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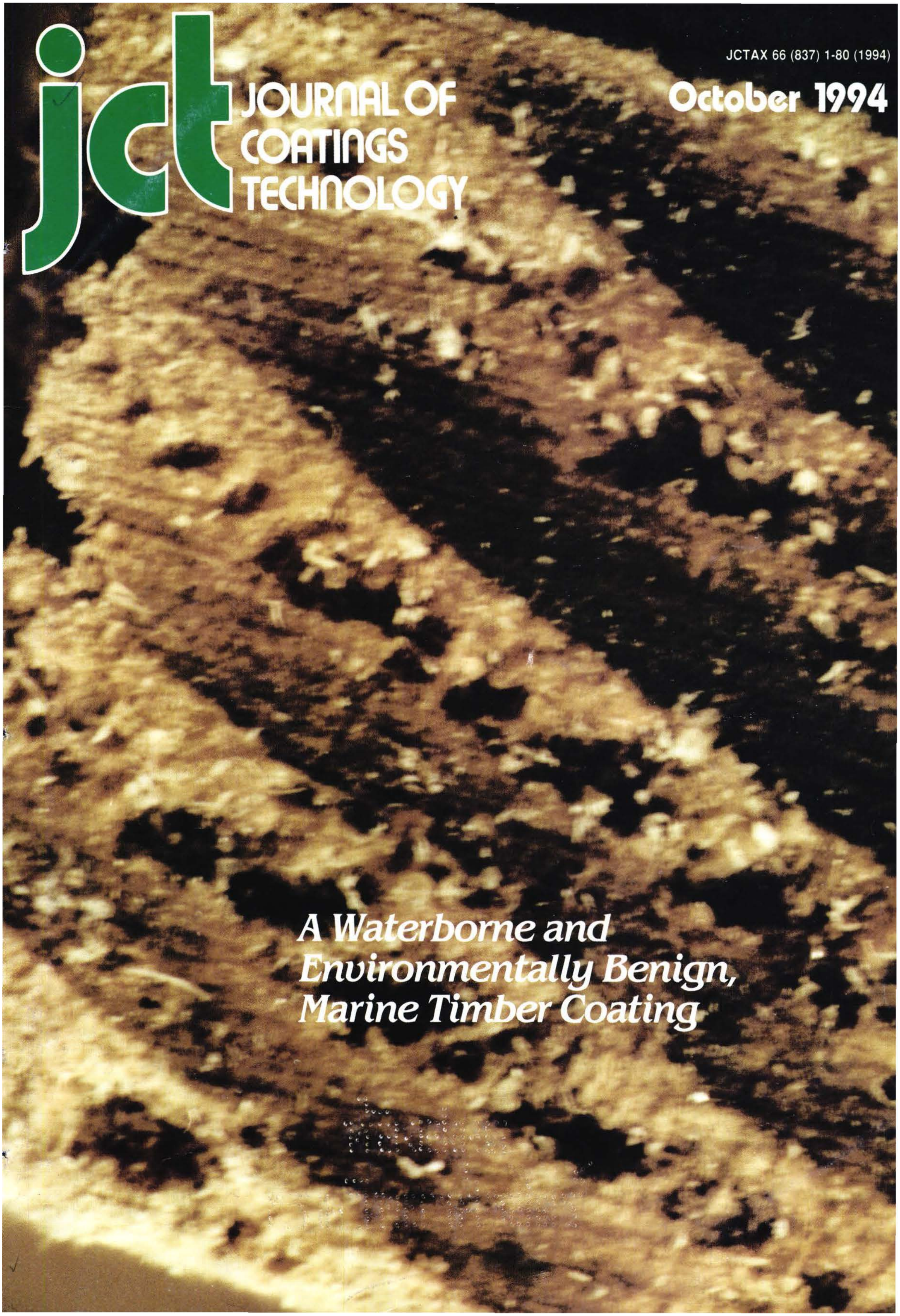

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VOLUME 66 NUMBER 837

Technical Articles

Federation News

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GUIDE FOR AUTHORS

GENERAL

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

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 All manuscripts will be assumed to be previously unpublished writing of the authors, not under consideration for publication elsewhere.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

The Journal of Coatings Technology has first right to the publication of papers presented at the 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.

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

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

Color prints and slides are unacceptable.

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

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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

What Would the Babe Say?

There are many things in life that are a given. Things that we have come to expect, that serve as mileposts on life's highway. And, as we get older and the highway quickly becomes a racetrack, these mileposts become even more important in establishing order in our lives. For those of us who care about these things, who take the time to give thought to life's passages large and small, this month brings not a milepost but a pothole. Something is missing and the void, though not great, does cause us pause in its not being there.

What two world wars and the Great Depression could not do was accomplished by the greed and egos of a select few. For the first time in history a baseball season was canceled. For only the second time in this century a World Series will not be held. You can look it up.

Who's right? Who's wrong? Who cares!

One of the great things about the game of baseball are the parallels found between it and life. The teamwork involved in a double play, the individual's accomplishment in a home run, the success (or lack thereof) over the long haul, and the statistical measurement of performance on a daily, yearly, and career-long struggle.

What does any of this have to do with the coatings industry or the FSCT—or even to us as individuals? References to baseball's problems aside, it's easy to understand that more is accomplished through cooperation and compromise than holding to a dichotomy of spirit.

What great deeds will remain undone? There are lessons to be learned this month. Think about it.

Robert F Ziegler

Robert F. Ziegler
Executive Vice President

Abstracts of Papers in This Issue

(Translation provided by: Cesar Fuentes Carrasco, of Instituto Mexicano de Tecnicos en Pinturas y Tintas. Due to unforeseen circumstances, the French translation is not included—Ed.)

A Waterborne and Environmentally Benign, Marine Timber Coating—B.G. Dixon and W. Gomes

JCT, 66, No. 837, 21 (Oct. 1994)

A novel waterborne coating system, which has significantly advanced the state of the art for protecting wooden structures from the ravages of marine borers, as well as fouling organisms in general, is discussed. The use of an innovative primer layer between the wood's surface and an overlaying protective polymer layer has imparted significantly improved resistance of coated wood samples to attack by wood boring organisms. The proposed technology is also attractive since it involves only environmentally compatible components and is easy to apply.

Chemical Analysis of Painted Thermoplastics by Thermal Degradation GC/MS—W.R. Rodgers et al.

JCT, 66, No. 837, 27 (Oct. 1994)

Paint finishes are an integral part of thermoplastic automotive applications. However, little is known about their chemical/physical behavior under reprocessing conditions or their effect on reprocessed thermoplastic.

Paint film degradation on exposure to 290-300°C in a nonoxidizing atmosphere (simulating thermoplastic processing conditions) was characterized by thermal desorption-gas chromatography/mass spectrometry. Some important conclusions are: degradation of paint systems begins at about 260°C; thermal desorption (Dynamic headspace)-gas chromatography/mass spectrometry is well-suited for studying this degradation; volatile emissions vary according to the paint system, its manufacturer, and the thermoplastic substrate; and some of the volatiles have the potential to degrade polymer substrates.

Chemical Reaction Kinetics of Sulfur Dioxide and Oxygen with Unsaturated Drying Oils—W.H. Simendinger and C.M. Balik

JCT, 66, No. 837, 39 (Oct. 1994)

A gravimetric technique has been used to investigate the reaction kinetics of SO_2, O_2, and mixtures of the two with unsaturated drying oils used in the formulation of alkyd paints, and with the alkyd paint itself. Data could be interpreted in terms of a simple first-order kinetic model based on the concentration of allylic sites in each sample. Rate constants obtained reflected the rate at which allylic sites (or drying oil molecules) were consumed. For reaction with either SO_2 and O_2, the ratio of these rate constants for linolenic and linoleic acid was close to the expected value of 4/3, which is based on the number of allylic sites in each molecule. The rate constant for the alkyd paint was higher than that for the individual drying oils, presumably due to the presence of a catalyst. Experiments in which the drying oils were exposed to mixtures of SO_2 and O_2 showed a much higher mass uptake for the mixture compared to the individual gases. This indicates that a synergistic effect occurs in the mixture which enhances the reactivity of the pure gases with these drying oils.

Recubrimiento Para Vigas Marinas Base Agua, El Cual es Benigno Para el Ambiente—B.G. Dixon y W.Gomes

JCT, 66, No. 837, 21 (Oct. 1994)

Se discute un novedoso sistema de recubrimiento base agua el cual ha tenido un significativo avance en la protección de estructuras de madera contra los destrozos que originan los ataques de moluscos y crustaceos en el mar, así como también contra el ataque de organismos en general. El uso de una capa protector ha impartido un significativo mejoramiento a la resistencia a organismos que fastidian la madera en muestras con este recubrimiento. La tecnología propuesta es atractiva debido a que involucra solo componentes ambientalmente compatibles y es fácil de aplicar.

Analisis Quimico De Termoplasticos Pintados Por Degradacion Termica GC/MS—W.R. Rodgers et al.

JCT, 66, No. 837, 27 (Oct. 1994)

Los terminados de pintura son una parte integral en aplicaciones termoplásticas automotrices. Sin embargo, poco se sabe acerca del comportamiento fisico-químico bajo condiciones de reproceso o su efecto en el reproceso termopi ástico.

La degradación de la película de pintura en exposiciones de 290-300°C en una atmósfera no oxidante (simulando condiciones de procesamiento termoplástico) fué caracterizada por una desabsorción termica de cromatografia de gases y espectroscopia de masa. Algunas conclusiones importantes son: La degradación de los sistemas de pintura empieza alrededor de los 260°C; para el estudio de esta degradación la desabsorción térmica de cromatografia de gases/espectroscopia de masa es mas conveniente; las emisiones volátiles varian de acuerdo al sistema de pintura. Al fabricante y el sustrato termopi astico; algunos de estos volátiles tienen el potencial para degradar a los sustratos poliméricos.

Cinetica de la Reaccion Quimica Del Bioxido de Azufre y Oxigeno con Aceites Secantes Insaturados—W.H. Simendinger y C.H. Balik

JCT, 66, No. 837, 39 (Oct. 1994)

Una técnica gravimétrica esta siendo utilizada para la investigación de la cinética de reacción del SO_2, O_2 y mezclas de ambos con aceites secantes insaturados utilizados en la formulación de pinturas alquidálicas. Los datos pueden ser interpretados en terminos de un modelo cinético simple de primer orden basado en la concentración de sitios alilicos en cada muestra. Las proporciones constantes obtenidas reflejan la porporción a la cual los espacios alilicos (o moléculas de aceite fueron consumidos. Para la reacción ya sea con SO_2 y O_2 el radio para acidos linolénicos y linoleícos en estas proporciones fue m oy cercana al valor esperado de 4/3. La cual esta basada en el número de sitios alilicos en cada molécula. La tasa constante de pinturas alquidálicas fue grande en los que respecta a aceites secantes debido a la presencia de un catalizador. Experimentos en los cuales los aceites fueron expuestos a mezclas de SO_2 y O_2 muestran una masa mayor para la mezcla comparado con la de los gases individuales. Esto indica que un efecto sinergistico ocurre en la mezcla con la cual se engrandece la reactividad de los gases con estos aceites.

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Correlation of Accelerated Exposure Testing and Exterior Exposure Sites—Cleveland Society for Coatings Technology

JCT, 66, No. 837, 49 (Oct. 1994)

The Cleveland Society Technical Committee has undertaken a long-term study which will provide some guidance and basic information for researchers working in the areas of accelerated testing and exterior exposure analysis. The ultimate goal will be the correlation of accelerated test methods to several geographically different exposure sites. The Technical Committee began the study by choosing nine different coatings systems which offer a wide variety of performance characteristics. These systems included a high solids epoxy, a high-solids urethane, several types of waterborne systems (waterborne epoxy, epoxy ester, acrylic, direct-to-metal (DTM) acrylic, water reducible alkyd, and styrenated acrylic) and a Type TT-E-266 specification alkyd. All systems were commercially available and except for the specification alkyd, are considered "compliant coatings."

These systems were placed on exterior exposure at nine different sites across the United States. Four are commonly referred to as heavy marine exposure sites and include Ocean City, NJ; Kure Beach, NC; Daytona Beach, FL; and San Francisco, CA (the Golden Gate Bridge). Three more can be considered moderate to heavy industrial exposure sites and include Cleveland, OH, North Kansas City, MO, and Miami, FL. Another site, the Los Angeles Basin area, is known for heavy smog,. and the last site, Portland, OR, was chosen for high humidity and rainfall. The first six month's exposure results and early correlations within these sites will be discussed, but longer exposure times will be required before many conclusions can be drawn.

These same nine systems have also been tested by use of six accelerated methods according to the protocol established by an ASTM Committee (D01.27.31) on accelerated corrosion testing. The methods include salt fog, cyclic salt fog, Prohesion® Cabinet, Cyclic Prohesion®/QUV®, and cyclic immersion/weathering (KTA-Envirotest®). In addition, positron annihilation lifetime spectroscopy (PALS) will be run at the end of the exposure period on the Daytona Beach panels. These methods are either in use today or have been proposed as more realistic replacements to those in current use. Results of these accelerated tests will be discussed and an attempt made to correlate the results among these accelerated methods.

Future work will focus on direct correlation of the long-term exposure results to the different accelerated methods.

Pueba de Correlacion de la Exposicion Acelerada y Sitios de Exposicion Exterior—Cleveland Society for Coatings Technology

JCT, 66, No. 837, 49 (Oct. 1994)

El cómite técnico de la sociedad de Cleveland ha tomado un largo estudio, el cual provee una guía e información para trabajos de investigadores en las areas de pruebas aceleradas y análisis de exposición al exterior. El cómite técnico empezo con el estudio seleccionando nueve diferentes sistemas de recubrimentos con una amplia variedad en las características de desempeño, se incluvó un sistema epóxico de altos sólidos. Un sistema de uretano de altos sólidos, varios sistemas base agua (epoxico, ester epoxi, acrilico, al quidálico y ester acrilico) y un tipo alquidálico con especificaciones TT-E-266. Todos estos sistemas se encuentran disponibles comercialmente.

Estos sistemas fueron puestos a una exposición exterior en nueve diferentes sitios de los Estados Unidos. Quatro de los cuales son sitios de exposición maritima, dentro de los que se encuentran Ocean, NJ, Kure Beach, NC, Daytona Beach, FL, y San Francisco, CA (en el puente Golden Gate). Tres mas son considerados lugares de exposición industrial moderada como Cleveland, OH, North Kansas City, MO y Miami, FL. Otro lugar en el area de Los Angeles, conocido por la alta contaminación que presenta y por ultimo. Portland, OR, fue seleccionado por la alta humedad que tiene y frequentes lluvias. Los resultados de los primeros seis meses de exposición y una rápida correlación en estos sitios serán discutidos. Sin requerirse un gran tiempo de exposición antes de que muchas conclusiones de presenten.

Estos mismos sistemas se han probado también en seis métodos de pruebra de acuerdo al protocolo del cómite de la ASTM (D01.27.31) de corrosión acelerada. Estos métodos incluven la cámara de niebla galina, de niebla salina ciclica. El cabinete Prohesion®, Prohesion/QUV Ciclico® y el de intemperismo de inmersión ciclica (KTA Envirotest®). Estos métodos son utilizados actualmente o han sido propuestos por su uso frecuente. Los resultados de estas pruebas aceleradas serán discutidos y seran correlacionadas con los metodos acelerados.

Futuros tradajos seran puestos en resultados de correlación directa a exposiciones de largo tiempo.

Federation News

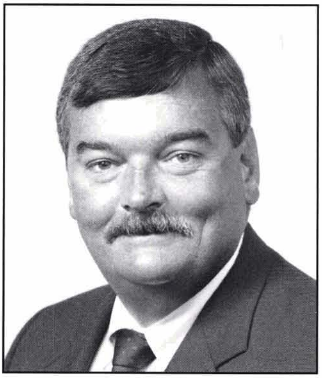
Joseph P. Walton, of Cleveland Society, Elected 73rd President Of the Federation, at Annual Meeting in New Orleans, LA

Joseph P. Walton (Cleveland Society), Executive Vice President, Jamestown Paint, Jamestown, PA, became the 73rd President of the Federation of Societies for Coatings Technology, on October 14, at the Federation's Annual Meeting, in New Orleans, LA.

Darlene R. Brezinski (Chicago Society), President, Consolidated Research, Mount Prospect, IL, was named President-Elect and Jay Austin (Chicago Society), Vice President/General Manager, Halox Pigments Division of Hammond Lead Products, Inc., Hammond, IN, was elected Secretary-Treasurer.

President Walton

Mr. Walton previously served as President-Elect of FSCT and is a member of the Executive Committee. He serves as a member of the Finance Committee, and is an ex-Officio member of the Professional Development Committee. Mr. Walton was a member of the Manufacturing Committee from 1985 to 1992, having served as Chairman from 1987 to 1990. He also was a member of the Annual Meeting Program and the Ad-Hoc Strategic Planning Committees.


J.P. Walton

Mr. Walton is Chairman of the Cleveland Society's Manufacturing and Directory Committees.

He was graduated from Wheeling Jesuit College and has been active in the coatings industry for 21 years. Mr. Walton served as Chairman of the National Paint & Coatings Association's Manufacturing Committee, and is the President of the Cleveland Paint and Coatings Association (CPCA). He was the recipient of the CPCA's Carl J. Byron Distinguished Service Award, the Western Reserve Chapter of the National Management Association's Manager of the Year Award, and the Thiel College Distinguished Service Award.

President-Elect Brezinski

Dr. Brezinski is a member of the FSCT Board of Directors, the Publications Committee, the Editorial Review Board of the JOURNAL OF COATINGS TECHNOLOGY, Co-Editor of the *Federation Series on Coatings Technology*, and Editor of *An Infrared Spectroscopy Atlas for the Coatings Industry (4th Edition)*. She also has served as Chairman of the Annual Meeting Program, George Baugh Heckel, Mattiello Lecture, and Roon Awards Committees. In 1983, Dr. Brezinski was the recipient of FSCT's George Baugh Heckel Award, and in 1991, she received the Union Carbide Award. Dr. Brezinski also is a member of the Gallow's Birds.

She has served as Chairman of the Chicago Society's Technical Committee and was instrumental in the development of the FSCT Panorama™ Coatings MSDS System on CD-ROM.

Dr. Brezinski was graduated from Mundelein College, and received the M.S. and Ph.D. Degrees in Chemistry from Iowa State University. She had served as Chairman of the Chemistry Department at Mundelein, prior to becoming a contributor to the coatings industry some 22 years ago. Dr. Brezinski is currently on the Executive Board of Scientific and Technical Advisors of the American Board of Forensic Examiners, Inc., International, and she recently attained the status of Board Certified Forensic Examiner.

Secretary-Treasurer Austin

Mr. Austin served as Chairman of the FSCT Corrosion Committee for six years (1986-92). He served as a member of the Corrosion Committee and was on the Editorial Review Board of the JCT.

As well as being active in the Federation, Mr. Austin is a member of the Steel Structures Painting Council, National Association of Corrosion Engineers, and the American Society for Testing Materials.

Graduated from Purdue University with a degree in Chemistry, he has worked in the coatings industry for 19 years.

Executive Committee

Gerry Gough (Birmingham Club), Deputy Manager, ICI Packaging Coatings—Holden Surface Coatings, has been elected for a three-year term on the Federation Executive Committee.

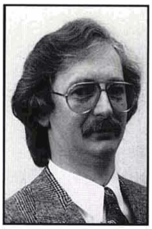
Mr. Gough served as Chairman of the Federation's Society Speaker Awards (1987-88), is a member of the Liaison Committee, and serves as the FSCT's Representative to IUPAC. Mr. Gough has been the Birmingham Club Representative to the Board of Directors since 1990.

He was President of the Club in 1987-88, was Publicity Officer in 1983-84, and served on the Club's Executive, Technical, and Membership Committees. Mr. Gough received the Birmingham Paint, Varnish & Lacquer Club Distinguished Service Certificate in 1994.

(Continued on next page.)


D.R. Brezinski


J. Austin


G. Gough

1994-95 Committee Chairmen Appointed by President Walton

Chairmen of 21 committees of the Federation of Societies for Coatings Technology for 1994-95 have been named by President Joseph P. Walton. A complete roster of all committees will be published in the 1995 FSCT *Year Book*.

An asterisk (*) indicates re-appointment for 1994-95.

Annual Meeting Host—Dennis Cahill, Archway Sales, Inc., St. Louis, MO.

Annual Meeting Program—Louis F. Holzknecht, Devoe Coatings Co., Louisville, KY.

Armin J. Bruning Award—Robert T. Marcus, Pantone Inc., Carlstadt, NJ.*

By-Laws—Thad T. Broome, J.M. Huber Co., Macon, GA*

Corrosion—Mike Jackson, Louisville, KY.*

Educational—Melinda Rutledge, Rheox, Inc., City of Industry, CA.

Finance—John A. Lanning, Courtaulds Coatings, Inc., Louisville, KY.

George Baugh Heckel Award—A. Clarke Boyce, Oakville, Ont., Canada.

Inter-Society Color Council—Ralph Stanziola, Neshanic Station, NJ.*

Liaison—Colin D. Penny, Coatings Technology, Inc., Hampton, VA.

Manufacturing—Don Mazzone, of The O'Brien Corp., S. San Francisco, CA.*

Joseph J. Mattiello Lecture—George Pilcher, Akzo Nobel Coatings, Inc.

Membership Services—Brenda Carr, of Coatings Development Co., Painesville, OH.*

Nominating—John A. Lanning.

Paint Industries' Show—Richard E. Max, of Zarco Industries, Chicago, IL.*

Planning—Richard J. Himics, Daniel Products Co., Jersey City, NJ.

Professional Development—Rose Ann Ryntz, Ford Motor Co., Detroit, MI.

Publications—Robert F. Brady, Jr., of U.S. Naval Research Lab., Gaithersburg, MD.*

Roon Awards—N. Bradford Brakke, of Lilly Industries, Inc., Indianapolis, MN.*

Society Secretaries Awards—John C. Kulnane, Ameritone Paint Corp., Long Beach, CA.

Technical Advisory—Gail Pollano, of Zeneca Resins, Wilmington, MA.*

Delegates to Other Organizations

National Association of Corrosion Engineers (NACE)—Mike Jackson.*

NPCA and Governmental Agencies—Sidney J. Rubin, of Empire State Varnish Co., Brooklyn, NY.*

Steel Structures Paint Council (SSPC)—Mike Jackson.*

FSCT/NPCA Joint Industry Advisory—Colin D. Penny.

Joseph P. Walton Elected President of FSCT

Continued from previous page.

Graduated from Coventry Technical College in 1975, Mr. Gough has been active in the coatings industry for 25 years.

Board of Directors

John J. Oates (New York Society), retired, Past-President of FSCT (1977-78), has been elected for a two-year term on the FSCT Board of Directors.

Mr. Oates has been a member of the Federation for 37 years and was elected to Federation Honorary Membership in 1989. He was a member of the Board of Directors for eight years and has chaired the Annual Meeting Host (1965), By-Laws (1968-69), Annual Meeting Program (1974), Finance (1978-79), and the Liaison (1979-80) Committees of the Federation. In addition, Mr. Oates has also served on the Annual Meeting Program, Educational, Annual Meeting Host, By-Laws, Liaison, Finance, Paint Show, Planning, Nominating, and Ad Hoc Building Committees.

He joined the New York Paint and Varnish Production Club in 1951, and served as a member of the Publicity and Technical Committees. In 1960, Mr. Oates was a recipient of the Society's Roy Kienle Award. After advancing through the chairs, he served as President of the Society in 1962. He also was presented with New York Society's PaVaC Award.

Mr. Oates was graduated with the B.Sc. Degree in Chemistry from the City College of New York, and has done graduate work in Chemistry at Brooklyn College. He was associated with Troy Chemical from 1963 until his retirement in 1988.

He has authored and co-authored a number of technical papers on coatings technology, and has been a frequent speaker before technical groups in the U.S., Europe, and Pacific Rim countries.

Elected to serve two-year terms as Members-at-Large on the Board of Directors are Freidun Anwari (Cleveland Society), Advanced R&D Chemist, Specialty Polymers and Chemicals Div., BFGoodrich Co., Cleveland, OH; and F. Louis Floyd (Baltimore Society), Technical Director, Duron Paints, Beltsville, MD.

Mr. Anwari is Past-President of the Cleveland Society and has been a member of the Society's Board of Directors since 1986. He is a member of the Society's Technical Committee, and served as Chairman from 1987-1992. In addition, Mr. Anwari currently is a member of the Society's Awards, By-Laws, and Program Committees. He also has served as a member of the Audit and Finance Committees. In 1991, Mr. Anwari was presented with the Society's Award of Merit.

He was graduated from North Dakota State University with the B.S. Degree in Chemistry, and from Cleveland State University with the M.S. Degree in Chemistry. Mr. Anwari has been a contributor to the coatings industry for eight years.

Mr. Floyd has served as Chairman of the Federation's Professional Development Committee and as a member of the Annual Meeting Program Committee. In addition, he has been a Trustee of the Coatings Industry Education Foundation and has served on the PRI Board of Trustees. In addition, Mr. Floyd has served on the Editorial Review Board of the JOURNAL OF COATINGS TECHNOLOGY since 1975. He holds four Roon Foundation Awards (1979—Second Prize; 1982—Third Prize; 1986—First Prize; and 1988—First Prize).

Mr. Floyd, who has 40 publications and over 100 presentations to his credit, is a Past Chairman of the Gordon Research Conference on Coatings and Films. Also, he is an active member of the American Chemical Society and several of its divisions.

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FSCT Publishes New Booklets in Coatings Technology Series—"Metal Surface Characteristics" and "Color and Appearance"

A primary goal of the Federation of Societies for Coatings Technology is the dissemination of technical information which will assist members of the coatings industry in the performance of their jobs. One way in which the FSCT achieves this goal is through the publication of its ongoing *Series on Coatings Technology*. Through the Series, readers can be exposed to the wide variety of topics which impact the industry. Authored by leading experts, these booklets provide comprehensive information in an easily affordable source.

Recently two new titles have been added to the Series: "Metal Surface Characteristics Affecting Organic Coatings," by Bruno M. Perfetti, and "Color and Appearance," by Percy E. Pierce and Robert T. Marcus.

* * *

The twenty-third booklet in the Series, "Metal Surface Characteristics Affecting Organic Coatings," provides a general overview of the factors associated with the preparation of the variety of metals which are commonly coated.

Although much has been written concerning the proper treatment and preparation of metallic surfaces for subsequent coating, most of the literature tends to be specific, and focuses on a particular end use. This booklet is addressed from a different perspective—that of the coatings scientist and the metals technologist.

The 74-page monograph helps readers to better understand the nature of the surfaces to which specifically chosen coatings are to be applied. Mr. Perfetti, retired from the Research Laboratory of the U.S. Steel Group of USX Corp., describes the best ways to satisfy the requirements for treatment of these surfaces to optimize the performance of the coatings systems.

The author focuses on some theoretical and technological considerations regarding metal surfaces. Discussion leads to various types of metal substrates and their unique characteristics. Among the metals mentioned are the major carbon and some alloy steels, coated steels with various zinc and alloyed-zinc, aluminum and alloyed aluminum, tin, chromium and paint coatings, magnesium and magnesium alloys, and copper and copper alloys. In the booklet, the author provides information on cleaning and treatment processes for the preparation of metal surfaces for organic coating and painting.

The discussions conclude with brief commentaries on processing operations and equipment, on characterization tests for assessment of surface cleanliness, and on tests for the quality of the pretreatment coatings.

* * *

The 44-page "Color and Appearance" serves as an introduction to the aspects of color and appearance that are relevant to the coatings industry. Topics presented are from the viewpoint of workers in the coating laboratory and production functions. The booklet provides the essential information required to deal effectively with the color and appearance decisions which might be encountered. The monograph also serves as a bridge to more specialized sources of information.

Authors Percy Pierce, of Consolidated Research, Inc., and Robert T. Marcus, of Pantone, Inc., discuss color perception, theories of color vision, color measurement, and the geometric attributes of appearance. Information is provided on color and appearance measurement instruments, color differences and tolerances, color standards, and pigments and color mixtures. The areas of color matching, batch correction, and color matching calculations are covered. The authors detail the creation of a pigment database for computer color matching and conclude with a discussion of hiding power and tinting strength.

A glossary of color terms is provided at the end of the monograph, along with a bibliography of useful sources.

* * *

Development of the Series is under the overall direction of Editors Dr. Thomas J. Miranda and Dr. Darlene Brezinski, of Consolidated Research.

The Series booklets, prepared in an 8 1/2 x 11 format, sell for $15 each, or $10 each with an order of the full set. The FSCT member discounted price is $7.50 each, or $5.00 with a purchase of the full set.

Orders for monographs may be placed by contacting Meryl Cohen, FSCT, 492 Norristown Rd., Blue Bell, PA 19422-2350.

Federation Series on Coatings Technology

"Film Formation"—Zeno Wicks, Jr. (1986)
"Introduction to Polymers and Resins" —Joseph Prane (1986)
"Radiation Cured Coatings"—J.R. Costanza, A.P. Silveri, and J.A. Vona (1986)
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"Corrosion Protection by Coatings"—Z.W. Wicks, Jr. (1987)
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"Application of Paints and Coatings" —Sidney B. Levinson (1988)
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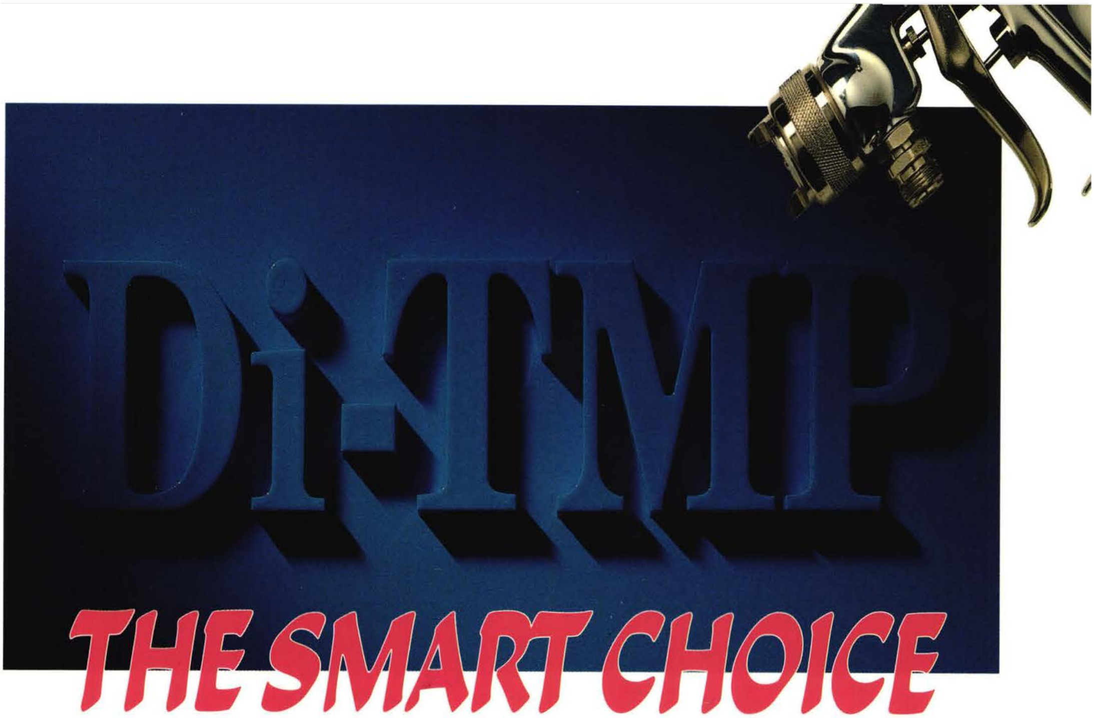
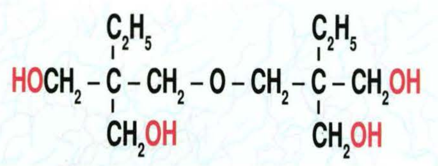
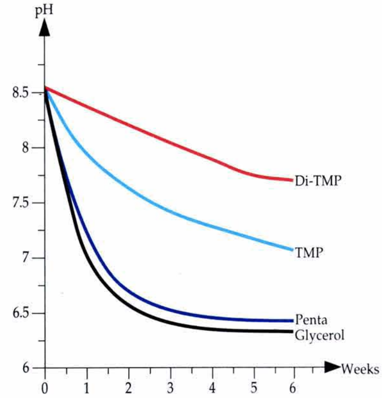




$$HOCH_2-\underset{CH_2OH}{\overset{C_2H_5}{C}}-CH_2-O-CH_2-\underset{CH_2OH}{\overset{C_2H_5}{C}}-CH_2OH$$

Di-TMP in coatings

Increased resistance to hydrolysis
Water-borne polyesters



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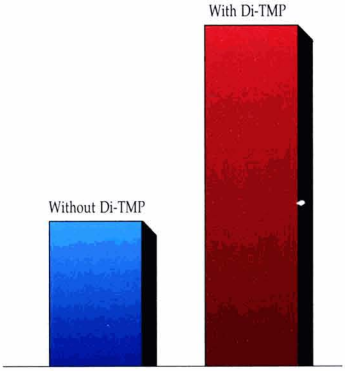
Acid curing lacquers



Di-TMP: Product Profile

Functionality:	4	Molecular weight:	250
OH number:	850–910	Melting point:	110°C
Appearance:	white crystalline flakes		

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Government & Industry

Industry Caucus Supports New Alternative Proposal

According to a report issued by the National Paint and Coatings Association (NPCA), Washington, D.C., the Industry Caucus voted by a two-thirds majority to support a new alternative industry proposal in the regulatory negotiation (reg-neg) for architectural and industrial maintenance (AIM) coatings. The vote was taken during a meeting of industry representatives on August 10.

The proposal, as well as an overview of the vote—supporters and nonsupporters and their reasons—has been provided to the U.S. Environmental Protection Agency (EPA) for its review. The proposal has also been sent to other reg-neg participants, including The Keystone Center, the State/Environmental Caucus, the User Caucus, and ALARM, as well as NPCA's Board of Directors and Executive Committee.

The alternative proposal was drafted based on industry concerns expressed in a series of meetings held this summer to discuss proposals made by EPA on June 3 and July 14. The industry proposal features a regulatory framework designed to achieve a 20% reduction in volatile organic compound (VOC) emission rates in 1996, an additional 10% reduction in the year 2000 (for a total of 30%), and an additional 10% reduction in 2004 (for a total of 40%). The proposal contains tables of standards for 1996 and 2000 to achieve these reductions. Under the 1996 table, the standards listed would have to be met by all products manufactured after July 1, 1996; products manufactured prior to July 1, 1996 could be sold until inventory was exhausted. The 2000 table, effective January 1, 2000, would allow a manufacturer to produce and sell a higher VOC product (up to the 1996 limit) in any category upon payment of an exceedance fee.

For 2004, the industry proposal stipulates that EPA should develop a table of standards by January 1, 2001, and that table would go into effect January 1, 2004. As part of this rulemaking, EPA would be required to determine whether the proposed 2004 limits were technologically and economically feasible, necessary to meet the goals of the Clean Air Act, and supported by existing scientific evidence. The table would also be designed to include exceedance fees.

At the August 10 meeting, the proposal was discussed for several hours before a vote was taken to assess support. While the Industry Caucus voted to support the proposal, the ALARM Caucus voted unanimously to reject it, and instead, recommended that if the reg-neg proceeds, then its own proposal or something similar should be considered. User Caucus representatives at the meeting also voted to support the alternative proposal.

At meetings held July 20 and 27, industry representatives could not come to a consensus to support and instead rejected the EPA's latest (July 14) proposal. In addition, on July 28 NPCA's Executive Committee also agreed to reject the EPA's July 14 proposal and directed staff to continue work with all industry representatives to create an alternative industry proposal. This alternative was the basis for discussion at the August 10 meeting.

If EPA and the other reg-neg caucuses are unable to reach consensus on the alternative industry proposal, the reg-neg will end and the agency will proceed with issuance of a proposed rule through the traditional rulemaking process of publication in the *Federal Register* and the formal solicitation of written comments.

For more information, contact Robert Nelson, NPCA, 1500 Rhode Island Ave., N.W., Washington, D.C. 20005-6272.

Sun Chemical's Colors Group Breaks Ground for New Facility

A groundbreaking ceremony was held in Wavre, Belgium, for Sun Chemical's Colors Group's, Cincinnati, OH, new European headquarters.

Upon completion next January, this facility will house the administrative offices for Colors Group International, the European, Latin American, and Asian arm of the Colors Group. In addition, the 7,000 square meters facility will comprise the administrative offices, sales and marketing offices, technical service laboratories, and warehouse space.

The Wavre headquarters will replace the division's present location in nearby Bierges.

Red Spot to Open Research Facility in October

A research center dedicated to the development of environmentally compatible coatings for plastic is scheduled to be opened by Red Spot Paint and Varnish Co., Evansville, IN, in October.

Located in Evansville, the 53,000 square foot building replaces the current 15,000 square foot center opened in 1968.

The $8.3 million center will house laboratories for research, color development, and testing to customer specifications. Technologies include interior and exterior waterborne coatings, other low VOC coatings, specialty finishes, and adhesion promoters for current and future rigid and flexible plastics. UV-curable coatings research and development is conducted in an 8,000 square foot building dedicated in 1992.

CYTEC Establishes Asia/Pacific Headquarters

CYTEC Industries, Inc., West Paterson, NJ, has established an Asia/Pacific regional headquarters in Singapore. The headquarters is located in the Singapore branch office of CYTEC Hong Kong Ltd.

CYTEC has offices and operations in Korea, Taiwan, Japan, Hong Kong, and Australia, as well as in Singapore. The company will focus its efforts on its core businesses.

CYTEC Industries, Inc. also is a partner with Mitsui-Toatsu Chemicals in Mitsui-Cytec Ltd., a Japan-based joint venture. Mitsui-CYTEC is a major manufacturer of organic polymers and coating resins. In August, the company started up a new 10,00 metric ton manufacturing facility dedicated to producing melamine-based coating resins.

Grow Group Acquires Sinclair Paint

Grow Group, Inc., New York, NY, has completed the purchase of Sinclair Paint, Los Angeles, CA, for $51 million. The acquisition was funded through a combination of cash and borrowings under an existing credit line with a consortium of banks headed by Chemical Bank, which was increased from $40 million to $60 million.

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A Waterborne and Environmentally Benign, Marine Timber Coating

Brian G. Dixon* and Wendy Gomes
Cape Cod Research, Inc.[†]

A novel waterborne coating system, which has significantly advanced the state of the art for protecting wooden structures from the ravages of marine borers, as well as fouling organisms in general, is discussed. The use of an innovative primer layer between the wood's surface and an overlaying protective polymer layer has imparted significantly improved resistance of coated wood samples to attack by wood boring organisms. The proposed technology is also attractive since it involves only environmentally compatible components and is easy to apply.

INTRODUCTION

The protection of wooden structures from the ravages of marine organisms is an age old problem. Historically, timbers to be used in a marine environment were treated with chemicals, such as arsenates, to prevent attack from marine borers such as *Limnoria*, ship worms, and boring clams (*Pholads*).[1,2] More recently, alternative treatment chemicals such as arsenical salts and organotin compounds have been similarly used, either alone or in combination. All of these techniques are only partially successful and suffer from the twin maladies of being environmentally unsound and hazardous.[3-7] In a recent review, Pendleton and O'Neill point out that the current annual cost of all timber piling used in new military construction, and to repair old structures, is about \$50 million.[8] Of this amount, up to half can be attributed to the effects of marine boring organisms. The cost for commercial applications is certainly in the \$100 million range, or higher. It is clear that improved, environmentally sound protection systems are desirable.

As opposed to the other primary fender and piling construction materials, wood possesses the multiple advantages of low cost, high strength, availability, workability, and resilience, among others; however, its lacks durability. Recently, pile wrapping techniques were evaluated and hold considerable promise. In this procedure the timber is wrapped with PVC or polyethylene sheets which physically prevents the borers from coming in contact with the wood. The disadvantage of this approach is that there is no covalent bonding between the dissimilar materials. It would seem that a simple procedure that provides a lot of strong covalent bonds between the hydrophilic cellulose/lignin of the wood and the hydrophobic organic polymer should greatly improve the endurance of the composite. The research described herein details exactly such a procedure, and one which would fit easily into currently employed preservation techniques.

RESEARCH OBJECTIVES

The primary objective of this research was to demonstrate, mainly through a series of ocean tests, that a polymer coated timber substrate that possessed significantly improved resistance to attack by marine boring organisms, such as ship worms, could be prepared. The development of a practical method for the improved adhesion between a protective organic polymer layer, and the cellulose/lignin of the wooden substrate, represents a substantial improvement in the state of the art of protecting wood in an environmentally acceptable fashion.

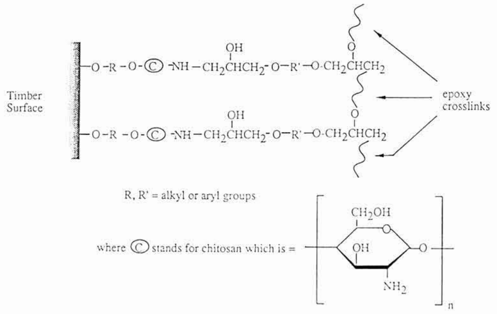
The basic approach involved creating superior covalent bonding between the wooden substrate and a protective epoxy topcoat such that boring organisms would be denied access to the wood. The key to the success of the approach lay in the bonding layer that held the epoxy and wood layers together. By design, this bonding layer was supposed to do double duty, first as a strong adhesive and then as a repellent to any organisms which might penetrate through the outer layer.

---

*Presented by Dr. Dixon at the Twentieth Waterborne, Higher-Solids & Powder Coatings Symposium in New Orleans, LA, February 24-26, 1993.

[†] 19 Research Rd., East Falmouth, MA 02536.

An idealized structure of the final composite material is shown:



The thin adhesive layer was composed primarily of chitosan. Chitosan is a naturally occurring glucose-amine biopolymer derived from seafood processing wastes, especially crabs and shrimp. It is very close in structure to cellulose, and therefore, very compatible. It was used to covalently bond the many reactive hydroxyl and phenolic groups of the wooden cellulose/lignin surface with an appropriate protective organic layer. Chitosan was perfect, in that it can be cast from a dilute acidic solution and dried to form a beautiful film onto wood. Above a pH of 7, it is very insoluble in water; therefore, in seawater it would not redissolve. A critical factor in choosing chitosan for the bonding layer was the presence of the amino group. It was hoped that the amine group would react with the epoxide groups of the exterior epoxide coating. It was also expected that there would be many of these covalent bonds, since chitosan possesses one amino group per monosaccharide ring, and they were to be evenly distributed over the entire surface of the wood.

Glutaraldehyde was used as the dialdehyde which would irreversibly connect the chitosan rings to the cellulosic base of the wood with strong ether linkages. In essence, the combined glutaraldehyde-chitosan layer was a primer. The epoxy resin applied next reacted with the amino groups to form a strong, well-bonded exterior that was found to be impermeable to marine borers.

EXPERIMENTAL

Wood, Chitosan, and Glutaraldehyde Solutions

Untreated yellow pine was cut into 7.5 × 10 cm lengths. These lengths were then lightly sanded using a belt sander. They were all weighed before they were dried in the drying oven ~2 hr at 30°C and were reweighed.

A 4% (wt) acetic acid solution was prepared. Enough chitosan was added to make a final concentration of ~3% (wt), and the mixture was stirred vigorously at ~60°C for two hours. This mixture was then filtered and refrigerated until needed. Glutaraldehyde was dispensed from 50% (wt) aqueous solutions.

The coating process was simply carried out by sequentially painting on (when called for) the glutaraldehyde solution, followed by the chitosan solution, and finally the epoxy resin. Between each step, the substrate was dried briefly at ~40°C.

Epoxy Formulations

A typically coating formulation for the amine-cured epoxy was: 19.0 g of DER 331 (Dow Chemical Co., 190 g/mole epoxy groups) and 11.5 g of 1,4-diaminocyclohexane were stirred, with or without filler, and the viscous mixture evenly painted onto the desired substrate. A typical coating procedure for the waterborne epoxy case was: 10.65 g of DER 331, 14.7 g modified polyamide (300 g/mole NH_2 groups) and 46 g of H_2O were stirred until a smooth mixture was obtained. When necessary, fillers were then mixed in as well. The mixture was painted onto the desired surface, and the resultant composite left to cure overnight at ambient temperature. In all cases, the samples were left to fully cure for a week.

Coating Physical Properties

The variously prepared coatings were tested for some basic physical properties, besides the very qualitative visual observations which have already been noted. Each of the various panels was tested for a few physical and adhesion properties prior to the actual biofouling tests. All of the formulations were observed to adhere very well to the various substrates used, as might be expected for epoxy based systems. Adhesion tests, carried out according to the standard ASTM 3359 method, resulted in a rating of 5B, which is the highest possible rating. In no instance was a delamination or peeling of a sample from the substrate observed.

Coating hardnesses were determined using the pencil hardness test, according to ASTM 3363, and resulted in hardnesses of 4 in a scale of 1-8. After exposure for 10 weeks, the hardnesses remained unchanged.

Analytical

Product identification was done primarily using Fourier Transform Infrared Spectroscopy (FTIR, Perkin-Elmer model 1600). The course and rate of the reactions were determined by following the disappearance or appearance of an empirically determined IR peak which is due solely to a reactant or product. The results led to the establishment of optimum reaction conditions for each case. The disappearance of the oxirane ring of the epoxy group, at ~850 cm^{-1}, was used to follow the epoxy cure as a function of time. In addition, the amino group of the chitosan, at ~1630 cm^{-1}, was also a characteristic peak which was used to establish the presence of the chitosan film on the wood surface.

Specular reflectance was used to characterize film coatings. This technique allows for the analysis of flat, coated surfaces and provides information concerning the chemical composition of such coatings. For this study, this was an especially attractive technique. Diffuse Reflectance using Fourier Transform Infrared Spectroscopy (DRIFTS) was also used, and is a useful method for analyzing solids in general. This method involved irradiating the sample, then measuring the spectrum of the scattered radiation relative to the spectrum of a non-absorbing standard such as KCl or KBr. The products were analyzed by this method as a three percent powder in KCl or KBr.

Table 1—Experimental Variables—Amine Cured and Waterborne Epoxy Formulations

	Sample Number									
Variable	1	2	3	4	5	6	7	8	9	10
Wooden panel	x	x	x	x	x	x	x	x	x	x
Glutaraldehyde		x		x	x		x	x	x	x
Chitosan			x	x		x	x	x	x	x
Amine cured epoxy					x	x	x		x	
Waterborne eopxy								x		x

RESULTS AND DISCUSSION

The experimental protocol involved testing both waterborne and conventional epoxies. As will be shown, the waterborne versions were found to perform as well as the conventional materials.

Wooden Substrates, Chitosan, and Glutaraldehyde Films

Commercially available and untreated 1 × 3 in. yellow pine was used in all cases as the wooden substrate. The edges and back of the samples were treated as well as the front surface. Chitosan films were cast from dilute aqueous acid solution onto the wooden surface. Chitosan is an excellent film former and was found to form strong, resilient, thin films on the wood. Glutaraldehyde was chosen as the dialdehyde to crosslink the chitosan films from the cellulosic substrate to the overlaying epoxy layer.

All of the samples were prepared in quadruplicate, and samples were periodically pulled and examined. For each set of samples that was put in the ocean, quadruplicate sets of plain wood samples were placed there as controls.

Epoxy Formulations Made Using the Amine Curing Agent

The timber samples were coated in three basic steps. The first layer to be painted onto the wood surface was a 50% (wt) aqueous glutaraldehyde solution which was then dried. The four percent acetic acid/chitosan solution was then similarly coated onto the wood and also dried. The final layer consisted of premixed DER 331 (Dow Chemical, Midland, MI), and the curing agent 1,4-diaminocyclohexane, which was also painted onto the wood and dried. After each step, the samples were weighed. The samples were then attached to a large plywood or aluminum panel, left to fully cure at ambient temperatures for a week, and then deployed into the ocean.

The various coatings included many variable combinations as shown in *Table* 1.

The photograph in *Figure* 1 is an amine-cured epoxy coated wood sample prior to deployment in the ocean.

Waterborne Epoxy Formulations

The wooden samples were coated in basically the same manner as described previously, with the exception that a water-based curing agent-epoxy system was employed. DER 331 was still the epoxy used, but the curing agent was a modified polyamide, which also served as a surfactant that made the 331 compatible with water. An important point is that this coating system contained no hazardous materials or VOCs. The waterborne epoxy mixture also handled well, and evenly coated the wood surfaces as shown by *Figure* 2. All of the coatings were aesthetically pleasing.

Filled Coatings

A series of waterborne coating tests were run using fillers to give higher strengths and resilience to the epoxy formulations. The chosen fillers included titanium dioxide, chitosan, chitin, zinc, zinc oxide, and a combination of zinc and zinc oxide together. Other than the fillers, the same experimental variables were used as in the previously described examples. The fillers were combined in the epoxy resin, curing agent, and water at loadings of between 5 and 30% by weight. These were then coated onto the timber samples, as described previously, to yield strong, even coatings on the wood.

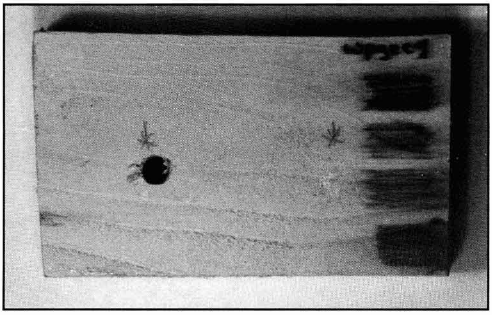


Figure 1—Amine-cured epoxy coated wood sample—unexposed

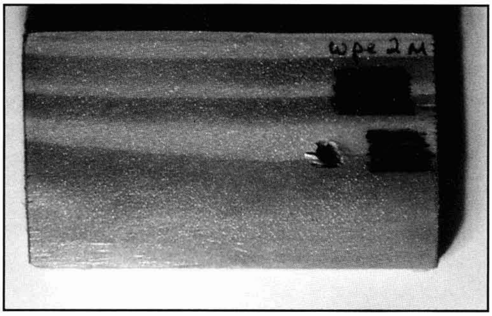


Figure 2—Waterborne epoxy coated wood sample—unexposed

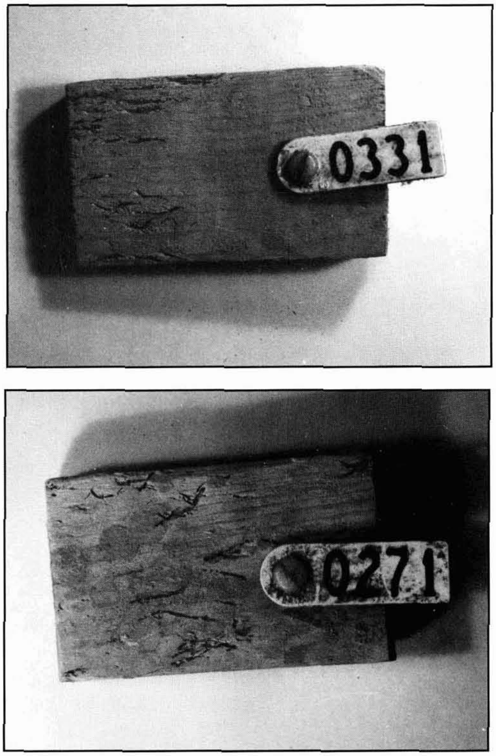


Figure 3—Untreated wood samples—10 weeks of exposure

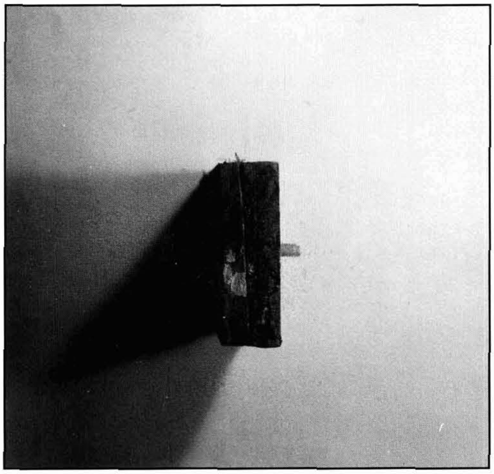


Figure 4—Chitosan treated wood samples—10 weeks of exposure

Figure 5—Glutaraldehyde treated wood samples—10 weeks of exposure

Ocean Test Protocol and Biofouling Results

The ocean test site chosen was the inner harbor at New Bedford, MA, which is a very high biofouling area during the summer, and which Cape Cod Research has used extensively in its ongoing antifouling paint testing program. The testing was carried out between May and September of 1991.

After all of the coatings had been completed and dried, the timber samples were attached to the large plywood or aluminum panels and tagged for identification. They were then deployed into New Bedford harbor. They were placed onto the large wooden panels which allowed for the continuous exposure (submersion) of the samples to seawater. They were checked every two weeks for obvious holes and, after longer periods, some were pulled for inspection of marine borers.

One of each sample type was pulled after 10 and 20 weeks of exposure and analyzed. The samples were cut longitudinally in several places in order to discern if there were any marine borers still in the wood and, if so, how far into the wood they had bored. In every case, the control samples (untreated wood) had the appearance of a jigsaw puzzle. That is, they were riddled with the paths made by marine borers, as can be seen in the photographs of *Figure* 3.

The most significant result in this project was that there was a clear correlation between the degree of borer attack

Figure 6—Glutaraldehyde, chitosan, and amine cured epoxy—10 weeks of exposure


Figure 7—Glutaraldehyde, chitosan, and waterborne epoxy—10 weeks of exposure


Figure 8—Glutaraldehyde, chitosan, and waterborne Zn/ZnO-filled epoxy

upon the wooden samples and types of coating treatment they had received. As one progresses through the list of coatings from control (no coating) to full treatment (glutaraldehyde, chitosan, epoxy resin, with or without filler), a large difference is seen in whether or not the marine borers were capable of attacking the wood. For example, the samples that were coated only with chitosan had holes, but the holes and paths were selective and only along the grain, as shown in *Figure* 4.

The samples that only had glutaraldehyde on them as a coating had holes and paths, but again, these holes and paths were along the grain of the wood, as seen in *Figure* 5.

The samples with both glutaraldehyde and chitosan as coatings did not fare much better. They had the same problems as the ones shown in *Figure* 5, with the paths going along the grain of the wood. The samples that were coated with only the epoxy also suffered the same fate as the others, in that the paths were along the grain of the wood, usually on the ends of the timber samples. The most interesting samples were the ones that had the full treatment of coatings; glutaraldehyde, chitosan, and the epoxy resin. After 10 weeks of exposure, these samples had no holes or paths through the wood at all. After 20 weeks, there was still no attack. This result was observed for both the amine-cured epoxy, and the waterborne ones. The obvious advantages to the waterborne system are that it is environmentally sound and does not involve hazardous materials, such as diamines. The results are shown in *Figures* 6 and 7.

In general, the filled samples performed as well as, but no better than, the unfilled specimens. Some of the fillers added an antifouling property to the coatings, as well as strength. *Figure* 8 shows an example of the filled specimens after 10 weeks of exposure.

SUMMARY AND CONCLUSIONS

This research demonstrated the feasibility of preventing marine borers from destroying wood through the use of a novel coating technology. The extension of the research to a waterborne system means that these coatings will be easy to apply, safe to handle, and be environmentally benign. More specifically, the following points can be made:

(1) The work has established that the proposed cellulose-glutaraldehyde-chitosan-epoxy sandwich coating provides exceptional protection to wooden substrates from attack by marine borers.

(2) It has been shown that a coating, based upon a new waterborne epoxy-based technology, provides protection that is just as good as classical amine cured epoxy resins.

(3) The new waterborne formulation contains no hazardous components or volatile organic compounds (VOCs).

(4) All of the composite coatings adhered very well to the wooded substrates over the course of all of the testing periods.

(5) Even unfilled, the composite coatings possessed excellent physical properties, including hardness and durability. They were even better when filled. Brittleness and/or cracking of the coatings was never observed.

(6) The coatings were aesthetically pleasing, possessing a satin-like sheen.

An expanded research and development program is currently underway whose goals are to optimize the formulation and to establish the long-term protective capabilities of the waterborne epoxy technology.

ACKNOWLEDGMENT

The support for this work by the National Science Foundation under Grant Number ISI-9060131 is gratefully acknowledged.

References

(1) (a) Hasson, D.F. and Crowe, C.R., *Materials for Marine Systems and Structures*, Academic Press, Orlando, FL (1988); (b) Evans, L.V. and Hoagland, K.D., *Algal Biofouling*, Elsevier Science Publishers B.V., New York (1986).

(2) Costlow, J.D. and Tipper, R.C., *Marine Biodeterioration: An Interdisciplinary Study*, Naval Institute Press, Annapolis, MD and references therein.

(3) Gitlitz, M.H., "Recent Developments in Marine Antifouling Coatings," JOURNAL OF COATINGS TECHNOLOGY, *53*, No. 678, 46 (1981).

(4) Atherton, D., Verborgt, J., and Winkeler, M.A.M., "New Developments in Anti-Fouling: A Review of the Present State of the Art," JOURNAL OF COATINGS TECHNOLOGY, *51*, No. 657, 88 (1979).

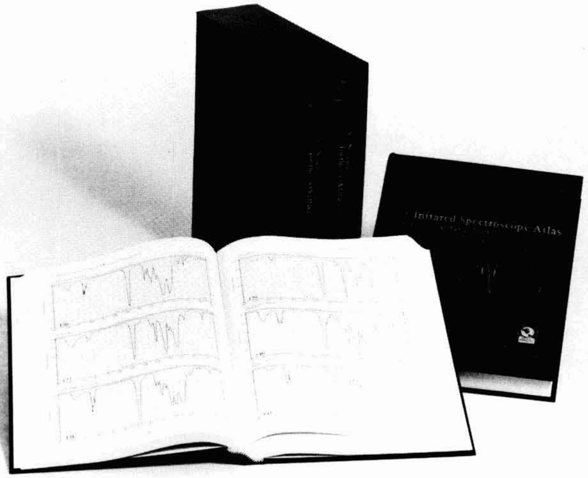
(5) Thomas, T.E. and Robinson, M.G., *Marine Environmental Research*, *18*, 215 (1986).

(6) Champ, M.A. and Lowenstein, F.L., *Oceanus*, *27*, 69 (1987).

(7) Clark, E.A., Sterritt, R.M., and Lester, J.N., *Environ. Sci. & Tech.*, *22*, 600 (1988).

(8) Pendleton, D. and O'Neill, T., Naval Civil Engineering Laboratory, Technical Note #N-1773, June 1987.

An Infrared Spectroscopy Atlas for the Coatings Industry



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Chemical Analysis of Painted Thermoplastics by Thermal Degradation GC/MS

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D.P. Thorton, and N. Somers*
General Motors Research and Development Center[†]

Paint finishes are an integral part of thermoplastic automotive applications. However, little is known about their chemical/physical behavior under reprocessing conditions or their effect on reprocessed thermoplastic.

Paint film degradation on exposure to 290-300°C in a nonoxidizing atmosphere (simulating thermoplastic processing conditions) was characterized by thermal desorption-gas chromatography/mass spectrometry. Some important conclusions are: degradation of paint systems begins at about 260°C; thermal desorption (dynamic headspace)-gas chromatography/mass spectrometry is well-suited for studying this degradation; volatile emissions vary according to the paint system, its manufacturer, and the thermoplastic substrate; and some of the volatiles have the potential to degrade polymer substrates.

INTRODUCTION

The automotive industry has interests in the physical degradation of painted thermoplastics that may occur during reprocessing/recycling since the degradation of thermoplastic properties may render the plastic non-reuseable for the same vehicle application. Painted scrap may be produced at the primary level of recycling, during manufacture, and at the secondary level marked by the end of the life of the vehicle.

Labels and guidelines on "what is recyclable" are appearing in industrial and governmental literature.[1,2] The automotive industry follows Society of Automotive Engineers (SAE) J1344 as a labeling guideline to identify polymers.[1] However, painted polymers do not necessarily fall under this guideline. Since the definitions of "recycle," "re-process," and "degradable" are not well-defined or understood by government, industry, and society, we do not attempt to attach these definitions to this study.[2] The intent of this study is to begin to understand the chemical phenomena occurring when painted plastic is exposed to processing conditions for a second time. The chemistry and the physical properties of painted polymers are not yet well-understood. Studies concerning the recyclability of automotive materials, and in particular the thermal stability of polymeric body panel applications, have concentrated on the ability of the polymers to physically withstand exposure to repeated processing cycles. In this study, we mimic the heat conditions applied to painted thermoplastics and chemically analyze the compounds evolved to gain insight to possible causes of polymer degradation in re-processing of painted thermoplastic scrap.

An automotive paint finish usually includes a primer coat, a pigmented base coat, and a protective clearcoat. Polyolefin substrates may also be coated with an adhesion promoter prior to conventional paint processes. In addition, a typical source of scrap would consist of a variety of color/manufacturer combinations; therefore the nature of the paint "contamination" is complex and variable. The analytical technique employed here, thermal desorption-gas chromatography/mass spectrometry (TD-GC/MS), permits one to thermally evolve compounds from a sample in a controlled manner with subsequent separation and identification of the compounds.

Pyrolysis is defined as the conversion of a substance to another substance by the use of heat alone. Analytical pyrolysis is typically used to characterize the original sample by identifying the pyrolysis products.[3] This technique has been utilized throughout the history of man, and is not a "new" or re-invented technique. Customarily, the term "pyrolysis" has been associated with studies of substances at

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Table 1—Chemical Species Evolved from Paint Formulations at 300°C

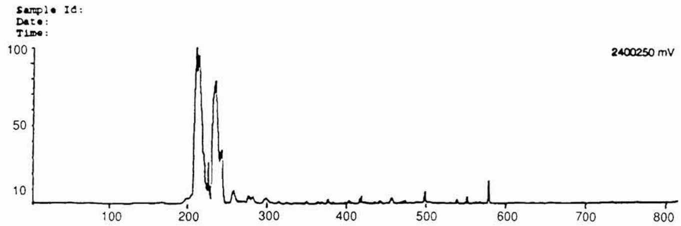
Paint Fims	MSDS Chemical Information	Major Components Evolved
Primer	Polyester resin, melamine	Alcohols, amides, methacrylate, cyclic ketones
Clearcoat	Acrylic resin, xylene, ethyl benzene, aromatics, melamine formaldehyde resin, aliphatic polyisocyanates	Methacrylates, acrylates
Basecoat 1	Water, reacted polyurethane resin, or acyric resin, melamine formaldehyde resin, ethylene glycol butyl ether, TiO_2	Methacrylate, butane/butene, cyclobutane, acrylates, phenols, styrene, butanol
Basecoat 2	Water, methylated melamine-formaldehyde resin, propylene glycol, alcohols, acrylic resin	Ethylene glycol, amines/amides, alcohol
Adhesion promoter	Not available (known: styrene, alkyd)	Styrene, phthalic anhydride, methacrylate

temperatures over ~300-400°C in an inert atmosphere, while the terms "off-gassing, headspace (dynamic or static), thermal desorption, thermal degradation" refer to studies of substances at temperatures below ~300-400°C.

The gas chromatograph (GC) detector, where one matches retention times of a component from a pyrolyzed sample with a set of standards, is the standard method used to detect off-gassing or pyrolysates [4, and references therein]. Many studies identifying and quantifying chemical components, from substances such as coal shales and rubber to seaweed, have been reported by using pyrolysis or thermal desorption techniques [5, and references therein]. Skilled chemists with samples of known origin and standards are successfully utilizing GC, infrared, and NMR analyzers to chemically identify the compounds thermally evolved from samples. A closed system where a sample is heated and directly introduced into a detector, such as a mass spectrometer (MS), is preferred.[5,6] Many researchers incorporate various mass spectrometry techniques to identify the oligomers[6] and molecular weight distributions of polymers.[7]

Table 2—Polycarbonate, Acrylonitrile/Styrene Butadiene

Major Compounds Evolved	Possible Sources
Ethylbenzenes, styrene	ABS
Propylbenzenes	Polycarbonate
Benzaldehyde	Polycarbonate



No.	Scan	Time	Name	Area	Amount	%Total
1	211	10:33	Ethylbenzene	24063700.	100.00	54.96
2	235	11:45	Styrene or 1,3,5, 7-Cyclooctatetraene	16440100.	68.319	37.55
3	258	12:54	Trimethyl or ethyl methyl benzene	953182.	3.961	2.18
4	277	13:51	Propylbenzene	403316.	1.676	0.92
5	283	14:09	Benzaldehyde	362996.	1.508	0.83
6	299	14:57	Isocyanobenzene or Benzonitrile	616605.	2.562	1.41
7	419	20:57	MW = 168, Hydrocarbon	163044.	0.678	0.37
8	499	24:57	MW = 158 or 3-Cyclohexen-1-yl-benzene	299007.	1.243	0.68
9	579	28:57	Naphthalenecarbonitrile or Isocyantonaphthalene	481403.	2.001	1.10

Here, we use computer controlled dynamic headspace sampling, thermal desorption, at a specified heating rate and time, and directly introduce the evolved gaseous sample into the gas chromatography-mass spectrometer detector system. This allows us to evolve, isolate, separate, and collect identifiable data of each sample without manually manipulating the sample between each step. We also utilize cryocooling of the gaseous sample to improve the chromatography of the sample. This system permits sensitive sample collection with minimal sample loss and duplication of conditions used in automotive painted thermoplastic re-processing. Advances in computer software for data collection and data searching coupled with a mass spectrometer allow us to identify complex mixtures which could not be accomplished using systems of the recent past. The extensive mass spectrometer library databases, raw data interpretation, and available resources permit identification of the data collected.

This study represents an initial observation on the complex interactions between paints and thermoplastic body panels at reprocess/recycle temperatures which are approximately 300°C. The samples are compilations of several (at least three) paint layers on selected thermoplastics. This study is a unique application of TD-GC/MS because the conditions used optimally simulate thermoplastic re-processing of automotive body panels and are not necessarily the same conditions used to optimize gas chromatographic conditions. The purpose of this experiment was to characterize the thermal stability and volatile degradation products of exterior paint systems on selected thermoplastics upon exposure to temperatures up to the reprocess/recycle temperature of 300°C.

EXPERIMENTAL

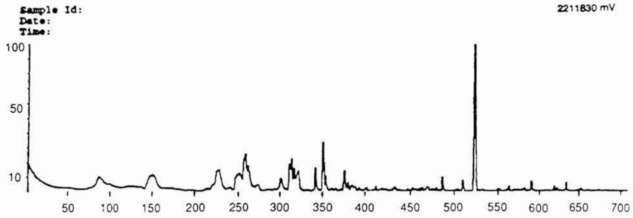
Thermal Desorption-Gas Chromatography/ Mass Spectrometry Analyses (TD-GC/MS)

Samples were analyzed by TD-GC/MS with dynamic head space sample collection and cryocooled sample focusing. The programmable pyroprobe apparatus reproducibly heated samples and thermally desorbed volatiles. The collected volatiles were subsequently separated by gas chromatography and the components identified by mass spectrometry.[8-10] This semi-quantitative dynamic head space study provides insight into thermal stability and identifies volatile degradation products of polymers and paints at elevated temperatures (290-300°C). Thermogravimetric data confirmed that the threshold temperature for polymeric degradation in these samples is between 260-270°C.[11-12]

MATERIALS: The paint, thermoplastics, and painted thermoplastic materials were supplied by a manufacturing site after processing. These materials are proprietary in nature; therefore, all descriptions are qualitative only (*Tables* 1-7). For the purpose of analysis, paint samples were prepared on glass slides using normal production conditions.

Table 3—Polycarbonate, Acrylonitrile/Styrene/Butadiene + Paint

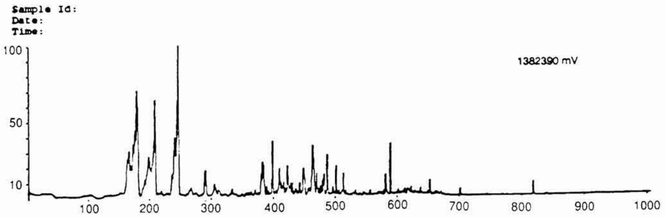
Major Compounds Evolved	Possible Sources
Butane/butene/propanediol	ABS breakdown
Ethylbenzene, styrene	Primer, paint films
Diisocyanatohexane	Paint films
Acrylates, methacrylates	Paint films



No.	Scan	Time	Name	Area	Amount	%Total
1	3	0:09	MW = 56, Butene/Cyclobutane	6667910.	100.000	19.46
2	87	4:21	Butanol	4293220.	64.386	12.53
3	150	7:30	Propanediol	3420550.	51.299	9.98
4	229	11:27	Ethylbenzene	2748410.	41.219	8.02
5	260	13:00	Styrene	4526080.	67.879	13.21
6	301	15:03	Isocyanobenzene or Benzonitrile	755660.	11.333	2.21
7	311	15:33	Methacrylic acid or Butenoic acid	937803.	14.064	2.74
8	314	15:42	Hexyl methacrylate	1450250.	21.750	4.23
9	317	15:51	Phenol	1207150.	18.104	3.52
10	351	17:33	Hydroxy propyl methacrylate	1736500.	26.043	5.07
11	351	17:33	$C_{10}H_{19}N$, MW = 138, 153	978169.	14.670	2.85
12	376	18:48	Methyl-(1-methylethenyl) benzene	523831.	7.856	1.53
13	491	24:33	Dimethylethylphenol	282639.	4.239	0.82
14	530	26:30	(Di)isocyantohexane	4738730.	71.068	13.83

Table 4—Nylon 66, Polyphenylene-Oxide, Styrene-Butadiene

Major Compounds Evolved	Possible Sources
Styrene, butane/butene, Amines, cyclopentanones, amides	Copolymer of Styrene/Butadiene Nylon 66



No.	Scan	Time	Name	Area	Amount	%Total
1	3	0:09	C_4H_6,C_4H_8, Butane/butene/ cyclobutane, MW = 54, 56	1308650.	16.939	5.14
2	104	5:12	Benzene and Cyclohexadiene?	524772.	6.793	2.06
3	180	9:00	Cyclopentanone or 2-Methyl-2-butenal	7725710.	100.000	30.32
4	209	10:27	4-Ehenyl cyclohexane	5086520.	65.839	19.96
5	247	12:21	Styrene or 1,3,5,7-Cyclooctatetraene	5454440.	70.601	21.41
6	291	14:33	$C_8H_{19}N$, Diethylbutanamine or N-Butylbutanamine	627084.	8.117	2.46
7	381	19:03	2,6-Dimethylphenol	152654.	1.976	0.60
8	383	19:09	$C_{11}H_{16}$	473678.	6.131	1.86
9	399	19:57	$C_9H_{16}O$, MW = 140, Methylpropyl cyclopentanone?	605311.	7.835	2.38
10	449	22:27	$C_{12}H_{18}$, MW = 162	423063.	5.476	1.66
11	464	23:12	$C_{12}H_{18}$, MW = 162	1019700.	13.199	4.00
12	487	24:21	N, N-Dibutytformamide	431118.	5.580	1.69
13	502	25:06	MW = 169, amide	423988.	5.488	1.66
14	513	25:39	N, N-Dibutylacetamide	163152.	2.112	0.64
15	590	29:30	2, 6-Bis(1,1-dimethylethyl)-4-methylphenol	723249.	9.362	2.84
16	653	32:39	1, 1'-(1,3-Propanediyl) bis-benzene	152100.	1.969	0.60
17	702	35:06	1-Octadecene	57771.	0.748	0.23
18	819	40:57	MW = 219, $C_{14}H_9N_3$?	126993.	1.644	0.50

PYROPROBE CONDITIONS: A Chemical Data Systems CDS 2000 Programmable Pyroprobe volatilized compounds from polymers and paints by dynamic head space sampling of ~1 mg of each material in 2.5 mm O.D. × 25.0 mm sealed-end quartz tubes. In order to minimize oxidation of sample gas evolved, each sample was heated in a helium atmosphere in the pyroprobe interface from 220-300°C at 40°C/min (approximately two minutes). Additionally, the pyroprobe coil heated the quartz tube with sample at 300°C for approximately three minutes.

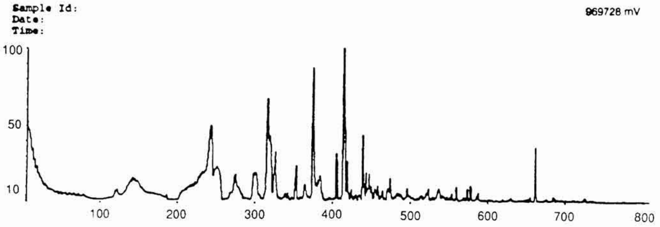
GC/MS PARAMETERS: A model 9610 Finnigan GC was used to separate compounds volatilized from the polymer and paint samples. A Hewlett-Packard HP-5 25 M × 0.22 mm × 0.33 mm column was cryogenically cooled to 10-20°C to collect and concentrate organic compounds volatilized from the samples. Then the column temperature was increased from 20 to 300°C at 4 or 8°C/minute. A split injection ratio of 10:1 or 20:1 was used to vent excess sample before GC column separation.

A Finnigan Model 4615 mass spectrometer was used to analyze the separated components in each sample. Two spectrometric methods were used to positively identify the chemical constituents volatilized by the dynamic head space sampling method. Electron impact mass spectral (EIMS) data provided fragmentation patterns of each GC component in the evolved organic compounds, while methane or isobutane chemical ionization (CIMS) provided protonated molecular ions. The source pressure for chemical ionization was ~2.0×10^{-6} Torr. Ions were collected between 45-750 amu for electron impact ionization, 60-750 amu for methane chemical ionization, and 95-750 amu for isobutane chemical ionization. Species with a mass number less than 45 are not included in this analysis. Each sample was analyzed at least twice. Samples were analyzed 2-5 times using EIMS, and once by CIMS to confirm molecular ions of the compounds reported in *Tables* 1-7.

The sampling method and analytical technique used here provide qualitative data. Data presented here are also semi-quantitative since sampling conditions included only approximate sample weight, GC split injection, no internal standard injected with samples, and nonhomogenous ionization efficiencies of the detected organic compounds. Relative abundance, semi-quantitative data, is reported as area percent of signal detected by the mass spectrometer for an identified compound in each sample and may not be directly

Table 5—Nylon 66, Polyphenylene-Oxide, Styrene-Butadiene + Paint

Major Compounds Evolved	Possible Sources
Butane/butene/butanol	Copolymer of styrene/butadiene
Cyclopentanone, cycloalkyls	Paint films
Acrylates, methacrylates	



No.	Scan	Time	Name	Area	Amount	%Total
1	2	0:06	MW = 54, Butene	5432690.	100.000	22.13
2	78	3:54	MW = 56, Butane	81259.	1.496	0.33
3	142	7:06	$C_2H_4N_2$? or Butanol?	1801830.	33.167	7.34
4	243	12:09	Cyclopentanone	3885600.	71.522	15.83
5	275	13:45	4-Ethenyl cyclohexene	1063490.	19.576	4.33
6	301	15:03	5-Hexen-1-ol or Bicyclo[3.1.0] hexene	1008230.	18.559	4.11
7	316	15:48	Styrene	2887940.	53.159	11.76
8	326	16:18	2-Butoxyethanol	759895.	13.987	3.10
9	364	18:12	2,2-Dimethyl-1,3-propanediol & 1-Ethyl-3-methyl benzene	205832.	3.789	0.84
10	375	18:45	Butyl methacrylate	1679680.	30.918	6.84
11	384	19:12	Isocyanobenzene or Benzonitrile	395609.	7.282	1.61
12	405	20:15	2-Ethyl-1-hexanol	499901.	9.202	2.04
13	414	20:42	$C_9H_{18}O_2$	1169400.	21.525	4.76
14	414	20:42	$C_9H_{15}NO$ or $C_{10}H_{19}N$ or $C_8H_{11}NO_2$	1980720.	36.459	8.07
15	415	20:45	Hydroxy propyl methacrylate	811322.	14.934	3.30
16	439	21:57	Methyl (1-methylethenyl) benzene	351489.	6.470	1.43
17	537	26:51	$C_{12}H_{18}$, MW = 162	136226.	2.508	0.55
18	662	33:06	2,6-Bis(1,1-dimethyl ethyl)-4-methyl phenol	397240.	7.312	1.62

comparable to another sample analysis on a µg/g basis. Although this data may not directly translate to the thermoplastic processing environment, it does trace volatilized chemical components back to the originating paint and/or polymer materials.

RESULTS AND DISCUSSION

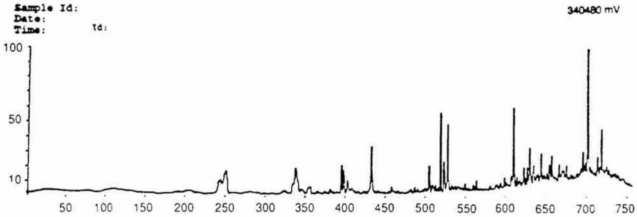
The results of the volatile analysis should be viewed as semi-quantitative. A summary of the chromatographic data, together with a compilation of the species identified by mass spectrometry, is included in *Tables* 1-7.

Only the major components have been identified and placed on a relative scale according to the most abundant species (amount = 100). Data interpretation of these complex mixtures required several resources in order to properly identify the volatiles listed in *Tables* 1-7. Many of these compounds were not readily recalled as "matches" by the commercial library search systems and electron impact data. Most structures were determined by combining information from both the Finnigan library search system and the Palisades Benchtop/PBM Wiley search system, Material Safety Data Sheets, chemical ionization data, and reference material on thermoplastic and paint processing, as well as several discussions with polymer and paint chemists at General Motors. Only those compounds which were detected and positively identified by EIMS and CIMS data are reported in *Tables* 1-7.

PAINT FILMS: *Table* 1 summarizes the results obtained on the volatiles evolved from individual paint films. Since the paint formulations are proprietary, only a summary of the Py-GC/MS data is reported here. It should be noted that many of the identified compounds evolved from the paint formulations at 300°C do not appear on Material Safety Data Sheets (MSDS). However, many of the compounds identified can be traced back in part to their origin in the paint system. For example, the MSDS was not available for the adhesion promoter sample, but it is known to be a styrene/alkyd (o-phthalate ester) paint system. The major components evolved from the adhesion promoter are styrene, phthalic anhydride, and methacrylate. The styrene and phthalic anhydride can be traced directly back to their styrene/alkyd origin. Also, the acrylic resins in clearcoat and basecoats can be identified by the various methacrylate and acrylate compounds evolved at 300°C. Finally, in basecoat, the polyester,

Table 6—Polyropylene

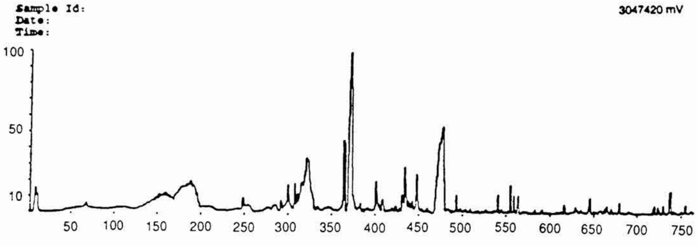
Major Compounds Evolved	Possible Sources
Alkyl fragments	Polypropylene
Cyclics, oxepanone	Additives



No.	Scan	Time	Name	Area	Amount	%Total
1	252	12:36	MW = 126, C_9H_{18}	413123.	100.000	25.37
2	338	16:54	Isocyanobenzene or Benzonitrile (phenol overlap)	235312.	56.959	14.45
3	396	19:48	MW = 168	164949.	39.927	10.13
4	433	21:39	2-Oxepanone	154032.	37.285	9.46
5	519	25:57	MW = 154, 210, or 256	169043.	40.918	10.38
6	610	30:30	Pentadecene?	194329.	47.039	11.93
7	702	35:06	Hydrocarbon?	297443.	71.999	18.27

Table 7—Polypropylene + Paint

Major Compounds Evolved	Possible Sources
Acrylates, methacrylates	Paint films
Oxepanone	Additives or paint films
Butanol/butane	Paint films



No.	Scan	Time	Name	Area	Amount	%Total
1	9	0:27	C_4H_8, Butene/cyclobutane	1565720.	11.447	2.53
2	68	3:24	C_4H_{10} Butane	3234320.	23.646	5.23
3	159	7:57	Butanol?	6707140.	49.036	10.85
4	189	9:27	Methyl methacrylate	12162800.	88.923	19.67
5	248	12:24	MW = 126, C_9H_{18}	1233760.	9.020	2.00
6	319	15:57	Styrene	3665970.	26.802	5.93
7	321	16:03	Butyl acrylate	5659930.	41.380	9.15
8	372	18:36	Butyl methacrylate	13677900.	100.000	22.12
9	401	20:03	2-Ethyl-hexanol	1062280.	7.766	1.72
10	434	21:42	C_8H_9N + Methyl(methylethenyl) benzene	1734790.	12.683	2.81
11	478	23:54	2-Oxepanone	10613000.	77.593	17.16
12	555	27:45	Pentadecene	513748.	3.756	0.83

formaldehyde-melamine, acrylic, and polyurethane resins may all contribute to the amine/amide, and alcohol generation at 300°C.

POLYMER SUBSTRATES: Most of the major compounds identified could be traced back to the originating parent polymer (*Tables* 2, 4, 6). In general, substantial butane/butene emission, as observed from the Nylon-66/poly-phenylene oxide/styrene-butadiene is attributed to the decomposition of the polybutadiene component. A substantial quantity of styrene copolymer emission is observed from the heating of the Polycarbonate/ABS; while the majority of volatiles emitted from polypropylene appear to be simple hydrocarbons.

PAINTED POLYMERS: An interesting feature of the analyses of painted regrind, especially the polycarbonate and Nylon-66, was the large quantities of butane, butene, and butanol evolved (*Tables* 3 and 5). All three gases appear in greater quantities when evolved from painted regrind than when evolved from paint or from the regrind substrates alone. This may be a synergistic decomposition process.

It should also be noted that both the polycarbonate and the nylon polymers contain a polybutadiene component. Although we have assigned each of the evolved chemicals to a potential paint source, there are some anomalies. These discrepancies may be attributed to the different paints and suppliers used. It is important to note that many of these compounds have the potential to degrade the polymer substrates, particularly at high temperatures.[11-12] For example, hydroxyl groups (alcohol and phenolic) will attack polycarbonate and Nylon-66. This study and the identification of chemical compounds present on painted thermoplastic substrates at processing temperatures may lead to explanations as to loss of physical properties of the thermoplastics and eventually to solutions in maintaining polymer properties after reprocessing.

SUMMARY AND CONCLUSIONS

A study characterizing the thermal stability and volatile degradation products of exterior paint systems and selected thermoplastics at recycle temperatures was accomplished using TD-GC/MS. The combination of pyrolysis and/or thermal desorption with GC/MS offers unique capabilities for polymer material analyses, such as:

(1) Exact temperature/atmosphere control;

(2) Separation of complex mixtures of thermally desorbed volatiles by GC;

(3) Positive identification of volatiles by MS fragmentation patterns; and

(4) The volatiles evolved, in most cases, can be traced back to their original sources.

In this study, paint samples, consisting of an adhesion promoter, a primer coat, a basecoat, and a clearcoat, have been analyzed both individually as free standing films and on various thermoplastic substrates. The TD-GC/MS conditions imposed, exposure to 300°C in a non-oxidizing atmosphere, duplicate as closely as possible those which may be encountered during thermoplastic processing.

The following specific conclusions concerning the thermal stability of the paint systems on the selected thermoplastics are: (1) degradation of paint systems, accompained by significant volatile evolution, will occur at temperatures above 260-270°C; (2) the clearcoat appears to be the most susceptible to degradation under these conditions; (3) the 'fingerprint' of the volatiles produced is affected by the paint system, its manufacturer, and the thermoplastic substrate; and (4) some of the volatiles identified contain chemical structures, e.g., phenolic-OH, alkyl-OH, acid-COOH and amines, which have the potential to attack and degrade polymer substrates.

At this stage it is not possible to indicate which particular coating offers the greatest threat to the recyclability of thermoplastic materials. Therefore, processing of painted thermoplastic substrates, at temperatures above 260-270°C, will result in paint degradation and the evolution of a significant quantity of volatiles which can attack the substrate and render it non-recyclable.

References

(1) "Marking of Plastic Parts," Society of Automotive Engineers, J1344, 1991.

(2) Federal Trade Commission Act to Environmental Advertising and Marketing Practices, Section 5 (1992); *Environmental Reporter*, Bureau of National Affairs, pp 1131-1136, 1992.

(3) Irwin, W.J., "Analytical Pyrolysis—An Overview," *J. Anal. Appl. Pyrol.*, 1, pp 3-25, 89-122 (1979).

(4) Irwin, W.J., *Analytical Pyrolysis*, Marcel Dekker Inc., New York, 1982.

(5) *Pyrolysis and GC in Polymer Analysis*, Liebman, S.A. and Levy, E.J. (Eds.), Chemical Data Systems, Inc., Marcel Dekker, New York, 1985.

(6) Cook, S. and Lehrle, R., *Eur. Polymer J.*, 29 (1), p 1-8 (1993).

(7) Vincenti, M., Pelizzetti, E., Guarini, A., and Costanzi, S., *Anal. Chem.*, 64, 1879-1884 (1992).

(8) Durairaj, T.B., Dimock, A.W., Samulski, E.T., and Shaw, M.T., *J. Polymer Sci.: Part A; Polymer Chemistry*, Vol. 27, pp 3211-3225, 1989.

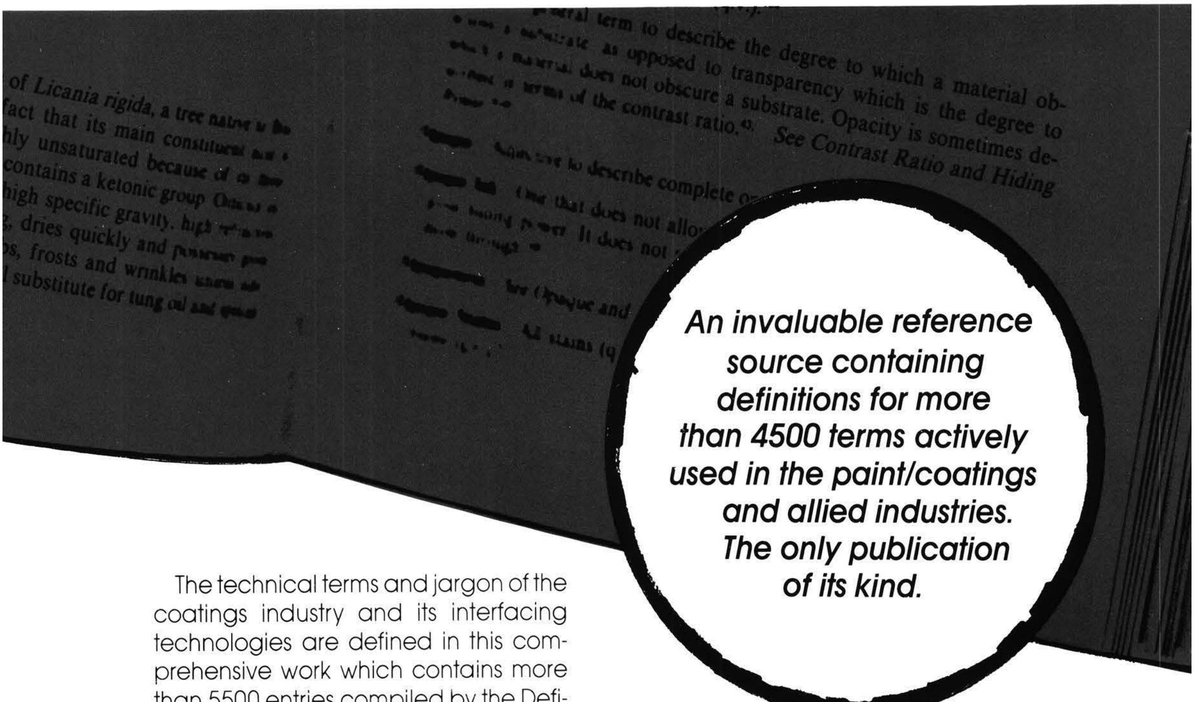
(9) Hiltz, J.A. and Bissonnette, M.C., DREA Technical Memorandum 88/209, Defense Research Establishment Atlantic, Canada (U.S. Department of Commerce, National Technical Information Service), 1988.

(10) Wampler, T.P., *J. Anal. and Appl. Pyrolysis*, 16, pp 291-322 (1989).

(11) Louis-Ferdinand, R.T., Patterson, S.W., and Plaver, F.M., "Saturn Corporation Recycled Material Applications for Painted Polycarbonate and Acrylonitrile-Butadiene-Styrene Regrinds," Society of Automotive Engineers Technical Paper No. 930470, 1993.

(12) Louis-Ferdinand, R.T., "Saturn Corporation Recycling Painted Thermoplastic Bumper Fascia," Society of Automotive Engineers Technical Paper No. 930540, 1993.

PAINT/COATINGS DICTIONARY



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Regulatory UPDATE

OCTOBER 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 Labor
Occupational Safety and Health Administration
August 22, 1994—59 FR 43268
Hazardous Waste Operations and Emergency Response
Action: Final rule

OSHA has issued technical amendments to its Hazardous Waste Operations and Emergency Response rules (29 CFR 1910.120 and 29 CFR 1926.65). The amendments include the updating of certain reference sources listed in *Appendix* B of the rules, as well as a new *Appendix* E for the rules which offers suggested guidelines for a more effective training curriculum and program.

The rule was effective September 21, 1994. For more information, contact James Foster, U.S. Department of Labor, OSHA, Office of Information and Consumer Affairs, Room N3647, 200 Constitution Ave., N.W., Washington, D.C. 20210, (202) 219-8151.

Department of Transportation
Research and Specific Programs Administration
August 15, 1994—59 FR 41848
Improvements to Hazardous Materials Identification Systems
Action: Notice to proposed rulemaking

The Hazardous Materials Transportation Uniform Safety Act of 1990 directed the Department of Transportation (DOT) to consider ways of improving the current system of placarding vehicles which transport hazardous materials, and to evaluate methods for establishing and operating a central reporting system and computerized telecommunication data center that would provide information to assist in responses to accidents or incidents involving the transportation of hazardous materials. In the proposed rule, DOT reports that the National Academy of Sciences has studied the feasibility and necessity of a central reporting system and recommended that the federal government not attempt to implement such a system. Regarding improvements to the current placarding system, DOT is proposing a variety of changes, including requirements to place identification number marking displays on truckload and carload shipments of non-bulk packages of hazardous materials having a single identification number, to lower the placarding exception in 172.504(c) from 454 kg to 400 kg aggregate gross weight of hazardous materials, and to prohibit displays of such slogans as "Drive Safely." Also, the agency discusses possible changes contained in the advanced notice on this rulemaking that are not being proposed: DOT is not proposing to eliminate the "Dangerous" placard; require added emergency response information to be displayed on placards or vehicles; revise placard visibility, size, location, information display, format, construction or attachment; change existing color requirements; or set up a centralized reporting system.

Written comments on the proposal are due by December 2, 1994, and should be submitted to Dockets Unit (DHM-30), Research and Special Programs Administration, U.S. DOT, Washington, D.C. 20590-0001. Comments should be identified as pertaining to Docket HM-206. A public hearing will be held October 18-19 at 9 am in Washington, D.C.; contact the RSPA docket clerk at (202) 366-5046.

For more information, contact Helen Engrum or John Potter, Office of Hazardous Materials Standards, RSPA, U.S. DOT, 400 Seventh Street, S.W., Washington, D.C. 20590-0001, (202) 366-4488.

Environmental Protection Agency
August 12, 1994—59 FR 41444
Notice Regarding Revisions to Toxic Chemical Release Inventory Reporting Forms
Action: Notice

The U.S. Environmental Protection Agency (EPA) has announced that the annual deadline for its receipt of voluntary revisions to Toxic Chemical Release Inventory Forms (Form R) will be changed to October 15, effective this year. The new deadline is six weeks earlier than the previously set deadline of November 30. The Toxic Release Inventory was established by Section 313 of the Emergency Planning and Community Right-to-Know Act, under the Superfund Amendments and Reauthorization Act of 1986.

Contact: Emergency Planning and Community Right-to-Know information hotline at (800) 424-9346.

Environmental Protection Agency
August 22, 1994—59 FR 43048
Notice of Change of Address for Submission of Trade Secrecy Claims and Petitions Requesting Disclosure of Chemical Identities Under the Emergency Planning and Community Right-to-Know Act
Action: Final rule; technical amendment

The final rule changes the mailing address to be used for submitting trade secrecy claims, or for requesting disclosure of chemical identities claimed as trade secrets, under Sections 303 (d) (2) and (d) (3), 311, 312, and 313 of the Emergency Planning and Community Right-to-Know Act (EPCRA). The new mailing address is: EPCRA Reporting Center, U.S. EPA, P.O. Box 3348, Merrifield, VA 22116-3348, Attn: ________________. The attention line should indicate whether the information enclosed pertains to Section 303, 311, 312, or 313.

The rule was effective August 15, 1994. For more information, contact Doug Sellers, Project Officer, Title III Reporting Center, U.S. EPA, 401 M St., S.W., Washington, D.C. 20460, (202) 260-3587.

Environmental Protection Agency
August 26, 1994—59 FR 44234
Effluent Guidelines Plan
Action: Notice of effluent guidelines plan

In this notice, the U.S. EPA outlines its plans for developing new and revised effluent guidelines, which regulate industrial discharges to surface waters and to publicly owned treatment works under authority of the Clean Water Act. Currently, EPA is developing new or revised effluent guidelines for nine categories: pulp, paper, and paperboard; pesticide formulating, packaging, and repackaging; metal products and machinery; centralized waste treatment; coastal oil and gas extraction; pharmaceutical manufacturing; industrial laundries; transportation equipment cleaning; and, landfills and incinerators. In addition, the agency will start work on two additional categories (yet to be determined) in 1996.

For further information, contact Eric Strassler, Engineering and Analysis Division (4303), U.S. EPA, 401 M Street, S.W., Washington, D.C. 20460, (202) 260-7150.

Environmental Protection Agency
August 30, 1994—59 FR 44678
Proposed Water Quality Guidance for the Great Lakes System
Action: Notice of data availability and request for comments

The U.S. EPA announced the availability of three reports it is considering as it develops final water quality guidance for the Great Lakes System, and requested comments on the possible application of data from the reports into the final guidance. The reports are "Results of Simulation Tests Concerning the Percent Dissolved Metal in Freshwater Toxicity Tests," "1991-92 Michigan Sport Anglers Fish Consumption Study," and "Great Lakes Water Quality Initiative Technical Support Document for the Procedure to Determine Bioaccumulation Factors, July 1994."

Written comments were due by September 29, 1994. For more information, contact Kenneth A. Fenner, Water Quality Branch Chief, (WQS-16J), U.S. EPA Region V, 77 W. Jackson Blvd., Chicago, IL 60604, (312) 353-2079.

Office of Management and Budget
July 26, 1994—59 FR 38092
Economic Classification Policy Committee; Standard Industrial Classification Replacement
Action: Notice of proposal to replace the Standard Industrial Classification (SIC) with a new North American Industry Classification System (NAICS)

The proposal contains the conceptual framework for a new North American Industry Classification System (NAICS), which would replace the current Standard Industrial Classification (SIC) system. The proposed NAICS, to be developed jointly by Canada, Mexico, and the United States, would provide the three countries with common industry definitions to facilitate economic analyses. The proposal includes background information, the proposed conceptual framework of the NAICS, a process for developing recommended actions, and an outline for implementing the NAICS in 1997.

Written comments on the proposed conceptual framework were due by October 3, 1994; written comments or proposals for new industries or for changing the boundaries of existing industries are due by November 7, 1994. Comments on the conceptual framework were to be sent to Jack E. Triplett, Chairman, Economic Classification Policy Committee, Bureau of Economic Analysis (BE-42), U.S. Department of Commerce, Washington, D.C. 20230. Comments on adding new industries or changing the boundaries of existing industries should be sent to Carole Ambler, Coordinator, Economic Classification Policy Committee, Bureau of the Census, U.S. Department of Commerce, Room 3685-3, Washington, D.C. 20233, (301) 763-5268, fax (301) 763-2324.

Hazardous Materials Transportation—On August 26, President Clinton signed into legislation the Hazardous Materials Transportation Act (HMTA) to renew the law that governs interstate transport of hazardous materials. The Senate had approved the bill (H.R. 2178) by unanimous consent on August 11 and the House passed it by voice vote on August 16.

The reauthorization of Department of Transportation (DOT) safety programs under HMTA legislation will authorize funds through fiscal 1997, including $18.54 million in fiscal 1994. Among other provisions, the law directs DOT to provide a comprehensive report to Congress every two years on hazardous materials transportation.

The legislation also exempts foreign offerors from U.S. hazardous materials transportation registration fees and makes minor changes to hazardous materials transportation law, which already underwent major congressional revision in 1990 in the Hazardous Materials Transportation Uniform Safety Act.

Superfund—The administration-backed Superfund bill (H.R. 3800) was approved by the House Ways and Means Committee on August 19 after being stalled for a week because of proposed tax provisions.

The Treasury Department ended the standoff over the legislation by putting together a compromise package to raise $8.1 billion in retrospective and prospective insurance taxes. Under the proposal, about half the money would be raised from retrospective taxes on policies written between 1968 and 1985, and the other half would be raised from policies written after the bill's enactment. The money would be used to set up an Environmental Insurance Resolution Fund to settle disputes between polluters and their insurers. Despite approval, there is still concern among some committee members over the insurance tax. The bill is now headed to the floor for action by the full House.

The Senate companion bill (S. 1834) was approved by the Senate Environment and Public Works Committee in August and is scheduled for markup by the Finance Committee on September 14.

States Proposed Legislation and Regulations

Alaska

Toxic Substances (Regulation)—The Alaska Department of Labor (DOL) proposed a rule which amends current standards for hazard communication, including requirements for developing and maintaining a written hazard communication program and a list of hazardous chemicals. The rule also establishes standards for labeling of chemical containers, shipping containers to other workplaces, preparing material safety data sheets for employees and downstream employers. In addition, the regulation develops employee training programs regarding chemical hazards and protective measures. Contact: Commissioner, DOL, P.O. Box 21149, Juneau, AK 99802-1149.

California

Hazardous Waste—CA A. 3263 (Campbell) requires the Office of Emergency Services to obtain and maintain a state delegation of the federal accidental release prevention program established pursuant to specified provisions of the Clean Air Act. It allows petitions to be submitted to the office to add a material to, or to delete a material from, the Acutely Hazardous Materials List, or to revise threshold planning quantities. The Senate and the Assembly approved amended versions of the legislation on August 23 and August 26, respectively.

Lead (Regulation)—The California Department of Health Services (DHS) has proposed amendments to the childhood lead poisoning prevention program, including provisions that would redefine "architectural coating distribution," require any firm doing business in California to collect a fee for all of its out-of-state lead-containing products sold in California, and establish fee exemptions. Contact: Ron Wetherall, DHS, (916) 657-0692.

Colorado

Hazardous Waste (Regulation)—The Colorado Hazardous Waste Commission (HWC) proposed more stringent hazardous waste incinerator standards which could increase the cost and difficulties associated with disposing of paint waste materials through incineration. Contact: Karen Osthus, HWC, (303) 692-3321.

Connecticut

Air Quality (Regulation)—The Connecticut Department of Environmental Protection (DEP) proposed regulations governing the volatile organic compound (VOC) content of architectural and industry maintenance (AIM) coatings and miscellaneous metal parts coatings. Contact: Susan Marsh, DEP, (203) 566-8797.

Florida

Toxics in Packaging (Regulation)—The Florida Department of Environmental Protection (DEP) has issued a final rule that amends the current toxics in packaging regulation. Contact: DEP, (904) 488-1073.

Georgia

Hazardous Waste (Regulation)—The Georgia Department of Natural Resources (DNR) has issued final regulations relating to reporting, response actions, and corrective actions for hazardous waste sites. Contact: Jennifer Kaduck, DNR, (404) 656-7802.

Indiana

Lead (Regulation)—The Indiana Department of Labor (DOL) has issued a final regulation that adopts, by reference, the federal Occupational Safety and Health Administration (OSHA) construction standard for lead exposure. The rule will be effective retroactively to February 22, 1993. Contact: (DOL, (317) 232-2655.

Massachusetts

Air Quality (Regulation)—The Massachusetts Department of Environmental Protection (DEP) has issued a final rule which amends current regulations regarding VOC emissions through the use of best available control techniques (BACT) and operator training. The rule became effective on July 29, 1994. Contact: DEP, One Winter Street, 3rd Floor, Boston, MA 02108.

The Massachusetts DEP adopted an emergency regulation that requires emissions inventory reporting by major stationary sources of VOC emissions. The regulation went into effect on July 1, 1994. Contact: Donald Squires of the DEP at (617) 292-5618.

Toxic Substances (Regulation)—The Massachusetts Administrative Council on Toxics Use Reduction (ACTUR) proposed amendments on regulations implementing the Toxic Use Reduction Act which adds new hazardous substances to the program's list of toxic substances and alters the notice period required before changes to the list become effective. Contact: Gina McCarthy, ACTUR, (617) 727-9800.

Michigan

Air Quality (Regulation)—The Michigan Department of Natural Resources (DNR) proposed a rule which establishes a permit program for emissions from stationary sources during malfunctions and shut-downs. Contact: DNR, P.O. Box 30028, Lansing, MI 48909.

Hazardous Waste (Regulation)—The Michigan Department of State Police (DSP) issued final regulations revising the state's underground storage tank (UST) standards. Contact: David Smith, DSP, (517) 322-1750.

Minnesota

Air Quality (Regulation)—The Minnesota Pollution Control Agency (PCA) is soliciting comments concerning revisions to the state's clean air program which include emission inventory requirements and calculation of a facility's emission fee. Contact: Michael Mondloch, PCA, (612) 297-5847.

Nebraska

Occupational Safety & Health (Regulation)—The Nebraska Department of Labor (DOL) proposed a regulation relating to the Workplace Safety Consultation Program. The rule requires the DOL to conduct workplace inspections and consultations and to help develop occupational safety programs for employers with high frequency and severity rates of work-related injuries. Contact: DOL, (402) 471-2230.

New Jersey

Transportation (Regulation)—The New Jersey Highway Authority has proposed regulations that would clarify state and federal requirements relating to the transportation of hazardous materials on the Garden State Parkway. Contact: Highway Authority, (908) 442-8600.

The New Jersey Department of Transportation (DOT) has proposed regulations that would allow the permitting of vehicles to increase the maximum amount of weight being transported with the use of lift axles. Contact: Raymond DeRocco, DOT, (518) 457-1155.

New York

Air Quality (Regulation)—The New York Department of Environmental Conservation (DEC) adopted a final rule that establishes the regulatory requirements necessary to collect annual emissions data. It requires this data to be collected and reported to the U.S. Environmental Protection Agency and demonstrates actual emissions for purposes of paying per-ton emissions by source owners. The regulation went into effect on August 15, 1994. Contact: Maris Tirums, DEC, (518) 457-6379.

Lead (Regulation)—The New York Department of Health (DOH) is continuing its consideration of a proposed rule that will establish lead poisoning standards. The regulation will establish abatement procedures, specify testing requirements, and require notification of lead poisoning conditions. Contact: Donald Macdonald, DOH, (518) 474-8734.

North Carolina

Air Quality (Regulation)—The North Carolina Department of Environmental Health (DEH) adopted a final rule that establishes requirements for air pollution control and procedures for air quality permit approval. The rule went into effect on July 1, 1994. Contact: DEH, (919) 733-4984.

Ohio

Air Quality (Regulation)—The Ohio Environmental Protection Agency (EPA) has proposed regulations that implement the federal clean air operating permit program, including regulations that establish a de minimis threshold and a federally enforceable emission limitation to exempt a facility from the requirement to obtain a permit. Contact: Jeanne Mallett, Ohio EPA, (614) 644-2115.

Hazardous Waste (Regulation)—The Ohio Underground Storage Tank Compensation Board (USTCB) has issued final amendments to its financial responsibility regulations, which include several clarifications and an increase in the penalty for late payments. Contact: Carol DeVore, USTCB, (614) 752-8963.

Water Quality (Regulation)—The Ohio Environmental Protection Agency (EPA) has issued the state's storm water permit program regulations in final form. Contact: Ohio EPA at (614) 644-2053.

Rhode Island

Air Quality (Regulation)—The Rhode Island Department of Environmental Management (DEM) proposed regulations that would eliminate the current exemption of tent frame coatings and coatings meeting military specifications from the clear air VOC emission control program. Contact: Barbara Morin, DEM, (401) 277-2808.

Tennessee

Air Quality (Regulation)—The Tennessee Department of Environment and Conservation (DEC) has proposed regulations controlling emissions of VOCs that, among other things, extends the applicability of an exemption based on low maximum theoretical emissions from a facility. Contact: Malcolm Butler, DEC, (615) 532-0600.

Texas

Air Quality (Regulation)—The Texas Natural Resource Conservation Commission (NRCC) has proposed amendments to the state's clean air program that establishes standards for demonstrating how the Houston/Galveston and Beaumont/Port Arthur areas will achieve a 3% reduction in VOC emissions each year after 1996 until 1999. In addition, the NRCC has proposed to change the expected date of ozone attainment for the El Paso area from 1999 to 1996. Contact: Liz Johnson-Orr, NRCC, (512) 239-1967.

Hazardous Waste (Regulation)—The Texas Natural Resource Conservation Commission (NRCC) has proposed to establish a comprehensive hazardous substance spill and emergency response program. Contact Marianne Baker, NRCC, (512) 239-0475.

Washington

Air Quality (Regulation)—The Washington Clean Air Authority (CAA) has issued an update to its air operating permits requirements that corrects certain inconsistencies. Contact: David A. Lauer, CAA, (509) 943-3396.

The Puget Sound Air Pollution Control Agency (PSAPCA) has proposed amendments to its clean air operating permit program that increase the emissions fees and penalties of the program. Contact: Jim Nolan, PSAPCA, (206) 689-4053.

The Washington Department of Ecology (DOE) has announced its intention to amend requirements relating to the registration of industrial and commercial facilities which are sources of regulated air emissions. Contact: Judy Geiser, DOE, (206) 407-6850.

West Virginia

Air Quality (Regulation)—The West Virginia Division of Environmental Protection (DEP) has announced that the agency has filed several regulations with the Legislative Rule-Making Review Committee that incorporate federal standards, including those relating to the new source review program, and the types of data that a source may use to demonstrate that it is in compliance. Contact: Dale Farley, DEP, (304) 348-4022.

Transportation (Regulation)—The West Virginia Secretary of State has approved a regulation on an emergency basis that establishes a uniform registration and permitting program for motor carriers of hazardous materials. Contact: Public Service Commission at (304) 340-0432.

Wisconsin

Air Quality (Regulation)—The Wisconsin Department of Natural Resources (DNR) issued a final rule concerning VOC emissions from molded wood parts and products, and wood door coating operations. The regulation identifies wood coatings that will be regulated, establishes VOC emission limits for wood coating facilities in nonattainment areas, establishes recordkeeping requirements, and provides compliance deadlines. The regulation was effective as of September 1, 1994. Contact: Jim Crawford, DNR, Lake Michigan District Headquarters, 1125 N. Military Ave., P.O. Box 10448, Green Bay, WI 54307.

The Wisconsin DNR proposed a rule which pertains to VOC emission limits for wood furniture coatings. The regulation establishes requirements under the Federal Clean Air Act Amendments of 1990 for reasonably available control technology (RACT) for existing major sources of VOC emissions in moderate or worse ozone nonattainment areas. Contact: Jon Heinrich, DNR, P.O. Box 7921, Madison, WI 53707.

Chemical Reaction Kinetics of Sulfur Dioxide and Oxygen with Unsaturated Drying Oils

William H. Simendinger and C. Maurice Balik
North Carolina State University*

A gravimetric technique has been used to investigate the reaction kinetics of SO_2, O_2, and mixtures of the two with unsaturated drying oils used in the formulation of alkyd paints, and with the alkyd paint itself. Data could be interpreted in terms of a simple first-order kinetic model based on the concentration of allylic sites in each sample. Rate constants obtained reflected the rate at which allylic sites (or drying oil molecules) were consumed. For reaction with either SO_2 and O_2, the ratio of these rate constants for linolenic and linoleic acid was close to the expected value of 4/3, which is based on the number of allylic sites in each molecule. The rate constant for the alkyd paint was higher than that for the individual drying oils, presumably due to the presence of a catalyst. Experiments in which the drying oils were exposed to mixtures of SO_2 and O_2 showed a much higher mass uptake for the mixture compared to the individual gases. This indicates that a synergistic effect occurs in the mixture which enhances the reactivity of the pure gases with these drying oils.

INTRODUCTION

The formulation and application of paint coatings to protect structures is a multibillion dollar per year industry. Consequently, significant economic losses could result if increased levels of atmospheric sulfur dioxide (SO_2) appreciably shortened the lifetime of a paint coating. As a result of the presence of atmospheric pollutants, it has now become important to determine how various paint films protect the underlying substrate from these pollutant gases. In previous papers, we reported the solubility and diffusivity of SO_2 in a typical alkyd paint.[1] We also found evidence for a chemical reaction between SO_2 and this paint, and upon further investigation determined that the unsaturated drying oils in the paint were the site of this reaction.[1,2] This chemical reaction has been shown to crosslink the paint film through sol-gel analysis. Differential scanning calorimetry (DSC) and Fourier-transform infrared spectroscopy (FTIR) techniques were employed to characterize the chemical reaction using model samples consisting of individual drying oils dispersed in an inert latex binder. The results obtained showed that SO_2 reacts with pre-existing hydroperoxide groups attached at the allylic carbon atoms, forming free radicals. Crosslinking then occurs by a free radical mechanism similar to normal auto-oxidation.

The following mechanism was proposed for the SO_2 crosslinking reaction:

$$R(R')CH\text{-}OOH + SO_2 \longrightarrow R(R')CH\text{-}OSO_3H$$
$$R(R')CH\text{-}OOH \longrightarrow R(R')CH\text{-}O\bullet + \bullet OH$$
$$R(R')CH\text{-}OSO_3H + R\,(R')CH\text{-}O\bullet \longrightarrow R(R')CH\text{-}OSO_3\text{-}CH(R')R + \bullet OH$$

A key ingredient in this scheme is the presence of pre-existing hydroperoxide groups at allylic sites on the drying oil molecule, represented previously by R(R')CHOOH. The hydroperoxide groups would be expected to be present in small concentrations due to incidental air exposure before the drying oil is exposed to SO_2. Drying oils which have "doubly activated" hydrogens, i.e., with double bonds on both sides of the allylic site, are much more reactive[3] and would contain more hydroperoxide groups than drying oils without doubly-activated allylic hydrogens. In accordance with this, we found linolenic and linoleic acid, which do contain doubly activated allylic hydrogens, to be much more reactive toward SO_2 than oleic acid, which has no doubly-activated allylic hydrogens.[2]

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*Dept. of Materials Science and Engineering, P.O. Box 7907, Raleigh, NC 27695-7907.

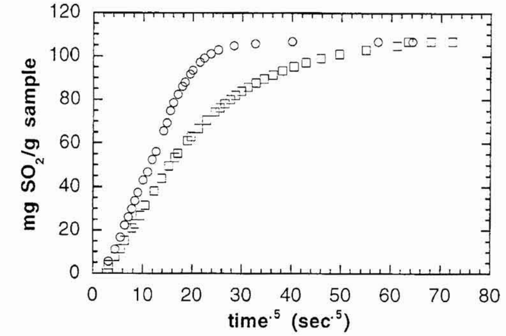

Figure 1—Sorption (circles) and desorption (squares) of SO_2 at 700 torr in the latex binder at 30°C; film thickness = 127 μm. Note that all of the SO_2 that diffuses into the latex is removed upon desorption indicating no chemical reaction has occurred. The initial linearity of the data indicates a Fickian diffusion mechanism

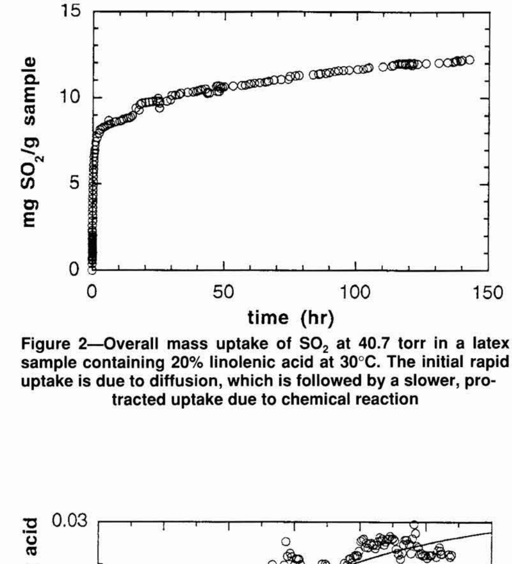

Figure 2—Overall mass uptake of SO_2 at 40.7 torr in a latex sample containing 20% linolenic acid at 30°C. The initial rapid uptake is due to diffusion, which is followed by a slower, protracted uptake due to chemical reaction

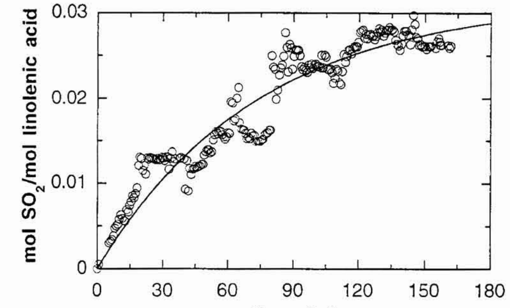

Figure 3—Expanded view of the chemical reaction portion of *Figure* 2. The solid line is the fit to the kinetic model

In the present paper, we attempt to quantify the relative reactivity of these unsaturated drying oils through reaction kinetics studies with SO_2. These results are compared with the fully formulated alkyd paint containing these oils, to the kinetics of the normal auto-oxidative reaction that occurs upon exposure to oxygen, and finally to a mixture of SO_2 and oxygen.

EXPERIMENTAL

The drying oils studied were oleic, linoleic, and linolenic acid, which are all C_{18} compounds and contain one, two and three double bonds, respectively. These were obtained from Aldrich and used as received. The oils were dispersed to about 20 wt% in an inert latex binder which was a terpolymer of vinyl acetate, vinyl chloride, and butyl acrylate. The resulting suspension was then cast into thin films (thickness ≈ 262 μm) on glass and allowed to dry in air at room temperature for two hours. The samples were then removed from the glass and stored in a vacuum chamber to remove residual water and solvents, and to prevent the drying oils from further reaction with atmospheric oxygen. Optical microscopy of these films showed that the drying oil was very finely and uniformly dispersed.

The thin film geometry was desired so that reaction kinetics measurements could be made gravimetrically using an electrobalance system enclosed in a temperature- and pressure-controlled glass vacuum chamber. The experimental procedure involved hanging a sample on the electrobalance, evacuating the chamber until the sample was completely degassed, and then backfilling with the desired experimental gas to a fixed pressure. Weight gain versus time data was collected automatically by computer. Sample weights were on the order of 100 mg, and all experiments were conducted at 30°C.

The latex binder was chosen because it was known to be unreactive with SO_2 and because SO_2 diffuses rapidly through it. This is illustrated in *Figure* 1, which shows the sorption/desorption kinetics for SO_2 in the pure latex material. All of the SO_2 that diffuses into the film is removed during desorption, indicating that SO_2 does not chemically react with the latex. It can also be seen that diffusion equilibrium is reached very rapidly. The sorption curve lies slightly above the desorption curve, which is typical for systems in which the diffusion coefficient is concentration dependent. The initial linearity of these curves indicates Fickian behavior, which can be described at short times by the following equation:

$$\frac{M(t)}{M(\infty)} = \frac{4}{h}\left(\frac{Dt}{\pi}\right)^{0.5}$$

Here M (t) and M (∞) are the mass sorbed or desorbed at time t or at t = ∞, respectively, h is the film thickness, and D is the diffusion coefficient. D is obtained from the slope of a line fitted to the initial portions of each curve which yielded D(sorption) = 8.39×10^{-8} cm^2/sec and D(desorption) = 3.77×10^{-8} cm^2/sec. These numbers are in good agreement with earlier work which yielded an average D = 8.2×10^{-8} cm^2/sec for SO_2 at 700 torr and 28°C.[4]

The alkyd paint was generously supplied by The Sherwin-Williams Co., and its composition is listed in *Table* 1. The soya component of the paint comprised 63 wt% of the binder, and contained approximately 27 wt% oleic, 53 wt% linoleic, and 7 wt% linolenic acid; the balance consisted of saturated drying oils. Films were cast on glass plates and were allowed to dry in air for 48 hr. Samples were cured in a drying oven for one hour at 100°C then were removed from the glass. The resulting film thickness was on the order of 100 μm. DSC experiments conducted on the alkyd films cured at 100°C for one hour displayed a small exotherm indicating that the paint film was not completely cured. Alkyd samples cured at 150°C for one hour displayed no DSC exotherm indicating a complete cure.[1] Since our objective was to study the effects of SO_2 on the normal auto-oxidation reaction, we chose the 100°C, one-hour cure to provide sufficient mechanical strength without completely curing the films.

RESULTS AND DISCUSSION

Kinetic Model

The auto-oxidative mechanism by which the drying oils become crosslinked is complex and consists of many free-radical reactions. However, the rate-determining step involves decomposition of hydroperoxide groups which are attached at the allylic carbons.[5-7] Earlier work has identified the allylic carbons in the drying oils as the site of the SO_2 reaction as well.[1,2] On this basis, the simplest kinetic model one might propose for the SO_2 reaction would be based on the following rate-determining step in the reaction mechanism:

$$[\text{R-OOH}] + [SO_2] \longrightarrow \text{crosslinking}$$

Furthermore, we would expect the concentration of hydroperoxide groups to be proportional to the number of allylic sites in a given drying oil molecule, as it is well-known that the reactivity of these compounds in the auto-oxidative reaction increases with the number of double bonds.[3,5-7] We therefore adopt the following reaction as the basis of our kinetic model:

$$[\text{allylic sites}] + [SO_2] \longrightarrow \text{crosslinking}$$

Although highly simplified, it will be shown that this model provides a reasonably good description of the data.

The rate of reaction can therefore be written as:

$$-\frac{dC}{dt} = k[SO_2]C \qquad (1)$$

where C is the concentration of allylic sites remaining in the sample at time t and k is the rate constant for consumption of allylic sites or drying oil molecules. Since diffusion equilibrium is reached very quickly, we can also assume that the concentration of SO_2 in the sample rapidly reaches a steady-state value, which results in pseudo first-order kinetics. Finally, we express C in terms of the measured quantities M(t) and M(∞), the mass of SO_2 sorbed due to chemical reaction only at time t and at t = ∞, respectively:

$$C = 1 - \frac{M(t)}{M(\infty)} \qquad (2)$$

Equation (2) redefines C as the fraction of unreacted allylic sites remaining in the sample at time t. Note that this also

Table 1—Alkyd Paint and Binder Composition

Component	Weight %	Function
Cargill 5070	48.8	binder
Mineral spirits	12.1	binder solvent
Bentonite clay	0.5	filler
Ethanol	0.3	coupling solvent
Zinc oxide	2.5	hiding pigment/mildewcide
Calcium carbonate	7.5	extender
Titanium dioxide	25.0	pigment
Butyl cellosolve	2.5	organic solvent
12% cobalt drier	0.2	naphthenate drier
10% calcium drier	0.2	naphthenate drier
18% zirconium drier	0.2	naphthenate drier
Methyl ethyl ketoxime	0.1	blocked crosslinker
Rabo anti-sag	0.4	clay filler
Binder (70% solids)		
Soya (fatty acids	63.0	crosslinking agent
Palmitic acid	10.0	$CH_3(CH_2)_{14}COOH$
Stearic acid	3.0	$CH_3(CH_2)_{16}COOH$
Oleic acid	27.0	$CH_3(CH_2)_7CH{=}CH(CH_2)_7COOH$
Linoleic acid	53.0	$CH_3(CH_2)_4(CH{=}CHCH_2)_2(CH_2)_6COOH$
Linolenic acid	7.0	$CH_3(CH_2CH{=}CH)_3(CH_2)_7COOH$
Phthalic anhydride	23.0	binder A
Polyoa	14.0	binder B

(a) The actual polyol used was not identified by The Sherwin-Williams Co.

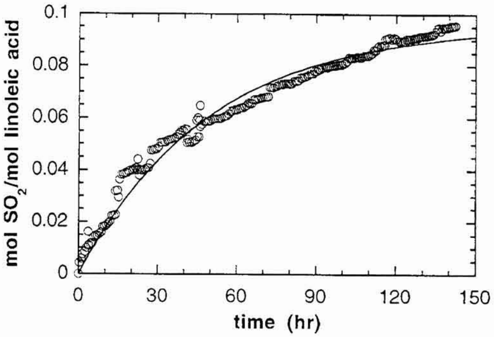

Figure 4—Chemical reaction portion of the mass uptake curve for 20% linoleic acid in latex exposed to 40.7 torr SO_2 at 30°C. The solid line is the fit to the kinetic model

Table 2—Rate Constants[a] for Reaction of SO_2 with Linolenic and Linoleic Acid

	40.7 torr SO_2	60.9 torr SO_2	Average
Linolenic acid	2.47×10^{-5}	2.11×10^{-5}	2.29×10^{-5}
Linoleic acid	3.26×10^{-5}	2.65×10^{-5}	2.96×10^{-5}
k(linoleic)/k(linolenic)	1.32	1.26	1.29

(a) Units: mole drying oil/mole SO_2-sec.

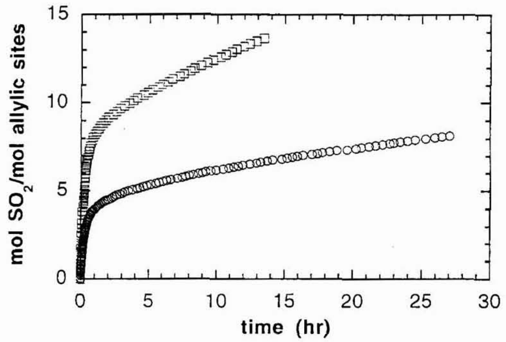

Figure 5—Overall mass uptake for SO_2 at 5.0 torr (circles) and 10.2 torr (squares) in the alkyd paint at 30°C. An initial rapid diffusion region can be seen, followed by a slower weight gain due to chemical reaction

redefines the units for the rate constant k in equation (1). Since C is dimensionless, k will have the inverse units chosen for $[SO_2]$ per unit time. After integration, we arrive at the following working equation:

$$M(t) = M(\infty)\{1 - \exp(-k[SO_2]t)\} \tag{3}$$

This equation could be linearized by plotting $\ln[1 - M(t)/M(\infty)]$ versus t. However, we chose to fit data directly to equation (3) using nonlinear regression techniques[8] since the value of $M(\infty)$ was not always apparent from the data. With $[SO_2]$ constant, this results in a two parameter fit yielding values for $M(\infty)$ and k.

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Reaction of SO_2 with the Drying Oils

The overall sorption kinetics for a sample containing about 20% drying oil dispersed in the latex binder and exposed to SO_2 typically resembled *Figure* 2, which shows the result for a linolenic sample exposed to 40.7 torr SO_2. The rapid initial uptake of SO_2 due to diffusion is evident, followed by a slower protracted weight gain which is due to the chemical reaction. It has been shown in previous papers that the SO_2 sorbed in this protracted region could not be removed upon extended exposure to vacuum, and hence was termed "residual" SO_2.[1,2]

The amount of SO_2 sorbed at diffusion equilibrium is easily determined from the break in the curve of *Figure* 2. This provides a value for $[SO_2]$ in equation 3. Subtraction of this value from subsequent data points yields the mass sorbed due to chemical reaction only; this portion of the curve is replotted in *Figure* 3 as moles SO_2 sorbed per mole of linolenic acid to facilitate comparison between data for different drying oils. The solid line in *Figure* 3 represents the fit to the kinetic model, equation (3), which yielded a rate constant $k = 2.47 \times 10^{-5}$ mol linolenic acid/mol SO_2-sec. The data is somewhat scattered since the mass uptake due to chemical reaction was small and not far above the working resolution limit of the electrobalance.

Similar results were obtained for 20% linoleic acid dispersed in latex, as shown in *Figure* 4. The rate constant obtained from the model in this case was somewhat higher at 3.26×10^{-5} mol linoleic acid/mol SO_2-sec. We expect the rate constant to be higher for linoleic acid since the gravimetric experiment actually measures the rate of consumption of drying oil via the uptake of SO_2 beyond diffusion equilibrium. Linoleic acid has fewer allylic sites available for reaction, and therefore would be consumed faster than linolenic acid. In other words, the rate constant in the model is inversely related to the number of allylic sites on the drying oil molecule. On this basis, we expect the rate constant ratio k(linoleic)/k (linolenic) to equal 4/3, the inverse ratio of allylic sites in these two drying oils. This is in fact the case, as k(linoleic)/k(linolenic) = 1.32 for the experiments conducted at 40.7 torr.

These experiments were repeated at an SO_2 pressure of 60.9 torr. At the higher pressure, the concentration of SO_2 in the sample at diffusion equilibrium increased proportionately. This caused a corresponding increase in the rate of reaction, but the rate constants should remain unchanged according to the model. The 60.9 torr rate constants are listed in *Table* 2 for comparison with the 40.7 torr values. Both rate constants are lower at 60.9 torr, with the linolenic acid values in better agreement than those for linoleic acid. However, the ratio of rate constants at 60.9 torr SO_2 is still close to the expected value of 1.33. When the rate constants obtained at each pressure are averaged, the ratio obtained is 1.29.

The same experiments were conducted with oleic acid samples. No measurable uptake due to chemical reaction could be observed. As stated previously,[2] this is attributed to the lower reactivity of oleic acid caused by the lack of any doubly-activated allylic hydrogens.

Reaction of SO_2 with the Alkyd Paint

The overall sorption curves for SO_2 at 5.0 and 10.2 torr in the fully formulated alkyd paint are displayed in *Figure* 5.

As with the drying oil/latex samples, an initial rapid uptake due to diffusion is observed, followed by a slower protracted uptake due to chemical reaction. At 10.2 torr, the concentration of SO_2 in the sample is about double that at 5.0 torr, and accordingly the rate of reaction is larger, as evidenced by the larger slope for the reaction portion of the curve. There is no indication that either curve is nearing completion of the chemical reaction in the time of the experiment, and an extended exposure to 5 torr SO_2 still showed no signs of leveling off after more than 90 hr. This is shown in *Figure* 6.

The chemical reaction portion of each curve was fitted to the kinetic model. Since the reaction had not neared completion, a value for $M(\infty)$ was assigned from previous experiments conducted at higher SO_2 pressures in which we determined that the saturation level of SO_2 sorbed due to chemical reaction was 4.76 mg SO_2/g-sample.[1] Insertion of a fixed value for $M(\infty)$ into equation (3) makes it a one-parameter fit to the data. The fit is shown as the solid line in *Figure* 6 for the 5.0 torr data, and the resulting rate constants for the 5 and 10.2 torr data are listed in *Table* 3.

In order to compare the rate constants for the alkyd paint to those for the pure drying oils, units for k were converted to moles allylic sites/mole SO_2-sec. This was done because it was not known how much SO_2 was reacting with each drying oil in the paint. When based on moles of allylic sites, the rate constants should all be equal. All of the rate constants for the SO_2 reaction are listed in *Table* 3. While there is fairly good agreement between the values for the drying oils, the k values for the paint are significantly higher. We attribute this to the presence of a catalyst in the paint to speed the auto-oxidation reaction; no catalyst was added to the drying oil/latex samples.

Table 3—Rate Constants[a] for Reaction of SO_2 with Linolenic Acid, Linoleic Acid, and the Alkyd Paint

	40.7 torr SO_2	**60.9 torr SO_2**	**Average**
Linolenic acid	9.88×10^{-5}	8.48×10^{-5}	9.18×10^{-5}
Linoleic acid	9.78×10^{-5}	7.95×10^{-5}	8.87×10^{-5}
	5.0 torr SO_2	**10.2 torr SO_2**	**Average**
Alkyd paint	2.69×10^{-4}	3.71×10^{-4}	3.20×10^{-4}

(a) Units: mole allylic sites/mole SO_2-sec.

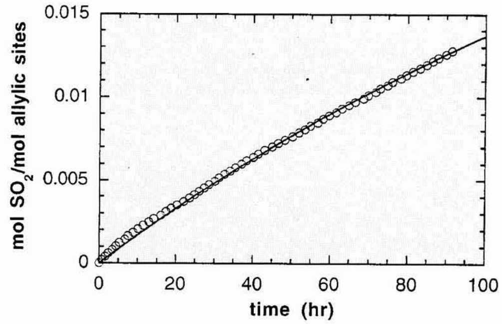

Figure 6—Chemical reaction portion of the extended mass uptake curve for the alkyd paint exposed to 5.0 torr SO_2 at 30°C. The end of the chemical reaction is not evident after 90 hr of exposure. The solid line is the fit to the kinetic model

Reaction of Oxygen with the Drying Oils

These experiments were conducted to compare the normal auto-oxidative reaction rates of the drying oils with the SO_2 reaction rates. The overall sorption curves for oxygen at 60.9 torr in drying oil/latex films are displayed in *Figure* 7. One clear difference between these curves and the corresponding SO_2 curves is the lack of an initial diffusion region. Diffusion of oxygen is not evident because oxygen has a much lower solubility than SO_2 in these samples. For the sample size used (about 100 mg), the amount of oxygen sorbed due to diffusion was too small to measure. Therefore, all of the oxygen uptake shown in *Figure* 7 is due to chemical reaction.

To apply the kinetic model to these data, $[SO_2]$ in equation (3) is replaced by $[O_2]$. Although $[O_2]$ is not measurable, it is safe to assume that it rapidly reaches a steady-state value, as was the case for SO_2. We then define a new rate constant, $k' = k[O_2]$, which will have units of $(\text{time})^{-1}$. This new rate constant clearly will depend on the oxygen pressure used, whereas k was independent of SO_2 pressure. Any rate constant comparisons made between samples must therefore be done at the same oxygen pressure to be meaningful.

The solid lines in *Figure* 7 show the results of fitting the revised model to the 60.9 torr oxygen data, and the k' values are listed in *Table* 4. The ratio k'(linoleic)/k'(linolenic) = 1.34, which is again very close to the ideal value of 1.33, and the rate constants are nearly equal for these two drying oils when expressed in terms of moles of allylic sites. This fur-

Table 4—Rate Constants[a] for Reaction of O_2 at 60.9 torr with Linolenic and Linoleic Acid

	mole O/mole drying oil	**mole O/mole allylic sites**
Linolenic acid	1.05×10^{-6}	4.20×10^{-6}
Linoleic acid	1.41×10^{-6}	4.23×10^{-6}
k'(linoleic)/k'(linolenic)	1.34	

(a) Units: sec^{-1}.

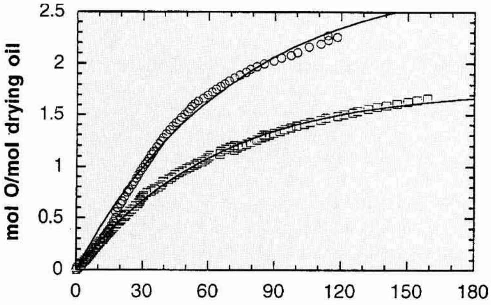

Figure 7—Chemical reaction portion of the mass uptake curve for 20% linolenic and 20% linoleic acid in latex (circles and squares, respectively) exposed to 60.9 torr O_2 at 30°C. Solid lines are fits to the kinetic model

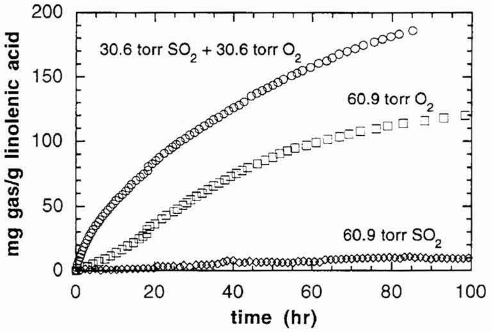

Figure 8—Chemical reaction portion of the mass uptake curve for 20% linolenic acid in latex exposed to SO_2 (diamonds), O_2 (squares) and a 50/50 mixture of the two (circles) at 30°C. The total pressure, about 61 torr, is the same in each case

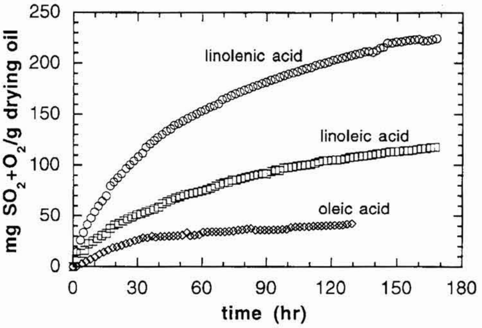

Figure 9—Chemical reaction portion of the mass uptake curve for 20% linolenic, linoleic, and oleic acid samples in latex (circles, squares, and diamonds, respectively) exposed to a mixture of 61.1 torr SO_2 and 35.5 torr O_2 at 30°C

ther strengthens the validity of this simple kinetic model based on number of allylic sites. The fact that the same kinetic model works for both the auto-oxidative reaction and the SO_2 reaction implies that the reaction mechanism is similar in both cases, or that they at least share the same rate-determining step.

The same experiments were also carried out with oleic acid samples. Again, no discernable uptake of oxygen could be measured for the sample sizes used.

Reaction of an SO_2/O_2 Mixture with the Drying Oils

Sulfur dioxide and oxygen are both present in the atmosphere. From a practical standpoint, it is important to know if the combination of both gases alters the chemical reaction rates. Unfortunately, the reaction kinetics cannot be precisely specified with the gravimetric technique when a mixture of gases is used, because we do not know how much of each gas is being sorbed by the sample. For this reason, we have not attempted to fit this data to the kinetic model or obtain rate constants. However, it is possible to make relative comparisons between samples exposed under similar conditions.

The chemical reaction portion of the mass uptake curve for a linolenic acid/latex sample exposed to a 50/50 mixture of SO_2 and O_2 is compared with similar samples exposed to SO_2 and O_2 alone in *Figure* 8. The same total gas pressure was used in all three cases. The amount of gas reacting per gram of linolenic acid is higher for the SO_2/O_2 mixture than for either pure gas. This suggests that some type of synergistic effect occurs when SO_2 and O_2 are simultaneously present during the auto-oxidation reaction. We speculate that adding oxygen produces many more hydroperoxide groups, and that SO_2 catalyzes the decomposition of these groups into free radicals. In other words, having both gases present ultimately results in a higher rate of radical production.

The relative uptake of gas by the three different drying oils when exposed to a mixture of 61.1 torr SO_2 and 35.5 torr O_2 is displayed in *Figure* 9. Again only the chemical reaction portions of the curves are shown. As expected, linolenic acid exhibited the highest uptake, followed by linoleic acid and oleic acid. This is the order expected based on the relative reactivity of and the number of allylic sites in these compounds. Of special significance is the fact that the combination of the two gases does produce a chemical reaction with oleic acid, whereas none could be measured with either pure gas. The reaction curves for the SO_2/O_2 mixtures shows that the combination of the two gases is much more reactive than either gas separately. This increase in reactivity is enough to compensate for the low reactivity of oleic acid. This indicates that a doubly activated allylic site is not needed for the chemical reaction to proceed when the drying oil is exposed to both gases simultaneously.

CONCLUSION

A simple gravimetric technique was used to follow the reaction of SO_2 and O_2 with linolenic acid, linoleic acid, and an alkyd paint containing both of these drying oils at 30°C. Trends in the data could be explained by a pseudo first-order kinetic model based on the concentration of allylic sites in each sample. For SO_2, the average ratio of the rate constants k(linoleic)/k(linolenic) was 1.29, and for O_2 the ratio was 1.34. Both values were very close to the expected ratio of 1.33 based upon the number of allylic sites in each drying oil. This result suggests that reaction mechanisms for SO_2 and O_2 with these drying oils are very similar, or that they at least share the same rate-determining step. The rate constant measured for the alkyd paint was higher than the rate constant for either linolenic or linoleic acid, presumably due to the presence of a catalyst in the paint. No chemical reaction could be detected between oleic acid and the individual gases SO_2 or O_2 with this technique.

Similar experiments were carried out for linolenic, linoleic, and oleic acid exposed to mixtures of SO_2 and O_2. The overall mass uptake of gas due to chemical reaction was substantially higher for the gas mixture than for either gas alone when measured at the same total gas pressure. This indicates that a synergistic effect occurs when SO_2 and oxygen are mixed which enhances the overall reactivity. This was especially evident in the case of oleic acid, for which significant chemical reaction occurred when exposed to the gas mixture, but not when it was exposed to either gas alone.

The combination of SO_2 and O_2 gases increases the chemical reaction rate of the auto-oxidation reaction. As a result, the alkyd paint film will dry more quickly, but it will become more brittle. There is also a noticeable discoloration of the paint film when exposed to SO_2. The increased crosslink density that results from combined exposure to SO_2 and O_2 will likely reduce the durability of the coating due to increased sensitivity to thermal cycling of the paint film and substrate.

ACKNOWLEDGMENTS

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References

(1) Simendinger, W.H. and Balik, C.M., "Solubility, Diffusivity, and Chemical Reactivity of Sulfur Dioxide with an Alkyd Paint," JOURNAL OF COATINGS TECHNOLOGY, *64*, No. 812, 37 (1992).

(2) Simendinger, W.H. and Balik, C.M., "Chemical Reactivity of Sulphur Dioxide with Unsaturated Drying Oils," JOURNAL OF COATINGS TECHNOLOGY, *66*, No. 831, 39 (1994).

(3) Lundberg, W.O., *Auto-oxidation and Antioxidants*, Vol. 1, Interscience Publishers, New York (1961).

(4) Hendricks, B.J. and Balik, C.M., *J. Appl. Polymer Sci.*, *40*, 953 (1990).

(5) Oil and Colour Chemists' Association, Australia, *Surface Coatings. Vol. 1, Raw Materials and Their Usage*, Tafe Educational Books, NSW, Australia (1974).

(6) Lambourne, R., *Paint and Surface Coatings: Theory and Practice*, John Wiley & Sons, Inc., New York, 1987.

(7) Holmberg, K., *High Solids Alkyd Resins*, Marcel Dekker, Inc., New York, 1987.

(8) Press, W.H., Flannery, B.P., Teukolsky, S.A., and Vetterling, W.T., *Numerical Recipes in C*, Cambridge University Press, 1992.

1993 CONSTITUENT SOCIETY PAPER

Correlation of Accelerated Exposure Testing and Exterior Exposure Sites

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Cleveland Society for Coatings Technology Technical Committee

The Cleveland Society Technical Committee has undertaken a long-term study which will provide some guidance and basic information for researchers working in the areas of accelerated testing and exterior exposure analysis. The ultimate goal will be the correlation of accelerated test methods to several geographically different exposure sites. The Technical Committee began the study by choosing nine different coatings systems which offer a wide variety of performance characteristics. These systems included a high-solids epoxy, a high-solids urethane, several types of waterborne systems (waterborne epoxy, epoxy ester, acrylic, direct-to-metal (DTM) acrylic, water reducible alkyd, and styrenated acrylic), and a Type TT-E-266 specification alkyd. All systems were commercially available and, except for the specification alkyd, are considered "compliant coatings."

These systems were placed on exterior exposure at nine different sites across the United States. Four are commonly referred to as heavy marine exposure sites and include Ocean City, NJ; Kure Beach, NC; Daytona Beach, FL; and San Francisco, CA (the Golden Gate Bridge). Three more can be considered moderate to heavy industrial exposure sites and include Cleveland, OH; North Kansas City, MO; and Miami, FL. Another site, the Los Angeles Basin area, is known for heavy smog, and the last site, Portland, OR, was chosen for high humidity and rainfall. The first six month's exposure results and early correlations within these sites will be discussed, but longer exposure times will be required before many conclusions can be drawn.

These same nine systems were also tested by use of six accelerated methods according to the protocol established by an ASTM Committee (D01.27.31) on accelerated corrosion testing. The methods include salt fog, cyclic salt fog, Prohesion® Cabinet, Cyclic Prohesion®/QUV®, and cyclic immersion/weathering (KTA-Envirotest®). These methods are either in use today or have been proposed as more realistic replacements to those in current use. Results of these accelerated tests will be discussed and an attempt made to correlate the results among these accelerated methods. In addition, positron annihilation lifetime spectroscopy (PALS) will be run at the end of the exposure period on the Daytona Beach panels.

Future work will focus on direct correlation of the long-term exposure results to the different accelerated methods.

INTRODUCTION

The ability to accurately predict the lifetime performance properties and, in particular, the corrosion resistance of an experimental formulation, would be extremely important to the coatings technologist. The ability to shorten research and development times and, ultimately, the costs required to introduce a new coating, would be extremely valuable to every coatings or materials company currently in business.

Reducing the cycle time between development and introduction of a new coatings formulation has been the goal of most companies, i.e., programs in raw material evaluations leading to more cost effective or better performing alternates. In addition to these driving forces, environmental legislation has been an added incentive. Developing new

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compliant systems is now a must for all coatings companies. The ability to reduce the cycle time is now more important than ever.

Fifteen years ago, the cost due to corrosion of metals was estimated at a staggering $70 billion.[1] Today, the amount is undoubtedly much higher than that. Formulating corrosion inhibitive coatings which are also compliant has it's own unique requirements. Included is the ability to withstand very harsh environments or passivate surfaces and provide barrier properties. These requirements make the rapid testing of these coatings critical, but also much more difficult.

The problems associated with the accurate prediction of coatings performance are not new. The goal of achieving fast, reliable methods which accelerate weathering and corrosion has been the aim of researchers for the past 70 years. In fact, the first attempt to use artificial weathering was cited in a paper by Nelson written in 1922.[2] A useful history of the development of artificial weathering is also available by Garlock and Sward.[3]

When researchers in corrosion science have performed accelerated testing, the most cited methods have utilized the salt fog spray cabinet.[4] Even so, many reservations have been voiced due to the unnatural results of this method. This is especially true when compared to natural weathering (except for the harshest of heavy marine exposure sites).[5] In particular, the unnatural chemistries of the corrosion products were cited by several researchers[6-8] as well as the exclusion of other commonly found chemical species; the presence of sulphates in the corrosion products from industrial atmospheres was known to Nelson, who tried to incorporate them into his early weathering chambers.

The presence of contaminants on the steel itself, and the resulting corrosion by-products, has been thoroughly investigated.[9] In the corrosion cell, the presence of sulphate in the form of soluble iron salts has also been known for years.[10] Today, the occurrence of acid rain is attributable to the sulphur and nitrogen by-products of our industrialized society. Tests for durability in this type of environment are available in the form of moist sulphur dioxide cabinets (i.e., the Kesternich cabinet), as well as immersion in standardized acid rain formulations available through the United States Environmental Protection Agency.

Timmins pointed out that salt fog testing was qualifying coatings in the lab, yet, these same coatings were failing in the field.[11] Speaking at a 1981 symposium sponsored by The National Association of Corrosion Engineers (NACE) on the use of organic coatings to protect steel, Leidheiser concluded by listing 10 unsolved problems related to coatings and the corrosion protection of steel.[12] The number one problem, as he saw it, was the " . . . development of an accelerated atmospheric corrosion test, the results of which correlate well with service experience."

Ultraviolet/condensation testing had been used as a means to simulate Florida exposure for fading and loss of gloss. This common accelerated test method is best embodied by ASTM Methods G 26-92 and G 53-91[13]: specifically, Xenon Arc and QUV®, respectively. Several studies were done to correlate these instruments to exterior exposures[14-16] with good results when corrosion was not a factor.

Several researchers investigated the use of wet/dry salt fog cycle testing,[17-18] leading to the development of tests used by the Society of Automotive Engineers (SAE),[19] as well as the use of modified atmospheres. Skerry and coworkers used a method developed by Timmins, dubbed the Prohesion® Test, to correlate exposures.[20] In that work, the additional use of a weathering cycle was first proposed. The early successes of this cyclic method, which requires a UV weathering cycle coupled with a corrosive prohesion cycle, have spawned a renewed interest and belief that true correlations to exterior exposures are possible.[21-28]

In 1990, ASTM Subcommittee D01.27.31 on Accelerated Testing in Corrosive Environments began to consider a round-

Table 1—Systems and Manufacturers Recommended Application and Coverage

System #	Description	Application Method	Recoat Time (Hr)	Wt% Solids	Vol% Solids	Wet Film	Dry Film
1	DTM self priming acrylic latex	Airless spray	2.0	—	37.5	4.0	1.5
	Topcoated with a DTM acrylic latex	Airless spray	2.0	—	37.5	4.0	1.5
2	Acrylic latex primer	Airless spray	2.0	—	37.5	4.0	1.5
	Topcoated with an acrylic latex semi-gloss	Airless spray	2.0	—	37.5	4.0	1.5
3	2-Component high-solids urethane basecoat	Conventional spray	4.0	66.7	52.3	1.9	1.0
	2-Component high-solids urethane topcoat	Conventional spray	5.0	66.9	66.9	1.5	1.0
4	High-solids solvent epoxy aluminum mastic	Airless spray	18.0	80.0	72.0	6.5	4.5
	Elastomeric styrene-acrylic latex topcoat	Airless spray	18.0	59.0	53.0	16.0	8.5
5	Waterborne acrylic-crosslinked epoxy basecoat	Airless spray	2.0	—	37.5	8.0	3.0
	Waterborne acrylic-crosslinked epoxy topcoat	Airless spray	2.0	—	37.5	8.0	3.0
6	Water-reducible alkyd—self priming	Conventional spray	0.5	48.6	34.5	2.9	1.0
	Water-reducible alkyd—self priming	Conventional spray	0.5	48.6	34.5	2.9	1.0
7	Styrene acrylic maintenance coating—self primed	Conventional spray	—	54.6	39.6	6.3	2.5
	Styrene acrylic maintenance coating—self primed	Conventional spray	—	54.6	39.6	6.3	2.5
8	Water-reducible epoxy ester rrimer	Conventional spray	18.0	44.0	30.7	3.7	1.1
	Semi-gloss acrylic latex topcoat	Airless spray	2.0	—	37.5	4.0	1.5
9	Specification alkyd primer—TTE-266	Conventional spray	24.0	59.7	37.5	4.7	1.8
	Specification alkyd—TTE-266	Conventional spray	24.0	55.8	38.0	4.6	1.8

robin program to identify and characterize several exterior corrosive sites as well as several types of accelerated test instruments. Their aim was to correlate these sites and instruments, using several industrial maintenance coatings in one part of the test, and several coil coatings in another.

The proposal was quite intriguing, but the choice of specification coatings could literally take decades to corrode in the chosen environments. Some coatings types also contained many ingredients that every state was now questioning for their environmental impact. The Cleveland Society for Coatings Technology Technical Committee decided to undertake a similar study, but would investigate newer compliant coatings.

Our test protocol, which will be discussed in more detail later, would be essentially that of ASTM Subcommittee D01.27.31. The accelerated methods would include salt fog (5.0% NaCl), cyclic salt fog (5.0% NaCl, run in a wet/dry cycling cabinet), wet/dry cycling cabinet with 0.05% NaCl and 0.35% $(NH_4)_2SO_4$ as the electrolyte (recommended Prohesion Cabinet cycle), UV condensation cabinet cycled with the wet/dry prohesion type cycle (QUV/Cyclic Prohesion with 0.05% NaCl and 0.35% $(NH_4)_2SO_4$), and cyclic immersion/weathering using the KTA-Envirotest® (0.05% NaCl and 0.35% $(NH_4)_2SO_4$). Additionally, positron annihilation lifetime spectroscopy (PALS) would be run for greater characterization of the exterior results. The first five methods are essentially those of the ASTM study; PALS was added by the Cleveland Society.

The Prohesion cabinet, which offers a rapid drying cycle and the use of an electrolyte consisting of ammonium sulphate ($(NH_4)_2SO_4$) and sodium chloride (NaCl), appears to give very good correlation with certain systems. The use of a weathering cycle, usually some form of ultraviolet (UV) radiation exposure, in conjunction with the Prohesion cabinet can improve correlation. An immersion cabinet, with both electrolyte treatment of the test panel, followed by a UV cycle, has also been developed. More removed from mainstream testing is the measurement of free volume by use of PALS to determine a coatings service life and performance properties.

By choosing coatings which employed newer technologies currently of interest to our members, a broader base of knowledge for future formulating reference could be obtained. Formulations that meet new regulatory requirements, including low toxicity inhibitive pigments, lower volatile organic content (VOC), and new higher performance binders, would make this data more timely.

Originally, six commercial sites were considered for exterior exposure in line with the ASTM proposal. This was modified to include a broader range of environments. The sites are Ocean City Research Corp., Ocean City, NJ; LaQue Center for Corrosion Technology, Inc., Kure Beach, NC; Battelle, Daytona Beach, FL; Sub-Tropical Testing Service, Miami, FL; Truesdail Laboratories, Inc., Tustin, CA; Coatings Research Group, Inc., Cleveland, OH; Tnemec, Inc., North Kansas City, MO; the Golden Gate Bride Authority, San Francisco, CA; and The Rodda Paint Co., Portland, OR.

The ultimate goal of this study is to determine whether the currently proposed methods statistically correlate with the exterior exposures. After only six months of exterior exposure, the results presented should be viewed as preliminary. Updates will be issued periodically, with a final report issued at completion of the exposures.

Cleveland Society 1992-1993 Technical Committee

Ben J. Carlozzo (Chairman)	Mameco International, Inc.
Jeff Andrews	Montana Products Co.
Freidun Anwari	Coatings Research Group, Inc.
Mark DiLorenzo	Engelhard Corp.
Roy Glover	The Mahoning Paint Corp.
Steven Grossman	The Q-Panel Co.
Carl J. Knauss	Kent State University
Joseph McCarthy	Plasti-Kote Co.
Brian Mysza	The Sherwin-Williams Co.
Rene Patterson	The Sherwin-Williams Co.
Russell Raymond	The Q-Panel Co.
Brian Skerry	The Sherwin-Williams Co.
Phillip M. Slifko	Coatings Research Group, Inc.
Walter Stipkovich	Coatings Research Group, Inc.
John C. Weaver	Case Western Reserve University
Michael Wolfe	Seegott, Inc.

EXPERIMENTAL

Test Paints

Eight systems were chosen based on the criteria that all coatings be VOC compliant under current California law. In addition, a ninth system was chosen to correlate our results to the ASTM study. All systems were commercially available products. *Table* 1 lists the systems and how they were applied. The systems included a direct-to-metal (DTM) waterborne enamel—self primed; an acrylic latex system with inhibitive primer with a semi-gloss latex topcoat; a high-solids, solvent-borne urethane—self primed; a high-solids epoxy aluminum mastic, top-coated with an elastomeric latex; a waterborne acrylic crosslinked epoxy primer, top-coated with an acrylic crosslinked epoxy; a water-reducible alkyd—self primed (DTM); a waterborne styrene acrylic—self primed (DTM); an aqueous epoxy ester primer, top-coated with a semi-gloss acrylic latex; and a low-solids specification alkyd (TT-E-266 Type)—self primed.

PROCEDURE

Panel Preparation

All coatings were spray applied at the manufacturers' recommended film build on 4 × 12 in. cold rolled steel panels (0.032 in. thick), ground on one side to a suitable finish. The topcoats were applied following the suppliers' recommendations for time to recoat. In order to obtain enough uniform panels for each study, a 30% excess was prepared for each system.

Sufficient panels were prepared for nine exposure sites and five accelerated tests. Forty-five 4 × 12 in. panels would be required for exterior exposure and twenty-five 4 × 6 in. panels for accelerated testing, i.e., five replicates of each system would be used for each test.

The panels were further prepared by scoring the bottom half of each and then edge dipping all four sides in a high melting point paraffin wax. Dry film build and gloss data of each would be recorded for statistical averaging.

All panels were primed on Saturday, August 1, 1992, and top-coated either that same day, if required by the manufacturers' instructions, or the following day. The panels were allowed to cure for four days at ambient temperature on spray racks constructed for this purpose. The panels were then labeled, placed in open boxes on edge, and separated by pieces of silicon treated release paper to prevent blocking. In the ensuing months, these panels were reviewed for dry film build, and gloss, cut to length for the accelerated tests, and scribed. Between work by the committee, the panels were stored on edge in open boxes, in a cool neutral environment.

In general, it is common practice to fully cure panels before beginning exposure studies. This handling procedure would allow coalescence to occur and finalize film formation, and, given the repeated handling to characterize and prepare each panel, all were considered fully cured. Treating all panels in this manner would minimize discrepancies from test to test, without retarding oxidative or reactive curing.

The last step required edge dipping all panels with wax to minimize edge effects. This original wax consisted of a high melting point (160°F) paraffin wax. This material proved unable to withstand the cold weather cycling and had poor adhesion to the water reducible alkyd enamel. When the panels were returned for inspection, the formulation was modified, by the addition of approximately 50% by weight of an ethylene/vinyl acetate copolymer (Elvax 205W, Dupont), which raised the melting point and made the wax more flexible. The exterior panels were re-dipped with this new formulation before being returned for additional exposure. The effectiveness of this new coating will be evaluated in a later report.

Exterior Exposures

The panels were concurrently placed on exterior exposure at all nine sites on October 15, 1992. After six months weathering, the panels from the nine exterior exposure sites were returned to Cleveland on April 15, 1993, for their first evaluation. The projected cycle of exposure will next require evaluation after one full year and then every year thereafter. They were returned to their respective exposure sites for an additional six months exposure on June 7, 1993.

All panels were rated for the following:

ASTM D 1654[29] *Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments*: Failure would be considered rust creepage from the scribe greater than 1/4 in. (ASTM rating of 3 or worse).

ASTM D 610[30] *Evaluating Degree of Rusting on Painted Steel Surfaces*: Failure was considered a surface which matches the visual standard for 16% or greater overall rusting (ASTM rating of 3 or worse).

ASTM D 714[31] *Evaluating Degree of Blistering of Paints*: For our purposes, failure will mean when a panel has achieved a medium density of blisters, regardless of the size. Often blisters will appear early in the test, only to disappear with continued exposure. Note of this was taken.

ASTM D 2803[32] *Filiform Resistance of Organic Coatings on Metal*: The presence or absence was noted as well as the frequency. ASTM does not currently recognize a visual standard for filiform corrosion, but a suggested visual reference can be found in the Federation publication "Pictorial Standards of Coatings Defects.'"

Accelerated Testing

The five labs which ran the six different tests were each given a set of panels by January 31, 1993. All testing, except for the PALS, was initiated by February 15, 1993. There has been some question as to the ability to make correlations between panels tested after an additional two months of storage. Given the scope of the undertaking, and the need to schedule instrument time, it was decided to delay the accelerated tests until all could be performed simultaneously. In this way, the intra-lab results should be statistically significant. At a later date, additional testing will be conducted to assess possible curing effects from this type of delay.

The following general guidelines and procedures for determining degree of failure and time to terminate the testing were given:

(1) The start date for this exposure should be as close to Monday, February 1, 1993 as possible.

(2) Due to the wide nature and type of coatings investigated, it is not possible to assign a total duration time for each accelerated exposure. The following criteria for the extent of failure would be used to determine when the accelerated exposure should be terminated:

(a) Failure will be determined by use of ASTM standards for blistering, rust creepage from the scribe, and overall degree of rusting as described in the exterior exposure section. A copy of these methods and pictorial standards were supplied to each lab.

(b) The test would run until approximately 60% of all the panels tested had failed (see ASTM methods for exterior exposure). All panels would be kept in the test chamber for the duration of the test. The time to failure for any particular panel would be noted in a log listing hours to failure as well as failure mode. A maximum time for operation was also given.

(3) Before testing, the labs were asked to note the condition of the edge coating. Some panels from the exterior exposure series showed signs of chipping and delamination of the wax, particularly the black coating. If present, they were asked to either re-dip the edges, or at least tape them to minimize edge effects during testing.

(4) Each panel had been scribed by use of a hand tool. A request was made to expose the panels so that the scribe was oriented on the lower half of the panel throughout the test, i.e., the bottom edge of the panel is the closest to the scribe. This would make it easier to evaluate degree of rusting, as previously described, without interference from rust staining from the scribe.

(5) The following suggested evaluation procedure was given: evaluate once a day for the first week (four times), once every two days for the second week (three times) and,

Table 2—Results of Testing by ASTM D 1654

Ocean City, NJ: 6 Months

SYS	1	2	3	4	5	Mean	S/D	Rank	
								tau	rho
1	5	4	4	4	3	4.0	0.7071	4	7.0
2	7[a]	6	7	6	7	6.6	0.5477	2	2.5
3	5	5	5	4	3	4.4	0.8944	4	7.0
4	3	3	2	6	4	3.6	1.5166	4	7.0
5	5	3	5	4	5	4.4	0.8944	4	7.0
6	4	5	5	5	4	4.6	0.5477	4	7.0
7	8[a]	7[a]	8[a]	8[a]	8[a]	7.8	0.4472	1	1.0
8	5	6	6	5	4	5.2	0.8367	3	4.0
9	7	7	7	7	7	7.0	0.0000	2.	2.5

Stand. dev. of means = 1.4802
Mean of stand. dev.'s = 0.7102

Kure Beach, NC: 6 Months

SYS	1	2	3	4	5	Mean	S/D	Rank	
								tau	rho
1	4	4	5	5	5	4.6	0.5477	3	8.0
2	7	7	8	7	7	7.2	0.4472	1	2.0
3	3	4	5	4	3	3.8	0.8367	4	9.0
4	3	5	10	5	3	5.2	2.8636	2	5.5
5	6	6	5	6	6	5.8	0.4472	2	5.5
6	5	6	5	6	6	5.6	0.5477	2	5.5
7	7[a]	8[a]	7[a]	7[a]	7[a]	7.2	0.4472	1	2.0
8	6	6	6	6	6	6.0	0.0000	2.	5.5
9	8[a]	7[a]	6[a]	7[a]	6[a]	6.8	0.8367	1	2.0

Stand. dev. of means = 1.1619
Mean of stand. dev.'s = 0.7749

Daytona Beach, FL: 6 Months

SYS	1	2	3	4	5	Mean	S/D	Rank	
								tau	rho
1	4	4	5	4	5	4.4	0.5477	5	8.0
2	8[a]	7[a]	7[a]	7[a]	7[a]	7.2	0.4472	2	3.0
3	3	3	3	3	3	3.0	0.000	6	9.0
4	10	9	9	9	10	9.4	0.5477	1	1.0
5	5	6	6	5	6	5.6	0.5477	4	7.0
6	6	6	6	6	6	6.0	0.0000	3	5.5
7	7[a]	7[a]	7[a]	7[a]	7[a]	7.0	0.0000	2	3.0
8	6	6	6	6	6	6.0	0.0000	3	5.5
9	7[a]	7[a]	7[a]	7[a]	7[a]	7.0	0.0000	2	3.0

Stand. dev. of means = 1.8178
Mean of stand. dev.'s = 0.2323

Cleveland, OH: 6 Months

SYS	1	2	3	4	5	Mean	S/D	Rank	
								tau	rho
1	7	6	7	7	8	7.0	0.7071	2	5.5
2	7	8	7	8	8	7.6	0.5477	2	5.5
3	5	5	6	5	6	5.4	0.5477	3	9.0
4	5	6	6	6	10	6.6	1.9494	2	5.5
5	7	7	8	7	7	7.2	0.4472	2	5.5
6	8	7	7	8	8	7.6	0.5477	2	5.5
7	8	8	9	9	9	8.6	0.5477	1	1.5
8	7	8	8	8	7	7.6	0.5477	2	5.5
9	9	8	9	8	9	8.6	0.5477	1	1.5

Stand. dev. of means = 0.9404
Mean of stand. dev.'s = 0.7100

N. Kansas City, MO: 6 Months

SYS	1	2	3	4	5	Mean	S/D	Rank	
								tau	rho
1	8	9	8	9	9	8.6	0.5477	1	4.0
2	9	9	9	9	9	9.0	0.0000	1	4.0
3	7[a]	7[a]	7[a]	7[a]	7[a]	7.0	0.0000	2	8.5
4	9	9	6	9	9	8.4	1.3416	1	4.0
5	7	6	7	7	7	6.8	0.4472	2	8.5
6	9	8	9	8	9	8.6	0.5477	1	4.0
7	9	9	9	9	9	9.0	0.0000	1	4.0
8	9	9	9	8	9	8.8	0.4472	1	4.0
9	9	9	9	8	9	8.8	0.4472	1	4.0

Stand. dev. of means = 0.8367
Mean of stand. dev.'s = 0.4198

Miami Beach, FL: 6 Months

SYS	1	2	3	4	5	Mean	S/D	Rank	
								tau	rho
1	8	8	8	8	8	8.0	0.0000	3	5.0
2	9	9	9	9	9	9.0	0.0000	2	3.0
3	5	5	5	5	5	5.0	0.0000	5	9.0
4	10	10	10	10	10	10.0	0.0000	1	1.5
5	10	10	10	10	8	9.6	0.8944	1	1.5
6	7	7	7	7	7	7.0	0.0000	4	7.5
7	8	8	8	8	8	8.0	0.0000	3	5.0
8	7	7	7	7	7	7.0	0.0000	4	7.5
9	8	7	8	7	8	7.6	0.5477	3	5.0

Stand. dev. of means = 1.5268
Mean of stand. dev.'s = 0.1602

Portland, OR: 6 Months

SYS	1	2	3	4	5	Mean	S/D	Rank	
								tau	rho
1	9	9	9	9	9	9.0	0.0000	1	4.0
2	9	8	9	9	8	8.6	0.5477	1	4.0
3	6	6	6	6	6	6.0	0.0000	3	9.0
4	10	10	8	8	10	9.2	1.0954	1	4.0
5	8	8	5	8	8	7.4	1.3416	2	8.0
6	9	9	9	9	9	9.0	0.0000	1	4.0
7	9	9	9	8	8	8.6	0.5477	1	4.0
8	9	9	8	9	9	8.8	0.4472	1	4.0
9	8	9	8	9	9	8.6	0.5477	1	4.0

Stand. dev. of means = 1.0236
Mean of stand. dev.'s = 0.5030

San Francisco, CA: 6 Months

SYS	1	2	3	4	5	Mean	S/D	Rank	
								tau	rho
1	7	7	6	7	6	6.6	0.5477	3	6.5
2	9	9	9	9[a]	9	9.0	0.0000	1	2.0
3	3	3	3[a]	3[a]	3	3.0	0.0000	5	9.0
4	10	10	10	10	6	9.2	1.7889	1	2.0
5	8	8	8	8	9	8.2	0.4472	2	4.5
6	5	6	6	5	5	5.4	0.5477	4	8.0
7	9[a]	8[a]	9[a]	8[a]	8[a]	8.4	0.5477	2	4.5
8	7	6	6	6	6	6.2	0.4472	3	6.5
9	9	8	9	8	9	8.6	0.5477	1	2.0

Stand. dev. of means = 2.0578
Mean of stand. dev.'s = 0.5416

Tustin, CA: 6 Months[b]

SYS	1	2	3	4	5	Mean	S/D	Rank	
								tau	rho
1	8	8	8	8	8	8.0	0.0000	2	7.0
2	9	9	9	9	9	9.0	0.0000	1	3.0
3	6	6	6[a]	6[a]	6[a]	6.0	0.0000	3	9.0
4	9	9	9	9	9	9.0	0.0000	1	3.0
5	9	9	8	9	8	8.6	0.5477	1	3.0
6	8	8	10	8	8	8.4	0.8944	2	7.0
7	9	9	9	9	9	9.0	0.0000	1	3.0
8	8	8	8	8	8	8.0	0.0000	2	7.0
9	9	9	9	9	9	9.0	0.0000	1	3.0

Stand. dev. of means = 0.9695
Mean of stand. dev.'s = 0.1602

(a) Indicates presence of filiform-like corrosion.
(b) All panels show staining which does not wash off with water or mineral spirits.

Table 3—Results of Testing by ASTM D 610

Ocean City, NJ: 6 Months

SYS	1	2	3	4	5	Mean	S/D	Rank	
								tau	rho
1	10	10	10	10	10	10.0	0.0000	1	4.5
2	10	10	10	10	10	10.0	0.0000	1	4.5
3	10	10	10	10	10	10.0	0.0000	1	4.5
4	10	10	10	10	10	10.0	0.0000	1	4.5
5	10	10	10	10	10	10.0	0.0000	1	4.5
6	8	8	8	8	8	8.0	0.0000	2	9.0
7	10	10	10	10	10	10.0	0.0000	1	4.5
8	10	10	10	10	10	10.0	0.0000	1	4.5
9	10	10	10	10	10	10.0	0.0000	1	4.5

Stand. dev. of means = 0.6667
Mean of stand. dev.'s = 0.0000

Kure Beach, NC: 6 Months

1	2	3	4	5	Mean	S/D	Rank	
							tau	rho
10	10	10	10	10	10.0	0.0000	1	3.0
7	8	9	9	9	8.4	0.8944	3	7.5
10	10	10	10	10	10.0	0.0000	1	3.0
10	10	9	9	9	9.4	0.5477	2	6.0
10	10	10	10	10	10.0	0.0000	1	3.0
7	6	7	7	7	6.8	0.4472	4	9.0
10	10	10	10	10	10.0	0.0000	1	3.0
8	9	8	9	8	8.4	0.5477	3	7.5
10	10	10	10	9	9.8	0.4472	1	3.0

1.1180
0.3205

Daytona Beach, FL: 6 Months

1	2	3	4	5	Mean	S/D	Rank	
							tau	rho
10	10	10	10	10	10.0	0.0000	1	3.5
10	10	9	9	10	9.6	0.5477	1	3.5
10	10	10	10	10	10.0	0.0000	1	3.5
10	10	10	10	10	10.0	0.0000	1	3.5
8	10	10	8	10	9.2	1.0954	1	3.5
8	8	8	8	8	8.0	0.0000	4	9.0
10	9	10	8	9	9.2	0.8367	2	7.0
8	9	9	8	9	8.6	0.5477	3	8.0
10	10	10	10	10	10.0	0.0000	1	3.5

0.7211
0.3364

Cleveland, OH: 6 Months

SYS	1	2	3	4	5	Mean	S/D	Rank	
								tau	rho
1	10	10	10	10	10	10.0	0.0000	1	5.0
2	10	10	10	10	10	10.0	0.0000	1	5.0
3	10	10	10	10	10	10.0	0.0000	1	5.0
4	10	10	7	9	10	9.2	1.3038	1	5.0
5	10	10	10	10	10	10.0	0.0000	1	5.0
6	10	10	10	10	10	10.0	0.0000	1	5.0
7	10	10	10	10	9	9.8	0.4472	1	5.0
8	10	10	10	10	10	10.0	0.0000	1	5.0
9	10	10	10	10	10	10.0	0.0000	1	5.0

Stand. dev. of means = 0.2667
Mean of stand. dev.'s = 0.1946

N. Kansas City, MO: 6 Months

1	2	3	4	5	Mean	S/D	Rank	
							tau	rho
10	10	10	10	10	10.0	0.0000	1	4.5
10	9	9	9	10	9.4	0.5477	2	9.0
10	10	10	10	10	10.0	0.0000	1	4.5
9	10	10	10	9	9.6	0.5477	1	4.5
10	10	10	10	10	10.0	0.0000	1	4.5
10	10	10	10	10	10.0	0.0000	1	4.5
10	10	10	10	10	10.0	0.0000	1	4.5
10	10	10	10	10	10.0	0.0000	1	4.5
10	10	10	10	10	10.0	0.0000	1	4.5

0.2646
0.1217

Miami Beach, FL: 6 Months

1	2	3	4	5	Mean	S/D	Rank	
							tau	rho
10	10	10	10	10	10.0	0.0000	1	4.5
10	10	10	10	10	10.0	0.0000	1	4.5
10	10	10	10	10	10.0	0.0000	1	4.5
10	10	10	10	10	10.0	0.0000	1	4.5
10	10	10	10	10	10.0	0.0000	1	4.5
10	10	10	10	9	9.8	0.4472	1	4.5
10	9	9	10	10	9.4	0.5477	2	9.0
10	10	10	10	10	10.0	0.0000	1	4.5
10	10	10	10	10	10.0	0.0000	1	4.5

0.2028
0.1105

Portland, OR: 6 Months

SYS	1	2	3	4	5	Mean	S/D	Rank	
								tau	rho
1	10	10	10	10	10	10.0	0.0000	1	5.0
2	10	10	10	10	9	9.8	0.4472	1	5.0
3	10	10	10	10	10	10.0	0.0000	1	5.0
4	10	10	9	10	10	9.2	0.4472	1	5.0
5	10	10	10	10	9	9.8	0.4472	1	5.0
6	10	10	10	10	10	10.0	0.0000	1	5.0
7	10	10	10	10	10	10.0	0.0000	1	5.0
8	10	10	10	10	10	10.0	0.0000	1	5.0
9	10	10	10	10	10	10.0	0.0000	1	5.0

Stand. dev. of means = 0.1000
Mean of stand. dev.'s = 0.1491

San Francisco, CA: 6 Months

1	2	3	4	5	Mean	S/D	Rank	
							tau	rho
10	10	10	10	10	10.0	0.0000	1	3.0
9	9	9	9	9	9.0	0.0000	2	7.0
10	10	10	10	10	10.0	0.0000	1	3.0
10	10	10	10	10	10.0	0.0000	1	3.0
10	10	10	10	10	10.0	0.0000	1	3.0
7	8	8	7	7	7.4	0.5477	3	9.0
10	10	10	10	10	10.0	0.0000	1	3.0
9	9	9	9	9	9.0	0.0000	2	7.0
10	9	9	9	10	9.4	0.5477	2	7.0

0.8743
0.1217

Tustin, CA: 6 Months

1	2	3	4	5	Mean	S/D	Rank	
							tau	rho
10	10	10	10	10	10.0	0.0000	1	1.5
10	10	10	10	10	10.0	0.0000	1	1.5
9	9	9	9	9	9.0	0.0000	2	5.0
9	9	9	9	9	9.0	0.0000	2	5.0
9	9	9	8	7	8.4	0.8944	2	5.0
7	7	7	7	7	7.0	0.0000	4	9.0
9	9	9	9	9	9.0	0.0000	2	5.0
8	8	8	8	8	8.0	0.0000	3	8.0
9	9	9	9	9	9.0	0.0000	2	5.0

0.9404
0.0994

thereafter, once every week until the 60% failure level is achieved.

(6) At a minimum, all panels would be rotated within the instrument at least once every 100 hr to eliminate false performance caused by "dead spots" and corners. This was not done for the KTA-Envirotest series. The panels continuously move in that cabinet and their attachment does not make changing their positions feasible. They were initially placed to get the widest distribution of systems in the instrument.

(7) When a 60% failure rate had been achieved, all panels would be evaluated one final time for degree of blistering, while still wet. This would allow us to keep track of any blistering which might otherwise recede during shipping.

Each lab was also given specific instructions pertinent to the test(s) they were running, including strength of solution and cycle times, etc.

Accelerated Tests

The following accelerated test methods were used for each:

(1) STANDARD SALT SPRAY—ASTM B 117-90: This test was run as standard salt fog B 117 which utilizes 5% NaCl at 35°C. Electrolyte parameters were maintained at normal levels for the duration of the test (electrolyte specific gravity, Ph, temperature, and collection rate).

(2) CYCLIC FOG EXPOSURE WITH 5% SODIUM CHLORIDE: This test was run in a Prohesion-type cabinet using a 5% NaCl solution instead of the weaker salt mixture recommended. The cycle was for one hour ambient spray followed by one hour forced dry air at 40°C.

(3) CYCLIC SPRAY CHAMBER TEST (PROHESION): This test was run in the classic Prohesion method with a spray consisting of 3.5 g/l $(NH_4)_2S0_4$ and 0.5 g/l NaCl. The cycle was the same as test #2, with one hour ambient spray followed by one hour forced dry air at 40°C.

(4) COMBINATION CYCLE OF CYCLIC SPRAY CHAMBER AND UV/CONDENSATION EXPOSURE: The electrolyte solution in this test is similar to that of tests #2 and #3 with 3.5 g/l $(NH_4)_2S0_4$ and 0.5 g/l NaCl as the spray. The major difference here is the cycle includes alternating between one week in a UV/condensation cabinet and the Prohesion-type cabinet. For our testing, a QUV accelerated weather tester was used for the weathering cycle. The prohesion cycle was similar to test #3, with one hour ambient spray followed by one hour forced dry air at 40°C. The QUV was run according to ASTM G 53 running a standard exposure of four hours UV at 60°C with UVA-340 lamps and four hours condensation at 50°C. The choice of lamps is discussed in the following section.

(5) CYCLIC IMMERSION WITH UV RADIATION (KTA-ENVIROTEST): This is one of the newest tests investigated. The stainless steel test cabinet has an axle which can be rotated. There is a timer which allows various cycles to be programmed. Eight sets of six rods are evenly spaced from end-to-end; the six rods in each set are evenly placed along the circumference (every 60 degrees). Each rod has a panel holder attached to the end, with stainless steel bolts for mounting test panels. The eight panels along the axis all undergo the same exposure at any given time. The inside top of the cabinet houses four UVA-340 bulbs, the same type as those used on the QUV-type cabinets. One row of eight panels receives direct UV light. The lower half of the cabinet can be filled with any electrolyte of interest.

At the recommended fill level, three rows of rods and their panels are immersed, while two rows are undergoing drying and one is in direct UV exposure. The wheel turns according to instruments from an electronic timer.

The newness of the test presented some problems as the parameters for testing have not been optimized and some design limitations, which may have been addressed in newer versions of this instrument, were evident here. For instance, the placement of the thermocouple, which controls cabinet temperature, was behind the bank of UV lights. This meant that control of the area near the panels would always be affected by the bulb temperatures. The heating system is a long heating element close to one of the drying rows. This heats the atmosphere of the cabinet. Since the element was only powered in response to drops in temperature, some rows during the test would receive more direct heat than others.

A minor problem arose when rusty water began staining the panels during immersion, making it difficult to determine rusting of the panels. A specified time for changing the electrolyte was not given, therefore the same solution was used throughout.

(6) POSITRON ANNIHILATION LIFETIME SPECTROSCOPY (PALS): This is a nondestructive, nonstimulating method of materials evaluation developed by Battelle and others. It utilizes information obtained from the interaction of positrons (the anti-matter counterpart of electrons) with materials to ascertain molecular level information on the material under investigation. The technique has been proven to be particularly sensitive for characterizing free volume in polymer based systems, and is, in fact, the only materials characterization method currently available which is capable of providing free volume information directly.

Extensive theories have been formulated to relate the physical and mechanical properties of polymer systems to the level of available free volume. These same theories provide a basis for understanding and predicting the behavior of many properties of organic coatings. Specifically, the application of PALS for predicting the barrier properties of organic coatings and characterizing the rate and degree of cure (crosslinking) in organic coatings has been demonstrated.[33]

This testing will be done as a part of the overall characterization of failure modes, and should give additional insight to the results obtained from the Daytona Beach exterior exposure panels.

The UV Light Source

In order to correlate all the artificial light exposure series, the decision was made to use only one type of light source. The pros and cons of UVA-340 type bulbs versus UVB-313 bulbs have been debated in literature.[34-41] UVA-340 bulbs were used in our study, not only due to their reputation as the most similar to natural exposure, but mainly because most of

Table 4—Results of Testing by ASTM D 714

Ocean City, NJ: 6 Months

System #	1	2	3	4	5	Mean	S/D
1	10	10	10	10	10	10.0	0.0000
2	10	10	10	10	10	10.0	0.0000
3	10	10	10	10	10	10.0	0.0000
4	10	10	10	10	10	10.0	0.0000
5	10	10	10	10	10	10.0	0.0000
6	10	10	10	10	10	10.0	0.0000
7	10	10	10	10	10	10.0	0.0000
8	10	10	10	10	10	10.0	0.0000
9	10	10	10	10	10	10.0	0.0000

Stand. dev. of means = 0.0000
Mean of stand. dev.'s = 0.0000

Kure Beach, NC: 6 Months

System #	1	2	3	4	5	Mean	S/D
1	10	10	10	10	10	10.0	0.0000
2	10	10	10	10	10	10.0	0.0000
3	10	10	10	10	10	10.0	0.0000
4	10	10	10	10	10	10.0	0.0000
5	10	10	10	10	10	10.0	0.0000
6	10	10	10	10	10	10.0	0.0000
7	10	10	10	10	10	10.0	0.0000
8	10	10	10	10	10	10.0	0.0000
9	10	10	10	10	10	10.0	0.0000

Stand. dev. of means = 0.0000
Mean of stand. dev.'s = 0.0000

Daytona Beach, FL: 6 Months

System #	1	2	3	4	5	Mean	S/D
1	10	10	10	10	10	10.0	0.0000
2	10	10	10	10	10	10.0	0.0000
3	10	10	10	10	10	10.0	0.0000
4	10	10	10	10	10	10.0	0.0000
5	10	10	10	10	10	10.0	0.0000
6	10	10	10	10	10	10.0	0.0000
7	10	10	10	10	10	10.0	0.0000
8	10	10	10	10	10	10.0	0.0000
9	10	10	10	10	10	10.0	0.0000

Stand. dev. of means = 0.0000
Mean of stand. dev.'s = 0.0000

Cleveland, OH: 6 Months

System #	1	2	3	4	5	Mean	S/D
1	10	10	10	10	10	10.0	0.0000
2	10	10	10	10	10	10.0	0.0000
3	10	10	10	10	10	10.0	0.0000
4	10	10	10	10	10	10.0	0.0000
5	10	10	10	10	10	10.0	0.0000
6	10	10	10	10	10	10.0	0.0000
7	10	10	10	10	10	10.0	0.0000
8	10	10	10	10	10	10.0	0.0000
9	10	10	10	10	10	10.0	0.0000

Stand. dev. of means = 0.0000
Mean of stand. dev.'s = 0.0000

N. Kansas City, MO: 6 Months

System #	1	2	3	4	5	Mean	S/D
1	10	10	10	10	10	10.0	0.0000
2	9F	10	10	10	10	9.8F	0.4472
3	10	10	10	10	10	10.0	0.0000
4	10	10	10	10	10	10.0	0.0000
5	10	10	10	10	10	10.0	0.0000
6	10	10	10	10	10	10.0	0.0000
7	10	10	10	10	10	10.0	0.0000
8	10	10	10	10	10	10.0	0.0000
9	10	10	10	10	10	10.0	0.0000

Stand. dev. of means = 0.0667
Mean of stand. dev.'s = 0.0497

Miami, FL: 6 Months

System #	1	2	3	4	5	Mean	S/D
1	10	10	10	10	10	10.0	0.0000
2	10	10	10	10	10	10.0	0.0000
3	10	10	10	10	10	10.0	0.0000
4	10	10	10	10	10	10.0	0.0000
5	10	10	10	10	10	10.0	0.0000
6	10	10	10	10	10	10.0	0.0000
7	10	10	10	10	10	10.0	0.0000
8	10	10	10	10	10	10.0	0.0000
9	10	10	10	10	10	10.0	0.0000

Stand. dev. of means = 0.0000
Mean of stand. dev.'s = 0.0000

Portland, OR: 6 Months

System #	1	2	3	4	5	Mean	S/D
1	10	10	10	10	10	10.0	0.0000
2	10	10	10	10	10	10.0	0.0000
3	10	10	10	10	10	10.0	0.0000
4	10	10	10	10	10	10.0	0.0000
5	10	10	10	10	10	10.0	0.0000
6	10	10	10	10	10	10.0	0.0000
7	10	10	10	10	10	10.0	0.0000
8	10	10	10	10	10	10.0	0.0000
9	10	10	10	10	10	10.0	0.0000

Stand. dev. of means = 0.0000
Mean of stand. dev.'s = 0.0000

San Francisco, CA: 6 Months

System #	1	2	3	4	5	Mean	S/D
1	10	10	10	10	10	10.0	0.0000
2	10	10	10	10	10	10.0	0.0000
3	10	10	10	10	10	10.0	0.0000
4	10	10	10	10	10	10.0	0.0000
5	10	10	10	10	10	10.0	0.0000
6	10	10	10	10	10	10.0	0.0000
7	10	10	10	10	10	10.0	0.0000
8	10	10	10	10	10	10.0	0.0000
9	10	10	10	10	10	10.0	0.0000

Stand. dev. of means = 0.0000
Mean of stand. dev.'s = 0.0000

Tustin, CA: 6 Months

System #	1	2	3	4	5	Mean	S/D
1	10	10	10	10	10	10.0	0.0000
2	10	10	10	10	10	10.0	0.0000
3	10	10	10	10	10	10.0	0.0000
4	10	10	10	10	10	10.0	0.0000
5	10	10	10	10	10	10.0	0.0000
6	10	10	10	10	10	10.0	0.0000
7	10	10	10	10	10	10.0	0.0000
8	10	10	10	10	10	10.0	0.0000
9	10	10	10	10	10	10.0	0.0000

Stand. dev. of means = 0.0000
Mean of stand. dev.'s = 0.0000

the existing work on cycled prohesion describes experiments using these types of bulbs. Some recent literature,[42,43] and some of the results that follow, suggest that a stronger light source is necessary, especially to correlate to noncorrosive but high UV sites.

RESULTS

Statistics

In order to attempt a correlation between different sites and instruments and the results between each, five replicates of each paint system were exposed. Once the results were tabulated, statistical modeling could be done.[44] The following equations were used to evaluate our exposure results:

(1) Mean (x):

$$\frac{\sum x}{n} = \frac{x_1 + x_2 + \ldots x_n}{n}$$

x = variable of interest; n = sample size.

(2) Sample standard deviation (σ):

$$\sigma = \sqrt{\frac{\sum (x - \bar{x})^2}{n - 1}}$$

x = variable of interest; $\bar{x}$ = mean; n = sample size.

(3) t Test statistic:

$$t = \frac{\bar{x} - \bar{x}'}{s/\sqrt{N}}$$

Number of samples, N = 5 : degrees of freedom, (N–1) = 4
The critical value at the 90% confidenc level = 2.132

(4) Spearman rank correlation coefficient (ρ):

$$\rho = 1 - \frac{6\sum(x - y)^2}{N(N^2 - 1)}$$

x = Rank of first experiment; y = rank of second experiment
Critical value for correlation coefficient at the 90% confidence level = 0.600

The mean of the resulting five values for each paint system and exposure type, and the standard deviation of this mean were calculated. For each test site, the standard deviation of all the means was calculated to give an indication of how well each differentiated the coatings. Also calculated was the mean of all standard deviations for each test method as a first approximation of the reproducibility.

Two types of ranking were investigated. The first, labeled tau, used a calculated "t" statistic to verify any statistical differences in the data. From this, a Spearman Rank, labeled rho, was calculated. The number of ties in the results required the averaging of the data, with individual numbers occupying their specified slots from one to nine (that is why a rank order might be 1.5, 1.5, 4, 4, 4, 6, 7, 8.5, 8.5 instead of 1, 1, 2, 2, 2, 3, 4, 5, 5, as would be suggested by the t statistic). For nine variables, the sum of all the rankings should equal 45.

In some cases, values with the same mean may have different rankings, by the t test, which uses the standard deviation to test whether one mean is statistically different

Table 5—Correlation Table: Exterior Site Versus Exterior Site

(a)	E1	E2	E3	E4	E5	E6	E7	E8	E9
E1	—	.871	.583	.788	.625	.138	.621	.538	.588
E2		—	.786	.842	.633	.433	.658	.785	.825
E3			—	.671	.708	.538	.721	.825	.788
E4				—	.725	.408	.750	.642	.750
E5					—	.300	.996	.525	.488
E6						—	.358	.792	.858
E7							—	.558	.533
E8								—	.925
E9									—

(a)E1 = Ocean City, NJ:	95% confidence level of correlation with E2 and E4. 90% confidence level of correlation with E5 and E7. 85% confidence level of correlation with E3 and E9. 80% confidence level of correlation with E8.
E2 = Kure Beach, NC:	95% confidence level of correlation with E3, E4, E5, E7, E8 and E9.
E3 = Daytona Beach, FL:	95% confidence level of correlation with E2, E4, E5, E7, E8, and E9. 80% confidence level of correlation with E6.
E4 = Cleveland, OH:	95% confidence level of correlation with E1, E2, E3, E5, E7, E8, and E9.
E5 = N. Kansas City, MO:	95% confidence level of correlation with E2, E3, E4, and E7. 90% confidence level of correlation with E1.
E6 = Miami Beach, FL:	95% confidence level of correlation with E8 and E9. 80% confidence level of correlation with E3.
E7 = Portland, OR:	95% confidence level of correlation with E2, E3, E4, and E5. 90% confidence level of correlation with E1. 80% confidence level of correlation with E8 and E9.
E8 = San Francisco, CA:	95% confidence level of correlation with E2, E3, E4, and E6. 80% confidence level of correlation with E1, E5, E8, and E9.
E9 = Tustin, CA:	95% confidence level of correlation with E2, E3, E4, and E6. 85% confidence level of correlation with E1. 80% confidence level of correlation with E7.

Table 6—Results of Accelerated Testing for ASTM D 1654

Salt Fog: 5% NaCl - 1258 hr

System #	1	2	3	4	5	Mean	S/D	Rank	
								tau	rho
1	8	7	8	8	8	7.8	0.4472	3	6.5
2	9	9	8	8	6	8.0	1.2274	2	4.0
3	9	10	9	9	10	9.4	0.5477	1	1.5
4	9	9	9	9	9	9.0	0.000	1	1.5
5	8	9	9	9	8	8.6	0.5477	2	4.0
6	7	6	7	4	7	6.2	1.3038	4	8.0
7	7	9	5	5	9	7.0	2.0000	3	6.5
8	8	8	9	8	7	8.0	0.7071	2	4.0
9	5	5	5	5	5	5.0	0.0000	5	9.0
Stand. dev. of means =						1.3964			
Mean of stand. dev's =							0.7534		

Cyclic Salt Fog: 5% NaCl - 1834 hr

System #	1	2	3	4	5	Mean	S/D	Rank	
								tau	rho
1	8	9	8	4	9	7.6	2.0736	1	3.0
2	6	5	8	9	9	7.4	1.8166	1	3.0
3	9	9	9	8	2[a]	8.75	0.5000	1	3.0
4	9	9	9	9	9	9.0	0.0000	1	3.0
5	9	9	9	9	9	9.0	0.0000	1	3.0
6	3	4	4	4	4	3.8	0.4472	4	9.0
7	8	8	7	7	8	7.8	0.5477	2	6.5
8	6	8	8	5	5	6.4	1.5166	2	6.5
9	4	4	5	5	5	4.6	0.5477	3	8.0
Stand. dev. of means =						1.8835			
Mean of stand. dev's =							0.8277		

Prohesion Cabinet - 1176 hr

System #	1	2	3	4	5	Mean	S/D	Rank	
								tau	rho
1	3	3	3	3	2	2.8	0.4472	5	9.0
2	4	4	4	4	4	4.0	0.0000	3	5.5
3	6	7	3	6	6	5.6	1.1566	1	1.5
4	6	5	5	4	6	5.2	0.8367	2	3.0
5	4	4	5	4	5	4.4	0.5477	3	5.5
6	4	5	5	4	4	4.4	0.5477	3	5.5
7	4	4	4	5	4	4.2	0.4472	3	5.5
8	4	7	7	6	6	6.0	1.2247	1	1.5
9	4	3	4	4	4	3.8	0.4472	4	8.0
Stand. dev. of means =						0.9804			
Mean of stand. dev's =							0.6683		

Cyclic Prohesion Cabinet

System #	1	2	3	4	5	Mean	S/D	Rank	
								tau	rho
1	6	6	6	7	6	6.2	0.4472	3	8.0
2	8	4	6	7	5	6.0	1.5811	2	4.5
3	9	5	4	6	7	6.2	1.9235	2	4.5
4	7	8	5	6	6	6.4	1.1402	2	4.5
5	3	5	5	6	5	4.8	1.0954	4	9.0
6	8	6	7	4	5	6.0	1.5811	2	4.5
7	10	7	10	8	10	9.0	1.4142	1	1.0
8	7	6	8	8	8	7.4	0.8944	2	4.5
9	8	5	8	8	6	7.0	1.4142	2	4.5
Stand. dev. of means =						1.1652			
Mean of stand. dev's =							1.2768		

KTA-Tator Envirotest - 2000 hr

System #	1	2	3	4	5	Mean	S/D	Rank	
								tau	rho
1	6	6	7	4	5	5.6	1.1402	2	6.0
2	6	7	5	7	6	6.2	0.8367	2	6.0
3	6	5	8	7	6	6.4	1.1402	1	1.5
4	7	6	6	6	7	6.4	0.5477	2	6.0
5	7	7	6	6	6	6.4	0.5477	2	6.0
6	6	6	6	6	6	6.0	0.0000	2	6.0
7	7	7	6	7	6	6.6	0.5477	2	6.0
8	6	6	7	7	7	6.6	0.5477	2	6.0
9	7	7	7	8	7	7.2	0.4472	1	1.5
Stand. dev. of means =						0.4410			
Mean of stand. dev's =							0.6395		

(a) Value for panel #5 omitted from calculation of mean and standard deviation.

Table 7—Results of Testing for ASTM D 610

Salt Fog: 5% NaCl - 1258 hr

System #	1	2	3	4	5	Mean	S/D	Rank	
								tau	rho
1	4	5	4	2	4	3.8	1.0954	5	9.0
2	8	6	9	6	8	7.4	1.3416	3	5.0
3	10	10	10	9	10	9.8	0.4472	1	1.5
4	8	8	9	9	9	8.6	0.5477	3	5.0
5	10	10	9	10	9	9.6	0.5477	1	1.5
6	7	7	7	7	8	7.2	0.4472	4	7.5
7	7	7	1[a]	5	6	6.3	0.9574	4	7.5
8	9	8	9	8	7	8.2	0.8367	3	5.0
9	9	9	9	10	9	9.2	0.4472	2	3.0
Stand. dev. of means =						1.8963			
Mean of stand. dev's =							0.7409		

Cyclic Salt Fog: 5% NaCl - 1834 hr

System #	1	2	3	4	5	Mean	S/D	Rank	
								tau	rho
1	10	9	9	9	9	9.2	0.4472	2.	5.0
2	6	9	8	9	9	8.2	1.3038	2	5.0
3	10	9	10	10	10	9.8	0.4472	1	2.0
4	8	8	9	9	8	8.4	0.5477	3	7.5
5	8	10	9	9	10	9.2	0.8367	1	2.0
6	8	7	8	8	8	7.8	0.4472	4	9.0
7	8	10	9	9	8	8.8	0.8367	2	5.0
8	8	9	8	9	8	8.4	0.5477	3	7.5
9	10	10	8	9	9	9.2	0.8367	1	2.0
Stand. dev. of means =						0.6280			
Mean of stand. dev's =							0.6945		

Prohesion Cabinet - 1176 hr

System #	1	2	3	4	5	Mean	S/D	Rank	
								tau	rho
1	10	9	8	10	9	9.2	0.8367	2	4.0
2	9	10	10	10	8	9.4	0.8944	1	1.5
3	10	10	10	10	10	10.0	0.0000	1	1.5
4	10	8	9	8	8	8.6	0.8944	2	4.0
5	8	7	7	8	9	7.8	0.8367	3	7.0
6	4	6	7	7	7	6.2	1.3038	4	9.0
7	10	6	6	6	8	7.2	1.7889	3	7.0
8	9	8	7	7	9	8.0	1.0000	3	7.0
9	9	9	9	9	9	9.0	0.0000	2	4.0
Stand. dev. of means =						1.1935			
Mean of stand. dev's =							0.8394		

Cyclic Prohesion Cabinet

System #	1	2	3	4	5	Mean	S/D	Rank	
								tau	rho
1	10	10	10	10	10	10.0	0.0000	1	4.0
2	9	8	9	9	9	8.8	0.4472	2	8.5
3	10	10	9	10	10	9.8	0.4472	1	4.0
4	10	10	10	9	10	9.8	0.4472	1	4.0
5	10	10	10	10	9	9.8	0.4472	1	4.0
6	10	7	8	6	9	8.0	1.5811	2	8.5
7	10	10	10	10	10	10.0	0.0000	1	4.0
8	10	9	10	10	9	9.6	0.5477	1	4.0
9	10	10	10	10	10	10.0	0.0000	1	4.0
Stand. dev. of means =						0.6856			
Mean of stand. dev's =							0.4353		

KTA-Tator Envirotest - 2000 hr

System #	1	2	3	4	5	Mean	S/D	Rank	
								tau	rho
1	10	6	10	10	10	9.2	1.7889	1	4.5
2	10	10	10	10	10	10.0	0.0000	1	4.5
3	10	10	10	9	10	9.8	0.4472	1	4.5
4	10	10	10	10	10	10.0	0.0000	1	4.5
5	9	9	10	10	10	9.6	0.5477	1	4.5
6	9	9	8	8	9	8.6	0.5477	2	9.0
7	9	10	9	10	10	9.6	0.5477	1	4.5
8	10	10	10	10	9	9.8	0.4472	1	4.5
9	10	10	10	10	10	10.0	0.0000	1	4.5
Stand. dev. of means =						0.4631			
Mean of stand. dev's =							0.4807		

(a) Value for panel #3 omitted from calculation of Mean and Standard Deviation from another. Only those which are statistically significantly different were given the next rank.

Exterior Exposure Weathering

After the exterior exposure panels were returned to Cleveland on April 15, 1993, each set was photographed and rated according to the methods outlined. The results are given in *Tables* 2-4, as well as the statistical data calculated for each of these systems at each site. Some of the more interesting photographic results will be detailed.

A first impression on visual inspection of the panels indicates some obvious differences between heavily corrosive sites and industrial sites. The differences between Cleveland and Miami are not nearly as great as those between Cleveland and Daytona Beach or even Daytona Beach and Miami.

Each panel was evaluated according to the ASTM criteria previously discussed. The presence of filiform type corrosion was noted by an asterisk. Differentiation of blisters occurring at the scribe, and blisters on the face of the panel were also made.

From the Spearman rho, a correlation table was constructed for each site compared to every other site (*Table* 5). From the set of correlation tables available, for this purpose, the critical value of rho, which would give a 90% confidence level in the results would be 0.600 and for the 95% confidence level a value of rho of 0.632 would be needed.

Accelerated Weathering

Similar data on accelerated weathering were compiled at the completion of the accelerated tests. The data is presented in *Tables* 6-8, and the correlation data given in *Table* 9. *Figures* 1-9 show the nine paint systems in a side by side comparison of test methods. The panels used for these photos represent the average degree of performance for the five replicates. From left to right, the panels represent (1) standard salt fog; (2) cyclic salt fog; (3) Prohesion testing; (4) cyclic Prohesion/QUV testing; and (5) KTA-Envirotest.

At the 60% failure level, it was possible to go 1278 hr in the salt fog testing, 1768 hr in the cyclic salt fog, 1176 hr in the Prohesion cabinet, 2000 total hr in the cyclic Prohesion (1000 hr QUV and 1000 hr salt spray), and a total 2000 hr in the KTA-Envirotest. A correlation table to compare the accelerated testing to the exterior results is given in *Table* 10.

DISCUSSION

The use of Spearman rank correlation coefficients has proven useful in earlier attempts to correlate natural exposure to accelerated weathering.[18,19,45] This method is particularly useful when analyzing nonparametric data, such as the appearance of a test specimen after exposure. The use of t-tests allowed us to assign a rank based on the statistical significance of the mean and standard deviations of our data.

The use of five replicates for each test should have given better statistical agreement on the mean data for the ASTM test under consideration. While generally true, some test results had outlying numbers which greatly increased the standard deviation. Most texts in statistics caution that a good rule of thumb with outlying data is to include it, unless some other rationale is known for its exclusion. For our data, there were only one or two cases where the result was so obviously different from the other replicates, that data was excluded. In the cases where this happened, the statistics were calculated with one less sample and resulted in fewer degrees of freedom, but the standard deviation was vastly improved.

One important caveat must be given before discussing the results of our testing. The test protocol was specifically designed to use coatings expected to give results with a wide difference in performance. The purpose of the testing was not to determine which coating system is better than another. While some systems used were designed for their anti-corrosive properties, and environments which required this performance, others were designed for mild, noncorrosive industrial, and even trade sales and consumer use.

The most important data collected was the ranking of one system versus another from exposure site to exposure site and from accelerated method to accelerated method. This made the choice of coatings systems somewhat arbitrary and was the reason commercially available, off-the-shelf systems were used. While early results are encouraging, they are indeed **early** results. Therefore, while correlations appear to be present, these may either strengthen or weaken as additional exterior exposure data becomes available. With this in mind, the following discusses the preliminary testing.

Exterior Exposures

Rust Creepage: After six months of exterior exposure, most northern, noncorrosive exposures showed little degradation. Most ratings were quite high, with little separation from system to system. One exception was the high-solids polyurethane topcoat (system #3) which surprisingly showed the poorest results in all testing for rust creepage (see *Figures* 10-12, system #3, Kure Beach, San Francisco, and Daytona Beach, respectively). This system would not normally be applied as a self-primed system over cold rolled steel and, as such, the appropriate primer would have improved its individual results. Most important to the task of correlation was the consistent ranking any system showed from site-to-site, while its position in that ranking was not.

The ability of the exposure sites to differentiate the coatings could be seen by calculating the standard deviation of the means. A large standard deviation would indi-

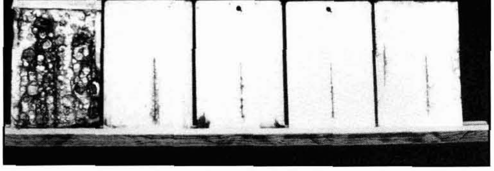

Figure 1—Comparison of results from five accelerated tests for System #1

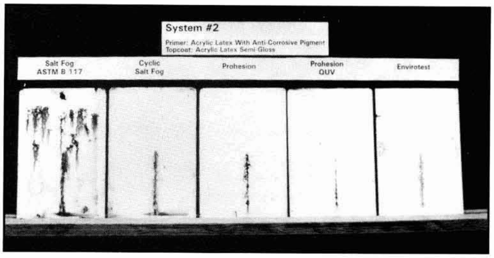

Figure 2—Comparison of results from five accelerated tests for System #2

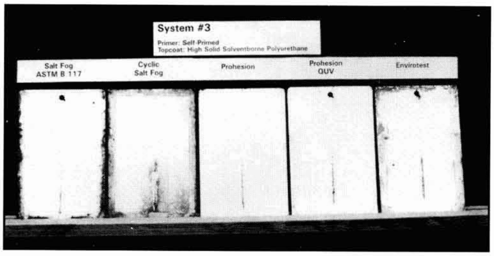

Figure 3—Comparison of results from five accelerated tests for System #3

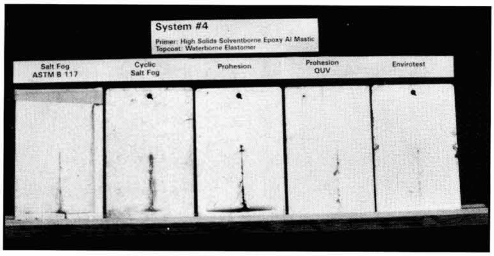

Figure 4—Comparison of results from five accelerated tests for System #4

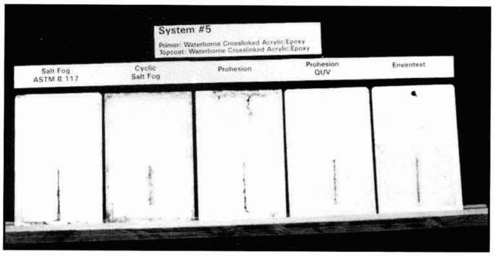

Figure 5—Comparison of results from five accelerated tests for System #5

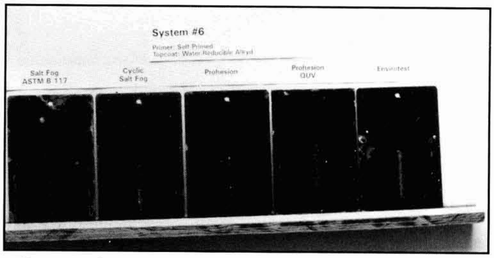

Figure 6—Comparison of results from five accelerated tests for System #6

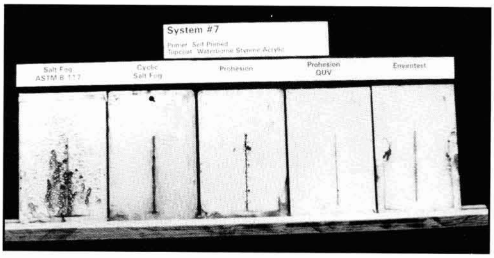

Figure 7—Comparison of results from five accelerated tests for System #7

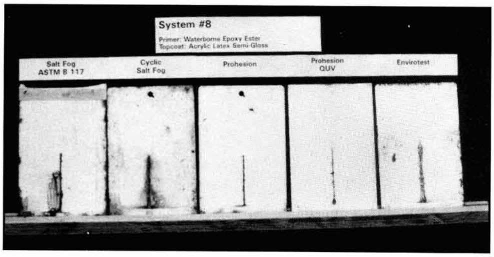

Figure 8—Comparison of results from five accelerated tests for System #8

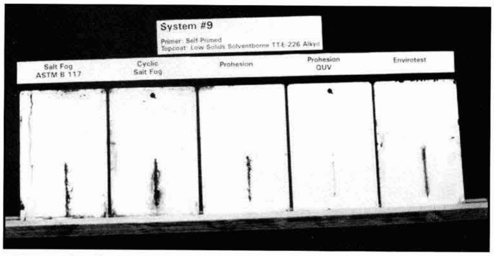

Figure 9—Comparison of results from five accelerated tests for System #9

Table 8—Results of Testing for ASTM D 714

Salt Fog: 5% NaCl - 1258 hr

	1	2	3	4	5	Mean	S/D	Rank	
System #								tau	rho
1	2D	2D	2D	2D	2D	2.0D	0.0000	3	8.5
2	8F	4M	8F	4M	8F	6.4F	2.1909	1	2.5
3	6F	6F	6F	6F	6F	6.0F	0.0000	2	6.0
4	8F	8F	8F	10	6F	8.0F	1.4142	1	2.5
5	8F	6F	6F	6F	6M	6.4	0.8944	2	6.0
6	6M	6F	6M	4M	6M	5.6M	0.8944	2	6.0
7	2D	2D	2D	2D	4F	2.4D	0.8944	3	8.5
8	8F	4M	8F	8F	4F	6.4F	2.1909	1	2.5
9	8F	8F	8F	8F	6F	7.6F	0.8944	1	2.5
Stand. dev. of means =						2.0923			
Mean of stand. dev's =							1.0415		

Cyclic Salt Fog: 5% NaCl - 1834 hr

	1	2	3	4	5	Mean	S/D	Rank	
System #								tau	rho
1	8F	8F	2F	8F	2F	6.4F	2.6077	1	4.5
2	6M	8F	8F	8F	6F	7.2F	1.0954	1	4.5
3	8F	6F	8F	8F	8F	7.6F	0.8944	1	4.5
4	8F	8F	8F	8F	8F	8.0F	0.0000	1	4.5
5	8F	8F	8F	8F	8F	8.0F	0.0000	1	4.5
6	6F	6F	6F	6F	6F	6.0F	0.0000	2	9.0
7	8F	8M	8M	8F	8M	8.0M	0.0000	1	4.5
8	8F	8F	6F	8F	8F	7.2F	1.0954	1	4.5
9	8F	8F	8F	8F	8F	8.0F	0.0000	1	4.5
Stand. dev. of means =						0.7513			
Mean of stand. dev's =							0.6325		

Prohesion Cabinet - 1176 hr

	1	2	3	4	5	Mean	S/D	Rank	
System #								tau	rho
1	10	10	10	10	10	10.0	0.0000	1	5.0
2	10	10	10	10	10	10.0	0.0000	1	5.0
3	10	10	10	10	10	10.0	0.0000	1	5.0
4	10	10	10	10	10	10.0	0.0000	1	5.0
5	10	10	10	10	10	10.0	0.0000	1	5.0
6	10	10	10	10	10	10.0	0.0000	1	5.0
7	10	10	10	10	10	10.0	0.0000	1	5.0
8	10	10	10	10	10	10.0	0.0000	1	5.0
9	10	10	10	10	10	10.0	0.0000	1	5.0
Stand. dev. of means =						0.0000			
Mean of stand. dev's =							0.0000		

Cyclic Prohesion Cabinet

	1	2	3	4	5	Mean	S/D	Rank	
System #								tau	rho
1	10	10	10	10	10	10.0	0.0000	1	4.5
2	10	10	10	10	10	10.0	0.0000	1	4.5
3	10	10	10	10	10	10.0	0.0000	1	4.5
4	10	10	10	10	10	10.0	0.0000	1	4.5
5	10	10	10	10	10	10.0	0.0000	1	4.5
6	10	8MD	8F	8M	10	8.8M	1.0954	2	9.0
7	10	10	10	10	10	10.0	0.0000	1	4.5
8	10	10	10	10	10	10.0	0.0000	1	4.5
9	10	10	10	10	10	10.0	0.0000	1	4.5
Stand. dev. of means =						0.4000			
Mean of stand. dev's =							0.1217		

KTA-Tator Envirotest - 2000 hr

	1	2	3	4	5	Mean	S/D	Rank	
System #								tau	rho
1	10	10	10	10	10	10.0	0.0000	1	5.0
2	10	10	10	10	10	10.0	0.0000	1	5.0
3	10	10	10	10	10	10.0	0.0000	1	5.0
4	10	10	10	10	10	10.0	0.0000	1	5.0
5	10	10	10	10	10	10.0	0.0000	1	5.0
6	10	10	10	10	10	10.0	0.0000	1	5.0
7	10	10	10	10	10	10.0	0.0000	1	5.0
8	10	10	10	10	10	10.0	0.0000	1	5.0
9	10	10	10	10	10	10.0	0.0000	1	5.0
Stand. dev. of means =						0.0000			
Mean of stand. dev's =							0.0000		

cate that some systems are doing very well, some systems are undergoing moderate weathering, and others are performing poorly. This is the type of data needed to accurately rank systems and allow accurate correlations between sites, and ultimately between sites and accelerated methods. Generally, the more severe sites differentiated coatings better at this early date.

The consistency of the data can be seen in the mean of the standard deviations. Smaller numbers indicate better panel to panel consistency within a system. Inspection of *Table* 3 shows that the sites on the ocean, and the high UV sites are showing the greatest values for standard deviations of the mean. In fact, all of the coastal exposure sites are showing some failures; this may terminate the testing after only one year. The mean of the standard deviations is relatively small for all the exterior sites.

The high-solids epoxy aluminum mastic, topcoated with an elastomeric styrene acrylic latex (system four), shows the greatest variation in standard deviation from site-to-site. In some cases, including corrosive and noncorrosive southern exposures, the ratings are all eights, nines, and tens, and the standard deviations are very low. In the northern exposures, except for Portland, the values within the exposure site run from tens to fours or fives. Closer inspection of the panels show that the visible creepage appears to be from only one side of the scribe. It is possible that our scribing technique may have damaged the harder more brittle epoxy coating and this damage is being accelerated in climates where freeze/thaw cycling is an issue. Portland, although a northern exposure, generally has very rainy weather, with little freezing during the winter. This would explain why these panels are not as affected as in other northern sites. The lowest ratings are obtained where corrosive environments can compound this phenomena.

SURFACE RUST AND BLISTERING: *Tables* 3 and 4 are presented for completeness, but to date, very little in the way of surface rusting or blistering has been visible with the exposures.

CORRELATION DATA: Only the rust creepage data is being considered for the present study. There has not been enough weathering for surface rust or blistering to be differentiated such that those comparisons would be meaningful. The calculated values for the Spearman rho correlation coefficient from *Table* 2 were used to prepare *Table* 5. A correlation coefficient was derived from each site-to-site comparison. For ranking nine samples, a value of rho ≥ 0.6000, is an indication of a statistically significant correlation at the 90% confidence level. As this table shows, not all sites correlated equally to all the others. The highest degree of correlation was among the northern and mid-continent corrosive environments. The correlation decreased as the corrosive environment became more southerly. Daytona Beach correlated with Kure Beach, but had a coefficient just under the critical for Ocean City correlation at the 90% confidence level. It did correlate at the 80% confidence level. This variation could indicate that a freeze/thaw cycle is differentiating the exposures. As testing continues, this correlation may also improve.

Table 9—Correlation Table: Accelerated Testing Vesrus Accelerated Testing

Instrument	Salt Fog ASTM B-117	Cyclic Salt Fog	Prohesion Cabinet	Cyclic Prohesion/ QUV	KTA-Envirotest
Salt fog-ASTM B-117	—	.775	.771	.246	.225
Cyclic salt fog	—	—	.258	-.121	.250
Prohesion cabinet	—	—	—	.433	.485
Prohesion/QUV	—	—	—	—	.458
KTA-Envirotest	—	—	—	—	—

There appears to be less of a degree of correlation between the Miami exposure and the Daytona Beach exposure. Here, the value for the correlation coefficient is again shy of the critical level of 0.6000 for 90% confidence. The mean values for rust creepage at the Miami site are not as low as the Daytona Beach site. Without the addition of a corrosive environment, the Miami data correlates best with the southern California site (Tustin), having one of the highest correlation values calculated.

The highest correlation coefficient was obtained between the North Kansas City exposures and the Portland exposures. This also is not very surprising, as these two sites showed the least weathering and the least differentiation of systems; most rust creepage rated eight or nine.

It is hoped that at the conclusion of our exterior exposure testing, we can establish known regions of similar exposure. However, as is seen in testing of materials at the NASA's Kennedy Space Center, FL, facilities, local conditions and specific on-site contaminants would tend to negate this generality. In this case, the need to protect against the degradation from shuttle launch exhaust and its high acidity, is critical.[46]

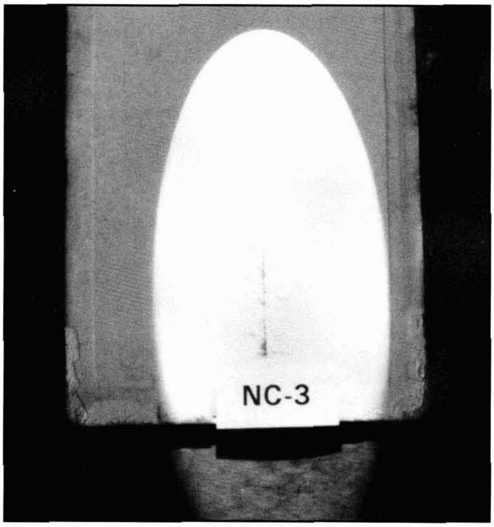

Figure 10—System #3 panel from the Kure Beach, NC, site

Table 10—Correlation Table: Exterior Sites Versus Accelerated Testing

	Exterior Sites[a]								
Instrument	E1	E2	E3	E4	E5	E6	E7	E8	E9
Salt fog ASTM B-117	-.229	-.321	-.046	-.395	-.075	.196	-.100	.000	.008
Cyclic salt fog	-.125	-.200	-.096	-.179	.025	.508	.021	.228	.228
Prohesion cabinet	-.004	-.167	.025	-.242	.058	-.168	.021	-.208	-.138
Prohesion/QUV	.710	.592	.608	.567	.646	-.175	.604	.250	.329
KTA-Envirotest	.363	.221	.108	.350	.288	-.038	.246	.188	.188

(a) Key to exterior sites:

E1 = Ocean City, NJ:	95% level of confidence for correlation with cyclic prohesion.
E2 = Kure Beach, NC:	85% level of confidence for correlation with cyclic prohesion.
E3 = Daytona Beach, FL:	90% level of confidence for correlation with cyclic prohesion.
E4 = Cleveland, OH:	80% level of confidence for correlation with cyclic prohesion.
E5 = N. Kansas City, MO:	95% level of confidence for correlation with cyclic prohesion.
E6 = Miami Beach, FL:	
E7 = Portland, OR:	90% level of confidence for correlation with cyclic prohesion.
E8 = San Francisco, CA:	
E9 = Tustin, CA:	

Accelerated Testing

Rust Creepage: In the accelerated tests, the most striking result was the large amount of reversals seen from test to test. Reversals are the ranking "flip flops" that occur as one material performs better in one environment versus another. This was especially true for the electrolyte exposure tests using high concentrations of sodium chloride, versus those using weaker solutions of salt and ammonium sulphate (*Figures* 1-9). This was true regardless of the presence or absence of UV light.

Good distribution of data was achieved in the salt fog, cyclic salt fog, and cyclic Prohesion/weathering testing. Values obtained in the KTA-Envirotest instrument showed the lowest standard deviation of the means. The inability to differentiate the systems by the procedure used points out the need for further method development and fine tuning of the test parameters.

The highest mean of the standard deviations was seen in the cyclic Prohesion testing. This lack of panel-to-panel agreement between systems would bring into question the reproducibility of results. The test panels were hand scribed. A machine tool scriber has been shown to greatly improve panel-to-panel agreement in this test. However, even though the standard deviations were large, the results were evenly distributed around this mean. In fact, the results of rust creepage for the cyclic Prohesion/UV weathering tests were the only ones to correlate to several of the exterior rust creepage results.

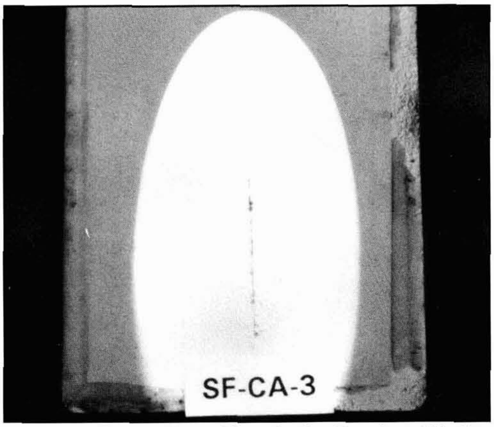

Figure 11—System #3 panel from the San Francisco, CA, site

The lowest mean of the standard deviations was observed for the KTA-Envirotest (most reproducible). However, the lowest standard deviation of the means was also seen for this test (least differentiating). All means of the values for rust creepage fell between a value of 5.6 and 7.2.

Surface Rusting and Blistering: *Tables* 7 and 8 list the results for surface rust and blistering. When these values for the exterior panels are more pronounced, the data will be analyzed for correlation. It should be noted that there is very little surface rusting on the cyclic salt fog, the Prohesion, cyclic Prohesion/QUV weathering, and the KTA-Envirotest panels. The standard salt fog test (B 117) is the only one which showed any differentiation of results for surface rusting.

The only tests which have currently shown any blistering have been the salt fog and the cyclic salt fog. Most of the blisters were no longer present when the panels were photographed, indicating they were mostly fluid filled blisters, which receded on drying. Results of salt fog on system #1 (*Figure* 13) compared to the Ocean City, exposures for this system (*Figure* 14) show quite graphically why it has always been a contention that this type of failure is one of the unnatural modes seen in standard salt fog testing.

The cyclic Prohesion/QUV weathering test did have one series of panels with small hard rust blisters. These are more typical of corrosive environments.

Correlation Data: As the correlation results in *Table* 9 demonstrate, the only correlation obtained was between the electrolytic non-UV irradiated test methods. Correlations between salt fog and cyclic salt fog gave positive statistically significant correlation at the 90 and 95% confidence levels. The Spearman rank coefficient was almost as large for the comparison of salt fog to Prohesion. Surprisingly, the results

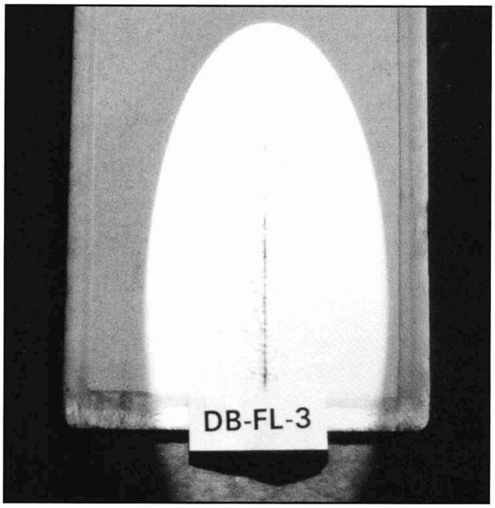

Figure 12—System #3 panel from the Daytona Beach, FL, site

of cyclic salt fog and Prohesion did not correlate. All other inter-test results showed no significant correlations.

Correlation of Exterior Exposures with Accelerated Tests: As mentioned earlier, although the results are very preliminary with regards to the length of exterior exposure and the questions of relating accelerated testing done on panels stored for an additional time before testing, *Table* 10 was constructed to see if even weak correlations might possibly exist between this data.

Statistically significant correlations were seen at the 95% confidence level for cyclic Prohesion/UV-condensation weathering testing and two of the exterior sites, namely Ocean City and North Kansas City. Two sites which correlated at the 90% confidence level include Daytona Beach and Portland. Two additional sites showed correlation at the 80% confidence level; these were Kure Beach and Cleveland. Only three sites did not show high levels or correlation with any great degree of confidence. Those with high UV exposures, such as Miami Beach and Tustin were two, while the other site with a weak correlation was the Golden Gate Bridge.

The corrosive mildness of the Golden Gate Bridge site (compared to Ocean City) belies the fact that the ocean is only 20 feet away. Other researchers have shown this site to be approximately 10 times weaker in corrosivity that the east coast sites. This may explain the lack of statistical fit with the Prohesion/weathering cycle.

The lack of UV intensity of the UVA-340 bulbs may be a factor in the lack of correlation to the Miami and Tustin sites. Skerry and co-workers found similar lack of fit when comparing some automotive coatings over various substrates.[43]

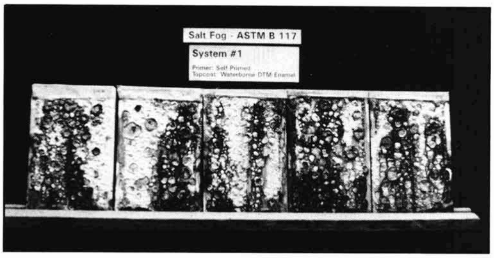

Figure 13—Results of salt fog testing (ASTM B 117) on system #1 (five replicate panels)

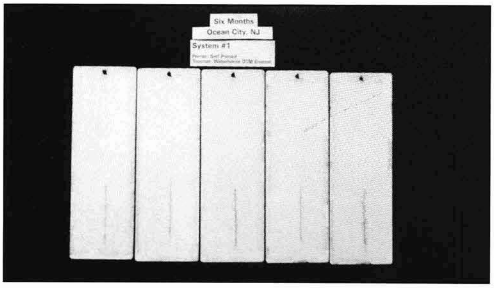

Figure 14—Results of six-month exposure testing at Ocean City, NJ, on system #1 (five replicate panels)

SUMMARY

The Cleveland Society for Coatings Technology Technical Committee has undertaken a long-term project to investigate several accelerated methods, including some shown to provide better correlation to exterior corrosive sites. Through the use of newer compliant and high-solids coatings systems, a rank order will be established for each system. This will provide site-to-site and instrument-to-instrument correlations. Ultimately, the goal will be to correlate the instruments to the sites. This information will allow researchers to shorten the development time between conception to introduction of a coating system.

To date, five accelerated methods have been investigated including salt fog, cyclic salt fog, Prohesion, cyclic Prohesion/weathering, and immersion/weathering. Nine systems were tested and ranked by performance. To determine statistically significant orders of rank, the test results were analyzed using a t statistic and primarily ranked at the 90% confidence level for statistically significant differences. These rankings were then converted to a suitable Spearman ranking and the Spearman coefficient, rho, was calculated. Values greater than the critical value for rho (0.600) were considered to show correlation. Values lower than this critical value showed correlation with lower levels of confidence (80 or 85%). The only instrument-to-instrument correlation occurred for the non-weathering tests, the salt fog, and cyclic salt fog.

The nine systems tested in accelerated tests were also placed on exterior exposure at nine different sites across the United States. The panels were rate at six months for rust creepage, surface rust, and blistering. The results of this testing were also subjected to statistical methods and correlation coefficients calculated to determine the presence of site-to-site correlations. These did exist at the six-month levels for several sites. The expectation is that this site-to-site correlation will strengthen for some and weaken for others as testing progresses.

A test of the results between sites and instruments currently shows only one accelerated test with statistically significant correlations at the 80, 85, 90, or 95% confidence level. That test is the cyclic Prohesion/weathering method. Although there are some sites which do not currently correlate to this or any of the other test methods investigated, this is likely due to the lack of differentiation after six-months exposure at these sites. Additional time on exposure should give greater differentiation and possible correlation.

Future accelerated work will investigate the practice of using aged panels for these tests (stored in a neutral non-weathering environment) versus fresher yet fully cured specimens. The belief is that little difference will be seen for panels stored for several months versus those allowed to cure for a few weeks, as long as a minimum 95% cure level has been reached.

As the exposures continue, this new data will be analyzed and any correlations will be updated and reported in the future.

ACKNOWLEDGMENTS

We would like to thank the Federation of Societies for Coatings Technology for helping to defray some of the costs of this project, and for their continued support throughout its duration.

We would like to thank the following organizations for their cooperation and support in conducting these studies: Case Western Reserve University; Coatings Research Group, Inc.; Engelhard Corp.; Harrison Paint Corp.; Kent State University; Mahoning Paint Corp.; Mameco International, Inc.; Montana Products Co.; Plasti-Kote Co., Inc.; Q-Panel Co.; Seegott, Inc.; and The Sherwin-Williams Co.

We would especially like to thank the Ocean City Research Corp., Ocean City, NJ; The LaQue Center for Corrosion Technology, Inc., Kure Beach, NC; Battelle, Daytona Beach, FL; Sub-Tropical Testing Service, Miami, FL; Truesdail Laboratories, Inc., Tustin, CA; Coatings Research Group, Inc., Cleveland, OH; Tnemec, Inc., North Kansas City, MO; The Golden Gate Bridge Authority, San Francisco, CA; and The Rodda Paint Co., Portland, OR. All exposure sites were supplied at substantial savings to the Cleveland Society, and in some cases, were supplied at little or no charge.

We would also like to specifically thank Lenore Marshall and Cynthia Meade, from Atotech USA, Inc. and Sandra Kalmbach of the Q-Panel Co., who voluntarily ran several of the accelerated exposures.

References

(1) Gerhart, H.L., "Prophetic Imperatives in Corrosion Control," *Corrosion Control by Coatings*, Science Press, 35 (1979).

(2) Nelson, H.A., "Accelerated Weathering of Paints on Wood and Metal Surfaces," *Proceedings, American Society for Testing Materials*, ASTEA, Vol. 22, Part II, 485 (1922).

(3) Garlock, N.B. and Sward, G.G., "Artificial Weathering," The Paint Testing Manual, Sward, G.G. (Ed.), *ASTM Technical Publication 500*, Thirteenth Edition (1972).

(4) B 117-90 Standard Test Method of Salt Spray (Fog) Testing, *Annual Book of ASTM Standards*, Volume 06.01, Paints, Related Coatings, and Aromatics: Paint—Tests for Chemical, Physical, and Optical Properties; Appearance; Durability of Nonmetallic Materials, 1993.

(5) Byrd, J.D., "How to Test Coatings for Specific Applications," *Materials Protection*, *4*, No. 4, 32 (1965).

(6) Appelman, B.R. and Campbell, P.G., "Salt Spray Testing for Short Term Evaluation of Coatings," JOURNAL OF COATINGS TECHNOLOGY, *54*, No. 686, 17 (1982).

(7) Funke, W., "Corrosion Tests for Organic Coatings—Usefulness and Limitations," *Corrosion Control by Coatings*, Science Press, 35 (1979).

(8) NACE Task Group T-6D-22, "Causes and Prevention of Coatings Failures," *Materials Protection*, *9*, No. 3, 32 (1970).

(9) Zurilla, R.J., "Important Correlations Arising from the Scribe Test for Appraising Paint/Pretreatment/Substrate Systems," *Corrosion Control by Coatings*, Science Press, 243 (1979).

(10) Fancutt, F. and Hudson, J.C., "Protective Painting of Structural Steel," Chapman and Hall Ltd., 34 (1968).

(11) Timmins, F.D., *J. Oil & Color Chemists' Assoc.*, *62*, 131 (1979).

(12) Leidheiser, H. Jr., "Corrosion of Painted Metals—A Review," *Corrosion*, No. 7, 374 (1982).

(13) G 53-91 Standard Practice for Operating Light- and Water-Exposure Apparatus (Fluorescent UV-Condensation Type) for Exposure of Nonmetallic Materials, *ASTM Annual Book of Standards*, Volume 6.01, Paint—Tests for Formulated Products and Applied Coatings, 1992.

(14) Fischer, R.M., "Accelerated Weathering Test Development with Fluorescent UV-Condensation Devices," SAE West Coast Meeting and Exposition, 1984.

(15) Grossman, G.W., "Correlation of Laboratory to Natural Weathering," JOURNAL OF COATINGS TECHNOLOGY, *49*, No. 633, 45 (1977).

(16) Holsworth, R.M. and Provder, T., "Weathering of Organic Coatings," *Corrosion Control by Coatings*, Science Press, 463 (1979).

(17) Lyon, S.B., Thompson, G.E., and Johnson, J.B., "Materials Evaluation Using Wet-Dry Mixed Salt-Spray Tests," New Methods for Corrosion Testing of Aluminum Alloys, Agarwala/Ugiansky (Eds.), ASTM STP 1134 (1989).

(18) D 2933-74 (1986), Standard Test Method for Corrosion Resistance of Coated Steel Specimens (Cyclic Method), *ASTM Annual Book of Standards*, Volume 6.01, Paint—Tests for Formulated Products and Applied Coatings, 1992.

(19) Townsend, H.E., "Status of a Cooperative Effort by the Automotive and Steel Industries to Develop a Standard Accelerated Corrosion Test," *Proceedings of the Automotive Corrosion & Prevention Conference* (P-228), December 1989.

(20) Skerry, B.S., Alavi, A., and Lindgren, K.I., "Environmental and Electrochemical Test Methods for the Evaluation of Protective Organic Coatings," JOURNAL OF COATINGS TECHNOLOGY, *60*, No. 765, 97 (1988).

(21) Appleman, B.R., "Survey of Accelerated Test Methods for Anti-Corrosive Coatings Performance," JOURNAL OF COATINGS TECHNOLOGY, *62*, No. 787, 57 (1990).

(22) Austin, M.J., "An Evaluation of the Prohesion Corrosion Test Cabinet," *Polymers Paint J.*, *182*, 570 (1992).

(23) Hoeflaak, M. and Tiemens, H., "An Improved Method for Testing Corrosion," *Polymers Paint Colour J.*, unknown.

(24) Jackson, M.A., "Guidelines to Formulation of Waterborne Epoxy Primers: An Evaluation of Anti-Corrosive Pigments," *Polymers Paint Colour J.*, October 17, 1990.

(25) Montle, J.F. and Korobov, Y., "Recent Advances in Accelerated Testing of Protective Coatings," *Am. Paint Coat. J.*, *76*, No. 29, 37 (1991).

(26) Appelman, B.R., "Cyclic Accelerated Testing: The Prospects for Improved Coating Performance Evaluation," *J. Protective Coat. Linings*, *6*, No. 11, 71 (1989).

(27) Skerry, B.S. and Simpson, C.H., "Combined Corrosion/Weathering Accelerated Testing of Coatings for Corrosion Control," Presented at Corrosion 91, The NACE Annual Conference and Corrosion Show, 1991.

(28) Simpson, C.H., Ray, C.J., and Skerry, B.S., "Accelerated Corrosion Testing of Industrial Maintenance Paints Using A Cyclic Corrosion Weathering Method," *J. Protective Coat. Linings*, *8*, No. 5, 28 (1991).

(29) D 1654-90 Standard Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments, *ASTM Annual Book of Standards*, Volume 6.01, Paint—Tests for Formulated Products and Applied Coatings, 1990.

(30) D 610-85 (1989) Standard Method for Evaluating Degree of Rusting on Painted Steel Surfaces, *ASTM Annual Book of Standards*, Volume, 6.01, Paint—Tests for Formulated Products and Applied Coatings, 1992.

(31) D 714-87 Standard Test Method for Evaluating Degree of Blistering of Paints, *ASTM Annual Book of Standards*, Volume 6.01, Paint—Tests for Formulated Products and Applied Coatings, 1992.

(32) D 2803-82, Standard Test Method for Filiform Corrosion Resistance of Organic Coatings on Metal, *ASTM Annual Book of Standards*, Volume 6.01, Paint—Tests for Formulated Products and Applied Coatings, 1992.

(33) Heater, K.J. and MacDonald, W.F., "The Application of Positron Annihilation Lifetime Spectroscopy to the Characterization of Cure and Barrier Properties of Organic Coatings," *Proceedings of The Cleveland Society for Coatings Technology Technical Symposium: Predicting the Durability of Coatings*, May 1993.

(34) Fedor, G.R., "Usefulness of Accelerated Test Methods for Sealant Weathering," *Science and Technology of Building Seals, Sealants, Glazing, and Waterproofing*; Second Volume, ASTM STP 1200, Klosowski, J.M. (Ed.), 10-28 (1992).

(35) Brennan, P. and Fedor, C., "Sunlight, UV, and Accelerated Weathering," National Society of Plastics Engineers Automotive RETEC, November 1987.

(36) Hare, C.H., "The Degradation of Coatings by Ultraviolet Light and Electromagnetic Radiation," *J. Protective Coat. Linings*, 9, No. 5 (1992).

(37) Brennan, P.J., "Improved Light Source Enhances Correlation in Accelerated Weathering," *Plastics Compounding*, March/April 1987.

(38) Fedor, G., and Brennan, P.J., "Correlation of Accelerated and Natural Weathering of Sealants," *Adhesives Age*, May 1990.

(39) Kinmonth, R.A. Jr. and Norton, J.E., "Effect of Spectral Distribution on Degradation of Organic Coatings," JOURNAL OF COATINGS TECHNOLOGY, *49*, No. 633, 37 (1977).

(40) McKwan, H.H. and Simpson, L.A., "An Evaluation of a Fluorescent UV-Condensation Apparatus for Acclerated Weathering Tests," Tioxide, Technical Brochure and Sun Spots, April 1987.

(41) Kinmonth, R.A., "When and Why to Use Fluorescent Sunlamps," Atlas Sun Spots, Vol. II, Issue 25, 1981.

(42) Bauer, D.R., Paputa-Peck, M.C., and Carter, R.O., III, "Evaluation of Accelerated Weathering Tests for a Polyester-Urethane Coating Using Photoacoustic Infrared Spectroscopy," JOURNAL OF COATINGS TECHNOLOGY, *59*, No. 755, 103 (1987).

(43) Skerry, B.S., Simpson, C.H., and Wilson, G.R., "Combined Corrosion/Weathering Testing of Coated Steel Products for Automotive Applications," *Proceedings of the 5th Automotive Corrosion & Prevention Conference* (P-250), October 1991.

(44) Newmark, J., *Statistics and Probability in Modern Life*, Third Edition, Saunders College Publishing, 1983.

(45) Clark, P. and Pattison, L., "Corrosion Testing of Electrocoatings," *Electrocoat '92 Conference Proceedings*, No. 6-1, 1992.

(46) MacDowell, L.G. III, "Testing VOC-Compliant Coatings Systems at Kennedy Space Center," *Mat. Performance*, *32*, No. 7, 26 (1993).

Future Society Meetings

Baltimore

(Oct. 20)—"Formulating for Long Term Protection and Environmental Compliance."

(Nov. 17)—39th Annual Awards Night.

CDIC

(Nov. 14)—"The Interaction of Associative Thickeners with Surfactants in Latex Paints"—Harold Haag, Aqualon.

(Dec. 12)—"Properties of Crosslinked Polyurethane Dispersions"—Valentino Tramontano, King Industries.

(Jan. 9)—"Acrylic-Polyurethane Hybrid Dispersions and Their Use in Waterborne Coatings"—Charles R. Hegedus, Air Products and Chemicals.

(Mar. 13)—Manufacturing Program.

(Apr. 10)—CDIC 75th Anniversary.

(May 8)—"Evaluation of New Generation Coalescing Agents for Industrial Acrylic Latexes"—Thomas M. Larson, Exxon Chemical Co.

Chicago

(Nov. 7)—"Comparative Dispersant Performance in High-Solids Systems"—Eric Nowick, Henkel Corp.

(Jan. 9)—"Reactive Oxazolidine Moisture Control Additives for Polyurethane Coatings"—Thomas L. Johnson, ANGUS Chemical Co.

(Feb. 6)—"Designing for Quality"—Laura J. Hansen, Orr & Boss.

(Mar. 6)—"Solving Practical Adhesion Problems in Coatings with Fundamental Studies in Surface and Bulk Effects of Adhesion"—Krishan C. Sehgal, Union Carbide Chemical & Plastics Co., Inc.

(Apr. 4)—"New Technology in Small Media Milling"—Harry Way, Netzsch, Inc.

(May 12)—Annual Awards Banquet.

Cleveland

(Nov. 15)—Environmental Symposium.

(Jan. 17)—Joint Meeting with CPCA, State of the Industry—John Danziesen, Glidden/ICI America.

To announce that special Society Meeting or Symposium, send all pertinent information, including photos, to the Editor, Journal of Coatings Technology, 492 Norristown Rd., Blue Bell, PA 19422 or Fax it to (610) 940-0292!

(Feb. 21)—"Foam & Foam Control Agents"—Andrew Romano, Drew Division/Ashland Chemical.

(Mar. 21)—"Using Kaolin Pigments to Replace Crystalline Silica"—Thad T. Broome, J.M. Huber Corp.

(Apr. 18)—"Unique Wetting & Dispersing Additives"—Edward Orr, BYK-Chemie.

(Apr. 28)—Educational Symposium.

(May 16)—Awards/Past President's/Spouses' Night.

Golden Gate

(Nov. 14)—"Titanium Dioxide in the Coatings and Allied Industries"—Bob Hopkins, SCM Chemicals.

(Jan. 16)—"Utilization of a New Reactive Diluent to Formulate Low VOC Coatings"—Dharma Kodali, Cargill Technical Oils.

(Mar. 13)—"Use of Smectite Clay Minerals in Waterborne Systems"—Dwayne Siptak and Bob Briell, Southern Clay Products.

(Apr. 17)—"Easily Dispersible, Low Oil Absorption, Opacifying Organic Pigments Encapsulating Titanated Lithopone"—Michael Issel, Sino American Pigments.

(May 15)—"High-Speed Dispersion Techniques"—Rocky Courtain, Morehouse Industries, Inc.

(June 19)—Manufacturing Committee Seminar.

Montreal

(Nov. 2)—DSL/TSCA Update—Dan Barker, Stochem.

(Jan. 11)—"Zero VOC Colorants"—Eliot Burrows, Engelhard Corp.

(Feb. 2)—Mini Symposium.

(Mar. 1)—"Accelerated Testing"—Dwight Weldon, KTA-Tator.

(Apr. 5)—"Rheology Modifiers"—Bob Briell, Southern Clay Products.

(May 3)—"Epoxy Technology"—Elizabeth Wrobel, Air Products/Pacific Anchor.

Pittsburgh

(Nov. 14)—Tour of Miles Inc.

(Jan. 9)—"Compliant Coatings/Problematic Paints"—Clifford Schoff, PPG Industries, Inc.

(Feb. 13)—"Natural vs. Artificial Weathering and the Equipment Available"—Atlas Electric Corp.

(Apr. 10)—Joint Meeting with SSPC, PDCA, NACE, and PSCT.

(May 8)—"Color Trends for the Coming Year"—PPG Industries, Inc. Past-Presidents' and Spouses' Night.

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Dell, Dave—Moline Paint Mfg. Co., Moline, IL.
Hallberg, Steven P.—Ace Hardware Paint Div., Matteson.
Hite, Frederick P.—Ace Hardware Paint Div., Matteson.
Hughes, Charles E.—Benjamin Moore & Co., Melrose Park, IL.
Johnson, Kenneth L.—Alumax Mill Products, Morris, IL.
Martin, Frederick L.—Sherwin Williams Co., Chicago, IL.
McCoy, Claire—Moline Paint Mfg. Co., Moline.
Niemeyer, Wayne P.—McCrone Associates, Westmont, IL.
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Iyer, Chris S.—Paramount Chemicals, Lincolnwood, IL.
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LaGala, Rudolph F.—Technical Coatings Co., Nutley, NJ.
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Fortune, Timothy—Summit Specialty, Fort Lee, NJ.
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Merrix, Kimberly L.—Actinic, Inc., Greensboro.
Nimmons, Tony—Astor Universal, Charlotte.
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Wilson, Paul F.—PPG Industries, Inc., Greensboro.

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Cools, Pablo A.—UCB Radcure Inc., Smyrna, GA.
Dively, Rogest W.—Aerotek Services Inc., Cocoa, FL.
Kraniak, Lynn G.—Luzenac America, Roswell, GA.

Book Review

THE SCIENCE OF POWDER COATINGS, VOLUME 2: APPLICATIONS

Written by
David Bate, John Copland, Ron Floyd, M. Letts, J.A. Scott, and Eric N. Tweddle

Edited by
J. Ashley Scott

Published by
Selective Industrial Training Associates Ltd.
3 Ridgeway Gardens, Wimbledon
London SW19 4SZ England (1994)
x + 333 pages

Reviewed by
Robert F. Brady Jr.
Naval Research Laboratory
Washington, D.C.

This book is the second in a two-volume set on powder coatings published by Selective Industrial Training Associates Ltd. The first volume covers raw materials and formulations for powder coatings.

The authors clearly know their subject. The book emphasizes the practical aspects of choosing, applying, and inspecting powder coatings. It contains a little bit of theory—on corrosion and electrostatics, for instance—but not much. There is also the occasional gripe: "It always seems that money is available for new equipment and machinery for fabrication, but never for new spray guns or spare parts in the spray shop." As you read the authors' words, you can almost see the paint on their shoes!

The first chapter, on selecting a powder coating, gives very practical information—the kind not usually found in books—about the relationship between the customer and the supplier. It contains checklists to be used by specifiers and also a case study on the pitfalls of specifying and selecting powder coatings. A chapter on pretreatment of surfaces before application gives detailed coverage of mechanical and chemical cleaning methods and conversion coatings. Ten clear figures illustrate types of equipment used for pretreatment.

The third chapter on equipment used for the application of powder coatings contains a very thorough discussion of manual and automatic spray guns, electrostatic spray application, conveyor apparatus, spray booths, and curing ovens. Critical factors to be evaluated in the selection of an application method are given. There are 62 carefully prepared figures to illustrate every aspect of the equipment and its operation. Chapter 4, on good practice and troubleshooting, teaches the reader how to run a powder coating plant. Such factors as plant design, process controls, quality control of raw materials, and recovery and reclamation of excess coating are covered. Inspection of the finished product is covered in much detail, defects in the coating are related to application parameters, and corrective measures are suggested. Troubleshooting 23 particular problems is simplified by a flow-chart decision diagram for each.

Chapter 5 explains the performance requirements for the powder application process and for the finished coating. Particular features of epoxy, polyester, epoxy/polyester, acrylic, polyester/urethane, and unmodified polyester systems are explained. Chapter 6 describes the production of powder coatings. Unit operations such as premixing, melt mixing, extrusion, and sieving are described fully, and the equipment involved is illustrated in 34 figures. The last chapter describes health and safety aspects of powder coatings, and includes examples of material safety data sheets from the United Kingdom and the United States.

This book is strengthened by excellent figures and references from around the world. It is sturdily printed and bound and contains an extensive index. I cannot imagine how anyone concerned with the manufacture or use of powder coatings could survive without this book.

SURFACE COATINGS: RAW MATERIALS AND THEIR USAGE, VOLUME 1

Edited by
P. Parsons, Chairman, Textbook Subcommittee of Surface Coatings Association of Australia

Published by
The New South Wales University Press
Postal Box 1
Kensington, NSW, Australia 2033
ix + 622 pages

Reviewed by
Paul R. Guevin Jr.
P.R. Guevin Associates
Westerville, OH

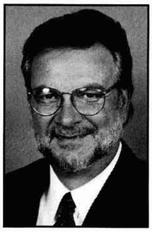
This book is an updated edition of *Surface Coatings*, first published in 1974 with a revised edition in 1983. In the chapter "The Future of the Coatings Industry," Dr. Thomas J. Miranda's 21 selected references are an excellent resource if the reader desires supplemental information.

The remaining 32 chapters discuss aspects of the coatings industry including alkyd, amino, epoxy, phenolic, and urethane resins from waterborne to solventborne, on to pigments and additives: emulsifiers, rheological, etc. There is even a chapter entitled "Safety in the Work Place."

The chapters are written by experts in their respective fields. Several authors are retired and most of them are from outside the United States, which reflects international technology.

This book has an excellent index containing 112 pages of cross-referencing terms. One of the book's shortcomings is a lack of references; however, the book is a worthwhile investment for the library of a coatings company or a raw material supplier to the industry that has only a few books on the broad subject coatings.

People



D. Mazzone

Don Mazzone has joined the staff of Dowd & Guild, Inc., San Ramon, CA, in a sales capacity. Mr. Mazzone comes to the company from the Fuller O'Brien Corp., where he held numerous positions in the laboratory, as well as plant management, over the past 29 years. He is a member of the Golden Gate Society.

Madison Chemical Industries, Inc., Milton, Ont., has named **Shiwei Guan** as Senior Research Scientist. Dr. Guan will manage research and product development, technical service, and quality assurance. Since joining the company in 1993, Dr. Guan has developed more than 20 high-solids and high performance polyurethane coatings. Dr. Guan is a member of the Toronto Society.

Kathy S. Langer has joined the Specialty Ceramics Division of Ferro Corp., Cleveland, OH, as a Sales/Service Representative for the Western Region. Ms. Langer will be responsible for sales and service of the company's products, ceramic mill media and linings, wear resistant materials, and engineered ceramics.

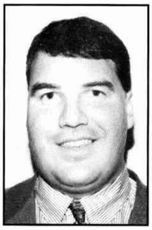
Troy Corp., East Hanover, NJ, has appointed **John A. Jakubowski** to the position of Manager, Technical Service at the company's Applied Research and Technical Service Center. Based in Newark, NJ, Mr. Jakubowski will manage the worldwide technical support activities on both new and existing Troy products. In addition, he will supervise the interface between the technical staff and its sales and product management groups.

Albert H. Bernhardt was promoted to Marketing Manager for Coatings at Chemcentral Corp., Bedford Park, IL. Mr. Bernhardt will serve the coatings industry from a technical and marketing perspective, as well as promote the company's specialty product lines.

William T. Jones was named Manager, Color and Chemical Compounding for Raabe Corp., Menomonee Falls, WI. Mr. Jones will oversee the color database and computer formulation system along with the technical staff responsible for color matching touch-up paint.

The ANGUS Chemical Co., Buffalo Grove, IL, has promoted **Ann M. Druffner** to the position of Product Development Manager. In this new position in the marketing department, Ms. Druffner will coordinate product development programs including opportunity assessment, project planning and management, and product introduction. She previously served as Sales Representative. Ms. Druffner is a member of the Chicago Society.

The position of Director, New Business Ventures for AlliedSignal, Inc., Morristown, NJ, has been accepted by **Ralph R. Day**. In this position, Mr. Day will be responsible for the Performance Additives Groups' full-scale initiative to expand the business through new ventures and acquisitions.



T. Katres

Hüls America Inc., Piscataway, NJ, appointed **Todd Katres** Southern Region Accounts Representative in the Coatings Raw Materials business group. Based in Roswell, GA, Mr. Katres has sales responsibilities in the Southern region for Hüls' isocyanates, diamines, specialty resins, and polyesters. He is a member of the Detroit Society.

Also, **Charles L. Hays** has been named Sales Representative for the Midwest. Operating from the company's Chicago, IL, office, Mr. Hays is responsible for the sales of poly-isocyanates, amines, specialty resins, powder crosslinkers, and Dynapol® polyesters.

In other news, **Gordon Dickey** has accepted the position of Director, International Sales for the Colorants and Additives business group. Mr. Dickey will implement sales programs and secure new business opportunities in Latin America, South America, and the Far East.

Jill Lucius was named Senior Public Affairs/Communications Representative for DuPont Automotive, Troy, MI. Ms. Lucius comes to the company from a Detroit-based public relations agency.

W.R. Grace & Co., Boca Raton, FL, announced the appointment of **Joseph G. Browder** as International Marketing Director for Grace Packaging. In his new position, Mr. Browder will lead business development and acquisitions.

The Puget Sound Section of the Pacific Northwest Society for Coatings Technology recently awarded a scholarship to **Harry Morley** of the Columbia Paint Co., Spokane, WA, to attend the "Introductory Short Course on Polymer Chemistry" at California Polytechnic State University, San Luis Obispo. Mr. Morley has been an employee of the Columbia Paint Co. for over 25 years, and is currently assigned to the company's Research and Development Laboratory.

Gonsalo Cabral will oversee the management of the Colormatching Systems Service Division of Ultrablend Systems, Inc., Londonderry, NH. Mr. Cabral is the former Service Manager of Colorgen.

The Chemicals Group at PPG Industries, Pittsburgh, PA, has announced the following promotions in its Specialty Chemicals marketing organization: **Charles Austin**—Business Manager, Specialty Surfactants; **David Roberts**—Business Manager of the alkoxylation, esterification, and silicone product lines; **Gavin Sinclair**—Business Manager for process chemicals; and **Tim Swiatek**—Business Manager of international sales and marketing.

Obituaries

Morris R. Keyser, a retired Rohm and Haas employee, died on July 19, 1994. He was 73.

Mr. Keyser was born in Leavenworth, KS, and received the B.S. Degree in Chemical Engineering from the University of Kansas. He also served in the Army Air Forces during World War II. Mr. Keyser worked as a Sales Representative for the Rohm and Haas Co. for 34 years, until his retirement in 1986. He was a member of the Kansas City Society.

Elvin Houts, former Vice President of Davis Paint Co., passed away on July 22. He was 81.

Mr. Houts was a 50-year member of NPCA.

Earl E. Stover, former owner of a manufacturing co., died on June 24. He was 79.

Mr. Stover owned the Welco Manufacturing Co. for 40 years, retiring in 1992. He was a Past-President of the Kansas City Paint and Coatings Association.

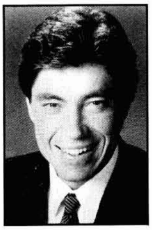
Meetings/Education

22nd Western Coatings Societies' Symposium and Show Gala Banquet and Show Entertainment Announced

The 22nd Western Coatings Societies' Symposium and Show (WCSSS) will be held on February 20-22, 1995 at the Hilton Hotel and Towers, San Francisco, CA. The event is sponsored by the Golden Gate, Los Angeles, Pacific Northwest, and Rocky Mountain Societies for Coatings Technology. As planning for this event continues, the entertainment for the WCSSS Gala Banquet and Show has been announced.

The Farewell Banquet and Entertainment will be held on Wednesday, February 22, 1995 in the Grand Ballroom of the San Francisco Hilton and Towers. A no-host reception is planned for the Yosemite Ballroom before dinner.

Serving as Emcee and Opening Act is Ross Shafer, a stand-up comedian and corporate entertainer for the last 10 years. In the 60's, Mr. Shafer became the host of the new "Match Game." Eventually, he became the opening act for people like Dionne Warwick, Eddie Rabbit, Crystal Gayle, and Neil Sedaka. Mr. Shafer's résumé also includes the following: comedy talk show "Almost Live" with Ross Schafer, "21 Jump Street," "Ross Shafer Comedy Specials," "Evening at the Improv," "Caroline's Comedy Hour," FOX network "The Late Show," and co-host of ABC entertainment magazine "Days End."


Ross Shafer


The Diamonds

The Diamonds, with their instant million selling hit called "Little Darlin'" conclude the WCSSS festivities. The Diamonds have turned to Nashville and contemporary country music and released their latest album entitled "Diamonds are Forever." Their performance will include the Billboard Top 100 singles "Just a Little Bit" and "Two Kinds of Women."

Tickets for the Banquet and Show are part of the full registration. Additional information may be obtained from Barry Adler, 750 La Playa, Ste. 918, San Francisco, CA 94121; (415) 681-5094.

(See registration form on next page.)

NPCA Sponsors Seminar On Management Development

The National Paint and Coatings Association, Washington, D.C., will conduct a "Production Planning and Inventory Management Seminar" on November 3-4 at the Sheraton Airport Hotel, Cleveland, OH.

This seminar is designed to help companies balance the three major objectives of most paint and coatings manufacturing companies. These objectives are: maximum customer service, minimum inventory investment, and efficient (low-cost) plant operations. The seminar covers these topics:

- Decision Process for Learning and Control
- Computer-Based Information Systems
- Inventory Functions
- Order Quantity Decisions
- Material Requirements Planning (MRP)
- Forecasting Methods
- Balancing Production Rates and Inventory Levels
- Batch Scheduling and Manufacturing Capacity
- Batch Sizes and Fill-Outs for Multiple Items
- Maximizing Savings
- Managing Material Costs
- Quality Management Basics
- Integrated Manufacturing and Materials Management
- Coatings Industry Requirements
- "Bench Mark" System Outline
- Practical Systems Characteristics
- Software and Hardware Procurement

The registration for "Production Planning and Inventory Management Seminar" is $725 and includes two breakfasts and two luncheons, and a manual will be sent with pertinent information upon receipt of registration. For additional information, contact Juliette Benedicto, NPCA, 1500 Rhode Island Ave., N.W., Washington, D.C. 20005-5597.

Call For Papers

Pacific Northwest Society for Coatings Technology's 48th Annual Spring Symposium

"PRACTICAL APPROACHES TO VOC REDUCTIONS"
(INNOVATIONS IN FORMULATING AND MANUFACTURING TECHNIQUES)

May 4-6, 1995
Portland, Oregon

The 1995 Annual Spring Symposium of the Pacific Northwest Society is scheduled for May 4-6, 1995 at the Red Lion Lloyd Center in Portland, OR.

The theme of the event is "Practical Approaches to VOC Reductions" (Innovations in Formulating and Manufacturing Techniques), and the Technical Committee is seeking papers covering topics pertaining to this theme. The deadline for abstracts is **December 2, 1994.** In addition to the abstract, potential speakers are asked to include a cover letter describing how the presentation relates to the theme.

Those interested in submitting a paper should contact Michael S. Zibit, Van Waters & Rogers, Inc., 3950 N.W. Yeon Ave., Portland, OR 97210.

PACIFIC NORTHWEST
GOLDEN GATE
ROCKY MOUNTAIN
LOS ANGELES

REGISTRATION APPLICATION

Western Coatings Societies'
22nd. Biennial
Symposium and Show

Hilton Hotel & Tower
San Francisco, California
February 20, 21, 22, 1995

Registration fees are payable to the **Western Coatings Societies'**. Mail to: **AMC, 750 LaPlaya, Suite 918, San Francisco, CA 94121.** All checks must be payable in U.S. funds. Any that are not will be returned. DEADLINE FOR ADVANCE REGISTRATION IS **FEBRUARY 6, 1995.** DO NOT INCLUDE HOTEL ACCOMODATION FEES WITH THIS APPLICATION.

Full Registration includes all technical sessions, exhibits, industry luncheon, and banquet/show

BADGE INFORMATION: This is how your badge will read.

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.

Full Spouse Registration includes Spousal Luncheon, Special Spousal Activities, Banquet/Show & Exhibits.

SPOUSES BADGE INFORMATION:

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

FIRST NAME LAST NAME

CITY STATE/PROV.

Registration Fees:

☐ FULL ADVANCE REGISTRATION	$110
☐ FULL ON SITE REGISTRATION	$130
DAILY REGISTRATION (EXHIBITS & PAPERS ONLY) MONDAY ☐ TUESDAY ☐ WEDNESDAY ☐	$ 25/DAY
☐ FULL ADVANCE SPOUSE REGISTRATION	$110
☐ FULL ON SITE SPOUSE REGISTRATION	$130
☐ BANQUET/SHOW	$ 85
☐ INDUSTRY LUNCHEON	$ 45
☐ SPOUSAL LUNCHEON	$ 45

Method of Payment:

Payment is due with registration form.

Total Amount Due $__________

☐ Cash $__________

☐ Enclosed is Check payable is U.S. funds to **WCS** #__________

CANCELLATION POLICY: Requests for cancellation will be honored in full ONLY if received by February 3, 1995. No refunds will be made after this date. All cancellation requests must be in writing.

Literature

Ink Delivery System

A product release introduces a delivery system for use with an ink jet system. This new system uses an ink accumulator to provide a reservoir of ink to ensure uninterrupted printing during ink changeover. Diagraph Corp., 3401 Rider Trail South, St. Louis/Earth City, MO 63045-1110 can provide more details on the Reservoir™ ink delivery system for use with the Series 2 large character and bar code ink jet system.

Circle No. 30 on Reader Service Card

SEM Analysis

Literature introduces immediate scanning electron microscope analysis as a new service. This system is designed to perform a concurrent analysis of a surface's crystal size, structure, and uniformity. For additional details, contact Man-Gill Chemical, 23000 St. Clair Ave., Cleveland, OH 44117.

Circle No. 31 on Reader Service Card

Waterborne Additives

Additives used in waterborne industrial maintenance coatings are highlighted in a brochure. Tables and figures are included to illustrate performance characteristics of these additives. Air Products and Chemicals, Inc., 7201 Hamilton Blvd., Allentown, PA 18195-1501, can be contacted for a copy of Publication No. 120-9351, "The Benefits of Surfynol® Surfactants in Waterborne Industrial Maintenance Coatings."

Circle No. 32 on Reader Service Card

Company Services

A four-color brochure describing a company's service network has been printed. Among the services illustrated are calibration/verification, validation, software, depot repair, and customer training. A free copy of the brochure on Service Solutions™ is available from Leeds and Northrup, 351 Sumneytown Pike, P.O. Box 2000, North Wales, PA 19454.

Circle No. 33 on Reader Service Card

Flow Monitoring

A fluid flow monitoring and reporting system has been introduced in a product release. This system provides long-term and short-term totals, and monitors fluid flow rates per month, week, day, or by color. For additional details on the Totalizer, write ITW Ransburg Electrostatic Systems, P.O. Box 913, Toledo, OH 43697-0913.

Circle No. 34 on Reader Service Card

Conductivity Meters

Literature introduces a line of conductivity meters. Each of the three meters has simultaneous displays, and two are available with TDS capabilities. For more details on the new conductivity series, write Markson Science, Inc., 5285 N.E. Elam Young Pkwy., Ste. A-400, Hillsboro, OR 97124-6462.

Circle No. 35 on Reader Service Card

Thermometer Catalog

A 44-page catalog contains technical information on thermometers and thermometer usage. Instructions on thermometer usage include the difference between total and partial immersion types, stem correction equations, and column reconnection. Requests for a free copy of Catalog #100 and price list can be sent to Brooklyn Thermometer Co., Inc., Dept. 942, 90 Verdi St., Farmingdale, NY 11735.

Circle No. 36 on Reader Service Card

Maintenance Coatings

A guide to more than 1500 articles and books published between 1984 and 1993 on industrial maintenance painting has been printed. This comprehensive work groups the references into broad categories and then cross-references them into more specific topics. Additional information on "TIPS Plus" can be obtained from the *Journal of Protective Coatings and Linings*, 2100 Wharton St., Ste. 310, Pittsburgh, PA 15203-1951.

Circle No. 37 on Reader Service Card

Coatings Additives

A company highlights its coatings additives in a press release. Zero VOC, liquid organic rheological, solvent-free specialty, and odor/solventless thickener additives are mentioned. Information on these additives is available from RHEOX, Inc., P.O. Box 700, Hightstown, NJ 08520.

Circle No. 38 on Reader Service Card

VOC Removal

A new closed-loop operation for VOC removal from industrial wastewater with zero air emissions is highlighted in a bulletin. This publication presents results from this system dealing with styrene, benzene, toluene, methylene chloride, and other VOCs. Purus, Inc., 2713 N. First St., San Jose, CA 95134, can be contacted for a free copy of "Industrial Wastewater Treatment."

Circle No. 39 on Reader Service Card

Lead Guidelines

A document describes lead issues related to remodeling and renovation. This brochure presents guidelines for renovation and remodeling activities that may create a risk of exposure to lead hazards. Copies of the brochure, "Reducing Lead Hazards when Remodeling your Home," are available from the U.S. Environmental Protection Agency, Office of Prevention, Pesticides and Toxic Substances, Washington, D.C. 20460.

Circle No. 40 on Reader Service Card

Transmittance Adapter

Literature introduces a new transmittance adapter as an accessory to a portable spectrophotometer. The adapter is designed for spectral transmittance measurements of specimens in liquid, plate, or film form, and is equipped with a pulsed xenon light source. More information on the CM-A76 transmittance adapter is available from Minolta Corp., 101 Williams Dr., Ramsey, NJ 07446.

Circle No. 41 on Reader Service Card

Release Coating

Using new coating technology and UV curing, a method of laying release coatings in lines, dots, patterns, and discrete areas on plastic films has been determined. Up to six colors flexo paint is available on the reverse side or in register with the release coating. Inquiries into this new method are being addressed by NMC Coatings Ltd., Broomhill Rd., Brislington, Bristol BS4 4TU, England.

Circle No. 42 on Reader Service Card

PVA Batch Systems

A new line of PVA adhesive batch systems that meter, measure, and mix PVA emulsion and crosslinker is introduced in a product release. The Willamette Valley Co., 675 McKinley St., P.O. Box 2280, Eugene, OR 97402, can be contacted for additional information on the Mix Manager®.

Circle No. 43 on Reader Service Card

Cabinet Oven

An electrically heated, modified cabinet oven used to bake paint samples on metal panels is introduced through literature. A recirculating blower for horizontal airflow and a roof-suspended motorized stainless steel turntable for the panels are provided. For a free catalog on the Grieve No. 718, write The Grieve Corp., 500 Hart Rd., Dept. 510, Round Lake, IL 60073-9989.

Circle No. 44 on Reader Service Card

Photoionization Detection

Literature describes photoionization detection technology with humidity compensation for monitoring low-concentration VOCs. The portable instrument finds application in emissions monitoring and leak detection in chemical facilities and manufacturing plants. For complete information on the Passport® PID organic vapor monitor, request data sheet 08-01-39 from Mine Safety Appliances Co., P.O. Box 426, Pittsburgh, PA 15230.

Circle No. 45 on Reader Service Card

Trace Analysis

A press release highlights a computer-controlled analyzer for polarography and voltammetry. The instrument features real-time plotting, peak ID, zooming, user-drawn baselines and tangents, calibration plots, and standard addition and curve methodology. Additional details on the Model 394 Electrochemical Trace Analysis System are available from EG&G Instruments, Princeton Applied Research, P.O. Box 2565, Princeton, NJ 08543.

Circle No. 46 on Reader Service Card

Industry Profile

A profile of the paint industry of the Americas has been published. This report reviews the structure of each of the national markets of Latin America, including production levels, consumption, and numbers of paint producers, as well as long-term trends and predictions. For further information on "A Profile of the Paint Industry of the Americas," contact Information Research Ltd., 262 Regent St., London W1R 5DA, United Kingdom.

Circle No. 47 on Reader Service Card

Steel Drum Shipping

Information on the selection, purchase, filling, and shipping of containers used to package hazardous materials has been printed. This publication illustrates new universal standards being used to enhance safety of transport, flexibility and technological innovation, and facilitated international commerce in the shipping field. Contact Trilla Steel Drum Corp., 2959 W. 47th St., Chicago, IL 60632, for a free copy of "HM-181 Shipper Responsibility."

Circle No. 48 on Reader Service Card

Accelerated Weathering

A press release illustrates an outdoor accelerated test device. This device is designed to mimic high incidences of UV radiation and a hot, humid environment while using natural sunlight to promote the degradation of paints, coatings, and other materials. Information on the Emmaqua® outdoor accelerated test device is available from the Customer Service Dept., Heraeus DSET Labs., Inc., 45601 N. 47th Ave., Phoenix, AZ 85027-7042.

Circle No. 49 on Reader Service Card

Coatings Directory

A European coatings directory which lists manufacturers and their products has been printed. The index organizes these under the categories of binders, pigments, solvents, extenders and fillers, additives, production and operation, test equipment, and environmental and safety. For more information on the "European Coatings Directory 1994/95—Official FATIPEC Yearbook," contact Vincentz Verlag, Schiffgraben 41-43, D-30175 Hannover, Germany.

Circle No. 50 on Reader Service Card

Pearlescent Dispersions

Literature highlights a new line of dispersions available in pearlescent gold, silver, or bronze. The dispersions are compatible with nitrocellulose, epoxy, alkyd, acrylic latex, and water reducible coatings. Additional information on Uni-Pearl™ pearlescent dispersions is available from Hüls America Inc., Colorants & Additives, P.O. Box 456, 80 Centennial Ave., Piscataway, NJ 08855-0456.

Circle No. 51 on Reader Service Card

Filter Papers

A swatchbook provides samples of 23 grades of creped and smooth finish filter papers. Papers are designed with a range of specifications to accommodate liquid and chemical filtration requirements. A copy of the Ropaco industrial filtration media swatchbook and information on a free test run offer are available from Custom Papers Group Inc., 110 Tredegar St., Richmond, VA 23219.

Circle No. 52 on Reader Service Card

Surface Preparation

A hand mitt for the preparation of curved surfaces for painting has been highlighted through literature. Since it can conform to the shape of the object being worked on, this product can reportedly prepare such surfaces as pipes, iron fences, and railings for painting. Information on the scraping mitt is obtainable from International Product Design, Publicity Dept., 2160 N. Central Rd., Fort Lee, NJ 07024.

Circle No. 53 on Reader Service Card

Paint Removal

A paint removal system for wood, brick, stone, metal, plaster, marble, or fiberglass is detailed in literature. The paste is applied by brushing, rolling, or spraying, and is formulated without methylene chloride or caustic. For spec sheets on Peel Away® 7 paint remover, contact Dumond Chemicals, Inc., 1501 Broadway, New York, NY 10036.

Circle No. 54 on Reader Service Card

Organofunctional Silanes

The introduction of a multi-dosing dispensing system has been made through a technical brochure. The system, applicable for such materials as liquids, pastes, powders, and granules, includes a metering valve which combines gravimetric and volumetric dispensing. For complete technical details or a copy of the brochure on the CYDEC Multi-Dosing System, write CYDEC, Inc., 45 Great Hill Rd., Naugatuck, CT 06770.

Circle No. 55 on Reader Service Card

Supervisor Development

A supervisors' development program is now available on CD-ROM interactive. Training modules cover topics such as accident investigation, employee safety training, safety inspections, and materials handling. The National Safety Council, Public Relations Dept., 1121 Spring Lake Dr., Itasca, IL 60143-3201, can provide further details on the supervisors' development program on CD-i.

Circle No. 56 on Reader Service Card

FTIR Accessory

An FTIR accessory for diffuse reflectance spectroscopy is detailed in a product release. This instrument is reportedly capable of analyzing such samples as powders, fibers, rough surfaces, and liquid chromatograph eluents. Information on the Collector™ is available from Spectra-Tech Inc., 2 Research Dr., P.O. Box 869, Shelton, CT 06484-0869.

Circle No. 57 on Reader Service Card

Monomers

A guide designed to simplify the selection process for monomer specifiers, purchasers, and users has been released. Reference charts are included, and more than 50 monomer products and their applications are covered. Free copies of the "Monomer Products Description & Application Guide" are obtainable from Rohm Tech Inc., Monomers Div., 195 Canal St., Malden, MA 02148.

Circle No. 58 on Reader Service Card

Drum Inserts

Literature introduces a new line of smooth-wall plastic inserts for chemicals, inks, paints, coatings, silicones, greases, and adhesives. These inserts, designed for use with follower plates, feature a contoured lip to prevent leakage between the insert and drum wall. Free samples and more information on the 5515, 5518, and 5524 are available from CDF Corp., 100 Enterprise Dr., Marshfield, MA 02050.

Circle No. 59 on Reader Service Card

Environmental Packaging

A press release discusses high performance, environmentally responsible packaging. Information is provided on industrial containers, fibre cartridges, and a prototype for a new recycled paperboard composite paint canister. For more information on these products, contact Marketing Services, Consumer Products Div., Sonoco Products Co., N. Second St., Hartsville, SC 29550.

Circle No. 60 on Reader Service Card

Viscosity Tubes

A product release presents a new viscosity tube holder with a corker, handle, and optional built-in thermometer. The dual tube holder is designed to stand on both ends so bubbles can be watched during viscosity measurement. For further details on the Gardco® viscosity tube holder, contact Paul N. Gardner Co., Inc., P.O. Box 10688, Pompano Beach, FL 33061-6688.

Circle No. 61 on Reader Service Card

Color Measurement

A company has introduced its new color measurement spectrophotometer in a press release. This instrument is designed for high volume reflectance color measurements in manufacturing, quality control, and retail point-of-sale applications. Information on the Dataflash™ 100 Color Measurement Spectrophotometer is available from Datacolor International, 5 Princess Rd., Lawrenceville, NJ 08648.

Circle No. 62 on Reader Service Card

Gloss Reduction

Technical literature has been issued describing efforts in reducing the gloss of polyester powder coatings. Included are experimental procedures and technical tables illustrating the results. A copy of "The Use of New Reactive Additives for Gloss Reduction in Polyester-Based Powder Coatings" can be obtained from AlliedSignal Inc., Performance Additives, 101 Columbia Rd., Morristown, NJ 07962-1039.

Circle No. 63 on Reader Service Card

Coating Thickness

An interactive, menu-driven modular coating thickness measurement device is described in a press release. Fourteen different combinations can be configured in the unit, which also accepts a variety of probes. Fischer Technology, Inc., 750 Marshall Phelps Rd., Windsor, CT 06095, can provide information on the Fischerscope® MMS (Multi Measurement System).

Circle No. 64 on Reader Service Card

Infrared Drying

Electric infrared drying of metal frames for seat springs, cushions, and upholstery is detailed in an application note. The system reportedly dries parts in three minutes with no further handling required before painting. A copy of CMF *TechApplication* Vol. 8, No. 1, "Electric Infrared Drying of Automotive Seat Risers," is available from the Center for Materials Fabrication, 505 King Ave., Columbus, OH 43201.

Circle No. 65 on Reader Service Card

Polymeric Spheres

Literature introduces expanded polymeric spheres for caulk and sealant manufacturers. The elastic, non-friable, shear-resistant, hollow spheres are purported to be capable of displacing organic solvents content while increasing volume solids. For additional details on Dualite® microspheres, write Pierce & Stevens Corp., P.O. Box 1092, Buffalo, NY 14240.

Circle No. 66 on Reader Service Card

Exterior Paints

Three new exterior house paint products are the topic of literature. One is formulated for maximum water repellency; the second is a solid color alkyd resin/linseed oil formulation for enhancing wood surfaces; and the third is a satin latex for general applications. Information on Dura-Seal with Aquabead™, Permastain®, and Imperial® satin latex exterior paint is available from Mercury Paint, 14300 Schaefer Hwy., Detroit, MI 48227.

Circle No. 67 on Reader Service Card

Test Chamber

A company highlights a programmable weathering test chamber for paints, coatings, inks, plastics, elastomers, and building products in a press release. The chamber uses a xenon arc light system and an optional computer serial interface. More information on the Ci65A Xenon Arc Weather-Ometer® is available from Atlas Electric Devices Co., 4114 N. Ravenswood Ave., Chicago, IL 60613.

Circle No. 68 on Reader Service Card

Powder Deposition

Technical literature introduces a new technique for applying coating powders to nonconductors. This system reportedly allows for uniform electrostatic deposition. Shell Chemical Co., Resins Communications Manager, One Shell Plaza, P.O. Box 2463, Houston, TX 77252-2463, can be contacted for further information on condensation under powder spray (CUPS).

Circle No. 69 on Reader Service Card

Surface Conditioning

Literature highlights introductory packs providing samples of products for grinding, finishing, deburring, cleaning, and surface preparation of metal, wood, plastic, or composite materials. Twenty different packs are offered, and the contents include surface conditioning discs, wheels, belts, and hand pads. Contact 3M Abrasive Systems Div., 3M Center Building 223-6N-01, St. Paul, MN 55144-1000, for information on the 3M coated abrasive and Scotch-Brite surface conditioning introductory packs.

Circle No. 70 on Reader Service Card

Coatings Additives

A new handbook on coatings additives provides basic technical information and reviews on the use and performance of additives and modifiers. The volume, which contains more than 300 figures, tables, and display equations, presents both theoretical and practical views. Contact Marcel Dekker, Inc., 270 Madison Ave., New York, NY 10016, for further information on the *Handbook of Coatings Additives, Vol. 2*.

Circle No. 71 on Reader Service Card

Organofunctional Silanes

A line of organofunctional silanes has been detailed in technical literature. These silanes reportedly enhance adhesion in caulks and adhesives, and provide a mechanism to moisture-cure polymers such as those used in sealants and coatings. Contact OSi Specialties, Inc., 39 Old Ridgebury Rd., Danbury, CT 06810-5121, for further information on the Silquest® line of organofunctional silanes.

Circle No. 72 on Reader Service Card

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.

1995

(May 17-21)—FSCT Spring Week. Spring Seminar on the 17th and 18th; Board of Directors Meeting on the 20th; Incoming Society Officers Meeting on the 21st. Fiesta Americana, Cancun, Mexico.

(Oct. 9-11)—73rd Annual Meeting and 60th Paint Industries' Show. Cervantes Convention Center, St. Louis, MO.

1996

(Oct. 23-25)—74th Annual Meeting and 61st Paint Industries' Show. McCormick Place North, Chicago, IL.

SPECIAL SOCIETY MEETINGS

1995

(Feb. 2)—"Chemistry for the Changing Times." Mini-symposium sponsored by the Montreal Society for Coatings Technology. (Alain Charbonneau, Miles Canada Inc., 7600 Trans-Canada Hwy., Pointe-Claire, Que., Canada H9R 1C8).

(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).

(May 4-6)—48th Annual Spring Symposium. Sponsored by the Pacific Northwest Society. Red Lion Lloyd Center, Portland, OR. (Ken Wenzel, Chemical Distributors, Inc., P.O. Box 10763, Portland, OR 97210; (503) 243-1082).

OTHER ORGANIZATIONS

1994

North America

(Nov. 8-10)—Fourth Annual Advanced Coatings Technology Conference and Exposition. Sponsored by The Engineering Society of Detroit. Hyatt Regency, Dearborn, MI. (Wael Berrached, The Engineering Society of Detroit, 2350 Green Road, Ste. 190, Ann Arbor, MI 48105).

(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

(Oct. 24-28)—"Surfactants and Polymers in Aqueous Solution." Course sponsored by the Institute for Surface Chemistry. Athens, Greece. (K. Môller, 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).

(Nov. 22-23)—"Forum de la Connaissance." Symposium sponsored by the French Association of Technicians of Paints (AFTPVA) in conjunction with The Coatings Research Institute (CoRI). Auditorium Hoechst-Tower Roussel, Hoechst-Paris-La Défense. (AFTPVA, 5, rue Etex, F-75018 Paris, France or CoRI, Avenue P. Holoffe, B-1342 Limelette, Belgium).

(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. 19-22)—18th Annual Meeting of The Adhesion Society. Crystal Sands Resort, Hilton Head, SC. (Joseph W. Holubka, Ford Motor Co., MD 3198, P.O. Box 2053, Dearborn, MI 48121).

(Feb. 24-26)—"Spring Decor 1995." Sponsored by the National Decorating Products Association (NDPA). Georgia International Convention Center, 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).

(Apr. 5-7)—10th Annual Conference sponsored by Architectural Spray Coaters Association (ASCA). Doral Ocean Beach Resort, Miami, FL. (ASCA, 230 W. Wells St., Ste. 311, Milwaukee, WI 53203).

(May 22-24)—Eighth International Symposium on Polymer Analysis and Characterization (ISPAC-8). Sanibel Island, FL. (ISPAC Registration, 815 Don Gaspar, Sante Fe, NM 87501).

(June 5-9)—"Advances in Emulsion Polymerization and Latex Technology." Short course sponsored by Lehigh University, Bethlehem, PA. (Mohamed S. El-Aasser, Emulsion Polymers Institute, Lehigh University, 111 Research Dr., Bethlehem, PA 18015).

(June 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).

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'Humbug' from Hillman

I think I am pleased to report that Dick Stewart, who rates high among my zanier correspondents, sent me another of his confusing observations on his life, friends, and the current scene. I quote:

"Dear Herb–I'm lost. I have gone out to find myself. If I should return before I get back, please ask me to wait.

You don't have to drive a car at 80 miles per hour. You aim it.

Frank Borrelle (actually it wasn't Frank but we can use him) had a friend who was dying. The friend made Frank promise that every time he went to the local watering hole for a pint of ale, he would also have one for his friend.

For years, every time Frank went for a pint he would order two, one for him and one for his departed friend. Then, one day he ordered just one pint. When the bartender asked why he wasn't having one for his friend, Frank replied, 'Oh, but I am. This one is for my friend. The doctor ordered me to stop drinking.'

Herb, you know, of course, that if I could buy you at what I think you're worth and sell you at what you think you're worth, I would be a rich man."

If Dick's contribution to Humbug should encourage similar crazies out of the woodwork, I would be horrified, but pleased, even if my readers question MY sanity.

• • • • • • • • •

—A pessimist is someone who feels bad when he feels good and fears he will feel worse when he feels better.

—Hiring people who are smarter than you are proves you're smarter than they are.

—Too bad we can't invest in taxes. They're sure to go higher.

—Experience is what you get when you don't get what you want.

—In 1626, Peter Minuit bought the island of Manhattan for $24. Last week one of his descendants paid more than that just to park there.

—Just think, if Edison hadn't invented the light bulb, we'd all be operating our computers by candlelight.

—The Lion

• • • • • • • • •

A lady in Vermont wrote to the Department of Agriculture and asked for a bit of advice on the care of chickens. "Every morning for the past month," she said, "I have discovered three or four of my hens lying on their backs with their feet in the air. What's the cause of this?"

The Secretary of Agriculture spoke to three assistants who called in the Undersecretary of State and some Ambassadors who happened to be around. They all put their heads together and sent the lady a telegram. "Your hens," it read, "are dead."

Mr. and Mrs. Williams' happy married life almost went on the rocks because of the presence in the household of old Uncle Ezra. For 12 long years he lived with the Williamses, always crotchety, always demanding, always the first at the table at mealtimes. Finally, the old man caught double pneumonia and died. On the way back from the cemetery, Mr. Williams told his wife that he had a confession to make. "Darling," he said, "If I didn't love you so much, I don't think I ever could have stood having your Uncle Ezra in the house all that time."

His wife looked at him, aghast. "MY Uncle Ezra!" she cried. "I thought that he was YOUR Uncle Ezra."

Laughing Stock— Edited by Bennett Cerf; 1945

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Art Buchwald's many years in Paris entitled him to give the following sage advice to European travelers.

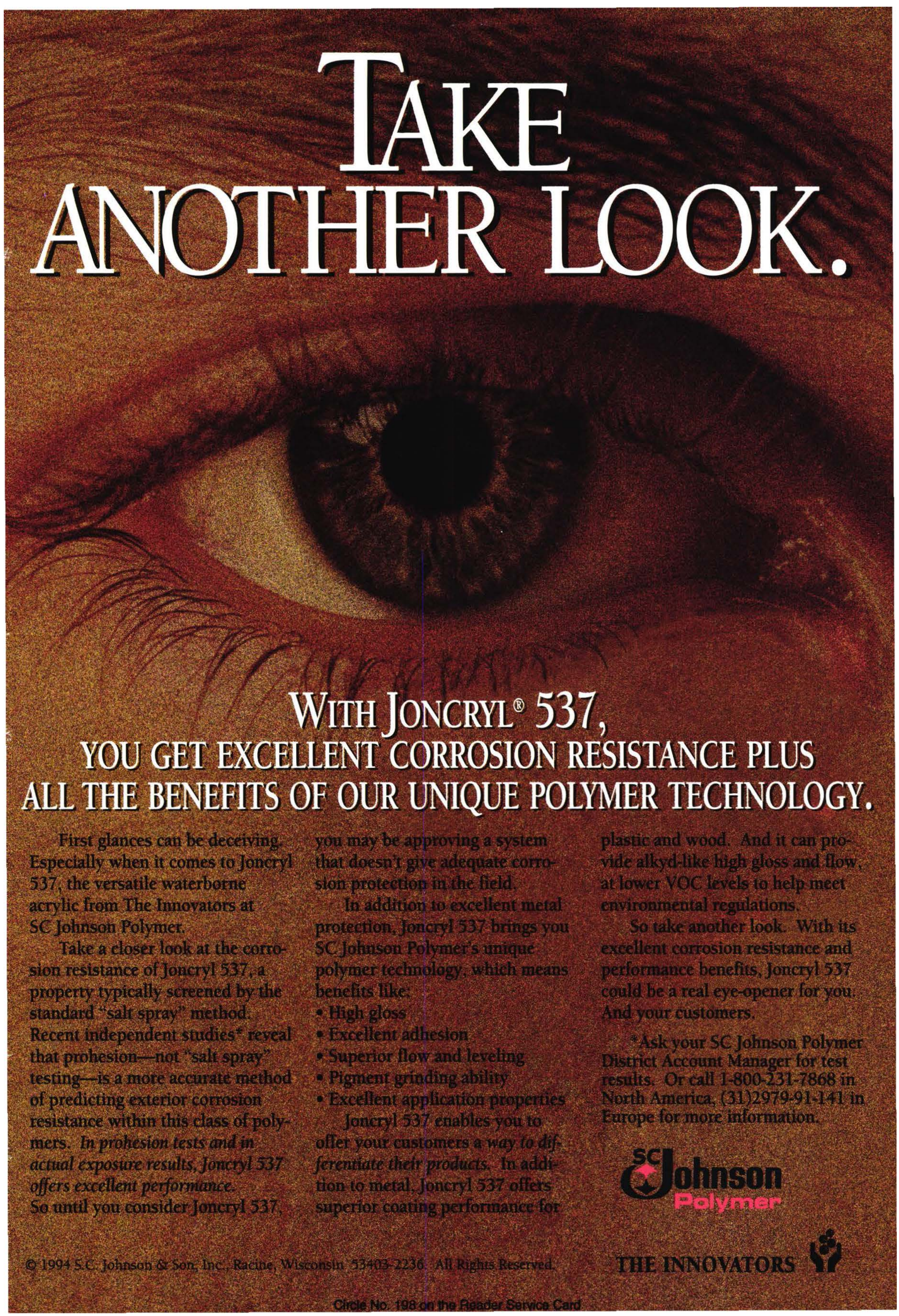
"It is very hard for a foreigner who is unfamiliar with French drivers to catch on to driving in Paris.

A few simple things to keep in mind might help them.

1. If someone extends his hand, that means the window is open.
2. If someone stops at a red light, it means his foot has slipped off the accelerator.
3. If the left rear blinker light is lit, it means the car will either turn left, right, or come at you in reverse.
4. If the right rear blinker light is lit, it means the car ahead will either stop or has a short circuit.
5. If you hear curses coming from another car, it means that you have done something that irks the other driver because he didn't think of it first.
6. Sounding the horn means the car has just struck a pedestrian, and the driver would like someone to be a witness.
7. A policeman with his hand up means that he has just witnessed a very gory accident and doesn't have the nerve to look at it. He is shielding his eyes with the other hand.
8. When a driver waves his hand up and down it means the girl with him is not his wife, and he would appreciate all courtesies."

Don't Forget to Write—World Publishing, 1960

—Herb Hillman
Humbug's Nest
P.O. Box 135
Whitingham, VT 05361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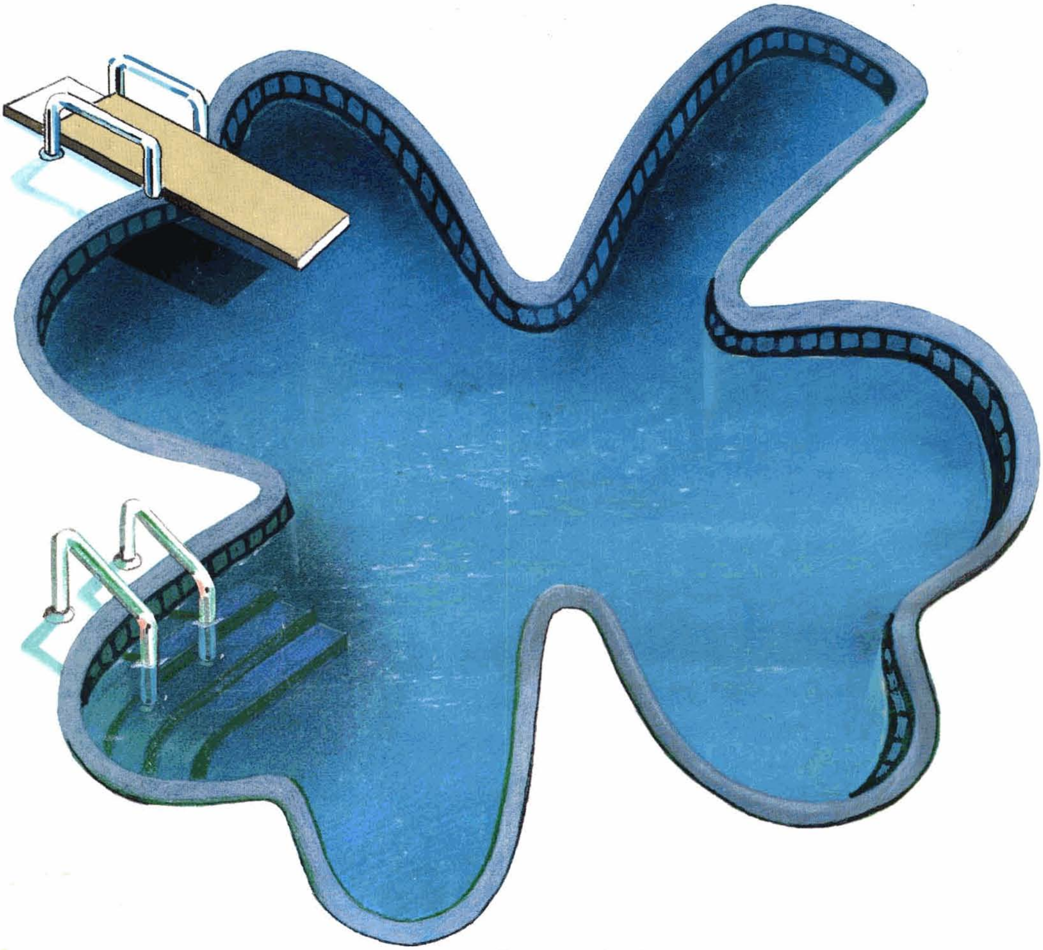

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