

April 1996

JCT

JOURNAL OF COATINGS TECHNOLOGY

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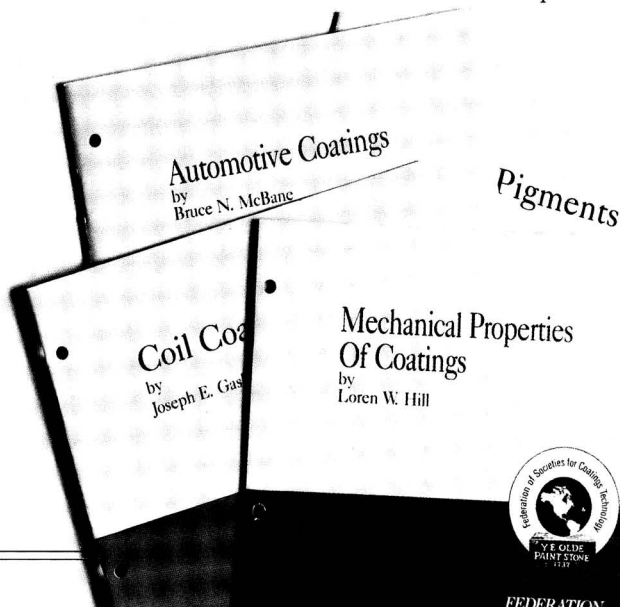
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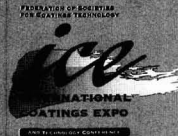
The conference venue is the prestigious Plaza International Hotel, where every room has a panoramic harbour view and which is in the centre of New Zealand's capital city. Conferees' partners will be able to choose from a wide variety of activities within Wellington and in the surrounding rural region, including Wairarapa's emerging vineyards.

Programme Outline

SCANZ Conference ----- 8th - 11th August
Australian Corrosion Association Symposium ----- 8th August
Back to Basics Seminars ----- 8th August
Industry Workshops ----- 9th - 10th August

For information, registration please contact:

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PO Box 38 546
Wellington
New Zealand
Phone / Fax: 64 4 568 8993
Email: frank_s@wn.planet.gen.nz



Technical Articles

- 35** Analytical Approach for High Quality Appearance Powder Coatings—J.C. Kenny, T. Ueno, and K. Tsutsui
The factors affecting the high quality appearance of a clear automotive powder topcoat are examined and quantified. The effects of particle size (average) and particle size distribution on appearance are well documented.
- 45** Unified Model for the Degradation of Organic Coatings on Steel in a Neutral Electrolyte—T. Nguyen, J.B. Hubbard, and J.M. Pommersheim
The authors present a unified model for the degradation of an organic protective coating on a steel substrate exposed to a neutral electrolytic environment. Model variables include blister size, distance between blister and defect, ion diffusivity, and potential gradients.
- 57** Migration of Light Stabilizers in Acrylic/Melamine Clearcoats—G. Haacke, F.F. Andrawes, and B.H. Campbell
The purpose of this paper is to discuss the migration of UV absorbers and HALS compounds taking place in acrylic/melamine coatings during cure. The coating composition was similar to those of many automotive clearcoats.
- 63** Characterization and Rheological Investigation of Polymer Microgels Used in Automotive Coatings—L.J. Boggs, M. Rivers, and S.G. Bike
This article will be of interest to formulators of automotive high-solids coatings, both for its relevant formulations and its illustrations of the use of rheological methods in coating characterizations.
- 75** Initiators for Water-Based Acrylate Emulsion Polymerizations—L.L. Anderson and W.M. Brouwer
The manuscript summarizes work which shows that organic peroxides can be used as highly effective monomer scavengers to reduce the levels of unreacted residual monomer in a latex.

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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 International Coatings Technology Conference of the Federation and at local regional meetings or symposia of the Constituent Societies.

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

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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 International Coatings Technology Conference Presentation

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

...for Roon Foundation Award Competition

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

MANUSCRIPT PREPARATION

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

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

Original Research Papers: The main technical content of the JOURNAL OF COATINGS TECHNOLOGY will continue to be original research papers. Editors support the trend in scientific writing to a direct, less formal style that permits limited use of personal pronouns to avoid repetitious 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 solicited. 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 afterwards 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.

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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 superscriptsⁿ and subscripts_s 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).

OTHER INFORMATION

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Offprints may be purchased in quantities of 100 or more. Authors will receive price quotations. Each author will receive a complimentary copy of the JOURNAL issue in which his or her paper was published.

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COMMENT

Laughter—The World's Best Motivator?



How can you increase productivity in the workplace? Theories, surveys and strategies abound. One current method involves a rather unique tool—humor. Well recognized organizations such as IBM, DuPont, the FBI, and even the IRS have worked with “humor consultants” who coach employees on how to laugh more often. Their philosophy is that if you “go through the motions, you can change your emotions.” Smiling and laughing more often makes you feel happier, and consequently, more motivated and better equipped to deal with problems and frustrations at work.

Another approach is through exercise. How many companies now offer on-site fitness facilities or discounted memberships to gyms? This theory proposes that healthy workers are happy workers and happy workers are—you guessed it—more productive ones.

The strategy supported by the FSCT is that we can best increase productivity by providing workers with opportunities to become better informed, better trained, and more experienced in their profession. Some of the best opportunities to achieve these goals will be provided at the FSCT convention, to be held in Chicago on October 23-25. There, you will have a variety of programs to choose from—all designed to answer your individual educational and training needs.

What better place to explore state-of-the-art technical products, services and equipment than the largest North American exposition for the industry—the International Coatings Expo? The Expo has expanded to include all aspects of coatings manufacture and application and you can learn first hand from experts.

In addition, the FSCT is sponsoring a stand-alone technical conference, to be held October 22-24. Are you new to the coatings industry and need a program on basics? One of the two-day conference programs is ideal. Want hands-on experience in spray application? A one-day preconference seminar will suit your needs. Technical writing, making effective technical presentations, examining coatings and substrates—whatever your interest, the opportunities are there to help you become more effective in your work and to gain greater expertise in the industry.

So, which of these three approaches best guarantees the highest productivity? You be the judge. But, for a little persuasion, turn to pages 11-13 for more information on the International Coatings Expo and the Technical Conference. For help to keep smiling, turn to the last page of the JCT—Humbug!

Patricia D. Viola
Editor

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

Analytical Approach for High Quality Appearance Powder Coatings—J.C. Kenny, T. Ueno, and K. Tsutsui

JCT, Vol. 68, No. 855, 35 (Apr. 1996)

High quality appearance of powder coatings was investigated using a five-stage model: (1) powder particle; (2) coalescence; (3) leveling; (4) curing, and (5) cooling. Appearance levels above target solvent-based systems were achieved using fine particle size and narrow distributions. Fine powders (~10 μ m) were found to have faster coalescence and better degassing. Cure contraction stress was much smaller than cool stress, yet caused significant image distortion due to localized gradients. Hardener crystals are a separate phase in the powder particles, a more uniform distribution of finer sized crystals gave improved appearance. Solutions to practical application of findings have been found.

Aproximación Analítica para Recubrimientos en Polvo con Alta Calida de Apariencia—J.C. Kenny, T. Ueno y K. Tsutsui

Fué investigada la alta calidad en la apariencia de recubrimientos en polvo usando un modelo de cinco etapas: (1) partículas en polvo, (2) coalescencia, (3) nivelación, (4) curado y (5) enfriamiento. Los niveles de apariencia arriba señalados sistemas base solvente fueron obtenidos usando partículas de tamaño fino y distribuciones estrechas: Fueron encontrados polvos finos (~10 μ m) para tener coalescencia más rápida y mejor desgazificación. La tensión de la contracción de cura fué mucho más pequeña que la tensión en frío, sin embargo causo una significant distorsión de imagen debido a gradientes localizados. Los cristales de endurecedor son una fase separada en las partículas en polvo, a una mayor distribución uniforme de partícula de cristales de tamaño más fino se logró una mejor apariencia. Han sido encontradas mezclas y algunas soluciones para una aplicación práctica de los resultados obtenidos.

Unified Model for the Degradation of Organic Coatings on Steel in a Neutral Electrolyte—T. Nguyen, J.B. Hubbard, and J.M. Pommersheim

JCT, Vol. 68, No. 855, 45 (Apr. 1996)

A unified model is presented for the degradation of an organic protective coating on a steel substrate exposed to a neutral electrolytic environment. This model is based on theoretical and experimental studies from our laboratory and on current understanding of the degradation process. The assumptions of the model are based on the concept that degradation of a coating/steel system occurs following the transport of ions through conductive pathways, which are presumably formed by an attack by water in the "hydrophilic," low-molecular-weight/low-crosslinked regions, followed by the connections of these regions. Models for the blistering and delamination resulting from corrosion processes are based on the diffusion of cations along the coating/steel interface from the defects to cathodic sites under the coatings. The resulting equations are solved to predict ion fluxes and concentration profiles along the interface and within blisters. Model variables include blister size, distance between blister and defect, ion diffusivity, and potential gradients. Experimental results agree well with theoretical predictions.

Modelo Unificado para la Degradación de Recubrimientos Orgánicos de Acero en un Electrolito Neutro—T. Nguyen, J.B. Hubbard y J.M. Pommersheim

Un modelo unificado es presentado para la degradación de un recubrimiento orgánico en un sustrato de acero expuesto a un ambiente electrolítico neutro. Este modelo se base en estudios teóricos y experimentales de nuestro laboratorio y en el actual conocimiento del proceso de degradación. Las consideraciones del modelo están basadas en el concepto de que la degradación de un sistema recubrimiento/acero ocurre siguiendo el transporte de iones a través de senderos conductivos, los cuales son presuntamente formados por un ataque con agua en las regiones de bajo entrecruzamiento, bajo peso molecular e "hidrofilicas," seguido por las conexiones de estas regiones. Los modelos para el abultamiento y la delaminación resultantes del proceso de corrosión están basados en la difusión de cationes a lo largo de la interfase acero/recubrimiento a partir de los defectos en sitios cátodicos bajo los recubrimientos. Las ecuaciones resultantes han sido resueltas para predecir los flujos de iones y los perfiles de concentración a lo largo de la interfase y en el interior de los abultadores. Las variables del modelo incluyen tamaño del abultador, distancia entre el abultador y el defecto, difusividad de ion y gradiente de potencial. Los datos experimentales concuerdan con las predicciones teoricas.

Migration of Light Stabilizers in Acrylic/Melamine Clearcoats—G. Haacke, F.F. Andrawes, and B.H. Campbell

JCT, Vol. 68, No. 855, 57 (Apr. 1996)

Experimental techniques have been developed to investigate the migration of UV absorbers and hindered amine light stabilizers taking place in acrylic/melamine clearcoats during cure. The basic approach consisted of microtoming the coatings into thin sections and measuring the additive concentration of each section. The stabilizer migration within single-layer coatings and between adjacent clearcoat layers was investigated. The effect of resin viscosity and layer swelling on the migration characteristics was studied. Stabilizer losses at the coating surface and migration into plastic substrates on cure were also determined.

Migración de Estabilizadores Ligeros en Recubrimientos Claros de Acrílico/Melamina—G. Haacke, F.F. Andrawes y B.H. Campbell

Han sido desarrolladas técnicas experimentales para investigar la migración de absorbedores UV y estabilizadores ligeros de melamina impedida tomando lugar en recubrimientos claros de acrílico/melamina durante la cura. La aproximación básica consistió en microtomizar los recubrimientos dentro de secciones delgadas y medir la cantidad de aditivo de cada sección. Fué investigada la migración de cada sección del estabilizador en el interior de recubrimientos de capa simple y entre capas de recubrimiento claro adyacente. Fué estudiado el efecto de la viscosidad de la resina y la hinchazón de la capa en las características de la migración. También fueron determinadas las pérdidas del estabilizador en la superficie del recubrimiento y la migración hacia sustratos de plástico en la cura.

Characterization and Rheological Investigation of Polymer Microgels Used in Automotive Coatings—L.J. Boggs, M. Rivers, and S.G. Bike

JCT, Vol. 68, No. 855, 63 (Apr. 1996)

The mechanism by which polymer microgels impart shear-thinning behavior and a yield stress to the Newtonian, low molecular weight resin of high-solids solvent-borne automotive coatings is not well understood. Toward identifying this mechanism, we measured the viscosity of several microgel dispersions as a function of particle volume fraction as well as the size and polydispersity of the particles. Variations in the relative "softness" of the particles, due to differences in the steric layer thickness or crosslink density of the particles, gave rise to differences in the viscometry behavior. When dispersed in acrylic polymer solutions, the microgels induced a yield stress that displayed a power-law dependence on particle concentration. Dynamic oscillatory measurements were used to investigate the nature of the structure formed by the microgels. The mechanism of structure formation can be attributed to depletion flocculation when the polymer does not absorb to the microgels, and to bridging flocculation when the polymer does absorb.

Caracterización e Investigación Reológica de Microgeles de Polímeros Usados en Recubrimientos Automotivos—L.J. Boggs, M. Rivers y S.G. Bike

Aún no está bien comprendido el mecanismo por el cual los microgeles de polímeros muestran un esfuerzo-adelgazamiento así como un comportamiento newtoniano en los recubrimientos automotivos base solvente de resinas de altos sólidos de bajo peso molecular. Para la identificación de este mecanismo, se midió la viscosidad de varias dispersiones de microgeles como una función de la fracción del volumen de partícula así como el tamaño y polidispersamiento de las partículas, debido a diferencias en los espesores de capas estéricas o densidad de entrecruzamiento de las partículas, dio por resultado un ascenso en las diferencias del comportamiento en el viscosímetro. Cuando se dispersó en soluciones de polímero acrílico, los microgeles indujeron una tensión que desplegó una dependencia poderley en la concentración de la partícula. Las mediciones oscilatorias dinámicas fueron usadas para investigar la naturaleza de la estructura formada por los microgeles. El mecanismo de formación de estructura puede ser atribuido a la floculación de agotamiento cuando el polímero no absorbe los microgeles, y a floculación de soporte cuando el polímero los absorbe.

Initiators for Water-Based Acrylate Emulsion Polymerizations—L.L. Anderson and W.M. Brouwer

JCT, Vol. 68, No. 855, 75 (Apr. 1996)

Traditionally persulfates have been used as initiators in redox water-based polymerizations systems. While persulfates are still used industrially, the use of organic peroxides has increased during the past decade. This paper summarizes work which shows that organic peroxides can be used as highly effective monomer scavengers to reduce the levels of unreacted residual monomer in a latex. In addition, organic peroxides can be used in place of persulfates for initiating a redox polymerization and offer some advantages over persulfates.

Iniciadores para Polimerizaciones de Emulsión de Acrilato Base Agua—L.L. Anderson y W.M. Brouwer

Los persulfatos han sido tradicionalmente usados como iniciadores en sistemas de polimerizadores redox base agua. Aun cuando estos tienen un gran uso industrial, el uso de peróxidos orgánicos se ha incrementado durante la década pasada. En este trabajo se muestra que los peróxidos orgánicos pueden ser usados como recuperadores altamente efectivos de monómeros para reducir los niveles de monómero residual sin reaccionar en un latex. Finalmente, los peróxidos orgánicos pueden ser usados en lugar de persulfatos para iniciar una polimerización redox y ofrecen algunas ventajas sobre los persulfatos.

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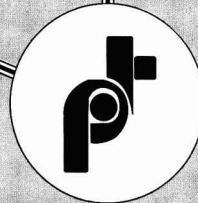
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Forty-Seven Exhibitors Contract for Space in the FSCT Co-Sponsored Pan American Coatings Expo in August

As of April 17, 47 exhibitors have reserved space for the first FSCT co-sponsored Pan American Coatings Expo, to be held at the Sheraton Maria Isabel Hotel & Towers, Mexico, on August 15-17, 1996. This event, co-sponsored by the Asociacion Nacional de Fabricantes de Pinturas y Tintas, A.C. (ANAFAPYT), the Instituto Mexicano de Tecnicos en Pinturas y Tintas (IMTPYT), and the Federation of Societies for Coatings Technology (FSCT), is an exhibition focused on the manufacturing, environmental, and formulating needs of the Latin American coating market. The Expo will be held in conjunction with the Annual Convention of ANAFAPYT and the Technical Conference of the Mexico Technical Institute.

Product categories to be represented include: additives, resins, pigments, plasticizers, emulsions, colorants, extenders and fillers, laboratory and testing instrumentation, consulting services, and all other raw materials, services, and equipment for the formulation, testing, manufacture, and applications of paints, inks, and powder and high-solids coatings.

The Expo is expected to attract management representatives, including managing directors, purchasing managers and plant managers; technical personnel, such as technical directors, chemists and technologists, and those involved in research and development; as well as industrial users and applica-

The geographical areas covered by the Pan American Expo are Mexico; Central America, including Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, Panama, and Belize; South America, including Argentina, Brazil, Columbia, Ecuador, Bolivia, Venezuela, Paraguay, Uruguay, Chile, and Peru; and the West Indies.

For additional information on exhibiting at or attending the Pan American Coatings Expo, contact FSCT, 492 Norristown Rd., Blue Bell, PA 19422-2350; (610) 940-0777; Fax: (610) 940-0292.

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Kady International
Kenrich Petrochemicals, Inc.
King Industries, Inc.

Lubrizol
Metapol, S.A. de C.V.
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Q-Panel Lab Products
Quimica San Diego S.A. de C.V.
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Reichhold Quimica de Mexico, S.A. de C.V.
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Sun Chemical Corp. Pigments
UCB Quimica de Mexico S.A. de C.V.
U.S. Polymers Inc./Accurez Corp.
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Zeneca Resins



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Effective May 1, 1996, the Federation of Societies for Coatings Technology will be offering a Fax-On-Demand service. This service will enable industry personnel the opportunity to receive FSCT information on conventions, seminars, publications, etc., within seconds of completing a call.

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FSCT Announces Program Schedule, Registration Information For Its New International Coatings Technology Conference

The Federation of Societies for Coatings Technology has announced the theme and course offerings for the International Coatings Technology Conference, to be held October 22-24, 1996, in Chicago, IL. As part of the FSCT's newly formatted convention programming, the Conference will be held in conjunction with the Federation's Annual Meeting and International Coatings Expo (ICE), scheduled for October 23-25.

The Conference, a series of one- and two-day technical seminars with the theme "Insights and Innovation," will feature programs conducted by known experts in the industry on a variety of topics and will be held at two sites, the Chicago Hilton and Towers, FSCT convention headquarters hotel, and at the McCormick Place convention complex, site of ICE.

The conference seminars take an in-depth look at subjects critical to achieving success in today's competitive industry and have been developed as educational "tracks" for various levels of industry professionals. Featuring one-day seminars on Tuesday, October 22, and two-day sessions on Wednesday and Thursday, October 23-24, the conference schedule includes the following:

Tuesday, October 22

(held at the Chicago Hilton and Towers)

SURFACTANT CHEMISTRY—Designed for R&D personnel, synthesizers, formulators and applicators. This course will provide registrants with a better understanding of surfactants and polymers; information on new uses and technologies in this area; and a working knowledge of surfactant synergy in waterborne technology.

WINNING TECHNICAL PRESENTATIONS—Targeted at all levels of lab and R&D personnel, in addition to marketing and sales staff and anyone else responsible for technical presentations. Program attendees will learn how to effectively develop visuals; proper speaking techniques and data organization; how to handle question and answer sessions; tips to transfer written information to speaking terms; and how to effectively communicate to all audiences. *Attendance limited to 25 registrants.*

EFFECTIVE TECHNICAL AND SCIENTIFIC WRITING WORKSHOP—Aimed at all levels of lab personnel, applicators, R&D staff and anyone responsible for communicating technical information. Participants will acquire skills and techniques for improved technical communication; learn proper methods of

data collection and tabulation to maximize data impact; and how to make technical issues understandable, to improve effectiveness in communicating technology. *Attendance limited to 25 registrants.*

DESIGN OF EXPERIMENTS—Targeted for lab personnel, R&D staff, project managers and technicians. Attendees will receive information on how to improve project management, including better planning; time saving methods; tips on how to receive greater certainty of results; ability to predict coatings properties; and truer selection criteria/evaluation methods.

SPRAY APPLICATION (to be held at Binks Manufacturing, Franklin Park, IL)—This course is designed for applicators, field service staff, specifiers, and formulators. Participants will gain a greater understanding of spray equipment (adjust, tip, size, fanning, technique); receive training on how to select the right equipment for the proper application and coating; and learn problem solving techniques. *Attendance limited to 40 registrants.*

TECHNOLOGY ASSESSMENT (an Executive Forum, includes dinner on Monday evening)—Primarily directed at marketing or sales directors and managers, small business owners, and senior R&D staff, such as group leaders, technical directors and senior chemists. Individuals will receive information on how to determine the feasibility of new technology, including concept/idea assessment and the financial issues related to the topic. *Attendance limited to 30 registrants.*

Wednesday and Thursday, October 23-24

(held at McCormick Place)

SUBSTRATES AND COATINGS—Developed for formulators, lab chemists, technical service personnel, in addition to sales personnel and R&D chemists. This course will provide an understanding of the physical nature of substrates, including definitions of various substrate types and surfaces (wood, plastic, metal, etc.); effect on substrate of coatings application and performance; tips on how to overcome or compensate for substrate problems by proper formulation; and how to formulate a coating for right substrate.

COATINGS CHARACTERIZATION—Designed for lab directors, QC managers, analytical staff and coatings specifiers. The program will review the basics of coatings characterization, while providing an update of recent developments related to criteria and

new equipment. Attendees will be made aware of what is available, such as practical equipment and services, in order to better study problems.

POLYMER CHEMISTRY—Aimed at coatings formulators, R&D chemists, and sales and marketing personnel with strong technical background and interests. Participants will gain a better understanding of the important basic concepts of polymer science; learn the fundamental principles behind chain-growth and step-growth polymerization; discover the most important classes of polymers used in coatings, the properties which can be expected from each type, and how polymer chemistry can be used to modify the properties; learn basic principles of emulsion polymerization and how it differs from solution polymerization; and how polymers are characterized using modern analytical techniques.

BACK TO BASICS IN COATINGS CHEMISTRY—This course is primarily for new chemists or those with minimal experience, technicians, and sales, marketing and field support. The program will provide attendees with an overview of coatings types; review the four basic coatings components (what they are, why, functions, and purpose); offer cost savings ideas for formulation; and provide a better understanding of the physical properties associated with coatings and tips on troubleshooting.

Conference fees are discounted for members of the FSCT and its Constituent Societies and include all course materials and access to the Expo and the Annual Meeting technical program sessions. If registering in advance, Conference attendance fees are \$195 member, \$295 nonmember for Tuesday's one-day sessions; \$395 member, \$495 nonmember for Wednesday-Thursday's two-day courses. Special package fees for all three days are \$495 for members, \$595 for nonmembers. Add \$50 to all fees for on-site registration.

The attendance fee for Tuesday's one-day Executive Forum on Technology Assessment, which includes a Monday evening dinner, is \$395 for FSCT and NPCA members, \$495 for nonmembers, in advance, \$50 additional on-site. Attendance at this Executive Forum session is limited to 30 persons.

For registration materials, contact the FSCT, 492 Norristown Rd., Blue Bell, PA 19422; Tel.: 610-940-0777; Fax: 610-940-0292; Fax-On-Demand: (800) 838-5445.

1996

International Coatings Expo List of Exhibitors

FEDERATION OF SOCIETIES
FOR COATINGS TECHNOLOGY



As of April 17, the International Coatings Expo (formerly Paint Industries' Show), McCormick Place North, Chicago, IL, October 23-25, 1996, is 90% SOLD OUT, contracting 90,000 sq. ft. of exhibit space to 254 exhibitors.

A.P. Dataweigh Systems
ACT Laboratories, Inc.
ARCO Chemical Co.
Aceto Corp.
Advanced Software Designs
Air Products & Chemicals, Inc.
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SPI Reports on Plastic Machinery Shipments and Plastics Resins Production for 1995

According to the 1995 year-end report issued by the Machinery Division of The Society of the Plastics Industry, Inc., Washington, D.C., shipments of plastics machinery in 1995 continued an upward trend established in 1992. Three of four industry segments showed an increase from 1994.

Shipments of injection molding machinery produced in the United States increased by 4.3% in 1995, with imports declining by 1.8%. Figures reported by the division's injection section show 2,875 units of injection molding machinery shipped from U.S. production, an increase of 4.3% over 1994 figures. This figure includes only those machines of a type used for processing thermoplastics.

An SPI survey to collect primary data on monthly imports into the U.S. for injection molding machines began in 1994. Fifteen major importers who account for the majority of U.S. imports participated in this survey, which reported 2,566 imported units in

1995 for a 1.8% decline from 1994 figures. Sales from domestic production plus imports increased from 5,370 units in 1994 to 5,441 units in 1995, up 1.4% overall.

Shipments of single screw extrusion machinery also were up in 1995, with 1,320 units shipped for an increase of 12.4% over the previous year. This followed a 5.5% increase in 1994.

Blow molding machinery data showed a decline in 1995, with unit new orders down by 5.4% from 1994. The blow molding section reported 279 new orders and 251 units shipped, compared with 295 orders and 297 shipments last year.

Shipments of auxiliary equipment showed an increase of 4.1% in 1995 as compared to 1994 data. The auxiliary section of SPI's Machinery Division gathers data from 19 reports representing the majority of the high volume sales in auxiliary equipment.

Auxiliary equipment reports for 1994 and 1995 include: chillers (portable and central); cooling towers and systems; blenders (central, on-the-machine, additive feeders and gravimetric); pneumatic conveyors (central and machine loaders); storage tanks; dryers (hot air, dehumidifying single and dehumidifying central); granulators (below-the-press, beside-the press and central); and robotics (sprue pickers, small traverse, and large traverse).

The Statistical Steering Committee of SPI's Machinery Division consists of four sections: auxiliary equipment, blow molding machinery, extrusion equipment and injection molding machinery. Each section has a monthly reporting system.

In a separate report, SPI's Commit-

tee on Resin Statistics stated that the production of plastics resins totaled 5.5 billion pounds in December 1995, a decrease of 4.6% from the same month in 1994.

The production figures for December 1995 were down 1.2% from those of the previous month. Production in 1995 year-to-date totaled 68.2 billion pounds, a 3.6% increase over the same 12-month period in 1994.

Sales and captive (internal) use of plastics resins in December 1995 totaled 5.4 billion pounds, a decrease of 3.5% from the same month one year ago. December 1995 sales and captive use was down 3.4% from the total of the previous month. Sales and captive use in 1995 year-to-date totaled 68.8 billion pounds, unchanged from the same 12-month period.

Statistics for both reports were compiled by Ernst & Young for SPI.

Marcus Hook, PA The Site of Rhône-Poulenc New Plant

A new ethoxylated surfactants plant has been opened by Rhône-Poulenc, Cranbury, NJ.

The new facility, located in Marcus Hook, PA, is part of the company's long-term manufacturing strategy. Under this strategy, Rhône-Poulenc is consolidating ethoxylate production from four facilities to two: Spartanburg, SC, and Marcus Hook.

The company's net capacity for ethoxylated surfactants will remain unchanged. The investment cost and capacity of the Marcus Hook plant were not disclosed.

Union Carbide Purchases Shares of Brazilian Plant

The purchase of the shares held by Rhodia SA of Companhia Alcoolquímica Nacional (CAN) has been completed by Union Carbide Corp., Danbury, CT. The transaction transfers approximately 95% of CAN's shares and control of its 80,000 metric-ton plant in northeastern Brazil to Union Carbide.

Presently, Union Carbide participates in two vinyl acetate joint ventures: American Acetyls with BP Chemicals, Inc., and Asian Acetyls, with BP Chemicals (Korea) Ltd. and Samsung Fine Chemicals Co., Ltd.

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Olin Corp. Contributes \$30,000 Grant To Drexel University for Workshop Series

The Olin Corporation Charitable Trust has provided a \$30,000 grant to Drexel University, Philadelphia, PA, to establish the Olin Workshop Series in Environmental Science and Engineering in cooperation with the university's Environmental Studies Institute.

The initial Olin Workshops, which will begin in April 1996, will address three areas of national priority and significant student interest: toxicology, environmental chemistry, and environmental policy. The workshop presenters will include experts from state and federal environmental agencies, environmental professionals from industry,

and Drexel faculty and graduate students. In many cases, the workshops will be conducted in laboratories or other settings conducive to hands-on learning by the students.

In addition to providing insights into how vital environmental issues are being addressed in industry and government, the workshops will offer Drexel students an opportunity for dialogue with industry personnel on environmental issues.

A special unit of Drexel University, The Environmental Studies Institute was established in the mid-1960s, making it one of the oldest graduate degree granting programs in environmental science and engineering in the country.

Eastman Chemical to Begin Construction of IPA Facility

Eastman Chemical Co., Kingsport, TN, will construct a facility to produce isophthalic acid (IPA). The company expects to have a plant with annual capacity of 150 million pounds (68,000 metric tons) on line in North America by mid-1998. Construction is slated to begin in the summer of 1996.

Elsewhere, Eastman has opened an office in Johannesburg, South Africa, to contribute to the economic growth that is occurring in the country. Eastman originally established an office in Johannesburg in 1976, however, due to apartheid, the company closed its office there in 1987. When the U.N. Embargo was lifted in 1993, Eastman resumed sales activities in South Africa.

In other news, PPG Industries, Pittsburgh, PA, has acquired Eastman's Evtech powder coatings business, based in Charlotte, NC. Terms were not disclosed.

U.S. Filter Announces Recent Acquisitions

United States Filter Corp., Palm Desert, CA, has announced the recent acquisitions of KBS Pure Water Pte. Ltd., of Singapore,

KBS Pure Water Sdn. Bhd. of Penang, Malaysia, Wastewater Treatment Systems (WTS) Inc., of San Francisco, CA, and Permutit (Egypt) Ltd.

KBS provides a variety of water treatment equipment and services—including service deionization (SDI), water purification equipment and wastewater equipment—to microelectronics manufacturers and other industrial customers in Asia.

WTS designs and assembles wastewater treatment systems, specializing in microelectronics, particularly in the Asian semiconductor fabrication market.

Located near Cairo, Permutit (Egypt) Ltd., designs water treatment systems used primarily in the Middle East.

Other recent acquisitions of U.S. Filter includes a 30,000 square foot facility in Singapore to anchor its expansion in Asia and Continental Water Systems of Atlanta.

McWhorter Technologies Forms Joint Venture

A letter of intent for the formation of a new resin supplier for the European paint industry has been signed by McWhorter Technologies, Carpentersville, IL. Also signing the letter of intent were AB Wilh. Becker (Sweden) and Tikkurila Oy (Finland).

The new company, to be called McWhorter Technologies Europe, will be formed by combining plants in Vantaa, Finland (Tikkurila); Mölndal, Sweden (Soab); and Bury, UK (Kemira Coatings).

The new company is anticipating sales of \$60 million at the three sites. Mölndal will serve as headquarters.

The existing sites have the capability to produce solvent-borne, water-reducible, and dispersion resin technologies.

Betz Laboratories to Acquire W.R. Grace's Dearborn Water Treatment Business Unit

Betz Laboratories, Inc., Trevose, PA, has signed a definitive agreement to acquire the Dearborn business unit of W.R. Grace & Co. for \$632 million. The transaction, which was approved by the boards of directors of Betz and Grace, is expected to close in this year's second quarter, subject to customary regulatory approval.

Dearborn is a global supplier of industrial water and process treatment chemicals, with 1995 sales of approximately \$400 million. It has operations and facilities throughout North America, Europe, and Latin America.

Operations Underway at ANGUS Chemical's New Pilot Plant Located in Sterlington, LA

ANGUS Chemical Co., Buffalo Grove, IL, recently commissioned a new \$5.4 million general purpose pilot plant at the company's Sterlington, LA, manufacturing facility. This pilot plant will enable ANGUS to develop

new processes as well as improve existing ones.

Construction of the new facility took 10 months after ground was broken in April 1995. The new pilot plant includes a 10,000 square foot covered process area on three levels, with an attached 2,000 square foot control center.

The control center features a distributed control system which controls all process equipment. An analytical and process laboratory is also housed in that area.

ICI's Atlas Point Site Wins 1995 Gold Award

ICI Surfactants', Wilmington, DE, manufacturing site, Atlas Point Site, New Castle, DE, captured a gold award in the 1995 worldwide ICI C&P Business in Excellence Award competition, for the second year in a row.

The site's nomination—In-Process Mini Lab Testing—won a Gold Quality Award for creativity and excellence in system design, teamwork, employee involvement, and the size of the challenge and speed of achievement. Faced with increased production, the Mini Labs presented a viable solution to offset the number of test analyses performed in the site's central lab.

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Program Finalized for Philadelphia Society's Eastern Training Conference May 8-10, 1996

The Philadelphia Society for Coatings Technology is conducting the Eastern Training Conference and Show on May 8-10, 1996 at the Valley Forge Convention Plaza, in King of Prussia, PA.

The following presentations are scheduled to be delivered during the three-day event:

"History of Coatings Technology"—Don Denny, of E.W. Kaufmann Co.;

ASTM Training Course Focuses on Paint VOCs

Due to the Clean Air Act of 1990, precise VOC determination on paint and related materials is required. The American Society for Testing and Materials (ASTM), West Conshohocken, PA, will present a two-day technical and professional training course on "Paint Volatile Organic Compounds (VOCs)" to show how to accurately run ASTM methods listed in the U.S. Environmental Protection Agency's Reference Method 24, and obtain meaningful results. The course will be held on May 1-2, 1996, at the ICI Strongsville Research Center, in Strongsville, OH.

The course is designed for chemists and others who use U.S. EPA tests to determine if paints or coatings meet VOC requirements. Individuals in the paint industry and paint users, shipbuilders, textile manufacturers, government regulatory bodies, and commercial laboratories will also benefit from this course.

The program will teach attendees to obtain good representative samples; prepare samples; run VOC measurements of coatings; identify the variables in each test method; calculate VOC as: grams/liter, grams/liter minus water, or kilograms VOC as applied solids; and improve precision on these methods.

In addition, laboratory demonstrations of ASTM test methods will be held at the ICI Strongsville Research Center.

The course fee is \$670 and includes ASTM's Manual 4, copies of all referenced ASTM standards, coffee breaks, transportation between class and laboratory demonstration, and a certificate of completion.

To register for the course, or for additional information, contact, Tina Falkenstein, ASTM, 100 Barr Harbor Dr., West Conshohocken, PA 19428-2959; (610) 832-9686.

"Pigments: White, Colored, and Extenders"—Tom Brown, of Consultants Consortium;

"Resins: Solvent-Based Architectural and Industrial Maintenance"—Bruce Johnson, of McWhorter Technologies;

"Resins: Solvent, OEM Industrial"—Don Fritz;

"Resins: Water-Soluble, Architectural, and Industrial"—Jeff Danneman, of Reichhold Chemicals;

"Resins: Emulsion, Architectural and Industrial"—Bob Klein, of Air Products and Chemicals;

"Additives I"—Sam Morell, of S.P. Morell;

"Additives II"—Tim Savage, of Troy Corp.;

"Paint Calculations"—Dao-ting Wu, of DuPont;

"Paint Testing"—Rich Granata, of Lehigh University; and

"Paint Application"—Bill Fabiny, of Sermagard Coatings.

In addition, several companies will be exhibiting during the Show. The following companies have currently reserved booth space: Air Products and Chemicals, Aqualon, BFGoodrich, Buckman Labs, Burgess Pigment Co., BYK-Gardner, BYK-Chemie, Calgon, Coatings Tech, Colortek, Cook Cook Composites and Polymers, Daniel Products, Disti-Kleen, DuPont TiO₂, E.W. Kaufmann, Eiger Machinery, Fawcett, Halox, Henkel, Hüls, Inland Leidy, JM Huber, King, 3M, Monsanto, Netzsch, Neville, NYCO Minerals, Paar Physica, Penn Colors, Pottery, Premier Mills, Q-Panel, Quaker City, Ronningen-Petter, Russell Finex, Silberline, Southern Clay, Specialty Minerals, Steel Shipping Containers, Summit Precision Polymers, Tego Chemie, Thiele Engineering, Tioxide America, Troy Chemical, Ultra Additives, Unimin, Van Horn & Metz, and Zeneca Resins.

For more information contact Wayne Kraus, Hercules Incorporated, Research Center, 500 Hercules Rd., Wilmington, DE 19808. To exhibit contact Sam Firestone, S.E. Firestone Associates, Inc., 101 Surrey Rd., Melrose Park, PA 19027.

Surface Coatings Association Australia's Annual Conference Slated for Aug. 14-17

Surface Coatings Association Australia (SCAA) Inc. will conduct its Annual Conference at the Sydney Convention and Exhibition Centre, in Sydney, Australia, on August 14-17, 1996.

The theme for this year's international conference is "Coatings, From Start to Finish" and over 60 experts from around the world have been lined up to present information on a wide cross-section of coatings related subjects ranging from raw materials, formulating, specification and application to service performance.

During this event, Philip Cox will be the Keynote Speaker, while John Gerlock will explore accelerated weathering and prediction during his Plenary Lecture.

In addition, the following will form the technical program: lecture stream, seminar stream, and workshop stream.

The lecture stream will consist of presentations covering current aspects of raw materials, future trends in coatings for specific substrates, alternative technologies, durability, regulations, conformity assessment and commercial business papers.

"Basics and Beyond," the theme of the seminar stream, will target the bench chemist, technical sales, marketing, and R&D managers where 12 specialists in the coatings industry will take participants through the following topics: formulating principles for coatings; resins and binder systems; pigment selection; and additives.

The workshop stream will consist of selective workshops over the three days of the conference. Subjects to be discussed include: marine and other protective coatings; recent advances in polymer chemistry; painting—restoration and color; recent advances in printing inks; OEM and refinish; modern applications and coating systems application equipment; recent advances in flat sheet automatic coating lines; coatings failures; and adhesives.

These technical program modules have been designed to meet the needs of chemists through chief executives.

For additional information, contact SCAA '96 Secretariat, GPO Box 128, Sydney NSW 2001, Australia; Phone: 61 2 262 2277; Fax: 61 2 262 3135.



Kent State University Coatings Short Courses To Explore Dispersion, Adhesion, and Rheology

Throughout 1996, the Professional Development Institute at Kent State University, Kent, OH, will conduct four coatings related short courses. The courses are: "Dispersion of Pigments and Resins in Fluid Media,"—May 6-10; "Adhesion Principles and Practice for Coatings and Polymer Scientists"—May 20-24; "Applied Rheology for Industrial Chemists"—June 3-7; and "Introduction to Coatings Technology"—June 11-14. The following is a day-by-day breakdown of each course.



"Dispersion of Pigments and Resins in Fluid Media"

MONDAY, MAY 6: "Fundamentals of Surface and Colloid Chemistry I"—Richard J. Ruch, Kent State University; "Dispersant Selection Based on Pigment Functionality"—Robert F. Conley, Mineral and Resource Technology; "Fundamentals of Surface and Colloid Chemistry II"—Richard J. Ruch; and "Inorganic Pigment Processing Parameters and Their Influence on Polymer Properties"—Robert F. Conley.

TUESDAY, MAY 7: "White Pigments—Surface Character and Rheological Characteristics"—Robert F. Conley; "Dispersion of Organic Pigments"—Theodore Vernardakis, Sun Chemical Corp.; "Dispersion of Fumed Silica and Carbon Black for Optimum Performance"—Maria Nargiello, Degussa Corp.; and "Wetting and Dispersing in Aqueous and Nonaqueous Coatings Systems"—Robert W. Vash, Iron Chemicals Inc.

WEDNESDAY, MAY 8: "Introduction to Dispersion Rheology"—Richard R. Eley, The Glidden Co.; "Determining Dispersion Quality by Rheological and Related Means"—Richard Eley; "Overview of Dispersion Equipment for Inks and Coatings"—Ramon Pineiro, Daniel Products Co.; and "Advances in Rotor-Stator Dispersion Technology"—David Ulrich, Ulrich and Assoc.

THURSDAY, MAY 9: "Primary Mixing and Blending"—Leo Dombrowski, Gibraltar Chemical; "High Viscosity Dispersion and New Dispersion Techniques"—James White, White Chemical Equipment Co.; "Small Media Milling and Dispersion Technology"—Leo Dombrowski; "Principles of Ball and Pebble Milling"—Warren Fuller, Paul O. Abbe, Inc.; "Attritor Grinding and Dispersing Equipment"—Arno Szegvari, Union Process, Inc.

FRIDAY, MAY 10: "Assessing Pigment Dispersion Through Fineness, Tint Strength, and Transparency"—Leo Dombrowski; "Particle Size Analysis of Coating Systems, Part I"—Theodore Provder, of The Glidden Co.; "Particle Size Analysis of Coating Systems, Part II"—Theodore Provder.

"Adhesion Principles and Practice for Coatings and Polymer Scientists"

MONDAY, MAY 20: "Interfacial Energies and Their Role in Adhesion"—Richard J. Ruch; "General Rheology and Its Application to Adhesion"—Donald L. Hunston, National Institute of Standards and Technology; "Fracture Behavior of Glassy Adhesives"—Donald L. Hunston; and "Deformation and Fracture of Elastomeric Adhesives"—Alan N. Gent, Polymer Physics and Engineering, The University of Akron.

TUESDAY, MAY 21: "Fracture Mechanics and Bond Durability Considerations"—David A. Dillard, Virginia Tech; "Surface Preparation of Adherents"—John G. Dillard, Virginia Tech; "Plasma Surface Treatment and the Effect on Adhesion"—Eric Finson, BOC Coating Technology; and "Microscopic/Spectroscopic Studies in Adhesion Related to Durability of Adhesively Bonded Metals and Composites"—John G. Dillard.

WEDNESDAY, MAY 22: "Organofunctional Silanes as Adhesion Promoters and Crosslinkers"—Bruce A. Waldman, OSi Specialties, Inc.; "Plastic to Plastic Adhesion"—Rose Ann Ryntz, Ford Motor Co.; "Principles of Elastomer Tack"—Gary R. Hamed, Institute of Polymer Science, The University of Akron; and "Adhesion Testing of Adhesives and Coatings"—James A. Miller, J. Miller Associates.

THURSDAY, MAY 23: "Application of Surface Analysis to Adhesion of Coatings"—Kenneth D. Bomben, Perkin-Elmer Physical Electronics Laboratory; "Surface Chemistry of Release"—Michael J. Owen, Dow Corning Corp.; "Structure Property Relationship in Adhesives"—Krishnan C. Sehgal, Union Carbide Corp.; and "Bonding and Chemistry of Structural Adhesives"—Kurt C. Frisch, Jr., 3M Company.

FRIDAY, MAY 24: "Bonding Plastics and Elastomers"—Edward M. Petrie, ABB Transmission Technology Institute; and "Adhesive Application Methods"—Edward M. Petrie.



"Applied Rheology for Industrial Chemists"

MONDAY, JUNE 3: "Introduction to Rheology and Rheometry"—Irvine M. Krieger, Case Western Reserve University; "Fundamentals of Linear Viscoelasticity"—Irvine M. Krieger; "Rheological Measurements: Controlled Stress or Controlled Strain, Which to Use?"—Abel Gaspar Rosas, Paar Physica USA, Inc.; and "Rheological

Instruments and Selection"—Richard M. Webber and Edward A. Collins, The Lubrizol Corp.

Tuesday, JUNE 4: "Meaningful Rheological Measurements"—Richard M. Webber and Edward A. Collins; "Application of Rheology to Processing"—Charles L. Rohn, Bohlin Instruments, Inc.; "Application of Rheology to End-Use Performance Problems"—Charles L. Rohn; "Rheological Additives for Flow Modification"—Sharad Thakkar, Scitex Digital Printing, Inc.

WEDNESDAY, JUNE 5: "Rheology of Dispersions"—Irvine M. Krieger; "Rheology in the Protective and Decorative Coatings Industry, Part I"—Richard R. Eley; "Rheology in the Protective and Decorative Coatings Industry, Part II"—Richard R. Eley; and "Control and Rheological Measurement of Crosslink Density in Films"—Loren W. Hill, Monsanto Chemical Co.

THURSDAY, JUNE 6: "Rheology of Liquid Coatings with Emphasis on Defect Formation"—Clifford K. Schoff, PPG Industries, Inc.; "Thermal Mechanical Properties of Coatings"—Daniel J. Skrovanek, Bayer Corp.; "Application of Rheology to Engineering Problems"—Donald Bigg, R.G. Barry Corp.; and "Chemorheology of Thermosetting Coatings"—Richard R. Eley.

FRIDAY, JUNE 7: "Cure Characterization for Product Research and Development, Part I"—Theodore Provder, The Glidden Co.; and "Cure Characterization for Product Research and Development, Part II"—Theodore Provder.



The "Introduction to Coatings Technology" course will be presented by John A. Gordon and Robert A. McNeill. The course will discuss the evolution of coatings technology and the progress the coatings industry is making in its rapid change from art to science. It will present the specialized language of the industry and will cover many raw materials and their functions in both architectural and industrial finishes. Some time will be spent on regulatory restrictions, economic forces, and other factors that influence the composition and performance of coatings. Formulation of coatings and basic, simple calculations will be discussed.

The fee for "Introduction to Coatings Technology" is \$690. The cost for Dispersion of Pigments, Adhesion and Applied Rheology is \$875.

For additional information, contact Carl J. Knauss, Professional Development Institute, P.O. Box 1792, Kent, OH 44240.

SPOTLIGHT

Environmental Services and Equipment



Environment

Acetone

In June 1995, the U.S. Environmental Protection Agency (EPA) removed acetone from the list of volatile organic compounds (VOCs) considered to be ozone precursors because of their photochemical reactivity. In the final rule, EPA concluded that acetone had negligible photochemical reactivity. VOCs demonstrate photochemical reactivity and are believed to participate in chemical reactions that contribute to the formation of ground-level ozone, a pollutant that may cause risk to human health.

Although acetone has been deleted from EPA's list of photochemically reactive compounds, each state may or may not remove acetone from its VOC control program. Paint manufacturers must determine on an individual basis if their state intends to implement this action. Since EPA will no longer give VOC reduction credit to states for reducing acetone emissions, states have no significant rationale for listing acetone as a VOC.

California Proposition 65

In 1995, the National Paint and Coatings Association (NPCA) filed an *amicus curiae* brief with the Superior and Appellate Courts in California supporting a challenge by Cotter and Company and urging the court to find that California's Proposition 65, as applied to paint products containing toluene, is preempted by the Federal Hazardous Substances Act (FHSA).

NPCA told the court that the practices of those pursuing enforcement of Proposition 65 have left no "actual alternative" to "affixing the Proposition 65 warning" to a container. Therefore, "labeling on the product provides the only certain means of ensuring compliance." However, requiring a state-mandated warning on the product label which is "in addition to" or "different from" that required by the FHSA places Proposition 65 in direct conflict with preemptive labeling requirements imposed under the FHSA, as NPCA stated in its brief.



However, the court would not reconsider and was hearing oral arguments, at presstime.

JCT Spotlight Environmental Issues

Of all the influences affecting the coatings industry, environmental regulations continue to have the greatest impact. This Spotlight focuses on the major issues that have affected the industry over the past year.

Information, in part, for the Spotlight is reprinted from the November 1995 issue of Coatings, courtesy of the National Paint and Coatings Association, 1500 Rhode Island Ave., N.W., Washington, D.C. 20005-5597.

Clean Air—Aerosols

In March 1995, the California Air Resources Board (CARB) unanimously adopted an aerosol coatings regulation which limited the VOC content of products offered for sale after January 1, 1996. The state of Oregon has also adopted a similar regulation for the Portland Air Quality Management Area. In addition, the U.S. EPA has announced its intention to promulgate a VOC rule for spray paints as part of its program under the 1990 Clean Air Act Amendments.

CARB's aerosol coatings regulation limits the VOC content of six general categories and 30 additional specialty categories. The rule contains two tables of standards (TOS)—one that went into effect on January 1, 1996 and another that goes into effect December 31, 1999. Although the initial TOS mandates VOC limits that are feasible and reasonable, the 1999 standards are unachievable by any known technology. Because of the dramatic reduction required by the 1999 standards, the rule specifically requires CARB to conduct hearings sometime during 1998 to determine the "technological and commercial feasibility" of the 1999 limits. Should the board determine that the 1999 limits are not feasible, the rule permits the board to invoke an extension period of up to five years before the 1999 limits become effective. During the extension period, the board is permitted to establish an interim standard for VOC content.

The aerosol regulation adopted in Portland is similar to the CARB rule with regard to the 1996 TOS and the definitions of product categories. The major difference between the two rules is that there is no future TOS in the Portland rule, and there is an unlim-

ited sell-through for products manufactured prior to January 1, 1996. The CARB rule only has an 18-month sell-through.

EPA is now researching the aerosol coatings industry. Under Section 183(e) of the 1990 Clean Air Act Amendments, the agency is required to regulate groups of consumer products according to a priority rating, as the result of a consumer products survey. Aerosol coatings are in the first group of products to be regulated. EPA has indicated that the federal rule must be based upon "best available controls" (BAC). In other words, the rule cannot be "technology forcing."

Clean Air—AIM Coatings

Efforts aimed at achieving a fair and workable national regulation of VOC emissions from architectural and industrial maintenance (AIM) coatings have continued.

NPCA has been working directly with EPA in an effort to reach common ground with regard to a proposed rule. During 1995, NPCA held several meetings with EPA representatives urging the adoption of the association's suggested national model rule.

AUGUST 1995: EPA issued an informational copy of its draft preamble to the proposed AIM rule. The draft did not distinguish that any potential regulation of AIM products in the year 2000 would be treated separately from the 1996 TOS rulemaking or that a different regulatory timetable would be accorded via separate notice and comment.

SEPTEMBER 1995: NPCA contacted EPA expressing its concerns over the draft preamble and, specifically, the TOS. In its letter, NPCA urged EPA to revise the draft preamble by clarifying several points: (1) that the notice of rulemaking is intended to promulgate a TOS for the year 1996 and attendant rules *only* and (2) EPA would only propose AIM limits, additional restrictions, and/or market-based components, after a full assessment and proper basis has been demonstrated as required by the Clean Air Act.

EPA indicated in its response that it would redraft its preamble to make a number of clarifications. On September 21, 1995, EPA released a revised draft preamble that reflected the selection of "best available controls" (BAC)

for 1996. However, the presentation and discussion of a second TOS as possibly representing BAC for the year 2000 remained as an integral part of the proposal.

On September 28, 1995, NPCA held discussions with EPA urging the agency to eliminate the TOS for the year 2000. NPCA also encouraged EPA to publish the rule in a timely manner, so that states taking credit for VOC reductions from a national AIM rule would not have to act independently. In addition, the association suggested language which justifies NPCA-recommended levels for flats, non-flats, and industrial maintenance coatings.

NOVEMBER 1995: EPA released a new draft framework for a proposed national AIM coatings rule, which is substantially based on a model AIM rule suggested by NPCA.

In conjunction with its proposal, EPA asked industry to participate in a post-rule study to determine whether there is any justification or need for further regulatory action beyond 1996.

JANUARY 1996: Members of the NPCA's Architectural and Industrial Maintenance (AIM) Steering Committee and Architectural Coatings Committee voted in favor of NPCA's offering its support of the U.S. EPA proposed AIM rule.

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

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

The post-rule VOC study, which should be finalized over the next three months, would be jointly managed and funded by EPA and the coatings industry and would likely begin after the effective compliance date of the AIM rule. The national rule and subsequent joint industry/government study should provide industry with an opportunity to obtain uniform regulations throughout the country while evaluating the scientific, technological, and economic questions surrounding the issue of future VOC control in AIM coatings. (See related articles on page 22).

Clean Air—National Ambient Air Quality Standard

EPA is currently reviewing the National Ambient Air Quality Standard (NAAQS) for ozone, and it plans on finalizing any actions regarding the standard by next spring. Any changes in the NAAQS, particularly those being recommended by EPA staff, will have dramatic impact on how states handle their ozone problems.

A key step in the reevaluation was taken in mid-September when members of the Clean Air Science Advisory Committee met and reviewed a scientific criteria document and paper that EPA staff had prepared to support a revised ozone standard.

The paper recommends the adoption of entirely new approach to ozone

protection that is based on a long-term standard. The current standard is based on an average concentration of ozone over a one-hour period and caps the allowable level of ozone at 0.12 parts per million (ppm). Areas are deemed to be in nonattainment if the standard is exceeded on more than three days in any consecutive three-year period.

The new recommendation would be based on an eight-hour average with the ozone limit tightened to the range of between 0.07 to 0.09 ppm. In addition, EPA staff is recommending that the number of exceedances allowed under the standard be changed. The paper suggests allowing areas to exceed the standard from between one

(Continue on page 23.)



California Moves to Ban Portable Spray Paints

Sen. Quinton Kopp (I-San Francisco) will soon introduce a bill to ban portable spray paints in California. Beginning in 1998, the bill would prohibit anyone from selling portable aerosol containers of paint. Based on a new Department of Justice certification process, only aerosol containers that need a source of energy to activate the paint may be used or sold in California. Intent language in the bill states that by legally restricting the portability of aerosol paint cans, "an opportunity will be created for private industry to develop new products that will achieve wide consumer acceptance while assisting in the eradication of graffiti in California."

Sponsored by the California District Attorney's Association, this new legislation is also supported by a company that has developed a prototype can that requires an electrical device in order to work. A similar bill has been introduced in Hawaii and New York. According to a letter by the District Attorneys' Association, the limitations on portable spray cans "will dramatically reduce acts of graffiti in California" without lessening consumers' demand for the product.



After careful review of the bill, the California Paint Council and the National Paint and Coatings Association have already begun efforts to determine the bill's full impact on paint manufacturers and consumers. CPC plans an "all-out" assault on this ban bill and has already started lobbying the Senate Criminal Procedure Committee where the bill will first be heard. Some of the problems have already been identified:

- Successful anti-graffiti programs must focus on the criminal behavior.
- To date, NPCA and CPC have identified only one *prototype* that meets the requirements of this bill.
- The technology behind electronically activated spray cans is primitive at best and cannot be mass produced.
- Retail losses caused by a ban would be approximately \$108 million a year.
- 1,300 retail jobs directly related to sales of spray paint would be eliminated.

—Information courtesy of California Paint Council

Local/Regional Paint Companies Express AIM Concerns

(Submitted by Paint Industries Task Force for True Ozone Policy)

PAINT INDUSTRIES TASK FORCE FOR TRUE OZONE POLICY, WASHINGTON, D.C.—MARCH 8, 1996: A letter signed by 46 paint company executives was hand-delivered to the office of U.S. Environmental Protection Agency Administrator Carol Browner. The letter raises industry objections to improprieties in U.S. EPA's process of developing a draft proposal for national regulation of architectural coatings. The paint industry letter also requests a face-to-face meeting with Administrator Browner to discuss various issues and concerns in greater depth.

Banding together under the name "Paint Industries Task Force for True Ozone Policy," the group describes itself in the letter as "a new group of independent, small to medium-sized and local or regional paint manufacturers, dealers and contractors..." The Task Force grew out of a paint industry meeting held in February to explore possible strategies for dealing

with U.S. EPA's latest draft proposal. Robert E. Mitchell, Chairman of Dunn-Edwards Corporation, explained that "the purpose of this meeting was not to establish a new organization, but to form a group that would have the single purpose of dealing with the rule—getting EPA to obey the law and pay attention to sound science. Once this mission was accomplished, the group could disband."

The Task Force "core group" of nine companies drafted the letter to U.S. EPA Administrator Browner, and circulated the letter to other paint industry members. Representatives of 37 companies added their signatures to the letter and additional endorsements are being gathered for an update to the letter, which focuses on four key concerns: (1) U.S. EPA's "expedited schedule" denies due process to the industry; (2) U.S. EPA has grossly underestimated the economic impacts of the rule if implemented; (3) U.S. EPA failed

to perform essential prerequisite duties mandated under Section 183(e) of the Clean Air Act Amendments of 1990; and (4) U.S. EPA is overreaching its authority in proposing to regulate attainment areas, where no air quality problem exists.

The letter also says, "We believe that this regulatory proposal, if implemented, will come at the expense of independent, smaller and local or regional companies, their employees, and consumers. Moreover, we believe that an objective, scientific analysis would prove convincingly that this rule cannot benefit the environment."

For additional information, contact Howard Berman at The Jefferson Group, 1341 G St., Ste. 1100, Washington, D.C. 20005, Phone: (202) 638-3535; Fax: (202) 626-8578.

Signatories:

Barry & Associates
M.A. Bruder & Sons, Inc.
Brod-Dugan Company
Bruning Paint Co.
M.F. Cachat Co.
Chem Materials Co.
Color Wheel Paint Manufacturing Co.
Cook & Dunn Paint Corp.
Dan-Tex Paint Mfg. Co.
Davis-Frost, Inc.
DeHart Paint and Varnish Company
Dunn-Edwards Corporation
Elite Coatings
Farrell-Calhoun Paint
Five Star Marketing West
The Flood Company
Gillespie Coatings, Inc.
Hanley Paint Mfg. Co., Inc.
Hirshfield's Paint Mfg., Inc.
Hoffer's Inc.
Hyklas Paints, Inc.
Induron Coatings, Inc.
Ingels, Inc.
KALCOR Coatings Co.
Kentucky Paint Mfg. Co.
A.E. Kohne & Associates
Mercury Paint Company
Miller Paint Company
Mobile Paint Mfg. Co., Inc.
OKON, Inc.
O'Leary Paint Company
Passonno Paints, Inc.
Pro-Mark Group
Rose Talbert Paint Company
Smiland Paint Company
Standard Paints, Inc.
Suntec Paint Inc.
Technical Coatings Inc.
Textured Coatings of America
Three-D Distributing
Triangle Coatings, Inc.
Trinity Coatings Company
Waterlox Coatings Corporation
Wattyl Paint Corp.
Wellborn Paint Co.
X-I-M Products, Inc.

AIM Regulations

On March 7, John Seitz, Director of the U.S. EPA's Office of Air Quality Planning, issued a memorandum allowing states to claim a 20% volatile organic compound (VOC) emissions reduction credit towards a requirement that they reduce VOC emissions by 15% under the Clean Air Act Amendments of 1990. The memorandum was issued as a result of EPA's forthcoming national AIM coatings VOC regulation.

The credit is significant to states with ozone nonattainment areas because they are required to reduce VOC emissions by 15% in those areas by November 1996. According to Jim Sell, Senior Counsel for the NPCA, many states had relied on EPA to issue a national AIM coatings VOC rule before that date and had based their reduction plans on this expectation. The national regulation, however, will not be effective until April 1997.

"If EPA had not issued the memorandum, many states, including those with high populations and significant markets for AIM coatings, would have felt compelled to issue their own individual AIM coatings regulations to ensure the integrity of their state implementation plans for meeting the 15% rate of progress requirement," explained Sell.

Failure to meet this requirement could result in significant sanctions being imposed on a state, including the cutoff of federal highway funds, as well as the imposition of additionally stringent requirements for further reductions in VOC emissions from newly-constructed plants. Notably, a federal district court recently rejected the state of Missouri's efforts to challenge EPA's authority to impose such sanctions.

Prior to an earlier EPA decision in 1994 to grant a VOC reduction credit to the states on the basis of the forthcoming national AIM rule, several states had initiated their own rulemakings. Some states were considering the stringent VOC limits found in California's South Coast Air Quality Management District.

(Continued from page 21.)

and five times a year averaged over a three-year period. If an exceedance level of three was chosen, an area would be allowed to exceed the standard nine times in three years without being penalized. This is an important issue with the states that are concerned about being bounced from attainment to nonattainment status after one bad ozone season.

EPA will soon be faced with a significant policy decision, when setting the exact allowable level of ozone. The difference in health protection between a 0.08 ppm and a 0.09 ppm standard is believed to be extremely small, but the economic impacts are dramatically increased at the 0.08 ppm level.

Experts have pointed out that an eight-hour standard between 0.090 and 0.095 would be approximately equivalent in stringency to the present one-hour standard. In other words, it would produce approximately the same number of nonattainment areas. Consequently, an eight-hour standard of 0.08 ppm would be significantly more stringent than the present standard. Most areas that are barely meeting the current standard would be hard pressed to remain in attainment and would be forced to seek additional VOC emission reductions. Therefore, an eight hour NAAQS of 0.08 ppm would have far-reaching ramifications for state governments and industry.

In anticipation of the coming change in the NAAQS for ozone and other criteria pollutants, EPA has formed an advisory subcommittee for assistance. The subcommittee will provide input on developing new implementation strategies and identifying and resolving impediments to the adoption of any new programs resulting from these changes.

Clean Air—Operating Permit Program

As mandated under the 1990 Clean Air Act Amendments, states are required to establish clean air operating permit programs that are consistent with EPA guidelines for all significant sources of air pollutants. Most programs became effective in 1995 and many facilities had to develop permit applications that year.

The permits set emission limitations related to specific air pollutants, affect daily compliance of manufacturing operations, and impose emissions monitoring, recordkeeping and certification requirements. Operating permits are intended to serve as single-

source documents that specify in detail all state and federal clean air requirements that pertain to a facility, and that ensure that the permit standards are met.

EPA has attempted to revise the program to make it more reasonable and flexible, and there have been congressional efforts to delay implementation of the program for one year to allow for a thorough review. However, many states have already established programs and are expected to proceed with implementation of at least the core features of these programs, whether or not there is a delay in federal requirements.

In addition to the operating permit program, states must also reduce VOC emissions by 15% by 1996 in ozone nonattainment areas and carry out additional programs aimed at reducing hazardous air pollutant emissions.

Clean Water Act Reauthorization

In May 1995, the U.S. House of Representatives passed legislation revising the Clean Water Act (CWA). Rep. Bud Shuster (R-Pa.) reportedly stated that the bill "retains the existing framework" of the act, while providing market incentives and a basis of sound scientific and economic principles.

Shuster is author of the legislation, which specifically addresses several issues of interest to the paint industry. One provision in the bill would exclude facilities whose storm water does not come into contact with industrial or commercial activities, materials or products. In addition, the bill requires EPA to prepare risk and cost/benefit analyses for each standard, effluent limitation, or other regulatory requirements under the CWA.

President Clinton has publicly stated that he intends to veto the revised CWA, if it passes the Senate. However, the issue remains unresolved in the Senate's Committee on Environment and Public Works.

Resource Conservation and Recovery Act

A number of changes took place in 1995 in relation to the Resource Conservation and Recovery Act (RCRA).

In January, members were notified that EPA had published a final rule at the end of 1994 setting land disposal requirements for hazardous waste generators and facility operators. The Land Disposal Restrictions (LDR) Phase II program establishes new treatment

standards for 42 newly listed hazardous wastes and consolidates the existing LDR compliance procedures by setting universal treatment standards for over 200 constituents. The required treatment standards for these wastes must be met before they are land disposed. Provisions of the new rule are also expected to reduce costs and simplify existing LDRs.

In May, the "universal waste" rule went into effect. This regulation streamlines hazardous waste management under RCRA, governing the collection and management of certain widely generated wastes. The rule eases the regulatory burden on retail stores and others that wish to collect wastes, while assuring that the wastes subject to the system will go to treatment and recycling facilities appropriate under RCRA regulatory controls. The rule is also expected to facilitate recycling programs that prevent such waste from entering municipal solid waste landfills and combustors. Paint is excluded from the provisions of the rule; however, states have been granted the authority to add wastes such as paints, fluorescent bulbs, and antifreeze to their own regulations.

EPA issued another final rule addressing restriction of air toxic emissions from hazardous waste tanks, containers, and surface impoundments under RCRA. The rule establishes additional air standards for hazardous waste treatment, storage and disposal facility owners and operators. The rule also amends the conditions for hazardous waste generators accumulating waste on-site in RCRA-permit-exempt tanks and containers to include air emission control requirements. Under these standards, airtight covers and vapor control devices must be placed on tanks and containers over 26 gallons that store hazardous waste. The rule will have a significant effect on paint manufacturers that are RCRA-permitted facilities and/or that generate and store hazardous waste on-site in RCRA-permit-exempt 90-day tanks and containers. Under the rule, affected paint manufacturers and other generators are required to modify storage tank covers, provide emission controls on tanks and distillation units and have portable leak detection equipment and continuous monitoring equipment for the control devices. NPCA and seven other parties have filed extensive





petitions for review with the Eighth Circuit Court of Appeals. As a result, EPA has published notice of data availability and proposed revisions to the rule.

While EPA held public meetings in June to discuss RCRA reform, Congress has not yet addressed reauthorization. Draft legislation has been circulated in the House of Representatives amending the remedy selection provisions for RCRA corrective action procedures. It would also give states administrative and enforcement responsibilities for RCRA cleanups. The authors of the bill hope to see it on the floor of the House this month. Meanwhile, the Senate has introduced a bill to reform corrective action in which EPA and the states would share enforcement of remediation plans.

Storm Water Multi-Sector General Permit

The EPA published a final National Pollutant Discharge Elimination System (NPDES) storm water multi-sector general permit for industrial activities in September 1995.

The permit for industrial activities applies to paint manufacturing facilities in 10 states. It is also intended to serve as a model for states with NPDES authority in issuing their states' general permit.

The multi-sector permit includes industry-specific pollution prevention requirements. In addition, it lists specific "best management" practices and pollution prevention measures that a facility can consider in developing a plan to address site conditions. Responding to NPCA's expressed concerns, the permit does not require monitoring for paint and coatings facilities. This provides considerable cost savings for paint manufacturers who participated in the NPCA-developed group permit.

Superfund

In 1995, industry continued to advocate for Superfund reform. In the House of Representatives, a joint measure was introduced which would eliminate liability for (1) any party that dumped waste at a site listed on the National Priority List before June 15, 1995, and that had

accepted municipal solid waste; (2) small businesses that contributed less than one percent of the waste at those sites before 1987; and (3) for other companies, a government rebate of up to 50% of cleanup costs in cases where waste was dumped before 1987.

In the Senate, the bill differed in several key points: (1) the Senate bill makes no exemption for the small businesses who dumped waste at municipal landfills; (2) it does not include the provision that would allow other companies to apply for a government rebate for past contribution; and (3) it would authorize a 50% tax credit for the paid costs of cleanup for waste dumped before 1980. The tax credit would depend on the responsible party abiding by the findings of a non-binding arbitration process which fixes its share of total cleanup costs at a site. Sponsors of both the House and Senate bills acknowledge that total reform or elimination of past liability altogether would necessitate a new source of funding.

Consumer Product Safety Commission—Bucket Labeling

The Consumer Product Safety Commission (CPSC) has discontinued its rulemaking aimed at reducing the potential drowning hazard associated with five-gallon buckets. CPSC's decision to terminate its rulemaking resulted from a review of the obvious and substantial costs that would be incurred by both the commission and the bucket manufacturing industry.

CPSC said it supports voluntary efforts by industry to educate and inform consumers of the potential drowning hazard and that it intends to continue working with industry and the American Society for Testing and Materials (ASTM) in the development of an acceptable performance standard for industrial containers.

On the state level, a law was passed in California in July 1995 allowing manufacturers, distributors, or sellers of four- to six-gallon buckets the option of using one or two labels to warn users of the dangers of childhood drowning.

If the one label option is chosen, the law requires that it be a minimum of six inches in height by two inches in width. Single labels must be placed on the side of the bucket where the handle is inserted. The top half must be in English and the bottom half in Spanish. If two labels are used, they must appear on the opposite sides of the bucket, one in English and one in Spanish.

California is the only state with a law requiring warning labels addressing the risks of childhood drowning in five-gallon buckets. Previously, the law had required two labels, without the one-label option. Since the law was written as an urgency statute, it went into effect immediately.

Ergonomics

In 1995 OSHA released a draft copy of its proposed rule on ergonomics. The draft, which was nearly 500 pages, included the following information: (1) proposed regulatory language; (2) a description of the "signal risk factors" that would trigger employer evaluation of a task; (3) appendices on: compliance assistance for employers, methods of controlling workplace risk factors, employee training, and medical management guidelines; (4) checklists to determine workplace ergonomic risk factors for specific jobs; and (5) reviews of disorders associated with poor ergonomic conditions, risk assessment and economic analysis, and regulatory flexibility analysis. Also included were specific risk factors that target jobs needing further evaluation.

Lead Issues—Federal

EPA continues to pursue regulations under the Residential Lead Based Paint Hazard Reduction Act (also known as Title X), which is primarily administered by the U.S. Department of Housing and Urban Development (HUD). Under Title X, EPA guidelines for state regulations on training and certification of lead abatement workers have been finalized. In addition, the final regulations requiring property owners to notify tenants of any known presence of lead have been issued. (*See related story on next page.*)

Industry's comments on the proposed notification rule stressed that some \$13.8 billion in unnecessary expenditures would be incurred by homeowners. NPCA has been invited to participate in an EPA-sponsored discussion group to define health-based standards for paint, dust and soil. NPCA continues to advocate "in-place management" as a means of lead exposure reduction. This method encourages repair and painting activities that can be undertaken in a lead-safe manner by a contractor or homeowner that is informed of potential hazards.

NPCA continues to expand its work on the environmental lead issue. Its most recent endeavor involves participation in a coalition of industry organizations aimed at reducing the risks

of childhood lead exposure. The project, known as CLEARCorps, recently received funding from the AmeriCorps National Service Corporation for three demonstration programs teaching residents to apply simple lead exposure reduction techniques in inner-city housing.

Lead Issues—State

State legislatures and regulatory agencies continue to address the issue of lead—lead in packaging, lead poisoning prevention, lead-related taxes—through various methods. Meanwhile, the industry is working hard to combat the negative impact of these measures. The following is a glimpse of some activity within the states over the past year.

In Maine, a bill was introduced in the legislature imposing a 25-cent-per-gallon tax on the sale of paint in order to fund the state's lead poisoning prevention program. NPCA staff appeared before the legislative committee and testified in opposition. The measure was subsequently removed from the proposed bill.

In Massachusetts, the legislature held hearings concerning "market share" legislation that creates a theory of liability in lead cases and would revive lawsuits seeking damages for corrective actions.

Having received a blanket exemption in a toxics-in-products statute in Minnesota, industry now faces legislation that requires statewide lead surveillance systems. In addition, the law specifies certain obligations of property owners concerning lead and establishes licensing and certification requirements for lead contractors and inspectors. Meanwhile, the state paint council and NPCA are working to repeal the toxics-in-products law.

In Ohio, a case was recently decided addressing a claim of childhood lead poisoning. The trial court's ruling to dismiss the complaint was reversed by the Ohio Court of Appeals. According to the higher court, the Ohio law, which is based on market share liability, could form the basis of a recovery if proven by the plaintiff.

Other lead-related legislation is underway in Connecticut, California, Kentucky, New York, and New Hampshire, as well as other states.

NIOSH Respiratory Protective Devices

A final rule was published in July 1995 by the National Institute for Occupa-

EPA Issues Regulations on Disclosure of Information Concerning Lead-Based Paint

The Administrator of the Environmental Protection Agency (EPA) and the Secretary of the Department of Housing and Urban Development (HUD) have signed a joint rule entitled *Lead: Requirements for Disclosure of Information Concerning Lead-Based Paint in Housing*. EPA and HUD are issuing these requirements to help ensure that all families buying or renting target housing (most housing built before 1978) receive the information necessary for making informed housing and lifestyle decisions to reduce their risk of exposure.

EPA is issuing a final rule under the authority of section 1018 of the *Residential Lead-Based Paint Hazard Reduction Act of 1992* (Title X). Under section 1018, EPA and HUD were directed to issue joint regulations for the disclosure of known information on lead-based paint and lead-based paint hazards before individuals purchase or lease target housing. In addition, the statute requires that sellers and lessors provide purchasers and lessees with an EPA lead hazard information pamphlet containing general information on the risks of exposure to lead and lead-based paint, as well as measures for preventing exposures.

Section 1018 also includes several provisions that apply uniquely to housing sales. In particular, purchasers must receive a 10-day opportunity to conduct and finance an inspection or risk assessment for the presence of lead-based paint hazards, unless mutually agreed otherwise in writing. This provision will ensure that purchasers can obtain site-specific information on lead hazards, even in housing where no information currently exists. Since proposing the rule, EPA and HUD have revised the rule based on comments received and believe that the revisions reflect the agencies' desire to maximize the rule's clarity, flexibility, consistency with other federal activities, and consistency with existing real estate practice.

To support the disclosure provisions mandated in Title X, EPA and HUD have provided a sample format for disclosure that could be used during transactions to sell or lease target housing. This form would document known information on lead-based paint and lead-based paint hazards, would alert purchasers and lessees to their rights under the Act, and would serve as a record of compliance for sellers, lessors, and agents. This final rule provides great flexibility to negotiating parties to develop their own forms provided that the form meets the mandated elements.

For More Information

For a copy of *Protect Your Family from Lead in Your Home*, the sample disclosure forms, or the rule, call the National Lead Information Clearinghouse (NLIC) at (800) 424-LEAD; Fax to (202) 659-1192; or by the Internet E-mail to ehc@cais.com.



tional Safety and Health (NIOSH) abolishing all previous classifications of dust respirators and replacing them with three new categories. The paint, lacquer and enamel respirator, or the paint spray respirator, previously certified by NIOSH is being discontinued.

The rule introduces new certification requirements for particulate filters for non-powered air-purifying respirators. Eliminated are previous classes of respirators used for dust, fumes, mists, paint spray, asbestos, and pesticides.

The old particulate filter types continue to provide adequate protection and may still be manufactured and used until 1998. However, by the end of the phase-in period, companies will only be able to purchase products in the new respirator and filter categories.

For most jobs, the new options will make it easier to choose appropriate respiratory protective equipment than in the past. However, for other jobs, including those involving spray application of coatings, the best choice is not yet defined.

OSHA Inspections

In 1995, the Occupational Safety and Health Administration (OSHA) targeted paint and allied coatings for increased inspection activity. OSHA confirmed that paint and allied coatings manufacturers represent a priority industry for programmed inspections, which means that members are more likely to be chosen for an OSHA inspection than they were in the past.

OSHA Respirator Proposal

OSHA proposed a rule in November 1994 that would modify existing general industry standards on respiratory protection. The rule would incorporate numerous details that are either not addressed or are left up to the employer under the existing regulation. OSHA's proposal includes language outlining specific requirements for selecting, fit testing, cleaning, maintaining, and storing respirators.

In 1995, NPCA filed comments in response to the proposed rule. In its comments, NPCA stated that it does not support the proposed requirement which calls for "an assortment of at

least three sizes for each type of facepiece and from at least two different manufacturers." While NPCA noted that OSHA is correct in stating that one size does not fit all, it is not appropriate to assume that it will be necessary for each individual to try six different face pieces to find one that provides a comfortable fit. The comments also pointed out that under the proposal, OSHA inspectors could easily interpret that an employer of a single respirator wearer must have a closet of respirators in three sizes made by two different manufacturers in order to comply with the standard.

NPCA also noted its support of the proposal's recognition of the possibility of appropriate and safe use of respirators in the absence of warning properties but does not think the use should be limited to occasions when the warning properties occur within three times the permissible exposure limit (PEL). Also mentioned was the fact that for some substances, the PEL is based on the potential for causing irritation and is set at a level more than three times below the average irritating concentration. For those materials a warning property exists, but could not be used under the proposed language.

In the comments, NPCA addressed issues surrounding the subject of fit testing. The association agreed with the lack of regulatory limitations on the use of contact lenses with respirators and the restriction of facial hair only if it interferes with the face seal or valves. The proposal's justification for conducting three independent quantitative fit tests per respirator was found to be inadequate by NPCA.

USDA Directive

In August 1995, a new U.S. Department of Agriculture (USDA) directive was issued requiring paint and coatings manufacturers and suppliers to provide a letter of certification or a complete listing of the chemical composition of paints and coatings applied in federally inspected meat and poultry facilities.

The directive is part of an audit program to ensure sanitary conditions in such facilities. In the past, manufacturers were required to seek prior approval for paints or coatings and receive a letter, which provided inspectors with a means of determining that the product complied with USDA requirements. NPCA's Product Safety Subcommittee formed a workgroup to develop recommended revisions to the directive. Although negotiations have not yet resulted in a revised directive,

Managing Leftover Paint

In an effort to address solid waste concerns and help reduce the risk of filling municipal landfills to capacity, the paint industry is working to make disposal a last resort for managing leftover paint and paint containers. Through its "Six-Point Program," the paint industry is educating consumers and regulators on how to avoid disposal by minimizing the amount of paint remaining after a project is finished and finding creative ways of dealing with any that is leftover.

The Six-Point Program suggests:

- 1 Buy only what you need and use it up;
- 2 Recycle the empty can;
- 3 Store leftover paint properly for touchups or future projects;
- 4 Donate unwanted paint—to neighbors, churches, community or theater groups, and, only as a last resort;
- 5 Dry and discard latex or water-based paint in the trash, but;
- 6 Save leftover liquid solvent-based paint for special collection.

A brochure entitled "Managing Leftover Paint: Six Ways You Can Help Protect the Environment" explains the Six-Point Program and is available free to consumers upon request through NPCA's Paint and Coatings Industry Information Center, (202) 332-3194.

the USDA's Food Safety and Inspection Service has agreed to withdraw the directive. The USDA also extended all existing product certifications, which were to have expired in August 1995, ensuring that coatings manufacturers can continue to sell previously approved products for this market until USDA revises the directive.

Mexican Labeling

According to NAFTA staff at the U.S. Department of Commerce (DOC), the Mexican government has issued new labeling requirements that are now in effect. In addition, DOC has indicated that the Mexican government has modified a previously stated position and will now permit paint and coatings manufacturers to affix precautionary warnings to affected products with appropriate sticker labels.

Labels on products exported to Mexico are subject to official Mexican standards (Normas Oficiales Mexicanas, or NOM), including a product-specific NOM for paints and coatings. The NOM regulates imports of both consumer and industrial paint and coatings products. The standards specify that the manufacturer provide certain product information on the label in Spanish. Such information includes the name and address of both the exporter and the importer, the importer's "RFC" number and/or its industry association registration number, net contents, and warning or precautionary language on hazardous materials.

In the past, the practice of many U.S. companies distributing products in Mexico was to apply a Spanish-language sticker label. The Mexican government had previously pronounced sticker labeling of U.S. products unacceptable and specified that Spanish language labels must be affixed to the

product "at the factory." At present, this position has been changed and appropriate sticker labels are considered acceptable. To date, the DOC is unaware of enforcement of the labeling regulation at the Mexican border.

Sales and Use Controls

Spray Paint Restrictions

In an attempt to stop the continued spread of graffiti vandalism, many cities are attempting to restrict the supply of graffiti tools through lock-up laws. A recent survey of legislative activity in the states regarding anti-graffiti issues indicates that California, Michigan, New Jersey, New York, Oregon, and Utah have all considered bills ranging from increasing penalties for vandalism to product restrictions.

Since the California Supreme Court issued a decision upholding the Los Angeles lock-up ordinance in 1993, the major cities in California, along with more than 20 California municipalities, have adopted lock-up ordinances. This year, despite an aggressive campaign by the National Council to Prevent Delinquency (NCPD), several cities enacted lock-up laws, including Phoenix, AZ; Irving and Seguin, TX; and Elizabeth, NJ.

Bills banning the sale of spray paint were introduced in New Mexico and in the New York City Council. Both bills, however, failed to move out of committee and are effectively dead. In the city of Albuquerque, the NCPD encouraged the mayor to establish a "Responsible Retailing" program instead. The program is in effect for a one-year trial and, if not successful, lock-up legislation will most likely be pursued.

In Irving, TX, where lock-up laws are prohibited, the city attorney at-

tempted to introduce such legislation. Instead, a substitute ordinance was drafted requiring retailers to use a theft-prevention device on each can of spray paint. This theft-prevention apparatus could potentially cost each retailer approximately \$6,000 per year. In addition, it has been reported that the anti-theft device is ineffective.

Other areas that are considering developing anti-graffiti programs are Tucson, AZ; Berkeley, CA; Denver, CO; Tampa, FL; Montgomery County, MD; Boston, MA; Buffalo, NY; and many others.

Transportation

DOT Hazardous Materials Transportation Registration and Fee Assessment Program

The Department of Transportation's Research and Special Programs Administration (RSPA) published a final rule this year maintaining the current annual registration fee of \$300. The fee applies to persons engaged in transporting or offering for transportation certain categories and quantities of hazardous materials in intrastate, interstate, and foreign commerce.

RSPA has also adopted changes to the program. The requirement for materials that are extremely toxic by inhalation has been expanded to include other materials. In addition, there is now an exception from the registration requirement for foreign offerers.

—*Information reprinted courtesy of the National Paint and Coatings Association*



Packaging Solutions and the Coatings Industry

Recycling Steel Containers

Steel paint cans, like steel cans used for other commodities, can be and are recycled successfully. All of today's steel products contain recycled steel, and are themselves recyclable. In fact, steel is the only material used in durable goods and packaging that *cannot* be made from 100% virgin material; previously manufactured steel is required.

Cans and other discarded steel products can be collected by ferrous scrap dealers or curbside waste haulers, who magnetically separate the steel from municipal solid waste or from other recyclables, and send them to be used in the production of new steel.

The Pittsburgh-based Steel Recycling Institute (SRI) sponsors vigorous educational efforts aimed at manufacturers, coatings users, and consumers, to teach them how to recycle steel paint containers, and to make the process as simple as possible.

SRI stresses the importance of emptying the containers completely, and leaving only a thin film of dry paint inside.

In an effort to make can recycling easier for consumers, hundreds of U.S. cities have initiated curbside collection of empty paint and aerosol cans.

Steel Drums

While municipalities, SRI, and the paint industry are encouraging consumers to recycle their paint cans, paint manufacturers and their suppliers are cooperating with efforts by SRI and the Steel Shipping Container Institute to promote the reconditioning, reuse, and ultimate recycling of steel

National, state, county, and municipal officials are increasingly concerned about decreasing landfill capacity, and the resulting problems with disposal of solid wastes, including product packaging. Manufacturers and retailers of all kinds of products are working to recycle or otherwise process their packaging wastes in order to keep those materials out of landfills.

Paints and industrial coatings are packaged primarily in two types of containers. The majority of paint cans and drums are made of steel, with most of the remainder made of rigid plastics. The following report, reprinted from NPCA's December 1995 "Issue Background" newsletter, details some of these packaging issues.

drums used by chemical manufacturers to ship paint raw materials to their customers.

Over 40 million drums are reconditioned every year—more than are manufactured. This indicates that established, cost-effective options for steel drum reclamation exist. Increasingly, drums and pails that cannot be reconditioned are directly recycled; that is, they are sent to a scrap processor to be crushed and sent to a steel mill to be made into new steel. In addition to proper emptying, users are learning to reduce return freight costs by accumulating a significant number of drums on site.

Plastic Paint Containers

It has been estimated that a quarter of all paints sold are packaged in plastic containers ranging from one- to five-gallon capacity. But for a number of reasons, the technology for recycling plastic paint containers has lagged behind that for steel containers.

A major barrier to plastic recycling is a current lack of appropriate collection systems. A representative of one supplier of pails to the paint industry says that the major problem is getting enough used pails together to make recycling worthwhile. "There is no return system," he says, adding that most plastic paint pails end up as trash on a contractor's job site, and then in a landfill.

However, material suppliers to the coatings industry are taking a long look at the feasibility and economics of recycling their rigid paint containers, and it is assumed that the practice will continue to become more widespread.

Government Regulations

Under the federal Resource Conservation and Recovery Act (RCRA), the U.S. EPA has some limited authority to regulate the disposal of solid waste, including packaging wastes, particularly if those wastes are involved in

interstate commerce. Legislation passed in 1992 would allow states to ban or tax solid wastes (consisting primarily of packaging wastes) brought in from other states.

But the EPA recognizes that the states play the primary role in the regulation of industrial solid (non-hazardous) waste. Therefore, the agency's initiatives so far have generally taken the form of efforts to gather information from interested parties, with the eventual goal of developing voluntary guidelines for owners and operators of waste disposal facilities.

Lacking much formal regulation at the federal level, the states have been active in the regulation of product packaging.

California, Oregon, and Wisconsin are among states that have addressed the subject of rigid plastic containers. The statutes set requirements for a specific percentage of recycled content, sometimes tied to the percentage of the material recycled in the state.

For example, in California, all rigid plastic containers with a capacity ranging between eight ounces and five gallons must meet at least one of a series of criteria relating to the use of recycled/recyclable material.

Other jurisdictions have chosen to address their particular concerns in a number of ways. Unfortunately, some states have adopted regulations requiring that "advance disposal fees" be added to the price of the item. Florida, which had adopted such a regulation in 1993 for packaging with a recycle rate lower than 50%, allowed the regulation to "sunset" in October 1995;



therefore, the fee will no longer be collected in the state.

Other bodies have concerns about heavy metals—lead, mercury, cadmium, and hexavalent chromium—in such packaging elements as inks, solders, etc. Model legislation written by the Council of Northeast Governors (CONEG) has been adopted by 19 states, either directly or in a modified version.

Container manufacturers that supply the paint industry say that they have changed their manufacturing practices to accommodate these legislative requirements, and that “toxics-in-packaging” laws are no longer an issue.

Not all calls for regulation relate to the disposal of containers in landfills. Empty five-gallon containers, once used for commodities such as bulk foods, paint, etc., are sometimes saved by house-holders and reused as pails for housecleaning chores. Concerned that toddlers can fall into those pails and drown in the water or cleaning solution they contain, California legislators acted to require labels, in two languages, to warn parents of this hazard.

At the national level, the Consumer Product Safety Commission considered (but later dropped) a formal rulemaking to require warning labeling nationwide, or to require that the containers be redesigned to eliminate the possibility of bucket drownings. Meanwhile, the California labeling law has been amended to allow for a single label with a warning in both English and Spanish, rather than requiring two separate labels.

A Global Concern

Management of packaging waste is a concern not only in the United States, but around the world. The nations of the European Union (EU) have set target percentages of packaging material to be recycled by the year 2001, but three countries—Denmark, Germany, and the Netherlands—have rejected the EU percentages as too small and have set more stringent requirements for themselves.

Canada and Japan are also among those nations looking for recycling solutions to their solid waste problems.

Here in the United States, the coatings industry continues to be a partner in efforts to reduce or eliminate packaging waste, at the paint manufacturer's factory, at a user's plant or shop, and in the consumer's home.

Q & A

Government Regulations Concerning Packaging

Q. *Who has authority to regulate the disposal of packaging wastes?*

A. Under the federal Resource Conservation and Recovery Act (RCRA), the U.S. Environmental Protection Agency (EPA) has some limited authority to regulate the disposal of solid waste, including packaging wastes, particularly if those wastes are involved in interstate commerce.

Legislation passed in 1992 would allow states to ban or tax solid wastes (consisting primarily of packaging wastes) brought in from other states.

Q. *How are the roles of the federal government and the states defined in regard to regulating the disposal of solid waste?*

A. EPA recognizes that the states play the primary role in the regulation of industrial solid (non-hazardous) waste. Therefore, the agency's initiatives so far have generally taken the form of efforts to gather information from interested parties, with the eventual goal of developing voluntary guidelines for owners and operators of waste disposal facilities.

Q. *Which states have been active in the regulation of product packaging?*

A. California, Oregon and Wisconsin are among states that have addressed the subject of rigid plastic containers. The statutes set requirements for a specific percentage of recycled content, sometimes tied to the percentage of the material recycled in the state.

For example, in California, all rigid plastic containers with a capacity ranging between eight ounces and five gallons must meet at least one of a series of criteria relating to the use of recycled/recyclable material.

Unfortunately some states have adopted regulations requiring that “advance disposal fees” be added to the price of the item. Florida, which had adopted such a regulation in 1993 for packaging with a recycle rate lower than 50%, allowed the regulation to “sunset” in October 1995, therefore, the fee will no longer be collected in the state.

Q. *Are there any laws that address toxics in packaging?*

A. In response to concerns about heavy metals in packaging, model legislation written by the Council of Northeast Governors has been adopted, either directly or in a modified version, by 19 states. Container manufacturers that supply the paint industry have changed their manufacturing practices to accommodate these legislative requirements, and “toxics-in-packaging” laws are no longer a real concern.

ENVIRONMENTAL SPOTLIGHT: source guide

	AIR POLLUTION EFFLUENT CONTROL	COMPUTER SOFTWARE/ HAZ. MAT. HANDLING	COMPUTER SOFTWARE/ MSDS	ENVIRONMENTAL/ REGULATORY SERVICES	ENVIRONMENTAL EQUIPMENT	HEAT RECOVERY SYSTEMS-WASTE	LABELING	SAFETY/HEALTH SERVICES	SOLVENT RECOVERY EQUIPMENT	WASTE COMBUS- TION/DISPOSAL
Acra Electric Corp.								X		
Advanced Software Designs		X	X				X			
Alar Engineering Corp.	X									
ATA Technologies Corp.	X									
Atlas Electric Devices Co.					X					
Atlas Weathering Services				X						
BatchMaster Software Corp.		X	X				X			
Brookhaven Instruments Corp.					X					
CB Mills								X		
CEM Corporation					X					
The Coatings Laboratory Inc.				X						
Control Instruments Corp.	X				X					
Corbus			X	X						
Datalogix			X							
Disti-Kleen								X		
D/L Laboratories				X						
Engelhard Corporation	X									
Enviro-Logic, Inc.	X									
Filter Specialists Inc.					X			X		
The Foxboro Company					X					
International Reserve Equipment	X					X		X		
International Specialty Products								X		
KTA/SET Environmental				X	X		X			
Littleford Day Inc.								X		
Manufacturing Business Systems			X							
Ocean Optics, Inc.	X				X					
Parasol Systems, Inc.		X	X				X			
S.G. Pinney & Associates					X					
Shimadzu					X					
Stretch-O-Seal Corp.				X						
Systech Environmental									X	
United McGill Corporation	X									
Wheeler Environmental Services				X						
Wilden Pump & Engineering								X		

ENVIRONMENTAL SPOTLIGHT: supplier listing

Acra Electric Corp.
3801 N. 25th Ave.
Schiller Park, IL 60176
Phone: (847) 678-8870
FAX: (847) 678-8889
Solvent Recovery Equipment

Advanced Software Designs
1795 Clarkson Rd., Ste. 220
Chesterfield, MO 63017
Phone: (314) 532-6021
FAX: (314) 532-2935
Ted Pliakos, Account Executive; Nancy
Whately, Marketing & Public Relations Mgr.;
Ray Cook, President
Computer Software—Haz. Mat. Handling
Computer Software—MSDS
Labeling

Alar Engineering Corp.
9651 W. 196th St.
Mokena, IL 60448
Phone: (708) 479-6100
FAX: (708) 479-9059
Air Pollution/Effluent Control
Water Pollution Control Equipment

ATA Technologies Corp.
1240 Valley Belt Rd.
Cleveland, OH 44131
Phone: (216) 459-1930
FAX: (216) 459-1958
Bob Summers, V.P. Technical
Air Pollution/Effluent Control

Atlas Electric Devices Co.
4114 N. Ravenswood Ave.
Chicago, IL 60613
Phone: (312) 327-4520
FAX: (312) 327-5787
Robert Herling, V.P. Sales & Marketing;
Robert Lattie, Director, National Sales; Rudy
Leber, Director, International Sales
Environmental Test Equipment

Atlas Weathering Services Group
17301 Okeechobee Rd.
Miami, FL 33015
Phone: (305) 824-3900
FAX: (305) 362-6276
Larry Master, President; Jack Martin, Site
Manager
Environmental Test Services

BatchMaster Software Corp.
1500 Pacific Coast Hwy., Ste. E
Seal Beach, CA 90740
Phone: (310) 799-8888
FAX: (310) 799-8833
Computer Software—Haz. Mat. Handling
Computer Software—MSDS
Labeling

Brookhaven Instruments Corp.
750 Blue Point Rd.
Holtsville, NY 11742
Phone: (516) 758-3200
FAX: (516) 758-3255
Sidney Li, Sales Mgr.
Environmental Test Equipment

CB Mills
1225 Busch Pkwy.
Buffalo Grove, IL 60089
Phone: (847) 459-0007
FAX: (847) 459-0598
David J. Pagor, National Sales Mgr.; Mary
E. Ryan, Marketing Assistant
Solvent Recovery Equipment

CEM Corporation
3100 Smith Farm Rd.
Matthews, NC 28105
Phone: (704) 821-7015
FAX: (704) 821-5185
Greg LeBlanc, National Sales Mgr.
Environmental Test Equipment

The Coatings Laboratory, Inc.
8605 Rayson Rd.
Houston, TX 77080
Phone: (713) 939-8853
FAX: (713) 939-8841
Environmental Test Equipment

Control Instruments Corp.
25 Law Dr.
Fairfield, NJ 07004
Phone: (201) 575-9114
FAX: (201) 575-0013
Debra Woods-Haley, Product Mgr.;
Joseph Corsi, Sales Director
Air Pollution/Effluent Control
Environmental Test Equipment

Corbus
206 Line Rd.
Kennett Square, PA 19348
Phone: (610) 444-5691
FAX: (610) 444-6461
Computer Software—MSDS
Environmental/Regulatory Services

Datalogix
100 Summit Lake Dr.
Valhalla, NY 10595
Phone: (914) 773-8000
FAX: (914) 773-8001
Computer Software—MSDS
Regulatory Compliance Software

Disti-Kleen
358 Nye Ave.
Irvington, NJ 07111
Phone: (201) 372-1500
FAX: (201) 372-8311
Michael J. Schmutzer; President; Dotty
Hackett, Vice President
Solvent Recovery Equipment

D/L Laboratories
116 E. 16th St.
New York, NY 10003
Phone: (212) 777-4445
FAX: (212) 505-8419
James Gniecko, Technical Director; Thomas
Sliva, Assistant Technical Director; Saul
Spindel, President
Air Pollution/Effluent Control
VOC Determinations

Engelhard Corp.
101 Wood Ave.
Iselin, NJ 08830-0770
Phone: (908) 205-6829
FAX: (908) 205-6146
Stan Mack, Director-Sales; Dennis M.
Jackson, Vice President & General Mgr.
Air Pollution/Effluent Control

Enviro-Logic, Inc.
9873 Kirkwood Ln.
Maple Grove, MN 25369
Phone: (612) 424-1164
FAX: (612) 424-9705
Karl Krueger, President
Air Pollution/Effluent Control

Filter Specialists Inc.
100 Anchor Rd.
P.O. Box 735
Michigan City, IN 46360
Phone: (219) 879-3307
FAX: (219) 877-0632
Contact sales department at 800-348-3205
for name of salesperson
Environmental Test Equipment
Solvent Recovery Equipment

The Foxboro Co.
33 Commercial St.
Foxboro, MA 02035
Phone: (800) 521-0451
FAX: (508) 549-6750
Thomas Bloomer, Director of Marketing
Environmental Test Equipment

International Reserve Equipment Corp.
Four South Prospect Ave.
P.O. Box 198
Clarendon Hills, IL 60514-0198
Phone: (708) 325-7040
FAX: (708) 325-7045
Thomas J. Mertz, Partner/Advertising
Air Pollution/Effluent Control
Heat Recovery Systems—Waste
Solvent Recovery Equipment

International Specialty Products
1361 Alps Rd.
Wayne, NJ 07470
Phone: (201) 628-3000
FAX: (201) 628-4117
Sotiri Papoulias, Director of Marketing
Solvent Recovery Equipment

KTA/SET Environmental
115 Technology Dr.
Pittsburgh, PA 15275
Phone: (412) 788-1300
FAX: (412) 788-1306
William Corbett, Field Services Mgr.
Environmental Monitoring
Environmental/Regulatory Services
Environmental Test Equipment
Safety/Health Services

Littleford Day Inc.
7451 Empire Dr.
Florence, KY 41042
Phone: (606) 525-7600
FAX: (606) 525-1446
William R. Barker, Product Mgr.
Solvent Recovery Equipment

Manufacturing Business Systems
1250 E. Walnut St., Ste. 150
Pasadena, CA 91106
Phone: (818) 585-0103
Herbert Molano, General Mgr.; Peter Elias,
Systems Consultant; Barbara Berger,
Systems Consultant
Computer Software—MSDS

Ocean Optics, Inc.
1237 Lady Marion Ln.
Dunedin, FL 34698-5314
Phone: (813) 733-2447
FAX: (813) 733-3962
Leeward Bean, Vice President of Sales &
Marketing; Marc Baum, OEM, Air Instru-
ments & Measurement Systems; Brien
Barney, OEM, NViscon Instruments, Inc.
Air Pollution/Effluent Control
Environmental Test Equipment

Parasol Systems, Inc.
1851 Craig Rd.
St. Louis, MO 63146
Phone: (314) 434-8300
FAX: (314) 434-3547
Computer Software—Haz. Mat. Handling
Computer Software—MSDS
Labeling

S.G. Pinney & Associates
Instrument Sales Inc.
2500 SE Midport Rd.
Port St. Lucie, FL 34985
Phone: (407) 337-0024
FAX: (407) 337-0294
Pat Marazzi, Instrument Sales Mgr.
Environmental Test Equipment

Shimadzu
7102 Riverwood Dr.
Columbia, MD 21046
Phone: (410) 381-1227
FAX: (410) 381-1222
Environmental Test Equipment

Stretch-O-Seal Corp.
538 South Euclid Ave.
Oak Park, IL 60304-1202
Phone: (708) 445-1900
FAX: (708) 848-3797
Albert J. Betz, President
Environmental/Regulatory Services

Systech Environmental Corp.
245 North Valley Rd.
Xenia, OH 45385
Phone: (800) 888-8011
FAX: (513) 374-4133
Waste Combustion/Disposal

United McGill Corp.
1779 Refugee Rd.
P.O. Box 820
Columbus, OH 43216
Phone: (614) 443-0192
FAX: (614) 445-8759
Air Pollution/Effluent Control

Wheeler Environmental Services
P.O. Box 501
Boyertown, PA 19512-0501
Phone: (610) 369-2905
FAX: (610) 369-2906
Environmental/Regulatory Services

Wilden Pump & Engineering
22069 Van Buren St.
Grand Terrace, CA 92313-5651
Phone: (909) 422-1730
FAX: (909) 783-3440
Solvent Recovery Equipment

ENVIRONMENTAL SPOTLIGHT: services/equipment listing

Air Pollution/ Effluent Control

Alar Engineering Corp.
ATA Technologies Corp.
Control Instruments Corp.
Engelhard Corp.
Enviro-Logic, Inc.
International Reserve Equipment Corp.
Ocean Optics, Inc.
United McGill Corp.

Computer Software— Hazardous Material Handling

Advanced Software Designs
BatchMaster Software Corp.
Parasol Systems, Inc.

Computer Software— MSDS

Advanced Software Designs
BatchMaster Software Corp.
Corbus
Datalogix
Manufacturing Business Systems
Parasol Systems, Inc.

Environmental/ Regulatory Services

Atlas Weathering Services Group
The Coatings Laboratory, Inc.
Corbus
D/L Laboratories
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Brookhaven Instruments Corp.
CEM Corp.
Control Instruments Corp.
Filter Specialists Inc.
The Foxboro Co.
KTA/SET Environmental
Ocean Optics, Inc.
S.G. Pinney & Associates
Shimadzu

Heat Recovery Systems—Waste

International Reserve Equipment Corp.

Labeling

Advanced Software Designs
BatchMaster Software Corp.
Parasol Systems, Inc.

Safety/Health Services

KTA/SET Environmental

Solvent Recovery Equipment

Acra Electric Corp.
CB Mills
Disti-Kleen
Filter Specialists Inc.
International Reserve Equipment Corp.
International Specialty Products
Littleford Day Inc.
Wilden Pump & Engineering

Waste Combustion/ Disposal

Systech Environmental Corp.

Regulatory Update April 1996

This digest of current regulatory activity pertinent to the coatings industry is published to inform readers of actions which could affect them and their firms, and is designed to provide sufficient data to enable those interested to seek additional information. Material is supplied by National Paint and Coatings Association, Washington, D.C. The Regulatory Update is made available as a service to FSCCT 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 FSCCT cannot guarantee its completeness or accuracy.

**Environmental Protection Agency
February 22, 1996— 61 FR 6805
Extension of Comment Period for the
Proposed Hazardous Waste Identifi-
cation Rule (HWIR)**

**Action: Proposed rule; extension of
comment period**

The Environmental Protection Agency (EPA) is extending the comment period for the proposed Hazardous Waste Identification Rule, which was originally published in the *Federal Register* on December 21, 1995. This rule would establish constituent-specific exit levels for low-risk solid wastes that are designated as hazardous because they are listed, or have been mixed with, derived from, or contain listed hazardous wastes.

For further information, contact the RCRA/Superfund Hotline, (800) 424-9346. For technical information on the proposal, contact William Collins, Greg Helms, Pamela McMains, or Tracy Atagi, EPA, (202) 260-8100.

**Environmental Protection Agency
February 29, 1996— 61 FR 7716
National Emission Standards for Haz-
ardous Air Pollutants (NESHAP) for
Source Categories: Organic Haz-
ardous Air Pollutants from the Syn-
thetic Organic Chemical Manu-
facturing Industry**

Action: Direct final rule

This action amends sections of the NESHAP from the Synthetic Chemical Manufacturing Industry, typically known as the hazardous organic NESHAP (HON). Under this direct final rule, source owners or operators are granted additional time to submit area source certification, indicating that they are "area" rather than "major" sources, and to establish minimum documentation requirements. The new deadline is May 14.

In addition, EPA has also extended the deadline for submittal of

implementation plans for emission points not included in an emissions average, originally due April 22, 1996, until December 31, 1996.

This rule will go into effect on April 19, 1996 unless significant, adverse comments were received by April 1. Submit comments, in duplicate, to Air & Radiation Docket and Information Center (6102), Attention Docket Number A-90-20, Room M-1500, EPA, 401 M St. S.W., Washington, D.C. 20460.

For additional information, contact Dr. Janet Meyer, EPA, (919) 541-5254.

**Department of Transportation
Research and Special Programs Ad-
ministration**

**February 20, 1996 - 61 FR 6478
Revision of Miscellaneous Hazardous
Materials Regulations; Regulatory
Review**

**Action: Notice of proposed rule-
making.**

The Research and Special Programs Administration (RSPA) has proposed to amend the Hazardous Materials Regulations (HMR) based on an interagency review and on public comments. The proposal is intended to reduce unnecessary regulatory burdens on industry without compromising safety. Among the proposed changes are revisions to current requirements for worker training and incident reporting.

In response to public comment, the agency has proposed reducing the frequency of worker training for hazardous materials transportation from every two years to every three. In addition, limited amounts of certain materials would be exempted from reporting requirements, including quantities of hazardous materials. The proposal would also require hazardous materials that contain two or more hazardous substances to identify at

least two of those substances on all packaging labels and papers.

For further information, contact John Gale or Jennifer Antonielli, RSPA, (202) 366-8553.

**Department of Transportation
Research and Special Programs Ad-
ministration**

**February 26, 1996 - 61 FR 7178
Hazardous Materials Pilot Ticketing
Program**

Action: Final rule

Under this final regulation, the Research and Special Programs Administration is implementing a pilot program for ticketing of certain hazardous materials transportation violations. The rule, which is part of the Clinton administration's National Performance Review, is designed to streamline administrative procedures, cut costs, and reduce regulatory burdens on facilities subject to federal hazardous materials transportation law.

The pilot program will allow RSPA to issue tickets for violations that have little or no direct impact on safety. Anyone receiving a ticket may pay the fine, respond informally to the agency, or request a formal hearing. Penalties will be substantially reduced for ticket recipients who choose to pay the fine. The agency has not published a formal list of violations covered by the program but will begin issuing tickets in the areas of registration, exemption renewal, and training recordkeeping requirements. Additional minor violations may be added to this list. In two years, the RSPA will re-evaluate this program for cost-saving and overall effectiveness. The final regulation goes into effect on May 15, 1996.

For additional information, contact RSPA's John O'Connell, Jr., (202) 366-4700 or Nancy Machado, (202) 366-4400

**Department of Transportation
Research and Special Programs Ad-
ministration**

March 8, 1996 - 61 FR 9518

**Hazardous Materials Transportation;
Registration and Fee Assessment
Program**

Action: Notice of filing requirements

This is intended to notify persons who transport or offer for transportation certain hazardous materials that they are required to annually file a registration statement and pay a fee to the Department of Transportation.

The persons affected by these regulations are those who offer or transport in commerce any of the following materials:

- ✓ Any highway route-controlled quantity of a Class 7 (radioactive material);
- ✓ More than 25 kilograms (55 pounds) of a Division 1.1, 1.2, or 1.3 (explosive) material in a motor vehicle, rail car, or freight container;
- ✓ More than one liter per package of a material extremely toxic by inhalation (a "material poisonous by inhalation" that meets the criteria for "hazard zone A"); and
- ✓ A hazardous material in a bulk packaging having a capacity equal to or greater than 13,248 liters (3,500 gallons) for liquids or gases or more than 13.24 cubic meters for solids; or A shipment, in other than a bulk packaging, of 2,268 kilograms (5,000 pounds) gross weight or more of a class of hazardous materials for which placarding of a vehicle, rail car, or freight container is required for that class.

If you registered under this program for 1995-96, you will be mailed a registration statement and informational brochure in April. The 1996-97 registration year will run from July 1, 1996 till June 30, 1997. Any person who engages in any of the specified activities during the 1996-97 registration year must file a registration statement and pay the associated fee before July 1, 1996 or before engaging in any of the activities, whichever is later.

For further information or to obtain a registration statement, contact David Donaldson, RSPA, (202) 366-4109.

On March 5, the Environmental Protection Agency issued a guidance document designed to help simplify the operating permit requirements under Title V of the Clean Air Act. The paper addresses several areas of concern for facilities seeking to comply with these requirements, including the issues of duplicative

federal and state rules and the simplification of permit applications.

According to the paper, facilities subject to Title V may avoid duplicative federal, state, and local regulations by complying with the most stringent air emission requirement applicable to them, thus eliminating the extra burden of overlapping requirements. In addition, the guidance includes information on simplifying the applicable requirements for sources emitting insignificant levels of pollutants and for streamlining the operating permit application procedure. Finally, the paper states that the amount of documentation required to determine major source status will be reduced.

Copies of the guidance document can be obtained electronically from the EPA Technology Transfer Network, (919) 541-5742, under the Clean Air Act Amendments bulletin board. For more information on the paper itself, contact Mike Trutna, EPA, (919) 541-5345.

**Department of Housing and Urban
Development**

Environmental Protection Agency

March 6, 1996 - 61 FR 9064

**Lead; Requirements for Disclosure of
Known Lead-Based Paint and/or
Lead-Based Paint Hazards in
Housing**

Action: Final rule

As required by the Residential Lead-Based Paint Hazard Reduction Act, the Department of Housing and Urban Development (HUD) and the EPA are jointly issuing a final regulation on the disclosure of lead-based paint and/or paint hazards in housing. This rule is applicable to persons selling or leasing housing constructed before the phaseout of residential lead-based paint use in 1978.

Included among the requirements of the regulation are: (1) sellers and lessors of most residential housing built before 1978 must disclose the presence of known lead-based paint and/or paint hazards in the housing; (2) sellers and lessors must provide purchasers and lessees with any available records or reports pertaining to the presence of lead-based paint and/or paint hazards; (3) sellers and lessors must provide purchasers and lessees with a federally approved lead hazard information pamphlet; (4) sellers must provide purchasers with a 10-day opportunity to conduct a risk assessment or inspection for the presence of lead-based paint and/or paint hazards before the purchaser is obligated under any contract; and - agents must

ensure compliance with these requirements.

These regulations are applicable for owners of more than four residential dwellings on September 6, 1996. For owners of one to four dwellings, the requirements go into effect December 6, 1996.

To obtain copies of the final rule, the pamphlet Protect Your Family From Lead In Your Home, or other background materials, contact the National Lead Information Clearinghouse, (800) 424-LEAD or fax, (202) 659-1192. Copies of the rule and pamphlet are also available at the National Safety Council's gopher site at cais.com or on the World Wide Web at <http://www.nsc.org/nsc/ehc/ehc.html>.

For technical information from HUD, contact Conrad Arnolts, (202) 755-1810 or John Shumway, (202) 708-9988. For technical information from EPA, contact Charles Franklin, (202) 260-1781, e-mail: franklin.charles@epamail.epa.gov.

**Compromise on Product Liability
Legislation Is Reached After Months
of Discussion**

—Members of the conference committee on product liability reform legislation (H.R. 956) announced on March 13 that they had agreed on compromise language for a final bill that closely resembles the version approved by the Senate. Conferees dropped provisions from the House version that would have limited civil litigation and medical malpractice awards. Under the final legislation, punitive damages in product liability cases would be restricted to \$250,000, or twice the compensatory damages, whichever is greater. For companies with less than 25 employees, the limit would be the less of the two amounts.

H.R. 956 is expected to be brought to the Senate floor for consideration by the end of March. However, administration officials have indicated that President Clinton is undecided about whether to sign the final legislation.

OSHA Reform Legislation

Approved in Committee—Legislation designed to reform the Occupational Safety and Health Administration (S. 1432) was approved on March 5 by the Senate Labor and Human Resources Committee. The bill includes provisions that would, among other things, exempt employers who have been certified by a safety and health program and who have outstanding safety records from

general inspections. It would also reduce penalties for violations not related to safety and health.

The committee approved a number of changes to the bill, including repealing a section which would have banned OSHA from inspecting a workplace unless it had received an employee complaint. A Democrat amendment that would make safety and health regulations applicable to federal, state, and local governments was also accepted. The measure was approved by a party-line vote, with Democrats expressing their concern that the bill undermines OSHA's authority. While speaking to reporters in February, Vice President Gore stated that the President is opposed to the legislation and will veto it, as currently written. A floor vote on the bill has not yet been scheduled.

RCRA Disposal Bill Approved by Congress—On February 20, the

Senate approved legislation (H.R. 2036) exempting decharacterized hazardous waste that will be disposed of in surface impoundments or injection wells from stringent Resource Conservation and Recovery Act (RCRA) requirements. The House has unanimously accepted Senate amendments to the bill, including a requirement that EPA conduct a study on the risk of disposing waste in injection wells, clearing the way to send it on to the President. The administration supports the legislation, and President Clinton is expected to sign it.

However, because the legislation has not yet been enacted, EPA was required by a court-ordered deadline to sign a final rule on February 16 that establishes RCRA treatment options for decharacterized wastes—the same standards which are relaxed under H.R. 2036. However, the agency has indicated that it will delay publishing the final rule in the *Federal Register*

since it appears that the bill will be signed fairly soon. However, if action on the bill is delayed, EPA will publish the regulation and then publish another rule withdrawing the sections dealing with RCRA treatment once the bill has been signed.

Superfund Discussions Continue—Members of the House Commerce Committee and their staffs are holding a series of broad bipartisan meetings in an effort to work out a compromise on the issue of Superfund reauthorization (H.R. 2500). Both sides differ on sections of the legislation dealing with the repeal of retroactive liability and with the issue of reopening Records of Decision. Currently, markup of H.R. 2500 by the House Commerce Committee is expected by the end of March, with the bill going to the House floor in mid-April.

States Proposed Legislation and Regulations

ALABAMA

Environmental Audits—AL H. 36 (A. Knight) encourages organizations to identify and rectify violations of laws and regulations by conducting environmental, health, or safety (EHS) audits; allows a qualified EHS audit privilege, which would apply in legal and administrative proceedings, to certain information generated by the organization in its EHS audit. Introduced on February 6, the legislation was reported favorably out of the House Committee on Commerce, Transportation, and Utilities on February 8.

ALASKA

Air Quality (Proposed Regulation)—The Alaska Department of Environmental Conservation (DEC) has proposed a regulation which would amend air quality control regulations by incorporating federally enforceable requirements, revising and clarifying the permitting process, and amending the state implementation plan. Contact Air Quality Maintenance, DEC, (907) 465-5100.

ARIZONA

Air Quality (Proposed Regulation)—The Arizona Department of Environmental Quality (DEQ) has announced its intention to amend regulations

governing new source performance standards and national emission standards for hazardous air pollutants (NESHAPs) by incorporating by reference federal air quality standards. Contact Martha Seaman, DEQ, (602) 207-2222.

Graffiti—AZ H. 2196 (Marsh) expands a law revoking a youth's driver's license for a second graffiti conviction to revoke on first conviction in certain counties. The legislation passed the House on February 27 and is currently being considered by the Senate Committee on Judiciary.

Water Quality—AZ S. 1290 (Buster) requires the DEQ to review and deny or certify requests for Clean Water Act Section 401 certification and to determine whether a discharge complies with water standards. The bill declares that a general permit holder qualifies in any case and establishes that department failure to act in 30 days is a waiver. The bill was signed by the governor on March 1.

CALIFORNIA

Air Quality—CA A. 1983 (Miller) repeals provisions which prohibit the manufacture or sale of specified chlorofluorocarbons (CFCs). Provides that, notwithstanding any other provision of law, a person may possess, use, manufacture, purchase, or sell

CFCs, and the possession, use, manufacture, purchase, or sale of CFCs does not subject any person to any penalty, fine, retaliatory action, or other punitive measure. The bill is currently being considered by the Assembly Committee on Governmental Organization.

Graffiti—CA A. 2290 (Cortese) requires the Department of General Services (DGS) to establish a toll-free nonemergency telephone system, solely to receive reports of incidents of juvenile graffiti, vandalism, and other nonviolent juvenile offenses. The legislation was introduced on February 14 and referred to the Assembly Committee on Public Safety on February 26.

CA A. 2295 (Sweeney) authorizes the court to order a person (or parent or guardian if the defendant is a minor), upon conviction of graffiti and in a jurisdiction that has adopted a graffiti abatement program, to keep the damaged property or another property free of graffiti for a specified period of time. The bill was introduced on February 14 and sent to the Assembly Committee on Public Safety on February 26.

CA A. 2331 (Goldsmith) makes it a felony or a misdemeanor for any person to deface with graffiti if the amount of defacement is \$400 or more but less than \$5,000, and provides that a person who violates this provision and is convicted of a felony

would be punishable by 16 months or two or three years in state prison. The bill was introduced on February 15 and referred to the Assembly Committee on Public Safety on February 29.

CA A. 2531 (Miller) specifies procedures for graffiti removal and recovery of costs. Introduced on February 21, the bill was sent to the Assembly Committees on Local Government and Public Safety.

CA S. 2065 (Russell) requires a law enforcement agency to disclose the name of any minor taken into custody for any defined graffiti or vandalism offense, upon the request of interested persons. The bill was introduced on February 23 and referred to the Senate Committee on Criminal Procedure on March 6.

Hazardous Waste (Regulation)—A final rule of the California Environmental Protection Agency (CAL EPA) adopts regulations to create a unified hazardous materials and hazardous waste management program. The rule became effective January 31, 1996. Contact Joan Ferber, CAL EPA, (916) 322-6409.

Hazardous Waste (Proposed Regulation)—A proposed rule of the California Department of Toxic Substances Control (DTSC) would exempt small quantity generators or non-RCRA hazardous wastes from preparing and submitting the 1995 biennial report and the interim-status non-RCRA hazardous waste facilities from preparing and submitting 1995 annual facilities reports. Contact Gary Murchison, DTSC, (916) 322-0807.

Lead—CA S. 1960 (Calderon) provides a tax credit in an amount equal to a specified amount of costs paid or incurred by a qualified taxpayer for qualified lead hazard control activities and that the credit would be refundable in an unspecified amount, as provided. The legislation was introduced on February 23 and referred to the Senate Committee on Revenue and Taxation.

CA S. 2080 (O'Connell) enacts the Comprehensive Childhood Lead Poisoning Prevention Act of 1996, which would make numerous findings, including that California lacks a comprehensive approach to lead hazard evaluation and control and that there is no consistent guidance for property owners, tenants, contractors, lenders, realtors, and insurers on how to evaluate and control lead hazards effectively. The bill would also set forth purposes and goals of the program. The legislation was introduced on February 23.

Solid Waste—CA A. 2508 (House) includes as a permitted criteria relating to California Integrated Waste Management Board (CIWMB) and rigid plastic packaging containers that, as determined by the board, the containers also be designed for a subsequent, compatible specific purpose within a particular user industry, as described. The legislation was introduced on February 21 and sent to the Assembly Committee on Natural Resources.

Spray Paint Restrictions—CA S. 1696 (Kopp) prohibits any person, firm, or corporation from selling, offering to sell, giving, or in any way furnishing to another person any portable aerosol container of paint, and would prohibit any person from possessing any aerosol container of paint while on the private property of another or in any public place. The bill was introduced on February 21, and referred to the Senate Committee on Criminal Procedure on March 6.

Toxic Substances (Proposition 65)—CA A. 3160 (Olberg) imposes civil penalties upon persons who violate prohibitions by knowingly and intentionally exposing any individual to a chemical known to the State to cause cancer or reproductive toxicity without giving a specified warning and establishes enforcement authority. The legislation was introduced on February 23.

Water Quality—CA A. 2620 (Morrissey) prohibits the State Water Resources Control Board (SWRCB) and the California regional water quality control boards from prescribing or enforcing waste discharge requirements relating to storm water discharges that are more stringent than federal requirements under the Clean Water Act. Introduced on February 21, the bill is currently being considered by the Assembly on Water, Parks, and Wildlife.

COLORADO

Air Quality (Regulation)—Final regulations of the Colorado Department of Public Health and Environment (DPHE) incorporate by reference the current federal definition of volatile organic compounds (VOCs), consolidate the negligibly reactive VOC list, and clarify federal standards for the control of hazardous air pollutants (HAPs) which have been incorporated by reference. The rules became effective March 1, 1996. Contact Air Quality Control Commission, DPHE, (303) 692-3100.

Hazardous Waste (Regulation)—A final rule of the Colorado DPHE adopts aerosol cans to the universal waste regulations. The rule was effective March 1, 1996. Contact Karen Osthus, DPHE, (303) 692-3321.

CONNECTICUT

Lead (Regulation)—A final rule of the Connecticut Department of Public Health and Addiction Services (DPHAS) adopts regulations to provide for licensing of lead abatement contractors, lead consultants, lead consultant contractors, and lead abatement workers and supervisors. The rule was effective November 29, 1995. Contact Environmental Health Services, DPHAS, (203) 240-9200.

CT H. 5414 (Committee on Housing) implements a comprehensive lead hazard reduction program in housing that includes adoption in regulation of essential maintenance practices, alternative compensation and limited liability, and establishment of a commission for lead related housing issues. Introduced on February 22, the bill was sent to the Joint Committee on Planning and Development on March 12.

Waste Paint—CT S. 423 (Committee on Environment) provides for a general permit for the temporary storage of waste house paint. Introduced on February 27, the legislation was referred to the Joint Committee on Environment.

FLORIDA

Hazardous Waste (Proposed Regulation)—The Florida Department of Environmental Protection (DEP) has proposed a rule which would amend underground storage tank systems provisions. Among other things, the rule would specify registration fees; and revise performance standards, inventory requirements, and discharge reporting procedures. Contact Betsy Hewitt, DEP, (904) 921-9638.

Occupational Safety and Health—FL S. 1786 (Holzendorf) amends the "Florida Occupational Safety and Health Act," changing from 10 to 20 the minimum number of employees that requires an employer to have a workplace safety committee. Introduced on March 5, the bill is currently being considered by the Senate Committee on Commerce and Economic Opportunities.

Water Quality—FL H. 325 (Lambert), identical to S. 96,

increases from 5 to 10 the term of years for certain water pollution permits issued by the Department of Environmental Protection (DEP); provides standards and an exception for renewal of wastewater treatment operation permits at the same fee. The legislation was introduced on March 5 and sent to the House Committee on Natural Resources.

FL S. 1148 (McKay), similar to H. 749, excludes solvent mixtures from substances that are subject to the tax on pollutants for water quality. The bill is currently being considered by the Senate Interim Committee on Natural Resources.

GEORGIA

Lead—GA H. 1436 (Thomas) provides that it shall be illegal to rent, let, or lease a residential dwelling if any portion is painted with lead-based paint and requires tenants to post notice of the possible presence of lead-based paint. The bill died on the House floor on March 8.

GA S. 554 (Henson and Madden) provides that implementation of certain lead paint abatement certification programs shall be contingent upon the promulgation of certain federal regulations. The legislation passed the House on March 7.

Lead (Proposed Regulation)—A proposed regulation of the Georgia Department of Natural Resources (DNR) would revise procedures and standards of the state program pertaining to the accreditation of lead-based paint activities training programs and would amend certification requirements for individuals and firms engaged in such activities. Although the regulation would not require mandatory abatement of lead-based paint, such activities in target housing and child-occupied facilities would have to be performed by certified individuals and firms. Contact John Taylor, DNR, (404) 362-2692.

Solid Waste (Regulation)—The Georgia DHR has adopted provisions governing solid waste for counties and municipalities without such requirements, defining relevant terms and providing for enforcement. The rule was effective August 1, 1995 and expires December 31, 1996. Contact John Gormley, DHR, (404) 730-1301.

HAWAII

Spray Paint Restrictions—HI H. 2747 (Arakaki) bans the sale of

certain indelible markers and certain types of spray paint cans. The bill died in committee.

ILLINOIS

Air Quality (Proposed Regulation)—The Illinois Pollution Control Board (PCB) has proposed a rule which would add the concept of allowing a source to propose an "equivalent alternative control plan," rather than complying with the otherwise applicable rule, and clarify recordkeeping and reporting requirements. Contact Dorothy Gunn, PCB, (312) 814-6931

Graffiti—IL H. 3681 (Martinez) provides for automatic adult criminal prosecution of a minor at least 15 years of age who knowingly damages the property of another without that person's consent by use of paint or any other similar substance. The legislation was introduced on February 9 and referred to the House Committee on Rules.

IL H. 2978 (Scott and Brunsvold) provides that a municipality may remove graffiti from private property but may not recover the cost from the owner. The bill was introduced on February 6 and referred to the House Committees on Rules and Cities and Villages.

Hazardous Waste (Proposed Regulations)—The Illinois PCB has proposed rules which would incorporate revisions to federal hazardous waste management standards. Among other things, the proposal would set forth provisions governing universal waste, clarify the applicability of hazardous waste management standards, and establish procedures for petitions relating to universal wastes. Contact Michael McCambridge, PCB, (312) 814-6924.

INDIANA

Air Quality (Regulation)—A final regulation of the Indiana Department of Environmental Management (DEM) limits emissions of VOCs from stationary vessels used to store volatile organic liquid in certain counties. The rule establishes testing and recordkeeping and reporting requirements. The rule was effective January 18, 1996. Contact Patricia Roth, DEM, (317) 233-5681.

The Indiana DEM has adopted a regulation which limits VOC emissions from wood furniture coatings operations in certain counties. The rule sets VOC emission limits; and establishes compliance

procedures and monitoring, recordkeeping, and reporting requirements. The rule became effective January 3, 1996. Contact Patricia Troth, DEM, (317) 233-5681.

IOWA

Air Quality (Proposed Regulation)—A proposed regulation of the Iowa Environmental Protection Commission (EPC) would (1) exempt acetone from the definition of VOCs; (2) clarify that the EPC reserves the right to require proof that national ambient air quality standards have not been violated by any source which is being exempted from the air quality construction permit requirement; (3) establish an optional "operating permit by rule for small sources" allowing small sources otherwise subject to Title V permitting to register for an operating permit by rule; and (4) allow smaller sources to accept annual emissions, established in the rule, which restrict their "potential to emit" and thus their exposure to "major source" requirements of the Clean Air Act. Contact Catharine Fitzsimmons, DNR, (515) 281-8941.

Air Quality (Regulation)—The Iowa EPC has adopted a final rule which requires Title V operating permit fees to be paid on July 1, changes the date for Title V sources to submit emission inventories to March 31, and clarifies the list of forms due to the department each year. The rule was effective March 20, 1996. Contact Catharine Fitzsimmons, DNR, (515) 281-8941.

A final rule of the Iowa EPC replaces the temporary air toxics fee with the Title V fee. The rule was effective March 20, 1996. Contact EPC, (515) 281-8693.

Lead (Regulation)—An emergency regulation of the Iowa Division of Labor Services (DLS) adopts by reference amendments to federal OSHA standards for occupational exposure to lead. Contact DLS, (515) 281-3606.

IA S. 2301 (Committee on Human Resources) relates to lead abatement and inspection, training and certification requirements, and provides penalties. The legislation was introduced on February 26.

Toxics-in-Packaging—IA S. 2287 (Committee on Natural Resources), identical to H. 2317, relates to the limitations on the use of toxic materials in packaging and provides additional exemptions. The bill passed the Senate and was sent to the House on March 5.

KENTUCKY

Hazardous Materials Transportation (Regulation)—The Kentucky Transportation Cabinet (KTC) has adopted a regulation which incorporates by reference amendments to federal hazardous materials transportation standards. The rule became effective January 8, 1996. Contact Sandra Pullen, KTC, (502) 564-4890.

Lead—KY S. 182 (Neal) defines "lead-hazard abatement." It also requires (1) all persons who perform or offer to perform lead-hazard detection or abatement services to be certified; (2) the Department for Health Services (DHS) to create and administer the certification program and promulgate administrative regulations to establish the training and testing requirements for certification; and (3) a permit for every lead-hazard abatement service performed. On February 23, the bill passed the Senate and was sent to the House.

KY H. 923 (Marzian) relates to lead poisoning prevention; defines relevant terms; places responsibility for the program with the DHS; and requires the department to coordinate prevention activities with health, housing, and environmental agencies. The bill was introduced on March 1 and referred to the House Committee on Health and Welfare.

MARYLAND

Graffiti—MD H. 1269 (Klausmeier) authorizes a court to order a person committing an act of graffiti to pay restitution or perform community service; and requires a juvenile court, on finding that a child has committed an act of graffiti, to order the *Motor Vehicle Administration (MVA)* to suspend the child's driver's license for up to 2 years. Introduced on February 15, the bill was referred to the House Committee on Judiciary.

Lead—MD H. 180 (Kach) requires new home builders to disclose or make a certain disclaimer to the owner as to the presence of any hazardous or regulated materials, including lead-based paint, radon, underground storage tanks, licensed landfills, and other environmental hazards present on the site of a new home. The legislation passed the House on February 20 and was referred to the Senate Committee on Judicial Proceedings.

MD H. 1457 (Guns) exempts maintenance, repair, renovation, and risk reduction treatments involving disturbance of three square feet or less

of lead containing substances in a room from specified accreditation requirements and work practices. The bill was introduced on March 8 and referred to the House Committee on Rules and Executive Nominations.

Lead (Proposed Regulation)—The Maryland Department of the Environment (DOE) has proposed a rule which would establish standards and procedures for the accreditation of persons who conduct inspections or risk assessments for lead paint, or who serve as contractors or supervisors for activities involving the abatement of lead paint hazards; and would provide standards for accredited training courses for workers and project designers who engage in lead paint hazard abatement projects. Contact Deanna Miles-Brown, DOE, (410) 631-3173.

MASSACHUSETTS

Lead (Proposed Regulation)—The Massachusetts Department of Revenue (DOR) has proposed a rule which would allow residential owners of dwellings constructed prior to 1978, paying for the abatement or containment of dangerous levels of lead, to claim a tax credit of up to \$1,500. Contact Kate Tobin, DOR, (617) 626-3250.

Lead (Regulation)—A final rule of the Massachusetts Department of Public Health (DPH) revises the definition of "lead poisoning", modifies environmental deleading requirements, and revises rental property standards to include lead notification to tenants. The rule became effective January 26, 1996. Contact Roy Petre, DPH, (617) 753-8422.

MISSISSIPPI

Graffiti—MS H. 753 (O. Scott) prohibits graffiti and provides penalties. The legislation passed the House and was referred to the Senate on February 14.

MISSOURI

Air Quality—MO H. 1227 (Harlan) repeals a restriction that does not allow Missouri Air Conservation Commission (ACC) rules to be stricter or enforced sooner than required by the federal Clean Air Act. The bill was introduced on January 23 and referred to the House Committee on Energy and Environment.

Hazardous Waste (Proposed Regulations)—The Missouri Department of Natural Resources (DNR) has

proposed regulations which would (1) establish new standards for underground storage tanks to conform to 1995 legislation including a one-time tank registration fee of \$75; (2) set forth requirements for site assessment, site characterization, and workplan development; and (3) amend the state underground storage tank insurance fund. Contact Hazardous Waste Program, DNR, (573) 751-3176.

Highway Transportation (Regulation)—A final rule of the Missouri Department of Economic Development (DEC) amends regulations pertaining to the transportation of goods in intrastate commerce by motor carriers in response to federal legislation which preempts the requirements of state laws and regulations. The rule is effective 30 days after publication in the Code of State Regulations. Contact David Woodside, DED, (314) 751-7100.

NEW HAMPSHIRE

Air Quality (Regulation)—The New Hampshire Department of Environmental Services (DES) has adopted an interim rule which updates the definition of "stationary source" to include any source that emits any federal-regulated or state-regulated pollutant. The rule was effective January 30, 1996 and expires May 29, 1996. Contact Susan Jones, DES, (603) 271-7874.

Environmental Audits—NH H. 275 (Tescher) encourages certain businesses to conduct self-audits, establishes a privilege extending to the environmental audit report, and sets forth a procedure detailing certain exceptions to the privilege. The bill passed the Senate on February 15 and was sent to the governor.

Lead—NH S. 516 (Stawasz) makes it clear that the law regulating discrimination in housing does not require a person to rent a dwelling or dwelling unit which has been found to have a lead exposure hazard present, if such dwelling or unit is to be occupied by a child of a certain age or younger. The bill passed the Senate with amendments and was sent to the House on March 7.

NH S. 663 (Wheeler and Herman) establishes lead paint risk reduction owner procedures which may be carried out by a property owner, thereby allowing the owner to qualify for certain insurance coverage. The legislation passed the Senate with amendments and was referred to the House on March 7.

NEW JERSEY

Water Quality (Proposed Regulation)—A proposed rule of the New Jersey Department of Environmental Protection (DEP) would readopt regulations to restructure the state pollutant discharge elimination system. Hearings were scheduled for April 9 in Trenton and April 8 in New Brunswick. Comments are due May 6, 1996. Contact Janis Hoagland, DEP, (609) 292-0716.

NEW MEXICO

Hazardous Waste (Proposed Regulation)—The New Mexico Environmental Improvement Board (EIB) has proposed a rule which would incorporate federal EPA lender liability provisions for underground tanks. A hearing is scheduled for April 12, 1996 and comments are due on that same day. Contact Anna Richards, EIB, (505) 827-2932.

Lead—NM S.J.M. 20 (Duran and Carraro) relates to the creation of a specialty license for residential lead-based paint abatement. On February 14, the bill was passed out of the Senate Committee on Conservation.

NEW YORK

Air Quality (Notice)—The New York Department of Environmental Conservation (DEC) has announced the availability of an enforcement directive to establish interim policies and procedures pertaining to the enforcement of VOC content limits for consumer and commercial products. Contact Elissa Armater, DEC, (518) 485-8477.

Graffiti—NY A. 8861 (Kaufman) creates a new crime of making graffiti when a person commits another graffiti crime on the same or another religious use property within a period of 10 years, with such new crime to be a Class E felony. The bill was introduced on February 22 and referred to the Assembly Committee on Codes.

OKLAHOMA

Water Quality (Proposed Regulation)—The Oklahoma Department of Environmental Quality (DEQ) has proposed a rule which would revise the state's pollution discharge elimination system by changing the application and annual fees for discharge permits and general permit authorizations under the program. Contact Cary Pirrong, DEQ, (405) 271-5205.

RHODE ISLAND

Hazardous Waste—RI S. 2782 (Sullivan) relates to the Hazardous Waste Management Act. Introduced on February 6, the legislation was referred to the Joint Committee on Environment and Energy.

Lead—RI S. 2615 (Izzo) relates to the Lead Poisoning Prevention Act. The legislation was introduced on February 6 and sent to the Senate Committee on Health, Education, and Welfare.

SOUTH CAROLINA

Air Quality (Regulation)—A final regulation of the South Carolina Department of Health and Environmental Control (DHEC) revises the definition of VOCs by adding acetone, parachlorobenzotrifluoride, and volatile methyl siloxanes to the list of exempted compounds. Contact Mohamed Abdelsalam, DHEC, (803) 734-4463.

Hazardous Waste (Proposed Regulation)—A proposed regulation of the South Carolina DHEC would incorporate federal hazardous waste revisions to the hazardous waste management program including the adoption of a new federal universal waste rule and treatment standards for newly identified wastes prior to land disposal. Contact John Litton, DHEC, (803) 896-4174.

The South Carolina DHEC has proposed a rule to reduce inconsistencies between federal and state hazardous waste management provisions by adopting new 10-year permit renewal periods, revising permit procedures, and reducing land disposal restriction notifications for small quantity generators of hazardous waste. Contact Randy Thompson, DHEC, (803) 734-5116.

TENNESSEE

Air Quality (Proposed Regulation)—A proposed rule of the Tennessee Department of Environment and Conservation would amend regulations in reference to volatile organic compounds. The rule would update standards for (1) the handling, storage, use, and disposal of VOCs; (2) automotive coatings, metal furniture coatings, and related coatings; (3) and facilities that emit VOCs of 100 tons per year. Contact Malcolm Butler, DEC, (615) 532-0600.

Solid Waste—TN H. 2763 (Purcell) authorizes funds from the

solid waste management fund to be used to enhance recycling efforts and to develop permanent collection sites for household hazardous wastes; imposes tipping fees on municipal solid waste received at Class I landfills. The legislation was introduced on February 2.

TN S. 2180 (Gilbert) makes substantive changes in solid waste statutes including (1) placing transport of waste under sway of the commissioner; (2) separating the definitions of recovered materials (recycling) from solid waste processing and redefining landfill; (3) changing provisions of municipal solid waste authorities; and (4) establishing a pilot program for household hazardous waste. The bill was reported favorably out of the Senate Committee on Environment, Conservation, and Tourism on March 6.

TEXAS

Air Quality (Proposed Regulation)—The Texas Natural Resource Conservation Commission (TNRCC) has proposed a rule which would provide the commission with the authority to adopt rules consistent with the policy and purposes of the Texas Clean Air Act which pertain to the control of air pollution by permits for new construction or modification. Contact Lisa Martin, TNRCC, (512) 239-4808.

Lead (Regulation)—A final rule of the Texas Department of Health (DOH) sets requirements for the accreditation of lead-training providers and certification of lead-based paint abatement workers in order to control and minimize public exposure from lead-based paint activities in target housing. The rule also provides for the imposition of penalty fees for non-compliance. The rule went into effect on February 19, 1996. Contact Division of Occupational Health, DOH, (512) 458-7236.

Solid Waste (Regulation)—The Texas TNRCC has adopted a regulation which specifies requirements for regional and local solid waste management plans and provides for the establishment of a financial assistance fund. The rule was effective February 26, 1996. Contact Waste Planning and Assessment Division, TNRCC, (512) 239-4640.

UTAH

Graffiti—UT H. 264 (Bigelow) creates a new section in the criminal code on graffiti, establishes liability

for removal costs of graffiti, and provides for the voluntary removal of graffiti by the responsible person. On February 23, the bill passed the House and was approved by the Senate on February 27.

UT S. 255 (Richards) relates to penalty for graffiti. Introduced on February 2, and was referred to the Senate Committee on Education.

Hazardous Materials Transportation (Regulation)—A final rule of the Utah Department of Transportation (DOT) incorporates by reference federal amendments regarding safety requirements for motor carriers transporting hazardous materials and/or hazardous waste. Contact Shirleen Hancock, DOT, (801) 965-4781.

VERMONT

Heavy Metals in Packaging—VT S. 344 (Committee on Natural Resources) defines certain terms that regulate heavy metals used in packaging and provides expiration dates for several exemptions. Introduced on February 21, the bill passed the Senate and was sent to the House Committee on Natural Resources and Energy on March 1.

VIRGINIA

Air Quality—VA H. 1512 (Stump) prohibits state agencies from entering into any agreement related to the transport of ozone if the proposed agreement contains stationary source emission requirements exceeding (1) the reasonable available control technology standard or (2) the nitrogen oxide standard contained in section 407 of the Clean Air Act. The bill passed the Senate with amend-

ments on March 6 and the House concurred on March 8.

Lead—VA S.J.M. 70 (Lambert) continues the study of the abatement of lead-based paint and monitors the implementation of the lead certification program. The bill passed the Senate on February 9 and the House on March 1 with amendments, which the Senate concurred with on March 5.

Solid Waste—VA H. 885 (Van Yahres) allows a permitted solid waste facility that devotes a specific storage area to household hazardous waste to store such waste for up to one year. The legislation passed the Senate on February 21.

Water Quality—VA S. 480 (Gartlan) requires persons responsible for discharging prohibited wastes into or upon state waters, storm drain systems or lands to report such discharges to either the State Water Control Board (SWCB), the Director of the DEQ, or the local emergency services coordinator, and the appropriate federal authorities. The bill was sent to the Governor on February 21, was sent back to the Senate with amendments that were accepted on March 5, and then sent to the House.

WASHINGTON

Air Quality (Proposed Regulation)—The Northwest Air Pollution Authority (NWAPA) has proposed a regulation which would exempt operating permit sources from the registration program, exempt acetone and perchloroethylene from the definition of VOCs, and when a federal standard is already applicable

exempt sources from compliance with state VOC control standards. Contact James Randles, NWAPA, (360) 428-1617.

Occupational Safety and Health—WA H. 2654 (Clements) provides that no citations may be issued if the employer demonstrates that they (1) maintain a written accident prevention program; (2) have safety rules that are adequate and hold safety meetings; (3) take measures to discover violations of safety rules and disciplines violators; and (4) provide employees with training and equipment in compliance with standards. On February 10, the legislation passed the House and was referred to the Senate Committee on Labor, Commerce, and Trade.

WYOMING

Hazardous Waste (Proposed Regulation)—A proposed rule of the Wyoming Department of Environmental Quality (DEQ) would incorporate air emission standards for tanks, surface impoundments, and containers; adopt universal waste standards; and set forth procedures for public participation in hazardous waste treatment, storage, and disposal facility permits. The rule would be necessary to maintain consistency with federal EPA hazardous waste management standards. Contact Robyn Dommel, DEQ, (307) 777-7752.

Labeling—WY S. 28 (Committee on Joint Agriculture) repeals the provision regulating the labeling of paint. The bill passed the Senate on March 1 and passed out of the House Committee on Appropriations on March 5.

Analytical Approach for High Quality Appearance Powder Coatings

J.C. Kenny, T. Ueno, and K. Tsutsui—Nippon Paint Co.*

INTRODUCTION

Today, due to the commercial success and growing popularity of powder coatings,¹⁻³ there is a great deal of ongoing research work in this field, particularly in powder coating chemistry.³⁻⁵ In the literature, experimental reports often rely on general assumptions as detailed mechanisms have yet to be elucidated for many of the more complex phenomenon in powder coatings. Such mechanisms have been the subject of considerable activity in recent research work.⁶⁻⁸

High quality appearance of powder coatings was investigated using an analytical approach based on a five-stage model (Figure 1). The model covers the various stages a powder goes through to produce a final cured film. Key points in each stage were studied to obtain insights into the film formation mechanism and methods for improvement. The model consists of the following stages: powder particle condition; coalescence and degassing, whereby the powder becomes a continuous film; flow and leveling of the film; cure reaction, producing the final crosslinked product; and cooling of the cured film. The analysis procedures used and significant findings in this study are presented.

EXPERIMENTAL

Materials

All tests were performed using acrylic resin based clear powder coatings. This type of coating is currently attracting a great deal of interest as the coating of choice for formulators developing clear topcoats for the automotive market.⁹⁻¹¹ The resin used was characterized by epoxy groups pendant to the acrylic backbone. Resin molecular weight M_n and M_w/M_n were 3,000 and 1.8, respectively. Resin T_g was 60°C. Curing was facilitated by the crosslinking reaction between resin epoxy groups and a diacid hardener, dodecane-dioic acid (DDA)¹² of melting point 129°C. Crosslink density and other parameters were adjusted to give satisfactory physical performance properties to satisfy requirements for automotive topcoatings.



High quality appearance of powder coatings was investigated using a five-stage model: (1) powder particle, (2) coalescence, (3) leveling, (4) curing, and (5) cooling. Appearance levels above target solvent-based systems were achieved using fine particle size and narrow distributions. Fine powders ($\sim 10 \mu\text{m}$) were found to have faster coalescence and better degassing. Cure contraction stress was much smaller than cool stress, yet caused significant image distortion due to localized gradients. Hardener crystals are a separate phase in the powder particles, a more uniform distribution of finer sized crystals gave improved appearance. Solutions to practical application of findings have been found.

Hardener Crystal Size

Standard commercial grade DDA has an average particle size of 9 μm . The powder production process kneading step produces high shear stresses that break down the DDA to 5 μm and one pass. This was determined by dissolving powder in xylene which dissolved resin and additives, leaving the DDA crystals free to be separated and sized.

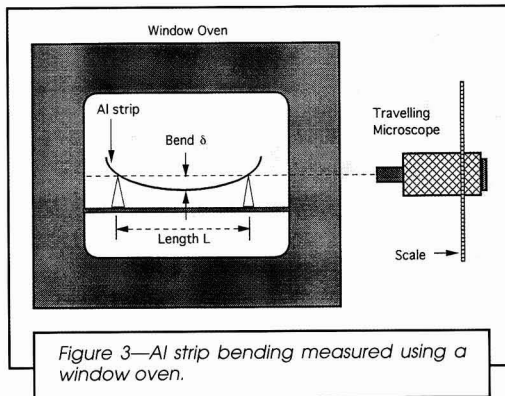
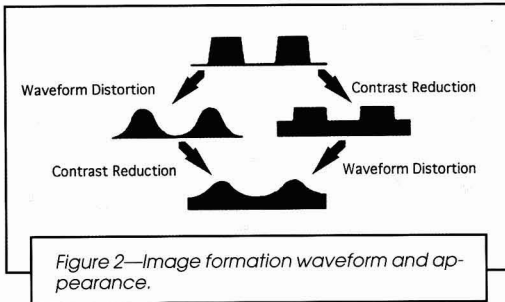
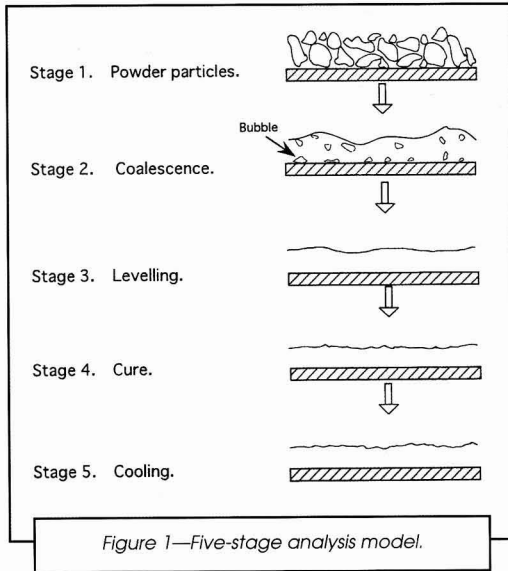
Finer grades of 4 and 3 μm DDA were also used. Kneading produced no size breakdown of these grades.

Powder Production

MATERIALS: Resin $\sim 80\%$ by weight, hardener $\sim 20\%$, and additives, were dry blended in a Supermixer, then melt mixed at 95°C by extrusion through a twin screw kneader. Kneading

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below the hardener melting point produced a dispersion of hardener crystals in the extrudant. The pellets produced were then ground using a size reduction atomizer to produce the final powder product.^{13,14} Both a sample mill from Fuji Paudal Co. and a Krypton mill from Kawasaki Heavy Industries Co. were used.

Particle Size Analysis

A model SRA-7997-10 microtrac particle size analyzer, manufactured by Leeds and Northrup Co., was used. This employed laser light scattering to measure particle size,¹⁵ and was used to produce profiles from 0.7-1,000 μm giving: average size (weight average) as the 50th percentile point of the distribution (D50); and distribution width as standard deviation (SD) of the distribution.

Film Preparation

Two electrostatic spray systems were used to apply the powders. Firstly, a Sames Co. spray system with a Stajet JR62 type gun was used. For work with fine powders, the Sames system proved unstable, so an Onoda Co. GX 3650T-UF spray system with a GX108 gun was used.

Standard 0.8 \times 100 \times 300 mm steel test panels supplied by Nippon Test Panel Co. were used. An electrodeposited primer and solvent-based midcoat were applied before the final powder topcoat.

Standard baking condition used to produce the final cured film was 150°C \times 25 min in an electric convection oven. This temperature, 20°C above the hardener melting point, ensures melt and flow of the powder elements before the melting of the hardener and subsequent cure gelation.

Film Appearance

Image clarity was measured by the Nippon Paint-Suga Test Instrument image clarity meter (NSIC).¹⁶⁻¹⁸ The NSIC meter has two measurement parameters, NSIC and NSIC*. Values of 100% represent mirror like image clarity.

NSIC responds preferentially to long wave (100's-1,000's μm) image wave form distortion, while NSIC* responds preferentially to short wave (10's-100's μm) contrast reduction as shown in Figure 2 from reference 17.

Surface roughness was measured by a needle stylus type model 470A Surfcom manufactured by Tokyo Seimitsu Co. Roughness was assessed by using Ra, the arithmetic average deviation of the profile.^{19,20}

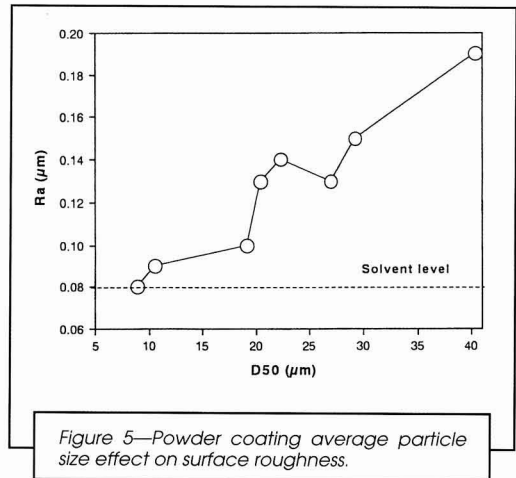
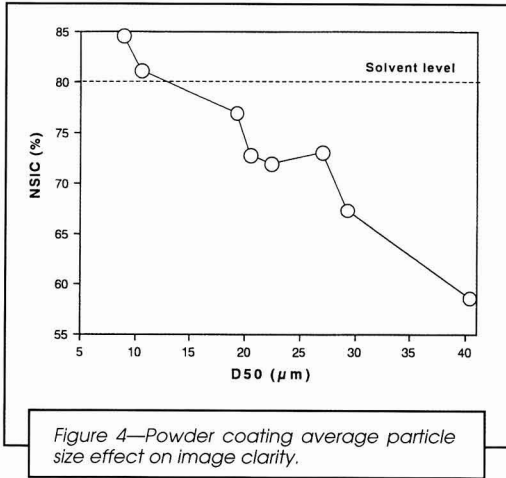
All appearance data presented is for a film thickness of 80 μm (3.1 mils) unless otherwise specified.

Sprayed Powder Assessment

Scanning electron microscopy (SEM) was used to assess sprayed surface condition of different sized powders and to assess coalescence extent in partially baked plates.

Powder Tester

Powder aerated density was measured by a Hosokawa Micron Co. model PT-N powder tester.



Internal Stress

Degree of bending of a thin aluminum strip during baking was used to calculate coating internal stress using the equation of Inoue and Kobatake²¹ where

$$\rho = \frac{L^2}{8\delta} + \frac{\delta}{2} \text{ and } P = \frac{10^8}{6h_1(h_1 + h_2)} \times \frac{E_2 h_2^3}{(1 - V_2^2)} \times \frac{(1 - 1)}{(\rho \rho_0)}$$

giving $P = \frac{8.13 \times 10^7}{6h_1(h_1 + 100)\rho}$

P = contraction power (Kg/cm²); h₁ = film thickness (µm); h₂ = Al thickness (100 µm); E₂ = Young's modulus of Al; V₂ = modulus ratio (Resin/Al); L = strip length (cm); and δ = strip bending (cm).

Cure and cool stresses were distinguished by use of a window oven constructed in our laboratory. A schematic of the window oven is shown in Figure 3.

Ring Camera

QUALITATIVE STRESS MEASUREMENT—Qualitative measurements of the effects of curing and cooling on image clarity were made using the UKT method (Ueno, Kenny, Tsutsui assessment method). Here assessment of degree of image distortion of a reflected light ring at 20X mag-

nification is made using a window oven to record real-time measurements during baking. The magnification used enabled analysis to focus on fine roughness levels in preference to longer wavelength distortion.

RESULTS AND DISCUSSION

Average Particle Size

A range of powder size grades from 40 to 10 µm was made by changing milling conditions, namely grinding speed and screen mesh size. Generally size distribution width closely follows average particle size. Within the powder particles it is envis-

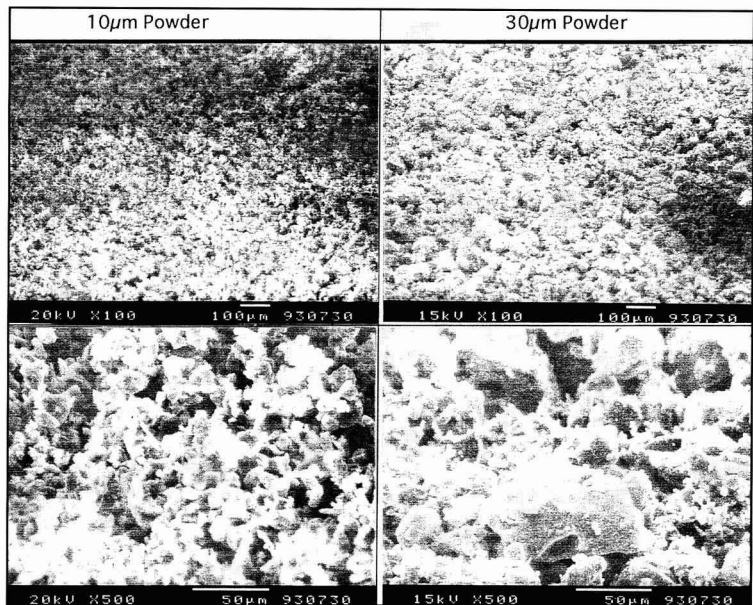


Figure 6—Appearance of surface texture of sprayed powder by SEM.

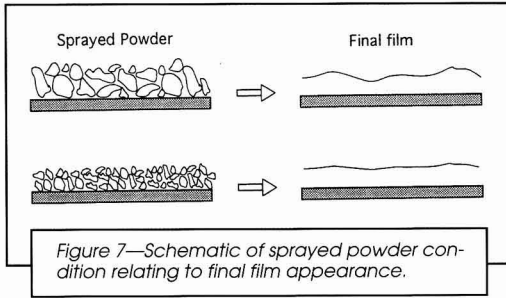


Figure 7—Schematic of sprayed powder condition relating to final film appearance.

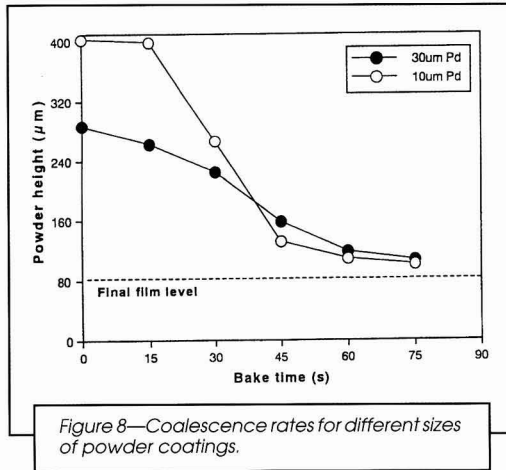


Figure 8—Coalescence rates for different sizes of powder coatings.

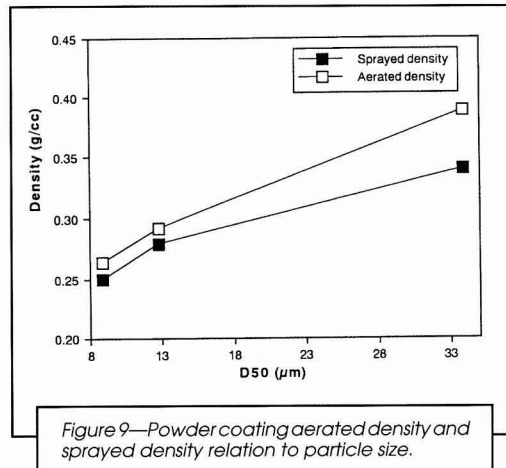


Figure 9—Powder coating aerated density and sprayed density relation to particle size.

aged that the micron sized hardener crystals are distributed at a uniform content level with smaller powder particles containing smaller crystals. Simple exclusion dictates that, for example, a 5 µm hardener crystal can only be contained as a 5 µm or larger particle. Sprayed panel appearance was found to improve dramatically with a decrease in average particle size (D50) (weight average), see Figures 4-5. The 10 µm powder coating appearance is about NSIC 15% and Ra 0.07 µm better than 30 µm powder. Additionally, the 10 µm powder appearance level reached, and even surpassed, the appearance level of a commercialized solvent-based 40 µm thick acrylic clearcoating.

SEM of Sprayed Powders

Scanning electron microscopy (SEM) photographs of panels sprayed with 10 and 30 µm powders are shown in Figure 6. The 10 µm powder has a smooth, evenly deposited surface texture, while the 30 µm powder surface is rough and has large irregularities. From a direct, simple physical perspective, the final film appearance relates to the sprayed powder condition as shown in Figure 7. Large irregularities in the deposited powder layer are not completely leveled out and give rise to irregularities in the final film.²²

Coalescence of Powders

Microscope measurements of height of powders on thin tin panels, where the same amount of powder was sprayed (sufficient for 80 µm film build), yielded the result of Figure 8. From the initial (t = 0) position, the powder particles melt (0-15 sec) and then rapidly coalesce (15-45 sec). From 45 sec onwards, the melted powder forms a continuous film and residual degassing is at a much slower rate and occurs via bubbling or pinholing. Thinner films would have a reduced level of degassing effects, but increased substrate viscous resistance reduces flow-out of irregularities.

The initial powder height is lower for the 30 µm powder. It is well known in the powder industry that density of coarse powder is higher than fine powder.²³ Comparison of powder aerated density with sprayed density (Figure 9) shows this general relation in both cases, sprayed values being slightly lower.

The rapid coalescence of the 10 µm powder, in spite of its initial low sprayed density, can be explained by analysis of the surface tension stress gradients of the melted particles. Coa-

Table 1—Different Distribution Width (SD) Grades of Powder Having the Same Size Class. In Every Case Narrower SD Results in Improved Appearance as Evidenced by Image Clarity NSIC and Surface Roughness Ra Measurements.

Size Class	D50 (µm)	SD (µm)	NSIC (%)	Ra (µm)
10 µm	8.9	6.4	84.6	0.08
10 µm	10.5	9.2	81.1	0.09
20 µm	19.1	8.3	79.2	0.10
20 µm	19.2	11.2	76.9	0.10
20 µm	20.5	17.4	72.8	0.13
20 µm	22.3	18.3	71.9	0.14
30 µm	29.6	10.6	72.6	0.14
30 µm	27.0	16.1	73.1	0.14
30 µm	29.3	17.4	67.4	0.15

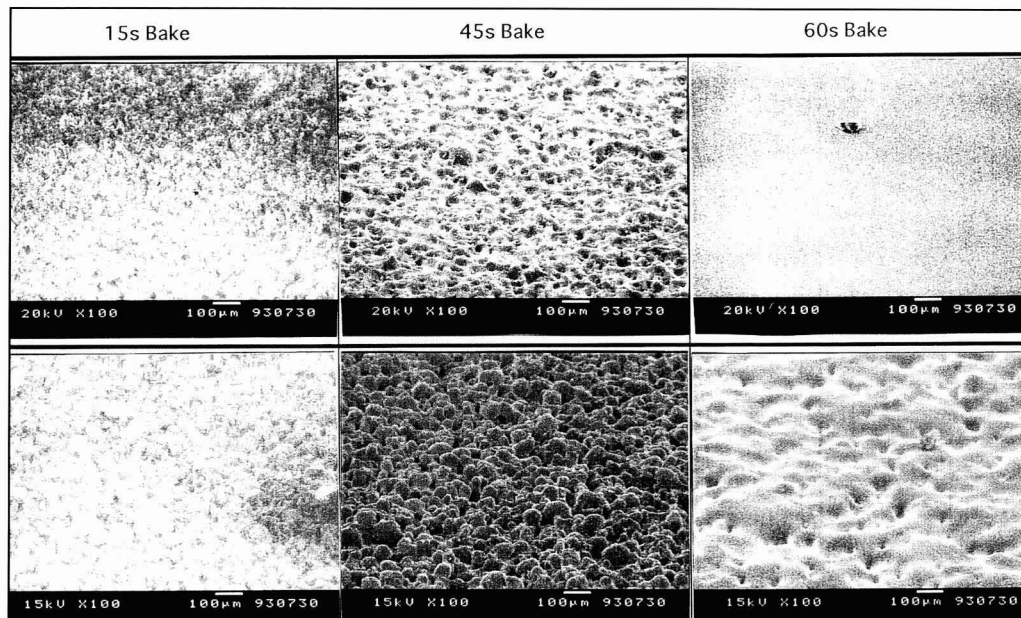


Figure 10—Coalescence behavior of 10 μm and 30 μm powders by SEM observation of partially baked samples.

lescence is driven almost entirely by surface tension, the effect of which depends on the angle of contact of the surfaces.^{22,24,25} According to Nix and Dodge,²⁶ the time t taken for two spherical particles to coalesce is given by $t = \eta R / 6\gamma$, where η = viscosity, R = particle radius, and γ = surface tension,^{22,26,27} showing a direct size dependence.

Another factor is the lower heat capacity of the smaller particles, which require less time to melt than the correspond-

ing larger particles. Faster melting clearly facilitates faster coalescence. In addition, the surface area of 10 μm powder is 1.05 m²/g while for 30 μm powder is 0.45 m²/g so the number of contact points in 10 μm powder is much higher.

Faster coalescence enables more void air to leave the coating before a continuous film is formed (~45 sec), so bubbling is reduced. When a bubble is released, it leaves a surface defect which is then covered by material reflow. Reflow, however,

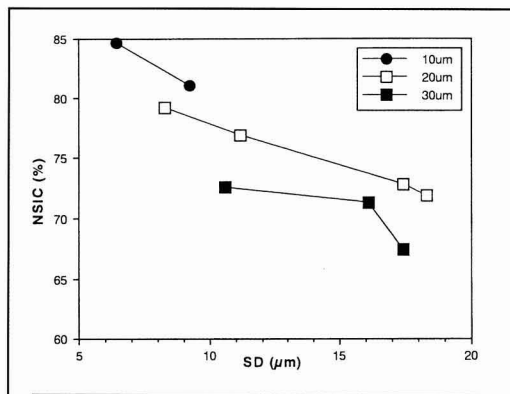


Figure 11—Effect of powder coating particle distribution width (SD) on image clarity at constant average particle size (D50).

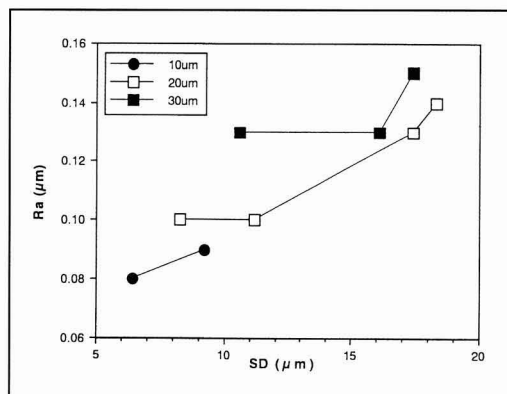
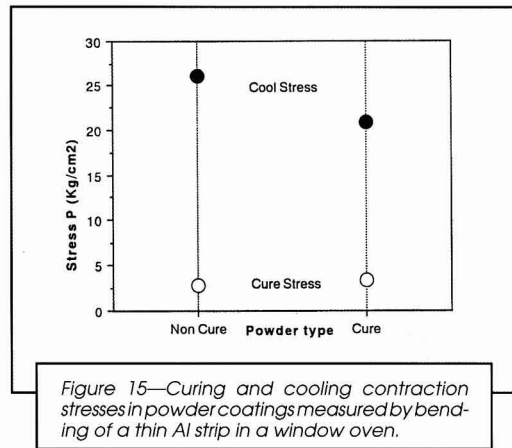
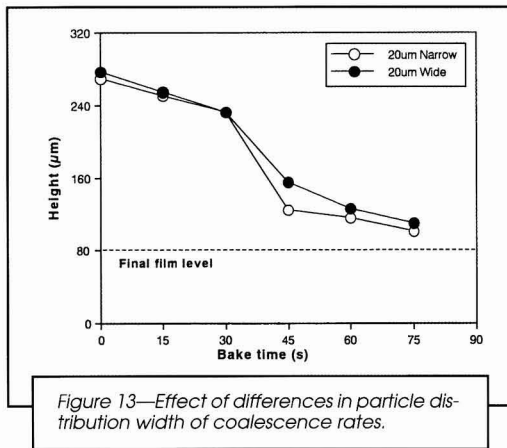


Figure 12—Effect of distribution width on surface roughness (Ra) at constant D50.



does not always completely remove the effects of bubbling, particularly in later stages when remaining flow time before cure gelation is short. Faster coalescence, therefore, leads to a reduced level of defects and better appearance.

SEM of Coalescence

SEM observation of the partially baked panels confirms the findings of Figure 8. Figure 10 shows the surface condition of the partially baked samples. By 45 sec the 10 µm powder has coalesced to a greater extent than the 30 µm powder. By 60 sec the 10 µm powder appearance is level and smooth while the 30 µm powder appearance is irregular and degassing is ongoing.

Effects of Distribution Width

By a combination of cyclone and mesh techniques, a variety of powder grades were prepared having the same average

size but different distribution widths (Table 1). Appearance data for the 10, 20, and 30 µm size classes are shown in Figures 11 and 12. The previously demonstrated trend of better appearance levels for smaller average size is apparent here, the 10 µm line being higher than the 20 µm line which is higher than the 30 µm line. Narrowing of the distributions (lower SD) results in improved appearance.^{28,29} With 20 µm powder, appearance was improved by NSIC 7%, and Ra 0.04 µm when SD was narrowed from 18 to 8µm.

Coalescence and Standard Deviation

Coalescence of wide and narrow distribution 20 µm powders are compared in Figure 13 by the same method that was used in Figure 8. Initial powder densities were about the same, but by 45 sec the narrow distribution powder has coalesced faster and has better degassing, which may account to some extent for its better appearance for reasons already discussed with Figure 8.

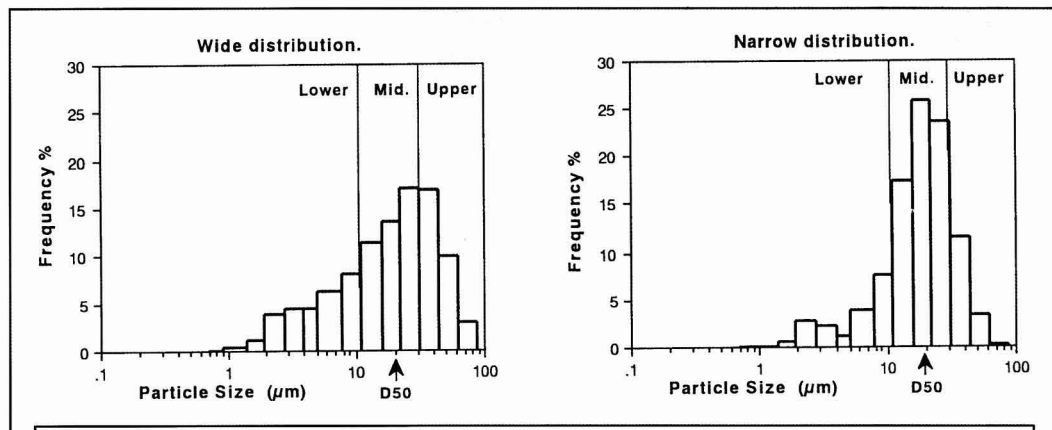


Figure 14—Comparison of composite elements of wide and narrow distribution powders, both having the same average particle size (D50) = 20 µm.

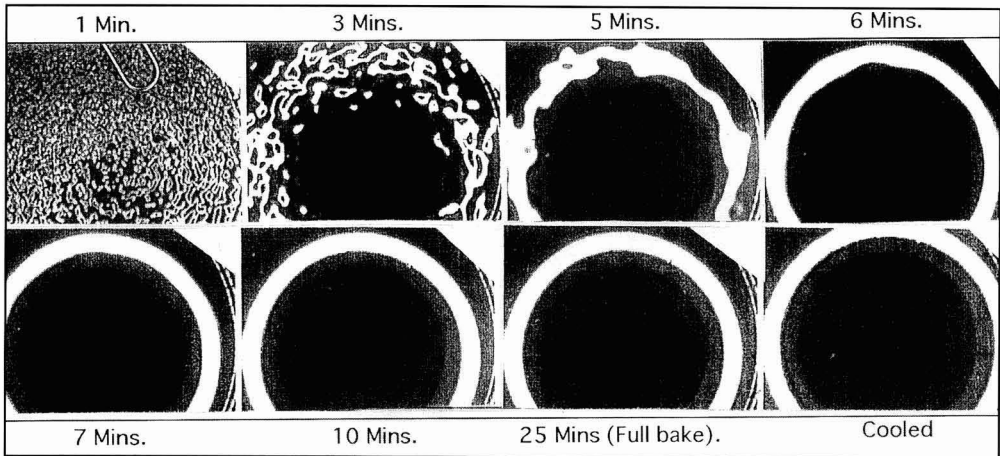


Figure 16—A reflected light ring (11 mm diameter) shows melt and flow of a noncuring powder (resin only) using a X20 magnification lens and a window oven. Image clarity of the ring improves continually throughout the bake. Cooling has little or no effect.

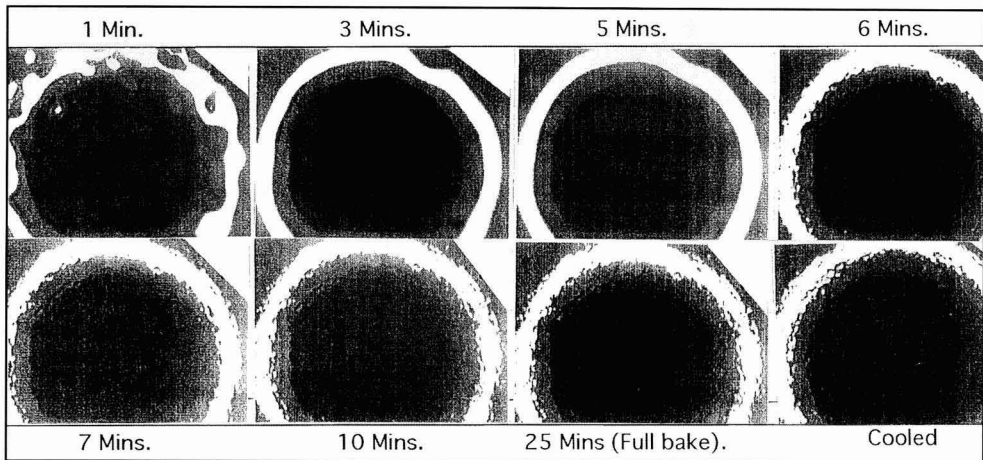


Figure 17—A reflected light ring shows melt, flow, and cure of a powder coating. Image clarity improves steadily up to five minutes. At six minutes, short wave roughness develops, coincident with the cure onset, image clarity drops and does not recover for the duration of the bake. Cooling has little or no effect.

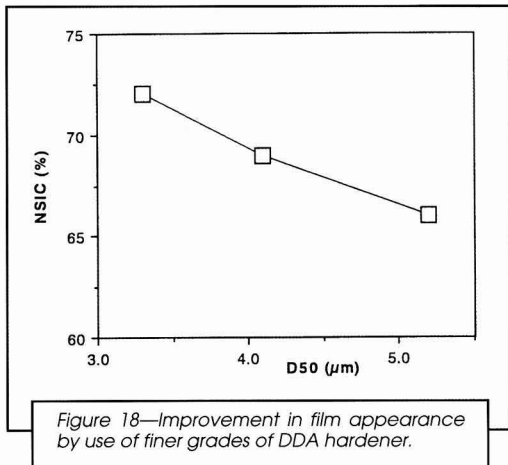
Distribution Profile Analysis

Analysis of the distribution profile of the two powders in Figure 13 shows (Figure 14) that the proportion of mid:upper sized particles (Table 2) is 4:1 for narrow SD and 4:3 for wide SD. With the spray system used, a higher content of fines gave no application problems, and given the slow coalescence and poor appearance of large sized powders already demonstrated, it is the relatively large content of coarse particles in the wide distribution powder that explains its poor appearance.

Cure/Cool Stress Quantitative

A quantitative measure of cure and cool contraction stresses was obtained by measuring the bending of an Al strip as described previously. Measurements inside a window oven produced the cure stress result, and external measurements gave the cool stress result (Figure 15).

Two samples, a noncure sample composed of resin only and a curing sample as described earlier, were used. In both cases the cure stress was extremely small, about 2 kg/cm² and



approached the limits of measurement as bend values of ~0.1 mm were involved. The nonzero value for the noncure type is simply a result of slight pooling of liquid resin in the center of the strip.

Cooling stress, on the other hand, is about 10 times larger than cure stress. The slightly lower value for the cured sample is due to its more rigid crosslinked structure.

Cure/Cool Stress Qualitative

A qualitative measure of the effects of cure and cool stresses on appearance was made by recording the degree of image distortion of a reflected light ring. A window oven facilitated real time measurements during baking.

The noncure powder (Figure 16) melts and levels over

time. Cooling produces no significant distortion of the ring image.

The cure powder (Figure 17) melts and levels for up to five minutes. Suddenly after this point, which corresponds to the onset of cure, short wave image distortion develops. This short wave distortion persists relatively unchanged to the end of the bake. Cooling does not significantly affect the appearance.

From these findings it is apparent that the cooling stress, although large, has little effect on appearance due to its uniform nature. Cure stress, however, produces significant image distortion at the onset of cure. This does not reduce over time, but is “frozen in” by cure gelation. Although the level of cure stress is extremely small when measured as an overall average, its large effect is due to high localized stress gradients, resulting from uneven curing.

Effect of Hardener Size

As uneven cure produces such a large distortion of image clarity, better distribution of smaller sized hardener crystals was tried to improve appearance. Standard DDA hardener crystals have an average crystal size of 5 µm in the powder after kneader processing. Additionally fine 4 and 3µm grades were tested.

Results show a definite improvement in appearance of up to NSIC 6% (Figure 18). The light ring test was used to confirm that the improved appearance was indeed due to reduced levels of short wave image distortion (Figure 19). Remaining image distortion is mostly due to long wave orange peel or surface tension variations.

SUMMARY

A clear relation between reduction in average particle size and improvement in appearance was shown. Narrowing of the particle size distribution was also shown to result in better appearance. In both cases improvement was due to the absence of coarse particles that produce large irregularities in the film and coalesce and de-gas slowly to give poor appearance. In practical terms, larger gains were made by simply reducing particle size. Narrowing of distribution width was work intensive and reduced yields.

Cure stress was shown to be a major source of short wave roughness while cooling stress had little or no effect on appearance. Cure stress gradients were identified as being caused by the phase separated nature of the micron sized hardener crystals. Cure stress gradients were reduced by use of a better distribution of finer sized hardener crystals giving improved appearance.

Handling characteristics of fine (~10 µm) powders presented some problems,³⁰ such as increased sintering or blocking of powders in storage, reduced flowability causing irregular feed rates, poor fluidiza-

Table 2—Composition of Wide and Narrow Distribution Powders. Narrow Powder with Mid:Upper Ratio = 4:1 has Improved Image Clarity, NSIC 5% Higher.

Distribution	D50 ± SD	Weight %				Mid:Upper	Image Clarity NSIC (%)
		Lower	Mid	Upper	Mid:Upper		
Narrow	19.2 ± 11.2	18.2	66.7	15.1	4:1	77.5	
Wide	20.5 ± 17.4	28.2	41.9	29.7	4:3	72.5	

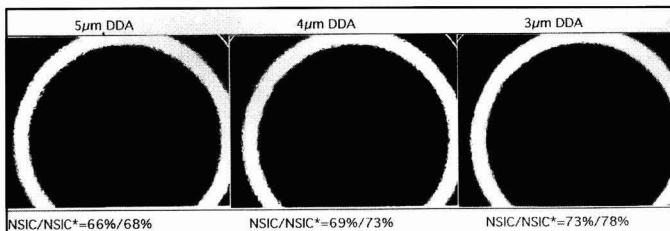


Figure 19—A reflected light ring shows reduced short wave roughness and improved image clarity from use of finer grades of DDA hardener.

tion properties, and increased impact fusion in tubing. These problems have been overcome by the development of a new spray system which is presently being extended for practical application.

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Unified Model for the Degradation of Organic Coatings on Steel in a Neutral Electrolyte

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J.M. Pommersheim—Bucknell University*

INTRODUCTION

Organic coatings are widely used to protect metals against corrosion. Despite improvements in coating technologies, problems continue to exist in long-term protection of metals from their environments. Considerable research on the degradation of coated metals has been performed and significant advances in understanding the mechanisms and modes of failure of these materials when exposed to a corrosive environment have been made.¹⁻⁸ However, there has been little work to quantitatively describe the degradation processes and to predict the performance of a coating/metal system during service. One of the main reasons for the lack of a comprehensive theoretical framework for understanding and predicting corrosion protection by a coating is the complexity of the coating/metal system and the many factors that affect the performance and service life of a coating system. For example, besides the physical and chemical properties of the coating, the substrate, and the coating/substrate interface, a coating system may contain inhomogeneities, both in the coatings and at the coating/substrate interface. These factors influence the transport of corrosive species through the coating and along the coating/substrate interface, as well as the degradation processes at the interface.

If the effectiveness of protective coatings is to be increased through development of improved selection and evaluation criteria, it is essential to develop improved methods for quantifying the degradation and predicting the service life of a coated metal. This paper presents a unified model, containing both conceptual and mathematical components, for the degradation of a protective coating on a steel substrate exposed to a neutral electrolyte. The unified model is based on theoretical and experimental studies from our laboratory as well as on current understanding of the degradation process. This model can provide a useful tool for better predicting the performance and service life of organic protective coatings.

DEGRADATION MODES OF ORGANIC-COATED STEEL IN NEUTRAL ELECTROLYTES

For a coating system containing a scribe mark or a large defect exposed to a neutral electrolyte, e.g., NaCl, the degradation

A unified model is presented for the degradation of an organic protective coating on a steel substrate exposed to a neutral electrolytic environment. This model is based on theoretical and experimental studies from our laboratory and on current understanding of the degradation process. The assumptions of the model are based on the concept that degradation of a coating/steel system occurs following the transport of ions through conductive pathways, which are presumably formed by an attack by water in the "hydrophilic," low-molecular-weight/low-cross-linked regions, followed by the connections of these regions. Models for the blistering and delamination resulting from corrosion processes are based on the diffusion of cations along the coating/steel interface from the defects to cathodic sites under the coatings. The resulting equations are solved to predict ion fluxes and concentration profiles along the interface and within blisters. Model variables include blister size, distance between blister and defect, ion diffusivity, and potential gradients. Experimental results agree well with theoretical predictions.

phenomenon is generally understood.⁵⁻¹² Corrosion takes place at the defects while delamination or blisters appear adjacent to the defects (Figure 1a). This degradation phenomenon, which is the most severe among the failure modes of organic-coated steel, is often observed on metal objects with damaged coatings, e.g., a dented car fender or a scratch on the outside wall of a building. The loss of adhesion in the vicinity of large defects is generally known as cathodic delamination and blistering because it is due to the half cell cathodic reaction of the corrosion process. In an alkaline electrolyte, cathodic delami-

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Figure 1—Degradation of coated steel panels in a neutral electrolyte: (a) with scribe mark, and (b) without apparent initial defects.

nation also occurs near a scribe; however, corrosion does not occur at the defect site (as in a neutral electrolyte) but under the coating adjacent to the scribe mark.¹³ Although the model presented here is generally applicable, this paper does not discuss further the degradation process in an alkaline electrolyte.

For coated steel panels containing pores, pinholes, or small-sized defects exposed to a neutral electrolyte, corrosion also occurs at the defects, and cathodic delamination takes place around the defects.^{3,8} However, cathodic blistering at the pores has also been observed.^{14,15} In this case, the anodic reactions take place on the metal surface below the pore bordered by circular cathodic sites. The pore, which contains corrosion products, is at the center top of the blisters. Funke suggested that corrosion products, which act as a semipermeable membrane, block the pores and cause increased water uptake around the defective areas. Martin et al.¹⁶ also observed cathodic blistering (Figure 1b) with a small corroded area near the blister center of alkyd-coated steel panels containing no apparent coating defects (undetected by a holiday detector), but subjected to constant immersion or cyclic wet-dry exposure to a NaCl solution. They noted that it took a much longer time for blisters to occur on these panels than on those containing a scribe mark. It is suspected that some types of defects must have been formed in the coatings of these panels during exposure because it has been shown that the degradation of organic-coated steel occurs only at the defects, even for coating films as thin as a monolayer.¹⁷ These results

suggest that organic-coated steel panels containing no apparent defects exposed to a neutral electrolyte follow the same degradation processes as specimens containing small-sized defects.

Although the degradation modes and mechanisms of organic-coated steel immersed in a neutral electrolyte are generally known, several critical questions remain unanswered. For example, do both cathodic delamination and blistering appear on the same coating/substrate system or does each mode occur on a certain type of the coatings? If the latter is true, then what are the fundamental properties of the coatings that dictate the cathodic failure mode, e.g., moduli, wet T_g ? Another question that needs to be addressed is whether cathodic blisters are formed randomly or are associated with certain sites at the coating/substrate interface, e.g., interfacial microvoids, defects in substrate surface structure? Answers to these questions would provide a clearer understanding of the corrosion and protection of organic coatings on metal.

UNIFIED MODEL FOR DEGRADATION OF ORGANIC-COATED STEEL

Conceptual Model

Based on the evidence presented in the preceding section, we believe the degradation of a typical organic-coated steel panel containing no apparent defects (good coating) exposed to a neutral electrolyte solution follows the steps (indicated by circled numbers in Figure 2) depicted graphically in Figure 2b. For completeness, a conceptual model for the degradation of a coated steel panel containing a large defect or a scribe mark is illustrated in Figure 2a; except for the events and the phenomena taking place away from the scribe, the processes at the scribe mark are similar to those proposed by Dickie and Smith.⁵

Formation of Conductive Pathways

One group of researchers has proposed that the formation of conductive pathways (step 1) that allows ions to reach the metal surface is the first step in the degradation of a good coating or a multilayer coating on a steel substrate exposed to a neutral electrolyte;^{3,18,19} while another school of thought believed that water sorption in the coating is the first step.^{20,22} A linkage between these two phenomena, i.e., water sorption and conductive pathway formation, would provide a unified view of the initial step in the degradation of a defect-free, organic protective coating.

Actually, these two views are not different from one another if conductive pathway formation is the consequence of the water uptake in the coatings. There are several pieces of information to support the linkage between these two phenomena. The strongest evidence is from the findings of numerous studies indicating that coating films inherently contain microscopic regions that take up large amounts of water and have low ion resistivity.²³⁻²⁸ Further, corrosion spots on the substrate have been found to be directly related to these regions.^{23,28} Additional evidence is from scanning electron microscopy (SEM) studies, which clearly showed that water does not diffuse into the film uniformly but in a dense layer along the boundaries of the polymer structure units, followed by penetration into the structures themselves.²⁹ Such diffusion leads to destruction of the molecular network structure

and the protective efficiency of the coating. Phase-contrast microscopy results also revealed that the water droplets in the low ionic-resistant coatings are finely dispersed, while the water droplets in the high-resistant films are isolated.²⁰ Mayne postulated that the transport of ions through isolated droplets is more difficult than through the finely dispersed water medium, and provided an explanation for the resistivity difference between the two coatings. Further, the induction period before cathodic blistering occurred on a coated panel containing no apparent defects has been found substantially longer than that containing a scribe mark.¹⁶ The results presented strongly support the notion that conductive pathway formation is a direct result of the water uptake in the coatings. Thus, for good or multilayer coatings, water uptake is the first step of the degradation process; this process causes the opening of conductive pathways in the coatings, allowing ions to reach the substrate surface. The exposure time required for this process to occur is expected to be a function of the coating type.

We believe that the formation of conductive pathways in an organic coating during the water uptake period is due to an attack by water in the "hydrophilic" regions in the film, followed by the interconnections of these regions. The presence of macroscopic defects such as craters and pinholes,^{30,31} air bubble inclusions,³² poor adhesion between pigment and binder,³³ or mechanical damages in the coatings would accelerate the pathway connections. Swelling, stress relaxation, and conformational changes in the coatings during exposure may all contribute to the formation and enlargements of such pathways.

Hydrophilic regions are regions that contain low-molecular-weight/low-crosslinked (LMW/LC) materials. They take up a large amount of water, have a low resistance to ion transport, and are susceptible to water attack, e.g., hydrolysis and dissolution. The inherent presence of inhomogeneities and phase separation in a polymer or coating film is well documented. Indeed, this property is the main cause of the deviations between experimental data and the theory of the equilibrium formation of crosslinked polymers, which leads to the introduction of empirical parameters into rubber elasticity laws. Karyakina and Kuzmak²⁹ have discussed in detail coating heterogeneity and concluded that organic coatings should be considered as consisting of microgels connected via a spacial network. Corti et al.²⁸ briefly reviewed the inhomogeneous nature of paint films and believed that this property is intrinsic in these materials. Funke^{34,35} has studied the effects of various processes on the phase separation of paint films, especially during the curing and drying processes.

The presence of low-molecular-weight (LMW) regions in coating films has been demonstrated by electron and light microscopy studies.^{36,37} Films made of epoxy, phenolic and phthalate resins were observed to consist of micelles or granules of high-density segments separated by narrow boundary regions of LMW material. At the film/substrate interface, the LMW material may exist as a thin continuous film or as channels between micelles, thereby providing pathways for the easy entry of water to the interface.³⁸ Bascom surmised that inhomogeneity in coating films is due to a phase separation during film formation. As the high-density segments approach one another from random initiating sites, they are unable to merge into a homogeneous structure. Instead, for chemically cured coatings the polymerization is terminated

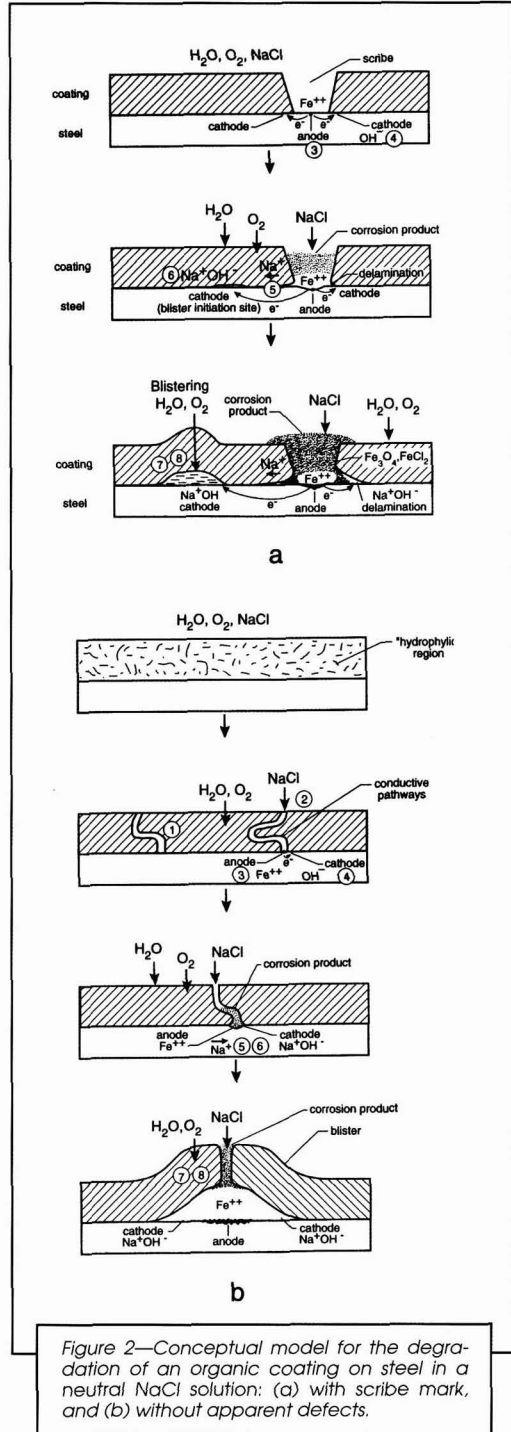


Figure 2—Conceptual model for the degradation of an organic coating on steel in a neutral NaCl solution: (a) with scribe mark, and (b) without apparent defects.

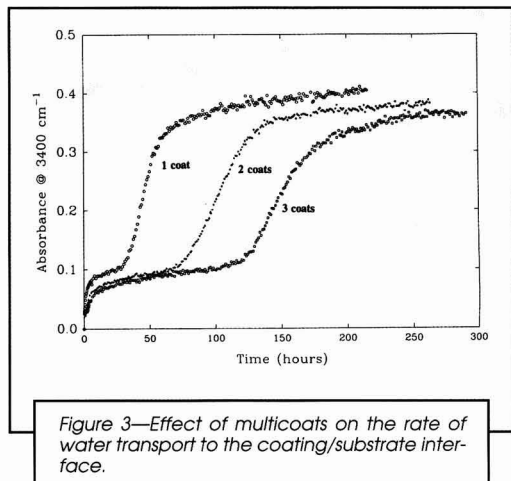


Figure 3—Effect of multicoats on the rate of water transport to the coating/substrate interface.

leaving the unreacted or partially reacted materials at the periphery.

Using D.C. resistance and microhardness measurements, Mayne and coworkers²³⁻²⁶ have identified a “conducting polymer phase,” which they designated as D area, in a variety of coating films. D areas, whose diameters range between 75 and 250 μm , constitute only a small fraction of the film and have physical and chemical properties completely different from the rest of the film. Fernandez-Prini and Corti^{27,28} have also observed an extensive degree of heterogeneity in epoxy/polyamide coal-tar films. Some regions in these films behave similarly to the D type described by Mayne. Mills and Mayne²³ postulated that D areas are formed by partially polymerized or “dead” molecules, which are present in the resin before casting. During drying, these molecules congregate, form micelles, and due to low functionality, do not crosslink to the same extent as the rest of the film. Thus, it appears that the low crosslinked (LC), D type areas observed by Mayne resemble the microscopically observed, low-molecular-weight

(LMW) regions described by Bascom.³⁸ Both of these descriptions are consistent with SEM observation of Karyakina and Kuzmak,²⁹ which showed that the transport of water through a coating film is along the boundaries around the polymer network units.

Corti et al.²⁸ have observed that the water sorption and transport characteristics of the D areas are typical for a hydrophilic, ion-exchange membrane. This type of material takes up about 45-75% water and has ion diffusion coefficient in the 10^{-5} cm^2/s range. This means that the LMW/LC (D type) regions would take up much more water and have much lower ionic resistances than the rest of the film. Typical organic coatings take up approximately 2-5% water and have ion diffusion coefficients in the 10^{-10} - 10^{-13} cm^2/s range.^{6,39} Further, the transport of ions in the LMW/LC regions probably follows the Cohen-Turnbull⁴⁰ mechanism, whereby the rate determining process for diffusion is the thermal density fluctuations of the mobile water molecules sorbed within the polymer. This transport mechanism is strongly dependent on the amount of water that has been taken up. The LMW/LC, high water uptake, low-ionic resistance regions (D type) in a coating film are referred to hereafter as the hydrophilic regions.

The assumption that conductive pathway opening is due to chemical activation by water is consistent with the observations of several studies. Kittelberger and Elm⁴¹ have attributed a much higher diffusion rate of NaCl in linseed oil films than in films of other resins, e.g., phenolic or alkyd, to the large concentrations of hydrolyzable materials in the linseed oil. Mayne²⁰ proposed that the easier passage of ions through linseed oil films relative to other coating films is due to a finely dispersed distribution of water in the former, as indicated earlier. Water soxhlet extraction studies by Walker⁴² also showed that long-oil alkyd and short-oil epoxy ester coatings lose about 4-5% water-soluble materials. Further, hydrolysis has been observed as a common mode of degradation of a variety of coatings and resins exposed to water and high relative humidities, both in the presence and absence of sunlight.⁴³⁻⁴⁹ Hydrolysis by water has been reported as the main cause of microcavitation, microcracking, irreversible mechanical loss, and etching (acid) of polymer and coating

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films.^{43,46,47,49} It should be mentioned that both ester and amide linkages, which are commonly present in coatings and related materials, are susceptible to hydrolysis reactions and are strongly catalyzed by an acid or a base.

Interestingly, several studies have linked coating degradation directly to the electrolytes. For example, Leidheiser et al.⁵⁰ and Tait⁵¹ suggested that cations of the electrolytes cause morphological changes in coatings leading to conductive pathways through the coatings. Walter¹⁹ also postulated that electrolyte solution ingresses permanently damage the film and that this damage increases with time. Cations generally do not directly attack a neutral, polymeric molecule, e.g., an ester, unless cations are of a strong base, e.g., NaOH, which is formed in the cathodic regions. In this case, the strong nucleophile, OH⁻, of the base adds readily to the carbonyl carbon of the ester following the nucleophilic addition-elimination mechanism.⁵² This would accelerate hydrolysis reactions with the formation of the salt of the cation (e.g., -COO⁻Na⁺). However, Leidheiser et al.⁵⁰ has provided evidence to show that corrosion could not cause the damage. Thus, it is more likely that cations are involved in the degradation process through the salt formation with the hydrolysis products in the hydrophylic regions, and not by reacting directly with the polymer chains. The resulting salts (soaps) are not only much more water soluble than the corresponding esters but are also capable of solubilizing nonpolar organic substances.

Based on the previously mentioned evidences and discussion, it is concluded that water attack, e.g., hydrolysis and dissolution, in the LMW/LC, hydrophylic regions causes a loss of coating material in these regions. This is probably the primary process leading to the formation and opening of conductive pathways in organic coating films exposed to electrolytes. This hypothesis is in good agreement with the observations by Mayne and Mills^{23,26} and Fernandez-Prini and Corti^{27,28} that the loss of coating protective capability starts in the low crosslinked, low resistant, D areas and that corrosion spots on the steel surfaces under coatings correspond directly to these areas. For poor coatings, some macroscopic defects may be large and continuous through the film, providing pathways for electrolytes to reach the interface within short exposure times. For good or multicoat films, defects may not be continuous or large enough for ions to migrate through. For these coatings, prolonged or repeated exposure is required for the formation and connection of openings in the hydrophylic regions. Since the percentage of hydrophylic areas in a film is small, the chance of one hydrophylic area overlapping another hydrophylic area in succeeding layers is low. Thus, a multicoat film is a more effective protective coating than a single coat of the same thickness, consistent with general practice.

The opening of new and/or enlargements of existing pathways during exposure has been proposed by several workers. Kendig and Leidheiser¹⁸ have related changes in electrical properties to the formation of pathways and indicated that ions initially penetrate to random depths at numerous sites; with time, paths of complete penetration develop. Similarly, based on evidence from potential, impedance, and degradation measurements, Walter¹⁹ postulated that there may be a few continuous pathways at first, but many pathways will develop with time. He also showed that pathway area increased with exposure time in solution. Skerry and Eden⁵³ estimated that the apparent area of the pores increased from

an initial $0.6 \mu\text{m}^2$ to $6700 \mu\text{m}^2$ per cm^2 of the coatings after 100 days exposure to the 0.6 mol/L NaCl solution. Another example of the increasing number of pathways with exposure is from a study of powder epoxy coatings on reinforced steel bars, showing that the number of holidays detected after 24 hr exposure to a 0.6 mol/L NaCl solution was higher than when initially inspected.⁵⁴

Nguyen et al.⁵⁵ have provided spectroscopic evidence to support the proposal that the transport of materials in coating films is through the interconnections of interrupted pathways; Figure 3 presents their results. These curves are plots of the Fourier transform infrared intensity corresponding to the amounts of water at the coating/substrate interface⁵⁶ for one, two, and three coats, respectively, of a water-reducible epoxy coating on a germanium substrate. The thickness of the one-, two-, and three-coat films were 141, 208, and 242 μm , respectively. The results clearly showed that the rate of water entering the coating/substrate interface (the slope) decreased with increasing number of coats. Thickness differences among the specimens cannot explain these results because film thickness generally only affects the time required for water from the outside to reach the coating/substrate interface (time-lag).

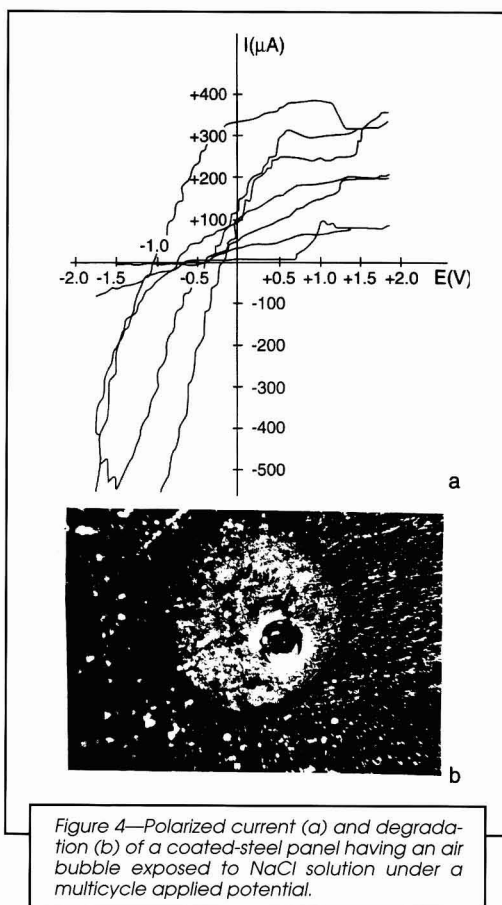


Figure 4—Polarized current (a) and degradation (b) of a coated-steel panel having an air bubble exposed to NaCl solution under a multicycle applied potential.

The results suggest that increasing the number of coats increases the tortuosity of the transport pathways in the coatings.

Transport of Corrosive Species to the Metal Surface

Following the pathway formation, the next step in the degradation of coated steel is the transport (step 2) of water, oxygen, and ions from the environment to the metal surface. However, typical organic films are permeable to water and oxygen so that the transport of these materials is not rate controlling.^{1,5,7} Further, it has been established that the loss of barrier properties and the development of conductive pathways in an organic-coated metal normally coincide with the initiation of corrosion processes at the metal surface. Based on experimental evidence, Walter^{2,19} suggested that the ingress of ions through the coating is the primary process responsible for the degradation of an epoxy primer/topcoat system. Mayne²⁰ shared this view for low-resistant coatings; but for high-resistant coatings, he believed the transport of ions is secondary to water uptake. Kittelberger and Elm⁴¹ reported a linear relationship between the rate of diffusion of NaCl and the reciprocal of the film resistance. Since coating resistivity is directly correlated with corrosion,⁵⁷ this result suggests that ion transport through the coatings may be the primary process in the degradation for certain types of coatings.

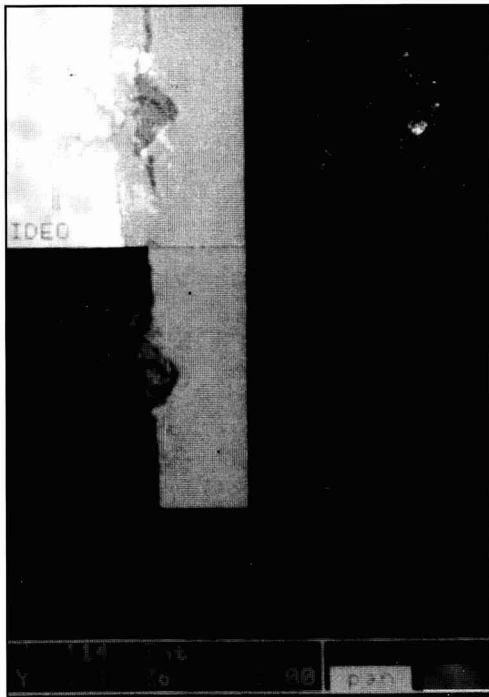


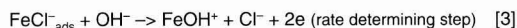
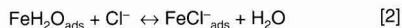
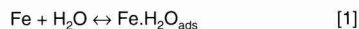
Figure 5—SEM image and distributions of Cl and Fe at the scribe mark in an organic-coated steel panel exposed to a 0.51 NaCl mol/L solution for 168 hr.

Regardless of the rate controlling step, the transport of ions from the environment to the metal surface is through discrete, least-resistant, conductive pathways in the coatings.^{3,18,19,58} This view is supported by the fact that the solubility of ions in a polymer matrix is extremely low, on the order of 10^{-8} mol/L in equilibrium with one molar electrolyte.⁷ Ion transport through conductive pathways is in agreement with the practical observation that corrosion of coated metals occurs on the bare metal area at the base of defects in the coatings or at mechanical damage sites. It is also consistent with the impedance equivalent circuit models, which generally consist of the coating capacitance shorted by a resistive element, due to the formation of ionically conducting pathways through the coatings.^{58,59}

Figure 4 provided both direct and indirect evidence to support the assumption that the transport of ions is through the lowest-resistance pathways. The specimen was a 60 μm thick, clear acrylic coating on a steel substrate containing one air bubble, which was enclosed in a corrosion cell containing a 0.51 mol/L NaCl solution. A multicyclic potential between -1.8V and $+1.8\text{V}$ was scanned across the specimen at a rate of 0.1V per second. The polarization currents (Figure 4a) rose rapidly within five minutes of applying the potential. No current was detected for specimens containing no bubbles or other defects, even after scanning for three hours under the same cyclic potentials. For the specimen shown in Figure 4, there was no evidence of corrosion inside or outside the bubble during the five-minute scanning. However, corrosion was observed upon further immersion as seen in Figure 4b (17.5X). Brownish corrosion products were visibly observed inside, and a light-color ring around the air bubble appeared after approximately one hour of exposure. The corrosion products in the bubble became voluminous and the area within the surrounding ring progressively expanded with exposure. Other examples with minor defects in the coatings also showed similar phenomena.⁶⁰ These results indicated that the transport of ions to the metal surface was through the least-resistant pathways and that corrosion starts at the base of the pathways. It should be emphasized that the cyclic applied potential caused very little, if any, physical damage to the coatings.^{60,61}

Degradation at the Defect or Pathway

Once conductive pathways are established and ions have reached the metal surface, the degradation of a coating system without apparent defects is believed to be the same as that containing a small defect, as indicated earlier. A corrosion cell is set up and near the defects or pathways. The anodes develop (step 3) on the bare steel at the bases of the pathways,^{3,6,7} where corrosion reactions take place following several steps⁶²:

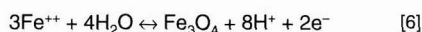


The net result is the production of electrons and Fe^{2+} ions in solution. The rate of formation of the first oxidized layer in

the presence of Cl^- ions has been found to be several orders of magnitude higher than that in water alone.⁶³ Subsequent oxidation and hydrolysis result in a decrease of the pH and formation of a complex mixture of hydrated iron oxides (rust) at the defects:



For coatings containing large defects or scribe marks, reactions [1] to [5] also occur at the bare steel of the coated panels (Figure 2a). In this case, anodes and cathodes may initially develop in the proximity.^{5,9} As corrosion products form and concentration gradients of corrosive species are established, the reaction sites separate and localize. Continued exposure leads to an increase of this separation. As corrosion progresses, the rust layers at the defects become a barrier to the transport of oxygen. According to Pourbaix,⁶⁴ the formation of Fe_3O_4 products is thermodynamically favored (large negative enthalpy of formation) in this environment, following the reaction:

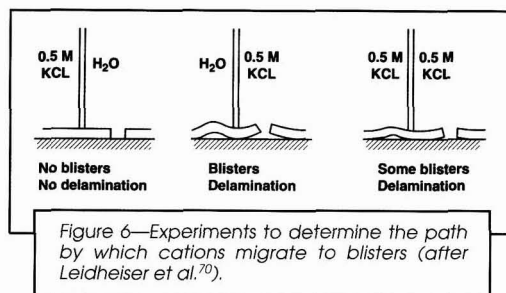


In the presence of chloride ions, HCl can form and aggressively promote the dissolution of iron at the defects, resulting in an increase of Cl^- ion migration. The effect is a rapidly accelerating, or autocatalytic, process at the bottom of the defect. With the buildup of excess Fe^{2+} and H^+ ions within the confined local electrolytes, negatively charged ions are required to preserve charge neutrality. However, for coated metals, mobile negative charged species are limited. The cathodically produced OH^- ions are captured near their production sites by the organic coating, as evidenced by the high pH at the delamination fronts.⁶⁵ On the other hand, Cl^- ions are abundant in the bulk solution and migrate into these locations to preserve electrical neutrality. The result is an increased local concentration of ferrous chloride following the reaction^{64,66}:



Thus, the products in the solution under the rust layers at the bottom of a scribe mark probably contain mostly $\text{FeCl}_2 \cdot 4\text{H}_2\text{O}$ and Fe_3O_4 (Figure 2a), similar to those observed for localized corrosion of uncoated iron. Oxidized corrosion products are anion-selective,⁶⁷ allowing Cl^- ions to continuously permeate through the rust layers and reach the metal surface. Sato⁶⁷ postulated that water probably continuously flows into the anodic sites under the rust layers by an electro-osmosis process, which accompanies the permeation of Cl^- ions.

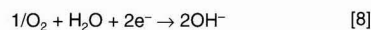
Reaction [7] accounts for the presence of large amounts of chloride at corroded sites, as illustrated in Figure 5. This figure shows a SEM image and the distribution of Cl, Fe, and Zn (Zn is from the pigment in the coating) elements at a scribe mark of an alkyd primer/topcoat on a steel panel immersed in a 0.51 mol/L NaCl solution for 168 hr. Although some corrosion products were lost during specimen preparation, the large concentrations of Cl deposited at the bottom of the scribe and around the Fe corrosion products are clearly seen in the Cl map. These results support the suggestion by Ritter and Rodriguez⁹ that the corrosion process under the corrosion products at a scribe mark is similar to that for localized corrosion of uncoated iron. The fluid within the crevices of uncoated iron exposed to neutral NaCl solutions is acidic and contains a 3-10 times higher concentration of Cl^- ions than



that of the bulk solution.⁶⁸ For coated iron, Ritter and Rodriguez⁹ reported a 3-4 times higher Cl^- ion concentration in the anode formed at the coating/iron interface than in the bulk after one week exposure to a 0.05 mol/L NaCl. Nguyen and Lin⁶⁹ also found a 10-fold higher Cl^- concentration in a corroded, anodic blister formed on an alkyd-coated steel panel exposed for six months to a 0.51 mol/L NaCl solution.

Degradation Around the Defect or Pathway

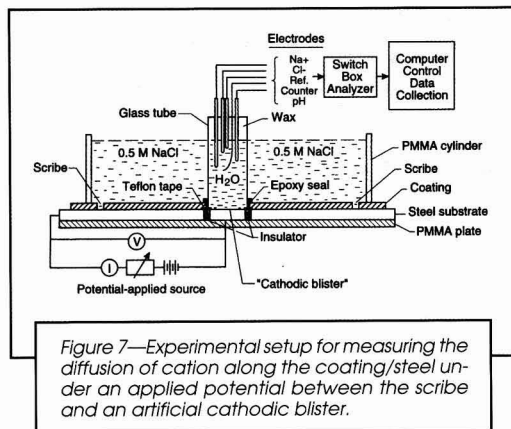
Under the coating near defects, cathodes are formed (step 4). The primary corrosion reaction is oxygen reduction^{3,5-7,70}:



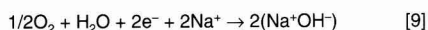
Every electron produced by the anodic reactions (reaction [3]) is consumed by the cathodic reaction. Thus, there is a strong electrochemical coupling between the defect (anode) and the cathodic sites under the coating. First, the transport of electrons results in a flow of a galvanic current (corrosion current) between the defect and the local cathodes. This flow requires cations transport between the two sites.⁷ The current is high if the ion conductivity between the defect and cathodes is high, which occurs, e.g., when the coating/substrate interfacial area between the anodes and cathodes has been delaminated or blistered.⁷¹ Preventing the flow of the corrosion current would halt the corrosion of organic-coated metals.

There is also a substantial potential gradient between the defect and an associated cathode at the coating/substrate interface. This potential has been found as the driving force for the cathodic delamination of organic-coated steel in electrolytes.^{7,72} Lowering this potential gradient would minimize the cathodic delamination and blistering.^{72,73} Using a Kelvinprobe technique, Stratmann and coworkers^{7,17,72} have measured the potential gradients between a defect and a random location at the coating/metal interface surrounding the defect. For coated iron exposed to an electrolyte, they range from +0.05 to -0.4V_{SHE}, with more negative voltages at locations closer to the defect. The measurement of this potential has provided a good way to nondestructively monitor the growth of the cathodic regions under coatings. The intact coating/metal interface is characterized by positive potentials, whereas a delaminated area is recognized by the negative potential plateau. The delamination front is identified by the transition between negative and positive potentials.

The regions underneath the coatings where cathodic reactions occur serve as the initiation sites for delamination or blistering. The pH at the cathodic delamination areas and



in cathodic blisters is high. This has been proven by the strong violet coloration, either from a transparent coating containing a phenolphthalein pH indicator⁷ or after spraying the same indicator over the delaminated area. Ritter and Kruger⁶⁹ have recorded pH values as high as 14 at the front of the delamination. The strong alkalinity at the cathodic sites has been attributed to the migration of cations (step 5) from the environment to the cathodic sites, neutralizing the negative charge of the hydroxide ions following the reaction^{6,7,13,73}:



The presence of Na in the cathodic delaminated areas has been verified by surface analytical techniques.^{7,74}

In the absence of an applied potential, the transport of Na⁺ ions to the cathodic sites appears to be along the coating/metal interface via defects, pores, or conductive pathways in the coatings, as demonstrated experimentally by Leidheiser et al.⁷⁰ (Figure 6). They found that cathodic blisters developed only if pores or similar coating defects extending to the metal surface were exposed to electrolytes. These results were confirmed by Funke.⁶ Based on evidence from Kelvinprobe measurements, Stratmann et al.⁷ went further to suggest that not only cation diffuses along the coating/metal interface from the defects to the cathodic sites but also this transport process is the rate controlling step of the cathodic delamination phenomenon. Nguyen and co-workers^{73,75,76} have assumed the same transport process as the rate determining step in their model for the cathodic blistering process of coated steel in neutral electrolytes. They further predicted that the cation flux into the cathodic blisters is almost a linear function of the potential gradient between the defect and cathodic sites.

For cathodic delamination, the alkalinity of the solution at the delamination front has been proposed as the cause for the disbondment (step 6) of a coating from a steel substrate.^{3,11,70,78} However, the rate of delamination is a function of many factors, including potential difference between the defect and local cathodes, applied potential across a coated panel, type and concentration of cations, type of coating and metal, metal surface pretreatment, temperature, and oxygen concentration.^{4,7,39,70,72} Three possible mechanisms have been advocated for the cathodic delamination of a coating: dissolution

of the oxide layer,^{65,70} alkaline hydrolysis of polymer,¹¹ and interfacial failure.⁷⁷ In some coating/metal systems, more than one of these mechanisms is involved, either simultaneously or in stages.⁷⁸ Recent developments have allowed the cathodic delamination rate to be measured more precisely, either nondestructively^{7,72} or destructively.¹³

For cathodic blistering, the alkalinity of the cathodic reaction products is also believed to be responsible for the interfacial disbondment at the cathodic sites. However, the high water solubility of the product from reaction [9] is probably responsible for blister formation.^{12,73} This alkaline material reduces the water activity and creates an osmotic pressure gradient (step 7) between the environment and the coating/steel interface at the blisters. This osmotic pressure gradient is probably the principle mechanism for the growth (step 8) of cathodic blisters.^{6,12,14,73,79,80} Alternately, Martin et al.¹⁶ suggested mechanical stress may be the main cause for growth of cathodic blisters.

Based on this conceptual model, the steps (circled numbers in Figure 2b) involved in the degradation of an organic-coated steel panel containing no apparent defects exposed to a neutral NaCl electrolyte may be summarized as in the following:

- (1) Conductive pathways develop by water attack in the hydrophilic regions of the film, followed by interconnection of these regions; macroscopic defects (in the coatings) accelerate this process;
- (2) Ions migrate through conductive pathways to the metal surface;
- (3) Anodes develop on the metal surface at the base of the pathways;
- (4) Cathodic contacts develop under the coating at the periphery of the pathways;
- (5) Sodium ions migrate along the coating/metal interface from the defect to the cathodic sites to neutralize the hydroxyl ions; this transport process is the rate determining step;
- (6) Alkalinity of NaOH product at cathodic sites causes disbondment (cathodic delamination);
- (7) Hygroscopic NaOH materials at cathodic sites produce a water activity difference between the environment and interface, setting up an osmotic pressure gradient; water is driven to cathodic sites through the coatings by an osmotic pressure gradient; and
- (8) For some coatings, blisters develop, enlarge (probably facilitated by mechanical stresses), and eventually coalesce, resulting in total delamination.

MATHEMATICAL MODEL

Transport of Ions to Metal Surface

As indicated earlier, once conductive pathways are established, the next step in the degradation of a good coating/steel system in a neutral electrolytic environment is the transport of ions through the pathways to the substrate surface. Our models of the transport through these types of coatings are based on mass diffusion through an impermeable slab punctured by tortuous transmembrane pores. The physics of this

transport is best illustrated in the simplest example: a planar membrane of thickness, l , containing pathways (pores) having contour length, δ' , initially free of diffusive species, with a steady concentration difference c_0 across the two faces. The pore-average transient flux through an imperfect, amorphous membrane is given by⁸¹:

$$\langle F(t, l) \rangle = \int_0^{\delta'} dx P(x) F(t, \sqrt{x}l) \quad (1)$$

and the steady-state flux is then given by:

$$\langle F(0, l) \rangle = \frac{Dc_0}{l} \int_0^{\delta'} dx x^{-1/2} P(x) \quad (2)$$

where $P(x)$ is the pore length probability function, $F(t, \sqrt{x}l)$ is the Fickian diffusive flux through a set of pores having the contour length $\delta' = x^{1/2}$, and D is the diffusion coefficient in the pores. $P(x)$ in an amorphous membrane has been described and calculated by Hubbard et al.⁸¹ in which pores were constructed by finite variance, continuous random walk algorithms. Simulation and analytical results for the length distribution of pores in 1-D, 2-D, and 3-D (D for dimension) for both asymmetric and symmetric membranes have been obtained. Hubbard et al. deduced explicit forms for $P(x)$ and derived the transient flux for corrosive species through amorphous membranes. For instance, equation (1) has the form (for a 1-D symmetric membrane):

$$\begin{aligned} \langle F(t, l) \rangle &= \frac{-4\pi Dc_0}{l} \sum_{k=0}^{\infty} \sum_{n=1}^{\infty} (-1)^{k+n} \\ &\times \left[4 \left(\frac{n}{2k+1} \right)^2 \frac{Dt}{l^2} \right]^{1/4} \\ &\times K_{1/2} \left[\frac{n(2k+1)\pi^2 (Dt)^{1/2}}{l} \right] \end{aligned} \quad (3)$$

where $K_{1/2}$ is the modified Bessel function of order 1/2. The long-time transient flux is a stretched exponential:

$$\langle F(\tau, l) \rangle = \frac{4\sqrt{\pi} Dc_0}{l} \exp(-\pi^2 \tau^{1/2}) \quad (\tau \rightarrow \infty) \quad (4)$$

where $\tau = Dt/l^2$.

Simulation and numerical results for the fluxes for 1-D, 2-D, and 3-D for symmetric and asymmetric membranes have been presented. The sharpest contrast between mass transport through pore-containing and homogeneous membranes is in the stretched exponential decay [$\exp(-t^\alpha, \alpha = 1/2)$] of the long-time transient diffusive flux for a pore-containing membrane versus simple exponential decay [$\exp(-t)$] for a homogeneous membrane. One interesting consequence of mass transport via membranes defect lines, which terminate at a surface, is that a composite membrane consisting of several layers in series should result in a more effective barrier to the diffusion of corrosive species than a single layer of the same overall thickness. This prediction is consistent with the result shown in Figure 3 and with the general practice of protective coatings.

Cathodic Blistering and Delamination

As stated previously, the principle mode of degradation of an organic-coated steel panel with or without defects in the coatings exposed to a neutral electrolyte is cathodic blistering

and delamination. Although the mathematical model was developed for cathodic blistering, it should be equally applicable for cathodic delamination because the governing parameters used in the model are the same for both degradation modes.

The main reaction in the cathodic regions is oxygen reduction with the formation of hydroxide ions (reaction [8]). The basis of the models developed by Nguyen, Hubbard, and McFadden⁷³ to describe this degradation is the transport of cations, especially those of alkali metals such as K, Na, Cs, and Li, along the coating/metal interface to neutralize the OH⁻ ions, which are generated from reaction [8]. The models are based on two assumptions: (1) transport of alkali cations from the defects (anodes) to the blister sites (cathodes) is along the coating/steel interface, and (2) alkali cation transport is the rate controlling step. The first assumption is in accordance with results of Leidheiser⁷⁰ and Funke⁴ for cathodic blistering. Recent experimental data on cathodic delamination by Stratmann et al.⁷ have verified both assumptions. The model is based on a 2-D, radially symmetric diffusion of an ionic species in an annular domain. The transport equation takes the form⁷³:

$$\frac{\partial C'}{\partial t'} = D \frac{1}{r'} \frac{\partial}{\partial r'} \left(r' \frac{\partial C'}{\partial r'} \right) + \mu E \frac{\partial C'}{\partial r'} \quad (5)$$

C' is the cation concentration at any point between the blister and the defect; t' is the exposure time; r' is the distance between the center of the blister and any location on the coated panel between the blister and the defect; D is the effective diffusion coefficient along the coating/steel interface; μ is the average mobility of cations; and E is the strength of the unscreened electric field.

Equation (5) was rewritten in dimensionless units, in terms of distance scale r , time scale t , and concentration scale C :

$$\frac{\partial C}{\partial t} = \frac{\partial^2 C}{\partial r^2} + \frac{1}{r} \frac{\partial C}{\partial r} + \frac{p}{r} \frac{\partial C}{\partial r} \quad (6)$$

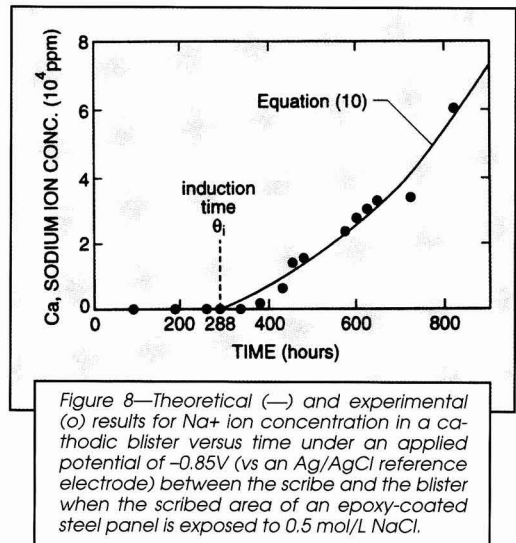
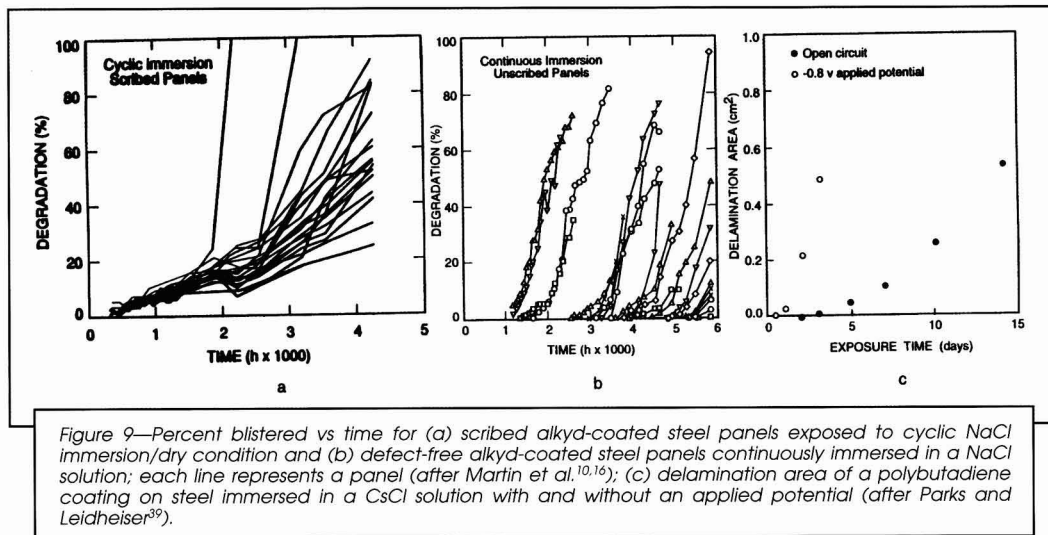


Figure 8—Theoretical (—) and experimental (o) results for Na⁺ ion concentration in a cathodic blister versus time under an applied potential of -0.85V (vs an Ag/AgCl reference electrode) between the scribe and the blister when the scribed area of an epoxy-coated steel panel is exposed to 0.5 mol/L NaCl.



where $C = C'/C_0$, $t = Dt'/L^2$, $L = R - a$, and $r = r'/(R - a)$, C_0 is the cation concentration in the environment; R is the distance between the defect and blister; and a is the radius of the blister. There are two dimensionless parameters in this model: the geometric aspect ratio, $k = a/R$, and the potential gradient parameter, $p = \mu(\Delta\phi)/D \log(l/k)$; $\Delta\phi$ is the potential difference between the defect and the blister.

Nguyen, Hubbard, and McFadden⁷³ solved the previous set of equations numerically and presented graphical results of the dimensionless concentration profiles and flux as functions of these parameters. Pommersheim et al.⁷⁵ have provided the analytical solutions of these equations for the steady-state. The models predict that, after a delay, the flux into the blister, and hence the cathodic blistering, increases rapidly with exposure time. The flux increases as the blister size increases or the distance between the blister and the defect is reduced. For two blisters of the same size and under the same potential gradient between the defect and blister, a blister that is one-fifth of the distance from the defect will have almost twice the amount of cation flowing into it. The models also imply that cation flux should increase almost linearly with applied potential between the defect and the cathodic blister. This prediction is in good agreement with Stratmann's results for a variety of coatings, which showed that the rate of cathodic delamination increased linearly with the potential difference between the defect and any location at the coating/metal interface.⁷² Based on these models, as long as the adhesion of a coating around a defect is maintained so as to minimize cation migration from the defect area to the potentially blistering area, the cathodic blistering around a defect will be minimized.

We refined these models further by proposing that the transport of cations to the blister-initiating sites takes place in two stages: an initial induction and a subsequent propagation period.^{75,76} In the induction period, cations diffuse and are adsorbed on the walls of the "interfacial gap" between the coating and the metal substrate. The problem is the diffusion of a boundary interface, which is described by equations (7)

and (8) for the presence and absence, respectively, of a radial potential gradient.

$$\frac{dr_i}{dt} = \frac{D \delta C_0 p}{\tilde{\rho}_s r_i} \frac{1}{\left(\frac{r_i}{R}\right)^p - 1} \quad (7)$$

$$\frac{dr_i}{dt} = \frac{D \delta C_0}{\tilde{\rho}_s r_i} \frac{1}{\ln \frac{r_i}{R}} \quad (8)$$

where $\tilde{\rho}_s$ is the amount of adsorbed cation per unit of interfacial area, r_i is the distance between the moving boundary (cation adsorbed site) and the center of the blister, and δ is the (average) thickness of the interfacial gap between the coating and the metal. These equations predict the rate at which cations move from the defect towards the cathodic blister. Solutions for the equations expressing the times required for cations to reach the blister were also derived.

The propagation period occurs after the cations have reached the cathodic blister sites. In this stage, cations enter the blister as a result of both diffusion and facilitated transport caused by the potential differential between the cathodic sites and the defect. The concentration of cations moving into the blister may be expressed by the following equation:

$$\frac{dC_A}{dt} = \frac{2\pi \delta D}{V \ln(1/k)} \left[C_0 - C_A \left(1 - \frac{k \ln(1/k)}{1-k} p \right) \right] \quad (9)$$

where V is the volume of the solution in the blister. Integrating provides an expression for the concentration of cations within the blister as a function of time.

$$\frac{C_A}{C_0} = \frac{1}{a} \left[1 - e^{-a\beta(t-\theta_i)} \right] \quad (10)$$

where $a = 1 - \frac{k \ln(1/k)}{1-k}$, $p = 1 - \left(\frac{p}{p'}\right)$, $\beta = \frac{2\pi \delta D}{V \ln(1/k)}$

Θ_i is the induction time, Θ_c can be determined from the solution of equation (6) by the time where cations first arrive at the blister ($r_i=a$). p^* , which is equal to $(1-k)/k \ln(l/k)$, is defined as the critical value of the potential gradient and depends on the size of the blister and the separation between the anodic and cathodic regions.

An experiment on the diffusion of cations along the coating/metal interface was carried out to verify the predictions of equation (10) in the presence of a potential gradient between a defect and a blister.^{76,82} The experiment measured the concentration of sodium ions *in situ* (using a sodium selective microelectrode) in an artificial, simulated cathodic "blister." Figure 8 schematically presents details of the experiment. The sodium ion migrated along the coating/metal interface from the defect (in contact with a 0.5 mol/L NaCl solution) to the blister (containing distilled water initially) under an applied potential of $-0.85V$ (vs. an Ag/AgCl reference electrode) between the defect and the blister. The pH in the blister was continuously monitored and was in the range between 10.2 and 11.0 after an induction period of about 335 hr. The metal in the blister remained uncorroded during more than 800 hr of measurements. The whiteness of the metal and the high pH in the blister indicated that the experiment was successful in simulating the cathodic blistering of organic-coated steel. Complete experimental details and results are given elsewhere.⁷⁶

Figure 8 displays both theoretical equation (10) and experimental data of sodium ion concentration versus time within the blister for an induction time Θ_i of 288 hr. Sodium ions have not broken through into the blister for times less than Θ_i . The induction period is shown as a horizontal line along the axis of Figure 8. The results over the full time range show good agreement between experimental data and theoretical predictions. The upward trend of the data is in accord with the theory. Equation (10) predicts that the blister will keep enlarging as long as there are sufficient sodium ions in the external solution and the potential gradient is equal to or greater than the critical value ($p \geq p^*$). The theory also predicts that small blisters will not grow until or unless a critical potential value (p^*) is reached. Blisters of larger size can grow under the combined effects of cation transport, osmosis, electro-osmosis, cathodic delamination, and mechanical stress. The shapes of the curves in Figure 8 (both induction and propagation periods) are in agreement with the experimental results on cathodic blistering obtained by Martin et al.^{10,16} for scribed and unscribed alkyd-coated panels continuously immersed in a 0.8 mol/L NaCl solution or exposed to cyclic NaCl immersion/dry condition (e.g., Figures 9a and b). The predictions were in agreement with cathodic delamination results of Parks and Leidheiser³⁹ for polybutadiene coatings on steel panels immersed in a 0.50 mol/L CsCl solution, both with and without a $-0.8V$ applied potential (e.g., Figure 9c), and of Stratmann et al.^{7,72} for a variety of coatings on surface-pretreated and untreated steel panels exposed to NaCl electrolytes.

SUMMARY AND CONCLUSIONS

A unified model, consisting of both conceptual and mathematical components, has been developed to describe various steps in the degradation of organic protective coatings on a steel panel exposed to a neutral electrolyte. The model for the

initiation of degradation of coatings containing no apparent defects (good or multilayer coatings) was based on the concept that ions reach the substrate surface by transport through conductive pathways in the coatings. Pathway formation is due to water attack in the hydrophilic, low-molecular-weight/low-crosslinked regions in the coatings, followed by interconnections of these regions. The models for cathodic blistering resulting from corrosion reactions are based on the transport of the alkali metal ions along the coating/steel interface from the conductive pathways or defects to the blisters. Theoretical predictions agree well with results of a cation diffusion experiment, which was carried out in the presence of a potential gradient. The predictions are also in agreement with experimental results on the cathodic blistering and delamination of coated panels exposed to electrolytes. The development of quantitative, physical models to describe the degradation of coated metals should greatly enhance our ability to develop effective protective coatings for metals.

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Addendum

During review, we came across two recent studies providing further evidences to support the conceptual model proposed in this paper. The first article was from an investigation by Tan et al.⁸³ who used an array of 121 isolated microelectrodes to probe at the inhomogeneity in films made with phenolic, alkyd, and polyurethane coatings. They showed that these coatings possessed regions of low D.C. resistance (D type) and that the area of these regions increased with increased time of exposure to three percent NaCl solution. These results further support our suggestion that organic films contain water-susceptible, hydrophilic regions where conductive pathways develop and enlarge during exposure. The second study was by Miskovic-Stankovic et al.⁸⁴ who investigated the penetration of NaCl solution in the microstructure of an isocyanate-modified epoxy coating electrodeposited on a steel substrate. Based on results obtained by A.C. impedance spectroscopy, water and electrolyte uptake, and optical microscopy/image analysis, they concluded that the degradation of the coating consisted of two steps: water uptake followed by water and ions penetration through the macropores. This conclusion is consistent with our view on the initial step in the degradation of a good or multilayer coating that water degrades and opens conductive pathways in the hydrophilic regions of the films, allowing ions to reach the metal surface.

Migration of Light Stabilizers in Acrylic/Melamine Clearcoats

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INTRODUCTION

Light stabilizers enhance the outdoor stability of polymeric coatings exposed to solar ultraviolet (UV) radiation.¹ It was recognized early that using two different stabilizers together can lead to synergistic effects which further improve the polymer stability.² For example, in automotive coatings combinations of UV absorbers with hindered amine light stabilizers (HALS) were found to provide the most effective protection.³

When light stabilizers are incorporated into organic coatings, the open structure of these amorphous polymers provides space for stabilizer migration. In single layers on metallic substrates, the migration is towards the surface as long as the diffusants can leave the coating by way of volatilization, dissolution in a liquid, or via a chemical reaction. Additives can also move in the opposite direction, i.e., into the substrate if the substrate is a plastic. In coating systems consisting of more than one polymeric layer, such as automotive clearcoat/basecoat combinations, interlayer diffusion takes place.^{4,5} The driving forces are concentration gradients, internal reactions, and chemical potential differences.

Stabilizer migration in coatings is rarely a desirable feature. The resulting losses lead to less protection. In thermoset coatings migration takes place during cure and later on outdoor exposure. The underlying processes are not well understood. Only limited experimental data are available for coatings,^{4,6} while a large body of data has been collected for plastics.⁷ Theoretical analysis is difficult because too many parameters influence the diffusion of additives in coatings. For example, migration to the surface is controlled by two mechanisms, the actual diffusion process and the loss process at the surface/air (liquid) interface. Assuming an initially uniform additive distribution in a homogeneous coating without chemical potential differences, the additive cannot diffuse until a finite amount is lost to the environment and an internal concentration gradient is established. This concentration gradient becomes the driving force for the additive migration. While the surface loss, e.g. volatilization, is governed by additive volatility, additive saturation solubility in the polymer, and additive concentration at the surface,⁸ many more factors influence the migration process. Among the properties of the resin matrix affecting the migration are the free volume, i.e., number and size of holes, the segmental

Experimental techniques have been developed to investigate the migration of UV absorbers and hindered amine light stabilizers taking place in acrylic/melamine clearcoats during cure. The basic approach consisted of microtoming the coatings into thin sections and measuring the additive concentration of each section. The stabilizer migration within single-layer coatings and between adjacent clearcoat layers was investigated. The effect of resin viscosity and layer swelling on the migration characteristics was studied. Stabilizer losses at the coating surface and migration into plastic substrates on cure were also determined.

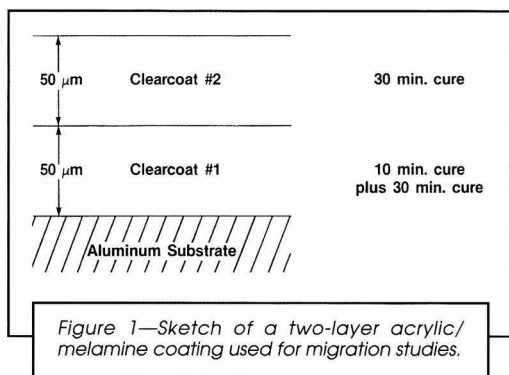
chain mobility, the existence of double bonds and polar groups, the degree of crosslinking, polymer crystallinity, and others.⁹ The characteristics of the migrating molecules are equally important. Here, the molecular size and structure, the existence of dipole moments as well as cyclization and branching are some of the elements which influence diffusion.¹⁰

The purpose of this paper is to discuss the migration of UV absorbers and HALS compounds taking place in acrylic/melamine coatings during cure. The coating composition was similar to those of many automotive clearcoats. The stabilizer migration in these clearcoats and losses at the surface and into plastic substrates were investigated. The general experimental approach consisted of cutting the coatings into thin slices, using a microtome, and measuring the stabilizer concentration in each slice.

EXPERIMENTAL

The clearcoats investigated in this study consisted of a styrene/acrylic backbone (Joncryl 500 acrylic oligomer, S.C. Johnson Corp.) and a methylated-isobutylated melamine crosslinker (Cymel® 1168 crosslinker, Cytex Industries Inc.).¹¹

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The backbone resin had an average molecular weight $M_n=1300$, a poly-dispersity $M_w/M_n=1.7$, and a hydroxyl number of solids of 140. The backbone to crosslinker ratio was 65:35 by weight. The OH/NOR ratio was 1:2.3. The catalyst was Cycat[®] 4040 p-toluene sulfonic acid (Cytac Industries Inc.) which was added at the 0.3% (solids content) level.

The coatings were drawn onto standard aluminum test panels or plastic substrates using a wire-cator rod and equilibrated in air for ten minutes. Curing (baking) was carried out in a forced-air convection oven. The cure conditions were 30/120°C, unless otherwise noted.

To study the diffusion of light stabilizers in the clearcoat matrix while curing is in progress, a two-layer system was designed¹² as shown in Figure 1. Clearcoat #1 was drawn first onto the substrate and cured for 10 minutes at 120°C. Thereafter, clearcoat #2, which had the same composition as #1, was drawn on top of clearcoat #1. Both layers were baked for 30 min at 120°C. Stabilizers were added to either layer #1 or #2. During the final cure, these additives migrated into the adjacent layer and set up concentration gradients which could readily be observed using the techniques described.

After bake, 5 cm × 5 cm squares were cut from the aluminum test panels and the coatings lifted off the substrate using a sharp razor blade. The cut samples were mounted on the support block of a Reichert-Jung Polycut E microtome and sliced into 4 or 5 μm thick sections parallel to the coating surface using techniques discussed previously.^{11,13} Coatings on plastic substrates were not lifted off the plastic. They were microtomed together with the substrate to determine the depth distributions in both the coating and the substrate.

Three analytical methods were used to determine the stabilizer concentration in each microtomed slice: solvent extraction followed by gas chromatography (GC), UV spectroscopy, and infrared (IR) spectroscopy. The extraction procedure consisted of immersing section samples of known weight in a measured volume of toluene. The extraction time was four hours at 80°C. Control experiments proved that the extraction efficiency of this process was better than 96%. An aliquot of the extract was injected into a Hewlett Packard 5890-II gas chromatograph for GC analysis.

The UV absorbance spectra were taken using a Perkin-Elmer Lambda 2 spectrophotometer. Each microtomed slice was sandwiched between microscope slides and positioned in the spectrometer beam. Absorbance spectra were recorded

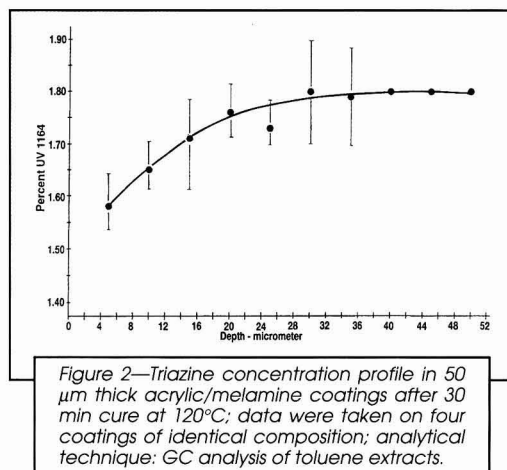
together with numerical values for absorbances at 400 and 340 nm. The solution spectra of the UV absorbers showed maxima at or close to 340 nm and no absorbance at 400 nm. Spectra of the absorbers in the coating samples matched the solution spectra down to approximately 330 nm where the absorbance of the glass slides became prominent. The glass slides themselves had some absorbance in the spectral region of interest as did the coating matrix. These effects were measured by scanning a sample, which did not contain UV absorber, and which was mounted between glass slides.

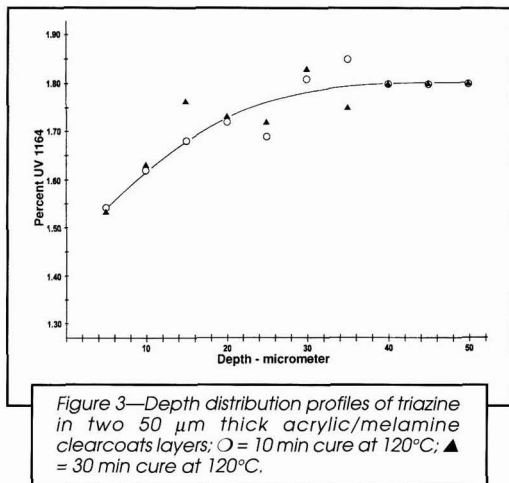
Infrared spectra were generated using a Perkin-Elmer PE 1500 Fourier transform IR spectrophotometer. Compared to UV analysis, IR measurements are more complicated and time consuming. The IR absorption bands of UV absorbing light stabilizers are considerably weaker than their UV bands at the concentrations used in automotive paints. In addition, the strong IR bands of the matrix resin mask the much weaker additive bands. For each IR sample scan, a scan of an identical matrix coating, not containing the additive, must be taken and this spectrum subtracted from the other to uncover the prominent additive bands. Infrared analysis, therefore, was mostly used for investigating the distribution profiles of HALS compounds which in general do not absorb in the UV region of interest.

RESULTS AND DISCUSSION

Loss of UV Absorbers During Cure

A typical depth distribution profile of a UV absorber in a cured single-layer acrylic/melamine coating, not subjected to exposure testing, is shown in Figure 2. The UV absorber was commercial 2-[4,6-bis(2,4-dimethylphenyl)-1,3,5-triazine-2-yl]-5-(octyloxy)phenol (Cyagard[®] UV 1164 UV absorber, Cytac Industries Inc.), hereafter referred to as triazine. The analytical method for this experiment was toluene extraction followed by GC. The data points represent measurements on four different coatings of identical composition. Each coating was 50 μm thick and was microtomed into 5 μm thick slices. The figure contains seven measured data points from 5 μm





through 35 μm . After cutting the 35 μm section, the microtome knife consistently lifted the remainder of the coating off the microtome support as a single 15 μm thick slice which was not analyzed. For this part of the coating the absorber concentration was assumed to be 1.8% which is valid considering that the GC values for the 30 μm and 35 μm sections were 1.8% and GC analysis of the uncured resin formulation also found 1.8% triazine.

The concentration profile of Figure 2 indicates that a small quantity of triazine escaped from the coating during cure. The average absorber concentration in the crosslinked resin was 1.74%. This translates into a total absorber loss of three percent under the given cure conditions. Three commercial benzotriazoles also were investigated. No significant differences in loss-on-cure behavior was found. The observed losses under identical cure conditions were in the 3-5% range. The benzotriazole losses tended to be near the upper end of this range.

The shape of the absorber depth profile in Figure 2 suggested that the loss mechanism consists of surface vaporization and diffusion to the surface. In-situ GC experiments were carried out to confirm that the absorbers actually vaporized during baking. For this purpose, coatings were drawn onto narrow steel strips and cured inside a GC injection port which was purged thoroughly with helium before the experiment. The column temperature was maintained at 20°C and no gas flowed at this point. At the completion of the cure, the sample strip was removed quickly from the injection port and the port rapidly heated to 300°C. The heating step was followed by a 30-min helium purge to sweep the vaporized UV absorber into the front end of the GC column which was still at 20°C to collect the sample. Thereafter, the column was heated to the operating temperature and the analysis carried out. The measured UV absorber concentrations in the gas phase translated into an approximately one percent loss of both triazine and benzotriazoles. This loss is smaller than the 3-5% determined from the depth concentration profiles and may have been caused by uncontrolled losses while the experiment was in progress. The important point, however, is that these experiments proved that UV ab-

sorber volatilization is a valid loss mechanism when coatings are cured.

The question arose in which time segment of the curing cycle did the bulk of the observed migration to the surface occur. To answer this question, coatings were prepared at different bake times without altering the bake temperature (120°C). The shortest time experimentally possible was 10 min. Less than 10 min resulted in coatings which were too soft for microtoming. The results of these experiments are summarized in Figure 3 which shows the depth distribution of the triazine in two samples cured 10 min and 30 min, respectively. It follows from the figure that the distribution profiles of both samples are identical suggesting that under the given experimental conditions most of the absorber migration took place within the first 10 min of cure. Insight into the underlying process could be gained if we knew the dependence of the absorber diffusivity on cure time for the system under investigation. This information is to our knowledge not available. However, a large body of applicable viscosity data has been published. The relationship between diffusivity D and viscosity η follows from the Nernst-Einstein equation¹⁴

$$D = \mu \cdot k \cdot T \quad (1)$$

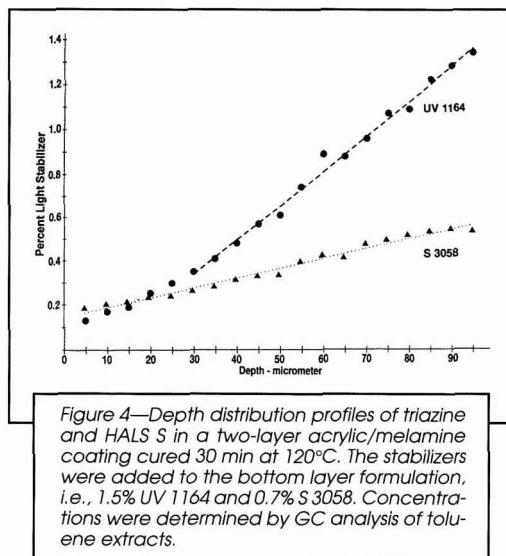
where μ is the absorber mobility, k is Boltzmann's constant and T is the absolute temperature. We also have

$$\mu = 1 / (\text{const.} \cdot \eta) \quad (2)$$

and, therefore,

$$D \sim 1/\eta \quad (3)$$

Detailed investigations of the dependence of the viscosity of acrylic/melamine resins on cure time have been carried out.^{15,16} For high-solids coatings, it was found¹⁵ that as the solvent evaporates in the first few minutes of heating, the solids level increases and, therefore, also the viscosity. At this stage the temperature does not yet increase appreciably. After



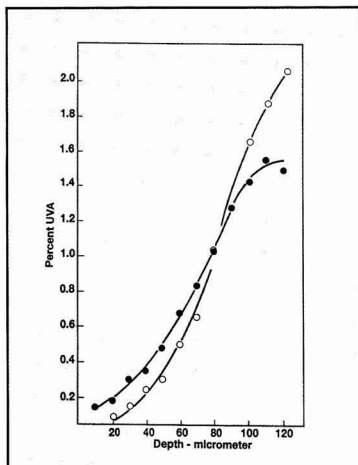


Figure 5—Depth distribution of triazine in two-layer acrylic/melamine coatings; ○—layer #1 cured 30 min; ●—layer #1 cured 10 min. Analytical technique: solvent extraction/GC. The interface between layers #1 and #2 is at 60 μm ; total coating thickness: 120 μm .

complete evaporation of the solvent and as the coating temperature rises toward the maximum bake temperature the viscosity temporarily decreases. When crosslinking commences, the viscosity rises again and becomes infinite at the gel point. Following equation (3), the diffusivity reduces to zero at the gel point. Since equation (3) is strictly valid for liquids only, we do not expect D to become zero but still to decrease by several orders of magnitude from the value it had before the coating was placed into the oven. As a consequence, the rate of additive migration drops precipitously.

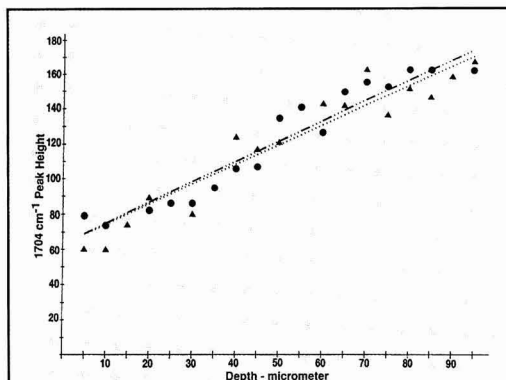


Figure 6—HALS S concentration versus depth in two-layer acrylic/melamine coatings cured at 120°C; ▲—60 min cure time; ●—30 min cure time. The stabilizer concentrations were determined by measuring the peak height of the 1704 cm^{-1} IR band.

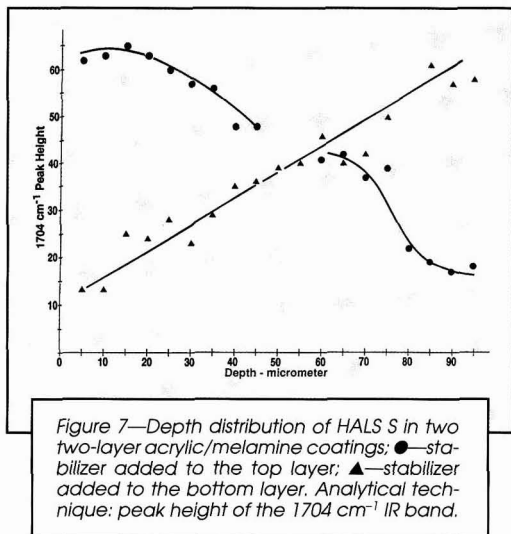
The previous discussion explains the feature displayed in Figure 3 that the stabilizer depth distribution profile is established within the first 10 min of cure. We assume that the gel point is reached within this time frame. The resulting drop in diffusivity drastically lowers the rate of migration and for the remaining 20 min the observable migration is negligible. Supporting evidence for this interpretation is given in references 15 and 16. Bauer and Briggs investigated the rheology of acrylic/melamine coatings from spray to cure. Their coatings were similar in composition to ours but did not contain light stabilizers. For high-solids coatings and high heat transfer rates, applicable to our experimental conditions, Bauer and Briggs found that the gel point is reached seven minutes after placing the coating into the oven. Similar results were reported by Nakamichi¹⁶ who also observed that in high-solids acrylic/melamine clearcoats the viscosity rises to infinity within the first seven minutes of baking at 120°C.

Stabilizer Migration During Cure

In earlier work,⁴ fast stabilizer migration between basecoat and clearcoat layers during cure was observed. To study the migration of stabilizers in clearcoats only, the double-layer configuration of Figure 1 was employed. Different distribution profiles developed depending on whether UV absorbers and/or HALS were added to layer #1 or layer #2. As an example, Figure 4 shows in a two-layer clearcoat the distribution of the triazine and 3-dodecyl-1-(1-acetyl,2,2,6,6-tetramethyl-4-piperidinyl)-pyrrolidin-2,5-dione (Sanduvor® S 3058, HALS compound sold by Sandoz) hereafter referred to as HALS S. Both stabilizers (1.5% UV 1164, 0.7% S 3058) were added to the resin of clearcoat #1. The additive concentration in each microtomed slice was determined by GC of toluene extracts. The data points can be well approximated by straight lines which in Figure 4 were obtained by linear regression analysis. Deviation from linearity occurred for the UV absorber near the surface indicating that in this case the rate of volatilization is the rate limiting step.⁸

The linear depth dependence of the stabilizer distribution shown in Figure 4 rules out that the migration from clearcoat #1 to clearcoat #2 followed Fick's law of diffusion. Fickian diffusion would lead to an error function distribution.^{17,18} This result is not unexpected considering that Fickian diffusion assumes constant diffusivity which, as we have seen, does not apply to thermosetting reactions.

Figure 4 shows that stabilizers migrated out of layer #1 into layer #2 in substantial concentrations. Some even reached the surface of layer #2. This seems to be surprising because we saw previously that the initial 10-min cure of layer #1 brought the resin beyond the gel point. The stabilizer diffusivity in this layer then should be so low that few stabilizer molecules would have the opportunity to migrate into #2. The explanation for this apparent contradiction is given by the rule that a crosslinked polymer will swell in a liquid if the polymer is soluble in this liquid before crosslinking.¹⁹ Applied to two-layer clearcoats, we can expect that after draw-down of the layer #2 resin, the resin solvent (xylene/butanol) diffused into the partially cured layer #1 and caused swelling. The degree of swelling depends on the crosslink density.^{20,21} Swelling decreases as the crosslink density increases which suggests that the slightly crosslinked layer #1 underwent a significant degree of swelling. The resulting change in viscosity is expected



to have raised D to levels enabling stabilizer migration into layer #2.

From published data on the velocity of the penetrant front of solvents in polymers,²² we can estimate how far the solvents are likely to move into layer #1 under our experimental conditions. For cyclohexane transport at 30°C in low-crosslink-density polystyrene, velocities of about 5 $\mu\text{m}/\text{min}$ were reported.²² In our experiments, a 10 min equilibration time was used between the draw-down of the resin layer and the beginning of the oven cure. Assuming similar solvent velocities as for polystyrene, we conclude that the solvent completely penetrated the 50 μm -thick layer #1 before the beginning of cure. This conclusion is also confirmed by the linear distribution profiles of Figure 4. The linearity is preserved up to the substrate.

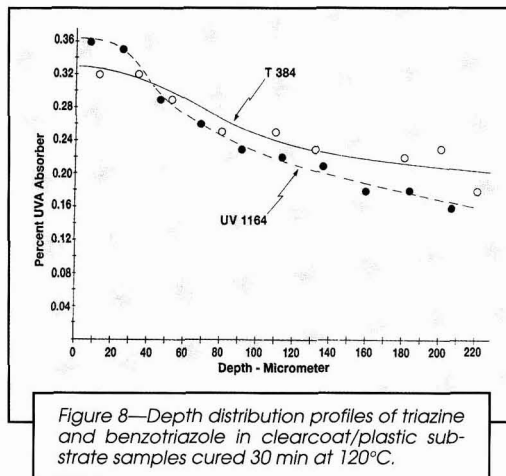
The influence of matrix swelling on stabilizer migration was investigated further by increasing the initial length of cure of layer #1. Longer cure times raise the crosslink density and lower the degree of swelling,²⁰ and, therefore, reduce the stabilizer diffusivity D in layer #1. As a consequence, layer #1 should retain more stabilizers; fewer stabilizer molecules will be able to migrate into the top layer #2. The results of these experiments are displayed in Figure 5 which shows the depth distribution profile of the triazine in two two-layer samples. In one sample the bottom layer received the standard initial cure of 10 min while in the second sample the initial cure time was increased to 30 min. As expected, the profiles unambiguously show that more absorber remains in the bottom layer that has been initially cured for 30 min than in the layer cured only for ten min. Still, even a 30-min cure allows swelling and the concomitant migration of additives.

Figure 5 has another noteworthy feature wherein the distribution profiles near the substrate/coating interface deviate from linearity. This effect is caused by the particular substrate used for these preparations. For all previous experiments, aluminum substrates were used. The coatings shown in Figure

5 were deposited on E-coated steel panels. Analysis of the E-coats revealed the presence of absorber confirming the well-known tendency of stabilizers to migrate into E-coats. This migration accounts for the observed curvature of the triazine depth profile.

Another confirmation of the swelling effect was indicated by our inability to microtome two-layer coatings whose second cure was carried out for 10 min only. While single-layer coatings were sufficiently crosslinked within 10 min to be microtomed, the degree of crosslinking of the top layer in the two-layer samples was lower after the same time of cure. The additional solvent from layer #1, as well as the reaction by-products isobutanol/methanol,²³ had to migrate back through layer #2 before leaving the sample and, therefore, retarded the crosslinking process. However, no further observable changes of the stabilizer distribution took place after 30 min cure. This can be concluded from the distribution of HALS in the two samples of Figure 6. One sample was cured 30'/120°C and the second one 60'/120°C. The data of Figure 6 were obtained by IR spectroscopy using the prominent 1704 cm⁻¹ band of the HALS, ratioed against the 1730 cm⁻¹ carbonyl band of the acrylic backbone.

The depth profile of HALS, added to the top layer of a two-layer coating, is plotted in Figure 7 together with an example of the stabilizer added to the bottom layer. The striking difference between the two profiles is that the depth distribution of the HALS deviates strongly from linearity when HALS is added to layer #2. The observed non-linearity is caused by two effects. The curvature of the distribution curve near the surface of layer #2 is due to the surface losses of HALS and migration to the surface as indicated in Figures 2 and 3 and discussed earlier. The non-linear distribution in layer #1 can be explained by the out-migration of the solvent which penetrated layer #1 from layer #2 before the final cure. As long as solvent remained in layer #1 stabilizer could diffuse into this layer. During the final cure, the penetrant solvent migrated to the coating surface and depleted layer #1 thereby reducing the HALS migration from layer #2 into layer #1. HALS migration ceased first into the area near the substrate. It continued migrating into the area closer to the layer #1/#2 interface until this area became also free of solvent.



Stabilizer Migration into Plastic Substrates

Most plastic substrates used in the automotive industry are amorphous polymers. As in coatings, the free volume existing in these plastics should give rise to migration of additives. Of particular interest is the question of what happens to stabilizers added to coatings on plastic substrates. From what we have seen thus far, we would expect to observe migration into the substrates. This is indeed the case.

Figure 8 shows the depth distribution of two UV absorbers in a clearcoat/substrate combination. The substrate was reaction injection molded DOW Spectrim® 50 and had a thickness of 1/8 inch. It was coated with the standard 50 μm thick clearcoat and cured 30°/120°C. The UV absorbers were the triazine and the benzotriazole Tinuvin 384 (Ciba-Geigy). The figure demonstrates that a significant amount of the stabilizers migrated from the coating into the substrate. Extrapolation of the curves reveals that the stabilizers migrated a distance L of between 300 μm and 500 μm into the plastic. From the distance of migration into the substrate and the migration time t we estimate D using the relation²⁴

$$D = L^2/6t \quad (4)$$

Although equation (4) is strictly valid only when a steady state is approached, it is applicable to our conditions if we are satisfied with an order of magnitude estimate of D . Using our experimental parameters, the estimated diffusion constants are in the 10^{-7} – 10^{-8} cm^2/s range. This range, although high, is not unreasonable. It is in general agreement with diffusivities in polyethylene and polypropylene published for HALS compounds of similar molecular weight.²⁵ The differences between the curves of the triazine and the benzotriazole give evidence that the benzotriazole has a higher diffusivity/solubility in the given plastic and coating than the triazine.

SUMMARY

The rate of stabilizer migration in clearcoats during cure is to a large degree determined by the viscosity of the thermosetting resin. While fast migration occurs in the early stages of cure, when the resin viscosity is low, the stabilizer diffusivity slows down by several orders of magnitude as crosslinking proceeds and the resin viscosity approaches infinity. Much longer observation periods than typical cure times are required for detecting migration effects in highly crosslinked coatings.

In two-layer coatings, swelling effects play an important role in stabilizer migration. Solvents from an adjacent layer can penetrate a partially crosslinked layer. The ensuing swelling increases the stabilizer diffusivity and facilitates migration.

When coatings are deposited onto plastic substrates, stabilizers migrate rapidly from the coating into the substrate during cure. The resulting losses from the coating are significantly higher than losses caused by vaporization at the surface.

ACKNOWLEDGMENTS

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Characterization and Rheological Investigation of Polymer Microgels Used in Automotive Coatings

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INTRODUCTION

The rheological behavior of a coating film is an important consideration in the final coating formulation, particularly with high-solids solvent-borne automotive coatings. The viscosity of the coating must be low enough to promote atomization during application, and once on the part, the viscosity must increase to prevent sagging of the film. High-solids coatings formulations were initially based on lower-solids solvent-borne coatings formulations. In order to increase the total solids of the coatings (and reduce the amount of organic solvent in the coating in response to EPA requirements), the polymer resin was modified by decreasing its molecular weight. Lowering the molecular weight of the resin reduces the viscosity and therefore less solvent is required to reduce the coating to application viscosity. As a result, these coatings have a greater tendency to sag in the bake oven than do low-solids coatings.¹⁻⁴

To prevent sagging in high-solids coatings where there is little solvent evaporation, the coating must be either pseudoplastic (the viscosity must decrease with increasing shear rate) or have a yield stress.^{5,6} Other works have demonstrated, and our work has confirmed, that the addition of polymeric microparticles, or "microgels," induces a yield stress and shear thinning behavior in a polymer solution with Newtonian rheological behavior.^{1,7} Microgels, formed by emulsion polymerization, find application not only as rheology control agents in solvent-borne and waterborne coatings, but also in adhesives, cosmetics, biochemicals, and pharmaceuticals.^{8,9} Polymer microgels are a particularly good choice for a "rheology control agent" in high-solids coatings because they do not significantly increase the high shear viscosity of the coating,¹⁰ which is critical to achieve sufficient atomization during spray application.

While polymer microgels have been used to modify the rheological behavior of high-solids coatings, the relationship between the nature of the microparticle interactions and the resulting rheological behavior is not well understood. Bauer et al.¹ evaluated the viscosity as a function of shear rate for increasing concentrations of one type of microgel dispersed in

The mechanism by which polymer microgels impart shear-thinning behavior and a yield stress to the Newtonian, low molecular weight resin of high-solids solvent-borne automotive coatings is not well understood. Toward identifying this mechanism, we measured the viscosity of several microgel dispersions as a function of particle volume fraction as well as the size and polydispersity of the particles. Variations in the relative "softness" of the particles, due to differences in the steric layer thickness or crosslink density of the particles, gave rise to differences in the viscometry behavior. When dispersed in acrylic polymer solutions, the microgels induced a yield stress that displayed a power-law dependence on particle concentration. Dynamic oscillatory measurements were used to investigate the nature of the structure formed by the microgels. The mechanism of structure formation can be attributed to depletion flocculation when the polymer does not adsorb to the microgels and to bridging flocculation when the polymer does adsorb.

10 different acrylic polymer solutions. The apparent yield value of these dispersions was a strong function of particle concentration and was proportional to the polymer solution viscosity. In addition, the yield value was independent of polymer and solvent composition (for sufficiently polar polymers) and polymer molecular weight. Ishikura et al.⁹ studied the effect of microgel properties such as crosslink density and swelling on the yield value of the coating film. Their work showed that microgels with larger swelling ratios (lowest crosslink density) induced a yield stress at lower concentrations than do microgels with smaller swelling ratios; this is

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Table 1—SEM Characterization of the Microgels

Microgel Dispersion	Particle Diameter ^a	Poly-Dispersity ^b	Volume Fraction ^c	Primary Solvent
1	107 ± 19 nm	1.030	0.394	Heptane
2	204 ± 20 nm	1.010	0.287	Xylene
3	280 ± 37 nm	1.018	0.393	Heptane
4	321 ± 91 nm	1.080	0.378	Xylene

(a) Number average diameter and standard deviation. $\bar{x} \pm s$, determined from SEM.
 (b) Weight average diameter divided by the number average diameter.
 (c) Determined experimentally (see text).

due to the larger effective volume occupied by the less densely crosslinked particles. Wolfe and Scopazzi¹¹ have shown that the flow behavior of a microgel dispersion can resemble that of either a colloidal dispersion or a polymer solution, depending on the crosslink density of the particles. However, none of these studies addressed either the time-dependent formation of the structure responsible for the yield value or the role of the microgel-polymer interactions in structure formation.

The objective of our work was to understand which physical and chemical variables of the microgel and the polymer solution most affect rheological behavior, and how those variables influence the microgel-polymer interactions that control final film performance. This paper describes the physical characterization of four different polymer microgels, including the average particle size and relative softness, or crosslink density, and addresses how these physical characteristics affect the rheological properties of the microgels dispersed both in solvent alone and in acrylic polymer solutions. We estimated the yield stress as a function of microgel concentration in the polymer solutions by determining the Casson yield value from steady-shear viscometry data. Dynamic oscillatory rheological measurements were used to monitor the storage modulus G' and the tangent of the phase angle, $\tan \delta$, as a function of time for dispersions of each of the microgels in acrylic polymer solution. These structure formation studies, not addressed in previous work with microgels, allowed us to investigate the mechanism responsible for the formation of the yield stress in high-solids coatings containing microgels.

This work demonstrates the usefulness of rheological measurements, particularly dynamic oscillatory measurements, in understanding the interactions in complex dispersions like paints and coatings. This work will lead to the ability to better design rheology control agents, which will result in the more efficient formulation of coatings.

EXPERIMENTAL

Materials

Samples of commercial microgels used in high-solids automotive coatings were supplied by PPG Industries, Inc., E.I. DuPont de Nemours & Co., Inc., BASF Corp., and Rhône-Poulenc Inc. The samples were received as dispersions of microgels in blends of organic solvents. A total of eight microgel samples were evaluated; this work focuses on four of the samples (referred to as microgels 1, 2, 3, and 4). These four samples were chosen because their particles displayed extreme characteristics in terms of particle size, polydispersity, steric layer thickness, or crosslink density.

Table 1 lists the actual volume fraction ϕ of the solid portion of the microgel dispersions. These values were determined based on the weight fraction (determined gravimetrically) of the samples using the density of the dried solid of the dispersion (measured using ASTM method D 792), and the density of the supernatant (ASTM D 1475). Also listed in Table 1 is the primary solvent (either the solvent present in the greatest volume or the solvent in which the microgel was most easily dispersed) for each of the microgels. The primary solvent for each microgel dispersion was used to dilute the dispersion to lower particle volume fractions for SEM observation and for viscometry measurements. Xylene and heptane were purchased from Mallinckrodt, and methyl amyl ketone (MAK), which was used to adjust the total solid percent in dispersions of microgels in acrylic resin, was donated by Chemcentral. All solvents were used as supplied.

Two acrylic resins were used to investigate the effect of microgels on the rheological properties of acrylic polymer solutions. A low molecular weight resin typical of that used in high-solids solvent-borne coatings¹² was prepared by Dr. Frank Jones of the Coatings Research Center at Eastern Michigan University. The number average molecular weight of this resin was 4,100 ($M_w/M_n=2.5$), the hydroxyl number was 151 (solids mg/g), and the resin was 61.5% solid by weight in MAK. This "EMU resin" was used to evaluate microgels 1, 3, and 4. Since microgel 2 was not compatible with the EMU resin, Poly-Tex 9008, a commercially available acrylic resin donated by Rhône-Poulenc, was used for this microgel sample. The number-average molecular weight of Poly-Tex 9008 was in the range of 10,000-20,000, the hydroxyl number was 86.3 (solids mg/g), and the resin was 65% solid by weight in methyl propyl ketone.

Scanning Electron Microscopy (SEM)

Low voltage scanning electron microscopy (SEM) (Hitachi S-800 Scanning Electron Microscope with a cold field emission electron gun) was used to measure the microgel size and polydispersity. The particles were prepared for observation by diluting each of the microgel dispersions in their primary solvents. Several drops of this dilute dispersion were placed on a 1.5 cm² square of aluminum flashing and allowed to dry in air. The samples were then sputter coated with a layer of gold/palladium (~2 nm) to reduce charging and were observed at 3 kV with a 5 mm working distance.

Viscometry

Viscometry was used to determine whether the microgels exhibit hard-sphere or linear-polymer behavior over a range of particle concentrations. For each microgel dispersion diluted with its primary solvent, the viscosity was measured as a function of microgel volume fraction. The concentrations of the dispersions ranged from 0-100% microgel dispersion, with the balance being the primary solvent; as a result, the high-volume-fraction limit was the concentration of the dispersion as received from the manufacturer.

The technique used to measure the viscosity depended on whether the volume fraction of the microgel/solvent dispersion was high (greater than 50% microgel dispersion by volume) or low (less than 50%). The viscosities of the high-volume-fraction dispersions were measured using a Bohlin VOR rheometer with concentric cylinder geometry. The vis-

Figure 1—SEM micrographs of (a) microgel 1; (b) microgel 2; (c) microgel 3; and (d) microgel 4. Magnifications are indicated on the micrographs.

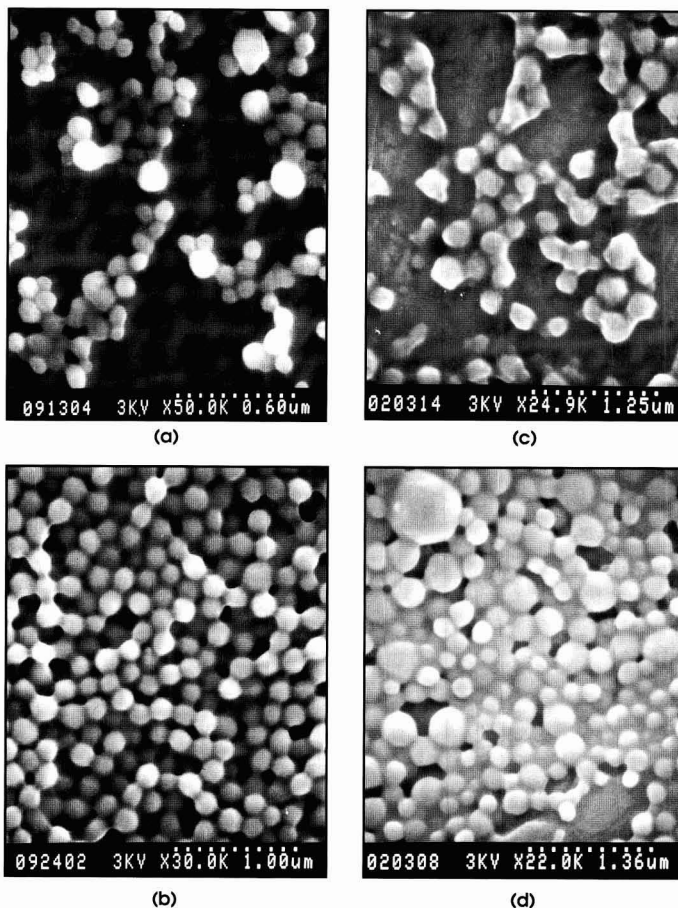
cosity as a function of shear rate ($\dot{\gamma}$) was measured using a C25 cup and bob (inner cylinder diameter 25 mm, outer cylinder diameter 27.5 mm, and bob height 37.5 mm).

The viscosities of the low-volume-fraction microgel dispersions were measured in a Cannon-Fenske capillary viscometer immersed in a constant temperature water bath (25°C). It was necessary to use a capillary viscometer to measure the viscosities of the dilute dispersions since the VOR rotational viscometer is not sensitive enough to measure very low viscosities accurately. Note that these dispersions exhibit Newtonian flow behavior (viscosity independent of shear rate) over the shear rate range studied.

A capillary viscometer was also used to measure the viscosities of the dispersing media that were obtained by centrifugation of the diluted microgel dispersions. The viscosity of the dispersing media was then used to calculate the relative viscosity (η_r), which is defined as the viscosity of the microgel/solvent dispersion (η) relative to the viscosity of the dispersing media (η_0). For the low-volume-fraction dispersions which displayed Newtonian flow behavior, the viscosity obtained from capillary viscometry was used to calculate η_r ; for the high-volume-fraction dispersions which exhibited shear thinning behavior, the high-shear limiting viscosity (η_∞) was used to calculate η_r .

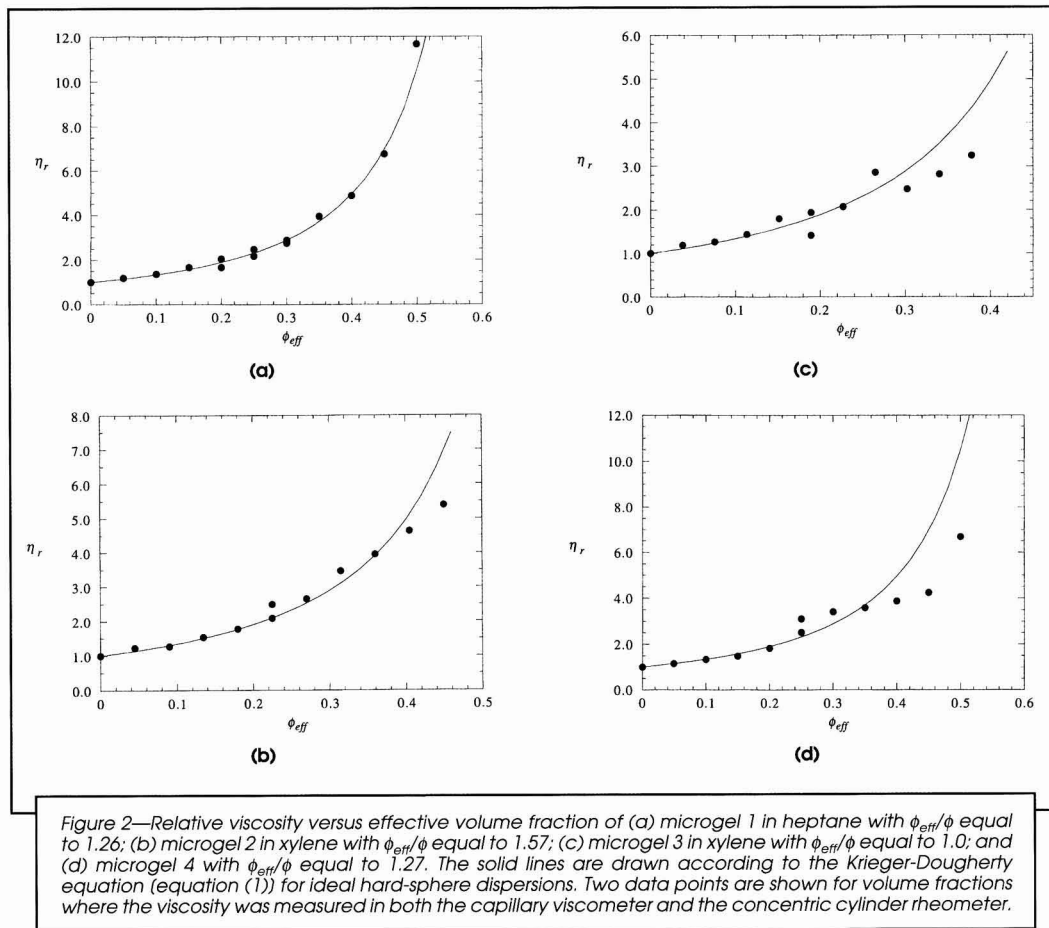
To quantify how the microgels affect the rheological behavior of high-solids coatings, the microgel dispersions were blended with either the EMU or Poly-Tex acrylic resins. These simplified "coatings" contain the two major components that affect rheological behavior in coatings—the rheology control agent and the polymer resin—and were used to gain information about the mechanism of rheology control that can be extended to actual coating systems. Apparent yield stresses of the dispersions were estimated from steady-shear measurements. The time-dependent structure formation in the dispersions was quantified using dynamic oscillatory measurements to monitor the increase in the storage modulus G' with time. The Bohlin VOR rheometer was used for both the steady-shear and dynamic oscillatory measurements.

The steady-shear measurements were conducted using the C25 cup and bob. The dispersions for these measurements were prepared by slowly stirring the microgel dispersion with the resin and solvent. The samples were then poured into the



cup, and the bob was lowered into place. A solvent trap was used to prevent solvent evaporation. The samples were presheared for 30 sec at the shear rate of 18.6 s^{-1} , and the materials that exhibited a yield stress were allowed to rest for 30 min prior to testing. This rest time was determined to be sufficient such that the viscosity versus shear rate curves were reproducible.

Dynamic oscillatory measurements were conducted using a C25HS high shear cup and bob (inner cylinder diameter 25 mm, outer cylinder diameter 26.5 mm, and bob height 37.5 mm). This geometry was chosen for the oscillatory measurements because the narrow gap of 1.5 mm intensifies the signal for weakly elastic samples like the microgel/resin dispersions. The dispersions for these measurements were prepared with a constant 15% by weight microgel solids based on the total solid weight of microgel and acrylic polymer. Samples were tested both immediately after sample preparation and after the samples had equilibrated for 24 hr at 25°C. These "initial" and "24 hr" samples were evaluated to determine if the characteristics of the structure formation changed due to the possible adsorption of the acrylic polymer onto the microgels. After the dispersions were loaded into the sample cup, they



were presheared for 30 sec at a shear rate of 7.42 s^{-1} . Measurements of the storage modulus and phase angle were taken at an oscillation frequency of 1 Hz at the maximum amplitude within the linear viscoelastic region for a period of 5,000 sec. This amplitude was measured for each sample by performing a strain sweep at 1 Hz to determine the maximum strain at which G' remained constant.

RESULTS AND DISCUSSION

Microgels

Electron micrographs of the microgels are shown in Figures 1a-d; note that while the particles all appear to be approximately the same size, the magnification of the micrographs is not the same for each microgel dispersion. In general, the microgels were spherical with polydispersity varying among the samples. While surface morphology could not be resolved with this technique, indications of the relative softness, or crosslink density, of the particles were observed when softer

particles were distorted slightly due to drying prior to the SEM evaluation. The average particle diameter, standard deviation, and polydispersity index for each microgel sample are reported in Table 2; these values were determined by measuring the diameters of 100 particles from each micrograph. All of the particles are submicron in size, with the average diameter ranging from 107 nm (microgel 1) to 321 nm (microgel 4).

The particles of microgel 1, shown in Figure 1a, are the smallest of the microgels studied and appear to be the most spherical of the dry microgels. Microgel 2 (Figure 1b) is the most monodisperse of the samples with visible evidence of softness in the form of a connecting film between the particles that was not removed with repeated washing of the dispersion. The particles of microgel 3 (Figure 1c) appear irregularly shaped in the micrograph. This is due to these particles being less densely crosslinked than the other particles, and they consequently swell to a greater degree when dispersed in solvent; as these swollen particles dry during preparation for SEM analysis, their shape is distorted. Microgel 4, shown in Figure 1d, is the most polydisperse of the samples, with particle diameters ranging from 100-800 nm.

To determine whether the dispersed microgels exhibit hard-sphere or linear-polymer behavior, the relative viscosity of each microgel dispersion (excluding resin) was determined as a function of particle volume fraction and compared to that expected for non-interacting hard spheres (Figures 2a-d). Samples with less than 70% microgel dispersion by volume ($\phi < 0.28$) exhibited Newtonian flow behavior; as the concentration of particles was increased further, the dispersions showed slight shear-thinning behavior characteristics of concentrated hard-sphere dispersions. The solid lines shown in Figures 2a-d are the predictions of the Krieger-Dougherty relationship¹³ which describes the dependence of the relative viscosity on the particle volume fraction for non-interacting, hard-sphere dispersions:

$$\eta_r = \frac{\eta}{\eta_0} = \left(1 - \frac{\phi}{\phi_c}\right)^{-k\phi_c} \quad (1)$$

For such dispersions, the maximum packing fraction ϕ_c is 0.71 and the exponent $k\phi_c$ is 1.93 where $\eta = \eta_\infty$ (the high-shear limit).¹⁴

In Figures 2a-d the relative viscosity is shown as a function of the effective volume fraction ϕ_{eff} . This volume fraction accounts for any swelling of the particle or extension of a steric (polymeric) layer that increases the effective particle diameter above the "core" diameter determined from SEM. The ϕ_{eff} is determined by fitting the relative viscosity data to equation (1), increasing the volume fraction ϕ by a constant fraction as necessary.¹⁴⁻¹⁸ This constant fraction represents the increase in the particle size above that based on the SEM analysis. Assuming that the microgels are composed of a hard core particle that does not swell and a softer steric layer that extends into the solvent, then the thickness of the steric layer d can be estimated as follows:¹⁹

$$d = a \left(\sqrt[3]{\phi_{\text{eff}} / \phi} - 1 \right) \quad (2)$$

where a is the average core radius determined from the electron micrographs and ϕ is the particle volume fraction based on this radius.

As shown in Figure 2a, the dependence of the viscosity of the microgel 1 dispersions on particle volume fraction is described very well by the Krieger-Dougherty relationship and thus exhibits ideal hard-sphere behavior as defined by this relationship. Using equation (1), ϕ_{eff}/ϕ is estimated to be 1.26. Assuming that this increase in volume fraction is due solely to a steric layer that extends outward from the particle surface, equation (2) yields an estimate of 4.4 nm for the steric layer thickness d giving a total particle diameter of 116 nm (core diameter = 1.07 nm). This increase in effective particle size of approximately eight percent is not sufficient to cause deviations from hard-sphere rheological behavior.

None of the other microgel dispersions exhibited "ideal" hard-sphere behavior, especially at higher volume fractions where particle-particle interactions can strongly influence the rheological behavior (Figures 2b-d). Specifically, the predicted relative viscosities are larger than those measured. These deviations from hard-sphere behavior are caused by "softness" of the microgels (due to a steric layer and/or swelling of the particles) that allows a maximum packing fraction greater than that for randomly packed hard spheres.¹⁹

The viscosity-particle volume fraction data for the microgel 2 dispersions are shown in Figure 2b. Using the viscometry data at lower volume fractions that was well described by the Krieger-Dougherty relationship, ϕ_{eff}/ϕ is estimated to be 1.57. This increase in particle size yields an estimate of 16.3 nm for d using equation (2), giving a total diameter of 235 nm (core diameter = 202 nm) or an increase in size of approximately 16%. The larger steric layer (or increased softness) of microgel 2 gave rise to the deviations from hard-sphere rheological behavior for $\phi_{\text{eff}} \geq 0.40$. Evidence of this larger steric layer was visible in the electron micrographs as a film connecting the particles that was not removed with repeated washing of the particles.

Mewis et al.²⁰ studied deviations from hard-sphere rheological behavior as a function of the ratio of the particle radius to the steric layer thickness, a/d . Hard-sphere behavior was observed for $a/d > 30$ while deviations from hard-sphere behavior were observed when $a/d = 5$; they concluded that the transition from hard-sphere to soft-sphere behavior will occur for a/d ratios between 5 and 30. Studying a similar system, Reynolds and Reid²¹ have found hard-sphere behavior at $a/d = 10$. Comparing these results to our systems, microgel 1 is characterized by $a/d \approx 12$ and microgel 2 by $a/d \approx 6$. That we observe deviations from hard-sphere behavior with microgel 2 but not with microgel 1 is consistent with these other studies.

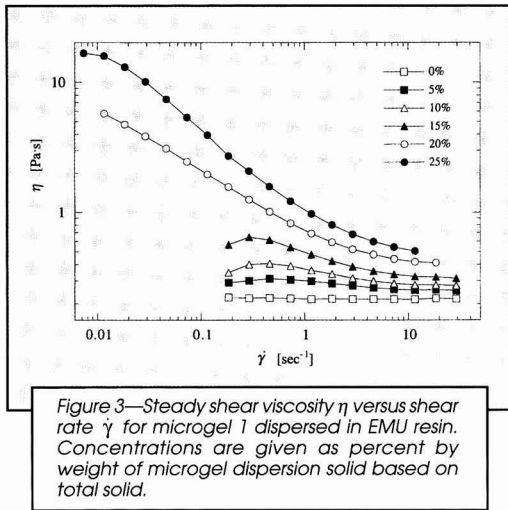
The deviation from hard-sphere behavior was more pronounced with microgels 3 (Figure 2c) and 4 (Figure 2d), which made the determination of ϕ_{eff} difficult. For microgel 3, this deviation was due to the greater relative softness of the particles that swelled in the solvent, resulting in the distortion of the dried particles as seen in Figure 1c. For microgel 4, the deviation from hard-sphere behavior was likely caused by two factors: softness of the particles and polydispersity in the particle size, both of which increase the maximum packing fraction above that for monodisperse hard spheres ($\phi_c = 0.71$). Both microgel dispersions exhibited deviations from hard-sphere behavior for ϕ_{eff} greater than approximately 0.30 to 0.35.

In summary, the microgels vary in size, polydispersity, and relative "softness." Dispersions of microgel 1 display hard-

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sphere rheological behavior [as defined by equation (1)], while dispersions of microgels 2, 3, and 4 show deviations at varying effective volume fractions. As a first attempt, we have consequently modeled the rheological behavior of the microgel dispersions using particles comprised of a hard core and a soft, short steric layer (instead of a linear polymer solution), as will be reported in a future publication.

Yield Value Measurements

Several researchers have reported that the addition of microgels to a low-molecular-weight Newtonian acrylic resin induces a yield stress and shear-thinning behavior in the resin.^{1,7} To understand how microgels affect these rheological changes, we measured the viscosity as a function of shear rate ($\dot{\gamma}$) of microgels 1, 3, and 4* dispersed in the “EMU resin,” which is typical of the polymer solutions used in high-solids automotive topcoats. Microgel concentrations ranged from 0-25% (percent by weight of the total solid) with the total solid concentration held constant for each microgel dispersion tested as follows: microgel 1, 58.0%; microgel 3, 55.5%, and microgel 4, 64.1%. For a 25% sample, for example, the volume fraction ϕ of the particles is approximately 0.12 (for a microgel of average density) and the resin solid volume fraction is 0.34.

Shown in Figure 3 are the viscometry results for microgel 1. The pure resin (0% microgel concentration) exhibited Newtonian flow behavior over the shear rate range tested. As the microgel concentration was increased, the viscosity at low shear rates increased and the dispersions became more shear thinning. Note, however, that the addition of microgels to the resin did not significantly increase the high-shear viscosity of the resin. This behavior is important for automotive topcoats where low viscosities are required for spray application, while the viscosity of the resulting film on the part must increase significantly to prevent sagging in the bake oven. Similar viscosity-shear rate behavior was noted for dispersions of microgels 3 and 4.

*Microgel 2 did not disperse in the EMU resin, probably because the surface of this microgel is significantly less polar than the resin.

The Casson equation²² was used to estimate the yield value of each of the dispersions. This constitutive equation was originally developed to model the flow of pigment-oil suspensions, and it represents the viscometry data of the microgel dispersions in the shear-thinning region very well.

$$\sigma^{1/2} = \sigma_c^{1/2} + (\eta_c \dot{\gamma})^{1/2} \quad (3)$$

σ_c is the Casson yield value and η_c is the Casson viscosity. Note that the Casson yield value is not a true yield “stress,” and instead should be viewed as a fit parameter whose magnitude provides information about the relative “strength” of the structure formed in the solutions. (Indeed, even the existence of a true stress is questionable.^{23,24}) A plot of the Casson yield value versus microgel concentration is shown in Figure 4 for microgels 1, 3, and 4. Two distinct regions are apparent. At low microgel concentrations (<10%), the Casson yield value increases slowly with increasing particle concentration. At particle concentrations greater than 10%, the Casson yield value increases at a faster rate with concentration. These results suggest that a critical volume fraction exists above which the structure formed by the microgels extends, or percolates, throughout the entire volume, leading to a greater rate of increase in the Casson yield value with concentration. Such behavior is analogous to the change in slope seen in the zero shear viscosity-molecular weight curves for polymer melts upon entanglement.²⁵

One way to conceptualize the relationship between the microgel concentration and the resulting structure is to represent the particles in three-dimensional space, as shown in Figure 5. These “snapshots” depict the random placement of non-interacting particles in a representative microgel dispersion (particle diameter of 200 nm, total solid concentration of 54% by weight) at five different particle concentrations. As shown in Figure 5a, at a concentration of five percent the particles are either in a singlet state or are clustered in small, non-interacting groups. At a concentration of 10% (Figure 5b) the particle clusters are larger, yet still isolated. Beginning at a concentration of 15% (Figure 5c), however, the particles (or groups of particles) are no longer isolated but appear to form a network that extends throughout the entire volume. The number of particle-particle contacts increase at concen-

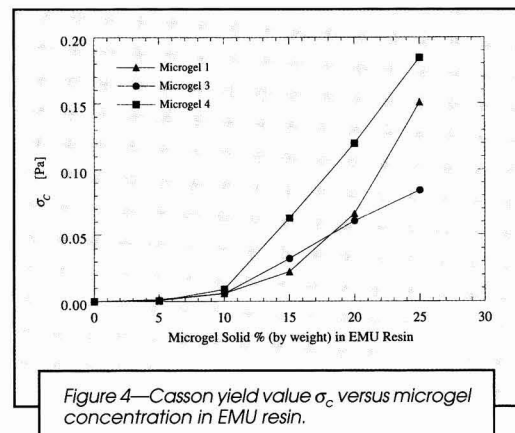


Figure 5—Representations of 200 nm diameter microgels dispersed in acrylic resin and randomly placed in three-dimensional space, corresponding to microgel concentrations of (a) 5%, (b) 10%, (c) 15%, (d) 20%, and (e) 25%. The total solid concentration is 54%.

trations of 20 and 25% (Figures 5d and e), having the effect of strengthening the existing microgel network. The formation of a network within the volume between a concentration of 10 and 15% corresponds to the change in slope noted in the Casson yield value curves in the same concentration range. Attractions between the particles would reduce the concentration at which the structure percolates through the volume.

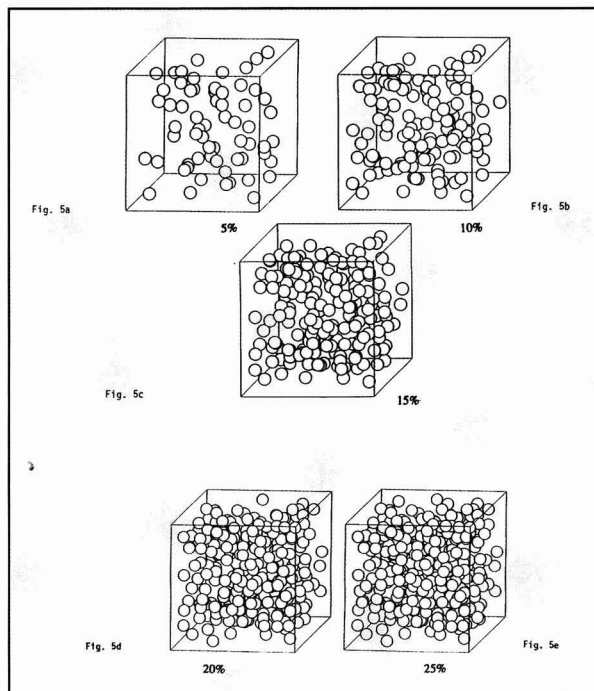
The existence of a critical volume fraction for network formation is supported by the data shown in Figure 6. In this figure, the Casson yield value as a function of total solids concentration is shown in microgel 3 dispersed in the EMU resin. The Casson yield value was calculated from viscometry data for 0 to 20% weight percent microgel at total solids percentages of 47.0, 51.2, and 56.4%. At a microgel concentration of 20 wt%, for example, these solid percentages correspond to microgel volume fractions, ϕ , of 0.080, 0.088, and 0.099. As expected, the Casson yield value increases with increasing total solids concentration. For the lowest solids concentration of 47%, however, the larger increase in Casson yield value with microgel particle concentration for concentrations greater than 10% was not observed. This suggests that the particles do not form a network structure that extends throughout the entire volume at this concentration.

Bauer et al.¹ have found that the yield stress can be related to the microgel concentration by the following relationship:

$$\frac{\text{yield stress}}{\eta_{\text{sol}}} = A \cdot [\text{microgel}]^{3.1 \pm 0.3} \quad (4)$$

where η_{sol} is the viscosity of the acrylic polymer solution, A is a constant that depends on the solution polymer (resin) polarity and the structure of the microgel, and $[\text{microgel}]$ is the weight percent of microgel based on the weight of the total solution. Equation (4) was derived for one type of microgel dispersed in 10 different acrylic copolymer solutions. The constant A was found to vary with the hydroxy functionality of the acrylic resin, and was independent of polymer molecular weight, composition, and solvent when the copolymer contained at least 20% hydroxy functional co-monomer.

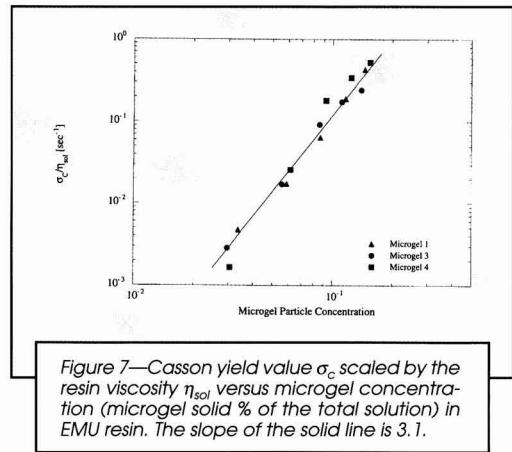
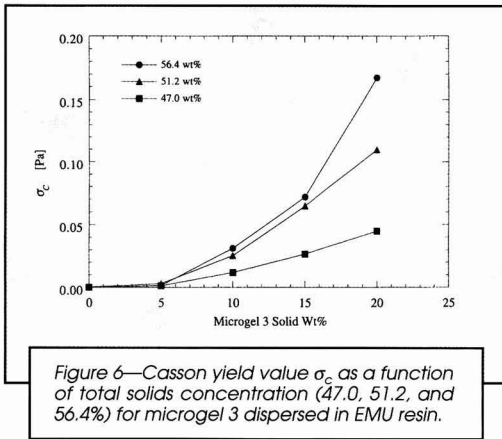
We have compared our data for Casson yield value (scaled by resin viscosity) as a function of microgel concentration to equation (4). As shown in Figure 7, this relationship between yield stress and microgel concentration also describes the rheological behavior of microgels 1, 3, and 4 in the EMU resin; the data are best fit by a straight line with a slope of 3.1 and A equal to 150 sec^{-1} . Note that while equation (4) was derived for one microgel dispersed in 10 different acrylic resins, our data for three different microgels each dispersed in the same acrylic resin exhibit the same third-power depen-



dence of the Casson yield value on concentration independent of the chemistry of the microgel. Others have found similar power-law relationships between the yield stress and particle concentration with the power-law index ranging from 2.5 to 4.4.²⁶ The work of Buscall et al.²⁷ suggests that the yield stress σ_y should scale with particle volume fraction and particle radius as $\sigma_y \approx \phi^\alpha a^\beta$ with $\alpha \approx 3$ and $\beta \approx -2$. While our data does not suggest a particle size dependence for the Casson yield value, such a dependence may exist but not be evident with our data since the microgels were somewhat polydisperse and all in approximately the same size range.

Structure Formation Measurements

The time required for the structure to form in automotive coatings is an important parameter since the structure must be sufficiently formed during the flash time (prior to when the part enters the bake oven) to prevent sagging of the coating film at the elevated temperatures. To monitor the formation of structure in our simplified coatings, we measured the storage (elastic) modulus G' and the tangent of the phase angle, $\tan \delta$, as a function of time using dynamic oscillatory measurements within the linear viscoelastic region. $\tan \delta$ is equal to the ratio of the loss modulus to the storage modulus, G''/G' , and thus provides a relative measure of the liquid-like and solid-like behavior of the viscoelastic dispersion ($\tan \delta$ is greater than unity for a more liquid-like dispersion and less than unity for a more solid-like dispersion). As described earlier, these measurements were conducted by oscillating the outer cup of the rheometer at a small enough amplitude such



that the existing structure is not irreversibly altered by the oscillation and G' is independent of the applied strain. While these types of measurements are not typically used to study particle interactions in colloidal dispersions like coatings, we have found such measurements to be highly sensitive to the nature of the interaction between the dispersed particles and between the particles and the solution polymer. In the graphs that follow, the open symbols represent measurements taken immediately after the microgel dispersion and polymer solution were stirred together ("initial"), and the solid symbols represent measurements taken after the samples were equilibrated for 24 hr at 25°C ("24 hr"). In addition, the total weight percent solid was held constant for all of the samples at 57.7% (15% microgel by weight). As noted earlier, all samples were presheared at 7.42 s⁻¹ for 30 sec prior to the dynamic measurements.

Figures 8a and b show the increase in the storage modulus G' and $\tan \delta$ as functions of time for microgels 3 and 4 dispersed in the EMU resin, respectively (the time of 0 sec in these figures, and similar ones that follow, corresponds to the end of the preshear). The dynamics of structure formation in the microgel 3 dispersions (Figure 8a) and microgel 4 dispersions (Figure 8b) is very similar. The maximum strain for which G' was independent of applied strain was 4.13% for both dispersions. The magnitude of G' attained 85-90% of its final value of 1.4 Pa for microgel 3 and 1.8 Pa for microgel 4 within the first 600 sec, which is the typical flash time for automotive coatings. In addition, no significant difference is noted in the dynamics of structure formation in either the initial or 24 hr samples of both microgel 3 and 4 dispersions—the structure that is formed with each of these microgels in the EMU resin is reversible. As expected, $\tan \delta$ decreases as structure is formed in dispersions of both microgels 3 and 4. This decrease in the ratio G''/G' confirms that the dispersions are becoming more solid-like as structure forms; that is, the storage modulus is increasing at a faster rate than the loss modulus (only initial data is shown because it is identical to the 24 hr data).

Different behavior is seen for the structure formation of microgel 1 dispersed in the EMU resin as noted by the time dependence of G' and $\tan \delta$ (Figures 8c and d). First, the

maximum strain within the linear viscoelastic region was significantly smaller: 0.30% for the initial sample (Figure 8c) and 0.14% for the 24 hr sample (Figure 8d). The greater scatter in the data noted in Figure 8d is a result of this lower strain required to remain in the linear viscoelastic region of the sample. Second, the storage modulus is approximately an order of magnitude higher for both samples. This comparison indicates that the structure formed in the microgel 1 dispersions is stronger as evidenced by the larger storage modulus, yet not as long-ranged as evidenced by the lower maximum strain defining the boundary of the linear viscoelastic region.

Third, the magnitude of both G' and $\tan \delta$ and their variations with time during structure formation depend on the age of the sample. Specifically, G' increases steadily from 12 to 22 Pa over 5,000 sec for the initial microgel 1 dispersion, with no evidence of a plateau in the modulus as seen with the microgel 3 and 4 dispersions. In contrast, G' remains approximately constant with time in the 24 hr microgel 1 dispersion. In addition, the magnitude of G' for the 24 hr dispersions was found to be sensitive to the amount of shearing that the sample was subjected to prior to testing, and ranged from approximately 2 Pa to 10 Pa. In contrast to the data for dispersions of microgel 3 and 4, $\tan \delta$ for the initial microgel 1 dispersion increases with time yet is approximately constant for the 24 hr dispersion. These dispersions are also more solid-like than those of microgel 3 and 4 as noted by the lower values of $\tan \delta$. That $\tan \delta$ is approximately equal to or less than unity indicates that the microgel 1 dispersions display at least equal elastic and viscous flow behavior (24 hr sample) or more elastic than viscous flow behavior (initial sample).

These significant differences in the dynamic oscillatory data for the microgel 1 dispersions as compared to the microgel 3 and 4 dispersions are in contrast to the similar steady-shear data noted for all of the dispersions (as seen by the comparable magnitudes of the Casson yield values). The differences in flow behavior at low deformations are observed because the dynamic oscillatory data are more sensitive to the nature of the interparticle interactions. The applicability of these types of low-deformation measurements in studying interactions in colloidal dispersions has been widely demonstrated (see, for example, references 16, 17, and 28-35).

The existence of a structure in the microgel dispersions results from flocculation of the particles. When colloidal particles are dispersed in a polymer solution, such as the microgels dispersed in the acrylic resin, flocculation can occur by one of two possible mechanisms: (1) depletion and (2) bridging.³⁶ When two colloidal particles are dispersed in a solution of nonadsorbing ("free") polymer and are separated by a distance less than twice the radius of gyration of the polymer, the polymer can be excluded from the interparticle space. This exclusion establishes a "depletion" zone between the particles, which leads to an osmotic pressure force that acts to push the particles together.³⁷⁻⁴⁰ The resulting flocculation under these conditions is termed depletion flocculation. Depletion flocculation is predicted to occur for an intermediate range of free-polymer volume fractions, where a dispersion stable to flocculation can be flocculated by the addition of free polymer and then may be restabilized by the further addition of free polymer. Bridging flocculation, on the other hand, occurs when one polymer molecule in solution adsorbs

onto two different colloidal particles. A primary difference between depletion and bridging flocculation is that depletion flocculation is reversible and bridging flocculation is irreversible (presuming irreversibility of polymer adsorption); in addition, depletion flocculation tends to give rise to a weaker attractive force than bridging flocculation.

The reversible behavior noted with dispersions of microgels 3 and 4 is consequently consistent with a depletion flocculation mechanism for structure formation. Tadros and co-workers^{17,41-43} and Patel and Russel³⁰ have also cited reversible rheological behavior as evidence that structure formed in dispersions of colloidal particles containing free polymer resulted from depletion flocculation. While it is difficult to distinguish experimentally between depletion and bridging flocculation,* the observation that the structure formation

*Phase separation was noted in all of the microgel dispersions after several weeks, which implies flocculation of the particles. Phase separation is not specific to either depletion or bridging flocculation, however, and hence cannot be used to distinguish between these two flocculation mechanisms.

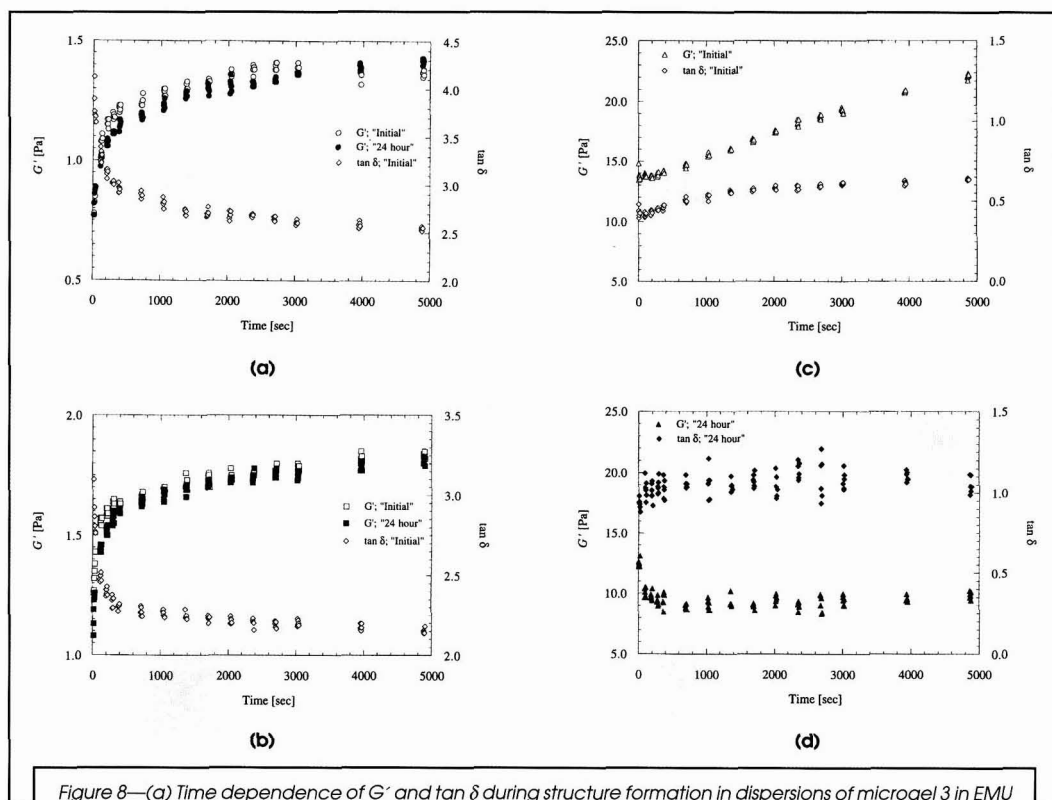
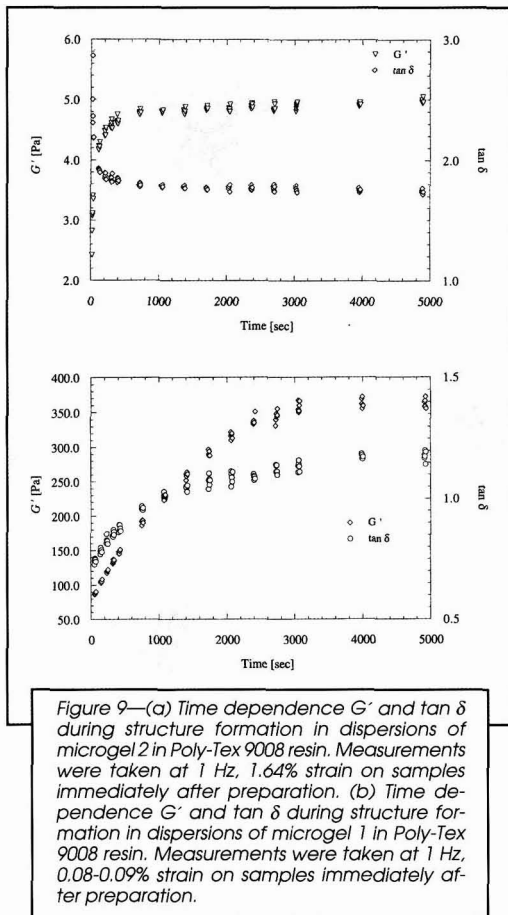


Figure 8—(a) Time dependence of G' and $\tan \delta$ during structure formation in dispersions of microgel 3 in EMU resin. Measurements were taken at 1 Hz, 4.13% strain. (b) Time dependence of G' and $\tan \delta$ during structure formation in dispersions of microgel 4 in EMU resin. Measurements were taken at 1 Hz, 4.13% strain. (c) Time dependence G' and $\tan \delta$ during structure formation in dispersions of microgel 1 in EMU resin. Measurements were taken at 1 Hz, 0.30% strain. (d) Time dependence G' and $\tan \delta$ during structure formation in dispersions of microgel 1 in EMU resin. Measurements were taken at 1 Hz and 0.14% strain. In all figures the open symbols correspond to measurements taken on samples that equilibrated for 24 hr prior to testing. All samples were presheared at 7.42 s^{-1} for 30 sec, and a time of zero in these figures corresponds to the end of the preshear.



was the same in both the initial and 24 hr dispersions provides indirect evidence that irreversible adsorption of the polymer resin onto the microgel surface does not occur. In addition, assuming the polymer does not adsorb, depletion flocculation is expected in these microgel dispersions since the free-polymer volume fraction is always greater than 0.3.⁴⁴ Bauer et al.¹ also proposed a depletion flocculation mechanism to explain the formation of an apparent yield stress in dispersions of microgels in low-molecular-weight polymer solutions.

The irreversible nature of the structure formed in dispersions of microgel 1 is consistent with bridging flocculation. In contrast to the behavior noted with the other microgel dispersions, G' increases steadily with time in the initial dispersion while it remains essentially constant in the 24 hr dispersion. Testing of samples at times greater than 24 hr gave behavior consistent with the 24 hr data shown in Figure 8d. Consequently, the sample aged irreversibly during the first 24 hr after preparation. Some insight as to the reason for this irreversible behavior can be ascertained from the phase angle data. $\tan \delta$ increases with time for the initial dispersion, while it remains approximately constant for the 24 hr disper-

sion; in addition, the initial dispersion has a lower value of $\tan \delta$ and hence is more solid-like than the 24 hr dispersion. The unexpected increase in $\tan \delta$ for the initial dispersion suggests that the particles are becoming more stable to flocculation during the first 5,000 sec after preparation, leading to a more liquid-like dispersion. This behavior is consistent with polymer from solution adsorbing onto the microgels during the first 24 hr after sample preparation and stabilizing the particles through a steric mechanism.

To evaluate the flow behavior of microgel 2 (which did not disperse in the EMU resin), similar structure formation studies were conducted with both microgels 1 and 2 dispersed in Poly-Tex 9008 resin. These experiments were also conducted to see if the unexpected behavior of microgel 1 depended on the acrylic resin in which it was dispersed. The total weight percent solid was 56.7%, with 15% microgel by weight, and the samples tested immediately after preparation. The results of these studies are shown in Figure 9a for microgel 2 and Figure 9b for microgel 1.

The time dependence of G' and $\tan \delta$ exhibited by microgel 2 dispersed in Poly-Tex (Figure 9a) is similar to that exhibited by both microgels 3 and 4 dispersed in the EMU resin (Figures 8a and b, respectively). For microgel 2, the maximum strain in the linear viscoelastic region was 1.64%. G' reached 95% of its final value (4.9 Pa) in less than 600 sec, and while $\tan \delta$ decreased during the 5,000 sec measurement period, the dispersion was still more viscous than elastic ($\tan \delta > 1$).

In addition, the time dependence of G' and $\tan \delta$ exhibited by microgel 1 dispersed in Poly-Tex (Figure 9b) is similar to the behavior seen for the initial dispersion of microgel 1 in the EMU resin (Figure 8d). The structure formed is short-range and strong, relative to that formed by microgel 2 dispersed in Poly-Tex. The maximum strain in the linear viscoelastic region was 0.08-0.09%, more than one order of magnitude lower than that for microgel 2 dispersed in Poly-Tex. Instead of rising quickly during the first 600 sec, G' for the microgel 1 dispersion increased steadily from 75 to 375 Pa, with a plateau at 3,000 sec. As also seen with the dispersions of microgel 1 in the EMU resin, $\tan \delta$ increased with time and has a value just greater than unity at the end of the measurement period. Consequently, the microgel dispersion is becoming more stable to flocculation during the first 5,000 sec after preparation.

These results suggest that the nature of the structure formed with dispersions of microgel 1 is not unique to the EMU acrylic polymer. Indeed, the microgel 1 particles dispersed in Poly-Tex yielded a structure indicative of bridging flocculation, as also noted for the dispersions in the EMU resin. In contrast, the microgel 2 particles dispersed in Poly-Tex yielded a structure indicative of depletion flocculation.

We correlated this apparent stabilization to the interaction of the solution polymer with the microgel surface by conducting studies with polymers of different hydroxyl numbers.⁴⁵ We observed irreversible structure formation behavior in dispersions of microgel 1 for polymers with hydroxyl numbers on the order of 150 mg KOH/g and less, indicative of polymer adsorption and subsequent bridging flocculation. In contrast, solution polymers with hydroxyl numbers greater than 150 mg KOH/g led to reversible structure formation behavior similar to that observed with the other microgels (2, 3, and 4). No differences in structure formation were observed

with dispersions of microgel 3 upon varying the solution polymer hydroxyl number.

These results indicate the importance of the solution polymer-microgel interactions in governing the formation of structure, and suggest that a careful balance of these interactions can yield the desired reversible structure. To investigate these interactions, we have developed a model experimental system of sterically stabilized Stöber silica spheres dispersed in the polymer solutions of varying hydroxyl number. This model system has allowed us to isolate and control the polymer-surface interactions in a known manner, and by doing so gain fundamental insight as to the relative importance of physical (particle softness and concentration) and chemical parameters (polymer polarity) in achieving rheology control. The results of these studies will be reported in a future publication.

SUMMARY

We have characterized microgels used as rheology control agents in high-solids automotive coatings. The microgels are spherical and show hard-sphere rheological behavior at low volume fractions, with some deviation at higher volume fractions due either to swelling of the particles or the presence of a large steric layer on the particle. The microgels induce a yield stress in low-molecular-weight acrylic resin typical of that used in high-solids coatings. The yield stress as a function of microgel concentration was estimated by determining the Casson yield value from the steady-shear viscometry data. For microgel concentrations less than 10%, the Casson yield value increased slowly with concentration, while for concentrations greater than 10% much larger increases in the Casson yield value were observed. The Casson yield value was found to scale with microgel concentration to the third power.

Structure formation in dispersions of microgels in acrylic resin was monitored with dynamic oscillatory measurements. The rheological behavior of the structure formed with three of the microgel dispersions was consistent with a depletion flocculation mechanism, with a non-adsorbing solution polymer leading to a relatively weak, reversible structure. The rheological behavior of a fourth microgel dispersion differed significantly from that of the others, and was characteristic of the solution polymer adsorbing onto the microgel leading to a structure by bridging flocculation.

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Initiators for Water-Based Acrylate Emulsion Polymerizations

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INTRODUCTION

Complete conversion of monomers into resinous polymer is a desire of every resin producer, as residual monomers may give a pungent odor to the end product. Toxicity may be an important issue as well. Various means exist to decrease residual monomers in (co)polymer resins, such as:

TEMPERATURE INCREASE: The propagation constants and diffusion constants will increase with higher temperature, thus favoring a faster conversion of the remaining monomer. However, several technical disadvantages accompany temperature increase.

ADDITION OF REACTIVE COMONOMER: In the case of copolymerizations, it is worth considering the reactivity ratios of the copolymerizing monomers. Sometimes a monomer that does not homopolymerize readily remains behind, but can be converted by addition of a fast reacting comonomer.

USE OF THE PROPER ORGANIC PEROXIDES: Selection of the proper initiators will give the highest reduction in the shortest time without deteriorating resin properties.

Of these options, this paper focuses on the use of organic peroxides to reduce residual monomer levels in aqueous emulsion polymer resins.

Organic peroxides also can be used as polymerization initiators for water-based resins. While persulfates have traditionally been used in this application, and still play a major role, interest in peroxide initiators is growing. Already, some manufacturers have converted to peroxide initiators or use organic peroxides in combination with persulfates. Since persulfates generate hydrosulfuric acid as a by-product upon decomposition, one obvious advantage that peroxides offer is that they are much less corrosive in nature. This paper explores the use of organic hydroperoxides as initiators in acrylate emulsion polymerizations.

EXPERIMENTAL

Styrene/n-Butyl Acrylate (40:60) Latex

A 250 mL jacketed glass reactor equipped with a reflux condenser, a thermocouple, a mechanical stirrer, and a nitrogen

Traditionally persulfates have been used as initiators in redox water-based polymerization systems. While persulfates are still used, the use of organic peroxides has increased during the past decade. This paper summarizes work which shows that organic peroxides can be used as highly effective monomer scavengers to reduce the levels of unreacted residual monomer in a latex. In addition, organic peroxides can be used in place of persulfates for initiating a redox polymerization and offer some advantages over persulfates.

inlet was charged with 90 mL distilled water, 275 mg sodium lauryl sulfate, 51 mg $\text{NaH}_2\text{PO}_4 \cdot \text{H}_2\text{O}$, and 2.2 mg $\text{FeSO}_4 \cdot 7 \text{H}_2\text{O}$. The reactor contents were heated to 50°C. The monomers, initiator (containing the emulsifiers), and reductant were added separately, but simultaneously, to the reactor. Monomers: a 50 g mixture of butyl acrylate and styrene (6:4) was prepared and 4 g of this mixture was quickly added to the reactor. The remainder was added after 15 min over approxi-

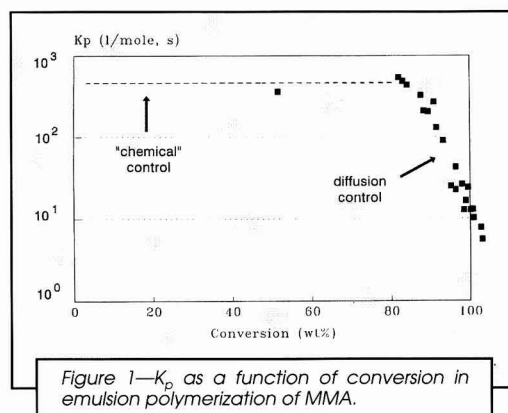


Figure 1— K_p as a function of conversion in emulsion polymerization of MMA.

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Table 1—Organic Peroxide Initiators for Water-Based Acrylate Polymerizations

Chemical	Akzo Nobel Tradename	Abbreviation
tert-Butyl peroxy-2-ethylhexanoate	Trigonox 21	TBPEH
tert-Butyl peroxy-diethylacetate	Trigonox 27	TBPD
tert-Butyl-3,5,5-trimethylhexanoate	Trigonox 42S	TBPIN
tert-Butyl perbenzoate	Trigonox C	TBPB
Cumene hydroperoxide	Trigonox K-80	CHP
tert-Butyl hydroperoxide	Trigonox A-W70	TBHP
tert-Amlyl hydroperoxide	Trigonox TAHP	TAHP

mately 2.5 hr. Initiator/emulsifier mixture: a mixture of 550 mg Elfapur N150 (FL, nonionic surfactant), 275 mg sodium lauryl sulfate (anionic surfactant), 0.80 mmol $K_2S_2O_8$, and 10 mL distilled water was prepared. A 10% (~1.10 g) portion of this mixture was quickly added to the reaction mixture. The remainder was slowly added after 15 min over 3.75 hr. Reductant: 141 mg vitamin C was dissolved in mL water and 10% of the mixture was quickly added to the reaction mixture. After 15 min the remainder was added slowly over approximately 4.25 hr.

After addition of the reductant was complete, the polymerization was continued for an additional hour to reduce residual monomer/initiator content. Residual initiator was removed by heating the latex for several hours at 90°C until no residual persulfate could be detected by iodometric titration. Final solids content was 39.9%; the weight average molecular weight was 638,000 g/mol. The latex was analyzed for both styrene and butyl acrylate content. Residual styrene content was deliberately brought to 0.64 wt% based on the total latex. The butyl acrylate content was kept below 0.04 wt%.

A redox initiator composed of reductant (μeq), oxidant (16 μeq) and iron sulfate (0.16 μeq) was added per 10 g of the

latex as prepared previously, which had been placed in ampoules. The ampoules were sealed under nitrogen and left undisturbed for the appropriate time at room temperature. Thereafter, residual monomer was analyzed by GC.

Vinyl Acetate/n-Butyl Acrylate/Methacrylic Acid (83:15:2) Latex

A reactor set up similar to that described earlier was charged with 20 g water, 0.1 g sodium acetate, 0.2 g hydroxyethyl cellulose, and 3.74 mmol sodium formaldehyde sulfoxylate (SFS). In a separate vessel, 65 g water was mixed with 2.42 g Witconate™ AOS EP (Witco, anionic surfactant) and 3.00 g Witconol™ NP 100 (Witco, nonionic surfactant). Then to this mixture were added 83 g vinyl acetate, 15 g butyl acrylate, and 2 g methacrylic acid. A hydroperoxide was used as the initiator: tert-butyl hydroperoxide (TBHP), tert-amyl hydroperoxide (TAHP), or cumene hydroperoxide (CHP). TBHP or TAHP (3.11 mmol) was added to 20 g water. CHP (3.11 mmol) was added directly to the monomer mixture with an additional 20 g water. The reactor was heated at 63°C; 10% of the monomer mixture and 10% of the initiator solution were added. After 30 min the addition was resumed, with the mixtures being added simultaneously over a period of three hours, after which the reaction was continued for an additional 30 min. The final solids content of the latex was 50%.

n-Butyl Acrylate/Methyl Methacrylate/Methacrylic Acid (52:46:2) Latex

A reactor set up similar to that described earlier was charged with 25 g water and 0.2 g sodium acetate. In a separate vessel, 75 g water was mixed with 2.42 g Witconate AOS EP (anionic surfactant) and 3.00 g Witconol NP 100 (nonionic

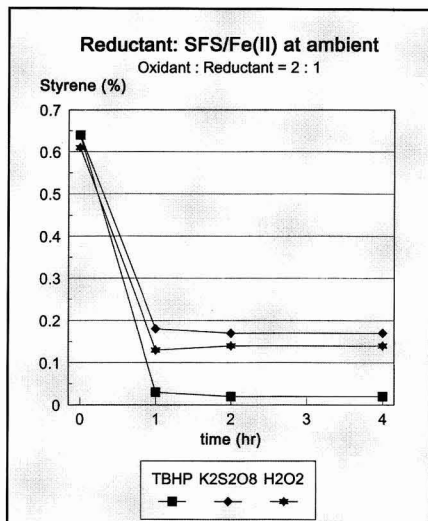


Figure 2—Reduction of styrene in St/BA latex.

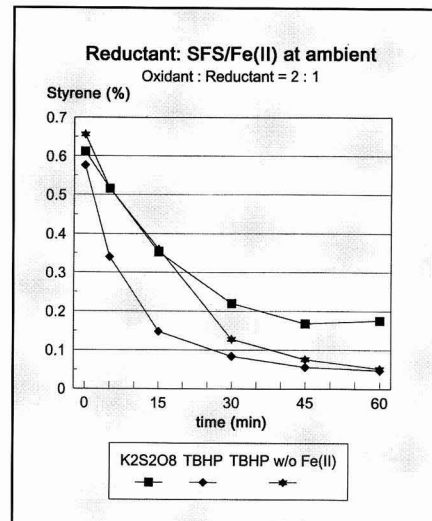


Figure 3—Reduction of styrene in St/BA latex.

surfactant). Then to this mixture were added 52 g butyl acrylate, 46 g methyl methacrylate, 2 g methacrylic acid, and 3.11 mmol TBHP or $K_2S_2O_8$. In another vessel, 20 g of water was mixed with 0.48 g sodium formaldehyde sulfoxylate. The reactor was heated to 60°C and 10% of each mixture was added. After 30 min the addition was resumed, with the mixtures being simultaneously added over a period of two hours, after which the reaction was continued for an additional 90 min. The final solids content of the latex was 46%.

RESULTS AND DISCUSSION

In an emulsion polymerization, whether using a water or oil soluble initiator, part of the initiator will be present in the water phase and therefore efficiency is only somewhat affected by the amount of polymer in the particle phase (Figure 1).¹ In an emulsion polymerization of methyl methacrylate, the drop in the propagation constant, k_p , above 80% conversion is attributed to a diffusion limitation, as transport of the few monomer molecules to the initiator radicals is rate determining.

For emulsion based systems, after the particle nucleation phase has ceased (generally conversion > 15%) or for seeded systems, the rate of propagation can be expressed by the following equation²:

$$R_p = k_p[M]Nn$$

- where: R_p = rate of propagation
- k_p = propagation constant
- $[M]$ = monomer concentration in particles
- N = concentration of latex particles
- n = average number of free radicals per latex particle

A drop in polymerization rate is to be expected because $[M]$ decreases. Provided the initiator concentration is kept constant by dosing, a further drop in polymerization rate can be explained by the decrease in k_p .

While much has been published on the subject of emulsion polymerization, relatively little work has been published on the use of organic peroxides in this application. Some examples of prior work in the area of water-based polymerizations are given in the references.³

The use of various hydroperoxides and peroxyesters, in combination with reductants, for reduction of residual monomer was studied at room temperature. The initiator system was added batchwise at $t = 0$ and the decrease in residual monomer (styrene) was recorded over time. This approach, followed as a batchwise addition to a latex storage tank, is a simple operation and does not affect the batch times in the reactor. The initiators used in this study are shown in Table 1.

Figure 2 shows the decrease in styrene content in the styrene/n-butyl acrylate latex for various oxidants and sodium formaldehyde sulfoxylate as the reductant. In this case a trace of iron (II) sulfate was used as the catalyst. It is apparent from this figure that TBHP was much more effective in reducing residual styrene content than either the persulfate or hydrogen peroxide.

In Figure 3, a more detailed analysis is given of the decrease of residual styrene in the first hour. In the absence of iron, the

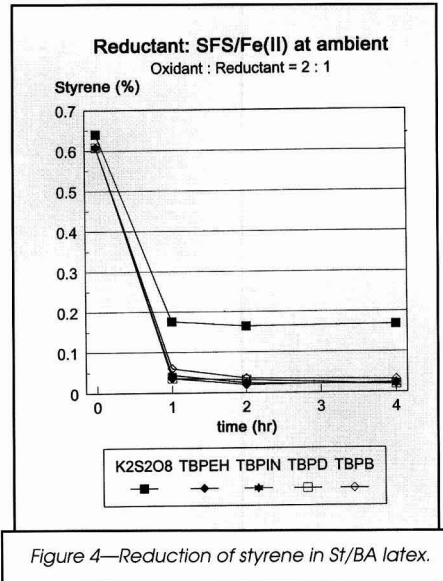


Figure 4—Reduction of styrene in St/BA latex.

Table 2—Properties of Latexes

Property	Potassium Persulfate	TBHP
Dn (nm)	260	282
Viscosity (cps)	17	18
pH	1.6	5.1

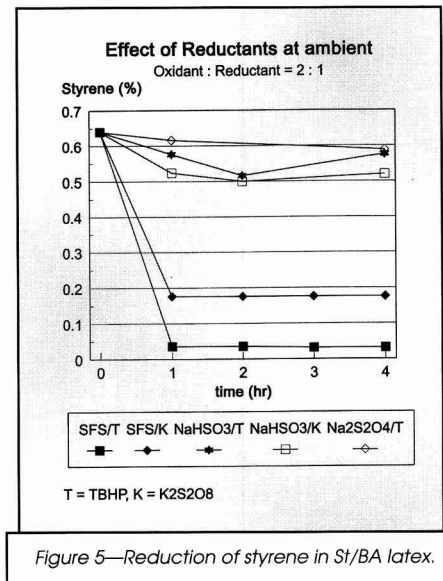


Figure 5—Reduction of styrene in St/BA latex.

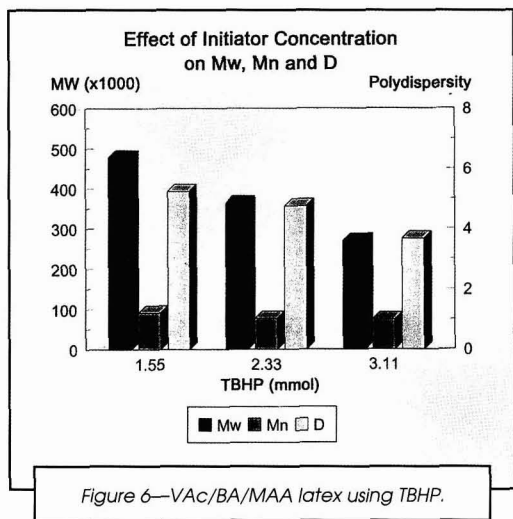


Figure 6—VAc/BA/MAA latex using TBHP.

same final reduction of residual styrene monomer is obtained when using TBHP, although the rate of reaction is somewhat slower.

Figure 4 shows that peroxyesters also are very active in reducing residual monomer in latex, again using sodium formaldehyde sulfoxylate as the reductant. The four peroxyesters gave virtually identical results.

It is obvious that the organic (hydro)peroxides perform better than hydrogen peroxide or potassium persulfate. The reason for this phenomenon is that at high conversion, virtually all of the monomer is swollen into the polymer latex particles. Effective monomer reduction apparently goes along with the presence of more monomer-soluble radicals. This hypothesis is further illustrated by changing the reductant polarity as well. Figure 5 shows the results for sodium metabisulfite, sodium dithionite, and sodium formaldehyde

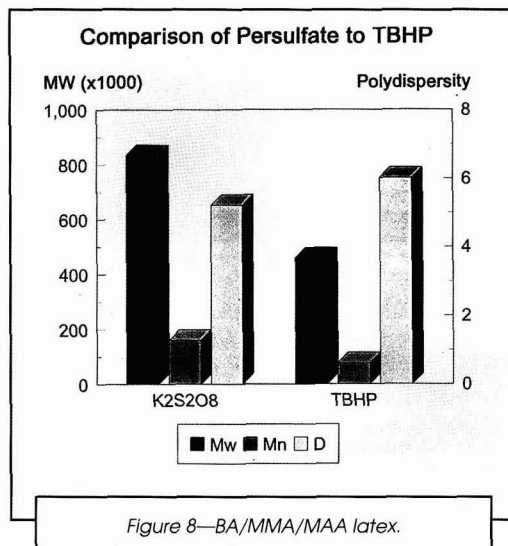


Figure 8—BA/MMA/MAA latex.

sulfoxylate. The more hydrophobic sodium formaldehyde sulfoxylate performs much better than sodium dithionite or sodium metabisulfite.

In a further set of experiments, vinyl acetate/n-butyl acrylate/methacrylic acid latexes were prepared using TBHP as the initiator at three concentrations. Figure 6 shows the effect of initiator concentration on polymer molecular weight. As expected, increasing the TBHP concentration resulted in decreasing the molecular weight. A decrease in polydispersity also was observed.

In Figure 7 three different hydroperoxides are compared. A concentration of 3.11 mmol/100 g monomer was used for all three initiators. In this case TBHP gave the highest molecular weight resin. This was followed by TAHP, with CHP giving the lowest molecular weight.

Potassium persulfate was compared to TBHP in the case of the n-butyl acrylate/methyl methacrylate/methacrylic acid latex. In Figure 8 it can be seen that TBHP gave a resin with a molecular weight of almost half that obtained using potassium persulfate. However, if a resin with a molecular weight equal to that obtained with the persulfate is desired, this could be achieved with TBHP by using a lower concentration of the initiator, as evidenced by Figure 6.

The resin made using potassium persulfate had a number average particle size of 260 nm determined by light scattering, while the hydroperoxide initiated resin had a number average particle size of 282 nm, as shown in Table 2. Thus, differences in particle size cannot account for the observed differences in molecular weight. Also shown in this table are the viscosities of the two resins which were virtually identical. The resin made from TBHP had a much more desirable pH than did the persulfate resin. A sodium acetate buffer was used in both cases during the polymerization, but neither resin was treated further after the reaction was complete. The more neutral resin produced from the hydroperoxide would be much less corrosive toward manufacturing equipment as well as in the final application.

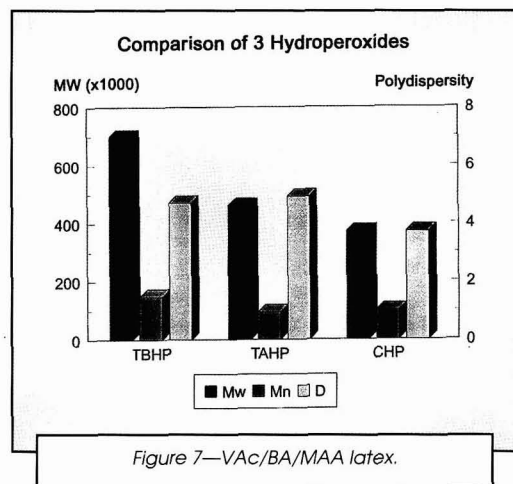


Figure 7—VAc/BA/MAA latex.

CONCLUSION

Organic peroxides, such as tert-butyl hydroperoxide, and peroxyesters are more effective than persulfates and hydrogen peroxide for reducing residual monomer in a latex when a redox system is used. The advantages of such a system are that no reactor capacity is consumed as the system is charged batchwise to a latex storage tank at ambient temperature and that there will be less increase in the ionic strength, which gives all the applicational advantages (less corrosion, lower water sensitivity in application, etc).

Organic hydroperoxides also can be effective initiators in the polymerization of acrylates in emulsion systems. Three hydroperoxides were studied and all were found to function as suitable initiators. Comparison of potassium persulfate to TBHP showed that the latter gave a resin with a much lower molecular weight and a much more desirable pH.

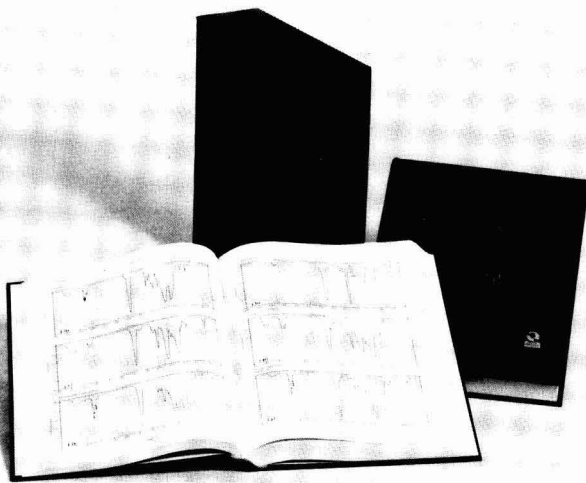
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LEA L. ANDERSON is a Chemist with Akzo Nobel at their research center in Dobbs Ferry, NY. She received the B.S. Degree in Chemistry from the University of Wisconsin-Madison in 1986 and the Ph.D. Degree from MIT in Inorganic Chemistry in 1991. As a graduate student, Dr. Anderson worked under the direction of Prof. Deitmar Seyferth. She currently works in the area of organic peroxides and focuses on their applications as initiators in acrylate polymerizations, both solvent and waterborne. Her work includes laboratory research and customer technical support.

WILFRIED M. BROUWER has served as Research Manager for Akzo Nobel's Polymer Chemicals business in the United States since 1993. He has held various positions with Akzo and has worked in various research areas. In 1981, Dr. Brouwer worked on micro-emulsions in the group headed by Prof. Overbeek in Utrecht, The Netherlands. After completing his Doctorate Thesis on polymer catalysis (Technical University Eindhoven, The Netherlands), he was a visiting scientist at the Emulsion Polymers Institute at Lehigh University, Bethlehem, PA, from 1984 to 1985. Dr. Brouwer's main research interests include catalysts and initiators for polymerization, colloid and interface chemistry, and latex applications.

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BALTIMORE—JANUARY

"Corrosion and Decision Making"

Society Representative Joe Guisto, of Lenmar Inc. was voted to receive Society Honorary Membership.

President Al Holder, of U.S. Navy CDNSWC, honored John Kurnas, of Mineral Pigments, Helene Ranfone, of Duron, Inc., and James Smith, of Eastech Chemical Inc. all Past-Presidents of the Baltimore Society.

The meeting was attended by representatives of the Baltimore Society, the Chesapeake Chapter of the Steel Structures Painting Council (SSPC), Baltimore/Washington Chapter of the National Association of Corrosion Engineers (NACE), the Baltimore Coatings Association (BCA), and the Washington Technical Paint Group (WPTG). A representative from each association provided an overview its activities.

Randolph Binter, of INDCO, Inc., delivered the evening's presentation on "CORROSION AND DECISION MAKING."

CDIC—FEBRUARY

Bosses' Night

Society Representative Bill Hollifield, of Perry & Derrick Co., Inc., reported that he will be attending the FSCT Strategic Planning Meeting in Chicago.

Hugh Lowrey, of Perry & Derrick Co., Inc., stated that the Tort Reform Legislation Bill has passed in the House of Representatives.

Educational Committee Chair Laura Miller, of Perry & Derrick Co., Inc., updated the members on committee activities. A fundamental coatings course is planned for fall and instructors for this course are being sought. In addition, the committee has become involved with the "Jobs for Cincinnati" program, where high school students are educated on pursuing a career in the paint and coatings industry.

Manufacturing Committee Chair Dave Sellers, of PPG Industries, Inc., stated that the committee will meet on March 11. He also stated the committee is seek-

ing additional members. Mr. Sellers informed the members that a plant tour of Sun Chemical has been arranged for April.

Technical Committee Chair Ken Pendleton, of K.A. Pendleton Co., announced that the "Adhesion of Water-Based Coatings for Polypropylene" project is underway.

Bob McGee, President of the Cincinnati Paint & Coatings Association (CPCA), gave an overview of the CPCA.

Dianne Grote Adams, of Emilcott dga, Inc., discussed "TRAINING REQUIREMENTS FOR EMERGENCY RESPONSE."

Ms. Adams highlighted some of the issues that must be considered when implementing an Emergency Response Plan and Training Program for an industrial facility. She observed that most recent OSHA regulations are moving to a performance oriented standard, rather than a specification oriented standard, meaning that compliance is a factor of interpretation.

Ms. Adams suggested that training to support Emergency Response Plans should be based on the duties and functions to be performed by the employee, and should be conducted well in advance of an employee taking part in an emergency incident. The

speaker also recommended that training be carefully documented.

It is helpful to review the training content for all emergency programs, since areas may overlap to minimize the total training time required. Ms. Adams stated that it is convenient and helpful to maintain the training records for a particular employee, on a single document, which is continually updated as training is received.

TERESA L. CASE, Secretary

CHICAGO—MARCH

"The Desirability Function"

An update of Host Committee Activities for the FSCT International Coatings Expo and Technology Conference slated for October 23-25, 1996 was presented.

Chicago Society member, Keith Moody, of Eastman Chemical Co., discussed "THE DESIRABILITY FUNCTION, A NEEDS IDENTIFICATION AND DEFINITION TOOL."

According to Mr. Moody, this is a method of assigning values to various customer parameters so that a statistical program can produce an optimization of cost and product performance properties.

VICTOR WILLIS, Publicity



At the March meeting of the Chicago Society, speaker Keith Moody (left), of Eastman Chemical Co. is photographed with Society President Dave Stromberg, of United Coatings Inc.



Chicago Society members in attendance at the March meeting included (from left): Dave Asplund, of Northwest Coatings Corp.; Leo Dombrowski, of Gilbralter Chemical; and George Goodwin, of Daniel Products Co., Inc.



Cleveland Society President Michael Wolfe (center), of Seegott, Inc., is photographed with guest speakers at the Society's January Meeting. The speakers include (from left): Richard Winkelhoffer, of EPA; Bill Skowronski, of EPA; Mr. Wolfe; David Puryear, of Harrison Paint; and Nancy Newman, of OSHA.

CLEVELAND—JANUARY

Joint CSCT and CPCA Meeting

A moment of silence was observed for the passing of Terryl Johnson, FSCT Past-President.

President Michael Wolfe, of Seegott, Inc., announced that a new group called Technical Advisory Panel (TAP), has been formed. Mr. Wolfe also mentioned that the Cleveland Society has established the following mission statement:

"To work in fellowship. To learn and educate others in the coatings industry."

Connie Williams, of The Lubrizol Corp., informed the members that the CSCT will once again be awarding a college scholarship of \$1,200.00.

The topic of the evening's talk was "UNDERSTANDING THE THINKING PROCESS OF EPA AND OSHA WHEN MAKING DECISIONS." Mr. Winklofer, of U.S. EPA, Mr. Skowronski, of Ohio EPA, David Puryear, of Harrison Paint, and Nancy Newman, of OSHA participated in the discussion.

Each speaker provided an overview of their responsibilities and then conducted a question and answer session.

JAMES J. CURRY, *Secretary*

KANSAS CITY—FEBRUARY

"Wax Additives for Coatings"

Educational Committee Chair Kim Nee, of Mozel Inc., reported that the Society's pilot "project" will be presented to sixth grade science classes on April 18.

Jim Sells, of NPCA, discussed the "Coatings Rule," the new EPA study, and the complex permitting program. Mr. Sells predicted that it is likely that there will be no major environmental changes before the November elections.

In addition, Mr. Sells reported that currently there is a push for the states to control VOC emissions from the Clean Air Acts of 1990.

The evening's technical presentation "WAX ADDITIVES FOR COATINGS" was delivered by New York Society Member Thomas D'Aquila, of Daniel Products Co.

Mr. D'Aquila gave an overview of surface treatment for coatings to "lower coefficient of friction," which provides many functions for the coatings.

According to the speaker, the following manufacturing methods are used: (1) compounding waxes for finer particle size; (2) micronizing or narrowing particle size distribution (100%) solids; and (3) emulsification of ultra-fine liquid to extremely fine particles for higher melting point. Each wax sizing has a definite function and effectiveness in the coatings industry other than as a slip aid.

CURRY SANDERS, *Secretary*

MONTREAL—MARCH

"Adhesion Promoters"

Society Representative Suzanne Richardson, of Tioxide Canada, gave an overview of the February FSCT Board Meeting held in Chicago. Ms. Richardson reviewed the Federation's strategic planning goals and objectives.

David Boothe, of The Lubrizol Corp., discussed "ADHESION PROMOTERS FOR AQUEOUS AND NON-AQUEOUS SYSTEMS."

Mr. Boothe divided his presentation into five parts: adhesion, corrosion inhibition, film integrity, hydrophobicity, and catalytic activity. He stated that phosphate acid ester types of adhesion promoters are used in solvent-borne and waterborne coatings.

The speaker also discussed ester synthesis and cure processes in condensation polymer systems. In addition, Mr. Booth stated that phosphate esters improve corrosion resistance and provide catalytic activity in acid-catalyzed polymers.

Physical specifications and formulation techniques in solvent-borne and water-reducible systems were also reviewed.

Q. What about use in UV curables?

A. Work is now in progress. Low temperature application includes ABS bumpers.

HORACE PHILIPP, *Publicity*

NEW ENGLAND—FEBRUARY

Federation Officer Visit

FSCT Director of Education, Mike Bell, discussed how the Federation's educational program assists members. Mr. Bell cited the following areas:

- (1) Technical Committee—meets with each section and assists in judging awards;
- (2) Joint Coatings/Forest Committee—Works with the wood association for information to consumers using coatings;
- (3) Educational Committee—Sponsored program on computer usage and polymer coatings; and
- (4) Society Speakers Program—FSCT-sponsored speakers increased attendance at the Louisville Society meeting by 30%, other Societies invited to make use of this service.

FSCT Secretary-Treasurer Tom Hill discussed "Reinventing the FSCT." Mr. Hill updated the members on plans for improvement. Two areas he touched on were responding to market (coatings) needs and restructuring the costs to be more competitive with other associations.

Mr. Hill also discussed the current strategic plan. The plan focuses on the following areas:

- (1) Providing centralized membership;
- (2) Expanding technology base;
- (3) More funding income via associated trade shows with the FSCT involved;
- (4) Restructuring the Board and Committees;
- (5) Development of marketing plan to show benefits of membership;
- (6) Development of common interest

groups (wood, powder coatings, and UV, for example); and

(7) Provide better training.

Ken Zacharias, Director of Membership Services for NPCA, outlined the ongoing services of his association.

RICHARD TWOMEY, *Secretary*

PACIFIC NORTHWEST— FEBRUARY

"Scale Up of Laboratory Dispersion"

Technical Committee Chair Yoichi Seo, of Flecto Coatings, Ltd., announced that Valerie Braund, of General Paint Ltd., has been added to the Committee.

The Committee is currently working on establishing goals for the production of a video tape.

Educational Committee Chair Tom Fairley, of Calcoast Labs Canada, provided a report on Kwantlen College Coatings Technology course. Over 20 students have signed up for the course that is designed for people working in or entering the laboratory environment. The format includes the following: coatings components, coatings manufacture, types of coatings, types of substrates, surface preparation, application techniques, safety and the MSDS, and failure analysis/remediation.

The speaker for the evening was John Pope, of BYK-Gardner. He discussed "CONSIDERATIONS FOR THE SCALE UP OF LABORATORY DISPERSION PROCESSES."

KELVIN J. HUGET, *Secretary*

PHILADELPHIA—FEBRUARY

General Membership Meeting

President Howard Salmon, of Akzo Nobel Coatings, Inc., announced that the FSCT is seeking nominees for the Bruning Award.

Wayne Kraus, of Hercules Incorporated, recognized Don Denny, of E.W. Kaufmann Co., Sam Firestone, of S.E. Firestone Associates, Inc., and Neil Shearer, of The 3E Group, for their efforts in planning the Eastern Training Conference, slated for May 8-9, 1996.

Technical Committee Chair Neil Shearer reported on the ChemCentral Plant Tour in January.

Society Representative Don Denny lead a discussion on the FSCT "White Paper."

PATRICIA M. PETERSEN, *Secretary*

Constituent Society Meetings and Secretaries

BALTIMORE (Third Thursday—Martin's West, Woodlawn, MD). JOSEPH SCHILARE, The Valspar Corp., 1401 Severn St., Baltimore, MD 21230.

BIRMINGHAM (First Thursday—Strathallan Hotel, Birmingham, England). DAVID C. MORRIS, PPG Industries (UK) Ltd., P.O. Box 359, Rotton Park St., Birmingham, B16 0AD, England.

CDIC (Second Monday—Location alternates between Cincinnati, Columbus, Dayton, and Indianapolis). THERESA CASE, Fibreglass Evercoat Co., Inc., 6600 Cornell Rd., Cincinnati, OH 45242.

CHICAGO (First Monday—Sharko's Restaurant, Villa Park, IL). GERRY K. NOREN, DSM-Desotech, Inc., 1122 St. Charles St., Elgin, IL 60120.

CLEVELAND (Third Tuesday—Monthly meeting site TBA). JAMES CURRIE, Jamestown Paint Co., 108 Main St., Jamestown, PA 16134.

DALLAS (Second Thursday following first Wednesday—Dallas Medallion Hotel, Dallas, TX). MIKE TEMPLIN, Hilton-Davis Co., 1696 Dickerson Dr., Arlington, TX.

DETROIT (Second Tuesday—meeting sites vary). RAY STEWART, Akzo Nobel Coatings, Inc., 1845 Maxwell St., P.O. Box 7062, Troy, MI 48007-7062.

GOLDEN GATE (Monday before third Wednesday—alternates between Francisco's in Oakland, CA, and Holiday Inn in S. San Francisco). DON MAZZONE, Dowd & Guild, Inc., 14 Crow Canyon Ct., #200, San Ramon, CA 94583.

HOUSTON (Second Wednesday—Medallion Hotel, Houston, TX). KEN MUNDY, Ribelin Sales, Inc., 7786 Blankenship Dr., Houston, TX 77055.

KANSAS CITY (Second Thursday—Cascone's Restaurant, Kansas City, MO). CURRY SANDERS, Tnemec Co., Inc., 123 N. 23rd Ave., N. Kansas City, MO 64116.

LOS ANGELES (Second Wednesday—Steven's Steakhouse, Commerce, CA). ARTHUR W. LORENZ, Sinclair-Ameritex Paint Corp., 6100 S. Garfield Ave., Los Angeles, CA 90040.

LOUISVILLE (Third Wednesday—Executive West Motor Hotel, Louisville, KY). PAUL BAUKEMA, Akzo Nobel Coatings, Inc., R&D Div., 4730 Crittenden Dr., P.O. Box 37230, Louisville, KY 40233.

MEXICO (Every fifteen days—Gabriel Mancera, Mexico City, Mexico). SERGIO ROJAS, Pinturas International, S.A. De C.V., Ganaderos 234, Col. Granjas Esmeralda, 09810 Mexico, D.F., Mexico.

MONTREAL (First Wednesday—Restaurant Le Bifhèque, St. Laurent, Quebec). ROBERT BENOIT, KRONOS Canada Inc., 3390 Marie Victorin, Varennes, Que., J3X 1T4 Canada.

NEW ENGLAND (Third Thursday—Best Western TLC, Wallham, MA). RICHARD TWOMEY, Kronos, Inc., 68 Fisher St., Medway, MA 02053-2004.

NEW YORK (Second Tuesday—Landmark II, East Rutherford, NJ). ROBERT W. SCHROEDER, Daniel Products Co., 400 Claremont Ave., Jersey City, NJ 07304.

NORTHWESTERN (Tuesday following first Monday—Jax Cafe, Minneapolis, MN). MICHAEL D. COAD, McWhorter Technologies, 1028 S. Third St., Minneapolis, MN 55415.

PACIFIC NORTHWEST (PORTLAND SECTION—Tuesday before third Wednesday—Tony Roma's, Mall 205, Portland, OR; SEATTLE SECTION—Third Wednesday—Wyndham Gardes Hotel, Sea-Tac, WA; VANCOUVER SECTION—Thursday after third Wednesday—Abercorn Inn, Richmond, B.C.). KENNETH WENZEL, Chemical Distributors, Inc., P.O. Box 10763, Portland, OR 97210.

PHILADELPHIA (Second Thursday—DoubleTree Guest Suites, Plymouth Meeting, PA). PATRICIA M. PETERSON, ARCO Chemical Co., 3801 West Chester Pike, Newtown Square, PA 19073-3230.

PIEDMONT (Third Wednesday—Ramada Inn Airport, Greensboro, NC). ALEX BIAHNIK, Chemcraft Sadolin, Inc., P.O. Box 669, Walkertown, NC 27051.

PITTSBURGH (Second Monday—Montemurro's Restaurant, Sharpsburg, PA). JAMES GIAMMARCO, Lockhart Chemical Co., 2873 W. Hardies Rd., Gibsonia, PA 15044.

ROCKY MOUNTAIN (Monday following first Wednesday—Monthly meeting site TBA). JOHN ELVERUM, Hauser Chemical Research, 5555 Airport Blvd., Boulder, CO 80301.

ST. LOUIS (Third Tuesday—The Salad Bowl Restaurant, St. Louis, MO). ROBERT PHELPS, P.D. George Co., P.O. Box 66756, St. Louis, MO 63166.

SOUTHERN (GULF COAST SECTION—third Thursday; CENTRAL FLORIDA SECTION—third Thursday after first Monday; ATLANTA SECTION—third Thursday; MEMPHIS SECTION—bi-monthly on second Tuesday; and MIAMI SECTION—Tuesday prior to Central Florida Section). EVE DE LA VEGA-IRVINE, J.M. Huber Corp., One Huber Rd., Macon, GA 31298.

TORONTO (Second Monday—Speranza Restaurant & Banquet Hall Convention Centre, Brampton, Ont., Canada). MIKE MOLNAR, CIBA Pigments, P.O. Box 2000, Mississauga, Ont., L5M 5N3 Canada.

WESTERN NEW YORK—MARKO MARKOFF, 182 Farmingdale Rd., Cheektowaga, NY 14225.



FSCT Technical Advisory Committee Meets with Society Technical Committee Chairs

August 17-18, 1995 – Sheraton Washington Hotel, Washington, D.C.

Sixteen Society Technical Committee representatives met with members of the Federation's Technical Advisory Committee (TAC) on August 17-18, 1995, at the Sheraton Washington Hotel, in Washington, D.C.

The meeting was called to order by FSCT Technical Advisory Committee (TAC) Chair Gail Pollano (New England) with the following in attendance: Roland Staples (Birmingham); Ken Pendleton (CDIC); Ben Carizzo (Cleveland); Latoska Price (Detroit); Tim Specht (Golden Gate); Lawrence Murphy (Kansas City); V.C. "Bud" Jenkins (Los Angeles); Ilona Duvall (Louisville); Sheila Westerveld (New York); William Hahn (Pacific Northwest); Bernadette Corujo (Philadelphia); Nellie Moretz (Piedmont); Mark Harley (Pittsburgh); John Baker (Rocky Mountain); Todd Yonker (St. Louis); and Walter Naughton (Southern).

Technical Advisory Committee Members in attendance were: Fred Anwari (Cleveland); Ed Ferlauto (Northwestern); Valerie Braund (Pacific Northwest); Noel Harrison (Dallas); and Rose Ryntz (Detroit).

FSCT President-Elect Darlene Brezinski (Chicago) and FSCT Director of Educational Services Michael G. Bell also attended the meeting.

Ms. Pollano reviewed the Adoptive Society Program. This program provides each Society with a Committee contact for assistance in any projects and also allows the Committee to have easy access to the Societies to both spread the word on meetings and collect meeting data.

Ms. Pollano also reviewed the TAC Mission Statement with the attendees. The statement reads:

"The mission of the FSCT Technical Advisory Committee is to establish guidelines, facilitate technical projects and encourage Constituent Societies to participate in programs in a way that will advance understanding in coatings and related areas so that there will be a continuity of technical projects which will result in the presentation of a technical paper at the Annual Meeting and publication in the JOURNAL OF COATINGS TECHNOLOGY."

Society Reports

BIRMINGHAM

No new programs have been started as the Committee works to complete existing ac-

tivities. The Club is working on a VOC table to be used in the lab. The Museum project is on hold awaiting funding. The Club is arranging a symposium for February 1996 on present and future legislation. There were also some arranged tours of facilities which were deemed successful.

CDIC

The Society is beginning its work on a computerized system of data for non-colored pigments. To develop ideas for projects, the Society is investigating the needs of Technical Directors in companies that sponsor FSCT membership. Several of the Society's members have assisted in the St. Louis Society project.

CLEVELAND

The following activities were reported on: the paper, "Correlation of Accelerated Exposure Testing and Exterior Exposure Sites," was published in the October 1994 issue of the JCT; Part II of the paper was presented at the 1994 Annual Meeting and has also been accepted for publication (with some minor revisions) in the JCT; Part III of the paper will be presented at the 1995 FSCT Annual Meeting in St. Louis; and the committee is planning to discuss accelerated weathering versus exterior exposures at Kent State University in early September.

DETROIT

The Detroit Society is continuing its research on interpenetrating polymer networks (IPN) and is focusing on the development of an IPN that is radiation curable. The operational plan is to have a paper ready for the 1996 APJ/Voss competition. The Society is also planning to work with the Pittsburgh Society on a technical project.

GOLDEN GATE

The Golden Gate Technical Committee was not very active over the past year, and the revisions and extra data on the coefficient of friction project failed to make the APJ/Voss Award deadline. The Committee was involved in the Western Coatings Show in February, which included 39 technical presentations in nine sessions. Golden Gate plans to enter a paper in the 1996 APJ/Voss competition.

KANSAS CITY

The Society is currently involved in compiling the results of three studies. The projects include: extender exposure based on CPVC; degree of resistance to staining of various waterborne coatings over aged plywood; and educational seminars for children. The Society Technical Committee is also responsible for securing speakers for both monthly meetings and the yearly meeting with the St. Louis Society.

LOS ANGELES

Plans are underway for a study on low/high VOC coatings. The Society will contact the Inter-Society Color Council for more information on a color project currently being worked on. Los Angeles presented two papers at the 1994 Annual Meeting in New Orleans.

LOUISVILLE

Louisville held a one-day technical symposium in April. There were eight speakers and the theme was "Spectrum of Coatings Science." The program drew 80 attendees. The Society's Technical Committee will be conducting another program in 1996.

MONTREAL

The Montreal Society is undertaking three projects at this time: an acid rain project with the Northwestern Society; a study of ultrafine TiO₂ to determine if it can improve the weatherability of stains; and an evaluation of latex sealers on light cement joint compounds on hiding and gloss variations.

NEW YORK

The New York Society will present a paper at the 1995 FSCT Annual Meeting entitled, "Recent Advances in Additives and Modifiers for Coatings." She announced that the Society recently celebrated its 75th anniversary. The Society did a VOC testing video several years ago and is interested in producing additional videos in the future. Also, a literature search on reactive diluents and their role with various types of coatings is being conducted by the Society.

NORTHWESTERN

The Society Technical Committee has re-submitted its acid rain paper to the JCT for publication, after making final edits. The paper will appear in the November 1995 issue. The acid rain project is being continued. The Technical Committee is contemplating another project, a study of wet adhesion and the relationship to water vapor transmission through the film, including the effect on corrosion. The Society also has been working on free formaldehyde contents in coatings materials, and this will be available when additional data is collected.

PACIFIC NORTHWEST

The Society has been working on rewriting the architectural specification manuals for paint, wallcovering, and wallboard. These specs are part of a two-year guarantee program for inspection. This project is being done in conjunction with the Painting and Decorating Contractors of America. Once this project is completed, the Chairs of the three sections will meet to discuss potential topics for future projects.

PHILADELPHIA

The Philadelphia Society reported on its current two-meeting concept, which consists of one regular meeting and one technical meeting. The Society is trying to change this format and concentrate on one meeting each month. Once the Society reduces the number of meetings, it can embark on new technical projects. Philadelphia plans to hold its first Eastern Training Conference in May 1996. This would consist of a technical program and exhibits. The Society's 1995 technical program entitled, "Industrial Maintenance Coatings—More than Just a Coat of Paint," drew 76 attendees.

PIEDMONT

The Society held a mini-trade show in March. Plans are underway to deliver its first technical paper at the FSCT Annual Meeting in St. Louis. The title of the paper is "EPA Reference Method 24 Round-Robin Analysis of Wood Furniture Amino Plast Coatings." The Society is working with the EPA and the Los Angeles Society/Cal Poly on VOC reg-neg testing activity.

PITTSBURGH

The Pittsburgh Society has reactivated its Technical Committee. The Society offered to help the Cleveland Society with its annual program speakers.

ROCKY MOUNTAIN

The Society will be delivering a paper at the 1995 FSCT Annual Meeting in St. Louis. The title of the paper is, "The Effects of Reverse Side Substrate Insulation on the Exterior Exposure Performance of an Acrylic Emulsion Coating." There are no plans in the immediate future for additional projects, but the Society does have a list of potential topics for consideration. One project deals with high infrared absorbing pigments and the other is a potential review of specific coatings.

St. LOUIS

The St. Louis Society has been working on a project entitled, "The Effect of Varying Stochiometric Curing Ratios in High Solids Two Component Epoxy Coatings," and wanted to look at the effect of these on measured VOCs. The Society had trouble assembling a Technical Committee this year and contacted both the CDIC and Kansas City Societies for assistance in the project. The Society also worked with Mike Van De Mark, of University of Missouri-Rolla, to review the work on the tests and will continue this in the future. The Committee will be working on the tests in the future.

SOUTHERN

The Society is working on a report on the yellowing of drywall. The tests the Society ran and the steps that need to be taken to prevent yellowing were discussed. Also discussed was the effect of titanium dioxide on the tests.

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FSCT Update

FSCT President-Elect Darlene Brezinski reviewed the status of activities within FSCT and its organizational direction. She said FSCT is at a critical point in its existence where it needs to make important decisions and wants feedback in this regard from its Constituent Societies and members.

Dr. Brezinski reviewed the Mission Statement of FSCT, which reads:

"The Mission of the FSCT is to provide technical education and professional development to its members and the industry through its Constituent Societies and collectively as a Federation."

APJ/Voss Award

Fred Anwari reported on the status of the changes in the APJ/Voss Award. He discussed the background of the award and

that the TAC would now be responsible for the review of the papers entered in the competition. The attendees each received a copy of the revised judging guidelines developed by the TAC for the competition. Mr. Anwari reviewed each of the definitions of the categories and explained how the totals would be determined.

Society Speakers Program

Valerie Braund reviewed the guidelines of the Society Speakers program, which will be judged by the TAC.

The Committee sought judges for the competition. Ms. Pollano asked each of those interested in judging during the Annual Meeting to contact her regarding participation. She added that it is required that the judges be available for all presentations, to ensure a uniform rating.

Lead Abatement Program

Mary McKnight, of NIST, made a presentation entitled, "NIST-BMD Lead-Hazard Abatement and Control Activities." She reviewed some of the reasons for the concerns of lead poisoning and said the legislation was done in response to rising levels of lead in the blood of children. Ms. McKnight also reviewed the level of lead as a coatings pigment, citing that white lead peaked in 1920 and red lead in 1970, thus it is difficult to find lead in paints today.

Ms. McKnight provided a brief history of the lead regulations and standards, highlighting some of the things that were done to reduce the amount of lead in coatings in the past. In addition to reviewing the past legislation, she said that rules can be expected soon in the areas of training/certification, health based standards and notification on the sale of property.

She also reviewed the NIST XRF Study and said the goal was to develop laboratory-based evaluation protocol to predict field performance, which was approached by systematically investigating the factors thought to affect response.

Another area covered in the presentation dealt with the Title X impacts on Paint, which changed the emphasis from lead-based paint to lead-based paint hazards. These hazards include deteriorated lead-based paint, lead-based paint on high wear surfaces, leaded dust and leaded soil.

Ms. McKnight discussed the differences between control and abatement and also discussed the field assessment methods such as portable X-ray fluorescence, chemical spot tests, chemical colorimetric procedures, and electrochemical procedures.



49th Annual Spring Symposium

May 2-4, 1996

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Seattle, WA

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

CIDIC

Active

Strickland, Bruce G.—Chemical Products, Cincinnati, OH.

CHICAGO

Active

Anderson, Ronald L.—Amoco Chemical Co., Naperville, IL.
 Berwanger, Dale J.—The Valspar Corp., Kankakee, IL.
 Buwolda, Barbara A.—The Sherwin-Williams Co., Chicago, IL.
 Erhan, Sevim Z.—U.S. Department of Agriculture, Peoria, IL.
 Farez, Tayeb—River Valley Coatings, Aurora, IL.
 Hacek, Katherine A.—The Valspar Corp., Kankakee.
 Johnson, Eddie C.—The Sherwin-Williams Co., Chicago.
 McKee, Catherine T.—Finishes Unlimited, Inc., Sugar Grove, IL.
 Petisce, James R.—DSM Desotech, Elgin, IL.
 Riviers, Daniel J.—Bemis Manufacturing Co., Sheboygan Falls, WI.
 Vora, James R.—Material Sciences, Elk Grove, IL.

Associate

Carey, Alan R.—MB Both, Wheaton, IL.
 Cox, Todd A.—Hickson Specialties, Schaumburg, IL.
 Labuda, Jason S.—Daniel G. Hereley Co., Des Plaines, IL.
 Large, W. Douglas—The CP Hall Co., Naperville, IL.

CLEVELAND

Active

Jaruff, Juan E.—XIM Products Inc., Westlake, OH.
 Swank, Jessica—Gibson-Homans, Twinsburg, OH.
 Uscheek, Dave P.—The Analyst, Chardon, OH.

Associate

Hirsch, Marc S.—Dow Chemical, Midland, MI.
 Patrick, Joseph Jr.—MF Cachat Co., Cleveland, OH.

DETROIT

Active

Beleck, Scott J.—Parker Amchem, Madison Hts., MI.
 Boyle, Esley—Standard Paint Co., Detroit, MI.
 Marshall, Paul W.—BASF Corp., Whitehouse, OH.
 Parekh, Chetan S.—Kay Automotive Graph, Lake Orion, MI.
 Pierce, Jeff H.—BASF Corp., Whitehouse.

Associate

Kucinski, Kimberly A.—Dow Corning Corp., Midland, MI.

LOUISVILLE

Active

Zanchi, Joseph D.—Akzo Nobel Coatings, Inc., Louisville, KY.

NEW YORK

Active

Goldstein, Howard—Amsterdam Color Works, Bronx, NY.
 Iyengar, Revathi—Ciba-Geigy Corp., Ardsley, NY.
 Kardash, Nadia—Amsterdam Color Works, Bronx.
 Laine, Patrick—Byk-Chemie USA, Wallingford, CT.
 Leotsakos, George S.—Technical Coatings, Flanders, NJ.
 Price, Joanne M.—Color-Plus, Union, NJ.
 Sikora, Jeffrey K.—International Paint, Union.
 Solimeno, Robert D.—International Paper, Tuxedo, NY.
 Sui, Manshi—Shamrock Technologies, Newark, NJ.

Associate

Jones, Timothy D.—BASF Corp., E. Windsor, NJ.
 Kraushaar, Douglas J.—Tioxide Americas Inc., Clayton, NJ.
 Millard, Keith A.—SC Johnson Polymer, Bedminster, NJ.
 Mycek, John A.—General Laboratory, Wayne, NJ.
 Royal, Gilbert V.—Argo Industrial, Clark, NJ.

NORTHWESTERN

Active

Boedigheimer, Jason P.—Hirshfield's Paint Mfg. Co., Minneapolis, MN.
 Gropel, Bill J.—The Valspar Corp., Minneapolis.
 Hamlow, Jonathan M.—ILSR, Minneapolis.
 Riddick, Wayne T.—McWhorter Technologies, Minneapolis.

Associate

Erickson, Robert L.—McWhorter Technologies, Carpentersville, IL.
 Marr, Darren, G.—Guertin Marr Co., Bloomington, MN.

Educator/Student

Li, Jumping—North Dakota State University, Fargo, ND.

NEW PUBLICATION

Coming Soon—
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“Silicones in Coatings”

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For more information, contact Meryl Simon,
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 492 Norristown Rd., Blue Bell, PA 19422
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PACIFIC NORTHWEST

Active

- Bowman, Ken P.—Modco Specialty Coatings, Delta, B.C.
Lozinski, Larry A.—Fargo Paint & Chemicals, Calgary, Alb.
Santella, Ed A.—Gibson Paints, Surrey, B.C.
Stubbs, Hailey J.—Flecto Coatings Ltd., Richmond, B.C.

Associate

- Doan, Garry C.—Quadra Chemicals (Western) Ltd., Delta, B.C.
Riddell, John Lees—Emchem Marketing Inc., Richmond, B.C.

PHILADELPHIA

Active

- Bielski, John F.—Sentry Paint Technology, Darby, PA.
Gilcinski, Andrew G.—Air Products & Chemicals, Allentown, PA.
Hess, Robert A.—Armstrong World Industries, Lancaster, PA.
Moon, Molly—Betz Metchem, Trevose, PA.
Thompson, Robert D.—Elf Atochem North America Inc., King of Prussia, PA.

Associate

- Barone, Glenn S.—Hercules/Aqualon, Wilmington, DE.
Lamendola, Ronald J.—Sun Co., Inc., Downingtown, PA.
Petershelm, Jerry K.—Seegott Inc., Morgantown, PA.
Richart, Douglas S.—D.S. Richart Associates, Reading, PA.

Sherman, Susan J.—DuPont Co., Wilmington.

PIEDMONT

Active

- Smith, Alan—BASF Corp., Charlotte, NC.

PITTSBURGH

Active

- Charske, Todd H.—PPG Industries, Inc., Allison Park, PA.
Crytzer, Thomas A.—PPG Industries, Inc., Springdale, PA.
Willock, George J.—Neville Chemical Co., Pittsburgh, PA.

Associate

- Kassner, James E.—Bayer Corporation, Pittsburgh, PA.

ROCKY MOUNTAIN

Active

- Theriot, Bill—OHM's Research Products, Phoenix, AZ.

SOUTHERN

Active

- Keller, T. Hugh—Crozier-Nelson Sales, Heber Springs, AR.
Latimer, Don—Archway Sales, Inc., Memphis, TN.

Associate

- Pearson, Bruce C.—3M Specialty Chemicals, Cumming, GA.

ST. LOUIS

Active

- Ray, Charles J.—U.S. Paint, St. Louis, MO.

Associate

- Reitter, Chuck—American Paint Journal, St. Louis, MO.

TORONTO

Active

- Cassidy, Karen L.—Technical Coatings, Burlington, Ont.
Mackimmon, Jamie S.—KUB Coatings, Kingston, Ont.
Noel, Shahnazarian—Canada Colors Chemicals, Don Mills, Ont.
Piton, Mark C.—Baylex Technologies Inc., Mississauga, Ont.
Quintal, Elizabeth—Sico Inc., Etobicoke, Ont.
Sarhan, Hani—Dominion Colour Corp., Pickering, Ont.
Sung-San Shen, Tom—A & A Coatings and Packaging, Brampton, Ont.
Soltes, Mark A.—Valspar Inc., Westhill, Ont.
Whitlock, Neil—Sico Inc., Etobicoke.

Associate

- Bijl, Gerrit—Canadian General Tower, Cambridge, Ont.
Collins, Jill—3M Canada, North York, Ont.
Gilliard, Scott A.—Zochem, Brampton, Ont.
Kokoletos, Nicole O.—Nacan Products Ltd., Brampton.

Future Society Meetings

Baltimore

(May 16)—General Meeting and Elections.

Birmingham

(May 2)—67th Annual General Meeting.

Chicago

(May 10)—Annual Awards Banquet.

Cleveland

(May 21)—Awards/Past-President/Spouse's Night.

Los Angeles

(May 8)—"THE LATEST TRENDS IN ACCELERATED CORROSION TESTING: PROHESION, QUV AND AUTOMOTIVE CYCLIC COR-

ROSION TESTING"—Steve Grossman, Q-Panel Corp.

New York

(May 14)—Pa Vac Awards Night. "COLORED ORGANIC PIGMENTS FOR THE COATINGS INDUSTRY"—Peter Lewis, Sun Chemicals.

Pacific Northwest

(May)—"THE LATEST TRENDS IN ACCELERATED CORROSION TESTING: PROHESION, QUV AND AUTOMOTIVE CYCLIC CORROSION TESTING"—Steve Grossman, Q-Panel Corp.

Philadelphia

(Apr. 26)—Awards Night

(May 8-10)—Eastern Training Conference and Technical Seminar.

Pittsburgh

(May 13)—Society Officer Elections and Spouses' Night.

Rocky Mountain

(May 6)—"THE LATEST TRENDS IN ACCELERATED CORROSION TESTING: PROHESION, QUV AND AUTOMOTIVE CYCLIC CORROSION TESTING"—Steve Grossman, Q-Panel Corp.

Toronto

(May 13)—"THE APPLICATION OF SCIENCE TO THE EXAMINATION AND CONSERVATION OF MUSEUM OBJECTS"—Sandra Lawrence, Ontario Gallery of Art.

JCT Review Process Questioned

Letter

TO THE EDITOR:

I have read the November 1995 issue of the JOURNAL OF COATINGS TECHNOLOGY. It contains a "Guide for Authors" which outlines the requirements for papers submitted for publication in this journal. One specific requirement is appropriately highlighted.

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

I thoroughly support this policy, as it protects the integrity of the publication, and maintains its status as the preeminent coatings scientific journal in the world.

I was then distressed to find the article, "Aliphatic Epoxy Emulsion Crosslinker for Waterborne Coatings," by D.R. Eslinger on page 45 of the same issue. This article deals with the performance of a commercial product, and by any reasonable measure, is promotional in nature. In my view, it would be much better suited for one of the trade magazines rather than a prestigious scientific journal.

Specifically, the article deals with Chempol® 20-1642, which is identified only

as an "aliphatic epoxy emulsion." The specific composition or structure of the material is never disclosed. It is referred to repeatedly in the article by its tradename. As such, it adds little to the scientific coatings literature. The summary is not a summary in the classic sense, but is simply a listing of features and benefits of this commercial product. This is much more appropriate for a technical data sheet than for the JCT.

The primary acrylic emulsion is referred to by its tradename, Chempol 20-4301. It is identified only as a styrene-free acrylic hydrosol emulsion with an acid value of approximately 40. Again, no compositions or structures are provided to enhance the scientific value of this article. It is claimed that this emulsion is "used for high quality indus-

trial finishes . . . Its primary features are . . ." These claims and features are unsubstantiated, and are promotional in character.

Other commercial products are referred to by their tradenames, without further identification or explanation. These include Chempol 10-1744, Chempol 10-0509, Coroc A-2678-M, and Butyl Cellosolve. Again, this approach is much more appropriate for a technical data sheet than for the JCT.

I thoroughly agree with your policy concerning the commercial content of papers for publication in the JCT. This policy must be applied universally, and the standards must be maintained.

MICHAEL J. WATKINS
Houston, TX

Reply

DEAR MR. WATKINS:

The article, "Aliphatic Epoxy Emulsion Crosslinker for Waterborne Coatings," by R. Eslinger, on page 45 of the November 1995 issue of the JCT does deal with a commercial product and has a promotional aspect to it.

The paper was rejected by a panel of reviewers, including myself, for publication as a "Technical Article" in the JCT in part because of its strong commercial flavor. Several of the reviewers including myself felt that the article had sufficient merit to justify publication in the JCT as a "Feature Article."

The reasons for this were:

1. The manuscript dealt with a topic of current interest to many JCT readers.
2. The treatment of the topic was technically sound.
3. The manuscript was well written and had many useful observations and teachings for the coating chemist.
4. The general claims of the author were documented and specific tests were recommended and discussed to substantiate these claims.

I am satisfied, after reviewing the Eslinger article and Mr. Watkins' letter, that the publishing of this article as a Feature Article was a sound decision, and I would in good conscience recommend the publication of this manuscript or similar article in the JCT in the future.

I do take issue with some of Mr. Watkins' comments about the use of tradenames in JCT articles. Since much coating work involves the use of proprietary products, it is

not inappropriate to use tradenames if these materials were used in the work reported in the manuscript as long as the author adheres to JCT guidelines. The Eslinger manuscript satisfies these guidelines as does the Northwestern Society's paper that appears under the Technical Articles Section in the same issue and also makes liberal use of proprietary materials and tradenames.

Mr. Watkins raises a significant question in his letter. To what degree should commercial promotion and commercial purposes be permitted in JCT Feature Articles?

I have rejected a number of product data sheet type manuscripts that have been submitted as Feature Articles and will continue to do so. I also have rejected a number of manuscripts whose commercial character, in my opinion, makes them better suited for trade journals. On the other hand, I also see some work appearing in trade journals that I think is suitable for publication as a Feature Article in the JCT.

I hope we hear from other JCT readers. How many would like to see more Eslinger type manuscripts? How many would agree with Mr. Watkins and would prefer that the JCT leave this type of manuscript to the trade journals?

Finally, I would like to say that I am thrilled that at least one JCT reader read an article in a current issue of the JOURNAL OF COATINGS TECHNOLOGY and was moved enough to write a thoughtful letter to the JCT giving his candid opinion of its aims and content. I thank Mr. Watkins for his comments. It will help us to make the JCT a better publication.

PERCY E. PIERCE
JCT Editorial Review Board

TO OUR READERS:

The JCT has experienced a number of changes in recent months. Our goal has been to enhance the appearance, format, and content to appeal to a broader segment of the FSC membership and the coatings industry.

The Journal is recognized for the quality of its technical research articles; its editors and reviewers are committed to maintaining this quality. However, as illustrated by the letters on this page, issues arise as we expand our editorial coverage.

We need your feedback! Your comment, suggestions, and reactions to the changes will help guarantee that the JCT remains an effective informational tool for the coatings industry.

Please address your letters c/o The Editor, JCT, 492 Norristown Rd., Blue Bell, PA 19422. We're looking forward to hearing from you!

—PVD
Editor, JCT

Mechanisms of Film Formation Explored

Letter

TO THE EDITOR:

In the last few years, I have seen many papers that try to develop mechanisms of film formation of various coatings. After over 45 years of experience in coatings science, I continue to be amazed by the difficulty of understanding the process of film formation from a liquid coating. In most situations a layer from 10 to 100 μ thick might be considered very thin and without much variability, but the nature of coating formation makes it almost impossible to prepare a totally homogeneous, attached film. The very process of forming a film which has good adhesion to the substrate insures that it will not be homogeneous. A consideration of the events that occur during film formation leads to the separation of the process into at least four distinct cases.

I. Formation from a homogeneous solution by evaporation of the solvent, but no reaction.

II. Formation from a homogeneous solution by solvent evaporation as well as a concurrent reaction. This can be subdivided further into case IIa where the reaction is with an external agent such as oxygen or water, and IIb where the reaction is between two ingredients of the dissolved solids, such as a polyol and a nitrogen resin or a polyisocyanate.

III. Formation from a non-homogeneous liquid consisting of simultaneous evaporation of the volatile liquid and coalescence to form a continuous film.

IV. Formation from a non-homogeneous liquid accompanied by some form of reaction between various portions of the solids.

In every case, however, some factors remain constant:

Evaporation occurs predominantly from the surface, so that during the process the surface has different physical as well as chemical properties than the interior of the film.

Reaction rate (where reactions occur) will be different at the surface compared to the interior. If the reaction is with an external reagent, the film surface will become less permeable and the reaction in the interior will be slower, so that much of it will occur after the solvent is gone. If the reaction is with a co-reactant and requires elimination of a reaction product, such as water or alcohol, the dry and reacted surface will retard this, so that the extent of reaction in the interior will be less than at the surface. In all cases shrinkage will occur, and this shrinkage will be different at the surface than at the substrate interface, where it will be severely restrained by the adhesion of the film to the substrate. Every one who has dried a film on an aluminum foil and seen it roll into a coil was witness to this fact.

The environment in which an element of the film dries affects its properties; if much of the solvent evaporates before the T_g of the film/solvent blend reaches the evaporation temperature, the film will be under less strain than if much solvent is left at that point and must evaporate while the film is rigid. If the reaction is incomplete when the glass transition of the polymer/solvent blend reaches the cure temperature, the reaction will stop as diffusion is slowed by many orders of magnitude. Since these factors will differ from surface to substrate, the film will be inhomogeneous through its thickness, more so for crosslinked films than for uncrosslinked films. In every case the surface will be more crosslinked, more rigid, and under greater stress than the interior near the substrate, and the thicker the film the greater the differences.

Another problem common to coatings is the changes in surface tension that occur during drying and curing of cases I and II. Since solvents have much lower surface tensions than most polymers, the surface tends to increase in surface tension as solvent evaporates. This is a thermodynamically unstable situation and results in the development of a circular flow within the film that causes the formation of Bénard cells; these have been shown to lead to weak spots at their junctions, and the film will often start to crack at these junctions. Thus the film is not only inhomogeneous through its vertical direction, but also in its horizontal plane.

One result of these processes is the failures observed in temperature cycling of films since in most cases, except for certain plastics, the substrate has a lower coefficient of thermal expansion than the coating, so that the film is constrained at the substrate inter-

face, and can't expand on heating or shrink on cooling. This sets up stresses that cause failures such as cracking or, if adhesion is weak, peeling.

If the film is not crosslinked homogeneously, water and solvent exposure will also cause problems, since interior swelling will likely be greater than surface layer swelling. Thus, recoating soon after the initial cure or drying will result in wrinkling and other failures.

Films formed from dispersed polymers such as latexes will also not be totally homogeneous, since the shrinkage that occurs during drying will be restrained at the substrate interface. Therefore, many of the same problems will be observed. In addition, for case IV, reactions will often occur at the particle interface to the extent that diffusion of the reagents into the interior of the particle is stopped, so inhomogeneities will also exist between the surface and the interior of the latex particles. Only if the reactions are sufficiently slow to allow thorough diffusion before reaction will this be avoided.

I am making these arguments to try to point out that any efforts to develop theories of film formation that will lead to better understanding of this process and from there to better products must also deal with the fact that none or very few of the films we work with are homogeneous and simple structures. The fact that so many of them work as well as they do is a tremendous credit to the knowledge and ingenuity of the coatings scientists, but let us not imagine that we are even close to understanding the real nature of the structures we deal with.

WERNER S. ZIMM
TUCSON, AZ

Join the FSCT at the
International Coatings Expo and Technology Conference
(formerly Annual Meeting and Paint Industries' Show)

FEDERATION OF SOCIETIES
FOR COATINGS TECHNOLOGY



October 23-25, 1996

McCormick Place North • Chicago, IL

Chicago Society member **Alison Azar** was appointed as Sales Representative for the sales team at the M.F. Cachet Co., Cleveland, OH. Based in Chicago, IL, Ms. Azar will cover Illinois, Western Michigan, and Northern Indiana.

Leonard S. Schwartz was named President and Chief Operating Officer for Aceto Corp., Lake Success, NY. Effective July 1, 1996, Mr. Schwartz will succeed **Robert E. Parsont** who is retiring. Mr. Schwartz is a member of the New York Society.

In other news, **Vincent Miata** was promoted to Vice President and will also assume the duties of Senior Executive of the Industrial Chemicals Department.

Richard L. Cartlidge was named Vice President-Finance and Chief Financial Officer for SCM Chemicals, Baltimore, MD. Mr. Cartlidge will plan, organize, direct, and control all of the company's financial functions.

Rick Fisher has joined the staff of Fusion UV Curing, Gaithersburg, MD, as Market Manager, Converting. Mr. Fisher has experience in coating and formulating, silicone release coatings, and pressure sensitive adhesives.

Edward H. Hoerster was appointed Vice President, Specialty Coatings for Akzo Nobel Coatings Inc., Troy, MI. Mr. Hoerster will manage the company's Specialty Coatings Unit in North America.

Harvey C. Johnson has assumed the title and responsibilities of New England Sales/Service Representative for the Powder Coatings Division of Ferro Corp., Cleveland, OH. Mr. Johnson will be responsible for the sales and service of Ferro's Vedoc® powder coatings to the general industrial markets in Vermont, Connecticut, Maine, Rhode Island, Massachusetts, and Eastern New York.

Scott W. Borst has been promoted to the position of Vice President—International for ANGUS Chemical Co., Buffalo Grove, IL. In his new position, Mr. Borst will develop and implement strategy to capitalize on market opportunities in the Pacific Rim, India, Latin America, and China.



S.W. Borst

Mr. Borst is a member of the Chicago Society.

The Gesellschaft Deutscher Chemiker (German Society of Chemists) has elected **George R. Pilcher**, of Akzo Nobel Coatings, Inc., Columbus, OH, as a Corresponding Member of its Paints and Pigments Division.

Mr. Pilcher was recognized for his role in furthering the education of the industry and public regarding the positive role of coatings chemistry in modern life. The Society also cited his delivery of the Keynote Lecture at the 50th Meeting of the Division in 1992 titled "Toward the Year 2000: How Will Technology Triumph?"

A member of the CDIC Society, Mr. Pilcher is a member of the FSCT Publications Committee. Currently, he is Chairman of the Federation's Joseph J. Mattiello Lecture Committee and a Trustee of the Coatings Industry Education Foundation (CIEF). Mr. Pilcher has also served on the Roon Awards Committee, and as Past-President of the CIEF.



G.R. Pilcher

Surface Protection Industries, Inc., Los Angeles, CA, has promoted **Harry Sheth** to Vice President of Research and Development. In this capacity, Mr. Sheth will assume responsibility for the technical aspects of the company, including research and development. He is a member of the Los Angeles Society.



M. Hedstrom

comprehensive analyses for customers in the paints, coatings, polymers, and resins industries.

Mark Hedstrom was named Group Leader of the Analytical Services Division of Paint Research Associates (PRA Laboratories, Inc.), Ypsilanti, MI. Mr. Hedstrom, a member of the Detroit Society, will spearhead the efforts of performing

Sonoco Products Co., Hartsville, SC, has announced the following three appointments for its new plastic drum manufacturing facility in Hazleton, PA.

Jim Craig was named Plant Manager. He will be responsible for the new plant start-up, including equipment procurement, workforce hiring and training, and customer development.

Phyllis Lynch was appointed as Sales Service Representative. Ms. Lynch will be the liaison between the regional sales office and the manufacturing facility.

Serving as Regional Sales Manager is **Nancy Harrington**. Ms. Harrington will oversee sales of plastic and fibre drums in the Northeast and Canada.

The promotion to Sales Manager/Systems Engineer for Union Process, Akron, OH, has been accepted by **Robert E. Schilling**. He will be responsible for sales of the company's attritor grinding mills and deltamill small media mills.

Degussa Corp., Ridgefield Park, NJ, has appointed **Keith J. Herbert** as Business Director, Stationary Emission Control Catalysts. Mr. Herbert will be responsible for the global business of the company's SEC catalysts.

In other news, **Michael Hirschhäuser** has been named Product Manager, Silica Division. Mr. Hirschhäuser will have product management functions for hydrophilic Aerosil® fumed silicas.

James A. Sharp has accepted the promotion to Vice President of Carl Zeiss, Inc., Thornwood, NY. In his new position, Mr. Sharp will direct all research and development activities related to Zeiss' microscopy systems, as well as worldwide sales, marketing, and service operations.

ICI Surfactants, Wilmington, DE, has announced the following personnel changes. **David C. Waterman** was named Director of Strategic Planning/Purchasing; **Christopher M. Garvey** has accepted the position of Industrial Business Manager; **Christopher W. Siemer** was appointed Ag Business Manager; and **Craig J. Aiken** will become Household Business Manager.

Nacan Products Ltd., Brampton, Ont., has appointed **Jim Wise** as Sales Manager, Resins & Specialty Chemicals Division. A member of the Toronto Society, Mr. Wise will be responsible for the sales of a wide range of polymers to the paint and coatings industry throughout North America, as well as sales to the adhesive, paper, construction, textile, and cosmetic industries in Canada.



J. Wise



S.P. O'Connor



F.M. Armbrecht



L. Capuano

Witco Corp., Greenwich, CT, has named **Sean Patrick O'Connor** to the position of Vice President of Specialty Products for Witco's Petroleum Specialties Group. Mr. O'Connor will handle the group's worldwide sales and marketing of industrial and specialty sulfonates used by the lubricants, rust preventatives, and coatings industries.

Elsewhere, **F.M. Ross Armbrecht Jr.** has assumed the title of Vice President for Research and Development for the Oleo/Surfactants Group. He will oversee worldwide product and applications development and technology improvement for the company's oleochemical and surfactants products.

Lorraine Capuano has accepted the newly created position of Director of Organization Development and Training. Dr. Capuano will be responsible for developing new programs in performance management and succession planning.

Buckman Laboratories, Memphis, TN, has appointed **Jack Treas** to the position of Vice President, Process Chemicals Division.

Also, **Mark Koskiniemi** was named Vice President, Human Resources.

The American Society for Testing and Materials (ASTM), West Conshohocken, PA, has elected the following new members to the 1996 Board of Directors:

Chairman—**Arthur Cohen**, of the Copper Development Association; Vice Chairman—**William M. Edmunds**, of Owens-Corning Fiberglas Corp.; Treasurer—**James S. Pierce**, of U.S. Bureau of Reclamation; Directors—**James D. Converse**, of Eastman Kodak Co.; **David E. Ederly**, of National Institute of Standards and Technology; **Gary M. Kralik**, of Naval Facilities Engineering Command Standards Office; **Hugh C. MacDonald**, of MacDonald Masonry Consultants Inc.; **Scott E. Nushart**, of ATM Corp.; and **Richard J. Schulte**, of International Approval Services.

Eastman Chemical Co., Kingsport, TN, has appointed **Norman Wong** as Business Development Director for Greater China. Mr. Wong will be based at Eastman's Hong Kong sales office.

In other news, **Garland S. "Buddy" Williamson** was named President of the Texas Eastman Division, Longview, TX. Mr. Williamson replaces **Paul D. Folzenlogen**.

The company also announced that **Bruce E. Moore**, currently President of Singapore-based Eastman Chemical Asia Pacific (ECAP) Private Ltd., will assume the additional duties of Managing Director.

In addition, **Marc R. Ramsdale** will relocate from Kuala Lumpur, Malaysia, to Singapore to become Vice President and Director of ECAP.

Tara Nuszer has joined the staff of Ultra Additives Inc., Paterson, NJ, as Technical Service Manager. Ms. Nuszer will support national sales activities by acting as the primary liaison between the company's technical service and sales departments.

OBITUARIES

Harry Feinberg, Founder and Chairman of Duron Paints & Wallcoverings, Inc., died on February 27 at the age of 85.

Mr. Feinberg's career in the paint and coatings industry began with the H.B. Davis Co., in Baltimore, MD. In 1949 he went out on his own and purchased a one-half-interest in the Norman Paint Co, which he renamed Duron Paints. By 1974, Duron was flourishing and Mr. Feinberg bought out his partner and continued to expand the company. In the early 1980s, he entered a long, semi-retirement.

Mr. Feinberg is survived by his wife; two daughters; a son; and six grandchildren.

William C. Hunt, former Executive Vice President and Chief Operating Officer for Tnemec Manufacturing passed away on February 13. He was 65 years old.

Jack L. Ferrell was elected President of the Society of Manufacturing Engineers (SME), Dearborn, MI. Retired from TRW Inc. where he served as Vice President, Manufacturing & Systems, Space & Defense Sector, Mr. Ferrell will emphasize service excellence during his term of office.

Why Renew?

Check Out Five Great Reasons Why You Should Renew Your Membership In The FSCT

A 1-year subscription to the **JOURNAL OF COATINGS TECHNOLOGY**, the technical publication of the coatings industry, is included with your membership.

Monthly Society technical talks offered locally keep **YOU** informed of the ever-changing technology in the coatings industry.

Incredible **networking** opportunities with industry colleagues.

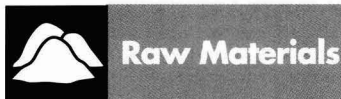
Federation publications and seminars are available to you at substantial **\$\$** savings.

Special **Member rates** for registration to the FSCT's International Coatings Expo and Technology Conference (formerly the Paint Industries' Show).

Your Membership In The Local Society Includes Membership In The Federation



For more information, contact your local Society, or write to Federation of Societies for Coatings Technology, 492 Norristown Rd., Blue Bell, PA 19422 (610) 940-0777 • Fax: (610) 940-0292



Luster Pigments

Two new grades have been added to the Mearlin® Dynacolor® series of luster pigments. Dynacolor GG (green) and BB (blue) consist of an absorption colorant deposited directly on a titanium dioxide-coated mica interference pigment. The Mearl Corp. colors are nontoxic, nonmetallic powders recommended for plastic applications, general surface coatings, and printing inks.

Circle No. 30 on Reader Service Card

Surface Modifier

A new low VOC surface modifier for titanium dioxide pigment is recommended for use by titanium dioxide pigment slurry manufacturers, paint and coatings manufacturers, and titanium dioxide pigment dispersion manufacturers. Tismod 94 reportedly provides improved physical characteristics such as drying time, abrasion, scrub resistance, and hardness. The dual-action surface modifier is available from IPMC Inc.

Circle No. 31 on Reader Service Card

Biocide

Calgon Corp. has received EPA registration in California for the use of Tektamer® 38 biocide as an in-can preservative in paints, coatings, adhesives, emulsions, and slurries. The product contains no formaldehyde or heavy metals and is designed for effectiveness over a wide pH range. The biocide is compatible with many other actives.

Circle No. 32 on Reader Service Card

Corrosion Inhibitor

A modified calcium pyroborate pigment for use as a corrosion inhibitor in coatings is lead, chromate, zinc, and barium free. The white pigment may be formulated into water and solvent-based coatings for consumer, maintenance, and industrial use. Butrol 9104, as well as formulating suggestions and literature on this product, is available from Buckman Laboratories International, Inc.

Circle No. 33 on Reader Service Card

Polyester Resins

Hybrid formulations of Rucote 555 and Rucote 555 HF, new carboxyl polyesters, have been developed by Ruco Polymer Corp. These resins are engineered to yield all-purpose powder coatings that combine good overall properties with competitive costs. Reported benefits include lower temperature cure capability, low resin viscosity, and formulating versatility.

Circle No. 34 on Reader Service Card

Dispersants

ICI Surfactants has introduced a new line of proprietary polymeric dispersants, which are engineered for dispersion of a range of organic pigments in water. Hypermer® 2434, 2630, and 2678 polymer surfactants offer zero VOC and contain no alkylphenol ethoxylates. Reported benefits include stabilization, color development, and minimal viscosity drift over time.

Circle No. 35 on Reader Service Card



Formulation

PC-based software, Formu-Tools™, has been developed to help coatings formulators manage, store, and retrieve raw material and formula information and make formulation analysis calculations. The program can also calculate the amounts of ingredients required for a formulation, meeting prescribed constraints commonly used in formulation work (P/B, VOC, PVC, fixed amount, ratios). This product is available from DTW Associates, Inc.

Circle No. 36 on Reader Service Card

Paint Problem Solver

An interactive CD-ROM version of the *Paint Problem Solver*, published by the National Decorating Products Association, is available. Using computer prompts in the program, a customer can find their specific paint problem and learn its cause as well as how to solve it or avoid it on future projects. They can also generate a printout listing specific product recommendations for solving their paint problem.

Circle No. 37 on Reader Service Card

Weighting Factors

A software package provides 72 sets of tristimulus weighting factors as well as nine standard and recommended CIE illuminants: A, C, D50, D55, D75, F02, F07, and F11. A text file explains file layouts and suggests ways to read files under program control. This tristimulus weighting factors software, adjunct to ASTM Standard Practice E 308, "Computing the Colors of Objects Using the CIE System," is available from ASTM.

Circle No. 38 on Reader Service Card

Chromatography

The Perkin-Elmer Co. has introduced Turbochrom™ Results Manager (TCRM) version 1.1, the latest version of the company's optional database software package for the Turbochrom Professional chromatography

data handling system. TCRM stores chromatographic results data and images in a relational database, providing users with a varied selection of queries and formats for sorting, organizing, and printing information. System suitability data and method/sequence parameters can be added.

Circle No. 39 on Reader Service Card

Remote Control

Multi-Comm software from Athena Controls allows remote monitoring and control of up to 100 Athena XT series temperature or process controllers. Up to 16 controllers, connected via an RS-485 network, may be viewed on the computer screen at one time with a full-color emulation of each instrument's front panel display showing process value and setpoint in real time. Controller configuration and data analysis are facilitated by menus and pop-up windows.

Circle No. 40 on Reader Service Card



Conveyor Oven

The Grieve No. 766, featuring an 8' long open loading zone for access to the 42" wide, 1" X 1" high carbon steel conveyor belt, is a gas-fired conveyor oven currently in use for heat treating pistons. It features two independent heating zones within its overall 49' processing length. This oven is built on a heavy-duty 6" channel steel frame, structurally reinforced and internally welded throughout.

Circle No. 41 on Reader Service Card

Air/Gas Dryer

The Sahara-Pak compressed air/gas dryer, which is capable of delivering dewpoints in the 0 to -40°F range, is designed to fit any compressor. The patented pre-piped and pre-wired unit uses the normally wasted heat of compression to regenerate its desiccant beds, eliminating the cost of drying air. There is no purge air lost in this Henderson Engineering Co., Inc. dryer, which uses no heaters or blowers.

Circle No. 42 on Reader Service Card

Solutions/Dispersions

Silverson Machines has developed a new system for the high speed entraining and instant dispersing of powders into liquids. Designed to handle powders including gelling agents, gums, caseinates, and polymers, the Flashblend produces homogeneous, agglomerate-free solutions/dispersions, and will reportedly incorporate up to 33,000 lbs. of powder with a minimum of aeration. Complete automation is possible.

Circle No. 43 on Reader Service Card



Books/ Publications

Lecithin Brochure

"The Industrial Lecithin Book" provides a look at what lecithin is and how it functions in different roles. The publication also explains different lecithin products' functional properties designed for individual industrial applications. This 12-page brochure can be obtained from Central Soya.

Circle No. 44 on Reader Service Card

Paint Pretreatment

The Chemical Coaters Association International has published the *Paint Pretreatment* training manual. Included are basic descriptions of processes and equipment, instruction on proper technique and design, comparisons of technologies, and information designed to aid in productivity. Cleaning, phosphating, rinsing, substrates, washer design, performance testing, waste treatment, and troubleshooting are discussed.

Circle No. 45 on Reader Service Card

UV Curing

A comprehensive guide details the ultraviolet curing process and products which Ciba Additives manufactures for the industry. Basics of the UV curing process and chemistry are highlighted, as is a range of applications in which this curing technology is used. "Photoinitiators for UV Curing" summarizes the chemistry, properties, and absorbance spectra of each of the company's photoinitiators and includes a selection guide to assist in various formulations.

Circle No. 46 on Reader Service Card

Industrial Filtration

A new textbook that covers a range of industrial filtration technology in its 250 pages and 14 chapters has been released by Parker Hannifin Corp.'s Filtration Group. Topics include fluids, contaminants, and media selection for applications in a variety of industrial markets. *Filtration Technology*, bulletin 0241-B, is designed for engineers, managers, educators, distributors, and sales personnel.

Circle No. 47 on Reader Service Card

Water Management

Water quality management and wastewater treatment services offered by the Environmental Resources Management Group are described in a brochure. The publication outlines water supply services, ground water investigations, regulatory compliance, permitting assistance, and watershed management. Also covered in "Water Management Services" are wastewater treatment ap-

proaches, such as concept engineering services, pollution prevention, and wastewater treatment design and operations.

Circle No. 48 on Reader Service Card

Surface Active Agents

Ashland Chemical Co.'s Drew Industrial Div. has announced the availability of its annual product/industry newsletter, *Drew Perspectives*. This 1995/96 edition discusses new rheology modifiers, aqueous dispersants, specialty waxes, and foam control agents. Charts provide details on highlighted products, and a discussion of the company's pursuit of ISO 9001 certification is included.

Circle No. 49 on Reader Service Card

Product Catalog

A new catalog contains nearly 2,000 pages of detailed product descriptions and full-color photographs. More than 750 manufacturers and over 15,000 products are represented in the 1996/97 edition of the Thomas Scientific catalog. Alphabetic and numeric listings and color-coded sections are included, the chemical section and technical appendix have been expanded, and a manufacturer's cross-reference has been added.

Circle No. 50 on Reader Service Card



Laboratory Apparatus

Solid/Liquid Injection

The new SLIM (solid/liquid injection manifold) injects solids and liquids directly into the high shear mix zone of a rotor/stator mixer. This instrument is designed to cut mixing cycles, even for such introductions as fumed silica, Carbopol, natural and synthetic gums, or concentrated pigments. Information on this system can be obtained from Charles Ross & Son Co.

Circle No. 51 on Reader Service Card

UV Transmittance

Three diode array based instruments designed for measurement of diffuse and total transmittance of ultraviolet light over the 250 nm to 450 nm wavelength region are highlighted. These Labsphere, Inc. mechanisms determine the UVA, UVB, and percent transmittance values of measured samples. Applications include determination of UPF or SPF.

Circle No. 52 on Reader Service Card

Two-Stage Valve

The two-stage valve, offered by HPS Division of MKS Instruments, Inc., is a vacuum isolation valve used to slow system evacuation. The apparatus consists of a main isolation valve and a small bypass valve. The

bypass valve creates a small opening for the initial pumpdown, which slows system evacuation, reportedly reducing contamination from particle turbulence and damage due to sudden pressure change.

Circle No. 53 on Reader Service Card

Media Mill

Production and benchtop size horizontal media mills are engineered to use the latest technology in small media milling to produce fine and ultra fine dispersions. New proprietary technology and designs reportedly provide shorter grind times and improved product quality. Information on Zinger™ horizontal media mills is available from Epworth Manufacturing Co., Inc.

Circle No. 54 on Reader Service Card



Sealants/ Caulks

Fluoroelastomer

Pelmor Laboratories, Inc. introduces a one-part fluoroelastomer sealant/caulk engineered to resist ozone, UV radiation, salt spray, and fungal growth. Formulated from a fluorine-containing synthetic rubber, Pelseal® OP is designed for heat and chemical resistance to withstand harsh environments. This product comes ready for immediate application with a caulking gun or trowel.

Circle No. 55 on Reader Service Card

Primerless Sealant

A primerless silicone adhesive for acrylic sheet is obtainable. Manufactured by Dow Corning Corp. and distributed by Cadillac Plastic, Trade Mate® sealant/adhesive is designed for adherence to acrylics, plastics, and most common substrates without a primer. Reported features include noncorrosive oxime cure, minimal odor, weatherability, gunnability, and reusable packaging.

Circle No. 56 on Reader Service Card



Miscellaneous

Conversion Chart

A compressed air/gas dewpoint conversion slide chart is obtainable from Sahara Air Dryer, a division of Henderson Engineering Co. The chart estimates operating costs for a range of compressed air/gas dryer types for varying utility costs. The chart also permits dewpoint conversions from atmospheric to elevated pressures up to 5,000 PSIG.

Circle No. 57 on Reader Service Card

FEDERATION MEETINGS



For information on FSCT meetings, contact Federation of Societies for Coatings Technology, 492 Norristown Rd., Blue Bell, PA 19422 (610) 940-0777, FAX: (610) 940-0292.

1996

(May 3-5)—FSCT Spring Week. Held in conjunction with the Pacific Northwest Society's Annual Spring Symposium. Seminar on the 3rd and 4th. Incoming Society Officers Meeting on the 4th. Board of Directors Meeting on the 5th. Doubletree Suites Hotel, Seattle, WA.

(Aug. 15-17)—Pan American Coatings Expo. Co-sponsored by Federation of Societies for Coatings Technology, ANAFAPYT, and Instituto Mexicano de Técnicos en Pinturas y Tintas. Sheraton Maria Isabel Hotel, Mexico City, Mexico.

(Oct. 22-24)—International Coatings Technology Conference. Chicago Hilton and Towers and McCormick Place North, Chicago, IL.

(Oct. 23-25)—International Coatings Expo (Formerly Annual Meeting and Paint Industries' Show). McCormick Place North, Chicago, IL.

1997

(Nov. 3-5)—International Coatings Technology Conference and Expo (Formerly Annual Meeting and Paint Industries' Show). Georgia World Congress Center, Atlanta, GA.

SPECIAL SOCIETY MEETINGS

1996

(Apr. 16)—FOCUS '96—"Driving Technology to Meet New Challenges." Sponsored by the Detroit Society. Michigan State University Management Center, Troy, MI. (Rosemary Brady, Akzo Nobel Coatings, Inc., 1845 Maxwell St., P.O. Box 7062, Troy, MI 48007-7062; (810) 637-8565).

(Apr. 17)—"Spectrum of Coatings Science." Sponsored by the Louisville Society. Executive West Hotel, Louisville, KY. (Ilona Duvall, Red Spot Paint & Varnish, 1107 E. Louisiana, Evansville, IN 47711; (812) 467-2337).

(Apr. 24-25)—"Formulating, Manufacturing, and Painting for the Future." 39th Manufacturing & Technical Symposium. Sponsored by the Cleveland Society. John S. Knight Center, Akron, OH. (Jim Miller, J. Miller & Associates, 3057 Kent Rd., Silver Lake, OH 44224; (216) 688-5761).

(May 2-4)—49th Annual Spring Symposium. Sponsored by the Pacific Northwest Society. DoubleTree Suites Hotel, Seattle, WA. (Beverly Spears, Tarr, Inc., 4510 B St., N.W., Auburn, WA 98001; (206) 859-2979).

(May 8-9)—Eastern Training Conference and Show. Sponsored by the Philadelphia Society for Coatings Technology. Valley Forge Convention Center, Valley Forge, PA. (Wayne Kraus, Hercules Incorporated, Research Center, 500 Hercules Rd., Wilmington, DE 19808; (302) 995-3435. Booth reservations: Sam Firestone, S.E. Firestone Associates, Inc., 101 Surrey Rd., Melrose Park, PA 19207-2931).

(May 8-10)—Southern Society Annual Meeting. Hyatt Regency-West Shore, Tampa, FL. (Walter R. Naughton Jr., Scott Paint Corp., P.O. Box 10218, Sarasota, FL 34278-0218; (813) 371-0015).

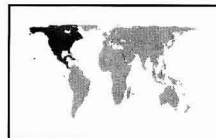
(June 14-15)—Joint Meeting of the St. Louis and Kansas City Societies. Holiday Inn, Lake of the Ozarks, MO. (Randall Ehmer, Walsh & Associates, Inc., 500 Railroad Ave., N. Kansas City, MO 64116; (816) 842-3014).

1997

(Feb. 18-20)—Western Coatings Societies' 23rd Biennial Symposium and Show. Sponsored by the Golden Gate, Los Angeles, Pacific Northwest, and Rocky Mountain Societies. Disneyland Hotel and Convention Center, Anaheim, CA. (Bruce Cotton, Pluess-Stauffer (California), Inc., P.O. Box 825, Lucerne Valley, CA 92356; (619) 248-7306; or Ron Elliott, J.R. Elliott Enterprises, Inc., 300 Thor Pl., Brea, CA 92621; (714) 529-0711).

OTHER ORGANIZATIONS

1996—North America



(Apr. 24-25)—"Advances in Polyurethane Foam Formulation." Seminar sponsored by Technomic Publishing Co., Program Division. Sheraton Colony Square Hotel, Atlanta, GA. (Program Division, Technomic Publishing Co., Inc., 851 New Holland Ave., Box 3535, Lancaster, PA 17604).

(Apr. 28-May 1)—American Oil Chemists' Society (AOCS) Meeting. Indiana Convention Center and RCA Dome, Indianapolis, IN. (AOCS Education/Meetings Dept., P.O. Box 3489, Champaign, IL 61826-3489).

(May 8-9)—ARMA Executive Committee Meeting and Board of Directors Meeting. Sponsored by Asphalt Roofing Manufacturers Association (ARMA). Baltimore, MD. (ARMA, 6000 Executive Blvd., Ste. 201, Rockville, MD 20852-3803).

(May 8-9)—"Surgical Tissue Adhesives." Seminar sponsored by Technomic Publishing Co., Program Division. Westin Hotel, San Francisco, CA. (Program Division, Technomic Publishing Co., Inc., 851 New Holland Ave., Box 3535, Lancaster, PA 17604).

(May 8-10)—"Frontiers in Polymer Chemistry." Short course sponsored by American Chemical Society. University of Akron, Akron, OH. (American Chemical Society, Dept. of Continuing Education, 1155 Sixteenth St., N.W., Washington, D.C. 20036).

(May 9)—Rheology Seminar. Sponsored by Brookfield Engineering Laboratories, Inc. Kansas City, MO. (Brookfield Engineering Laboratories, Inc., Dept. NR-118, 240 Cushing St., Stoughton, MA 02072).

(May 12-16)—42nd Annual Technical Meeting and Exposition of the Institute of Environmental Sciences. Radisson Twin Towers Hotel, Orlando, FL. (Institute of Environmental Sciences, 940 E. Northwest Hwy., Mt. Prospect, IL 60056).

(May 13-17)—"Physical Testing of Paints and Coatings." Short Course sponsored by University of Missouri-Rolla (UMR), Rolla, MO. (UMR Coatings Institute, 1870 Miner Circle, Rolla, MO 65409-0010).

(May 13-18)—"Interpretation of IR and Raman Spectroscopy." Short course sponsored by the Fisk Infrared Institute. Vanderbilt University, Nashville, TN. (Clara Craver, Fisk Infrared Institute, 1000 17th Ave., N., Nashville, TN 37208).

(May 14-17)—"Practical Emulsion Polymerization." Conference sponsored by Business Communications Co., Inc. Ramada Plaza, Stamford, CT. (Business Communications Co., Inc., 25 Van Zant St., Norwalk, CT 06855).

(May 15-17)—"Spray Finishing Technology Workshop." Sponsored by Bowling Green State University and ITW DeVilbiss. (Richard A. Kruppa, Bowling Green State University, College of Technology, Bowling Green, OH 43403).

(May 20-22)—"Advances in Flame Retardancy of Polymeric Materials: Applications, Materials, Industry Developments, Markets." Conference sponsored by Business Communications Co., Inc. Ramada Plaza, Stamford, CT. (Business Communications Co., Inc., 25 Van Zant St., Norwalk, CT 06855).

(May 20-24)—"Adhesion Principles and Practice for Coatings and Polymer Scientists." Short course sponsored by Kent State University, Kent, OH. (Carl J. Knauss, Director, Professional Development Institute, P.O. Box 1792, Kent, OH 44240).

(May 20-24)—"Corrosion and Its Control by Protective Coatings." Short course sponsored by Lehigh University. Bethlehem, PA. (Richard D. Granata, Lehigh University, Sinclair Lab, 7 ASA Dr., Bethlehem, PA 18015).

(May 21-23)—Eastec Advanced Productivity Exposition. Sponsored by the Society of Manufacturing Engineers (SME). Eastern States Exposition Center, West Springfield, MA. (SME, One SME Drive, P.O. Box 930, Dearborn, MI 48121-0930).

(May 21-24)—"Experiment Design Made Easy." Sponsored by Stat-Ease Inc. Minneapolis, MN. (Carol Summer, Stat-Ease Inc., Hennepin Square, Ste. 191, 2021 E. Hennepin Ave., Minneapolis, MN 55413-2723).

(May 21-24)—"Coatings Science for Coatings Technicians." Short course sponsored by The University of Southern Mississippi (USM), Hattiesburg, MS. (Shelby F. Thames, Director, USM, Box 10037, Hattiesburg, MS 39406).

(June 3-6)—Applied Machine Vision Conference. Sponsored by the Society of Manufacturing Engineers (SME). Regal Cincinnati Hotel, Cincinnati, OH. (SME, One SME Drive, P.O. Box 930, Dearborn, MI 48121-0930).

(June 3-7)—"Applied Rheology for Industrial Chemists." Short course sponsored by Kent State University, Kent, OH. (Carl J. Knauss, Director, Professional Development Institute, P.O. Box 1792, Kent, OH 44240).

(June 3-7)—"Advances in Emulsion Polymerization and Latex Technology." Short course sponsored by Lehigh University, Bethlehem, PA. (Mohamed S. El-Aasser, Emulsion Polymers Institute, Lehigh University, 111 Research Dr., Bethlehem, PA 18015).

(June 3-14)—"Intensive Coatings Science Course." Short course sponsored by North Dakota State University, Fargo, ND. (Debbie Shasky, Program Coordinator, 54 Dunbar Hall, NDSU, Fargo, ND 58105).

(June 10-13)—AESF SUR/FIN '96—"The Keys to Your Finishing Future." Sponsored by American Electroplaters and Surface Finishers Society (AESF). Cleveland Convention Center, Cleveland, OH. (Allen Shaw, AESF, Central Florida Research Park, 12644 Research Parkway, Orlando, FL 32826-3298).

(June 11)—Rheology Seminar. Sponsored by Brookfield Engineering Laboratories, Inc. Providence, RI/Boston, MA. (Brookfield Engineering Laboratories, Inc., Dept. NR-118, 240 Cushing St., Stoughton, MA 02072).

(June 11-14)—"Introduction to Coatings Technology." Short course sponsored by Kent State University, Kent, OH. (Carl J. Knauss, Director, Professional Development Institute, P.O. Box 1792, Kent, OH 44240).

(June 13)—Rheology Seminar. Sponsored by Brookfield Engineering Laboratories, Inc. Detroit, MI. (Brookfield Engineering Laboratories, Inc., Dept. NR-118, 240 Cushing St., Stoughton, MA 02072).

(June 16-19)—CPMA 66th Annual Meeting. Sponsored by the Color Pigments Manufacturers Association, Inc. (CPMA). The Greenbrier, White Sulphur Springs, WV. (CPMA, P.O. Box 20839, Alexandria, VA 22320-1839).

(June 18-21)—"Coatings Science for Coatings Chemists." Short course sponsored by The University of Southern Mississippi (USM), Hattiesburg, MS. (Shelby F. Thames, Director, USM, Box 10037, Hattiesburg, MS 39406).

(June 24-26)—"Additives for Metallocene-Catalyzed Polymers." Conference sponsored by Intertech Corp. Holiday Inn Mart Plaza, Chicago, IL. (Melanie Briggs, Intertech Conferences, U.S. 411 Route One, Portland, ME 04105).

(June 24-26)—"The Fundamentals of Corrosion and Its Control." Sponsored by LaQue Corrosion Services. Holiday Inn SunSpree Resort, Wrightsville Beach, NC. (S. Darden, LaQue Corrosion Services, P.O. Box 656, Wrightsville Beach, NC 28480).

(June 25-28)—"Coatings Science for Coatings Formulators." Short course sponsored by The University of Southern Mississippi (USM), Hattiesburg, MS. (Shelby F. Thames, Director, USM, Box 10037, Hattiesburg, MS 39406).

(July 10-11)—"The ABC's of Establishing Color Tolerances." Seminar sponsored by Chroma Corp. McHenry, IL. (Stephanie Schettig, Seminar Coordinator, Chroma Corp., 3900 Dayton St., McHenry, IL 60050).

(July 14-18)—Fifth World Congress of Chemical Engineering. Sponsored by American Institute of Chemical Engineers. Marriott Hotel, San Diego, CA. (AIChE Service Center, 345 E. 47th St., New York, NY 10017-2395).

(July 15-17)—"Basic Coatings for Sales, Marketing, and General Personnel." Short Course sponsored by University of Missouri-Rolla (UMR), Rolla, MO. (UMR Coatings Institute, 1870 Miner Circle, Rolla, MO 65409).

(July 16-19)—"Introduction to Powder Coatings Technology." Short course sponsored by The University of Southern Mississippi (USM), Hattiesburg, MS. (Shelby F. Thames, Director, USM, Box 10037, Hattiesburg, MS 39406).

(Aug. 3-5)—31st National Heat Transfer Conference. Sponsored by American Institute of Chemical Engineers. Westin Galleria, Houston, TX. (AIChE Service Center, 345 E. 47th St., New York, NY 10017-2395).

(Aug. 5-8)—50th Sea Horse Institute Conference. Sponsored by LaQue Corrosion Services. Blockade Runner Hotel, Wrightsville Beach, NC. (LaQue Corrosion Services, P.O. Box 656, Wrightsville Beach, NC 28480).

(Aug. 9-14)—31st Intersociety Energy Conversion Engineering Conference. Sponsored by the Institute of Electrical & Electronics Engineers, Inc. Omni Shoreham Hotel, Washington, D.C. (AIChE Service Center, 345 E. 47th St., New York, NY 10017-2395).

(Aug. 19-22)—ARMA Fall Committee Meetings. Sponsored by Asphalt Roofing Manufacturers Association (ARMA). New Orleans, LA. (ARMA, 6000 Executive Blvd., Ste. 201, Rockville, MD 20852-3803).

(Sept. 4-11)—Manufacturing '96 Conference. Sponsored by the Society of Manufacturing Engineers (SME). McCormick Place, Chicago, IL. (SME, One SME Drive, P.O. Box 930, Dearborn, MI 48121-0930).

(Sept. 8-12)—1996 EOS/ESD Symposium. Sponsored by the ESD Association. Lake Buena Vista, FL. (ESD Association, 7902 Turin Rd., Ste. 4, Rome, NY 13440).

(Sept. 9-12)—Safety in Ammonia Plants and Related Facilities. Sponsored by American Institute of Chemical Engineers. Westin at Copley Place, Boston, MA. (AIChE Service Center, 345 E. 47th St., New York, NY 10017-2395).

(Sept. 9-13)—"The Basic Composition of Coatings." Short Course sponsored by University of Missouri-Rolla (UMR), Rolla, MO. (UMR Coatings Institute, 1870 Miner Circle, Rolla, MO 65409-0010).

(Sept. 22-25)—1996 Manufacturers and Suppliers Workshop and Exposition. Sponsored by The American Ceramic Society. Adam's Mark Hotel, Charlotte, NC. (The American Ceramic Society, 735 Ceramic Place, Westerville, OH 43081-8720).

(Sept. 23-27)—"Introduction to Paint Formulation." Short Course sponsored by University of Missouri-Rolla (UMR), Rolla, MO. (UMR Coatings Institute, 1870 Miner Circle, Rolla, MO 65409-0010).

(Oct. 23-24)—"The ABC's of Establishing Color Tolerances." Seminar sponsored by Chroma Corp. McHenry, IL. (Stephanie Schettig, Seminar Coordinator, Chroma Corp., 3900 Dayton St., McHenry, IL 60050).

(Oct. 23-25)—109th Annual Meeting of the National Paint and Coatings Association (NPCA). Palmer House (Hilton), Chicago, IL. (Cheryl Matthews, NPCA, 1500 Rhode Island Ave., N.W., Washington, D.C. 20005-5597).

(Oct. 28-30)—"The Fundamentals of Corrosion and Its Control." Sponsored by LaQue Corrosion Services. Holiday Inn SunSpree Resort, Wrightsville Beach, NC. (S. Darden, LaQue Corrosion Services, P.O. Box 656, Wrightsville Beach, NC 28480).

(Oct. 29-31)—Fabtech West Conference & Exposition. Sponsored by the Society of Manufacturing Engineers (SME). San Jose Convention Center, San Jose, CA. (SME, One SME Drive, P.O. Box 930, Dearborn, MI 48121-0930).

(Nov. 1-3)—"Fall Decor '96." Sponsored by the National Decorating Products Association (NDPA). Minneapolis Convention Center, Minneapolis, MN. (Teri Flotron, NDPA, 1050 N. Lindbergh Blvd., St. Louis, MO 63132-2994).

(Nov. 6-8)—ARMA Executive Committee Meeting and Board of Directors Meeting. Sponsored by Asphalt Roofing Manufacturers Association (ARMA). Tucson, AZ. (ARMA, 6000 Executive Blvd., Ste. 201, Rockville, MD 20852-3803).

(Nov. 10-15)—Annual Meeting of the American Institute of Chemical Engineers. Sponsored by American Institute of Chemical Engineers. Palmer House Hilton, Chicago, IL. (AIChE Service Center, 345 E. 47th St., New York, NY 10017-2395).

(Nov. 12-14)—Autofact Conference & Exposition. Sponsored by the Society of Manufacturing Engineers (SME). Cobo Center, Detroit, MI. (SME, One SME Drive, P.O. Box 930, Dearborn, MI 48121-0930).

(Nov. 17-21)—SSPC '96. 1996 International Conference and Exhibition. Charlotte, NC. (Dee Boyle, SSPC, 40 24th St., 6th Floor, Pittsburgh, PA 15222-4643).

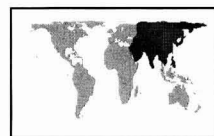
(Nov. 19-22)—"The Fourth Color Imaging Conference: Color Science, Systems, and Applications." Sponsored by the Society for Imaging Science & Technology (IS&T) and the Society for Information Display (SID). The Radisson Resort, Scottsdale, AZ. (IS&T, 7003 Kilworth Lane, Springfield, VA 22151; or SID, 1526 Brookhollow Dr., Ste. 82, Santa Ana, CA 92705-5421).

1996—Asia

(May 28-31)—ChinaCoat. Exhibition sponsored by Sinostar International Ltd. Guangzhou, China. (Sinostar International Ltd., 1001 Siu Lam Bldg., 23 Luard Rd., Wanchai, Hong Kong).

(June 5-6)—Asia-Pacific Coatings Show. Exhibition and Conference sponsored by FMJ International. Hong Kong Convention and Exhibition Centre, Hong Kong. (Mike Tarrant, FMJ International Publications Ltd., Queensway House, 2 Queensway, Redhill, Surrey RH1 1QS, England).

(June 5-8)—The International Exposition for Coatings & Paints. Sponsored by Chinese Chemical Society (CCS) and Chemical Industry and Engineering Society of China (CIESC). Shanghai Exhibition Center, Shanghai, P.R. China. (Worldwide Exhibitions Service Co., Ltd. (WES), 4/F, Bldg. 2, 1486 Nanjing Rd. (W), Shanghai 200040, P.R. China).



(June 12-13)—Korean Coatings Show '96. Exhibition and Conference sponsored by FMJ International. Hong Kong Convention and Exhibition Centre, Hong Kong. (Nicky Molloy, FMJ International Publications Ltd., Queensway House, 2 Queensway, Redhill, Surrey RH1 1QS, England).

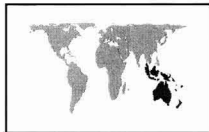
(July 9-12)—Autofact Asia Conference. Sponsored by the Society of Manufacturing Engineers (SME). Singapore International Convention and Exhibition Center (Suntec City), Singapore. (SME, One SME Drive, P.O. Box 930, Dearborn, MI 48121-0930).

1996—Australia

(Aug. 8-11)—"Cradle to Grave, The Life Cycle of Paint Products." Sponsored by the Surface Coatings Association New Zealand (SCANZ). Plaza International Hotel, Wellington, New Zealand. (SCANZCON'96 Secretariat, P.O. Box 38 546, Wellington, NZ; 64 4 568 8993).

(Aug. 11-16)—Third International Hydrocolloids Conference. Cosponsored by the CSIRO and the Cooperative Research Centre for Industrial Plant Biopolymers. Landmark Park Royal Hotel, Potts Point, Sydney, Australia. (Gail Hawke, Third International Hydrocolloids Conference, P.O. Box N399, Grosvenor Place, Sydney, NSW 2000, Australia).

(Aug. 14-17)—"Coatings from Start to Finish." Sponsored by the Surface Coatings Association Australia (SCAA). Sydney Convention and Exhibition Centre, Sydney, Australia. (SCAA '96 Secretariat, GPO Box 128, Sydney NSW 2001, Australia; 61 2 262 2277).



1996—Europe

(May 8-10)—"Medical Packaging Technology and Validation of the Packaging Process." Seminar sponsored by Technomic Publishing AG. Zurich Hilton Hotel, Zurich, Switzerland. (Program Division, Technomic Publishing Co., Inc., 851 New Holland Ave., Box 3535, Lancaster, PA 17604).

(May 13-17)—"Paint Technology Training Course." Sponsored by The Paint Research Association (PRA), Teddington, Middlesex, United Kingdom. (Sue Benjamin, PRA, 8 Waldegrave Rd., Teddington, Middlesex, TW11 8LD, United Kingdom).

(May 20-22)—"Protective Coatings for Structural Steel Training Course." Sponsored by The Paint Research Association (PRA), Teddington, Middlesex, United Kingdom. (Sue Benjamin, PRA, 8 Waldegrave Rd., Teddington, Middlesex, TW11 8LD, United Kingdom).

(May 23-24)—"Thermoplastic Foams." Seminar sponsored by Technomic Publishing AG. Hotel International, Basel, Switzerland. (Program Division, Technomic Publishing Co., Inc., 851 New Holland Ave., Box 3535, Lancaster, PA 17604).

(May 30-31)—"Nanomaterials: Design, Preparation, Characterization, and Applications." Seminar sponsored by Technomic Publishing AG. Hotel International, Basel, Switzerland. (Program Division, Technomic Publishing Co., Inc., 851 New Holland Ave., Box 3535, Lancaster, PA 17604).

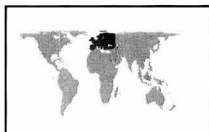
(June 3-5)—"Styrenics '96." Sponsored by Maack Business Services. Zürich, Switzerland. (Maack Business Services, Moosacherstrasse 14, CH-8804 AU/Zürich, Switzerland).

(June 3-5)—"Radiation Curing Technology Training Course." Sponsored by The Paint Research Association (PRA), Teddington, Middlesex, United Kingdom. (Sue Benjamin, PRA, 8 Waldegrave Rd., Teddington, Middlesex, TW11 8LD, United Kingdom).

(June 4-5)—"Sealing Technology: Materials, Design, and Applications." Seminar sponsored by Technomic Publishing AG. Hotel International, Basel, Switzerland. (Program Division, Technomic Publishing Co., Inc., 851 New Holland Ave., Box 3535, Lancaster, PA 17604).

(June 10-12)—"Printing Ink Technology Training Course." Sponsored by The Paint Research Association (PRA), Teddington, Middlesex, United Kingdom. (Sue Benjamin, PRA, 8 Waldegrave Rd., Teddington, Middlesex, TW11 8LD, United Kingdom).

(June 10-14)—23rd FATIPEC Congress. "Performance, Environment, and Legislation: Challenges and Sources of Innovation in the Coatings Industry." Conference sponsored by the Belgian Association of Coatings Technicians. Brussels, Belgium. (Congress Secretariat DO, Rue des Drapiers 46, B-1050, Brussels, Belgium).



(June 11-13)—European Coatings Show '96. Exhibition and conference sponsored by Vincentz Verlag. Brussels, Belgium. (Michael Kuhn, Vincentz Verlag, Postfach 6247, 30062 Hannover, Germany).

(June 10-13)—"Science and Technology of Pigment Dispersion." Vitznau (Luzern), Switzerland. (Angelos V. Patsis, Director, Institute for Materials Science, State University of New York, New Paltz, NY 12561).

(June 17-19)—18th International Conference in Stabilization and Controlled Degradation of Polymers. Luzern, Switzerland. (Angelos V. Patsis, Director, Institute for Materials Science, State University of New York, New Paltz, NY 12561).

(June 24-25)—"Radiation Coatings and Inks: Application and Performance." Sponsored by The Paint Research Association (PRA). Cairn Hotel, Harrogate, England. (Richard Kennedy, PRA, 8 Waldegrave Rd., Teddington, Middlesex, TW11 8LD, United Kingdom).

(June 25-26)—SURFEX '96. Sponsored by Oil & Colour Chemists' Association (OCCA). Harrogate, North Yorks, England. (Chris Pacey-Day, SURFEX Ltd., Priory House, 967 Harrow Rd., Wembley HA0 2SF, England).

(July 1-3)—Ninth International Symposium on Polymer Analysis and Characterization. Keeble College, Oxford University, United Kingdom. (John Dawkins, Dept. of Chemistry, Loughborough University of Technology, Loughborough, Leicestershire, LE11 3TU, United Kingdom).

(July 1-5)—22nd International Conference in Organic Coatings—Waterborne, High-Solids, Powder Coatings. Vouliagmeni (Athens), Greece. (Angelos V. Patsis, Director, Institute for Materials Science, State University of New York, New Paltz, NY 12561).

(Sept. 15-20)—Fifth International Conference on Plasma Source Spectrometry. Sponsored by The Perkin-Elmer Corp. University of Durham, England. (Grenville Holland, Department of Geological Sciences, University of Durham, Science Laboratories, South Road, Durham City DH1 4RL, England).

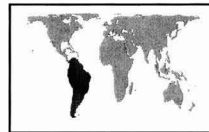
(Sept. 18-20)—EUROCOAT '96. Congress/Exhibition sponsored by Union des Associations de Culture Méditerranéenne (UATCM). Congress Centre, Genova, Italy. (AITIVA/EUROCOAT '96. Dr. R. Ferretto c/o Boero Colori, Via Molassana, 60, I-16138 Genova, Italy).

(Sept. 18-20)—"Polypropylene '96." Sponsored by Maack Business Services. Zürich, Switzerland. (Maack Business Services, Moosacherstrasse 14, CH-8804 AU/Zürich, Switzerland).

(Oct. 21-22)—"World Congress PET '96." Sponsored by Maack Business Services. Zürich, Switzerland. (Maack Business Services, Moosacherstrasse 14, CH-8804 AU/Zürich, Switzerland).

1996—South America

(July 10-11)—Latin American Coatings Show '96. Sponsored by FMJ International. Sheraton Hotel, Buenos Aires, Argentina. (Mike Tarrant, FMJ International Publications Ltd., Queensway House, 2 Queensway, Redhill, Surrey RH1 1QS, England).



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Humbug from Hillman

Dick Stewart never lets me down when I feel the need for a zany story. Here's one of his milder ones.

The accused was clearly guilty of murder in the first degree, but the kindly judge, seeing extenuating circumstances, had a soft heart.

"I want a verdict of manslaughter," he said quietly to one of the jurors. "Don't you come back with a first degree murder verdict."

The jury was out for almost three days but they did come back with a manslaughter verdict.

Later, the judge spoke to the juror, "You were out for almost three days. What took you so long,"

"It was awful," the juror replied. "Everyone else was for letting him go but I finally talked them out of it."



Well, so much for the ridiculous. If not to the sublime, let's turn to the uplifting. For example, it seems that Dave Platt is still learning. He proudly writes:

—I've learned that if you go to a garage sale, you'll almost always buy at least one item you didn't need.

—I've learned that phone calls after midnight seldom bring good news.

—I've learned that people in a hurry to get to the "good life" often rush right by it.

—I've learned that people who say, "Money isn't everything," usually have plenty of it.



If you haven't had enough of words of wisdom to live by, Dr. Luxman De Silva has sent us some more all the way from Cambridgeshire, England.

—I had six faithful serving men. They taught me everything I know. Their names were:

What
and Where
and When
and Why
and How
and Who

—May your life be as arithmetic:

Friends added
Enemies subtracted
Joys multiplied
and sorrows divided

—You can draw a straight line through points on any graph providing the line is thick enough.

AND if you doubt any of the above, Luxman adds:

"It's better to know nothing and be of no doubt than to know a little and be of doubt." So there!

For just about a year, I have been saving the following item from pen pal Larry Hill's column, "Overspray" in *Down Under's* fine technical magazine, *Surface Coatings Australia*. I think our readers should be ready for it at this point.

It seems that Larry and an old friend were in the habit of using an old pub for a wholesome but cheap lunch—after retirement. On one such occasion, they returned to the bar for a drink. Larry turned away for a moment and saw, with considerable annoyance, a monkey with his nose in Larry's beer. He expostulated with the barman, who replied, "Don't yell at me mate, it's the pianist's monkey." Glowering, Larry shouldered his way through the crowd to the pianist. "Excuse me," he cried, "but do you know your monkey has his nose in my beer?"

Bloodshot eyes peered up at Larry through an alcoholic haze. "No can't say as I do mate—but hum a few bars and I'll soon pick it up."



Bobby D. Moore wrote me about an incident that I'm sure he felt was amusingly ironic.

General Coatings, a manufacturer of fire retardant coatings for many years, sold their business in Savannah, GA, to another manufacturer several years ago. The building that was sold was a very old one on the edge of town.

They moved everything out of the building and cleaned it completely down to the floor.

One year later, after closing the doors for the last time, the building burned down to the ground.

Bobby adds, "I'm sure they never knew how effective their products were!"



Two farmers met and started to chat. One said, "I've got a mule with the fits. What did you do when your mule had the fits?"

"I gave it a mixture of turpentine and kerosene."

The next day the two farmers met again. The first one said, "I gave my mule some of that mix of turpentine and kerosene. The mixture killed him."

The other one said, "Killed mine too."

The parents of an 8-year-old boy who was away at camp for the first time had not heard from him. They finally telephoned the youngster and were both relieved, but also disappointed to discover that he hadn't missed them at all.

"Have any of the other kids gotten homesick?" inquired the mother.

"Only those who have dogs," replied the boy.

Insurance: Something that you pay thousands of dollars for so that you'll have nothing to worry about when you're dead.

—The Lion

—Herb Hillman, *Humbug's Nest*,
P.O. Box 135, Whitingham, VT 05361.



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