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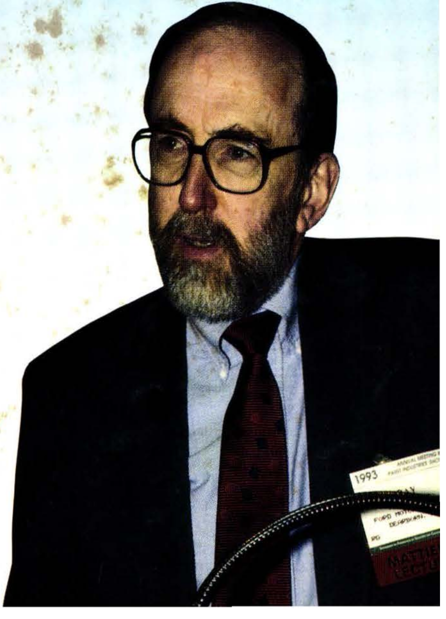
1993
Joseph J.
Mattiello
Memorial
Lecture

Chemical Origins of Paint Performance



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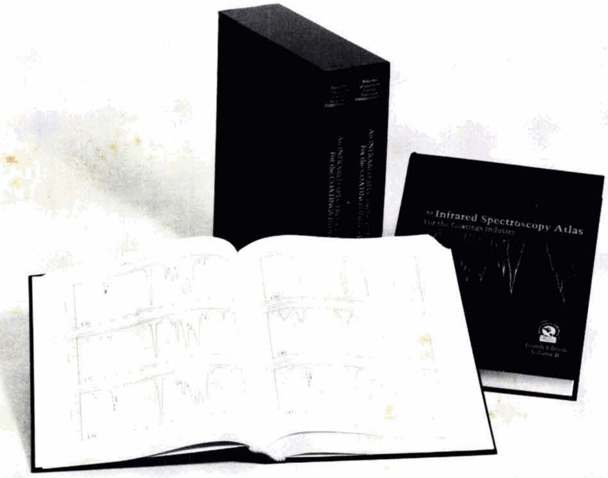
An Infrared Spectroscopy Atlas
For the Coatings Industry

JULY 1994

jct

VOLUME 66 NUMBER 834

Technical Articles

Open Forum

Federation News

Departments

BPA

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jct JOURNAL OF COATINGS TECHNOLOGY

GUIDE FOR AUTHORS

GENERAL

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

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 All manuscripts will be assumed to be previously unpublished writing of the authors, not under consideration for publication elsewhere.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

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

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

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...for the Journal

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

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

...by Constituent Societies For Annual Meeting Presentation

Ten complete copies of the manuscript are required for committee review. The set of copies should be addressed to the Editor at the address listed previously.

...for Roon Foundation Award Competition

Ten complete copies of the manuscript are required, and should be submitted to the Chairman of the 1994 Roon Awards Committee, N. Bradford Brakke, Lilly Industries, Inc., 521 W. McCarthy St., Indianapolis, IN 46225. (For complete details, see "Roon Awards" section of the Journal in the January 1994 issue.)

MANUSCRIPT PREPARATION

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

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

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

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

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

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

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

Manuscripts should be typed with double spacing on one side of $8^1/_2$ x 11 inch (22 x 28 cm) paper, with at least one-inch (2.5 cm) margins on all four sides. All paragraphs should be indented five spaces, and all pages should be numbered at the top center, or upper right corner.

Title

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

Authors' Biographies and Photographs

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

Abstracts

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

Text

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

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

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

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

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

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

Tables, Graphs, and Drawings

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

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

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

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Color prints and slides are unacceptable.

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

Nomenclature

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

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

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

Equations

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

Summary

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

Acknowledgment

If used, it should follow the summary.

References

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

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

(2) Davidson, H.R., "Use and Misuse of Computers in Color Control," JOURNAL OF COATINGS TECHNOLOGY, *54*, No. 691, 55 (1982).

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

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

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

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Comment

Globalization—Are We There Yet?

"The world is getting smaller . . . ," has been said so often that it has attained the not so lofty position of being considered a trite expression, something so obvious that it "goes without saying." While this may be obvious to some, when you consider that it may take a person most of the day to get from Louisville to Dallas (with a day thrown in for the luggage) just how small is the world?

Many of the larger companies, both suppliers and now manufacturers, are now international with some familiar names sporting unfamiliar letters, such as GmbH, Ltd., and S.A. de P.V. When returning telephone calls one now needs a world clock to see if the work day has started. And the fax bin is now full at the *start* of the day.

The FSCT has been affected as well by this onslaught of technology and global shrinkage. Just this year, the Federation has been represented at meetings and events in six countries and four continents. The latest of which will be the Trans Tasman Conference in Brisbane, Australia, this August. These meetings offer a unique opportunity to bring the FSCT message and the force of U.S. technology and markets to the many parts of the world.

In addition, the FSCT is an integral partner in, and currently acts as the General Secretariat of, the reorganized Coatings Societies International (formerly known as the ICCATCI), a group whose members are the coatings technical associations around the world, including OCCA in England, FATIPEC in Europe, SCAA in Australia, NZSCA in New Zealand, JSCM in Japan, SLF in Scandinavia, and proposed for membership is IAPPM of the Commonwealth of Independent States (formerly the Soviet Union).

As international agreements such as NAFTA and GATT flourish and the global regulatory and environmental climate intensifies, these liaisons will bear much fruit in the growth of the FSCT and its members.

Is the world smaller? No. And, no, we're not there yet, we're not even close!

Robert F. Ziegler

Robert F. Ziegler
Executive Vice President

Abstracts of Papers in This Issue

(Translations provided by: French—Montreal Society Member Alain Brisson, of Hoechst Canada, Inc. and Spanish—Mexico Society Member Cesar Fuentes Carrasco, of Instituto Mexicano de Tecnicos en Pinturas y Tintas.)

Chemical Origins of Paint Performance—R.A. Dickie

JCT, 66, No. 834, 28 (July 1994)

The resistance of organic coatings to environmental degradation is usually evaluated in terms of changes in physical properties or appearance. Thus, paint system weatherability is assessed in terms of embrittlement and cracking, loss of adhesion, and loss of gloss, while corrosion protection is assessed in terms of paint blistering, loss of paint adhesion, and pitting or perforation of the substrate. The design and evaluation of accelerated tests are based on correlation of the physical changes induced by the selected test exposure condition with those observed under some standard conditions (e.g., a defined course of natural exposure). Many of the changes in physical properties and appearance that result from environmental degradation have their origins in chemical degradation processes. Examination of the chemical origins of physical change affords a complementary approach and potentially an alternative to accelerated performance testing for the evaluation of protective coating systems. The underlying theme of chemical origin of paint performance suggests a chemical paradigm for study of paint degradation, which in turn leads to the development of chemical protocols for the evaluation of durability. The implications of the chemical paradigm for research methods and test design are discussed.

A Study of Water at the Organic Coating/Substrate Interface—T. Nguyen, D. Bentz, and E. Byrd

JCT, 66, No. 834, 39 (July 1994)

Quantitative information on the water layer at the coating/substrate interface is crucial for understanding and preventing the failure of organic coating systems. A method, based on a two-layered model derived rigorously from internal reflection theory, was developed for determining the amount and thickness of water at the organic coating/substrate interface. The method gives new insight into the processes by which water degrades the coating/substrate bonds. The method requires application of a transparent or opaque organic coating of sufficient thickness on an internal reflection element (IRE), which is used as the substrate. A water chamber is attached to the coated specimen. After adding water to the chamber, FTIR-MIR (Fourier transform infrared-multiple internal reflection) spectra are taken automatically at specified time intervals with-

Origines Chimiques de la Performance des Revêtements—R.A. Dickie

JCT, 66, No. 834, 28 (July 1994)

La résistance des revêtements organiques à la dégradation due à l'environnement est habituellement évaluée avec l'aide des changements de propriétés physiques ou d'apparence. Donc, la résistance aux intempéries est évaluée par des mesures de craquement, perte d'adhésion et de brillant, tandis que la protection contre la corrosion est évaluée par des mesures decloquage, perte d'adhésion et perforation du subjectile. Le design et l'évaluation des tests accélérés sont basés sur la corrélation des changements physiques induits par les conditions d'exposition avec ceux observés avec des conditions standards (exposition naturelle). Plusieurs changements physiques et d'apparence résultant de la dégradation due à l'environnement ont comme origine une dégradation chimique. L'examen des origines chimiques des changements physiques offre une approche complémentaire et une alternative potentielle aux tests de performances accélérés pour l'évaluation des systèmes de revêtements protecteurs. Le thème de l'origine chimique de la performance des revêtements suggère un paradigme chimique pour l'étude de la dégradation des revêtements, lequel mène au développement de protocoles chimique pour l'évaluation de la durabilité. Les implications du paradigme chimique pour les méthodes de recherche et design de tests sont discutés.

Etude de L'eau à L'Interface Revêtement Organique/Subjectile—T. Nguyen, D. Bentz et E. Byrd

JCT, 66, No. 834, 39 (July 1994)

L'information quantitative sur la couche d'eau à l'interface revêtement/subjectile est cruciale pour la compréhension et la prévention de la défaillance des systèmes de revêtements organiques. Une méthode, basèe sur un modèle bi-couche dérivée de la théorie de la réflection interne, a été développée pour déterminer la quantité et l'épaisseur d'eau à l'interface revêtement organique/subjectile. La méthode donne une nouvelle perspective sur le procédé par lequel l'eau dégrade les liens revêtement/subjectile. La méthode requière l'application d'un revêtement organique opaque ou transparent d'une épaisseur suffisante sur l'élément de réflection interne (IRE), qui est

Origen Quimico en el Desempeño de Pinturas—R.A Dickie

JCT, 66, No. 834, 28 (July 1994)

La resistencia de los recubrimientos orgánicos a la degradación ambiental es usualmente evaluada en términos de los cambios en sus propiedades físicas o de apariencia. Así, un sistema de pinturas resistente a la intemperie se avalua en términos de su quebrantamiento o ruptura, pérdida de la adhesión y pérdida de brillo, mientras que la protección a la corrosión se avalua en términos del ampollamiento en la pintura, pérdida de la adhesión y escoraciones o perforaciones del sustrato. El diseño y la evaluación de pruebas aceleradas se basa en la correlación de los cambios físicos inducidos por las condiciones de exposición de pruebas selectivas observadas bajo alguna condición estándar (ej. el curso definido de exposición natural). Muchos de los cambios en las propiedades físicas y de apariencia que resultan de la degradación ambiental tienen sus origenes en los procesos de degradación química. Las pruebas del origen químico y de los cambios físicos ofrecen un aprovechamiento complementario y una alternativa potencial para las pruebas de desempeño aceleradas a la evalución de sistemas de recubrimientos protectores. El tema fundamental del origen químico en el desempeño de pinturas sugiere un paradigma químico para el estudio de la degradación en pinturas, la cual conduce al desarrollo de protocolos químicos para la evalución de la durabilidad. Además, se discuten las implicaciones de los paradigmas químicos para los métodos de investigación y diseño de pruebas.

Un Estudio de Agua en la Interface Sustrato/Recubrimiento Organico—T. Nguyen, D. Bentz y E. Byrd

JCT, 66, No. 834, 39 (July 1994)

Información cuantitativa en la capa de agua de la interface sustrato/recubrimiento orgánico es crucial para entender y prevenir las fallas de sistemas de recubrimientos orgánicos. Un método basado en un modelo de dos capas derivado de la teoría de reflección interna fue desarrollado para determinar la cantidad y espesor de agua en la interface sustrato/recubrimiento orgánico, el método de nuevas visiones dentro del proceso por el cual el agua degrada la adhesión del sustrato/recubrimiento. El método requiere de la aplicación de un recubrimiento orgánico o transparente de suficiente espesor en un out disturbing the specimens or the instrument. Water uptake in the coating and FTIR-MIR spectra of water on the coating-free substrate are also used for the analysis. Results for a clear epoxy coating on a Ge substrate and a pigmented alkyd on an SiO_2-Si substrate are presented to demonstrate the method. In addition to measuring water at the coating/substrate interface, the method provides a means for studying the transport of water through a coating adhered to a substrate. Information obtained by this method is valuable for interpreting corrosion, blistering, and delamination of organic coating systems and for developing models for use in predicting the service lives of protective coatings.

Evaluating Traffic Paint Degradation Using Image Analysis—B. Pourdeyhimi and A. Nayernouri

JCT, 66, No. 834, 51 (July 1994)

Currently, there are no objective methods available for evaluating the appearance of coating systems. The American Society for Testing Materials (ASTM) offers pictorial standards that are time-consuming and perhaps inaccurate. This paper examines the feasibility of image analysis in quantifying degradation of the visual appearance of current ASTM pictorial standards used in evaluating traffic paint degradation for abrasion and chipping resistance.

Coping with Errors in Electrochemical Impedance Spectroscopy Data from Coated Metals—W.S. Tait

JCT, 66, No. 834, 59 (July 1994)

Variations in electrochemical impedance spectroscopy (EIS) data are largely due to variations in a coating system, and not to equipment measurement errors. The relative statistical error is greatest when the repetition number for each variable is less than five. Sample standard deviation also significantly affects error magnitude when repetition number is less than five. One scheme for coping with statistical error in EIS data is to use both: (1) five or more repetitions per variable, and (2) scattergrams to assess data trends as a function of time.

Developments of Marine Paint Formulations Based on Thiotriazole Compounds—A.B. Tadros

JCT, 66, No. 834, 63 (July 1994)

4-Amino-3-hydrazino-5-thio-1,2,4-triazole (I), its copper complex, and its chlorinated derivatives have been synthesized and tested as antifouling and anticorrosive agents.

The tests were carried out through the incorporation of the three compounds in

utilisé comme subjectile. Une chambre d'eau est attachée au spécimen. Après l'addition d'eau à la chambre, des spectres FTIR-MIR (réflection interne multiple de transformée de Fourier) sont pris automatiquement à des intervalles de temps spécifiques sans déranger les spécimens ou l'instrument. La prise d'eau dans le revêtement et les spectres FTIR-MIR de l'eau sur le subjectile vierge sont également utilisés pour l'analyse. Les résultats pour un revêtements époxydique clair sur un subjectile Ge et un alkyde pigmenté sur un subjectile SiO_2-Si sont présentés pour démontrer la méthode. De plus, pour la détermination d'eau à l'interface revêtement/subjectile, la méthode procure un moyen pour étudier le transport d'eau à travers un revêtement adhéré à un subjectile. L'information obtenue par cette méthode est précieuse pour l'interprétation de la corrosion, cloquage et la délamination de systèmes de revêtements organiques et pour le développement de modèles pour prédire la durée de vie de revêtements protecteurs.

Evaluation de la Dégradation de Revêtement pour le Trafic Avec l'aide de L'Analyse d'Images—B. Pourdeyhimi et A. Nayernouri

JCT, 66, No. 834, 51 (July 1994)

Il n'y a présentement aucunes méthodes objectives pour l'évaluation de l'apparence de systèmes de revêtements. Les méthodes ASTM offrent des standards visuels qui requièrent beaucoup de temps et sont peu précises. Cette publication examine l'emploi de l'analyse d'images pour quantifier la dégradation de l'apparence visuelle des standards visuels d'ASTM utilisés dans l'évaluation de la dégradation de l'abrasion et de la résistance à l'écaillement des revêtements pour le trafic.

Venir à Bout Des Erreurs Dans les Donnés de Spectroscopie D'Impédance Electrochimique Pour des Métaux Enduits de Revêtements—W.S. Tait

JCT, 66, No. 834, 59 (July 1994)

Les variations dans les données de spectroscopie d'impédance électrochimique (EIS) sont largement dues aux variations dans le système de revêtement, et non aux erreurs de mesure des divers equipements. L'erreur statistique relative est plus grande lorsque le nombre de répétition pour chaque variable est moins de cinq. La déviation standard d'un échantillon affecte aussi de facon significative l'amplitude de l'erreur lorsque le nombre de répétition est moins de cinq. Une alternative pour venir à bout des erreurs statistiques avec les données de EIS est d'utiliser: (a) cinq répétitions ou plus par variable et; (b) diagrammes de diffusion pour évaluer les tendances des données en fonction du temps.

elemento de reflección interna (IRE), el cual es usado como sustrato, un recipiente se une a un especimen recubierto, después de añadir agua al recipiente espectros FTIR-MIR (Tranformadas de Fourier infrarroja-de reflección interna multiple) son tomados automáticamente con intervalos específicos de tiempo sin tener disturbio del especimen o el instrumento. El agua tomada en el recubrimiento y el espectro FTIR-MIR de agua en el recubrimiento libre del sustrato también es usado en el análisis. Son presentados para demostrar el método resultados para un recubrimiento epoxico en un sustrato de Germanio y un alquidal pigmentado en un sustrato de SiO_2-Si. En adición a la medición de agua en la interface el método provee un significado para estudiar el movimiento de agua a traves de un recubrimiento adherido al sustrato. La información obtenida por este método es valiosa para la interpretación de la corrosión, ampollamineto y delaminación de sistemas de recubrimientos orgánicos y para el desempeño de modelos para el uso en la predicción de la vida de servicio de recubrimientos protectivos.

Evaluacion de la Degradacion de la Pintura de Trafico Usando un Analisis de Imagen—B. Pourdeyhimi y A. Nayernouri

JCT, 66, No. 834, 51 (July 1994)

Frecuentemente, no hay métodos objetivos que esten disponibles para la evaluación de la apariencia de sistemas de recubrimiento. La "ASTM" ofrece estandares que consumen tiempo y son inadecuados. Este documento examina la factibilidad del análisis de imagen para cuantificar la degradación de la apariencia visual de estándares ASTM usados en la evaluación de la degradación de la pintura de tráfico por abrasión y resistencia al despostillamiento.

Cubierta Con Errores en Datos Eloctroquimicos de Impedancia Espectroscopica de Metales Recubiertos—W.S. Tait

JCT, 66, No. 834, 59 (July 1994)

Las varicaciones en los datos de la impedancia de espectroscopia electroquímica (EIS) son grandes debido a las variaciones en el sistema de recubrimiento, y no debido a los errores en el equipo de medición. El error estadístico relativo es grande cuando el numero de repeticiones por cada variable es menor a cinco, las desviaciones de pruebas estandar también afectan significativamente la magnitud del error cuando el número de repeticiones es menor a cinco.

different paint formulations, which were applied to polyvinyl chloride (PVC) and steel substrates. The coated panels were tested in Alexandria's western harbor's water. Some of the prepared paints showed steel protection from marine corrosion after an exposure of approximately one year.

Lead-Based Paint and The Lead-Abatement Issue in the United States—Northwestern Society for Coatings Technology Technical Committee (E.C. Ferlauto)

JCT, 66, No. 834, 69 (July 1994)

The issue of lead abatement has been related in the media directly to lead-based paint. Although other sources have been greater contributors to high blood lead levels in children according to major studies conducted in recent years, abatement programs seem to concentrate efforts on detection and control of lead-based paint in residences. This paper serves as an introduction to the history to lead used in paint. It defines current problems associated with abatement and the diversity of federal, state, and local regulations. Questions under scrutiny by the courts are also reviewed. Although no simple answers have been derived to detect and control lead hazards, government agencies, and professional and industrial organizations are working towards adequate definition and control of the problem. This is being accomplished by focusing on standards, specifications, guidelines, methods of analysis, and accreditation for contractors, inspectors, and laboratories needed to correct hazardous conditions.

Le Développement de Formulations de Revêtements Marins á Base de Composés Thiotriazole—A.B. Tadros

JCT, 66, No. 832, 63 July (1994)

Le 4-amine-3-hydrazino-5-thio-1,2,4-triazole (I), son complexe cuivré et ses dérivés chlorinés ont été synthétisés et vérifiés en tant qu'agents antimoisissure et anticorrosif.

Les vérifications ont été effectuées par l'addition de trois composés dans différentes formulations de revêtement, et appliquées sur de subjectiles de chlorure de polyvinyl (PVC) et de métal. Les panneaux enduits ont été vérifiés dans l'eau du port occidental d'Alexandria. Quelque uns des revêtements ont démontré une bonne protection du métal contre la corrosion, et ce aprés une période d'exposition d'un an.

Revêtements à Base de Plomb et le cas de la Diminution du Plomb aux Etats-Unis—Northwestern Society for Coatings Technology Technical Committee (E.C. Ferlauto)

JCT, 66, No. 834, 69 (July 1994)

Le cas de la diminution du plomb a été relié directement aux revêtements par les média. Même si d'autres sources ont contribuées largement aux haut taux de plomb dans le sang des enfants, selon des études majeures effectuées dans les années récentes, les programmes de diminution semblent concentrer leurs efforts sur la détection et le contrôle de revêtements à base de plomb dans les résidences. Cette publication sert à introduire l'histoire du plomb utilisée dans les revêtements. Elle définit les problèmes actuels associés avec la diminution du plomb et la diversité règlements fédéraux, provinciaux et municipaux. Les questions scrutées par les tribunaux sont également revues. Même si aucunes réponses simples ne sont élaborées pour détecter et contrôler les problèmes reliés au plomb, les agences gouvernementales, professionnelles et industrielles travaillent dans le but de définir et contrôler le problème. Ceci est accompli en ciblant sur les standards, spécifications, guides et méthodes d'analyse et d'accréditation pour les contracteurs, inspecteurs et laboratoires requis pour corriger les conditions risquées.

Desarrollo de Las Formulaciones en Pintura Marina Basado en Componentes de Tiotriazol—A.B. Tadros

JCT, 66, No. 834, 63 (July 1994)

El complejc de cobre 4-Amino-3-hidrazino-5-trio-1,2,4-triazol (I) y sus derivados clorinados han sido sintetizados y probados como agentes antiespumantes y anticorrosivos.

Las pruebas fueron llevadas a cabo atráves de la incorporación de a compueatos en diferentes formulaciones de pintura aplicadas estas en sustratos de cloruro de polivinilo (PVC) y acero. Los paneles recubierios fueron probados en el puerto maritimo de Alejandria del Oeste. Algunas de las pinturas preparados mestraron una protección en el acero contra la corrosión marina después de una exposición de cerca de un año.

Pintura a Base de Plomo y Los Resultados de la Reduccion de Plomo en los Estados Unidos—Northwestern Society for Coatings Technology Technical Committee (E.C. Ferlauto)

JCT, 66, No. 834, 69 (July 1994)

Los resultados de la reducción de plomo ha sido relacionada directamente con las pinturas a base de plomo. De acuerdo con la mayoría de los estudios conducidos en años recientes otras fuentes contribuyen enormemente y en mayor grado en el incremento de los niveles de plomo en la sangre en infantes; los programas de reducción parecen concentrar sus esfuerzos en la detección y control de la pintura a base de plomo en residencias. Este documento sirve como introducción a la historia del plomo en pinturas, define los problemas comunes asociados con el abatimiento y la diversidad de regulaciones federales, estatales y locales. Las agencias gubernamentales, organizaciones profesionales e industriales estan trabajando hacia la adecuada definición y control del problema, esto ha llevado a enfocarse en las necesidades para corregir condiciones peligrosas a estandares, especificaciones, quías métodos de análisis y acreditaciones para inspectores y laboratorios.

Federation News

Northwestern Society Hosts 1994 Spring Week in Minneapolis, MN, on May 12-15

Although prepared for the temperatures normally associated with a "northern exposure" locale, participants at the 1994 FSCT Spring Week activities were treated to uncommonly balmy breezes and delightful Midwestern hospitality of the Northwestern Society members during the 1994 Federation Spring Week, hosted by Minneapolis, MN, on May 12-15.

Held at the Marriott City Center Hotel, the meeting began on May 12-13 with the Federation Spring Symposium, "Adhesion in Coatings: Technology and Characterization," sponsored by the FSCT Technical Advisory Committee. The Incoming Society Officers Meeting, held annually to assist incoming officers as they move through the chairs of the Constituent Societies, was held on May 14. Spring Week activities concluded on May 15 with the FSCT Board of Directors Meeting.

Board of Directors Highlights

Attendance: Thirty-five members of the Board, plus 10 guests attended the meeting, (including eight Society Officers).

Financial report: The 1993 Statement of Income and Expense and 1994 Operating Budget were reviewed in detail by staff. The First Quarter 1994 Statement showed income and expense well within the budget set at $2.99 million.

Annual Meeting and Paint Show: The theme for the Annual Meeting & Paint Industries' Show, "Excellence Through Innovation," accurately describes the means by which the industry will advance in the future. Innovating techniques will be discussed at technical presentations as well as at the exhibit booths. Technical programming, under the direction of Chairman Ronda Miles, of Union Carbide, will feature nearly 50 presentations over the three-day event. The program theme will be the focus of the Keynote Address, entitled "Futureview," to be given by Daniel Burrus, noted science and technology forecaster.

Over 92% of exhibit space has been contracted for the 1994 Paint Industries' Show, with more than 260 exhibiting companies occupying 90,000 sq. ft. of exhibit space. Housing and registration information have been sent to all members.

Officer/Board Nominations: The slate for 1994-95, presented by the Nominating Committee is:

President-Elect—Darlene R. Brezinski, of Chicago Society.

Secretary/Treasurer—Jay Austin, of Chicago Society.

Executive Committee—Gerry Gough, of Birmingham Club (Three-year term).

Board Members at Large—Freidun Anwari, of Cleveland Society and F. Louis Floyd, of Baltimore Society. (Two-year terms each).

Board (Past-President)—John Oates, of New York Society. (Two-year term).

By-Laws: The Board approved revisions to By-Laws affecting NPCA representation on FSCT Board of Directors.

It was determined that the passage of first reading on October 25, 1993, of the proposed amendment to allow expansion of eligibility for Society Representatives was in conflict with established procedures. Therefore discussions were held regarding the provision to By-Laws allowing Associate Members to hold Society Representative office. After lengthy discussion, the amendment was defeated.

An amendment to the Standing Rules was made regarding a proposal by the Mexico Society to expand its territory. This was approved and the Mexico Society territory has been expanded to include all of the country of Mexico and Central and South America.

NPCA Report: Executive Director of the National Paint & Coatings Association, J. Andrew Doyle, provided a report on current activities of NPCA as well as the status of FSCT/NPCA cooperative efforts. In discussing the $100,000 grant provided in 1993 and 1994 by the FSCT, he stated that these funds have been targeted for the support of the State Paint Council Network. He announced that two new Councils have been initiated, in Ohio and in the Pacific Northwest, and credited the FSCT grant for making this possible. Mr. Doyle emphasized the importance of local Society involvement in the Councils.

Society Officers Meeting

The 18th annual orientation meeting for Incoming Society Officers was attended by representatives of 24 Societies. Informal round-table sessions featured discussions on topics of importance to both the FSCT and Society operations: Administration and Committee Structure; Membership Retention and Recruitment Programs; Education and Program Development; Communications and Public Relations; and Finances and Budgeting. Led by Federation Officers and Staff, the discussions were enthusiastic and many ideas were generated to benefit both the local Constituent Societies and the FSCT.

FSCT Spring Seminar

Developed by the FSCT Technical Advisory Committee (Gail Pollano, Chair), the two-day seminar featured the following presentations: "Surfaces/Adhesion"; Corrosion/Adhesion"; "Effects of Sudden Temperature Changes on Multilayer Coated Composites"; "In-Mold Plasma"; "Surface Modification of Molded Polyolefin Parts with Electrical Discharges"; "An Investigation into How Chlorinated Polyolefins Promote Adhesion of Coatings to Polypropylene"; "Powder Coating for Non-Metallic Substrates"; "How to Maximize Powder Coating Adhesion and Corrosion Resistance"; "Nondestructive Ultrasonic Gaging of Paint Coating Layers on Plastic or Metal"; "High Speed and Low Temperature Curing Using UV for Processing of Coatings, Inks and Adhesives"; "VOC Reduction of TPO Adhesion Promoter Using Supercritical Fluid Spray Process"; "Water-Base Paint Technologies for Automotive Plastics"; "Adhesion Testing"; "Surface Quality Analysis of Class "A" Surfaces for Automotive Application"; and "Stone Impact Damage to Automotive Paint Finishes: Techniques to Evaluate Loss of Adhesion at the Metal/Polymer Interface." Open Forum Sessions completed each day's presentations.

* * *

We sincerely thank the members of the Northwestern Society for their generous hospitality and support of the Spring Week events, and for sponsoring the Minneapolis/St. Paul tour. The Society's assistance in all aspects of Spring Week was invaluable. Also gratefully acknowledged are the official Spring Week sponsors: Milsolv Minnesota Corp., SCM Chemicals, and Engineered Polymer Solutions.

The FSCT sincerely appreciates the efforts of the Technical Advisory Committee for their development of the seminar and their assistance on-site.

Industry Support Continues to Grow for FSCT Panorama™ MSDS Retrieval System

Interest in and support of the FSCT's Panorama™ MSDS on CD-ROM Retrieval System is growing dramatically as the volume of MSDS and the number of participating companies featured on the System continue to expand. To be released in mid-July, the third Panorama disc in the 1994 series will feature 14,000 MSDS from approximately 110 suppliers to the coatings and allied industries.

Responding to the growing need for some method of relief in dealing with governmental regulations pertaining to the 30-year storage of information contained on MSDS, the Federation developed the Panorama System. Initially released in early 1994, the first CD in the Panorama series contained approximately 8,000 MSDS of raw materials used in the coatings industry.

Each updated disc, released on a quarterly basis, contains the original Material Safety Data Sheets submitted for the System, as well as all updated MSDS. Superceded and updated MSDS are obviously flagged to allow the user to easily distinguish between them. In this way, the System permits compliance with government regulations by maintaining the trail of MSDS while insuring that the most recent MSDS is immediately accessible.

The Panorama System features powerful search software which allows easy access to MSDS through a variety of means. Searches can be done on company name, product name, CAS number, or any series of terms in a matter of seconds. As a special feature of the System, users may incorporate their own in-house product codes to access MSDS.

After accessing the desired MSDS, users can download pertinent information to their own PC hard drive for printing or to incorporate desired sections to aid in creating a new MSDS.

Subscriptions to Panorama are offered on an annual basis and the subscription fee includes four quarterly updates, a user's manual, and access to telephone support.

To subscribe to the System, send a subscription and license agreement with payment to FSCT headquarters. License agreements are included in issues of the JOURNAL OF COATINGS TECHNOLOGY, or may be requested by contacting FSCT headquarters at 492 Norristown Rd., Blue Bell, PA 19422. Phone: (610) 940-0777.

Raw Material Supplier Participation

The FSCT invites raw material suppliers to participate—at no cost whatsoever— in a program which benefits the entire coatings industry—the Panorama MSDS on CD-ROM System. Material Safety Data Sheets for all of the raw materials used by the coatings industry *(and allied industries, such as plastics, paper, inks, dyes, textiles, etc.)* should be submitted. These submissions should be in electronic format that will conform to one of the following standards:

▲ ASCII format. (The majority of programs, e.g., Wordperfect and Microsoft Word have the capability to save files in ASCII format).

▲ The media for submission must be either a high density 3.5 diskette or Sony P6 120 MP 8 mm Video ANSI labeled tape cartridge.

▲ Each diskette or tape should have the following information: Company Name and Address, a Directory Printout of each diskette, and the Software Package used to generate the file. A hard copy of each MSDS is required. Computer file names should be located on the MSDS hard copy.

OR

▲ Paper format is acceptable if electronic format is not feasible.

Submissions should be sent to Michele (Wollheim) Cortopassi, Accu-Mem Systems, Inc., 3105 N. Wilke Rd., Suite D, Arlington Heights, IL 60004. Phone: (708) 670-7030, FAX: (708) 670-7046.

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The parties to this agreement are Federation of Societies for Coatings Technology (hereinafter "Licensor") and the Licensee identified on the first page of this Agreement ("Licensee" or "us").

2. The Product

The Panorama™ Coatings MSDS CD Retrieval System, "the Product," consists of the database listed above stored on CD-ROM disc(s) issued quarterly during the term of the subscription agreement, a user's manual, and the software (the "Personal Librarian Software") required to access the database. The database consist of information contained in Material Safety Data Sheets ("MSDS") for raw materials, as well as technical specifications contained in a Raw Material Index for raw materials used in the manufacture of paint, coatings, and inks. The CD-ROM discs are designed to be accessed through a CD-ROM drive coupled to either an IBM-compatible personal computer (PC/AT™ 386 or greater with MS.DOS 3.3 or later, with Microsoft Windows™ 3.0 or later, and 2 MB or RAM minimum). Host adapters and SCSI interface cables are also required.

3. Multiple Subscriptions

Multiple subscriptions shall be defined as orders for multiple discs by a single organization to be shipped to a single address.

4. The License

In consideration of payment of the license fee, which is included in the subscription price, the Licensor grants to Licensee a non-transferable, non-exclusive license to use the Product according to the terms and conditions of this Agreement, which license shall terminate after twelve (12) months or twenty-four (24) months, depending on the term of the subscription, after the delivery of the Product to the Licensee, unless extended by Licensor upon renewal of the subscription at the then current rates. Licensee shall use Product only for internal purposes, shall not use the Product as a component of, or a basis for, a directory or database prepared for commercial sale or distribution outside the Licensee's organization and shall neither duplicate the Product or alter the Product in any way; provided, however, that the Licensee may make backup copies of the Product, in whole or in part, for use only in accordance with the terms in this Section 4.

5. Ownership of Data and Database

The database ordered on the Agreement as formatted for CD-ROM publishing is owned by Licensor and no right to the database in this form or any part thereof is conveyed to Licensee except the right to use it within the Licensee's normal business operations. In no event may persons other than the Licensee and its employees be permitted to use the data in the CD-ROM disc form. In no event may the database be downloaded for sale or conveyance for value by Licensee to a third party.

6. CD-ROM Disc Drives

The Product have been designed to operate on CD-ROM Disc Drives which have been tested by Licensor or in accordance with procedures established by Licensor. A list of such drives and procedures is available from Licensor.

7. Confidentiality

Licensee shall take all necessary action whether by instruction, agreement, or otherwise, to restrict and control the use, copying, protection and security of the Product data, software, documentation and other support materials to assure compliance with the terms hereof and shall prevent access to the Product except to those permitted to have access by the terms of this Agreement.

8. Hotline

For one year from the date of delivery of the Product, Licensor will have consultants available by telephone during its normal business hours to answer questions and provide assistance for Licensee. Use of such hotline will be at Licensee's sole risk and Licensor shall not be liable for any loss or damage arising therefrom, whether resulting from negligence or otherwise.

9. Product Updates

The Product ordered on this Agreement will be updated on a quarterly schedule in the form of completely new current discs with the new information added. Upon receipt of an updated disc, Licensee shall return the outdated disc to Licensor within 30 days. Failure to return the outdated disc will result in the withholding of subsequent updated discs. If and when software updates become available, Licensee shall have the right to purchase such updates at Licensor's then current prices.

10. Lost Discs

CD-ROM discs which are lost or stolen will be replaced at a cost of $25.00 per disc. Defective discs which are returned to Licensor will be replaced at no charge.

11. Limited Warranty and Disclaimer

Licensor warrants and represents that it has the complete right to enter into this Agreement and to deliver the Product and the database contained in the Product and the data in such database. THE FOREGOING WARRANTY IS IN LIEU OF ANY AND ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING WITHOUT LIMITATION, WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. LICENSOR NEITHER ASSUMES NOR AUTHORIZES ANY OTHER PERSON TO ASSUME FOR LICENSOR ANY OTHER LIABILITY IN CONNECTION WITH THE LICENSING OF THE PRODUCT UNDER THIS AGREEMENT. ALTHOUGH CARE IS USED IN PREPARING THE DATABASE CONTAINED IN THE PRODUCT, LICENSOR AND THE SUPPLIERS OF THE DATA CANNOT BE HELD RESPONSIBLE FOR ERRORS OR FOR ANY CONSEQUENCES ARISING FROM THE USE OF THE INFORMATION CONTAINED ON THIS CD-ROM. THE DATA PROVIDED ON THE PRODUCT WAS FORMULATED WITH A REASONABLE STANDARD OF CARE TO INSURE ACCURACY. INFORMATION CONTAINED IN THE DATABASE IS SUPPLIED TO LICENSOR BY THIRD PARTIES, AND LICENSOR EXPRESSLY DISCLAIMS ANY RESPONSIBILITY OR LIABILITY FOR THE NEGLIGENCE OR WILLFUL MISCONDUCT OF SUCH SUPPLIERS IN THE PROVISION OF THIS INFORMATION. USERS OF THIS PRODUCT ARE SOLELY RESPONSIBLE FOR COMPLIANCE WITH ANY COPYRIGHT RESTRICTIONS AND ARE REFERRED TO THE COPYRIGHT NOTICES APPEARING IN THE DATABASE ON THE CD-ROM OR IN THE ORIGINAL PRINTED MATERIAL, ALL OF WHICH IS HEREBY INCORPORATED BY REFERENCE.

12. Limitation of Liability

Licensee agrees to hold Licensor harmless from any liability arising from incorrect operation of the Product. Licensee further agrees that LICENSOR ASSUMES NO RESPONSIBILITY WITH RESPECT TO LICENSEE'S USE OF THE PRODUCT AND SHALL NOT BE LIABLE FOR LOSS OF PROFITS, LOSS OF USE OR INCIDENTAL, CONSEQUENTIAL OR EXEMPLARY DAMAGES, EVEN IF AWARE OF THE POSSIBILITY THEREOF. INCLUDING, WITHOUT LIMITATION, LIABILITY UNDER ANY FEDERAL, STATE OR LOCAL ENVIRONMENTAL LAWS OR REGULATIONS. IN NO EVENT MAY EITHER LICENSOR OR LICENSEE BRING ANY CLAIM OR CAUSE OF ACTION AGAINST THE OTHER MORE THAN ONE YEAR AFTER SUCH CLAIM OR CAUSE OF ACTION ARISES. LICENSOR SHALL IN NO EVENT BE LIABLE FOR MORE THAN THE LICENSE FEE THEN PAID FOR THE PRODUCT (WHETHER LICENSOR'S LIABILITY ARISES FROM BREACH OF WARRANTY, BREACH OF ANY OBLIGATION ARISING FROM BREACH OF WARRANTY, OTHER BREACH OF THIS AGREEMENT, OR OTHERWISE , WHETHER IN CONTRACT OR IN TORT). SOME STATES DO NOT ALLOW THE EXCLUSION OR LIMITATION OF THE IMPLIED WARRANTIES OF LIABILITY FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES, SO THE ABOVE LIMITATION MAY NOT APPLY TO EACH LICENSEE.

13. Term

The term of this Agreement shall be one year or two years, depending on the applicable subscription fee paid, and may be renewed at the fees current on the renewal date.

14. Termination of License

If Licensee breaches any term of this Agreement, in addition to all other legal remedies, Licensor may immediately terminate the License granted hereunder. Upon termination of the License by Licensor or Licensee for any reason, Licensee shall, unless otherwise agreed to in writing by Licensor, immediately return to Licensor the Product and all copies thereof, whether modified, merged or included with other data or software and shall certify in writing to Licensor that Licensee has not retained the Product or copies thereof. The provisions of this Agreement which protect the proprietary rights of Licensor shall continue in force after termination.

15. Indemnification

Licensee agrees to indemnify and hold Licensor harmless from and against any and all claims of third parties (including copyright infringements) arising out of or related to the use of the Product by Licensee.

16. Notices

All notices, consents or other communications referred to herein shall be in writing, and shall be sent to the other party by first class mail addressed to that party at the address specified in this Agreement or to such alternate address as either party may furnish in writing to the other.

17. No Assignment by Licensee

This Agreement, and the License contained herein, may not be assigned by Licensee.

18. Force Majeure

Licensor shall not be responsible for any failure to perform (or delay in performance), in whole or in part, due to unforeseen circumstances or circumstances beyond Licensor's control, including but not limited to acts of God, war, riot, embargoes, acts of civil or military authority, fire, flood, accidents, strikes and shortages of transportation, facilities, fuel, labor, or materials.

19. Entire Understanding

This Agreement represents the entire understanding of the parties with respect to the subject matter hereof, and there are no representations, promises, warranties, covenants or understandings with respect thereto other than those contained in this Agreement. Without limiting the generality of the foregoing, it is expressly agreed that the terms of any purchase order issued by Licensee with respect to this Agreement of the Product shall not be applicable and that any acceptance of such purchase order by Licensor shall be for acknowledgment purposes only.

20. Illegality and Unenforceability

If a term or condition of this Agreement is found by a court or administrative agency to be invalid or unenforceable, the remaining terms and conditions shall be enforceable to the maximum extent permitted by law.

20. Governing Law

This Agreement shall be governed by and construed in accordance with the laws of the Commonwealth of Pennsylvania without giving effect to the principles of conflict of law thereof.

Women in Coatings Accepting Nominations for Eighth Annual Achievement Awards

Women in Coatings (WIC) is accepting names of all women who have made a significant contribution in support of paint and coatings and related industries, for the 1994 WIC Achievement Awards. The presentations will take place during the Federation of Societies for Coatings Technology's Annual Meeting on October 12-14, 1994, in New Orleans, LA.

Contributions can include the publication of technical or nontechnical papers, presentations of information or any significant accomplishment benefiting the industry in general. The dedication of these active women in the paint industry should be above and beyond their normal job responsibilities. Membership in WIC is not required to be considered for a WIC Achievement Award.

The award categories are as follows:

COMMUNICATIONS—Overall contributions such as product information, promotions, advertising, and general public relations.

MANAGEMENT—Overall management of products, projects, customer accounts, department, or staff.

LEADERSHIP—Ability to lead within the industry as in actively participating in professional and trade associations.

RESEARCH AND TECHNOLOGY—Overall contribution by way of R&D such as product innovation and processes.

SALES AND MARKETING—Overall contribution by way of sales and marketing as evidenced by increased recognition by customers and business associates with the industry, significant increase in sales, and development of a certain market segment.

PURCHASING—Overall contribution resulting in cost savings of purchased materials, improvement of product quality by purchasing from quality conscious suppliers, and JIT inventory.

INDUSTRY SUPPORT—Other branches within the companies that are not included in the preceding categories. Examples of such groups are the laboratory technicians, secretarial and clerical help, customer service and order desk, shipping and receiving, and computer operators.

The WIC Awards recognize those who have contributed to the advancement of paint and coatings and provide incentive to those women striving for excellence in their fields.

WIC attempts to unite women in paint and coatings and related industries in a forum where support can be derived and common experiences can be shared in overall pursuit of creating a stronger and more versatile industry.

All nominations for the 1994 WIC Awards are due no later than September 9. Send the nominee's name, award category, and accomplishment(s), and appropriate date(s), to Eve De La Vega-Irvine, c/o J.M. Huber Corp., Clay Div., One Huber Rd., Macon, GA 31298.

United Minerals Opens Surface Modification Facility in Arkansas

The toll treatment facility for the surface modification of filler materials has been opened by United Minerals Corp., Tamarac, FL. The new plant, located in Malvern, AR, currently has a capacity of 10,000 tons per year, with expansion capability to more than double this production level.

This facility incorporates technology to attach organo functional coupling agents to most of the fillers used in the paint, plastics, rubber, caulk, and sealant industries. Some of the materials treated include silicas, kaolins, micas, wollastonite and ATH, among others.

United Minerals is in the final stages of becoming a subsidiary of the AIM Group, Inc., a materials technology company with interests in industrial minerals, chemicals, and new generation coatings.

C.P. Hall Increases Memphis Plant's Production Capacity

The C.P. Hall Co., Chicago, IL will expand their Memphis, TN, production unit. This facility manufactures a line of dry liquid dispersions, such as slab dips, release agents, and compounded products. The expansion consists of bulk liquid storage, new production equipment, and facility improvements.

The C.P. Hall Co. supplies a line of chemicals, additives, and industrial chemical products to various polymer industries.

PPG Industries Expands Lake Charles, LA Plant; Ends Auto Coatings Agreement with Nippon Paint

A multimillion dollar expansion of its Lake Charles, LA, precipitated amorphous silicas plant has been approved by PPG Industries, Pittsburgh, PA. The flexible manufacturing facility will be capable of producing products to serve the tire and rubber industry and dentrifice business. Among the new products are Hi-Sil 255, Hi-Sil EZ silica, and Hi-Sil 2000. Construction of the facility has already begun, and it is scheduled to be in operation later this year.

In other news, PPG Industries and Nippon Paint Co., Osaka, Japan, have ended agreements by which they cooperatively served coatings requirements of Japanese automakers in North America and Europe.

PPG and Nippon will continue to jointly serve customers during a one-year post-agreement transition; thereafter, PPG will provide uninterrupted service to their customers.

Through the 1987 agreements, Nippon Paint provided product qualification technical support and licensed certain products to PPG who has continuing rights to the product technology, and anticipates adding capacity to make products that Nippon Paint supplied under the agreements.

Akzo Coatings Changes Name Following Merger

Following the recent merger between Akzo nv and Nobel Industrier AB, former Akzo Coatings Inc. locations across the United States have changed their legal names to Akzo Nobel Coatings Inc. The Canadian locations will also undergo a name change in the near future, but will continue operating as Akzo Coatings Ltd. in the interim.

The merger between Akzo nv of Arnhem, the Netherlands and Nobel Industrier AB of Sweden was finalized in February 1994. The new company, Akzo Nobel nv, is headquartered in Arnhem.

New Construction Contracts Drop Seven Percent in April

Following a rebound in February and March, new construction contracts fell seven percent in April, according to the F.W. Dodge Division, New York, NY, of McGraw-Hill. A loss of momentum for nonresidential building and housing was the cause of the decline, as nonbuilding construction (public works and utilities) held steady.

The latest month's report lowered the seasonally adjusted Dodge Index to 103 (1987=100), down from March's revised 111 in a retreat from the stronger totals which were posted in the prior two months.

Nonresidential building in April dropped 12%, with lower contracting reported by most of the structure types. Commercial building returned to a pace more typical of recent months, as March had drawn support from the bunching of several large retail and office projects.

The institutional sector also retreated from its March surge, reflecting a slight one percent downturn for school construction and more substantial declines for other categories, such as healthcare building.

Due to moderate weakening for single family housing, which still remained at a relatively healthy volume, residential construction decreased seven percent in April. Multifamily housing, in a more depressed condition, fell back from its heightened March amount. The residential decline was most pronounced in the West, while the other regions of the country stayed close to the previous month.

Nonbuilding construction in April remained unchanged, as modest strengthening throughout most of the public works categories offset a low level of utility construction. Highways and bridges held close to their higher volume of recent months, while sewer and water supply contracting showed a seven percent improvement.

Through 1994's January-April period, total construction on an unadjusted basis maintained a six percent lead over the same period a year ago, supported by an 11% pickup for residential building. Nonresidential and nonbuilding construction posted more subdued gains of three and two percent, respectively. Regionally, the West led the nation with 15% growth, followed closely by 13% expansion in the Midwest. The seven percent advance in the South Central and the four percent advance in the South Atlantic were closer to the national average. The Northeast, down 13% in 1994's first four months, continued to show the impact of a harsh winter experienced at the year's outset.

Sun Chemical Expands in Cincinnati

The acquisition of the Drackett Company office complex in Cincinnati, OH has been announced by Sun Chemical Corp., Fort Lee, NJ. The 10-acre site will become the new headquarters of Sun's Colors Group, which manufactures organic pigments and pigment dispersions; Colors International will continue to be based in Bierges, Belgium.

While the main intent of this acquisition was the expansion of the Colors Group's technical service laboratories, the new facilities will also house the administrative offices as well as the sales, research, engineering, and data processing departments. The new site is located near the Colors Groups pigment plant, and features more than 230,000 square feet of space; of which 50,000 square feet is laboratory space and its pilot plant.

The Colors Group is presently in the process of relocating to the Drackett office complex. The division expects transfer to the new facility to be completed by the end of 1994. All manufacturing operations in the Cincinnati area, however, will remain at the Chickering Ave. and Amelia locations.

Grow Group, Inc. Purchases Sinclair Paint's Assets

Grow Group, Inc., New York, NY, has signed an agreement to purchase certain assets and assume liabilities of Sinclair Paint, a division of Insilco Corp., Los Angeles, CA, for a price of $51 million plus other considerations (subject to adjustment at the closing). Adding to Grow's Devoe & Raynolds and Ameritone operations, Sinclair generated over $95 million of revenues in calendar year 1993 through 49 company-operated stores.

The closing, which is subject to a number of conditions, including a Hart-Scott-Rodino filing, is expected to take place on or about August 1, 1994. In connection with the anticipated acquisition, Grow Group is negotiating an increase in its credit line to $60 million.

Emulsion Systems Inc. Acquires New Production Facility

Emulsion Systems Inc. (ESI), Valley Stream, NY, acquired an additional production facility adjoining its current site in Lemont, IL.

The facility was originally part of the Unocal Chemical Division purchased by Rohm and Haas in 1992. This newly acquired six-acre site will provide the company with approximately 100 million pounds of added polymer production capacity, automated processing, and extensive finished product storage.

The ESI Lemont facility now covers more than 10 acres. The company intends to keep the existing facility open and is currently looking to expand its central Research and Development Laboratories.

Emulsion Systems Inc. manufactures emulsion polymers for the coatings industry. The company distributes its products primarily to manufacturers of graphic arts materials, floor polish, and adhesives worldwide. Portions of ESI technology have been licensed to Valchem, Australia (a division of ICI), Hispano Quimica in Spain, and Indofil in India.

Purity Zinc Forms Alliance With North American Oxide

North American Oxide Inc., Clarksville, TN, and Purity Zinc Metals Co. Ltd., Stoney Creek, Ont., have announced their affiliation under common ownership. The owners of North American Oxide have purchased Purity Zinc Metals Co., Ltd.

Purity Zinc Metals manufactures zinc dusts, zinc alloys, and marine and electroplating anodes, and recycles zinc materials. The company also supplies automotive paint and chemical customers throughout the U.S. and Canada.

North American Oxide, who started the production at their Tennessee plant in 1990, is North America's newest manufacturer of zinc oxides. Their customers include the rubber, paint, ceramic, and chemical industries throughout the U.S. and Canada.

Hüls de Mexico Purchases Sales Agency in Mexico

Hüls de Mexico, S.A. de C.V., a subsidiary of Hüls America, Inc., Piscataway, NJ, has acquired the C.T.J. Maass sales agency in Mexico City, Mexico.

C.T.J. Maass has serviced the Mexican coatings and ink industries for over 48 years representing many Mexican, American, and British suppliers.

The existing organization and its staff will continue to support the sales activity of Hüls' Paint Colorants and Additives businesses. New personnel will be added to specifically support the marketing activity of the company's coatings raw materials and specialty polymer products, sourced from both the U.S. and Germany.

Regulatory UPDATE

July 1994

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.

Department of Transportation
Research and Special Programs Administration
June 2, 1994—59 FR 28487
Transportation of Hazardous Materials; Miscellaneous Amendments
Action: Final Rule

The Research and Special Programs Administration (RSPA) has implemented a final rule that incorporates changes to the Hazardous Materials Regulations (HMR; 49 CTR parts 171-180). The changes are based on either requests from the industry or agency initiative.

The amendments primarily clarify and correct certain inconsistencies appearing in the HMR, add a specific shipping description currently authorized by approval, and update certain standards that had been incorporated by reference. These changes signify no new changes for those subject to the HMR.

The changes will be effective July 1, 1994. For further information, call Diane LaValle (202) 366-4488 at RSPA, Office of Hazardous Materials Standards, U.S. DOT, Washington, D.C.

Department of Transportation
Research and Special Programs Administration
May 27, 1994—59 FR 27650
International Standards on the Transport of Dangerous Goods
Action: Notice of Public Meeting

The ninth session of the Subcommittee of Experts on the Transport of Dangerous Goods will be held in Geneva, Switzerland, July 4-July 15. In preparation for that meeting, RSPA is holding a public meeting on June 28 to exchange views on U.S. proposals previously submitted to the U.N.'s Subcommittee.

Topics of discussion include amendments to the *U.N. Manual for Tests and Criteria*, criteria for liquid and solid oxidizing substances review of portable tank requirements, requirements for non-bulk packagings and intermediate bulk containers used to transport dangerous goods, requirements for segregating dangerous goods in transport, international activities relating to harmonization of chemical classification and labeling requirements, restructuring of the UN Recommendations as a model regulation, and other proposed amendments to the UN Recommendations.

For further information on the June 28 discussions, please contact Fritz Wybenga, International Standards Coordinator, Office of Hazardous Materials Transportation, U.S. DOT, Washington, D.C. 20590, (202) 366-0656.

Lead—Legislation banning lead in most paints, toys, and game pieces, inks, glass coatings, lead solder used in plumbing systems, and packaging passed the full Senate at the end of May.

The bill, S. 729, sponsored by Sen. Harry Reid (D-NV), does not apply to artists' paint, but it does apply to lead in paint-tube packaging.

The general effective dates of the bans on lead would be one year after enactment for the importation, manufacture, and processing, and two years after enactment for its market distribution. For paint, primers, and coatings containing lead used on motor vehicle parts and equipment used for agriculture, construction, and industrial forestry purposes, there would be a phase-out of lead—up to 13 years for production and 14 years for distribution. Certain expressed glass coatings (architectural, automotive window, mirror backings) are given five years for manufacture and six years for distribution.

The bill differs from a 1992 proposal in that it has a new built-in appropriation of $54 million to pay for the state inspection and reporting of lead hazards in day care centers and elementary schools.

Superfund—At the end of May, the House Energy and Commerce Committee approved legislation that would overhaul the "superfund" toxic waste cleanup law.

By a vote of 44-0, the committee passed H.R. 3800 which would establish a new procedure for determining liability for pollution—distributing cleanup costs among all companies responsible for dumping at the site. Currently a single company can be liable for all cleanup costs at a site, even if that party is responsible for only a small part of the pollution.

The measure will be considered in early summer by the House Public Works and Transportation Committee. Reportedly, Rep. Bill Zeliff (R-NH) plans to offer an amendment to reconstruct the funding mechanism by setting up a trust fund for future cleanups. The fund will be established with monies from higher environmental taxes levied on businesses currently on EPA's polluter list.

The Senate Environment and Public Works Subcommittee on Superfund , Recycling, and Solid Waste Management approved comprehensive legislation to reform the superfund law this week. As approved, the Superfund Reform Act of 1994 (S. 1834) leaves intact the bulk of President Clinton's proposal and is similar to the House bill HR 3800, which was unanimously approved May 18 by the House Energy and Commerce Committee. Industry reaction to the Senate proposal has been positive.

Clean Water Act—The U.S. Environmental Protection Agency (EPA) is in the process of completing a Clean Water Act (CWA) briefing book for members of Congress. The briefing book is part of the continuing effort to encourage reauthorization of the CWA this year.

Despite EPA's efforts, a number of groups have expressed concern that reauthorization this year will not be possible due to the many contentious issues surrounding the process–including protection of pristine waters and private property rights.

Reportedly, the briefing book is fairly comprehensive–containing side-by-side analyses of various CWA rewrite proposals, including a measure (H.R. 3948) sponsored by Reps. Norman Mineta (D-CA) and Sherwood Boehlert (R-NY), a bill (S. 2093) approved by the Senate Environment and Public Works Committee, as well as the Clinton Administration position paper.

On the Senate side, the Senate Environment and Pubic Works Committee Chairman, Max Baucus (D-MT) is committed to moving their bill to the floor this summer. The committee approved the bill earlier this year.

Occupational Safety and Health—Legislation revamping the Occupational Safety and Health Act was reported favorably from the House Education and Labor Committee on May 26.

The Comprehensive Occupational Safety and Health Reform Act (H.R. 1280) extends far beyond the scope of the Occupational Safety and Health Act itself. The following provisions are included in the legislation:

1. Mandated safety and health committees for employers with 11 or more employees;
2. Detailed written safety and health programs, including a plan for providing employee training and education; expansion of National Institute for Occupational Safety and Health (NIOSH) authority in OSHA enforcement; increased involvement in the settling of standards priorities and permissible exposure limits;
3. Expanded employee participation rights from inspection to settlement in OSHA enforcement actions; employees would be provided with new whistle-blower protection and refusal-to-work writes;
4. Expanded existing OSHA criminal penalties; provisions from earlier high-risk notification proposals;
5. Increased OSHA enforcement authority and changes in OSHA's reporting/recordkeeping requirements;
6. Mandates that OSHA issue generic standards for exposure monitoring, medical surveillance, and ergonomics hazards.

The legislation has not been scheduled for floor action.

In the Senate, the Labor and Human Resources Committee concluded hearings on March 22 on a companion bill, S. 575. Markup of that legislation is anticipated this summer.

Product Liability—On May 23, the Senate reached a unanimous consent agreement providing for the consideration of the product Liability Fairness Act (S. 687). However, no date has been set for consideration.

The bill, which was reported favorably by the Commerce, Science, and Transportation Committee last November, would regulate interstate commerce by providing for a uniform product liability law.

S. 687 would set national standards for determining compensation for victims of faulty products and would provide incentives to settle lawsuits quickly. The bill provides no cap for punitive damage awards.

In the unlikely event this bill passes both Houses of Congress, the President would probably not sign it into law. Reportedly, the Administration objects to the legislation because it favors manufacturers over consumers and strictly limits a victim's ability to sue.

States Proposed Legislation and Regulations

Alabama

Hazardous Waste (Regulation)—The Alabama Department of Environmental Management (DEM) has promulgated a final rule under AAC 335-14 to incorporate changes made to federal EPA regulations, including changes to land disposal restrictions; corrections to amendments for boilers and industrial furnaces burning hazardous waste; financial responsibility requirements for third-party liability, closure, and post-closure; and identification and listing requirements for corrective action. The rule became effective on April 29, 1994. For more information, contact Steven Jenkins, DEM, Office of General Counsel at (205) 271-7726.

Alaska

Air Quality (Regulation)—A final rule of the Alaska Department of Environmental Conservation (DEC) amends regulations under 18 AAC 50 regarding user fees and air contaminant emission fees. In addition, the rule adopts new emission fees for all facilities required to have air quality control permits and revises existing fees. Once the rule is filed by the lieutenant governor, it becomes enforceable thirty days thereafter. For more information, contact Bob Hughes, DEC, (907) 465-5100.

California

Air Quality (Regulation)—A report from the Bay Area indicates that toxic pollutant emissions from stationary sources dropped by roughly 50% over 1989 levels. Significant reductions in emissions of hexavalent chromium, ethylene oxide, 1,4,-dioxane, and perchloroethylene were achieved while emissions of benzene and methylene chloride remained relatively unchanged between 1991 and 1992. For more information, contact Brian Bateman, Bay Area Permits Division at (415) 749-4653.

Hazardous Waste (Regulation)—A final rule of the California Water Resources Control Board (WRCB) amends regulations pertaining to underground storage tanks. The rule revises exemptions; extends the deadline for approval of components used in new tank construction to January 1, 1995; requires owners and operators of new tanks to obtain local agency approval for monitoring programs; and requires monitoring programs for existing USTs to be in writing. The rule also requires releases to be reported to the local agency; specifies corrective action requirements; and revises tank lining requirements. The rule became effective May 4, 1994. For more information, contact Barbara Wightman, WRCB, Division of Clean Water Programs at (916) 227-4318.

Solid Waste (Regulation)—An emergency rule of the California Integrated Waste Management Board amends regulations revising procedures for the adoption of source reduction and recycling elements and county-wide plans for the reduction of waste. The rule revises the method of calculating disposal goals by jurisdictions, updates reporting and monitoring requirements, and allows cities and counties to form regional agencies that would be solely responsible for achieving the 25% and 50% statutorily mandated reduction goals. The rule became effective on April 30, 1994. For more information, contact Elliot Block, IWMB, (916) 255-2821.

Colorado

Air Quality (Regulation)—A proposed rule of the Department of Health (DOH), Air Quality Control Commission amends regulations clarifying the definition of "major source," specifying that fugitive emissions that are not insignificant under Part C of the standards would be considered in determining whether a stationary source of hazardous air pollutants is a major source. A hearing is scheduled for July 21, 1994 in Denver and comments are welcome. For more information, contact DOH, Air Quality Control Commission at (303) 692-3180.

The Department of Health, Air Quality Control Commission has proposed a rule to amend regulations regarding compliance extensions for early reductions of hazardous air pollutants. The proposal would adopt provisions of the federal early reduction program and establish a similar program for compliance extensions from the state maximum achievable control technology/generally available control technology requirements and establish procedures for participating sources to obtain permit fee credits. A hearing is scheduled for July 21, 1994 and comments are welcome. For more information, contact DOH, Air Quality Control Commission at (303) 692-3180.

Hazardous Waste (Regulation)—A final rule of the Colorado Department of Health, Hazardous Waste Commission amends the hazardous waste management regulations to incorporate federal EPA amendments under 40 CFR parts 260, 261, 262, 264, 265, 267, and 268 relating to toxicity characteristic standards. The rule also adopts federal financial responsibility requirements for third-party liability, closure, and post-closure in addition to settlement agreements. The rule went into effect on April 30, 1994. For more information, please contact Karen Osthus, Hazardous Waste Commission, (303) 692-3321.

The Department of Health, Hazardous Waste Commission has proposed a rule incorporating federal EPA amendments promulgated between October 15, 1992 and February 18, 1994 relating to liquids in landfills, listing of production wastes from chlorinated toluenes, frequency of inspecting off-site hazardous waste disposal sites, and the treatability studies sample exclusion. For more information, please contact Karen Osthus, Hazardous Waste Commission at (303) 692-3321.

Water Quality (Regulation)—The Colorado Department of Health, Water Quality Control Commission has proposed a new rule regarding the state's discharge system and amending the basic standards for surface and ground water. The proposal would clarify the criteria for designating waters and making determinations on whether significant degradation will occur and update the organic chemical table and adjust the domestic water supply criterion for cadmium, nickel, selenium, and thallium in Table III. A hearing is scheduled for July 11, 1994 in Denver. No comment due date has been established yet. For more information, contact DOH, Water Quality Control Commission at (303) 692-3520.

The Colorado Department of Health, Water Quality Control Commission has proposed a new rule regarding CWA Section 401 certification standards, specifying application procedures, establishing criteria to be used to make determinations, and clarifying criteria for granting conditional or unconditional certification, among other things. A mandatory pre-hearing conference is scheduled for July 13, 1994. The hearing is scheduled for August 8, 1994, in Denver. For more information, contact DOH, Water Quality Control Commission at (303) 692-3520.

Connecticut

Labeling—CT H. 5111 (Committee on General Law) requires warning labels of combustibility to be placed on drying oils and drying oils products. This bill was signed by the Governor on May 26.

Lead—CT H. 5560 (Committee on Housing) provides incentives and a comprehensive system of lead paint abatement and management in private multi-family residential structures containing 50 or more dwelling units. The legislation passed the Senate on May 4.

CT H. 5561 (Committee on Housing) establishes a comprehensive lead risk reduction plan in housing authorities. On May 4, the bill passed the House and was sent to the Senate.

Water Quality (Regulation)—The Connecticut Department of Environmental Protection (DEP) amends regulations regarding water permit fees. The rule restores the annual fee requirement that was inadvertently deleted. The rule became effective March 1, 1994. For more information, contact Terri Nelson at the DEP, Water Management Bureau at (203) 566-2742.

Florida

Solid Waste (Regulation)—The Florida Department of Environmental Protection (DEP) announced changes to a proposed rule that would clarify the process by which the department would review permit applications for industrial waste disposal and update storm water requirements. For more information, contact Mary Jean Yon, DEP, Solid Waste Section at (904) 922-6104.

A proposed rule of the Florida DEP would implement a schedule requiring a phased removal of incidental amounts of toxic materials from packaging and packaging components manufactured or distributed in the state. For more information, contact Heidi Cordero at the DEP, Bureau of Solid and Hazardous Waste at (904) 488-0300.

Illinois

Air Quality (Regulation)—The Illinois Pollution Control Board (PCB) has issued a final rule amending regulations regarding major stationary source construction and modification. The rule corrects a typographical error to specify that a net emission increase in PM-10 is significant if it amounts to at least 15 tons per year. The rule went into effect April 15, 1994. For more information, contact Marie Tipsord at the PCB at (312) 814-4925.

Hazardous Waste (Regulation)—The Illinois Department of Commerce and Community Affairs announces hearings on a proposed rule concerning petroleum underground storage tanks (UST). The proposal would adopt procedures concerning the remediation of UST sites due to the release of petroleum and other substances; establish procedures for a leading UST program that would oversee and review any remediation required for UST systems and for the administration of the UST fund and provide for a fund to satisfy UST financial assurance requirements. The proposal also would adopt procedures for eligible owners and operators to seek payments for the cost of site investigation and remediation and specify procedures for review and audit and approval of corrective action efforts performed by licensed professional engineers. For more information, contact Linda Brand at the DCCA at (217) 785-6354.

The Illinois Pollution Control Board has issued a final rule incorporating federal EPA requirements promulgated between January 1, 1993 through June 30, 1993 regarding corrective action management units and temporary units, land disposal restrictions for third-third wastes. The rule was effective April 26, 1994. For more information, contact Michael McCambridge at the Pollution Control Board at (312) 814-6924.

Indiana

Air Quality (Regulation)—A notice of the Indiana Department of Environmental Management (DEM) solicits comment on revisions to regulations limiting emissions of volatile organic compounds from wood furniture coatings operations in Clark, Floyd, Lake and Porter Counties. The department seeks specific comments on the following methods described in draft control technique guidelines prepared by the U.S. EPA: coating reformulation; add-on controls; cleanup solution reformulation; and work practice changes.

A notice of the DEM solicits comment on revisions to regulations limiting emissions of volatile organic compounds from architectural and industrial maintenance coatings operations in Clark, Floyd, Lake, and Porter Counties. The department seeks specific comments on the use of lower solvent coatings for uses such as architectural coatings, traffic markings, high performance specialty coatings, and industrial maintenance coatings.

A notice of the DEM solicits comment on revisions to regulations limiting emissions of volatile organic compounds from automobile refinishing operations in Clark, Floyd, Lake, and Porter Counties. The department seeks specific comments on the use of lower solvent coatings and automatic spray gun cleaners as described in draft control technique guidelines prepared by the U.S. EPA.

For more information, contact Phil Doyle at DEM, Office of Air Management at (317) 232-8420.

Iowa

Occupational Safety & Health (Regulation)—The Iowa Labor Services Division (LSD) has proposed a rule regarding personal protective equipment for general industry, adopting federal OSHA standards promulgated April 6, 1994.

An emergency rule was adopted by the Iowa Labor Services Division that adopts amendments to federal OSHA standards promulgated January 3, 1994 and February 9, 1993, regarding occupational exposure to cadmium and hazard communications. The rule became effective May 11, 1994.

Toxics in Packaging—IA S. 2205 (Committee on Environment and Energy Utility) prohibits a manufacturer or distributor from selling a package or packaging component or a product in a package that includes in the package itself or in the packaging component any lead, cadmium, mercury, or hexavalent chromium that has been intentionally introduced as an element during manufacturing or distribution. It allows the incidental presence of these metals in an amount not to exceed established concentration levels. The bill was signed by the Governor on April 19.

Kansas

Water Quality (Regulation)—A proposed rule of the Kansas Department of Health and Environment (DHE) would amend water quality regulations necessary to retain authorization of the federal wastewater discharge permit program. The proposal would expand the number of specific criteria to reflect federal standards, clarify mixing zone provisions and methods for calculating wastewater treatment plant effluent limits, adjust federal EPA gold book criteria to reflect bioavailability, and adopt standards to address effluent created flow from wastewater treatment discharges to dry streams or ditches. For more information, contact Bethel Spotts, DHE, (913) 296-5519.

Kentucky

Hazardous Waste (Regulation)—An emergency rule of the Kentucky Petroleum Storage Tank Environmental Assurance Fund Commission establishes certification requirements for contractors performing corrective action at underground storage tank sites. The rule specifies application, experience, and examination requirements in addition to certification and renewal procedures. The rule went into effect March 1, 1994. For more information, contact Stephen Atwood at the PSTEAFC at (502) 564-5981.

The Kentucky Division of Waste Management (DWM) has proposed a rule regarding out-of-service underground storage tank systems and closure that incorporate by reference the following documents: "Closure Assessment Report Form," dated November 1990, "Notice of Intent to Permanently Close Underground Storage Tank Form," dated January 1994, and "Underground Storage Tank System Closure Outline," dated January 1994. For more information, contact James Hale at the DEP at (502) 564-6716.

Water Quality (Regulation)—The Kentucky Department for Environmental Protection, Division of Water would amend requirements for public notification for violations of maximum contaminant levels for an additional 63 contaminants, in addition to adding nitrate as an acute tier one violation. For more information, contact John Smither at the DEP, Division of Water at (502) 564-3410.

Louisiana

Air Quality (Regulation)—A proposed rule of the Department of Environmental Quality, Office of Air Quality and Radiation Protection establishes procedures for the banking of emission reduction credits. The proposal would allow the storage of emission reduction credits for future use or to meet the 15% VOC emission reduction requirements of the reasonable further progress SIP mandated CAA Section 182 (b) (1). The changes allow a 30 day comment period for affected facilities to respond to the department's confiscation of an alternative emissions reduction proposal or submit a new proposal, establish procedures for refunding unused emission reduction credits, and require bank balances to be submitted March 1 of every year. For more information, contact David Hughes at the DEQ, Enforcement and Regulatory Compliance Division at (504) 765-0399.

Hazardous Waste (Regulation)—The Louisiana Department of Environmental Quality (DEQ) has issued a proposed rule in order to achieve consistency with the most recent HSWA federal regulations affecting air emission standards; closure and post-closure procedures; general provisions for treatment, storage, and disposal facilities; generator requirements; groundwater protection; hazardous waste lists; incinerators; interim status; land treatment; landfills; recyclable materials; and surface impoundments and waste piles. For more information, contact David Hughes at the DEQ, Enforcement and Regulatory Compliance Division at (504) 765-0399.

Toxic Substances (Regulation)—The Louisiana DEQ, Office of Air Quality and Radiation Protection issued a final rule amending regulations regarding chemical accident prevention and fees. The rule establishes a threshold quantity of a chemical that must be present at a major source for the source to be regulated, requires regulated sources to minimize risks of chemical accidents, and specifies registration fees for regulated sources. The rule is effective as of April 20, 1994. For more information, contact David Hughes at the DEQ, Enforcement and Regulatory Compliance Division at (504) 765-0399.

Maine

Air Quality (Regulation)—A proposed rule of the Maine Department of Environmental Protection (DEP) would amend regulations regarding new source review, definitions, growth offsets, and emission licenses. The proposal would specify that new sources of emission are required to obtain offsets in the Ozone Transport Region as well as nonattainment areas, add offset provisions specific to ozone nonattainment areas and provide for the crediting of emissions reductions achieved by the shutdown or curtailment of an existing source under certain conditions. For more information, contact Andrea LaPointe at the DEP, Bureau of Air Quality Control at (207) 287-2437.

Water Quality (Regulation)—The Maine Bureau of Water Quality Control has proposed a rule concerning the state's surface waters toxic control program. The proposal would implement procedures to determine if surface waters are free of pollutants in concentrations that render the water unsuitable for designated uses. The proposal also would establish schedules for testing of discharges for specific chemical pollutants, and for toxicity to living organisms. For more information, contact Donald Hague at the DEP at (207) 287-7671.

Maryland

Environmental Liability—MD S. 341 (Baker) authorizes personal representatives, trustees, and other fiduciaries to take specified actions to comply with environmental laws. It includes inspecting property, taking action to remedy actual or potential environmental liabilities, setting or compromising claims, or paying specified costs. The Governor signed the legislation on May 26.

Hazardous Waste (Regulation)—A final rule of the Maryland Department of the Environment (DOE) allows for reimbursement of an owner or operator of a registered underground oil storage tank system for certain oil-contaminated site environmental cleanup costs. For more information, contact Deanna Miles-Brown at the DOE at (410) 631-3173.

Occupational Safety & Health (Regulation)—A final rule of the Maryland Department of Licensing and Regulation incorporates by reference the January 3, 1994 amendments to the federal OSHA construction industry standards for occupational exposure to cadmium. The rule went into effect May 9, 1994. For more information, contact DLR, Division of Labor and Industry at (410) 333-4184.

The Maryland DLR has proposed a rule to incorporate federal OSHA standards relating to hazard communication. The proposed rule would clarify certain exemptions from labeling and other requirements; revise aspects of the written hazard communication program and labeling requirements; and clarify the duties of distributors, manufacturers, and importer to provide material safety data sheets to employees. For more information, contact DLR at (410) 333-4184.

Massachusetts

Air Quality (Regulation)—The Massachusetts Department of Environmental Protection (DEP), Division of Air Quality Control has proposed a rule regarding the state implementation plan that would set VOC content limits for architectural and industrial maintenance coatings and automotive refinishing coatings. For more information, contact DEP, Division of Air Quality Control at (617) 292-5618.

Automotive Refinish—MA H. 1803 (Valianti and Cabral) regulates the sale of automotive paint products. If passed, this bill would ban the sale of automotive paint products to any person not licensed by the Commonwealth. On May 17, it was released from the Joint Committee on Commerce and Labor.

MA S. 35 (Durand) relates to the illegal use of certain automotive paint and paint by-products. It restricts the sale of automotive paint products to registered motor vehicle repair shops. This bill was released from the Joint Committee on Commerce and Labor on May 17.

Labeling—MA H. 555 (Walrath) requires the following recyclable materials identification bar codes: Number 1, Color Blue (metals); Number 2, Color White (plastics); Number 3, Color Yellow (Wood, cloth, toxic incineration); Number 4, Color Green (glass); Number 5, Color Black (garbage); and Number 6, Color Red (hazardous waste). This bill was released from the Joint Committee on Natural Resources and Agriculture on May 17.

Lead (Regulation)—The Massachusetts Department of Labor and Industries (DLI) has issued an emergency rule that amends existing regulations concerning lead abatement. The rule provides for the use of encapsulants in lead abatement procedures. The regulation went into effect on April 5, 1994. For more information, contact Spencer Demetros, DLI, Office of the General Counsel (617) 717-3454.

MA S. 31 (Birmingham) regulates the removal of lead paint. It was released from the Joint Committee on Commerce and Labor on May 17.

Toxics in Packaging—MA H. 4012 (Angelo) reduces heavy metals in consumer packaging. Prohibits a package or packaging component from being offered for sale if such package includes inks, dyes, pigment, adhesives, stabilizers, or any other additives, or any lead, cadmium, mercury, or hexavalent chromium that has been intentionally introduced as an element during manufacturing or distribution. It prohibits the sum of concentration levels of lead, cadmium, mercury, and hexavalent chromium from exceeding 600 parts per million 2 years from adoption. On May 23, the bill was released from the Joint Committee on Natural Resources and Agriculture with H. 4930.

MA H. 4930 (Committee on Natural Resources and Agriculture) reduces heavy metals in consumer packaging. It prohibits a package or packaging component from being offered for sale if such package includes inks, dyes, pigment, adhesives, stabilizers, or any other additives, or any lead, cadmium, mercury, or hexavalent chromium that has been intentionally introduced as an element during manufacturing or distribution. In addition, it prohibits the sum of concentration levels of lead, cadmium, mercury, and hexavalent chromium from exceeding 600 parts per million 2 years from adoption. The legislation was referred to the House Committee on Ways and Means on May 23 in conjunction with H. 4012.

Michigan

Air Quality (Regulation)—The Michigan Department of Natural Resources (DNR) has proposed a rule establishing requirements for the federal CAA Title V operating permit program and updating existing standards. The proposal would revise performance standards by establishing additional reporting requirements for air emissions that exceed state or federal standards due to start-up, shutdown, or malfunction. For more information, contact the DNR, Air Quality Division at (517) 373-7069.

Hazardous Waste (Regulation)—As of March 3, 1994, all powers, authority, and duties of the leaking underground storage tank program, underground storage tank regulatory program, and underground storage tank financial assurance program has been transferred to the Underground Storage Tank Division in the Michigan Department of Natural Resources' Environmental Protection Branch.

Labeling—MI S. 187 (Bouchard) amends the Consumer Protection Act to include under unlawful conduct the representation that a bag or container is degradable, biodegradable, or photodegradable if it is not capable of being broken down by biodegradation, photodegradation, or chemical degradation into component parts within 360 days under exposure to the elements or composting. The legislation passed the House on June 8 and was sent to the Senate for concurrence.

Lead—MI H. 5601 (Clack) brings Michigan into compliance with federal law on lead poisoning abatement. The bill was introduced on June 1 and sent to the House Committee on Public Health.

MI H. 5619 (Clack) brings Michigan into compliance with federal law regarding lead abatement. On May 7, the bill was introduced and sent to the House Committee on Conservation, Environment, and Great Lakes Affairs.

Minnesota

Lead—MN S. 2710 (Solon) relates to lead abatement programs. It modifies standards for home assessments; removes specific standards from the statutes; specifies information to be collected and disseminated; requires notice to the Department of Health of all violations identified in home assessments; bars removal of intact paint unless proven to be a source of actual lead exposure; and provides for standards for activities which are not lead abatement but which may disrupt lead-based paint surfaces. The bill was signed by the Governor on May 5, 1994.

Occupational Health & Safety (Regulation)—The Minnesota Department of Labor and Industry (DLI), Occupational Safety & Health Division has proposed a rule to incorporate various federal OSHA standards promulgated between June 24, 1993 and January 31, 1994 relating to safety standards for electrical protective equipment, standards for cadmium in shipyard employment and construction, occupational exposure to lead in construction and general industry standards for construction safety. For more information, contact DLI, Occupational Safety & Health Division at (612) 297-3254.

Toxic in Products—MN S. 1788 (Johnson, J.) relates to waste management. Among other things, the bill establishes a process for resolution of disputes related to toxics in packaging and clarifies the prohibition on toxics in products. This bill is an amendment to its 1991 toxic metals in paints law. It was signed by the Governor on May 6. Accordingly, the following key provisions will be implemented as part of the amended law:

- Paints, pigments, inks, dyes, and fungicides manufactured after September 1, 1994 for sale or use in Minnesota must contain no lead, cadmium, mercury, or hexavalent chromium which has been intentionally introduced.
- The concentration of any of the above metals which may be incidentally present in paint cannot exceed 100 parts per million per metal.
- Products are exempt from the above provisions if the manufacturers notify the Commission of the Pollution Control Agency by no later than August 1, 1994: (1) that compliance is not technically feasible and (2) how compliance will be achieved by July 1, 1997. The exemption expires on July 1, 1997.
- By July 1, 1996, manufacturers of exempted products must inform the Agency of progress being made toward meeting the law's requirements.
- Users of paints containing one or more of the proscribed metals may submit, on behalf of the manufacturer, a request for the exemption only if the manufacturer fails to submit its own request for exemption.

For additional information, contact Cathy Latham of the Minnesota Pollution Control Agency at (612) 296-8585.

Nevada

Air Quality (Regulation)—A final rule of the Nevada State Environmental Commission (SEC) amends regulations to address deficiencies in air quality regulations regarding the review of new sources of air pollution in nonattainment areas and incorporate comments received from federal EPA concerning the state's newly adopted integrated new source review/Title V operating permit program. Some portions of the rule became effective March 29, 1994 while other portions will become effective on November 15, 1994. For more information, contact David Cowperthwaite at the SEC at (702) 687-3188.

A final rule of the Nevada SEC updates the existing regulations regarding air quality operating permit programs and hazardous air pollutants. The rule establishes emission-based fees, enhances application requirements, and repeals certain toxic pollutant standards. Some portions of the rule became effective December 12, 1993 while others will go into effect July 1, 1994 and November 15, 1994. For more information, contact David Cowperthwaite at the SEC at (702) 687-3188.

New Hampshire

Lead—NH S. 650 (Shaheen) establishes a lead-based substance abatement fund to be administered by the New Hampshire Housing Finance Authority. It states that the fund is to be used to assist owners of rental property which is primarily occupied by low-income tenants when such owners are required to undertake lead abatement activities, and makes an appropriation for the start-up costs of the fund. On May 26, the Conference Committee report on the bill was adopted by both the House and the Senate.

New York

Labeling—NY S. 8338 (Hannon) provides that the terms "biodegradable," "degradable," and "photodegradation" may only be used in advertisements, packaging, and product labeling when determined to be scientifically accurate by the Commissioner of Environmental Conservation. A violation of this provision will constitute false advertising. The legislation also provides for injunctive and monetary relief. It was introduced on May 5 and sent to the Senate Committee on Consumer Protection.

Lead—NY S. 8274 (Galiber) requires that clinical laboratories provide the parent or guardian of a child with information on lead poisoning prevention whenever examining specimens of a child six years of age or under. It also implements a program of public service announcements concerning the hazards of lead paint. The bill was introduced on May 4 and referred to the Senate Committee on Health.

NY S. 8277 (Galiber) imposes a $100 surcharge on any building code violation relating to lead paint and creates a lead paint education program within the Department of Health to be funded by such a surcharge. The bill was introduced on May 4 and sent to the Senate Committee on Health.

Packaging—NY S. 7760 (Johnson) establishes the Packaging Waste Reduction Task Force to examine the issues of reducing packaging waste and improving post-consumer packaging materials. The bill was released from the Senate Committee on Environmental Affairs on May 3.

Water Quality (Regulation)—The New York Department of Environmental Conservation (DEC) has announced its intention to issue ambient water quality guidance values and maximum allowable concentrations for 19 potentially toxic substances. For more information, contact John Zambrano at the DEC, Division of Water at (518) 457-3651.

North Carolina

Lead—NC H. 1736 (Dickson) regulates lead abatement in accordance with federal law. The House adopted the Committee on Health Resources's amendment to this bill on June 10 and then sent the bill to the House Committee on Finance.

NC S. 1611 (Cooper) regulates lead abatement in accordance with federal law. The bill was introduced on May 27.

Ohio

Hazardous Waste (Regulation)—The Ohio Petroleum Underground Storage Tank Release Compensation Board has proposed a rule that would clarify financial responsibility requirements and increase the penalty fee for late payment of a supplemental fee. For more information, contact Carol DeVore at the UST Release Compensation Board at (614) 752-8963.

Solid Waste (Regulation)—The Ohio EPA adopted regulations which conform to the federal EPA municipal solid waste landfill requirements under 40 CFR parts 257 and 258. The rule is effective as of June 1, 1994. For more information, contact Nikki Mackey at OEPA at (614) 644-3037.

Oklahoma

Graffiti—OK S. 971 (Haney) makes it a misdemeanor to knowingly sell paint containing metallic powders dispensed from a pressurized container, or any glue, to a person under 18 years of age. On May 26, 1994, the Senate adopted the Conference Committee report on the legislation.

Lead—OK H. 2063 (Leist) relates to the Oklahoma Lead-based Paint Reduction and Regulation Act. It provides that the Environmental Quality Board shall promulgate rules governing lead-based paint activities and requires the board to establish a schedule of fees for certification of abatement of contractors and training and lead-based paint activity programs. The bill was signed by the Governor on June 8 and will go into effect on July 1, 1994 as an emergency regulation.

OK H. 2497 (Hamilton) establishes the Comprehensive Childhood Lead Poisoning Prevention Program, to be administered by the State Department of Health; requires the State Board of Health to promulgate rules regarding lead toxicity screening of certain children, risk assessment, blood lead tests, health education and counseling and other requirements; and creates a nine-member Childhood Lead Poisoning Prevention Advisory Council. The bill was signed into law by the Governor on May 9.

Occupational Safety & Health (Regulation)—The Oklahoma Department of Labor (DOL) has announced its intention to submit for gubernatorial approval a proposed rule mandating the designation of a safety coordinator and the implementation of safety programs by employers with 25 or more employees. For more information, contact Nathan Powell at the DOL at (405) 528-1500.

Water Quality (Regulation)—The Governor approved a proposed rule of the Department of Environmental Quality (DEQ) that implements provisions of the state's Pollutant Discharge Elimination System Act by establishing permitting and public notification procedures, specifying effluent limitations and guidelines, and describing storm water permit requirements. For more information, contact Jeannine Hale at the DEQ at (405) 271-8140.

Oregon

Hazardous Waste (Regulation)—A final rule of the Oregon Department of Environmental Quality increases the annual fee for underground storage tank permits from $25 to $35. The rule became effective March 22, 1994. For more information, contact Larry Frost at the DEQ at (503) 229-5769.

Permit Violations (Regulation)—The Oregon Department of Environmental Quality has issued a final rule regarding exceptions to the five-day advance warning notices issued to permit violators. The rule was effective March 14, 1994. For more information, contact Ed Druback at the DEQ, Enforcement Section at (503) 229-5151.

Pennsylvania

Hazardous Waste (Regulation)—A proposed rule of the Pennsylvania Environmental Quality Board would establish financial responsibility requirements for taking corrective action and for compensating third parties for bodily injury and property damage caused by a release from underground storage tanks. Comments are due July 6, 1994. For more information, contact Cedric Karper at the Department of Environmental Protection, Division of Storage Tanks at (717) 772-5800.

Water Quality (Regulation)—The Pennsylvania Infrastructure Investment Authority (PIIA) has proposed a rule to make owners and operators of storm water facilities eligible to apply for financial assistance for the acquisition, construction, improvement, expansion, repair, or rehabilitation of storm water facilities. For more information, contact Paul Marchetti at PIIA at (717) 787-8137.

South Dakota

Air Quality (Regulation)—A proposed rule of the South Dakota Department of Environment and Natural Resources (DENR) establishes an initial $100 applicant fee for new sources and increases to $6.10 the annual air fee for each ton of actual emissions. For more information, contact Brian

Gustafson, DENR, Point Source Control Program at (605) 773-3351.

Texas

Air Quality (Regulation)—The Texas Department of Environmental Quality/Natural Resources Conservation Commission has adopted a rule concerning the air pollution caused by solvent-using and surface coating processes. The rule adds volatile organic compound (VOC) emission limits for lacquers, sanding sealers, stains, shellac, and varnish used in the surface coating of wood; revises the "once-in, always in" requirement to provide additional flexibility in response to a request by the Chemical Council; and clarifies the wording of the cleanup requirements for automobile refinishing operations. The rule became effective on May 27, 1994. For more information, contact the Natural Resources Conservation Commission, Office of Air Quality, (512) 463-8159.

The Texas Natural Resource Conservation Commission (NRCC) has adopted a rule that adds definitions for alcohol as used in offset lithographic printing, lacquers, polyester resin materials, polyester resin operation, sanding sealers, shellac, and varnish. The rule became effective on May 27. For additional information, contact the NRCC Air Quality Planning Division, (512) 239-1488.

The Texas NRCC has added standard permits as a new source review permit category. The final rule also requires fees for standard permits at the time of registration. The rule was effective May 4, 1994. For more information, contact Gary McArthur at the NRCC at (512) 908-1917.

Vermont

Lead—VT H. 169 (Ross and Babcock) establishes a program for training, certification, and licensing of lead hazard abatement workers; makes blood lead screening and testing of children available upon request of parents and mandatory if warranted; provides for inspection and testing of child care facilities; ensures that lead-based paint hazards are disclosed in the sale or rental of housing; establishes a standard of reasonable care on the part of owners of rental housing and day care facilities. On May 25, the bill was sent to the Governor for signature.

Virginia

Solid Waste (Regulation)—A final rule of the Virginia Waste Management Board (WMB) establishes guidelines for public participation in the development and promulgation of regulations. The rule was effective May 18, 1994. For more information, contact Cindy Berndt at the Department of Environmental Quality at (804) 762-4378.

Water Quality (Regulation)—A final rule of the Chesapeake Bay Local Assistance Board (CBLAB) amends guidelines which set out board procedures for identification and notification of interested parties to comment on actions in all phases of the regulatory process. The rule was effective May 20, 1994. For more information, contact Scott Crafton at CBLAB at (804) 225-3440.

The Virginia State Water Control Board has adopted regulations to establish a general permit for storm water discharges from the following industries: heavy manufacturing facilities, light manufacturing facilities, specified construction sites, and other miscellaneous facilities. For more information, contact Cindy Berndt, Department of Environmental Quality, (804) 762-4378.

Washington

Air Quality (Regulation)—The Washington Department of Ecology (DOE) is considering adopting regulations that would establish fees for reasonably available control technology (RACT) analysis and determination. The proposal would identify additional fees the department may charge based upon the complexity of the analysis and establish fees for review of proposed new sources. For more information, contact Audrey O'Brien, DOE, (206) 407-6875.

West Virginia

Air Quality (Regulation)—A final rule of the West Virginia Air Pollution Control Commission (APCC) narrows the applicability of new stationary source permits to construction of new non-major sources, modification, and relocation of non-major sources and non-major modification of existing major sources. The rule went into effect April 27, 1994.

A final rule of the West Virginia APCC adopts the federal NESHAP standards promulgated through May 1, 1993 under 40 CFR part 61. The rule was effective April 27, 1994.

The West Virginia APCC has adopted a final rule incorporating the federal new source performance standards under 40 CFR part 60 promulgated through May 1, 1993. The rule was effective April 27, 1994.

A final rule of the West Virginia APCC adopts federal emission standards for process vents and equipment leaks for boilers and industrial furnaces burning hazardous waste under 40 CFR parts 264, 266, and 270. The rule went into effect April 27, 1994.

For more information, contact Dale Farley at the Department of Commerce, Labor, and Environmental Resources at (304) 558-4022.

Wisconsin

Hazardous Waste (Regulation)—A proposed rule of the Wisconsin Department of Natural Resources (DNR) would adopt regulations regarding hazardous waste management, used oil management and polychlorinated biphenyls, enabling the state to enforce recently promulgated federal EPA requirements. For more information, contact Al Matano at the DNR, Bureau of Solid and Hazardous Waste Management at (608) 264-6008.

Lead (Regulation)—The Wisconsin Department of Health and Social Services (DHSS) has adopted a rule that relates to certification for lead hazard reduction activities and approval of training courses; enables the Wisconsin Childhood Lead Poisoning Prevention Program and the Department of Administration's Division of Housing to implement the HUD grant which requires that only trained and certified lead (Pb) workers and supervisors perform necessary lead hazard reduction activities. The rule went into effect on June 1, 1994.

Solid Waste (Regulation)—A final rule of the Wisconsin Department of Natural Resources (DNR) adopts regulations to establish provisions for the training and certification of solid waste landfill operators. The rule was effective June 1, 1994. For more information, contact William Schultz at the DNR, Bureau of Solid Waste and Hazardous Waste Management at (608) 264-6008.

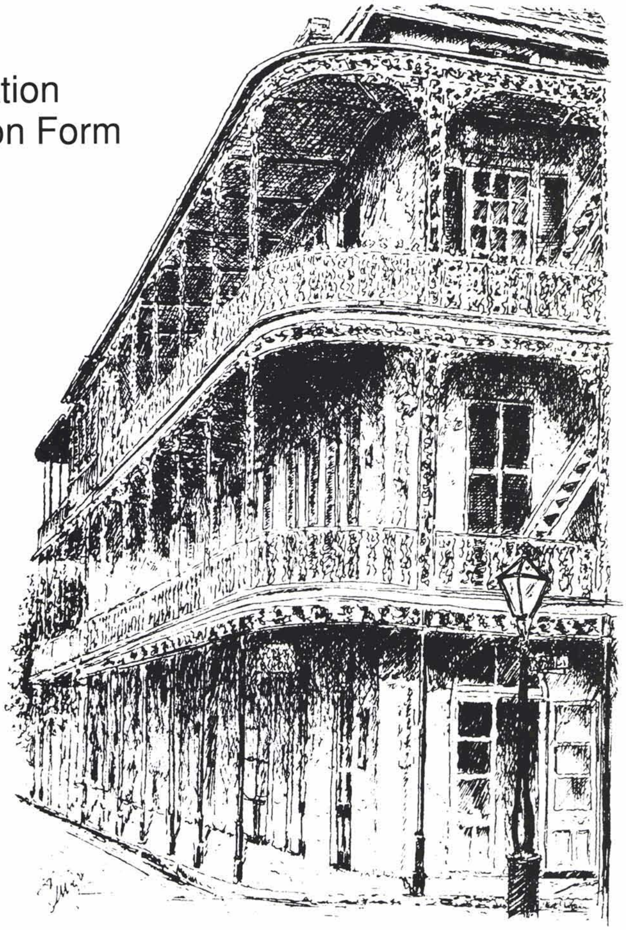
Federation of Societies for Coatings Technology

72nd Annual Meeting & 59th Paint Industries' Show
FSCT 1994
New Orleans Convention Center
New Orleans, LA
October 12-13-14, 1994

1994 Annual Meeting & Paint Industries' Show

- Hotel Information
- Reservation Application
- Advance Registration Form

"Excellence Through Innovation"



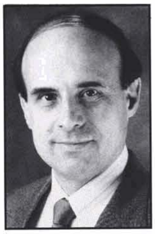
Ernest N. Morial Convention Center
Wednesday, Thursday, Friday • October 12-13-14, 1994
New Orleans, Louisiana

The combined Annual Meeting and Paint Industries' Show, to be held at the Ernest N. Morial Convention Center, is a major educational activity of the Federation of Societies for Coatings Technology. This international coatings manufacturing industry event consists of three days of technical program sessions and exhibits, running concurrently. Registration is required for admission.

From the President:

Welcome to the Big Easy! We invite you to participate in the main event of the coatings industry—the Federation's 72nd Annual Meeting & 59th Paint Industries' Show. Here in New Orleans, we will meet with representatives from over 60 countries to experience the paint and coatings industry's largest exhibition of raw materials, equipment, and services. In addition, the technical programs will offer a variety of dynamic topics sure to assist you in achieving "Excellence Through Innovation."

To be held in the newly expanded Ernest N. Morial Convention Center, this unique program is rivalled in excitement only by a city that offers such attractions as the French Quarter, the Superdome, Bourbon Street, and the bayous! As you might imagine, the 1994 Annual Meeting and Paint Show will be an event to be remembered! Don't delay—make plans now to be a part of it all "way down yonder in New Orleans!"



John A. Lanning
President, FSCT

"Excellence Through Innovation"

Attendees at the 1994 Annual Meeting can attend technical programs on a wide variety of pertinent topics revolving around the theme, "Excellence Through Innovation." Program sessions are being developed to cover the following topics:

- ❖ Advanced Topics in Coatings Research
- ❖ Color Technology
- ❖ Innovations in the Development of VOC Compliant Corrosion Inhibitive Coatings:Testing and Technology
- ❖ The Human Side of Process Safety Management
- ❖ Formulating for Low VOC Coatings
- ❖ Roon Award Competition Papers
- ❖ APJ/Voss Award (Society) Competition Papers
- ❖ International Papers
- ❖ ISO 9000 Case Study

Presentation subjects will include:

- ❖ Powder Coatings
- ❖ Accelerated Testing
- ❖ Epoxy Coatings
- ❖ Additives
- ❖ Waterborne Coatings
- ❖ Dispersion Technology
- ❖ UV Technology

To be a competitor in tomorrow's coatings industry, you will have to be well versed in customer satisfaction, committed to continuous improvement, and prepared to work with and develop new technologies. These sessions will give you answers and insights to meet these challenges.

Papers will be presented by industry experts, familiar with what it takes to achieve success. They will convey to you that, more than ever before, customer satisfaction requires a balance of enhanced performance, cost effectiveness, and product consistency. You'll learn the latest in products, processes and packaging, in addition to finding out about the new technologies that will make "Excellence Through Innovation" a reality.

New to the event are "Early Bird" sessions on Thursday, October 13, to give you more detailed information on pertinent subjects. Initial offerings will cover "Empowerment" and "Quality" The program will again open with the popular Technical Focus Speaker on Wednesday, October 12, at 1:00 p.m.

Two additional presentations you'll want to attend are the Keynote Address at Wednesday morning's Opening Session and the Mattiello Memorial Lecture, scheduled for Friday morning at 10:30 a.m. Both sessions are in the "must attend" category of all serious coatings professionals!

Make it a point to visit the Poster Session on Thursday. This all-day event will feature non-commercial work covering new ideas and techniques in coatings research and will let you glimpse at the work of future industry leaders.

World's Premier Paint Show to Feature Products of Over 250 Companies

The largest coatings-related exhibition in the world—the FSCT Paint Industries' Show—will be held in conjunction with the Annual Meeting at the Ernest N. Morial Convention Center—New Orleans. Over 250 supplier companies to the coatings manufacturing industry will be present to discuss their newest products and services. In over 90,000 sq. ft. of exhibits will be displayed a wide variety of raw materials, production equipment, containers and filling equipment, laboratory apparatus, and testing devices for the paint and coatings producer.

Key personnel from the top technical and sales staff of supplier companies will be available to provide attendees with an opportunity to learn of the latest developments in their products and services.

Exhibit hours will be:

Wednesday, October 12	10:00 a.m.-5:00 p.m.
Thursday, October 13	9:00 a.m.-5:00 p.m.
Friday, October 14	9:00 a.m.-12:00 Noon

Hotel Information

Whether you desire the value of a moderately-priced hotel, or the luxury of an upscale property, the choice is yours. The FSCT has arranged for convention rates at 12 official Paint Show hotels. All reservations must be placed through the FSCT Housing Bureau to obtain the preferred rates. The Housing Bureau will confirm all reservations. *(Housing opens June 15.)*

Do it Your Way and Save!

You have the convenience of placing a phone call or faxing your request for hotel accommodations to the FSCT Paint Show Housing Bureau.

Call! 800-345-1187 or 504-566-5005

Have the information requested on the Hotel Reservation Form available before you place your call. Reservationists are available 7:00 a.m. - 7:00 p.m., Monday through Friday, Central Time. Reservations will be immediately confirmed over the phone and also by mail or fax if fax number is provided.

Fax! 504-522-6123

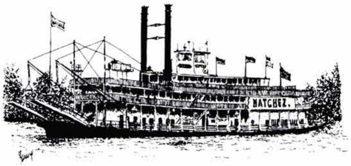
Anytime, any day. Fax the Hotel Reservation Form at your convenience. Be sure to include a phone and fax number and retain your copy of the form for your records. Confirmations will be sent via fax within three working days of receipt of request.

Mail!

Send your form to the FSCT Paint Show Housing Bureau for processing. Be sure to include a phone and fax number and keep a copy of the form for your records. Your confirmation will be mailed or faxed, if a fax number is provided.

Deposits

A $100 deposit per guest room and $100 deposit per suite is required in order to process requests. This is a refundable deposit if the reservation is cancelled 72 hours prior to arrival. The following methods of payment are acceptable: checks made payable to the FSCT Paint Show Housing Bureau or credit cards. Credit card choices include American Express, MasterCard, or Visa. Please note that the deposit will be applied immediately to the credit card used.



Deadlines

To obtain the convention rates, reservations must be placed by September 1. Reservations placed after September 1 will be on a space available basis. To make reservations after September 9, call the hotel directly.

Changes/Cancellations

For changes or cancellations prior to September 9, call the FSCT Paint Show Housing Bureau at 504-566-5005 or fax your change to 504-522-6123. After September 9, call the hotel directly.

Registration Information

The Advance Registration fees include three days of admission to the Paint Industries' Show and the Opening Session, and all concurrent program sessions of the Annual Meeting. To register, simply complete the Advance Registration Form and forward it with payment to FSCT. The Advance Registration prices will be available until **September 1**. The form with accompanying payment must be received at FSCT by September 1. Registration options are listed below:

Full Time	Advance	On-Site
Member	$ 75	$ 90
Non-member	$100	$125
Social Guest	$ 60	$ 70

Your registration credentials will be mailed to you in advance of the Annual Meeting & Paint Industries' Show. Badges for registrations received after September 1 will be available in the FSCT Paint Show Registration Area.

The Registration Services Area will be located at the Ernest N. Morial Convention Center and will be open over the following days and times to assist you.

Day	Time
Tues., October 11	8:00 a.m. - 5:00 p.m.
Wed.-Thurs., October 12-13	7:30 a.m. - 5:00 p.m.
Fri., October 14	7:30 a.m. - 12 Noon

On-site registration will also be available during the times noted above.

Method of Payment

Acceptable types of payment include checks in U.S. funds made payable to FSCT, as well as credit cards: VISA, MasterCard, and American Express. Payment is due with registration form. Forms received without payment will not be processed. Please note: **if payment is made with a credit card, the form may be faxed to FSCT Headquarters Office. If faxing, please do not mail original form.**

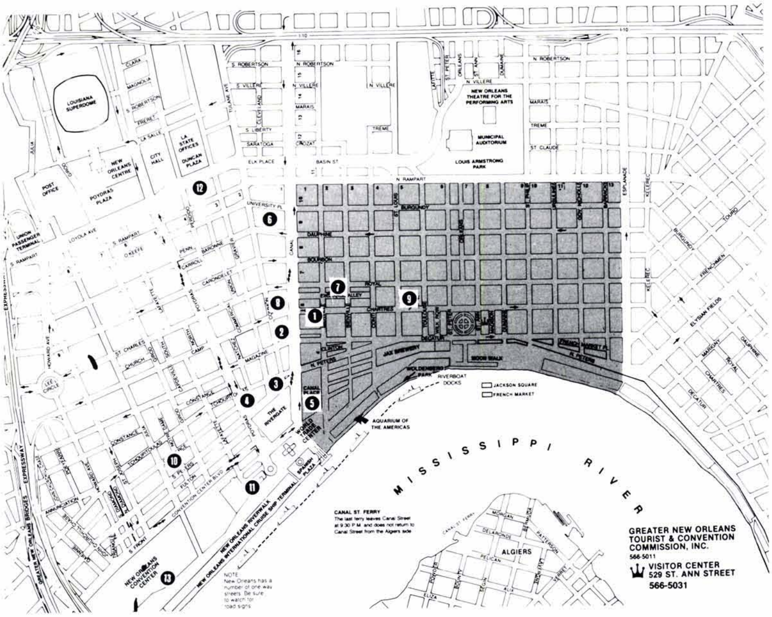
Cancellation and Refund Policy

All cancellations must be submitted in writing to the FSCT Headquarters Office. All badges that have been mailed must be returned to FSCT for refund processing. Cancellations received by September 28 will be subject to a $10 handling charge. A $25 charge will apply after that date.

1994 Paint Show Hotel Summary

Hotel	Room Type and Rates				No. of Restaurants/ Bars	Swimming Pool	Health Club
	Single	Double	Suites 1 BR	Suites 2 BR			
*Marriott (Standard)	$138	$158	$550-1,100	$688-1,238	3/2	yes	yes
(Concierge level)	146	166					
*Sheraton (Standard)	138	158	250-1,000	350-1,185	4/4	yes	fitness center
(Executive)	158	178					
Doubletree	115	135	225-250	325-375	1/1	yes	yes
Holiday Inn Crowne Plaza	125	145	560	685	2/2	yes	exercise room
Westin Canal Place	130	150	240-400	400-1,500	1/2	yes	yes
Fairmont	125	145	295-1,200	475-1,200	3/3	yes	fitness center
Monteleone	127	147	290-520	430-680	3/2	yes	yes
Le Meridien	140	160	450-500	650-1,500	1/2	yes	yes
Omni Royal Orleans	140	160	325	525	3/4	yes	yes
Radisson Suites	125	145			1/1	yes	no
Hilton (Standard)	145	165	504-1,490	695-1,685	4/5	yes	jogging track
(Executive)	165	185					
(Towers)	185	205					
Holiday Inn Downtown	90	105			1/1	yes	no

*Marriott and Sheraton will be co-headquarters. Guest rooms at both hotels will be limited to 10 per company.



CANAL ST. FERRY
The last ferry leaves Canal Street at 9:30 P.M. and does not return to Canal Street from the Algiers side

NOTE
New Orleans has a number of one way streets. Be sure to watch for road signs

GREATER NEW ORLEANS TOURIST & CONVENTION COMMISSION, INC.
566-5011
VISITOR CENTER
529 ST. ANN STREET
566-5031

Shuttle Schedule

Route 1

Meridien	Sheraton
Sheraton	Canal Street
Doubletree	South Peters
Holiday Inn Crowne Plaza	South Peters

Route 2

Westin	North Peters
Marriott	Canal Street
Omni Royal Orleans	Marriott*
Monteleone	Marriott*

*Limited shuttle service will be available from the Royal Orleans and the Monteleone to the Marriott.

Route 3

Holiday Inn Downtown	Loyola Street
Fairmont	Baronne Street

Schedule

Tues., Oct. 11	8 a.m. - 5 p.m.
Wed., Oct. 12	7:30 a.m. - 6 p.m.
Thurs., Oct. 13	7:30 a.m. - 6 p.m.
Fri., Oct. 14	7:30 a.m. - 3 p.m.

Legend

1 — Marriott
2 — Sheraton
3 — Doubletree
4 — Holiday Inn Crowne Plaza
5 — Westin Canal Place
6 — Fairmont
7 — Monteleone
8 — Le Meridien
9 — Omni Royal Orleans
10— Radisson Suites
11— Hilton
12— Holiday Inn-Downtown
13— Convention Center

72nd Annual Meeting & 59th Paint Industries' Show
FSCT
1994

Hotel Reservation Form

(Housing opens June 15)

MAIL FORM & DEPOSIT TO:

FSCT Paint Show
1520 Sugar Bowl Dr.
New Orleans, LA 70112

PHONE/FAX:

(800) 345-1187 Continental U.S.
(504) 566-5005 International
FAX: (504) 522-6123

HOTEL PREFERENCE

List the hotels of your preference. First choice will be assigned if available. List other preferences to avoid delay. If your first choice is not available, your deposit will be applied to your next available choice. The deadline is September 1.

(1) ____________ Hotel
(2) ____________ Hotel
(3) ____________ Hotel

RESERVATION REQUEST

Number of rooms requested ☐

Names of Occupants	Room Type	Rate	Arrival	Departure

For additional reservation requests, feel free to copy this form.
Requests for the Marriott and Sheraton will be limited to 10 rooms per company.

DEPOSIT

A deposit of $100 per room is required. No form will be processed without a deposit. Credit cards will be billed immediately for first night's deposit.

Credit Card: ☐ American Express ☐ Mastercard ☐ VISA Cardholder's Signature: ____________

____________ Card Number
____________ Expiration Date
____________ Print Cardholder's Name

or Check made payable to: "Paint Show Housing Bureau" $ ____________ enclosed. Check No. ____________

DIRECT CONFIRMATIONS TO:

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

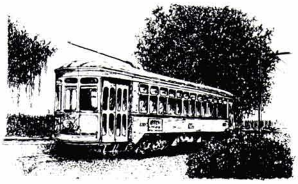
If requested room rate is not available, the nearest rate will be assigned by the FSCTPaint Show Housing Bureau. We cannot guarantee that the accommodations will be assigned in your preferred hotels.

☐ ____________ requires special assistance. Please call: ____________
Name

Airport & City Transportation

From New Orleans International Airport:
Airport Shuttle (service to downtown hotels, provided by Airport Shuttle New Orleans) is $10 each way. The shuttle may be boarded by the baggage claim area. The trip takes approximately 30 minutes.

Taxi Service from the airport to downtown hotels is $21 per person, $10 per person with two passengers, and $6 per person with three passengers.



Slash Air Fare Expense

Minimize your travel expense to the Paint Show by using discounted zone fares offered by **Delta Airlines** to the Paint Show. NO SATURDAY NIGHT STAY IS REQUIRED!

From City	Regular Coach	**FSCT Zoned Fares**
Atlanta	$576	**$408 - 464**
Chicago	$1,210	**$408 - 514**
Denver	$1,006	**$348 - 408**
Los Angeles	$1,196	**$448 - 518**
New York City	$990	**$408 - 514**

To obtain these fares, you, your secretary, or your travel agent must refer to the following file codes when contacting the airlines:

Delta 1-800-241-6760 mention code I5014

FSCT Travel Desk: mention Paint Show

Domestic U.S.	1-800-448-FSCT
International	1-215-628-2549
Fax:	215-628-0310

FSCT Travel Desk is able to provide zone fares on both Delta and United Airlines. If you desire a Saturday night stay, a 5% discount on the lowest fare applicable can be obtained. On all discounted fares, there may be certain restrictions and penalties for changes or cancellations. Airport surcharges may apply.

Mardi Gras MAGIC Annual Luncheon

Curious why droves of people flock to New Orleans in February for its biggest party, Mardi Gras? Then attend the Federation's Annual Awards Luncheon on Thursday, October 13. Along with the re-creation of Mardi Gras Magic, featuring Big Easy music and a Mardi Gras Tableau Presentation, will be the presentation of Federation awards.

Luncheon tickets can be purchased in advance or on-site at $25 each. Social guest registration includes the Luncheon ticket.

Social Program

'Big Easy' Arts and Entertainment

Activities for social guest registrants begin at the Marriott on Wednesday, October 12, with an Afternoon Social for re-acquainting with friends and meeting new ones over refreshments and local entertainment. New Orleans is a city whose mystique has captured the imagination of both its locals and visitors. The Social will feature local artists demonstrating their vocal, culinary and decorative talents to the participants.

On Thursday, October 13, following a continental breakfast at the Marriott Hotel, registered social guests will depart on deluxe motorcoaches for a visit to the exquisite city estate Longue Vue House and Gardens, once home to the prominent Stern family. There, guests will have an opportunity to stroll the beautifully landscaped grounds, tour the mansion, enjoy refreshments under the pavilion, and attend informative programs on various collections displayed at Longue Vue.

After Longue Vue, guests will board motorcoaches for the Convention Center to attend the Federation's Mardi Gras Magic Luncheon. The festivities include Big Easy entertainment and a presentation by a local expert on the symbolism of the Mardi Gras Krewe and colors.

Following the luncheon, participants will have time on their own to explore the many New Orleans attractions and shops.

Social guest registration is $60 in advance and $70 on site, and includes the Wednesday Social, Thursday Breakfast and Tour, as well as the Mardi Gras Magic Luncheon.

Registration is limited to 700 participants.

NPCA to Meet Same Week

The National Paint & Coatings Association will hold its annual meeting on October 10-12, at the New Orleans Hilton and Towers, in New Orleans.

NPCA will admit advance registered attendees of the FSCT Paint Industries' Show to the Forum Sessions being held during its annual meeting at no additional charge. The Forum Sessions will be conducted at the New Orleans Hilton on Monday and Tuesday, October 10 and 11. For admittance to these sessions, FSCT Paint Show attendees must complete NPCA's complimentary registration form available at the NPCA registration area located in the New Orleans Hilton Hotel.

1994 Advance Registration

FSCT Annual Meeting & Paint Industries' Show

New Orleans, LA • October 12-14, 1994

DEADLINE—SEPTEMBER 1

BADGE INFORMATION: This is how your badge will read and where it will be mailed.

FIRST NAME (as you wish it to appear on badge)

FIRST NAME LAST NAME

COMPANY

MAILING ADDRESS (or P.O. Box)

CITY

STATE/PROV.

COUNTRY (OTHER THAN U.S.)

POSTAL CODE

TELEPHONE NO.

FAX NO.

SOCIAL GUEST BADGE INFORMATION:

FIRST NAME (as you wish it to appear on badge)

FIRST NAME LAST NAME

MAILING ADDRESS (or P.O. Box)

CITY

STATE/PROV.

POSTAL CODE

BUSINESS CLASSIFICATION DATA FOR INDUSTRY REGISTRANT:

YOUR COMPANY (CHECK ONE ONLY)

- AA ☐ Manufacturers of Paints, Varnishes, Lacquers, Printing Inks, Sealants, Adhesives
- BB ☐ Manufacturers of Raw Materials
- CC ☐ Manufacturers of Equipment and Containers
- DD ☐ Sales Agents for Raw Materials and Equipment
- EE ☐ Government Agency
- FF ☐ Research/Testing/Consulting
- GG ☐ Educational Institution/Library
- HH ☐ Paint Consumer
- YY ☐ Environmental Services
- JJ ☐ Other

YOUR POSITION (CHECK ONE ONLY)

- KK ☐ Management/Adm.
- LL ☐ Mfg. & Engineering
- MM ☐ Quality Control
- NN ☐ Research & Development
- PP ☐ Technical Sales Service
- QQ ☐ Sales & Marketing
- RR ☐ Consultant
- SS ☐ Educator/Student/Librarian
- TT ☐ Other

Registration credentials will be mailed to the address noted if received at FSCT Headquarters by **September 1**.

If received after that date, they may be picked up on-site at the Ernest N. Morial Convention Center.

Registration Fees:

A ☐ FSCT Member FSCT Society ______________	$75.00
B ☐ Non-Member	$100.00
D ☐ Social Guest	$60.00
G ☐ Special Fee for Retired Member	$25.00
H ☐ Special Fee for Social Guest of Retired Member	$25.00

FSCT Mardi Gras Luncheon Tickets: (Thurs., Oct. 13)

(Social guest registration includes the luncheon)

☐ NUMBER REQUIRED: ________
$25 EACH

Method of Payment:

Payment is due with registration form.
We are pleased to accept faxes for credit card payment only.

Total Amount Due $ ________

Please Check One:

☐ Enclosed is Check #________
payable in U.S. Funds to FSCT

☐ Charge to the following card:

___ MC ___ VISA ___ AMEX

Card No. ______________________

Expiration Date: __ __ Mo. __ __ Yr.

____
Signature (Credit card registrations only)

____
Please print cardholder's name

All registrations received **by September 1** will be processed and Registration Credentials will be mailed to the address provided. All registrations received **after September 1** will be processed and can be picked up at the Paint Show Registration Services Area. A $10 charge will be made for cancellations received prior to September 28. A $25 charge will be made for cancellations received after that date.

Mail completed form to:

FSCT, 492 Norristown Rd., Blue Bell, PA 19422-2350

(For credit card registrations only—**FAX: 215-940-0292**—do not mail original)

1994 Paint Industries' Show

Current List of Exhibitors

Aceto Corp.
Adhesion International
ACT Labs., Inc.
Advanced Software Designs
Air Products & Chemicals, Inc.
Air Quality Sciences, Inc.
Akzo Nobel Chemicals, Inc.
Akzo Nobel Resins
Alcan-Toyo America, Inc.
Alcoa Industrial Chemicals
Alt-Chem International
C.M. Ambrose Co.
American Chemical Society
Amoco Chemical Co.
ANGUS Chemical Co.
Anker Labelers USA, Inc.
Aqualon Co.
Arco Chemical Co.
Ashland Chemical, Inc.
Atlas Electric Devices Co.
Aztec Peroxides Inc.

BASF Corp., Chem. Div.
Blackmer Pump
Bohlin Instruments
Brookfield Engineering Labs.
Brookhaven Instruments Corp.
Buckman Laboratories
Burgess Pigment Co.
BYK-Chemie USA
BYK-Gardner, Inc.

C&E News
Cabot Corp., CAB-O-SIL & Special Blacks Div.
Caframo Ltd.
Calgon Corp.
Cappelle Inc.
Cardolite Corp.
CB Mills, Div. of Chicago Boiler
CCP Polymers
Celite Corp.
Chemical & Engineering News
Chemical Week Associates
CIBA-GEIGY Corp.
Cimbar Performance Minerals
The Coatings Laboratory Inc.
Coatings Magazine
Coldec Verkoop BV
Color Communications, Inc.
Color Corp.
Colorgen Industrial Group, Inc.
ColorTec Associates
Columbian Chemicals Co.
Consolidated Research, Inc.
COROB S.r.l.
CPI Purchasing Magazine
CR Minerals Corp.
Crosfield Co.
Cuno, Inc.
Custom Fibers International
CYTEC Industries

D/L Laboratories
Daniel Products Co., Inc.
Datacolor International
Day-Glo Color
Degussa Corp.
University of Detroit-Mercy
Disti
Dominion Colour Corp.
Dow Chemical USA
Dow Corning Corp.
Draiswerke, Inc.
Drew Industrial Div.
Dry Branch Kaolin Co.
DSA Consulting, Inc.
DSM Resins U.S., Inc.

Eagle Zinc Co./ Meadowbrook
Eastern Michigan University
Eastman Chemical Co.
Ebonex Corp.
ECC International
Eiger Machinery, Inc.
Elcometer, Inc.
Elf Atochem North America
Elmar Industries, Inc.
EM Industries, Inc.
Engelhard Corp.
Engineered Polymer Solutions
Epworth Mfg. Co., Inc.
EQ—The Environmental Quality Co.
Etna Products Inc., Spec. Chems.
European Coatings Journal
Exxon Chemical Co.

Fawcett Co., Inc.
Federation of Societies for Coatings Technology
Filter Specialists, Inc.
Fischer Technology Inc.
Fluid Management
FMJ International Publications
Fryma, Inc.
Fugi Silysia Chemical Ltd.
H.B. Fuller Co.

GAF Filter Systems
Paul N. Gardner Co., Inc.
Georgia Pacific Resins, Inc.
The BFGoodrich Co., Specialty Chemicals
The Goodyear Tire & Rubber Co., Chem. Div.
W.R. Grace & Co., Grace Div.
Guertin Polymers

Haake, Inc.
C.P. Hall Company
Halox Pigments
Harcros Pigments, Inc.
William Harrison Corp.
Henkel Corp., Coatings & Inks
Heraeus DSET Laboratories
Heucotech Ltd.
Hilton-Davis Co.
Hockmeyer Equipment Corp.
Hoechst Celanese Corp., Pigments
Horiba Instruments Inc.
J.M. Huber Corp., Calcium Carbonate Div.
J.M. Huber Corp., Clay Div.
Hüls America Inc.
Hunter Associates Laboratory
Huntsman Corp.

Ideal Mfg. & Sales Corp.
Industrial Paint & Powder Magazine
INSITEC, Inc.
Interfibe Corp.
International Resources, Inc.
International Specialty Chemicals
International Specialty Products
ITT Marlow/ITT A-C Pump

S.C. Johnson Polymers
Journal of Coatings Technology

K-T Feldspar Corp.
Kady International
Kemira, Inc.
Kenrich Petrochemicals, Inc.
King Industries, Inc.
KTA-Tator, Inc.

LaQue Center/Kure Beach Atmospheric Testing
Leeds & Northrup
The Leneta Co.
Liquid Controls Corp.
Littleford Day Inc.
The Lubrizol Corp.
Luzenac America

3M, Specialty Chemicals Div.
3M/Zeelan Industries, Inc.
MacBeth, Div. of Kollmorgen
Magnesium Elektron, Inc.
Malvern Instruments
Malvern Minerals Co.
The McCrone Group
McWhorter, Inc.
The Mearl Corp.
Michelman, Inc.
Micro Powders, Inc.
Microfluidics Int'l Corp.
Micromeritics
Micromet Instruments, Inc.
Mid-States Eng. & Mfg. Co.
Milton Can Co.
Milwhite, Inc.
Mineral Pigments
Ming-zu Chemical Industries
MiniFIBERS, Inc.
Minolta Corp.
Mississippi Lime Co.
Univ. of Missouri-Rolla
Modern Paint & Coatings
Morehouse-Cowles, Inc.
Morton International, Inc.
Mountain Mineral Co., Ltd.
Myers Engineering

Nacan Products Ltd.
National Chemical Company
National Paint & Coatings
Netzsch Inc.
Neupak, Inc.
New Way Packaging Mach.
Norman International
North Dakota State University
NYCO Minerals Inc.

Oak Printing
Obron Atlantic Corp.
Ohio Polychemical Co.
Olin Chemicals
Omega Recycling Technologies
Ortech International
OSi Specialties, Inc.

Paar Physica USA, Inc.
Pacific Micro Software Eng.
Paint & Coatings Industry Magazine
Pen Kem Inc.
Peninsula Polymer
Phenoxy Associates
Poly-Resyn, Inc.
PPG Industries, Inc., Silica Products
PPG Industries, Inc., Specialty Chem., Chem. Group
PQ Corp./Potters Industries
Premier Mill Corp.
Progressive Recovery, Inc.
Pyosa, S.A. de C.V.

The Q-Panel Co.
Quantachrome Corp.
K.J. Quinn & Co., Inc.

Raabe Corp.
Ranbar Technology, Inc.
Red Devil Equipment Co.
Rheox, Inc.
Rohm and Haas Co.
Ronningen-Petter
Charles Ross & Son Co.
Russell Finex Inc.

San Esters Corp.
Sandoz Chemicals Corp.
Sanwa Chemical Industries Co., Ltd.
Schenectady International
Schuller Filtration Inc.
Scott Bader, Inc.
Semi-Bulk Systems, Inc.
Serac, Inc.
Shamrock Technologies
Sheen Instruments Ltd.
Shell Chemical Co.
Sherwin-Williams Chemicals
Silberline Manufacturing Co.
Sino-American Pigment Systems
Software 2000, Inc.
Sonoco Products Co.
South Florida Test Services
Southern Clay Products, Inc.
Univ. of Southern Mississippi
Specialty Minerals, Inc.
Startex Chemical Inc.
Steel Structures Painting Council
Sub-Tropical Testing Services
Süd-Chemie, Rheologicals
Sun Chemical Corp.
Sunkyong Industries Ltd.
Systech Environmental

21st Century Conatiners, Inc.
TA Instruments, Inc.
Tayca Corp.
Tego Chemie Service USA
Thiele Engineering Co.
Transac Inc.
Troy Corp.

U.S. Borax, Inc.
U.S. Sack Corp.
Union Carbide Corp.
Union Miniere
Union Process, Inc.
United Mineral & Chemical Corp.

Van Waters & Rogers, Inc.
R.T. Vanderbilt Co., Inc.
Versa-Matic Pump Co.
Viking Pump, Inc., A Unit of IDEX
Vorti-Siv/MM Industries, Inc.

Wacker Silicones Corp.
Wilden Pump & Engineering
Witco Corp.

X-Rite, Inc.

Zeneca Biocides
Zeneca Resins

FSCT Publications Order Form

Order From:
Federation of Societies for Coatings Technology
492 Norristown Road, Blue Bell, PA 19422-2350
Phone: (215) 940-0777 • FAX: (215) 940-0292

Journal of Coatings Technology

(Annual Subscription included with FSCT Membership)

	U.S. and Canada	Europe (Air Mail)	Other Countries
1 Year	$ 30.00	$ 60.00	$ 45.00
2 Years	57.00	117.00	87.00
3 Years	82.00	172.00	127.00

______Journal of Coatings Technology

Technical Volumes

______Paint/Coatings Dictionary *(Member Price—$30.00; List Price—$50.00)*
______Infrared Spectroscopy Atlas (1991) *(Member Price—$150.00; List Price—$200.00)*
______Glossary of Color Terms *(Price—$6.00)*

New Federation Series on Coatings Technology

(Member Price—$7.50 ea., or $5.00 ea. with order of full set;
List Price—$15.00 ea., or $10.00 ea. with order of full set)

Quantity

______"Film Formation"—Z.W. Wicks, Jr.
______"Radiation Cured Coatings"—J.R. Costanza, A.P. Silveri, and J.A. Vona
______"Introduction to Polymers and Resins"—J. Prane
______"Solvents"—W.H. Ellis
______"Coil Coatings"—J.E. Gaske
______"Corrosion Protection by Coatings"—Z.W. Wicks, Jr.
______"Mechanical Properties of Coatings"—L.W. Hill
______"Automotive Coatings"—B.N. McBane
______"Coating Film Defects"—P.E. Pierce and C.K. Schoff
______"Application of Paints and Coatings"—S.B. Levinson
______"Organic Pigments"—P.A. Lewis
______"Inorganic Primer Pigments"—A. Smith
______"Marine Coatings"—H.R. Bleile and S. Rodgers
______"Sealants and Caulks"—J. Prane
______"Aerospace and Aircraft Coatings"—A.K. Chattopadhyay and M.R. Zentner
______"Introduction to Coatings Technology"—A. Brandau
______"Cationic Radiation Curing"—J. Koleske
______"Rheology"—C.K. Schoff
______"Powder Coatings"—J.H. Jilek
______"Introduction to Pigments"—J.H. Braun

Audio/Visual Presentations

______Causes of Discoloration in Paint Films *($40.00)*
______Introduction to Resin Operations *($65.00)*
______A Batch Operated Mini-Media Mill *($60.00)*
______Operation of a Vertical Sand Mill *($75.00)*
______Laboratory Test Procedures (VHS Format) *($50.00)*

Pictorial Standards of Coatings Defects

______Complete Manual *($100.00)*

Individual Standards *($3.00 ea., plus $3.00 per photo as noted in ( ))*
Adhesion (1) ____; Checking (1) ____; Filiform Corrosion (3) ____; Print (1) ____;
Traffic Paint Abrasion (2)____; Blistering (4) ____; Cracking (1) ____; Flaking (2) ____;
Roller Spatter (5) ____; Traffic Paint Shipping (2) ____; Chalking (1) ____;
Erosion (1) ____; Mildew (3) ____; Rust (4) ____

______Record Sheets (pad of 100 Sheets) *($3.50)*

Ordering Information

All Information below must be completed

Your Company

Check the **one block** which applies most specifically to the company or organization with which you are affiliated.

A ☐ Manufacturers of Paints, Varnishes, Lacquers, Printing Inks, Sealants, etc.
B ☐ Manufacturers of Raw Materials
C ☐ Manufacturers of Equipment and Containers
D ☐ Sales Agents for Raw Materials and Equipment
E ☐ Government Agency
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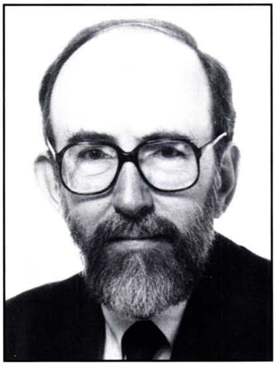
Ray A. Dickie

Dr. Dickie was graduated from the University of North Dakota with a B.S. in Chemistry. He earned his Ph.D. Degree in Physical Chemistry at the University of Wisconsin, and did postdoctoral research at the University of Glasgow and at Stanford Research Institute. He joined Ford Motor Company in 1968, and is currently Senior Staff Scientist in the Chemical and Physical Sciences Laboratory at Ford.

Dr. Dickie's research interests center on the chemistry of the polymer-metal interface and related areas of surface coating technology and adhesive bonding. The interfacial chemistry of corrosion-induced adhesion failure has been an area of special interest.

He was awarded the Distinguished Alumni Lectureship in Chemistry at the University of North Dakota in 1989. In 1991, he received the Midgley Award of the Detroit Local Section of the American Chemical Society for "outstanding contributions in the field of chemistry related to the automotive industry." In 1992, Dr. Dickie received the prestigious Roy Tess Award in Coatings from the American Chemical Society. To date, he has published more than 80 papers, and has been awarded 40 patents.

Dr. Dickie is a member of the Detroit Society for Coatings Technology, the Society of Rheology, and the American Chemical Society. He served as Chairman of the ACS Division of Polymeric Materials: Science and Engineering in 1987, and was General Secretary of the ACS Macromolecular Secretariat in 1990. He has organized ACS symposia on composites, crosslinking systems, and corrosion protective coatings. He is currently on the editorial advisory and/or review boards of the JOURNAL OF COATINGS TECHNOLOGY, *Progress in Organic Coatings*, and the *Journal of Adhesion Science and Technology*.



1993 JOSEPH J. MATTIELLO MEMORIAL LECTURE

Chemical Origins of Paint Performance

R.A. Dickie
Ford Motor Co.

The resistance of organic coatings to environmental degradation is usually evaluated in terms of changes in physical properties or appearance. Thus, paint system weatherability is assessed in terms of embrittlement and cracking, loss of adhesion, and loss of gloss, while corrosion protection is assessed in terms of paint blistering, loss of paint adhesion, and pitting or perforation of the substrate. The design and evaluation of accelerated tests are based on correlation of the physical changes induced by the selected test exposure condition with those observed under some standard conditions (e.g., a defined course of natural exposure). Many of the changes in physical properties and appearance that result from environmental degradation have their origins in chemical degradation processes. Examination of the chemical origins of physical change affords a complementary approach and potentially an alternative to accelerated performance testing for the evaluation of protective coating systems. The underlying theme of chemical origin of paint performance suggests a chemical paradigm for study of paint degradation, which in turn leads to the development of chemical protocols for the evaluation of durability. The implications of the chemical paradigm for research methods and test design are discussed.

INTRODUCTION

The way in which a scientific investigation is approached—the assumptions made, the themes selected, the paradigms adopted, the nature of the test protocols devised—affects how the subject is perceived, what problems are worked on, and how the results are interpreted and applied. Jack Oliver[1] comments that one should study the earth as well as the science of geology; that is, one should study not only one's immediate technical subject but also how science is done. This paper focuses on themes, paradigms, and protocols of research on coatings durability: paraphrasing Oliver, it deals with paint and with coating science. Paint testing and evaluation have generally been based on observation and measurement of changes in appearance, physical properties, and mechanical integrity. This paper proposes an alternate approach to studying the durability of coating systems, based on a chemical paradigm, and employing an observational, iterative approach to experimental design.

THEMES IN COATING SCIENCE

Themes in science provide a foundation for organizing information. Themes in science are easier to discern after the fact than they are when the science is in ferment, so discussions in the literature are typically written from a historical perspective. For example, Holton[2] characterizes Kepler's fundamental cosmological themes in terms of his view of the universe as a physical machine, in mathematical harmony, and with a central theological order. In the same spirit, Holton views the theme of classical physics as "continuity" ("completeness" or "determinacy" could well be added), and that of modern quantum physics as "discontinuity" ("indeterminacy" or "uncertainty" could be added).

Whether explicitly recognized as such or not, the underlying themes of research have a profound influence on approach, style, methodology, goals and, arguably, on the results of a research effort. For complex systems, no single organizing principle is likely to encompass all the materials or properties of interest. Any given theme will necessarily place emphasis on some aspects of the subject under discussion to the exclusion (or at least to the diminution) of others. The merit of a particular "theme" can be judged on the basis of its utility in organizing and understanding some fraction of the available body of information.

The idea of research "themes" is interesting to pursue for focused topics and immediate problems as well as for the large scale propositions more commonly considered by the philosophers and historians of science. For example, critical

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pigment volume concentration as a means of understanding the role of pigments in coating formulation and performance has been one of the themes of modern coatings technology. The relationship between molecular structure and physical properties is another major theme of modern coatings science. This theme underlies many key principles of coating resin design and formulation, including the dependence of adhesion phenomena on molecular functional groups and interfacial acid-base interactions; the relationship between molecular structure and glass transition temperature; and the effect of crosslink density and crosslink network structure on the solvent resistance and physical properties of thermoset coatings.

To these themes can be added the idea that the physical changes observed as materials age and weather have their origins in chemical change. An understanding of the chemical changes responsible for physical degradation provides guidance in polymer synthesis and coating formulation, facilitates the development of objective methods for determining the validity of accelerated test methods, and can provide the basis for new methods of evaluating coating performance.

Consider for a moment the changes in physical properties that are commonly used to evaluate and quantify coating durability. The weathering of coatings may be evidenced by embrittlement and cracking, by loss of gloss, or by loss of adhesion. The failure of corrosion protective coating systems is evidenced by blistering, by loss of adhesion, and ultimately by destruction of the substrate metal. There is no question that physical (including mechanical) properties and physical processes can and do contribute to coating failure processes and perceived coating system performance. However, in the development of new materials, it is essential to look beyond the symptoms of degradation—the observed physical changes—to the root causes of change in the chemistry of the system and the environment.

The simple notion of chemical change as the cause of change in physical properties in, for example, weathering, has potentially profound consequences. If chemical processes are responsible for undesirable changes in physical properties, then changes in properties can be understood in chemical terms, and potentially can be quantified, controlled, and suppressed by chemical means.

Table 1—Chemistry of Painted Steel Corrosion

Experiment	What We Know as a Result	Questions Raised
Identify initial modes of failure	Coating adhesion loss is due to corrosion	Controlling parameters
Evaluate corrosion mechanism	Role of cathodic corrosion reaction	Locus of failure; interfacial chemistry
Analyze interfacial chemistry	System-dependence of locus role of polymer degradation	Influence of polymer and substrate on rate and mechanism
Modify polymer structure	Mechanism and rate influenced by polymer composition	System interactions: role of substrate and pretreatment
Modify substrate	Effect of conversion coatings on cathodic reaction	Role of mechanical factors

In the corrosion of painted metals, the chemical processes range from straightforward substrate corrosion (and physical undermining of the coating) to a broad range of interfacial reactions, including polymer hydrolysis, that tend to weaken or disrupt the interfacial region often termed the interphase. Physical controls in corrosion protection focus primarily on preventing the initiation of corrosion, for example, by establishing an impermeable barrier to corrosive agents. Chemical controls in corrosion protection focus on limiting the spread of corrosion from an initial site. Chemical controls include, for example, incorporation of corrosion inhibitive pigments and electrochemically active fillers in coating formulations and the use of resin compositions that resist interfacial attack by the products of corrosion reactions.

In weathering, the chemical processes responsible for the changes in physical properties are typically hydrolysis and photodegradation. Thus, the loss of gloss of traditional (single coat) automotive enamels has long been attributed to the degradation of the binder resin, a chemical process. The physical erosion that is the proximate cause of loss of gloss (by the washing away of the degradation products, and the resultant exposure of pigment particles) is not the rate controlling step in the degradation process. Resistance to photodegradation has been a more fruitful goal of resin design and coating formulation than resistance to erosion by water.

Perceived performance also depends on the nature of the physical degradation processes. Moderate chalking or a gradual loss of gloss may be less objectionable than cracking or adhesion loss, even though the rates of chemical degradation may be comparable. Such subjective differences in performance contribute to problem selection and prioritization, but are generally not directly resolvable by chemical methods. Chemical methods are thus probably best used to compare performance within a given class of materials or failure modes.

Of course, there are other degradation mechanisms and mitigating chemical processes (for example, photostabili-zation or corrosion inhibition) to be considered, but these complicating factors do not diminish the fundamental importance of the chemical origin of changes in physical properties.

CHEMICAL PARADIGM FOR STUDY OF PAINT DURABILITY

Building on the thematic idea that most of the physical changes that occur during paint degradation have their origins in chemical processes, a chemical paradigm for the study of paint durability can be formulated. The key characteristics of the chemical paradigm are:

- a qualitative identification of modes of failure;
- a focus on the early stages of the degradation process;
- an emphasis on the chemistry of degradation;
- the use of chemical criteria in testing; and
- a preference for the evaluation of total systems.

The first step of a study following the chemical paradigm is identification of modes of failure and selection of modes appropriate for chemical study. The early stages of problem identification are qualitative and subjective. Since failure modes are just those changes in properties and appearance that result in customer dissatisfaction, there is a strong influence of perception and value judgment that is difficult to quantify. The identification of modes of failure thus entails both a characterization of discernible changes in physical properties or appearance and an evaluation of the impact of those changes on the customer's acceptance of the product. This view of product evaluation suggests that not every change in physical properties or appearance constitutes failure; thus, an objective evaluation of changes in physical properties should not be used as the sole method of performance assessment.

Placing heavy emphasis on chemical modes of degradation can cause physical modes of degradation to be ignored unless they have chemical origins or influence the degradation chemistry. Purely physical modes of degradation—for example, chip resistance and cold crack or thermal shock resistance—need to be considered separately.

The second characteristic of a study based on the chemical paradigm is a focus on the early stages of failure processes. The failure of coatings in real environments is often a long, complicated series of events. Secondary processes can obscure the nature of the critical early steps of degradation. In the chemical paradigm, it is asserted that it is most important to pay attention to the first or initiating steps of failure processes. From a practical, product-development viewpoint, the sensitivity of a product to the early steps of degradation may be more amenable to modification or control than the more complex final stages of the failure process.

Emphasis on the degradation chemistry, the third characteristic of the chemical paradigm, results in identification of chemical processes underlying the physical changes characteristic of the degradation of diverse systems. Just as with the focus on the early steps of failure processes, the focus on chemistry arises from the practical consideration that understanding of the degradation chemistry is likely to provide direction for improvement of coating systems through changes in chemical composition and formulation.

The fourth characteristic of the chemical paradigm is the use of chemical criteria in the development of test methods for materials research, evaluation, and specification. The chemical paradigm emphasizes the importance of monitoring the chemistry of degradation both as a direct method for evaluating durability and as a means of validating test methods. Tests and acceptance criteria based on chemical criteria are the result. The underlying assumption is that most aspects of coating durability are chemistry-specific. In conventional accelerated testing, the preferential acceleration of one or another aspect of a complex set of chemical reactions can result in failure modes different from those encountered under normal exposure conditions.[3] Errors in the ranking of systems that are affected differently by the intensification of exposure conditions are the almost inevitable result. The term "unnatural chemistry" has been used to describe the new or altered degradation chemistry observed under accelerated test conditions, but in fact the chemistry is not unnatural: it is merely reflective of the particular experimental conditions of the "accelerated" test, and may or may not be relevant to the evaluation of the performance of the coating system under real world exposure conditions. The basic assumption for the design of accelerated test conditions using the chemical approach is that the chemical mechanism of degradation under accelerated test conditions should be the same as it is in the service conditions of interest. In the evaluation of paint weathering, this approach leads, for example, to the suggestion that an increase in light intensity or exposure time may be preferable to the use of shorter wavelengths in accelerated testing.

Table 2—Chemistry of Paint Weathering

Experiment	What We Know as a Result	Questions Raised
Identify initial modes of failure	Loss of gloss, cracking	Controlling parameters
Study effect of exposure conditions	Principal process is photooxidation	Methods of study and assessment of photooxidation
Study coating photooxidation	Differences in rate anticipate weathering: PIR, IR, ROOH as tools	Influence of polymer structure; role of additives
Polymer structure	Identity of likely chromophores; role in photooxidation	Strategy for resin design and formulation
Role of additives	Mechanism of action; factors influencing effectiveness and longevity	Strategy for use of additives; system interactions

The fifth step in a study based on the chemical paradigm goes beyond the evaluation of a single material to look at system issues. The behavior of complex systems is rarely an additive function of the properties of the systems' constituents. The systems issues of interest for coatings include issues of component design, manufacturing practice, and performance expectation as well as material systems questions (interactions between the coating, the substrate to which it is applied, and the environment in which it is placed in service). The study of complex systems is typically iterative, with the results of each study resulting in modification of previous assumptions and suggesting new approaches for experimental study and interpretation. This suggests an emergent experimental design, a concept discussed in more detail later in this paper.

EXAMPLES OF THE CHEMICAL PARADIGM

The ideas underlying the discussion of the chemical paradigm have evolved from work that my colleagues and I at Ford have done on corrosion performance and paint weathering. In the study of paint corrosion performance, and specifically the loss of paint adhesion attributable to corrosion processes, the chemical themes have been the chemistry of metal corrosion, the chemistry of coating adhesion, and the disruption of adhesion as a result of corrosion processes. In the study of the exterior durability of automotive topcoats, the chemical themes have been the chemistry of photooxidation and hydrolysis and the chemistry of photostabilization.

Although these are not the only processes that are important in corrosion and paint weathering, respectively, selection of these themes has allowed progress to be made in understanding the processes of degradation.

These examples are illustrated in *Tables* 1 and 2 in terms of the approach to some key experiments, the results of these experiments, and the questions raised by the results at each stage. The technical details have been discussed at length in many presentations and papers and are not reviewed here.

The first steps of study in both cases involve qualitative observation of system performance to identify the modes of failure. For painted steel corrosion, the experimental observation is that there is a loss of paint adhesion near sites of corrosion, allowing corrosion to spread. The obvious chemical questions address issues of the chemical mechanisms of interfacial degradation and the material and environmental parameters that control the degradation process. These questions have, of course, been investigated by many people over the years, including Leidheiser and his students at Lehigh, in terms of the corrosion process and the parameters that control it;[6] Funke et al. at FPL in Stuttgart, in terms of transport processes and adhesion;[5] by vanOoij et al., in terms of the effects of long term natural exposure;[7] and by my group, in terms of interfacial chemistry of adhesion loss.[4]

A specific set of corrosion processes—dominated by underfilm cathodic reactions, leading to a highly alkaline interfacial environment—were identified as providing the engine for the initial corrosion-induced failure of coatings on, e.g., steel substrates. The molecular locus of failure and the chemistry of the interfacial processes were subsequently defined using surface analytical methods including XPS (X-ray photoelectron spectroscopy) and SIMS (secondary ion mass spectroscopy). The influence of polymer composition and substrate on rate and mechanism were systematically investigated and the composition of the coating polymer system was found to be one of the rate controlling factors in the corrosion failure process, but not the only important factor. Combining studies of corrosion phenomenology, coatings performance, and interfacial chemistry, there appears to be a hierarchy of corrosion-related paint adhesion failure modes on painted steel.[8] In terms of coating system development, the hierarchy of failure modes can be regarded as a sequence of progressively more difficult performance challenges that must be met by a new coating system. The steps of the hierarchy are:

- spontaneous delamination (resulting, e.g., from a combination of intrinsically weak adhesion and excessive shrinkage during cure);
- water disruption of adhesion (i.e., disruption of interfacial interactions by water with little or no chemical change in either adherend);
- cathodic alkali disruption of adhesion (similar to water disruption, but involving the more aggressive alkaline environment generated by the underfilm cathodic corrosion reaction); and
- cathodic alkali degradation (in which either the coating or the substrate are chemically degraded, resulting in both a weakening of the interface and an expansion of the area available for cathodic corrosion activity).

These failure modes are observed for coating systems that are progressively more resistant to corrosion.

There are many other questions of interest in the study of paint adhesion loss from steel substrates, including the role of zinc coatings and questions of mechanical stress effects on corrosion performance. From a product development and evaluation perspective, one of the most challenging questions is the mechanism of failure at very long exposure times of some of the outstanding coatings systems now in commercial use.

A detailed review of corrosion and corrosion protective coatings is beyond the scope of the present discussion. The key point is that approaching the problem of paint adhesion loss in corrosion systematically as a chemical problem, with a chemical explanation and a chemical means of control, has been a fruitful approach to the evaluation and development of coatings systems.

The chemistry of paint weathering provides another example of a study based on the chemical paradigm of paint degradation. The durability of automotive topcoats can largely be understood in terms of the photostability of the coating polymer, as summarized recently by Bauer.[9] The outline of study closely parallels that given for the investigation of the corrosion of painted steel. The first step is identification of the initial modes of failure. Qualitative observation of the behavior of automotive paint systems indicates that the characteristic failure modes are loss of gloss and, for basecoat/clearcoat paint systems, cracking and loss of adhesion of the clearcoat. These failure modes are typically observed in coatings subjected to exterior exposure (the standard test procedure has for many years included a period of exposure under defined conditions in Florida) or to certain accelerated tests that include intense light and, generally, periods of high humidity. The principal process of degradation is a photooxidation process. The questions of interest are the nature of the photo process and the system and exposure variables that control it. Study of these questions requires that methods of studying the photo process and of assessing the mechanism and rate of photooxidation be devised.

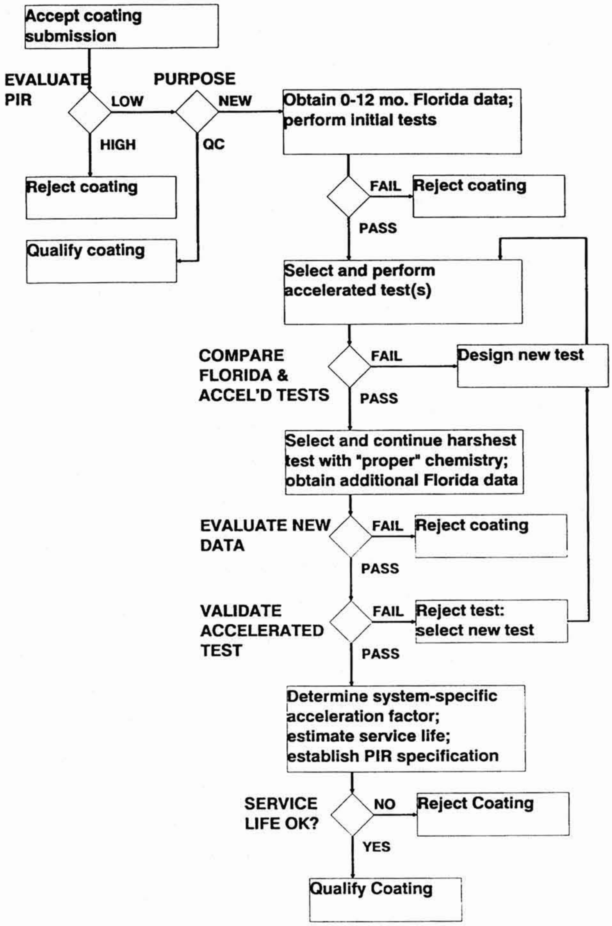
The challenge thus becomes the development of methods for studying and quantifying coating photooxidation. The chemical focus is especially evident in studies of photooxidation and the effects of resin structure and additive chemistry. Of course, many factors come into play determining the durability of automotive topcoats. For modern basecoat/clearcoat paint systems, the key factors affecting durability, as summarized by Bauer,[9] are:

- the resistance of clearcoat to acid attack and hydrolysis;
- the intrinsic photostability of the clearcoat (as indicated, for example, by free radical formation rates);
- the nature of the photooxidative pathway (chain scission versus crosslink formation);
- the permanence of light absorbers; and
- the photostability of other coatings comprising the system (the basecoat and the primer, in most cases).

The corrosion of painted steel and the weathering of paints are very different processes and require very different experimental techniques for their understanding and resolution. In both cases, however, the physical changes characteristic of paint degradation originate in chemical processes. Further, provided that the physical mode of failure does not change, an understanding of the chemistry can give a rational basis for materials development and evaluation.

PROTOCOLS FOR EVALUATION OF COATINGS

The chemical paradigm concentrates on identification of modes of failure, the chemistry of the early stages of degradation, and the unifying or common chemistry and physics. Much of the chemical insight gained in studies guided by the chemical paradigm can be applied directly in materials development. The chemical paradigm is also of great utility in the development of criteria for testing and evaluation of total systems. The development of improved test protocols for rapid evaluation of coating system durability has assumed special importance with the rapid development and implementation of new coatings systems necessitated by regulation of solvent emissions from painting operations. The development of chemical protocols for coating evaluation arose both from a recognition of the need for improved methods in materials development and from a growing sense that conventional test protocols based on accelerated tests do not always provide reliable evaluations of new coatings system performance. (In this context, "reliability" refers to the correspondence of test results to in-service or field performance, not to the reproducibility of the results.)



adapted from: D. R. Bauer, J. L. Gerlock, and R. A. Dickie, *Progress in Organic Coatings*, **15** (1987) 209-221.

Figure 1—Scheme for coating qualification based on chemical measure of coating photostability (adapted from reference 11)

Conventional test protocols are based on observation of physical failure, such as loss of adhesion, loss of gloss, etc. To shorten the test time and obtain a rapid response, the degradation process is accelerated, typically by intensifying one or more of the environmental exposure factors. The basis for acceptance of the accelerated test method is the similarity of failures in type and overall appearance to "normal" failures.

The accuracy of quantitative life predictions from accelerated tests can be improved by comparing the initial results from outdoor and accelerated tests to derive "acceleration factors," as pointed out by Simms.[10] With adequate safeguards, and within closely related coating formulations, this approach can be very effective. The major advantage of the conventional protocols is their familiarity. The test methods are generally agreed upon, and the results are reliable for established coating families. Further, chemical insight into the mechanisms of degradation is not required for application of the test method or interpretation of results. On the other hand, the test times involved are typically fairly long, even for accelerated tests. Too much acceleration or too short an observation time can lead to erroneous results, so the potential for shortening test times is limited. Test validity is suspect for new coating systems, since the chemical mechanisms of failure (hence, the effect of accelerated exposure) can change. Finally, there is little or no chemical information gained from the testing, and therefore there is little to guide the chemist in development of new products.

Chemical protocols are based on the use of measurements of chemical change to evaluate the degradation of a coating system. Measurements of rate of change are generally more informative than measurements of amount of change. For rapid response, chemical protocols may be based on early detection of chemical rates of change under ambient or near-ambient conditions rather than on detection of changes following accelerated exposure conditions. The measurement of chemical change by itself does not give rise to a prediction of lifetime. However, just as comparisons of physical changes in accelerated and nominally natural exposures can be used

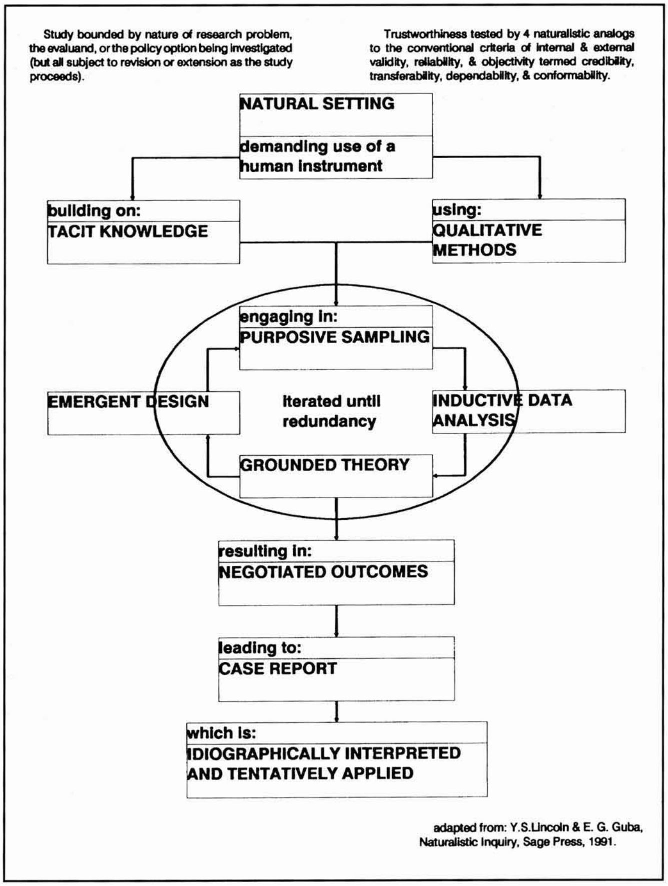


Figure 2—Flow of naturalistic inquiry (adapted from reference 12; reproduced with permission)

to define acceleration factors, measurements of chemical change under different exposure conditions can be used to measure acceleration factors for coatings.

Once validated, the use of a chemical evaluation scheme can allow testing at very short times even for exposure under ambient or near-ambient conditions. A key advantage over accelerated exposure methods is that the chemical mechanisms of degradation are not altered when natural exposure conditions are used. Since the focus is on the chemistry, substantial chemical insight is gained that can be of direct use in material development.

The main challenges of the chemical protocol are that new procedures and more detailed chemical knowledge of the systems tested are required. There is an implied assumption that the chemical process of degradation does not change during the life of the coating; clearly, this is not always a safe assumption. Use of chemical methods does require continuing attention to the nature of the failure process, including the physical modes of expression of the chemical changes and the governing chemical mechanisms of failure.

One way of using a chemical protocol to guide development and acceptance of coatings systems is outlined in *Figure* 1, adapted from Bauer, Gerlock, and Dickie.[11] This protocol was directed at the problem of evaluating weatherability of automotive topcoats, especially clearcoats. Cast in terms of a flow chart or decision tree for coating acceptance or rejection, the basic idea is that a chemical measurement of the intrinsic photostability of the coating should be used as the initial screening tool for evaluation of coating submissions. For quality control purposes, it is proposed that the chemical measurement should be sufficient for acceptance or rejection, although at the submission stage no quantitative prediction of service life is implied. It is assumed that intrinsically unstable coatings will have poor long term performance.

In the first version of the protocol, measurements of photoinitiation rates (PIRs) were used as the metric for photostability. In more recent discussions, the PIR measurements (which required the use of electron spin resonance spectroscopy) have been supplanted by a combination of infrared spectroscopy and hydroperoxide titration, but the principles of the method remain the same.

For new coatings, for which the validity of the chemical test has not been established, a scheme of validation and comparison with outdoor exposure results was suggested, as shown in *Figure* 1. The criterion for test design is that the chemistry of degradation be the same as that observed under the specified outdoor exposure; conditions in this case, conventional Florida exposure results.

CASE STUDIES, EXPERIMENTAL DESIGN, AND MODEL OF PERFORMANCE

Broadly, the goals of materials testing and evaluation are determining fitness for purpose and guiding development of new materials and processes.

The determination of fitness for purpose generally includes an estimation of service life under defined conditions. There are various approaches to achieving these goals, but prediction and control are the essential themes, with designed experiments based on accelerated test methods and selected, anticipated failure modes as the typical means. There are other legitimate goals—including discovery and understanding—that may be better served by a descriptive or case study method than by highly structured designed experiments. The most fruitful approach may well be a combination of methods, including by turns naturalistic case studies, formulation of predictive models of performance, and development of mechanistic models of performance.

Most materials research does begin with a case study, and then evolves into either a predictive or mechanistic investigation of performance. Typically, the predictive mode is aimed at materials specification and acceptance, while the mechanistic mode is aimed at materials development. The "conventional" and "chemical" protocols outlined in the preceding section can be regarded as iconic examples of these different approaches to coatings evaluation. The conventional protocol is a good example of a predictive model. The chemical protocol is basically a mechanistic model, but in the detailed form discussed here and in reference (8), it has been combined with a predictive model.

Naturalistic Case Study

The initial case study phase of problem identification and definition is rarely discussed in detail in research papers in the physical sciences. Technical papers are generally highly structured and are presented in logical (rather than temporal) sequence. What actually happens in research, though, is often neither particularly logical nor well organized, at least initially. Most studies begin with a naturalistic case study, that is, with a qualitative and initially unstructured examination of specific instances of system performance to gain insight into failure modes and mechanisms, and to develop methods of problem study and resolution. The direction and goals of a study can change as a result of the initial tentative attempts to explore a new problem or challenge. Indeed, this is the stage of discovery, and discovery is notoriously difficult to plan and to document.

In the development of the case study, there may be concurrent development of methods of study and problem definition leading to a progressive refinement of conclusions. Lincoln and Guba,[12] in a discussion of naturalistic methods of case study in the social sciences, term this iterative process emergent experimental design. An outline description of naturalistic case study, adapted from Lincoln and Guba, is given in *Figure* 2. Although some adjustment in terms and definitions is required to fit the model presented by Lincoln and Guba to materials or coatings research, the parallels in the proposed structure of inquiry are striking.

An initial case study is at least implicit in dealing with materials evaluation and durability prediction. The case study initially involves a qualitative and unstructured evaluation of, for example, coating failure modes and mechanisms, with a concurrent and ongoing development of methods of problem study and resolution. In the initial stage, as the process of sampling and analysis of information is begun, the approach to the study is based on the experience of the investigator in earlier studies and on tacit knowledge. The methods and focus of the study are modified as the study proceeds, as appropriate in light of initial results. The initial observations and analysis are necessarily qualitative. Especially at the earliest stages of study, quantitation of observations tends to impose an implicit model of the system and gives priority to quantifiable observables. The initial stages of data analysis and formulation of data-based (grounded) theory provide the basis for further refinement of experimental design and study; the design thus emerges during the course of enquiry. The iterative process of sampling, analysis, theory development, and experimental design continues until there is a clear identification and definition of the phenomena of interest. The outcome is a case study that forms the basis for further designed experimentation and evaluation. In materials research, the initial stage of the study is not likely to be documented, even though the course of subsequent investigation is based on the findings of this phase of study. Upon completion of the initial phase of study, there is likely to be a choice made between pursuit of a mechanistic investigation (how things work, how they change with age, use, and exposure) and predictive investigation (how, and how soon, things will fail).

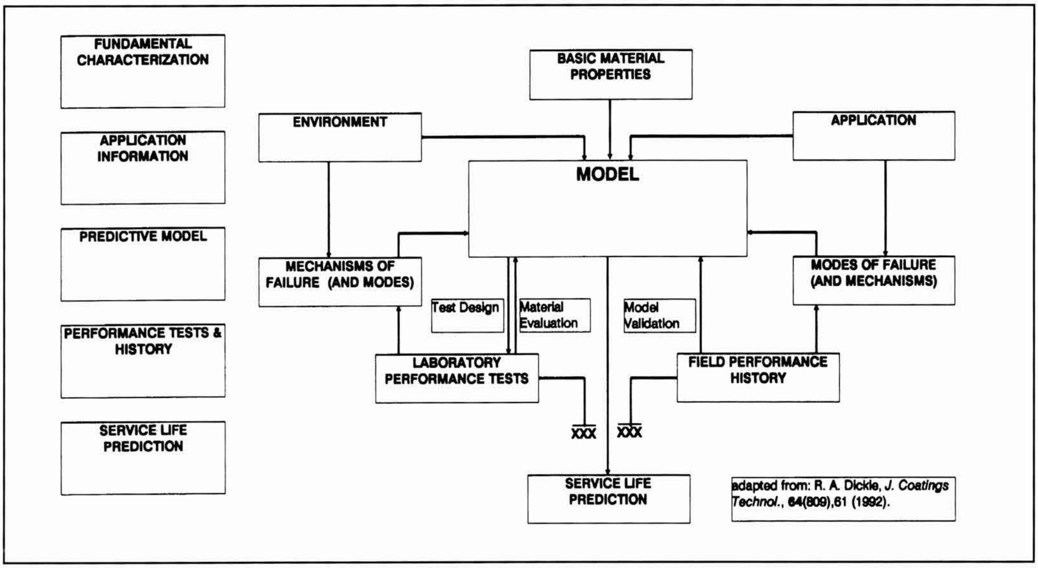
Predictive Models of Performance

In this discussion, predictive models of performance are exemplified by service life prediction methods. Predictive models are based on correlation of changes in physical properties between accelerated test conditions and natural exposure conditions (typically, a defined but constrained natural exposure). Comparison of chemical mechanisms between accelerated tests and natural conditions can be used to improve the validity and reliability of the prediction, but are not an intrinsic part of a predictive methodology.

A significant advantage of a service life prediction methodology is that the prediction can be quantified over certain ranges of material and exposure variables; designed experiments and reliability methodology can be used to estimate lifetimes.[13,14] Such methods lend themselves well to prescriptive applications, as, for example, in material specifications. The weakness of service life prediction as a methodology and the fundamental problem of material specification is a classical philosophical problem: it is not possible to predict the unknown, and therefore the effects of new exposure conditions and new coating compositions are not necessarily (and in general terms cannot be) accounted for appropriately or reliably.

In a recent "Open Forum" article in this Journal,[15] I briefly discussed predictive models and proposed a unified framework for service life prediction. In brief, the argument made was that neither simple accelerated performance tests nor limited field durability data are sufficient to predict durability. It was suggested that integrated models (incorporating the results of laboratory tests, field performance evaluation, characterization of macro and micro environments, and knowledge of fundamental processes) were necessary for the prediction of service life. A simplified version of the unified framework is shown in *Figure* 3. The framework highlights the central importance of a predictive model in relating basic studies, environmental and design data, accelerated testing and field performance history, with the likely results of actual use (i.e., with a prediction of the service life).

The key to the unified framework—and its chief weakness—lie in the formulation of the central predictive model. As discussed in the original article proposing the "unified framework," whether explicitly stated or not, a model is required for the use of accelerated test methods or field performance history in the prediction of performance. The model at the heart of the unified framework is difficult to



adapted from: R. A. Dickie, *J. Coatings Technol.*, 64(809),61 (1992).

Figure 3—Unified framework for service life prediction (adapted from reference 15)

define. Initially, the difficulty appears to lie in the need for a large amount of data (and a large number of studies relating, for example, exposure conditions to degradation chemistry. However, there is a larger difficulty which arises from the nature of models and theories in an empirical science and the basic relationship of models, or theories, to data. In an empirical science, models represent a very high level of abstraction from data. Models are not independent of data, but are directly based on empirical facts (data). The predictive capability of the models is, then, limited to that which we have known to be true in the past. In terms of coatings science, and predictive models of performance, what is excluded is prediction of performance for systems representing new technology; yet it is for these systems that the need is undoubtedly greatest. In essence, the model can be regarded as a grounded theory, that is, as theory based on data and open to modification and expansion as new data become available and as new understanding is developed.

Mechanistic Mode of Inquiry

Grounded theory is a way of describing what we know in orderly, constructive terms; we can use it to make reasoned guesses about things that we don't know on the basis of things we do know, but it is not complete and does not let us predict the unknown with certainty. The best we can do is to make reasonable guesses based on available data. For prediction of coatings performance, an understanding of how age and exposure effect changes in properties can improve the quality of the guesses we make. This suggests that emphasis should be put on understanding, and for chemical processes, understanding typically means defining mechanisms. I have termed this approach a mechanistic mode of inquiry.

In contrast to the predictive mode of inquiry, which is focused outward toward a projection of future behavior, the mechanistic approach turns inward to the available data on systems, the environment, and the application, and interrelationships between the variables characterizing each. The mechanistic inquiry is based on:

- qualitative observation of in-use performance, using naturalistic case study methods;
- identification, characterization, and continuous monitoring of failure modes;
- early detection of chemical change; and
- determination of the basic elements of the (chemical) cause of (physical) degradation.

The emphasis in mechanistic inquiry is on understanding and continuous improvement rather than prediction and specification. Evaluation stresses fitness for purpose, based on an understanding of the whole system. The range of applicability of the grounded theory developed in the course of the investigation—including the quality and utility of the prediction of service life—becomes one of the metrics for gaging the progress of development of understanding (or of models or theories), rather than the goal. Field exposure, including customer experience, becomes part of the investigation, and the results become part of the data on which models and theory are based.

The mechanistic mode of inquiry incorporates the ideas of case studies, emergent experimental design, and grounded theory, and adds to these an investigation of the underlying chemical phenomena responsible for physical change. The development of theory and of chemical understanding contribute to the further development of the experimental design. As the theory is developed, adjusted, and refined, the next steps of the study can be defined and the study can continue.

Case studies take time. A method based on observation of past performance does run the risk of providing answers only to the problems of obsolete systems. A mechanistic understanding of the underlying chemistry of degradation greatly enhances the generality and utility of the case study approach, and provides an initial basis for evaluation of new systems. The evolution of coating systems will produce surprises. While such surprises cannot be avoided, they can be accommodated and eventually explained by a mechanistic investigation which, like grounded theory in general, is open to expansion, refinement, and iteration.

Naturalistic case study, emergent experimental design, iterative formulation of grounded theory, and development of chemical understanding are inextricably linked in the mechanistic investigation. Their application to understanding the performance of coating systems is reminiscent of the hermeneutic circle of literary analysis: the whole cannot be understood without an understanding of the detail, but neither can the detail be understood without an understanding of the whole.

Long term longitudinal studies in medicine and the social sciences, which in some cases have continued for decades, have provided fundamental advances in understanding. Establishment of long term longitudinal studies of coatings performance could provide an invaluable resource to the coatings industry, especially if approached from an observational, mechanistic point of view rather than as highly constrained designed experiments. Such studies pose major logistical challenges. The time scales of such studies are not consistent with academic degree programs or with development of commercial products. They could be consistent with the goals and activities of, for example, the technical committees of local societies. Such studies might comprise, for example:

- monitoring and documentation of local and micro climatological conditions specific to coating test locations and field evaluation sites;
- development of systematic methods and criteria for describing and recording performance;
- selection of a defined set of samples and establishment of procedures for observation;
- observation, retrospectively and prospectively, of paint performance and failure modes by location, microclimate, and use (automotive, architectural, maintenance, etc.);
- evaluation of data and reporting of results; and
- design and execution of mechanistic studies for selected coatings and applications to establish the underlying chemistry of real time failure modes.

Understanding paint performance requires study of what happens to real paint systems in real time under real exposure conditions. As Jack Oliver[1] says of earth science,"...the best way to learn about the Earth is careful observation. Careful collection of data and careful study of them are the keys to success..."

SUMMARY

In discussing chemical origins of paint performance, I started with a discussion of themes in science. I suggested that one of the themes of coatings science is the chemical origin of physical change in coatings degradation. Next, I proposed a chemical paradigm for the study of coating degradation, and discussed as examples of the application of the chemical paradigm studies of the corrosion of painted steel and studies of the weathering of paint. I outlined the application of the chemical paradigm in development of test protocols for paint evaluation. This led to a discussion of the goals and methods of inquiry in coatings research. I compared and contrasted predictive models and naturalistic inquiry and their relationship to service life prediction. I proposed a mechanistic mode of inquiry incorporating naturalistic methods and the chemical paradigm for physical change during degradation. The mechanistic mode of inquiry is open ended, and focuses on understanding of degradation processes and performance issues: its consistent application should lead to continuous improvement of product, process, and test method.

ACKNOWLEDGMENTS

The contributions of my colleagues D.R. Bauer, J.L. Gerlock, J.W. Holubka, S.S. Labana, and H. van Oene at the Ford Research Laboratories to the development of the ideas presented in this paper are gratefully acknowledged. Prof. Virginia Allen Dickie brought Lincoln and Guba's book to my attention and contributed to the development of the discussion of emergent experimental design. Finally, special thanks to the members of the Mattiello Lecture Committee for giving me the opportunity to present the 1993 Joseph J. Mattiello Memorial Lecture.

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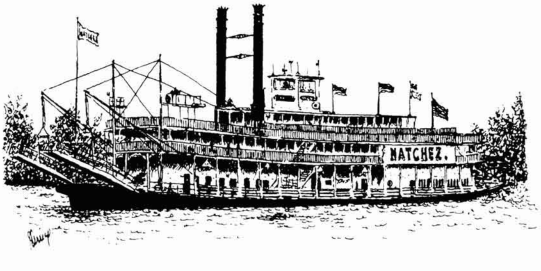

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A Study of Water at the Organic Coating/Substrate Interface

Tinh Nguyen, Dale Bentz, and Eric Byrd
National Institute of Standards and Technology*

Quantitative information on the water layer at the coating/substrate interface is crucial for understanding and preventing the failure of organic coating systems. A method, based on a two-layered model derived rigorously from internal reflection theory, was developed for determining the amount and thickness of water at the organic coating/substrate interface. The method gives new insight into the processes by which water degrades the coating/substrate bonds. The method requires application of a transparent or opaque organic coating of sufficient thickness on an internal reflection element (IRE), which is used as the substrate. A water chamber is attached to the coated specimen. After adding water to the chamber, FTIR-MIR (Fourier transform infrared-multiple internal reflection) spectra are taken automatically at specified time intervals without disturbing the specimens or the instrument. Water uptake in the coating and FTIR-MIR spectra of water on the coating-free substrate are also used for the analysis. Results for a clear epoxy coating on a Ge substrate and a pigmented alkyd on an SiO_2-Si substrate are presented to demonstrate the method. In addition to measuring water at the coating/substrate interface, the method provides a means for studying the transport of water through a coating adhered to a substrate. Information obtained by this method is valuable for interpreting corrosion, blistering, and delamination of organic coating systems and for developing models for use in predicting the service lives of protective coatings.

INTRODUCTION

Water at the organic coating/substrate interface is often the main cause of degradation of organic coating systems. The most visible effects are blistering when organic-coated substrates are exposed to high relative humidities or immersed in aqueous solutions. Water and aqueous solutions of corrosion products may also weaken or break the coating/substrate (oxide) bonds causing delamination of a coating from a substrate.[1-5] The detrimental effects of water and water vapor on the adhesion of organic coatings to metals and on adhesive bonds are well documented.[6-9] For metal substrates, water is the main ingredient necessary for corrosion reactions to occur and the presence of a water layer at the coating/metal interface is essential for the corrosion process to continue.

Measurement of water at the organic coating/substrate interface is a subject of great interest in many industries such as those concerned with organic coatings, adhesives, electronic packaging, and asphaltic concrete pavements. Funke and Haagen[10] have used the "crossover" point—that point in time where a coated metal absorbs more water than the free film—to indicate when water starts to accumulate in substantial amounts at the coating/metal interface. AC impedance spectroscopy has been shown to be capable of measuring the water uptake in a coating,[11] but it does not discriminate between the water in the coating and that at the interface. Time domain spectroscopy, a technique based on dielectric response, has been described as a promising means

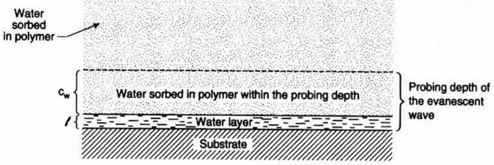

Figure 1—The two-layered model used for quantifying water at the coating/substrate interface

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for distinguishing between dispersed and aggregated water in a coating.[11] However, no information on the utility of this technique for measuring water at the coating/substrate interface has been given. In a study of water disbondment of organic-coated metals, Leidheiser and Funke[6] suggested the use of sensors placed at the coating/metal interface to determine the thickness of the water layer at that location.

In previous publications[12,13] we have described a technique based on Fourier transform infrared-multiple internal reflection (FTIR-MIR) spectroscopy for studying water *in situ* at the polymer/germanium and polymer/iron interfaces. In this technique, a polymer film is applied to the surface of a metallic or metal-coated internal reflection element. A water chamber is attached to the coated substrate and spectra of water accumulating in the coating/metal interfacial region are collected automatically at specified time intervals without disturbing the specimen, the conditions of the experiment, or the optical alignment of the instrument. Calculations confirmed that the technique provides information on water at the polymer/metal interface. An empirical approach based on a concentration-intensity calibration curve was presented for quantifying water at the polymer coating/substrate interface.[14]

In this paper, a method for determining the amount and thickness of the water layer at an organic coating/substrate interface, which is derived rigorously from the theory of internal reflection spectroscopy, is presented. Quantitative information on water at the coating/substrate interface will enhance understanding of the mechanisms of blistering, delamination, and corrosion of organic-coated materials, and of the controlling factors.

The method utilizes Fourier transform infrared (FTIR) spectroscopy in the multiple internal reflection (MIR) mode. This method offers a number of advantages for quantifying water at the coating/substrate interface: (1) it is sensitive to molecular water, its dissociated OH group, and its state of bonding; (2) it can be used at ambient conditions, thus it is suitable for *in situ* measurements; and (3) it detects water from the substrate side, thereby avoiding the interference of water from the environment.

THEORETICAL FORMULATION

As stated earlier, the method uses Fourier transform infrared spectroscopy in the multiple internal reflection mode (FTIR-MIR). Harrick[15,16] has developed the quantitative aspects of internal reflection spectroscopy, particularly when infrared absorbing species are uniformly distributed in either a thin film or an infinitely thick sample. Tompkins[17] has expanded this technique for studying species which are distributed nonuniformly in the sample. Mirabella[18] and Iwamoto and Ohta[19,20] have provided experimental data for a variety of applications to validate the quantitative capability of MIR spectroscopy. FTIR-MIR is a very sensitive technique and is suitable for surface and interface studies. One example of that was demonstrated by Yang et al.[21] who recorded quality spectra from films representing 0.01-0.1 of a monolayer of stearic acid adsorbed on an internal reflection element. Further evidence of the sensitivity of the FTIR-MIR technique is found in numerous reviews on its applications for studies of adsorbed species, ultrathin organic films, and single-monolayer Langmuir-Blodgett films on substrates.[22-27] In this section, the theoretical background for quantitative analysis of water at the organic coating/substrate interface using FTIR-MIR is given.

The measurement of water at the organic coating/substrate interface by FTIR-MIR spectroscopy depends on the interaction between the sample and the evanescent wave produced on total reflection in a substrate. The interaction causes the attenuation of the reflection of the propagating infrared beam inside the substrate. Detection of the attenuated radiation at the exit of the substrate yields an infrared spectrum of the sample within the probing depth of the evanescent wave. When an organic coated specimen is exposed to water, water will eventually enter the coating/substrate interfacial region, interact with the evanescent wave, and be detected. The model in which water at the coating/substrate interface is quantified by the FTIR-MIR technique is illustrated in *Figure* 1. The substrate in this case is an internal reflection element (IRE) having a refractive index greater than those of organic coatings and water. The problem is treated as a two-layered sample model. The first layer consists of a water layer having thickness, *l*, in contact with the substrate. The second layer contains the water in the coating that is detected by the evanescent wave.

The water detected is the sum of the amounts in the layer at the coating/substrate interface and in the coating layer probed by the evanescent wave.[12] Using infrared (IR) absorbance to express the amounts of water, this statement may be written

$$A = A_{wi}(l) + A_{wc}(l) \tag{1}$$

where A is the IR absorbance corresponding to the total amount of water detected, A_{wi} is the absorbance corresponding to the amount of water layer at the coating/substrate interface, and A_{wc} is the absorbance corresponding to the amount of water detected in the coating film by the evanescent wave. Both A_{wi} and A_{wc} vary with *l*. If water is taken up only in the bulk coating and does not enter the coating/substrate interface ($l = 0$), then $A = A_{wc}$. This means that the water detected is the water sorbed in the coating only. On the other hand, if the thickness of the water layer at the interface is very large ($l \rightarrow \infty$), than $A = A_{wi}$, indicating that only water at the interface is detected. In the following paragraphs, the derivation of expressions for determining the amount and thickness of the water layer at the coating/substrate interface will be presented.

The theoretical basis of this method is derived from the penetration-depth concept of internal reflection spectroscopy developed by Harrick[16] for thin and thick films. The application of this concept for a two-layer, polymeric system has been demonstrated by Iwamoto and Ohta.[19,20] The absorbance, A, of a band in an IR internal reflection spectrum of a surface film having a thickness, *L*, on a substrate is given by

$$A = \frac{n_2 \alpha}{n_1 \cos\theta} \int_0^L E^2 \, dz \tag{2}$$

where α is the absorption coefficient per unit thickness for the band of interest, θ is the incident angle, n_2 and n_1 are the refractive indexes of the sample and substrate, respectively, z is the depth from the interface, and E is the amplitude of the evanescent wave at distance z. E decays exponentially with distance from the surface according to

$$E = E_0 e^{(\frac{-z}{d_p})} \tag{3}$$

where E_0 is the amplitude of the evanescent wave at the surface and d_p is the depth at which the amplitude, E, has decreased to 1/e of its value at the surface. d_p is commonly known as the "penetration depth" of the evanescent wave in the sample. For nonabsorbing and weakly absorbing materials, d_p is given by[15]

$$d_p = \frac{\lambda}{2\,\pi\, n_1[\sin^2\theta - (\frac{n_2}{n_1})^2]^{\frac{1}{2}}} \tag{4}$$

where λ is the wavelength of the IR radiation in vacuum. For absorbing samples, Muller et al.[28] have derived a more exact expression for d_p:

$$d_p = \frac{\lambda}{\sqrt{2}\pi n_1\{([\sin^2\theta - (\frac{n_2}{n_1})^2 + (\frac{n_2}{n_1})^2\kappa^2]^2 + [2(\frac{n_2}{n_1})^2\kappa^2]^2)^{\frac{1}{2}} + (\sin^2\theta - (\frac{n_2}{n_1})^2 + (\frac{n_2}{n_1})^2\kappa^2)\}^{\frac{1}{2}}} \tag{5}$$

where κ, the extinction coefficient (the imaginary part of the refractive index) is given by $\alpha\lambda/4\pi$. Basically, this equation indicates that, for an absorbing group, the refractive index used is not simply n_2/n_1 but rather the complex refractive index $n_2/n_1\ (1 + i\kappa)$. Equation (5) reduces to equation (4) for $\kappa = 0$.

Substituting for E in equation (2) yields

$$A = \frac{n_2\,\alpha\,E_0^2}{n_1\cos\theta}\int_0^L e^{(\frac{-2z}{d_p})}\,dz \tag{6}$$

Combining equations (2) and (3) for the water layer of the two-layered model depicted in *Figure* 1 yields

$$A_{wi} = \frac{n_2\,\alpha_2\,E_0^2}{n_1\cos\theta}\int_0^l e^{(\frac{-2z}{d_{pw}})}\,dz \tag{7}$$

where n_2 and α_2 are the refractive index and absorption coefficient of water at the coating/substrate interface, *l* is the thickness of the water layer, and d_{pw} is the penetration depth of the evanescent wave in water. At the water layer/coating interface, the evanescent wave will have decayed to

$$E(l) = E_0\, e^{(\frac{-l}{d_{pw}})} \tag{8}$$

so that, within the coating layer, E will vary according to

$$E = E_0 e^{(\frac{-l}{d_{pw}})} e^{(\frac{-z}{d_{pc}})} \tag{9}$$

where d_{pc} is the penetration depth of the evanescent wave in the coating.

Substituting (9) into (2) yields the following equation for the absorbance by water in the coating layer:

$$A_{wc} = \frac{c_w n_3\,\alpha_3\,E_0^2}{n_1\cos\theta} e^{(\frac{-2l}{d_{pw}})}\int_0^\infty e^{(\frac{-2z}{d_{pc}})}\,dz \tag{10}$$

where n_3 and α_3 are the refractive index and absorption coefficient of sorbed water in the coatings and c_w is the fraction of water sorbed in the coating. Assuming that the refractive index and absorption coefficient of water at the coating/substrate interface are the same as those for water sorbed in the coating (i.e., $n_2 = n_3$ and $\alpha_2 = \alpha_3$), equations (7) and (10) may be combined as shown in equation (1) to yield

$$A = K[\int_0^l e^{(\frac{-2z}{d_{pw}})}\,dz + c_w\, e^{(\frac{-2l}{d_{pw}})}\int_0^\infty e^{(\frac{-2z}{d_{pc}})}\,dz] \tag{11}$$

where

$$K = \frac{n_2\,\alpha_2\,E_0^2}{n_1\cos\theta}$$

When the water layer at the coating/substrate interface is very thick ($l \rightarrow \infty$, i.e., $l > d_{pw}$), integration of equation (11) gives

$$A_\infty = \frac{K\,d_{pw}}{2} \tag{12}$$

Physically, this means that the water layer at the interface is so thick that the amplitude of the evanescent wave decays to a negligible value within it [1/e of the value at the substrate surface, equation (3)].

When the thickness of the water layer at the interface is finite, $0 < l < \infty$, the integrated form of equation (11) may be written

$$A = \frac{K\,d_{pw}}{2}[1 - (1 - c_w\frac{d_{pc}}{d_{pw}})e^{(\frac{-2l}{d_{pw}})}] = A_\infty[1 - (1 - c_w\frac{d_{pc}}{d_{pw}})e^{(\frac{-2l}{d_{pw}})}] \tag{13}$$

Rearranging gives

$$\frac{A}{A_\infty} = 1 - (1 - c_w\frac{d_{pc}}{d_{pw}})e^{(\frac{-2l}{d_{pw}})} \tag{14}$$

or

$$l = \frac{d_{pw}}{2}[-\ln\frac{1 - \frac{A}{A_\infty}}{1 - c_w\frac{d_{pc}}{d_{pw}}}] \tag{15}$$

Equation (15) is still valid for the case where the water layer at the coating/substrate interface is not continuous, e.g., discrete droplets, provided that the height of the droplet is not greater than the probing depth of the evanescent wave in water.

Assuming water is uniformly distributed over the entire surface area of the specimen, the amount of water at the coating/substrate interface, w_i, will be given by

$$w_i = l\,a\,\rho \tag{16}$$

where *a* is the area in contact with water and ρ is the density of water at the interface.

From equations (15) and (16), the thickness (*l*) and amount (w_i) of the water layer at the coating/substrate interface as a function of time can be determined. A, the FTIR-MIR absorbance of water detected at a given exposure time, is obtained from the FTIR-MIR spectrum of the *in situ* measurement; A_∞, the FTIR-MIR absorbance of liquid water, is determined from the FTIR-MIR spectrum of water alone in contact with the substrate; c_w, the amount of water sorbed in the coating, is determined in a water uptake experiment on free films of the coating; and d_{pc} and d_{pw} are calculated from equation (4) or (5).

In this paper, the thickness and amount of the water layer at the coating/substrate interface for two organic coatings on two substrates determined using equations (15) and (16) will be presented to demonstrate the application of the method.

EXPERIMENTAL SECTION

Three separate experiments were conducted to provide data for quantifying water at the coating/substrate interface: (1) FTIR-MIR *in situ* measurement of organic-coated specimens exposed to water; (2) FTIR-MIR analysis of water in contact with the coating-free substrates; and (3) water uptake in the free films of the coating. These experiments will provide A, A_∞, and c_w, respectively, as needed for use in equation (15).

FTIR-MIR *In Situ* Measurements on Coated Specimens Exposed to Water

Specimens of two organic coatings on two substrates were used. The two coatings were a solvent-based, pigmented alkyd and a clear epoxy. The alkyd was a medium oil, aromatic ester top coat, and the epoxy was a stoichiometric mixture of a low molecular weight, diglycidyl ether of bisphenol A and a polyethertriamine. There was no solvent in the epoxy coating. The alkyd contained 47.5% pigment (by mass), consisting of 31.5% TiO_2 and 16% reinforcing pigments, and 26.5% (by mass) of mineral spirit as the solvent. The two substrates were 50 x 10 x 3 mm spectroscopic grade, 45° parallelogram internal reflection elements (IRE) of germanium (Ge, refractive index $n_1 = 4.0$) and silicon (Si, refractive index $n_1 = 3.5$). At a 45° incident angle, these elements provide 17 reflections inside the substrates. When received, each IRE (substrate) was wrapped in a soft cloth and hermetically sealed in a plastic envelope inside a rigid box containing desiccant and packaging foam. The substrates were used as received immediately after unwrapping without surface cleaning or treatment. Ellipsometric measurements showed that the surfaces of the Si IREs were covered with an SiO_2 layer having a thickness of 2.25 nm and a refractive index of 1.46. These IREs were designated as being an SiO_2-Si substrate. The surfaces of the SiO_2-Si substrates were assumed to be covered with silanol (SiOH) groups. There was no attempt to characterize the surfaces of the Ge substrate before use.

The epoxy coating was applied on the Ge substrate and the alkyd on the SiO_2-Si substrate using a drawdown technique. The coatings were flooded on one end of the substrate, then firmly pulled down toward the other end using a round glass rod. Masking tape strips of 1 mm width placed along the length of the substrate (IRE) were used to control the thickness of the coatings. The coating thicknesses were measured, using a micrometer, on the dried, free films removed from the substrates after the conclusion of the experiment. The quality of the specimens was good and no visible pinholes or air bubbles were observed on the specimen surfaces. After curing for one week at ambient conditions, a water chamber (*Figure* 2) was attached to the coated specimens, using a room-temperature-cure silicone adhesive. The geometry and materials of the chambers and the procedure to fabricate them are described in reference 12. Each chamber had the same length and width as those of the substrate, i.e., 50 x 10 mm and a wall thickness of 1.5 mm. Each chamber was closed on five sides, leaving the side to be attached to the coated substrate open. One side of the chamber contained inlet and outlet ports to introduce and remove water. *Figure* 2 illustrates the specimen configuration used in the *in situ* measurement and quantification of water at the coating/substrate interface. It is noted that the coating layer around the edges (where the walls of the water chamber were to be attached) was made (by brushing) substantially thicker than the rest of the specimen. This was to insure that the only pathway for migration of water from the outside to the coating/substrate interface was through the coating layer within the walls of the water chamber.

In situ measurements on coated specimens exposed to water were carried out using an FTIR spectrometer with a variable angle ATR (attenuated total reflection) accessory. The spectrometer was equipped with a liquid nitrogen-cooled mercury cadmium telluride (MCT) detector. The specimen with the water chamber attached was placed vertically in an ATR accessory holder (*Figure* 2). After placing the ATR accessory with the mounted specimen in the spectrometer, and prior to filling the chamber with water, FTIR-MIR spectra of the unexposed specimens were taken. Distilled water was then added to the chamber and the inlet and outlet ports were sealed to prevent water evaporation. FTIR-MIR spectra of the water-exposed specimens were taken automatically every half-hour until the experiment was complete. There was no disturbance to the spectrometer or to the specimens throughout the measurements. The spectrum obtained was the ratio between the single beam spectrum taken at each exposure time and that of the background (specimen-free spectrometer). Difference spectra were acquired by subtracting the spectrum of the unexposed specimen from that of the water-exposed specimen. All spectra were taken at a 4 cm^{-1} resolution using 32 scans and purged dry air. Unpolarized radiation at an angle of incidence of 45° was used. The "peak height" method, which measures the absorbance at the absorption maximum of the band of interest, was used for quantitative analyses.

FTIR-MIR Analysis of Water on Ge and SiO_2-Si Substrates

In this study, a water chamber was attached to the coating-free substrates using a silicone adhesive. After filling the chamber with distilled water, FTIR-MIR spectra of water were collected. The spectrum of water was the ratio between the single beam spectrum of water in contact with the substrate and that of the water-free substrate with the chamber attached.

Water Uptake in Free Films of Coating

The uptake of water in free films of coating as a function of time was measured using the gravimetric method. The water uptake in the alkyd free films was obtained from a one-face water absorption experiment as described in reference 14. For the epoxy free films, specimens were prepared, weighed, and immersed in distilled water; they were taken out, blotted, and reweighed at specified time intervals. The thickness of the alkyd free films was 109 μm and that of the epoxy was 145 μm. Water uptake was expressed as a fraction of the mass of the initial, dry specimen. Three specimens of each coating were used.

A computer spreadsheet was used to facilitate calculations using the inter-relationships shown in equations (15) and (16) to obtain the thickness and amount of water at the

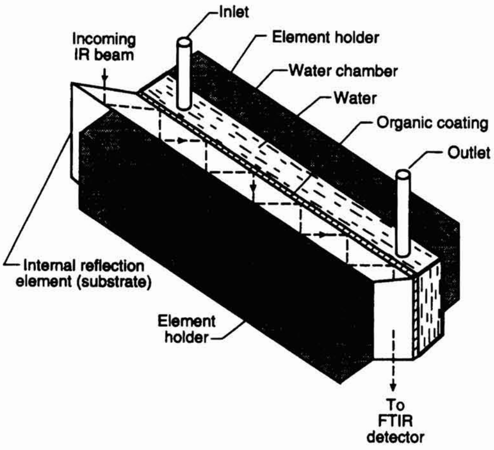

Figure 2—Experimental setup for measuring water at the coating/substrate interface

coating/substrate interface as a function of time for the alkyd/ SiO_2-Si and epoxy/Ge coating systems.

RESULTS AND DISCUSSION

FTIR-MIR *In Situ* Measurements on Coated Specimens Exposed to Water

Figure 3 presents typical, unprocessed FTIR-MIR spectra for an organic coated specimen before and during exposure to water for different time intervals. Each spectrum was obtained by ratioing the spectrum of the exposed specimen against the corresponding background spectrum, as described in the experimental section. The effects of water show up in the intensity increases in the 3100-3650 and 1625-1645 cm^{-1} bands. To accentuate the effects of water, difference spectra were acquired by subtracting the spectra collected before exposure to water from those obtained at different exposure times, as described in the experimental section. The subtraction was done after adjusting for the baseline shift. The difference spectra are presented in *Figure* 4 for the alkyd/ SiO_2-Si and epoxy/Ge coating systems. The thickness of the alkyd was 143±7 μm and of the epoxy was 475±12 μm. As emphasized earlier, there were no mirror or sample adjustments throughout the measurements. If there were no effect from the exposure to water, all difference spectra would be straight lines, with the exception of the intensity fluctuations of the CO_2 bands from the air in the spectrometer. Bands above or below the baseline of a difference spectrum indicate an increase or a decrease, respectively, of the concentration of a chemical functional group as a result of water exposure. Difference spectra such as those shown in *Figure* 4 were used for quantitative studies of water at the coating/ substrate interface.

Figure 4 clearly shows the effect of water on the coated specimens. The intensity of the bands in the 3100-3650 and 1625-1645 cm^{-1} regions increased with exposure time, while the intensity of the coating bands, e.g., at 1737 cm^{-1} for the alkyd and at 1510 cm^{-1} for the epoxy, decreased with the time of water exposure. These changes are the result of water entering the coating/substrate interfacial region and interacting with the evanescent wave, as discussed previously.[12] These changes are not due to swelling caused by water uptake in the coatings, because the penetration depths of the evanescent wave in water-saturated and in water-free coatings are essentially the same, as shown later. Further, any swelling of the coatings will result in a decrease, and not an increase, in the intensity of the coating OH stretching in the 3100-3650 cm^{-1} region of the FTIR-MIR spectrum.

That the bands near 3400 and 1640 cm^{-1} in *Figure* 4 are due to water is verified by *Figure* 5, which exhibits FTIR-MIR spectra of double distilled, liquid water on the same substrates. These are considered spectra of bulk water because the probing depth of the evanescent wave in the samples is several hundred nanometers. Except for the difference in the maximum intensity absorbance, *Figure* 5 shows little difference in band shapes of liquid water on SiO_2-Si and Ge substrates. The intensity differences are due to the difference in the refractive indexes between the SiO_2-Si and Ge substrates, which produces a difference in their d_p values in water, as will be shown later. The FTIR-MIR spectrum of liquid water shows a band peaking near 3400 cm^{-1}, due to OH stretching, and a band near 1640 cm^{-1}, due to H–O–H bending. In addition to verifying the water bands for the *in situ* measurements, *Figure* 5 was used to provide A_∞ values in equation (15).

In an FTIR-MIR experiment of different water concentrations in D_2O,[29] it was observed that the H–O–H bending band of liquid water did not appear at low concentrations (5-20% in D_2O) and that the shape of the shoulder near 3250 cm^{-1} varied at high water concentrations (> 50% in D_2O). For these reasons, the peak height (instead of peak area) of the water OH stretching (instead of OH bending) was used for quantitative analysis of water at the coating/substrate interface.

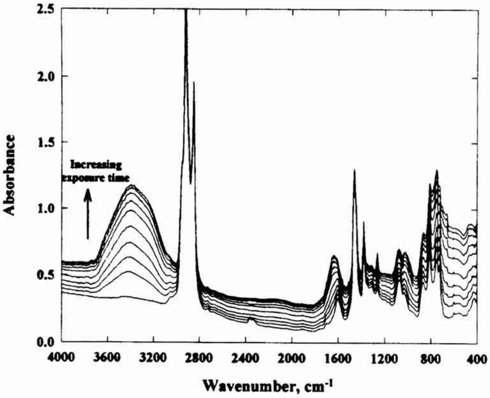

Figure 3—Typical unprocessed FTIR-MIR spectra of *in situ* measurement of water at the coating/substrate interface for several exposure times

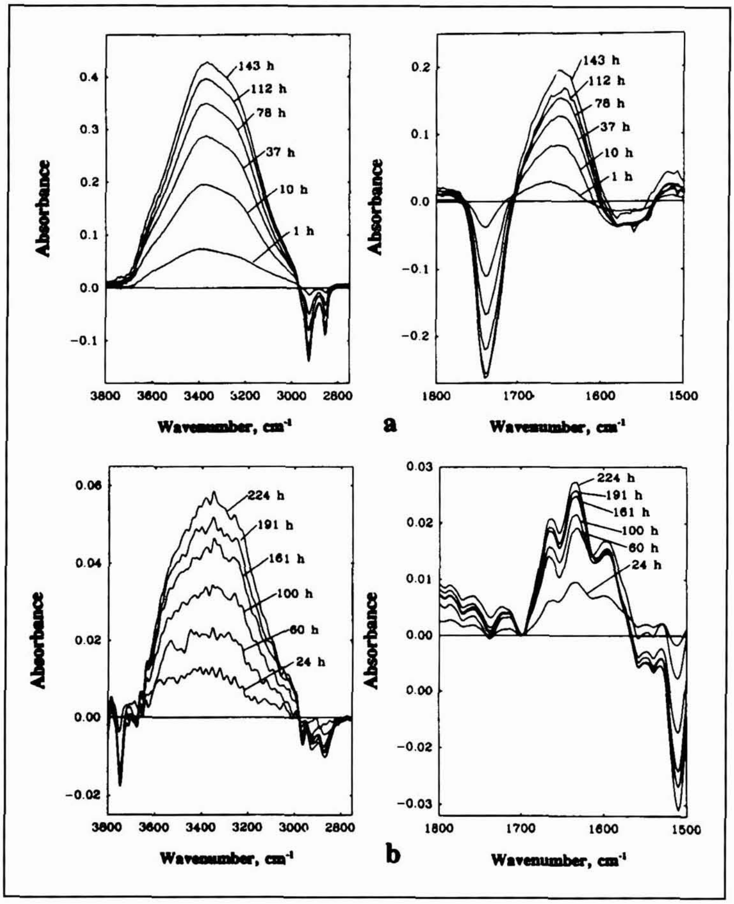

Figure 4—FTIR-MIR difference spectra at different times of exposure to water: (a) alkyd/SiO_2-Si system, and (b) epoxy/Ge system

Figure 6 depicts the intensity (peak height) changes of water OH stretching band at 3400 cm^{-1} as a function of exposure time for both the alkyd/SiO_2-Si and epoxy/Ge coating systems. The concentration of detected water increased rapidly at short exposure times. Thereafter, it rose at a slower rate. The increase was much greater for the alkyd/SiO_2-Si than for the epoxy/Ge system. The coating bands, i.e., 1737 cm^{-1} for the alkyd and 1510 cm^{-1} for the epoxy, decreased with exposure time. The decrease has been found to depend on the band's absorption strength: the stronger the band, the larger the decrease.[12]

QUANTITATIVE ANALYSES

FTIR-MIR Probing Depth in Organic Coating/Substrate Sample

Determination of the thickness of the water layer at the coating/substrate interface using the method described here requires data on the penetration depths of the evanescent wave in polymers (d_{pc}) and water (d_{pw}) at the water OH stretching frequency [equation (15)]. These parameters can be calculated from equation (4) or (5), depending on the absorptivity of the OH stretching in polymers and water. As stated earlier, equation (4) is generally valid for nonabsorbing or weakly absorbing materials and equation (5) is intended for absorbing functional groups. To determine whether equation (4) or (5) is more suited for obtaining d_{pc} and d_{pw}, the effects on the penetration depth (d_p) of the absorptivity (expressed by the extinction coefficient, κ) of the OH stretching in polymers and water must be examined.

As seen in *Figure* 5, the absorption by the OH stretching of water is relatively strong. The extinction coefficient at the 3400 cm^{-1} frequency (peak maximum) of this band has been measured by IR spectroscopy to be 0.275.[30] The peak maxima for the OH stretching in the two coatings also occurred at 3400 cm^{-1}. κ of the OH stretching of the clear epoxy was experimentally determined in this study to be approximately 0.01, following the procedure described by Allara et al.[31] The measurement was made using the FTIR-transmission spectrum of a 2.5 μm thick film of the coating on a NaCl substrate. Due to the pigment, κ of the OH stretching of the alkyd coating could not be measured in this study. However, it is expected to be similar to that of the epoxy. This is because the FTIR-MIR absorbance (not shown) of the OH stretching of the alkyd/SiO_2-Si specimen before exposure was slightly higher than that of the epoxy/Ge specimen (~0.08 units for the alkyd and 0.06 units for the epoxy), despite d_p in the alkyd being 42 nm greater than that in the epoxy.

Figure 7a depicts the effect of the extinction coefficient in the 0-0.5 range (typical for water and organic polymers) on d_{pc} and d_{pw} at the 3400 cm^{-1} frequency for the Si and Ge substrates according to equation (5). The calculations were made using a 45° angle of incidence and refractive index (n) values as follows: Ge = 4, Si = 3.5,[15] water = 1.30 (at 3400 cm^{-1},[32] epoxy and alkyd coatings = 1.5.[33] Note that although a pigmented coating is a composite of the polymer and the pigment,[34] we use the refractive index value for the unpigmented polymer in the calculation. The use of this value is correct for this study because although water may be primarily sorbed in the polymers and at the polymer/pigment interface, it will not be absorbed in the pigment particles. In the calculation, we also ignored the influence of the SiO_2 layer because this layer is not only very thin (2.25 nm) but also has a refractive index (1.46) close to that of the polymers. Thus, it has little effect on d_p.

Figure 7a shows that d_{pc} and d_{pw} decrease with increases in κ. The effect is greater for the lower refractive index substrate (Si) and the higher refractive index sample (polymer). When κ increases from 0 to 0.5, d_{pc} and d_{pw} for the Si substrate decrease by 7.3 and 5.1%, respectively, and d_{pc} and d_{pw} for the Ge substrate decrease by 4.9 and 3.6%, respectively. Further analysis indicated that the effect of κ on d_p is substantial when a low refractive index substrate, e.g., thallium bromide iodide (KRS-5, $n_1 = 2.4$), is used. For example, d_{pc} and d_{pw} values at 3400 cm^{-1} decrease by 33 (from 0.590 to 0.393 μm) and 19% (from 0.444 to 0.362 μm), respectively, as κ increases from 0 to 0.5. On the other hand, the effect of the refractive index of the sample (n_2) on d_p diminishes with increasing κ. For example, for an $n_1 = 2.4$, d_{pc} and d_{pw} values are 0.590 and 0.444 μm at $\kappa = 0$, but are only 0.393 and 0.362 μm at $\kappa = 0.5$.

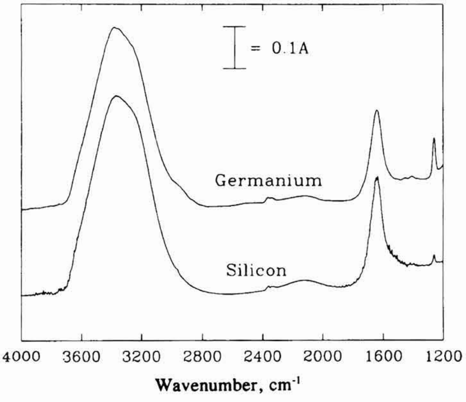

Figure 5—FTIR-MIR spectra of liquid water in contact with SiO_2-Si and Ge substrates

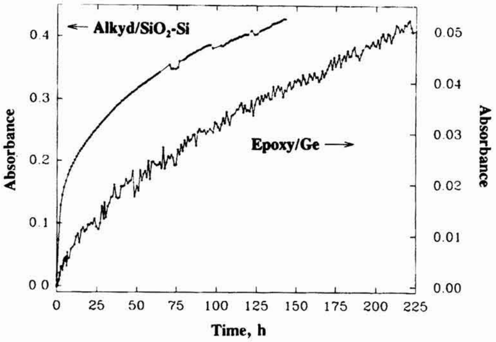

Figure 6—Intensity changes of water OH stretching bands as a function of exposure time for alkyd/SiO_2-Si and epoxy/Ge systems (each dot represents a data point). Note: For clarity, different scales are used for the two systems

It is apparent from *Figure* 7a that the effect of absorption by the OH stretching on d_p for water ($\kappa = 0.275$) and the two coatings ($\kappa < 0.1$) used in this study is small. The effect is less than two percent for both d_{pc} and d_{pw} on Si and Ge substrates. The effect is also minimal for other absorption bands, e.g., water OH bending (1640 cm^{-1}, $\kappa = 0.13$)[30] or C = O stretching (1732 cm^{-1}, $\kappa = 0.36$ for poly(methyl methacrylate),[31] when a high refractive index substrate is used. For a low n_1 substrate, e.g., KRS-5, the effect is about 5.4% for d_{pw} ($\kappa = 0.275$) but it is > 8% for d_{pc} for coatings having $\kappa > 0.2$. These results demonstrate that, for high refractive index substrates ($n_1 > 3$), d_p in a nonabsorbing region or at an absorbance peak of water and organic coatings can be conveniently calculated from the simple equation (4), instead of the more complex equation (5). It is emphasized that this conclusion is valid for determining d_p at the peak maximum of an absorbance band because, at this point, n_2 is reasonably near the value measured at some distance from the band. However, n_2 changes rapidly from one side of the peak maximum to the other (dispersion effect). Thus, d_p in the vicinity of the peak maximum may be substantially different from that at or away from it, particularly for low n_1 and low angles of incidence (θ). This has been demonstrated recently by Owaki[35] who showed that d_p at the lower frequency side of the 1500 cm^{-1} band of a material having $\kappa = 0.6$ on a substrate having $n_1 = 2.4$ at $\theta = 45°$ was about four times that at the center of the band. However, he showed essentially no effect of n_2 dispersion on d_p when $n_1 = 4$ and $\theta = 60°$. Further discussion of the effect of n_2 dispersion on d_{pc} and d_{pw} is beyond the scope of this study. For low n_1, equation (4) may be used to obtain d_{pw} but equation (5) should be employed to provide d_{pc} values for materials having $\kappa > 0.15$. Since this study utilized high refractive index substrates, we used only equation (4) for the analysis.

The penetration depths in the nonabsorbing and absorbing regions of polymers and water on Si and Ge substrates as a function of wavelength obtained from equation (4) are presented in *Figure* 7b. The calculations were made using

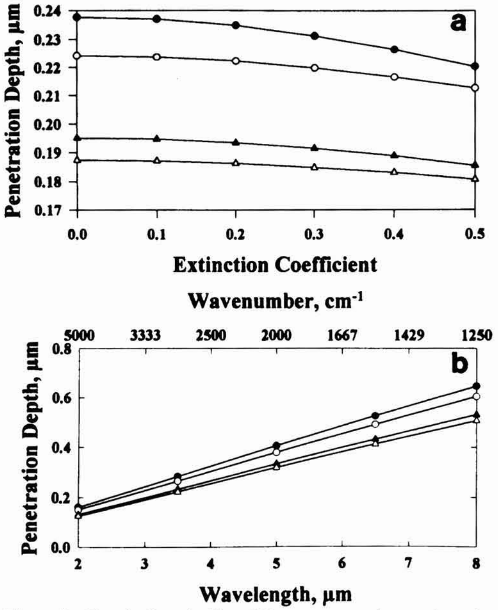

Figure 7—Penetration depths of the evanescent wave in polymer and water on Si and Ge substrates: (a) as a function of extinction coefficient using equation (5), and (b) as a function of wavelength using equation (4). Legend: circle—Si; triangle—Ge; unfilled—water; and filled—polymer

the same values of n_1, n_2, and θ as for *Figure* 7a. As can be seen at long wavelengths, the MIR technique can probe rather deeply into the polymers and into water. Further, d_p in polymers is greater than in water and this difference varies with wavelength, being smaller at shorter wavelengths. For the water OH stretching (2.94 µm wavelength), there is only a small difference in the d_p values whether a polymer or water is in the interfacial region. At this wavelength, d_{pc} values for Si and Ge substrates are 0.238 and 0.195 µm and d_{pw} values are 0.224 and 0.187 µm, respectively. These values, which will be used for the determination of the thickness and amount of water layer at the coating/substrate interface, indicate that the signals observed in *Figure* 4 were derived mostly from water close to the coating/substrate interface (within 0.25 µm of the substrate).

Water Uptake in the Coatings

The total water detected in the interfacial region is the sum of (1) the sorbed water detected in the coatings by the evanescent wave, and (2) the water layer in the coating/substrate interface, as depicted in the model (*Figure* 1). By accounting for (1), the amount and thickness of the water at the coating/substrate interface can be deduced. The amount of water sorbed in the coating was determined from the water uptake of the free film; these results are given in *Figure* 8. It should be mentioned that the water sorption process in the alkyd films was from only one face of the specimen as explained in reference 14. This process simulates the experiment used for quantifying water at the interface. On the other hand, the water uptake in the epoxy films took place on both faces of the films. Accordingly, to provide a rough correction for the difference in the experimental conditions, the time scale in *Figure* 8 for the epoxy has been multiplied by two. Both coatings took up water rapidly in the first 10 hours; thereafter, the rates of uptake fell to a very low value by 150 h. The maximum uptake in the alkyd was about 4.0% and that in the epoxy was 2.0%. The mass fraction of water sorbed in the coating, as detected by the evanescent wave (c_w), was extrapolated from *Figure* 8, assuming that the water in the film was uniformly distributed and that the concentration of sorbed water remained constant. The latter assumption implies that, at steady state, the transport of water from the outside to the interface follows a Fickian diffusion process.

Thickness and Amount of Water at the Coating/Substrate Interface

The thickness of the water layer at the organic coating/substrate interface and the amount of water in it were determined using equations (15) and (16), as stated earlier. A_∞, A, and c_w values in equation (15) are obtained directly from the results shown in *Figures* 5, 6, and 8, respectively. Values of d_{pc} and d_{pw}, the penetration depths in coatings and water at 3400 cm^{-1} frequency (2.94 µm wavelength), are taken from *Figure* 7b. The amount of water was determined by equation (16) using an area value of 329 mm^2, the surface area of the coated substrate within the water chamber, and a density of water at the coating/substrate interface of 1 Mg/m^3.

Figure 9 presents the thickness and amount of water at the coating/substrate interface as a function of exposure time for the alkyd/SiO_2-Si and epoxy/Ge coating systems. It can be seen that the water layer at the alkyd/SiO_2-Si interface is much thicker than that at the epoxy/Ge interface and that the rate of increase of the thickness of the water layer on the SiO_2-Si substrate was also much higher than that on the Ge. The results suggest that the epoxy/Ge system is more resistant to displacement by water than the alkyd/SiO_2-Si system. Further, water probably entered the alkyd/SiO_2-Si interface by breaking the water-silanol bonds and building up the water layer on the silanol-terminated surface. This is because the hydrogen bonds between the first layer of water and the silanol groups on an SiO_2 surface are rather weak, about 25 kJ/mol, as compared to stronger bonds (> 40 kJ/mol) between the first and second layer of water.[36]

Figure 9 shows that, at long exposures times, the water layer at the interface is tens of nanometers thick for the alkyd/SiO_2 coating systems. This means that many monolayers of water have accumulated at the interface (one water monolayer is about 0.3 nm). Indeed, this is the case because we observed substantial amounts of liquid water beneath the alkyd coating as it was slowly peeled from the SiO_2-Si substrate at the conclusion of the experiment. This result is in agreement with practical experience for polymer/glass and asphalt/siliceous aggregate bonds, which are known to be sensitive to high relative humidities.[37,38] The presence of water underneath the epoxy coating was also evidenced by the wetness, which disappeared instantaneously, on the Ge substrate at the peeling front. These results strongly indicate that the intensity increase of the water bands and intensity decrease of the coating bands observed in *Figure* 4 are due to the increase of the thickness of the water layer at the coating/substrate interface. As the thickness of the water layer at the interface increased, the amount of coating material within the probing depth decreased because the coating was pushed further away from the substrate.

When the thickness of the water layer at the interface increases to tens of monolayers, there should not be any residual adhesion between the coating and the substrate. Indeed, this was observed experimentally. The alkyd coating was readily lifted off of the substrate at the conclusion of the experiment. And by using a scalpel to initiate a separation between the coating and the substrate, the epoxy was also peeled off easily from the Ge substrate at the conclusion of the experiment. The results suggest that the intensity changes of the water and coating bands during exposure of the specimens to water may be related to the loss of adhesion of the coatings on the substrate. If further work confirms that such a relationship exists, the method may be useful for studying "wet adhesion" (adhesion in the presence of water). Funke[39] has addressed the importance of wet adhesion in the corrosion of organic-coated metals.

Discussion

In using the approach presented in this paper for quantifying water at the coating/substrate interface, we made three main assumptions:

(1) At a given time, all sorption "sites" in the coatings/substrate system took up water equally;

(2) Water breaks the coating/substrate bonds as it reaches them; and

(3) Water spreads readily over the surface of the substrate.

Assumptions (1) and (2) formed the basis for using the variable water uptake in the coatings of *Figure* 8 in the quantitative analysis, while assumption (3) allowed us to use a constant thickness layer in the two-layered model. The following section addresses these assumptions.

Assumption (1) implies that all sorption sites in the coatings must be occupied by the same amount of water before the next layer of water is sorbed. Brown[40] made a similar assumption in his analysis of water clustering in polymers. Although there has been much work on the sorption of water in polymers,[41,42] there is no information that could be used to test this assumption. However, the premise that each sorption site in the coatings is occupied before the next water layer is formed is consistent with adsorption of water on oxide surfaces.[43] For these materials, because of the strength of the oxide-H_2O interaction, water does not generally favor multiple occupancy of sites until almost all sites are occupied. This is in contrast with the adsorption of water on clean metals, which have a strong tendency to begin to form multilayers at low coverage.[43] For these substrates, the adsorption of water directly on the metal sites and on other water molecules are energetically equivalent. Consequently, multilayers of water can start to form on a clean metal surface even before the first layer is saturated.

Assumption (2) is consistent with the analysis by Wu[44] and results of Kinloch[45] and Comyn[46] who showed that the thermodynamic work of adhesion between a polymer adhesive and a high-energy solid in the presence of water is always negative. Nguyen and Byrd[47] reported similar results for an epoxy coating/steel system in aqueous environments. The negative work of adhesion indicates that, in the presence of water, the coating/metal (oxide) interfacial bonds are not stable and that water is capable of displacing the organic coating from the substrate. This means that water is likely to enter and accumulate at the interface when an organic-coated metal is exposed to a humid environment. This assumption is in accord with the practical observation that bonds between a polymer and a high-energy, polar substrate, such as silica or iron oxide, have a limited service life in the presence of water.[45]

The assumption that in a humid environment water accumulates at the coating/high-energy substrate interface and breaks the interfacial bonds is substantiated by the results of this study. *Figure* 9 and visible observation (stated earlier) indicate that substantial amounts of water had collected at the interfaces of the two coating/substrate systems. Further, besides an increase in the intensity of the water bands, the intensity of the coating bands decreased with time of exposure to water (*Figure* 4). The decrease is similar to that observed for other coating/substrate systems.[12] Since the probing depths of the evanescent wave in water-saturated and water-free coatings are essentially the same, the decrease of coating band intensity with increasing exposure time may only be explained by the fact that water had entered the interfacial region and pushed the coating films away from the substrate.

The accumulation of water at the coating/substrate interface is also supported by other studies. For example, Leidheiser and Funke,[6] in an extensive review on the water disbondment of organic coatings on metals, gave examples of and cited references to, evidence of the presence of multilayers of water at the coating/metal interface. Further evidence is provided by comparative studies of water uptake in free films and films applied to a substrate (applied film)[7,10,48]; they show that the water uptake in applied films is higher than that in the corresponding free films. Funke and Haagen[10] attributed the extra water in the applied film to water accumulated at the coating/metal interface. The amount of water at the coating/substrate interface is greatly increased

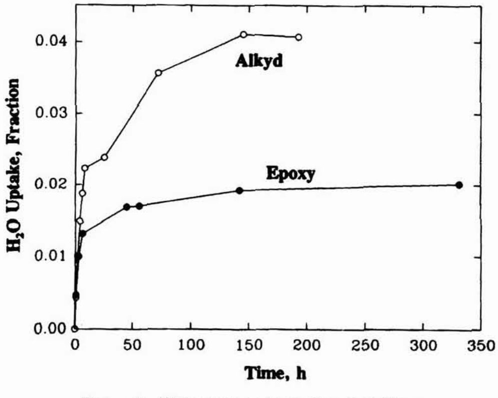

Figure 8—Water uptake in coating free films

if osmotic driving forces exist between the interface and the outside,[6] or when the interface also contains hydrophilic contaminants. One example of the latter case is from the work of Bowden and Throssell,[49] who found that even at a relative humidity of 50%, a metal contaminated with 10^{-7} g/cm^2 of potassium hydroxide would sorb the equivalent of five monolayers of water.

The breaking of the coating/substrate bonds by water may be substantiated by the fact that there was no residual bond strength on either specimen at the end of the experiment, as indicated earlier. This is consistent with the view expressed by Leidheiser and Funke[6] that the main mechanism responsible for the disbondment of organic-coated metals is the formation of a water film many layers thick at the coating/substrate interface. Similarly, in an intensive study on the mechanism of adhesion loss of epoxy/inorganic systems in humid environments, Lefebvre et al.[50] proposed that water "condensation" on the hydroxyl groups of the polymer at the polymer/substrate interface is the main cause of the sudden loss of the adhesion in high relative humidities. Further evidence of the effect of water in causing adhesion loss of organic-coated substrates comes from extensive data on the durability of adhesive bonds,[9] organic coatings on metals,[6-8] and asphalt pavements.[38] These studies all showed that the bond strength of an organic film/untreated, high-energy substrate system decreases significantly after exposure to water and high humidities.

The magnitude of the chemical bonds which water forms with metals and oxide surfaces are typically in the range of 40-65 kJ/mol.[43] Thus, compared with adsorbates such as CO or O_2, water is a weakly-sorbed species. The fact that water entered the interfacial region and that most of the bond strength between the coatings and substrate was lost during water exposure indicate that the organic coating/high-energy substrate bonds are weak (< 65 kJ/mol). These results suggest that, except for a few special cases where the organic films contain strong acidic groups, either present initially[51] or formed during oxidative curing,[52-54] the majority of organic films interact with untreated inorganic oxide and metal surfaces by means of secondary forces. The contention that the interactions between most organic films and a high-energy, inorganic surface are weak is supported by a comprehensive analysis by Bolger and Michaels.[55] They showed that there are only a few organic-substrate combinations, e.g., strong acidic organic/strong basic substrate or strong basic organic/strong acidic substrate, that can resist the displacement by water. The reason for this is mainly that most common metals are considerably more electropositive than the carbon atoms in organic compounds. Consequently, the electron density on the oxygen atom in the oxide surface group (–MOH, where M is the metal) is considerably greater than that on the oxygen in water or in most organic compounds. In general, therefore, covalently-bonded interfaces rarely exist in organic film/oxide systems,[55] and the secondary-force bonds that do occur are too weak to resist the affinity of water for the polar, high-energy substrate. Thus, if the high-energy surfaces are not modified, water is likely to form a layer at the interface when an organic/high-energy substrate system is exposed to water or a high relative humidity environment. This will, in turn, lead to one or more of the following: disbondment, corrosion, and blistering of the system.

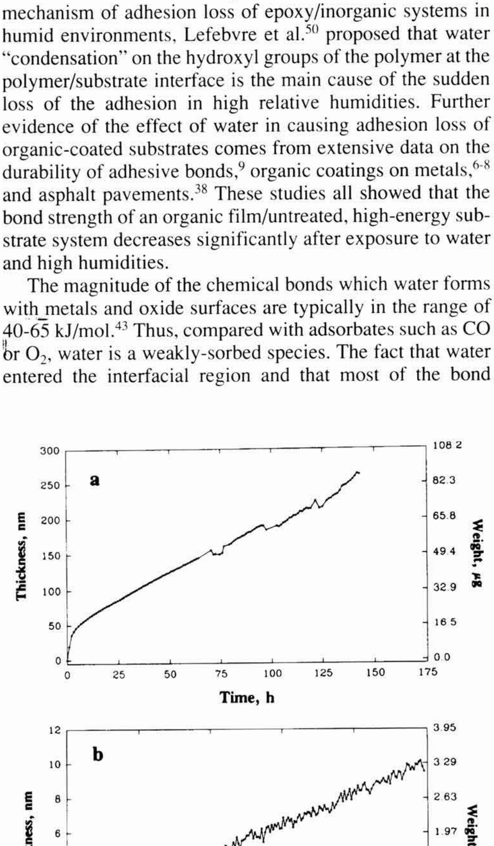

Figure 9—Amount of water and thickness of the water layer at the coating/substrate interface: (a) alkyd/SiO_2-Si, and (b) epoxy/Ge (each dot represents a data point)

What would be the effect on the thickness of the water layer at the coating/substrate interface if assumptions (1) and (2) did not hold or were only partially correct—that is, if the interfacial bonds were relatively stable, and water was absorbed in voids, cavities, and cracks in the coating, or by water-soluble impurities in it? In such a case, a substantial amount of water might be taken up in the coating before entering the interface. We address this question by determining the thicknesses of the water layer at the interface for the two coating/substrate systems where water built up in the coatings before entering the interface. We took the extreme case; that is, we assumed that water completely saturated the coatings before entering the interface. In this situation, we used the maximum fraction values (instead of the variable fraction/time) of water uptake from *Figure* 8 for c_w in equation (15). This would yield a lower limit on the thickness of the water layer at the coating/substrate interface. The results obtained showed essentially no difference between the two cases for the alkyd/SiO_2-Si system and a small difference at the low water thickness values for the epoxy/Ge system. For instances where the coating takes up a substantial amount of water and the amount of water at the interface is small, the difference could be significant. For the alkyd coating, we also determined the thickness of the water layer at the coating/substrate interface for the case where, due to the presence of pigment, the fraction of water in the depth probed by the evanescent wave might be different from that in the bulk. The analysis showed that even a factor of two difference would have little effect on the results shown in *Figure* 9a.

We tested assumption (3) by placing a water droplet on clean surfaces of Ge and Si IREs. As expected, water spread readily on these surfaces (contact angle < 5°) since water, a low-energy liquid, always spreads spontaneously on high-energy solids as long as the substrate surface is not contaminated with a material such as oil which has a lower surface tension than that of water. For cases where water does not spread readily on the substrate surface, the analysis presented in this paper is still valid provided that the height of the water "droplets" is not greater than the probing depth of the evanescent wave in water. For such situations, only the amount (not the thickness) of water can be used to represent water at the interface.

For interpreting corrosion, blistering, and water disbondment of organic coatings on substrates, information on the transport of water through a film applied to a substrate (applied film) should be used instead of that through a free film. This is because the transport of water through an applied film may be different from that of a free film.[6] In order to obtain transport properties of water through an applied film, quantitative information on water at the coating/substrate interface must be obtained, as demonstrated recently.[56] Thus, the method described here not only measures water at the coating/substrate interface, but also provides a tool for measuring the rate of water transport through films adhered to a substrate. Further, although the method was developed for water, it should be equally applicable for quantifying organic and inorganic compounds and ions, such as solvents, amines, $SO_4^=$, and NO_x, at the coating/substrate interface, or measuring their transport through coatings applied to a substrate.

Finally, the examples given in this paper used an infrared transparent material as the substrate. To study water at the interface between an organic coating and an industrial metal, such as aluminum or steel, a thin film of the metal can be evaporated on the IRE prior to application of the organic coating. *In situ* measurement of water at the coating/iron interface using this type of arrangement has been demonstrated.[13] For this arrangement, the effects of the metal film on the penetration depths of the evanescent wave in the organic coating and water must be taken into account. Further, for an oxidizable metal, such as iron, the loss of material due to corrosion during the measurement may complicate the analysis.

SUMMARY AND CONCLUSIONS

Exposure to water causes disbondment of a coating from an organic-coated metal and may cause corrosion of the metal. Quantitative information on the water layer at the coating/substrate interface is crucial for understanding and preventing the failure of organic-coated substrates. A method for determining the amount and thickness of water at a coating/substrate interface has been developed. The method is based on a two-layered model, which was derived rigorously from internal reflection theory. The model takes into account: (1) water at the coating/substrate interface, (2) water taken up by the coating within the probing depth of the evanescent wave, and (3) change of the penetration depth as water displaces the coating from the substrate. Experimentally, the method requires the application of an organic coating, transparent or opaque, of sufficient thickness on an internal reflection element, which is used as the substrate. A water chamber is attached to the coated specimen. After adding water to the chamber, FTIR-MIR (multiple internal reflection) spectra are taken automatically at specified time intervals without disturbing the specimen or the instrument. Water uptake in the coating and FTIR-MIR spectra of water on the substrates are also obtained and used for the analysis. Although the only examples presented here are those of a clear epoxy coating on a Ge substrate and a pigmented alkyd on an SiO_2-Si substrate, other substrates can also be studied using this method. This method also provides a means for determining the rate of water transport through a coating attached to the substrate. Quantitative information on water at the coating/substrate interface and the transport of water through organic coatings on a substrate is essential for the development of models for predicting the service lives of coating systems. Finally, the method should be equally applicable to studies of organic and inorganic compounds at the coating/substrate interface and their transport rates through coatings adhered to a substrate.

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Evaluating Traffic Paint Degradation Using Image Analysis

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Currently, there are no objective methods available for evaluating the appearance of coating systems. The American Society for Testing Materials (ASTM) offers pictorial standards that are time-consuming and perhaps inaccurate. This paper examines the feasibility of image analysis in quantifying degradation of the visual appearance of current ASTM pictorial standards used in evaluating traffic paint degradation for abrasion and chipping resistance.

INTRODUCTION

Typically, degradation of a coating system is accompanied by a change in appearance. Therefore, it is not surprising that ASTM pictorial standards are the method of choice for evaluating changes in the appearance of coatings. When changes in appearance reach a threshold and become prominent, repainting of the surface becomes necessary. As indicated by Munger: "The extent of coating failure is one of the most important items in determining when a coating is to be repaired."[1]

The ASTM procedures involve comparing the sample to be evaluated with pictorial standards and ranking the sample based on the numerical scales associated with the standards. As with other subjective visual assessments, the results are often sensitive to biases in perception. Recommended protocol often requires the estimation of size, shape, and distribution characteristics by eye—perceptual judgments that are often tedious and time-consuming. Hence, it would be desirable to develop automated instrumental methods for evaluating paint integrity and measuring degradation.[2-4]

Currently, there are two ASTM standard methods of evaluating traffic paint degradation.[5] These are:

Abrasion—standard ASTM D 821 (*Figure* 1a). The recommended method of evaluation is a comparison with a series of photographic standards.

Chipping—standard ASTM D 913 (*Figure* 1b). The recommended method of evaluation is a comparison with a series of photographic standards.

Appearance may be evaluated in the context of surface textural analysis, where the term texture refers to the local and spatial characteristics of the surface in question. The textural discrimination of surface may be approached in as many ways as there are definitions of visual texture. Here, one can completely characterize textural features of coating systems using such components as contrast, texture coarseness (i.e., periodicity), and surface roughness.

According to Rao,[6] a general approach to this analysis involves classifying naturally occurring textures in terms of

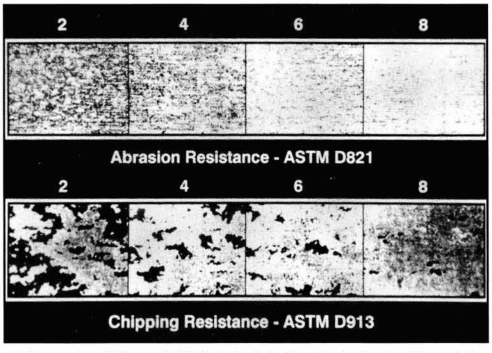

Figure 1—a) Gray ASTM pictorial standards for traffic paint abrasion resistance, and b) gray ASTM pictorial standards for traffic paint chipping resistance

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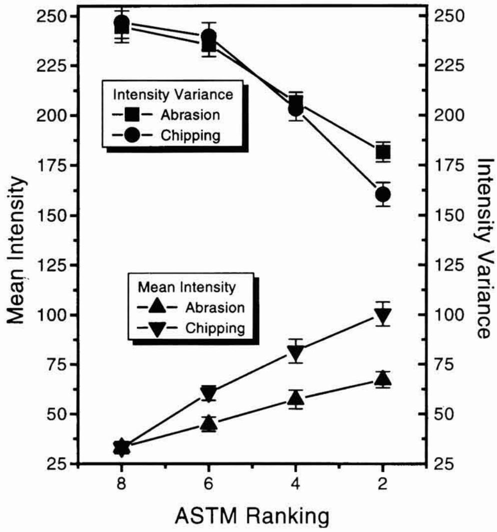

Figure 2—Surface mean intensity and standard deviation

texture order. Strongly ordered textures are composed of repeating features that are distributed in a regular fashion throughout the image, and may be characterized by specifying feature geometry and spatial distribution. Textures without well-defined texture elements may nonetheless exhibit considerable regularity, i.e., local spatial correlation with directional features, such as the flow patterns found in fluids. These are designated as weakly ordered textures; Rao suggests that an appropriate description is furnished by the geometric theory of differential equations. Disordered textures contain a negative category that cannot be characterized in terms of either global repeating units or flow patterns because of a lack of spatial correlation in intensity.

The perspective adopted for the textural analysis of traffic paints may be based on properties that detect attributes that describe global properties but ignore internal (local) differences. In this sense, they yield one-dimensional statistics. Some of these attributes are concerned with intensity per se, and its frequency distribution; e.g., mean, variance, coefficient of variation, skewness, and kurtosis, or the co-occurrence of intensities, as in a sample of point pairs having a specified spatial relationship to one another, e.g., co-occurrence statistics. These are the micro-texture or statistical attributes of some authors. A second group of attributes evaluates the range of intensity variation in a surface, sometimes referred to as "roughness," e.g., fractal dimension.

Another set of attributes is used specifically for detecting spatial structure or features in the image; such attributes depend on distance as well as intensity. Strongly ordered textures may contain objects, i.e., sharp gradients in intensity that are capable of being resolved into closed curves. Such objects can then be described individually in terms of geometry or collectively with respect to spatial distribution. Regions with less distinct boundaries can be analyzed with the aid of morphological operations that utilize the rules of image algebra. Textures without objects may nonetheless display regular changes in spatial correlation, e.g., periodic variation, that can be measured in terms of amplitude and frequency.^{7,8} Finally, spatial structure may be manifest locally, in spatially correlated intensity gradients such as those seen in flow-like patterns. These may be described in terms of average gradient angle and magnitude for a given region.^{6}

One may wish to analyze texture attributes for the purpose of classification or identification. For example, a disordered texture may be defined as lacking in a directed flow pattern (e.g., intensity gradients are uniformly distributed) or periodicity (amplitude fluctuates around a constant value). Another approach, and the one adopted in this study, is to examine a series of textures of varying properties with respect to a given image property. This limits to some extent the applicability of some attributes, depending on how much structure the image contains. Most demanding of all is the evaluation of objects. For example, object geometry is defined only for images where it is possible to extract simple closed boundaries from gray level gradients.

All of the following discussion falls within the context of a digital world. Accordingly, texture refers to information contained in a digital image. This study is exclusively concerned with gray scale intensity, where images are digitized to a range of 256 gray levels. In general, a digital image is a matrix having X by Y dimensions and XY elements or pixel positions. A gray scale intensity level G with range (0, 255) is defined for each position, and the intensity value of a particular position is given as $G_{x,y}$. Angle of illumination and surface irregularities or facets determine an image intensity pattern, a two-dimensional projection of three-dimensional data where intensity gradients reflect the interaction of surface relief, lighting, and perspective. The resulting image may be seen as an intensity surface with coordinates x, y, and $G_{x,y}$. Properties of this surface are discussed in the following.

Image characteristics examined in this paper relate to intensity moments, surface relief, roughness, the second-order statistics contrast, and run length statistics. They cannot resolve large scale features or macro-textures. However, they rely on the fewest assumptions regarding texture properties and thus are applicable to virtually any kind of image.

This is the first in a series of papers planned for outlining an automated alternative to existing standards that combines existing camera technology with computer vision algorithms programmed by the authors.

METHODS

Image Capture

There are a number of ways that images may be input into a computer thereby providing complete flexibility. Still images often provide the best quality. We routinely use a camera equipped with a macro lens and fitted with a digital attachment that digitizes and stores images internally, thus eliminating problems that could arise during the development of a photograph. These images can be downloaded onto a personal computer quickly and efficiently.

Another alternative is to directly digitize images using a CCD video camera together with an image capture board. Image capture boards can typically digitize signals from any video source. Coupled with a CCD camera, the board becomes the input device for most types of image processing systems. Image capture boards having 24-32 bits per pixel are used to represent color at spatial resolutions ranging from 512 by 486 pixels to 756 by 486 pixels. The 24 bits contain three 8-bit groups for red, green, and blue components, allowing a color resolution for this system of 2^{24} or 16.8 million colors, and 2^8 or 256 intensity levels for each of the red, green, and blue intensity levels. Since gray or luminance is a composite of the three-color components, 256 levels of gray are available.

Another alternative is to digitize images stored on a video tape. This system requires the ability to search and to freeze frames for capture. A PC-controlled video recorder and an image capture board offers the simplest choice. Image capture devices that can compress and record images real time on computer storage devices are becoming available. Regardless of the method employed, however, these images are generally lower in resolution.

As our host processor, we typically use personal computers having an 80486 processor because of the advantage in computation speed.

Images used in this study were scanned at a resolution of 600 dots per inch using a flat bed 24-bit color scanner from original black and white photographs purchased from ASTM. Three images were scanned for each pictorial standard at different brightness levels. The data reported relate to the means of three replicates and their standard error.

Image Analysis Methods

The software necessary for performing these tasks has been developed by the authors. The code is written in C, a programming language well-known for its portability and speed of execution, and the software will run under Microsoft Windows, an environment for personal computers that permits the display of multiple image windows simultaneously. The methods employed in this paper are discussed in the following.

Mean and Variance: The pictorial standards differ in their intensity moments, the mean (x) and standard deviation (s) of image intensities. Elementary statistics[7-8] suggest that an image generated by randomly sampling a discrete uniform distribution, $U(G_{\min}, G_{\max})$ has an expected intensity value of

$$\frac{G_{\min}+G_{\max}}{2} \tag{1}$$

and a variance of

$$\frac{(G_{\max}-G_{\min}+1)^2-1}{12} \tag{2}$$

In evaluating ASTM pictorial standards, one may conclude that appearance change is mainly due to a change in overall reflectance and surface patchiness arising from the loss of the paint (see *Figures* 1a and 1b). This increasing darkened appearance may be quantified by studying the distribution of pixel intensities and their variance in intensity.

Area Fraction: This represents the simplest method available for gross evaluation of images. This method requires a two-valued or black and white (binary) image. Typically, a gray scale image is thresholded using the mean intensity or other similar statistics where all values above the threshold are turned on (white) and those below are turned off (black). The fraction of the total number of pixels that are black is then taken as a measure of overall surface degradation. This method is highly dependent on the method selected in thresholding the image and especially subject to biases when illumination is not uniform. In noisy images or where there is an intensity gradient present in the image, one may have to devise more reliable thresholding.

Co-Occurrence Statistics: Spatial co-occurrence examines the second order joint conditional probability density function, $f(i,j|d,\theta)$ for the probability of sampling a pair of pixel positions with intensity values i and j, separated by distance d in direction θ. This is a well-known technique for texture analysis. In practice, an image needs to be systematically sampled by examining every pixel of an image for which a neighboring pixel exists d units away in direction θ. The intensities of the current pixel, i, and that of its neighbor, j, constitute a single co-occurrence of i and j given the sampling parameters d (pixels) and θ. The frequencies of all co-occurences are stored in a matrix M having dimensions N by N. Thus entry i, j in the matrix is the number of i, j pairs sampled in the image. Typically, these frequencies are normalized by the sample size. For a rectangular raster, there are eight directions: 0 (right), 90 (up), 45 (up right), 135 (up left), 180 (left), 225 (down left), 270 (down), and 315 (down right).[7,8]

As may be seen from the ASTM pictorial standards shown in *Figure* 1, surfaces become increasingly patchy with degradation. The degree of spatial correlation of the image will be reflected in the co-occurrence matrix. If the intensities change over short distances, the frequencies will be spread more evenly across the matrix than if intensities change gradually. A number of statistics have been devised to describe this spread or moment away from the main diagonal of M. This paper reports only contrast (otherwise known as inertia), defined as:

$$\text{Contrast} = \sum\sum (i-j)^2 M_{ij} \quad M_{ij} > 0 \tag{3}$$

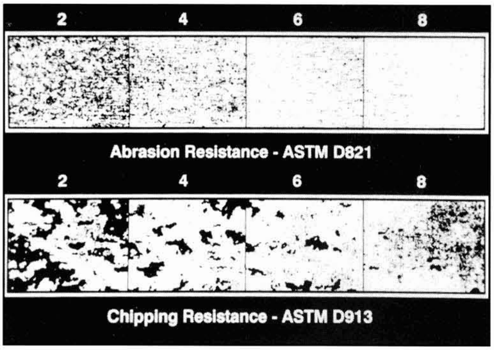

Figure 3—a) Binary ASTM pictorial standards for traffic paint abrasion resistance, and b) binary ASTM pictorial standards for traffic paint chipping resistance

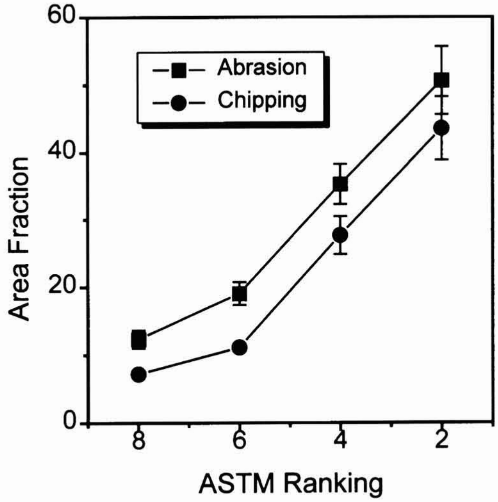

Figure 4—Black area fraction

Contrast is a moment statistic and is proportional to the degree of spread away from the main diagonal.[7-8]

Surface Area and Normalized Relief: It would be desirable to have a measure of surface roughness based on intensity variation. One such measure for a digital image is the area of surface relief. $G_{x,y}$ may be used as an altitude coordinate, i.e., the height of a column of G cubes, each having the dimensions one pixel by one pixel by one standard intensity level. The gray level area of a digital image is defined as equivalent to the total number of exposed faces in a landscape composed of gray level columns. Here, only the lateral area is examined and the top face of each column may be ignored. This quantity can be measured by comparing the intensities of pairs of edge-adjacent positions, that is, those sharing a side. The number of exposed faces on one side of a column depends on the difference, D, between the intensity of the current position, $G_{x,y}$, and the intensity of the adjacent position, $G_{x+i,y+j}$. Non-negative differences would be of interest. Therefore,

$$D = G_{x,y} - G_{x+i,y+j} \text{ if } G_{x,y} >= G_{x+i,y+j} \tag{4}$$

and 0, otherwise.

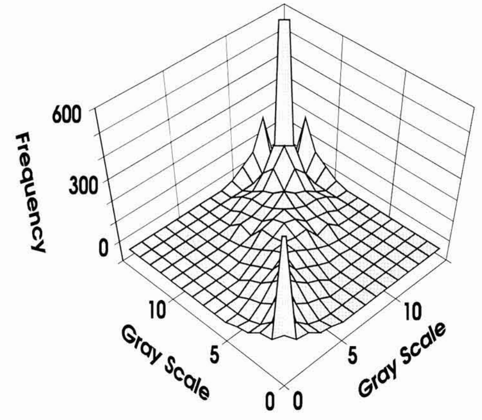

Figure 5—Horizontal co-occurrence matrix for ASTM chipping resistance standard two (upper) and eight (lower)

The area of relief, A_R, is the sum of the area of all sides of all columns. But A_R is also a function of the number of position pairs, P, and image size. To remove size effects, this quantity is normalized by computing:

$$a_R = \frac{A_R}{P} \tag{5}$$

Note that P depends on whether the image is bounded (i.e., has a perimeter) or unbounded (e.g., an inner subset of a bounded image). In an unbounded image, every column has four sides and

$$P = 4XY \tag{6}$$

whereas in a rectangular bounded image the columns on the perimeter have less than four sides with adjacent positions, and

$$P = 8 + 6[(X-2) + (Y-2)] + 4[(X-2)(Y-2)] \tag{7}$$

For the sake of simplicity, an unbounded image is used in the following discussion. Let us consider a_R for some idealized images. When $D = 0$ for all position pairs, i.e., the image is monochromatic or flat, a_R is zero. The maximum possible relief area, $a_R = 127.5$, occurs in a regular checkerboard pattern composed of alternating 0 and 255 intensities. For an image generated by randomly sampling a discrete uniform distribution, $U(0, N\text{-}1)$, the average difference,

$$G_{x,y} - G_{x+i,y+j} = \sum x_i f(x_i) \tag{8}$$

About half the time for large N, this difference is non-negative

$$p(G_{x,y} >= G_{x+i,y+j}) = \frac{1+\frac{1}{N}}{2} \tag{9}$$

The average normalized relief of such an image is

$$E(a_R) = \sum \frac{x_i(N-x_i)}{N^2} \tag{10}$$

where i has the range $[0, N-1]$.

Run Length: A gray level run length is a set of consecutive collinear pixels having the same gray level value. The length of the run is dictated by the number of points in the run. As with other directional algorithms, a gray level run length matrix may be computed having one of several directions.

The matrices may be quantified using a number of statistics.[9] This paper reports on short run emphasis, long run emphasis, and run percent.

Short run emphasis (SRE) is given by:

$$SRE = \frac{\sum_{i=1}^{N_g} \sum_{j=1}^{N_r} \frac{p(i,j)}{j^2}}{\sum_{i=1}^{N_g} \sum_{j=1}^{N_r} p(i,j)} \tag{11}$$

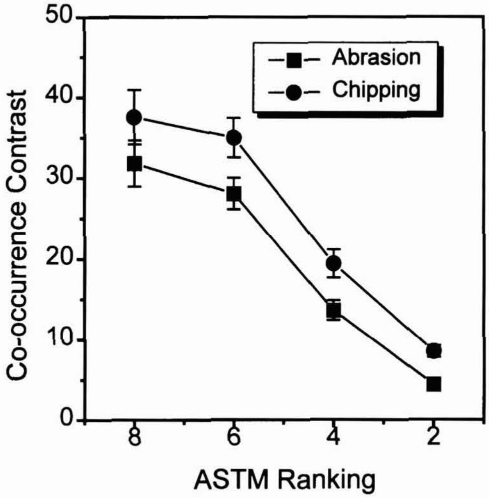

Figure 6—Horizontal co-occurrence

where $p(i,j)$ = the (i,j)th entry in a run length matrix
N_g = the number of gray levels in the image
N_r = the number of different runs in the image

Since this function divides each run length value by the length of the run squared, it tends to emphasize short runs. The denominator is the total number of runs in the image and serves as a normalizing factor.

Long run emphasis (*LRE*) is given by

$$LRE = \frac{\sum_{i=1}^{N_g} \sum_{j=1}^{N_r} j^2\, p(i,j)}{\sum_{i=1}^{N_g} \sum_{j=1}^{N_r} p(i,j)} \tag{12}$$

As this function multiples each run length value by the length of the run squared, it will emphasize long runs. As above, the denominator acts as a normalizing factor.

$$RP = \frac{\sum_{i=1}^{N_g} \sum_{j=1}^{N_r} j^2\, p(i,j)}{P} \tag{13}$$

where P is the total number of pixels in the image.

Fractal Dimension: The idea of using the fractal dimension of images as a means of measuring surface roughness was discussed by Gagnepain[10] and Pentland,[11] who noted a correspondence between fractal dimension and perceived roughness. The random function $I(x)$ is a fractal Brownian function if for all x and Δx,[10]

$$p\left(\frac{I(x+\Delta x) - I(x)}{\|\Delta x\|^H} < y\right) = F(y) \tag{14}$$

where $F(y)$ is the cumulative distribution function.

The fractal dimension of $I(x)$ is

$$D = T + 1 - H \qquad 2 < D < 3$$

where T is the topological dimension of $I(x)$.

The range of D is $2 < D < 3$, that is, between a flat plane and a three-dimensional object. A truly fractal surface shows the same degree of roughness at all magnification levels; natural surfaces may exhibit fractal properties for a restricted range of magnification. Given some measure of surface relief obtained at scale λ applied n times, then[10]

$$N(\lambda) = n\lambda^{-D}$$

or

$$\log(N) = \log(n) + b\log(l) \quad \text{where } b = -D \tag{15}$$

This study uses the reticular cell counting method, as described by Rao,[6] who recommends it for its computational efficiency. Conceptually, the image intensities define a surface space of dimensions $X \times Y \times G_{max}$. This space is subdivided into cubes of $\lambda \times \lambda \times \lambda$, and $N(\lambda)$ is the number of cubes that intersect a portion of the surface. The fractal dimension is estimated by regressing $\log(N)$ against $\log(\lambda)$

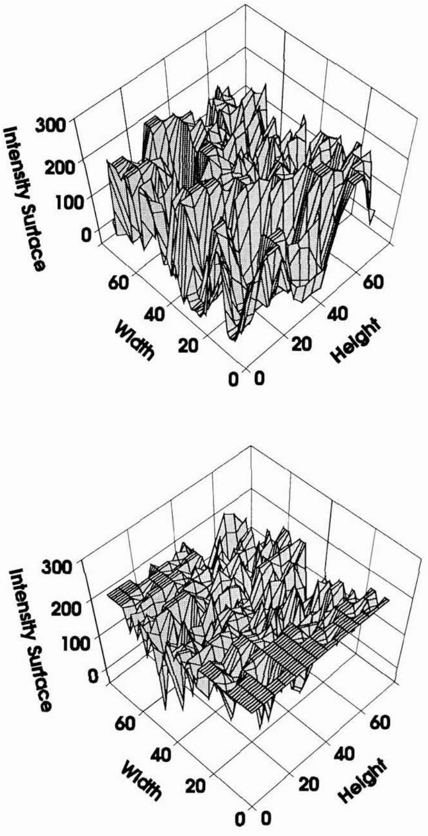

Figure 7—Intensity surfaces for ASTM abrasion resistance standard two (upper) and eight (lower)

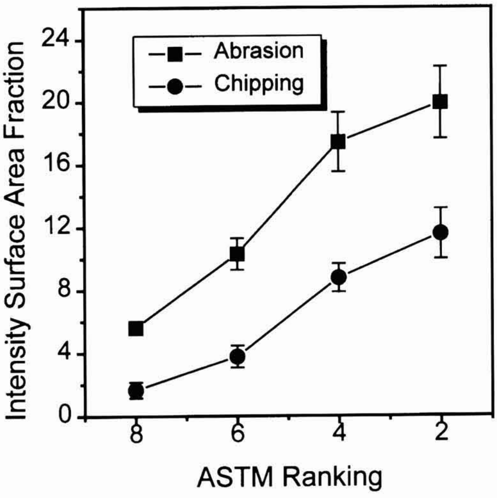

Figure 8—Intensity surface area fraction

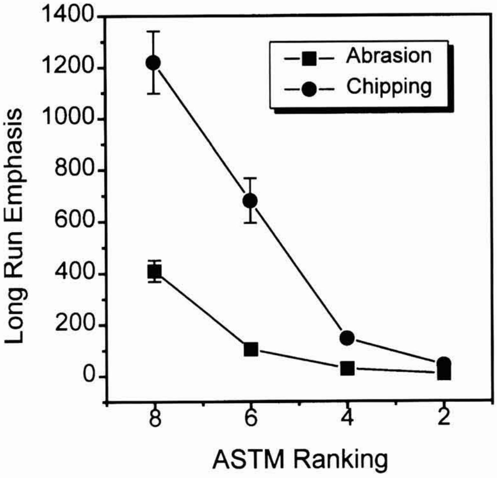

Figure 10—Horizontal long run emphasis

and computing the slope. In this study, λ ranges from 1 to 50.

An assumption is made that natural surfaces display fractal properties over the range of scale employed. Rao notes that while different methods for estimating D produce similar rankings, they differ numerically.[6] Thus, estimates for fractal dimension should be considered in a relative sense.

RESULTS AND DISCUSSION

In the discussion that follows, each of the attributes is addressed separately. It is interesting that the trends for both abrasion and chipping resistance are similar in all cases.

Mean and Standard Deviation: As traffic paints wear, they generally exhibit a darkened appearance accompanied by an increasing variance in intensity. The results are summarized in *Figure* 2. The data reveal that the surface intensity decreases rapidly with a parallel increase in variance, indicating that the paint has been removed from the surface, exposing more of the road surface.

Area Fraction: Binary segmented images for abrasion and chipping standards are shown in *Figures* 3a and 3b. It may be seen that the segmentation method used works effectively in isolating defects from the background.

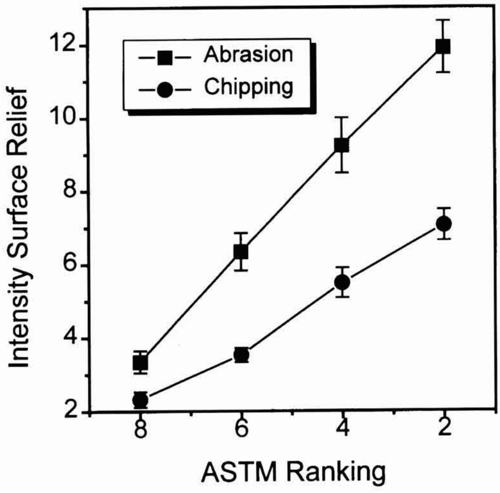

Figure 9—Intensity surface relief

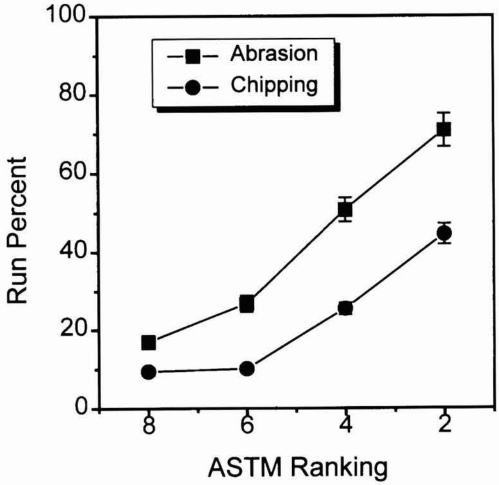

Figure 11—Horizontal run percent

The area fraction, or ratio of black to white pixels in the image, provides a direct measure of overall surface degradation. In some circumstances, severity of coating degradation may be related to gray-level intensity. It is then possible to refine this technique so as to yield a distribution of area fractions for several gray levels—hence several grades of degradation. An appropriate weighted average of gray level area fractions may then provide an indication of the severity of coating deterioration.

The results for area fraction are plotted in *Figure* 4 where the area of black is increasing with degradation. The back areas represent the substrate (road surface).

Co-occurrence: Clearly, co-occurrence contrast increases with paint degradation because of the formation of contrasting textures. A typical co-occurrence matrix is shown in *Figure* 5. The results for co-occurrence contrast measured in the horizontal direction is shown in *Figure* 6, indicating that contrast increases with paint degradation. The vertical direction exhibits a similar trend.

Surface Area and Relief: Intensity surfaces for selected ASTM standards are shown in *Figure* 7. The total surface area fraction results are displayed in *Figure* 8 where the surface area decreases with wear as more of the darker background color is becoming visible. The normalized surface relief shown in *Figure* 9 also confirms that the surface terrain is becoming rougher and showing more activity as the paint degrades.

Run Length: The results for run length statistics are shown in *Figures* 10-11. The results indicate that horizontal long runs decrease with degradation, implying that a less degraded painted surface will have long sections of connected areas or is less patchy. Run percent also confirms that longer runs are lost as degradation proceeds. Runs in the vertical direction exhibit a similar trend.

Fractal Dimension: The results for fractal dimension are plotted in *Figure* 12 where D increases with degradation, indicating an increase in roughness, or in this case, an increase in patchiness. Note the almost linear behavior of the fractal dimension.

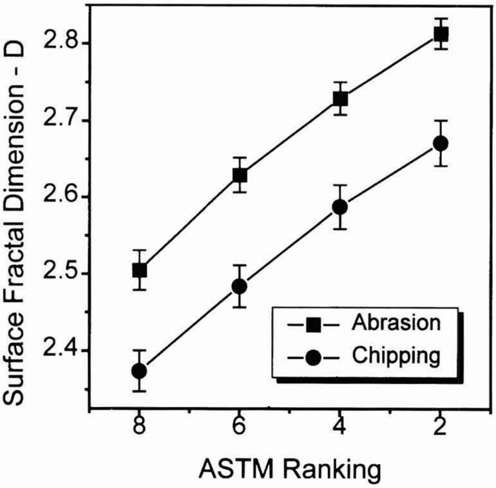

Figure 12—Surface fractal dimension

SUMMARY NOTES AND CONCLUSIONS

Many physicochemical degradation processes undergo acceleration at some stage. For example, paint separation is taken as an indicator of coating strength and integrity; strength would show negative acceleration as it approaches zero. An efficient visual assessment by humans or automated systems depends on some understanding of how physicochemical processes manifest themselves as images, i.e., two-dimensional intensity data. While the interactive chemistry will vary given differences in resins, pigments, substrate and ambient conditions, some general conclusions may be drawn regarding the progress of degradation processes in surface coatings. Any long range planning for evaluating paints or coating systems will need to address sampling protocol in the field. The decision to adopt a particular sampling strategy reflects a compromise between accuracy, thoroughness, and limited resources. Differing sampling situations will determine the characteristics of the sampling unit. For example, the effectiveness of a sampling program may be related to the size and shape of individual units. Edge effects may arise when one wishes to count individual paint defects and finds that a large number intersect the field boundary. Edge effects can create problems in analysis and interpretation, and are in part a result of the ratio of perimeter to area. This is minimal with a circular image field and can be quite large in an elongated rectangle. Optimality of sample unit dimensions (in the statistical sense) may be evaluated empirically by plotting mean, variance, standard error, and 95% confidence interval of sample variables against sample unit size and shape. Precision (e.g., low standard error) may be maximized by many units of small dimensions (and hence large sample size), whereas variation between samples may be minimized (low standard deviation per square unit) by using elongate units that sample more surface heterogeneity. For instance, a sampling area of 100 m^2 would typically yield high precision results if divided into 100 units of dimensions 1 m^2, whereas between-sample heterogeneity would probably be minimized if divided into 20 units measuring 10 m × 0.5 m. Some generalized idea of efficiency in sampling design may be obtained by combining cost of sampling with statistical heterogeneity. A well-known formula of this type for estimating the best sampling dimension has been proposed by Hendricks. Sampling design will ultimately have to take variation in access to surfaces into account, as well as differential risk of failure based on a priori knowledge.

Overall, this paper has attempted to show that pictorial standards can be analyzed and quantified using global image analysis methods. Accurate size information can also be obtained from these images. To characterize size and shape characteristics of surface defects, one may resort to a variety of techniques such as geometrical particle size analysis or one may use morphological methods. The utility of these and other similar methods will be demonstrated in future papers.

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Coping with Errors in Electrochemical Impedance Spectroscopy Data From Coated Metals

W. Stephen Tait
S.C. Johnson & Son, Inc.

Variations in electrochemical impedance spectroscopy (EIS) data are largely due to variations in a coating system, and not to equipment measurement errors. The relative statistical error is greatest when the repetition number for each variable is less than five. Sample standard deviation also significantly affects error magnitude when repetition number is less than five. One scheme for coping with statistical error in EIS data is to use both: (1) five or more repetitions per variable, and (2) scattergrams to assess data trends as a function of time.

INTRODUCTION

Organic coatings are often used to protect metals from corrosion, and electrochemical impedance spectroscopy (EIS) has been used to measure various types of coated metal corrosion, such as delamination,[1,2] metallic corrosion under coatings,[3,4] and coating water uptake.[5] Correlations between predictions developed from EIS data and actual long-term corrosion/coating behavior have also been published.[6,7]

However, it is often difficult to obtain reproducible EIS data from coated metals.[8-10] The objectives of this paper are to discuss variability in EIS data from coated metals, and to suggest a method for dealing with data variability.

EXPERIMENTAL

Electrochemical impedance spectroscopy measurement equipment, test cells, test electrode fabrication from commercial epoxy-coated tinplated steel, and determination of corrosion parameters (corrosion resistance and double layer capacitance) and coating parameters (pore resistance and coating capacitance) have been discussed in previous publications.[1,11]

A 10 millivolt (peak-to-peak) AC voltage was applied to test electrodes using a 100 KHz to 5 mHz frequency spectrum. Test electrolytes used for this study were (1) 0.4 M potassium chloride, and (2) 18 megaohm•cm resistivity deionized water. Repetitive measurements on an EG&G Princeton Applied Research model 1700-1126 Rev. 0, AC impedance dummy cell were included in this study to determine measurement error of the EIS testing equipment.

RESULTS

Figure 1 contains 100 replicate measurements obtained from epoxy coated tinplated steel exposed to 0.4M KCl solution; *Figure* 2 contains 28 replicate measurements ob-

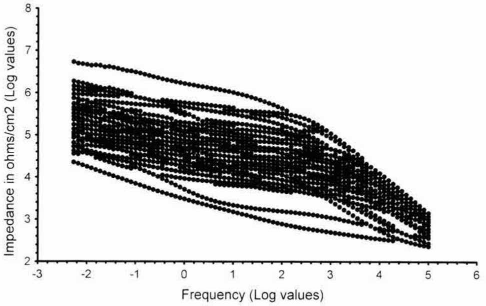

Figure 1—EIS spectra for a corroding coated metal (100 repetitions)

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*1525 Howe St., Racine, WI 53402.

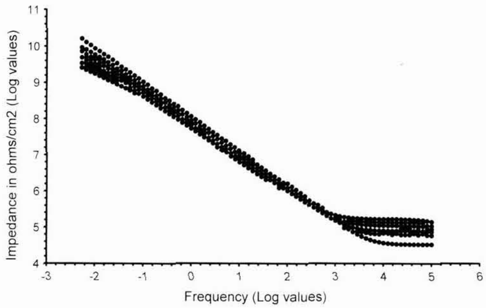

Figure 2—EIS spectra for a noncorroding coated metal (28 repetitions)

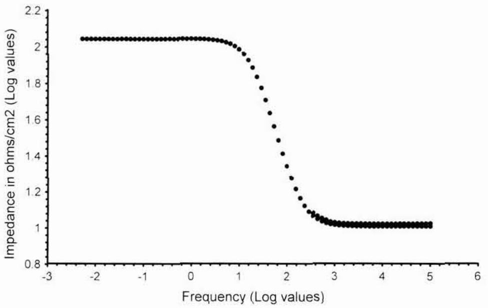

Figure 3—EIS spectra from an AC impedance dummy cell (56 repetitions)

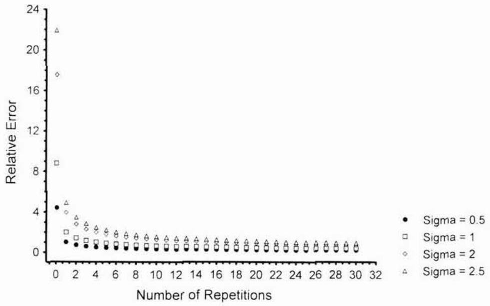

Figure 4—Statistical error as a function of repetition number (four standard deviations)

tained from epoxy coated tinplated steel exposed to 18 megaohm deionized water; and *Figure* 3 contains 56 replicates obtained from the AC impedance dummy cell. *Figure* 1 data is observed when metallic corrosion occurs under the coating, and *Figure* 2 data is observed when the coating absorbs water, but metallic corrosion does not occur.

The variability of data in *Figure* 1 is approximately three orders of magnitude, and the variability in *Figure* 2 is approximately one order of magnitude. The variability for data obtained from the dummy cell is approximately three percent. Variations in multiple replicates for other types of corrosion tests on coated metals have also been observed by other researchers.[13-15] Variations in multiple replicates from other corrosion tests, and the low level of variation observed from dummy cell spectra lead to the conclusion that data variability is due to the coated metal, and not the test equipment.

DISCUSSION

Examination of *Figures* 1 through 3 raise two questions: (1) How many repetitions for each variable are needed to account for data variability? and (2) How can data with such variability be used to predict coated metal long-term corrosion behavior?

To answer the first question, *Figures* 1 and 2 demonstrate that sample deviation can be large, particularly for corroding coated metals, and raises the question: How many repetitions are needed? Even though it has been our experience that EIS data are not normally distributed,[8] one way to illustrate how repetition number effects the statistical error is to examine the relative error equation for normally distributed data:[16]

$$\text{Error} = [Z_{\alpha/2}\bullet\sigma]\sqrt{n} \qquad (1)$$

where: $Z_{\alpha/2}$ = statistical confidence level (i.e., What fraction of the time do we want to be correct?)
σ = sample standard deviation
$\sqrt{n}$ = square root of the number of repetitions

Unfortunately, looking at this equation leaves the impression that the answer to the question of how many repetitions is: How wrong do you want to be? A graph of the error as a function of repetition number, such as that in *Figure* 4, provides a more satisfactory answer.[17]

Figure 4 illustrates a couple of important points about number of replicates: (1) the relative error is greatest when the number of replicates is small, and (2) the standard deviation also has more influence on relative error magnitude when the replicate number is small. For example, the error for $\sigma = 2$ is approximately twice that for $\sigma = 1$ (17.5 versus 8.5) when there is only one measurement per variable. When the repetition number is increased to 30, the error for $\sigma = 2$ and $\sigma = 1$ is approximately the same.

However, thirty replicates for each variable is not often practical. It can be seen from *Figure* 4 that the rate of decrease in relative error, with increasing repetition number, appears to be an exponential function and the point of diminishing return occurs at approximately five replicates. Consequently, a minimum of five replicates is a reasonable compromise that minimizes both relative error magnitude and its sensitivity to sample standard deviation.

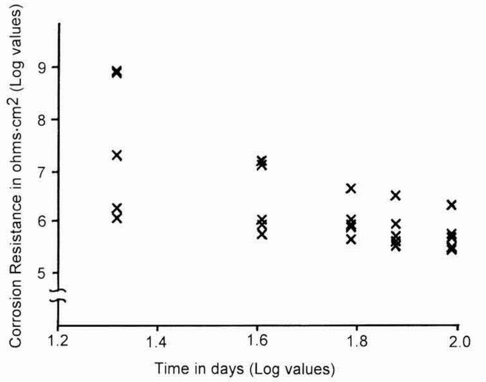

Figure 5—Scattergram of corrosion resistance as a function of time (five repetitions per time)

In response to the question of how can data with such variability be used to predict coated metal long-term corrosion behavior, *Figure* 5 contains a graph, referred to as a scattergram,[18] of corrosion resistance as a function of time that was published in a previous issue of this Journal.[6] Scattergrams are simple, yet powerful statistical tools for analyzing data. They contain information on both magnitude of the parameter being measured (e.g., corrosion resistance or coating capacitance), along with its variability. Scattergrams are also useful for assessing time trends in corrosion parameters; particularly when parameters from EIS spectra are being used to develop long-term predictions about corrosion behavior. The downward trend in corrosion resistance data can be readily seen in *Figure* 5. Coated metal failure in this example is expected to occur when corrosion resistance decreases below 10^7 ohms•cm^2, which is observed for all replicates in *Figure* 5 after 40 days (1.6 on X-axis).

SUMMARY

Observed variations in EIS data are the result of variations in coatings on metals, and are not due to equipment measurement errors. The relative statistical error is greatest when the number of repetitive measurements is less than five. The sensitivity of error magnitude to sample standard deviation is also greatest when the number of repetitions is less than five. One scheme for coping with variability in EIS spectra is to use a minimum of five repetitions per variable, and scattergrams to determine time trends in parameters derived from EIS spectra.

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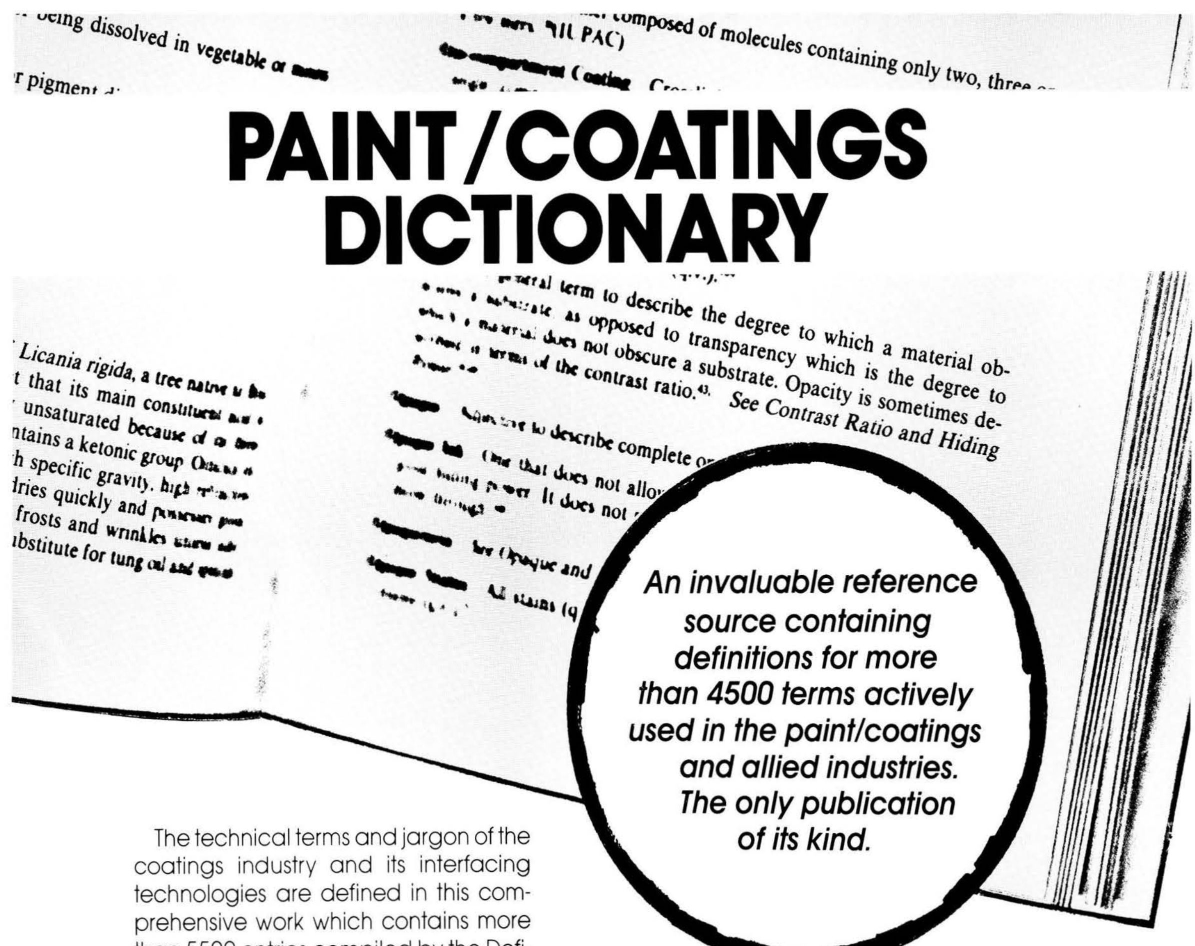
PAINT/COATINGS DICTIONARY



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Developments of Marine Paint Formulations Based on Thiotriazole Compounds

Aida B. Tadros
National Institute of Oceanography and Fisheries*

4-Amino-3-hydrazino-5-thio-1,2,4-triazole (I), its copper complex, and its chlorinated derivatives have been synthesized and tested as antifouling and anticorrosive agents.

The tests were carried out through the incorporation of the three compounds in different paint formulations, which were applied to polyvinyl chloride (PVC) and steel substrates. The coated panels were tested in Alexandria's western harbor's water. Some of the prepared paints showed steel protection from marine corrosion after an exposure of approximately one year.

INTRODUCTION

Previous work detailed preparation and testing of 4-amino-3-hydrazino-5-thio-1,2,4-triazole (I), its compounds, and their metal complexes.[1] The biological assessment of the compounds at 74% by volume technique indicates that the paints containing (*p*-n, n'-dimethylamino and *p*-anisalidine) benzylideneamino-3-hydrazino-5-thio-1,2,4-triazole and their copper complexes were heavily attacked by tubeworms, while the paints based on (chloro or dichloro) benzylideneamino derivatives of compounds I have differential resistance against tubeworms and barnacles.[1] On the other hand, 4(*p*-n,n'-dimethyl-aminobenzylideneamino)-3-hydrazino-5-thio-1,2,4-triazole was more efficient than compound I and its monobenzylideneamino derivative in inhibiting acid dissolution of steel.[2]

Copper, nickel, and cobalt metal complexes of I in the presence of some of its chloro or nitro derivatives were tested for fouling and corrosion prevention by incorporating them in a variety of marine paints. The paints had antifouling properties for four months, and they protected steel from marine corrosion for about a month.[3]

Also, trials to develop the antifouling and anticorrosive properties of the metal complexes of I in the presence of some of its chloro or nitro derivatives have been carried out by incorporating them in a variety of marine paint formulations and testing them in Alexandria's harbor water. Paints containing copper complex of I and *p*-(chlorobenzylideneamino)-3-*p*-(*p*-chloro-benzylidenehydrazino)-5-thio-1,2,4-triazole protected steel from corrosion and polyvinyl chloride (PVC) from fouling for four months. This paint has better antifouling and anticorrosion potential than the paints containing only one of the previously mentioned compounds and were formulated in a similar manner.[4] On the other hand, the protection efficiency of the paints is based not only on the compounds, but also on the formulation irrespective of the percent of the compounds in the dry paint films.

The objective of this work was to improve the anticorrosion properties of the paints that contain 4-amino-3-hydrazino-5-thio-1,2,4-triazole, its copper complex, and 4-(*p*-chlorobenzylideneamino)-3-hydrazino-5-thio-1,2,4-triazole. To achieve this objective, three new marine paints containing the compounds were prepared and applied on different substrates. The coated panels were tested in Alexandria's harbor water.

METHODS

Preparation of Compounds

4-Amino-3-hydrazino-5-thio-1,2,4-triazole (I), and its derivative 4-(*p*-chlorobenzylideneamino)-3-hydrazino-5-thio-1,2,4-triazole (II) were prepared according to Dickinson and Jacobsen.[5]

Preparation of Substrate

Cold-rolled steel plates (90 × 50 × 2 mm) were used. Xylene was used to remove oil and grease from the steel plates, which were sandpapered with sandpaper No. 100.

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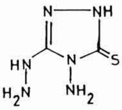
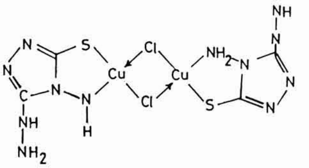
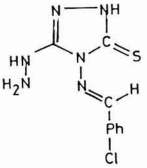
* Kayet Bay, Alexandria, Egypt.

Table 1—List of Investigated Compounds

Compound	Structure	Color,M.P.°C
4-Amino-3-hydrazino-5-thio,1,2,4-triazole $H_2AHTtrz$ (LI)		White, 228
Copper complex of (LI) $Cu(HAHTtrz).Cl.Cu_2Cl_2.2H2O$		Violet, >300
4-(p-chlorobenzylideneamino)-3-hydrazino-5-thio-1,2,4-triazole $H_2ClAHTtrz$ (LII)		Pale yellow, 270

White polyvinyl chloride panels of 3 mm thickness were cut to a dimension of 200 × 150 mm.

Paint Formulation

Three marine paint compositions were prepared. Four different paint formulations, identified as FI-FIV, were based on either compound (LI), (LII), or the copper complex of LI and a mixture of the copper complex of (LI) and (LII) were prepared with the same paint composition A except for the type of the effective compound (*Table* 2). Four different paint formulations related to paint composition B were prepared and designated FV to FVIII. The effective compounds which were added with these formulations are LI, LII, a mixture of the copper complex of LI + LII and the copper complex of LI. Three paint formulations related to paint composition C were prepared, FIX to FXI. They differed only in the type of effective compounds since the other ingredients were kept constant. The compounds used with these formulations are LI, a mixture of copper complex of LI + LII, and the copper complex of LI alone. The three paint compositions formed a total of eleven. The paint ingredients were mixed by first adding the binder materials and then the pigments used in each formulation. After milling this mixture for approximately 18 hr, the effective compound in each paint formulation was added and the milling was continued for 24 hr. The viscosity of the paint formulations was adjusted using a blend of xylene and methyliso-butyl ketone. Unfortunately, the final grind at the end of milling was not measured. The binder material was vinyl copolymer (resin

Table 2—Dry Paint Film Composition

Composition No.	Formulation No.	Vinyl Copolymer	Rosin	Linseed Oil	Iron Oxide	Filler & Extender	Effective Pigment[a] (%)		Pigment/ Binder Ratio
A	FI	12.5	12.5	—	25	25	$H_2AHTtrz$	(25)	3:1
A	FII	12.5	12.5	—	25	25	$H_2ClAHTtrz$	(25)	3:1
A	FIII	12.5	12.5	—	25	25	$Cu(HAHTtrz).Cl.Cu_2Cl_2.2H_2O + H_2ClAHTtrz$	(25)	3:1
A	FIV	12.5	12.5	—	25	25	$Cu(HATtrz).Cl.Cu_2Cl_2.2H_2O$	(25)	3:1
B	FV	25	5	—	10	35	$H_2AHTtrz$	(25)	2.33:1
B	FVI	25	5	—	10	35	$H_2ClAHTtrz$	(25)	2.33:1
B	FVII	25	5	—	10	35	$Cu(HAHTtrz).Cl.Cu_2Cl_2.2H_2O + H_2ClAHTtrz$	(25)	2.33:1
B	FVIII	25	5	—	10	35	$Cu(HAHTtrz).Cl.Cu_2Cl_2.2H_2O$	(25)	2.33:1
C	FIX	—	—	25	10	30	$H_2AHTtrz$	(10)	2:1
C	FX	—	—	25	10	30	$Cu(HAHTtrz).Cl.Cu_2Cl_2.2H_2O + H_2ClAHTtrz$	(10)	2:1
C	FXI	—	—	25	10	30	$Cu(HAHTtrz).Cl.Cu_2Cl_2.2H_2O$	(10)	2:1

(a) See Table 1.

VYHH), boiled linseed oil, or a mixture of rosin material and vinyl copolymer.

Materials Used in Paint Formulations

Ennesin G.H. 103 was obtained from Leon Frenkel Ltd. of England. A polyvinyl chloride, vinyl resin VYHH, was obtained from Union Carbide. The Egyptian Paint Company provided the linseed oil. A micronized grade of baryte was obtained from China by the General Company for Trading and Chemicals. A highly micronized red oxide, iron oxide 130M, was obtained from Bayer AG.

Fouling Test Procedure

The paints were applied to the PVC panels and cut to the dimension 10 × 7.5 cm. After the panels were sandpapered, they were wiped with xylene before paint application. The paints were applied to the panels by brush using two successive coats with drying between the coats. They were then immersed in the water of Alexandria's western harbor at a depth of 150 cm. This region of the harbor is known for its high growth rates of serious fouling organisms on a year-round basis.[6]

Corrosion Test Procedure

The coated steel panels were immersed in vessels filled with seawater as previously described.[7] The seawater was collected from Alexandria's eastern harbor and changed every two days. Periodic visual and photographic recording of the exposed panels were recorded.

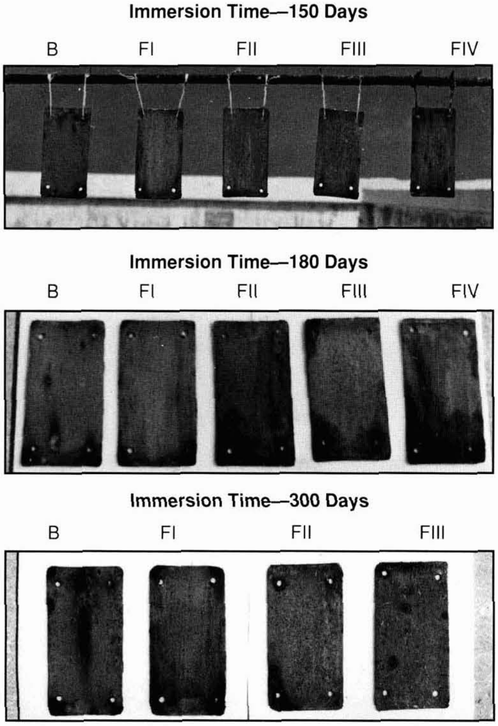
RESULTS AND DISCUSSIONS

Paints containing organic compounds have several potential advantages over the heavy metal compounds generally used. They do not have the corrosion stimulating action of the metallic compounds.

The structure of the three compounds used in the paint formulation are shown in *Table* 1.

Paint Formulation on Steel

Paint compositions A and B were based on vinyl copolymer as a binder in the presence of rosin material with 1:1 and 5:1 ratio, respectively (*Table* 2). The paint containing 4-amino-3-hydrazino-5-thio-1,2,4-triazole (FI) showed the best corrosion protection of the steel from marine corrosion followed by (FV) which contained the same compound with the same ratio in the paint film. The protection period of both formulations extended to more than 15 months (*Figures* 2 and 3). FV showed some film peeling and rust spots but no film lifting was observed.


Immersion Time—150 Days

B FI FII FIII FIV

Immersion Time—180 Days

B FI FII FIII FIV

Immersion Time—300 Days

B FI FII FIII

Figure 1—Steel plates coated with paint composition (A)

With paint compositions A and B, the addition of $H_2ClAHTtrz$ compound (*Table* 1) to $Cu(HAHTtrz).Cl.Cu_2Cl_2.2H_2O$ (the copper complex of the ligand $H_2AHTtrz$) in one paint improved the anticorrosion potential of the paint in comparison with that containing the complex of copper as a sole effective pigment. So, it is clear from *Figures* 1 and 2 that FIII and FVII have the paint compositions A and B, respectively, and each of them is based on the two compounds $Cu(HAHTtrz).Cl;Cu_2Cl_2.2H_2O$ and $H_2ClAHTtrz$ showed less rusting than FIV and FVIII which contained only the complex $Cu(HAHTtrz).Cl;Cu_2Cl_2.2H_2O$) in their formulations. The formulations FV-FVIII had some film peeling after two months of immersion. This effect phenomenon, which was not observed with paint composition (A), may be due to the lower iron oxide pigment content (10% in the dry paint film). With respect to paint composition (CII), which is based on linseed oil as a binder, the paint formulation before the addition of any compounds (paint without effective pigment—blank) showed protection of steel sur-

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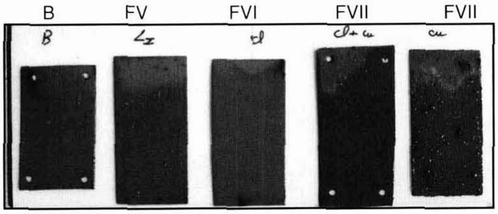
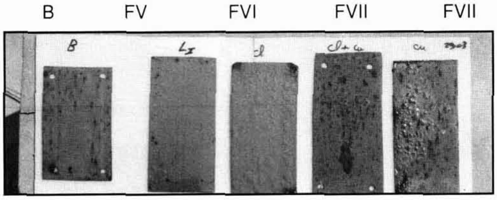
Immersion Time—45 Days



Immersion Time—190 Days



Immersion Time—420 Days

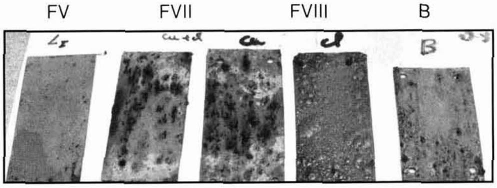


Figure 2—Steel plates coated with paint composition (B)

faces for about six months.[7] H_2AHTtrz-containing paint (FIX) offered the best protection to the steel surface within the series of the prepared compounds. After the seventh month of immersion, film peeling and edge corrosion were observed. Opposite to what was observed with paint compositions A and B, with formulations related to paint composition C, the addition of H_2ClAHTtrz (LII) and the complex Cu(HAHTtrz).Cl.Cu_2 Cl_2.$2H_2O$) in one paint (FX) impaired the anticorrosion film property of a paint containing the copper complex only (FXI).

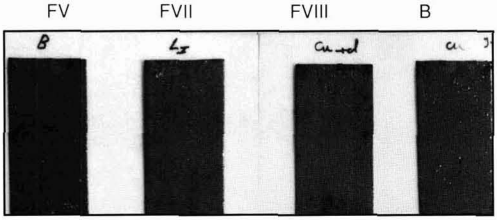
All formulations related to paint compositions A and B dried very quickly. The blank of paint formulations C (paint without effective pigment) did not dry quickly. However, this composition in the presence of H_2ClAHTtrz (FX) dried within 30 min. This reveals the advantages of the compound 4-(*p*-chlorobenzylideneamino-3-hydrazino-5-thio-1,2,4-triazole when used with paint based on linseed oil as a binder, since it makes the paint dry more quickly.

Paint Formulation of PVC

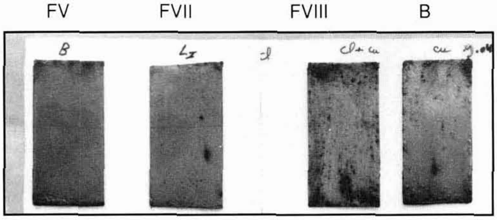
PVC-coated panels were immersed in Alexandria's western harbor water to test for fouling. Paint formulations FIII and FVI containing a mixture of ((CuHAHTtrz).Cl. Cu_2.Cl_2.$2H_2O$ + H_2ClAHTtrz)) and H_2ClAHTtrz, respectively, showed the best antifouling properties within the series of the prepared formulations related to paint compositions A and B. Also, the paint surface of FVI had the fewest barnacles after a month of immersion, but a slime film of green algae was observed.

After one month of immersion, the paint formulations related to paint compositions A and B were compared. It is clear that FIII contained the two effective compounds H_2ClAHTtrz and the copper complex of Cu(HAHTtrz).Cl.Cu_2Cl_2.$2H_2O$ and belongs to paint composition A. It was less infested with barnacles and tubeworms when compared to FII, which contains only H_2ClAHTtrz and has the same paint composition. On the other hand, the coated surface of FVI, with paint composition B and effective pigment H_2ClAHTtrz showed about 15% fouled surface, but the paint surface of FVII was heavily attached with barnacles. The latter formulation is based on the compounds H_2ClAHTtrz and Cu(HAHTtrz).Cl. Cu_2Cl_2.$2H_2O$ complex. Both FVI and FVII formulations have the same ingredients of paint com-

Immersion Time—33 Days



Immersion Time—130 Days



Immersion Time—150 Days

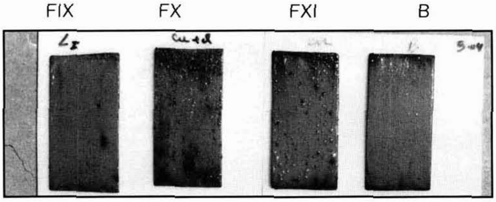


Figure 3—Steel plates coated with paint composition (C)

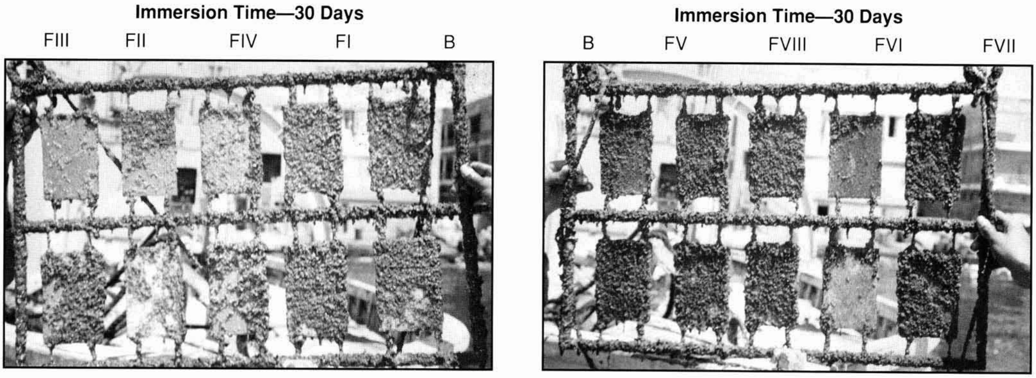


Figure 4—PVC coated panels

position B; they differ only in the type of effective compounds. Therefore, the addition of Cu(HAHTtrz).Cl.$Cu_2Cl_2.2H_2O$ and $H_2ClAHTtrz$ compounds in one paint results in better antifouling properties than if the same paint contains only the $H_2Cl_2AHTtrz$ compound. However, the addition of the same two compounds in paint composition B gave worse antifouling resistance than the same paint composition that contains only $H_2Cl_2AHTtrz$. This result is shown in the photographic inspection after one month of immersion. After three months most of the coated panels were nearly completely fouled and look like the control.

CONCLUSIONS

Some linseed oil-based paints with the pigment binder ratio 2:1 could protect steel from marine corrosion for six months without the addition of an anticorrosive agent. The compound 4-(*p*-chlorobezylideneamino)-3-hydrazino-5-thio-1,2,4-triazole can be used as a drier for linseed oil-based paints. The addition of the copper complex prepared from 4-amino-3-hydrazino-5-thio-1,2,4-triazole together with 4-(*p*-chlorobezylideneamino)-3-hydrazino-5-thio-1,2,4-triazole to paint composition A showed, after one month of immersion, higher resistance towards the growth of barnacles and tubeworms than the same paint composition A that contains only the second compound added with the same solid percent of the two compounds. Different behavior was recorded with paint composition B. When its formulation was based on $H_2ClAHTtrz$, it produced a less barnacle-infested surface than the same composition, but contains both of the mentioned compounds.

All the paint compositions A, B, and C that contained the compound $H_2AHTtrz$ showed the highest anticorrosion potential within the prepared series of formulations.

The addition of the copper complex of the ligand $H_2AHTtrz$ and $H_2Cl_2AHTtrz$ compound in one paint formulation of composition A or B showed higher anticorrosion potential and better film properties than the formulations containing only $H_2Cl_2AHTtrz$ and belonging to the same composition. On the other hand, paint composition C, which contained $H_2Cl_2AHTtrz$ ligand, showed better anticorrosion property than if it was based on both compounds.

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OPEN FORUM

Lead-Based Paint and the Lead Abatement Issue in the United States

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Northwestern Society for Coatings Technology
Technical Committee

The issue of lead abatement has been related in the media directly to lead-based paint. Although other sources have been greater contributors to high blood lead levels in children according to major studies conducted in recent years, abatement programs seem to concentrate efforts on detection and control of lead-based paint in residences. This paper serves as an introduction to the history of lead used in paint. It defines current problems associated with abatement and the diversity of federal, state, and local regulations. Questions under scrutiny by the courts are also reviewed. Although no simple answers have been derived to detect and control lead hazards, government agencies, and professional and industrial organizations are working towards adequate definition and control of the problem. This is being accomplished by focusing on standards, specifications, guidelines, methods of analysis, and accreditation for contractors, inspectors, and laboratories needed to correct hazardous conditions.

INTRODUCTION

There is a lead problem in the United States that has affected and continues to threaten the population; particularly the health of children. The sources of hazardous lead have largely been identified but the means to control, correct, and prevent costly health problems are still being developed. This paper is intended to be an introduction to the lead abatement issue and may be of value to those interested in playing an active role professionally either on a national level or within the communities where the issue is being discussed and legislative action is taking place.

THE LEAD PROBLEM

Lead taken into the body persists primarily in the bone, but lead in the bloodstream is a reliable indicator of exposure to lead and the potential for adverse health effects. Overexposure is associated with brain and nervous system damage, kidney damage, cardiovascular effects, anemia, and gastrointestinal and digestive problems.[1,2]

Revised guidelines from the Centers of Disease Control have decreased the at-risk level of lead in blood from 25 µg/dl (1985) to 10 µg/dl (1992).[3] The number of children at risk under the new guideline has been claimed to be as high as seven million compared with 200,000 estimated at the 25 µg/dl level.[3,4]

Exposure to lead occurs as a result of its use in many manufactured products. Other sources include drinking water that passes through lead pipes or plumbing that contains lead or lead solder, lead dust from leaded gasoline emissions, industrial waste emissions, lead paint, and improperly glazed china and pottery. Food cans soldered with lead are no longer a source of lead in the United States. The amount of lead in ambient air is not usually sufficient to cause a problem. However, lead dust caused by sanding lead containing paint or other abatement techniques can be a hazard. Lead exposure usually is through ingestion of lead contaminated dust and soil.[5]

In rural areas, background lead levels in soils range from 5 to 10 ppm. Urban residential soil contains 10 to 100 times more lead than rural soil depending on proximity to highway and traffic arteries. Fallout from incineration/power debris can be 100 to 1000 ppm.[6]

The EPA estimate (1987) of the monetary cost for medical care and compensatory education was $5.75 billion plus an estimated $10 billion lost to the affected children through reduced earnings.[6]

The news services[7] reported that more than one-sixth of the nation's large public water systems reporting test results to the EPA have lead levels that exceed government thresholds. It was reported that out of 660 systems, 130 were found to have lead levels greater than the federal drinking water standard of 15 ppb. These 130 systems provide drinking water for 32 million people. It is reported that most (91.5%) of the houses painted with paint that contains lead pig-

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ment (white lead at about 50% by weight in the paint) were painted before 1950.[6,8]

A recent report (ATSDR 1988[9]) concluded that 52% of all houses contain lead-based paint (0.7 mg lead/cm^2 or more) and 7.7% of all U.S. houses contain lead-based paint in unsound condition. It is estimated that 87% of all U.S. children under seven years of age live in houses painted with lead-based paint; that is, painted with paint that contains 0.7 mg lead/cm^2 or more in the film.

It is reported that most of the houses painted with paint that contains lead pigment (white lead at about 50% by weight in the paint) were painted before 1950.

A current question being addressed by government agencies and representatives of the paint industry is the risk posed by the presence of paint that contains lead. Only 1.5% of the 87% population of children that live in lead painted housing are lead poisoned (study based on blood lead levels greater than 25 µg/dl) and the presence of lead-based paint does not correlate with population blood lead levels. In addition, 90% of the children living in unsound lead painted housing are not lead poisoned.[9]

The Agency of Toxic Substances and Disease Registry (ATSDR 1988) indicated that the primary route of lead exposure is ingestion through hand-to-mouth activity. Deteriorating housing increases the amount of lead dust available for ingestion and blood lead levels are higher in deteriorating housing even in children who do not engage in excessive mouthing and pica behavior. Much older housing stock has acted as dust traps, collecting lead from all exterior sources including leaded gasoline dust, paint dust, and other sources. Also, traditional lead paint removal practices have resulted in increasing the numbers of lead poisoned children due to scraping, sanding, and heating techniques. As a result there is increased emphasis on dust suppression efforts.[1,9]

Patrick Reagan[6] stated that the literature shows that blood lead levels are higher in urban areas than in small town or rural areas. Within urban areas there are two major sources of lead. These sources are lead from the combustion of leaded gasoline and lead in paint pigments. Comparison of gross tonnages indicates that nearly twice as much lead was used in leaded gasoline from 1940 to 1989 than was used in white lead pigmented paints from 1910 to 1989. It has been estimated that between 1940 and 1990 there were seven millions tons of lead used in gasoline and about 75% of that was released into the environment.[8] Prior to that estimate, it was stated that 72% of all emissions have occurred since 1920 (through 1980) and 60-70% of the 90% of emissions that are attributable to man-made sources are from the combustion of oil and petrol.[10] All of the lead emitted from the combustion of leaded gasoline is in the form of lead dust, whereas most of the lead cured in paint is still intact and exists as a large, thin mass.[6]

Research on urban soil lead levels in St. Paul and Minneapolis, MN, show a definite gradient in soil medium concentration away from central business districts of both cities.[5] The maps provided in a report by Mielke and Adams show the distribution of soil lead in the Twin Cities. The report concludes that lead has accumulated in a pattern associated with geographic location within the city. Inner city locations with the highest traffic have the highest soil-dust lead concentrations. This conclusion was also evident in studies conducted in other cities including Oakland, CA; Baltimore, MD; Washington, D.C.; Boston, MA; and Pittsburgh, PA.[8]

Childhood exposure as measured by blood lead levels follows the same trend as the pattern of lead in soil-dust. Some places within the St. Paul and Minneapolis city region appear to be so contaminated that large numbers (over 20%) of the children who live there are at risk of suffering learning impairment due to lead exposure.[6]

Historical Background

Lead-based paint with 1.0 mg lead/cm^2 or more exists in 57 million privately owned houses, according to a report issued in 1990 by the U.S. Department of Housing and Urban Development (HUD).[11]

The American Academy of Pediatrics stated that between 1976 and 1980 more than 780,000 American preschool children had excessive levels of lead in their blood. Federal attention to the lead problem was initiated in 1971 when Congress passed the Lead-Based Paint Poison Prevention Act (LBPPPA), thereby prohibiting the use of lead-based paint in residential structures constructed or rehabilitated by the federal government or with federal assistance. Subsequent amendments of this act directed the federal government to establish procedures to eliminate lead-based paint poisoning in housing constructed before 1950 that were covered by mortgage insurance or housing assistance payments.[6]

In late 1988 and early 1989, the National Institute of Building Sciences (NIBS), under contract to HUD, developed technical guidelines for the testing, abatement, cleanup, and disposal of lead-based paint. This guide was used by HUD to develop the September 1990 document entitled, *Lead-Based Paint: Interim Guidelines for Hazard Identification and Abatement in Public and Indian Housing*.[11]

Lead-containing paints (those formulated with lead carbonate) have generally not been manufactured since the 1940s or early 1950s, but are known to contain an excess of 50% lead (based on dry weight). Other historical uses of lead in paint included colored pigments (lead chromates) at concentrations of 5 to 7% (dry weight), and lead driers and catalysts (naphthenates and litharge) at concentrations of less than 0.5%. In the early 1920s, lithophone (zinc sulfide and barium sulfate) exceeded the use of lead in interior paint as the primary pigment. By the early 1940s, other pigments, such as lithophone and titanium dioxide, which were better and less costly, accounted for more than 80% of the pigment used by the paint industry.[1]

By 1953, industry consensus standards limited use of lead in house paints to no more than 1.0%, which was later revised to no more than 0.5% in 1962. The Lead-Based Paint Poisoning Prevention Act of 1972 established a maximum of 0.5% allowable lead use in house paints and was the standard adopted at that time by the Consumer Product Safety Commission (CPSC) with provision to study whether a lower limit of 0.06% was advisable. In 1977, the final regulation as published in the *Federal Register* set the maximum allowable amount of 0.06% effective in 1978. The CPSC also banned the use of lead in consumer paints in 1978.[1]

HUD's procedures for determining the presence of lead-based paint have been mandated by federal statute, and are based on two different sampling and analytical methods with quite different errors and biases.

The first, which is a field test method, utilizes a portable X-ray fluorescence (XRF)

Lead-based paint with 1.0 mg lead/cm^2 or more exists in 57 million privately owned houses, according to a report issued in 1990 by the U.S. Department of Housing and Urban Development (HUD).

instrument. This instrument measures lead concentration in paint and is intended to indicate when the HUD definition of lead contamination for residences is exceeded (defined as 1.0 mg lead/cm^2). This is equivalent to a concentration of greater than 12% lead and only encompasses paints formulated before the early 1940s. The second is a laboratory method based on dissolution of a collected sample and analysis with an atomic absorption or emission spectrograph instrument.

The XRF data developed in the 1990 HUD report could not be confirmed using more accurate laboratory methods. The typical XRF instrument has an estimated precision of +/- 60% of true value and casts doubt on the actual number of dwellings that contain lead-based paint compared with the HUD estimate of 57 million dwellings. However, it must be understood that the more accurate laboratory methods cannot be conducted on site, require more time to obtain, and are much more expensive than the use of the XRF-type instrument.[1,12]

Currently, many organizations are contributing to clarification of methods and procedures. Some of these include on-site wipe tests with chemical indicators or variations in procedures of sampling a room or a wall in a dwelling. Guidelines are being prepared through the efforts of the American Society for Testing Materials (ASTM) in Committee E-6 Subcommittee E06.23 that has picked up the challenge where NIBS left off. Guidelines and specifications are in the process of being established to test and measure lead according to XRF and laboratory methods. Abatement procedures for contractors, encapsulation techniques, and accreditation for contractors and testing laboratories are also being documented.

STATUS OF LEGISLATION AND SUPPORT FOR LEAD ABATEMENT ISSUE ON A NATIONAL LEVEL

Title X of the Housing Bill, HR 2519, signed in 1992 by President Bush just prior to the November election, calls for an extensive regulatory development program on lead poisoning and lead-paint abatement. Title X of the law focuses on lead-based paint that remains in housing built prior to 1976. The law requires HUD to issue guidelines within a year to govern the conduct of risk assessments, inspections, interim controls, and abatement of lead-based paint hazards. The measure recognizes that different lead exposure problems require different solutions and also recognizes in-place management of lead-based hazards as a viable protective step. The National Center for Lead-Safe Housing was established and is co-sponsored by the Alliance to End Childhood Lead Poisoning.[13,14]

HUD is authorized to spend $125 million in fiscal 1993 and $250 million in fiscal 1994 to help state and local governments evaluate and reduce lead-based paint hazards in low-income private housing and Section 8 rental housing. All federally assisted project-based housing built prior to 1978 requires inspection, risk assessment, risk disclosure, and hazard reduction measures.[14]

The Title X law, according to Stephen Sides of the National Paint and Coatings Association (NPCA), calls for development of a national strategy to build an abatement infrastructure to eliminate lead-based hazards expeditiously. It requires creation of a public education program on the sources and abatement of lead-based paint. It also established a task force to develop recommendations on a number of issues, including real estate transactions.[14]

Real estate provisions of Title X of the Housing Bill require that in three years, purchasers of homes built prior to 1978 must receive an EPA lead hazard information pamphlet and must be allowed up to 10 days to get a lead hazard risk assessment or inspection. The sale contract must include a specific lead warning statement, and sellers must disclose the presence of known lead-based paint. Also, in three years, prospective lessors of pre-1978 housing must be given the EPA pamphlet, and the landlord must disclose the presence of known lead-based paint.[14]

> *The American Academy of Pediatrics stated that between 1976 and 1980 more than 780,000 American preschool children had excessive levels of lead in their blood.*

Mr. Sides indicated that the paint industry must voice its opinion on the creation of key definitions involving lead-based hazards, since it will help determine the type of action needed to deal with lead-based paint in housing. Costly abatement by total removal could be avoided in cases where lead-based paint is present but poses no hazard.[14]

Title X includes provisions for dealing with the issue of lead testing, analysis, training, abatement, certification, and accreditation for laboratories and those working in the field. The law also states that 12 months after the date-of-enactment a program for proficiency testing and laboratory accreditation will go into effect.

The EPA has designated that five training groups around the nation offer courses that focus on lead inspection, lead project design, abatement contractor/supervisor, and lead abatement worker training.[15]

There was a lack of definitive health standards for worker protection until OSHA released its interim final standard on lead exposure in construction jobs. The standard, 29 CFR 1926.62, was published in the *Federal Register* of May 4 with the effective date June 3, 1993.

This new standard is meant to protect almost one million construction workers against the hazards of lead. The standard reduces the permissible exposure limit (PEL) for lead in construction from 200 $\mu g/m^3$ of air as an eight-hour time weighted average (TWA) to 50 μg lead/m^3 of air. This sets air action level at 30 μg lead/m^3 of air which is the same as the general industry standard. Although the general industry standard is widely used in the painting industry, these PEL's are now law.[16]

The action level provisions invoked at 30 μg lead/m^3 includes periodic exposure monitoring, biologic monitoring, and employee training. Under the Occupational Safety and Health Administration (OSHA) Hazard Communication Standard and other construction standards referenced in the interim final standard rule, the employer is required to provide training for all employees exposed on any day at or above the action level.[16]

LEGISLATION BY THE STATES

A review of the bills proposed and/or passed by some states serves to indicate the activity and diverse rulings which are part of the complexity that faces the nation in dealing with the detection and abatement of lead hazards.

Massachusetts

Comprehensive amendments that add to the Massachusetts state lead law were passed in 1987.[17] The regulatory scheme for preventing lead poisoning in the Commonwealth of Massachusetts has been recognized as a model program by the Alliance to End Childhood Lead Poisoning. At the state level in December 1990, the legislature designated funds to be used for a deleading loan program to be administered by the Massachusetts Housing Finance Agency and was to be available in 1991.[18] These funds were not made available from the sale of paint in the state. The Massachusetts lead law was enacted as Chapter 773 of the Acts of 1987 and appears primarily in Chapter 11, Sections 190-199A.

Minnesota

In Minnesota, a bill for an Abatement Act was introduced to the legislature in 1992.[19] The essence of the Abatement Act funding was challenged by the Minnesota Paint Council. The bill, HF 1936, would have imposed a 10-cent per gallon tax on all trade sales paint sold in Minnesota. It also contained provisions for a tax on petroleum products and common solvents used in paint making. A notable feature of the provisions is the emphasis on covering contaminated soil with uncontaminated soil, wood chips, or grass to minimize hand-to-mouth ingestion of lead by children and distribution of dust in homes.

Provisions for the paint tax were deleted in the final bill approved by the Finance Committee. Funds were established to study the problem and make recommendations at the next legislative session (1993) but no action has been taken.

California

The California Department of Health Services drafted emergency regulations to implement the state's 1991 Childhood Lead Poisoning Prevention Act. This act requires that a fee be paid by manufacturers of products that currently contain lead or that contained lead in the past.

Assembly Bill 2038 of the Childhood Lead Poisoning Prevention Act of 1991 under provisions Related to Collection of Fees for the health safety code states that, "a fee is to be imposed on manufacturers formerly, presently, or both formally and presently engaged in the stream of commerce or products containing lead, or who are otherwise responsible for identifiable resources of lead, which have significantly contributed historically, currently contributed, or both have significantly contributed historically and contributed currently to environmental lead contamination." The term environmental lead contamination means the persistent presence of lead in the environment, in quantifiable amounts, that results in ongoing and chronic exposure to children. Paint manufacturing is third on the list of sources of contamination following petroleum and lead smelting industries.[20]

The fees are intended to generate a $16 million-a-year fund for a state lead poisoning testing program to screen children under the age of six for elevated blood lead levels and provide case management for chronic exposures. The California Paint Council (CPC) and Western States Petroleum Association have argued that a fee allocation system that excludes significant past and present users of lead may be invalid under the law and refers to manufacturers of lead acid batteries, plumbing parts, solder, and crystal among others.

The EPA estimate (1987) of the monetary cost for medical care and compensatory education was $5.75 billion plus an estimated $10 billion lost to the affected children through reduced earnings.

The CPC is concerned that the allocation system sought by the Department of Health Services might be used to establish fees for other lead-related projects such as lead abatement or lead poisoning interaction or by the plaintiff's attorneys to establish liability in lead poisoning tort cases.[20]

The burden of proof is placed on the persons taxed according to the act which states "No fee shall be assessed upon a person if that person can demonstrate, as determined by the department, that his or her industry did not contribute in any awareness to environmental lead contamination" and similarly "if that party demonstrates that the lead or product containing lead with which it is currently or was historically associated does not currently, or did not historically, result in quantifiable environmental lead contamination. No fee shall be assessed upon any retailer of lead or products containing lead."[21]

California Assembly Bill No. 3487 that would have required contractor lead abatement certification was vetoed by the Governor of California.

New Jersey

The New Jersey legislature attempted to focus on HUD's private housing abatement grant by first adopting contractor licensing and training regulations. Testing of children, and establishment of real estate disclosure laws and liability issues followed. In 1992, four bills were considered. Bill A-729 sought to establish the presumption that lead toxicity is due to lead paint in the residence. Bill A-1038 would have mandated testing of children before they enter day care or nursery school. Bill A-1350 was to establish certification and training for lead abatement workers. Bill S-131 would have eased discovery in liability suits in lead and asbestos contamination cases. Also considered were tax credits and loans to help homeowners and apartment owners meet the costs of abatement.[22]

Illinois

The August 7, 1992 proposed amendment (Volume 16, use 32) to 77 Illinois Code 845 Lead Poison Prevention Code is a comprehensive document that incorporates many of the actually acceptable guidelines. These include lead screening provisions, blood lead screens, inspection of dwellings, lead inspector licensing, and safety guidelines for workers, abatement techniques/procedures, and services of X-ray fluorescence and spectrum analysis portable instruments. It is to be noted that abatement action is initiated based upon a 20 μg/dl blood lead level in children.

Maryland

The Maryland House Bill 1265 was signed into law in May 1992 and provides a 15-member commission charged with recommending means of rehabilitating and compensating individuals injured by elevated blood lead levels. The commission will also recommend means for inspecting and remediating rental dwelling units and other properties found to have lead paint on surfaces accessible to children. In addition, the commission will recommend how to secure funding for lead paint poisoning prevention and compensation.

A system is to be developed to compile and update a list of rental dwelling units in Maryland and provide for the collection of registration fees in the amount of $2.00 per dwelling unit for each unit built before 1978 and owned by a private landlord who owns five or more rental dwelling units in Maryland.

The original bill provided for a paint fee to be collected from each paint retailer based on their quarterly sales volume. However, this provision was eliminated from the bill prior to its passage into law.

The Maryland Lead Abatement Law COMAR 26.02.07 establishes acceptable and unacceptable means of lead abatement and encapsulation for various interior and exterior surfaces. It establishes safety standards for all lead abatement workers and others who enter buildings in which lead abatement is taking place. It poses responsibility for clean-up of lead abatement work areas and disposal of wastes. All contractors who perform lead abatement are required to be certified. The law also provides for recordkeeping and inspection of properties from which lead has been abated.

LEGAL CASES/COURT RULINGS

Lead-based paint disputes have entered the nation's court system. A class action suit, *City of Philadelphia v. Lead Industries Association*, was brought on behalf of all cities with population of more than 100,000 and their public housing authorities against lead-based paint and pigment manufacturers and their trade association. The plaintiffs in *City of Philadelphia* alleged that the defendants knew the hazards of lead-based paints since the 1920s but engaged in a "decades long media campaign to persuade the public otherwise so that they could market their product effectively." On April 23, 1992, the judge dismissed the *City of Philadelphia* suit reasoning that the plaintiffs had failed to allege that paint purchases were based on misrepresentations of the lead-paint industry, failed to properly plead conspiracy of concert of action, and failed to meet proximate causation pleading requirements. The plaintiffs in *City of Philadelphia* intended to appeal to the 3rd U.S. Circuit Court of Appeals.[23]

White v. City of Newark, another class action suit, is on behalf of 28,000 children charging that Newark and certain landlords failed to properly screen for lead poisoning, failed to inspect dwellings or notify owners to do so, and failed to reinspect dwellings following abatement. The Superior Court granted two classes for claims against the city only, consisting of children diagnosed with high blood lead levels and children at risk for contracting lead poisoning. At the time of writing, the *White* case was pending.

Individual plaintiffs have been rebuffed also as in *Santiago v. The Sherwin-Williams Co.*, in which the judge rejected market share and concert of action theories against Sherwin-Williams Co., the Glidden Co., and Richfield Corp. The concert of action theory requires the plaintiff to show that one of the defendants caused the plaintiff's injury. Due to the pervasiveness of lead sources and the lack of a "signature" lead-based paint injury, the *Santiago* plaintiff could not meet this burden. This also led to rejection of market share theory, due to the absence of any clear link between the plaintiff's injury and the risk to which the defendants had exposed the plaintiff.[23]

Other market share liability cases are pending in New Orleans, LA. Tenants have filed suit against the New Orleans Housing Authority for delays in removing lead paint from their properties. The Housing Authority is trying to bring former lead pigment manufacturers into the case to take a share of the blame levied by the tenants.[23]

A Cleveland, OH, family has named a number of paint companies and manufacturers for damages caused by lead paint in residences during the past 30 years. This is based on their two children who have been lead poisoned.

A class action suit was filed in Cuyahoga County Common Pleas Court on behalf of all residents in the state who have had problems with lead poisoning. Until the federal ban on the use of lead-based paint in 1978, there were no special warning instructions on the label stating the material is dangerous, yet it was known as far back as the 1920s that lead was considered dangerous to children. The attorney representing the family in the suit predicted that the courts will reject the plea because of the product identification problem.[23]

A market share liability bill (Massachusetts House Bill 2789) was approved by the Massachusetts House of Representatives at the end of 1993.[23] Senate action was not taken in sufficient time (January 4, 1994 deadline) for passage of the bill into law. It has potential impact on the lead abatement issue if passed in a future session. The bill targets suppliers of lead materials but not paint producers, although paint manufacturers are mentioned in the bill. The bill would allow individuals claiming to be injured by exposure to lead-based paint to recover financial settlements long after the paint was applied. It would place a burden on defendants in such cases to prove they could not have been the source of the lead causing any health problems.

INDUSTRIAL AND PROFESSIONAL ORGANIZATIONS

NPCA has the lead abatement problem at the top of its list of priority issues, stated NPCA President B.F. Mautz, Jr., at NPCA's annual meeting in Chicago on October 19, 1992.[25] The goals as stated by Mr. Mautz and which are consistent with current efforts are as follows:

- To develop a comprehensive industry position paper on lead-based paint and childhood lead poisoning.
- To monitor lead-related litigation.
- To lobby Congress for reasonable latitude regarding the continued use of lead in certain industrial coatings.
- To address federal and state legislation that would tax paint sales to pay for lead abatement programs.
- To offer support of programs on lead abatement.
- To develop a comprehensive tracking system to monitor and report on lead legislation in the states.

The Federation of Societies for Coatings Technology (FSCT) and NPCA have established closer coordination of activities. A proposed framework of joint activities will result in increased effectiveness that should encompass the lead abatement issue.

The National Institute of Building Sciences (NIBS) announced a program in March 1993, to develop lead-based paint guide specifications to help home and building owners obtain services that pertain to lead abatement. The project is being sponsored by New Jersey and California through grants the states will secure from HUD.

NIBS is also compiling a database of federal and state lead-based paint related laws, regulation and guidance documents which is to be updated at appropriate intervals. A panel discussion at the Environmental Integration Forum held by a NIBS Consultive Council in Washington, January 12, 1993, recommended establishment of a building environment council to encourage dialogue between industry and regulators. There is a need for uniformity in enforcement and interpretation of regulation among federal agencies and state and local governments.[26]

As indicated earlier in this paper, NIBS helped provide guidelines for the 1990 HUD document. However, lack of funding prevented further work along these lines.

ASTM has task group activities in Subcommittee E06.23 that include the development of field and laboratory test methods, removal methods, encapsulation methods, laboratory accreditation, abatement contractor accreditation, and terminology that relates to lead abatement. There is also a lead policy issue group active in ASTM Committee D-1 Subcommittee 01.21.

A proficiency testing program approved in May 1992 by the American Industrial Hygiene Association (AIHA) Board of Directors is being made available to help laboratories improve their performance.[27]

Environmental Lead Proficiency Analytical Testing (ELPAT) provides quarterly proficiency samples of paint, soil and/or wipes of settled dust. Participation in this program is mandatory for laboratories seeking accreditation under the AIHA Environmental Lead Laboratory Accreditation Program.[27]

The EPA estimates that it will need between 3,000 and 9,000 labs to perform lead-related testing and analytical work in the

Lead-containing paints (those formulated with lead carbonate) have generally not been manufactured since the 1940s or early 1950s, but are known to contain an excess of 50% lead (based on dry weight).

coming years. In the recent past, there were about 200 labs considered "recommended" by HUD.[27]

It is believed the efforts at proficiency testing accreditation and the ASTM E06.23 guidelines will provide the basis of a coordinated and responsible effort to deal with the lead abatement problem.

SUMMARY

It is essential that public agencies deal effectively with all likely sources of lead in the environment to minimize the social and economic costs and suffering imposed upon innocent children and their families. Soil contaminated with lead from gasoline emissions is a very real source of lead exposure for children and may be the primary source of lead in household dust. Lead contaminated water has also been shown to contribute substantially to children's exposure.

EPA, HUD, and Centers for Disease Control (CDC) are aware that paint is not the sole source of lead in the environment and may not be the primary source of exposure. This is important not only from the perspective of protecting the paint industry but also from the standpoint that so much expense is required to correct the problem that attacking the wrong problem can be tragic and ineffective. The public must be provided with the best scientific knowledge available since corrective action will require their voting approval at the state and local level to deal with city and regional lead poisoning problems.

Members of the FSCT can aid in the important task required to inform the public and legislators at community, state, and local levels by participation in regional paint councils of the NPCA.

ACKNOWLEDGMENT

The members of the Northwestern Society Technical Committee thank Mary Somerville of the Baltimore Society for the review of Maryland regulations for lead abatement. The following Northwestern Society Technical Committee members provided editorial comments: Michael Grivna, Eric Habeck, Sarah Oebser, and Lowell Wood.

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Society Meetings

CHICAGO .... MAY

Introduction of 1994-95 Officers

Chicago Society Officers for the year 1994-95 were announced as follows: President—Natu Patel, of Ace Hardware Corp., Paint Div.; Vice President—Carl D. Stromberg, of United Coatings Inc.; Secretary—Marcella G. Nichols, of Tru-Test Manufacturing Co.; Treasurer—Gerry Noren, of DSM Desotech, Inc.; and Society Representative—Evans Angelos, of OMYA, Inc.

In addition to the above, the following will serve on Chicago's Executive Committee: Past President 1993-94—Gregory E. McWright, of ANGUS Chemical Co.; Past President 1992-93—William W. Fotis, of The Valspar Corp.; Associate Representative—Alison Azar, of Seegott, Inc.; and Associate Representative—Richard L. Cranstoun, of G.R. O'Shea Co.

Immediate Past-President Gregory McWright presented Presidential Appreciation Certificates to members of the SYMCO '94 Committee for their efforts in preparing this Society sponsored event.

Joint Education Committee Chairman of the CSCT/CPCA Joint Educational Committee, Walter Krason, of The Valspar Corp., announced the five recipients of the Grant-in-Aid/Scholarships. They are as follows (most are children of Society Members): Kimberly R. Wieringo, daughter of Barbara Wieringo, of G.R. O'Shea Co.; Elizabeth A. Connors, daughter of Thomas Conners, of Milsolv Co.; Craig A. Brouillette, son of Bruce R. Brouillette, of United Coatings Inc.; Antoinette L. Tortorello, daughter of Anthony J. Tortorello; and Daren L. Zable, daughter of Robert E. Zable, of Prefinish Metals.

Also, Society Educational Committee Chairman Frank Leo, of Henkel Corp., announced that Merit Scholarships were awarded to: Christopher D. Cranstoun, son of Richard and Sandra Cranstoun, of G.R. O'Shea Co.; and Emily Strauch, daughter of Marvin J. Strauch, of Strauch Chemical Co.

Victor M. Willis, of Ace Hardware Corp., Paint Div., presented Gerald O'Shea, of G.R. O'Shea Co., with a 50-year membership pin.

CLIFFORD O. SCHWAHN,
Publicity

SOCIETY PAST-PRESIDENTS IN ATTENDANCE AT CHICAGO'S MAY MEETING (standing, left to right): Karl E. Schmidt (1991); Ross C. Johnson (1986); Gregory E. McWright (1994); Raymond J. Cziczo (1988); William W. Fotis (1993); Evans Angelos (1989); and Walter J. Krason (1979). Seated: Robert W. Zimmerman (1974); Raymond F. Pfohl (1969); Kenneth W. Wilkinson (1973); Victor M. Willis (1966); and Warren C. Ashley (1955)

Chicago Society Past-President Victor M. Willis (left) presents Gerald O'Shea with a 50-year Member Award

Chicago Society President Natu Patel (left) accepts the Nuodex Gavel from Patrick Gorman, of Hüls America

Natu Patel (right) presents Gregory McWright with a Certificate of Appreciation for his many years of service to the Society

DALLAS .... MAY

"Formulating Trade Sales and Industrials"

It was announced that the following members have been elected as Society Officers for 1994-95: President—Benny Puckett, of Kelly-Moore Paint Co., Inc.; Vice President—Paul Kaplan, of Cookson Pigments, Inc.; Secretary—Chip Newcomb, of Trinity Coatings; Treasurer—Donald McBride, of Ribelin Sales, Inc.; and Society Representative—Charles A. Kaplan, of Gillespie Coatings, Inc.

Committee Chairman for 1994-95 are: Membership—Barry Clinger, of Van Waters & Rogers; Technical—Ted Best, of The Valspar Corp.; and Publicity—Ed Spradlin, retired.

The technical presentation was given by Southern Society Member John C. Ballard, of Burgess Pigments. He spoke on "FORMULATING TRADE SALES AND INDUSTRIALS."

During his talk, Mr. Ballard made the following suggestions for the coatings chemist:

—Find raw materials that work in several applications;

—Never use a material that does not have at least one competitive offset;

—Establish physical property value limits and require certificates of analysis from suppliers;

—Use tall oil-based alkyds to reduce yellowing;

—Increase knowledge of raw material composition through test such as infrared and atomic absorption and by use of the Federation's Panorama™ Coatings MSDS CD Retrieval System.

Mr. Ballard also presented an overview of clay mining, classification and production, as well as several ideas on how to determine the surface areas of odd shapes that require painting.

ED SPRADLIN,
Publicity

DALLAS SOCIETY MAY MEETING—John Ballard, of Burgess Pigment Co. speaks on "Formulating Trade Sales and Industrials"

GOLDEN GATE .... MAY

"Abrasion Resistant Coatings"

A moment of silence was observed for the passing of Society Past-President Jack Duis, of Pacific Coast Chemicals, who died suddenly on May 5.

The evening's technical speaker was Paul Sassoon, of SDC Coatings Inc., and his topic was "ABRASION RESISTANT COATINGS FOR PLASTIC SUBSTRATES."

The speaker presented a brief overview of market trends, typical applications, how the coatings are applied and cured, performance properties, and new coating developments. Mr. Sassoon also discussed the future of these coatings in nonplastic applications.

Q. What method was used to determine chemical resistance?

A. ASTM Method G 26.

EVE STROMQUIST, *Secretary*

LOS ANGELES .... MAY

"Coatings for Plastic Substrates"

A moment of silence was held for the passing of Society Member Bud Schaedel, of Guardsman Chemicals, and Golden Gate Society Member Jack Duis, of Pacific Coast Chemicals.

Society President V.C. "Bud" Jenkins informed the membership that Maurice Samson has been nominated to Society Honorary Membership.

It was announced that the following members have reached the 25-year membership point: Conrad Angenent, of Continental Coatings, Inc.; Brian Bradstock, of Sprayon Products; Andrew Corty, retired; Robert Chavey, of R.G.C. Co.; Henry Higa, of Ellis Paint Co.; Art Holst, of Fine Line Paint Corp.; Frank Kuba, of Major Paint Co.; Russ James, retired; Frank Ramiro, of Sinclair Paint Co.; Barry Sakamoto, of Surface Protection Industries, Inc.; and Gordon Yanagi, retired.

Vice-President Philip C. Bremenstuhl, of ZENECA Resins, announced this year's recipients of Society scholarships. The 1994-95 winners are: Amelia Nucup, Rina Dhaliwal, Michelle Balow, Tin Htay, Wendy Blanda, Mikeal Eastep, Sonia Dhaliwal, Myron Mialo, Marie Sarte, and Jody Sakamoto.

"ABRASION RESISTANT COATINGS FOR PLASTIC SUBSTRATES," was highlighted during the meeting by Paul Sassoon, of SDC Coatings.

Mr. Sassoon noted that these types of coatings are typically used at dry film thicknesses of one-half to three or four microns and are used on plastic substrates. According to the speaker, the coatings' main function is to provide a high amount of abrasion resistance as well as chemical resistance and resistance to atmospheric conditions. These coating can be applied by a variety of methods including dip, spin, and spray. The criterion used for selection of abrasion resistant coatings are:

(1) Substrate—Long term durability is usually needed as is clarity. Mr. Sassoon noted the concern for impact resistance, especially in safety items. Flexibility modulus, T_g, coefficient of expansion and processability of the part, be it large or small, are all additional concerns. Typical end-use markets include opthalmic, plastic sheet products, automotive, injection molded parts, transit (bus windows), and aerospace markets.

(2) Requested Physical Requirements—Total adhesion, high abrasion, scuff resistance, and chemical resistance are all typically required.

The speaker commented that the coatings are based on silicone silicate technology. They exhibit excellent hardness but are not too flexible, only having about one percent elongation but having excellent weatherability.

In conclusion, Mr. Sassoon addressed coating processability or application methods. There are various application methods including, spin, flow, and spray. The speaker stated that the systems typically encountered are completely enclosed so as to allow for solvent recapture via scrubbing.

Q. What kind of plastic is the hardest to coat?

A. Overall, coating plastic is very difficult. In general, polyolefins are the most difficult.

ROBERT SKARVAN, *Secretary*

LOS ANGELES .... JUNE

"High-Speed Dispersers"

The slate of Committee Chairmen for 1994-95 are as follows: Awards—Sandra L. Dickinson, of Synergistic Performance Corp.; Budget and Audit—Maurice Samson, retired; Career Development—Dan Gilbert, of Hill Brothers Chemical Co.; Computer—John C. Kulnane, of Ameritone Paint Corp.; Constitution and By-Laws—James D. Hall, of Sinclair Paint Co.; Educational—Edward Barrie, Jr., of Sinclair Paint Co.; Employment—Sandra L. Dickinson; Environmental—Dave Muggee, of E.T. Horn Co.; Entertainment—Scott P. Hoffer, of Ashland Chemical Co.; Good Fellowship, Photography and Publicity—Lambert Osen; Library—Carl V. Thompson, of Superior Industries Int'l., Inc.; Meetings—Richard T. Hays, of E.T. Horn Co.; Membership—Glenn Wool, of John K. Bice Co.; Scholarship—John A. Gordon, of Pacific Technical Consultants; Technical—V.C. "Bud" Jenkins, Consultant; and Yearbook—Brian H. Turk, of Union Carbide Corp.

Dan Gilbert, reporting on behalf of Environmental Committee Chairman Dave Muggee, informed members that SCAQMD is in the final stages of preparing its 1994 Air Quality Management Plan. Closing meetings will be held in June. He also reported that the Environmental Impact Report is now available.

President Bud Jenkins thanked Myers Engineering and Sam Rumfola, of TCR Industries, for donating a twin blade mixer and a lab mixer, respectively, for the letdown lab.

The first speaker of the evening was scheduled to be Dan Fenske, of International Coatings, whose talk was entitled "DRUM DISPOSAL DANGERS." But due to an emergency, Mr. Fenske was unable to present his paper. In his absence, President Jenkins reviewed the focal point of the talk which centered on a citation issued by the Los Angeles County Sanitation District to International Paint for improper disposal of a 20-gallon drum. The rule apparently states that drums which have contained hazardous waste and are greater in size than five gallons, regardless of cleanliness, cannot be disposed of in the trash.

Mark Drukenbrod, of Myers Engineering, was the technical speaker of the meeting. His presentation was on "HIGH-SPEED DISPERSERS."

Mr. Drukenbrod began by stating that the object of the high-speed dispersion disk is to take particulate matter and move it into the dispersion properly, so that it remains there. It has been proven that most of the work conducted in a dispersion is done on the flat surfaces of the disk; the pumping is done by the teeth.

The speaker continued by discussing the difference between a lab mixer and a production size mixer stating that the main difference is in the way the drives are configured. There can be one or numerous belts in a high-speed drive. Mr. Drukenbrod displayed one with a movable center drive in which the motor moved back and forth on a trolley. He also displayed one with an actual crank on the front of the mixer which works directly on the pulley.

At this point in the presentation, Mr. Drukenbrod displayed a laboratory size, dual high-speed shaft mixer. This type of configuration increases size of the high-shear zone which means that at any given time you are getting more material worked on and it also lessens vortexing when you are trying to put alot of work into the material. The speaker mentioned that a production size model can come with one or two motors; the drive can be shared between both shafts or each shaft could be driven by one motor.

In building a dual shaft mixer, stated the speaker, one is limited by the viscosity that can be handled in a given tank by the poor pumping capability of a high-speed blade. This blade can be taken and placed in a tank with another blade that is designed specifically for doing the pumping for the other blade. Mr. Drukenbrod displayed a basic low speed anchor blade which draws material down and around the shaft, pushes it out and along the bottom of the tank, and then pushes it up along the sides. If a high-speed disperser blade is inserted, the material is circulated into and out of the high-shear zone. For the incorporation of powders in high viscosity materials, a gate blade would be added. The speaker noted that if a very high viscosity material is being used, the anchor blade would pump the dispersion around, the high-speed blade would do the dispensing, and something is needed to break the surface and help incorporated dry, puffy powders. Mr. Drukenbrod said that this is where sweep impellers are used.

The speaker concluded by discussing a dual shaft mixer which incorporates scrapers that automatically scrape the sides.

ROBERT SKARVAN, *Secretary*

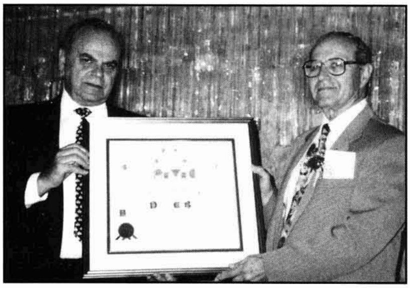
New York Society's May 1994 Meeting

DonaldE. Brody, Consultant, Receives New York Society's PaVaC Award

Donald E. Brody, Consultant, is the recipient of the 1994 New York Society for Coatings Technology's PaVaC Award. The award was presented to Mr. Brody at the Society's May 10, 1994 meeting. The PaVaC Award was established in 1950 and is bestowed on Society members for their outstanding contributions to the advancement of the protective coatings industry and the New York Society.

Mr. Brody has been actively involved in the coatings industry for over 40 years. Currently a Consultant, he has both a Bachelor's and Master's Degree in Chemical Engineering. He has published numerous papers and is the author of several patents dealing with coatings, polymers, and pigments.

For 23 years, Mr. Brody has taught the New York sponsored two-year, four-semester course on coatings technology. He has been active on many Committees over the years. In 1971 Mr. Brody was the recipient of the Roy H. Kienle Award, and in 1972 he served as President of the Society. Mr. Brody is currently Chairman of the Educational Committee.



New York Society Awards Committee Chairman, Saul Spindel (left) presents Donald E. Brody with the Society's PaVaC Award

SOCIETY PAST-PRESIDENTS IN ATTENDANCE AT THE MAY 1994 MEETING OF THE NEW YORK SOCIETY (standing, left to right): Irwin H. Young (1989); Marvin Wexler (1972); Alfred A. Sarnotsky (1976); Raymond P. Gangi (1989); Jeffrey C. Kaye (1992); Roger P. Blacker (1991); Michael C. Frantz (1993); John W. Burlage (1988); Michael Iskowitz (1985); Arthur A. Tracton (1990); Donald E. Brody (1982); and Saul Spindel (1979). Seated: John J. Oates (1962); George J. Dippold (1978); Sidney B. Levinson (1968); Herman J. Singer (1969); William Singer (1977); Sidney J. Rubin (1980); and Moe Bauman (1959)

ST. LOUIS .... MAY

Election Night

A moment of silence was observed for the passing of Society Honorary Member Glenn O. Stephenson.

The slate of St. Louis Society Officers for 1994-95 is: President—Chuck Reitter, of ID Financial Services; Vice President—James Lindsley, of Akzo Nobel Coatings Inc.; Secretary—Michael P. Hefferon, of Walsh & Associates, Inc.; Treasurer—Robert Phelps, of P.D. George Co.; and Assistant Treasurer—Lou L. Voit, of Cemsac Chemicals Corp.

Past-President and Society Honorary Member Fred C. Weber, Jr., of Archway Sales, Inc., was recognized for being a member of the Society for 50 years.

It was announced that the Society is planning five joint meetings with the St. Louis Paint and Coatings Association next year. Program Chairmen from each group will meet to set up a coordinated program.

Todd K. Yonker, of Carboline Co., presented a technical report on "The Effect of Varying the Stoichiometry in High-Solids Two-Component Epoxy Coatings."

Mr. Yonker explained that his project covers some of the advantages and disadvantages of varying the stoichiometric curing ratios of high-solids, two-component epoxy coatings. He said that coatings formulated with bisphenol A and bisphenol F type epoxy resins were cured with: (1) excess amine, and (2) excess epoxy. Noticeable differences were observed in adhesion, chemical resistance, MEK double rubs, water spotting, flexibility, and weathering performance.

James B. Lindsley, *Secretary*

TORONTO .... MAY

"Wet Dispersion Process"

It was announced that the following members have been elected as Society Officers for 1994-95: President—David P. Jack, of Technical Coatings Co. Ltd.; Vice President—Bob C. Ng, of Hoechst Canada Inc.; Secretary—Natalie Janowsky, of Degussa Canada Ltd.; Treasurer—Kevin Pelling, of Inortech Chimie Inc.; Society Representative—Art Hagopian, of ICI Paints (Canada) Inc.; and Past-President—Mike Hazen, of L.V. Lomas Ltd.

The evening's guest speaker was Christ Zoga, of Premier Mill Corp. He presented the talk entitled, "Look Both Ways to Improve Your Wet Dispersion Process."

Mr. Zoga noted that most companies focus on the media mill as the sole ingredient for success they are in milling their pigment dispersions. Although the media mill is the dominant piece of equipment used, and commonly isolated as the problem source in coatings manufacture, other variables exist in this process: raw materials, formulae, letdown techniques and processing, and operators, etc.

According to Mr. Zoga, there are typically two types of mills used today: the vertical mill and the horizontal mill. The vertical mill which has been in existence since the 1950s, and is now being supplanted by the horizontal mill, is capable of handling only about 50% of the grinding media as compared to 80-85% for the horizontal mill. Today's horizontal mills feature accessories such as instrumentation, pressurized seals, flow meters, etc., all of which facilitate and improve the end product. According to the speaker, attempts are being made to achieve "sub-micron" grinds with low viscosity pastes.

Mr. Zoga continued by discussing the storage conditions used for the raw materials (Toronto and Houston were used as examples). During the summer months in Houston, where humidity is high, an open bag of pigment could conceivably pick up sufficient atmospheric moisture that would affect its performance under grind, or dispersion conditions. Toronto, on the other hand, would be affected in a completely different manner, or not affected at all. The speaker emphasized that regardless of the location, proper raw materials storage and conditions are the keys to a quality end product.

At this point in the presentation, Mr. Zoga turned his attention to the area of premixing and its impact on the dispersion quality of a system. He stated that in manufacturing operations where premixing is employed, it is important to realize that proper flow patterns within the dispensing medium are also required at this step, and not just in the mill itself. By ensuring proper premixing techniques, maximum performance of the mill will naturally follow.

The speaker briefly covered the topic of filtration and the importance of using the correct filter. Bag filters are commonly used to screen for traces of grinding media which may have resulted during the milling process. Also, according to Mr. Zoga, they serve to screen for large agglomerates which may have broken down completely in the mill.

In conclusion, the speaker discussed the selection of grinding mill.

Kevin Pelling, *Secretary*

Audio/Visual Presentations

(All A/V presentations include slides, cassette tapes, and scripts)

CAUSES OF DISCOLORATION IN PAINT FILMS

Some of the common causes of paint discoloration, such as mildew, sulfide staining, dirt retention, and staining by cedar or redwood, are illustrated on houses and on painted panels. Chemical tests for distinguishing between these types of stains are shown. A test for distinguishing efflorescence and chalking of paint films is also described.
15 minutes
(37 slides) **$40**

HIGH SPEED DISPERSION

Produced by the Manufacturing Committee, Montreal Society for Coatings Technology

The program covers theoretical and practical techniques used for dispersion in paint plants, showing laboratory test equipment and plant scale manufacturing procedures. 20 minutes
(60 slides) **$65**

INTRODUCTION TO RESIN OPERATIONS

Produced by the Manufacturing Committee, Toronto Society for Coatings Technology

This presentation has been developed to assist in the selection and training of resin plant operators, and focuses on basic concepts of manufacture and the role of a resin operator.
12 minutes
(58 slides). **$65**

A BATCH OPERATED MINI-MEDIA MILL

Produced by the Manufacturing Committee, New York Society for Coatings Technology

This presentation describes the design and operation of a batch operated mini-media mill, and was developed to assist in the training of plant personnel to operate such equipment.
8½ minutes
(51 slides) **$60**

OPERATION OF A VERTICAL SANDMILL

Produced by the Manufacturing Committee, Kansas City Society for Coatings Technology

This program describes the design and operation of a vertical sandmill, to assist in the training of plant personnel to operate such equipment.
14 minutes
(73 slides) **$75**

VCR TAPE ON LABORATORY TEST PROCEDURES

The program, which runs approximately 60 minutes, describes and demonstrates the correct procedures for conducting 15 quality control tests on liquid resin solutions or coatings. A list of instruments and equipment necessary for conducting each test is included, along with instructions for operating the test equipment and determining correct results. A training manual (which includes supplementary information on each of the tests) accompanies the tape (VHS) **$50**

Audio/Visual Presentations

- ☐ Causes of Discoloration in Paint Films **$40**
- ☐ High Speed Dispersion **$65**
- ☐ Introduction to Resin Operations **$65**
- ☐ A Batch Operated Mini-Media Mill **$60**
- ☐ Operation of a Vertical Sandmill **$75**
- ☐ VCR Tape on Laboratory Test Procedures **$50**

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Elections

BALTIMORE

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Cornelius, John M.—SCM Chemicals-Americas, Baltimore, MD.
Fasolo, Joseph A.—Morrison Ink, Baltimore.
Stewart, Vincent T.—Duron, Inc., Beltsville, MD.

Associate

Murphy, David M.—Mineral Pigments Corp., Beltsville, MD.
Sullivan, Gene D.—E.M. Sullivan Associates, Haverford, PA.
Taylor, Mark—Colorgen Industrial, Ashburn, VA.

BIRMINGHAM

Active

McDonald, Matthew J.—Skylon Coatings Ltd., Birmingham.
Tovey, Steven J.W.—PPG Industries (UK) Ltd., Polesworth, Tamworth.
Sheppard, David Graham—Cornelius Chemical Co., Ltd., Romford, Essex.

CDIC

Associate

Doll, Eugene J.—Schabel Products Corp., Cincinnati, OH.

KANSAS CITY

Active

Golden, Theodore F.—Hillyard Industries, Inc., St. Joseph, MO.

MONTREAL

Active

Girard, Josey—UV Tech Reg., La Baie, Que.
White, Barton—Canbro Inc., Valleyfield, Que.

Associate

Cote, Paul A.—Tioxide Canada Inc., Tracy, Que.

NEW ENGLAND

Active

Fedorchak, Gregory A.—Daniel Products Co., Jersey City, NJ.
Johnson, Lewis H.—Avery Dennison Corp., Framingham, MA.
Keller, Viktor M.—Spalding Sports, Chicopee, MA.
Markusova, Masha V.—Zeneca Resins, Wilmington, MA.

Associate

McKeon, James F.—S.P. Morell Co., Wilbraham, MA.
Ray, Jeremy P.—Inolex Chemical Co., Portland, ME.

NEW YORK

Active

Helmy, Samir S.—Summit Precision Polymers Corp., Mountaintop, PA.
Ilaria, Joseph E.—Benjamin Moore & Co., Flanders, NJ.
Marinzulich, Gerald—H.B. Fuller Co., Edison, NJ.
Schroeder, Robert W.—Daniel Products Co., Jersey City, NJ.

Associate

Forgione, Anthony F.—Ruco Polymer Corp., Hicksville, NY.
Ouimet, Henry M.—Painters Edge, Waterbury, CT.
Skora, Alexander J.—Estron Chemical, Inc., Parsippany, NJ.
Weber, Robert A.—Cosmair, Inc., Clark, NJ.

NORTHWESTERN

Active

Breining, Dennis R.—3M, St. Paul, MN.
Holland, Lowell W.—3M, St. Paul.
White, Kerry R.—Andersen Corp., Bayport, MN.

Associate

Benda, Bruce C.—Miles, Inc., Edina, MN.
Daniels, Jack W.—Arizona Chemical Co., Egan, MN.
Larson, Michael A.—Grefco Inc., Golden Valley, MN.
Lang, James—Union Carbide Corp., Crystal Lake, IL.
Lipinski, Patrick G.—Mellgma, Co., Minneapolis, MN.
Murphy, Patrick E.—W.R. Grace Davison, Baltimore, MD.
Rice, Kenneth M.—Kenneth M. Rice Co., Des Plaines, IL.

PIEDMONT

Active

Edwards, Ben E.—W.R. Meadows, Inc., Blowing Rock, NC.
Fenbert, Frank W.—Akzo Coatings, Inc., High Point, NC.
Gansman, William B.—PPG Industries, Inc., Greensboro, NC.
Jacobs, Charles C.—Guardsman Products, Inc., High Point.
Zuidema, Keith J.—Guardsman Products, Inc., High Point.

Associate

Crimmins, Patrick J.—Sekisui Chemical, Philadelphia, PA.
Moore, Jerry N.—Azalea Color, Atlanta, GA.
Shay, Greg D.—Union Carbide Corp., Cary, NC.
Stobierski, William D.—Lawter International, Norcross, GA.

ROCKY MOUNTAIN

Active

Olson, Russell L.—Paint and Lacquer Co., Englewood, CO.

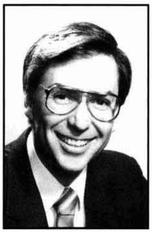
Associate

Wright, Charles E.—Aqualon Co., Flower Mound, TX.

SOUTHERN

Active

Miles, William Mark—Akzo Coatings Nobel Inc., Clinton, MS.
Sixto, George F.—Caribbean Paint Mfg., Co., Miami, FL.
Symthe, Thomas J.—Warren Paint & Color, Nashville, TN.



M.C. Frantz

Michael C. Frantz has been named Vice President, Sales, of Daniel Products Co., Inc., Jersey City, NJ. He succeeds **Elio Cohen** who is retiring after a 35-year career with Daniel Products. Mr. Frantz will focus on increasing the company's share of the colorant and additives business for environmentally safe coatings. He joined Daniel Products in 1974 as a Technical Salesman and became Technical Sales Manager, Northeast three years later. In 1988, he was given the additional title of Director of Advertising/Sales Promotion. Mr. Frantz is a member and Past-President of the New York Society and currently serves as Society Representative on the FSCT Board of Directors.

PPG Industries, Pittsburgh, PA, has named **William E. Michael** Manager, Automotive Sprayable Technology, Research and Development, in their Research Center in Allison Park, PA. Mr. Michael is a member of the Pittsburgh Society.

Hüls America, Inc., Piscataway, NJ, announced the promotion of **Martin L. Feldman** to Director of Marketing, Coatings Additives, Driers, and Biocides within its Colorants and Additives group. Dr. Feldman will oversee the marketing of the company's coatings additives, driers, and biocides product lines to the coatings and associated industries on a worldwide basis. He is a member of the New York Society.

Also, **John W. Du** was appointed Group Manager, Industrial Colorants Technology and Colorants Pilot Plant, within Hüls' Colorants and Additives Division. Mr. Du is responsible for new product development and technology-related activities for Hüls' industrial colorants. Mr. Du is a member of the New York Society.

AlliedSignal, Morristown, NJ, announced the appointment of **Ann Tiefenthaler** as Distributor Sales Coordinator within its Performance Additives business unit. Ms. Tiefenthaler will oversee the development and expansion of the unit's marketing efforts at the distributor level, as well as coordinate all aspects of distributor relations, and develop ongoing initiatives to enhance the overall partnership between the company and its U.S. distributor base.

In recognition of his outstanding contributions to the plastics industry, **Rudolph D. Deanin** has been elected Fellow of the Society of Plastics Engineers (SPE), Brookfield, CT. Dr. Deanin was recognized for his dedication to plastics education, most notably via his commitment to the Plastics Engineering program at the University of Lowell, Lowell, MA, where he serves as a Professor. Dr. Deanin is a member of the New England Society.

Jeffrey R. Hagerlin has accepted the promotion to the newly-created position of Vice President of Research and Development for O'Brien Powder Products, Inc., Houston, TX. He will be responsible for activities relating to the technology aspects of the company's business, including both decorative and functional coatings groups. Mr. Hagerlin is a member of the Houston Society.

Also, **John M. Biesmann** was elected Treasurer of O'Brien. Mr. Biesmann also serves as Vice President of Finance, a position he has held since 1993.

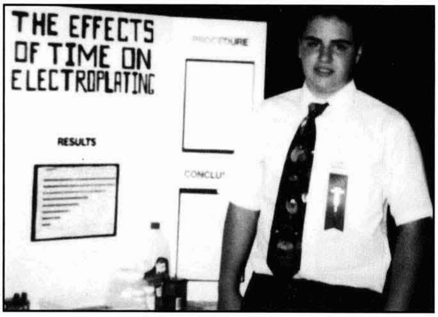
John McCasland has accepted the position of National Sales Manager for ColorTec, Lebanon, NJ. Mr. McCasland will supervise sales of the company's ColorSoft® color formulation and quality control software, spectrophotometers from a variety of manufacturers, and the ColorTec-PCM™. He has 12 years of sales and marketing experience in the color and appearance industry.

G.N. Robinson

The position of Manager—Technical Service at ANGUS Chemical Co., Buffalo Grove, IL, has been accepted by **Glenn N. Robinson**. In this capacity, Mr. Robinson will manage the technical service function, a primary source of support for customers worldwide using the company's nitroparaffins, nitroparaffin derivatives, and biocides. He has over 20 years experience with ANGUS and its predecessor companies, particularly working with coatings in related markets. During this time, he has supported both current and new product sales development, received several patents, and published a variety of articles on coatings technology. He is a member of the Chicago Society.

Fusion UV Systems Corp., Rockville, MD, has restructured its senior management organization following the acquisition of Aetek International, Inc. The following are taking on new responsibilities and titles: **Barry D. Silver**—Vice President Operations; **Al Kalaczinski**—Director of Operations; **Bill Wiseman**—Director of North American Sales; **David E. Blake**—Marketing Director; **Dwighd Delgado**—Director of Manufacturing; and **Lee Comstock**—Director of Corporate Manufacturing.

Todd Joseph Spencer Receives Hanna Award in Coatings



Todd Joseph Spencer, a 7th grade student at Perry Middle School, Perry Township, OH, received the Annual Hanna Award in Chemical Coatings. The award, which recognizes the best project in the science and technology of chemical coatings, was presented at Ohio Science Day, held at Ohio Wesleyan University. The judges found Todd's project, entitled "The Effects of Time on Electroplating," to be both comprehensive and well thought-out, exhibiting a balanced regard for both scientific content and practical application. The Hanna award is given by the Columbus, OH, facility of Akzo Nobel Coatings Inc., to help create a greater interest in and awareness of the chemical coatings industry at the middle school and high school levels, and to help foster a greater interest in chemical coatings as a potential career in science and technology.

The Painting and Decorating Contractors of America (PDCA), Fairfax, VA, has chosen **Paula D. Clements** as their Executive Vice President. Ms. Clements comes to PDCA from the National Association of Women in Construction (NAWIC), where she served as Executive Director. Before serving as Executive Director, she was Editor/Director of Communications at NAWIC. She has also been a staff writer and audio visual coordinator/producer at a Ft. Worth, TX, advertising firm.

H. Larry Pelegrin has accepted the position of Vice President, Sales and Marketing for the United States Filter Corp., Rockford, IL. Mr. Pelegrin will be responsible for all the company's sales and marketing activities in the U.S. and Canada.

Also, the company has aligned its U.S. sales management into three regions. The following will manage these areas: **G. Kent Peterson**—Vice President, Sales Central U.S.; **John Gannon**—Vice President, Sales Eastern U.S.; **Joseph Zuback**—Vice President, Sales Western U.S.

Donald M. Waters was elected the 50th President of the National Association of Corrosion Engineers (NACE) International, Houston, TX. Mr. Waters is an Engineer at Corrpro/PSG Corrosion Engineering, San Diego, CA.

The following were also elected as new officers of NACE International: Vice President—**W. Brian Holtsbaum** and Treasurer—**Elaine Bowman**.

Macbeth, New Windsor, NY, announced the promotion of **Cathy McMahon** to General Manager of its Munsell Division. Ms. McMahon will be responsible for the management of Sales, Marketing, and Operations, which provides tools for selecting, communicating, and controlling color.

Rafique E. Jangda has assumed the title and responsibilities of National Sales Manager of QVF Process Systems, Inc., Corning, NY. Mr. Jangda is charged with all sales activities taking place in the U.S. and Canada. He most recently served as a Regional Sales Manager for the former Corning Process Systems.

The Dexter Corp., Windsor Locks, CT, has named **John D. Thompson** as Vice President, Corporate Services. In this position, Mr. Thompson's responsibilities include the areas of corporate development, technology, and quality management. He succeeds **T. Daniel Clark** who accepted the position of Senior Division President, Dexter Packaging Products Division. Based in Waukegan, IL, Mr. Clark will continue to serve a Vice President in addition to his new duties. He succeeds **Harold T. Crutcher**.

Peter A. Wolter was named Vice President and General Manager of REVCO/Lindberg, a unit of General Signal, Watertown, WI. Mr. Wolter, who has been with the company for 13 years, most recently served as Vice President of the Lindberg/MPH operations.

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Solution to June's *"CrossLinks"*

Calvin S. McCamy has been elected an Honorary Member of the Inter-Society Color Council, Arlington, VA. While working at Macbeth Division of Kollmorgen Corp., Mr. McCamy found the first explicit equation for computing Munsell Value from CIE Y precise enough for critical color work, invented a method for designing and constructing color filters, based on a novel principle of optical integration, and designed the illumination system for a spectrophotometer to permit direct measurement of whiteness by the Griesser method.

For his contributions to the application and understanding of the minimally distinct border (MDB) photometric technique, **Peter Kaiser** received the 1994 Macbeth Award of the Inter-Society Color Council. Dr. Kaiser's research on MDB began in 1968 with a paper he coauthored with Bob Boynton. Most recently, he has investigated the physiological basis of the MDB spectral sensitivity function in macaque retina in the laboratory of the physiologist Barry B. Lee.

In other news, ISCC announced its new officers and directors. They are: **Roland Connelly**—President; **Ellen C. Carter**—President-Elect; **Daniel Walton**—Treasurer; and **Danny C. Rich**—Secretary. The recently elected directors include: **Michael A. Hammel, Richard W. Riffel,** and **William S. Vogel**.

The Polymers Division of Ciba-Geigy Corp., Hawthorne, NY, promoted **Edward G. Bozzi** to President, Ciba Polymers, Brazil. Dr. Bozzi is charged with strengthening the business relationship between North and South America, creating a technology link to optimize synergies, and providing better servicing to the company's international base.

Raffi and Swanson, Inc., Wilmington, MA, appointed new unit managers following the formation of the Textile Coatings Business Unit and the Industrial Products Business Unit in their sales and technical departments. **Richard Harrington Sr.** will serve as Business Manager and **Kris Krishnan** will act as Technical Director of the Textile Coatings Business Unit, which focuses on the coating needs of the textile industry. The Industrial Products Business Unit, which includes graphic arts, architectural, and industrial market segments, will be headed by **Theodore Kubacki**, Business Manager. **Daniel M. Zavisza** will serve as Technical Director.

Detroit Society's FOCUS Seminar Draws Record Crowd

On April 12, the Detroit Society for Coatings Technology hosted the 19th Annual FOCUS Seminar at the Michigan State University Management Conference Center, Troy, MI. The seminar drew a record turnout of approximately 160 attendees. The following presentations focused on the theme "New Technologies for Achieving Durable Compliant Coatings":

"New Developments in Waterborne Coatings"—Rich Johnson, of Cargill, Inc.;

"Compliance Options for Auto Assembly Paint Operations"—Frank Hussey, of Durr Industries;

"Low VOC Polyurethane Coatings for Corrosion Control"—Sanjay Luthra, of Miles, Inc.;

"HVLP: Maintaining Quality Appearance and Production Rates in High-Solids and Waterborne Coatings"—John Treuschel, of ITW Finishing Institute, Devilbiss;

"Accelerated QUV Weathering of Clearcoats Studied by Dynamic Mechanical Analysis"—Loren Hill, of Monsanto Co.;

"Coatings Failures: Causes and Remedies"—Eric S. Kline, of KTA-Tator, Inc.;

"Recent Developments in Organic Corrosion Inhibitors for Coatings"—I-Chyang Lin, of Ciba-Geigy;

"Spray Coating Using Carbon Dioxide: A New Pollution Prevention Technology with Application Advantages"—Kenneth Nielson, of Union Carbide Corp.;

"The Role of Water Immiscible Solvents in the Water Resistance of Acrylic/Urethane Paints"—Thomas S. Larson, of Exxon Chemical Co.;

"Paint Degradation and a Smart Injection System"—Peter Bankert, of Graco, Inc.;

"Novel Blocked Isocyanates for Urethane Coatings"—Ronald Wojcik, of Olin Corp.;

"Automotive Applications for Powder Coatings"—Michael Barrett, of H.B. Fuller Co.;

"Field Correlation of Cyclic and Conventional Salt Spray Testing"—M. Jay Austin, of Halox Pigments; and

"Compliant Coatings: Problematic Paints"—Clifford K. Schoff, of PPG Industries.

The Detroit Society members have begun to plan the 20th Annual FOCUS Conference scheduled for April '95.

FOCUS Speakers and Moderators (front row, from left): Peter Bankert, Rich Johnson, Peter Clark, Clifford Schoff, John Treuschel, and I-Chang Lin; (Back row, from left): Michael Barrett, Jim Jakubowski, Thomas Larson, Raymod Stewart, M. Jay Austin (hidden), David Nordstrom, and Loren Hill

Cleveland Society Held Annual Technical Symposium

The Cleveland Society for Coatings Technology held their 37th Annual Technical Symposium at the BFGoodrich Research and Development Center, Brecksville, OH, on May 17, 1994.

The theme for the one-day symposium "Advances in Coatings Technology" was presented in two sessions: "Film Characterization and Properties" and "Chemistry and Physics of Film Formation."

The symposium concluded with the presentation of the Best Speaker Award, which was presented to Peter Kamarchik, of PPG Industries, for his talk on "Coatings Applications of Thermal Mechanical Analysis: Background and Current Practice."

The Cleveland Society's monthly dinner meeting followed the symposium. Vic Stanislawczyk, of BFGoodrich presented "Use of Statistical Methods in Emulsion Polymer Development," as the dinner speaker. At the conclusion of the meeting, attendees were able to tour the BFGoodrich Research and Development Center.

Call For Papers

22nd Annual Waterborne, Higher-Solids, and Powder Coatings Symposium

Sponsored by:
The Southern Society for Coatings Technology
and
The University of Southern Mississippi

February 22-24, 1995
New Orleans, LA

The Southern Society for Coatings Technology and the Department of Polymer Science at The University of Southern Mississippi invite all interested persons to submit papers for presentation at the 22nd Annual Waterborne, Higher-Solids, and Powder Coatings Symposium.

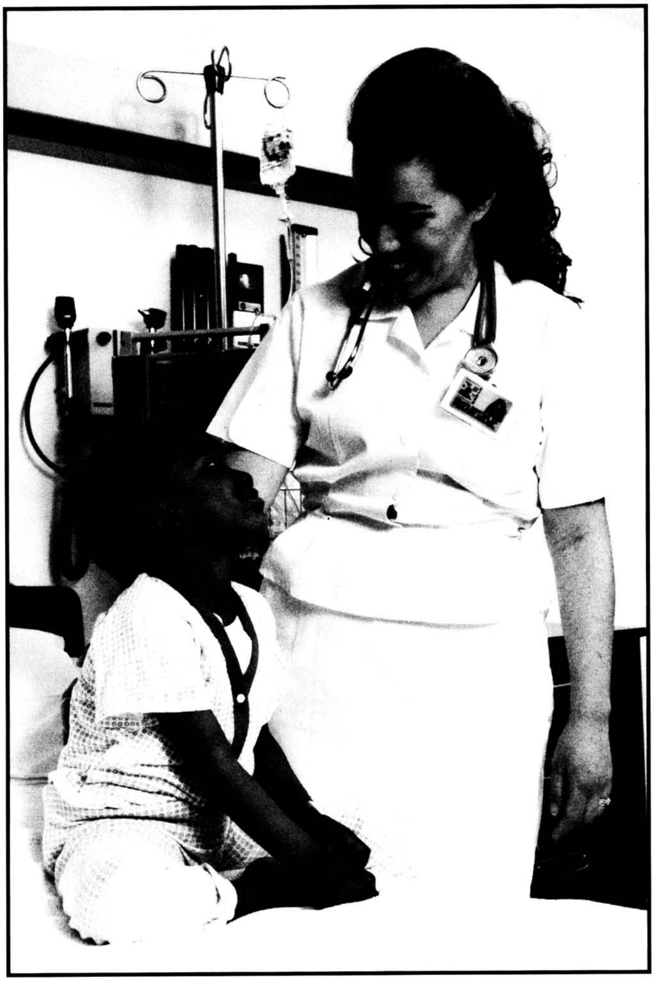
Papers relating to the chemistry, formulation, and marketing of waterborne, higher-solids, powder and other advanced coating systems are solicited. Papers relating to engineering aspects of coating systems or solvent abatement are also solicited.

Title, abstract, and author's name(s) (speaker's name underlined) should be submitted not later than August 15, 1994 to Dr. Robson F. Storey or Dr. Shelby F. Thames, Co-Organizers, WBHS & PC Symposium, Department of Polymer Science, The University of Southern Mississippi, Box 10076, Hattiesburg, MS 39406-0076.

The completed paper should be submitted by December 2, 1994. The preliminary program will be developed based on the submitted abstracts. Manuscripts will be required for inclusion in the Symposium Proceedings.

It is required that all papers be original and of scientific value.

For additional information call (601) 266-5193, or 4475.



Literature

Corrosion Study

A scanning reference electrode technique is the focus of a data sheet. The instrument is used to measure potentials on the surfaces of materials and results from microgalvanic currents produced during corrosion. Contact EG&G Instruments, P.O. Box 2565, Princeton, NJ 08543, for more information on the Model SP100 Planar SRET®.

Circle No. 30 on Reader Service Card

Scientific Catalog

A 2,100-page catalog contains product descriptions and photographs. More than 750 manufacturers and 25,000 products are represented in this full-color publication, which includes technical information and metric conversion charts. A copy of the 1994-95 Thomas Scientific Catalog is obtainable from Thomas Scientific, 99 High Hill Rd., Swedesboro, NJ 08085-1799.

Circle No. 31 on Reader Service Card

Pearlescent Pigments

Information introduces four new grades to a line of white pearlescent luster pigments. These titanium dioxide coated mica pigments are designed for use in surface coatings, printing inks, and plastics incorporation. To obtain technical details on Mearlin® MagnaPearl™ 3000, 3100, 4000, and 5000, contact The Mearl Corp., 41 E. 42nd St., New York, NY 10017.

Circle No. 32 on Reader Service Card

Quality Control

Information introduces a quality control software system. The system features a display of CMC tolerance ellipses, single-key stroke for selecting standards and taking measurements, and exportation of data in ASCII format. Contact Colorgen Industrial Group, Inc., 12 Federal St., Newburyport, MA 01950, details on version 7.1 of Quality Control Software QC2000.

Circle No. 33 on Reader Service Card

Color Measurement Software

Literature announces the network compatibility of a color measurement software system. This system allows multiple users to access data files stored by a single instrument to perform color matching, batch correction, quality control, and data analysis functions, or share a common data base. Literature and a demonstration diskette are available from ColorTec, P.O. Box 386, 74 Main St., Lebanon, NJ 08833.

Circle No. 34 on Reader Service Card

Microscope Analysis

A company introduces a new analysis capability for their line of FTIR Microscopes. This product is designed to enable analysis of coatings and films on metallic substrates to the monomolecular level. Applications include analysis of ultra-thin films and coatings. For further information on the grazing angle objective, write Spectra-Tech Inc., 2 Research Dr., P.O. Box 869, Shelton, CT 06484-0869.

Circle No. 35 on Reader Service Card

Spectrometer

An atmospheric pressure ionization (API) mass spectrometer designed for applications ranging from biotechnological to pharmaceutical to environmental samples is introduced through literature. For further information on the API III*Plus* LC/MS/MS System, write The Perkin-Elmer Corp., 761 Main Ave., Norwalk, CT 06859-0012.

Circle No. 36 on Reader Service Card

Test Machine

A flexible test machine designed to perform different functions with a change of probe and software is described in a press release. Applications include incoming quality control, process control, and process optimization. Write Qualitest, 15 Forest Ridge Dr., Toronto, Ont. M6B 1H2, Canada, for further details on the Pro-Tester.

Circle No. 37 on Reader Service Card

Polyamide Powder

A company announces the availability of four grades of ultrafine polyamide powders. These powders may be used in applications which come in contact with food, in both solvent-borne and waterborne systems, and are designed to be low density and abrasion resistant. More information on Orgasol® additives is available from Elf Atochem North America, Inc., 2000 Market St., Philadelphia, PA 19103-3222.

Circle No. 38 on Reader Service Card

Coating Thickness Measurement

Literature details two coating thickness measurement instruments which feature plug-in smart probes with automatic probe recognition and read/write memory for application-specific data. One is designed for measuring nonferrous coatings and all nonconductive coatings over iron and steel. The other measures nonconductive coatings on nonferrous substrates. For more information on the Deltascope® and Isoscope® MP2C & 3C, write Fischer Technology, Inc., 750 Marshall Phelps Rd., Windsor, CT 06095.

Circle No. 40 on Reader Service Card

Chemical Resistance

A bulletin describes chemical resistance for ambient cure epoxy formulations. Included are reviews of choices available in epoxy curing agents and resins and recommendations of the best options for specific chemical resistance. Application areas include maintenance and marine coatings, floorings, mortars, and grouts. A copy of "Chemical Resistance for Ambient Cure Epoxy Formulations" can be obtained by requesting Publication No. 125-9326 from Air Products and Chemicals, Inc., Pacific Anchor Chemical, 7201 Hamilton Blvd., Allentown, PA 18195-1501.

Circle No. 41 on Reader Service Card

Returnable Container

A patent has recently been issued for a returnable container. The invention relates to a chemical dispenser comprising a container, mechanical metering pump, and a connecting apparatus for the two, as well as to a method for dispensing chemicals which enables the user to return, refill, and reuse the container. More information on the reusable container can be obtained from Drew Industrial Division, One Drew Plaza, Boonton, NJ 07005.

Circle No. 42 on Reader Service Card

Low VOC Waterborne Dispersion

A product release presents a waterborne, oil-modified urethane dispersion for wood finishes and varnishes and architectural and industrial coatings. Reported features include low VOC, fast drying, mar and scuff resistance, easy flatting, and package stability. This product is designed to be flexible and impact resistant. For further details on Spensol® F96, contact Reichhold Chemicals, Inc., P.O. Box 13582, Research Triangle Park, NC 27709-3582.

Circle No. 39 on Reader Service Card

Capabilities Brochure

An eight-page capabilities brochure details a full line of high performance and corrosion resistant coatings. Coatings discussed include those for the chemical, over-the-road transportation, and maritime industries. For a copy of the brochure, contact Advanced Polymer Sciences, Inc., P.O. Box 269, Avon, OH 44011.

Circle No. 43 on Reader Service Card

Fumed Silicas

A bulletin highlights performance characteristics and market applications of a line of fumed silica products. The literature covers fields of uses, applications, and quality control statistics. For more information or a copy of "Basic Characteristics of Aerosil®," write Degussa Corp., Silica Div., 65 Challenger Rd., Ridgefield Park, NJ 07660.

Circle No. 44 on Reader Service Card

Recyclable Solvents

A brochure describes four recyclable solvents designed as replacements for methylene chloride, 1,1,1-trichloroethane, acetone, N,N-dimethylformamide, toluene, and xylenes. Physical properties, recycling information, and formulation are discussed. A copy of "NMP/GBL: The Replacement Solvents," is available from ARCO Chemical Co., 3801 West Chester Pike, Newtown Square, PA 19073.

Circle No. 45 on Reader Service Card

Liquid Dyes

Information on liquid dyes, compatible with water as well as commonly used solvents, has been printed. These dyes are transparent and available in a full range of colors. Uses are found in formulation of non-grain raising coatings for furniture, paneling, molding, and interior metal substrates. For more information on Zapon® liquid dyes, contact BASF Corp., 1255 Broad St., P.O. Box 6001, Clifton, NJ 07015-6001.

Circle No. 46 on Reader Service Card

Dispersion Mill

A dispersion mill that offers continuous or batch operation, variable frequency drive, interchangeable mixing/dispersion heads, and an optional sweep arm has been detailed in technical literature. The mill allows mixing and dispersion for liquid-to-liquid or liquid-to-solid systems. Further details on the Kady 4-in-1 lab mill are available from Kady International, 1276 Pleasant Hill Rd., P.O. Box 847, Scarborough, ME 04070-0847.

Circle No. 47 on Reader Service Card

Urethane Polymer

A new self-crosslinking waterborne urethane polymer for use in wood, concrete, metal, and plastic coatings is introduced in a product release. This polymer reportedly imparts chemical, water, and abrasion resistant properties. Samples, technical data sheets, and formulation data on Sancure® 843 are available from BFGoodrich Specialty Chemicals, Performance Resins and Emulsions Div., 300 Whitney St., Leominster, MA 01453-3202.

Circle No. 48 on Reader Service Card

Polypropylene Insert

A five-gallon, seamless, semi-rigid polypropylene pail insert is described in literature. The insert is vacuum-formed in polypropylene and has an average wall thickness of 15 mils. The liner is designed to keep five-gallon pails clean and in constant use. For a free sample and technical information, contact CDF Corp., 100 Enterprise Dr., Marshfield, MA 02050.

Circle No. 49 on Reader Service Card

Moisture Analyzer

A product release details a moisture analyzer which uses digital-balance technology to detect moisture levels. Features include user-programmable test starts, built-in menu prompts, real-time display of test dynamics, a statistical software package, and automatic data storage. For more information on the MAX-2000 moisture analyzer, contact Arizona Instrument, 4114 E. Wood St., Phoenix, AZ 85040-1941.

Circle No. 50 on Reader Service Card

Wiping System

A company presents its new wet wiping system for surface preparation in a press release. The product is comprised of a container that houses a roll of dry wipers that are activated by pouring a solvent on top and enclosing the system. This system reportedly helps reduce VOC emissions and the chance of chemical spills. More details on the WetTask™ Wiping System are available from Scott Paper Co., Scott Plaza, Philadelphia, PA 19113.

Circle No. 51 on Reader Service Card

Aerosol Monitor

A portable dust/particulate monitor which provides continuous real-time measurement and readouts of airborne particle concentrations has been introduced in a press release. This monitor is designed to measure mass concentrations of airborne dust, smoke, mists, and fumes in industrial and ambient environments. Further details on the DataRAM™ are available from Monitoring Instruments for the Environment, Inc., 1 Federal St., #2, Billerica, MA 01821-3500.

Circle No. 52 on Reader Service Card

Acrylic Dispersion

A high-jet, high-gloss, water-based black acrylic dispersion is the topic of literature. The compound, with a reportedly low VOC, contains no alcohols or surfactants and can be used in flexographic or rotogravure printing inks for film or foil applications and high-jet water-based coatings applications. Samples and information on BS 15877 are available from CDI Dispersions, 27 Haynes Ave., Newark, NJ 07114.

Circle No. 53 on Reader Service Card

Chromatography Catalog

A chromatography catalog and reference guide is now available. This 350-page catalog includes more than 200 GC chromatograms, with 55 being newly published. Featured topics include gas chromatography, capillary electrophoresis, solid phase extraction, and high performance liquid chromatography. For a free copy of the 1994-95 J&W Scientific Catalog and Reference Guide, write J&W Scientific, 91 Blue Ravine Rd., Folsom, CA 95630-4714.

Circle No. 54 on Reader Service Card

Corrosion Testing

Two new volumes in a series on corrosion testing for the entry-level technician have been published. One of these covers galvanic corrosion test methods; the other details techniques and equipment basic to most corrosion tests. Copies of "Corrosion Testing Made Easy: Galvanic Corrosion Test Methods" or "Corrosion Testing Made Easy: The Basics," are available from Nace International, P.O. Box 218340, Houston, TX 77218-8340.

Circle No. 55 on Reader Service Card

Acrylic Emulsions

A company presents two new acrylic emulsions in a product release. One is a pure acrylic terpolymer, for use as a binder in premium quality exterior wood or masonry coatings; the other is a pure acrylic copolymer, for use as a binder in heavy, textured finishes. Further details on Tamcryl 58 and 621 are available from Tambour Ltd., Industrial Zone Akko, P.O. Box 2238, Akko 24121, Israel.

Circle No. 56 on Reader Service Card

Drawing and Stamping Oils

Information is available on two new nonchlorinated drawing and stamping oils. One combines high viscosity oil, rust inhibitors, and a nonchlorinated extreme pressure additive; the other is a low viscosity version of the first. These oils are reportedly rust resistant and nonstaining. Man-Gill Chemical Co., 23000 St. Clair Ave., Cleveland, OH 44117, can provide further information on Magnudraw DO-8A and Magnudraw DO-9A.

Circle No. 57 on Reader Service Card

Polyurethane Prepolymers

Literature details a new polyurethane prepolymer designed to formulate low VOC coatings for two-component and moisture-cure weatherable polyurethane topcoats. Reported benefits include low residual diisocyanate monomer levels and reduction of viscosity with the addition of solvent or temperature increase. Contact Air Products and Chemicals, Inc., 7201 Hamilton Blvd., Allentown, PA 18195-1501, for more details on Airthane® ASN-540M.

Circle No. 58 on Reader Service Card

Errata

In the article, "The Dynamic Contact Angle—A Characteristic to Predict the Lifetime of a Wood Topcoat," by Guido Hora, in the May 1994 issue of the Journal of Coatings Technology, pages 55-59, *Figures* 2 and 3 were inadvertedly transposed. They are correctly shown below. We are sorry for any inconvenience this may have caused.—*Ed.*

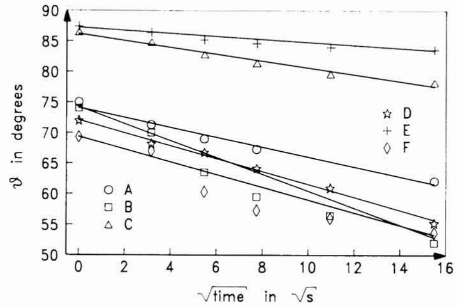


Figure 2—Contact angle time function of the six-month weathered wood topcoats

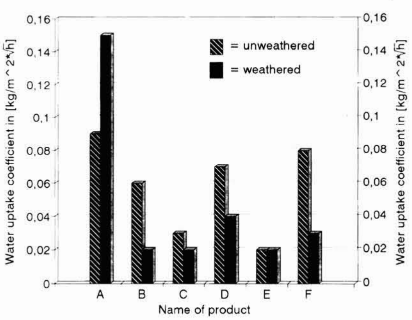


Figure 3—Water uptake coefficient of unweathered and six-month weathered mainly waterborne wood topcoats applied on spruce (products are briefly characterized in the text)

Coming Events

FEDERATION MEETINGS

For information on FSCT meetings, contact Federation of Societies for Coatings Technology, 492 Norristown Rd., Blue Bell, PA 19422 (610) 940-0777, FAX: (610) 940-0292.

1994

(Oct. 12-14)—72nd Annual Meeting and 59th Paint Industries' Show. New Orleans Convention Center, New Orleans, LA.

1995

(Oct. 9-11)—73rd Annual Meeting and 60th Paint Industries' Show. Cervantes Convention Center, St. Louis, MO.

(May 17-21)—FSCT Spring Week. Fiesta Americana Coral Beach Cancun, Cancun, Mexico.

1996

(Oct. 23-25)—74th Annual Meeting and 61st Paint Industries' Show. McCormick Place North, Chicago, IL.

SPECIAL SOCIETY MEETINGS

1994

(Sept. 22-25)—20th Annual Meeting of the Mexico Society. Ixtapa, Zihuatanejo, Mexico. (César Fuentes, ANAFAYPT, Gabriel Mancera 309, Col. Del Valle, 03100 Mexico, D.F. Apartado Postal 44-099; 543-64-88).

1995

(Feb. 20-22)—Western Coatings Societies' 22nd Biennial Symposium and Show. Sponsored by the Golden Gate, Los Angeles, Pacific Northwest, and Rocky Mountain Societies. Hilton Hotel and Towers, San Francisco, CA. (Gordon Pioch, WCSSS Chairman, Eureka Chemical Co., P.O. Box 2205, S. San Francisco, CA 94083; (415) 761-3536).

(Feb. 22-24)—22nd Annual Waterborne, Higher-Solids, and Powder Coatings Symposium. Sponsored by the Southern Society and The University of Mississippi (USM). New Orleans, LA. (Robson F. Storey or Shelby Thames, Co-Organizers, WBHS&PC Symposium, Dept. of Polymer Science, USM, P.O. Box 10076, Hattiesburg, MS 39406-0076).

OTHER ORGANIZATIONS

1994

North America

(July 18-20)—"Basic Coatings for Sales and Marketing Personnel." Short course sponsored by University of Missouri-Rolla (UMR), Rolla, MO. (Cynthia N. Campbell, UMR Coatings Institute, Dept. of Chemistry, 142 Schrenk Hall, Rolla, MO 65401-0249).

(July 28-29)—1994 FLC/TTC Government Laboratory/Industry Technology Transfer Conference. Sponsored by Technology Transfer Conferences, Inc. The Ritz Carlton—Pentagon City, Washington, D.C. (Lucy W. Malone, Technology Transfer Conferences, Inc., 325 Plus Park Blvd, #108, Nashville, TN 37217).

(Aug. 17-19)—1994 Weather-Ometer® Workshop. Sponsored by Atlas Electric Devices Co. Holiday Inn O'Hare, Chicago, IL. (Margaret MacBeth, Atlas Electric Devices Co., 4114 N. Ravenswood Ave., Chicago, IL 60613).

(Aug. 29-30)—1994 Midwest University/Industry Technology Transfer Conference. Sponsored by Technology Transfer Conferences, Inc. Westin Hotel—O'Hare, Chicago, IL. (Lucy W. Malone, Technology Transfer Conferences, Inc., 325 Plus Park Blvd, #108, Nashville, TN 37217).

(Sept. 19-20)—25th Anniversary Symposium. Sponsored by The Polymer Institute/Polymer Technologies, Inc. University of Detroit Mercy. Detroit, MI. (The Polymer Institute, University of Detroit Mercy, 4001 W. McNichols Rd., P.O. Box 19900, Detroit, MI 48219-0900).

(Sept. 26-30)—"Introduction to Paint Formulation." Short course sponsored by University of Missouri-Rolla (UMR), Rolla, MO. (Cynthia N. Campbell, UMR Coatings Institute, Dept. of Chemistry, 142 Schrenk Hall, Rolla, MO 65401-0249).

(Sept. 28-30)—"Accelerated and Natural Weathering Techniques." Short course sponsored by Kent State University, Kent, OH. (Carl J. Knauss, Director, Cooperative & Continuing Education—Chemistry, Kent State University, P.O. Box 5190, Kent, OH 44242-0001).

(Oct. 3-4)—1994 Canadian University/Crown Laboratories/Industry Technology Transfer Conference. Sponsored by Technology Transfer Conferences, Inc. Holiday Inn Crown Plaza Airport Hotel, Toronto, Ont., Canada. (Lucy W. Malone, Technology Transfer Conferences, Inc., 325 Plus Park Blvd, #108, Nashville, TN 37217).

(Oct. 4-5)—"Advanced Radiation (UV/EB) Curing Marketing/Technology." Seminar sponsored by Armbruster Associates Inc. Marriott Hotel, Newark Airport, Newark, NJ. (David Armbruster, Armbruster Associates Inc., 43 Stockton Rd., Summit, NJ 07901).

(Oct. 4-7)—"Introduction to Coatings Technology." Short course sponsored by Kent State University, Kent, OH. (Carl J. Knauss, Director, Cooperative & Continuing Education—Chemistry, Kent State University, P.O. Box 5190, Kent, OH 44242-0001).

(Oct. 10-12)—107th National Meeting of the National Paint and Coatings Association (NPCA). Hilton Hotel, New Orleans, LA. (NPCA, 1500 Rhode Island Ave., N.W., Washington, D.C. 20005).

(Oct. 11-13)—Powder Coating '94. Technical conference sponsored by The Powder Coating Institute. Cincinnati Convention Center, Cincinnati, OH. (Andy Goyer or Vicky Thatcher, Goyer Management International, Inc., P.O. Box 54464, Cincinnati, OH 45254).

(Oct. 12-14)—"Partnering for Corrosion Control." Annual Conference and Exhibition sponsored by National Association of Corrosion Engineers (NACE) International, Southeast Region. Orlando, FL. (Louis MacDowell, Conference Chairman, NASA, Mail Code DM-MSL-22, Kennedy Space Center, FL 32899.).

(Nov. 11-17)—SSPC '94—Annual International Conference and Exhibition. Sponsored by Steel Structures Painting Council (SSPC).Georgia World Congress Center, Atlanta, GA.(SSPC, 4516 Henry St., Ste. 301, Pittsburgh, PA 15213-3728).

(Nov. 13-16)—Third North American Research Conference on Organic Coatings Science and Technology. Sponsored by the American Chemical Society, PMSE Division. Hilton Head, SC. (A.V. Patsis, Institute of Materials Science, State University of New York, New Paltz, NY 12561).

(Nov. 15-18)—"Second Color Imaging Conference: Color Science Systems and Applications." Sponsored by the Society for Imaging Science and Technology (IS&T), Springfield, VA, and the Society for Information Display (SID), Playa del Rey, CA. (Pam Forness, IS&T, 7003 Kilworth Ln., Springfield, VA 22151).

(Nov. 16-18)—1994 Weather-Ometer® Workshop. Sponsored by Atlas Electric Devices Co. Holiday Inn O'Hare, Chicago, IL. (Margaret MacBeth, Atlas Electric Devices Co., 4114 N. Ravenswood Ave., Chicago, IL 60613).

(Dec. 1-2)—1994 Southwest University/Industry Technology Transfer Conference. Sponsored by Technology Transfer Conferences, Inc. Dallas Airport Marriott Hotel, Dallas/Ft. Worth International Airport. (Lucy W. Malone, Technology Transfer Conferences, Inc., 325 Plus Park Blvd, #108, Nashville, TN 37217).

Asia

(Nov. 17-19)—"IndChem '94." World Trade Center, Bombay, India. (R. Rajagopal, Colour Publications Pvt. Ltd., 126-A, Dhuruwadi, A.V. Nagwekar Marg, Prabhadevi, Bombay 400 025, India).

Europe

(Aug. 22-26)—"Advances in Emulsion Polymerization and Latex Technology." Davos, Switzerland. (G.W. Poehlein, OIP/CRB, Georgia Institute of Technology, Atlanta, GA 30332-0370).

(Sept. 14-15)—"Waterborne Coatings and Additives." Symposium sponsored by the Royal Society of Chemistry and the Society of Chemical Industry. Manchester Conference Centre, UMIST, UK. (Carol L. Sharp, Conference Secretary,The Royal Society of Chemistry, 41 Exeter Rd., Davyhulme, Manchester, UK, M41 ORF).

(Sept. 27-29)—"Eurocoat '94." Congress-Exhibition organized by the AFTPV Congress and Exhibition Palace, Sitges, Spain. (Secretariat UATCM, Domicilio Social de la Unión, 5 rue Etex, F. 75018 Paris, France).

(Sept. 28-30)—"Fluorine in Coatings." Conference organized by the Paint Research Association in conjunction with Chemical-Polymer and Chemserve (UMIST). Salford, England. (Conference Secretary, Paint Research Association, 8 Waldegrave Rd., Teddington, Middlesex TW11 8LD, UK).

(Oct. 4-5)—"Polypropylene '94." Conference sponsored by Maack Business Services. Swissôtel, Zürich, Switzerland. (Maack Business Services, Moosacherstrasse 14, CH-8804 AU/Zürich, Switzerland).

(Oct. 24-28)—"Surfactants and Polymers in Aqueous Solution." Course sponsored by the Institute for Surface Chemistry. Athens, Greece. (K. Möller, Institute for Surface Chemistry—YKI, P.O. Box 5607, S-114 86, Stockholm, Sweden).

(Oct. 24-26)—"Speciality Plastics '94." Conference sponsored by Maack Business Services. Swissôtel, Zürich, Switzerland. (Maack Business Services, Moosacherstrasse 14, CH-8804 AU/Zürich, Switzerland).

(Oct. 31-Nov. 3)—"U.K. Corrosion '94" and "Eurocorr '94." Sponsored by The Institute of Corrosion. Bournemouth International Centre, Bournemouth, United Kingdom. (Turret Group plc., 171 High St., Rickmansworth, Hertford, WD3 1SN United Kingdom).

(Nov. 16-17)—"Resins and Pigments '94." Exhibition sponsored by The Paint and Chemical Division of FMJ International Publications Ltd. Bella Center, Copenhagen, Denmark. (Jane Malcolm-Coe, PR & Publicity Manager, FMJ International Publications Ltd., Queensway House, 2 Queensway, Redhill, Surrey RH1 1QS, United Kingdom).

(Dec. 6-7)—"Styrenics '94." Conference sponsored by Maack Business Services. Swissôtel, Zürich, Switzerland. (Maack Business Services, Moosacherstrasse 14, CH-8804 AU/Zürich, Switzerland).

Pacific Rim

(Nov. 6-10)—International Adhesion Symposium. Sponsored by The Adhesion Society of Japan. Tokyo, Japan. (Hiroshi Mizumachi, Professor, Chemistry of Polymeric Materials, The University of Tokyo, Yayoi 1-1-1, Bunkyo-ko, Tokyo 113, Japan).

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1995

North America

(Jan. 14-18)—RCMA 1995 Annual Conference & EXPO. Sponsored by the Roof Coatings Manufacturers Association (RCMA). The Ritz-Carlton Laguna Niguel, Dana Point, CA. (Sally Choquette, RCMA Meetings Coordinator, RCMA, 6000 Executive Blvd., Ste. 201, Rockville, MD 20852-3803).

(Feb. 1-3)—"Bridging the Environment." The Fourth World Congress on Coating Systems for Bridges and Steel Structures. Sponsored by the University of Missouri—Rolla (UMR). Marriott Airport Hotel, St. Louis, MO. (Michael R. Van De Mark or Norma Fleming, 119 ME Annex, UMR, Rolla, MO 65401).

(Feb. 24-26)—"Spring Decor 1995." Sponsored by the National Decorating Products Association (NDPA). Atlanta, GA. (Teri Flotron, NDPA, 1050 N. Lindbergh Blvd., St. Louis, MO 63132-2994).

(Mar. 26-31)—"Corrosion '95." Annual Conference sponsored by National Association of Corrosion Engineers (NACE) International. Orlando, FL. (NACE International, P.O. Box 218340, Houston, TX 77218-8340).

(June 25-29)—"Coating Work in Nuclear Facilities." Symposium sponsored by The National Board of Registration for Nuclear Safety Related Coating Engineers and Specialists. Marriott Hotel, Philadelphia, PA. (Dean M. Berger, Executive Secretary, NBR, P.O. Box 56, Leola, PA 17540).

Advertisers Index

'Humbug' from Hillman

Sid Lauren's penchant for buying second (or more) hand cars brings good fortune to Humbug. On one of his frequent visits to his auto mechanic, Sid found a copy of *Parts Plus* published for the enjoyment of mechanics and their customers. After dallying over the attractive "girlie" photos and the suggestive humor, I finally settled on a few items more acceptable to my Editor.

From the February issue of *Parts Plus*:

Their grass was greener,
their flowers bloomier,
which made my lawn
look all the gloomier—
but winter's here
and now who cares?
My snow is just
as white as theirs.

The skeptic didn't believe in computers so he wrote down a question and fed it to the machine.

Question: "Where is my father?"

Answer: "Your father is fishing off the coast of Florida."

The skeptic knew that wasn't right because his father had been dead for the past 10 years. He then asked the computer the same question, only phrased differently.

Question: "Where is the husband of my mother?"

Answer: "The husband of your mother has been dead for the past 10 years. Your father is still fishing off the coast of Florida."

The Instructor at a company sponsored first-aid course asked one of the workers: "What's the first thing you'd do if you found out you had rabies?"

Worker: "Bite my boss!"

Let's continue last month's list of Borrelle's church bulletin daffynitions:

Marriage: the rite that makes two people one and starts the lifelong struggle to determine which one.

Husband: one who has lost life and liberty in the pursuit of happiness.

Wife: one who knows her mate's stories backwards and tells them that way.

Highbrow: someone who enjoys Brahms bursting in air.

Old Age: the time in life when you feel your corns more than your oats.

Egotist: a fellow with a gleam in his "I".

Not to be outdone, Dick Kiefer sent in a list of definitions to keep on hand in case "IT" comes to pass:

Universal Health Care

When (and if) the new "universal" health care goes into effect...here are some "official" definitions:

Artery	Study of paintings
Bacteria	Back door to cafeteria
Barium	What doctors do when treatment fails
Bowels	A, E, I, O, U
Caesarean Section	A district in Rome
CAT Scan	Search for kitty
Colic	A sheep dog
Congenital	Friendly
D&C	Where Washington is
Dilate	To live long
Enema	Not a friend
Fester	Quicker
Genital	Not Jewish
Impotent	Distinguished; well known
Pap smear	Fatherhood test
Postoperative	Letter carrier
Prostate	Flat on your back
Seizure	Roman Emperor
Terminal Illness	Getting sick at the airport
Vein	Conceited

In case any of our readers wondered, or cared, or remembers—R.J. Bull, of the U.K., kindly supplied me with the true explanations of the parenthesized initials at the conclusion of the "Toe Tac Wally Ti" story in the March column. I was enlightened and if any of you would like the references explained—well, let it go at that!

In any event, friend R.J. concluded by asking: "Why do cats eat cheese?" . . . "To wait outside a mouse hole with bated breath."

Recent great-grandfather Dave Platt cut these quotes from what to me looks like a *Dreyfus Newsletter*:

"Sometimes I get the feeling that the two biggest problems in America today are making ends meet—and making meetings end."—Robert Orben

"A committee is a group that takes minutes and wastes hours."—Anon

"Meetings are like cocktail parties. You don't want to go but you're cross when you're not to be asked."—Jilly Cooper

"Everytime I fill a vacant office I make 10 malcontents and one ingrate."—Louis XIV

—Herb Hillman
Humbug's Nest
P.O. Box 135
Whitingham, VT 05361

The Main Event

Federation of Societies for Coatings Technology
1994 Annual Meeting & Paint Industries' Show

Excellence Through Innovation

October 12•13•14, 1994

Ernest N. Morial
Convention Center
New Orleans, Louisiana

Join the Federation of Societies for Coatings Technology and your fellow coatings professionals from around the world at the 72nd Annual Meeting and 59th Paint Industries' Show, October 12-14, 1994 in New Orleans.

Excellence Through Innovation

... On the Show Floor

The Paint Industries' Show offers a unique learning experience. Excellence Through Innovation centers on the challenges and opportunities facing all professionals in the industry.

- **More than 250 Exhibitors**

... At Technical Program Sessions

The 72nd Annual Meeting will be the best yet, with a variety of technical program sessions running concurrently during the show.

Annual Meeting Technical Session Topics

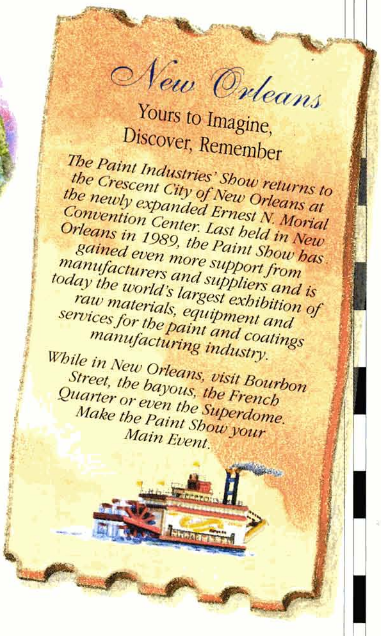
- *Advanced Coatings Research*
- *Color Technology*
- *Corrosion Inhibitive Coatings*
- *Process Safety Management*
- *Low VOC Coatings*
- *Manufacturing*
- *New Technologies*
- *Powder Coatings*
- *Radiation Curing*

... and More!

The Federation of Societies for Coatings Technology
492 Norristown Road, Blue Bell, PA 19422

Find Out How to Make Your Company More Productive, Cost Effective

Key supplier technical and sales personnel will be at the exhibits during the Show to provide you with an opportunity to learn of the latest developments in the industry. Presenters during the technical sessions represent the most progressive and dynamic coatings companies worldwide. You will come away from the Show with new facts that can help you and your company produce a better product and even cut costs.



New Orleans

Yours to Imagine, Discover, Remember

The Paint Industries' Show returns to the Crescent City of New Orleans at the newly expanded Ernest N. Morial Convention Center. Last held in New Orleans in 1989, the Paint Show has gained even more support from manufacturers and suppliers and is today the world's largest exhibition of raw materials, equipment and services for the paint and coatings manufacturing industry.

While in New Orleans, visit Bourbon Street, the bayous, the French Quarter or even the Superdome. Make the Paint Show your Main Event.

*H*ow to Register by Mail or Fax

Join the thousands of coatings professionals who will attend the FSCT Annual Meeting and Paint Industries' Show in New Orleans. A variety of registration options are available to meet most attendee requirements – whether you attend for the entire event or just one day. A social guest program is also available. To be part of the Main Event, please contact the FSCT to receive the Advance Registration Packet.

Registration

	Advance Registration	On-site Registration
Federation of Societies for Coatings Technology Members		
• Full Three-Day Show	$75	$90
• One Day (Wednesday or Thursday)	–	70
• One Day (Friday)	–	40
Non-Members		
• Full Three-Day Show	$100	$125
• One Day (Wednesday or Thursday)	–	90
• One Day (Friday)	–	50
Special Social Program	$60	$70
• Call for program details		

A $10 charge will be made for cancellations received prior to October 1. A $25 charge will be made for cancellations received after that date.

Paint Show Hotel and Shuttle Service

Twelve New Orleans hotels have reserved blocks of rooms for the '94 Paint Show. Official housing forms are provided in the Advance Registration Packet. The cutoff for requesting accommodations is September 1.

Shuttle service will be provided between the cooperating hotels and Ernest N. Morial Convention Center.

For more details on registration, hotel accommodations or to obtain a registration packet, please call the FSCT at (215) 940-0777 or Fax at (215) 940-0292.

VISA, MasterCard and American Express gladly accepted.

Show Hours

Wednesday, October 12
12:00 noon – 5:00 p.m.

Thursday, October 13
9:00 a.m. – 5:00 p.m.

Friday, October 14
9:00 a.m. – 12:00 p.m.

Deadline for Advance Registration is October 1!

Circle No. 9 on the Reader Service Card