vinyl acrylic latexes with 5% Tyzor 131 catalyst were stored at room temperature for four weeks. Coatings were baked at 250°F for 20 min and further cured at 23°C and 50% RH for seven days.

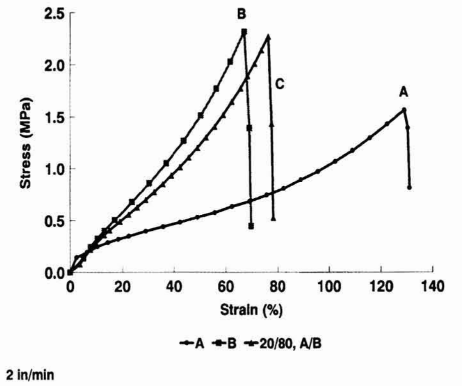

Figure 7—The stress-strain curves of cast silylated acrylic clearcoats. (A) 14% MPMDM/A-189; (B) 14% A-174/A-189; and (C) A/B blend at wt ratio 20/80.

Table 10—NMP Paint Adhesion Test Results of Vinyl Acrylic Latex Films Cast from Polymer Containing 1.0%-3-Methacryloxypropyltriisobutoxysilane vs. Concentrations of Titanate Catalysts[a]

	NMP Paint Adhesion[b] (Minutes)			
	Catalyst Concentration			
Catalyst	0.05%	0.5%	1%	2%
Tyzor 131	5.5	—	—	—
Tyzor LA	5.6	18	39	56

(a) The film thickness was 2 mils. The values were average values taken out of three coated stainless steel panels. Coatings were baked at 121°C for 20 min, then further cured at 23°C and 50% RH for seven days.

(b) The adhesion at the paint-metal interface was determined by the use of N-methyl pyrrolidone (NMP) heated at 60°C. In all cases, a 2.0 cm^2 sample was immersed in NMP and the time for paint removal was noted.

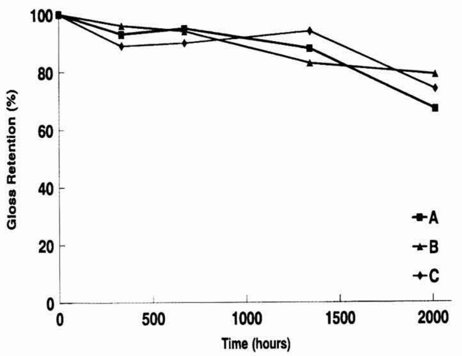

Figure 8—The gloss retention of silylated acrylic clearcoats under QUV aging process. (A) 19% A-174/A-189; (B) 19% MPMDM/A-174/A-189; and (C) 14% MPMDM/A-189.

cessful attempts to incorporate silanes at 10% and higher levels.

The principles in our work involved the use of hindered, slow-to-hydrolyze alkoxy silanes, together with catalysts selected for good performance and for in-can stability.

EXPERIMENTAL

Preparation of Silylated Vinyl Acrylic Latexes

The synthesis ingredients for silylated vinyl acrylic latex (9.4% silane) is shown in *Table* 6. The procedure is as follows:

Deionized water, IGEPAL CA-897 and IGEPAL CA-630 surfactants (from Rhône-Poulenc), sodium bicarbonate and Natrosol 250 MXR (from Aqualon) were charged to a reactor equipped with a condenser and a stirrer. The system was heated to 65°C with a heating mantle and purged with nitrogen. Ammonium persulfate and ABEX EP-110 (from Rhône-Poulenc) were added. Monomer feed was started. After the seeded latex was formed by adding the first 10% of the monomer blend and reacting for 15 min, the remaining monomer mixture was added over three hours at 75°C. In the presence of t-butyl hydroperoxide-sodium formaldehyde sulfoxylate, reaction was continued for another hour to complete polymerization. Ammonium hydroxide was used to adjust the pH of the latex to 7.5 before straining.

The synthesis ingredients for a silylated acrylic latex (19% silane) is shown in *Table* 7. The procedure is described as follows:

Into a one-liter reaction vessel equipped with a stirrer, thermometer, dropping funnel, and nitrogen gas inlet were charged deionized water (479.4 g), IGEPAL CA-897 (44 g, from Rhône-Poulenc), butyl acrylate (55.0 g), methyl methacrylate (120.8 g), methacrylic acid (2.8 g), 3-methacryloxypropyltriisopropoxysilane (41.8 g), aqueous 0.15% ferrous sulfate solution (6.0 g), and potassium persulfate (3.0 g) at ambient temperature. They were mixed for five minutes. A two percent aqueous solution of sodium formaldehyde sulfoxylate (12.0 g) was added. The exotherm increased the temperature from ambient to 60° to 65°C. The mixture was cooled to 35°C. A second mixture of butyl acrylate (65.0 g), methyl methacrylate (121.4 g), methacrylic acid (2.8 g), and 3-methacryloxypropyltriisopropoxysilane (27.8 g) was added to the reaction vessel. A second charge of a two percent aqueous solution of sodium formaldehyde sulfoxylate (12.0 g) was added to the reaction vessel. The mixture was allowed to heat up to a temperature of 60° to 65°C, and then cooled to 50°C. Then t-butyl hydroperoxide-70 (0.1 g) was slowly added to the reaction mixture followed by a two percent sodium formaldehyde sulfoxylate solution (6.0 g). The reaction mixture was stirred and then cooled to room temperature. Concentrated ammonium hydroxide solution was used to adjust the pH of the silylated polymer emulsion to 7.5.

RESULTS AND DISCUSSION

Stable Silylated Acrylic and Vinyl Acrylic Latexes

The alkoxy groups included selected hindered or long alkoxy chains, such as iso-propoxy, n-butoxy, i-butoxy, n-octoxy. Concentrations of silane co-monomers ranged from 0.2 to 24 wt%, or up to 8 mole%. Stable, aqueous emulsion copolymers with alkoxysilane crosslinking functionality were prepared by emulsion polymerization. In order to balance the reactivity of co-monomers, the silylated vinyl acrylic latex was prepared by a semi-continuous batch process. The silylated acrylic latex was prepared by a two-staged batch process. These systems showed no seeding or viscosity increase after 12 months of room temperature storage. Solution ^{29}Si NMR detected only the T^0 species at a seven-month room temperature storage. In contrast, latexes containing methoxy or ethoxy silanes at levels greater than five percent gel during preparation or with a few days of room temperature storage.

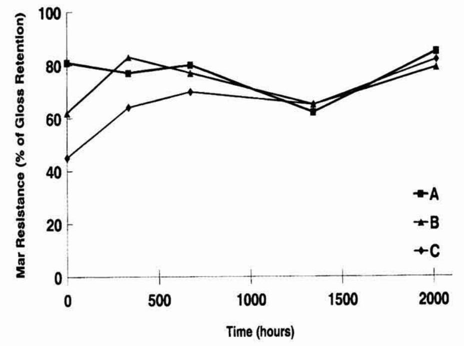

Figure 9—The mar resistance of silylated acrylic clearcoats under QUV againg process. (A) 19% A-174/A-189; (B) 19% MPMDM/A-174/A-189; and (C) 14% MPMDM/A-189.

Performance Improvements of Silylated Emulsion Polymer Coatings

Tables 8 and 9 show the performance improvement created by silane incorporation. The silylated acrylic latexes demonstrate a self-curing system which may not require an organometallic catalyst. The methacrylic acid co-monomer, which may function as an acid catalyst at the film forming stage, may play an important role in this self-curing system. When the fugitive base evaporates and the system moves to acidic pH, the conditions favor the hydrolysis and condensation reactions of the hindered silanes. Alternatively, water soluble or dispersible organotitanates and organotins are compatible with the silylated emulsion polymers in one-pack systems. As shown in *Table* 9, the presence of the water-soluble chelated titanate catalyst, Tyzor® 131, in the silylated vinyl acrylic system which contains no acid copolymer does accelerate the siloxane crosslinking and solvent resistance.

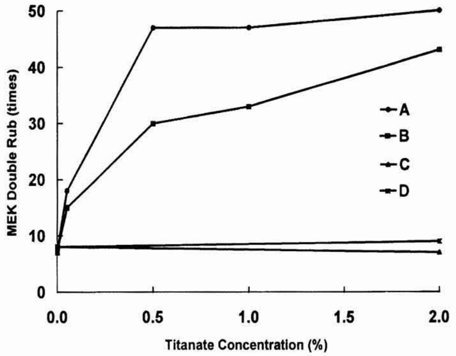

Figure 10—The effect of titanate concentration on the MEK resistance of silylated vinyl acrylic and control vinyl acrylic latex coatings.

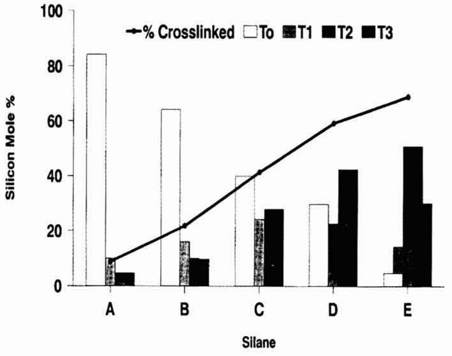

Figure 11—The siloxane crosslinking of silylated vinyl acrylic films studied by solid state ^{29}Si NMR.

Effects of Catalysts in the Silylated Vinyl Acrylic Systems

Moving from a solvent system to a waterborne system, the choice of cure catalyst and its compatibility with latexes are crucial. *Figure* 10 depicts the effect of titanate concentration on the solvent resistance of the 1.0% 3-methacryloxypropyltriisobutoxysilane silylated vinyl acrylic latex coating. The results show that controls without silane in the latexes do not show enhanced solvent resistance, even with catalyst. The NMP paint adhesion[10] at the paint-metal interface was evaluated on the same latex in the presence of various concentrations of titanate catalysts (see *Table* 10). The adhesion at the paint-metal interface was enhanced by increasing the concentration of water-miscible titanate catalysts.

Further studies on the catalytic effects and the stability of a one-pack system silylated latex containing a

Table 11—Solvent Resistance of Films Cast from Vinyl Acrylic Latexes Containing 4 mole% of Silanes and 5% Tyzor 131 vs. the Storage Time of the Admixtures[a]

	MEK Double Rubs (times)				
	Storage Time				
Silane in Latexes with Tyzor 131	0	2 Weeks	4 Weeks	8 Weeks	15 Months
3-Methacryloxypropyltriisopropoxysilane	38	80	119	99	157
3-Methacryloxypropyltriisobutoxysilane	50	97	122	125	251
3-Methacryloxypropyltrioctoxysilane	50	81	103	128	19
Vinyltriisobutoxysilane	38	74	100	97	255
Vinyltri-t-butoxysilane	29	47	75	67	8

(a) Tyzor 131 is a catalyst from DuPont. The silylated vinyl acrylic latexes with 5% Tyzor 131 were stored at room temperature. At a determined time, portions of these latexes were taken in preparing the films. No gel or seeding was noted. MEK resistance of the coatings was conducted according to ASTM D 4752-87. The film thickness was 2 mils. The values were determined by averaging three data points tested on the same steel panels. Coatings were baked at 121°C for 20 min and further cured at 23°C and 50% RH for seven days.

Table 12—Solvent Resistance of Films Cast from 4 mole% 3-Methacryloxypropyltrioctoxysilane Vinyl Acrylic Latex Film in the Presence of Various Organotin Catalysts, after Curing at Room Temperature and at 121°C[a]

	MEK Double Rubs (times)	
Catalyst	RT	Baked
Fomrez® UL-1	39	51
Fomrez® UL-22	48	53
Fomrez® UL-32	41	49
No catalyst	15	19

(a) Fomrez® UL-1, UL-22 and UL-32 are organotin catalysts from Witco Corporation. MEK resistance of the coatings was conducted according to ASTM D 4752-87. The film thickness was 2 mils. The values were determined by averaging three data points tested on the same steel panel. Coatings were baked at 121°C for 20 min and/or cured at 23°C and 50% RH for seven days.

Table 13—Gel Contents of the Solid Films Made from Vinyl Acrylic Latexes Containing Various Silanes with and without a Titanate Catalyst

	Gel Content (%)	
Type of Silane in Latex	No Catalyst[a]	With Titanate[b]
3-Methacryloxypropyl triisopropoxysilane	13.1	25.4
3-Methacryloxypropyl triisobutoxysilane	49.9	75.6
3-Methacryloxypropyl trioctoxysilane	69.7	78.3
Vinyltriisobutoxysilane	23.8	53.1
Vinyltris(t-butoxy)silane	0.9	0

(a) The silylated vinyl acrylic copolymer films were cast from freshly made 4 mole % silane-containing latexes without catalyst. The films were further cured at ambient conditions for 10 weeks. The gel content is the amount (in wt%) of polymer remaining after being swollen in solvent (MEK).

(b) The silylated vinyl acrylic copolymer films were cast from 4 mole % silane-containing latexes with 5% Tyzor 131, which were stored at ambient condition for eight weeks. The films were further cured at ambient condition for 10 days.

catalyst, have been carried out. Mixtures of various silane-modified silylated vinyl acrylic latexes with 4 mole% silanes and 5 wt% Tyzor® 131 were prepared. The solvent resistance represented by MEK double rub data for these films versus storage period (up to 15 months) is described in *Table* 11. Hindered silanes with isopropoxy or isobutoxy groups put considerable steric hinderance adjacent to the silicon atom generating hydrolytic stability. They work well in silylated polymer/catalyst one-pack systems. The bulky t-butoxy group hinders the silicon atom so severely it is hard to hydrolyze/cure even with a catalyst. The long chain silane with octoxy group performs well in a two-pack system due to its higher reactivity for hydrolysis. Water-stable tin catalysts are also effective (*Table* 12).

Siloxane Crosslinkage of Silylated Vinyl Acrylic Films

The siloxane crosslinking of vinyl acrylic films containing 10 wt% of various silanes were studied by solid state ^{29}Si NMR. The percent of crosslinking, T^0, T^1, T^2, and T^3 are presented in *Figure* 11. Solid powder prepared from a 10 wt% 3-methacryloxypropyltrimethoxysilane gel was also investigated for a comparison. It is concluded that in the absence of a catalyst, the percent of siloxane crosslinks among the films increases according to the order: vinyltriisobutoxysilane < 3-methacryloxypropyltriisopropoxysilane < 3-methacryloxypropyltriisobutoxysilane < 3-methacryloxpropyltrioctoxysilane < 3-methacryloxypropyltrimethoxysilane.

The gel contents of the coatings of vinyl acrylic latexes containing various silanes with and without titanate catalysts are described in *Table* 13. In the presence of a titanate catalyst, the gel contents of the latexes were enhanced, except for the extremely unreactive vinyltris(t-butoxy)silane-containing latex.

CONCLUSIONS

By increasing the concentrations of silanes, the mar and abrasion resistance properties of automotive clearcoats are improved. The rate of abrasion correlated directly with coefficient of friction and inversely with hardness, modulus, and toughness. The crosslinking rate becomes much slower after curing for 10 days. Silylated acrylic clearcoats cured at ambient conditions for one year afford approximately 75% of the total potential crosslinks.

Stable, aqueous emulsion copolymers with hindered alkoxysilane crosslinking functionality were achieved. OFS serve as "latent crosslinking monomers," crosslinking the polymer upon subsequent complete drying of the latex particles. The monomeric acid containing silylated acrylic latex provides a self-curing thermosetting latex that can be cured without added crosslinking agent. Mixtures of the silylated emulsion polymers with water miscible or dispersible organometallic catalysts did not seed or gel over a 15-month period of ambient storage. The compositions have improved properties including solvent resistance, adhesion, hardness, abrasion resistance, and mar resistance.

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References

(1) Plueddeman, E.P., *Silane Coupling Agents*, 2nd Ed., Plenum Press, New York, 1991.

(2) Witucki, G.L., "A Silane Primer: Chemistry and Applications of Alkoxy Silanes," JOURNAL OF COATINGS TECHNOLOGY, *65*, No. 822, 57 (1993).

(3) Osterholtz, F.D. and Pohl, E.R., *J. Adhesion Sci. Tech.*, 6, 1, 127-149 (1992).

(4) Corcoran, EM., Robert, A.G., and Schurr, G.G., *Paint Testing Manual*, 13th Edition, Chapter 5, American Society for Test and Materials, Philadelphia, PA, 1972.

(5) ASTM D 1242-92, Standard Test Method for Resistance of Plastic Materials to Abrasion.

(6) (a) Lee, L.H., (Ed.), *Polymer Wear and Its Control*, Chapter 2, American Chemical Society, 1985; (b) Lancaster, J.K., in *Polymer Science*, Jenkins, A.D. (Ed.), Vol. 2, Chapter 4, North Holland, London (1972); (c) Ratner, S.B., Farberova, I.I., Radyukevich, O.V., and Lure, E.G., *Soviet Plastics*, 7, 37 (1964); (d) Hornbogen, E., Wear, 33, 251 (1975); and (e) Rice, J.R., *J. Appl. Mech.*, 35, 379 (1968).

(7) Dowbenko, R., et al., U.S. Patent 4,499,150 and U.S. Patent 4,499,151 (February 12, 1985).

(8) Bourne, T.R., Bufkin, B.G., Wildman, G.C., and Grawe, J.R., "Feasbility of Using Alkoxysilane-Functional Monomers for the Development of Crosslinkable Emulsions," JOURNAL OF COATINGS TECHNOLOGY, *54*, No. 684, 69 (1982).

(9) Masuda, T., Hatano,T., and Ando, N., JP 6[1994]-25,502 Feb. 1994.

(10) Sabata, A., Van Ooij, W.J., and Kocj, R.J., *J. Adhesion Sci. Tech.*, Vol. 7, No. 11, 1153-1170 (1993).

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Corrosion Resistance and Dielectric Properties of an Iron Oxide Filled Epoxy Coating

N. Kouloumbi, G.M. Tsangaris, C. Vourvahi, and F. Molnar[†]—National Technical University*

INTRODUCTION

One of the mechanisms by which protection against corrosion of steel surfaces is offered, involves the formation of a barrier coating against diffusion and penetration of corrosive agents such as water vapor, oxygen, and ions.[1-3]

Typical examples of coatings possessing these properties are composite coatings containing various pigments like glass, polyaramide or graphite fibers or flakes, talc, micaceous iron oxide, and aluminum flakes. Glass, polyaramide, graphite, and aluminum pigments possess low permeability for water and corrosive species and low conductivity,[4] and they can combat many of the more severe corrosive environments. Furthermore, they offer additional strength and improved abrasive resistance.[5-7]

Micaceous iron oxide paints have a well established[8-15] record for long-term corrosion protection of steel structures exposed to all kinds of environmental conditions. This performance is mainly attributed to a barrier effect exerted by this oxide when it is used at a required pigment volume concentration, forming part of a coating system of specified thickness. Additionally, this oxide as a special form of haematite is slightly conductive, possesses chemical inertness, and exhibits galvanic potential versus a hydrogen electrode (-0.300 V) very close to that of the millscale on steel.[2]

Recently, it has been found that a barrier effect is also exerted by some particulate conductive composite coatings. These composite coatings with metallic fillers (Fe, Al, Ni, Cu) have found numerous important industrial applications[16,17] and though they can greatly alter conductivity and dielectric characteristics of the epoxy matrix[19-22] they exhibit similar[23,24] or slightly lower[25] protective properties than the unfilled epoxies. In such systems, the evolution of corrosion products of the metallic filler throughout the film modifies the characteristics of the coating exerting a barrier effect which counterbalances the increase in conductivity.

Polymeric composites of a bisphenol-A-epoxy resin and iron oxide filler (15% w/w) were deposited on pretreated steel specimens. The applied coatings had a thickness of 80 μm and 220 μm. The modification of the anticorrosive and dielectric characteristics of these coatings, in a corrosive environment (3.5% NaCl), were monitored by potentiodynamic polarization measurements, electrochemical impedance spectroscopy, and dielectric measurements.

Corrosion resistance of composite coatings was found to be somewhat higher than that of unfilled epoxy coatings. Coatings containing iron oxide exhibited capacitive behavior as revealed by dielectric and EIS measurements. This behavior is more pronounced in high thickness composite coatings.

In this paper the effect of a low concentration micaceous iron oxide filler to the modification of the dielectric characteristics and the anticorrosive performance of composite epoxy coatings in an environment of 3.5 wt% NaCl solution is investigated.

Potentiodynamic polarization, AC impedance, and dielectric measurements were performed.

EXPERIMENTAL

Materials

The test specimens were circular steel disks (Diameter Φ=6 cm) with the following weight percent composition: C 0.12, Mn 0.5, P 0.005, S 0.05, and balance Fe. The coating used was a bisphenol-A based epoxy resin with

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Table 1: Composition of Micaceous Iron Oxide

SiO_2	Fe_2O_3	FeO	MgO	Al_2O_3	SO_3	S^{2-}	Mn	P	Cu
2.22	90.30	1.93	0.56	0.90	0.27	0.48	0.08	0.02	traces

Loss of ignition: 2.71
Residue on 100 µm sieve: traces
Residue on 63 µm sieve: 5 -15%
Bulk density (g/ cm^3): 1.45

epoxy equivalent 500-535 g/A_{eq} (grams resin containing one epoxy equivalent), epoxy index 1.95 A_{eq}/kg (number of epoxy equivalent in one kilo resin), density 1 - 1.02 g/cm^3 at 20°C, molecular weight about 1025 and viscosity 30 - 40 sec (DIN 53211, 4mm, 20°C). The curing agent was a high viscosity polyaminoamide with amine value 240-260 (DIN 16945) and density 0.95 - 0.97 g/ cm^3 at 20°C. The ratio resin/curing agent was 200/65 by weight.

This system was used either in this formulation or filled with powdered micaceous iron oxide in a content of 15% by weight. The composition and the characteristics of the iron oxide according to the manufacturer's data sheet are given in *Table* 1.

It was decided to study the previously mentioned content though it is lower than what is actually used in anticorrosive applications, because of the dielectric measurements where a high content would create undesirable percolative conductivity effects.

Sample Preparation

The metallic substrate was cleaned by immersion in a strong solution of HCl with an organic corrosion inhibitor, washed with water, polished with emery paper (up to 000 grit), degreased for 10 min in boiling xylene, and stored before coating in a desiccator containing silica gel, to avoid any influence of moisture.

Each prepared mixture of epoxy and iron oxide was stirred thoroughly to avoid regions rich in hardener or epoxy with the consequent limitation to the extent of crosslinking. Then each mixture was deposited on the metal surface by a film applicator. According to the manufacturers' curing schedule, specimens were initially cured at ambient for 24 hr for the promotion and development of the three-dimensional network. Then, when the rate of the cure became low, a post-curing at 40ºC for 48 hr followed, to ensure that all of the epoxy groups had been consumed and the coatings had attained the optimum physical and mechanical properties.[26]

Thereafter, specimens with coatings having a dry film thickness 80±5 µm or 220±10 µm were chosen from a greater production number and exposed to 3.5% NaCl solution for predetermined time. Specimens coated only with epoxy resin were used as reference specimens.

Test Instrumentation and Conditions

The electrochemical cell for both AC impedance and polarization measurements consisted of a hollow Teflon cylinder, attached by a clamp to the surface of the metal

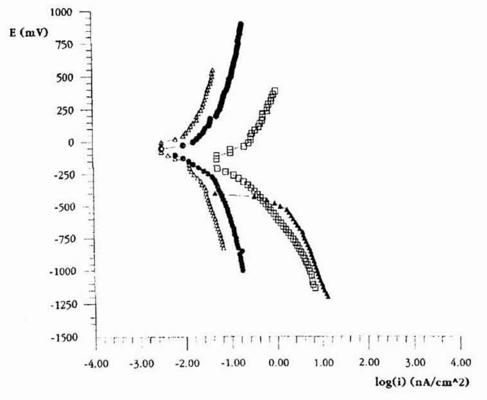

Figure 1—Potentiodynamic polarization plots for different types of epoxy coated steel specimens just after immersion to 3.5% NaCl. Δ—epoxy, 220 µm; ●—epoxy + iron oxide, 220 µm; □—epoxy + iron oxide, 80 µm; and ▲—epoxy, 80 µm.

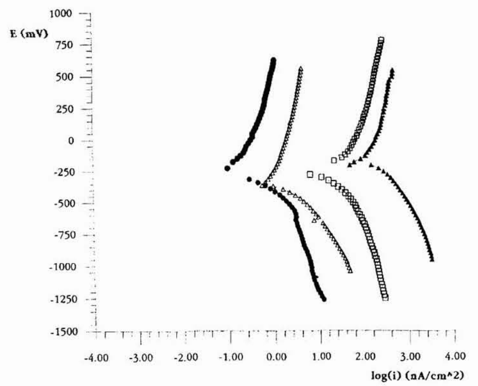

Figure 2—Potentiodynamic polarization plots for different types of epoxy coated steel specimens after 90 days of immersion to 3.5% NaCl. Δ—epoxy, 220 µm; ●—epoxy + iron oxide, 220 µm; □—epoxy + iron oxide, 80 µm; and ▲—epoxy, 80 µm.

substrate and creating by an O-ring seal the vessel for the electrolyte (3.5% NaCl). The working electrode was the coated specimen having an exposed surface area equal to 15.904 cm^2. As reference and counter electrode, a silver circular disk was used which was connected in series with a 100 µF capacitor in order to exclude the input of the DC potential of the cell to the frequency analyzer. All measurements were carried out at ambient temperature with the electrolyte in contact with air.

Before each measurement, the change in electrical potential was recorded, until the achievement of an almost stable potential, referred to as the corrosion potential, E_{corr}. The potentiodynamic polarization measurements were performed on two separate specimens, one for the anodic and one for the cathodic polarization, using a Princeton Applied Research Model 331 potentiostat/galvanostat. The scan rate was always 1 mV/s. Each measurement at every exposure time tested was performed in triplicate.

The AC impedance measurements were performed using sine wave signals of 15 mV, by means of a Video Bridge T-2100 of Electro-Scientific Industries Inc., in the frequency range of 20 Hz to 5 KHz, and by an impedance analyzer LF4192A of Hewlett Packard, in the frequency range of 5 KHz to 13 MHz. Each value was the mean value of five measurements in a logarithmic sweep of the frequencies (20 points per logarithmic unit) and was obtained from measurements on three samples at every type of specimens.

Dielectric measurements were performed in a three terminal guarded system, constructed according to ASTM D 150-92. At predetermined immersion times, coated specimens were taken out of the corrosive environment, washed with acetone, dried in air, and placed in the three terminal dielectric cells. There they formed the dielectric element of the capacitor. Capacitance values and the loss factor (D) of the coating were measured in the frequency range 20 Hz-13 MHz using the previously mentioned bridges. From these measurements the dielectric permittivity and dielectric losses were calculated.[21]

RESULTS AND DISCUSSION

Corrosion Current Measurements

The protective performance of the coating was evaluated by potentiodynamic polarization measurements. Representative results of anodic and cathodic scanning, which were always triplicated, are given in *Figures 1* and 2 at the beginning and after 90 days of immersion in the corrosive environment. Each plot represents a separate anodic and cathodic scan and is considered as the polarization plot of a separate metal specimen.

The resistance to corrosive conditions just after the immersion to the corrosive environment is roughly the same for coatings with or without micaceous iron oxide in the epoxy matrix depending only on the thickness of the coating. In all cases the corrosion current density exhibits very low values. This is attributed to the high impermeability of the epoxy matrix to wet and chemically polluted conditions.[18]

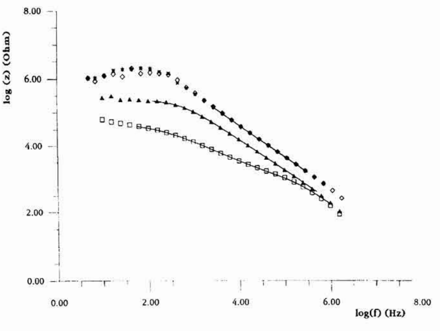

Figure 3—Bode plots for different types of epoxy coated steel specimens exposed to 3.5% NaCl for two days. ✳—epoxy, 220 µm; ◊—epoxy + iron oxide, 220 µm; □—epoxy + iron oxide, 80 µm; and ▲—epoxy, 80 µm.

After three months of exposure to the corrosive environment, the corrosion current density of specimens coated with epoxy resin containing micaceous iron oxide, regardless the coating thickness, is lower than that of the unfilled epoxy. Micaceous iron oxide filled coatings are resistant because the oxide particles present are oriented parallel to the substrate producing layers of overlapping and interleaning flaky particles which increase the path for water and corrosive permeation.[8-15] These types of coatings, for a thickness higher than about 150 µm, have proved to be very resistant to accelerated weathering. [13]

Impedance Measurements

Representative Bode plots, log|z| and phase angle versus log |f|, of coated specimens after two and 90

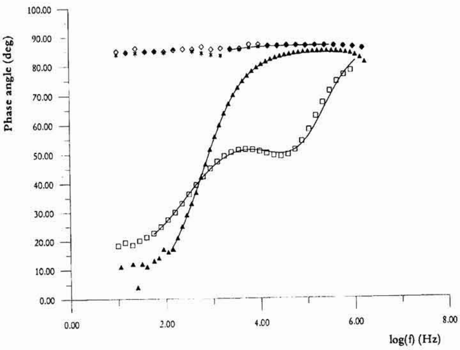

Figure 4—Phase angle plots for different types of epoxy coated steel specimens exposed to 3.5% NaCl for two days. ✳—epoxy, 220 µm; ◊—epoxy + iron oxide, 220 µm; □—epoxy + iron oxide, 80 µm; and ▲—epoxy, 80 µm.

Table 2—Water Uptake Calculated from Capacity Measurements at 10^4 Hz.

	Type of Coating			
	Thickness : 80 μm		Thickness : 220 μm	
Exposure Time (Days)	Epoxy	Epoxy + Iron Oxide	Epoxy	Epoxy + Iron Oxide
0	0.000	0.0000	0.0000	0.0000
2	0.0253	0.0240	0.0371	0.0120
15	0.0486	0.0422	0.0558	0.0326
30	0.0921	0.0847	0.0992	0.0506

days of immersion are presented in *Figures 3-6*. Data obtained by electrochemical impedance spectroscopy were processed by suitable NLLS software, and the best fit is shown in these figures (full lines) for the generally accepted equivalent circuits[27-30] for barrier and non-barrier type coatings.

At early exposure time and at the frequency range of measurements, the impedance plot shape of the high coating thickness samples (220 μm) shows a distinct capacitive behavior expressed by a kinetic scheme corresponding to one time constant throughout the frequency range. The phase angle, in that case, acquires almost stable values of about 90°, and the log|z| plots are straight lines having a slope close to -1.

Bode responses are almost the same irrespective to the formulation of the coating. This can be attributed to the characteristics of a high thickness epoxy coating. It has been already mentioned that epoxy matrix possesses high intrinsic impermeability[18] and as a consequence, it can show high resistance for a long exposure period; especially when the coating thickness is high. Impedance measurements, which are mainly influenced by water and aggressive ions penetration, cannot reveal the exact role of the filler in such a system.

Bode plots of 80 μm thickness of coatings of the filled epoxy, at early exposure time, possibly suggest the existence of two processes through the coatings. At the frequency range of the performed measurements, normally only the response of the organic coating is observed while the response of the corroded substrate is observed in a lower frequency range (10^{-3} - 10 Hz).[30] The process at high frequencies (>10^4 Hz) is attributed to the bulk properties of the epoxy matrix.[31] At intermediate frequencies the response may be attributed to a transport process related to the interfaces created between epoxy matrix-iron oxide filler. *Figures* 3 and 4 demonstrate that this latter process does not exist in the unfilled coatings.

After long-term immersion in the corrosive environment, all types of specimens are characterized by one time constant, irrespective to the coating thickness. An indicative plot of this situation is presented in *Figures* 5 and 6 for 90 days of exposure. Here the course common to all tested samples reveals a capacitive behavior. The high thickness coatings maintain this behavior in the whole frequency range used, regardless of the exposure time, while for the low thickness coatings this frequency range is broadened with immersion time.

The suppression of the intermediate frequencies time constant of filled low thickness coatings seems to be related to the sorbed water by the epoxy matrix. The water uptake of these coatings increases with time, at least for the first 30 days of exposure to corrosion environment as shown by values obtained through the measurements of the capacity at 10^4 Hz and Brasher's law[32] (*Table* 2).

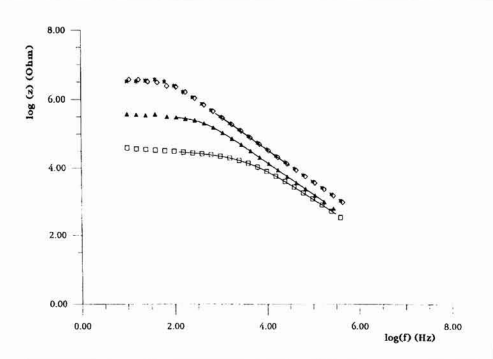

Figure 5—Bode plots for different types of epoxy coated steel specimens exposed to 3.5% NaCl for 90 days. ✻—epoxy, 220 μm; ◊—epoxy + iron oxide, 220 μm; □—epoxy + iron oxide, 80 μm; and ▲—epoxy, 80 μm.

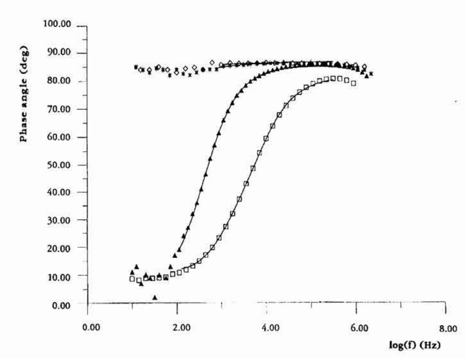

Figure 6—Phase angle plots for different types of epoxy coated steel specimens exposed to 3.5% NaCl for 90 days. ✻—epoxy, 220 μm; ◊—epoxy + iron oxide, 220 μm; □—epoxy + iron oxide, 80 μm; and ▲—epoxy, 80 μm.

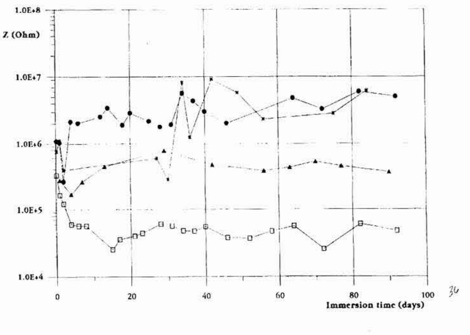

Figure 7—Impedance vs. immersion time for different types of epoxy coated steel specimens. ✻—epoxy, 220 μm; ◊—epoxy + iron oxide, 220 μm; □—epoxy + iron oxide, 80 μm;and ▲—epoxy, 80 μm.

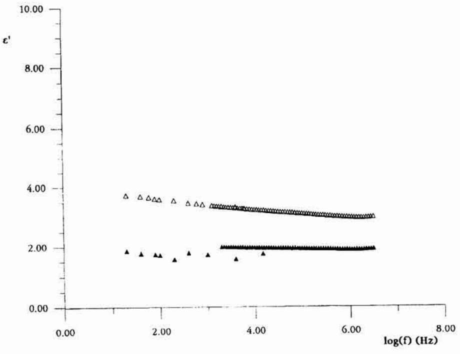

Figure 8—Dielectric permittivity versus frequency for high-thickness coatings before their exposure to corrosive environment. ▲—epoxy, 220 μm; and Δ—epoxy + iron oxide, 220 μm.

The water uptake of the iron oxide filled coating affects the impedance responses and the two time constants cannot be distinguished. The dominant process is the modification of the bulk epoxy matrix by the water capacitive characteristics which masks the transport process corresponding to the epoxy-iron oxide interfaces.

In that case, the phase angle data shift towards higher frequencies indicating a decrease of the corrosion resistance and an increase of the corrosion area at the metal-coating interface.[33] However, both z and phase angle values prove that the coatings are still resistant after three months of exposure, a result also shown by the potentiodynamic polarization measurements.

Time dependence of impedance values is presented in *Figure* 7.

Just after the immersion to the corrosive environment, a short period of impedance decrease is observed first, followed by a plateau of higher impedance values. Just after the immersion, water penetrates easier into voids and microdefects of the coating resulting in a local increase of coating permittivity and consequently in a decrease of impedance values. Thereafter the sorbed water is diffused through the capillaries into the bulk of the coating at the surroundings of these voids and microdefects provoking a local swelling which reduces their dimensions. This assumption can explain the increase of the impedance values after the short period of decrease.

After about 20 days of immersion, the coatings exhibit an almost steady state impedance value, which suggests the maintenance of their protective behavior. In high thickness coatings, steady-state impedance values are about the same regardless of the presence or not of iron oxide in the coating (differences between them are lower than the scattering of the measurement).

In filled coatings impedance values are influenced by the conductivity induced by iron oxide and the barrier effect that this filler exerts. In high thickness coatings containing micaceous iron oxide, the water sorbed is lower than that of pure epoxy coatings as a result of the non-absorbing trait of the micaceous iron oxide and the overlapping layers these flaky oxide particles produce in the polymeric matrix. At the same time, the presence of iron oxide increases the conductivity of the former coatings counteracting the effect of the lower water quantity (*Table* 2) and resulting in a situation which is almost the same regardless of the presence or not of iron oxide in the coating.

In low thickness coatings, the water uptake values of filled and unfilled coatings are close (*Table* 2), so the increased conductivity of the filled coatings is due to the presence of the micaceous iron oxide. This could explain why impedance values of filled low thickness coatings are somewhat lower than those of the unfilled ones.

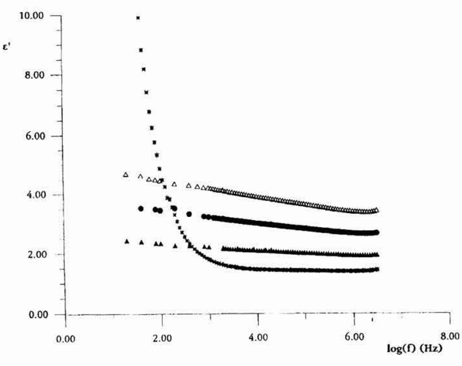

Figure 9—Dielectric permittivity vs. frequency for different types of epoxy coated steel specimens exposed to 3.5% NaCl for 15 and 90 days. ✻—epoxy + iron oxide, 80 μm, 15 days; Δ—epoxy + iron oxide, 220 μm, 15 days; ▲—epoxy, 220 μm, 15 days; and ●—epoxy, 220 μm, 90 days.

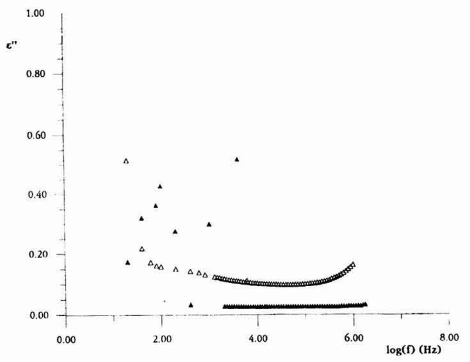

Figure 10—Dielectric losses vs. frequency for high thickness coatings before their exposure to corrosive environment. ▲—epoxy, 220 μm; and Δ—epoxy + iron oxide, 220 μm.

Dielectric Permittivity Measurements

Figures 8 and 9 show the permittivity (ε′) versus frequency of the different types of coatings for various immersion times. Iron oxide, which has higher dielectric permittivity than the epoxy matrix, results in increased dielectric permittivity of the composite coating at early immersion time (*Figure* 8), as a consequence of the logarithmic law of mixtures[34] applied to the composite coatings.

The increase of the immersion time (*Figure* 9) leads to a greater amount of water sorbed and, consequently, to higher dielectric permittivity values in all types of coatings. The interfaces generated due to the addition of iron oxide particles increase the interfacial polarization at low frequencies.

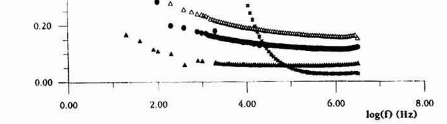

Figure 11—Dielectric losses vs. frequency for different types of epoxy coated steel specimens exposed to 3.5% NaCl for 15 and 90 days. ✻—epoxy + iron oxide, 80 μm, 15 days; Δ—epoxy + iron oxide, 220 μm, 15 days; ▲—epoxy, 220 μm, 15 days; and ●—epoxy, 220 μm, 90 days.

In high thickness coatings, the quantity of both iron oxide and absorbed water is higher than that in low thickness coatings, despite the same concentration level of iron oxide in both coatings. The increased quantity of these species creates extended interfaces and high dielectric permittivity. The same consideration is applied on the coatings short of iron oxide. In the latter case, the governing factor is the quantity of the water absorbed.

The dielectric losses (ε″) versus frequency of the pure epoxy coatings and of the coatings containing iron oxide are shown in *Figures* 10 and 11. In all cases as immersion time increases more water is absorbed by the polymeric matrix. Dielectric losses increase and move to higher frequencies.

Coatings of 220 μm thickness acquire low values of dielectric losses for the major part of frequency range, thus revealing the capacitive behavior of these coatings both at the beginning of the exposure to the corrosive environment and for a longer immersion time.

Iron oxide in low thickness coatings alters its capacitive characteristics generating conductive pathways as it can be deduced by the appearance of the straight line at low frequencies.[35]

Ratings of Visible Damage

Visual examination of test specimens during the exposure revealed that at the end of the exposure time, no significant damage occurred in all cases, with respect to blistering (ASTM D 714-87) and rusting (ASTM D 610-85). After one month of exposure, green colored spots appeared. These spots are produced either by the chloride ions attack on iron oxide filler and/or by the corrosion of the steel substrate. In the latter case, during the formation process of iron oxide or oxyhydroxides, in chloride environment, green complexes are precipitated as intermediate products.[36] These bulky corrosion products can establish a barrier effect which explains the feature of the Bode plots at long immersion time. After three months of exposure, blistering ratings could be classified as No. 4 Few for coatings containing iron oxide having 220 μm and 80 μm thickness and as No. 4 Few and No. 6 Medium for unfilled coatings having 220 and 80 μm thickness, respectively. The corresponding rating for rusting is No. 10 (no rusting) and No. 4 (10% of surface rusted) for filled coatings and No. 9 (0.03% of surface rusted) and No. 4 (10% of surface rusted) for unfilled coatings of 220 and 80 μm thickness, respectively.

CONCLUSIONS

The corrosion resistance of steel specimens with composite coatings composed of epoxy resin and iron oxide, after three months of exposure to NaCl 3.5%, is somewhat higher than that of unfilled epoxy coatings. This is valid for both low (80 μm) and high (220 μm) thickness coatings in spite of the low (15% by weight) concentration level of iron oxide.

EIS measurements possibly suggest, in low thickness coatings at early exposure time, the appearance of a transport process related to the interfaces created between epoxy matrix-iron oxide filler. At long-term exposure, all coatings possess a capacitive behavior. This is more distinct for high thickness coatings in good agreement with the results of the polarization measurements.

The dielectric measurements reveal the modification of the dielectric characteristics of the coatings. Interfaces are created between the polymeric matrix and the oxide particles leading to increased interfacial polarization. Composite coatings of 220 μm thickness proved again capacitive, while in lower thickness coatings conductive pathways are generated.

ACKNOWLEDGMENT

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References

(1) Al-Hashem, A., Thomas, D., "AC Impedance in Predicting the Corrosion Behavior of Metallic Spots Contained in Polymer Films," JOURNAL OF COATINGS TECHNOLOGY, 62 , No. 783, 51 (1990).
(2) Schmid, E., *Exterior Durability of Organic Coatings*, FMJ International Publications Ltd., Surrey, England, p.184, 227, 1988.
(3) Van Westing, E., *Determination of Coating Performance with Impedance Measurements*, TNO Centre for Coatings Research, Delft, pp. 23-25, 1992.
(4) Schwartz, M.M., *Metal/Polymer Composites*, McGraw Hill, New York, p. 376, 1984.
(5) Normand, B., Pierre, A., and Pagetti, J., *Progress in the Understanding and Prevention of Corrosion*, Costa, J.M. and Mercer, A.D. (Eds.), The Institute of Materials, Vol.1, p. 149, 1993.
(6) Schweitzer, P.A., *Corrosion and Corrosion Protection Handbook*, Marcel Dekker, New York, p. 375, 1983.
(7) Klenowicz, Z., and Miszczyk, A., in J.M. Costa and A.D. Mercer (Eds.), *Progress in the Understanding and Prevention of Corrosion, Vol.1*, Institute of Materials, London, p. 149, 1993.
(8) Carter, E., *Polymers Paint Colour J.*, April 2, 1986.
(9) Carter, E., *Anti-Corrosion*, pp. 12-15 (October 1986).
(10) Wiktorek, S., *Surface Coatings*, Australia, pp. 11-16 (May 1987).
(11) Hendry, C.M., and Klugman, W., *Amer. Paint Coat. Tech.*, June 27, 1988.
(12) Hendry, C.M., "Designed Permeability of Micaceous Iron Oxide Coatings," JOURNAL OF COATINGS TECHNOLOGY, 62, No. 786, 33 (1990).
(13) Barnett, H., Stolz, O., *EuroCoat 11*, pp. 728-739 (1991).
(14) Wiktorek, S., *Surface Coat.*, Australia, Vol. 30, 7, pp. 6-11, (July 1993).
(15) Zobel, F., *Anti-Corrosion*, Vol. 184, 4345, pp. 82-83 (March 9, 1994).
(16) Delmonte, J., *Metal/Polymer Composites*, Van Nostrand Reinhold, New York, pp. 163-171, 1990.
(17) Pierre, C., Deltour, R., Peterboom, J.A.A.J., and Van Bentum, P.J.M., *Phys. Rev. B*, 42 (6), p. 3380 (1990).
(18) Carter, E., *Polymer Paint Colour J.*, August 5/19, pp. 82-83 (1981).
(19) Sheldom, R.P., *Composite Polymeric Materials*, Applied Science, Publishers, London, p.110, 1982.
(20) Baziard, V., Breton, S., Toutain, S., Gourdenne, A., *Eur. Polym.*, J. 24, p. 521 (1990).
(21) Tsangaris, G.M., Psarras, G.C., Kontopoulos, A.J., *J. Non-Crystalline Solids*, 1164, pp. 131-133 (1991).
(22) Bosch, W., and Funke, W., *Proc. XXth FATIPEC Congress*, Nice, France, 1990.
(23) Kouloumbi, N., Tsangaris, G.M., Skordos, A., Karkanas, P., and Kyriopoulou, I. , *Mat. Sci. Forum*, Vols. 192-194, pp. 813-824 (1995).
(24) Kouloumbi, N., Tsangaris, G.M., Skordos, A., and Kyvelidis, S., *Prog. Org. Coat.*, Vol. 28, 2, pp. 117-124 (1996).
(25) Kouloumbi, N., Tsangaris, G.M., and Kyvelidis, S.T., "Evaluation of Corrosion Behavior of Metal-Filled Polymeric Coatings," JOURNAL OF COATINGS TECHNOLOGY, 66, No. 839, 83 (1994).
(26) Ellis, B., *Chemistry and Technology of Epoxy Resins*, Blackie Academic and Professional, London, p. 216, 1993.
(27) Mansfeld, F., *Corrosion*, 37, p. 301 (1981).
(28) Mansfeld, F., Kendig, M.W., and Tsai, S., "Evaluation of Corrosion Behaviour of Coated Metals with AC Impedance Measurements", *Corrosion-NACE*, 38, No. 9, p. 478 (1982).
(29) Babic, R., and Metikos-Hukovic, M., *Prog. Org. Coat.*, 23, p. 275 (1994).
(30) Macdonald, J.R., *Impedance Spectroscopy; Emphasizing Solid Materials and Systems*, John Wiley and Sons, New York, 1987.
(31) Murray, J.N., and Hack, H.P., *Corrosion*, Vol. 47, 6, pp. 480-489, 1991.
(32) Brasher, D.M. and Kinsbury, A.H., *J. Appl. Chem.*, 4, p.62, (1954).
(33) Scully, J.R., "Electrochemical Impedance of Organic Coated Steel: Correlation of Impedance Parameters with Long-Term Coating Deterioration," *J. Electrochem. Soc.*, 136, No. 4, p. 979 (1989).
(34) Lichtenecker, K., Rother, K., *Phys. Z.*, 32, p. 255 (1931).
(35) Leidheiser, H., Jr., "Towards a Better Understanding of Corrosion Beneath Organic Coatings,,"*Corrosion-NACE*, 39, No. 5, p. 189 (1983).
(36) Misawa. T., Hashimoto, K., and Shimodaira, S., *Corrosion Science*, 14, p. 131 (1974).

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High Performance Coating Films Cured by Novel Penetrating Method: Anionic Resin Paints

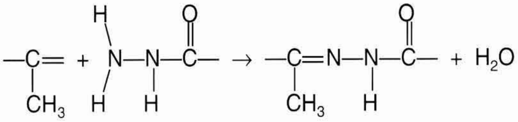
Yasuharu Nakayama—Kansai Paint Co., Ltd.*

This study deals with a method of curing paint film at ambient temperature with a film-penetrative crosslinker. The method is based on the phenomenon that, after a wet coating film becomes thermoplastic, it is dipped in an aqueous solution of crosslinker. The crosslinker then penetrates into the film, and the film can be cured with the passage of dipping time.

Herein an anionic copolymer containing diacetone acrylamide was employed as the main resin and carbohydrazide as the film-penetrative crosslinker. Cured films can be prepared with a short dipping time using this method. Excellent films were obtained when they were dipped in a suitable crosslinker solution containing the proper organic solvents (accelerator of penetration rate) and an appropriate acid (promoter of the reaction). In particular, the adhesion after the water resistance test was excellent compared with that of the coating film obtained by the two-component coating method.

INTRODUCTION

A novel coating method shown in *Figure* 1 has been studied to cure industrial paint at ambient temperature. This method is based on the phenomenon that after a wet coating film becomes thermoplastic in the first drying process, it is dipped in an aqueous solution of a crosslinker. The crosslinker then penetrates into the film which can be cured with the passage of dipping time. Herein a diacetone acrylamide copolymer was employed as the main resin and carbohydrazide as the film-penetrative crosslinker. Following the dehydration, the reaction between the carbonyl group in the copolymer and the hydrazide group in the crosslinker occurs rapidly at ambient temperature, particularly under acidic condition.[1]



$$-\underset{\mathrm{CH_3}}{\mathrm{C}}= + \underset{\mathrm{H}}{\overset{\mathrm{H}}{\mathrm{N}}}-\underset{\mathrm{H}}{\mathrm{N}}-\overset{\mathrm{O}}{\overset{\|}{\mathrm{C}}}- \rightarrow -\underset{\mathrm{CH_3}}{\mathrm{C}}=\mathrm{N}-\underset{\mathrm{H}}{\mathrm{N}}-\overset{\mathrm{O}}{\overset{\|}{\mathrm{C}}}- + \mathrm{H_2O}$$

In a previous paper,[2] crosslinking rates were measured under various conditions. The major conclusions were the following: (1) the penetrating rate was closely related to the film curing speed; (2) the rate was accelerated with an increase in the organic solvent content in the crosslinker solution, with an increase in the hydrophilic property of the resin and with rising dipping temperature; (3) the curing was sped up with acids in the reaction system; and (4) the curing front propagated from the film surface toward the substrate surface according to the penetration of the crosslinker.

In this paper, the properties of anionic resin film (cationic resin will be discussed in another paper) cured by the penetrating method have been studied in relation to the properties of the resins, the components of the crosslinker solutions, and the curing conditions. The properties of the film, for example, solvent resistance, water resistance, etc., were improved with crosslinking by the penetrative crosslinker. We have also attempted to compare the penetrating curing method with the two-component coating in order to characterize this method. The adhesion property of the cured films obtained by the former was much better than that of the latter because of the different curing mechanisms. Excellent coating films were obtained by dipping for 5-10 minutes at 40°C.

EXPERIMENTAL

Preparation

PREPARATION OF RESINS: Ordinary laboratory equipment and preparation methods were used for the synthesis of the resins. All the materials used were commer-

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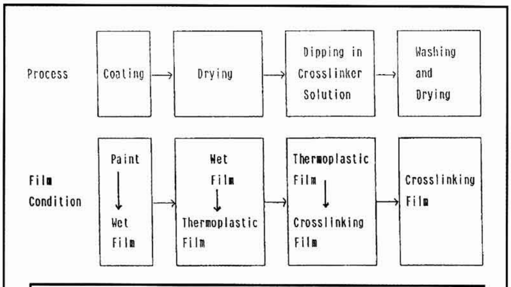


Figure 1—Process and film condition of novel coating method.

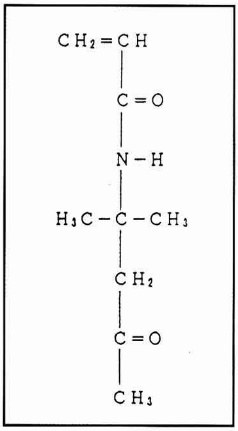


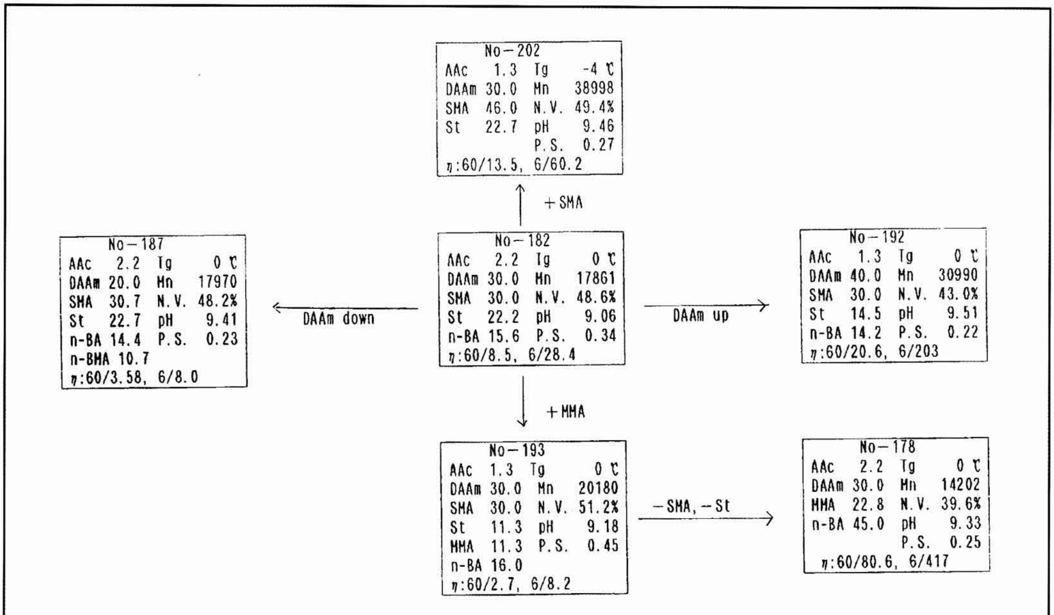
Figure 2—Chemical structure of diacetone acrylamide (DAAm).

cial grade and were not purified further. Diacetone acrylamide (DAAm) shown in *Figure* 2 was used as the monomer containing a carbonyl group. The copolymerization was performed by the dropwise addition of a mixture of the monomers and an initiator (azobisisobutyronitrile) into heated propylene glycol monomethyl ether (PGME) at 110°C. The copolymers used in this study are systematically classified in *Figure* 3. The copolymers were neutralized with triethylamine, diluted by the addition of isopropanol and then dispersed mechanically in water. The emulsions obtained were distilled under reduced pressure to eliminate the isopropanol.

Preparation of Aqueous Crosslinker Solution: After carbohydrazide (CH) shown in *Figure* 4 was dissolved in deionized water, propylene glycol monopropyl ether (PGPE), propylene glycol monomethyl ether (PGME), and an acid were added. As shown in the previous paper, PGPE which could swell the resin was the promoter for penetration of the crosslinker, and PGME was a hydrophilicity donor to make the former solvent compatible with water. Acetic acid or phosphoric acid was added in order to promote the crosslinking reaction. *Table* 1 shows the compositions of aqueous crosslinker solutions which were used in this study.

Preparation of Test Panels for Penetrating Method: Paint coatings were developed with a bar coater on the surface of zinc-phosphated and non-treated cold-rolled steel panel and then dried for 10 min at 80°C.

Preparation of Crosslinking Films by Penetrating Method: The test panels covered with thermoplastic



No−202
AAc 1.3 Tg −4 ℃
DAAm 30.0 Mn 38998
SMA 46.0 N.V. 49.4%
St 22.7 pH 9.46
P.S. 0.27
η:60/13.5, 6/60.2

No−187
AAc 2.2 Tg 0 ℃
DAAm 20.0 Mn 17970
SMA 30.7 N.V. 48.2%
St 22.7 pH 9.41
n-BA 14.4 P.S. 0.23
n-BMA 10.7
η:60/3.58, 6/8.0

No−182
AAc 2.2 Tg 0 ℃
DAAm 30.0 Mn 17861
SMA 30.0 N.V. 48.6%
St 22.2 pH 9.06
n-BA 15.6 P.S. 0.34
η:60/8.5, 6/28.4

No−192
AAc 1.3 Tg 0 ℃
DAAm 40.0 Mn 30990
SMA 30.0 N.V. 43.0%
St 14.5 pH 9.51
n-BA 14.2 P.S. 0.22
η:60/20.6, 6/203

No−193
AAc 1.3 Tg 0 ℃
DAAm 30.0 Mn 20180
SMA 30.0 N.V. 51.2%
St 11.3 pH 9.18
MMA 11.3 P.S. 0.45
n-BA 16.0
η:60/2.7, 6/8.2

No−178
AAc 2.2 Tg 0 ℃
DAAm 30.0 Mn 14202
MMA 22.8 N.V. 39.6%
n-BA 45.0 pH 9.33
P.S. 0.25
η:60/80.6, 6/417

Figure 3—Components and properties of DAAm copolymers. P.S.: particle size μm, η : viscosity (poise) measured by Brookfield viscometer with 60 round/min., 6 round/min.; N.V.: non-volatile component %; AAc: acrylic acid; SMA: stearyl methacrylate; St: styrene; n-BA : n-Butyl acrylate; nBMA : n-butyl methacrylate; and MMA: methyl methacrylate.

resin film were dipped in the crosslinker solutions for a fixed time, followed by washing with water as shown in *Figure* 5. After that, the test panels were dried for 10 min at 80°C.

Preparation of Crosslinking Films by Two-Component Method: Aqueous DH solution (10% by weight) was added to the emulsions. After various induction times, the mixture was coated with a bar coater on the surface of zinc-phosphated and non-treated cold-rolled steel panel at room temperature.

Measurement

Solvent Resistance: Two drops (about 0.05 cc) of acetone were placed on a cured film. Solvent resistance was estimated by the appearance of the test film after evaporation of the acetone. The results were classified into four categories, bad (dissolution), poor (dense with fine wrinkles), fair (few large wrinkles) and good (no change).

Pencil Hardness: A pencil scratch test was done according to JIS (Japan Industrial Standard) K5400 8.22 (1990). Breaking of the coating film was the basis of the evaluation.

Erichsen Value: A breaking distance method that involved pressing a steel ball into the coating until cracking and peeling were generated was used. The steel ball was pushed out from the back of the coated panel using an Erichsen tester. The pushing distance until cracking or peeling occurred, was measured. When no cracking and no peeling occurred even with a pushing distance of 7 mm, the notation was "7<." The procedure was done according to JIS K500 8.2 (1990).

Impact Strength: A DuPont impact tester was used. The falling weight was 1 kg. The radius of the top sphere of the shock mold was 1/2 in. The test was done by changing the falling height on the coated side of the panel. The notation indicates the maximum height that did not damage the paint film. When no damage occurred with a height of 50 cm, the notation was "50<." The procedure was done according to JIS K5400 8.3.2 (1990).

Adhesion Test: A cross-cut test was used. Eleven incisions at 1 mm intervals were made vertically and horizontally on the film. One hundred pieces measuring 1 mm × 1 mm square were obtained. The adhesion was indicated by the number of pieces which were not peeled off by adhesive tape. The procedure was done according to JIS K5400.

Water Resistance: The coating panel was immersed in deionized water for a fixed time. Thereafter, the film condition was evaluated.

RESULTS AND DISCUSSION

Curing by the Penetrating Method

The changes in properties of the coating film with dipping time were believed to be caused by the crosslinking

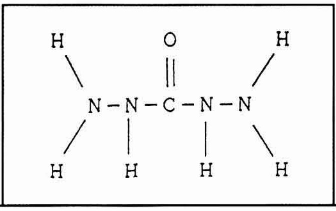


Figure 4—Chemical structure of carbohydrazide (CH).

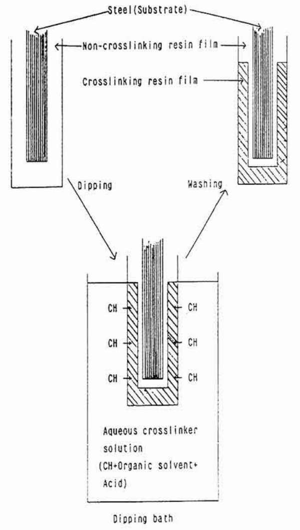


Figure 5—Scheme of curing process by the penetrating method.

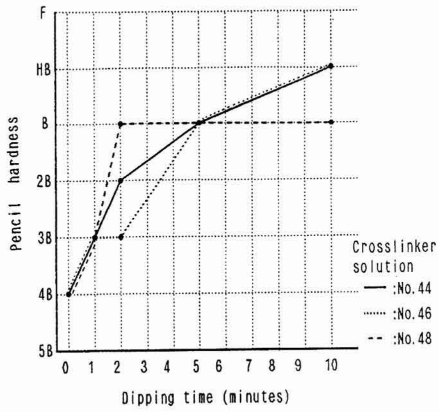


Figure 6—Pencil hardness as a function of dipping time with different crosslinker solution.
Dipping temperature: 40°C
Resin: No. 182
Substrate: zinc-phosphated cold-rolled steel
Film thickness: 30-35μm

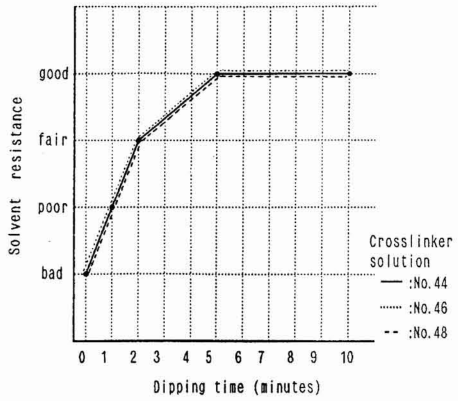


Figure 7—Solvent resistance as a function of dipping time with different crosslinker solution. Test conditions are the same as Figure 6.

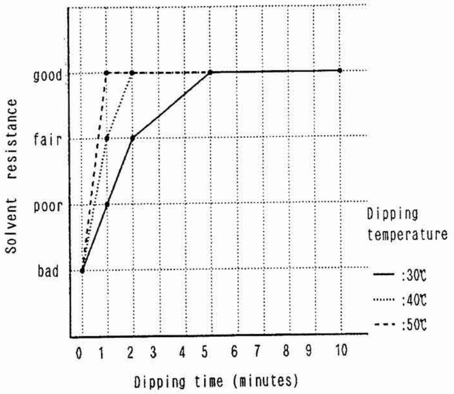


Figure 9—Solvent resistance as a function of dipping time at different dipping temperature. Test conditions are the same as Figure 8.

reaction, that is, the reaction between the carbonyl group of the resin in the film and the hydrazide group of the crosslinker from the aqueous crosslinker solution.

Effect of Acidic Component: *Figures* 6 and 7 show the pencil hardness and the solvent resistance as a function of dipping time, which represent information on the progress of the crosslinking. Three crosslinker solutions were chosen with widely different acidic components: No. 44 was a basic type without acid, No. 46 was an acidic type with acetic acid (organic acid), and No. 48 was an acidic type with phosphoric acid (inorganic acid). Although the acid was an essential component for the crosslinking reaction as a promoter, the inner portion of the anionic resin film could be crosslinked with the basic solution No. 44 containing no acid, because the anionic resin itself contained a carboxyl group to promote the crosslinking reaction. As the result, we could not observe a clear difference among these crosslinker solutions from these two figures. However, the part of the film surface contacting the basic crosslinker solution could not be crosslinked because of the surrounding basic condition. In the case of the basic crosslinker solution, the gloss of the film was lost due to dissolution or excessive swelling of the surface resin. On the contrary, glossy coating films were obtained by dipping in the two other acidic crosslinker solutions, No. 46 and No. 48, at an earlier dipping time. When the dipping time became longer, wrinkled films were often obtained. The reason for this behavior is not clear, but it may be caused

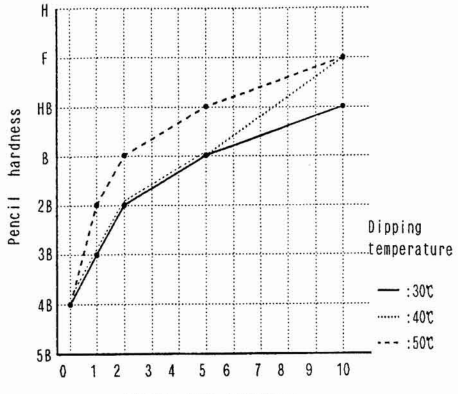


Figure 8—Pencil hardness as a function of dipping time at different dipping temperature.
Resin: No. 192
Crosslinker solution: No. 48
Substrate: zinc-phosphated cold-rolled steel
Film thickness: 25-30μm.

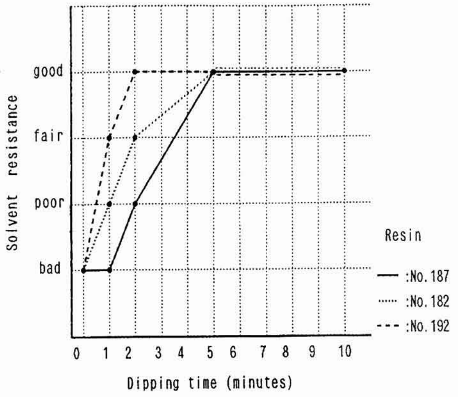


Figure 10—Solvent resistance as a function of dipping time.
Dipping temperature: 40°C
Crosslinker solution: No. 48
Substrate: zinc-phosphated cold-rolled steel
Film thickness: 25-35 μm.

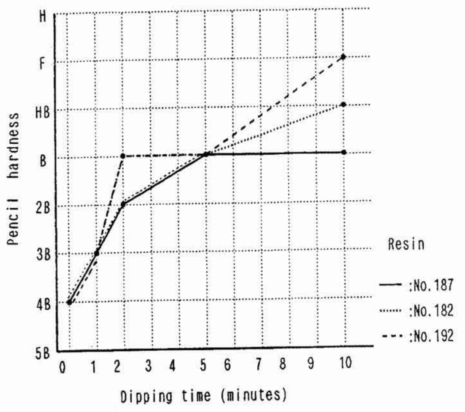


Figure 11—Pencil hardness as a function of dipping time. Test conditions are the same as in Figure 10.

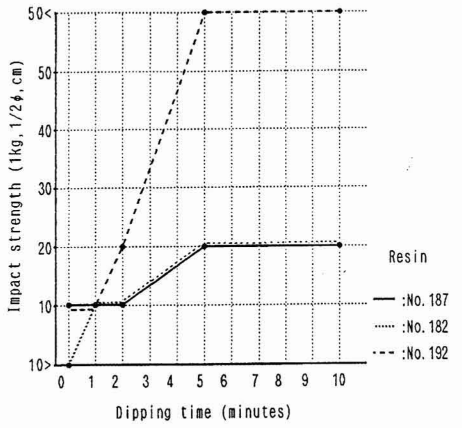


Figure 12—Impact strength as a function of dipping time. Test conditions are the same as Figure 10.

by excessive swelling of weakly crosslinked film at earlier dipping time and violent shrinkage due to dense crosslinking in the subsequent dipping time.

When a coating panel of non-treated cold-rolled steel was dipped in solution No. 46 containing acetic acid, brown rust developed during the dipping time. On the other hand, we did not observe such a phenomenon in the case of solution No. 48 containing phosphoric acid. This result is explained by the difference in the acid contained in these crosslinker solutions. This is to say, acetic acid having good compatibility with the organic resin film can penetrate the substrate surface through the organic coating film, but phosphoric acid cannot penetrate into it due to its poor compatibility. Concentration of the acid did not influence this behavior.

EFFECT OF RESIN COMPOSITION: Three resins that contained different amounts of DAAm were used for the examination of the crosslinking behavior. The DAAm contents of resins No. 189, 182, and 192 were 20%, 30%, and 40%, respectively. As shown in a later section, it is evident from the measurement of the various film properties that the crosslinking rate was closely related to the content of DAAm in the resins.

We mentioned previously that the films of No. 182 wrinkled during a long dipping time. However, glossy coating films were obtained with resin No. 192. Faster crosslinking of this resin than that of resin No. 182 seems to prevent the excessive film swelling and the wrinkling. In this case of resin No. 187, a similar wrinkle observed with resin No. 182 at a later dipping time was also observed to some extent at an intermediate dipping time. Such a wrinkle was commonly noticed in the resins containing methylmethacrylate (MMA), such as resins No. 193 and 178. This wrinkle was also observed in some other resins which were not reported in this paper. This result can also be explained by excessively fast swelling relative to the crosslinking rates. Namely, copolymers of MMA exhibited significantly faster swelling rates than that of hydrophobic monomers, as was reported in the previous paper.[2] In particular, when the most hydrophiolic resin, No. 178, was applied, holes could be seen in the curing film surface. On the contrary, the film made from resin No. 202 which was prepared by copolymerization with more hydrophobic monomers such as styrene (St) and stearylmethacrylate (SMA) had a good appearance throughout the entire process of this penetrating method. A certain balance between swelling and crosslinking would be necessary in order to obtain good appearance.

EFFECT OF DIPPING TEMPERATURE: Increased temperature sped up property changes such as the pencil hardness and solvent resistance as shown in *Figures* 8 and 9. There were two possible explanations for this behavior.

Table 1—Compositions and Properties of Crosslinker Solutions

Crosslinker Solution No.	pH	Carbohydrazide (% by wt.)	Deionized Water (% by wt.)	Acid Compound (% by wt.)	Swelling Solvent (% by wt.)	Hydrophilic Solvent (% by wt.)
No. 22	5.02	10.0	57.0	Phosphoric acid 3.0	—	MMB 30
No. 44	9.41	10.0	60.0	—	PGPE 20.0	PGME 10.0
No. 46	5.80	10.0	59.5	Acetic acid 0.5	PGPE 20.0	PGME 10.0
No. 48	6.74	10.0	59.9	Phosphonic acid 0.1	PGPE 20.0	PGME 10.0

MMB: 3-Methyl-2-methoxybutanol.
PGPE: Propylene glycol monopropyl ether.
PGME: Propylene glycol monomethyl ether.

Table 2—Properties of Resins No. 182 Films Cured with Two-Component Method

Hydrazide/ Carbonyl (mole ratio)	Substrate	Induction Time*	Appearance	Adhesion	Water Resistance 7 Days
0.8	A	5 min	fair (fog)	100	Poor (blister, white)
		30 min	Good	60	Poor (blister)
		3 hr	Good	100	Poor (blister)
		6 hr	Fair (crack)	100	Poor (blister)
		12 hr	Bad (crack)	—	—
	B	5 min	Poor (fog)	100	Poor (blister, white)
		30 min	Good	95	Poor (blister)
		3 hr	Good	100	Poor (blister)
		6 hr	Fair (crack)	100	Poor (blister)
		12 hr	Bad (crack	—	—
0.5	A	5 min	Good	100	Good
		30 min	Good	100	Fair (blister)
		3 hr	Good	100	Fair (blister)
		6 hr	Fair (crack)	100	Good
		12 hr	Fair (crack)	100	Poor (Blister)
	B	5 min	Good	100	Good
		30 min	Good	100	Fair (blister)
		3 hr	Good	100	Fair (blister)
		6 hr	Fair (crack)	100	Good
		12 hr	Poor (crack)	100	Poor (blister)

A: Non-treated cold-rolled steel, B: Zinc-phosphated cold-rolled steel.
Film thickness: 30 μm.
*Time after mixing but prior to application.

Table 3—Properties of Resin No. 187 Films Cured with Two-Component Method

Hydrazide/ Carbonyl (mole ratio)	Substrate	Induction Time*	Appearance	Adhesion	Water Resistance 7 Days
0.8	A	5 min	Good	100	Poor (blister, white)
		4 hr	Good	0	Poor (blister)
		12 hr	Good	99	Poor (blister)
		1 day	Fair (crack)	97	Poor (blister)
		2 days	Bad (crack)	95	Poor (blister)
		5 days	Bad (peel)	—	—
	B	5 min	Good	100	Poor (blister)
		4 hr	Good	99	Poor (blister)
		12 hr	Good	99	Poor (blister)
		1 day	Good	99	Poor (blister)
		2 days	Fair (crack)	99	Poor (blister)
		5 days	Bad (peel)	—	—
0.5	A	5 min	Good	99	Fair (blister, white)
		4 hr	Good	100	Good
		12 hr	Good	97	Fair (blister)
		1 day	Good	95	Poor (blister, rust)
		2 days	Good	98	Poor (blister, rust)
		5 days	Fair (crack)	95	Bad (blister, rust)
	B	5 min	Good	100	Fair (blister, white)
		4 hr	Good	100	Fair (blister)
		12 hr	Good	99	Poor (blister)
		1 day	Good	95	Poor (blister)
		2 days	Good	98	Poor (blister)
		5 days	Good	100	Bad (blister, rust)

A: Non-treated cold-rolled steel, B: Zinc-phosphated cold-rolled steel.
Film thickness: 30 μm.
*Time after mixing but prior to application.

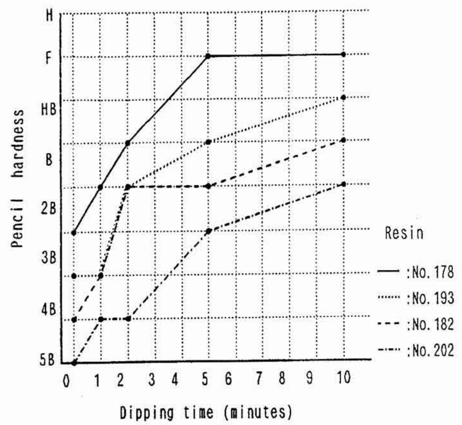


Figure 13—Pencil hardness as a function of dipping time. Test conditions are the same as Figure 10.

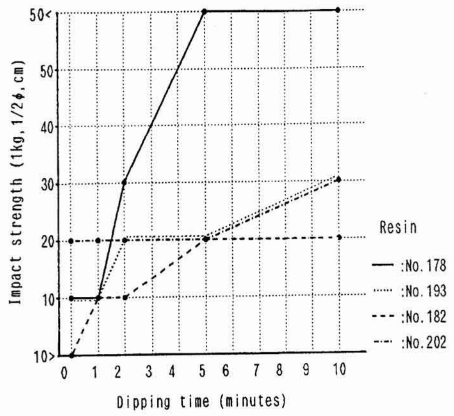


Figure 14—Impact strength as a function of dipping time. Test conditions are the same as Figure 10.

The first was based on the increasing penetration rate and the second was based on the increasing reaction rate. However, we could not distinguish the two effects. The same tendencies were observed in other properties such as impact resistance and water resistance.

Properties of Coating Film Cured by Penetrating Method

Solvent Resistance: The crosslinking reaction proceeds from the outer surface to the inner according to the penetration of the crosslinker (CH) as shown in a previous paper.[2] At an earlier stage of the dipping time, only a thin surface layer of the film became crosslinked, and the inner layer remained unaltered. When acetone was placed on such a film, it caused swelling of the crosslinked layer and dissolution of the non-crosslinked layer. As a result, the swelling film was inevitably located on a very loose dissolving film. This situation was responsible for the film wrinkling during the solvent resistance test. The wavelength of the wrinkle became longer with a thicker crosslinked layer, and a fully crosslinked film on the substrate surface did not wrinkle. The solvent resistance measured with acetone indicated the progress of the crosslinking. The results of solvent resistance tests for the three resins cured under the same conditions, dipping in crosslinker solution No. 48 at 40°C, are summarized in *Figure* 10. The extent of crosslinking increased with dipping time and DAAm content.

Pencil Hardness and Impact Strength: *Figures* 11 and 12 show the pencil hardness and the impact strength as a function of dipping time. Both properties were simultaneously improved with the dipping time and the extent of the improvement was roughly related with the DAAm content. In particular, the impact resistance of the films of resin No. 192 containing the largest amount of DAAm was excellent when the films were dipped for a rather long time in spite of the weakness of the starting resin.

In another paper,[2] we reported that the hydrophilic property of resin tended to increase the penetrating rate of CH. *Figures* 13 and 14 summarize the pencil hardness and the impact strength for four resins having different polarities and the same DAAm content, in which they are plotted versus dipping time. *Figure* 14 illustrates the faster curing rate of a hydrophilic resin film than that of a hydrophobic one. However, we cannot discern a clear tendency from *Figure* 13

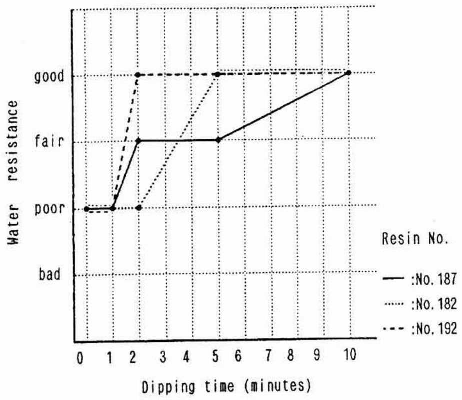


Figure 15—Water resistance as a function of dipping time.
Crosslinker solution: No. 48
Dipping temperature: 40°C
Substrate: Zinc-phosphated cold-rolled steel
Film thickness: 25-35μm
Test time: 7 days
Evaluation: bad = deep white and non-glossy; poor = deep white; fair = light white; and good = no change.

Table 4—Properties of Resin No. 192 Films Cured with Two-Component Method

Hydrazide/ Carbonyl (mole ratio)	Substrate	Induction Time*	Appearance	Adhesion	Water Resistance 7 Days
0.8	A	5 min	Good	100	Poor (blister, white)
		1 hr	Good	0	Poor (blister)
		5 hr	Poor (crack)	100	Bad (blister)
	B	5 min	Good	85	Bad (blister)
		1 hr	Good	60	Bad (blister)
		5 hr	Poor (crack)	100	Bad (blister)
0.5	A	5 min	Good	0	Poor (blister)
		1 hr	Good	0	Fair(blister)
		5 hr	Poor (crack)	98	Bad (blister)
	B	5 min	Good	99	Poor (blister)
		1 hr	Good	99	Poor (blister)
		5 hr	Poor (crack)	100	Bad (blister)

A: Non-treated cold-rolled steel, B: Zinc-phosphated cold-rolled steel.
Film thickness: 25 μm.
*Time after mixing but prior to application.

due to the difference in starting resin pencil hardness.

Erichsen Value: Erichsen values of the curing films were also measured. This value was easily increased beyond 7 mm even with a very short dipping time, because the crosslinking of the shallow top surface layer could protect the film from cracking caused by slow deformation. The stepwise improvement with dipping time was confirmed only by dipping in crosslinker solution No. 22, which was much less effective because of the absence of a hydrophobic organic solvent.

Adhesion and Water Resistance: Adhesion was good in all cases and water resistance was excellent when the films were dipped for a rather long time as shown in *Figures* 15 and 16. It was quite remarkable that the films coated on non-treated cold-rolled steel maintained a perfect appearance, without any whitening and blistering after a one week water resistance test. Blisters did not appear in all cases. The reason will be discussed in the next section.

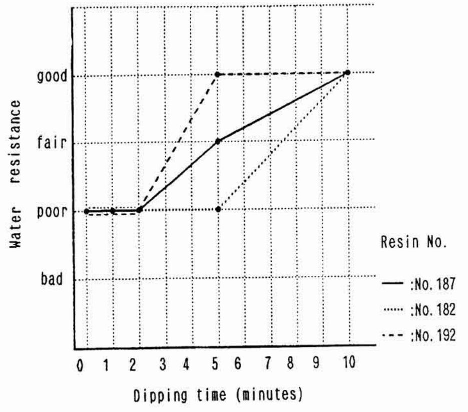


Figure 16—Water resistance as a function of dipping time.
Substrate: non-treated cold-rolled steel
Other test conditions are the same as Figure 15.

Comparison Between Penetrating and Two-Component Method

In order to characterize the penetrating method, we have attempted to compare the penetrating method with the two-component method.

Crosslinking Mechanism: Crosslinkers in the two-component method are found uniformly dispersed in the coating film as shown in *Figure* 17, and crosslinking reactions occur uniformly throughout the whole film. In this case, the internal stress produced by the curing

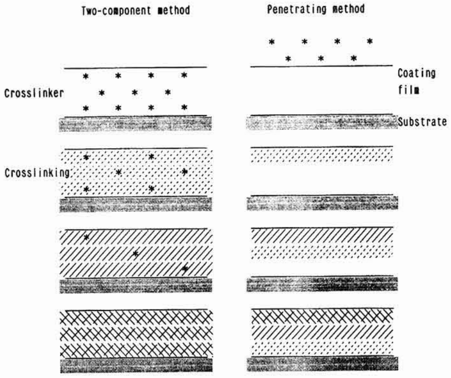


Figure 17—Scheme of crosslinking mechanisms of both methods.

weakens the adhesion force between coating film and substrate. On the other hand, the crosslinking in the penetrating method is carried out stepwise from the outer to the inner surface. Therefore, the development of internal stress may be reduced due to film heterogeneity, even when the crosslinking spreads over the whole film. Further crosslinking after complete disappearance of the non-crosslinked resin naturally produces the internal stress.

Water Resistance and Adhesion: The results for resin No. 182 are given in *Table* 2. One of the most remarkable differences between the two coating methods could be detected in the film appearance after the water resistance test. The films cured by the penetrating method changed from transparent to white during the water resistance test, if curing was not sufficient. On the other hand, the films obtained by the two-component method tended to develop blisters. In the former case, non-crosslinked resin remaining under the crosslinked layer caused whitening, and in the latter case, the internal stress produced by the crosslinking reaction was responsible for this blistering, because the adhesion force between the coating film and the substrate was weakened by the internal stress. The film cured sufficiently by the penetrating method posseses excellent water resistance, because the crosslinking in the penetrating method can be done without accumulation of internal stress.

Poor adhesion of the two-component coating film was also observed in the cross-cut test as shown in *Table* 2. It tended to appear at a high concentration of the crosslinker and at a particular induction time after mixing. It is not clear why the time does complicatedly influence the adhesion, but this phenomenon is observed not only in this table but also in the following two tables. *Table* 3 shows the results for resin No. 187 containing a smaller amount of DAAm (20%). In this case, the permissible time prior to application was naturally prolonged, and the pencil hardness was low compared with that of resin No. 182 because of the low content of the crosslinkable group. However, the tendency of blistering detected in the water resistance test was also recognized in this table, and the adhesion measured by the cross-cut test was weak at a particular induction time. The same tendency is strongly shown in *Table* 4, where resin No. 192 containing the largest amount of crosslinkable group was used. This table shows weak adhesion not only on the non-treated cold-rolled steel panel but also on the zinc-phosphated cold-rolled steel in the scotch-cut test. Blisters recognized in the water resistance test were larger and denser than those of the other two resins. The excellent water resistances observed for the penetrating method as shown in *Figures* 15 and 16 are quite surprising in contrast to the results.

Other Properties: Solvent resistance in the two-component method was good in all cases due to the homogeneous network spreading over the entire film. Pencil hardness and impact strength are more moderate compared to that in the penetrating method, apparently for the same reason.

CONCLUSIONS

Crosslinking films were prepared using this penetrative method during short dipping time. The curing front propagates from the film surface towards the substrate surface in the proportion to the penetration of the crosslinker. Excellent coating films are obtained when they are dipped in a suitable crosslinker solution containing organic solvents and acid. In particular, its adhesion after the water resistance test is much better than that of the coating film obtained by the two-component coating.

A more detailed study of the difference between the penetrating method and the two-component coating will provide insight concerning the ideal network structure in the cured film.

References

(1) Zabicky, J., *The Chemistry of Amides, Part 2,* John Wiley & Sons, Inc., New York, 1970, p. 560.

(2) Nakayama, Y., "New Developments on Colour Material in Japan," *Prog. Org. Coat.*, in press.

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The Use of Spherical Extenders in VOC Compliant Coatings

Ben J. Carlozzo—DCA Coatings*

Introduction

Naturally occurring extenders with approximately spherical shapes have been used for many years to maintain usable viscosities in paints, coatings, and sealants. While a certain amount of extender pigment is needed as a spacing particle to optimize hiding in titanium dioxide (TiO_2)[1,2] and colored pigments, the vast majority of extenders are used to lower costs in these products. Nodular extenders with relatively low oil absorption (below 35) are preferred for their efficiency. Examples of these nodular extenders include calcium carbonates, Blanc-Fixe (synthetic barium sulphate), and co-precipitated barium sulfate—zinc sulfide, known as lithopone. The major benefit of a calcium carbonate is derived from its lower oil absorption compared to clays and talcs, which permits higher loadings without exceeding critical pigment volume concentrations (CPVC). This is extremely important in maintaining the performance properties of most types of organic coatings.[3] This is also a benefit with barytes and lithopone, which also have lower oil absorption. In addition, lithopone can contribute to hiding due to its high refractive index.

Film properties, especially those which relate to durability and weathering, will also be improved if the CPVC can be raised by the substitution of a low absorbing extender pigment for an equal volume of a high oil absorbing pigment. This is similar to blending equal PVC paints made with two different particle sizes of the same pigment which optimizes pigment packing. A paper published by the Cleveland Society for Coatings Technology gives a good overview of this phenomena and the associated performance enhancements due to lowering the reduced CPVC, Λ (the ratio of PVC/CPVC).[4] Λ is also important when the corrosion resistance of a film is a dominant performance concern. Skerry and co-workers found that whether or not the coating was formulated above or below a Λ of 1.0 could greatly influence the outcome of corrosion testing as measured by AC impedance and electrochemical noise techniques, particularly when the amount and type of inhibitive pigment varied.[5]

As one might expect, if nodular extenders like those previously mentioned can improve the performance properties of a coating, a perfectly spherical particle of roughly the same size as these extender pigments, that is substituted at an equal volume for that extender, will have even lower oil demand. This would permit higher loadings which could control cost, as well as further improve the film properties as previously described. Several of these types of extender pigments are, in fact, commercially available and will be the major focus of this paper.

Synthetically produced microscopic spherical extenders (known as microspheres for short) have been available for many years. They are produced as both solid and hollow spheres and those which have the smoothest surface (lowest oil demand) are the glass and ceramic types. Several manufacturers supply a number of different versions varying in particle size and end use.

Organic versions are also available but are mainly used for latex coatings. Acrylic opaque polymer beads, as well as polyester based vesiculated beads are known, but these cannot be used in solvent containing paints. They are supplied in aqueous slurries and are added to contribute to dry hiding due to the air voids which they introduce to the dried film. The opaque polymers do have low oil demand and are in fact usually considered as part of the resin component in PVC calculations of the finished paint. No further discussion of these organic/plastic microspheres will be given here, but the ramification of their use is discussed in another Cleveland Society Technical Committee paper.[6]

There are advantages and disadvantages to each type of glass or ceramic microsphere. The following discussion will briefly describe the various types and delineate some of these issues.

SOLID SPHERES

Solid Glass Spheres: Solid glass spheres have been around for at least 60 or 70 years. Production of glass microspheres has involved recycling of glass by crushing to size and fire polish-

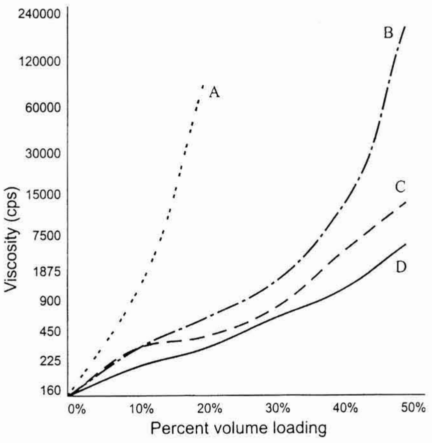

Figure 1—Viscosity as a function of loading for various types of extenders. A = talc (3 μm) @ 26°C; B = $CaCO_3$ (19 μm); C = ceramic hollow spheres (4.4 μm); D = glass micro-balloons (70 μm).

---

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Table 1—White Semi-Gloss Interior Enamel Formula

			Microsphere Modification			
	Control*		Equal NVV, VOC		Equal Stormer Visc.	
Ingredient	Pounds	Gallon	Pounds	Gallon	Pounds	Gallon
High-solids alkyd resins[a]	238.09	29.04	238.09	29.04	261.22	31.86
Mineral spirits, Rule 66	35.93	5.55	35.93	5.55	39.42	6.09
Anti-settling agent[b]	3.59	0.42	3.59	0.42	3.94	0.46
Titanium dioxide[c]	215.59	6.47	215.59	6.47	236.54	7.10
Calcium carbonate[d]	395.24	17.53	—	—	—	—
Microspheres[e]	—	—	160.90	17.53	175.95	19.23
Biocide[f]	4.90	0.33	4.90	0.33	5.38	0.36
High solids alkyd resin[a]	157.14	19.16	157.14	19.16	172.41	21.03
Cobalt drier[g]	2.99	0.41	2.99	0.41	3.28	0.45
Auxiliary drier[h]	8.98	1.09	8.98	1.09	9.85	1.20
Drier accelerator[i]	0.71	0.09	0.71	0.09	0.78	0.10
Anti-skinning agent[j]	3.59	0.47	3.59	0.47	3.94	0.52
Mineral spirits, Rule 66	125.75	19.44	125.75	19.44	75.15	11.61
Totals	1192.51	100.00	958.17	100.00	987.85	100.00

*Reichhold, Inc. suggested formulation.

(a) Beckosol® 10-539, Reichhold, Inc.
(b) Thixatrol® ST, Rheox, Inc.
(c) Ti-Pure® R-900, E.I. Dupont de Nemours & Co.
(d) OmyaCarb® 6, Omya, Inc.
(e) Sphericel® 110P8, Potters Industries Inc.
(f) Nopcocide® N-96, Henkel Corp.
(g) 6% Co Chem® 250, OMG, Inc.
(h) NeoChem® 250, OMG, Inc.
(i) Drymax®, OMG, Inc.
(j) Exkin® No. 2, Hüls America, Inc.

Table 2—2.8 VOC White Acrylic Polyurethane Topcoat*

			Microsphere Modification			
	Control*		Equal NVV, VOC		Equal Stormer Visc.	
Ingredient	Pounds	Gallon	Pounds	Gallon	Pounds	Gallon
Component I						
Acrylic-polyester polyol[a]	359.40	41.50	359.40	41.50	386.11	44.60
Adhesion promoter[b]	19.01	2.36	19.01	2.36	20.40	2.54
Titanium dioxide[c]	327.00	10.12	327.00	10.12	350.91	10.86
Ground quartz[d]	111.56	5.06	—	—	—	—
Microspheres[e]	—	—	46.29	5.06	49.70	5.43
Thixatrope[f]	31.55	3.41	31.55	3.41	33.86	3.66
HALs UV absorber[g]	4.44	0.54	4.44	0.54	4.77	0.58
Wetting agent[h]	1.43	0.18	1.43	0.18	1.54	0.19
Defoamer[i]	7.08	0.97	7.08	0.97	7.60	1.04
Ester solvent[j]	127.43	17.53	127.43	17.53	83.23	11.44
Methyl amyl ketone	22.53	3.31	22.53	3.31	23.97	3.59
Component II						
Isocyanate resin[k]	145.62	15.01	145.62	15.01	156.26	16.07
Totals	1157.05	100.00	1091.78	100.00	1118.35	100.00

*Bayer Corp. suggested formulation #291-22/2.

(a) Desmophen® A LS-2945, Bayer Corp.
(b) Caspol® 5007, CasChem, Inc.
(c) Ti-Pure® R-960, E.I. Dupont de Nemours & Co.
(d) Novacite® L-207, Malvern Minerals
(e) Sphericel 110P8, Potters Industries Inc.
(f) Ircogel® 906, Lubrizol Corp.
(g) Tinuvin® 292, Ciba-Geigy, Inc.
(h) Anti-Terra® U, BYK Chemie USA
(i) DC®-56 (1% in Exxate 600), Dow Corning Corp.
(j) Exxate® 600, Exxon Chemicals
(k) Desmodur® N-3300, Bayer Corp.

ing, as well as the use of batch processes which blend sand, soda ash, dolomite, and feldspar in a melting tank which is then heated at 2,400°F. The molten glass flows through an orifice as a free falling stream. Through impinging with air, or the use of paddles or splattering against a surface, the stream is broken into small droplets which are cooled in air to form spheres. These processes give relatively large spheres with top ends that approach the size of marbles. Glass microspheres from these processes are in the range of 325 to 20 mesh, or 30 to 750 µm. At this size they are usually used in the thermoplastic industry, especially as additives to improve the flow of fiber reinforced plastic (FRP) laminates and molded compounds. Solid glass spheres used for FRP laminates are generally coated with various silanes to improve wet out in the particular resin system employed.

A newer process uses fly ash from coal burning power plants. The recovered glass spheres are much smaller in size, giving microspheres in the range of 0.3 to -30 µm. These smaller spheres are used in paints and coatings.[7]

Solid Ceramic Microspheres: There is only one current supplier of solid ceramic microspheres and the product was still in the pilot plant stages as of this writing.[8] Commercial introduction was slated for May 1996. In general, ceramics are both more costly and harder to process. This new series of products is based on a unique process which is patent pending. They are white due to the nature of the ceramic alloy. However, their refractive index is only 1.55 which means they will contribute little to the hiding in a film. Like other spherical extenders, they will allow for high loading levels, and due to their small particle size can be of benefit in all types of coatings including gloss latex and solvent-borne enamels. Like other similar particles, they do lower viscosities when substituted for acicular or platy extenders (see *Figure* 1). Another benefit might be their ability to improve the fire retardancy of coatings due to their ceramic composition and their increased thermal reflectance.

General Comments: Solid microspheres are used to improve tensile strength, flexural modulus, hardness, and abrasion resistance. They generally have very good compressive strengths and can improve heat deflection temperatures during the molding process. With their lower oil demand, they can be used to improve film integrity leading to better water resistance, corrosion resistance, flame retardancy, and fracture toughness. In the processing of FRP laminates, they improve the dispersion of other materials, especially chopped glass fiber. Their low oil demand can lead to another improvement when used in gunable grades of caulks and sealants, i.e., reduced film shrinkage. In high-temperature processes, their high heat capacity and uniform shape can lead to more uniform cooling which will lessen warpage.

HOLLOW MICROSPHERES

The advent of the fly ash process in solid glass microsphere production also led to the discovery of a unique by-product, namely, hollow glass microspheres. Usually called floaters, these materials were skimmed off the surface of fly ash ponds, and were found to have a void or cavity in the center of the sphere. Since this discovery, and due to the fact that floaters represent only one to three percent of the fly ash waste, newer methods which involve the use of blowing agents were evolved. The blowing agents expand in the molten gas when small crushed particles are passed through a hot zone. The expanded particles are cooled in air and the walls solidify before the internal gas pressure is reduced. This same basic process is used to make hollow spheres regardless of the composition.

The benefits of solid microspheres are also obtained with hollow microspheres with some specific benefits directly attributable to the void space.[9]

Hollow Glass Microspheres: The most recognizable use of hollow glass microspheres can be seen in the production of lightweight caulks and spackling compounds. Large, space filling, hollow

Table 3—White Epoxy-Polyamide Topcoat

			Microsphere Modification			
	Control		Equal NVV, VOC		Equal Stormer Visc.	
Ingredient	**Pounds**	**Gallon**	**Pounds**	**Gallon**	**Pounds**	**Gallon**
Component I						
Epoxy resin[a]	366.43	40.92	366.43	40.92	377.25	42.13
Pigment dispersant[b]	3.76	0.13	3.76	0.13	3.87	0.13
Titanium dioxide[c]	183.21	5.37	183.21	5.37	188.62	5.53
Talc[d]	73.29	3.32	73.29	3.32	75.45	3.42
Calcium carbonate[e]	64.12	2.84	—	—	—	—
Microspheres[f]	—	—	26.03	2.84	26.80	2.93
Glycol ether[g]	61.79	8.10	61.79	8.10	63.61	8.34
Dibasic esters[h]	16.35	1.80	16.35	1.80	16.84	1.85
Flow and leveling agent[i]	1.01	0.11	1.01	0.11	1.04	0.11
Methyl ethyl ketone	43.42	6.50	43.42	6.50	24.97	3.74
Component II						
Epoxy curing agent[j]	153.19	19.17	153.19	19.17	157.71	19.74
Glycol ether[g]	52.00	6.79	52.00	6.79	53.54	6.99
n-Butyl alcohol	33.35	4.95	33.35	4.95	34.34	5.09
Totals	1051.92	100.00	1013.83	100.00	1024.04	100.00

(a) Epon® 1001, Shell Chemical Co.
(b) IAF Compound® X2280, Ciba-Geigy Corp.
(c) Ti-Pure® R-902, E.I. Dupont de Nemours & Co.
(d) MP® 12-50 Talc, Pfizer Corp.
(e) Duramite®, E.C.C. America, Inc.
(f) Sphericel 110P8, Potters Industries Inc.
(g) Arcosolv® PM, Arco Chemical Co.
(h) D.B.E. Dibasic Esters®, E.I. Dupont de Nemours & Co.
(i) BYK® 346, BYK-Chemie USA
(j) Epi-Cure® 8515, Shell Chemical Co.

Table 4—Physical Properties

A) White Semi-Gloss Interior Enamel

	Control	Equal NVV, VOC	Equal Stormer Visc.
Physical Properties			
PVC, %[a]	36.31	36.31	36.31
NVW, %[a]	82.09	77.71	82.76
NVV, %[a]	67.22	67.22	73.22
VOC, g/l[a]	256.00	256.00	198.00
Stormer, KU[b]	92	75	92
ICI, Poise[e]	3.6	2.3	4.5
Sag resistance[c]	6	5	6
Leveling[d]	6	8	6

B) White Acrylic Polyurethane Topcoat

	Control	Equal NVV, VOC	Equal Stormer Visc.
Physical Properties			
PVC, %[a]	27.33	27.33	27.33
NVW, %[a]	75.96	74.54	78.10
NVV, %[a]	61.67	61.67	66.15
VOC, g/l[a]	333	333	294
Stormer, KU[b]	72	66	72
Sag resistance[c]	4	4.5	5
Leveling[d]	6.5	6	6

C) White Epoxy/Polyamide Topcoat

	Control	Equal NVV, VOC	Equal Stormer Visc.
Physical Properties			
PVC, %[a]	18.75	18.75	18.75
NVW, %[a]	73.90	70.44	71.80
NVV, %[a]	61.40	61.40	63.35
VOC, g/l[a]	360.00	360.00	347.00
Stormer, KU[b]	96	89	95
Sag resistance[c]	15	17	17
Leveling[d]	4	6	4

(a) This does not assume additives are 100% volatile.
(b) ASTM D 562.
(c) ASTM D 4400.
(d) ASTM D 4062.
(e) ASTM D 4287.

microspheres, commonly known as micro-balloons, are used. These types have very thin walls. Incorporation of these micro-balloons can be problematic, requiring care to prevent crushing of the product. The crush-strength of these types of products is in the 100 to 300 pounds per square inch (psi) range. The basic use of these materials is to extend resin and increase volume solids, yielding a lower weight finished product. Besides yielding very lightweight materials, glass spheres of this type sand very well and are incorporated into sanding sealers and automotive repair "body fillers."

The pH of these types of materials is usually very high (approximately 9.5) and can limit their use to alkaline stabilized latex products or other systems insensitive to high pH. The variability in the volume associated with very small changes in density can be a disadvantage with these types of microspheres. A variation of .02 g/cc, which is a typical specification range for 0.22 g/cc density microspheres will yield a ±10% difference in volume. This is not an insignificant difference and would require manufacturers to modify the weight of microspheres added to maintain batch-to-batch volumes. As these products are still sold by the pound, the cost of their use would have to be averaged over all the batches made in a given time period to get an accurate figure. Most production facilities do not like modifying batch tickets to account for this variability due to the chance of error.

A more useful product for the paint formulator, and the one used in the experimental data which follows, is a 1.1 g/cc density microsphere, with insignificant color (this type of glass is totally transparent to visible light) and exceptional crush strength (greater than 3,000 psi showing only negligible volume loss).[10] In fact, even at 10,000 psi, volume loss due to crushed spheres was measured at only 13%.[11] The particle size of this product allows for five to six Hegman grinds to be achieved, and this crush strength is more than sufficient to allow these materials to be incorporated in the dispersion with other pigments and extenders in high speed Cowles® type dispersers. Additionally, hiding can be improved by the addition of voids into an otherwise tight resin matrix. This can offset the high cost of this product due to the removal of a portion of TiO_2. The high cost can also be offset by replacing a portion of the corrosion inhibitive pigments at equal or better performance.

Hollow Ceramic Spheres: One of the major benefits of hollow ceramic spheres is the fact that the wall thickness is such that these spheres have tremendous crush strength. This is also one of the disadvantages in that this makes their densities quite high. At 2.3 g/cc to 2.6 g/cc, this is on the order of calcium carbonates. Even though these microspheres are relatively inexpensive at $0.40/pound, this higher cost makes their substitution unattractive for calcium carbonates, unless the benefits in viscosity reduction are over-riding. Their other disadvantage is their color. The basic ceramic used is gray and leads to a gray product whenever these materials are mixed with TiO_2. The lighter color versions of these materials are also very expensive, with the lightest versions being the most expensive (approximately $2.70 per pound).

Versions made with ceramic fly ash are usually lower in density, and approach the low end density of 0.22 g/cc which is similar to hollow glass microballoons. Their size is also in the same range with particle diameters approaching a mean of 75 µm. Low end size is approximately 30 µm and top ends can reach as high as 200 µm. Of course, as density goes down, wall thickness decreases and the crush strength goes way down. This is usually controlled by producing spheres that are within tight specification in regards to particle diameter/wall thickness ratios. This is important as smaller sized, hollow microspheres are produced.

Intermediate versions with intermediate particle size and densities in the vicinity of 0.7 g/cc are beneficial with their 1,500 psi crush strengths. The lower densities allow for higher loading and replacement of extender pigments and the high compressive strengths make high-speed dispersability possible. Due to the better consistency of the product, a problem associated with the use of thin walled, lower density spheres is eliminated, namely, the variability in the volume associated with very small changes in density.

As with hollow glass microspheres, a variation of .02 g/cc in the density of the 0.22 g/cc ceramic microspheres will also yield a large difference in volume. That same difference of 0.02 g/cc in a 0.7 g/cc material translates into a more manageable ±3% variation. These intermediate products are very useful in high viscosity applications such as mastics and sealants, where high pigment and extender loadings are common.

For the current study, data will be presented which will illustrate just how the 1.1 g/cc density material, composed of a boro-silicate glass, is used as a specialty extender and can be incorporated into various traditionally solvent-rich coatings to help maintain or achieve compliance with government volatile organic content (VOC) legislation. Additional performance benefits, such as improvements in hiding and corrosion resistance, will also be illustrated.

Experimental

To investigate the effects that incorporation of hollow glass 1.1 g/cc microspheres would have on the physical

Table 5—Dry Film Properties: Equal Volume Substitution (Equal NVV, VOC)

White Semi-Gloss Interior Enamel

Property	Control	Microspheres
Contrast ratio, %	97.9	98.4
Y-Reflectance, %	87.3	89.3
Yellowness index[a]	2.7	2.5
20° gloss, sealed	12.6	12.0
60° gloss, sealed	50.4	45.3
85° sheen, sealed	80.2	79.5
K&N ink[b]	2.9	1.5
Scrub resistance[c], liters	138.0	58.0
Falling sand abrasion resistance[d], scrubs	1313	885

(a) ASTM E 313.
(b) ASTM D 3258. Y-reflectance loss.
(c) ASTM D 4213.
(d) ASTM D 968.

Table 6—Dry Film Properties: Equal Volume Substitution (Equal NVV, VOC)

2.8 VOC White Acrylic Polyurethane Topcoat

Property	Control	Microspheres
Contrast ratio, %	98.1	97.8
Y-Reflectance, %	91.5	93.5
Yellowness index[a]	1.8	1.6
20° gloss, sealed	83.2	58.9
60° gloss, sealed	95.1	88.6
85° sheen, sealed	86.3	82.7
20° gloss, unsealed	77.5	55.5
60° gloss, unsealed	94.6	87.4
85° sheen, unsealed	87.8	85.6
K&N ink[b]	2.9	2.5
Tabor abrasion, mg lost[c]	58.1	77.7

(a) ASTM E 313.
(b) ASTM D 3258. Y-reflectance loss.
(c) ASTM D 4060, 1,000 g weight, 1,000 cycles, CS-17 wheel.

Table 7—Dry Film Properties: Equal Volume Substitution (Equal NVV, VOC)

White Epoxy-Polyamide Topcoat

Property	Control	Microspheres
Contrast ratio, %	94.3	95.2
Y-Reflectance, %	89.6	89.7
Yellowness index[a]	4.3	4.2
20° gloss, sealed	65.6	66.1
60° gloss, sealed	93.1	93.3
85° sheen, sealed	86.3	86.5
20° gloss, unsealed	64.2	65.4
60° gloss, unsealed	93.1	93.3
85° sheen, unsealed	86.0	86.5
K&N ink[b]	2.9	1.8
Taber abrasion, mg lost[c]	83.6	50.1

(a) ASTM E 313.
(b) ASTM D 3258. Y-reflectance loss.
(c) ASTM D 6040, 1,000 g weight, 1,000 cycles, CS-17 wheel.

Table 8—Brookfield Viscosity ASTM D 2196

System	Viscosity @ 10 RPM	Viscosity @ 20 RPM	T.I.
Epoxy			
Control	1900 cps	1925 cps	.99
Equal NVV	1750 cps	1763 cps	.99
Equal stormer	2150 cps	2175 cps	.99
Polyurethane			
Control	400 cps	400 cps	1.00
Equal NVV	350 cps	350 cps	1.00
Equal stormer	550 cps	550 cps	1.00

RVF instrument, #3 spindel, measured at 10 and 20 RPM and thioxtropic index calculated.

Table 9—ICI Viscosity ASTM D 4287

Alkyd	ICI Visc.
Control	3.60
Equal NVV	1.80
Equal stormer	4.50

Table 10—QUV Testing ASTM G 53

A = Control; B = Microspheres; C = Modified Microspheres

Sample	(-Y)	Y.I.	Gloss 20°	Gloss 60 °	Gloss 80 °
Alkyd A					
Before QUV	88.09	5.02	12.6	50.4	80.2
After QUV	83.44	14.12	1.6	2.5	30.4
Alkyd B					
Before QUV	87.49	4.73	12.0	45.3	79.5
After QUV	84.99	12.89	1.6	3.5	14.7
Alkyd C					
Before QUV	87.16	4.06	8.9	39.2	77.0
After QUV	85.34	12.00	1.7	3.6	13.8
Urethane A					
Before QUV	92.87	1.99	90.1	97.9	98.5
After QUV	91.60	3.28	87.4	95.2	104.8
Urethane B					
Before QUV	91.89	-.14	70.1	93.9	96.8
After QUV	91.32	.47	61.4	93.8	103.9
Epoxy A					
Before QUV	89.85	3.25	47.4	84.0	95.7
After QUV	81.12	26.83	1.6	2.5	53.2
Epoxy B					
Before QUV	87.80	1.18	55.4	87.3	95.3
After QUV	81.60	21.92	1.6	2.5	44.5

properties of various coatings, three different coating systems were chosen. The systems included a white high-solids semi-gloss alkyd; a white, two-component acrylic urethane topcoat; and a white, two-component polyamide cured epoxy. In most cases the standard formulation was used as supplied by the resin manufacturer and substitutions were made on a volume basis to maintain pigment volume concentration (PVC). This would insure that changes in performance would be due primarily to the pigment geometries (a smooth spherical shape versus an irregular or highly porous surface).

One of the major advantages possible with a low density, very low oil absorption extender pigment is the ability to lower the solvent demand of a system and its effect on the viscosity obtained. This enhancement is even greater when the extender is a spherical particle. The benefit of using this type of extender to replace all or a portion of a higher oil absorption extender is the ability to increase the solids of the coating while maintaining the viscosity at a usable level.

Therefore, in order to assess the benefits of microspheres, an equal viscosity sample would be prepared to give a direct measurement of the solids possible without altering the composition of the dry film. In addition, comparison of the wet film properties of all three samples (standard and both high and low solids beaded versions) would give some insight into the formulation latitude possible with this product, especially the effects on sag and leveling.

Discussion and Results

The results of this study are given in the tables that follow. Each result will be discussed in detail, however, a brief recap of some of the highlights follows.

General Observations: In general, the suspected benefits of microsphere additions were confirmed. A tighter film was obtained as confirmed by the K&N Ink study (*Tables* 5-7). While not particularly critical in a high-gloss or semi-gloss formulation, this advantage would be very important in a heavily extended flat formulation. Higher PVCs, below the CPVC would be possible. As previously discussed, film durability, especially on exterior exposure, depends heavily on staying below the CPVC.

When an equal volume substitution of microspheres is made for extender pigment, the resulting film gives exceptionally good results in salt fog corrosion testing. In all cases, microsphere replacement resulted in improved film appearance with less rusting throughout as well as fewer and smaller blisters at the scribe.

The suppliers of microspheres usually offer both treated and untreated versions. Silane treatments have been used for years in the FRP markets to help incorporate glass microspheres into various resin systems and can be tailored to the resin used. In the alkyd system, both treated and untreated microspheres were tried because of earlier investigations which showed that microspheres had a tendency to float in an alkyd system. The largest amount of microsphere floatation was usually seen when the microspheres were added after the letdown stage of manufacture.

It was discovered, as a result of the current study, that microsphere floatation is more a dispersion issue than one of resin incompatibility. A stabilized pigment dispersion which contains microspheres is unlikely to have floaters. Conversely, an unstable dispersion, which would be prone to hard settling with typical mineral extenders such as clays, talcs, or calcium carbonates, would also show the tendency for microsphere floatation. In subsequent alkyd, urethane, and epoxy studies, only untreated microspheres were used as microsphere floatation was no longer an issue.

The current alkyd study also employed a resin designed for high solids use. The formulation of the standard was again based on the supplier's suggested formulation. A comparison of the experimental and standard formulations is given in *Table* 1.

The acrylic urethane coating formulation was obtained from Bayer and was used without modification as the standard composition. In this particular formulation, the use of a hard, low oil absorbing silica is optimal. White VOCs can be lowered significantly by using microspheres, the differences in hardness can detract from the coatings' performance. Most differences were minor and the savings in VOC would still make this a justifiable substitution. The acrylic urethane formulations are given in *Table* 2.

The two-component epoxy-polyamide system is a typical floor coating formulation. The improvement in Taber abrasion resistance using microspheres is substantial in this formulation.

The increased contrast ratio, although it appears as a relatively small amount, is actually quite substantial and would indicate that a sizable amount of TiO_2 could be removed. This agreed with similar results seen in earlier studies. The epoxy formula variations are given in *Table* 3.

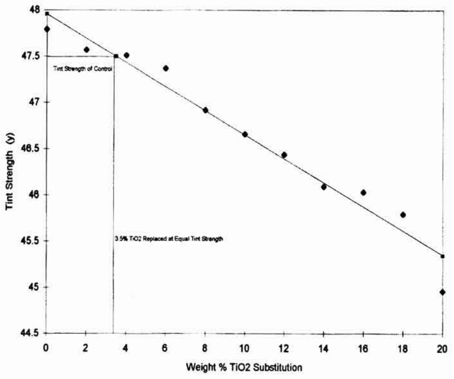

Figure 2—Tint strength as a function of percent spherical extender modification: equal tint strength matches for modified vs. unmodified alkyd semigloss formulations.

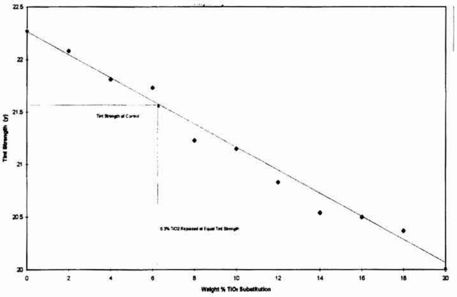

Figure 3—Tint strength as a function of percent spherical extender modification: equal tint strength match for modified vs. unmodified acrylic-urethane formulations.

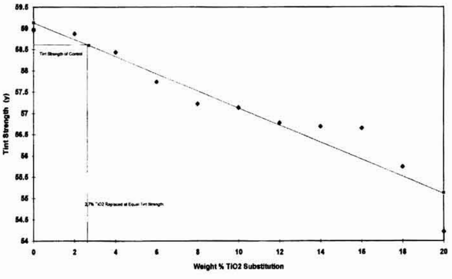

Figure 4—Tint strength as a function of percent spherical extender modification: equal tint strength match for modified vs. unmodified two-component epoxy/polyamide formulations.

Table 11—Spreading Rate ASTM 2805

System	Spreading Rate (Sq. Ft/Gal)
Alkyd	
Control	398
Equal NVV (microsphere)	580
Equal NVV (modified microspheres)	483
Epoxy	
Control	211
Equal NVV microspheres	222
Polyurethane	
Control	458
Equval NVV microspheres	538

Table 12—Hardness (Pencil, Sward) ASTM D 2134(a) and ASTM D3363(b)

System	Sward Hardness (a)	Pencil Hardness (b)
Alkyd		
Control	34	Pass 4B
Equal NVV microspheres	44	Pass 4B
Equal NVV (silane modified)	34	Pass 4B
Epoxy		
Control	74	Pass F
Equal NVV microspheres	76	Pass F
Polyurethane		
Control	88	Pass HB
Equal NVV microspheres	66	Pass B

Table 13—Chemical and Stain Resistance ASTM 1308

A = Control; B = Microspheres; C = Modified Microspheres

	Alkyd			Epoxy		Urethane	
Chemical/Solvent	**A**	**B**	**C**	**A**	**B**	**A**	**B**
1) Ammonium dichromate	—	—	—	—	—	—	—
2) Ammonium hydroxide	s1	s2	s1	—	—	—	—
3) Sodium hydroxide 20%	sd	sd3	sd2	—	—	—	—
4) Bleach	—	—	—	—	—	—	—
5) Hydrochloric acid 10%	s	—	—	—	—	s	s
6) Acetic acid 4%	—	—	—	s	—	—	—
7) Ethyl acetate	sf	sf	sf	s	s	sf	sf
8) Methyl ethyl ketone	rf	rf	rf	—	—	rf	rf
9) Xylene	sf	sf	sf	—	—	sf	sf
10) Methanol	rf	rf	rf	—	—	sf	sf
11) Mineral spirits	—	—	—	—	—	—	—
12) Gasoline	—	—	—	—	—	—	—
13) Acetone	sf	sf	sf	—	—	rf	rf
14) Dimethyl sulfoxide	bf	bf	bf	s	s	bf	bf
15) Ethanol 50%	rf	rf	rf	—	—	—	—
Stain Resistance (5 Stains) ASTM D 1308							
1) Red ink	s	s	s	s	s	s	s
2) Merthiolate	s	s	s	—	—	—	—
3) Coffee	sls	sls	sls	—	—	—	—
4) Shoe polish	s	s	s	—	—	—	—
5) Mustard	s	s	s	s	s	s	s

Key
—: No stain or effect.
sx*: Stains films to varying degrees (1<2<3).
sd*: Staining and film degrades (1<2<3).
rf: Removes film.
s: Stains film.
sls: Slight stain.
sf: Softens film.
bf: Blisters film.

The physical properties of the previously listed formulations are given in *Table* 4. Dry film properties for the formulations follow in *Tables* 5-7.

Table 14—Equal Tint Strength Formula

White Semi-Gloss Interior Enamel—Modified with Microspheres

Ingredient	Pounds	Gallon
High solids alkyd resin[a]	238.09	29.04
Rule 66 mineral spirits	35.93	5.55
Anti-settling agent[b]	3.59	0.42
Titanium dioxide[c]	208.76	6.27
Calcium carbonate[d]	—	—
Microspheres[e]	162.75	17.74
Biocide[f]	4.90	0.33
High-solids alkyd resin[a]	157.14	19.16
Cobalt drier[g]	2.99	0.41
Auxiliary drier[h]	8.98	1.09
Drier accelerator[i]	0.71	0.09
Anti-skinning agent[j]	3.59	0.47
Rule 66 mineral spirits	125.75	19.44
	953.18	100.00

(a) Beckosol 10-539, Reichhold, Inc.
(b) Thixatrol ST, Rheox, Inc.
(c) Ti-Pure R-900, E.I. Dupont de Nemours & Co.
(d) OmyaCarb 6, Omya, Inc.
(e) Sphericel 110p8, Potters IndustriesInc.
(f) Nopcocide N-96, Henkel Corp.
(g) 6% Co Chem 250, OMG, Inc.
(h) NeoChem 250, OMG, Inc.
(i) Drymax OMG, Inc.
(j) Exkin No. 2, Hüls America, Inc.

Physical Testing

Grind (Hegman)—ASTM D 1210: Initial Hegman grinds were very good for all products. In the epoxy and polyurethane systems, Hegman grinds of 7/6 were obtained. Similar results were seen in the alkyd, even with the treated microspheres. After sitting, the standard microsphere formulations remained the same, but the treated microsphere in the alkyd began to develop some grittiness.

Brookfield Viscosity—ASTM D 2196: The urethane and epoxy formulations were tested for the viscosity benefits by running Brookfield viscosities on both the standard and modified formulations. The lower viscosity found with microsphere substitutions was enough to allow several percent solvent removal, thus lowering VOCs while maintaining usable viscosity (see *Table* 8).

ICI Viscosity—ASTM D 4287: The epoxy and urethane formulations are not usually brushed. Therefore, ICI viscosity is not normally run. Both systems intrinsically have very high ICIs (higher than 10). The use of microspheres did lower ICI viscosity (8.0-9.0), but not into a usable brushing range (1.0-5.0) (see *Table* 9).

Salt Fog Resistance—ASTM B 117: Panels were prepared for all three systems on 1/32 in. cold-rolled steel and also on blasted hot-rolled steel for the urethane and the epoxy coatings. Dry film build was 3-4 mils for the alkyd and the urethane systems and 6-7 mils for the epoxy. After 500 hr, the panels were evaluated for degree of rusting. All panels which incorporated microspheres performed better than those which did not. In particular, large degrees of improvement were seen for the hot-rolled steel urethane samples as well as for the cold rolled alkyd samples. (Specific gravity of salt = 1.035; pH = 6.8; collection rate = 1.3 ml/hr; chamber temperature = 96°F).

Scrub Resistance/Falling Sand Abrasion Resistance (Alkyd Only)—ASTM D 4213 and ASTM D 968: Scrub resistance tests are generally run to determine the durability of interior trade sales coatings, and falling sand abrasion is used to test the wearability of floor coatings. Alkyds are generally used in these applications and as such, both tests were run on the alkyd system. The results of these tests on the alkyd system are given in *Table* 5. These results are somewhat disappointing, but not totally unexpected. A spherical extender may not be bound to the substrate as tightly as an irregularly shaped extender or an extender with a porous surface profile. Falling sand impinging at an angle would be more likely to dislodge a spherical extender. The same would be true for the action of the bristles of a brush in the scrub resistance test. However, if this were true, one would expect that silane modification, which would allow the resin to bind to the surface of the microsphere, would improve the results. Silane modified microspheres were actually somewhat poorer than unmodified microspheres in the falling sand test (47 liters of sand vs. 58 liters), and essentially the same in scrub resistance (888 scrubs vs. 885 scrubs). The answer may lie in the fact that a hard crystalline silica impinging on a boro-silicate glass sphere has enough energy to break that sphere and initiate the catastrophic failure of the film.

While valid for an alkyd coating, these tests would be totally inappropriate for either urethane or epoxy systems. Both of these systems are used in heavy industrial environments where their superior abrasion resistance can stand up to vehicular traffic. See the Taber abrasion section for a discussion of these systems and *Tables* 6 and 7 for the results of testing.

QUV Testing—ASTM G 53: The paints were drawn down on aluminum panels and placed in a QUV instrument using UVA bulbs. The panels were originally tested for reflectance (Y), yellowness index (Y.I.), and 20°, 60°, and 80° gloss. The test was run for 431 hr.

One interesting result of the QUV testing is the fact that the microsphere modified samples in all cases had a better yellowness index than the unmodified samples. It also should be noted that all microsphere modified materials showed less yellowing on exposure. Even though the microsphere samples generally had lower reflectance values than the controls, they retained higher values after QUV exposure (see *Table* 10).

Spreading Rate—ASTM D 2805: The spreading rate is normally a function of the ease of brushing and relates directly to ICI viscosity. As such, this property is not normally run for coatings such as epoxies and urethanes. We decided to

Table 15—Equal Tint Strength Formula

White Semi-Gloss Interior Enamel—Modified with Microspheres

Physical Properties	
PVC, %	36.31
NVW, %	77.71
NVV, %	67.22
VOC, g/l	256.00
Stormer, KU	75
ICI, Poise	2.3
Sag resistance	5
Leveling	8

Table 16—Tint Strength Match Formulation

2.8 VOC White Acrylic Polyurethane Topcoat

	Microsphere Modified Formulation	
Ingredient	**Pounds**	**Gallon**
Component I		
Acrylic-polyester polyol[a]	359.40	41.50
Adhesion promotor[b]	19.01	2.36
Titanium dioxide[c]	306.04	9.48
Ground quartz[d]	—	—
Microspheres[e]	52.14	5.70
Thixatrope[f]	31.55	3.41
HALS UV absorber[g]	4.44	0.54
Wetting agent[h]	1.43	0.18
Defoamer[i]	7.08	0.97
Ester solvent[j]	127.43	17.53
Methyl amyl ketone	22.531	3.31
Component II		
Isocyanate resin[k]	145.62	15.01
Totals	1077.03	100.00

(a) Desmophen ALS-2945, Bayer Corp.
(b) Caspol 5007, CasChem Inc.
(c) Ti-Pure R-960, E.I. Dupont de Nemours & Co.
(d) Novacite L-207, Malvern Minerals.
(e) Sphericel 110P8, Potters Industires Inc.
(f) Ircogel 906, Lubrizol Corp.
(g) Tinuvin 292, Ciba-Geigy, Inc.
(h) Anti-Terra U, BYK-Chemie, USA.
(i) DC-56 (1% in Exxate® 600), Dow Corning Corp.
(j) Exxate 600, Exxon Chemicals.
(k) Desmodur N-3300, Bayer Corp.

run this property since the need to touch-up coatings could be encountered. The effects of the microspheres are dramatic especially in the alkyd and urethane system. The spreading rate is used in hiding power calculations as defined in ASTM D 2805, Hiding Power of Paints by Reflectometry (see *Table* 11).

Hardness (Pencil, Sward)—ASTM D 2134(a) and ASTM D 3363(b): These results dramatically show the effects of substituting a softer pigment for a harder one and vice versa. This explains several of the shortcomings that the microspheres showed in the polyurethane system since a hard extender (Novacite L 207) was replaced by a somewhat softer one in the microsphere (see *Table* 12).

Chemical, Solvent (15 Chemicals) and Stain Resistance (5 Stains)—ASTM D 1308: The chemical and solvent resistance of the coatings were checked according to the procedures outlined in ASTM D 1308. Essentially, the paints are cast on clean glass (this magnifies adhesion problems), and after two weeks cure, the films are spotted with various chemicals and each area is covered with a watch glass to minimize evaporation. After 15 min, the films are checked for any effects from the chemical of interest.

As the results of this test show, the presence or absence of microspheres does not seem to affect the outcome to any great extent. If a coating is prone to staining, the microspheres will not change the results.

The same appears to be true with results of the chemical resistance testing. In most cases, the same degree of resistance is seen regardless of whether or not microspheres are present. In the epoxy, for instance, better resistance is seen only in four percent acetic acid for the microsphere modified sample compared to the unmodified sample (see *Table* 13).

Tint Strength—ASTM D 2745: Tint strength is run by adding 1/2 ounce of black colorant (in this case, Hüls Colortrend 888 line, lampblack) to one gallon of coating, making drawdowns using a 7-mil casting knife and measuring the reflectance of each and determining if there are any differences between standard and control. Tint strength studies were done to determine potential TiO_2 substitutions with microspheres, where a sample of the modified and the unmodified was taken and tinted with the black colorant. The "Y" tristimulus values were then recorded for each blend over a sealed, white, drawdown chart. Tint strength was calculated as follows:

$$T.S. = \{ [(1 - R_\infty)^2 / (2 * R_\infty)]_{CaCO3} / [(1 - R_\infty)^2 / 2 * R_\infty)]_{microsphere}\} * 100$$

where

T.S. = tint strength

R_∞ = reflectance of tinted paint as infinite film thickness ("Y" reflectance at complete hiding)

Using this method on the alkyd paint system, it was determined that the tint strength with microspheres replacing the calcium carbonate in the formula, was approximately 14% better than the unmodified paint.

Tabor Abrasion Resistance—ASTM D 4060: The Taber Abraser is used to check the durability of very tough high performance coatings. The test involves taking a 1,000 g weight and placing it on an arm holding two abrasive wheels which can be changed depending on the type of coating used and to best discern differences between coatings. The test is run for a minimum of 1,000 cycles (revolutions of the coating applied to a substrate and spun on a spindle) or until the coating is abraded through to the substrate. The weight loss, in milligrams, is reported. For the urethane and epoxy systems used in this study, CS-17 Wheels (one of the most abrasive types of wheels available) was used.

The results of testing are given in *Table* 6 for the urethane coating and *Table* 7 for the epoxy coating. These results tend to confirm the falling sand and scrub resistance results, i.e., when a harder extender is replaced by the microspheres, the abrasion results are poorer, as in the urethane coating, but, when the softer extender, like calcium carbonate is replaced by the glass microspheres, the results are better than the standard, as in the epoxy coating. However, this should be taken only as a general guide, since each coating had a different PVC of extender which was substituted for by microspheres. Regardless of this, the overall PVC was low enough in each of these systems that this would probably not be an over-riding factor for film integrity and subsequent abrasion resistance.

Additional Investigations

TiO_2 SUBSTITUTION STUDY

As a result of the tint strength study showed, there was a theoretical basis for removing some of the TiO_2 replacing it with microspheres and obtaining equal hiding. This would also offset some of the additional cost incurred in using the microspheres. To further explore this result and see if the same were true for all three white coatings investigated, the alkyd, urethane, and epoxy coatings were tested by comparing blends of microsphere modified and unmodified paints and determining the tint strength match to the standard. Those results were graphed and appear as *Figures* 2-4. The equal tint strength formulations and the physical properties of these formulas are given in *Tables* 14 and 19.

The following discusses each coating separately.

White Alkyd Semi-Gloss Interior Enamel: Briefly, an alkyd interior enamel was prepared based on a suggested formulation from Reichhold Chemical, Inc. As before, microspheres were substituted for the extender pigment, in this case OmyaCarb 6. A third formulation was prepared which replaced the extender plus 20% of the titanium dioxide (TiO_2) with an equal volume of microspheres. Samples of all three coatings were then tinted using a black tinting paste, at a level of 1/2 ounce of tint per gallon of coating.

The microsphere formulations were then blended in increments of 10% by volume yielding 11 paints with varying titanium substitution levels. The standard and these test blends were then measured for Y values on a Macbeth colorimeter. The Y values were graphed versus % microsphere substitution. A straight line was calculated by linear regression, and the blend which matched the unmodified paint was determined along that straight line. For the alkyd, percent of substitution which gives a match was 15.92%, this translates into a replacement of 3.2% of the volume of TiO_2 in the formulation. For this formula, that level is approximately seven pounds of TiO_2 per 100 gallons.

White Urethane Acrylic Topcoat: As with the white alkyd enamel, a standard formulation was prepared from a Bayer, Inc. suggested formulation. A modified formulation was then prepared where the entire extender, in this case a fine particle crystalline silica, was replaced with microspheres. A third coating was also formulated which had extender and 20% of the TiO_2 replaced by microspheres. Other than the fact that this was a catalyzed system, similar blends were made after adding the second component and the resulting films were also measured for Y value. This material was tinted using 1/2 oz of colorant per gallon of catalyzed coating. As in the previous section, the resulting Y values were graphed

Table 17—Tint Strength Match Formulation

2.8 VOC White Acrylic Polyurethane Topcoat

Physical Properties

PVC, %	27.33
NVW, %	74.54
NVV, %	61.67
VOC, g/l	333.00
Stormer, KU	66
Sag resistance	4.5
Leveling	6

Table 18—Tint Strength Match Formulation

White Epoxy-Polyamide Topcoat

	Microsphere Modified Formulation	
Ingredient	**Pounds**	**Gallon**
Component I		
Epoxy resin[a]	366.43	40.92
Pigment dispersant[b]	3.76	0.13
Titanium dioxide[c]	178.54	5.23
Talc[d]	73.29	3.32
Calcium carbonate[e]	—	—
Microspheres[f]	27.29	2.98
Glycol ether[g]	61.79	8.10
Dibasic esters[h]	16.35	1.80
Flow and leveling agent[i]	1.01	0.11
Methyl ethyl ketone	43.42	6.50
Component II		
Epoxy curing agent[j]	153.19	19.17
Glycol ether	52.00	6.79
n-Butyl alcohol	33.35	4.95
Totals	1010.42	100.00

(a) Epon 1001, Shell Chemical Co.
(b) IAF Compound X2280, Ciba-Geigy Corp.
(c) Ti-Pure R-902, E.I. Dupont de Nemours & Co.
(d) MP 12-50 Talc, Pfizer Corp.
(e) Duramite, E.C.C. America, Inc.
(f) Sphericel 110P8, Potters Industries, Inc.
(g) Arcosolve PM, Arco Chemical Co.
(h) D.B.E. Dibasic Esters, E.I. Dupont de Nemours & Co.
(i) BYK 346, BYK-Chemie USA
(j) Epi-Cure 8515, Shell Chemical Co.

Table 19—Tint Strength Match Formulation

White Epoxy-Polyamide Modified with Microspheres

Physical Properties

PVC, %	18.75
NVW, %	70.44
NVV, %	61.40
VOC, g/l	360
Stormer, KU	87
Sag resistance	17
Leveling	6

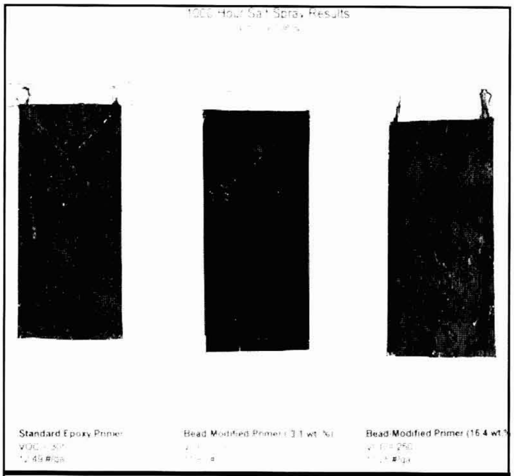

Figure 5—Salt fog test panels showing results of 1,000 hours testing for a standard red iron oxide primer formulation vs. a microsphere modified formulation at equal PVC and a high loading modified microsphere formulation.

and the tint strength match determined.

White Epoxy-Polyamide Topcoat: Following the same procedure as the other catalyzed system, this two-component epoxy-difference polyamide coating was prepared from as the earlier standard coatings. A calcium carbonate extender was replaced by microspheres in the second formulation and extender and 20% of the TiO_2 was replaced in the third.

EPOXY PRIMER CORROSION STUDY

A corrosion study of a red oxide primer was conducted to explore the benefits seen in earlier testing. For this study, a red oxide primer with no microspheres was prepared as a standard, as well as the original modified primer. Also prepared was a primer which used high levels of microspheres to extend the entire formulation. This primer was blended with the original microsphere modified primer to give a ladder of 0, 33, 66, and 100% level of microsphere addition. See *Table* 20 for the standard and modified formulas. Their dry film properties are given in *Table* 21.

Duplicate panels of each coating and the blends were run in a standard salt fog chamber for 1,000 hr. The panels

Table 20—Red Iron Oxide Two-Component Epoxy/Polyamide Primer

	Standard Formula		Sphericel I* Modification		Sphericel 2** Modification	
Material Name	**Pounds**	**Gallons**	**Pounds**	**Gallons**	**Pounds**	**Gallons**
Part A						
Epoxy resin[a]	412.14	45.41	412.14	46.05	342.60	37.75
Flow control agent[b]	10.85	1.29	10.85	1.29	9.02	1.07
Anti-flood/float[c]	4.34	0.15	4.34	0.15	3.61	0.12
Anti-settling[d]	10.67	1.45	10.67	1.47	8.87	1.21
Red irox oxide[e]	86.77	2.45	87.77	2.48	72.12	2.03
Mica[f]	4.34	0.18	4.34	0.19	0.15	0.25
Calcium carbonate[g]	86.77	3.84	87.77	3.91	72.12	3.19
Talc[h]	86.77	3.79	87.77	3.84	72.12	3.15
Zinc phosphate[i]	300.34	11.64	202.34	7.58	165.86	6.43
Microspheres[j]	—	—	36.32	3.96	184.07	20.12
Foam control agent[k]	0.04	0.01	0.04	0.01	0.03	0.01
Xylene[l]	110.03	15.16	110.03	15.37	91.47	12.60
MEK[m]	29.31	4.38	29.31	4.44	24.36	3.64
Part B						
Curing agent[n]	86.19	10.26	86.19	10.40	71.65	8.53
Totals	1228.55	100.00	1169.75	100.00	1121.52	100.00

* Microspheres added to replace a portion of zinc phosphate.
** Microspheres added to extend entire formulation.

(a) Epi-Rez® 2036, Shell Oil Co.
(b) Modiflow®, Monsanto Co.
(c) IAF Compound® X2280, Ciba-Geigy Corp.
(d) MPA® 2000X, Rheox, Inc.
(e) Denox® Iron Oxide, E&B, Inc.
(f) Mica 325, Smithko, Inc.
(g) #10 White, Georgia Marble Co.
(h) VanTalc® 6H, R.T. Vanderbilt Co., Inc.
(i) Zinc Phosphate 222, Wayne Pigment Corp.
(j) Sphericel® 110P8, Potters Industries, Inc.
(k) Paint Additive #7, Dow Corning® Corp.
(l) Xylene, Commerical Solvents Corp.
(m) Methyl Ethyl Ketone, Commerical Solvents Corp.
(n) CA-18®, Cycloaliphatic Amine, Mascon Williams.

were also run in a Prohesion® cabinet using the recommended one hour on/one hour off cycle, as well as the weaker electrolyte solution recommended by the manufacturer. It should be noted that the average film build of these primers was approximately 2 mils and that they were run without topcoats for 1,000 hr.

The salt fog results confirmed the benefits a tighter film can make, even when zinc phosphate is removed. When additional microspheres are used to extend the formulation, the results tend to deteriorate as the PVC increases. However, the results were substantially better than the standard without microspheres (see *Figure* 5). The Prohesion cabinet results all appeared about equal after 1,000 hr of exposure. This test is not as aggressive with the recommended electrolyte solution as salt fog testing and requires longer exposure to see differences.

The following discussion gives an overview of the testing.

A standard primer was developed for this study which incorporated several types of extenders including talc, mica, and calcium carbonate, as well as a typical amount of corrosion inhibitive pigment. From this formulation a modified formulation was derived which substituted a large part of the zinc phosphate in the formulation with microspheres. Earlier testing had shown this formulation to out-perform the standard due in large part to the tighter film possible with microsphere substitution. This modified primer formulation was then further modified by extending the entire formulation by the addition of microspheres. This essentially raised the PVC and the subsequent viscosity, but tended to lower the overall cost and the VOC of the formulation. Both of the modified formulations were prepared in sufficient quantity to use in the blend study. The unmodified primer formulation was also prepared to use as a test standard in the salt fog and Prohesion cabinet testing. The two modified formulations were then blended to give a range of microscope substitutions (four in all). All six coatings were than applied to 1/16 in. thick, sand-blasted, hot-rolled steel panels and placed under test for 1,000 hr in a standard salt fog chamber and a standard Prohesion cabinet. Each coating blend was run in duplicate.

The results of the salt fog testing showed that an appreciable amount of zinc phosphate could be removed from the standard primer formulation, confirming the results obtained in other studies. The best results, showing little or no rusting on the face of the panels, were obtained from the standard microsphere modified coating, which replaced a third of the zinc phosphate by volume with microspheres. When additional microspheres were added to that coating, raising the PVC, the results were all poorer, but even at the highest level of modification, the results were better than the standard primer.

Table 21—Red Iron Oxide Two-Component Epoxy/Polyamide Primer

Physical Properties

	Control	Equal NVV, VOC	High Modification
PVC	40.78	40.78	57.45
Volume solids	53.85	53.85	61.06
Lbs/gal	12.49	11.80	11.22
Cost/gal	12.67	11.72	14.16
Weight solids	71.23	69.54	73.73
VOC (g/L)	304.97	300.75	249.99
Levels with Additives;			
V.S.	64.83	64.83	71.01
WS	79.63	78.43	81.40
Stormer viscosity	95 KU	91KU	105 KU
Gloss, 60°	29.5/16.7	29.5/18.9	20.1/11.0
Pot life	12 hr	12 hr	12 hr
Dry time	5 hr	5 hr	5 hr

In the more realistic weathering of the Prohesion cabinet, the high modified formulation was still quite serviceable showing only a small amount of surface rust. These were excellent results considering the degree to which resin binder had been decreased in this coating.

The formulation with the highest level of microsphere modification, which had the lowest VOC, was not usable without some concession to application methods. Brushing was quite hard with a very high ICI viscosity. This level of modification was probably the upper limit possible, without using an epoxy diluent to lower the viscosity. Spray application would have also required some dilution at the job site. This, however, would not have been that unusual for an epoxy coating. Dilution was not used in our application of these coatings to the test panels, and it is possible that this application difficulty contributed to the somewhat poorer results seen in the salt fog testing.

Conclusion

The results of this study clearly show that definite advantages exist with using hollow light density spheres to replace an extender on an equal volume basis. There are additional monetary benefits to replacing TiO_2 as seen by the results of the tint strength study. The corrosion study was probably the most convincing display of the benefits of hollow spheres. Almost one-third of the inhibitive pigment was removed while achieving better corrosion resistance at equal volume solids and PVC.

The ability to lower VOCs was demonstrated by the equal Stormer viscosity matches possible by removing solvent

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in the modified formulations. Addition of microspheres alone, which reduced VOCs faster, was not always practical due to the higher PVCs obtained.

The overall results show large benefits attributable to the use of spherical extenders which are well worth the investigation.

REFERENCES

(1) Stieg, F.B., "Effect of Extender on Crowding of Titanium Dioxide Pigment," JOURNAL OF COATINGS TECHNOLOGY, *61*, No. 788, 67 (1989).

(2) Braun, J.H., "Crowding and Spacing of Titanium Dioxide Pigments," JOURNAL OF COATINGS TECHNOLOGY, *60*, No. 758, 67 (1988).

(3) Bierwagen, G.P. and Hay, T.K., "The Reduced Critical Pigment Volume Concentration as an Important Parameter in Interpreting and Predicting the Properties of Organic Coatings," *Prog. Org. Coat.*, 3, 281 (1975).

(4) The Cleveland Society for Coatings Technology, "Changes in Hiding During Latex Film Formation: Part II. Particle Size and Pigment Packing Effects," JOURNAL OF COATINGS TECHNOLOGY, *63*, No. 802, 35 (1991).

(5) Skerry, B.S., Chen, C-T., and Ray C.J., "Pigment Volume Concentration and Its Effect on the Corrosion Resistance Properties of Organic Paint Films," JOURNAL OF COATINGS TECHNOLOGY, *64*, No. 806, 77 (1992).

(6) The Cleveland Society for Coatings Technology, "Changes in Hiding During Latex Film Formation: Part V. Effect of Opaque Polymer," JOURNAL OF COATINGS TECHNOLOGY, *65*, No. 816, 86 (1993).

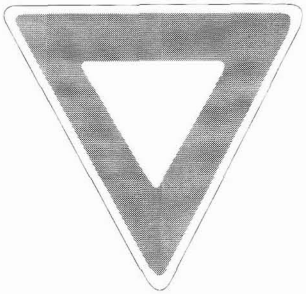
(7) Ryan, B. and Tardy, B., *Handbook of Fillers and Reinforcements for Plastics*, Katz, H.S. and Milewski, J.V. (Eds.), Van Nostrand Reinhold Company, New York, Chapter 18, 1978.

(8) Zeeland Industries Inc., Div. of 3M, 3M Center, Bldg. 220-8E-04, St. Paul, MN 55144-1000.

(9) Ryan, B. and Tardy, B., *Handbook of Fillers and Reinforcements for Plastics*, Katz, H.S. and Milewski, J.V. (Eds.), Van Nostrand Reinhold Company, New York, , Chapter 19, 1978.

(10) Sutker, B.J., "Hollow Spheres for Engineering Thermoplastics," *Plastics Compounding*, September/October (1989).

(11) Potters Industries, Inc., Valley Forge, PA.



Technical Focus Article

Fundamentals of Adhesion

Jamil A. Baghdachi—Innovative Techical Systems Corp.*

ADHESION THEORIES AND MECHANISMS

Adhesion occurs when two bodies are held together by intimate interfacial molecular contact in such a way that a unit is formed. Adhesion is a complex phenomenon related to physical effects and chemical reactions in the "interface." Multiplicity of interfaces in a typical industrial coating system is shown in *Figure* 1. Since each identifiable surface usually will have several layers of adsorbed or chemisorbed molecules associated with it, the number of actual interfaces is unknown. The question is where to draw the line between two surfaces and where actually the adhesion takes place.

Adhesive forces are set up as the coating is applied to the substrate and during curing or drying. The magnitude of these forces will depend on the nature of the surface and the binder (resin, polymer, vehicle). These forces may be broadly categorized as one of two types, primary valency forces and secondary valency forces (*Table* 1). Chemical bonds are examples of the primary valency forces and provide much higher adhesion values than do the secondary forces. Secondary valency bonding is based on much weaker physical forces typified by hydrogen bonds. These forces are more likely to be found in materials having polar groups such as carboxylic acid functionalities than on nonpolar surfaces such as polyethylene.

The actual mechanism of coating attachment is not yet fully understood. However, the forces holding the two bodies together (the paint and the substrate) may be of mechanical interlocking, by way of paint diffusion, electrostatic attraction or true chemical bonding between coating and the substrate. Depending on the chemistry and physics of both substrate surface and the coating used, one or a combination of these postulated mechanisms may be involved. Some of the theories suggested are discussed below.

1. **MECHANICAL THEORY:** This mechanism of coating action occurs when the substrate surface upon which the coating is spread contains pores, holes, crevices, and voids into which the coating solidifies. In this manner the coating, much like a nail in a wood assembly, acts as a mechanical anchor. If the substrate has undercut areas that are filled with cured coating, a mechanical component makes removal of the coating even more difficult, analogous to holding two dovetailed pieces of wood together. Many instrumental analyses and mapping (profile) of various surfaces indicate that the coating can indeed penetrate to complex tunnel shaped undercuts and cracks where, upon curing to a hard mass, it provides mechanical attachment. Adhesion of coatings and various paints to old and weathered coatings as well as adhesion to sand blasted substrates are examples of this type of adhesion mechanism. Iron or zinc phosphate tend to provide larger contact area for coatings and thus enhance adhesion and corrosion resistance. *Figure* 2 illustrates a hypothetical profile of a substrate surface and a coating penetration.

Surface roughness affects the interfacial area between the coating and the substrate. Because the forces required to remove coatings are related to the geometric surface area, whereas the forces holding the coating on to the substrate are related to the actual interfacial contact area, the difficulty of removing a coating can be increased by increasing the surface area. This usually can be accomplished by surface roughening by various mechanical abrasion methods. Comparison of surface cross section of geometric area and the actual interfacial area is given in *Figure* 3. The actual interfacial contact area is generally several times larger than the geometric area. The increase in adhesion as a result of an increase in surface area by sanding is illustrated in *Figure* 4. Obviously due to many other factors, the adhesion will not increase in the same proportion, but noticeable increases are usually observed.

Greater surface roughness is only advantageous if the coating penetrates completely into all irregularities of the surface. Failure to completely penetrate can lead to less coating to interface contact than the corresponding geometric area and will leave voids between the coating and the substrate. Trapped air bubbles in voids allow accumulation of moisture and eventually loss of adhesion will result.

Quite often intercoat adhesion (particularly in automotive coatings) can be improved by scuff sanding the previous cured coating. Especially in the case of basecoat/clearcoat systems where the clearcoat is designed to be smooth, glossy, and with low surface tension, adhesion of the second coat takes place with some difficulties. The problem is even more severe when such a cured coating is baked at considerably higher temperatures than the intended original bake and/or its cure time is extended. In both of these cases, light sanding of the immediate surface has been shown to dramatically improve the adhesion. Although surface roughening generally improves the adhesion, care must be taken to avoid deep and sharp profiles. Deep hills generated by roughening may cause telegraphing (read through) which in some cases may not be desirable. In addition, sharp and deep hills allow the formation of non-uniform films which act as stress points that tend to reduce the coating durability by weakening the adhesion. As long as the films are somewhat fluid, the shrinkage, uneven depths, and three-dimensional changes introduce little unrelieved stress. As viscosity and film stiffness increase and as film adhesion to the substrate develops, substantial stresses are accumulated

Table 1—Bonding Forces and Binding Energies

Force	Type	Energy	Example kcal/mole
Covalent	Primary	15-170	Most organics
Hydrogen bond	Secondary	<12	Water
Dispersion	Secondary	<10	Most molecules
Dipole	Secondary	<5	Polar organics
Induction	Secondary	<0.5	Non-polar organics

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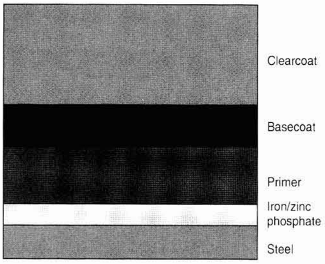


Figure 1—Schematic representation of cross-section of a typical automotive coating system

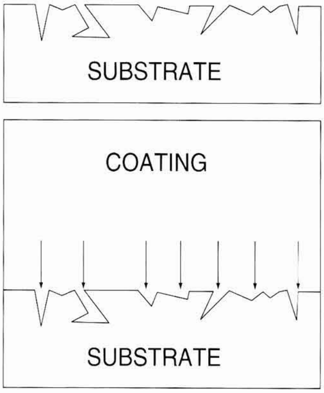


Figure 2—Schematic representation of hypothetical surface profile and a mechanical adhesion

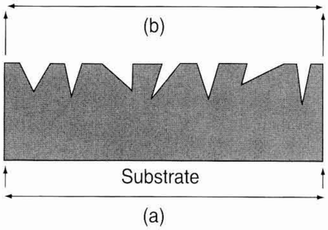


Figure 3—Surface cross-section comparison of (a) geometric area and (b) actual interfacial coating area

and retained in the dry film. Obviously under the fixed application parameters (wet and dry film thickness) the film thickness on top of hills will be less than the valleys, affording variable physical properties. The resultant non-uniform film with high levels of internal stress will enter the service environment where it will be further subjected to solvent attack from repair coatings or weathering, occasionally pushing such films beyond their capacity for stress. Cracking or delamination or other evidence of lost film integrity will be the result.

The adhesion of metal platings to polypropylene and ABS plastics has been shown to arise from mechanical interlocking.[1,2] The metal plating process involves first treating the plastic surface to produce numerous cavities capable of mechanical interlocking, sensitizing with stannous chloride solution, activating by depositing Pd^0 from Pd^{2+} solution, depositing electroless nickel and then electroplating the desired metal, such as chromium.[1] Strong adhesion of the metal plating to the plastics is obtained only when the plastics have been pretreated to produce interlocking cavities.[1,3] Various metal pretreatments[4] may not only change the surface chemical compositions, but also produce interlocking surface sites. Mechanical interlocking contributes greatly, if not critically, to adhesion to such surfaces. *Figure* 5 shows the surface topography of an original and phosphate treated cold-rolled steel. The original surface is relatively featureless and smooth. After phosphating, numerous intermeshing platelets of iron phosphate crystals can be seen on the surface. The interplatelet spaces provide numerous interlocking sites.

2. **Chemical Bonding Theory:** The formation of covalent chemical bonds across the interface is possible and very likely takes place in thermoset coatings. This type of bonding is expected to be the strongest and most durable. It does however, require that there be mutually reactive chemical groups tightly bound on the substrate surface and in the coating. Chemical bonding at the interface is difficult to detect, mostly because of the thinness of the interface. However, as will be discussed, interfacial bonding has been shown to occur, and greatly contributes to the adhesion strength. Some surfaces, such as previously coated surfaces, wood, composites and some plastics, contain various chemical functional groups which, under appropriate condition, can produce chemical bonds with the coating material. Some functional groups capable of forming chemical interactions are shown in *Figure* 6.

Organosilanes are widely used as primers on glass fibers to promote the adhesion between the resin and the glass in fiberglass-reinforced plastics.[5,6] They are also used as primers or integral blends to promote adhesion of resins to minerals, metals, and plastics. Essentially, during application, silanol groups are produced which then react with the silanol groups on the glass surface or possibly with other metal oxide groups to form strong ether linkages. *Figure* 7 illustrates this type of chemical bonding which may take place between a silane functional coating and metal hydroxide on the surface of glass, ceramics, and some metallic substrates.

Coatings containing reactive functional groups such as hydroxyl or carboxyl moieties tend to adhere more tenaciously to substrates containing similar groups. One example of the existence of such a mechanism is the superior adhesion of melamine cured acrylic topcoats over melamine cured polyester primers. One possible explanation is that the residual unreacted hydroxyl functional groups on the surface of the (cured) primer react with melamine curing agents in the topcoat, essentially tying the topcoat to the primer layer. When such a primer is overbaked (longer times and/or higher bake situations), adhesion of topcoat becomes noticeably weak and occasionally nonexistent. The evidence for a possible contribution from the residual hydroxyl come from the fact that the IR spectra of the standard baked primer is rich in hydroxyl groups, (spectrum a) while the overbaked primer (spectrum b) contains very little, if any, hydroxyl functional groups (*Figure* 8). The schematic presentation of the surface chemistry of a standard and overbaked primer and the effect on topcoat adhesion is shown in *Figure* 9.

Chemical bonding also may occur when a substrate contains reactive hydroxyl groups which under an appropriate condition, may react with isocyanate groups from the incoming coating in thermoset polyurethane coatings

Most likely chemical bonding accounts for the strong adhesion between an epoxy coating and a substrate with a cellulose interface. Obviously epoxy groups of an epoxy resin react with the hydroxyl groups of a cellulose at the interface, as evidenced by IR spectroscopy. The chemi-

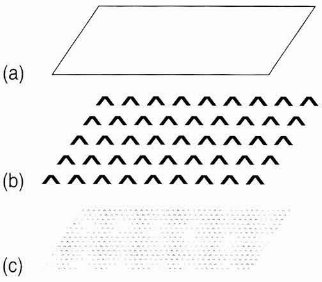
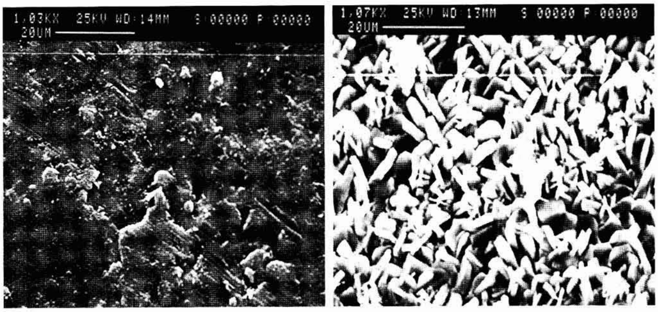


Figure 4—Surface roughness and increase in actual contact area by means of sanding



(a) (b)

Figure 5—Surface topography of an (a) untreated and (b) phosphate treated cold rolled steel. (Henkel Corp., Parker Amchem, Madison Heights, MI)

cal reaction causes the OH stretching band at 3350 cm^{-1} and the C–O stretching bands at 1100-1500 cm^{-1} of the cellulose to diminish, and the epoxide band at 915 cm^{-1} and the anti-symmetric O-bridge stretching band at 1160 cm^{-1} of epoxy resin to disappear.[7] A representative reaction of cellulose molecule with an epoxy functionality is shown in *Figure* 10.

Some polymers adhere weakly to crosslinked polymeric surfaces, failing interfacially. Incorporation of a small amount of certain nitrogen-containing groups has been claimed to greatly enhance the adhesion.[8,9] An example is the strong adhesion of an amino polymer to a crosslinked alkyd resin, due to interfacial amine-ester interchange reaction between the two phases to form amide bonds.

R_1NH_2	+	$RCOOR_2$	→	$RCONHR_1$
Polymer bound amine functionality		Crosslinked alkyd resin functionality		Amide bonds from amine-ester reaction

The amine-ester interchange reaction can readily be seen by using butylamine as a model compound for the amino polymer. When this amine is added to a toluene solution of an uncured alkyd resin, it readily reacts with the latter at room temperature to form dibutyl phthalamide, which crystallizes and precipitates out.

A mixture of an amino polymer and an uncured alkyd resin was examined by FTIR spectroscopy. After baking the mixture, the amino absorption band decreases with concurrent appearance of the amide absorption band, suggesting that amin-ester interchange reaction can indeed occur at the interface.

3. Electrostatic Theory: It is conceivable that electrostatic forces in the form of an electrical double layer are formed at the coating-surface interface. Both coatings and surfaces contain residual electrical charges dispersed throughout the system. Interaction between these charges could account for some adhesion. Electrostatic forces are primarily dispersion forces, and forces arising from the interaction of permanent dipoles. One important attractive force between molecules of a substance that possesses a permanent dipole moment is the *dipole-dipole attraction* between the positively polarized region of one molecule and the negatively polarized region of the other. Induced dipole-induced dipole attractions, called *London forces*, or dispersion forces which are one type of *van der Waals force*, also contribute to adhesion. For certain substrate/coating systems, these forces provide much of the attraction between the coating and surface. It should be noted that such interactions are only operational on a very short range and their effectiveness decreases with the sixth or seventh power of the distance of separation. Because neither of these forces is significant beyond about 0.5 nm (5Å), the need for intimate contact between coating and surface becomes obvious.

4. Diffusion Theory: When two phases of coating and the substrate (polymeric) attain molecular contact by wetting, segments of the macromolecules will diffuse across the interface to various extents, depending on material properties and curing conditions. The phenomenon is a two-stage process; wetting is followed by interdiffusion of chain segments across the interface to establish the entangled network as shown in *Figure* 11.

Dissimilar polymers are usually incompatible because of their long chain nature and their low diffusion coefficients. Consequently, diffusion of an entire macromolecule across the interface is unlikely. However, both theory and experimental data show that local segmental interdiffusion can occur readily forming a diffuse interfacial layer 10-1000Å between two polymers. Indirect evidence of diffusion of coatings includes the effect of contact time, cure temperature, pressure, and molecular structure (molecular weight, chain flexibility, side group, polarity, double bond, and physical compatibility). Direct evidence includes the measurement of diffusion coefficient[10,11] and observation of interfacial structure by electron microscopy,[12] radiothermoluminiscence techniques, and optical microscopy. Obviously, this type of diffusion can best take place in polymeric substrates such as engineering plastics, where the free volume between molecules is large and molecules are much farther apart from each other as compared with metallic substrates.

MECHANICS OF ADHESION DEVELOPMENT

When two dissimilar materials are brought into "intimate" contact, a new interface is formed at the expense of two free surfaces in air. The nature of the interaction of the interface determines the strength of the bond which forms between the coating and the substrate. The extent of these interactions is greatly determined by the wettability of one phase by the other. In the case of coatings that are applied in liquid state, mobility of the coating phase is also of great help. Wetting, therefore, may be viewed as intimate contact between a coating and a substrate. Schematic representation of compete and

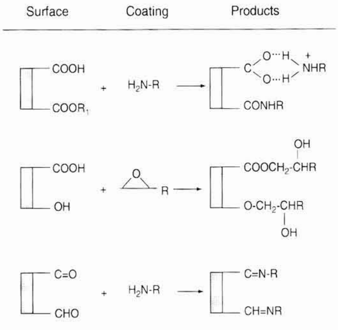


Figure 6—Possible relationships of surface functionalities with amine and epoxy-containing coatings

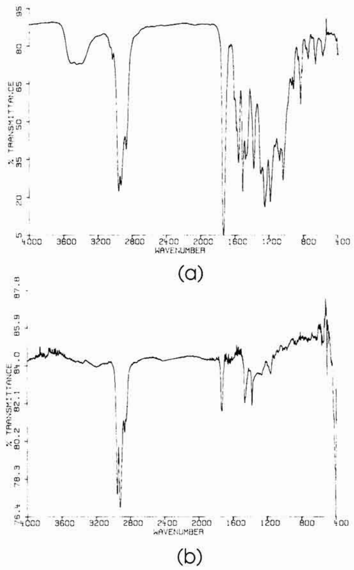
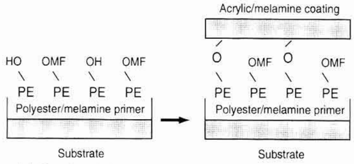
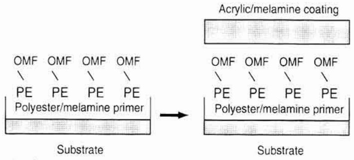


Figure 8—Comparison infrared spectra of (a) standard baked (cured) and (b) overbaked primer coat



(a) Standard primer



(b) Overbaked primer

PE = Polyester; MF = Melamine-Formaldehyde

Figure 9—Schematic representation of surface chemistry of (a) a standard and (b) overbaked primer and its effect on the adhesion to topcoat

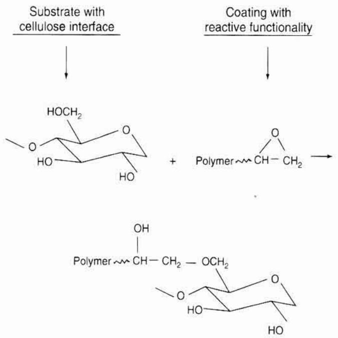


Figure 10—Partial chemical structure of cellulose molecule and its representative reaction with epoxy functionality

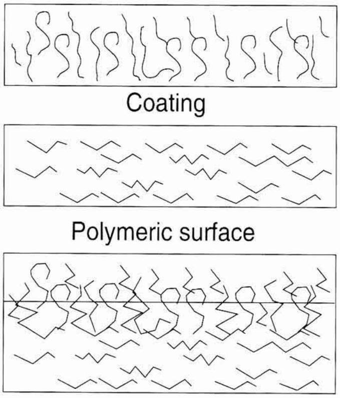


Figure 11—Schematics of diffusion of coatings in polymeric medium

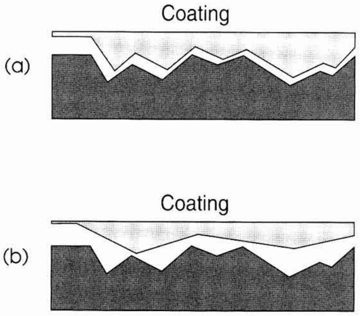


Figure 12—Schematic representation of (a) good wetting and (b) incomplete wetting

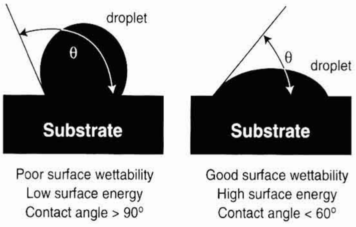


Figure 13—The degree to which a liquid coating wets a solid surface is measured by the contact angle θ

incomplete wetting is shown in *Figure* 12. In addition to initial wetting, in order for adhesion to remain between substrate and the coating it is important that intimate wetting and bonds remain intact after the coating has solidified.

Coatings solidify as a result of:

(a) cooling to below the melting temperature (glass transition temperature, T_g), or

(b) a chemical crosslinking reaction, or

(c) evaporation of solvents and diluents.

An example of a type (a) coating is the thermoplastic powder coating or the melt extrusion lamination of polymers to metals and to other polymers. Type (b) coatings include one- and two-part crosslinkable epoxy, polyurethane, or melamine cured acrylic systems. Printing inks and lacquer paints are examples of type (c) coatings where the pigment binders may also have some crosslinking ability on drying. The wetting of substrates by coatings is, therefore, central to bond formation and, hence, to adhesion.

1. **Wettability and Surface Energetics:** Wetting is a necessary criteria for adhesion. Mechanisms of adhesion previously discussed are only operational if, and only if, effective wetting is present between the coating and the substrates. The wetting of a surface can be described in thermodynamic terms. The surface tension of the coating in its liquid state and the surface energetics of both the substrate and the solid coating are important parameters which can influence the strength of the interfacial bond and adhesion development.

The molecules or atoms at the surface of a homogeneous solid or liquid are in a different environment from those in the interior. In the interior, each molecule is surrounded by similar ones, and the average distance between them is governed by the trade-off between attractive forces pulling the molecules together and strong repulsive forces that prevent different molecules from occupying the same space. Molecules at the surface, however, are no longer attracted equally in all directions. They interact somewhat with the substance, normally air, lying above the surface, while they are attracted inwards by the molecules lying below the surface. The attraction of the underlying molecules tends to pull them inwards, minimizing the number of molecules at the surface, and hence, the surface area. This attraction gives rise to the *surface tension* of liquids and accounts for a liquid droplet behaving as though it were covered by an elastic skin. In addition, the surface molecules are generally at a greater intermolecular spacing than in the bulk and are therefore in a state of higher energy. Work must be supplied to move molecules from the interior to the surface. The increase in the Helmholtz free energy accompanying a unit increase in the surface area of a liquid is, by definition, the surface tension.

2. **Interfacial Thermodynamics:** The degree to which a liquid coating wets a solid surface is measured by the contact angle (θ) as illustrated in *Figure* 13. When $\theta = 0$, the liquid spreads freely over the surface and is said to completely wet it. Complete wetting occurs when the molecular attraction between the liquid and solid molecules is greater than that between similar liquid molecules.[13] The surface tensions are related to the contact angle by an expression from equilibrium consideration.[14]

$$\gamma_{sv} = \gamma_{sl} + \gamma_{lv}\,\mathrm{COS}\,\theta$$

Where γ_{sv} is solid/vapor surface tension; γ_{sl} is solid/liquid surface tension; and γ_{lv} is liquid/vapor surface tension. The surface tension γ_{sv} of a solid that has absorbed a layer of vapor is generally less than that of the solid *in vacuo* γ_s and this reduction is termed the spreading pressure π_s

$$\pi_s = \gamma_s - \gamma_{sv}$$

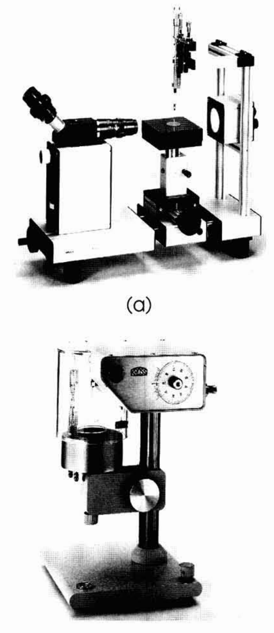


Figure 14—Typical contact angle meter and (b) interfacial tensiometer. (Kruss USA, Charlotte, NC)

However, the liquid surface tension is little affected by the vapor phase, so that $\gamma_{lv} = \gamma_l$. Whether or not a given coating will wet a solid surface depends on the surface tension of both substances. The ability of a liquid to wet and spread on a solid is often described by the spreading coefficient S_{sl}, which is related to the surface tension:

$$S_{sl} = \gamma_{sv} - \gamma_{sl} - \gamma_{lv}$$

A large positive S_{sl} implies that a liquid will spontaneously wet and spread on the solid. A negative S_{sl} implies lack of wetting and spreading by the liquid and the existence of a finite contact angle, $\theta > 0$.

3. **Contact Angle and Critical Surface Tension:** A widely-used method for determining the surface tension of a solid has been developed using contact angle measurements. The calcu-

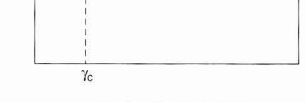


Figure 15—Critical surface tension by Zisman plot for a particular solid surface and a homologous series of liquids

Table 2—Surface Tensions of Typical Solvents Used in Coatings

Solvent	Surface Tension dynes/cm
Water	72.7
Ethylene glycol	48.4
Propylene glycol	36.0
o-Xylene	30.0
Toluene	28.4
n-Butyl acetate	25.2
n-Butanol	24.6
Mineral spirits	24.0
Methyl isobutyl ketone	23.6
Methanol	23.6
VM&P naphtha	22.0
n-Octane	21.8
Lactol spirits	19.9
n-Hexane	18.4

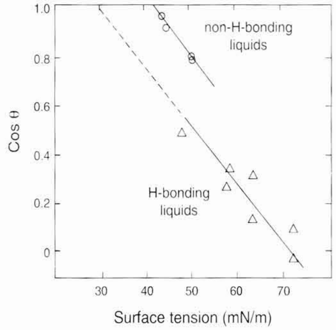


Figure 16—Comparison of Zisman plots of H-bonding and non-H-bonding liquids on polystyrene. (Data taken from reference 25)

Table 3—Surface Tensions of Typical Polymers and Additives Used in Coatings

Polymer	Surface Tension dynes/cm
Melamine resin	57.6
Polyvinyl butyral	53.6
Benzoguanamine resin	52
Poly(hexamethylene adipamide)	46.5
Epon 828®	46
Urea resin	45
Polyester melamine film	44.9
Polyethylene oxide diol Mw 6,000	42.9
Polystyrene	42.6
Polyvinyl chloride	41.9
Polymethyl methacrylate	41
65% Soya FA alkyd	38
Polyvinyl acetate	36.5
Polybutyl methacrylate	34.6
Poly(n-butyl acrylate) Mn 32,000	33.7
Modaflow®	32
Polytetrafluoroethylene Mw 1,088	21.5
Polydimethyl siloxane Mn 1,200	19.8
Polydimethyl siloxane Mn 162	15.7

lation of surface free energy from contact angle measurements has been the subject of much controversy. This subject still remains unresolved because the surface free energy of a solid cannot be measured directly. However, it is not the intention of this monograph to debate all the different issues, but to provide a sound guide for the practitioner through the array of conflicting ideas so that the reader can make a first step in estimating thermodynamic parameters of surfaces.

Approximate and apparent contact angle can be measured by contact angle meters available from various test equipment suppliers. One such device is depicted in *Figure* 14. In this method a drop of several different kinds of liquids is put on the desired surface and the angle is measured. One measure of the quality of a surface is the critical surface tension, γ_c. This surface energy is determined by measuring the contact angle of a series of liquids on the surface, plotting the cosines of the angles versus the surface tension of the respective liquids, and extrapolating to $\cos\theta = 1$ ($\theta = 0°$), as in *Figure* 15. The extrapolated surface tension is called the critical surface tension of the surface. For example, following the above procedure, the critical surface tension polyethylene is determined to be 31 dynes/cm. All liquids with surface tensions equal to, or less than, the critical surface tension will spontaneously spread on the surface if applied as a drop. Therefore, an epoxy resin which exhibits a surface tension of 47 dynes/cm will not wet the polyethylene surface. On the other hand, a silicone mold release agent with a surface tension of 24 dynes/cm will spread on the surface.

The development of this concept is due to Zisman.[15,16] The critical surface tension γ_c has therefore been taken as an approximate measure of the surface free energy γ_s of the solid. It should be noted, however, that the precise value of γ_c is generally dependent on the particular series of liquids used to determine the contact angle.

The critical surface tension concept would seem to indicate that a paint with surface tension less than the critical surface tension would be necessary to achieve good substrate wetting. In practice, it is found that good wetting and adhesion can occur with contact angles above 0°. In general, a low paint surface tension and, therefore, a low contact angle is desirable. Part of the problem with the critical surface tension concept is that different series of test liquids can extrapolate to different critical surface tensions for the same surface. A series of polar hydrogen bonding liquids such as alcohols give a lower γ_c than simple hydrocarbons, which interact less strongly with the same surface (*Figure* 16).[17]

Polyolefins and fluorocarbon polymers have low values of γ_c and are said to have low energy surfaces; these materials are difficult to wet and paint. Metals, ceramics, and polar polymers have high value of γ_c (high energy surfaces), can be readily wet by many paints, and exhibit good adhesion. Data on surface tensions of some typical solvents commonly used in coatings are shown in *Table* 2. In *Table* 3 are the surface tensions of some resins and additives used in coating formulations.

A dramatic example of the importance of wetting is provided by experiments with an epoxy resin and polyethylene.[18] The adhesion is low (if any) when uncured epoxy is poured onto a polyethylene surface and then allowed to cure; however, if the polyethylene is melted and then applied to a surface of cured epoxy, the adhesion is much stronger. In the first case, a high surface energy liquid, e.g., epoxy, will not wet a low surface energy solid, e.g., polyethylene, with low critical surface tension. In the second case, wetting is favored because the liquid polyethylene is of lower surface energy than the solid epoxy. This demonstration is particularly significant because molten polyethylene has a high viscosity, typically about 10^3 Pa.s, compared to liquid epoxy, which has a viscosity of about 1 Pa.s. Apparently, viscosity is not important in this instance when sufficient time is allowed for good wetting to take place.

Zisman plots are not without other drawbacks. Wu[19] and others have pointed out that critical surface tensions often are low compared to surface tensions determined by extrapolation of melt or solution polymer data. Methods to treat contact angle data which are especially suitable for coatings and adhesives have been developed. In the Owns[20] procedure, the contact angles of at least two pure liquids, typically water and methylene iodide, are determined on the surface of interest. The surface tension is regarded as being composed of two contributions, dispersion and polar, such that

$$\gamma_l = \gamma_i^d + \gamma_i^p$$

where γ_l is the surface tension and γ_i^d and γ_i^p are its dispersion and polar components, respectively. The contact angle is related to the surface tension by the equation.

$$\gamma (1 + \cos \theta)/2 = (\gamma_1^d \gamma_2^d)^{1/2} + (\gamma_1^p \gamma_2^p)^{1/2}$$

Where γ_1 is the surface tension of the liquid and γ_2 is the surface tension of the solid. The results, using this equation, are generally in reasonable agreement with results obtained by other methods. In addition to contact angle measurements, standard wettability tests which are quick, robust, and easy to interpret have been developed.

References

(1) Abu-Isa, I.A., *Polymer-Plast. Technology Eng.*, 2 (1), 29 (1973).

(2) Mijovic, J.S. and Koutsky, J.A., *Polymer-Plast. Technology Eng.*, 9 (2), 139 (1977).

(3) Fitchmun, D.R., Newman, S., and Wiggle, R., *J. Appl. Polymer Sci.*, 14, 2441 (1970).

(4) Snogren, R.C., *Handbook of Surface Preparation*, Palmerton, New York, 1974.

(5) Plueddemann, E.P., in *Interfaces in Polymer Matrix Composites*, New York: Academic Press, pp 173-216, 1974.

(6) Plueddemann, E.P., *J. Adhes.*, 2, 184 (1970).

(7) O'Brien, R.N. and Hartman, K., *J. Polymer. Sci.*, C34, 293 (1971).

(8) Uno, K., Makita, M., Ooi, S., and Iwakura, *J. Polymer Sci.*, A-1, 6, 257 (1968).

(9) US Patents, 2, 940, 872; 2, 730, 883; (1957).

(10) Klein, J. and Briscoe, B.J., *Proc. R. Soc. Lond.*, A365, 53 (1979).

(11) Rhee, C.K., Ferry, J.D., and Fetters, L.J., *J. Appl. Polymer. Sci.*, 21, 783 (1977).

(12) Van Oene, H. and Pummer, H.K., *ACS Org. Coatings Plastic Prep.*, 37, (2) 498 (1977).

(13) Fowkes, F.W., in R. L. Patrick (Ed.), *Treatise on Adhesion and Adhesives*, New York: Marcel Dekker, Inc., 1967.

(14) Young, T., *Philos. Trans. R. Soc. Lond.* 95, 65 (1805).

(15) Zisman, W.A., in "Contact Angle, Wettability and Adhesion," *(Adv. in Chem. Ser., 43)*, Gould, R. F. (Ed.), American Chemical Society: Washington, D.C., 1964, Chapter 1.

(16) Zisman, W.A. "Surface Enegertics of Wetting, Spreading, and Adhesion," JOURNAL OF PAINT TECHNOLOGY, 44, No. 564, 41 (1972).

(17) Dann, J.R., *J. Colloid Interface Sci.*, 32, 302, 321 (1970).

(18) Sharpe, L.H., *Contact Angle, Wettability and Adhesion*, American Chemical Society: Washington, D.C., 1964.

(19) Wu, S., *J. Colloid Interface Sci.*, 71, 605 (1969)

(20) Owns, D.K. and Wendt, R.C., *J. Appl. Polymer Sci.*, 13, 1740 (1969).

Color Guide

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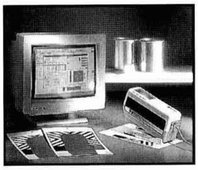

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HUNTERLAB

Color formulation software designed by HunterLab enables the user to formulate new colors, reformulate existing colors, make batch corrections, and work off waste. Featuring point and click simplicity, this color formulation system can be used as a quality control tool for tasks like strength determination of raw materials and pass/fail inspection of final product. EasyMatch™ is compatible with HunterLab's family of spectrophotometers.

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Color Formulation

DSA CONSULTING, INC.

DSA Consulting Inc. has introduced its revised Desk Top Laboratory software. Designed for any computer platform and operating system, these programs begin with a color formulation program that calculates accurate matches for transparent, opaque, and hiding films along with calculations of contrast rations and PVC for match.

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Color-Eye® 7000A

GretagMacbeth

A dual beam bench-top spectrometer designed for dedicated color analysis is available from GretagMacbeth. The Color-Eye 7000A features a motorized adjustable UV control that stores up to three settings. In addition, a motorized specular insert allows the user to measure color shifts as a result of gloss or texture. A touch screen display lets the user view instrument status at a glance.

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Color Tolerance System

COLOR COMMUNICATIONS, INC.

Color Communications Inc. has introduced a color tolerance system that reportedly eliminates differences in color, gloss, or texture. In addition, the system features an upgrade to the color standards on the charts. These standards are 50% larger and are mounted flush to the left or right edge of the color chart.

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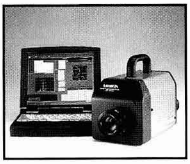
CS-1000

MINOLTA CORP.



The CS-1000 spectroradiometer by Minolta Corp. measures spectral disribution, luminance, color, and correlated color temperature of CRTs/LCDs and lamps/LEDs. The spectroradiometer measuring range is 0.01 to 80,000 cd/m^2, and the unit includes both a standard and macro lens. The wavelength accuracy of the CS-1000 is ±0.3 (center of gravity) over a range of 380 to 780 nm with a measuring angle of 1°.

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SpectroCube 300

DATACOLOR INTERNATIONAL

The SpectroCube 300, a color measurement spectrophotometer designed for OEM use features a self-contained color measuring device to fit many OEM housings. This product features flexible mounting configurations to accommodate rack, panel, or cabinet. SpectroCube is based on diffuse/8° measuring geometry and uses pulsed xenon illumination.

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CLEVELAND—APRIL

"High Gloss Emulsion Brushing Enamels"

President Richard A. Mikol, of Tremco Inc., presented the following 1997-98 officers: President—James Currie, of Jamestown Paint Co.; President-Elect—Lamar Brooks, of Coatings Research Group Inc.; Secretary—Patricia Wagle, of The Flood Co.; Treasurer—Sara Rodts, of The Sherwin-Williams Co.; Assistant Treasurer—Tom Pyzoha, of Maroon Chemical; Member-at-Large—Phil Haagensen, of Chem-Materials Co., Inc.; and Society Representative—Brenda Carr, of Coatings Development Co.

Bob Toth, of the Ohio Paint Council, reported that the comment period for the particulate matter is over and it does not appear that the coatings industry will get support from Congress to have the EPA negotiate on the proposed regulations.

The evening's speaker, Freidun Anwari, of The BFGoodrich Co., presented "HIGH GLOSS EMULSION BRUSHING ENAMELS."

Mr. Anwari stated that water-based products should be available since they are low in toxicity and flammability, meet VOC regulations, and are consumer friendly. Then, the speaker compared the properties of solvent-based alkyds to traditional and new emulsions. He noted that there are many fallacies regarding emulsion technology: (1) polymers are brittle and require high coalescent levels; and (2) emulsions have poor corrosion and chemical resistance.

Mr. Anwari reviewed the three types of brushing enamels and described the conditions of maintenance, architectural, and factory spot repair.

The speaker also discussed minimum film formation temperature (MFFT) vs. hardness, MFFT vs. block resistance, gloss, wet adhesion, corrosion resistance, weatherability, stain resistance, and fingerprinting. He also provided test results that demonstrated these properties in comparison to the traditional technology.

Mr. Anwari focused his discussion on formulation considerations. The first system discussed was the coalescent/cosolvent system. It includes a combination of slow and fast cosolvents. Hydrophilic or hydrophobic coalescents can be used; however, all hydrophilic coalescents reduce thickener efficiency. Aggressive cosolvents can increase wet adhesion.

The second system discussed was the thickener system. Usually when formulating one would use a two-thickener system: one having a high KU with a low ICI efficiency and another with a KU with a high ICI efficiency. The speaker described the commonly used types of thickeners as well.

Mr. Anwari concluded by stating that with proper selection, new technology emulsions can approach the performance of alkyds. MFFT, hardness, flexibility, and block resistance can be independently varied for new technology emulsions. Proper formulation is critical for maximum performance. However, new technology emulsions allow for much greater latitude.

Q. Which coalescent is the best?

A. Four parts DM with one part PPH. When applying to metals, it is best to stay away from glycols.

JENNIFER RUMBERG-VAN SCOTER, *Secretary*

LOS ANGELES—MAY

Awards Night

Three LASCT members were presented with 50-Year Service Awards. Honored at this meeting were Hugh J. Miles, of H.J. Resins Co., Inc.; Dan Heisler, retired; and Joe King, retired. In addition, 25-Year Service Awards were presented to Brian Bradstock, of S-W Diversified Brands; John Boeheim, retired; Harry Benetatos, of Waymire Drum Co., Inc.; Harry Esqueda, of Tnemec Co. Inc.; Benita Ko, retired; Bill Pompeo, of Behr Process Corp; and John Warner, retired.

The Outstanding Service Award was given to Dane Jones, of Cal Poly State University, San Luis Obispo. Dave Muggee, of E.T. Horn Co. received the Honorary Member Award. Also, Max Wills, of Cal Poly State University, San Luis Obispo was recognized for his research on VOC and his presentation on behalf of the LASCT and the university at the 1996 FSCT Annual Meeting in Chicago.

Nominating Committee Chair Henry Kirsch, of Trans Western Chemicals, announced that the Committee has found a candidate for the office of Secretary. Darin Everhart, of Behr Process Corp., has met the qualifications for the position.

Environmental Committee Chair Dave Muggee, of E.T. Horn Co., reported that nine new chemicals have been added to the Proposition 65 list of carcinogens or reproductive toxins. Of the nine chemicals, nitromethane may be of interest to the industry.

In addition, Mr. Muggee stated the EPA has not issued paperwork for the TRI form R reporting but still expects the data to be turned in by July 1, 1997.

Also, Mr. Muggee reported that reauthorization of a hazardous materials law proposed to Congress would allow DOT inspectors to open and examine materials labeled as hazardous or a package believed to contain a hazardous material. The Supreme Court has ruled that closely regulated industries are subject to warrantless searches as long as they are reasonable.

Steve Seneker, of ARCO Chemical Co., discussed "A NEW CLASS OF POLYPROPYLENE GLYCOLS."

These products are made with a unique catalyst system leading to a narrow molecular weight distribution with low "Monol" content. Mr. Seneker described making polyurethane pre-polymers from these polypropylene glycols and how they were subsequently converted to urethane dispersions.

JOE REILLY, *Secretary*

PACIFIC NORTHWEST VANCOUVER SECTION—APRIL

"Rheology Testing"

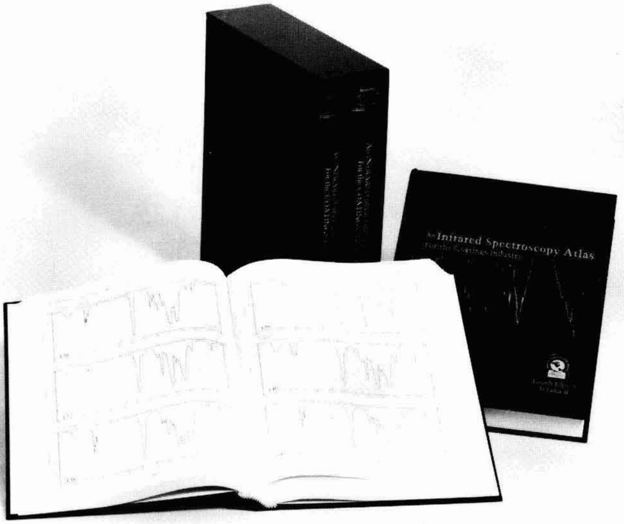
Environmental Committee Chair Paul Andreassen, of Consolidated Coatings Corp., extended an invitation of behalf of the Environmental Managers Association to attend their upcoming meeting.

Tom Fairley, of Calcoast Labs Canada Inc., appealed to the members for applications for the Bill Biddle Scholarship. There is $1,400 available for a member to attend a Cal Poly course.

Scott Krane, of Haake Instruments, presented "RHEOLOGY TESTING FOR THE PAINT INDUSTRY."

KELVIN J. HUGET, *Secretary*

An Infrared Spectroscopy Atlas for the Coatings Industry



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This revised and expanded two-volume, fourth edition contains a compilation of more than 2,500 spectra, fully indexed, of materials commonly used in the coatings industry. All spectra have been generated on high resolution Fourier Transform spectrophotometers with recorded spectral ranges covering the region between 4,000 and 400 cm $^{-1}$.

Authored by experts in the field of coatings infrared analysis, the 1024-page text consists of eight fundamental and comprehensive chapters, including theory, instrumentation, IR instrumentation accessories, sample preparation, and qualitative and quantitative analysis.

A fully indexed literature survey represents the most complete bibliography published in this type of text. It is organized into sections such as theory, general information, reviews, instrumentation, experimental techniques, compilation of spectra, quantitative analysis, coatings, polymers applications and pigment applications. Each section is in chronological order.

This handsome set is packaged in a sturdy slip case for easy shelf storage.

Also, a computerized database of all the spectra featured in the Atlas has been developed by the Nicolet Instrument Corp., in cooperation with the Federation. The Nicolet Coatings Technology Database is available at additional cost from Nicolet to assist in computer searching during quantitative infrared analysis.

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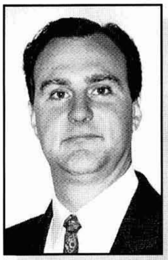


M. Draving

Mitchell Draving has joined ECC International, Roswell, GA, as Technical Marketing Leader for the company's Performance Minerals Group. A member of the Dallas Society, Mr. Draving will be responsible for technical service, product development, and product training for calcium carbonate and kaolin clays for the paint and coatings, adhesives, caulks, and sealants industries.

Georgia Marble, Kennesaw, GA, has promoted **Brian Mills** to Vice President of Sales for its Industrial and Consumer Divisions. Mr. Mills joined the company in 1996 as Director of Industrial Sales. He is a member of the Southern Society—Atlanta Section.

Elizabeth Armstrong has been appointed General Manager Resins (Worldwide) for Zeneca Resins, Waalwijk, The Netherlands. Dr. Armstrong, who succeeds **Stuart Palmer**, joined the company in 1996.

Brian Quinn has been appointed Business Director of the European operations of Fabricolor, Inc., Paterson, NJ. Mr. Quinn will be responsible for creating a technically based sales and distribution organization covering the European Economic Community and the Middle East.

Karen Winkowski has joined Hüls America Inc. as a Scientist for its Industrial Biocides business group. Dr. Winkowski's work will include the research and development of microbiological test methods for industrial preservatives, fungicides, and algaecides.

Richard H. Trampenau has been appointed Vice President for Commercialization for International Specialty Products (ISP), Wayne, NJ. Mr. Trampenau will work with all of ISP's business units on technology licensing, marketing alliances, acquisitions, and selected commercial development opportunities.

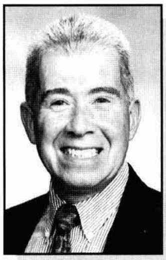
International Specialty Products (ISP), Wayne, NJ, has elected **Andrew G. Mueller** to the position of Executive Vice President, Operations. Mr. Mueller will report to **Peter R. Heinze**, President and Chief Operating Officer of ISP.

Akzo Nobel Bestows Stephanie M. Gleason with 10th Annual Hanna Award

Stephanie M. Gleason, of Miami View Middle School, South Charleston, OH, received the 10th Annual Hanna Award in Chemical Coatings for the Best Project at Ohio Science Day. Ms. Gleason's project, "Rust Buster 2—The Alternative Use for Tobacco," explored the corrosion-inhibiting properties of certain chemical constituents of the tobacco plant. The Hanna Award, consisting of $500 and an engraved plaque, is given by Akzo Nobel Coatings Inc., Columbus, OH.

S.M. Gleason

Elf-Atochem North America, Inc., Philadelphia, PA, has appointed **Wayne Skilton** as Staff Technician at the company's fluoropolymer research and development facility in King of Prussia, PA. In this position Mr. Skilton will establish and maintain a materials property database for all experimental grades of Kynar® polyvinylidene fluoride (PVDF) resin.



D.F. Tompkins

David F. Tompkins, Vice President of Loos & Dilworth, Inc., Bristol, CT, has been appointed a global strategic partner for its BP Chemicals Polybutene product line. Mr. Tompkins will be responsible for the strategic direction of the company's polybutene line for the adhesives, sealants, coatings, lubricants, and rubber markets. He is a member of the Philadelphia Society.

The Society of the Plastics Industry (SPI), Washington, D.C., presented the Midwest Section Founders Award to **Maureen Steinwall**, of Steinwall, Inc., Coon Rapids, MN. Ms. Steinwall is the first woman to be recognized with this award, which recognizes exceptional service to the plastics industry and SPI.

Geoff Holton has been named Technical Sales Specialist for Harcros Organics. Mr. Holton will provide technical sales support for the company's branch offices in the southeastern United States.

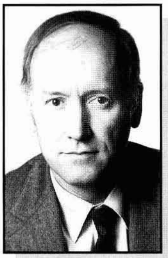
Janet R. Katz was named Manager, Inside Sales & Technical Support for The M.F. Cachat Co., Cleveland, OH. Ms. Katz will be responsible for selected key accounts and coordination of technical support for seven Midwestern states.

The Inter-Society Color Council (ISCC), Reston, VA, has selected **Ann Campbell Laidlaw** as the recipient of its Nickerson Service Award. Ms. Laidlaw, Manager of Applications at SheLyn, Inc., Greensboro, NC, has served on ISCC's Board of Directors. This award recognizes outstanding long-term contributions toward ISCC and its aims and purposes.

Brawn Mixer, Inc., Holland, MI, has announced the addition of **Paul Malik** to its staff as Manager of Marketing and Sales. Mr. Malik's will develop the company's rep organization.

Joyce Bellefeuille has joined the staff of United States Filter Corp., Lowell, MA, as CDI™ Systems Product Manager. Ms. Bellefeuille will be responsible for product support and management of the company's proprietary continuous deionization systems.

The American Chemical Society's Division of Polymeric Materials: Science and Engineering (PMSE) will present the 1997 Tess Award in Coatings to **Werner J. Blank**, of King Industries, Inc., Norwalk, CT. Mr. Blank delivered the Mattiello Lecture during the 1981 FSCT Annual Meeting. In addition, he has au-thored 25 technical papers and 10 text book chapters. Mr. Blank has been granted 30 U.S. patents as well.



W.J. Blank

N. Pappas

D.L. Blankenship

Witco Corp., Greenwich, CT, has elected two new members to the company's Board of Directors. The new directors are **Nicholas Pappas**, recently retired Vice Chairman of the Board of Rollins Environmental Services, Inc. and **Don L. Blankenship**, Chairman, President, and Chief Executive Officer of A.T. Massey Coal Co.

Roy F. Weston, Inc., West Chester, PA, has named Executive Vice President **Patrick G. McCann** to the position of Chief Operating Officer. Mr. McCann brings more than 20 years of experience to this position.

Michael Caruso has been named Senior Sales Engineer for CSM Environmental Systems, Inc., Mountainside, NJ. Mr. Caruso will be responsible for the worldwide sales of the company's air pollution control products and services.

Ocean Optics, Inc., Dunedin, FL, has announced several appointments to the company's staff. Taking on new responsibilities and titles are the following: **Charles Neel** has been named Manufacturing Manager; **Brian Grabbe** was appointed to the position of Materials Manager; **Brenda Winans** and **Brian Rogers** accepted positions as Electro-Optic Technicians; **Donna Salamida** was named Optical-Mechanical Technician; and **Jeffrey Milyard** has joined the staff as Technical Service Representative.

Reichhold Chemicals Inc., Research Triangle Park, NC, has appointed **Patrick A. Jones** to the position of Business Manager, Epoxy Products. In this capacity, Mr. Jones will develop and implement a corporate strategy for the company's epoxy resins business throughout North America, South America, and Europe.

Donald L. Washabaugh has joined the Technical Sales Staff of CheMarCo Inc., Greenville, SC. Mr. Washabaugh brings experience in the coatings industry in technical, quality control, sales, and production management to his new position.

Computational Systems, Inc., (CSI), Knoxville, TN, has announced four recent senior management appointments. **Kevin Carey** has been named Vice President of Acquisitions and Mergers.

David Lambacher has joined CSI as Vice President of North American Sales and Marketing.

Bob Wilson has been named General Manager of Paragon Field Services.

Grahame Fogel has been named General Manager of Paragon Training.

Henri Dyner has been promoted to the position of President and Chief Operating Officer for Sun Chemical Corp., Fort Lee, NJ. Mr. Dyner will continue to oversee Sun Chemicals' European operations.

David A. Lamoureux Jr. has joined the Process Development Group at R.T. Vanderbilt Co., Inc., Norwalk, CT. Prior to his new position, Mr. Lamoureux served as Plant Manager for ChemDesign Corp.

Literature Review

Waterborne and Solvent-Based Epoxies and Their End-User Applications

Edited by:
P.K.T. Oldring
P.K.H. Lam

Published by:
SITA Technology Ltd.
3 Ridgeway Gardens
Wimbledon
London SW19 4SZ England
1996, xii + 490 pages, $130

Reviewed by: Robert F. Brady, Jr.,
Washington, D.C.

More than 30 years ago environmental and worker safety considerations began to transform the life of the coatings formulator. The coatings industry responded with many clever chemistries which used well-established resins in new and environmentally benign ways. This book focuses on the epoxy resins used in coatings and describes the modern technologies now available for epoxies, arguably the most versatile of resins for coatings.

This volume contains the efforts of eight authors, skillfully blended by the editors, P. Oldring and P. Lam, who wrote about 60% of the book himself. It begins with a brief introductory chapter which contains information on the toxicity of epoxy resins and the concern that bisphenol A might function as a mimic of estrogen. This information is a part of the daily life of the coatings chemist nowadays, and the authors are to be complimented for making this knowledge readily accessible. The following three chapters comprise the majority of the book and thoroughly cover the chemistry of epoxy and modified epoxy resins, curing agents, catalysts, and the chemistry of curing reactions. Waterborne, solvent-borne, and unsolvated resins are covered, and the chemistries of ambient and elevated-temperature cures are described. These chapters are extensively referenced, but the references were not prepared with care. Patent numbers and assignees are given, but authors and dates are not.

There are six chapters on industrial, automotive, heavy-duty, and metal decorating coatings, coil coatings, and coatings for protection of concrete and metal. Within these chapters are contained discussions on resins and starting point formulations for a range of powder, radiation-cure, electrospray, electrodeposition, water-soluble, and water-dispersible coatings. Because much of this technology is proprietary, very few references are given. Unfortunately, many of the formulations specify ingredients only as "epoxy resins," "glycol ether," and "acid catalyst." This will not be a barrier to an experienced formulator who knows raw materials and their properties, but it does reduce the value of the formulations to the novice.

The book contains many tables, figures, and molecular formulae, all clearly drawn. It is sturdily bound and contains an extensive subject index. Its few flaws do not diminish its value as a reference for today's epoxy formulator, and this book will take its proper place among the few reference texts which deal with modern epoxy coatings.

Equipment

Twist Mount Mixers

Designed for mixing production finishes and coatings in bulk containers, the Cleveland Twist Mount Mixer features a sealed tank flange with impeller shaft and special quick connect coupling welded as an assembly to the tank. Available from EMI Inc., the six models are equipped with either air or TEFC electronic motors ranging from 1/3 to 1 HP. Explosion proof models are optional.

Circle No. 30 on Reader Service Card

Perl Mill

Drais Mannheim has introduced the newly developed double cylinder Couette Perl Mill Cosmo®. This product features two ring-cylindrical gap-shaped chambers, which are formed between a smooth hollow cylinder rotor and two smooth cylindrical working surfaces of the stator housing. Some preferred applications include dispersing of thermosensitive products, pharmaceuticals, and cosmetics.

Circle No. 31 on Reader Service Card

Inert Atmosphere Oven

The No. 799 Grieve oven is an electrically heated inert atmosphere cabinet oven used to process ceramic components. This oven has a maximum operating temperature of 750°C (1,382°F) and workspace dimensions of 38 in. by 38 in. by 50 in. A 60KW heat input has been installed in an alloy wire high-temperature plug heater. In addition , a 3,000 CFM, 3 HP alloy recirculating blower provides horizontal airflow across the workload inside 12 in. insulated walls.

Circle No. 32 on Reader Service Card

Fiberglass Mini-Sump

Containment Technologies' new fiberglass mini-sump enables the user to retrofit submersible pumps and associated piping for EPA compliance. The mini-sump is 20 in. tall and mounts to the top of the pump riser with a flange adapter. The bolt-down gasketed lid prevents water entry.

Circle No. 33 on Reader Service Card

DCF Filters

Ronningen-Petter offers steam or water jackets for DCF Series Clean-In-Place Filters. These jackets help maintain temperatures for heat sensitive materials. Designed for highly viscous streams and potentially hazardous contaminants, DCF filters feature permanent media which replaces disposable media.

Circle No. 34 on Reader Service Card

Homogenizer/Filter/Extruder

A high pressure homogenizer/filter/extruder, EmulsiFlex™-C5, reaches a capacity of 3-5L/h, with a minimum sample volume of 7 mL. Available from Avestin, Inc., this product features stainless steel wetted parts that are autoclavable. In addition, the entire instrument can be made autoclavable.

Circle No. 35 on Reader Service Card

Oven Tracker

Datapaq has introduced the Oven Tracker XL, which features an enhanced version of Datapaq's Windows™ software. The product's Datalogger, half the size of the previous logger, reportedly records more than eight times the readings (50,000), is three times more accurate (+/- 0.5°C) and the readings intervals, with time or temperature triggers, are programmable. Four, six, or eight channel dataloggers are available.

Circle No. 36 on Reader Service Card

Laboratory Apparatus

Infrared Microscopes

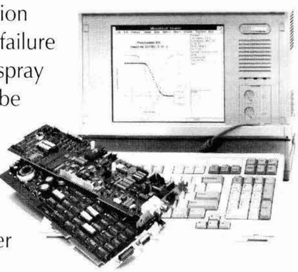
Spectra-Tech, Inc., has introduced the ATR Objective for use exclusively on Nicolet and Spectra-Tech microscopes. This objective features single reflection and micro-ATR geometry. The objective is offered with a zinc selenide crystal; however several optional crystals, such as diamond, silicon, and germanium, are available. This product is designed for analyzing contaminants, glass fiber, coatings, and materials on hard substrates.

Circle No. 37 on Reader Service Card

Lab Dyeing Machine

A laboratory dyeing unit that provides sample dyeing on all fiber types has been developed by Datacolor International. The AHIBA EasyDye® can handle liquid ratios down to 1:3 with man-made fibers and 1:5 with natural fibers. This product is directed by a one-program controller.

Circle No. 38 on Reader Service Card



Circle No. 295 on Reader Service Card

UV Platform

Fusion UV Systems, Inc., has introduced a Versatile Irradiance Platform with interchangeable bulbs in the 308, 535, and 350 nm ranges. The new system, named VIP, features an Irradiator platform designed so that all new bulbs will be useable in a common bulb cavity. This feature will reportedly allow manufacturers to customize their UV-curing requirements to the particular spectral output of the chemistry being used.

Circle No. 39 on Reader Service Card

Paints/ Coatings

Precision Color

Raabe Corp. offers touch-up paint in acrylic lacquer, acrylic enamel, and a 3.5 pounds per gallon high-solids enamel paint system. Precision Color™ paint systems can be color matched to a customer-provided color standard. These paints are available in aerosols, brush-in-cap bottles, paint pens, and a variety of liquid containers. Private labeling, formula development, and specialty packaging services are also available.

Circle No. 40 on Reader Service Card

Odor-Free Paint

Duron Paints and Wallcoverings has created a new interior latex paint that reportedly emits no detectable odor. Genesis Odor-Free is produced without solvents; therefore, the product gives off very little odor and contains no VOCs.

Circle No. 41 on Reader Service Card

Electroless Nickel Coating

Illumi-Layer™, developed by Surface Technology, Inc., is a composite electroless nickel coating containing phosphorescent, light emitting particles. Under normal incandescent or fluorescent light, the coatings are silvery-gray in color. Various colors are available depending on the particles chosen for incorporation into the coating.

Circle No. 42 on Reader Service Card

Diffuse Coating Service

Optoblack™ diffuse coating for use over the 0.25 to 16Êm wavelength is available from Labsphere. The coating reportedly displays high lambertian characteristics and light absorption properties necessary for stray light control, thermal control, visual target cues, and calibration. Optoblack is a water-based, spray-applied coating.

Circle No. 43 on Reader Service Card

Books/ Publications

Light Stabilizers

A book published by Vincentz Verlag discusses the advantages of light stabilizer blends, as well as measures that can be taken to prevent undesirable side effects. Written by Andreas Valet, *Light Stabilizers for Paints* describes UV absorbers, antioxidants, HALS, quenchers, etc., with comments on their mode of action. Information on the practical aspects of light stabilizers, whether in automotive paints or wood finishes is also included.

Circle No. 44 on Reader Service Card

Corrosion

NACE International has published the following four books on corrosion. *Corrosion Testing Made Easy: Microbiologically Influenced Corrosion* addresses microbiologically influenced corrosion in various operating systems. *Forms of Corrosion—Recognition and Prevention* features 180 new case histories of corrosion failures in various industries. *Reference Electrodes* focuses on experimental aspects of reference electrodes. *Practical Guidelines for Corrosion Protection in the Mining and Metallurgy Industry* presents a practical outline of some of the problems encountered with corrosion in the mining and metallurgy industry.

Circle No. 45 on Reader Service Card

Polymer Technology

A product list entitled "A World of Paint and Coating Polymer Technology" is available from Nacan Products Ltd., Resin Division. This four-page guide features a complete listing of Nacan's polymer product offerings in chart form. Each product listing is accompanied by product attributes and suggested applications, as well as information on polymer type and physical properties.

Circle No. 46 on Reader Service Card

Rheometer Catalog

A new 40-page Brookfield Catalog describes the company's line of process and laboratory viscometers, rheometers, and accessories. This catalog includes new programmable viscometers and rheometers and high shear viscometers used for QC and R&D applications. These viscometers are used to measure liquids, slurries, pastes, creams, gels, chemicals, foods, printing inks, paints, oils, cosmetics, etc.

Circle No. 47 on Reader Service Card

ISO 14000

A new booklet available from Excel Partnership, Inc., provides answers to questions about the ISO 14000 series of environmental management system standards. This publication provides basic information about the ISO 14000 series and describes who needs ISO 14000, how to implement and register for ISO 14000, and the benefits to business.

Circle No. 48 on Reader Service Card

Carbon Blacks

Raven® carbon blacks for paint and coatings applications are detailed in a brochure from Columbian Chemicals Co. The 20-page brochure provides information on 27 different Raven grades and discusses the properties, advantages, and applications range for these products.

Circle No. 49 on Reader Service Card

Circulation Attritors

A brochure profiles the HQ Series High Speed Circulation Attritor. Published by Union Process, this brochure discusses the circulation grinding process and the general advantages of utilizing circulation grinding. A schematic drawing of the HQ Attritor illustrates the vertical grinding process. An engineering data chart lists specifications for three different models.

Circle No. 50 on Reader Service Card

Miscellaneous

Spill Response Kits

Waterproof, softside emergency spill response kits are available from Green Stuff Absorbent Products, Inc. This kit features Green Stuff® absorbent which reportedly has the capacity to absorb paint, related products, and virtually any chemical up to 15 times its own weight. Standard kits are available with socks, pads, pillows, and protective gear.

Circle No. 51 on Reader Service Card

Plastic Drums Video

A video produced by The Society of the Plastic Industry, Inc.'s (SPI) Plastic Drum Institute, describes the plastic drum's competitiveness with other industrial containers in product protection, performance, and environmental impact. The 30-minute video presents the findings of the PDI's comprehensive research program on the environmental attributes of plastic drums, as well as the performance of drums made with recycled content.

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CC ☐ Manufacturers of Equipment and Containers
DD ☐ Sales Agents for Raw Materials and Equipment
EE ☐ Government Agency
FF ☐ Research/Testing/Consulting
GG ☐ Educational Institution/Library
HH ☐ Paint Consumer
JJ ☐ Other

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KK ☐ Management/Adm.
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MM ☐ Quality Control
NN ☐ Research & Development
PP ☐ Technical Sales Service
QQ ☐ Sales & Marketing
RR ☐ Consultant
SS ☐ Educator/Student/Librarian
TT ☐ Other

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004	024	044	064	084	104	124	144	164	184	204	224	244	264	284
005	025	045	065	085	105	125	145	165	185	205	225	245	265	285
006	026	046	066	086	106	126	146	166	186	206	226	246	266	286
007	027	047	067	087	107	127	147	167	187	207	227	247	267	287
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012	032	052	072	092	112	132	152	172	192	212	232	252	272	292
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014	034	054	074	094	114	134	154	174	194	214	234	254	274	294
015	035	055	075	095	115	135	155	175	195	215	235	255	275	295
016	036	056	076	096	116	136	156	176	196	216	236	256	276	296
017	037	057	077	097	117	137	157	177	197	217	237	257	277	297
018	038	058	078	098	118	138	158	178	198	218	238	258	278	298
019	039	059	079	099	119	139	159	179	199	219	239	259	279	299
020	040	060	080	100	120	140	160	180	200	220	240	260	280	300

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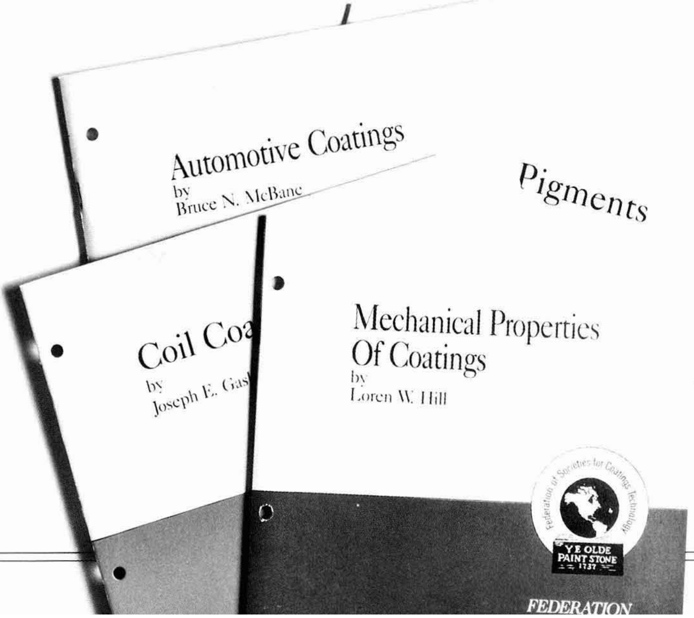
Automotive Coatings
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Bruce N. McBane
Pigments
Coil Coa
by
Joseph E. Gas
Mechanical Properties
Of Coatings
by
Loren W. Hill
YE OLDE
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FEDERATION

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. Web site: http://www.coatingstech.org

1997

(Nov. 3-5)—ICE '97—FSCT Annual Meeting and International Coatings Expo and Technology Conference (Formerly Annual Meeting and Paint Industries' Show). Georgia World Congress Center, Atlanta, GA.

1998

(Oct. 14-16)—ICE '98—FSCT Annual Meeting and International Coatings Expo and Technology Conference (Formerly Annual Meeting and Paint Industries' Show). Ernest N. Morial Convention Center, New Orleans, LA.

SPECIAL SOCIETY MEETINGS

1997

(Sept. 12)—"Corrosion Control Through Coatings." Conference co-sponsored by the Los Angeles Society and California State Polytechnic University at Pomona. Kellogg West Conference Center, Pomona, CA. (LASCT, 11278 Los Alamitos Blvd., #104, Los Alamitos, CA 90720; fax: (310) 594-6862).

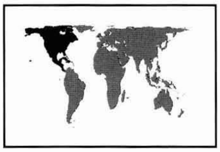
1998

(Feb. 18-20)—25th Annual International Waterborne, High-Solids, and Powder Coatings Symposium. Sponsored by the Southern Society and The University of Southern Mississippi (USM). New Orleans, LA. (Robson F. Storey or Shelby F. Thames, Co-Organizers, WHS&PC Symposium, Dept. of Polymer Science, USM, Box 10076, Hattiesburg, MS 39406-0076).

(May 11-14)—Eastern Training Conference II. Sponsored by the Philadelphia Society. Valley Forge Convention Center, King of Prussia, PA. (Wayne Kraus, Hercules Incorporated, Research Center, 500 Hercules Rd., Wilmington, DE 19808).

OTHER ORGANIZATIONS

1997—North America



(Aug. 7-8)—"Spectroscopy Instrumentation and Application Seminars." Sponsored by Labsphere, Inc. North Sutton, NH. (Labsphere, Inc., P.O. Box 70, Shaker St., North Sutton, NH 03260).

(Aug. 11-13)—"International Symposium on Polymer Analysis and Characterization (ISPAC-10)." (Stephen T. Balke, Dept. of Chemical Engineering and Applied Chemistry, University of Toronto, Toronto, Ontario, Canada M5S 1A4).

(Aug. 11-15)—AVS National Short Course Program. Sponsored by American Vacuum Society (AVS). Château Laurier Hotel, Ottawa, Canada. (AVS, 120 Wall St., 32nd Fl., New York, NY 10005).

(Sept. 2-4)—"Correctly Applying SPC Tools in Laboratory and Continuous Flow & Batch Processes." Sponsored by Oklahoma State University Engineering Extension. Tulsa, OK. (George Collington, Oklahoma State University Engineering Extension, 512 Engineering North, Stillwater, OK 74078).

(Sept. 4-5)—"Engineering and Construction Contracting Conference." Sponsored by the American Institute of Chemical Engineers (AIChE). Sheraton Harbor Island, San Diego, CA. (AIChE, 345 E. 47th St., New York, NY 10017).

(Sept. 8-12)—"Basic Composition of Coatings." Short course sponsored by University of Missouri-Rolla (UMR), Rolla, MO. (UMR Coatings Institute, 236 Schrenk Hall, 1870 Miner Circle, Rolla, MO 65409).

(Sept. 9-11)—"Industry-On-Campus Tour." Sponsored by The Adhesive and Sealant Council, Inc. Virginia Tech, Blacksburg, VA. (The Adhesive and Sealant Council, Inc., 1627 K St., N.W., Ste. 1000, Washington, D.C. 20006).

(Sept. 10-11)—Sixth Annual Advanced Radiation (UV/EB) Curing Marketing/Technology Seminar. Sponsored by Armbruster Associates, Inc. Marriott Hotel, Newark Airport, Newark, NJ. (David C. Armbruster, Armbruster Associates Inc., 43 Stockton Rd., Summit, NJ 07901).

(Sept. 12)—"Corrosion Control Through Coatings." Conference co-sponsored by the Los Angeles Society and California State Polytechnic University at Pomona. Kellogg West Conference Center, Pomona, CA. (LASCT, 11278 Los Alamitos Blvd., #104, Los Alamitos, CA 90720; FAX: (310) 594-6862).

(Sept.14-15)—Inter-Society Color Council (ISCC) Annual Meeting. Marriott Inner Harbor, Baltimore, MD. (Robert T. Marcus, ISCC Publicity Chairman, D&S Plastics International, 100 S. Mitchell Rd., Mansfield, TX 76063).

(Sept. 14-18)—Third Annual ASM Surface Engineering Symposium. Sponsored by The Materials Information Society. Indianapolis, IN. (ASM Member Services Center, Materials Park, OH 44073-0002).

(Sept. 14-19)—"A Systems Approach to Service Life Prediction of Organic Coatings." The Village at Breckenridge, Breckenridge, CO. (Jonathan W. Martin, NIST, Bldg. 226, Rm. B350, Gaithersburg, MD 20899).

(Sept. 15-17)—"Fine Powder Processing." Sponsored by The Particulate Materials Center of The Pennsylvania State University in cooperation with Hosokawa Micron Powder Systems. Penn State Scanticon Hotel and Conference Center, State College, PA. (Particulate Materials Center, 147 Research Bldg. W., University Park, PA 16802-6809).

(Sept. 22-25)—"Safety in Ammonia Plants and Related Facilities." Sponsored by the American Institute of Chemical Engineers (AIChE). Fairmont Hotel, San Francisco, CA. (AIChE, 345 E. 47th St., New York, NY 10017).

(Sept. 22-26)—"Introduction to Paint Formulation." Short course sponsored by University of Missouri-Rolla (UMR), Rolla, MO. (UMR Coatings Institute, 1870 Miner Circle, Rolla, MO 65409).

(Sept. 23-25)—"Greensboro '97 Advanced Productivity Exposition." Sponsored by Society of Manufacturing Engineers (SME). Greensboro Coliseum Complex, Greensboro, NC. (SME, One SME Dr., P.O. Box 930, Dearborn, MI 48121-0930).

(Sept. 29-Oct. 1)—"Fundamentals of Corrosion and Its Control." Sponsored by LaQue Corrosion Services, Wrightsville Beach, NC. (Sherree Darden, LaQue Center for Corrosion Technology, Inc., P.O. Box 656, Wrightsville Beach, NC 28480).

(Oct. 7-9)—"ISA Tech/97." Sponsored by International Society for Measurement and Control. Anaheim, CA. (ISA, 67 Alexander Dr., P.O. Box 12277, Research Triangle Park, NC 27709).

(Oct. 7-9)—Powder Coating '97. Sponsored by The Powder Coating Institute. Charlotte Convention Center, Charlotte, NC. (Vicki Thatcher, Conference Coordinator, P.O. Box 54464, Cincinnati, OH 45254).

(Oct. 14-16)—17th Aerospace Testing Seminar. Sponsored by the Institute of Environmental Sciences and The Aerospace Corp. Los Angeles, CA. (Institute of Environmental Sciences, 940 E. Northwest Hwy., Mount Prospect, IL 60056).

(Oct. 16-17)—"Spectroscopy Instrumentation and Application Seminars." Sponsored by Labsphere, Inc. North Sutton, NH. (Labsphere, Inc., P.O. Box 70, Shaker St., North Sutton, NH 03260).

(Oct. 21-23)—"Cleveland '97 Advanced Productivity Exposition (APEX)." Sponsored by Society for Manufacturing Engineers (SME). I-X Center, Cleveland, OH. (SME, One SME Dr., P.O. Box 930, Dearborn, MI 48121-0930).

(Oct. 22-24)—"Spray Finishing Technology Workshop." Sponsored by Bowling Green State University and ITW DeVilbiss. ITW DeVilbis Training Center, Maumee, OH. (Richard A. Kruppa, Dept. of Technology Systems, College of Technology, Bowling Green, OH 43403-0301).

(Oct. 24-25)—"Fall Decor '97: Paint & Decorating Show." Sponsored by the National Decorating Products Association (NDPA). Cervantes Convention Center, St. Louis, MO. (Teri Flotron, NDPA, 1050 N. Lindbergh Blvd., St. Louis, MO 63132-2994).

(Oct. 26-29)—Fall Convention. Sponsored by The Adhesive and Sealant Council, Inc. Hyatt Regency Dearborn, Dearborn, MI. (The Adhesive and Sealant Council, Inc., 1627 K St., N.W., Ste. 1000, Washington, D.C. 20006).

(Oct. 26-29)—"Adhesive Short Course II." Sponsored by The Adhesive and Sealant Council, Inc. Hyatt Regency Dearborn, Dearborn, MI. (The Adhesive and Sealant Council, Inc., 1627 K St., N.W., Ste. 1000, Washington, D.C. 20006).

(Oct. 26-29)—"End Use Applications Short Course." Sponsored by The Adhesive and Sealant Council, Inc. Hyatt Regency Dearborn, Dearborn, MI. (The Adhesive and Sealant Council, Inc., 1627 K St., N.W., Ste. 1000, Washington, D.C. 20006).

(Nov. 2-4)—110th Annual Meeting and Industry Leadership Conference of the National Paint and Coatings Association (NPCA). Atlanta Hilton and Towers, Atlanta, GA. (NPCA, 1500 Rhode Island Ave., N.W., Washington, D.C. 20005-5597; (202) 462-6272).

(Nov. 3-5)—ICE '97—FSCT Annual Meeting and International Coatings Expo and Technology Conference (Formerly Annual Meeting and Paint Industries' Show). Georgia World Congress Center, Atlanta, GA. (Federation of Societies for Coatings Technology, 492 Norristown Rd., Blue Bell, PA 19422 (610) 940-0777, FAX: (610) 940-0292. Web site: http://www.coatingstech.org).

(Nov. 6-8)—Second North American Research Conference on Emulsion Polymers/Polymer Colloids. Sponsored by the State University of New York. Hilton Head Island, SC. (Angelos V. Patsis, Institute of Materials Science, State University of New York, New Paltz, NY 12561).

(Nov. 12)—"Effects of Surface Finish on Corrosion Testing." Sponsored by the American Society for Testing and Materials (ASTM). San Diego, CA. (ASTM, 100 Barr Harbor Dr., West Conshohocken, PA 19428-2959).

(Nov. 15-17)—1997 Fluid Controls Institute Annual Meeting. LeMeridien, Boston, MA. (Fluid Controls Institute, Inc., 1300 Sumner Ave., Cleveland, OH 44115-2851).

(Nov. 17-20)—ICALEO '97. Sponsored by The Laser Institute of America. Catamaran Resort Hotel, San Diego, CA. (Laser Institute of America, 12424 Research Pkwy., Ste. 125, Orlando, FL 32826).

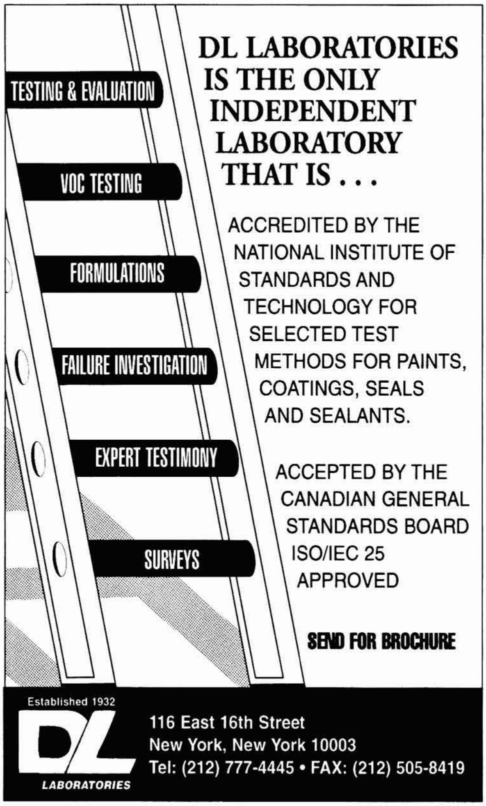
(Dec. 8-10)—Electroless Nickel '97. Sponsored by *Products Finishing* Magazine. Hyatt Regency, Cincinnati, OH. (Cindy Goodridge, Gardner Management Services, 6915 Valley Ave., Cincinnati, OH 45244-3029).

1998—North America

(Jan 13)—PCI Technical Subcommittee on Test Methods and ASTM D01.51 on Powder Coatings. Sponsored by the American Society for Testing and Materials. Sheraton Harbor Island Hotel, San Diego, CA. (Jeffrey Hagerlin, O'Brien Powder Products, 9800 Genard Rd., Houston, TX 77041).

(Jan. 14-17)—"Winter Leadership Conference." Sponsored by The Adhesive and Sealant Council, Inc. The Registry, Naples, FL. (The Adhesive and Sealant Council, Inc., 1627 K St., N.W., Ste. 1000, Washington, D.C. 20006).

(Jan. 20-23)—"Environmentally Compliant Coatings." Course sponsored by The Department of Polymers and Coatings, North Dakota State University. Crowne Plaza Resort, Hilton Head Island, SC. (Debbie



Shasky, Program Coordinator, North Dakota State University, Dept. of Polymers and Coatings, 54 Dunbar Hall, Fargo, ND 58105).

(Feb. 22-24)—"Color and Design: 21st Century Technology and Creativity." Williamsburg Conference sponsored by the Inter-Society Color Council. Williamsburg, VA. (Robert T. Marcus, ISCC Publicity Chairman, D&S Plastics International, 100 S. Mitchell Rd., Mansfield, TX 76063).

(Feb. 23-25)—"Basic Coatings for Sales, Marketing, and General Personnel." Short course sponsored by University of Missouri-Rolla (UMR), Rolla, MO. (UMR Coatings Institute, 236 Schrenk Hall, 1870 Miner Circle, Rolla, MO 65409).

(Mar. 8-12)—AIChE Spring National Meeting/Petrochem and Technochem '98." Sponsored by the American Institute of Chemical Engineers (AIChE). Sheraton New Orleans, New Orleans, LA. (AIChE, 345 E. 47th St., New York, NY 10017).

(Mar. 22-25)—Spring Convention. Sponsored by The Adhesive and Sealant Council, Inc. Buena Vista Palace, Orlando, FL. (The Adhesive and Sealant Council, Inc., 1627 K St., N.W., Ste. 1000, Washington, D.C. 20006).

(Mar. 23-27)—"Basic Composition of Coatings." Short course sponsored by University of Missouri-Rolla (UMR), Rolla, MO. (UMR Coatings Institute, 236 Schrenk Hall, 1870 Miner Circle, Rolla, MO 65409).

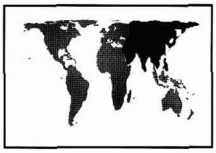
(Mar. 24-26)—"Silicone in Coatings II." Sponsored by The Paint Research Association. Disney World Village, Orlando, FL. (Dip Dasgupta, Paint Research Association, 8 Waldegrave Rd., Teddington, Middlesex TW11 8LD United Kingdom).

(Apr. 20-24)—"Introduction to Paint Formulation." Short course sponsored by University of Missouri-Rolla (UMR), Rolla, MO. (UMR Coatings Institute, 1870 Miner Circle, Rolla, MO 65409).

(May 11-14)—Eastern Training Conference II. Sponsored by the Philadelphia Society. Valley Forge Convention Center, King of Prussia, PA. (Wayne Kraus, Hercules Incorporated, Research Center, 500 Hercules Rd., Wilmington, DE 19808).

(May 17-20)—1998 Fluid Controls Institute Annual Meeting. The Cloister, Sea Island, GA. (Fluid Controls Institute, Inc., 1300 Summer Ave., Cleveland, OH 44115-2851).

1997—Asia

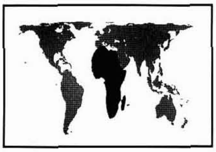


(Oct. 22-24)—"New Developments in Colour Material Science and Technology." 70th Anniversary Conference on Colour Materials Tokyo sponsored by the Japan Society of Colour Material. Arcadia Ichigaya (Shigaku Kaikan), Tokyo, Japan. (Shuichi Hamada, Japan Society of Colour Material, Kitamura Bldg. 5F, 9-12, 2-chome, Iwamoto-cho, Chiyoda-ku, Tokyo 101, Japan).

(Nov. 3-5)—ChinaCoat '97. Sponsored by Paint & Coatings Chemical Industry Research Institute of the Ministry of Chemical Industry and Paint & Coatings Industry General Information Station of the Ministry of Chemical Industry. Shanghai International Exhibition Centre, Shanghai, PR. China. (Sinostar International Ltd., Unit 1501, Connaught Commercial Bldg., 185 Wanchai Rd., Wanchai, Hong Kong).

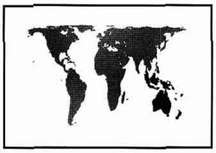
(Nov. 27-29)—Second International Paint, Varnish, Ink and Auxiliary Products Industry Conference and Exhibit. Sponsored by Union of Chambers of Turkish Engineers and Architects (UCTEA). Istanbul Convention and Exhibition Center, Istanbul, Turkey. (Dr. Mehmet Konuray, Ferit Tek Sok. No:20/5, Moda 81010 Kadiköy/Istanbul).

1998—Africa



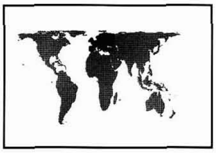
(Mar. 6-8)—"Coatings for Africa '98." Sponsored by The Oil & Colour Chemists' Association's (OCCA) South African Division, the Natal Section, and Surfex Ltd. International Convention Centre, Durban, South Africa. (Christopher Pacey-Day, OCCA, 967 Harrow Rd., Wembley, Middlesex, England HA0 2SF).

1998—Australia



(July 29-Aug. 1)—"Coatings for the Future." Second Trans Tasman Surface Coatings Conference. Co-sponsored by Surface Coatings Association, New Zealand, Inc., and Surface Coatings Association, Australia, Inc. The Carlton Hotel, Auckland, New Zealand. (98 Transtas Conference, P.O. Box 5192, Wellesley St., Auckland, New Zealand).

1997—Europe



(Aug. 18-22)—"Advances in Emulsion Polymerization and Latex Technology." Short course co-sponsored by the Emulsion Polymers Institute, Lehigh University and Georgia Institute of Technology. Berghotel Schatzalp, Davos, Switzerland. (F. Joseph Schork, School of Chemical Engineering, Georgia Institute of Technology, Atlanta, GA 30332-0100).

(Sept.15-17)—"PP '97." Sponsored by Maack Business Services. Zürich, Switzerland. (Maack Business Services, Moosacherstrasse 14, CH-8804 AU/Zürich, Switzerland).

(Sept. 17-19)—"Crystal Growth of Organic Materials." Sponsored by University of Bremen. Bremen, Germany. (Dr. J. Ulrich, University of Bremen, Verfahrenstechnik/FB4, Postfach 330440, D-28334 Bremen, Germany).

(Sept. 23-25)—"Eurocoat '97" Organized by the Union of Associations. Parc des Expositions, Lyons-Eurexpo. (AFTPVA, 5, Rue Etex-75018 Paris, France).

(Sept. 23-25)—"High Temperature Surface Engineering." Conference sponsored by The Institute of Materials. Edinburgh Conference Centre, Edinburgh, Scotland. (Lisa Davies (C712), The Conference Dept., The Institute of Materials, 1 Carlton House Terrace, London, SW1Y 5DB, United Kingdom).

(Oct. 13-14)—"Co-Mold '97." Sponsored by Maack Business Services. Zürich, Switzerland. (Maack Business Services, Moosacherstrasse 14, CH-8804 AU/Zürich, Switzerland).

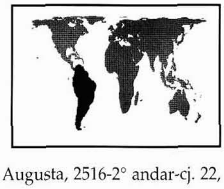
(Oct. 16-18)—"Polveri '97." Sponsored by ANVER (National Coating Association). Veronafiere, World Trade Center, Verona, Italy. (ANVER Palazzo Larice, Edifico M, Via Torri Bianche, 3, 20059 Vimercate MI).

(Oct. 27-29)—"Coating, Inks, and Adhesives for Plastics and Elastomers." Sponsored by The Paint Research Association. Milan, Italy. (Dip Dasgupta, Paint Research Association, 8 Waldegrave Rd., Teddington, Middlesex TW11 8LD United Kingdom).

(Nov. 3-5)—"PET '97." Sponsored by Maack Business Services. Zürich, Switzerland. (Maack Business Services, Moosacherstrasse 14, CH-8804 AU/Zürich, Switzerland).

(Dec. 1-3)—"SP '97." Sponsored by Maack Business Services. Zürich, Switzerland. (Maack Business Services, Moosacherstrasse 14, CH-8804 AU/Zürich, Switzerland).

1997—South America



(Sept. 15-17)—Fifth International Paint Congress and Exhibition on Paint Industry Suppliers. Sponsored by the Brazilian Association of Paint Manufacturers (ABRAFATI). Palacio de Convenções do Anhembi, São Paulo, Brazil. (Congress Organization Secretariat, Especifica S/C Ltda., Rua Augusta, 2516-2° andar-cj. 22, 01412-100-São Paulo, SP-Brazil).

(Oct. 6-9)—"Latin-American Interfinish." Hotel Transamerica's Convention Center, São Paulo, Brazil. (Associação Brasileira de Tratamentos de Superfície, Av. Paulista, 1313, 9°a., conj. 913, CEP 01311-923 São Paulo, SP-Brazil).

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Humbug from Hillman

Thank you, Carl Rabinowitz, for your warm and encouraging letter which included a copy of the column, "Some Truths About Getting Old Are Only Too Self Evident" which appeared in the April 27th edition of the *New York Times*. I'm sure that a number of readers have seen it but it is worth another look. Here are some excerpts.

"Some of the ways that people cope with that experience (getting old) were on display recently when the American Association of Retired Persons invited visitors to its American On-line site to take part in an electronic bulletin board discussion called, "I Knew I Was Old When.....".

Robert W. Stock

—I knew I was growing old when I stopped wearing a girdle and high heeled shoes because I realized no one was looking any more.

—An old friend said, "Gee, you're looking good." I realized there are three stages of life: Youth, Middle Age, and You're Looking Good."

—When I saw a sign on the freeway which said, "Forgive and forget: It will add years to your life." I said to my spouse, "I'm getting so good at the forgetting part I may live forever."

—Everything I have either started leaking or dried up.

—I helped an old lady across a busy intersection and she turned out to be my wife.

—Knew I was getting old when I started getting some urges and couldn't remember what they were for."

—When the older I get, the better I was.

—I knew I was old when I couldn't find anyone who knew about Burma Shave signs. . . . . . (We known that's not so, don't we, June Katzer.)

* * *

Bob Athey asks if you noted this in the *Chemical and Engineering News*?

Selected Questions & Answers from Courtrooms

The *Salt Lake Tribune* claims that these have come from official court records nationwide:

Q. Was that the same nose you broke as a child?

Q. Were you alone or by yourself?

Q. How long have you been a French Canadian?

Q. Now, Mrs. Johnson, how was your first marriage terminated?
A. By death.

Q. You say that the stairs went down to the basement?
A. Yes.
Q. And these stairs, did they go up also?

Q. Have you lived in this town all your life?
A. Not yet.

Q. Do you have any children or anything of that kind?

Q. I show you exhibit 3 and ask if you recognize that picture?
A. That's me.
Q. Were you present when the picture was taken?

* * *

Werner Schmeisky translated the following from a German magazine and sent it to us from Ontario.

"A farmer bought a Mercedes. When he was presented with the bill, he became quite upset when he noted that it contained a long list of standard components and their separate prices, as well as a few extra high priced accessories.

By coincidence, a member of the Mercedes Board of Directors lived on a neighboring farm and came to the farmer to buy a cow. When the deal was concluded, the farmer's bill had a familiar list.

One cow standard edition	6,800.00
Two-tone special styling (black & white)	300.00
Genuine leather cowhide covers	600.00
Four built-in spigots for standard or automatic operation	150.00
Two durable, weather resistant bumpers fine horn quality	600.00
Fly swatter, semi-automatic	125.00
Dual fertilizer dispensers	350.00
Multi-tone signal system	250.00
Multi-choice fuel operation	2,500.00
Total cow with accessories	11,675.00

Price does not include delivery and dealer preparation.

* * *

And Marvin Schnall is responsible for sending me another set of "actual events." This time it's an insurance accident report:

—Coming home I drove into the wrong house and collided with a tree I don't have.

—The other car collided with mine without giving warning of its intentions.

—A truck backed through my windshield into my wife's face.

—The pedestrian had no idea which way to run, so I ran over him.

—The guy was all over the road. I had to swerve a number of times before I hit him.

—I though my window was down but I found out that it was up when I put my head through it.

—I saw a slow moving, sad faced old man as he bounced off the roof of my car.

—I was thrown from the car as it left the road. I was later found in a ditch by some stray cows.

—Herb Hillman, Humbug's Nest,
P.O. Box 135, Whitingham, VT 05361.


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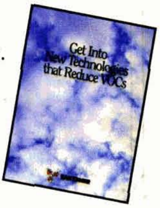
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