

December 1996

JCT

JOURNAL OF COATINGS TECHNOLOGY

SPECIAL ISSUE - POWDER COATINGS

Hydroxylated
Guayule Rubber
in Powder Coatings

Defects in Powder
Coatings on Hot-Dipped
Galvanized Steel

Also - JCT 1996
Annual Index

PRODUCT OVERVIEW
Lab Apparatus and Equipment





The Federation of Societies for Coatings Technology's New...

1997

**International
Coatings Expo
& Technology Conference**



Atlanta

November 3-5, 1997

**Georgia World Congress Center
(The NEW "Paint Show")**

For further information, please call
the Federation of Societies for Coatings Technology at

610-940-0777 or fax 610-940-0292

Visit our new web site at www.coatingstech.org

What Do These Terms Have In Common?

ACETYLATED CONGO S.B.P. SPIRITS SAGGING

They can all be found in the NEW Coatings Encyclopedic Dictionary

Editor: Stanley LeSota

This is the world's most up-to-date, comprehensive, authoritative reference for the language of YOUR INDUSTRY.

- ▶ Over 6,000 industry terms defined
- ▶ Cross referenced for synonyms and related categories
- ▶ Current industry vocabulary, including state-of-the-art technologies and regulatory terms
- ▶ Quick, clear references for technical, as well as commonly used industry terms

This is a **MUST HAVE** resource for *anyone* working in the paint, coatings, ink, art, visual and related industries.

Perfect for marketing, sales, R&D, chemists, government and regulatory workers, artists, architects, manufacturers, technicians, teachers, students and more. Developed and approved by the Federation of Societies for Coatings Technology.



Call 610-940-0777

Fax 610-940-0292

Or use the order form below.

**CALL
NOW TO
RESERVE
YOUR
NEW EDITION!
610-940-0777**

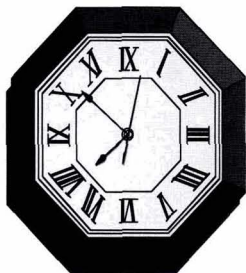
YES! Send me the *NEW EDITION* of the *COATINGS ENCYCLOPEDIA DICTIONARY NOW!*
Please refer to #JC1296 when ordering

Number of Copies _____	Federation Members Non-Members	Soft Cover \$80* \$105*	Hardback \$105* \$135*
I am paying by:	<input type="checkbox"/> Check or money order	<input type="checkbox"/> Company Purchase Order (please attach)	
	<input type="checkbox"/> MasterCard	<input type="checkbox"/> Visa	<input type="checkbox"/> American Express
Credit Card Number _____	Exp. Date _____		
Signature _____			
Company name _____		Attn: _____	
Address _____		City/State/Zip _____	

Mail to: Federation of Societies for Coatings Technology, 492 Norristown Rd., Blue Bell, PA 19422-2350

*Volume pricing is also available on orders of 5 or more. Please call for more information. Shipping and handling charges and appropriate sales tax (PA 6%) are additional.

How Much



Do You Spend in Training?

SciQuest—A Revolutionary Coatings Tool for State-of-the-Art Multimedia Training . . .

- Eliminates the Need for Expensive Off-Site Training
- Offers Employees at Every Level the Opportunity to Increase Knowledge and Experience
- Provides the Most Comprehensive Overview of Coatings Technology and Manufacturing

Here's What the Experts Have to Say:

"Volume I of SciQuest is a MUST for coatings technologists, forensic chemists, professors and teachers, sales and marketing personnel, managers and others. In addition, office personnel and other non-technologists will find it is fun to use and easy to understand. The 24 embedded videos and thousands of graphics provide a quick, visual understanding and feeling for many processes."

—Dr. Joseph V. Koleske, Editor
ASTM Paint and Coatings Test Manual,
14th Edition of the Gardner-Sward Handbook

"SciQuest is the most accessible, in-depth resource of information on coatings, in my experience."

—Robert Springate
R&D Supervisor
TruTest Manufacturing

"This user friendly, informative CD is a must for industrial and university information centers and serious coatings operations. It is easily accessed, very readable and like having a consultant at your disposal. Get one!"

—Dr. Thomas J. Miranda
Adjunct Professor, Chemistry
Indiana University, South Bend

With just a keystroke, the world of coatings can be yours to explore and master!

System Requirements: IBM PC or compatible, 386 or greater, Microsoft Windows with 8 MB of RAM, VGA monitor, 256 Color recommended, CD-ROM drive.

For more information on [SciQuest](#), contact:

Federation of Societies for Coatings Technology
492 Norristown Rd., Blue Bell, PA 19422-2350.
Phone: (610) 940-0777 or FAX: (610) 940-0292

**Call for a Free
CD DEMO DISC
(610) 940-0777**

Technical Articles

- 15** Hydroxylated Guayule Rubber in Powder Coatings—A. Niroomand, T.P. Schuman, and S.F. Thames
The authors describe a novel hydroxylated rubber used in a powder coating with improved toughness, flexibility, and solvent resistance of the cured coating.
- 21** Defects in Powder Coatings on Hot-Dipped Galvanized Steel—T. Glauser et al.
This manuscript provides insights into pinhole formation in powder coatings on galvanized steel, and illustrates that most of the pinhole problems can be resolved by modifying coating rheology.
- 29** Amine-Functional Curatives for Low Temperature Cure Epoxy Coatings—D.J. Weinmann, K. Dangayach, and C. Smith
Low temperature cure epoxy coatings are the subject of this paper. Acrylated epoxy resins and epoxy resins are compared. It is shown that acrylated epoxy resins cure much faster at low temperatures.
- 39** Rapid Electrochemical Assessment of Paint—M. Kendig et al.
Approximately 100 carbon steel specimens painted with a variety of primarily solvent-based automotive paints were evaluated by two rapid electrochemical methods: electrochemical impedance spectroscopy and cathodic disbonding.

Formulation and Production Forum

- 51** Stabilization of Zinc Pigments in Aqueous Alkaline Media by Paint Resins—B. Müller
This study of the stabilization of aqueous dispersions of metallic zinc pigments identifies some types of resin binders as stabilizers and compares their effectiveness.

Federation News

- 10** Adhesion Monograph is Added to the Federation Series on Coatings Technology

Product Overview

- 80** Laboratory Apparatus

Departments

JCT Guide for Authors	4	Future Society Meetings	72
Comment	7	New FSCT Members	73
Technical Abstracts	8	People in the News	75
Industry News	11	Obituary	75
Meetings Update	13	New Products	77
Regulatory Update	49	Calendar of Events	79
1996 JCT Annual Index	55	Humbug from Hillman	82
Society Reports	66		

© 1996 by FEDERATION OF SOCIETIES FOR COATINGS TECHNOLOGY

THE JOURNAL OF COATINGS TECHNOLOGY (ISSN 0361-8773) is published monthly by the Federation of Societies for Coatings Technology, 492 Norristown Rd., Blue Bell, PA 19422-2350, Phone (610) 940-0777; Fax: (610) 940-0292.

Periodicals postage paid at Blue Bell, PA and at additional mailing offices. POSTMASTER: Send address changes to JOURNAL OF COATINGS TECHNOLOGY, 492 Norristown Rd., Blue Bell, PA 19422-2350.

Subscription: U.S. and Canada - 1 year, \$40; 2 years, \$75; 3 years, \$110. Europe (Air Mail) - 1 year, \$70; 2 years, \$135; 3 years, \$200. Other Countries - 1 year, \$55; 2 years, \$105; 3 years, \$155.



Guide for Authors



GENERAL

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

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

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

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

SUBMISSION OF MANUSCRIPTS...

...for the Journal

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

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

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

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

...for Roon Foundation Award Competition

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

MANUSCRIPT PREPARATION

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

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

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

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

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

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

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

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

Title

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

Authors' Biographies and Photographs

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

Abstracts

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

Text

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

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

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

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

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

Metric System

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

Tables, Graphs, and Drawings

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

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

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

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

Photographs

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

Color prints and slides are unacceptable.

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

Nomenclature

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

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

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

Equations

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

Summary

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

Acknowledgment

If used, it should follow the summary.

References

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

- (1) Pascal, R.H. and Reig, F.L., "Pigment Colors and Surfactant Selection," *Official Digest*, 36, No. 475 (Part 1), 839 (1964).
- (2) Davidson, H.R., "Use and Misuse of Computers in Color Control," *JOURNAL OF COATINGS TECHNOLOGY*, 54, No. 691, 55 (1982).
- (3) Stephen, H.G., "Hydrogen Bonding—Key to Dispersion?," *J. Oil & Colour Chemists' Assoc.*, 65, No. 5, 191 (1982).
- (4) Patton, T. (Ed.), *Pigment Handbook*, Vol. 1, John Wiley & Sons, Inc., New York, 1973.
- (5) Henderson, W.A. Jr. and Singh, B. (to American Cyanamid Co.), U.S. Patent 4,361,518 (Nov. 30, 1982).

OTHER INFORMATION

Galley proofs will be sent to the author for checking about six weeks prior to publication.

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

* * * *

The JOURNAL OF COATINGS TECHNOLOGY is copyrighted by the Federation of Societies for Coatings Technology. The editorial contents of the JOURNAL may not be reprinted in whole or in part without written permission of the publisher.

The JOURNAL OF COATINGS TECHNOLOGY is published monthly by the Federation of Societies for Coatings Technology at 492 Norristown Rd., Blue Bell, PA 19422-2350. Phone: (610) 940-0777. FAX: (610) 940-0292.

Annual dues for Active and Associate Members of the Federation of Societies for Coatings Technology is \$25.00. Of this amount, \$16.75 is allocated to a membership subscription to this publication. Membership in the Federation is obtained through prior affiliation with, and payment of dues to, one of its 26 Constituent Societies. Non-member subscription rates are:

	U.S. and Canada	Europe (Air Mail)	Other Countries
1 Year	\$40.00	\$70.00	\$55.00
2 Years	\$75.00	\$135.00	\$105.00
3 Years	\$110.00	\$200.00	\$155.00

When available, single copies of back issues of the JOURNAL OF COATINGS TECHNOLOGY are priced as follows: \$10.00 each for current calendar year issues; \$15.00 each for all other issues.

Publisher Robert F. Ziegler
Editor Patricia D. Viola
Technical Editor Robert F. Brady, Jr.
Managing Editor Kathleen M. Wikiera
Assistant Editor Jonna D. Coachman
Director of Marketing Lyn Pollock
Subscription Fulfillment Manager Audrey E. Boozar
National Advertising Representative Scott Walter
 22785 Cass Ave., Woodland Hills, CA 91364
 (818) 224-3226; Fax: (818) 222-0194

Publications Committee

B. Carr, Chair
 R.F. Brady
 R.A. Dickie
 J. Hinkle
 R.E. Bish
 L. Price
 J. Stauffer
 R. Woodhall
 P.D. Viola
 R.F. Ziegler

Editorial Review Board

Robert F. Brady Jr., Chair
 M. Ahmed
 D.R. Bauer
 H. Bender
 J.H. Braun
 D. Brezinski
 R.A. Dickie
 P.R. Guevin, Jr.
 C.R. Hegedus
 L.W. Hill
 T. Hockswender
 S.F. Kia
 J.V. Koleske
 H. Lowrey
 J.W. Martin
 J.L. Massingill
 P.E. Pierce
 G.R. Pilcher
 T. Provder
 R.A. Ryntz
 C.K. Schoff
 R. Stanzola
 J.O. Stoffer

The JOURNAL OF COATINGS TECHNOLOGY has first rights to the publication of papers presented at the International Coatings Technology Conference of the Federation and at local and regional meetings of the Federation's Constituent Societies.

The JOURNAL OF COATINGS TECHNOLOGY is available on microfilm from University Microfilms, a Xerox Co., Ann Arbor, MI 48106.

The Federation of Societies for Coatings Technology assumes no responsibility for the opinions by authors in this publication.

Copyright 1996 by the Federation of Societies for Coatings Technology. All rights reserved. No portion of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying, recording or by any information storage or retrieval system without permission in writing from the publisher. Authorization to photocopy items for internal or personal use, or the internal or personal use of specific clients is granted by the Federation of Societies for Coatings Technology for users registered with the Copyright Clearance Center (CCC) Transactional Reporting Service, provided that the base fee of \$1.00 per copy, plus .25 per page is paid directly to CCC, 27 Congress St., Salem, MA 01970. For those organizations that have been granted a photocopy license by CCC, a separate system of payment has been arranged. The fee code for users of the Transaction Reporting Service is: 0032-3352/86 \$1.00 + .25.

FSCT Board of Directors—1996-97

PRESIDENT

*JAY AUSTIN
 Halox Pigments
 1326 Summer St.
 Hammond, IN 46320

PRESIDENT-ELECT

*THOMAS E. HILL
 24 Lily Brook Ct.
 East Amherst, NY 14051

SECRETARY-TREASURER

*FOREST FLEMING
 Akzo Nobel Coatings, Inc.
 1431 Progress St.
 P.O. Box 2124
 High Point, NC 27261

MARK D. ALGAIER
 Hillyard Industries, Inc.
 St. Joseph, MO

EVANS ANGELOS
 Omya, Inc.
 Clarendon Hills, IL

FREIDUN ANWARI
 BFGoodrich Co.
 Brecksville, OH

GEORGE AMRICH, JR.
 Benjamin Moore & Co.
 Flanders, NJ

A. CLARKE BOYCE
 A.C.B. Consultants
 Oakville, Ont., Canada

DONALD W. BOYD
 PPG Industries, Inc.
 Allison Park, PA

LARRY BRANDENBURGER
 The Valspar Corp.
 Minneapolis, MN

*DARLENE R. BREZINSKI
 Consolidated Research Inc.
 Kingsford, MI

JOSEPH CARAVELLO
 Guardsman Products, Inc.
 Sugar Land, TX

BRENDA L. CARR
 Coatings Development Co.
 Painesville, OH

MARTHA COLIN
 Colin y Lozano S. de RL
 Mexico DF, Mexico

DONALD F. DENNY
 E.W. Kaufmann Co.
 Southampton, PA

J. ANDREW DOYLE
 National Paint & Coatings
 Association
 Washington, D.C.

VAN S. EVENER
 Toledo, OH

F. LOUIS FLOYD
 Duron, Inc.
 Beltsville, MD

JAMES E. GEIGER
 Consultant
 Largo, FL

*TERRY GELHOT
 Carboline Co.
 St. Louis, MO

JOSEPH D. GIUSTO
 Lenmar, Inc.
 Baltimore, MD

*GERRY J. GOUGH
 ICI Packaging Coatings
 Holden Surface Coatings
 Ltd.
 Birmingham, England

JAMES D. HALL
 ICI Paint Co.
 Los Angeles, CA

WILLIAM M. HOLLIFIELD
 D & L Paint Co.
 Liberty, IN

WILLIAM F. HOLMES
 Ameritex Chemical &
 Coatings Inc.
 Irving, TX

DAVID JACK
 Technical Coatings Co., Ltd.
 Burlington, Ont., Canada

CHARLES A. KAPLAN
 Gillespie Coatings, Inc.
 Longview, TX

MAUREEN M. LEIN
 Davidson/Textron
 Dover, NH

GARY MARSHALL
 Chemcraft Sadolin Inc.
 Walkertown, NC

RONDA K. MILES
 Bossco Industries
 Plano, TX

*J. DICK MULLEN
 G-3 Industries
 Aurora, CO

DENNIS R. OWEN
 Technical Coatings Co.
 Santa Clara, CA

HORACE PHILIPP
 PWGSC
 Ottawa, Ont., Canada

GEORGE R. PILCHER
 Akzo Nobel Coatings, Inc.
 Columbus, OH

LARRY PITCHFORD
 Reynolds Metals
 Louisville, KY

YVON POITRAS
 Mills Paint Sales, Ltd.
 Delta, B.C. Canada

PATRICIA SHAW
 Radiant Color
 Richmond, CA

WILLIAM C. SPANGENBERG
 Hammond Lead Products, Inc.
 Pittsburgh, PA

*Executive Committee Members

EXECUTIVE VICE PRESIDENT

ROBERT F. ZIEGLER
 FSCT Headquarters
 492 Norristown Rd.
 Blue Bell, PA 19422



Mission Accomplished



The 1996 FSCT Annual Meeting Program Committee set out on a journey in September 1995 to redesign the educational programming for the Annual Meeting. To accomplish this, the committee reviewed the types of programming done by FSCT in the past and also studied the successful events held by many other organizations. In addition, the committee reviewed data from attendees of many FSCT events and spoke to quite a few members and non-members to

learn what they would like to see done from an education standpoint at the Annual Meeting

After hours and hours of hard work, the International Coatings Technology Conference was born. The inaugural event was run on October 22-25, 1996 in Chicago. The conference consisted of five one-day pre-convention seminars, a one-day Executive Forum and four two-day courses.

The results of the conference are in and by all indications this first one was a success. The programming drew 525 attendees—over twice as many as the target goal—and many of the critique responses were positive. The survey responses also provided many useful ideas to be incorporated into future events. As you are reading this, the Program Committee has taken these ideas and is already assembling the conference for 1997, scheduled for Atlanta on November 3-5.

Hats off to the Annual Meeting Program Committee members: Chairman Steve Hodges, Gail Pollano, Thom Johnson, Andy Gilicinski, Susan Farnsworth, Latoska Price and Beverly Spears. Their hard work and creativity provided state-of-the-art education for 525 industry participants and a solid foundation for future programs to build upon.

Michael G. Bell
Director of Educational Services

Hydroxylated Guayule Rubber in Powder Coatings—A. Niroomand, T.P. Schuman, and S.F. Thames

JCT, Vol. 68 No. 863, 15 (Dec. 1996)

The synthesis, characterization, and application of hydroxylated low molecular weight guayule rubber as a powder coating component is described. In particular, our interest was in the generation of secondary alcohol moieties on a guayule rubber backbone, and its use as part of a novel and, as yet, unreported powder coating formulation. Hydroxylated guayule rubber was found to improve toughness, flexibility, and solvent resistance of powder coatings.

Goma de Guayule Hidroxilada en Recubrimientos en Polvo—A. Niroomand, T.P. Schuman, y S.F. Thames

Se describe la síntesis, caracterización y aplicación de la goma de guayule hidroxilada de bajo peso molecular como un componente de la pintura en polvo. En particular, se enfocó la investigación sobre la generación de porciones de alcohol secundario en el espinazo de una goma de guayule, así como su uso como parte de una nueva y aún no reportada formulación de recubrimiento en polvo. La goma de guayule hidroxilada para los recubrimientos en polvo fué formulada para mejorar la rugosidad, flexibilidad y resistencia a los solventes.

Defects in Powder Coatings on Hot-Dipped Galvanized Steel—T. Glauser et al.

JCT, Vol. 68 No. 863, 21 (Dec. 1996)

The occurrence of pinholes in the powder coating of hot-dipped galvanized steel items is investigated. A polyester powder resin crosslinked with triglycidylisocyanurate was used as a model system. The effects of a rheological modifier on the curing process and on the cured material were investigated. The effect of the substrate was studied by using steel with two different silicon contents. The results show that pinholes are likely to appear if the surface's silicon content lies in a given range, which in turn will produce a rough zinc surface. Phosphates and silanes were used as conversion coatings, but neither had an effect on the occurrence of pinholes. The rheological modifier improves the flow properties and helps to solve most pinhole problems.

Defectos de Recubrimientos en Polvo sobre Acero Galvanizado por Inmersión—T. Glauser et al.

Fuó investigada la aparición de pequeños agujeros en el recubrimiento en polvo del productos de acero galvanizado por inmersión. Se uso como modelo una resina de poliéster en polvo entrecruzada con triglicidilisocianurato. Fueron investigados los efectos del modificador de reología en los procesos de curado y en materiales curados. Se estudio el efecto del sustrato en aceros con dos diferentes contenidos de silicon. Los resultados muestran que los pequeños agujeros son propensos a aparecer si el contenido de silicon en la superficie se encuentra en un rango determinado, el cual en cambio producirá una superficie de zinc rugosa. Fueron usados silanos y fosfatos en la conversión de los recubrimientos, pero ninguno tuvo influencia sobre la aparición de los pequeños agujeros. El modificador de reología mejoro las propiedades de flujo y ayudo a resolver problemas adicionales de los pequeños agujeros.

Amine-Functional Curatives for Low Temperature Cure Epoxy Coatings—D.J. Weinmann, K. Dangayach, and C. Smith

JCT, Vol. 68 No. 863, 29 (Dec. 1996)

An active area of technology development is the design of improved epoxy/amine binder systems for low temperature cure coatings. Low temperature cure epoxy coatings allow applicators to extend the painting season because coatings can be applied even when the temperature falls below 50°F. This paper begins with a basic overview of the curing agent technologies available for low temperature epoxy/amine coatings. The coatings performance of several low temperature curatives with standard liquid epoxy resin is studied in this work. Differential scanning calorimetry is used to monitor the binder systems' cure rate at 40°F over a 14 day period. The coatings performance in clear varnish formulations is presented; cured at standard ambient conditions (77°F, 55% RH) and at sub-ambient, high humidity conditions (50°F, 90% RH and 40°F, 80% RH) This study concludes with evaluation of a new approach to low temperature cure epoxy coatings. This approach uses low temperature curatives in combination with polyacrylated epoxy resins. The results show that these new binder systems give improved clarity, blush resistance, and cure development under low temperature, high humidity conditions.

Agentes de Curado Amino Funcional para Recubrimientos Epóxicos con Curado a Baja Temperatura—D.J. Weinmann, K. Dangayach y C. Smith

Un área áctiva del desarrollo tecnológico es el diseño de mejores sistemas de aglomerante epoxi/amina para recubrimientos de curado a baja temperatura. Los recubrimientos epóxicos de curado a baja temperatura permiten el uso de aplicadores para extender la período de pintado ya que los recubrimientos pueden ser aplicados aún cuando la temperatura caé por debajo de 50°F. Este documento inicia con un panórama básico de las tecnologías disponibles para recubrimientos epoxi/amina a baja temperatura. También se estudia el desempeño de los recubrimientos con varios agentes de curado a baja temperatura con resinas epóxicas líquidas. El método de calorimetría de búsqueda diferencial es usado para monitorear la rápidex de

curado de los sistemas de aglomerante a 40°F por un período de 14 días. Se presenta el desempeño de recubrimientos con formulaciones de barnices claros; curados a condiciones de ambiente normales (77°F, 55% RH) y en sub-ambiente, así como en altas condiciones de humedad (50°F, 90% RH y 40°F, 80% RH). El estudio concluye con la evaluación de una nueva aproximación a recubrimientos epóxicos de curado a baja temperatura. Esta aproximación usa agentes de curado a baja temperatura en combinación con resinas epóxicas poliácridadas. Los resultados muestran que estos nuevos sistemas aglomerantes proporcionan mejor claridad, resistencia al blanqueo y desarrollo de curado a bajas temperaturas y altas condiciones de humedad.

Rapid Electrochemical Assessment of Paint—M. Kendig et al.

JCT, Vol. 68 No. 863, 39 (Dec. 1996)

Approximately 100 carbon steel specimens painted with a variety of primarily solvent-based automotive paints were evaluated by two rapid electrochemical methods: electrochemical impedance spectroscopy (EIS) and cathodic disbonding. The results were compared with salt fog exposure life. The salt fog times to failure as determined by several different criteria correlated well with the rapid electrochemical evaluation. Regression coefficients useful for predicting the long-term salt fog life from the short (24 hr) electrochemical tests are presented.

Aseguramiento Electroquímico Rápido de Pintura—M. Kendig et al.

Aproximadamente 100 muestras de acero al carbón pintados con una variedad de pinturas automotivas base solvente, fueron evaluados por dos métodos electroquímicos rápidos: Espectroscopía de Impedancia Electroquímica (EIS) y Desvinculación Catódica. Los resultados fueron comparados con los obtenidos mediante la exposición a cámara salina. Los tiempos de cámara salina para falla han sido determinados por diferentes criterios bien correlacionados con la evaluación electroquímica rápida. Fueron presentados útiles coeficientes de regresión para la predicción de largo tiempo de exposición en cámara salina desde las pruebas electroquímicas cortas (24 hr).



For up-to-date information on the
Federation of Societies for Coatings Technology's
activities, visit our World Wide Web Site at

<http://www.coatingstech.org>



"Adhesion Aspects of Polymeric Coatings" Published as Newest Title in Coatings Series

The Federation of Societies for Coatings Technology has released the newest offering in its continuing *Series on Coatings Technology*. "Adhesion Aspects of Polymeric Coatings" the 27th title in the *Series*, is authored by Dr. Jamil Baghdachi, of BASF Corporation's Coatings and Colorants Division.

According to Dr. Baghdachi, a practicing scientist in the area of coatings, adhesives, and adhesion science for the past 18 years, the knowledge of adhesion of polymeric coatings is of paramount importance to both formulators and processors. The 36-page publication examines the complex phenomenon of adhesion, from fundamental theories and mechanisms, to methods of measuring adhesion. In addition, chapters provide information on the chemical, physical and mechanical factors that affect adhesion and on methods for promoting and maintaining adhesion.

Discussion also focuses on adhesion promoting primers and coupling agents which may be used to form bonds to either the substrate or the applied surface coating, or both. Adhesion loss, due to factors such as chemical instability of coating vehicle, corrosion, or other factors, is investigated. The booklet concludes with a description of the methods used to measure adhesion.

The *Federation Series on Coatings Technology* is a well recognized educational resource for the industry. Recently published titles include:

- "Methodologies for Predicting the Services Lives of Coatings Systems"—J.W. Martin, et al.—This booklet reviews the general attributes of the service life prediction problem and offers discussion on current durability methodology and reliability-based methodology.
- "Finishing Exterior Wood"—William Feist—The characteristics of wood and wood finishes and their proper application to solid and reconstituted wood products are examined. The effect of manufacturing and construction practices, as well as how various types of finishes interact with the surfaces of wood products, is discussed. Methods for selecting and applying various exterior wood finishes are presented.
- "Silicones in Coatings"—William A. Finzel and Harold L. Vincent—The monograph explores the variety of sili-

con-based monomers, polymers, copolymers, and blends used in the coatings industry. Discussion describes terminology, silicone resins, reactive intermediates, water repellents, additives, fouling release coatings, and applications.

Additional monographs in the *Series* include:

- "Film Formation"—Zeno W. Wicks, Jr.
- "Introduction to Polymers and Resins"—Joseph W. Prane
- "Radiation Cured Coatings"—J.R. Costanza, et al.
- "Coil Coatings"—Joseph Gaske
- "Corrosion Protection by Coatings"—Zeno Wicks, Jr.
- "Mechanical Properties of Coatings"—Loren W. Hill
- "Automotive Coatings"—Bruce N. McBane
- "Coating Film Defects"—Percy E. Pierce and Clifford K. Schoff
- "Application of Paints and Coatings"—Sidney B. Levinson
- "Organic Pigments, *Second Edition*"—Peter A. Lewis
- "Inorganic Primer Pigments"—Alan Smith
- "Marine Coatings"—Henry R. Bleile and Stephen Rodgers

- "Sealants and Caulks"—Joseph Prane
- "Aerospace and Aircraft Coatings"—A.K. Chattopadhyay and M.R. Zentner
- "Introduction to Coatings Technology"—Alan Brandau
- "Cationic Radiation Curing"—Joseph Koleske
- "Rheology"—Clifford K. Schoff
- "Powder Coatings"—Josef Jilek
- "Introduction to Pigments"—Juergen Braun
- "Painting of Plastics"—Rose Ann Ryntz
- "Metal Surface Characteristics Affecting Organic Coatings"—Bruno M. Perfetti
- "Color and Appearance"—Percy E. Pierce and Robert T. Marcus
- "White Pigments"—Juergen Braun

The *Federation Series on Coatings Technology* is edited by Dr. Thomas J. Miranda, formerly of Whirlpool Corp., and Dr. Darlene Brezinski, of Consolidated Research. The *Series* booklets, prepared in an 8 1/2 x 11 format, sell for \$25 each. The FSCT member discounted prices is \$15. Additional discounts are available with the purchase of the entire *Series*.

FSCT Publishes 1997 JCT Buyers' Guide

The FSCT recently published its first annual *JCT Buyers' Guide*. Compiled from the results of a mailed survey of the industry, the 112-page publication offers an in-depth profile of over 700 suppliers and distributors to the paint and coatings industry. The *1997 JCT Buyers' Guide* is separated into three sections: Supplier Listings, Product Listings, and Distributor Listings.

Listed alphabetically, the Supplier Listings are categorized into four groups: raw materials, production equipment, laboratory apparatus and testing equipment, and services. Each listing contains addresses, phone, fax and principle contacts, as well as the products/services supplied.

The Product Listings are categorized into four primary areas as well. More than 650 product categories are cross-referenced to direct readers to the suppliers of specific products and services.

Distributors and independent sales agents are listed alphabetically by geographical territory in the final section.

The *1997 JCT Buyers' Guide* is distributed to all members and subscribers as a supplement to the November issue of the *JOURNAL OF COATINGS TECHNOLOGY*. Additional copies may be purchased for \$50 by contacting FSCT Headquarters at 492 Norristown Rd., Blue Bell, PA 19422. (610) 940-0777; fax: (610) 940-0292.

Angus Wurtele Receives NPCA's Heckel Award; Other Awards Presented at Annual Meeting

The National Paint and Coatings Association (NPCA), Washington, D.C., has bestowed C. Angus Wurtele with the George Baugh Heckel Award. The Award was presented during the Honors Session of NPCA's 109th Annual Meeting in Chicago, IL, on October 23-25.

Mr. Wurtele, Chairman of The Valspar Corp., Minneapolis, MN, was NPCA's President in 1990 and served on the Executive Committee, the Board of Directors, and various committees.

The Heckel Award is given in recognition of outstanding achievement and the contribution of significant time and energy toward the furtherance of a specific association goal.

Allen W. Clark Award

The 1996 Allen W. Clark Award was presented to the Cleveland Paint and Coatings Association and the Wisconsin Paint and Coatings Association. Receiving third place honors was the Chicago Paint and Coatings Association.

The Cleveland Paint and Coatings Association organized an effort to repaint the exteriors of seven deteriorated Victorian homes of low-income residents. In addition to providing labor, the association arranged for donations of paint, supplies and meals for the occasion. The CPCA also sponsored the renewal of L'Arche home for disabled adults. Over several weekends, members of CPCA repaired walls, floors and ceilings prior to paint day.

In Wisconsin, the local association organized a record 11 PIP projects this year, including repainting a senior center, homes for the elderly and/or physically challenged, group homes, a shelter for abused children, a foster home for children, a child care center, and private inner-city residences; removing and/or repainting graffiti on homes, businesses, churches, garages and alleys in Milwaukee; and an ongoing project to repaint corridors and classrooms of a Milwaukee school.

The Chicago Paint and Coatings Association organized several community service projects. The association's primary project was to participate in the Chicago Cares Serv-a-thon, a one-day citywide effort to paint, fix, clean, and otherwise serve community organizations and schools. The association also

held the Chicago's Finest Painted Ladies competition, a contest that recognizes homes and business properties that were repainted and beautified within the past year. In addition, the association donated paint to a youth and family center, a school, and a home for physically challenged adults, and participated in Habitat for Humanity projects to build homes for low-income families.

Pollution Prevention

Engineered Polymer Solutions, Inc., ICI Paints North America/Glidden, and PPG Industries Inc., received NPCA's Pollution Prevention Award.

Engineered Polymer Solutions, Inc., Marengo, IL, was recognized with an award in pollution prevention processing for its commitment to reducing pollution, including air emissions. EPS designed and built its new plant with a vapor recovery unit rather than the more commonly used incinerator or oxidizing fume scrubber system.

ICI Paints North America/Glidden was also awarded for pollution prevention process by creating a wash water management program to help eliminate plant waste at its Carrollton, TX, manufacturing facility. This facility established a team to analyze and remove obstacles which prevented wash water reuse.

PPG Industries, Inc., received a Pollution Prevention Award for a corporate pollution prevention program. PPG's Waste Minimization Program was recognized for its goal to "support vigorously the reduction of waste disposal and toxic

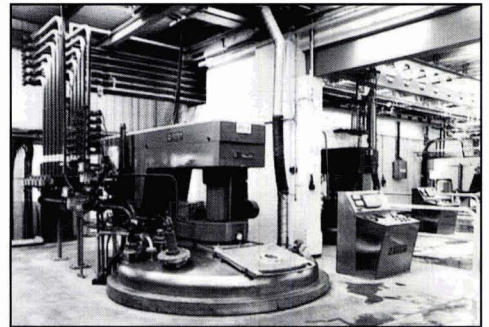
or noxious emissions, through recovery, recycling, and/or reuse of raw materials and by-products." The program requires all research and projects involving new or modified process units to include an assessment of the practicality of elimination, recycling, or reduction of all discharges into the air, water, and environment.

Industry Statesman

In recognition of long and devoted service to the paint and coatings industry, seven were honored with Industry Statesman Awards. They are: Joseph J. Castiglia, Pratt & Lambert United, Inc.; John P. DeVido, retired, Aqualon Division, Hercules, Incorporated; Fred Holtzman, retired, D.H. Litter Co.; Carmine Ianuzzi, posthumous, Camager Chemical Systems, Inc.; Thomas E.

(Continued on next page)

The DISSOLVER for all applications



Dissolvers available with many standard options or to the customer's own specification.

- * Special design and dimensions according to local conditions.
- * Standard design for free floor mounting or support for through floor operation.
- * Vacuum Dissolvers.
- * Side and/or bottom scrapers.
- * High speed or slow speed versions.
- * Vessel covers for different pot diameters and heights.

WESTERLINS MASKINFABRIK AB

Box 9075, S-20039 Malmö/Sweden
 Telefon Int. +46 40 21 04 10
 Telefax Int. +46 40 22 04 03

Circle No. 118 on Reader Service Card

August Resin Production Statistics Up from July

In a report released by the Committee on Resin Statistics at The Society of the Plastics Industry, Washington, D.C., production of plastics resins totaled 6.3 billion pounds in August 1996, an increase of 15.8% over the same month in 1995.

August 1996 production figures were up 0.7% from July 1996. Production in 1996 year-to-date totaled 48.8 billion pounds, a 6.9% increase over the same eight-month period in 1995.

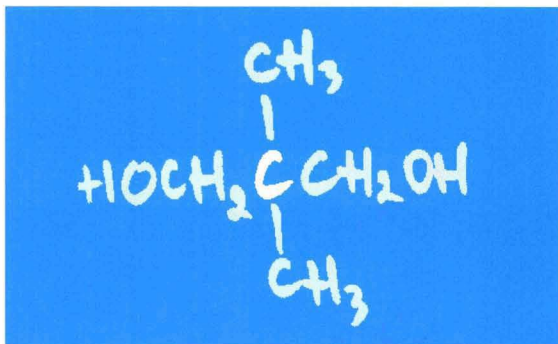
Sales and captive (internal) use of plastics resins in August 1996 totaled 6.2

billion pounds, an increase of 6.6% over the same month one year ago. August 1996 sales and captive use was down 3.4% from the total of the previous month, July 1996. Sales and captive use in 1996 year-to-date totaled 51.4 billion pounds, an 11.4% increase over the same eight-month period in 1995.

August 1996 figures are based on primary data on selected major plastics materials as compiled by Association Services Group, LLC for SPI's Committee on Resin Statistics.

B A S F I N T E R M E D I A T E S

NEOL® neopentylglycol offers unique properties for coatings.



NEOL offers rapid esterification and high chemical and thermal stability for your:

Gel Coat Resins

- NEOL improves hydrolytic and chemical stability.
- Increases corrosion resistance.
- Produces high-quality resins with high molecular weight.

Powder Coating Resins

- NEOL-based powder coating resins exhibit greater thermal and UV stability.

Alkyd Coating Resins

- Provides improved stability to heat and ultraviolet radiation.

BASF NEOL is produced at Freeport, Texas, under ISO 9002 certification.

Call us!

Mike Travers
(800) 526-1072
Ext: 4773
Fax: (201) 426-4752

Creative Chemistry for Creative Chemists.

BASF

NEOL is a registered trademark of BASF Corporation

Circle No. 133 on the Reader Service Card

BYK-Gardner to Consolidate R&D and Manufacturing

BYK-Gardner USA, Silver Spring, MD, has announced plans to consolidate its operations in the United States by moving its research and development division to Germany by mid 1997. In addition, plans to transfer its manufacturing operations to Germany by the end of 1997 were also revealed.

BYK-Gardner is a division of Altana Inc., a subsidiary of Altana AG of Bad Homburg, Germany.

According to Klaus Oehmichen, President of the Altana Chemicals Division, "BYK-Gardner's European-based research and development unit will be increased to accommodate the move and to continue to provide the same level of service here. Meanwhile, the company will add staff to the U.S. based sales and marketing operations located in Silver Spring and open a new facility in Columbia, MD, in January 1997."

Wurtele Receives NPCA's 1996 Heckel Award

(Continued from previous page)

Maggio, retired, Hüls America Inc.; Joseph M. Quinn, retired, Devoe Marine Coatings; and Maurice C. Workman, retired, Benjamin Moore & Co.

Industry Achievement Award

Eight individuals were acknowledged for exceptional achievement in community service through the Picture it Painted (PIP) community service program: Dianne Mahoney, Ashland Chemical Co.; Marge Suranovic, Ace Hardware Corp.; Brenda Svenneke, Chicago Paint and Coatings Association; Paul Beaudry, Etna Products; Sam Cannata, Cansto Paint and Varnish Co.; M. Bridget Vaughn, Cleveland Paint and Coatings Association; J. Kirk Menefee, Hy-Klas Paints, Inc.; and Bill Newbauer, Mautz Paint Co.

In addition, 10 industry members were recognized for outstanding achievement in service to the industry: Benjamin M. Belcher, Jr., Benjamin Moore & Co.; Roy L. Bever, Ashland Chemical Co.; George E. Sabino, Jr., Union Carbide Corp.; Ernest Scheller, Jr., Silberline Manufacturing Co., Inc.; Augustus E. Williamson, SCM Chemicals; Phil Pesola, Delta Laboratories; Charles E. Bennett, Guardsman Products, Inc.; Sandra B. Skommesa, Ellis Paint Co.; Manfred Buller, BASF Corp.; and John Danzeisen, ICI Chemicals America.

WCS Symposium and Show Slated for February 18-20, 1997 in Anaheim, CA

The 23rd Biennial Western Coatings Societies' Symposium and Show will be held at the Disneyland Hotel and Convention Center on February 18-20, 1997 in Anaheim, CA. The event is co-sponsored by the Golden Gate, Los Angeles, Pacific Northwest, and Rocky Mountain Societies for Coatings Technology.

The preliminary program is as follows:

"When Policy Loses Touch with Science"—Robert Wendoll, El Rap;

"Proposition 65: Ten Years After"—Chris Foster, Smiland and Khachigian;

"Chemical Specification Profiles of A.C."—Dane Jones, CalPoly, San Luis Obispo;

"The Paint Plant for the 21st Century"—Charles Alack and Patrick Lutz, Semi-Bulk Systems, Inc.;

"Decorative Finishing Techniques"—Deborah Zimmer, Rohm and Haas;

"New Crosslinking for Acrylates and Urethanes"—Charles Shearer, Zeneca Resins;

"Silicone Technologies Improve Cementitious Finished Products"—Bruce Bergland, Wacker Chemie;

"Branched Ester Latices for Interior/Exterior Applications"—Oliver Smith, Union Carbide;

"Optimization of Paint Formulations Made Easy with CAD of Experiments for Mixtures"—Mark Anderson, Stat-Ease, Inc.;

"Characterization and Film Properties of Very Low VOC Coatings Based

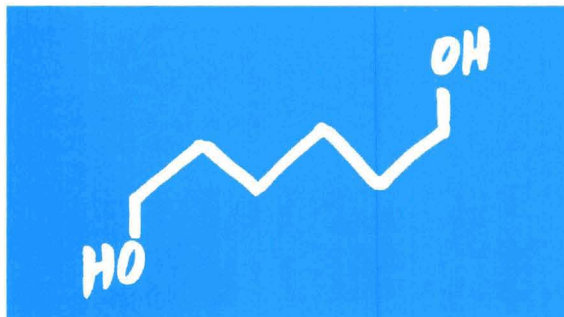
on Epoxy-Amine Technology"—Kalyan Ghosh, Shell Chemical Co.;

"Efflorescence of Latex Paint"—Charles Kan, Dow Chemical Co.;

(Continued on next page)

B A S F I N T E R M E D I A T E S

1,6 HDO® Hexanediol



Can HDO work for you?

Look at these performance characteristics:

- Improved flexibility
- Greater elasticity
- Better oil resistance
- Good anti-leaching properties
- Good adhesion
- Surface hardness
- Hydrolytic stability
- Dry grip

Look at some applications in Polyurethanes:

- Automotive coatings
- Epoxy adhesives
- Personal care

In Polyesters:

- High solids formulation for coil coatings
- Modifier for PE resins
- Hot melt adhesives

In Acrylics:

- Radiation curable coatings
- GMA acrylic alloys

Call us!

Mike Travers
(800) 526-1072
Ext: 4773
Fax: (201) 426-4752
Canada: (416) 674-2888
Fax: (416) 674-2839

Creative Chemistry for Creative Chemists.

BASF

HDO is a registered trademark of BASF Corporation

40th Annual Technical Symposium

"WATERBORNE COATINGS:
SINK OR SWIM"

Sponsored by
Cleveland Society for
Coatings Technology

May 22-23, 1997

Case Western Reserve University
Cleveland, OH

Contact: Vicki Fisher,
Jamestown Paint Co.,
108 Main St., Jamestown, PA 16134;
(412) 932-3101

Circle No. 132 on the Reader Service Card

UMR Coatings Institute Introduces a New Short Course "Layman's Introduction to Coatings" to 1997 Schedule

The Coatings Institute at the University of Missouri-Rolla (UMR), Rolla, MO, has added a new course to its slate of offerings for 1997. "Layman's Introduction to Coatings," designed to give an end-user or a newcomer without technical training an introduction to paint and coatings, will be held on July 14-16, 1997, at the St. Louis Airport Marriott, in St. Louis, MO.

The participant will gain a better understanding of the terms used and typical uses for various coatings. The course will include: basic knowledge of the composition of coatings; substrate and surface preparation; specifications and testing; and general manufacturing criteria.

Also in 1997, "Basic Coatings for Sales, Marketing, and General Personnel," is scheduled for February 24-26, in St. Louis. This course is designed especially to aid sales, marketing, and general personnel in the coatings industry to have a better understanding of the composition of coatings. Topics to be discussed include composition of coatings, relationships between composition and performance characteristics, customer's specifications and testing techniques as related to formulation criteria, and business aspects of coatings.

"The Basic Composition of Coatings" is designed to introduce the newcomer, as well as those involved in raw material manufacture, sales and technical service, to the technical aspects of paint manufacture, testing, and use. Topics of discussion will include the history of

Technical Papers Highlight 23rd WCS Symposium

(Continued from previous page)

"Finding New Opportunities in the Coatings Industry"—John Martin, Arthur D. Little;

"Pigment Intermix Systems"—Romesh Kumar, Hoechst Celanese;

"Phenolic Ester Reactive Diluents for High Solids"—Vijay Swarup, Exxon Chemical Co.; and

"High Gloss, Corrosion Resistant Emulsion"—Mike Wildman, of Engineered Polymer Solutions, Inc.

In addition, Walt Gozdan, of Rohm and Haas, will present a panel discussion on masonry.

For more information, contact Keith Venia, Tavco Chemicals, Inc., 25401 Cabot Rd., Ste. 121, Laguna Hills, CA 92653; (714) 770-7666.

paint, materials used in manufacture, simple formulating techniques that you can put to immediate use, introduction to the equipment used to make and test modern protective coatings, modern chemical instrumentation as applied to coatings, and simple cost accounting that allows beginners to start on a stable economic basis. The course will be presented at the UMR campus on April 7-11 and September 8-12.

A course titled "Introduction to Paint Formulation" will be offered on April 21-25 and September 22-26, on the Rolla campus. This intensive five-day course will take the attendee through the basic steps of paint formulation, from understanding the process to an actual laboratory formulation. Through study and work in a laboratory, you can learn to formulate paints to meet specific requirements. In addition, participants will have the opportunity to study and experiment with basic raw materials and their influences on the performance of the finished coating, formulation and testing of coatings in the laboratory to meet the special demands of the job, limitations of plant production equipment, and formulation variables for moving a coating from the

lab to the plant and modern chemical instrumentation as applied to coatings.

The fifth course offered by UMR, "Physical Testing of Paints and Coatings," is designed to improve quality control protocol for paints and coatings. Scheduled for May 19-23 at the Rolla campus, the course will focus on monitoring the manufacturing process, finished product testing, setting up specifications, color computer technology, raw materials, government regulations, record keeping, modern chemical instrumentation as applied to coatings, and the importance of calibration and standards.

The course fee for "Layman's Introduction to Coatings" and "Basic Coatings for Sales, Marketing, and General Personnel" is \$745. The cost for "The Basic Composition of Coatings" is \$845, while the fee for both "Introduction to Paint Formulation" and "Physical Testing of Paints and Coatings" is \$945.

For more information on attending these courses, contact Karen K. Markley, Coordinator, UMR Coatings Institute, 1870 Miner Circle, 236 Schrenk Hall, Rolla, MO 65409-0010.

Reserve Your 1997 Western Coatings Show Exhibit Space Now!

The 1997 Western Coatings Society Symposium Committee would like to invite all potential exhibitors to reserve exhibit space now while there are still plenty of choice booth spaces left. Don't miss out on a tremendous opportunity to display your products and services to a West Coast audience! Additionally, please note that the next chance you'll get to exhibit on the West Coast probably won't be until 2001! The Show will be held February 18-20, 1997 at the Disneyland Hotel.

To reserve your space, please call: John Long at Smiland Paint (213) 222-7616, ext. 277, or Roberta Garcia at ICI Paints, (213) 888-8888, ext. 8343.

Flame Retardancy Conference Slated for June 2-4

"Advances in Flame Retardancy of Polymeric Materials: Applications, Materials, Industry Developments, Markets," is scheduled for June 2-4, 1997 at the Holiday Inn Select, Stamford, CT. Sponsored by Business Communications Co., Inc., Norwalk, CT, this meeting will consider the various new developments, technologies, products and processes arising in the ever-expanding flame retardancy arena.

Aside from the presentations, attendees will be able to participate in short 15-

minute new product/research announcements, exhibits, and poster sessions.

In addition, all prospective authors are invited to submit a 100-150 word abstract for paper presentation to: Dr. Menachem Lewin, Polymer Research Institute, Polytechnic University, 6 Metrotech Center, Brooklyn, NY 11201.

The fee for this conference is \$850. To obtain additional information, contact Business Communications Co., Inc., 25 Van Zant St., Norwalk, CT 06855.

Hydroxylated Guayule Rubber in Powder Coatings

Amir Niroomand, Thomas P. Schuman, and Shelby F. Thames—University of Southern Mississippi*

INTRODUCTION

Guayule is a shrub native to the southwestern United States and northern Mexico and is a source of natural rubber, cis-1,4-polyisoprene. The current status of natural rubber in the United States is one of total dependence on imports of *Hevea brasiliensis* from Malaysia. Thus, it is important to establish a domestic natural rubber industry in the United States, and this will require commercialization of a variety of guayule-derived industrial products. The revenues available from, and the quantity of guayule's high molecular weight natural rubber is insufficient to sustain a domestic industry.¹ Thus, commercialization efforts must look to the preparation and exploitation of value added materials from guayule coproducts. Several coproduct fractions are a result of the processing of the Guayule shrub, i.e.:

- high molecular weight guayule rubber;
- low molecular weight guayule rubber (LMWGR);
- guayule resin; and
- a water-soluble fraction of unknown composition.

LMWGR is obtained as a raw, dark brown, viscous liquid via a solvent extraction process. Due to its low molecular weight, LMWGR can be used in its raw, desinated form, thereby offsetting energy intensive mastication necessary to produce commercial hevea low molecular weight rubber. The value of LMWGR to the coatings industry is underscored by the poly-cis-isoprene modification potential.² Chlorinated LMWGR can be used in marine, maintenance, industrial, swimming pool, and clear finishes.^{3,4} Chlorinated-hydroxylated LMWGR and chlorinated-acrylated LMWGR incorporated into high solids ultraviolet and thermally cured coatings offer excellent results.^{5,6} Chlorinated-maleinized LMWGR exhibited excellent properties as a reactive crosslinker and novel matting agent in epoxy-polyester and polyester-hydroxyalkylamide powder coatings.⁷

This research has focused primarily on hydroxylation of the LMWGR and its application in powder coatings. Hydroxyl functional groups on the poly-cis-isoprene backbone enables a variety of chemical reactions to be performed, and thus forms the basis of this research

The synthesis, characterization, and application of hydroxylated low molecular weight guayule rubber as a powder coating component is described. In particular, our interest was in the generation of secondary alcohol moieties on a guayule rubber backbone, and its use as part of a novel and, as yet, unreported powder coating formulation. Hydroxylated guayule rubber was found to improve toughness, flexibility, and solvent resistance of powder coatings.

project. After purification of LMWGR, the hydroxylated product was obtained by hydroboration/oxidation, a sequence of reactions well documented by Brown, et al.⁸ The hydroboration of guayule rubber has not been reported, although Perera et al.⁹ have reported the hydroboration of polyisoprene. The hydroboration of poly-cis-1,4-isoprene normally yields a terpolymer of three species I, II, and III as shown in Figure 1.

Synthetic epoxidation/hydrolysis methods employing strong oxidizers were attempted, but produced unusable, severely degraded gel rubber. Hydroboration, on the other hand, is a mild, selective anti-Markovnikov

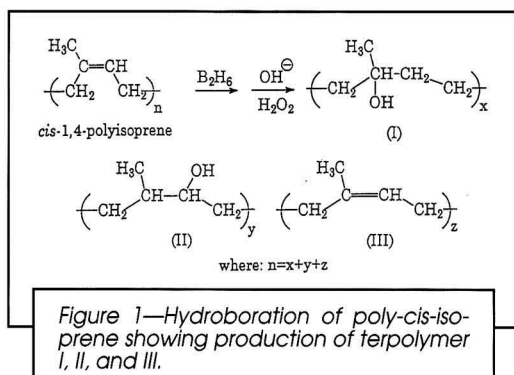
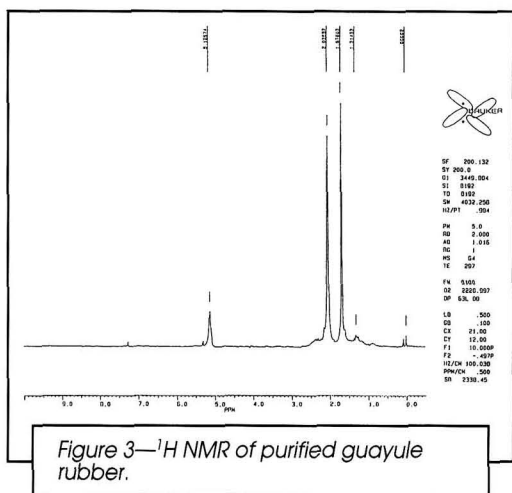
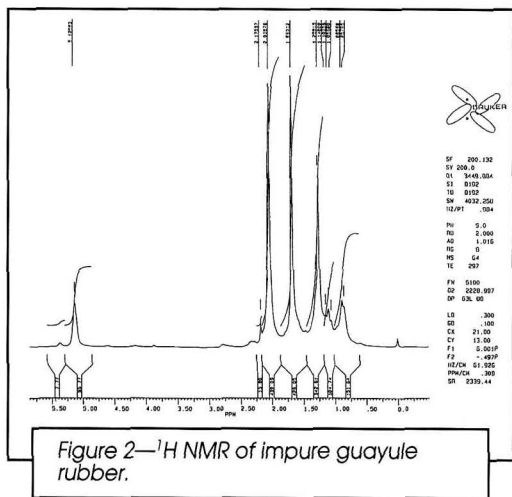


Figure 1—Hydroboration of poly-cis-isoprene showing production of terpolymer I, II, and III.

*Box 10037, Hattiesburg, MS 39406-0037.



addition reaction to alkenes by which selective oxidation to the less hindered hydroxyl groups can be affected.⁸ Consequently, this synthetic protocol is the method of choice for hydroxylation of guayule rubber and is the subject of this manuscript.

EXPERIMENTAL

Materials

All glassware was oven dried at 150°C before use and assembled while hot under a gentle flow of dry nitrogen. Guayule rubber was purified by a Soxhlet acetone wash, followed by the replacement of acetone with diethyl ether to separate gel rubber from sol rubber.¹⁰ The diethyl ether was removed by evaporation *in vacuo* and the rubber was twice precipitated from methylene chloride into methanol which was removed *in vacuo*. Figures 2 and 3 are proton nuclear magnetic resonance (¹H NMR)

spectra of guayule rubber before and after purification, and verify a significant increase in purity by the dramatic decrease in the 1.25 ppm impurity absorption frequency. The remaining reagents including THF, borane complexed with THF, 30% hydrogen peroxide, and sodium hydroxide were purchased from Aldrich Chemical Co. and used as received.

Analytical

Proton (¹H NMR) and carbon (¹³C NMR) nuclear magnetic resonance spectra were obtained with a 200 MHz Bruker AC 200. The NMR collection parameters are specified on each spectrum. Fourier transform infrared (FTIR) spectra were obtained with a Nicolet IR/42, and the differential scanning calorimetry (DSC) thermograms were taken with a Mettler TA-4000/DSC-30 at a heating rate of 10°C/min under nitrogen atmosphere. Gel permeation chromatography (GPC) was performed with a Perkin-Elmer LC250 pump and LC-30 refractive index detector coupled with Polymer Labs PL gel columns of 500, 50, and 5 μm pore diameters.

Hydroboration of Guayule Rubber Followed By Oxidation

Purified guayule rubber (1 g) was dissolved in 50 mL of anhydrous THF. A complex prepared from 2 mL of borane and THF was added dropwise to the rubber solution at 0°C and the mixture was allowed to stand at 0°C for 15 min. The solution was then heated to 40°C and 10 mL of 30% aqueous sodium hydroxide added dropwise, followed by 5 mL of 30% hydrogen peroxide. The mixture was allowed to stand at 40°C for one hour after which time hydroxylated rubber was precipitated by pouring into excess water and after collection was dried *in vacuo*.¹¹ Elemental analyses were performed by M-H-W Laboratories in Phoenix, AZ.

Powder Coating Preparation

The ingredients (Table 1) were delivered to the Henschel FM-10 mixer for premixing prior to extrusion. The mixed ingredients were compounded with a Werner-Pfleiderer ZSK-30 extruder according to the processing conditions summarized in Table 2. The die output was cooled via chill rolls, broken into small pieces, pulverized in a Micron Bantam Mill, and subsequently sieved through a Kemutec centrifugal sifter to obtain a maximum particle size of 105 μm.

The powder coatings were applied onto 3 in. x 6 in. x 0.02 in., cold rolled, low carbon, mild steel QD-36 panels by a corona electrostatic spray technique and cured at

Table 1—Powder Coating Formulations

Ingredient	wf%	wf%	wf%
Cargill 30-3016	84.14	72.50	61.50
Cargill 24-2430	15.52	21.16	27.16
Hydroxyl rubber	—	5.00	10.00
Troy EX 486	1.34	1.34	1.34
Total	100.00	100.00	100.00

Table 2—Processing Conditions for Powder Coating Preparation

Stage 1 premix in 8 m Welex	200 rpm - 60 sec
Stage 2 premix in 8m Welex	200 rpm - 60 sec
Screw temperature	81°C
Die temperature	110°C
Screw speed	200 rpm
Extrudate temperature	139°C

193°C for 15 min. Cure cycle criteria was determined from post cure DSC analysis in that completely cured panels lacked a 160-300°C endotherm characteristic of uncured powders. The coatings were allowed to equilibrate for seven days before testing.

Testing Conditions

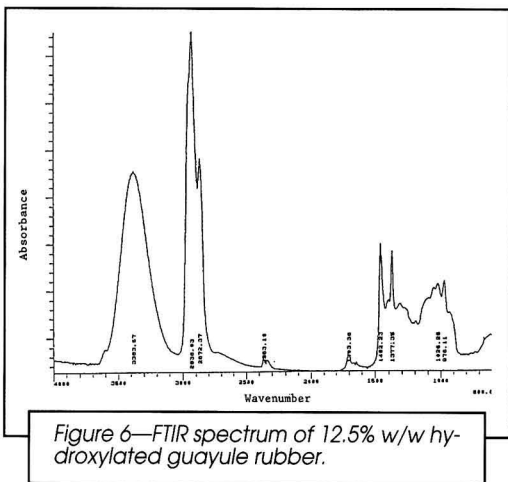
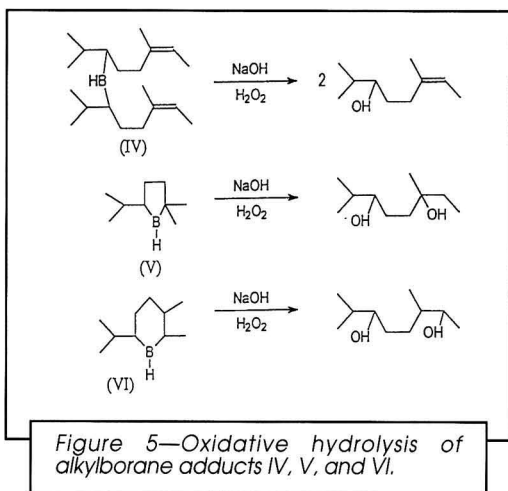
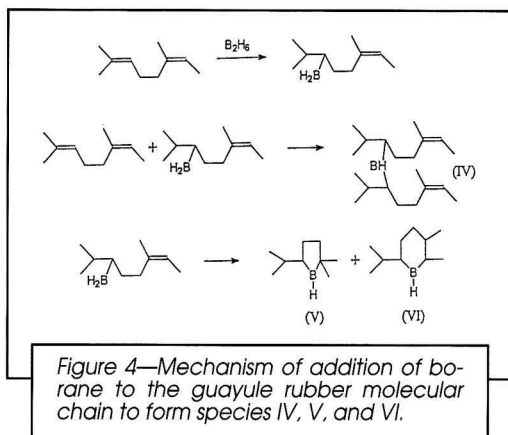
All coating tests except methyl ethyl ketone (MEK) double rub resistance were performed via standard ASTM testing procedures. Dry film thicknesses were measured by a Gardco Minitest 4000 Microprocessor coating thickness gauge (ASTM D 1186). Impact resistance was determined with a BYK-Gardner impact tester, using a 1.82 Kg (4 lb), 1.27 cm (1/2 in) diameter steel pin (ASTM D 2794). Pencil hardness (scratch) was expressed in terms of pencil leads of known hardness (ASTM D 3363). The hardness scale of the pencil leads ranges from 6B (softest) to 9H (hardest). Adhesion was assessed by applying and removing a Permacel #99, pressure-sensitive tape over a crosshatch constructed by eleven cutting blades (ASTM D 3359). Flexibility was measured by bending coated panels on a Paul N. Gardner, Model MN-CM conical mandrel (ASTM D 522). Specular gloss was measured at 20° and 60° with a Gardco Statistical Novogloss glossmeter (ASTM D 523). Crosslinking efficiency was determined via MEK double rub resistance test (10% MEK/90% xylene) as per the Powder Coating Institute solvent cure procedure #8.

RESULTS AND DISCUSSION

The hydroboration reaction of poly-cis-1,4-isoprene is reported to yield species IV, V, and VI as shown in *Figure 4*. Species V and VI were reported by Perera et al.,⁹ whereas species IV is deduced from the observed tendency of the rubber solution to gel with borane addition. The remaining boration adducts (species IV, V, and VI shown in *Figure 4*) do not further react with olefin due to steric hinderance; a fact supported by earlier observation⁹ and limited upper percent conversion.

Hydroboration is rapid and if the reaction is allowed to continue near the stoichiometric amounts, hydroxylation efficiency decreases due to side reactions and solution gelation.¹¹ At higher conversions of borated polyisoprene post oxidation, the product gradually becomes a white thermoplastic. When the borane THF complex is added to the rubber solution, gelation typically occurs immediately, but the gel cannot be dissociated by hydrolysis (*Figure 5*).

Oxidative hydrolytic cleavage of the gel confirms that it is formed as a result of boron crosslinks and not oxida-



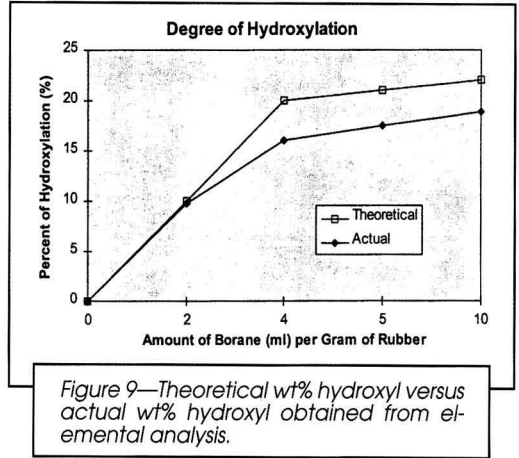
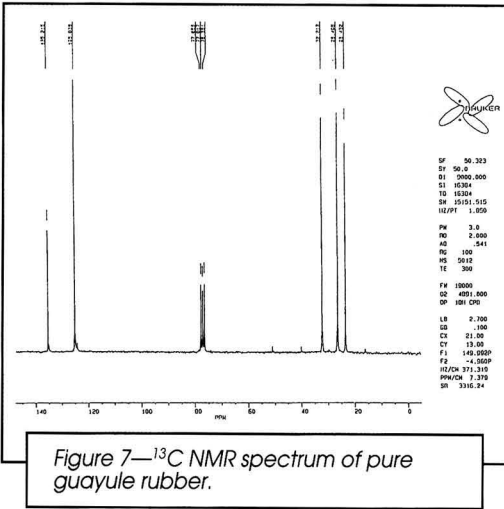
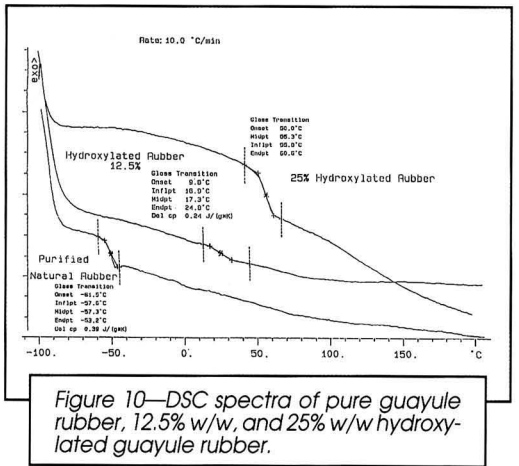
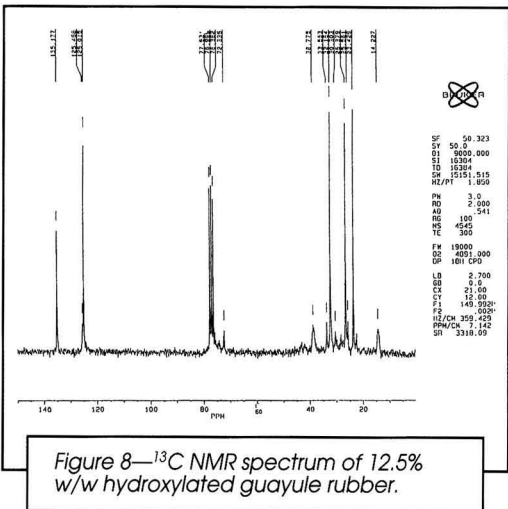


Table 3—Physical Properties of Powder Coatings With and Without Hydroxy Rubber Incorporated in the Coating

Property	Control Formulation	Formulation with 5% Hydroxy Rubber	Formulation with 10% Hydroxy Rubber	ASTM Reference Number
Thickness (μ)	55	48	50	D 1186
Pencil hardness	2B	H	5H	D 3363
Crosshatch adhesion	5B	5B	5B	D 3359
Gloss 60°	99.0	98.2	70.1	D 523
Gloss 20°	93.0	55.8	32.5	D 523
Direct Impact (J)	9.05	11.31	18.10	D 2794
Indirect Impact (J)	2.26	2.26	6.79	D 2794
Flexibility (cm)	0.64	0.32	0.32	D 522
MEK double rubs ^a	50	80	90	—

(a) MEK double rub test performed via Powder Coating Institute solvent cure procedure #8.



tive degradation. The IR spectrum (Figure 6) is characterized by a strong, broad absorption at 3383 cm^{-1} , an indicator of alcohol functionality. Compared to the ^{13}C NMR spectrum of pure poly-cis-isoprene (Figure 7), the ^{13}C NMR spectrum (Figure 8) indicated both tertiary and secondary alcohol groups at 72.3 ppm and 76.3 ppm, respectively,⁹ although initially only secondary groups were anticipated via anti-Markovnikov reaction conditions. However, the production of tertiary hydroxyls can be explained via the formation of V. For instance, the addition of trihydroborane to an alkene moiety, followed by addition of the monoalkyl dihydroborane to a second alkene group produces a dialkene borane. This phenomenon can occur intermolecularly (IV) and intramolecularly (V and VI). Intramolecular addition can provide either five- or six-membered rings, depending on the addition site to the double bond. Oxidation of five-membered rings (Figure 5) gives secondary and tertiary alcohol functionality.

The degree of hydroxylation can be altered to an extent by varying the concentration of borane-THF complex added to the rubber solution. The efficacy of hydroboration is noted in Figure 9 which depicts a comparison of theoretical and experimentally determined degree of hydroxylation. Thus, it is clear that gelation restricts the efficiency of hydroboration above 18.2%, even with stoichiometric excesses.

The glass transition temperature (T_g) of rubber, an important factor in powder coatings design, is altered via the degree of hydroxylation. For instance, a DSC analysis of pure guayule rubber shows a T_g at approximately -57°C (Figure 10). However, the introduction of hydroxyl moieties as part of the rubber backbone significantly increases T_g . Figure 10 allows comparison of the DSC scans for pure, 12.5% and 25% theoretical w/w hydroxylated rubbers while Figure 11 is a plot of T_g versus theoretical percent by weight hydroxylation.

Hydroboration also influences polymer degradation to an extent. For instance, a free radical presence is known to degrade rubber by autooxidation¹² and in this experimental protocol radical formation can occur via thermal treatment of hydrogen peroxide solution. This phenomenon has been confirmed by gel permeation chromatography (Figures 12 and 13). For instance, the number average molecular weights (M_n) of the rubber samples are 26,509 g/mol and 14,315 g/mol before and after hydroxylation, respectively.

Incorporation into Powder Coatings

Secondary hydroxyl groups are more reactive to the isocyanate functionality than tertiary hydroxyl groups, and thus secondary hydroxyl rubber offers a more attractive raw material for use in thermoset powder coatings. Table 3 demonstrates the properties of powder coatings where 5 to 10% hydroxyl rubber is included in the formulation.

Rubber Toughening

Increasing the rubber content of the powder coating binder increases coating flexibility as confirmed by con-

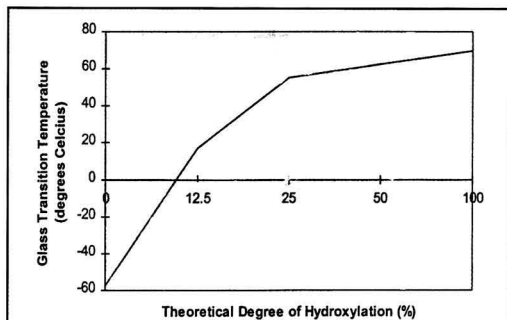


Figure 11—Change in glass transition temperature (T_g) versus degree of hydroxylation (%w/w).

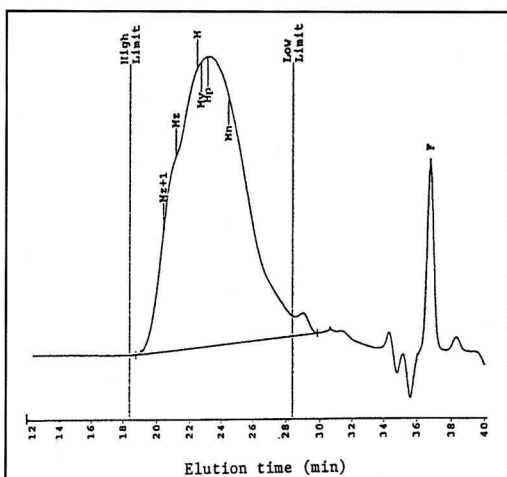


Figure 12—GPC spectrum of pure guayule rubber.

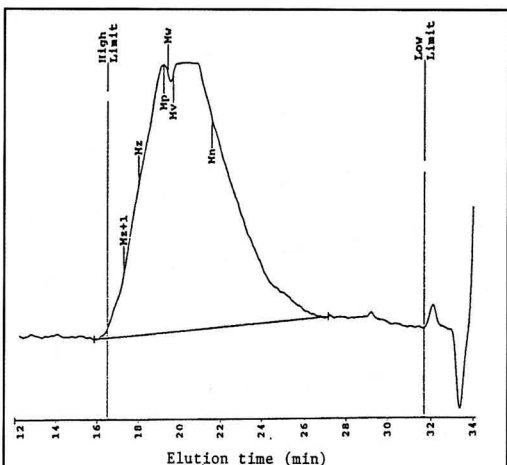


Figure 13—GPC spectrum of 12.5% w/w hydroxylated guayule rubber.

cal mandrel tests. In addition, direct impact resistance likewise improved significantly, indicating increasing toughness.

Other property enhancements included improvements in MEK solvent resistance, adhesion, and in pencil hardness from 2B to 5H. Gloss loss was also noted, and is a potential attribute for powder coating formulations.

CONCLUSIONS

Guayule low molecular weight rubber was hydroxylated through hydroboration/oxidation. The degree of alcohol substitution varied from 0-20% after which gelation, cyclization, and rearrangement reactions predominate. The secondary alcohol moieties thus formed adequately crosslink via urethane formation and thereby became part of a variety of powder coatings formulations. The coating properties obtained show several improvements over the control formulations including toughness, flexibility, and solvent resistance. Hydroxylated rubber was also a gloss reducing agent.

ACKNOWLEDGMENTS

This material is based upon work supported by the Cooperative State Research, Education, and Extension Service, U.S. Department of Agriculture, under Cooperative Agreement No. 93-COOP-1-9531. Our thanks to Dr. Daniel Kugler and Mrs. Carmela Bailey for their time and support.

References

- (1) Thames, S.F. and Wagner, J.P., "Recent Advances in Guayule Coproduct Research and Development," in Whitworth, J.W. and Whitehead, E.E. (Eds.), *Guayule Natural Rubber*, 311, University of Arizona, Tucson, 1991.
- (2) Gelling, I.R. and Porter, M., "Chemical Modification of Natural Rubber," in Roberts, A.D. (Ed.), *Natural Rubber Science and Technology*, 420, John Wiley Interscience, New York, 1988.
- (3) Thames, S.F. and Kaleem, K., "Synthesis and Characterization of Chlorinated Low-Molecular Weight Guayule Rubber," in Glass, J.E. and Swift, G. (Eds.), *Agriculture and Synthetic Polymers: Utilization and Biodegradability*, 230, ACS Symposium Series 433, Washington, D.C., 1990.
- (4) Thames, S.F. and Poole, P.W., "The Modification of Secondary High Molecular Weight Guayule Rubber with Metachloroperbenzoic Acid," *J. Applied Polymer Sci.*, 47, 1255 (1993).
- (5) Thames, S.F. and He, Z.A., "100% Solids Ultraviolet Curing Acrylated Chlorinated Rubber Coatings," *J. Applied Polymer Sci.*, 53, 275 (1994).
- (6) Thames, S.F. and He, Z.A., "Chlorinated Hydroxylated Low Molecular Weight Guayule Rubber as a Convertible Binder in Thermoset Coatings," *Industrial Crops and Products*, 2, 75 (1994).
- (7) Purvis, W.A. and Thames, S.F., "Chlorinated-Maleinized Guayule Rubber: A Novel Matting Agent for Powder Coatings," *JOURNAL OF COATINGS TECHNOLOGY*, 68, No. 857, 67 (1996).
- (8) Brown, H.C., *Hydroboration*, W.A. Benjamin, New York, 1962.
- (9) Perera, M.C.S., Elix, J.A. and Bradbury, J.H., "A ^{13}C NMR Study of Hydroxylated Natural Rubber," *J. Applied Polymer Sci.*, 33, 2731 (1987).
- (10) Whitby, G.S., "The Structure of Rubber and Other Elastic Colloids," *J. Physical Chemistry*, 36, 198 (1932).
- (11) Minoura, Y. and Ikeda, H., "Hydroboration of Diene Polymers," *J. Appl. Polymer Sci.*, 15, 2219 (1971).
- (12) Dufraisse, C., "Autooxidation and Deterioration by Prooxygens and Antioxygens," in Blake, C.C. and Davis, J.T. (Eds.), *The Chemistry and Technology of Rubber*, 440, Reinhold Publishing Corp., New York, 1937.

Defects in Powder Coatings on Hot-Dipped Galvanized Steel

T. Glauser and A. Hult*—Royal Institute of Technology†

A. Hirn and B. Johansson—Swedish Institute for Metal Research**

INTRODUCTION

Powder coatings are an alternative to conventional solvent-borne polymer coatings and their market expansion is strongly related to environmental concern and legislation.¹ Their intrinsic properties are also of much interest.^{2,3} For example, powder coatings exhibit very good adherence compared to conventional solvent-borne systems and porosity is usually reduced, since there is no late solvent evaporation.

However, the powder coating process has a few disadvantages, such as a melt viscosity which can be a hundred times higher than that of solvent-borne coatings. When viscosity stays high during the whole melting-curing process, entrapped air does not have time to escape from the coating layer. The bubbles will lead to pores, or large areas where there is no intimate contact between the coating and the substrate. This problem can usually be solved by addition of rheological additives⁴⁻⁶ to the resin formulation in order to control its flow, thus giving a good adherence and a well degassed melt. The cured film does not stand alone, but is part of a so-called duplex system, i.e., a multi-layer system where each constituent has a well defined function. For example, in the system discussed in this article, steel is protected from corrosion by a zinc coating, on which a polymer coating is applied in order to obtain a glossy and color-versatile finish. A conversion coating is often applied on the zinc to promote adhesion to the polymer. Phosphates⁷ are commonly used by the industry as conversion coatings, but environmental concerns push toward new solutions. Silanes seem to be a promising alternative, according to some studies.⁸⁻¹⁰ The interfaces are of prime importance in a system with so many components, and much care must be taken in all the cleaning steps to avoid premature failure of the whole duplex system.

Hot-dip galvanizing¹¹ consists of dipping the steel item to be protected in molten zinc (460°C), in order to protect it from corrosion. At these high temperatures, steel and zinc react to form an intermetallic, the thickness and nature of which will depend partly on the

The occurrence of pinholes in the powder coating of hot-dipped galvanized steel items is investigated. A polyester powder resin crosslinked with triglycidylisocyanurate was used as a model system. The effects of a rheological modifier on the curing process and on the cured material were investigated. The effect of the substrate was studied by using steel with two different silicon contents. The results show that pinholes are likely to appear if the surface's silicon content lies in a given range, which in turn will produce a rough zinc surface. Phosphates and silanes were used as conversion coatings, but neither had an effect on the occurrence of pinholes. The rheological modifier improves the flow properties and helps to solve most pinhole problems.

dipping time, but mainly on the silicon content of the steel. The Sandelin range^{12,13} is an interval of silicon content in the steel which gives a rough zinc layer due to irregular growth of the intermetallic. Voids and much pure zinc are entrapped in the resulting bush-like morphology. Steels with a silicon content lying in the Sandelin range, as defined in Figure 1, should not be hot-dip galvanized, because of the high zinc consumption, the rough resulting surface, and the difficulty of applying a smooth polymeric coating. When the silicon content is either lower (low Si steel) or higher (high Si steel) than the Sandelin range a columnar intermetallic is formed, as can be seen in Figures 6 and 7 respectively. Both of these types of steel are used for hot-dip galvanizing, and were investigated in this study. The nature of the outer layer is quite complex in the case of galvanized steel, since it reacts with oxygen and water as soon as it leaves the zinc bath. The formed products as well as the under-

*To whom all correspondence should be addressed.

†Department of Polymer Technology, S-100 44 Stockholm.

**Drottning Kristinas väg 48, S-114 28 Stockholm.

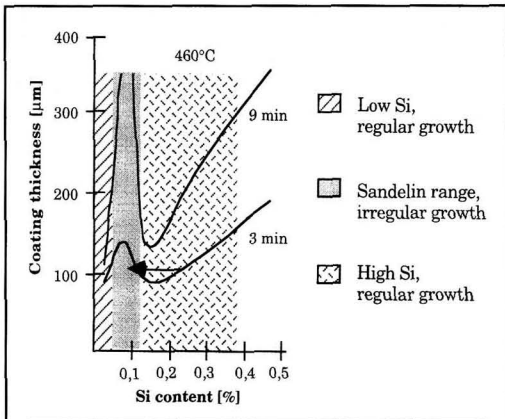


Figure 1—Thickness of the intermetallic formed during hot-dip galvanizing steel as a function of the silicon content. Outside of the Sandelin range the intermetallic has a columnar structure. When internal oxidation occurs, the surface silicon concentration is shifted to the left of the bulk silicon concentration. It can be noticed that internal oxidation of a steel with a low silicon content will never bring the silicon content into the Sandelin range.

lying zinc will continue to react with the environment, giving a time dependent variation of the surface. Under "normal" storage conditions, oxides (ZnO_2), hydroxides ($Zn(OH)_2$), and patina ($2ZnCO_2 \cdot 3Zn(OH)_2$) are present at the metal surface. Patina is a strong protective layer which comes from a slow carbonation of the hydroxides. On the other hand, oxides and hydroxides are soluble in water. Neither of the latter two compounds form a compact layer, so they absolutely must be removed prior to the application of any polymer coating. The weak interface they form will cause the duplex system to fail, even though adherence of the polymer coating is high. Formation of hydroxides under the film is also detrimental, because the strong increase in specific volume during the oxidation process may lead to further debonding. A good adhesion of the polymer to the zinc substrate will slow this under-film corrosion. Other compounds can appear, such as zinc chlorides in marine atmospheres and zinc sulphates in a sulphur polluted environment. In industrial atmospheres with a high sulphur content, the otherwise stable protective patina will decompose into hydroxides again.

The formation of pinholes, which seem to occur in an unpredictable way, is a specific problem of the duplex system this article deals with. It is generally recognized that they are due to the evolution of the gas adsorbed to the powder and metal surface, or entrapped in the powder layer. Indeed the non-cured powder layer can contain up to 60% air. With galvanized steel there is no decomposition or reaction known to take place at the oxide-polymer interface at common curing temperatures. Haines et al.¹⁴ have found a correlation between the thickness of the galvanized steel substrate and the appearance of pinholes. According to previous studies,¹¹

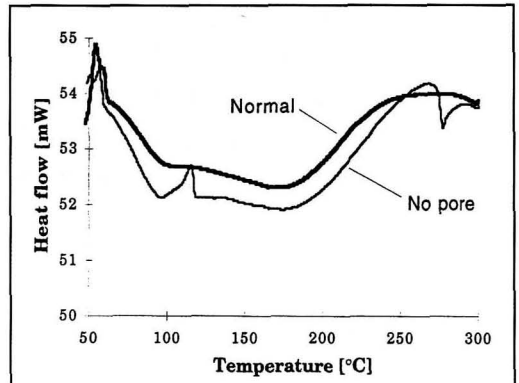


Figure 2—DSC scan (10 K/min) during cure of the Normal and the No pore powder. Both powders have two broad endothermic peaks. The small exothermic peak at 115°C is believed to be due to the rheological modifier.

pinholes do not affect the corrosion resistance of the system. However, the main purpose of the polymer coating is to achieve a high gloss finish and to provide a large variety of colors to choose from. Thus, the appearance of the film is of major importance, and any defects will be highly detrimental to the finish.

This work has mainly focused on the study of pinholes on hot-dipped galvanized steel. Troubleshooting of this common industrial problem should be simplified by the identification of the key factors promoting the appearance of pinholes. One of the main questions was whether the nature or the thickness of the steel had any effect on the appearance of pinholes. The second field of interest was to investigate the effect of a rheological modifier on the molten polymer during the cure, and to determine if its effect was sufficient to avoid the appearance of pinholes on difficult substrates.

EXPERIMENTAL

Instrumentation

Glow discharge optical emission spectrometry (GDOES) was performed on a LECO GDS750 with a current of 60 mA. Size exclusion chromatography (SEC) was performed on a Waters SEC system equipped with a WISP 710B automated injector and a Waters 410 differential refractometer. The columns used were 3 Mixed-B with a pore size of 10 µm from Polymer Laboratories, and THF was used as eluant. Linear polystyrene standards with low polydispersity indexes were used for calibration. Differential scanning calorimetry (DSC) was performed with a DSC 7 from Perkin-Elmer. Samples were sealed in 30 µl aluminum pans with holes. The rheological measurements were performed on a Rheometrics Dynamic Analyzer RDA-II Rheosources Series with a parallel plate geometry. An electrostatic fluidized bed C-30 from Electrostatic Technology Incorporated was used for applying the powder coatings.

Materials

Two kinds of steels, low silicon content (<0.02% Si; 3 mm thick) and high silicon content (0.16% Si, 0.28% Si and 0.20% Si; 5, 10, and 20 mm thick), were used. Two powder coatings were used respectively. One was a linear polyester crosslinked with triglycidylisocyanurate (TGIC). The other was a modified version of the first powder containing a rheological modifier to decrease the viscosity of the melt in the interval between the melting and the curing of the powder. The powders are named Normal and No pore, respectively. The silane used as a conversion coating was A-187 (γ -glycidoxypropyltrimethoxysilane) in ethanol, supplied by OSi Specialties.

Methods

The hot-dip galvanizing was performed using the following scheme. The steel was degreased in an alkaline bath (five percent solution of Castrol Meggem-Clean 8,693 at 60°C for three minutes), pickled (in HCl 12% at 25°C for three minutes) and fluxed (ZnCl₂ 11% and NH₄Cl 17% at 80°C for two minutes) prior to galvanizing. Thin substrates (3 mm) were dipped for three minutes in the molten zinc bath (460°C), whereas the thick ones were dipped for four (5 mm), six (10 mm), and eight (20 mm) minutes. The degreasing of the galvanized samples was realized by dipping the sample in a solution of NaOH (0.8%; pH=12-13) and a complexing agent (0.5% EDTA), for two minutes at 60°C (Procedure 1). The removal of the zinc oxides and hydroxides was done by brushing the sample with a solution of ammoniac (10%) at room temperature (25°C) for two minutes (Procedure 2). The zinc-nickel phosphate coatings were made by Ytteknik AB, Sweden, with their products and using the scheme presented in Table 1. Each step was followed by a water rinse. The silane coating was realized by dipping the samples at room temperature for one minute in a five percent solution of A-187 in ethanol (Procedure 3). The powder was applied with an electrostatic fluidized bed, and then cured at 200°C for 30 min (unless another temperature scheme is indicated).

A depth profile of the different components of the steel (carbon, oxygen, zinc, and iron) was obtained with GDOES. This method allows contaminants of a surface and the thickness of an oxide layer to be determined. Both polymers were investigated using two different temperature schemes on the DSC. To follow the curing mechanism, the temperature was increased from 40° to 300°C at a rate of 10°C/min. Using this procedure, the reaction is spread out, and the signals from the glass transition and the cure reaction do not overlap. To investigate the properties of the cured film, the cure of the powder at 200°C for 15 min was followed by a cooling down to room temperature, and a temperature scan, between 40° and 300°C at a rate of 10°C/min, in order to detect the glass transition (T_g) of the cured film.

A frequency of 1 Hz and a strain of one percent were applied during the rheological measurements done with the RDA. The geometry of the sample was maintained manually. Parallel plates ($\varnothing = 40$ mm) were used to follow the cure and structure build-up of the polymer. The

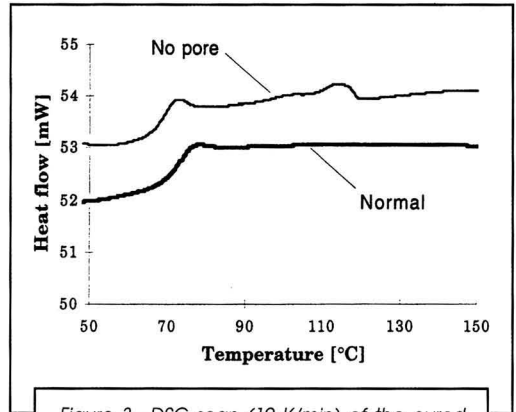


Figure 3—DSC scan (10 K/min) of the cured Normal and No pore powder. Both powders have a T_g of 50°C. The rheological modifier exhibits an exothermic peak around 115°C.

Table 1—Conditions Used for Depositing a Phosphate Conversion Coating

	Solution	Time (min)	Temperature (°C)
Degreasing	NaOH, Na•Ph, Na•Si	5	60
Pickling	NaOH, Na•Ph	5	45
Activation	Suspension of Ti•Ph	45 s	25
Phosphate depos	Zn•Ph, Ni•Ph, Mn•Ph	4	55
Drying (oven)		5	110

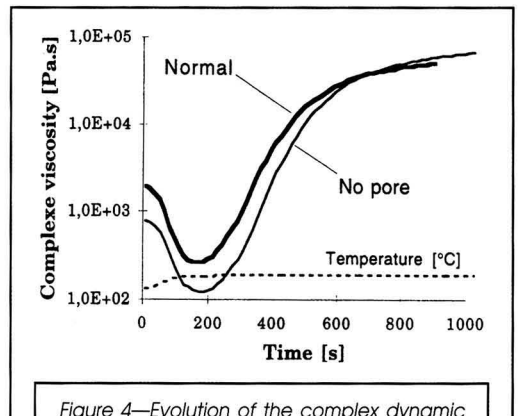


Figure 4—Evolution of the complex dynamic viscosity (η^*) during curing. The No pore powder has rheological agent which lowers the viscosity of the melt and leaves more time for the flowing and the leveling of the film. Parallel plates ($\varnothing=25$ mm) were used in the RDA.

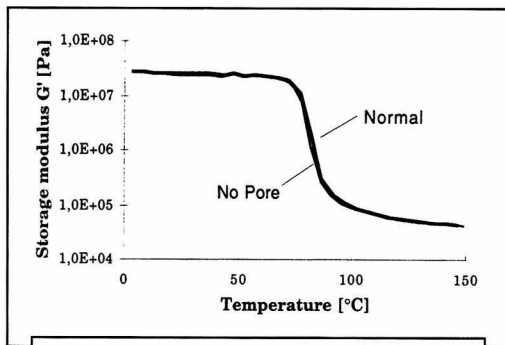


Figure 5—Evolution of the storage shear modulus (G') during a temperature scan. Both cured powders behave the same way. Parallel plates ($\varnothing=8\text{mm}$) were used in the RDA.

sample was melted at 140°C and left to degas at that temperature for 10 min. The temperature was then increased to 200°C (\approx one minute of heating) and the sample cured at that temperature for 10 min. The temperature (T) and the complex shear modulus (G^*) were monitored versus time (t). The elastic shear modulus (G'), the loss shear modulus (G'') and the complex viscosity (η^*) were calculated from the value of G^* . Samples were also cured between parallel plates ($\varnothing = 8\text{mm}$) and then submitted to a temperature scan from -40° to 300°C to measure T_g and the shear modulus.

The samples without any conversion coating were degreased (Procedure 1) and then the hydroxides were removed (Procedure 2) prior to powder coating. The phosphate coated samples were simply degreased prior to powder coating (Procedure 1). The samples with a silane conversion coating were degreased (Procedure 1) and the hydroxides were removed (Procedure 2). The cleaned samples were silane coated (Procedure 3), and then directly powder coated.

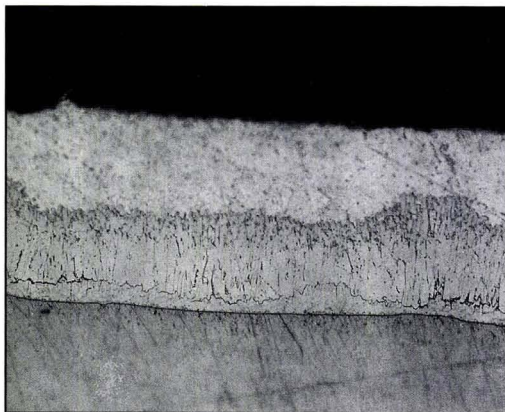


Figure 6—Typical columnar microstructure of the intermetallic obtained when galvanizing a low Si steel. A layer of pure zinc can be seen at the surface.

The surface and cross-section of the different samples were studied with an optical stereo microscope, which is very convenient for detecting tri-dimensional defects such as pinholes. The cross-sections were mounted in bakelite, polished with $1\ \mu\text{m}$ diamond, and etched with a two percent Nital solution (1% HNO_3 in ethanol). Scanning electron microscopy (SEM) was also conducted on some of these samples in order to determine the structure of the steel-zinc intermetallic.

RESULTS AND DISCUSSION

Steel Substrate and Galvanizing

Steel with both a high (high Si steel) and a low silicon (low Si steel) content were used in this study, since industrial contacts¹⁵ reported that coating galvanized high Si steel leads more often to a pinhole problem than coating a galvanized low Si steel. The GDOES study did not show any significant difference in the composition or the thickness of the surface oxides of the different steels. An average oxide layer of $15\ \mu\text{m}$ was found. When galvanized, the low Si steel has a silvery appearance since the intermetallic is covered by a layer of pure zinc. On the other hand, the high Si steel has a dark gray surface since the reactive intermetallic grows all the way to the surface.

Powder Coating

A polyester crosslinked with TGIC was selected, since it is the most commonly used powder coating in Europe. The same powder with a rheological modifier was also used in this study, in order to determine its effect on pinholes, on the rheology of the melt, and on the final mechanical properties of the polymer. The number average molecular weight (M_n in Daltons) and the weight average molecular weights (M_w in Daltons) obtained by SEC were very similar for both powders. The Normal

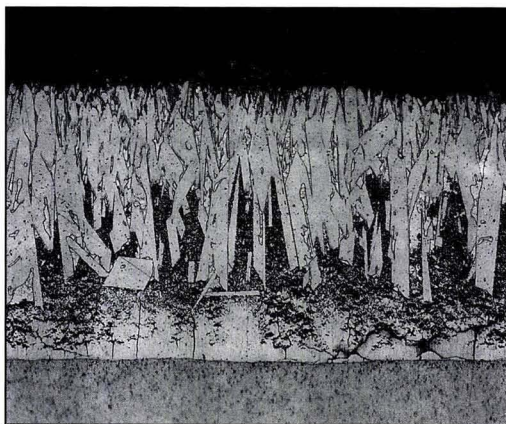


Figure 7—Typical columnar microstructure of the intermetallic obtained when galvanizing a high Si steel.

powder showed values of 20,100 and 26,800 respectively, whereas the No pore powder showed values of 19,600 and 26,100. Both powders had a polydispersity index (PDI) of 1.33. Thus, the two powders could not be differentiated by using SEC. The rheological modifier was in the same range of molecular weight as the polyester and/or the TGIC or in such low amount that it is not detectable.

During the cure in the DSC, presented in *Figure 2*, a peak could be seen around 55°C. This can probably be explained as the relaxation of the stresses created during mechanical processing. Both powders exhibit two broad endothermic peaks (70-150°C and 120-250°C) which are assigned to the curing reaction and "hide" the T_g of the powder. The No pore powder shows a small exothermic peak at 115°C which is believed to be related to the rheological modifier. This additive seems to start decomposing around 280°C. The DSC measured value of T_g of both cured powders, presented in *Figure 3*, is 58°C. The no pore powder still exhibits a small exothermic peak around 115°C. This shows that the modifier is not part of the cured structure, i.e., that phase separation occurs.

It can be seen on the rheological data obtained with the RDA, shown in *Figure 4*, that the viscosity of the melt drops to lower values before curing when a rheological agent is added. Therefore, the time for flow and leveling is longer, hence giving a higher surface quality and a decrease in the number of pinholes.

The storage shear modulus (G') of both polymers was measured after curing and is shown in *Figure 5*. No significant difference can be noticed between the Normal powder and the No pore powder in the final shear modulus and T_g . This shows that the rheological modifier reduces the viscosity during cure but does not affect the mechanical properties of the cured product to any measurable extent.

Influence of Internal Oxidation

Pinholes were obtained by serendipity on one of the high Si steel batches. The samples, with thicknesses of 5, 10, and 20 mm, all exhibited a large number of pinholes, but the most striking feature was the considerable roughness of the zinc surface. Smooth surfaces are generated by the columnar structure of the intermetallic normally found when galvanizing low Si steels, presented in *Figure 6*, or high Si steels, presented in *Figure 7*. Optical observation of the cross-section of these samples, presented in *Figure 8*, revealed a zinc-iron intermetallic structure similar to the one found when galvanizing steels with a silicon content in the Sandelin range. Instead of being columnar, the intermetallic has a bush-like structure, which entraps much pure zinc, and gives rise to a rough surface and a porous layer. The bulk silicon content value of the steel corresponds to a high silicon steel. The problem arises in the first nanometers, where the silicon has been oxidized, thereby lowering the actual concentration of available silicon. The steel is said to be internally oxidized and problems occur when the silicon concentration of the surface drops into the Sandelin range. In order to observe the effect of internal oxidation on the

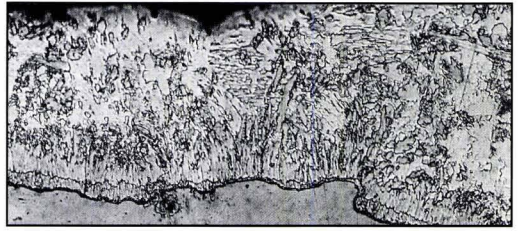


Figure 8—Bush-like structure obtained when galvanizing a high Si steel which has undergone internal oxidation. The resulting surface is rough.

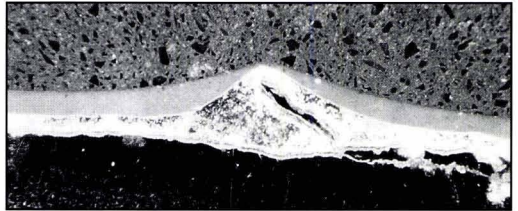


Figure 9—A flake-off due to the high reactivity of the hot zinc bath will give a rough surface, for which the polymer coating might not be able to compensate.

quality of the polymer coating, one side of the steel sample was polished with sufficient cooling, so the silicon of the "fresh" surface would not be re-oxidized. The intermetallic on the polished side exhibited a smooth zinc surface, typical of high silicon content steel. These samples had one side which behaved like an internally oxidized steel, with surface silicon content laying in the Sandelin range, and one side which behaved like a normal high silicon content steel. When coated with the Normal powder, large pinholes could be seen on the oxidized side, whereas the polished side exhibited a pinhole-free surface. The oxidation of the silicon in the steel seems to have a fairly strong effect on the quality of the zinc coating, which in turn strongly influences the polymer coating quality.

Influence of Thermal History

The thermal history of the steel is important. If the steel has been hot rolled or maintained at high temperatures it is likely that the silicon atoms in the first 20 nm will react with oxygen, forming very stable silica, which will not further influence the reactivity of the steel. The percentage of available silicon then drops into the Sandelin range and the zinc coating will have a totally different structure. It is important to note that it is not the bulk silicon content which will determine the structure of the intermetallic, but the amount of free silicon in the first few nanometers. According to our observations, as well as those of van Eijnsbergen,¹⁶ voids will also be created in the zinc surface. When pure reactive zinc enters one of these cavities, it may flake off a piece of

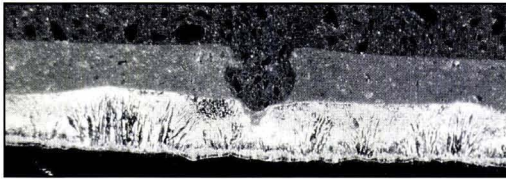


Figure 10—A defect in the zinc layer will entrap air, which will strongly expand at the high cure temperatures, thus creating a pinhole.

intermetallic, as can be seen in Figure 9. The flake will stay in the vicinity of the surface and react with the molten zinc, creating a big bump in the zinc coating. This defect may be too big for the polymer to cover, leaving the zinc uncovered. The void may also stay empty. In that case there will be an air pocket under the polymer coating. At the cure temperature (200°C) the air occupies a much larger volume than at room temperature, so even a small air pocket may create a large pinhole in the crosslinking polymer, as can be seen in Figure 10. Thus, the irregular growth of the intermetallic phase is very detrimental to the polymer's coating properties. When a steel with a low silicon content is galvanized there is no risk of dropping into the Sandelin range because of inner oxidation. This is in accordance with the industry's experience, where it is observed that it is easier to coat a low Si steel than a high Si steel. Fine steels with a high silicon content are often cold rolled to obtain a smooth surface and a good control over the thickness of the steel, therefore inner oxidation is very low and no irregular growth of the intermetallic will be noticed.

Influence of Thickness

It should be noted that a behavior different from that shown by Haines, namely that pinhole occurrence is related to the substrate's thickness, was observed. The quality of the polymer layer was good as long as the silicon concentration at the surface of the steel lays outside the Sandelin range, no matter if the substrate had a thickness of 5, 10, and 20 mm. Haines' results could be explained by considering that thicker steel requires higher pressures and temperatures for rolling, which will cause the silicon to be oxidized and the surface to have more imperfections.

Other Factors

Our early trials highlighted the difficulty of obtaining pinholes when working in a clean and well controlled environment, such as a laboratory. Many of these were run in order to identify the process difference between industrial and laboratory conditions, which is responsible for the appearance of pinholes. For example, the curing temperature was varied between 180° and 240°C, galvanized samples were exposed under an outdoor shelter for 15, 30, and 45 days, and old cleaning solutions

were used. Interestingly, none of this treatment promoted the appearance of pinholes in the samples prepared in the laboratory.

In order to see the effect of different conversion coatings on the appearance of pinholes, phosphates and silanes were applied prior to powder coating. No difference in pinhole concentration was noted when these conversion coatings were applied.

The pretreatment does not seem to influence the quality of the polymer coating. Neither phosphates nor silanes improved coating properties. Both these conversion coatings give too thin layers to be effective in smearing out the imperfections of the zinc coating. However, they might have an effect on the long term adhesion or on the corrosion resistance of the protective coating. This is presently being investigated.

CONCLUSIONS

The main goal of this study was to investigate why and how pinholes are formed when a powder coating is applied on galvanized zinc. Haines has correlated pinholes to the thickness of the galvanized substrate. According to our results, the presence of pinholes mainly depends on the quality of the zinc surface. With a silicon content lying outside the Sandelin range, the growth of the crystals is columnar, resulting in a flat surface which usually does not give rise to a pinhole problem. However, the thermal history of the steel becomes important when hot-dip galvanizing a steel with a high silicon content (> 0.23%), since its silicon content may drop into the Sandelin range. The growth of the intermetallic will then be bush-like and the empty spaces will be filled with zinc. This will give a rough surface and porous layer, which is much more likely to lead to problems during the powder coating. The galvanized specimens left outdoors prior to powder coating had a polymer coating just as good as the specimens which were coated directly after galvanizing, showing that an appropriate cleaning of a zinc surface of good quality allows the storage of galvanized goods in a warehouse prior to coating. The cleaning of the galvanized steel before coating is very important, since any remaining grease and/or hydroxides will give a bad interface. This in turn gives a polymer coating which will easily flake-off or blister, thus destroying the protective and aesthetic properties of the coating.

ACKNOWLEDGMENTS

This study has been financially supported by The National Swedish Board for Technical and Industrial Development (NUTEK). We are indebted to H. Eriksson, Nordisk Föorzinkningsförening for this constant support and to Sir J.F.H. van Eijnsbergen for sharing with us his broad knowledge in duplex systems. Special thanks to our industrial partners for valuable discussions and comments.

References

- (1) Russell, B., *Sheet Metal Industries*, 69, (2), 24, Feb. 26, 1992.
- (2) Misev, T.A., *Powder Coatings—Chemistry and Technology*, John Wiley & Sons Ltd., 1991.
- (3) van Eijnsbergen, J., *Oberflaeche JOT*, 32(1), 26-8, 1992.
- (4) Boothe, D.P., and George H.F., *Ind. Paint Powder*, 1/94, pp. 27-30.
- (5) Boothe, D.P., and George H.F., *Ind. Paint Powder*, 2/94, pp. 24-26.
- (6) Boothe, D.P., and George H.F., *Ind. Paint Powder*, 3/94, pp. 20-22.
- (7) Erikson, M., *Special Metal Finishing—Organic Finishing Guidebook*, 1994.
- (8) Plueddemann, E.P., in *Silane Surfaces and Interfaces*, D.E. Leyden, Gordon and Breach (Eds.), Science Publishers, 1986.
- (9) Batsch, C.D., in *Silane Surfaces and Interfaces*, D.E. Leyden, Gordon and Breach (Eds.), Science Publishers, 1986.
- (10) Sabata, A., van Ooij, W.J., and Koch, R.J., *J. Adhesion Sci. Tech.*, Vol. 7, No. 11, p. 1153-1170 (1993).
- (11) van Eijnsbergen, J.F.H., *Duplex Systems—Hot Dip Galvanizing Plus Painting*, Elsevier Science B.V., 1994.
- (12) Sandelin, R.W., *Wire and Wire Products*, Vol. 15, pp. 655-676, (1940); Vol. 15, pp. 721-749 (1940); and Vol. 16, pp. 28-35, (1941).
- (13) *Proc. 13th Int. Galvanizing Conf.*, London, 1982, Zinc Development Association, London.
- (14) Haines, C.W. and Bromley, B., Annual Technical Conference at Telford Moat House Hotel, Sept. 23-25, 1992.
- (15) Industrial partners: Corro-Coat AS (N), Eskilstuna Galvan AB (S), Gallac AB (S), Galvano AS (N), Herberts Powder Coatings AB (S), Herning Varmforzinkning A/S (DK), Herning Galvanisering A/S (DK), Prozink AB (S), Reime Prozess A/S (N), Skoglösa Mek. Verkstad AB (S), Vadstena Varmforzinkning AB (S), Ørsta Stålindustri AS (N), Nordisk Föorzinkningsförening (S, N, DK, SF).
- (16) Personnel communication with Sir J.F.H. van Eijnsbergen.

FSCT Publications Order Form

Buyer Information

YOUR COMPANY: Check the one block which applies most specifically to the company or organization with which you are affiliated:

- A Manufacturers of Paints, Varnishes, Lacquers, Printing Inks, Sealants, etc.
- B Manufacturers of Raw Materials
- C Manufacturers of Equipment and Containers
- D Sales Agents for Raw Materials and Equipment
- E Government Agency
- F Research/Testing/Consulting
- G Educational Institution/Library
- H Paint Consumer/Applicator
- J Other _____
please specify

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

- A Management/Administration
- B Manufacturing and Engineering
- C Quality Control
- D Research and Development
- E Technical Sales/Service
- F Sales and Marketing
- G Consultant
- H Educator/Student
- J Other _____
please specify

Billing Address

FSCT Member **Non-Member**

Name _____

Title _____

Company _____

Address _____

City & State _____

Country _____ Postal Code _____

Phone _____ FAX _____

Shipping Address (if different)

Name _____

Title _____

Company _____

Address _____

City & State _____

Country _____ Postal Code _____

Phone _____ FAX _____

Method of Payment

Please check one:

- Charge to the following card:
 - MC VISA
 - AMEX DISCOVER
 - Check # _____
(checks must be payable in U.S. Funds on U.S. Bank)
 - P.O. # _____
- Exp. Date: _____

Credit Card Number: _____

Name _____
(print cardholder's name)

Signature _____

Total Amount Due: _____

(No shipping or handling charges on prepaid orders. PA residents, please add 6% sales tax.)

Orders

Series	Member	Non-Mem.	Quantity Ordered
	\$15	\$25	
<i>(Less 10% for Full Series Purchase)</i>			
Film Formation	<input type="checkbox"/>	<input type="checkbox"/>	___
Radiation Cured Coatings	<input type="checkbox"/>	<input type="checkbox"/>	___
Introduction to Polymers and Resins	<input type="checkbox"/>	<input type="checkbox"/>	___
Coil Coatings	<input type="checkbox"/>	<input type="checkbox"/>	___
Corrosion Protection by Coatings	<input type="checkbox"/>	<input type="checkbox"/>	___
Mechanical Properties of Coatings	<input type="checkbox"/>	<input type="checkbox"/>	___
Automotive Coatings	<input type="checkbox"/>	<input type="checkbox"/>	___
Coating Film Defects	<input type="checkbox"/>	<input type="checkbox"/>	___
Application of Paints and Coatings	<input type="checkbox"/>	<input type="checkbox"/>	___
Organic Pigments, Second Edition	<input type="checkbox"/>	<input type="checkbox"/>	___
Inorganic Primer Pigments	<input type="checkbox"/>	<input type="checkbox"/>	___
Marine Coatings	<input type="checkbox"/>	<input type="checkbox"/>	___
Sealants and Caulks	<input type="checkbox"/>	<input type="checkbox"/>	___
Aerospace and Aircraft Coatings	<input type="checkbox"/>	<input type="checkbox"/>	___
Introduction to Coatings Technology	<input type="checkbox"/>	<input type="checkbox"/>	___
Cationic Radiation Curing	<input type="checkbox"/>	<input type="checkbox"/>	___
Rheology	<input type="checkbox"/>	<input type="checkbox"/>	___
Powder Coatings	<input type="checkbox"/>	<input type="checkbox"/>	___
Introduction to Pigments	<input type="checkbox"/>	<input type="checkbox"/>	___
Painting of Plastics	<input type="checkbox"/>	<input type="checkbox"/>	___
Metal Surface Characteristics			
Affecting Organic Coatings	<input type="checkbox"/>	<input type="checkbox"/>	___
Color and Appearance	<input type="checkbox"/>	<input type="checkbox"/>	___
White Pigments	<input type="checkbox"/>	<input type="checkbox"/>	___
Methodologies for Predicting			
the Service Lives of Coatings Systems	<input type="checkbox"/>	<input type="checkbox"/>	___
Silicones	<input type="checkbox"/>	<input type="checkbox"/>	___
Adhesion Aspects of Polymeric Coatings	<input type="checkbox"/>	<input type="checkbox"/>	___

JCT: _____ (specify no. of yrs.) (annual subscrp. included w/FSCT membership)

	U.S. & Canada	Europe (Air Mail)	Other Countries
1 Year	<input type="checkbox"/> \$40	<input type="checkbox"/> \$70	<input type="checkbox"/> \$55
2 Years	<input type="checkbox"/> \$75	<input type="checkbox"/> \$135	<input type="checkbox"/> \$105
3 Years	<input type="checkbox"/> \$110	<input type="checkbox"/> \$200	<input type="checkbox"/> \$155

- Coatings Encyclopedic Soft Cover \$80 \$105
- Dictionary* Hard Cover \$105 \$135
- Glossary of Color Terms \$6 (one price)
- Infrared Spectroscopy Atlas \$150 \$200
- Pictorial Standards \$100 (one price)
- SciQuest \$750 \$800

* Volume discount on five or more.

Federation of Societies for Coatings Technology

492 Norristown Rd., Blue Bell, PA 19422 Phone: (610) 940-0777 Fax: (610) 940-0292

FSCT Publications are also available at:
Jesus Camacho, ANAFAPYT, Gabriel Mancera 309,
Col. Del Valle, 03100 Mexico, D.F., Mexico

Amine-Functional Curatives for Low Temperature Cure Epoxy Coatings

D.J. Weinmann, K. Dangayach, and C. Smith—Shell Chemical Co.*

INTRODUCTION

In today's marketplace, formulators of epoxy/amine coatings face the challenging dual task of meeting VOC regulations and improving the coatings' cost/performance ratio relative to historical industry standards. Traditional epoxy/polyamide coatings have served the industry well for more than 40 years but newer curative technologies eliminate some of the polyamides' well-known limitations. In recent years, these new technologies have led to specialty amine hardeners for low temperature epoxy coatings. Low temperature cure coatings allow applicators to extend the painting season into the fall and early winter months because coating application can continue even when the temperature falls below 50°F.

This paper provides an overview of the curative technologies for low temperature epoxy coatings. The coatings performance of four low temperature amine curatives in unpigmented films is determined. Differential scanning calorimetry (DSC) is used to monitor the cure rate of these binder systems. This study concludes with an evaluation of a new approach to low temperature epoxy/amine formulations. This approach uses low temperature curatives in combination with polyacrylated epoxy resins. This new approach gives improved clarity, blush resistance, and cure development under low temperature, high humidity conditions. The one drawback is that pot lives for these new systems are very short.

ROUTES TO LOW TEMPERATURE CURE COATINGS

Epoxy/Amine Accelerators

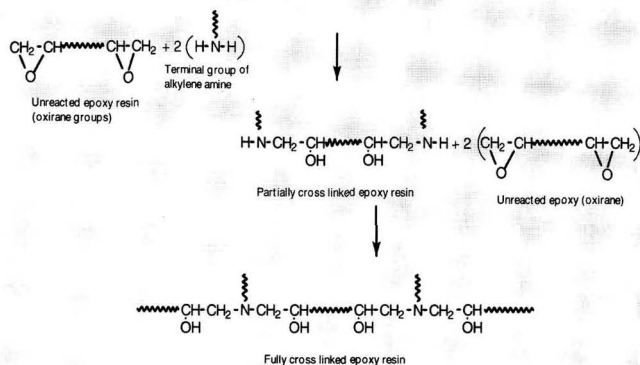
One technology for speeding dry times and increasing the cure rate of epoxy/amine coatings for low temperature ($\leq 50^\circ\text{F}$) applications is to accelerate the epoxy/amine reaction.¹ A simplified epoxy/amine reaction is shown in *Reaction 1*.

Several classes of chemicals accelerate this crosslinking reaction. These chemical classes include: organic acids² (e.g., salicylic or benzoic), tertiary amines³ (e.g., BDMA -

An active area of technology development is the design of improved epoxy/amine binder systems for low temperature cure coatings. Low temperature cure epoxy coatings allow applicators to extend the painting season because coatings can be applied even when the temperature falls below 50°F. This paper begins with a basic overview of the curing agent technologies available for low temperature epoxy/amine coatings. The coatings performance of several low temperature curatives with standard liquid epoxy resin is studied in this work. Differential scanning calorimetry is used to monitor the binder systems' cure rate at 40°F over a 14-day period. The coatings performance in clear varnish formulations is presented; cured at standard ambient conditions (77°F, 55% RH) and at sub-ambient, high humidity conditions (50°F, 90% relative humidity and 40°F, 80% relative humidity). This study concludes with evaluation of a new approach to low temperature cure epoxy coatings. This approach uses low temperature curatives in combination with polyacrylated epoxy resins. The results show that these new binder systems give improved clarity, blush resistance, and cure development under low temperature, high humidity conditions.

benzyl dimethyl amine or tris-2,4,6 dimethylaminoethyl phenol), alcohols (e.g., methanol), water, alkyd-substituted phenols⁴ (e.g., nonylphenol, bisphenol A) and primary aliphatic amines² (e.g., DETA - diethylenetriamine, TETA - triethylenetetramine). The amount of accelerator required for acceptable cure rate depends on the specific chemical chosen and the concentration of active accelerator in the final formulation.

Presented at the 73rd Annual Meeting of the Federation of Societies for Coatings Technology, on October 11, 1995, in St. Louis, MO.
*Resins Dept., Coatings Group, Box 1380, Houston, TX 77251-1380.

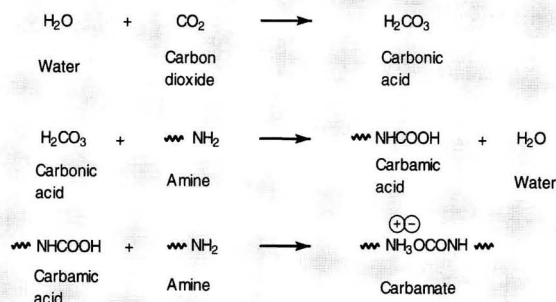


Reaction 1: Simplified epoxy/amine reaction.

The traditional workhorse of amine curatives is the polyamidoamines (or polyamides). Polyamides find applications in such diverse coatings areas as marine, industrial maintenance, water storage and treatment, pulp and paper, equipment finishes and transportation coatings. Polyamides are made by reacting dimer fatty acid with multifunctional ethylene amines such as DETA or TETA. Polyamides are generally not recommended for application at temperatures below 55°F because of their slow reactivity.⁵ Acceptable cure rates at lower temperatures (45-50°F) are possible if the epoxy/polyamide is accelerated with phenolic tertiary amines such as tris-2,4,6-(dimethylaminomethyl) phenol.^{5,6} However, accelerator levels in the film must be minimized if maximum coating performance (e.g., water-, corrosion- and chemical-resistance) are to be maintained. Shorter pot life is another disadvantage of accelerating epoxy/polyamide coatings.

Modified Amine Adducts

In addition to meeting dry time and cure rate requirements, low temperature amine curing agents must be designed for blush and water spot resistance. Primary amines react with atmospheric carbon dioxide and wa-



Reaction 2: Formation of carbamates by amines and moist air.

ter to form carbamates that can exude to the surface and produce blush.⁷ The formation of blush (sometimes called blooming or exudate) usually has a detrimental effect on coating performance because it can lead to gloss reduction, increased yellowing, poor recoatability, and intercoat adhesion problems. Low temperature, high humidity conditions increase the probability of blush formation. The chemical reactions which lead to carbamate formation are found in Reaction 2.

To minimize carbamate formation and improve early water spot resistance, curing agent manufacturers have developed a wide variety of modified amine adducts.

These adducts reduce or eliminate blush formation because the primary amine hydrogens are prereacted with epoxide groups. Amine adducts are prepared by reacting excess primary amines with epoxy resin.⁸ The reaction between liquid epoxy resin and an aliphatic polyamine is shown in Reaction 3.

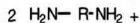
A wide variety of amine curatives and epoxy resins are utilized for amine adduct reactions.⁹ Some of the most common aliphatic and cycloaliphatic amines include:¹⁰ diethylenetriamine (DETA), triethylene tetramine (TETA), tetraethylene pentamine (TEPA), isophorone diamine (IPDA), bis-para-aminocyclohexyl methane (PACM), and 1,2-diaminocyclohexane (1,2-DACH). The epoxy resins range from liquid epoxy resins through solid epoxy resins. Since the amine adduct reaction increases molecular weight, these products are less corrosive and less volatile than their unmodified amine precursors. Most importantly, amine adducts are less susceptible to blush formation so they are well-suited for low temperature cure coatings. However, these advantages come with a significant increase in curative viscosity. To lower viscosity, amine adducts are cut with solvents or modified with plasticizers (such as benzyl alcohol). For low temperature cure, amine adducts are often accelerated to speed property development in the final coating.¹¹

Phenalkamines

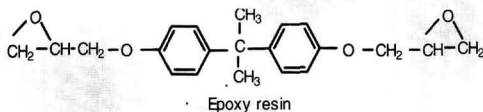
Phenalkamine curing agents are derived from 3-(n-penta-8'-decenyl)phenol which is the major constituent of cashew nutshell oil. Using this constituent (Figure 1), several multifunctional phenalkamines have been developed for low temperature cure applications.¹² These curatives are usually darkly colored and depending upon molecular weight, highly viscous.

Mannich Bases

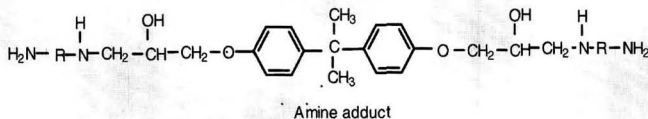
These curatives are prepared by reacting amines with phenol (or alkyl phenols)



Alkylene polyamine



Epoxy resin



Amine adduct

Reaction 3: Formation of standard amine adduct.

and formaldehyde to form condensates, or Mannich bases as they are commonly known. The reaction to form a Mannich base is depicted in *Reaction 4*.

Although this reaction decreases the functionality of the amine, the presence of a hydroxyl functionality on the aromatic ring produces a substantial accelerating effect on the epoxy/amine reaction. Mannich bases cure rapidly at low temperature (35-45°F).¹¹ They have better compatibility with epoxy resins than unmodified alkylene amines and are more resistant to blush and water spotting. In certain cases, external phenolic accelerators such as nonyl phenol are added to further improve low temperature cure performance. The choice of phenol-type and amine dictate the film performance properties. In some cases, plasticizers are added to improve film flexibility but these plasticizers often reduce the coatings' chemical resistance.

PERFORMANCE SURVEY OF LOW TEMPERATURE CURATIVES

Experimental Section

Several commercial curatives (Appendix I) were studied to determine the performance of these products in low temperature applications. A phenalkamine curing agent was used as the control in this study because its low temperature performance is well-known to the industry. Curative 1 is a modified amine adduct designed for low temperature applications. Curative 2 is an amine adduct supplied at 60% wt nonvolatiles in n-butanol/xylene. Low temperature epoxy coatings based on this curative have rapid hardness development and excellent solvent resistance. Curative 3 is a phenol-free, modified Mannich base that provides fast-setting, low temperature cure coatings. The physical properties of these curatives are shown in *Table 1*.

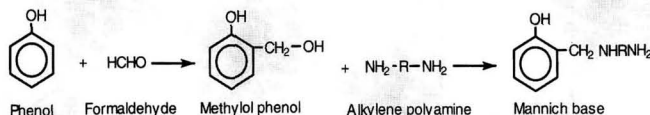
The first part of this coatings study evaluates the performance of these curatives with standard difunctional liquid epoxy resin (WPE = 198, Appendix I). Each binder system was mixed and reduced to Gardner H viscosity

with an equal weight blend of MIBK/xylene/n-butanol. The varnish was mixed for five minutes and then applied to glass panels with a draw-down bar (1.5 mil DFT, 63 microns). After application, the coating was immediately placed in a constant temperature, constant humidity chamber. Film clarity, film tack, and pencil hardness were periodically evaluated over a two week period. Each binder system was cured using three different environmental conditions: 77°F, 55% relative humidity; 50°F, 90% relative humidity, and 40°F, 80% relative humidity. The results of this testing are summarized in *Table 2*.

In addition to determining the coating performance of clear films, we monitored the binder systems' cure rate using differential scanning calorimetry (DSC). This technique involves three steps. The first step is to run simultaneous DSC/TGA (thermogravimetric analysis) on the mixed components (no added solvent) to determine the temperature scanning range. This DSC/TGA technique shows the range of temperatures covered by the curing exotherm and sets the upper temperature limit where weight loss is still negligible (i.e., less than 1% wt).

After the temperature scanning range was established by the DSC/TGA run (from -50 to 170°F), a constant heating rate (10°C/min) DSC scan was performed to determine the total heat of reaction (ΔH_{total}) for each binder system. After reaching the upper temperature limit, the sample was quench-cooled to -50°C and reheated to determine if any post-curing occurred. In all cases, no post-curing was observed during the second DSC scan.

The final step of analysis was to load a freshly mixed sample into a DSC cell and immediately freeze the sample to -130°C (dry ice); while waiting for seven samples to be prepared. Total preparation time for these seven



Reaction 4: Mannich base reaction.

Table 1—Physical Properties of Curatives Used in this Study^a

	Control (Phenalkamine)	Curative 1 (Amine Adduct)	Curative 2 (Amine Adduct Solution)	Curative 3 (Mannich Base)
Amine value	300-335	240-265	225-257	350-390
Viscosity, cP at 25°C	30,000	2500	2500	500
Gardner color	17 max	4 max	9 max	5 max
Solvent content, %w	0	0	40	0
Solvent	—	—	n-butanol/xylene	—

(a) See Appendix I for commercial names of these curatives.

samples was less than five minutes. The sealed DSC cells were stored in a refrigerator at 40°F for a pre-determined number of days. On the appropriate day, one hermetically-sealed sample was removed from the refrigerator and immediately scanned by DSC using a 10°C/min temperature ramp. Integrating the area under this DSC scan gives the residual heat of reaction ($\Delta H_{\text{residual}}$) for the binder system after X days

of cure at 40°F. The extent of reaction (or % cure) for each sample was calculated using equation (1).

$$\text{Extent of Reaction, \%} = \left(1 - \frac{\Delta H_{\text{residual}}}{\Delta H_{\text{total}}}\right) * 100 \quad (1)$$

The results of the DSC study using standard liquid epoxy resin are summarized in Figure 2.

Table 2—Property Development with Liquid Epoxy Resin^a

	Control (Phenalkamine)	Curative 1 (Amine Adduct)	Curative 2 (Amine Adduct Solution)	Curative 3 (Mannich Base)
Cure Conditions: 77°F and 55% relative humidity				
Solids content, %wt (theory) ...	81	85	65	88
Mix ratio, phr	72	60	124	40
Shyodu gel time (100 gm)	49 min	21 min	63 min	13 min
Set to touch, hrs.	0.5	1.25	1.25	0.75
Cotton free, hrs.	4.75	3.5	2.75	1.75
Thru-dry, hrs.	6.75	5.75	5.0	4.25
Days to clear film	1	1	1	1
Days to tack-free film	1	1	1	1
Pencil hardness (ASTM D3363)				
1 day	4B	F	B	HB
5 days	B	F	F	F
7 days	HB	F	F	F
14 days	F	H	F	F
Cure Conditions: 50°F and 90% relative humidity				
Days to clear film	14 (w/Sl.haze)	2	1	1
Film tack ^b				
1 day	Sl. tack	Tack-free	Sl. tack	Tack-free
3 days	Tack-free	—	Tack-free	—
5 days	—	—	—	—
Pencil hardness (ASTM D3363)				
1 day	6B	5B	6B	4B
5 days	5B	B	4B	HB
7 days	4B	B	B	F
14 days	3B	HB	HB	F
Cure Conditions: 40°F and 80% relative humidity				
Pot life @ 40°F	2.5	2.5	3.0	2.5
(hrs to double initial viscosity)				
Days to clear film	14 (w/haze)	3	1	5 (w/Sl. blush)
Film tack ^b				
1 day	M. tack	M. tack	Sl. tack	Sl. tack
3 days	Sl. tack	Tack-free	Tack-free	Tack-free
5 days	Tack-free	—	—	—
Pencil hardness (ASTM D3363)				
1 day	<6B	<6B	<6B	<6B
5 days	<6B	2B	<6B	HB
7 days	5B	2B	3B	F
14 days	3B	B	HB	F

(a) See Appendix I.

(b) Film tack: Sl=slight; M=moderate; V=very.

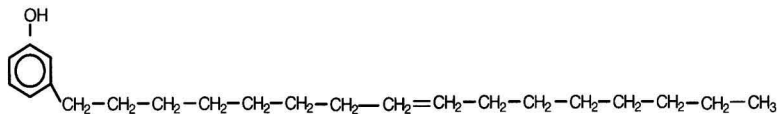


Figure 1—Chemical structure of 3-(n-penta-8'-decenyl)phenol.

Observations/Conclusions (with Standard Liquid Epoxy Resin)

Under standard ambient conditions (77°F and 55% relative humidity), we find that when each curative is combined with liquid epoxy resin, the coatings have relatively fast dry times with short gel times. Curative 3 has the highest reactivity because it has the fastest gel time and shortest Gardner dry times. Curative 2 has the longest gel time reading but this curing agent contains solvent that slows down the Shyodu gel time. Curative 2 is a solid resin in the absence of solvent, so a true measure of its gel time is impractical. The Gardner dry times for Curative 2 are the second fastest for the binders based on liquid epoxy resin but some of this speed may be a pseudo-lacquer dry from this amine adduct solution.

Acceptable pot life in fast-reacting epoxy/amine systems is a practical concern for coatings applicators. To better understand relative reactivities of these curatives in solvent-based coatings, the clear varnish formulations (reduced to Gardner H viscosity) were cooled to 40°F in an ice/water bath. Initial Brookfield viscosities ranged from 1200 cP - 1500 cP. At 40°F, each binder system required 2.5-3.0 hours for the varnish to double its viscosity.

At 50°F and 90% relative humidity, differences in tack-free times and clarity development start to become apparent. The film hardness development for Curative 3 is superior to the other curatives tested in this study. Curative 1 gives tack-free films overnight with good ultimate film hardness but the film clarity is slowed by the very high humidity level. The phenalkamine control

has a longer tack-free time and, even after 14 days, is softer and hazier than the other curatives examined in this study.

At 40°F and 80% relative humidity, each curative has its own particular strengths and limitations which might influence selection of one curative versus another depending on the requirements of each application. In clear formulations, ultimate film clarity and blush resistance are very important properties but in pigmented formulations, other properties such as film hardness and tack-free times may be more important. To address these types of situations, a powerful graphing technique called a "spider chart" or a "radar chart" is available in today's spreadsheet software packages.¹³ The axes in spider charts are oriented so that better performance gives a longer ray; therefore, binders with more balanced performance have a larger area enclosed by their "performagon." The performance of these curatives at 40°F is summarized in Figure 3.

The DSC technique used in this study is a powerful tool for evaluating the extent of reaction in low temperature cure binders. When cured with liquid epoxy resin, each of the curatives gives superior cure development at 40°F. To illustrate this fact, compare the low temperature reactivity of these curatives to the performance of polyamides. The cure rate of three polyamide curatives (accelerated and non-accelerated) was determined at 40°F using a similar DSC technique.¹⁴ The results for the polyamides show that the extent of reaction on the third day ranged from 33-43% and even after 14 days cure, the extent of reaction was only 55-65%. With the low temperature curatives (Figure 2), the extent of reaction after three days ranged from 65-75% and after 14 days, the extent of reaction ranged from 75-95%.

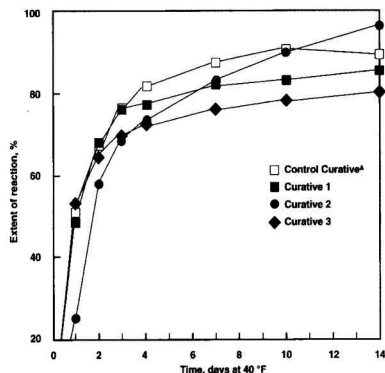


Figure 2—Cure development with liquid epoxy resins at 40°F.

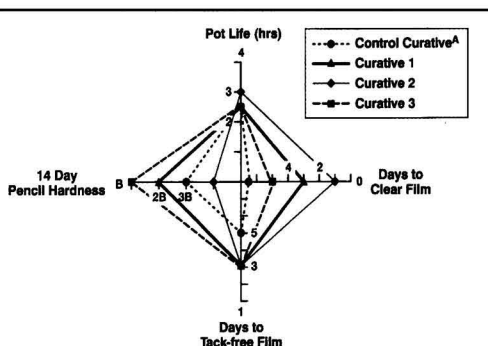


Figure 3—Performance of low temperature curatives (with liquid epoxy resin) at 40°F and 80% relative humidity.

Table 3—Physical Properties of Polyacrylated Epoxy Resin^a

	Polyacrylated Epoxy One	Polyacrylated Epoxy Two	Polyacrylated Epoxy Three	Polyacrylated Epoxy Four
Viscosity, cP at 25°C	2180	950	700	110
Shyodu gel time (w/EPI-Cure [®] 3271)	7 min.	1 min.	5 min.	5.5 min.
Equivalent wt. by reaction with amine	177	140	192	150
WPE.....	210	310	220	315

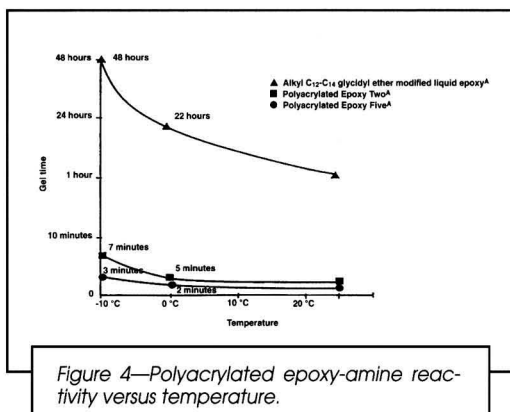
(a) See Appendix 1.

At 40°F, compared to the other curatives in this study, curative 2 has the slowest cure rate during the first four days, but it ultimately reaches the highest extent of reaction after 14 days. The superior reactivity of these new curatives, compared to polyamides, is most evident in the initial stages of cure when development of coating properties is most critical. For this reason, water spot resistance and early chemical resistance are expected to be much improved for the low temperature curatives.

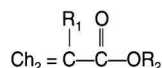
While the curatives in this study possess excellent low temperature reactivity, other performance tests¹⁵ indicate that each curative is best-suited for particular applications. Curative 1 is suitable for waste water applications and solvent-free marine coatings because it possesses superior water resistance and good corrosion resistance. Curative 2 is suitable for 2.8 pounds/gallon VOC-compliant formulations for industrial maintenance, marine and solvent-resistant tank linings. The high reactivity of curative 3, combined with its superior chemical resistance, makes it a candidate for tank linings, synthetic flooring and as a co-curing agent for polyamide-based coatings.

IMPROVED BINDER SYSTEMS FOR LOW TEMPERATURE CURE

Although these curatives have good performance with standard liquid epoxy resin, even under low temperature, high humidity conditions, an improved binder system can be formulated by replacing the liquid epoxy resin with a low viscosity epoxy/polyacrylate resin. These resins are based on standard Bis A epoxy resin



that has been modified with multi-functional acrylate esters.¹⁶ By tailoring the amount and type of modification, a wide range of resin reactivities can be obtained in the final binder (Table 3). Acrylate esters are represented by the general formula:



R₁ = H or CH₃; R₂ = H or alkyl

The nature of the R groups determine the properties of each monomeric ester and the polymers derived from it. Aliphatic primary amines add rapidly across the acrylate double bond in a Michael's addition reaction. Secondary amines do not react well with the acrylic modifications. Aliphatic amines and cycloaliphatic amines are recommended for use with polyacrylated epoxy resins but amidoamines and polyamides generally do not work as hardeners for these resins.¹⁷

In the second phase of this study, we examined the performance of polyacrylate epoxy four with the low temperature curatives studied earlier. Using the testing procedures described in the Experimental Section, we applied the binder varnishes to glass panels and cured them in the environmental chamber. The results of this testing are summarized in Table 4.

Observations/Conclusions (With Polyacrylated Epoxy Resin)

Polyacrylated epoxy resins, in combination with curatives 1, 2, and 3, show significant advantages over

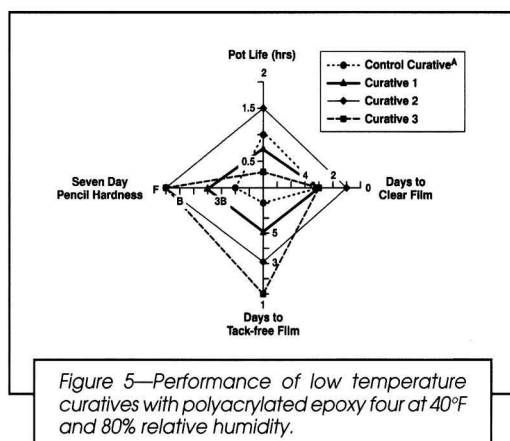


Table 4—Film Properties with Polyacrylate-Modified Liquid Epoxy Resin^a

	Control (Phenalkamine)	Curative 1 (Amine Adduct)	Curative 2 (Amine Adduct Solution)	Curative 3 (Mannich Base)
Cure Conditions: 77°F and 55% relative humidity				
Solids content, %wt (theory) ...	85	95	67	100
Mix ratio, phr	90	76	155	51
Shyodu gel time (100 gm)	43 min	18.5 min	27 min	5 min
Set to touch, hrs.	1.25	1.25	1.25	0.5
Cotton free, hrs.	3.5	4.0	3.5	1.25
Thru-dry, hrs.	13.5	6.0	5.25	1.75
Days to clear film	1	1	1	1
Days to tack-free film	4	2	1	1
Pencil hardness (ASTM D3363)				
1 day	<6B	4B	F	HB
5 days	5B	2B	F	F
7 days	4B	HB	F	F
14 days	2B	F	F	F
Cure Conditions: 50°F and 90% relative humidity				
Days to clear film	3	1	1	1
Film tack ^b				
1 day	Tacky	M. Tacky	Tack-free	Tack-free
3 days	M. Tacky	Tack-free	—	—
5 days	Tack-free	—	—	—
Pencil hardness (ASTM D3363)				
1 day	<6B	<6B	4B	B
5 days	5B	6B	HB	HB
7 days	3B	HB	F	F
14 days	HB	HB	F	F
Cure Conditions: 40°F and 80% relative humidity				
Pot life @ 40°F	1.0	0.75	1.5	0.25
(hrs to double initial viscosity)				
Days to clear film	3	3	1	3 days with Sl. haze
Film tack ^b				
1 day	V. tacky	Tacky	Sl. tacky	Tack-free
3 days	Tacky	Sl. tacky	Tack-free	—
5 days	Sl. tacky	Tack-free	—	—
7 days	Tack-free	—	—	—
Pencil hardness (ASTM D3363)				
1 day	<6B	<6B	<6B	<6B
5 days	<6B	5B	F	HB
7 days	<6B	4B	F	F
14 days	4B	2B	F	F

(a) See Appendix I.

(b) Film tack: S=slight; M=moderate; V=very.

standard liquid epoxies in low temperature, high humidity conditions. The improvements in blush resistance, clarity, and hardness development come from the rapidity of the Michael's addition reaction. A unique feature of epoxy polyacrylates is that their reactivity is relatively independent of temperature effects (see Figure 4).¹⁷

The advantage of this unique reactivity in low temperature applications is that the cure rate of polyacrylated epoxy resin is less affected by temperature than the cure rate of standard liquid epoxy resins. Polyacrylated epoxy resins bring two additional advantages to low temperature coating applications: increased blush resistance at high humidity and low viscosity for high solids or solventless formulations.

Table 5 shows that the gel times for these new binder systems are very short (i.e., less than 30 min). Curatives 2 and 3, when combined with polyacrylated epoxy four,

have gel times that are two times faster than their gel times with standard liquid epoxy resin (Table 2). The control and curative 1 also have shorter gel times, but the difference is not as dramatic (e.g., curative 1/polyacrylate epoxy: 18 min gel; curative 1/standard epoxy: 21 min gel time).

Higher reactivity is also reflected in faster thin film dry times for room temperature applications. Curative 3 is particularly interesting because its thru-dry time decreases from 4.25 hr with standard liquid epoxy down to only 1.75 hr with polyacrylated epoxy four. Faster dry times are the key reason that polyacrylated epoxy resins are used extensively in flooring and adhesive applications. Other potential applications for fast dry epoxy resin systems include auto refinish, railcar applications, and industrial finish coatings.

Even at 40°F, the pot life of these polyacrylate epoxy system are too short for standard application equip-

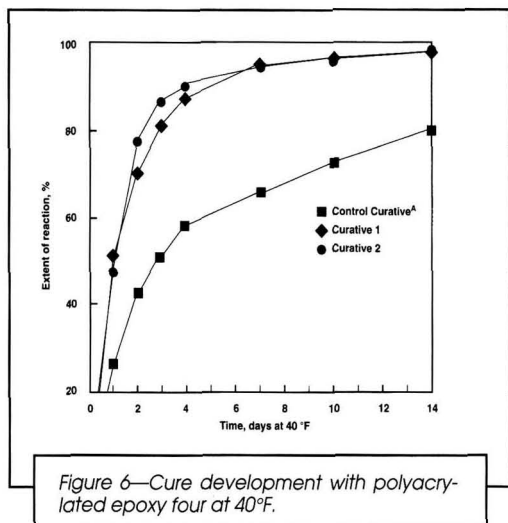


Figure 6—Cure development with polyacrylated epoxy four at 40°F.

ment. However, the low viscosity of these systems is perfectly suited for plural component, solventless equipment which is gaining acceptance in many shop-based applications.¹⁸ Since the binder viscosity is low, heated plural component equipment may not be required to reach acceptable application viscosities.

DANIEL J. WEINMANN earned his B.S. in Chemistry from the University of Oklahoma and his Ph.D. from the University of North Dakota in Grand Forks. Dr. Weinmann joined Shell in 1988 as a member of the Resin's Process Group where he conducted scaleup research for new resin products. In 1991, he transferred to his current position in the Resin's Coatings Group where he provides technical service to the marine and industrial maintenance coatings industry. Dr. Weinmann's research focuses on performance testing of new epoxy resins and amine curatives with special emphasis on developing starting point formulations for waterborne, high solids and solventless ambient-cure coatings.

KAILASH C.B. DANGAYACH joined Shell Development in 1979 in the Chemical Engineering Department, where he worked in the area of polymer engineering. Dr. Dangayach transferred to the Resins Department in 1986, where has been involved with the application of resins in electronics packaging and coatings applications. Recently, he transferred to the Corterra® Polymers with the responsibility to develop the application of Corterra polymers in Engineering Thermoplastic area.

CARL SMITH joined Shell Chemical Company in 1980 as a member of Westhollow Technology Center's Analytical Department. Mr. Smith worked in the chromatography section supporting resins activities. Several years later, he transferred to Bellaire Technology Center where he worked in the Analytical Department and then the Petrophysical Services, both in support of Shell Oil Company's Exploration and Production activities. In 1993, he transferred to his current position in the Resins' Coatings Group at the Westhollow Technology Center. Mr. Smith specializes in the application and testing of starting point formulations based on waterborne and high solids epoxy binder systems.

Three formulation alternatives for longer pot life are to either (1) blend standard epoxy resin with the polyacrylated resin to decrease reactivity; (2) choose a lower reactivity modified resin such as polyacrylated epoxy three; or (3) select an aliphatic amine which is less reactive than the curatives tested in this study. The binder system based on curative 2 with polyacrylated epoxy resin four is unique because it has a pot life of 1.5 hours at 40°F with fast clarity and hardness development. The performance of each binder system at 40°F is summarized in Figure 5.

The long tack free times and slow hardness development in the Control suggest that it may not be suitable for use with polyacrylate epoxy four. Since polyacrylated epoxy four has a high level of modification, an alternative polyacrylated epoxy resin with lower modification (such as polyacrylated epoxy three) might be a more suitable epoxy resin for this curative.

In addition to testing the coating performance of these new binders, we determined their cure rates using the DSC technique described earlier. Curative 3 was not able to be included in this part of the study because the reactivity of the binder at 40°F was too fast to allow accurate determination of the ΔH_{total} . As soon as the two reactants were combined, a significant exotherm was observed—even when using precooled (40°F) epoxy resin and curative components. The results of this DSC study are summarized in Figure 6. The DSC results show that binders based on curatives 1 and 2 reach a high extent of reaction (>80%) after only three days cure. The control curative has a much slower reaction rate at 40°F. It eventually reaches a reasonable degree of crosslinking, comparable to polyamides, but the film hardness remains very soft (4B after 14 days).

SUMMARY

This paper summarizes recent efforts to evaluate epoxy/amine binder systems for low temperature cure coatings. The first section reviews the curing agent technologies used for these applications. Several commercially-available low temperature curatives were evaluated with standard liquid epoxy resin in clear varnish formulations to determine their film performance under different cure conditions: 77°F and 50% relative humidity, 50°F and 90% relative humidity, 40°F and 80% relative humidity. A differential scanning calorimetry (DSC) technique is discussed in detail which measures the extent of reaction during the critical early cure period. Polyacrylate-modified liquid epoxy resins have been used for several years in the flooring industry for their superior low temperature reactivity. This study evaluates the performance of a polyacrylate-modified liquid epoxy resin with low temperature curatives.

The results of this study demonstrate that these new binder systems have significantly better clarity, blush-resistance, and hardness development than comparable systems based on standard liquid epoxy resin. Based on the positive results from this study, we have started testing the performance of these binder systems in white enamel starting point formulations.

References

- (1) King, J.J. and Bell, J.P., *Epoxy Resin Chemistry*, Bauer, R.S., (Ed.), ACS Symposium Series 114, American Chemical Society, Washington, D.C., Chapter 16, 1979.
- (2) Gough and Smith, "Accelerated Amine Curing of Epoxy Resins," *J. Oil & Colour Chemists Assoc.*, 43, 409-410 (1960).
- (3) Zumstein, "Rapidly Hardenable Mixtures of Epoxy Resins and Polyamide Resins," U.S.S. 2,977,332.
- (4) Lee and Neville, *Handbook of Epoxy Resins*, McGraw Hill Book Company, New York, 10-4, 1967.
- (5) Hare, C.H., (Ed.), *Protective Coatings—Fundamentals of Chemistry and Composition*, Technology Publishing Company, 215, 1994.
- (6) 2,4,6-(dimethylaminomethyl) phenol = EPI-Cure® 3253 (Shell Chemical Company); DMP-30 (Rohm and Haas); Ancamine® K54 (Air Products Pacific Anchor Chemicals)
- (7) Tess, R.W., *Epoxy Resins—Chemistry and Technology*, May, C.A. (Ed.), Marcel Dekker, Inc., New York and Basel, 743-744, 1988.
- (8) Lee and Neville, *Handbook of Epoxy Resins*, McGraw Hill Book Company, New York, 7-15 to 7-19, 1967.
- (9) Mika, T.F. and Bauer, R.S. *Epoxy Resins—Chemistry and Technology*, May, C.A. (Ed.), Marcel Dekker, Inc., New York and Basel, 468, 1988.
- (10) Ashcroft, W.R., *Chemistry and Technology of Epoxy Resins*, Ellis, B. (Ed.), Blackie Academic & Professional, London, 39 & 43, 1993.
- (11) Ashcroft, W.R., in *Chemistry and Technology of Epoxy Resins*, Ellis, B. (Ed.), Blackie Academic & Professional, London, 53, 1993.
- (12) Sielski, K., "Surfactants and Additives Derived from Cashew Nutshell Liquid," presented at Chemspec Europe, Amsterdam, March, 1991.
- (13) "Radar Chart" is a chart-type found in Microsoft® Excel for Windows on the PC platform; supplied by the Microsoft Corp., "Spider Chart" is a chart-type found in DeltaGraph Pro 3 for the Macintosh platform; supplied by DeltaPoint, Inc.
- (14) Thomas, R.W. and Lucas, P.A., "Development in Raw Materials for Epoxy-based Secondary Containment Systems" *Mod. Paint Coat.*, 108-116 (October 1994).
- (15) Performance results published in Shell technical bulletins for EPI-Cure® 3378, 3292-FX-60 and 3251 Curing Agents. Unpublished results of white enamel formulations based on these low temperature curatives.
- (16) McWhorter, M.F., U.S. Patent #4,051,195 to Celanese Polymer Specialties.
- (17) Kincaid, D.S., "Epoxy Polyacrylate Hybrids - A Continuing Study," presented at the Epoxy Resin Formulator Division of The Society of the Plastics Industry, Inc., San Antonio, TX, March 9-10, 1992.
- (18) Weinmann, D.J., "Solventless Epoxy Coatings for the Rail Car Industry," *Materials Performance*, 33, No. 6, 29-32 (June 1994).

Appendix I: Commercial Products Used in this Study

Generic Description	Trade Name	Supplier
Phenalkamine Curative (Control)	Cardolite® NC541	Cardolite Corporation
Modified Amine Adduct (Curative 1)	EPI-Cure® 3378 Curing Agent	Shell Chemical Company
Amine Adduct Solution (Curative 2)	EPI-Cure 3292-FX-60 Curing Agent	Shell Chemical Company
Mannich Base (Curative 3)	EPI-Cure 3378	Shell Chemical Company
Liquid Epoxy Resin	Epon® Resin 828	Shell Chemical Company
Polyacrylated Epoxy One	Epon Resin 8161	Shell Chemical Company
Polyacrylated Epoxy Two	Epon Resin 8111	Shell Chemical Company
Polyacrylated Epoxy Three	Epon Resin 8101	Shell Chemical Company
Polyacrylated Epoxy Four	Epon Resin 8021	Shell Chemical Company
Polyacrylated Epoxy Five	Epon Resin 8121	Shell Chemical Company
Alkyl C12-C14 glycidyl ether modified standard epoxy resins	Epon Resin 8132	Shell Chemical Company

FSCT Membership

Offers the Right Mixture for Success



PUBLICATIONS

- A **Complimentary subscription** to the *Journal of Coatings Technology* is included with your membership dues. The JCT, published monthly, is respected around the world for the quality of its technical information. Each issue features papers on the cutting edge of technology, as well as information covering regulatory updates, people in the news, new products, etc.
- The Year Book, the **Who's Who in the Coatings Industry** provides names, addresses, phone and fax numbers of over 7,400 coatings professionals. Included with dues, the spiral-bound desk reference lists FSCT's 26 Constituent Societies and Affiliated members. (a \$150 value)
- FSCT's reference materials including the *Coatings Encyclopedic Dictionary*, *SciQuest*, and the *Series on Coatings Technology* are available to members at discounted prices - you can **save up to 25%**.

EDUCATIONAL PROGRAMS

- Gain **useful ideas and methods** to implement on the job by attending FSCT's regional seminars.
- Network with industry peers at the **FSCT Technology Conference** featuring training sessions and courses for both veterans and beginners in the coatings industry.
- Evaluate the newest trends in technology at the **International Coatings Expo (ICE)**. Held in conjunction with the Technology Conference, the Expo is the largest international trade show for the coatings industry.
- Receive **mailings on FSCT programs**, including updates on the ICE and other FSCT- sponsored events.

SERVICES

- Further your **leadership skills** by serving on Society/FSCT Committees.
- **Save over 25% on registration rates** when attending the FSCT International Coatings Expo and Technology Conference.
- Obtain discounted travel rates through the **FSCT Travel Desk** by calling 800-448-FSCT or 215-628-2549.
- Request information from FSCT's Fax on Demand Service by calling 800-838-5445. International callers please use 215-953-7893.



For more information, contact:
FSCT Membership Services
492 Norristown Rd.
Blue Bell, PA 19422-2350
Phone: (610) 940-0777
Fax: (610) 940-0292

Web Site: <http://www.coatingstech.org>



NOVEMBER 3-5, 1997
ATLANTA, GA

Rapid Electrochemical Assessment of Paint

M. Kendig and S. Jeanjaquet—Rockwell Science Center*
R. Brown and F. Thomas—Rockwell SVI S.A.†

INTRODUCTION

A need exists to rapidly predict the life of organic coatings and specifically paints (pigmented or organic coatings) on steel. As Dickie recently pointed out, the need for rapid methods has become critical now that older coating systems must be replaced by coatings having lower solvent emissions.¹ Among the first to apply electrochemical methods for characterizing paints was the work by Bacon, Smith, and Rugg² who used direct current (dc) electrochemical methods. Later Brasher and co-workers^{3,4} used a single frequency alternating current (ac) method to determine the capacitance across a coating metal interface. They interpreted observed increased capacitance with electrolytic exposure in terms of water uptake by the coating. The science evolved in the early 1970s to the application of broad frequency impedance measurements.⁵⁻⁸ Despite many reports published in the early 1980s,⁹⁻¹⁶ a complete review of which remains beyond the scope of this paper, Skerry and Eden held the opinion as late as 1987 that "no truly acceptable method exists for assessing the corrosion protective performance capabilities of paints."¹⁵ Although considerable development of impedance methods for predicting coating life has taken place, a detailed protocol for its application in very short times has not been forthcoming. Indeed, many impedance studies have involved measurement of only selected samples over weeks to months, time scales similar or longer than standard salt fog tests. With few exceptions (such as the work by Tait¹⁷ and Scully¹⁸), only a small number of samples have been considered. Furthermore, the electrochemical impedance of a paint exposed to corrosive electrolyte quantifies subtle changes in the degradation of the coating barrier, but its ability to predict long-term adhesion under corrosive conditions remains in question.¹⁹ A protocol for rapidly predicting paint life must not only quantify the stability of the paint as a barrier, but must also quantify the susceptibility of the paint to lose adhesion under corrosive conditions. Such an approach addresses key chemical steps of the initiation and propagation of corrosion of painted steel and as such follows the paradigm outlined by Dickie.¹

The primary focus of this work has been on automotive applications, but the methods can be applied to most painting operations, not to mention other coating

Approximately 100 carbon steel specimens painted with a variety of primarily solvent-based automotive paints were evaluated by two rapid electrochemical methods: electrochemical impedance spectroscopy (EIS) and cathodic disbonding. The results were compared with salt fog exposure life. The salt fog times to failure as determined by several different criteria correlated well with the rapid electrochemical evaluation. Regression coefficients useful for predicting the long-term salt fog life from the short (24 hr) electrochemical tests are presented.

processes. The overall objective is to rapidly and simply predict the corrosion-limited life of a coated part. A shorter term objective is to use a rapid measurement as a paint process control. Traditional corrosion tests require relatively long-term (48-450 hr depending on the application) accelerated exposure (e.g., salt fog testing using ASTM B117 or the Renault Methode d'Essai No. 1058²⁰). Furthermore, the results from these conventional accelerated-exposure tests are only pass/fail, and, therefore, give no insight into mechanism; nor can they quantitatively rank coating performance.

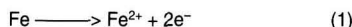
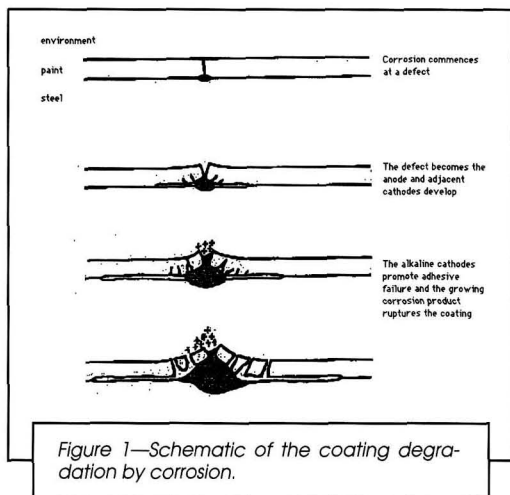
BACKGROUND

Our approach relies on an understanding of the corrosion mechanism for painted steel in near neutral aqueous environments. Figure 1 schematically shows the generally accepted mechanism for the corrosion of painted steel in near neutral, aerated aqueous environments.

Corrosion is an electrochemical process involving the anodic oxidation of the metal to ferrous ions, followed by oxidation to the higher valent iron species and hydrolytic oxide formation:

*1049 Camino dos Rios, Thousand Oaks, CA.
†42007 St. Etienne Cedex 1, France.

²⁰No. 1058 uses the ASTM B117 environment but specimens contain a 45° chevron-shaped scribe and are mounted in the chamber at 30°.



The driver for this anodic electrochemical reaction is the reduction of water-dissolved oxygen at cathodic sites to form hydroxide ion:



Since the metal substrate can provide a convenient path to transport the electronic charge, reactions 1 and 3 often occur at separate locations on the metal surface. Typically the oxidation, reaction 1, occurs near defects; while the cathodic reaction, reaction 3, proceeds at regions adjacent to the defect. The cathodic half of the reaction, reaction 3, generates sodium hydroxide at the coating/metal interface. Charge balance is maintained by Na ion transport through the coating or via lateral transport at the coating/metal interface. The alkaline cathodic corrosion product is particularly detrimental to the coating-to-metal bond, and, therefore, propagates the coating failure. In addition, the generation of voluminous anodic product (the oxides have about half the density of the metal), serves to rupture the coating thereby degrading its barrier properties. While this basic model has been developed over many years of indirect observations,²⁰⁻²³ recent use of scanning Kelvin probe methods confirm the model by direct mapping of the potential at the coating/metal interface.²⁴

EXPERIMENTAL APPROACH

Two general approaches exist for rapidly assessing corrosive failure of materials. First, the failure process can be accelerated to observe the failure in a short time. Second, the onset and propagation of failure can be monitored under realistic conditions using a sensitive measurement of a critical property of the coating's integrity. Both methods are used to rapidly assess the corrosion resistance of coated metal within a 24 hr time period.

The coating integrity or barrier property is precisely determined initially and after a short (typically 24 hr) exposure using electrochemical impedance spectroscopy. Second, applied cathodic polarization to a scribed sample in 0.5 M NaCl accelerates the cathodic process, and the resulting disbondment produced after 24 hr is determined.

The impedance test procedure entails immersing a portion of the sample, contained within an electrochemical cell (see Figure 2), in 0.5 M NaCl aqueous solution under ambient conditions of temperature and pressure for typically 24 hr. The electrochemical impedance is determined within one hour of exposure and at the end of the exposure period. A parallel test involves scribing the sample through the paint down to the bare metal. The scribe marks are made at right angles to form a 2 x 2 cm cross. An electrochemical cell is then placed over the cross, and a biasing voltage of -1050 mV (cathodic polarization) vs. saturated calomel reference electrode (SCE) is applied for typically 24 hr to accelerate reaction 3. While a bias as cathodic as -1050 mV vs. SCE in neutral chloride may initially accelerate reactions other than that of equation 3 (water reduction to form hydrogen, for example), evidence exists which suggests that iR drop precludes hydrogen formation and oxide reduction at the propagating disbond front as it advances away from the scribe.²⁴⁻²⁶ Furthermore, once a steady

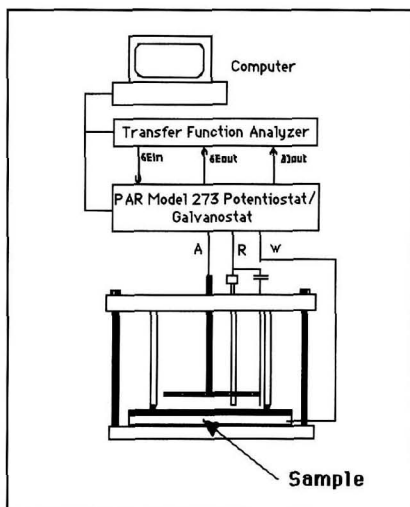


Figure 2—Schematic for the apparatus used to evaluate the electrochemical impedance for a coated sample. The coated metal serves as the working electrode (W) and is clamped to a gasketed cell containing the electrolytic test environment. A sinusoidal potential is applied across the coating with respect to a reference electrode (R) using a stainless steel auxiliary electrode (A) to inject the required alternating current. A transfer function analyzer performs the frequency transformation of the respective current and potential fluctuations ∂i and ∂E respectively to determine the impedance $Z = \partial E / \partial i$.

state alkaline environment develops at the interface, oxygen reduction (equation 3) will be thermodynamically favored over hydrogen formation, the equilibrium potential for the latter being about -1.24 V vs. SCE at pH 13, a typical pH observed for the electrolyte in the disbond zone.

Following the cathodic treatment, adhesive tape is applied over the coating in the vicinity of the cross and pulled to reveal the extent that the cathodic polarization produces disbondment. Determinations of the extent of disbondment for five samples usually shows good reproducibility. For both tests, impedance and cathodic disbondment, a simple clamp-on electrochemical cell may be used. It may be applied to an actual part or to a test (witness) coupon.

Other laboratories²⁷ in the automotive industry are attempting to apply electrochemical impedance spectroscopy for the rapid assessment of paint. The approach described here is unique in that both aspects of the corrosive degradation of the coated metal are rapidly evaluated: (1) the barrier behavior characterized by the impedance measurement; and (2) the corrosion induced disbonding simulated by the cathodic disbonding test.

ANALYSIS

The frequency dependence of the electrochemical impedance usually can be modeled by an equivalent circuit shown in Figure 3. The nonconducting organic coating appears as a dielectric capacitor, C_c . Ionically conducting paths either due to the presence of defects or pores, or due to the slight degree of solvation of water and ions by the coating produce a finite resistive element or coating resistance, R_{po} , that shorts the coating. In series with this resistive element is a parallel resistance, R_{cor} , and frequency-dependent element (CPE) representing the impedance of the electrolyte-saturated coating/metal interface. The corrosion resistance, R_{cor} , relates inversely to the actual corrosion rate for the sample. The CPE takes the mathematical form:

$$Z_{cpe} = Q_{cor} / (j\omega)^n \tag{4}$$

where Q_{cor} is a constant $j^2 = -1$, ω is the angular frequency (equal to $2\pi f$) and n is a constant ranging between 0 and 1. This impedance element corresponds to a nonideal capacitance that models the charging of the double layer at the coating/metal interface. Such a capacitance is said to be very "lossy" in that its phase angle is substantially positive to -90° thereby producing substantial dissipation or energy loss in a hypothetical charging and discharging. In the case that $n = 1$, the CPE is identical to a capacitor of capacitance $1/Q_{cor}$. Finally, in series with the entire network representing the coated surface is R_{soln} , the resistance due to ohmic drop within the electrolyte. In the case of organic coatings immersed in 0.5 M NaCl, R_{soln} is negligible as compared to the impedance of the coating and can, hence, be ignored.

The elements are evaluated from nonlinear least squares analysis of the frequency dependent impedance as shown schematically in Figure 4. The phase angle is conventionally plotted as the negative phase angle. In

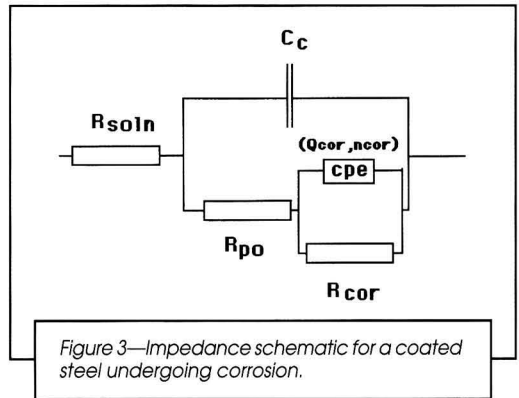


Figure 3—Impedance schematic for a coated steel undergoing corrosion.

general, capacitive impedances are out of phase (to give negative phase angles). Instrumentation software, however, correctly presents the angle without multiplying it by -1 . At high frequencies there is a $1/f$ dependence of the impedance due to domination of the impedance by the coating capacitance (equal to $1/(2\pi f C_c)$). At intermediate frequencies, a plateau appears at $Z \sim R_{po}$. As f approaches zero, most current flows through $R_{po} + R_{cor}$ since the impedance represented by C_c and CPE approaches infinity. R_{cor} generally exceeds R_{po} and hence will dominate the lowest frequencies. At low frequencies then, the interfacial impedance dominates the measurement. Nonlinear least squares analyses,²⁸ or a combination of methods can evaluate these individual parameters from an impedance spectrum, as shown by the

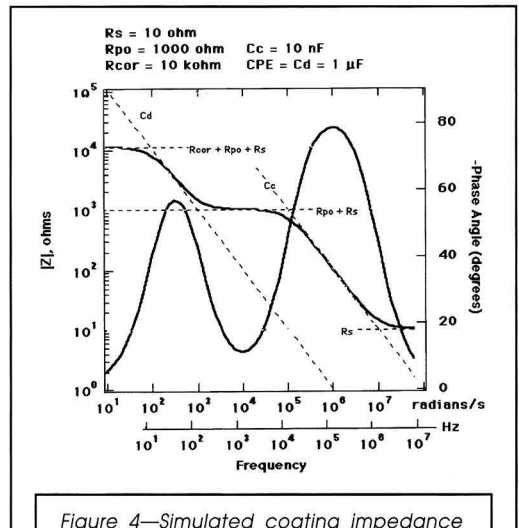
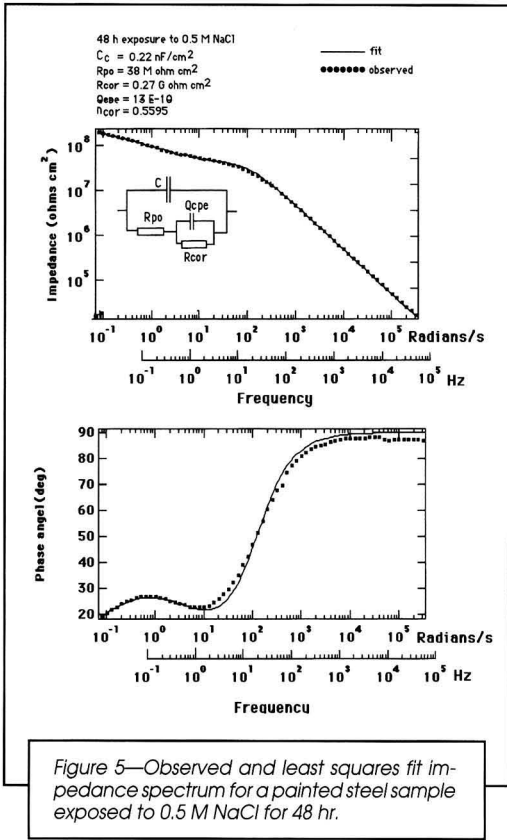


Figure 4—Simulated coating impedance spectrum illustrating frequency regions where the various components of the coating impedance dominate the frequency dependence. The frequency can be expressed in units of Hz (cycles/s) or angular frequency (rad/s) which equals $2\pi f$ where f is frequency in Hz.



example for a coated automotive brake handle after 48 hr of exposure to 0.5 M NaCl (Figure 5). The combined methods may include K-K integration²⁹ or evaluation by Circlefit³⁰ of the remaining impedance, Z_i , following subtraction of the parallel capacitive coating impedance (see Appendix).

The coating resistance, R_{po} , and the corrosion resistance R_{cor} provide indices for the integrity of the coating. The coating capacitance, C_c , can be used to estimate the water uptake by the coating using the approximation equation:

$$\text{volume fraction of water} \sim \text{Log}(C_t/C_o) \text{Log}(80) \quad (5)$$

where C_t is C_c at the time t and C_o is the initial coating capacitance. In the case that R_{po} is so low as to short the capacitance for all but the highest frequencies, C_c cannot be determined with sufficient accuracy to determine water uptake.

Since C_c is due to the charging of the coating dielectric, as a first approximation it can be related to coating thickness d and relative dielectric constant ϵ of the coating material by the following equation:

$$C_c = \epsilon \epsilon_0 / d \quad (6)$$

where ϵ_0 is the dielectric constant of free space (8.85×10^{-14} F/cm). Hence, the initial coating capacitance, measured

before water uptake modifies ϵ , provides a measure of coating thickness with appropriate calibration. For each coating ϵ must be evaluated. In actual practice C_c not only depends on the dielectric properties of the coating material as given in equation (6), but also results from a combination of the coating dielectric capacitance in series with an interfacial capacitance C_o . Hence, the actual dependence of C_c on thickness is

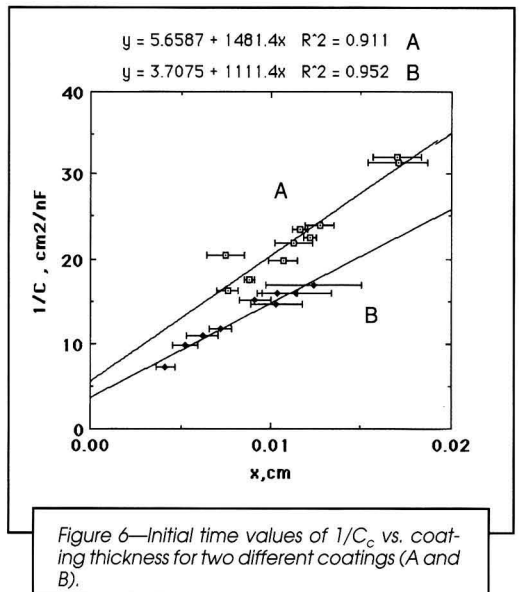
$$1/C_c = 1/C_o + (d/(\epsilon \epsilon_0)) \quad (7)$$

Calibration curves such as that shown in Figure 6 can be generated.

EXPERIMENTAL PROCEDURES

Procedure for Performing the Electrochemical Impedance Analysis

Gasketed cells were applied to five replicate specimens of the paint/substrate to be tested. The cell contains a counter electrode (passivated stainless steel, Ni, carbon, or any noble metal), a salt bridge with a porous glass tip extending to within several mm of the surface and a reference electrode (typically a saturated calomel reference electrode, SCE). The test electrolyte is 0.5 M NaCl. Typically 56 cm^2 of the sample area is exposed in the cell. A Pt or Au pseudo-reference electrode insulated except for its tip by a glass or plastic sheath is also placed within several mm of the sample surface. This electrode is capacitively coupled (0.1 μF) to the reference electrode. The electrochemical impedance is measured in a three-electrode potentiostatic mode with a ± 10 mV potential modulation about dc. The dc potential of the sample is held at the corrosion potential of the sample, or held at -600 mV vs. SCE if no stable potential exists, as is often the case for high quality, defect-free films at



initial times. The impedance is typically measured between 10^4 to 0.1 Hz immediately after introducing the 0.5 M NaCl electrolyte and then between 10^4 and 0.01 Hz after 24 ± 2 hr exposure at $22 \pm 2^\circ\text{C}$. The detailed analysis of the impedance is presented in the Appendix. Briefly, this analysis entails first evaluating the coating capacitance from the region of the impedance spectrum where the phase angle lags by at least 85° . The resulting capacitive admittance is subtracted from the total admittance, and the resulting impedance spectrum is then fit to equation A8 in the Appendix. This yields C_c , R_{po} , R_{cor} , C_{cor} and n . Coating capacitance from the initial and 24 hr data allows evaluation of the volume fraction of water uptake using equation (5).

Procedure for Performing the Cathodic Disbonding Analysis

Bisecting 2 cm lines are scribed in the coating so as to penetrate to the substrate. The lines mutually bisect at 90° and are made with a SiC tool. The sample is placed in a gasketed cell containing a Pt counter electrode and a SCE in a salt bridge. The cell is filled with 0.5 M NaCl as equilibrated with the air. The sample is polarized at -1050 mV vs. SCE for 24 ± 2 hr at room temperature (22°C).

Upon removing the electrolyte, wiping the sample dry and applying adhesive tape to the scribed region, a pull of the tape removes disbonded coating. In addition, a sharp tool such as a knife edge probes any lift-up of the coating that was not removed by the tape pull. A measurement is made of the average dimension (or pull-back) of the disbond away from the scribe in units of mm. The measurement is made to within a tenth of a mm. If the disbond front is not uniform, an average "pull-back" (or damage extending away from the scribe) is estimated. The value dx/dt is calculated by dividing this dimension by the time of the test in hours (usually within two hours of 24 hr). Note that no observed disbonding defines a default value of 10^{-4} mm/hr.

Salt Fog

Samples have been evaluated using the rapid electrochemical evaluation of paint (REAP) protocol described and by conventional ASTM B117 salt fog exposure. For the REAP tests, typically five replicate specimens were evaluated, and average values of impedance parameters and disbond rates were determined. For the salt fog tests, the specimens were scribed according to Renault's Methode d'Essais No. 1058 and exposed in duplicate using the ASTM B117 protocol. The scribe according to this procedure is an inverted V 10 cm long and crossing at 45° . Visual inspections were made at 72, 125, 250, 500, 750, and 1,000 hr according to the Renault Method. The samples were removed at 1,200 hr. The samples are mild steel coupons prepared by Rockwell-SVI (St. Etienne, France), Rockwell-Fumagalli (Sao Paulo, Brazil), Rockwell Suspension Systems (Troy, MI and Milton, Ont., Canada) using a variety of production painting processes.

Since salt fog time-to-failure (TTF) varies from analyst to analyst, one of the authors made all of the visual

inspections. However, audits by another member of the team showed good agreement in his assessment of corrosion rating and "pull back" of damage from the scribe. The definition of salt-fog time-to-failure has been determined in three different ways: (1) from the time required for the sample to exhibit a >3 mm average corrosion pull-back (dimension of corrosion produced blistering extending away from the scribe); (2) from the time for the sample to exhibit a corrosion rating <9 according to the ASTM D610 standard; or (3) from the average of these two times to failure. Most of the specimens failed within the 1200 hr test. In the case that no failure occurred, a 1200 hr default was used. These three times-to-failure are called pull-back time-to-failure, denoted TTF(PB); corrosion time-to-failure, denoted TTF(cor); and overall time-to-failure, denoted TTF.

RESULTS

The respective times-to-failure described in the previous section were compared with the following data from the electrochemical tests: $\text{Log } R_{cor}$, $\text{Log } R_{po}$, $\text{Log } C_{cor}$, $\text{Log } dx/dt$, and % water uptake in 24 hr. The TTFs were fitted to these parameters using regression analysis. First, all of the parameters cited were used in the regression. From the standard deviation of the estimated regression coefficients, parameters whose coefficient was of a magnitude less than the estimated standard deviation were not considered to be relevant for predicting the TTF response and were eliminated from the regression model. This is essentially a stepwise regression analysis.

The results show that the overall TTF depends on $\text{Log } R_{cor}$ and $\text{Log } dx/dt$. TTF is estimated using the following equation:

$$\text{TTF} = c_0 + c_1 * \text{Log } R_{cor} + c_2 * \text{Log}(dx/dt) \quad (8)$$

where the estimates for $\{c_i\}$ appear in Table 1. A plot appears in Figure 7 of the TTFs observed from the salt fog test vs. those TTFs calculated from $\text{Log } R_{cor}$ and

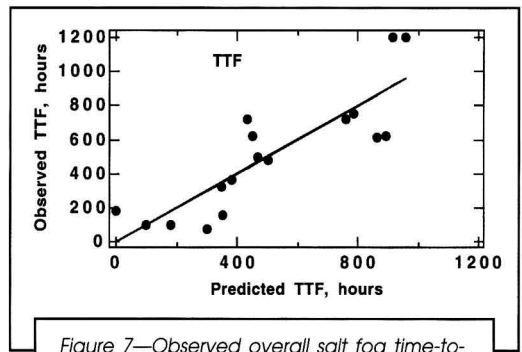


Figure 7—Observed overall salt fog time-to-failure (TTF) vs that predicted from 24 hr electrochemical test. The predicted time to failure is evaluated using equation 8 with the respective coefficients in Table 1 and average electrochemical parameters as determined from the 24 hr tests (typically an average of five).

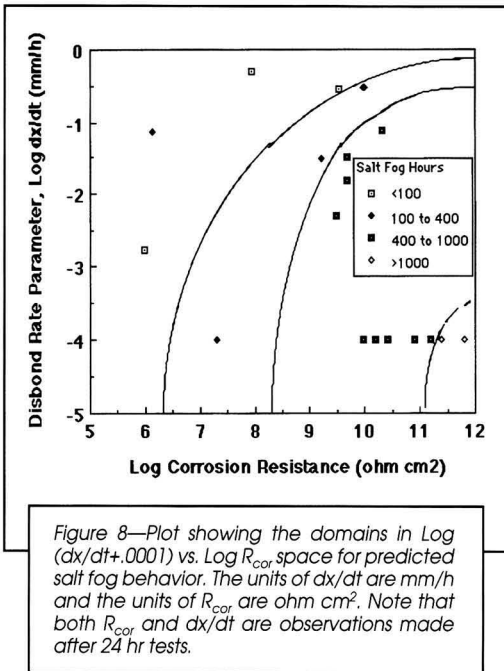
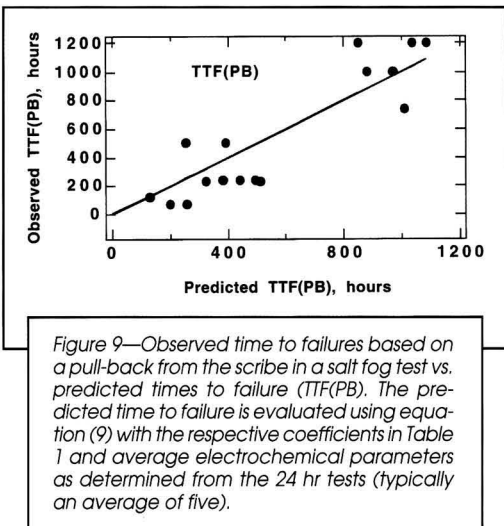


Table 1—Regression Coefficients for Linear Regression of Salt Fog Lifetimes

	TTF	TTF(PB)	TTF(cor)
c_0	-804.5 ± 298	-830.1 ± 347	-734 ± 565
c_1	109.4 ± 33	118 ± 32	137.6 ± 58
c_2	-118.7 ± 36	-169.2 ± 35	
c_3		-48.3 ± 32	



$\text{Log}(dx/dt)$ determined in the rapid 24 hr electrochemical tests and the regression coefficients of equation (8) as they are listed in Table 1. If the prediction was perfect, all of the points would fall on the line shown in the figure. Each point in the figure represents the calculation determined from five duplicate electrochemical tests plotted against the observations averaged from two duplicate specimens subjected to salt fog exposure.

As an alternative presentation of the results, Figure 8 presents the same data in terms of the nonlinear contours estimated by inspection on the plane defined by the two parameters $\text{Log } dx/dt$ and $\text{Log } R_{cor}$. This plot provides a rapid visual assessment of coating integrity based on the values of $\text{Log } dx/dt$ and $\text{Log } R_{cor}$ and has been found useful for practical application of the methodology.

Although the 24 hr measurements of $\text{Log } R_{cor}$ and $\text{Log}(dx/dt)$ predict the overall salt fog TTF, an even better correlation was obtained from the regression analysis of the pull-back time to failure, TTF(PB), with respect to the parameters $\text{Log } R_{cor}$, $\text{Log}(dx/dt)$, and % water uptake (all obtained at 24 hr immersion in 0.5 M NaCl). The results predict the pull-back life TTF(PB) as:

$$\text{TTF(PB)} = c_0 + c_1 * \text{Log } R_{cor} + c_2 * \text{Log}(dx/dt) + c_3 * \% \text{water (24 hr)} \quad (9)$$

where the $\{c_i\}$ appear in Table 1. Figure 9 shows TTF(PB) as observed from the salt fog exposure vs. those TTF(PB)s predicted from an average of the five electrochemical test data using equation (9) and the respective coefficients listed in Table 1.

Finally, the TTF(cor), as determined from the visual observation of the unscribed portion of the coupon using the ASTM D610 corrosion rating showed no significant correlation with any combination of the rapidly determined electrochemical parameters. TTF(cor) showed a barely significant dependence only on $\text{Log } R_{cor}$ according to the equation:

$$\text{TTF(cor)} = c_0 + c_1 * \text{Log } R_{cor} \quad (10)$$

where c_0 and c_1 appear in Table 2. A plot of the observed TTF(cor) vs. those values predicted using equation (10) and the coefficient in Table 2 appears in Figure 10.

We have also considered correlations of the TTF and TTF(PB) using only the electrochemically determined parameter $\text{Log } R_{cor}$:

$$\text{TTF} = c_0 + c_1 * \text{Log } R_{cor} \quad (11)$$

$$\text{TTF(PB)} = c_0 + c_1 * \text{Log } R_{cor} \quad (12)$$

The results for these analyses in terms of observed TTF and TTF(PB) from salt fog exposure vs. the respective predictions obtained from the average of the five electrochemical tests using the respective equations (11) and (12) and the respective coefficients in Table 2 appear in Figures 11 and 12. As can be seen, there is considerable deviation between the data and the line representing the location of the points if the correlation were perfect. Clearly the analysis using equations (11) and (12) cannot be considered as predictive as the respective equations (8) and (9) for TTF and TTF(PB).

DISCUSSION

The best long-term prediction in terms of short-term measurement has been obtained for the TTF(PB), time-to-failure defined by pull-back from the scribe. TTF(PB) is best predicted by three parameters, $\text{Log } R_{\text{cor}}$, $\text{Log } dx/dt$, and % water taken up after 24 hr exposure to 0.5 M NaCl (see Figure 9). The parameters $\text{Log } R_{\text{cor}}$ and $\text{Log } (dx/dt)$ also predict the overall salt-fog failure, TTF, as shown in Figure 7. Salt-fog failure defined as TTF(cor) is significantly less correlated with any of the parameters, even $\text{Log } R_{\text{cor}}$, as shown by Figure 10. We believe that the TTF(cor) depends primarily on the presence of initially present defects and less on the transport kinetics of corrodents across the paint.

$\text{Log } R_{\text{cor}}$ does not predict the TTF and TTF(PB) nearly as well by itself as it does in a multiple regression combining several of the other parameters (compare Figures 7 and 9 with Figures 11 and 12). As stated previously TTF(cor), the time-to-failure based on visual observations as per ASTM D610, shows really no good correlation with any combination of the electrochemical parameters. TTF(cor) shows barely statistically significant dependence only on $\text{Log } R_{\text{cor}}$ by itself. TTF(cor) would appear then to be strongly influenced by initially present defects and less on the coating properties of water and electrolyte transport.

This set of data suggests that the salt fog life in hours to failure can be predicted by the following:

$$\text{TTF} = -804.5 + 109.4 * \text{Log}(R_{\text{cor}}) = 118.7 * (\text{Log}(dx/dt)) \quad (13)$$

$$\text{TTF(PB)} = -830.1 + 118 * (\text{Log}(R_{\text{cor}})) - 169.2 * \text{Log}(dx/dt) - 48.03 * \% \text{water} \quad (14)$$

where the variables ($\text{Log } R_{\text{cor}}$, $\text{Log } dx/dt$, and % water) are determined from a 24 hr exposure with an impedance measurement and a 24 hr disbonding test. The units of R_{cor} and dx/dt are ohm cm^2 and mm/hr , respectively.

This study has focused only on predicting long-term salt fog behavior from a short-term, 24 hr test. Although the salt fog has come under considerable criticism regarding its validity to actual life of coated steel in the field, it remains an accepted standard for assuring consistency of painting processes. Also, the general approach for developing the correlation that we have used can ultimately be applied to other tests, including field exposure. The correlation of a short (24 hr test) to a longer term salt fog exposure we view as a first but necessary step in getting these two electrochemical methods (impedance and cathodic disbonding) recognized as a standard. The basic principles of this approach are twofold:

(1) to expose the test piece for a substantially shorter time than the longer term "accelerated" exposure test to a simulated environment followed by EIS measurement to establish defect density (as measured by R_{cor}) and water uptake (from coating capacitance change), and

(2) to establish the rate of cathodic disbonding in the simulated environment.

Clearly, conditions of environment other than immersion in 0.5 M NaCl can be envisioned using this

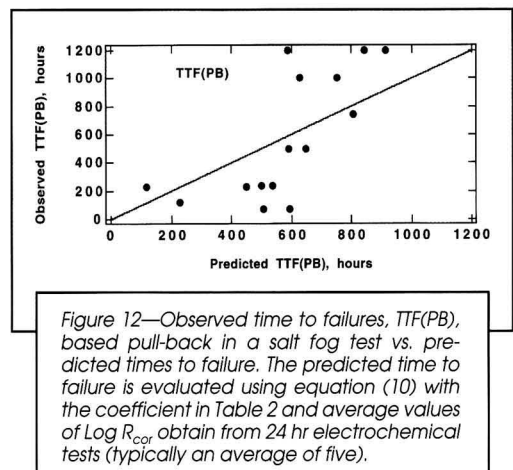
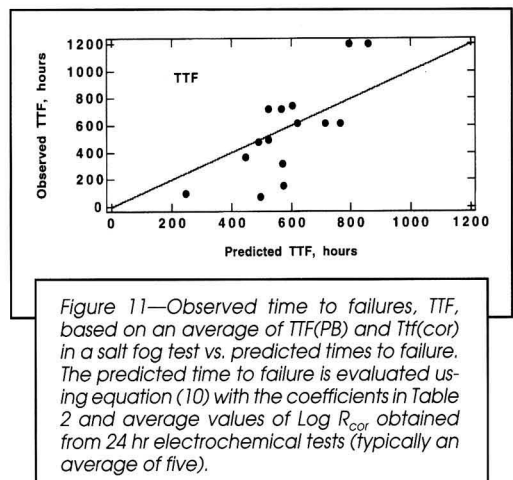
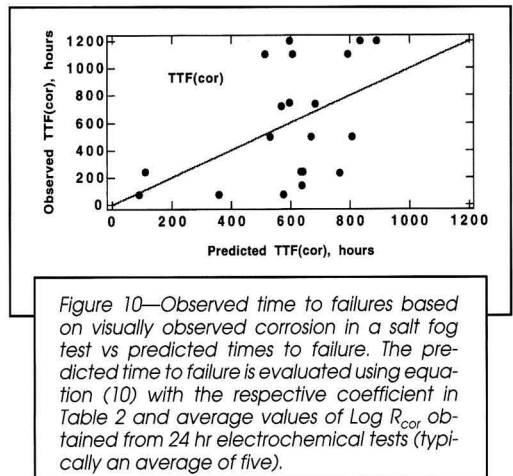


Table 2—Regression Coefficients for Linear Regression of Salt Fog Lifetimes with Respect for Log R_{cor}

	TTF	TTF(PB)	TTF(cor)
C_0	-1010 ± 372	-1183 ± 459	-734 ± 565
C_1	158 ± 38	177.7 ± 48	137.6 ± 58

Table 3—Log R_{cor} Observed after Exposing Specimens to Different Environments³¹

Sample	Environment	Log R_{cor} (R_{cor} in units of ohm cm ²)
E-Coat-(l)	Immersion	10.0
E-Coat-(h)	Immersion	10.6
Polyester	Immersion	11.6
E-Coat-(l)	Salt fog	9.5
E-Coat-(h)	Salt fog	8.1
Polyester	Salt fog	11.4
E-Coat-(l)	Cycle	9.5
E-Coat-(h)	Cycle	9.9
Polyester	Cycle	11.4

E-Coat = electrochemically coated.

l = light coating.

h = heavy coating.

Cycle: 1 hour @ 60°C, 30 min. @ -25°C, 1 hour and 15 min. in 5% NaCl, 1 hour and 15 min. in open air at room temperature, 21 hours in a humidity cabinet.

Salt fog: 24 hr exposure to ASTM B117 conditions.

Polyester = polyester powder coating.

same principle. For example, tests on coated samples exposed to one cycle of a cyclic corrosion (see notes in Table 3) followed by impedance measurement in 0.5 M NaCl, or to 24 hr of ASTM B117 salt fog, followed by an impedance measurement in the test electrolyte, appear in recent work³¹ to discriminate between two high quality coatings, an E-coat and a polyester powder coating. As shown in Table 3, R_{cor} observed after one cycle of the cyclic corrosion test or 24 hr of salt fog shows greater discrimination between the two coatings as compared to the immersion condition. Impedance measurements could also be used for an early evaluation of coating degradation by selected mechanically,³² or radiatively³³ stressful environments in addition to the chemically stressful environments. In any case, sufficient statistics will be required.

SUMMARY

Corrosion resistance, rate of cathodic disbonding, and water uptake observed after 24 hr of exposure can predict long-term (up to 1,200 hr) salt fog exposure life, where we define salt fog time-to-failure by either scribe pull-back or combined appearance and scribe pull-back. Quantitative expressions for these correlations appear in equations (13) and (14).

Salt fog time to failure as defined only by visual appearance of unscribed panels is not as well correlated with the rapid electrochemical analysis. This salt fog time-to-failure shows only a statistical dependence on

the corrosion resistance as measured after 24 hr immersion of the sample in 0.5 M NaCl.

The general approach entails early impedance analysis after exposure to a stressful environment, and an additional accelerated test for cathodic disbonding in a relevant environment to predict longer term behavior. This method could, in principle, be applied for predicting Prohesion, SCAB, or actual field exposure given sufficient data for the statistical correlation.

ACKNOWLEDGEMENT

Authors gratefully acknowledge provision of additional tests samples by Tom King (Rockwell Suspension Systems, Milton, Ontario), Jose Antonio da Costa (Rockwell do Brasil Ind. e Com. Ltda. Divisio Fumagalli, Sao Paulo, Brazil), Don Polk (Rockwell International Corp. Automotive Division, Troy, MI). In addition, we recognize the leadership provided by Dr. Paul Newman in motivating the initiation of this work.

References

- (1) Dickie, R.A., "Chemical Origins of Paint Performance," JOURNAL OF COATINGS TECHNOLOGY, 66, No. 834, 29 (1994).
- (2) Bacon, R., Smith, J., and Rugg, F., *Ind. and Eng. Chem.*, 40, 161 (1948).
- (3) Brasher, D and Kingsbury, A., *J. Appl. Chem.*, 4, 62 (1954).
- (4) Brasher, D. and Nurse, T., *J. Appl. Chem.*, 9, 96 (1959).
- (5) Bonora, P.L., Epelboin, I., Morel, P., and Takenouti, H., "Fast Electrochemical Test of the Protecting Power of Paints Coating a Metal," European Conference on Corrosion, 5th, Paris, 1973.
- (6) Beaunier, P.L., Epelboin, I., Lestrade, J.C., and Takenouti, H., *Surface Technology*, 4, 237 (1976).
- (7) Kendig, M.W. and Leidhesier, Jr., H., *J. Electrochem. Soc.*, 123, 982 (1976).
- (8) Leidhesier, Jr., H. and Kendig, M.W., *Corrosion*, 32, 69 (1976).
- (9) Walter, G.W., *J. Electroanal. Chem.*, 118, 259 (1981).
- (10) Sato, Y., *Prog. Org. Coat.*, 9, 85 (1981).
- (11) Szauer, T., *Prog. Org. Coat.*, 10, 171 (1982).
- (12) Kendig, M.W., Mansfeld, F., and Tsai, S., *Corros. Sci.*, 23, 317 (1983).
- (13) Mansfeld, F. and Kendig, M.W., *Electrochemical Impedance Tests for Protective Organic Coatings*, ASTM STP 866, G. Haynes and R. Baboian (Eds.), (1985).
- (14) Walter, G.W., *Corros. Sci.*, 26, 39 (1986).
- (15) Skerry, B. and Eden, D.A., *Prog. Org. Coat.*, 15, 269 (1987).
- (16) Pebere, N., Picaud, T., and Duprat, M., *Corros. Sci.*, 29 (9), 1073 (1989).
- (17) Tait, W.S., "Coping With Errors in Electrochemical Impedance Spectroscopy Data from Coated Metals," JOURNAL OF COATINGS TECHNOLOGY, 66, No. 834, 59 (1994).
- (18) Scully, J.R., *J. Electrochem. Soc.*, 136 (4), 979 (1989).
- (19) Kendig, M., Mansfeld, F., and Tsai, C.H., *Corrosion*, 47 (12), 964 (1991).
- (20) Leidheiser, Jr. H., *J. Adh. Sci.*, 1, 79 (1987).
- (21) Leidheiser, Jr., H., Wang, W., and Igetoft, L., *Prog. Org. Coat.*, 11, 19 (1983).
- (22) Castle, J.E. and Watt, J.F., *I&EC Product R&D*, 24, 361 (1985); Watts, J.F., J.E. Castle, *J. Materials Cl.*, 18, 2987 (1983).
- (23) Holubka, A.J.W. and Dickie, R.A., "Resin Structure and the Corrosion Resistance of Organic Coatings: Epoxy-Alkanolamine Resins," JOURNAL OF COATINGS TECHNOLOGY, 56, No. 714, 43 (1984).
- (24) Stratmann, J., Feser, R., and Leng, A., *Electrochimica Acta*, 39, 1207 (1994).
- (25) Kendig, M., Lumsden, J., Stocker, P., and Jeanjaquet, "Mechanism of Disbonding of Pipeline Coatings," Final Report, 1991-1994, Gas Research Institute, Contract # 5091-260-2115 (1996).

- (26) Watts, J. and Castle, J.E., *J. Mater. Sci.*, 19, 2259 (1984).
 (27) Wang, Y-M. and Radovic, D., *Plating and Surface Finishing*, 76 (2), 52 (1989).
 (28) Boukamp, B., EQUIVCRT Users Manual, Report CT 188/265/128, University of Twente, Netherlands, 1988.
 (29) Kendig, M. and Mansfeld, F., *Corrosion*, 39 (11), 466 (1983).
 (30) Kendig, M., Meyer, E., and Mansfeld, F., *Corrosion Sci.*, 23, 1007 (1983).
 (31) King, T., Rockwell International Suspension Systems, Milton, Ont., Canada, private communication, August 1995.
 (32) Simpson, T. and Hoffman, J.D., "Effects of Substrate Phosphate Type on the Painted Corrosion Performance of Galvaneal Coated Steel," *Proc. International Congress*, SAE International, Detroit, 1995.
 (33) Armstrong, R.D., Jenkins, A.T.A., and Johnson, B.W., "An Investigation into the UV Breakdown of Polyester Coatings Using Impedance Spectroscopy," *Proc. Symp. on Advances in Protection by Organic Coatings II*, Scantlebury, D. and Kendig, M. (Eds.), PV 95-13, The Electrochemical Society, 1995.

Appendix—Further Analytical Considerations

Definitions

To a very good approximation, the electrochemical impedance of a painted steel exposed to a corrosive electrolyte gives a frequency response that can be modeled by the schematic shown in Figure 3, where the parameters have the following definitions:

R_{soln} = uncompensated ohmic resistance, usually negligibly small

R_{po} = resistance for the ionic transport through the film

R_{cor} = corrosion resistance of the coated metal

CPE = $1/Ys^n = Q_{cpe}/s^n$, where n is unitless phenomenological constant ranging between 0 and 1, and Y is a constant. s equals the complex frequency $j2\pi f$ where f is in Hz and $j^2 = -1$. The element CPE represents the very lossy capacitance of coating metal interface.

The element Z_c is the impedance due to the dielectric capacitance of the organic film:

[A1] $Z_c = 1/sC_c$ where C_c is the dielectric capacitance of the coating

$C_c = \epsilon\epsilon_0/d$ where ϵ is the relative dielectric constant and ϵ_0 is the dielectric constant of free space, d is the coating thickness. As the coating picks up water; ϵ increases such that the following approximation can be used:

$$[A2] (C_c(t)/C_c(0) = 80^v$$

where v is the volume fraction of water and $C_c(t)$ is the coating capacitance at time t .

The complex impedance of the coated metal surface, Z , then may be defined by the following equation:

$$[A3] Z = R_{soln} + Z_c Z_i / (Z_c + Z_i)$$

where the interfacial impedance, Z_i , takes the following form:

$$[A4] Z_i = R_{po} + R_{cor} / (1 + (\tau s)^n)$$

Here τ is a time constant for the electrochemical response of the coating/metal interface. It may be interpreted as equaling $R_{cor} C_{dl}$ where R_{cor} and C_{dl} are the corrosion resistance and double layer capacitance, respectively, for the actively corroding surface under the coating.

Evaluation and Approximation

The above parameters can be approximated by several useful extrapolations or averaging methods.

In the region of the spectrum where the phase angle remains below -85° , C_c may be approximated by the following:

$$[A5] C_c = 2\pi \text{Imaginary}(1/Z)$$

An average of C_c by the above equation taken over the set of data where the phase angle remains below -85° provides a very good estimate of C_c .

Since R_{soln} can be ignored:

$$[A6] 1/Z = 1/Z_c + 1/Z_i$$

Hence, C_c can be used to determine Z_c in order to extract the complex interfacial impedance Z_i with the following transformation:

$$[A7] 1/Z_i = 1/Z - 1/Z_c$$

This transformation accurately determines Z_i for the low frequency region where the phase angle generally is greater than -85° .

$$[A8] Z_i = R_{po} + R_{cor} / (1 + (s \tau)^n)$$

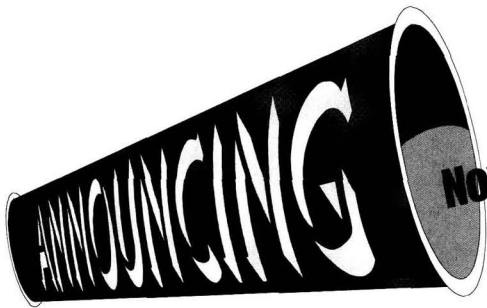
The imaginary component of the above equation takes the following form:

$$[A9] \text{Imag}(Z_i) = \tau^n |s|^n R_{cor} \sin(\pi n / 2) / [1 + 2|s|^n \tau^n \cos(\pi n / 2) + |s|^{2n} \tau^{2n}]$$

This function can be rewritten in terms of $\log_e |s| = x$ as

$$[A10] \text{Imag}(Z_i) = \tau^n R_{cor} \sin(\pi n / 2) [e^{nx} / (1 + 2 \tau^n \cos(\pi n / 2) e^{nx} + \tau^{2n} e^{2nx})]$$

Correction of the observed impedance to obtain Z_i is easily made once C_c is evaluated. Evaluation of the other parameters, in particular τ , n and R_{cor} is much more difficult and requires in general a non-linear least squares evaluation using equation [A10], or other nonlinear methods including a Kramers Kronig²⁹ integration or Circlefit.³⁰



Now Available from FSCT . . .

**Two New Monographs from the
Federation Series on Coatings Technology**

“Finishing Exterior Wood”

**William C. Feist
Consultant**

and

**“Adhesion Aspects of
Polymeric Coatings”**

**Jamil A. Baghdachi
BASF Corp.**

**For a complete listing of available monographs, contact
Meryl Simon, FSCT, 492 Norristown Rd., Blue Bell, PA 19422**

(610) 940-0777; Fax: (610) 940-0292

Web Site: <http://www.coatingstech.org>

Regulatory Update December 1996

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

**Environmental Protection Agency
October 28, 1996 — 61 FR 55612
Emergency Planning and Commu-
nicity Right-to-Know; Notice of Pub-
lic Meetings**

Action: Notice of public meeting

The Environmental Protection Agency (EPA) held a public meeting on December 3-4 to discuss the agency's advanced notice of proposed rulemaking on adding reporting elements to toxic chemical release reporting. The agency is considering expanding the data collected by the Toxic Release Inventory to include all potential components of chemical use. The meeting was held in Washington, D.C. at EPA headquarters.

For more information on the meeting, contact Denise Coutlakis, EPA, (202) 260-5558; e-mail: coutlakis.denise@epamail.epa.gov.

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

**October 25, 1996 — 61 FR 55364
Harmonization With The United Na-
tions Recommendations, Interna-
tional Maritime Dangerous Goods
Code, and International Civil
Aviation Organization's Technical
Instructions**

**Action: Notice of proposed rulemak-
ing**

The Research and Special Programs Administration (RSPA) is proposing to amend the Hazardous Materials Regulations to maintain alignment with corresponding provisions of international standards. Because of recent changes to international requirements, including recommendations from the United Nations, these proposed amendments are necessary to facilitate the transport of hazardous materials in international commerce.

Some of the more significant amendments in this notice include (1) a revision of the definition of "aerosol;" (2) new provisions for marking and use of salvage packagings; (3) amendments to the Hazardous Materials Table, including hazard class; (4) changes to the List of Marine Pollutants; and (5) new criteria for classifying packing groups to mixtures of materials possessing oral and dermal toxicity hazards.

Comments on this proposal were due on Nov. 25. For additional information, contact RSPA's Bob Richards, (202) 366-0656, or Beth Romo, (202) 366-8553.

**Environmental Protection Agency
October 29, 1996 — 61 FR 55842
National Emission Standards for Haz-
ardous Air Pollutants and Control
Techniques Guideline Document;
Aerospace Manufacturing and
Rework Facilities**

**Action: Proposed amendments to fi-
nal rule and release of draft con-
trol techniques guideline (CTG)
document for public review.**

This action proposes several amendments to the national emission standards for hazardous air pollutants (NESHAP) for aerospace manufacturing and rework facilities that were published in the September 1, 1995 *Federal Register* (60 FR 45948). In addition, the Environmental Protection Agency (EPA) has announced the availability of a draft CTG document for control of volatile organic compound emissions from such facilities for public comment.

Among other things, this (1) amends standards for new and existing sources using dry particulate filters to control emissions from topcoat and primer application and depainting operations; (2)

adds an exemption for certain water-reducible coatings; (3) specifies the applicability of new source maximum achievable control technology to spray booth standards; (4) clarifies the requirements for new and existing primers at topcoat application operations; and (5) includes an appendix containing definitions for specialty coatings.

Comments must be received by Dec. 30, 1996. Send two copies on the NESHAP to Air and Radiation Docket and Information Center (6102), (LE-131), Docket No. A-92-20, EPA, 401 M Street S.W., Washington, D.C. 20460. Electronic copies may also be submitted as an ASCII file to a-and-r-docket@epamail.epa.gov. Comments on the draft CTG should be sent to James Szykman, Policy Planning and Standards Group, Emission Standards Division (MD-13), EPA, Research Triangle Park, NC 27711.

Copies of the draft CTG document are available from EPA's Technology Transfer Network electronic bulletin board, at (919) 541-5742. For additional information, contact James Szykman, EPA, (919) 541-2452.

**Environmental Protection Agency
October 29, 1996 — 61 FR 55872
Preliminary Assessment Information
and Health and Safety Data Re-
porting; Addition of Chemicals
Action: Final rule**

The Toxic Substances Control Act (TSCA) Interagency Testing Committee has revised the TSCA Priority Testing List by recommending 18 additional chemical substances for testing. The Environmental Protection Agency is adding certain of these substances to two model information-

gathering rules – the TSCA Section 8(a) Preliminary Assessment Information Rule and the TSCA Section 8(d) Health and Safety Data Reporting Rule. These model rules will require manufacturers and importers of the specified substances to report certain production, use and exposure-related information. Additionally, manufacturers, importers, and processors of these chemical substances must report unpublished health and safety data to the agency.

This rule went into effect November 29, 1996. For further information, contact Susan Hazen, EPA, (202) 554-0551.

**Department of Labor
Occupational Safety and Health Administration**

**November 4, 1996 —61 FR 56746
Occupational Exposure to 1,3-Butadiene**

Action: Final rule

The Occupational Safety and Health Administration (OSHA) has issued a final standard which lowers the permissible exposure limit (PEL) for 1,3-butadiene. The new limits reduce the PEL to an eight hour time-weighted average of 1 part per million and a short term exposure limit of 5 ppm for 15 minutes. In order to reduce exposures and protect employees, the regulation includes requirements for engineering controls, measurement of employee exposure, work practices, personal protective equipment, training, hazard communication, emergency procedures and recordkeeping.

The effective date of this standard is Feb. 3, 1997. For further information, contact Anne Cyr, OSHA, (202) 219-8151.

**Environmental Protection Agency
November 7, 1996 —61 FR 57748
Comprehensive Guideline for Procurement of Products Containing Recoverable Materials**

Action: Proposed rule

The Environmental Protection Agency (EPA) has proposed an amendment to the May 1, 1995 Comprehensive Procurement Guideline which designates 13 new items that can be made with recovered materials, including latex paint. EPA is required by law to indicate such items and to recommend practices for the procurement of these items by other agencies. Facilities regulated

by these guidelines include federal, state, and local agencies, and independent contractors doing government contract work.

EPA has also issued a draft Recovered Materials Advisory Notice which provides guidance for the procurement of items made with recycled material. Comments on both items will be accepted until Feb. 5, 1997. Send an original and two copies to RCRA Information Center (5305W), EPA, 401 M Street S.E., Washington, D.C. 20460. Please place the docket number F-96-CP2P-FFFFF on all copies.

For technical information on this rule, contact Terry Grist, EPA, (703) 308-7257.

Legislation—The Year In Review

Air Quality—Overall, the 104th Congress did not spend much time on air quality issues; the legislation that was introduced was aimed at reducing the requirements of the Clean Air Act. Representative Joe Barton (R-TX) introduced legislation (H.R. 3519) in May to amend the Clean Air Act by allowing, among other things, sources of pollution to trade emissions credits. The measure would permit state emission trading programs as long as they do not cause a region to miss an attainment deadline or a rise in emissions. In addition, the bill would allow facilities to make minor changes in their operations without first obtaining approval from the Environmental Protection Agency.

Other provisions of the bill included excluding minor new source reviews from the operating permit program, providing for facility-wide emission caps instead of subsections of facilities, and extending the term for operating permits from five years to ten. Although the measure was not considered on the House floor, supporters of the bill hope to introduce some of its provisions in a second bill in the next Congress.

Environmental Crimes—As part of his reelection campaign, President Clinton proposed legislation which would increase penalties for environmental crimes and would provide prosecutors with new ways to prevent such crimes. The bill (S. 2096) based on this proposal was introduced by Senator Frank Lautenberg (D-NJ) on Sept. 19.

Provisions in the bill included (1) increasing the maximum prison sentence for serious injuries or deaths occurring as a result of a violation of an environmental statute; (2) allowing prosecutors to seize the assets of those charged with environmental crimes prior to a conviction; (3) extending the statute of limitations for environmental crimes an additional three years if a polluter has deliberately concealed a violation; (4) forcing individuals convicted of violating federal environmental laws to help pay for the cost of their prosecution and for cleanup of the polluted area; and (5) permitting prosecutors to charge individuals or companies with attempted criminal acts against the environment even if the violation is not actually committed.

Although Congress adjourned before any action could be taken on the bill, supporters hope that the issues raised will be considered in another bill in the next Congress.

Superfund—The inability to reach an agreement on bipartisan language to reform the Superfund hazardous waste cleanup program, as well as an emphasis on other environmental issues, led to a stalemate on reform legislation in Congress. The House Superfund bill, H.R. 2500, stalled in the House Commerce Committee without even being marked up for consideration. In the Senate, negotiators from both parties worked through the summer to develop a compromise, but finally conceded defeat when they were unable to reach agreement on specific issues.

Reforming the retroactive liability provisions of the Superfund program was the primary issue that dominated the disagreements between Republicans and Democrats. Republicans wanted at least a partial repeal of retroactive liability, which holds companies responsible for waste that was disposed of legally before enactment of Superfund in 1980. However, Democrats bitterly opposed any shift of cleanup costs away from polluters and onto the federal government. At presstime, the Clinton administration was said to be considering pushing for a more-scaled back Superfund reform bill in the next Congress, rather than the comprehensive reform that the GOP wants.

Republican leaders had not yet decided whether to concentrate on Superfund reform next year.

Additionally, the taxes that fund the Superfund program expired at the end of 1995 and have not been reenacted. Although Democrats introduced a bill at the end of the session to reauthorize these taxes, it died in the Senate. Key Republicans, including Bill Archer (R-TX), the chair of the House Ways and Means Committee, have stated that they oppose reauthorizing the taxes until the Superfund program itself has been overhauled.

Product Liability—Republican efforts to reform product liability lawsuits ended on May 2 when President Clinton vetoed legislation (H.R. 956) that would have limited damages awarded in such lawsuits. The legislation would have restricted punitive damages

in product liability cases to \$250,000, or twice the compensatory damages, whichever is greater. For small businesses with less than 25 employees, the limit would have been the lesser of the two amounts. In his veto message, Clinton stated that he vetoed the bill because he believes that, although the American legal system is in need of reform, H.R. 956 would not have sufficiently protected consumers' safety. The House's attempt on May 9 to override the veto fell 23 votes short of the two-thirds majority needed.

Toxic Substances Bill Introduced Before Adjournment—Only a few days before Congress adjourned, H.R. 4234, the Public Right-to-Know and Children's Environmental Health Protection Act, was introduced. Among other things, the bill would expand the report-

ing requirements for toxic chemicals, including the submission of annual materials accounting information. New reporting thresholds for toxic substances such as cadmium, lead and other heavy metals would be established. The bill would also require the Environmental Protection Agency to create a program to make this information readily available to the public. Additionally, the legislation would allow private citizens to bring a civil suit against a facility for failing to disclose a hazardous synthetic chemical in any children's food or consumer product.

Congress adjourned before any further action could be taken on the legislation. However, interest in expanding toxic substances reporting is increasing; a similar bill may be introduced in the next session of Congress.

States Proposed Legislation and Regulations

CALIFORNIA

Air Quality (Proposed Regulation)—A proposed rule (96 CARR 1851; 10/4/96) of the California Air Resources Board (CARB) would postpone the effective date of the 25% standard for aerosol adhesives to January 1, 2002 and would require aerosol adhesives operations to provide information on product sales, and research and development. Contact Julie Billington, CARB, (916) 327-1516.

A proposal (96 CARR 1855; 10/4/96) issued by the California CARB would incorporate by reference a new test method for the determination of volatile organic compounds (VOCs) from consumer products, and would amend provisions regarding the reduction of VOC emissions from aerosol coatings. Contact George Lew, CARB, (916) 263-1630.

The South Coast Air Quality Management District (SCAQMD) adopted amendments to their Rule 1113 regulating VOC emissions from architectural coatings. The amendments affect flat house paints, lacquers, specialty coatings, and traffic paint. The revisions establish VOC emissions from flat house paints at 100 grams per liter by July 1, 2001; in 2008, the limit will be set at 50 g/l. Contact SCAQMD, (909) 396-2000.

Hazardous Waste (Regulation)—The California Department of Toxic Substances Control (DTSC) has readopted an emergency rule (96 CARR 1712; 9/6/96) which establishes procedures for public agencies to operate permanent household hazardous waste collection facilities under permit-by-rule standards. The regulation went into effect Aug. 23. Contact Joan Ferber, DTSC, (916) 322-6409.

A final rule (96 CARR 1890; 10/4/96) of the California DTSC eliminates obsolete hazardous waste facility permitting requirements and simplifies permitting standards. The regulation went into effect Oct. 20. Contact Joan Ferber, DTSC, (916) 324-1806.

Lead—CA A. 1195 (Morrissey) requires the adoption of regulations which define a *de minimis* amount of lead use and provides that any employer who is within this definition is exempt from payment of certain fees. The governor signed the bill on Sept. 21.

Toxic Substances (Notice)—The California Office of Environmental Health Hazard Assessment (OEHHA) has requested information (96 CARR 1864; 10/4/96) on chemicals, including cadmium, to be considered by the state Science Advisory Board for regulating

under Proposition 65. Contact Cynthia Oshita, OEHHA, (916) 445-6900.

CONNECTICUT

Air Quality (Regulation)—A final rule (58 CTLJ 9B; 9/24/96) adopted by the Connecticut Department of Environmental Protection (DEP) amends the definition of VOC to exclude acetone; parachlorobenzotrifluoride; and cyclic, branched or linear methylated siloxanes. The regulation was effective Aug. 23. Contact Ellen Walton, DEP, (203) 424-3027.

FLORIDA

Occupational Safety and Health (Proposed Regulation)—The Florida Department of Labor and Employment Security (DLES) proposed a rule (22 FLAR 5692; 10/4/96) which would increase the number of employees to 20 after which an employer must establish a workplace safety committee. Contact Matt Croghan, DLES, (904) 488-3044.

Solid Waste (Regulation)—A final regulation (22 FLAR 5454; 9/20/96) of the Florida Department of Environmental Protection (DEP) simplifies criteria for underground

storage tank systems by establishing registration fees and financial responsibility standards; amending performance and inventory requirements; and modifying procedures for reporting discharges. The rule became effective Sept. 30. Contact Betsy Hewitt, DEP, (904) 921-9638.

The Florida DEP proposed a regulation (22 FLAR 5583; 9/27/96) which would eliminate fees assessed for storage tank system non-compliance. Contact Mary Stewart, DEP, (904) 488-9730.

HAWAII

Water Quality (Regulation)—A final regulation adopted by the Hawaii Department of Health (DOH) amends current requirements concerning national pollution discharge elimination system permits, including increasing filing fees. The rule was effective Sept. 23. Contact DOH, Environmental Management Division, (808) 586-4309.

ILLINOIS

Air Quality—IL H. 3763 (O'Connor) provides that an owner or operator seeking an operating permit for a pollution control facility may not conduct any operations at that facility before the final permit has been issued without an interim permit. The bill was introduced on Nov. 7 and sent to the House Rules Committee.

Lead (Proposed Regulation)—A proposed regulation (20 ILR 13283; 10/11/96) of the Illinois Department of Public Health would, among other things, delete the requirement that children under the age of seven provide proof of a blood test for lead poisoning before entering day care or school; require the state to identify high- and low-risk areas for lead poisoning; and specify methods for investigating sources of lead poisoning. Contact Gail DeVito, DPH, (217) 782-6187.

INDIANA

Air Quality (Regulation)—The Indiana Department of Environmental Management (DEM) adopted a final rule (20 INR 6; 10/1/96) concerning air quality which adds two new subdivisions specifically applicable to dip or flow operations at miscellaneous

metal coating operations. The regulation became effective Sept. 20. Contact Patricia Troth, DEM, (317) 233-5681.

A final regulation (20 INR 8; 10/1/96) adopted by the Indiana Department of Environmental Management (DEM) establishes a permit-by-rule for sources with very small actual emissions; sets up procedures for exempting sources from Title V requirements; requires sources to demonstrate compliance if requested by the state; and specifies recordkeeping requirements. The rule went into effect Oct. 5. Contact Mike Brooks, DEM, (317) 233-5686.

Auto Refinishing (Notice)—The Indiana DEM issued a policy document concerning requirements for gun cleaners used in automotive refinishing operations which states the state will not impose any enforcement action for gun cleaning standards until Feb. 1, 1997. Contact DEM, (317) 232-8223.

IOWA

Lead (Proposed Regulation)—The Iowa Department of Public Health (DPH) has issued an emergency rule (19 IAAB 657; 10/9/96) which establishes procedures for the voluntary certification of lead inspectors. The regulation was effective Sept. 16. Contact DPH, (515) 281-5787.

KANSAS

Air Quality (Regulation)—The Kansas Department of Health and Environment (DHE) has adopted a rule which establishes a general Class II air emission source operating permit for facilities that have actual emissions below 50 % of major source thresholds. Contact Connie Careno, DHE, (913) 296-6422.

Water Quality (Regulation)—A final regulation (15 KSR 1402; 9/12/96) of the Kansas DHE establishes new waste water permit fee categories, and sets up fees for general and storm water permits. The rule went into effect Sept. 27. Contact Christine Seeds, DHE, (913) 296-5506.

KENTUCKY

Air Quality (Proposed Regulation)—A regulation (23 ARKY 1646; 10/1/96) proposed by the Kentucky Department for Environ-

mental Protection (DEP) would, among other things, (1) establish Part 70 operating permit application procedures; (2) specify application information and renewal procedures; (3) adopt methods for making permit modifications; and (4) establish permit issuance procedures. Contact Kenneth Hines, DEP, (502) 573-3382.

Lead (Proposed Regulation)—The Kentucky Department for Public Health (DPH) intends to promulgate a regulation which would establish training and certification requirements for persons who perform lead hazard detection and abatement; and specify permit fees, permit requirements and procedures, and standards for performing lead hazard abatement in target housing and child-occupied facilities. Authority for this rule is provided by S. 168, approved earlier this year. Contact DPH, (502) 564-2150.

LOUISIANA

Hazardous Materials Transportation (Regulation)—The Louisiana Department of Public Safety and Corrections (DPSC) has issued an emergency regulation (22 LAR 801; 9/20/96) which amends hazardous materials transportation requirements to establish a permit fee of \$75. The rule was effective Sept. 1, and will expire on Dec. 30, 1996, or upon adoption as a final rule, whichever comes first. Contact Mike Manuel, DPSC, (504) 925-6006.

MAINE

Air Quality (Proposed Regulation)—A proposed regulation of the Maine Department of Environmental Protection (DEP) would establish air quality performance standards and emission limits based on controls for regulated industries and incorporates federal requirements for recordkeeping and monitoring. Contact Deb Avalone-King, DEP, (207) 287-2437.

MARYLAND

Occupational Safety and Health (Regulation)—The Maryland Department of Labor, Licensing and Regulation (DLLR) adopted a final regulation (23 MDR 1466; 10/11/96) which incorporates by reference federal amendments

concerning personal protective equipment in general industry. The rule was effective Oct. 21. Contact DLLR, (410) 333-4184.

MASSACHUSETTS

Air Quality (Regulation)—A final rule (801 MAR 75; 10/4/96) of the Massachusetts Department of Environmental Protection (DEP) revises the state operating permit program and establishes a 50 percent rule to defer a facility's applicability to Titles III and V of the federal Clean Air Act Amendments. The regulation went into effect Oct. 4. Contact Robert Donaldson, DEP, (617) 292-5619.

Regulatory Fees (Proposed Regulation)—The Massachusetts DEP proposed a regulation (801 MAR 38; 10/4/96) which would clarify, reduce, eliminate or add fees affecting air quality, hazardous waste, water quality, and waste cleanup. Contact Victoria Phillips, DEP, (617) 338-2255.

MICHIGAN

Water Quality (Proposed Regulation)—A proposed regulation (1996 MIR 78; 9/30/96) of the Michigan Department of Environmental Quality (DEQ) would amend requirements for water quality standards and effluent limit development for toxic substances by specifying standards for waste load allocations; detailing special conditions for bioaccumulative chemicals; and establishing compliance schedules. Contact DEQ, (517) 373-1949.

MINNESOTA

Occupational Safety and Health (Proposed Regulation)—The Minnesota Department of Labor and Industry (DLI) proposed a rule (21 MNSR 418; 9/23/96) which would incorporate by reference federal Occupational Safety and Health Administration (OSHA) standards for personal protective equipment used in general industry. Contact DLI, (612) 297-3524.

NEW HAMPSHIRE

Air Quality (Proposed Regulation)—A regulation (16 NHRR 3; 9/20/96) proposed by the New Hampshire Department of Environmental Services (DES) would simplify requirements for all major sources of hazardous air

pollutants and would maintain the current air toxics program for three years. Contact Susan Jones, DES, (603) 271-7874.

The New Hampshire DES has proposed a temporary rule (16 NHRR 11; 9/20/96) which would establish two types of open market trading programs. Under the programs, sources may generate or use emission reductions credits to comply with VOC requirements. Contact Joseph Fontaine, DES, (603) 271-6794.

NEW JERSEY

Hazardous Waste—NJ A. 2250 (Bagger) limits the liability of hazardous substance facilities at which accidental discharges damaged property or natural resources. The Assembly Committee on Agriculture and Waste Management amended and released the bill on Nov. 7.

NEW MEXICO

Hazardous Materials (Regulation)—A final rule (7 NMR 829; 10/15/96) of the New Mexico Department of Public Safety (DPS) establishes a new curriculum for hazardous material accident response training and certification programs. The regulation was effective Oct. 15. Contact Max Johnson, DPS, (505) 827-9223.

Hazardous Waste (Proposed Regulation)—The New Mexico Environmental Improvement Board (EIB) proposed a regulation (7 NMR 730; 9/30/96) which would incorporate by reference amendments to the current federal standards for hazardous waste management. Contact Coby Muckelroy, EIB, (505) 827-1558.

Solid Waste (Proposed Regulation)—A proposal (7 NMR 730; 9/30/96) of the New Mexico EIB would update underground storage tank requirements by amending standards for registration of tanks, annual fees, release detection, closure, and financial responsibility. A hearing on the rule was held on Dec. 13 in Santa Fe. Contact Anna Richards, EIB, (505) 827-0158.

NEW YORK

Air Quality (Regulation)—A final regulation (18 NYSR 5; 10/2/96) adopted by the New York Department of Environmental Conservation (DEC) establishes a phased

schedule for acting on Title V permit applications submitted by major sources of air pollution. The rule went into effect Oct. 11. Contact Maris Tirums, DEC, (518) 457-6374.

Solid Waste (Proposed Regulation)—A proposed rule of the New York DEC would incorporate federal hazardous waste management standards for testing and monitoring procedures; the definition of solid waste; the universal waste standard; organic air emission standards for specified facilities; and land disposal Phase III restrictions. Contact Antoinette Norfleet, DEC, (518) 457-0532.

Water Quality (Notice)—The New York DEC has issued a technical and operational guidance document which details procedures for incorporating toxicity testing into state pollution discharge elimination system permits. Contact Edward Kurzia, DEC, (518) 457-7470.

OKLAHOMA

Lead (Regulation)—An emergency rule adopted by the Oklahoma Department of Environmental Quality (DEQ) establishes general provisions, procedures, and fee schedules for the examination and certification of persons who are trained to inspect for the presence of lead-based paint or to evaluate the hazards associated with lead-based paint. The rule, which went into effect Sept. 3, will expire on July 14, 1997. Contact Toni Payne, DEQ, (405) 290-8247.

OREGON

Lead (Regulation)—An emergency rule of the Oregon Division of Health (DOH) establishes certification requirements for lead-based paint inspectors, risk assessors, and other personnel. The regulation went into effect Sept. 30 and will expire March 28, 1997. Contact Malinda Schofield, DOH, (503) 731-4000.

Occupational Safety and Health (Proposed Regulation)—The Oregon Occupational Safety and Health Division (OSHD) proposed a regulation (36 ORRB 11; 10/1/96) which would incorporate by reference federal standards for personal protective equipment requirements for general industry. Contact Sue Joye, OSHD, (503) 378-3272.

PENNSYLVANIA

Solid Waste (Regulation)—A final rule (26 PAB 4735; 9/28/96) of the Pennsylvania Environmental Quality Board (EQB) incorporates federal standards for underground storage tanks, eliminates unnecessary certification categories, amends certification renewal requirements and performance standards, and updates tank tightness testing criteria. The regulation was effective Sept. 28. Contact Karl Sheaffer, EQB, (717) 772-5800.

TENNESSEE

Air Quality (Proposed Regulation)—The Tennessee Air Pollution Control Board (APCB) proposed a rule which would limit VOC emissions from wood furniture coating and lithographic printing operations in specific counties in the state. Contact APCB, 9th floor, L&C Annex, 401 Church Street, Nashville, TN 37243-1531.

Occupational Safety and Health (Regulation)—The Tennessee Department of Labor (DOL) adopted a final rule which establishes a program to provide employers with exemptions from general schedule inspections and establishes procedures for obtaining such an exemption. The regulation became effective July 29. Contact DOL, (615) 741-7151.

Water Quality (Regulation)—A regulation adopted by the Tennessee Department of Environment and Conservation (DEC) concerning the national pollutant discharge elimination system specifies criteria for issuing permits and licenses, details notification and recordkeeping requirements, and establishes methodology for the calculation of permit conditions. The rule went into effect Nov. 25. Contact: Thomas Roehm, DEC, (615) 532-0625.

TEXAS

Lead (Proposed Regulation)—A proposed regulation (21 TXR 9225; 9/27/96) of the Texas Department of Health (DOH) would reduce the adult elevated blood lead reporting level from 40 micrograms per deciliter of blood to 25 in order to meet federal guidelines. Contact Patricia Schnitzer, DOH, (512) 458-7269.

UTAH

Air Quality (Proposed Regulation)—The Utah Department of Environmental Quality (DEQ) proposed a rule (96 UTSB 41; 9/1/96) which would incorporate federal national emission standards for hazardous air pollutants, and would simplify reporting and enforcement requirements for sources of air pollution. Contact Jan Miller, DEQ, (801) 536-4042.

The Utah DEQ adopted a final rule (96 UTSB 96; 10/1/96) which incorporates by reference federal new source performance standards for stationary sources. The regulation became effective Sept. 9. Contact Jan Miller, DEQ, (801) 536-4042.

Occupational Safety and Health (Proposed Regulation)—A proposed rule issued by the Utah Industrial Commission (IC) would incorporate by reference federal occupational safety and health requirements for the use of personal protective equipment in general industry. Contact William Adams, IC, (801) 530-6897.

VIRGINIA

Lead (Regulation)—A rule adopted by the Virginia Board for Asbestos Licensing and Lead Certification (BALLC), among other things, creates standards for conducting lead-based paint

activities, and establishes training requirements for individuals involved in lead paint abatement. The regulation became effective Nov. 13. Contact David Dick, BALLC, (804) 367-8507.

WASHINGTON

Air Quality (Regulation)—The Washington Department of Ecology (DOE) adopted a rule (96 WASR 18; 10/2/96) which adds new source category requirements for sources of air pollution in the form of maximum achievable control technology and new source performance standards; amends the definition of VOC to conform with the federal definition; and makes it illegal to make a false statement on any form or report. The regulation was effective Oct. 14. Contact Peter Lyon, DOE, (360) 407-7530.

WISCONSIN

Transportation (Proposed Regulation)—A proposed rule (489 WIAR 31; 9/30/96) of the Wisconsin Department of Transportation (DOT) would adopt federal standards for motor carrier safety for both intrastate and interstate commerce. Contact Lyle Walheim, DOT, (608) 266-0305.

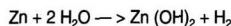
Water Quality (Proposed Regulation)—A proposal (489 WIAR 26; 9/30/96) issued by the Wisconsin Department of Natural Resources (DNR) would, among other things, (1) update methodologies regarding surface water quality criteria for toxic substances; (2) permit the determination of temporary secondary values for toxic substances to calculate water quality; and (3) allow for the implementation of pollution minimization programs. Contact Beth Goodman, DNR, (608) 266-3219.

Stabilization of Zinc Pigments in Aqueous Alkaline Media by Paint Resins

Bodo Müller—Fachhochschule Esslingen - Hochschule für Technik*

Introduction

Zinc pigment¹ has been used as an anti-corrosive pigment in solvent-borne paints, especially primers. Waterborne paints, whose pH values are about 8, significantly reduce the emission of organic solvents to the atmosphere during paint application. One of the problems of waterborne anticorrosive paints with zinc pigment is the corrosion reaction of zinc in aqueous alkaline paint media, which causes the formation of hydrogen (detailed studies of the corrosion reaction of different types of zinc pigments in aqueous alkaline media are presented in references 2 and 3):



Therefore, inhibition of this corrosion reaction is necessary. Zinc pigments can be stabilized by addition of chromate⁴ which is carcinogenic. So, alternative nontoxic methods for the inhibition of this corrosion reaction are required.

Recent investigations reported the corrosion inhibition of aluminum pigment in aqueous medium (pH = 10/dimethylethanolamine) by paint resins.⁵ Furthermore, some paint resins were found to be fair corrosion inhibitors for zinc pigments in aqueous medium (pH = 10/ammonia).⁶ The corrosion inhibition of zinc pigment by paint resins could be much improved if triethylamine (TEA) instead of ammonia was used for adjusting the pH value of 10⁶; unfortunately, only a few experiments were carried out with TEA.⁶

There are now two open questions with respect to the stabilization of zinc pigments by paint resins:

(1) Are there other paint resins (neutralized with TEA) which are better corrosion inhibitors for zinc pigment than those examined in reference 6?

(2) How do paint resins work at a pH value of 8 (the commonly used pH in waterborne paints)? All previous experiments with paint resins were carried out at a pH value of 10.⁶

The second question is not trivial because high-molecular weight polyacrylic acids accelerate the corrosion reaction of aluminum pigment at pH = 8 whereas they inhibit at pH = 10.^{7,8} So, further investigations of the stabilization of zinc pigments by paint resins in waterborne systems are necessary.

The subject of the present investigation is the assessment of different paint resins as possibly effective corrosion inhibitors for zinc pigments in aqueous media at pH values of 8 and 10 (TEA).

Experimental

Lamellar Leafing Zinc Pigment

An unstabilized paste of a lamellar leafing zinc pigment ("zinc flakes")¹ for solvent-borne paints was used for most of the experiments; the paste (average particle 14 μm; specific surface about 8 m²/g solids) contains 10 wt% hydrocarbon solvent. The medium was a mixture of water and butyl ether of ethylene glycol in the ratio 9:1 (butyl ether of ethylene glycol is the most common organic cosolvent in waterborne paints) with addition of 2.0 wt% of a wetting agent (adduct of 10 moles of ethylene oxide to nonylphenol). The pH of the medium was raised to 8.0 and 10 with triethylamine (TEA), a commonly used amine for waterborne air-drying paints. Using a magnetic stirrer, 8.76 g of zinc pigment paste was dispersed for five minutes in 100 mL in the medium. The progress of the corrosion reaction at room temperature was studied by daily volumetric measurement of the evolved hydrogen over 35 days. Volumetric measurement of the hydrogen was

performed with a glass flask (containing the zinc pigment dispersion) connected by a glass tube to an inverted graduated cylinder filled with water (Figure 1). Each 2.5 wt% (solids) of different paint resins was dissolved in the solvent mixture before the dispersion of the zinc pigment; this addition level of paint resin is approximately equal to the pigment-binder-ratio of anticorrosive paints with lamellar zinc pigments.¹ The data of the paint resins are summarized in Table 1; because of the fundamental character of this study, paint resins which are not commonly used in anticorrosive paints were included (e.g., saturated polyesters, acrylic resins).

Zinc Dust

In a final test series, spherical zinc dust (average particle 4 μm; specific surface about 0.25 m²/g) was examined (7.88 g zinc dust in 100 mL corrosion medium).

Results and Discussion

Lamellar Leafing Zinc Pigment

Figure 2 shows the progress of the corrosion reaction determined by volumetric measurement of the evolved hydrogen

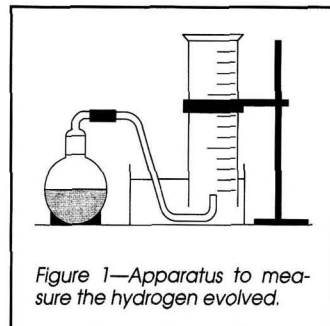


Figure 1—Apparatus to measure the hydrogen evolved.

*Chemieingenieurwesen/Farbe-Lack-Umwelt, Kanalstr. 33, D-73728 Esslingen, Germany.

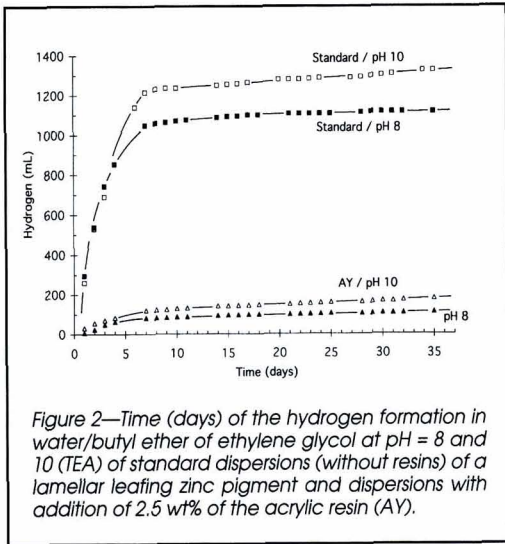


Figure 2—Time (days) of the hydrogen formation in water/butyl ether of ethylene glycol at pH = 8 and 10 (TEA) of standard dispersions (without resins) of a lamellar leafing zinc pigment and dispersions with addition of 2.5 wt% of the acrylic resin (AY).

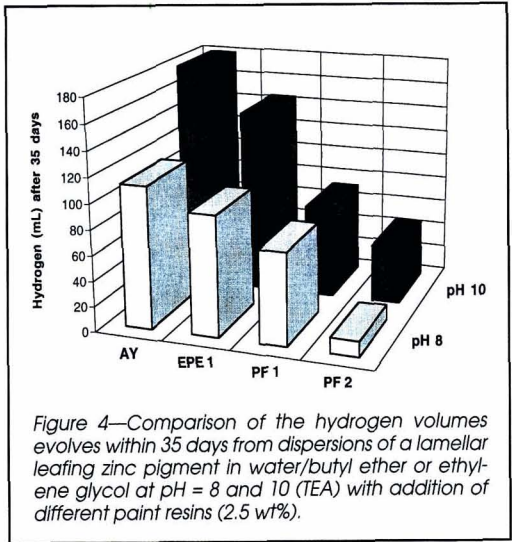


Figure 4—Comparison of the hydrogen volumes evolves within 35 days from dispersions of a lamellar leafing zinc pigment in water/butyl ether or ethylene glycol at pH = 8 and 10 (TEA) with addition of different paint resins (2.5 wt%).

of the standard zinc pigment dispersions (without resin), where, as expected, more hydrogen was evolved at pH = 10 than at pH = 8. Neither standard zinc pigment dispersions reacted completely within 35 days. It was reported previously that a standard zinc pigment dispersion at pH = 10 with ammonia reacted completely to a nearly colorless precipitate (presumably zinc hydroxide) within three weeks at room temperature. The hydrogen volume by complete reaction of the zinc pigment was determined to 2.59 L.³ This is the average value out of 27 gas-volumetric tests with a mean deviation of four percent and a maximum deviation of eight percent which shows the reproducibility of the method.³ With TEA, only 1.33 L of hy-

drogen was evolved from the standard zinc pigment dispersion at pH = 10 (Figure 2). It is obvious (Figure 2) that with addition of 2.5 wt% of the acrylic resin (AY), the corrosion reaction of the zinc pigment was inhibited; at pH = 10 more hydrogen was evolved than at pH = 8 again.

Volumetric measurement of the corrosion reaction of all zinc pigment dispersions with addition of the examined resins showed the same type of time dependency of the hydrogen evolution (see Figure 2). All gas-volumetric results with addition of paint resins at pH = 10 are summarized in Figure 3 (for clarity only the hydrogen volumes after 35

days are plotted). The corrosion inhibiting effect of the paint resins can be classified as follows:

- Good corrosion inhibitors (hydrogen volume < 200 mL): AK 1 - 4, EPE 1, AY and PF 1,2; or
- Fair corrosion inhibitors (hydrogen volume > 200 mL): SP 1, 2 and EPE 2.

Unfortunately, the chemical compositions of the two epoxy ester resins EPE 1 and 2 are not clearly specified by the suppliers (Table 1), so the difference of

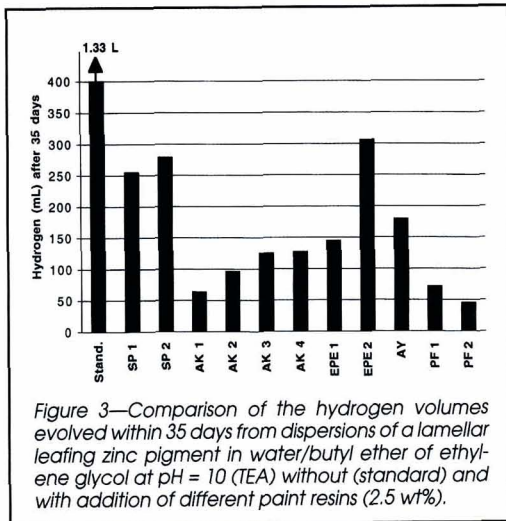


Figure 3—Comparison of the hydrogen volumes evolved within 35 days from dispersions of a lamellar leafing zinc pigment in water/butyl ether of ethylene glycol at pH = 10 (TEA) without (standard) and with addition of different paint resins (2.5 wt%).

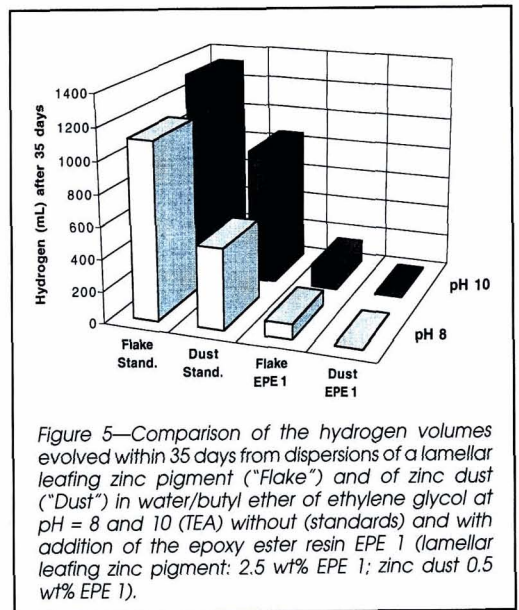
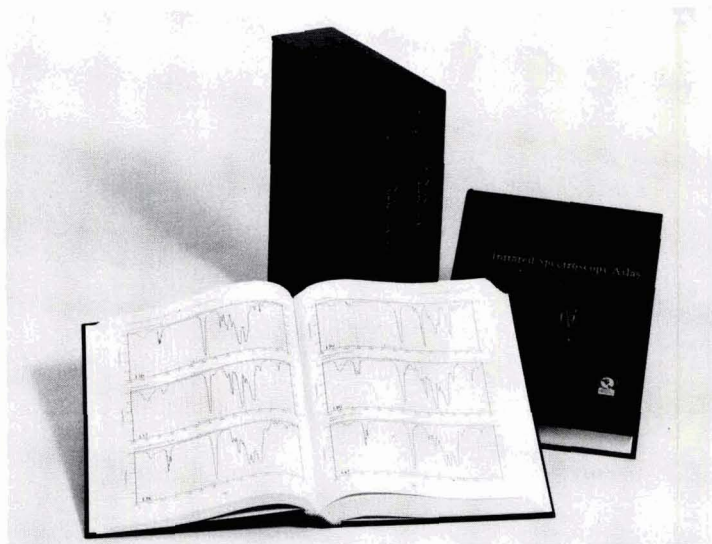


Figure 5—Comparison of the hydrogen volumes evolved within 35 days from dispersions of a lamellar leafing zinc pigment ("Flake") and of zinc dust ("Dust") in water/butyl ether of ethylene glycol at pH = 8 and 10 (TEA) without (standards) and with addition of the epoxy ester resin EPE 1 (lamellar leafing zinc pigment: 2.5 wt% EPE 1; zinc dust 0.5 wt% EPE 1).

An Infrared Spectroscopy Atlas for the Coatings Industry



Two Volumes—1024 Pages, Over 2500 Spectra

This revised and expanded two-volume, fourth edition contains a compilation of more than 2,500 spectra, fully indexed, of materials commonly used in the coatings industry. All spectra have been generated on high resolution Fourier Transform spectrophotometers with recorded spectral ranges covering the region between 4,000 and 400 cm^{-1} .

Authored by experts in the field of coatings infrared analysis, the 1024-page text consists of eight fundamental and comprehensive chapters, including theory, instrumentation, IR instrumentation accessories, sample preparation, and qualitative and quantitative analysis.

A fully indexed literature survey represents the most complete bibliography published in

this type of text. It is organized into sections such as theory, general information, reviews, instrumentation, experimental techniques, compilation of spectra, quantitative analysis, coatings, polymers applications and pigment applications. Each section is in chronological order.

This handsome set is packaged in a sturdy slip case for easy shelf storage.

Also, a computerized database of all the spectra featured in the Atlas has been developed by the Nicolet Instrument Corp., in cooperation with the Federation. The Nicolet Coatings Technology Database is available at additional cost from Nicolet to assist in computer searching during quantitative infrared analysis.

\$150—Federation Members/\$200—Non-Members

Please make all checks payable in U.S. Funds on a U.S. Bank

Federation of Societies for Coatings Technology

**492 Norristown Rd., Blue Bell, PA 19422-2350
(610) 940-0777 • Fax: (610) 940-0292**

Table 1—Data of the Paint Resins According to the Specifications of the Suppliers

Paint Resins Abbreviation	Description	Acid Number ^a (mg KOH/g)	Supplier
1. Saturated Polyester Resins			
SP 1	oil free, linear saturated polyester	50-70	Worlée
SP 2	oil free, branched saturated polyester	45-60	Worlée
2. Alkyd Resins			
AK 1	short-oil, non-drying AK (oil content 32%)	40-50	Worlée
AK 2	short-oil, drying AK (oil content 37%)	35-45	Worlée
AK 3	medium-oil, drying AK (oil content 50%)	50-60	Worlée
AK 4	medium-oil, drying AK (oil content 52%)	48-58	Worlée
3. Epoxy Ester Resins			
EPE 1	drying epoxy ester	45-55	Hoechst
EPE 2	drying epoxy ester (oil content 41%)	no data	DSM
4. Acrylic Resin			
AY	with amino resins crosslinking acrylic resin	70-85	Hoechst
5. Phenolic Resins			
PF 1	heat setting, phenol-epoxy resin precondensate	no data	Hoechst
PF 2	heat setting, plasticized phenolic resin	no data	Hoechst

(a) Acid number refers to solid resin.

their corrosion inhibiting effects could not be explained.

In another test series, the corrosion inhibiting effects of EPE 1, AY, PF 1 and 2 were studied at pH = 8; these gas-volumetric results (compared to pH = 10) are summarized in Figure 4 (for clarity only the hydrogen volumes after 35 days are plotted). It is obvious (Figure 4) that the hydrogen evolution at pH = 8 is mostly lower than at pH = 10. With the addition of PF 2 only 12 mL of hydrogen were evolved at pH = 8; so, only 0.5% of the zinc pigment have reacted. These results show that the corrosion reaction of the lamellar leafing zinc pigment could be effectively inhibited by paint resins.

Zinc Dust

It was reported previously^{2,3} that the rate of the corrosion reaction of zinc pigments in aqueous alkaline medium is influenced by the specific surface area of the zinc pigments; with the lamellar leafing zinc pigment (specific surface about 8 m²/g) more hydrogen was evolved than from spherical zinc dust (specific surface about 0.25 m²/g). In a final test series, the corrosion inhibition of zinc dust by the epoxy ester resins EPE 1 was studied because EPE 1 is a good corrosion inhibitor for the lamellar zinc pigment and epoxy esters are commonly used as binders for zinc-rich paints. The addition level of EPE 1 was only 0.50 wt% which is approximately equal to the pigment-binder-ratio of zinc-rich primers. Figure 5 shows the results with zinc dust in comparison to the lamellar zinc pigment (for clarity only the hydrogen volumes after 35 days are plotted). As expected, the hydrogen volumes

evolved after 35 days are lower for the standard zinc dust dispersions (without resin) than for the lamellar zinc pigment (Figure 5). With addition of 0.50 wt% of EPE 1, only 2 mL of hydrogen were evolved from the zinc dust dispersions within three to six days (pH = 8 and 10); from the 6th to the 35th day no more hydrogen was formed (2 mL of hydrogen are close to the limits of measuring accuracy of the gas-volumetric test method). The aqueous alkaline dispersions of zinc dust with addition of EPE 1 were nearly stable.

Summary

Zinc pigments react in alkaline aqueous media for the evolution of hydrogen. Paint resins inhibit this corrosion reaction at pH value of 8 better than at pH = 10. The examined alkyd resins, phenolic resins, acrylic resin, and one epoxy ester resin are good corrosion inhibitors for the lamellar leafing zinc pigment.

The rate of the corrosion reaction is influenced by the specific surface area of the zinc pigments; with a lamellar leafing zinc pigment (specific surface about 8 m²/g) more hydrogen is evolved than from spherical zinc dust (specific surface about 0.25 m²/g). Addition of one epoxy ester resin almost stabilizes aqueous alkaline dispersions of zinc dust.

The paint resins examined in this study are commercial products used for different types of paints. It should be possible to synthesize paint resins (e.g., epoxy esters) with improved properties "tailor-made" for waterborne anticorrosive paints with zinc pigments.

Acknowledgment

The author is grateful to his former students I. Förster, G. Imblo, P. Kienitz, and W. Kläger for their skillful experimental work.

References

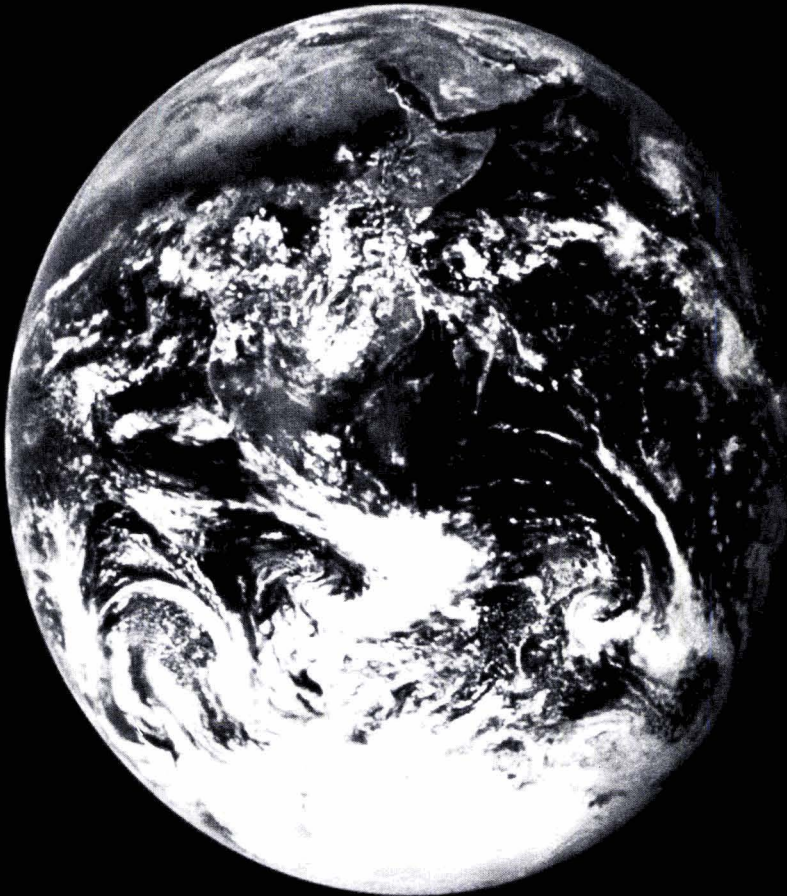
- Besold, R., "Novel Anti-Corrosion Systems Based on Lamellar Zinc Pigments," *Farbe & Lack*, 89, No. 3, 166 (1983).
- Müller, B. and Heilig, M., "Corrosion of Zinc Pigments in Alkaline Aqueous Medium" *Werkst. Korros.*, 46, No. 3, 165 (1995).
- Müller, B. and Kienitz, P., "Zinc Pigments in Waterborne Coatings—Part 1: Influence of the Neutralizing Agents," *Farbe & Lack*, 101, No. 11, 919 (1995).
- Craft Tulloch, R.W., "Waterborne Inorganic Zincs," *Am. Paint Coat. J.*, 75, No. 49, 36 (1991).
- Müller, B., Schmelich, T., and Gampper, M., "Interaction of Binders with Aluminum Pigments in Waterbased Lacquer Systems," *Farbe & Lack*, 101, No. 2, 101 (1995).
- Müller, B. and Kienitz, P., "Zinc Pigments in Waterborne Coatings—Part 2: Influence of the Binders," *Farbe & Lack*, 102, No. 4, 49 (1996).
- Müller, B., Franze, K., and Mebarek, D., "Corrosion Inhibition of Aluminum Pigments in Aqueous Alkaline Media at Different pH Values," *Corrosion*, 51, No. 8, 625 (1995).
- Müller, B. and Dawidowski, U., "pH-Dependency of the Corrosion Inhibiting Respectively Stimulating Effect of Polyacrylic Acids on Aluminum Pigments," *Werkst. Korros.*, 47, No. 3, 154 (1996).

JCT

JOURNAL OF COATINGS TECHNOLOGY

1996 Annual Index of the Journal of Coatings Technology

Volume 68 – Numbers 852-863
January-December, 1996



Keyword Subject Index

Additives

Anti-Sag Aug., p. 57
 Chlorinated Maleinized Gualule Rubber June, p. 67
 Curing Agents Dec., p. 29
 Hardeners Jan., p. 73; Feb., p. 49
 Hindered Light Stabilizers Apr., p. 57
 Initiators Apr., p. 75
 Photoinitiators May, p. 41; Nov., p. 37
 Rheological Agents Mar., p. 51; Apr., p. 63;
 Aug., p. 57; Dec., p. 21
 Silicones Mar., p. 51; Mar., p. 59
 Surface Control Mar., p. 83
 Surfactants June, p. 103; Sept., p. 63
 Thickeners Mar., p. 51
 UV Absorbers Apr., p. 57

Analysis

Accelerated Testing July, p. 47; Dec., p. 39
 Attenuated Total Reflectance June, p. 93
 Casson Yield Value Apr., p. 63
 Chamber Experiments May, p. 41
 Corrosion Resistance Mar., p. 73; June, p. 75
 Dielectric June, p. 99; Oct., p. 97
 Differential Scanning Calorimetry Mar., p. 83;
 Aug., p. 67; Nov., p. 25
 Dynamic Mechanical Analysis Jan., p. 39; Mar., p. 65;
 Nov., p. 25
 Dynamic Thermogravimetric Analysis Mar., p. 73
 Electrical Impedance Spectroscopy June, p. 75; Aug., p. 73;
 Dec., p. 39
 Electrical Resistance Method May, p. 31
 Exposure June, p. 75; July, p. 47
 Fluorescent Microscopy June, p. 83
 FTIR June, p. 93
 Gas Chromatography Oct., p. 87
 Glass Transition Temperature Mar., p. 65; May, p. 49;
 Sept., p. 63; Oct., p. 97; Nov., p. 37
 Impact Strength Mar., p. 65
 Impedance July, p. 33
 Interpretation Graphs July, p. 71
 Lap Shear Mar., p. 65
 Life Cycle Assessment Oct., p. 117; Dec., p. 39
 Microscopy Mar., p. 83
 Microtoming Apr., p. 57
 Phase Inversion Temperature July, p. 39
 Prohesion®/QUV July, p. 47
 Salt Fog Dec., p. 39
 Statistical July, p. 33; July, p. 71
 Tensile Mar., p. 73
 Thermal Stability Mar., p. 65; Oct., p. 97
 Thermomechanical Analysis Nov., p. 25
 UV Irradiance July, p. 47
 Viscometer Aug., p. 57
 Water Vapor Sorption Mar., p. 51

Chemical Compounds

Peroxides Apr., p. 75

Chemical Process

Corrosion Apr., p. 45; June, p. 75; July, p. 47;
 Dec., p. 39; Dec., p. 51
 Degradation May, p. 27; July, p. 33
 Emulsification Feb., p. 49; July, p. 39
 Polymerization Apr., p. 75
 Weathering May, p. 23

Coatings Components

Acrylates Apr., p. 75
 Acrylics Jan., p. 73; Apr., p. 57; June, p. 99;
 Sept., p. 39; Oct., p. 107
 Alkyds July, p. 39
 Bisphenol A and F Jan., p. 73; Mar., p. 65
 Caprolactone Polyols Sept., p. 49
 Chlorinated Rubber July, p. 33
 Chromate Replacement Mar., p. 73; Aug., p. 73
 Chromic Acid Aug., p. 73
 Cycloaliphatic Epoxides Sept., p. 49
 Epoxy Jan., p. 73; Feb., p. 49; Mar., p. 51;
 Mar., p. 65; June, p. 75; Aug., p. 73; Dec., p. 15; Dec., p. 29
 Esters (Poly-) Jan., p. 25; Mar., p. 83; July, p. 63; Dec., p. 15
 Ethylene Diamine Mar., p. 83
 Hindered Lights Stabilizers Apr., p. 57
 Isocyanate Dimer Mar., p. 83
 Latex Jan., p. 39; Jan., p. 63; Feb., p. 33; Feb., p. 41; May, p. 27;
 Sept., p. 63; Oct., p. 97; Nov., p. 25; Nov., p. 37
 Melamine Apr., p. 57; July, p. 63; Aug., p. 83
 Melamine Formaldehyde Jan., p. 25
 Microcapsules Mar., p. 83
 Peroxides Apr., p. 75
 Persulfates Apr., p. 75
 Photoinitiators May, p. 41
 Polycaprolactone Mar., p. 83
 Polyisocyanates Jan., p. 25
 Polyurethane Jan., p. 51; June, p. 93; Sept., p. 39; Dec., p. 15
 Reactive Diluents June, p. 75
 Silicones Jan., p. 69
 Styrene Acrylic Feb., p. 41; May, p. 49
 Sulphuric Acid Aug., p. 73
 Surfactant June, p. 103
 Toluene Mar., p. 83
 Vinyl Acrylic Jan., p. 63; Sept., p. 63
 Volatile Methylsiloxanes Jan., p. 69

Coatings

Adhesion May, p. 27; June, p. 83
 Air-Dry Feb., p. 59; July, p. 63
 Aqueous Sept., p. 39; Nov., p. 19; Nov., p. 33
 Architectural Jan., p. 63; Nov., p. 37
 Automotive Mar., p. 63; Apr., p. 63; June, p. 99;
 Aug., p. 47; Sept., p. 83; Oct., p. 87; Oct., p. 117; Dec., p. 39
 Bake Feb., p. 59; Aug., p. 57
 Basecoat June, p. 99; Oct., p. 87
 Blistering July, p. 47
 Characterization Mar., p. 83

Clearcoat Apr., p. 57; June, p. 99; Aug., p. 47; Oct., p. 87
 Coalescence Feb., p. 33; Aug., p. 35; Sept., p. 63;
 Oct., p. 97; Oct., p. 107
 Composites May, p. 23
 Corrosion (Anti-) Mar., p. 73; Apr., p. 45; June, p. 75;
 Dec., p. 39; Dec., p. 51
 Critical Pigment Volume Concentration Feb., p. 33
 Crosslinkers Jan., p. 25; Feb., p. 59
 Crosslinking Mar., p. 83; June, p. 67; June, p. 93;
 Oct., p. 107; Nov., p. 37
 Curing Jan., p. 63; Jan., p. 73; Apr., p. 35;
 June, p. 99; Aug., p. 67; Dec., p. 29
 Defects June, p. 75; Dec., p. 21
 Degradation Apr., p. 45; May, p. 27
 Deterioration July, p. 33
 Diffusion Mar., p. 51
 Dirt Pickup Nov., p. 37
 Drying June, p. 99; Sept., p. 63; Oct., p. 97
 EB Curing Mar., p. 59
 Emulsification July, p. 39; Nov., p. 43
 Exposure June, p. 75
 Film Formation Jan., p. 25; Jan., p. 51; Feb., p. 33;
 Feb., p. 49; Apr., p. 35; Sept., p. 63; Oct., p. 97; Oct., p. 107
 Flame Retardant Feb., p. 41
 Flexibility Nov., p. 33
 Floor Polish Oct., p. 97
 Free Radical Polymerization Mar., p. 59
 Furniture May, p. 41
 Gloss July, p. 47; Oct., p. 107; Nov., p. 37
 Hardness Nov., p. 33; Nov., p. 37
 High Solids Jan., p. 73; May, p. 49; Aug., p. 83;
 Sept., p. 49; Oct., p. 117
 Hybrid Sept., p. 39
 Industrial July, p. 39; July, p. 47; July, p. 63; Sept., p. 39
 Interface Apr., p. 45
 Interpenetrating Polymer Network Mar., p. 65; Sept., p. 39;
 Nov., p. 25
 Life Cycle Assessment Oct., p. 117
 Low Temperature Dec., p. 29
 Low/Zero VOC Jan., p. 39; Jan., p. 51; Jan., p. 63;
 Feb., p. 41; Feb., p. 59; June, p. 67; Aug., p. 57; Sept., p. 49;
 Oct., p. 117; Nov., p. 19; Nov., p. 33
 Maintenance Coatings Oct., p. 117
 Marine July, p. 47
 Mechanical Properties Jan., p. 39; Jan., p. 51
 Migration Apr., p. 57
 Mixtures July, p. 71
 Model Apr., p. 45; Oct., p. 107
 Morphologies Nov., p. 25
 One-Component System Mar., p. 83
 Overspray Oct., p. 87
 Particle Size Aug., p. 47; Sept., p. 63; Nov., p. 25
 Pigment Volume Concentration Feb., p. 33
 Powder Apr., p. 35; June, p. 67; June, p. 103;
 Aug., p. 47; Oct., p. 107; Dec., p. 15; Dec., p. 21
 Radiation Curing Mar., p. 59
 Repeat Units Jan., p. 73
 Rheological Measurements Apr., p. 63
 Rheology Apr., p. 63; Aug., p. 57; Nov., p. 33
 Self-Emulsification Feb., p. 49
 Solvent-borne May, p. 49
 Solventless Jan. p. 25
 Sprayability Aug., p. 57
 Stains May, p. 23
 Stability Mar., p. 83; June, p. 103; Aug., p. 83; Nov., p. 43
 Stress Feb., p. 33
 Topcoat June, p. 99; Aug., p. 47
 Thermoset Feb., p. 59

Two-Component Jan., p. 51
 UV Curing Mar., p. 59; May, p. 41; Aug., p. 67; Nov., p. 33
 UV Transparent Aug., p. 67
 Varnish Feb., p. 59
 Viscosity May, p. 49; Sept., p. 49
 VOC Jan., p. 39; Jan., p. 63; Feb., p. 41; Feb., p. 59; May, p. 41;
 June, p. 67; Aug., p. 57; Sept., p. 49; Oct., p. 87;
 Oct., p. 117; Nov., p. 33
 Waterborne Jan., p. 51; Jan., p. 63;
 Jan., p. 73; Feb., p. 41; Feb., p. 49; July, p. 39;
 Sept., p. 49; Oct., p. 87; Nov., p. 19; Nov., p. 33
 Water Reducible July, p. 63
 Water Repellents May, p. 23
 Water Sensitivity Mar., p. 51
 Water Sorption Mar., p. 51
 Water Thinnable Jan. p. 25
 Weathering May, p. 23
 Wood May, p. 23; May, p. 27; May, p. 31;
 May, p. 41; May, p. 49
 Wood Fillers Aug., p. 67
 Zinc Rich Primers Dec., p. 51

Computer Applications

Coatings Formulation July, p. 71
 Design of Experiments July, p. 71
 Mixture Design July, p. 71
 Predictive Model July, p. 71; Aug., p. 73
 Statistical Approach July, p. 33; July, p. 71

Films

Curing Jan., p. 63; Jan., p. 73;
 Mar., p. 65; Apr., p. 35; June, p. 99
 Degradation Apr., p. 45
 Dispersion Nov., p. 33
 Drying Oct., p. 97
 Formation Jan., p. 39; Jan., p. 51; Feb., p. 33; Feb., p. 49;
 Apr., p. 35; Sept., p. 63; Oct., p. 97; Oct., p. 107
 Gloss July, p. 47
 Gloss Retention July, p. 47
 Latex Coalescence Jan. p. 39
 Local Film Straining Feb., p. 33
 Mass Transport June, p. 75
 Stress Feb., p. 33
 Structure Apr., p. 63
 Transverse Film Strains Feb., p. 33
 UV Curing Mar., p. 59

Formulation

Design July, p. 71
 Guidelines Nov., p. 19
 Models Apr., p. 45; July, p. 71; Aug., p. 73
 Optimization July, p. 71
 UV Curable Emulsions Nov., p. 43

Oils

Drying Mar., p. 73
 Castor Oil July, p. 63; Sept., p. 57
 Lesquerella Oil July, p. 63
 Linseed Oil Mar., p. 73; Sept., p. 57
 Seed Mar., p. 73
 Styrenation Sept., p. 57
 Sunflower Oil Mar., p. 73
 Vegetable Oil Sept., p. 57

Optics/Color

Distinctness of Image (DOI) Aug., p. 47
Gloss July, p. 47; Oct., p. 107; Nov., p. 37

Pigments

Aluminum Aug., p. 67; Nov., p. 19
Corrosion Inhibitors June, p. 7
Dispersion June, p. 103; Nov., p. 33
Extenders Aug., p. 67
Titanium Dioxide June, p. 103
Zinc Dec., p. 51

Polymeric Components

Acrylic Jan., p. 63; Apr., p. 57; June, p. 99;
Sept., p. 39; Oct., p. 107; Nov., p. 37
Alkyds July, p. 39
Amines Dec., p. 29
Bisphenol A and F Jan., p. 73; Mar., p. 65
Epoxy Jan., p. 73; Mar., p. 65; Dec., p. 15; Dec., p. 29
Epoxy Acrylate Nov., p. 43
Esters (Poly-) Jan., p. 25; July, p. 63; Dec., p. 15; Dec., p. 51
Interpenetrating Polymer Network (IPN) Mar., p. 65;
Sept., p. 39; Nov., p. 25
Isocyanates (Poly-) Jan., p. 25; Jan., p. 51; Jan., p. 63;
Mar., p. 83
Isomers Jan., p. 73
Melamine Apr., p. 57; July, p. 63; Aug., p. 83
Melamine Formaldehyde Jan. p. 25
Novolaks Feb., p. 59
Persulfates Apr., p. 75
Phenolic Feb., p. 59
Polypropylene June, p. 83
Radiation Curable Oligomers Nov., p. 33
Resoles Feb., p. 59
Silicones Jan., p. 69
Styrene Nov., p. 37
Styrene Acrylic Feb., p. 41; May, p. 49
TMI Jan., p. 63
Urethane (Poly-) Jan., p. 51; Mar., p. 65;
June, p. 93; Sept., p. 39; Dec., p. 15
Urethane Acrylates Mar., p. 65; Nov., p. 43
UV Curable Emulsions Nov., p. 43
Vinyl Acrylic Jan., p. 63
Volatile Methylsiloxanes Jan., p. 69

Polymers

Curing Jan., p. 73
Dispersions Sept., p. 39
Free Radical Polymerization Mar., p. 59
Interpenetrating Polymer Network (IPN) Mar., p. 65;
Sept., p. 39; Nov., p. 25
Latex Coalescence Jan., p. 39
Microencapsulation Mar., p. 83
Polymerization Mar., p. 59; Apr., p. 75; Nov., p. 43

Solvent-borne May, p. 49
Thermoplastic Nov., p. 37
Water Vapor Permeability Nov., p. 37

Pretreat/Application

EB Curing Mar., p. 59
Electrostatic Aug., p. 47
Equipment Aug., p. 47
Hot Dipped Dec., p. 21
Overspray Oct., p. 87
Powder Feed Aug., p. 47
Radiation Curing Mar., p. 59
Spray Aug., p. 47
Sprayability Aug., p. 57
UV Curing Mar., p. 59; May, p. 41; Nov., p. 33; Nov., p. 43

Regulatory

Acid Rain May, p. 27
Boothwater Oct., p. 87
Chemical Treatment Oct., p. 87
Emissions May, p. 41; Oct., p. 87
Environment Oct., p. 117
Overspray Paint Oct., p. 87
VOC Content May, p. 41; May, p. 49
Wastewater Oct., p. 87

Solvents

Diluents Jan., p. 69; Sept., p. 49
Exempt Jan., p. 69
Volatile Methylsiloxanes Jan., p. 69

Substrates

Aluminum June, p. 75; Aug., p. 73
Chlorinated Polyolefin June, p. 83
Coating Interface Apr., p. 45; June, p. 93
Corrosion Mar., p. 73; Apr., p. 45;
June, p. 75; July, p. 47; Dec., p. 39; Dec., p. 51
Dirt Nov., p. 37
Furniture May, p. 41
Galvanized Steel Dec., p. 21
Hardboard May, p. 23
Hardwood May, p. 23
Metal Feb., p. 59; Mar., p. 73
Plastics June, p. 83
Plywood May, p. 23
Rust July, p. 33; July, p. 47
Softwood May, p. 23
Steel Apr., p. 45; July, p. 33
Surface June, p. 93
Thermoplastic Olefin June, p. 83
Wood May, p. 23; May, p. 27; May, p. 31;
May, p. 41; May, p. 49
Wood Paneling May, p. 31
Western Redcedar May, p. 27

Alphabetical Listing of Papers

A

- Amine-Functional Curatives for Low Temperature Cure Epoxy Coatings—D.J. Weinmann, K. Dangayach, and C. Smith, Dec., p. 29.
- Analytical Approach for High Quality Appearance Powder Coatings—J.C. Kenny, T. Ueno, and K. Tsutsui, Apr., p. 35.
- Application Equipment for High Quality Appearance Powder Coatings, Especially for Automotive Clear Topcoats—K. Yanagida, M. Kumata, and M. Yamamoto, Aug., p. 47.
- Aqueous Acrylic-Polyurethane Hybrid Dispersions and Their Use in Industrial Coatings—C.R. Hegedus and K.A. Kloiber, Sept., p. 39.
- Aqueous Dispersions for Ultraviolet Light Curable Coatings—Z.J. Wang, J.A. Arceneaux, and J. Hall, Nov., p. 33.

C

- A Challenge: Aluminum Pigments in Aqueous Coatings—Chapman, D.P., Nov., p. 19.
- Characterization and Rheological Investigation of Polymer Microgels Used in Automotive Coatings—L.J. Boggs, M. Rivers, and S.G. Bike, Apr., p. 63.
- Characterization of Two-Stage Latexes Using Dynamic Mechanical Thermal Analysis—B. Rearick, S. Swarup, and P. Kamarchik, Nov., p. 25.
- Chlorinated-Maleinized Guayule Rubber: A Novel Matting Agent for Powder Coatings—W.A. Purvis and S.F. Thames, June, p. 67.
- Coalescence and Film Formation from Latexes—K.L. Hoy, Feb., p. 33.
- Colloidal Aspects of Waterborne Epoxy Paints—V.V. Verkholtantsev, Feb., p. 49.
- Compatibilization of Titanium Dioxide Powders with Non-Polar Media: Adsorption of Anionic Surfactants and Its Influence on Dispersion Stability—M. Arellano, I. Michel-Hacisci, D.L. Feke, and I. Manas-Zloczower, June, p. 103.

D

- Defects in Powder Coatings on Hot-Dipped Galvanized Steel—T. Glauser, A. Hult, A. Hirn, and B. Johansson, Dec., p. 21.
- Dielectric and Thermal Analysis of the Film Formation of a Polymer Latex—J.W. Schultz and R.P. Chartoff, Oct., p. 97.

E

- Electrochemical Impedance Spectroscopy Evaluation of Various Aluminum Pretreatments Painted with Epoxy Primer—S.M. Cohen, Aug., p. 73.
- Emulsification of Alkyds for Industrial Coatings—G. Östberg and B. Bergenstahl, July, p. 39.
- Examination of the Distribution of TPO Adhesion Promoter Material in a Painted TPO System—T.J. Prater, S.L. Kaberline, J.W. Holubka, and R.A. Ryntz, June, p. 83.
- Extent of Solvents and Chemical Oxygen Demand Build-Up in Boothwater Systems Using Waterborne Paint—S.F. Kia, D.N. Rai, and R.L. Williams, Oct., p. 87.

F

- Factors Affecting Dirt Pickup in Latex Coatings—A. Smith and O. Wagner, Nov., p. 37.
- Field Study on the Effect of Acidic Conditions on the Adhesion of Paint to Western Redcedar—M.T. Knaebe, R.S. Williams, and J.W. Spence, May, p. 27.

- Film Formation Mechanism of Two-Component Waterborne Polyurethane Coatings—C.R. Hegedus, A.G. Gilicinski, and R.J. Haney, Jan., p. 51.
- Film Formation of Vinyl Acrylic Latexes; Effects of Surfactant Type, Water and Latex Particle Size—G.A. Vandezande and A. Rudin, Sept., p. 63.
- Flame-Retardant Brominated Styrene-Based Polymers. IX. Dibromostyrene-Based Latexes—J.-L. Wang and N.A. Favstritsky, Feb., p. 41.
- Full-Scale Method for Testing Moisture Conditions in Painted Wood Paneling—S. Hjort, May, p. 31.

H

- High-Solids Coatings Using Benzylanilinium Sulfonates-II α,α -Dimethylbenzylpyridinium *p*-Toluenesulfonate, an Effective Blocked Sulfonic Acid—S. Nakano, T. Morimoto, and T. Endo, Aug., p. 83.
- Hydroxylated Guayule Rubber in Powder Coatings—A. Niroomand, T.P. Schuman, and S.F. Thames, Dec., p. 15.

I

- Impedance Study of the Effect of a Thin Rust Layer at the Steel-Port Interface on Coating Deterioration—S. Feliu, Jr., M. Morcillo, and S. Feliu, July, p. 33.
- Initiators for Water-Based Acrylate Emulsion Polymerizations—L.L. Anderson and W.M. Brouwer, Apr., p. 75.

L

- Latex Blends: An Approach to Zero VOC Coatings—M.A. Winnik and J. Feng, Jan., p. 39.
- Liquid, Sprayable, "Zero" VOC Coatings Utilizing Cycloaliphatic Epoxies—R.F. Eaton and K.T. Lamb, Sept., p. 49.
- Low and No-VOC Architectural Coatings Containing Ambient Curing Functional Groups—Z. Wang and S.F. Thames, Jan., p. 63.

M

- Method for Corrosion Inhibitor Mechanism Studies in Epoxy Coated Aluminum—R.C. MacQueen, R.R. Miron, and R.D. Granata, June, p. 75.
- Microencapsulation of Isocyanates. Characterization and Storage Stability of Microcapsules in a Polyester α,ω -ol—E. Quérat, L. Tighzert, and J.-P. Pascault, Mar., p. 83.
- Migration of Light Stabilizers in Acrylic/Melamine Clearcoats—G. Haacke, F.F. Andrawes, and B.H. Campbell, Apr., p. 57.

N

- Novel Inorganic/Organic Coatings Based on Linseed Oil and Sunflower Oil with Sol-Gel Precursors—S.J. Tuman and M.D. Soucek, Mar., p. 73.

O

- Optimization of Paint Formulations Made Easy with Computer-Aided Design of Experiments for Mixtures—M.J. Anderson and P.J. Whitcomb, July, p. 71.

P

- Painting and Finishing Exterior Wood—W.C. Feist, May, p. 23.
- Performance Optimization of 100% Solids, UV-Cure Inks and Wood Fillers Using Aluminum Trihydroxide (ATH) Filler—

- N.R. Dando, P.L. Kolek, E.S. Martin, and T.R. Clever, Aug., p. 67.
- Phenolic Resins: Revisiting an Established Technology—K. Bourlier, Feb., p. 59.
- Predicting the Water-Sensitivity of Film-Forming Coatings Additives by Water Vapor Sorption: With Application to Thickeners and Rheology Modifiers—G.D. Shay, K.R. Olesen, and J.L. Stallings, Mar., p. 51.
- Preparation of UV Curable Emulsions Using PEG-Modified Urethane Acrylates and Their Coating Properties—M.-E. Song, J.-Y. Kim, and K.-D. Suh, Nov., p. 43.

Q

- Quantitative Determination of Isocyanate Concentration in Crosslinked Polyurethane Coatings—B.W. Ludwig and M.W. Urban, June, p. 93.

R

- Rapid Electrochemical Assessment of Paint—M. Kendig, S. Jeanjaquet, R. Brown, and F. Thomas, Dec., p. 39.
- Recent Developments in Epoxy Resins and Curing Agents—D. Helfand, Jan., p. 73.
- Release of Photoinitiator Fragments from UV-Cured Furniture Coatings—T. Salthammer, May, p. 41.
- A Review of Radiation Curing: New Surface Control Additives—K. Bowling, J. Adams, and S. Struck, Mar., p. 91.
- Rheology of Acrylic Powder Coatings—S.G. Yates, T. Annable, B.J. Denton, G. Ellis, R.M.D. Nasir, D. Perito, and I. Parker, Oct., p. 107.

S

- Stabilization of Zinc Pigments in Aqueous Alkaline Media by Paint Resins—B. Müller, Dec., p. 51.
- Studying the Drying and Curing Rates of Acrylic Automotive Topcoats Using Dielectric Analysis—D.D. Shepard, June, p. 99.
- Synthesis, Characterization, and Application of Lesquerella Oil and Its Derivative in Water-Reducible Coatings—S.F. Thames and H. Yu, July, p. 63.

T

- Toward Solventless Liquid Coatings—F.N. Jones, Jan., p. 25.

U

- Unified Model for the Degradation of Organic Coatings on Steel in a Neutral Electrolyte—T. Nguyen, J.B. Hubbard, and J.M. Pommersheim, Apr., p. 45.
- Use of Castor Oil in the Preparation of Various Oil-Based Binders—O.S. Kabasakal, F.S. Guner, A. Arslan, A. Ergun, A.T. Erciyas, and Y. Yagci, Sept., p. 57.
- Using LCA to Select Coatings for Optimum Environmental and Cost Performance—N.J. Hazel, Oct., p. 117.

V

- Viscosity Reduction via Monomer Selection in Solvent-Borne High-Solids Styrene/Acrylic Coating Resins—C.A. Zezza and K.D. Talmo, May, p. 49.
- Volatile Methylsiloxanes as Exempt Solvents in Protective Coatings—W.A. Finzel, Jan., p. 69.

Author Index

A

- Adams, J.—See Bowling, K.
- Anderson, L.L. and Brouwer, W.M.—Initiators for Water-Based Acrylate Emulsion Polymerizations, Apr., p. 75.
- Anderson, M.J. and Whitcomb, P.J.—Optimization of Paint Formulations Made Easy with Computer-Aided Design of Experiments for Mixtures, July, p. 71.
- Andrawes, F.F.—See Haacke, G.
- Annable, T.—See Yeates, S.G.
- Arceneaux, J.S.—See Wang, Z.J.
- Arellano, M., Michel-Haciski, I., Feke, D.L., and Manas-Zloczower, I.—Compatibilization of Titanium Dioxide Powders with Non-Polar Media: Adsorption of Anionic Surfactants and Its Influence on Dispersion Stability, June, p. 103.
- Arslan, A.—See Kabasakal, O.S.

B

- Benton, B.J.—See Yeates, S.G.
- Bergensstahl, B.—See Östberg, G.
- Bike, S.G.—See Boggs, L.J.
- Boggs, L.J., Rivers, M., and Bike, S.G.—Characterization and Rheological Investigation of Polymer Microgels Used in Automotive Coatings, Apr., p. 63.
- Bourlier, K.—Phenolic Resins: Revisiting an Established Technology, Feb., p. 59.
- Bowling, K., Adams, J., and Struck, S.—A Review of Radiation Curing: New Surface Control Additives, Mar., p. 91.

- Brouwer, W.M.—See Anderson, W.M.
- Brown, R.—See Kendig, M.

C

- Campbell, B.H.—See Haacke, G.
- Chapman, D.P.—A Challenge: Aluminum Pigments in Aqueous Coatings, Nov., p. 19.
- Chartoff, R.P.—See Schultz, J.W.
- Clever, T.R.—See Dando, N.R.
- Cohen, S.M.—Electrochemical Impedance Spectroscopy Evaluation of Various Aluminum Pretreatments Painted with Epoxy Primer, Aug., p. 73.

D

- Dando, N.R., Kolek, P.L., Martin, E.S., and Clever, T.R.—Performance Optimization of 100% Solids, UV-Cure Inks and Wood Fillers Using Aluminum Trihydroxide (ATH) Filler, Aug., p. 67.
- Dangayach, K.—See Weinmann, D.J.
- Denton, B.J.—See Yeates, S.G.

E

- Eaton, R.F. and Lamb, K.T.—Liquid, Sprayable, "Zero" VOC Coatings Utilizing Cycloaliphatic Epoxies, Sept., p. 49.
- Ellis, G.—See Yeates, S.G.

Endo, T.—See Nakano, S.
Erciyas, A.T.—See Kabasakal, O.S.
Ergan, A.—See Kabasakal, O.S.

F

Favstritsky, N.A.—See Wang, J.L.
Feist, W.C.—Painting and Finishing Exterior Wood, May, p. 23.
Feké, D.L.—See Arellano, M.
Feliu, S., Jr., Morcillo, M., and Feliu, S.—Impedance Study of the Effect of a Thin Rust Layer at the Steel-Paint Interface on Coating Deterioration, July, p. 33.
Feliu, S.—See Feliu, S., Jr.
Feng, J.—See Winnik, M.A.
Finzel, W.A.—Volatile Methylsiloxanes as Exempt Solvents in Protective Coatings, Jan., p. 69.

G

Gilicinski, A.G.—See Hegedus, C.R.
Glauser, T., Hult, A., Hirn, A., and Johansson, B.—Defects in Powder Coatings on Hot-Dipped Galvanized Steel, Dec., p. 21.
Granata, R.D.—See MacQueen, R.C.
Guner, F.S.—See Kabasakal, O.S.

H

Haacke, G., Andrawes, F.F., and Campbell, B.H.—Migration of Light Stabilizers in Acrylic/Melamine Clearcoats, Apr., p. 57.
Hall, J.—See Wang, Z.F.
Haney, R.J.—See Hegedus, C.R.
Hazel, N.J.—Using LCA to Select Coatings for Optimum Environmental and Cost Performance, Oct., p. 117.
Hegedus, C.R. and Kloiber, K.A.—Aqueous Acrylic-Polyurethane Hybrid Dispersions and Their Use in Industrial Coatings, Sept., p. 39.
Hegedus, C.R., Gilicinski, A.G., and Haney, R.J.—Film Formation Mechanism of Two-Component Waterborne Polyurethane Coatings, Jan., p. 51.
Helfand, D.—Recent Developments in Epoxy Resins and Curing Agents, Jan., p. 73.
Hirn, A.—See Glauser, T.
Hjort, S.—Full-Scale Method for Testing Moisture Conditions in Painted Wood Paneling, May, p. 31.
Holubka, J.W.—See Prater, T.J.
Hoy, K.L.—Coalescence and Film Formation from Latexes, Feb., p. 33.
Hubbard, J.B.—See Nguyen, T.
Hult, A.—See Glauser, T.

J

Jeanjaquet, S.—See Kendig, M.
Johansson, B.—See Glauser, T.
Jones, F.N.—Toward Solventless Liquid Coatings, Jan., p. 25.

K

Kabasakal, O.S., Guner, F.S., Arslan, A., Ergan, A., Erciyas, A.T. and Yagci, Y.—Use of Castor Oil in the Preparation of Various Oil-Based Binders, Sept., p. 57.
Kaberline, S.L.—See Prater, T.J.
Kamarchik, P.—See Rearick, B.
Kendig, M., Jeanjaquet, S., Brown, R., and Thomas, F.—Rapid Electrochemical Assessment of Paint, Dec., p. 39.

Kenny, J.C., Ueno, T., and Tsutsui, K.—Analytical Approach for High Quality Appearance Powder Coatings, Apr., p. 35.
Kia, S.F., Rai, D.N., and Williams, R.L.—Extent of Solvents and Chemical Oxygen Demand Build-Up in Boothwater Systems Using Waterborne Paint, Oct., p. 87.
Kim, J.-Y.—See Song, M.-E.
Kloiber, K.A.—See Hegedus, C.R.
Knaebe, M.T., Williams, R.S., and Spence, J.W.—Field Study on the Effect of Acidic Conditions on the Adhesion of Paint to Western Redcedar, May, p. 27.
Kolek, P.L.—See Dando, N.R.
Kumata, M.—See Yanagida, K.

L

Lamb, K.T.—See Eaton, R.F.
Ludwig, B.W. and Urban, M.W.—Quantitative Determination of Isocyanate Concentration in Crosslinked Polyurethane Coatings, June, p. 93.

M

MacQueen, R.C., Miron, R.R., and Granata, R.D.—Method for Corrosion Inhibitor Mechanism Studies in Epoxy Coated Aluminum, June, p. 75.
Manas-Zloczower, I.—See Arellano, M.
Martin, E.S.—See Dando, N.R.
Michel-Haciski, I.—See Arellano, M.
Miron, R.R.—See MacQueen, R.C.
Morcillo, M.—See Feliu, S., Jr.
Morimoto, T.—See Nakano, S.
Müller, B.—Stabilization of Zinc Pigments in Aqueous Alkaline Media by Paint Resins, Dec., p. 51

N

Nakano, S., Morimoto, T., and Endo, T.—High-Solids Coatings Using Benzylanilinium Sulfonates-II α,α -Dimethylbenzylpyridinium p -Toluenesulfonate, an Effective Blocked Sulfonic Acid, Aug., p. 83.
Nasir, R.M.D.—See Yeates, S.G.
Nguyen, T., Hubbard, J.B., Pommersheim, J.M.—Unified Model for the Degradation of Organic Coatings on Steel in a Neutral Electrolyte, Apr., p. 45.
Niroomand, A., Schuman, T.P., and Thames, S.F.—Hydroxylated Guayule Rubber in Powder Coatings, Dec., p. 15.

O

Olesen, K.R.—See Shay, G.D.
Östberg, G. and Bergenstahl, B.—Emulsification of Alkyds for Industrial Coatings, July, p. 39.

P

Parker, I.—See Yeates, S.G.
Pascault, J.-P.—See Quérat, E.
Perito, D.—See Yeates, S.G.
Pommersheim, J.M.—See Nguyen, T.
Prater, T.J., Kaberline, S.L., Holubka, J.W. and Ryntz, R.A.—Examination of the Distribution of TPO Adhesion Promoter Material in a Painted TPO System, June, p. 83.
Purvis, W.A. and Thames, S.F.—Chlorinated-Maleinized Guayule Rubber: A Novel Matting Agent for Powder Coatings, June, p. 67.

Q

Quérat, E., Tighzert, L., and Pascault, J.-P.—Microencapsulation of Isocyanates. Characterization and Storage Stability of Microcapsules in a Polyester α,ω -ol, *Mar.*, p. 83.

R

Rai, D.N.—See Kia, S.F.
 Rearick, B., Swarup, S., and Kamarchik, P.—Characterization of Two-Stage Latexes Using Dynamic Mechanical Thermal Analysis, *Nov.*, p. 25.
 Rivers, M.—See Boggs, L.J.
 Rudin, A.—See Vandezande, G.A.
 Ryntz, R.A.—See Prater, T.J.

S

Salthammer, T.—Release of Photoinitiator Fragments from UV-Cured Furniture Coatings, *May*, p. 41.
 Schultz, J.W. and Chartoff, R.P.—Dielectric and Thermal Analysis of the Film Formation of a Polymer, *Oct.*, p. 97.
 Schuman, T.P.—See Niroomand, A.
 Shay, G.D., Olesen, K.R., and Stallings, J.L.—Predicting the Water-Sensitivity of Film-Forming Coatings Additives by Water Vapor Sorption: With Application of Thickeners and Rheology Modifiers, *Mar.*, p. 51.
 Shepard, D.D.—Studying the Drying and Curing Rates of Acrylic Automotive Topcoats Using Dielectric Analysis, *June*, p. 99.
 Smith, A. and Wagner, O.—Factors Affecting Dirt Pickup in Latex Coatings, *Nov.*, p. 37.
 Smith, C.—See Weinmann, D.J.
 Song, M.-E., Kim, J.-Y., Suh, K.-D.—Preparation of UV Curable Emulsions Using PEG-Modified Urethane Acrylates and Their Coating Properties, *Nov.*, p. 43.
 Soucek, M.D.—See Tuman, S.J.
 Spence, J.W.—See Knaebe, M.T.
 Stallings, J.L.—See Shay, G.D.
 Struck, S.—See Bowling, K.
 Suh, K.-D.—See Song, M.-E.
 Swarup, S.—See Rearick, B.

T

Talmo, K.D.—See Zezza, C.A.
 Thames, S.F. and Yu, H.—Synthesis, Characterization, and Application of Lesquerella Oil and Its Derivative in Water-Reducible Coatings, *July*, p. 63.
 Thames, S.F.—See Niroomand, A.
 Thames, S.F.—See Purvis, W.A.
 Thames, S.F.—See Wang, Z.
 Thomas, F.—See Kendig, M.
 Tighzert, L.—See Quérat, E.
 Tsutsui, K.—See Kenny, J.C.

Tuman, S.J. and Soucek, M.D.—Novel Inorganic/Organic Coatings Based on Linseed Oil and Sunflower Oil with Sol-Gel Precursors, *Mar.*, p. 73.

U

Ueno, T.—See Kenny, J.C.
 Urban, M.W.—See Ludwig, B.W.

V

Verkholantsev, V.V.—Colloidal Aspects of Waterborne Epoxy Paints, *Feb.*, p. 49.
 Vandezande, G.A. and Rudin, A.—Film Formation of Vinyl Acrylic Latexes; Effects of Surfactant Type, Water and Latex Particle Size, *Sept.*, p. 63.

W

Wagner, O.—See Smith, A.
 Wang, J.-L. and Favstritsky, N.A.—Flame-Retardant Brominated Styrene-Based Polymers. IX. Dibromostyrene-Based Latexes, *Feb.*, p. 41.
 Wang, Z. and Thames, S.F.—Low and No-VOC Architectural Coatings Containing Ambient Curing Functional Groups, *Jan.*, p. 63.
 Wang, Z.J., Arceneaux, J.A., and Hall, J.—Aqueous Dispersions for Ultraviolet Light Curable Coatings, *Nov.*, p. 33.
 Weinmann, D.J., Dangayach, K., and Smith, C.—Amine-Functional Curatives for Low Temperature Cure Epoxy Coatings, *Dec.*, p. 29.
 Whitcomb, P.J.—See Anderson, M.J.
 Williams, R.L.—See Kia, S.F.
 Williams, R.S.—See Knaebe, M.T.
 Winnik, M.A. and J. Feng.—Latex Blends: An Approach to Zero VOC Coatings, *Jan.*, p. 39.

Y

Yagci, Y.—See Kabasakal, O.S.
 Yamamoto, M.—See Yanagida, K.
 Yanagida, K., Kumata, M., and Yamamoto, M.—Application Equipment for High Quality Appearance Powder Coatings, Especially for Automotive Clear Topcoats, *Aug.*, p. 47.
 Yeates, S.G., Annable, T., Denton, B.J., Ellis, G., Nasir, R.M.D., Perito, D., and Parker, I.—Rheology of Acrylic Powder Coatings, *Oct.*, p. 107.
 Yu, H.—See Thames, S.F.

Z

Zeza, C.A. and Talmo, K.D.—Viscosity Reduction via Monomer Selection in Solvent-Borne High-Solids Styrene/Acrylic Coating Resins, *May*, p. 49.

Constituent Society Papers

Cure Behavior of Silicone-Epoxy and Urethane Modified Acrylates in Interpenetrating Polymer Networks—Detroit Society for Coatings Technology, *Mar.*, p. 65.
 Correlation of Accelerated Exposure Testing and Exterior Exposure Sites Part II: One-Year Results—Cleveland Society for Coatings Technology, *July*, p. 47.

Rheology Modifiers for Low VOC Bake Coatings—New York Society for Coatings Technology, *Aug.*, p. 57.



FEDERATION OF SOCIETIES
FOR COATINGS TECHNOLOGY

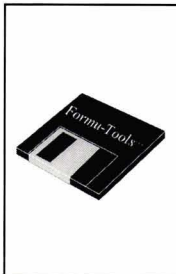


Join Us at the
75th Anniversary Annual Meeting
and
International Coatings Expo and
Technology Conference
of the
Federation of Societies for Coatings
Technology
November 3-5, 1997
Georgia World Congress Center
Atlanta, GA

For more information, contact
FSCT, 492 Norristown Rd., Blue Bell, PA 19422;
(610) 940-0777; Fax: (610) 940-0292
World Wide Web: <http://www.coatingstech.org>

Formulation Software

DTW ASSOCIATES, INC.



Formu-Tools™, from DTW Associates, Inc., is a PC-based software package for raw material and formula information management, formulation analysis and formulation design. The formulation design utilizes an algorithm for calculating ingredient composition, meeting pre-specified formulation variable constraints (such as P/B, VOC, PVC, % solids, etc.). The software allows custom-designed and seven standard analyses.

Circle No. 53 on Reader Service Card

Bench-Top Spectrophotometer

MACBETH DIVISION OF KOLLMORGEN INSTRUMENTS



Macbeth's Color-Eye 7000A, a dual beam bench-top spectrophotometer, is designed for dedicated color analysis in the lab or manufacturing setting. This instrument builds on the reliability and inter-instrument agreement of the Color-Eye 7000, while incorporating several additional automated features including a motorized adjustable UV control, a motorized specular insert, and a touch screen display.

Circle No. 57 on Reader Service Card

Rotor Stator Lab Mill

KADY INTERNATIONAL

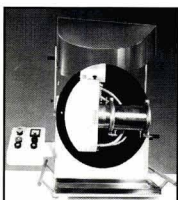


The L2000 top entry, rotor stator, high-speed dispersion lab mill features an enclosed shaft for deaerating capabilities, decreased aeration, and new prop mixers for increased flow. This Kady lab mill is designed to offer continuous thru put rates of 3 to 5 GPM, or batch operation one pint to 3/4 gallons. A newly designed integrated control panel provides variable speed drive for speed and temperature control. Other options include interchangeable dispersion heads.

Circle No. 54 on Reader Service Card

PM1 Lab Media/Perl Mill

DRAISWERKE, INC.



The PM1 Lab Media/Perl Mill introduced by Draiswerke, Inc., offers a screen cartridge for media separation that allows wet grinding and dispersion studies to be conducted with various media sizes down to as small as 200 microns. The mill has been designed to accommodate numerous chambers with varying sizes and materials of construction including ceramic, stainless steel, carbide, or plastic lined.

Circle No. 58 on Reader Service Card

Microwave Digestion Systems

CEM CORPORATION

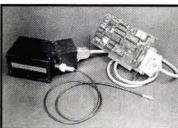


CEM's simultaneous temperature accelerated reactions (STAR) systems are flexible open-vessel microwave digestion systems designed to improve laboratory workflow by eliminating the need to batch sample types. The STAR systems have the ability to run six independent samples with different methods at simultaneous or separate start times and digest larger sample sizes (up to 100 grams-sample dependent).

Circle No. 55 on Reader Service Card

CCD Spectrophotometer

CVI LASER CORP.

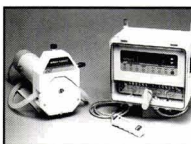


CVI Laser Corp., highlights the SpectraMatch® GT for spectral and color analysis in the production line, QC, and laboratory environments. This instrument has a spectral range of 380 to 760 nm, takes a measurement in 0.5 seconds, has a spectral resolution of 5 nm and can measure small areas with its probe/sensor requiring a surface area of 3 mm in diameter. The SpectraMatch system includes a general purpose Microsoft Windows™ based software package.

Circle No. 59 on Reader Service Card

NEMA Controllers and Pump Drives

BARNANT COMPANY



Four new pump controllers (two in NEMA-ISO enclosures, two in benchtop format) in combination with NEMA 4X "wash down" rated pumps are featured in product literature by Barnant Company. The Series 7592, microprocessor-based controller, provides flow rate, speed, rpm, torque, and repeat dispensing. The Series 7591 offers a full range of speed control, dispensing capability, and torque regulation.

Circle No. 56 on Reader Service Card

Color Formulation and Control

HUNTERLAB



A brochure published by HunterLab, describes EasyMatch™ new color formulation software for paint and opaque coatings. This software lets both the novice and expert formulate new colors, reformulate existing colors, make batch corrections, and work off waste. Color formulation is detailed through 10 different screen displays. There are two ways to complete color formulation: EasyMatch selects the colorants or you do.

Circle No. 60 on Reader Service Card

Laboratory Measurement

BYK-GARDNER



Product information from BYK-Gardner USA, highlights the Universal Stand with positioning accessories, a laboratory stand for the portable handy-color® and handy-spec® instruments. This product allows easy installation of instruments and repeatable positioning of all types of samples, from powders and pellets to draw downs and chips as well as curved or irregular surfaces. In addition, the instrument can be mounted horizontally, vertically, or angled.

Circle No. 61 on Reader Service Card

Coating Thickness Gage

DEFELSKO



The PosiTest® 1000 is the result of an alliance between DeFelsko and Apple Computer's Newton™ MessagePad™. With touch-screen activated buttons, the PosiTest 1000 requires no special commands or keywords to memorize. The user may define processes and create and annotate batches of measurements by selecting from lists of parts and operators created once. The need to download to a PC for analysis has been eliminated.

Circle No. 64 on Reader Service Card

Process Manufacturing System

SOFTWARE 2000



Process manufacturing is an integrated real-time ERP-MRP II system designed by Software 2000 to support

multiple software modules that can be implemented together or on an as needed basis. These modules include advanced planning, manufacturing control, and formula, regulatory, and laboratory management. Seamless integration with Software 2000's financial management, HR/payroll, and materials management applications create a comprehensive solution for process manufacturing organizations.

Circle No. 62 on Reader Service Card

Dual Compartment Electric Universal Oven

THE GRIEVE CORP.

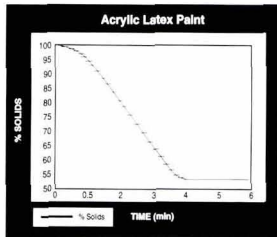
The Grieve Corp. highlights the No. 643, a dual compartment, electrically heated, universal oven. This unit, which cures paint samples, has dimensions of 47 in. x 66 in. x 48 in. and features two compartments, each with a work space of 24 in. x 18 in. x 18 in. The No. 643 includes a separate temperature control for each compartment, mounted in a single control cabinet. Each compartment is equipped with manual reset excess temperature controller, separate heating element control contactors, 130 CFM powered forced exhauster, recirculating blower and powered exhauster air flow safety switch, and purge timer with door interlock.

Circle No. 63 on Reader Service Card

The Mark 2



Simply **the Best**
In Solids Analysis



MATERIAL TESTED

Adhesive
Laminate Material
Paint - Polyurethane Based
Solvent Based Paint
Paint - Acrylic Latex
Pigment Powder - Yellow

Reference

Percent (%)
12.50 S
40.08 S
71.30 S
52.44 S
53.30 S
0.133 M

MARK 2

Percent (%)
12.37 S
40.14 S
71.35 S
52.41 S
53.33 S
0.149 M

- One button operation to start a test with results in minutes
- User friendly with built-in validation/calibration prompt and reporting
- Storage capacity for 200 materials by name
- Durability backed by 2-year warranty

For a Free Evaluation or Information Contact OMNIMARK at:

800-835-3211

Distributed exclusively by

OMNIMARK

INSTRUMENT CORPORATION

101rev1096

CDIC—OCTOBER

"Fires in Paint Plants"

A moment of silence was observed for the passing of Bill Gruber.

Jack Avery, of Cintech Industrial Coatings, Inc., received the Society's Past-President's pin.

Society Representative William Hollifield, of D&L Paint Co., reviewed the proposed FSCT organizational changes regarding membership. Mr. Hollifield requested guidance on how to present the Society's position on various issues to be discussed at the FSCT Board Meeting. A consensus was developed to provide him with clear direction on how to represent CDIC's position on the proposed changes.

The Educational Committee proposed that the Society purchase a series of technology manuals prepared by the Toronto Society for the upcoming paint technology seminars.

A change in the Bylaws was proposed to move up officer elections to allow the incoming treasurer each year to attend the FSCT's new officer orientation meeting.

Jim Reppermund, of DuPont, presented a discussion on "FIRES IN PAINT PLANTS—THE EFFECTS ON PEOPLE."

Mr. Reppermund stated that there are two important items to remember: (1) paint making is a hazardous process; and (2) people do not stop buying paints when a plant is shut down. According to the speaker, 40% of plants with fires go out of business immediately, while 60% are forced to close within a year of the fire due to the loss of business.

Mr. Reppermund focused on deflagration, a fire where the flame speed is under sonic velocity. In a deflagration people are burned by exposed skin areas yielding first and second degree burns. However, in a fuel fed fire, third degree burns are more likely. The key is to protect employees by limiting exposed skin.

The type of clothing worn by the employee can help mitigate the effects of a flash fire, the speaker noted. A video depicted a test dummy on which various types of clothing could be tested to determine the effects of varying duration deflagrations. Using a cotton/poly blend shirt and pants, a 1.5-second burn

would be survivable whereas a three-second burn would be fatal. By contrast, a one-second burn would yield only minimal effects. An all poly shirting material, on the other hand, would melt and catch on fire resulting in a 1.5-second burn. Ultimate protection was provided with a uniform made of Nomex® material which provided survivability up to a five-second burn.

Mr. Reppermund recommended that gloves and a full face shield that covers ears, chin, and the crown of the head be worn in areas where a conflagration is possible. Using the test dummy, he demonstrated the effects of the flame with a limited face shield and a full coverage shield and showed that the shield itself will survive a flash fire.

Q. Are all employees in your plants expected to wear Nomex clothing?

A. No, areas where a conflagration may be found are where employees are expected to wear the clothing. It is important to emphasize it be worn correctly to make it effective. Areas would include loading/filling operations, and handling of open containers.

JOHN E. IMES, *Secretary*

CLEVELAND—SEPTEMBER

"High Pressure Fluid Processing"

On behalf of Dar-Tech, Inc. and Hüls America Inc., Tom Elias, of Dar-Tech Inc., presented a plaque to Society President Richard A. Mikol, of Tremco, Inc.

In addition, Charles Beck presented Mr. Mikol with a book documenting the achievements and contributions made by the chemical and coatings industries in Cleveland from 1796 to 1996.

Mr. Mikol presented Michael Wolfe, of Seegott, Inc., with the Past-President's Pin.

It was announced that the Educational Symposium will be held on May 22-23, 1997.

The evening's technical presentation was delivered by George Weckenbrock, of Divtech Equipment Co. He spoke on "HIGH PRESSURE FLUID PROCESSING."

Mr. Weckenbrock introduced and defined the primary physical forces that



1996-97 Officers of the Cleveland Society include (from left): President—Richard Mikol, Tremco Inc.; Membership Chair—Chris Harding, Coatings Research Group, Inc.; Vice President—Jim Currie, Jamestown Paint Co.; Secretary—Jennifer Rumberg, The Mahoning Paint Corp.; Treasurer—Lamar Brooks, Coatings Research Group, Inc.; and Assistant Treasurer—Pat Wagle, The Flood Co.



Members of the Cleveland Society who attended the September meeting.

drive any mixing process: shear, impact, and cavitation. He continued by comparing the mixing equipment and techniques used to determine the relative contribution of shear, impact, and cavitation to the mixing process.

In order to achieve consistent results in the mixing process, Mr. Weckenbrock explained that a constant pressure and fixed geometry of the mixing device must be present. He also discussed the various types of mixing devices, including a detailed description of each and their relative applications, strengths and limitations. Propeller mixers, disc dispersers, french press, media mill, valve homogenizer, and microfluidizer were compared.

The speaker analyzed several pumping systems, by comparing the pump curves produced by a simplex, duplex, triplex, and Microfluidics intensifier pump to an ideal pump curve. He stated that the intensifier pump offers a higher total pressure capability and consistent pressure stability.

In conclusion, Mr. Weckenbrock explained that each mixing process has a required energy input to achieve the desired result and it is crucial to determine which physical forces (shear, impact, and cavitation) are most important to the process when selecting the proper mixing device.

JENNIFER RUMBERG, *Secretary*

GOLDEN GATE—OCTOBER

Past-Presidents' Night

Scholarship Committee Chair, Marnie Hartmann, of Jones-Hamilton Co., introduced Miles Wilson, of the University of California-Berkeley. Mr. Wilson was awarded one of the Society's scholarships to attend a coatings course at the University of Missouri-Rolla.

Pacific Northwest Society member, Roy Seeman, of Fuji Silysia, spoke on "SILICA GEL FLATTING AGENTS FOR TODAY'S INDUSTRIAL FINISHES."

Mr. Seeman stated that gloss is reduced through silica flattening agents by light diffracted differently due to the roughness of the film surface. There are several different types of flattening agents with different advantages and disadvantages: (1) extender pigments are inexpensive, increase film, and are easily dispersed; however, they are dirty and not efficient; (2) natural silica is also cheap and increases film properties, but it results in silicosis, poor efficiency, and transparency; and (3) amorphous silicas are efficient, very white, transparent, and have a controlled particle size, but they



Officers of the Dallas Society for 1996-97 are (from left—seated): President—Don McBride, Ribelin Sales; Vice President—Mike Templin, Zeneca Resins; and Secretary—Bill Bristol, Jones-Blair Paint. Standing: Treasurer—Joe Hilburn, Sherwin-Williams Paint Co.; and Membership Chair—Barry Clinger, Crozier-Nelson Sales.

are expensive and have a high oil demand.

According to Mr. Seeman, there are three basic types of amorphous silicas: fumed, precipitated, or micronized silica. The primary particles for the precipitated and the fumed are 0.018-0.012 microns, but they are used as flattening agents in the aggregated form of 1.2-1.8 microns. Because the micronized silicas are milled to a controlled size for flattening, they have much less opportunity to be shear sensitive. This also gives a better control in particle size, pore volume, and surface treatment.

One of the main effects of flattening with silicas is film shrinkage; however, this has changed with new technologies. For water-based systems, increasing the pore volume and the particle size improves efficiency. In UV coatings where there is no film shrinkage, the silica needs to be

kept near the surface. Mr. Seeman recommended surface treated low oil absorption varieties. Special considerations include camouflage coatings where the ratio of 60° gloss to 20° gloss is important, therefore, large particle sizes are better. Smaller particle size gives better clarity.

TIM SPECHT, *Secretary*

KANSAS CITY—SEPTEMBER

Installation of Officers

Past-President Lawrence Murphy, of Tnemec Co., Inc., presented Society President Randy Ehmer, of Walsh & Associates, with the President's gavel.



Elected to serve as officers of the Golden Gate Society for 1996-97 are (from left) President—Eve Blackburn, The Flecto Co., Inc.; Treasurer—Harold R. Harlan, III, Harlan Associates, Inc.; Vice President—Don Mazzone, Western Equipment Co.; and Secretary—Timothy G. Specht, The Flecto Co.

Constituent Society Meetings and Secretaries

BALTIMORE (Third Thursday—Martin's West, Woodlawn, MD). COLIN D. CROWLEY, ChemCentral Corp., P.O. Box 690, Fallston, MD 21047.

BIRMINGHAM (First Thursday—Strathallan Hotel, Birmingham, England). RICHARD J. VICKERMAN, Ciba Polymers Ltd., Duxford, Cambridge, Cambs. CB2 4QA, England.

CDIC (Second Monday—Location alternates between Cincinnati, Columbus, Dayton, and Indianapolis). JOHN E. IMES, DuPont Co., 8065 Holyrood Ct., Dublin, OH 43017.

CHICAGO (First Monday—Sharko's Restaurant, Villa Park, IL). WILLIAM C. BELLMAN, The Valspar Corp., 300 Gilman, Wheeling, IL 60090-5808.

CLEVELAND (Third Tuesday—Monthly meeting site to TBA). JENNIFER L. RUMBERG, The Mahoning Paint Corp., P.O. Box 1282, Youngstown, OH 44501-1282.

DALLAS (Second Thursday following first Wednesday—Dallas Medallion Hotel, Dallas, TX). BILL J. BRISTOL, Jones-Blair Co., 2728 Empire Central, P.O. Box 35286, Dallas, TX 75235.

DETROIT (Second Tuesday—meeting sites vary). RAYMOND S. STEWART, Akzo Nobel Coatings, Inc., 1845 Maxwell St., P.O. Box 7062, Troy, MI 48007-7062.

GOLDEN GATE (Monday before third Wednesday—alternates between Francisco's in Oakland, CA, and Holiday Inn in S. San Francisco). DON MAZZONE, Dowd & Guild, Inc., 14 Crow Canyon Ct., #200, San Ramon, CA 94583.

HOUSTON (Second Wednesday—Medallion Hotel, Houston, TX). LARRY BAUER, O'Brien Powder Products, Inc., 9800 Genard, Houston, TX 77041.

KANSAS CITY (Second Thursday—Cascone's Restaurant, Kansas City, MO). DEBBIE KOSS, Davis Paint Co., 1311 Iron St., P.O. Box 7589, N. Kansas City, MO 64116.

LOS ANGELES (Second Wednesday—Steven's Steakhouse, Commerce, CA). JOSEPH C. REILLY, Rohm and Haas Co., 432 Cienaga Dr., Fullerton, CA 92635.

LOUISVILLE (Third Wednesday—Executive West Motor Hotel, Louisville, KY). CHRIS A. LOCKHART, Reynolds Metals Co., 4101 Camp Ground Rd., Louisville, KY 40211.

MEXICO (Every fifteen days—Gabriel Mancera, Mexico City, Mexico). JORGE HUIJUELOS BUENFIL, Hi Fil Pinturas, S.A. de C.V., Camino Canteras No. 3, KM 18.5 Carret, Libre Mexico-Puebla, 56400 Los Reyes la Paz, Mexico.

MONTREAL (First Wednesday—Restaurant Le Bifithèque, St. Laurent, Quebec). ROBERT BENOIT, Kronos Canada Inc., 3390 Marie Victorin, Varennes, Que., J3X 1T4 Canada.

NEW ENGLAND (Third Thursday—Best Western TLC, Waltham, MA). DAVID GORVINE, RSM Sales, 79 Park Rd., Lynn, MA 01904.

NEW YORK (Second Tuesday—Landmark II, East Rutherford, NJ). LARRY WAELE, Troy Corp., 8 Vreeland Rd., Florham Park, NJ 07932.

NORTHWESTERN (Second Tuesday—Jax Cafe, Minneapolis, MN). GLEN VETTER, The Valspar Corp., 1101 S. Third St., P.O. Box 1461, Minneapolis, MN 55440.

PACIFIC NORTHWEST (PORTLAND SECTION—Tuesday before third Wednesday—Tony Roma's, Mall 205, Portland, OR; SEATTLE SECTION—Third Wednesday—Wyndham Gardes Hotel, Sea-Tac, WA; VANCOUVER SECTION—Thursday after third Wednesday—Abercorn Inn, Richmond, B.C.). BEVERLY SPEARS, Synergistic Performance Corp., 5950 6th Ave., St., Ste. 109, Seattle, WA 98108.

PHILADELPHIA (Second Thursday—DoubleTree Guest Suites, Plymouth Meeting, PA). SUE M. NIELSEN, Best Bros. Paint Manufacturing Co., Inc., 172 Shillington Rd., Sinking Spring, PA 19608-2056.

PIEDMONT (Third Wednesday—Ramada Inn Airport, Greensboro, NC). CLARENCE D. HOFFMAN, Kohl Marketing, Inc., 4 Tarrywood Ct., Greensboro, NC 27455.

PITTSBURGH (Second Monday—Montemurro's Restaurant, Sharpsburg, PA). JOSEPH E. HUNT, Palmer Supplies Co. of Pittsburgh, 8980 Perry Hwy., Pittsburgh, PA 15237.

ROCKY MOUNTAIN (Monday following first Wednesday—DelMonico Hall, Denver, CO). JOHN ELVERUM, Hauser Chemical Research, 5555 Airport Blvd., Boulder, CO 80301.

ST. LOUIS (Third Tuesday—The Salad Bowl Restaurant, St. Louis, MO). LOU L. VOIT, Cemsac Chemicals Corp., P.O. Box 6427, Chesterfield, MO 63006.

SOUTHERN (GULF COAST SECTION—third Thursday; CENTRAL FLORIDA SECTION—third Thursday after first Monday; ATLANTA SECTION—third Thursday; MEMPHIS SECTION—bi-monthly on second Tuesday; and MIAMI SECTION—Tuesday prior to Central Florida Section). GREG SCHARFETTER, Thompson Minwax Co., 10136 Magnolia Dr., P.O. Box 667, Olive Branch, MS 38654.

TORONTO (Second Monday—Speranza Restaurant & Banquet Hall Convention Centre, Brampton, Ont., Canada). ALEXANDER KING, Tioxide Canada, Inc., 350 Burnhamthorpe Rd., W., Ste. 210, Mississauga, Ont. L5B 3J1, Canada.

The 1996-97 Society Officers were introduced. They are: President—Randy Ehmer; Vice President—Curry Sanders, of Tnemec Co., Inc.; Secretary—Debbie Koss, of Davis Paint Co.; and Treasurer—Ray Rosiere, of Kansas Paint & Color.

In addition, the Board has commissioned Tom Hilton, of Weskem Hall, as Assistant to the Treasurer.

Society Representative Mark Algaier, of Hillyard Industries, Inc., reported on the FSCT Strategic Plan Implementation Proposal and sought comments/suggestions from the members.

Educational Committee Chair Kim Nee, of Mozel, Inc., reported that the Committee has been developing a program to increase the awareness of the coatings industry to the youth in neighboring communities. Ms. Nee stated that the group has an outline on a demonstration on "How to Make Paint." The committee will present the program to fifth and sixth grade classes.

The meeting's speaker was St. Louis Society member Phil Reynolds, of BYK-Chemie. Mr. Reynolds discussed "ADDITIVES."

Mr. Reynolds explained various additives used in the manufacture of coatings.

According to the speaker, wetting and dispersing additives are used for pigment concentrates. Wetting and dispersing processes are important in all systems, especially water-based and anti-corrosion systems.

Mr. Reynolds discussed the chemistry and properties of silicone additives. In addition, he covered solving defects in paint surfaces with silicone additives, and the relationship with surface tensions of the systems.

Mr. Reynolds described the lifetime of foam and types of foams, explaining that pure liquids do not foam. There are polymeric defoamers and silicone defoamers; they have recently been advanced technically to allow increased foam control.

DEBBIE KOSS, *Secretary*

LOS ANGELES—OCTOBER

"Flating Agents"

A moment of silence was observed for the passing of Jim Elliot, of J.R. Elliot Enterprises, and Neil Conroy.

Denise Crick, of Ameron PCD, reported that the LASCT *Year Book* has been completed and is in the mail.

Environmental Committee Chair Dave Muggee, of E.T. Horn, reported that the U.S. Department of Transportation no longer allows shipping hazardous materials in DOT marked containers (drums). An exception is allowed if the drum was filled before October 1, 1996.

California Proposition 65 added 10 new materials on its list; epichlorohydrin, a reproductive toxicant which can be found in epoxy resins, was one of the ten. Chemical wholesalers and others are to be added to TRI reporting, Section 313. EPA is proposing TRI reporting to be done in mass balance actual numbers rather than ranges. Total workers and total workers exposed are to be reported.

Western Coatings Societies' Symposium and Show (WCSSS) Chair Robert Skarvan, of Engineered Polymer Solutions, Inc., introduced the following committee members: Sam Bellettiere, of TCR Industries, Inc.; Dave Muggee, of E.T. Horn, and Roberta Garcia, of ICI Paints. Mr. Skarvan noted that a memorabilia booth of 1940 and 1950 tools, articles of commerce, and other paint-related objects is being planned.

In addition, Mr. Skarvan stated that the Golden Gate Society is planning only a symposium for 1999 WCSSS.

Pacific Northwest Society member Roy Seeman, of Fuji Silysia Chemical spoke on "SILICA GEL FLATTING AGENTS FOR TODAY'S HIGH QUALITY INDUSTRIAL FINISHES."

Mr. Seeman reviewed the fundamentals of light scattering and what leads to low gloss or flattening of finishes. In addition, he outlined various classes of flattening aids from low cost extender pigment types, e.g., clay or CaCO_3 , and modest efficiency types, e.g., Celite and quartz, through the most efficient silica types.

The amorphous silica agents were classified as either fumed (pyrogenic), precipitated, or micronized. According to Mr. Seeman, these types have a great degree of clarity. He briefly described their origin and keyed in on the latter type also known as silica gel types which are larger particle size (1.8 microns) than the fumed and precipitated type which are in the nanometer size. He reviewed primary particle size, stabilization, surface treatments, and pore volume of the silica gel type and the benefits of pore volume.

Mr. Seeman then discussed several applications including aqueous clears for furniture finishes and UV furniture finishes. The latter cause a special challenge to flattening attempts because of their



Officers for the Montreal Society for 1996-97 include (from left—seated): Past-President—Alain Charbonneau, Bayer Inc.; Treasurer—Luc P  pin, Sico Inc.; President—Ralph Weberbauer, Debro Chemical; and Vice President—Jean-Pierre C  t  , L.V. Lomas. Standing: Mike Montagano, St. Lawrence Chemical Co.; Special Events—Jean J. Brunet, Van Waters & Rogers Lee.; Sylvain B  lisle, Ashland Chimie; Suzanne Richardson, Tioxide Canada Inc.; Technical Chair—R  n   D  cary, Kronos Canada, Inc.; and Society Representative—Horace Philipp, Supply & Services Canada.

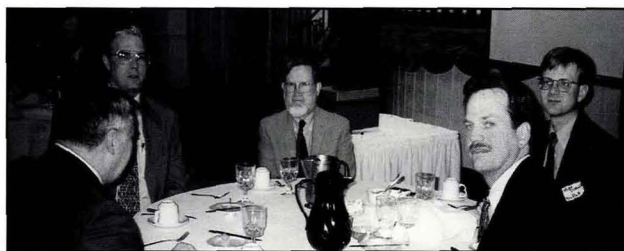


The following will serve as Officers of the Northwestern Society for 1996-97 (from left): Society Representative—Larry Brandenburger, The Valspar Corp.; Treasurer—Robin Norcutt, G.C. Brandt Co.; Vice President—Mike Coad, McWhorter Technologies; President—Jeff Gundry, Horton-Earl Co.; and Secretary—Glen Vetter, The Valspar Corp.



Elected to serve as Officers of the Rocky Mountain Society for 1996-97 are (from left): Secretary—Mike Zink, Kwal-Howells, Inc.; Vice President—Charles E. Schroeder, Fel-Pro Chemical Products L.P.; President—Paul Delmonico, Old Western Paint Co.; Treasurer—John Elverum, Hauser Chemical Research; and Society Representative—Dick Mullen, G-3 Industries.

PITTSBURGH SOCIETY MARCH MEETING



intrinsic gloss. He explained the significance of gloss to sheen ratio as it relates to the angle of observation and why a ratio of one is desirable.

JOE REILLY, *Secretary*

NEW YORK—OCTOBER

Installation of Officers

A moment of silence was observed for the passing of Benjamin Joachim, founder of Superior Materials.

George S. Weber, of Calgon Corp., was recognized for his 25-year membership.

President John Du, of Hüls America Inc., presented the Past-President's pin to Cary Grobstein, of LBL Sales.

Technical Committee Chair Sheila Westerveld, of Standard Coatings Corp., reported that a new project on rheology modifiers is underway.

In addition, Ms. Westerveld stated that NYSCT has a Web site (www.nysct.org). The Web page features information on the Society and the educational programs.

Paul Mazer, of Troy Corp., noted that the 1997 NYSCT Third Bi-Annual Symposium on Additives and Modifiers for Modern Coatings is slated for April 30-May 1, 1997 at the Holiday Inn-North Conference Center. A call for papers has also been issued.

The speaker of the evening was a U.S. Secret Service agent who discussed the agency's history, counterfeiting, and the new \$100 bill.

LARRY WAELDE, *Secretary*

PACIFIC NORTHWEST (VANCOUVER SECTION)— SEPTEMBER

"Factors Affecting Dirt Pickup in Latex Coatings"

Deryk Pawsey, of Rohm and Haas Canada Inc., has been declared a Society Honorary Member.

Technical Committee Chair Yoichi Seo, of Flecto Coatings, Ltd., announced that the Educational and Technical Committees of all three sections will collaborate on a video.

Also, Mr. Seo stated that the University of British Columbia's Forestry Department is interested in starting a coatings related course.

Kelvin Huget, of Imasco Minerals, Inc., will serve as the Chair of the 1997 Spring Symposium, slated for May 8-10, at the Pan Pacific Hotel in Vancouver, British Columbia.

Yvon Poitras, of Mills Paint Sales Ltd., highlighted the FSCT's Strategic Plan. The plan focuses on membership, common interest groups, and organizational restructure.

Dick Stewart, of Firestop Systems, Inc., has resigned as Publicity and Entertainment Chair.

Piedmont Society member Alan Smith, of BASF Corp., discussed "FACTORS AFFECTING DIRT PICKUP IN LATEX COATINGS."

KELVIN HUGET, *Secretary*

ROCKY MOUNTAIN—OCTOBER

"Flattening Agents"

President Paul Delmonico, of Old Western Paint Co., presented a plaque to Christine LesCamela, of Kwal-Howells, Inc., for her past four years of service.

Melinda Rutledge, of Rheox, Inc., urged the members to attend the Western Coatings Societies' Symposium and Show, on February 18-20, 1997, in Anaheim, CA.

The evening's technical speaker was Pacific Northwest Society member Roy Seeman, of Fuji Silysia. He discussed "SILICA GEL FLATTING AGENTS FOR TODAY'S HIGH QUALITY INDUSTRIAL FINISHES."

MIKE ZINK, *Secretary*



Professional Development Committee of the Federation of Societies for Coatings Technology

Presents

“Crosslinking for the Coatings Chemist”

Wednesday-Friday, April 22-24, 1997

Orlando, FL

Course Description

The purpose of this course is to provide information on the physical chemistry involved in crosslinking, including topics such as what it is, fundamentals of inter-intra molecular crosslinking, the temperature requirements, and measurement criteria. The course is designed for the following individuals: formulators, polymer chemists, and those involved in the following end-use applications: automotive, architectural, and general industry. All attendees are required to have a background in chemistry.

Topics to be Covered

Attendees will receive information on the following topics:

Types of Crosslinking Mechanisms
How to Measure Crosslinking Density
Kinetic vs. Diffusion Controlled Crosslinking
Temperature Requirements and Oven Selection
Catalyst Effects
Advances and Interactions with Formulation Variables
Influence of Basecoat Primer

For more information, contact Mike Bell, Director of Educational Services, Federation of Societies for Coatings Technology,
492 Norristown Road, Blue Bell, Pennsylvania 19422-2350; Phone: (610) 940-0777; Fax: (610) 940-0292;
Web Site: <http://www.coatingstech.org>

Baltimore

- (Jan. 16)—"HOW TO CHOOSE THE RIGHT SILICONE ADDITIVE"—Robert E. Ruckle, OSI Specialties.
- (Feb. 20)—Plant tour of General Motors facility.
- (Mar. 20)—General Meeting—To be announced.
- (Apr. 17)—"HIGH PERFORMANCE EMULSIONS FOR UNIVERSAL PRIMERS"—Mike Wildman, E.P.S. and Nominations.
- (May 15)—Election of Officers.

Chicago

- (Jan. 6)—"ISO 9001/BALDRIDGE EXPERIENCES"—Beth Demarest, DSM Desotech.
- (Feb. 3)—"COALESCING SOLVENTS: VOC AND ODOR"—Mike Anchor, BASF Corp.
- (Mar. 3)—"NEW DEVELOPMENTS IN ACRYLATE MODIFIED EPOXY-AMINE CURED COATINGS"—Michael Bailey, Sartomer Co.
- (Apr. 7)—"GENERAL INDUSTRIAL MELAMINE—CROSSLINKED POLYESTER COATINGS—STRUCTURE/PROPERTY CHARACTERISTICS OF DIBASIC ACIDS AND THEIR RELATIONSHIP TO WEATHERING"—Phil Heidt, Eastman Chemical Co.
- (May 30)—Annual Awards Banquet.

Los Angeles

- (Jan. 8)—Federation Officer Visit. "INTRODUCTION OF A 'NEW' DISPERSION TECHNOLOGY"—Herman Hockmeyer, Hockmeyer Equipment Co.
- (Feb. 12)—Spouses' Night.
- (Mar. 12)—"EFFICIENT USE OF TiO₂ IN ARCHITECTURAL FINISHES"—DuPont White Pigments & Minerals Products.
- (Apr. 9)—Bosses' Night. "RHEOLOGY TESTING FOR THE PAINT INDUSTRY"—Scott Crane, Haake Instruments.
- (May 14)—"THE USE OF POLYOLS A 'NEW GENERATION' IN HIGH PERFORMANCE COATINGS"—Steve Seneke, Arco Chemical Co.
- (June 11)—Annual Meeting and Election of Officers.

New York

- (Jan. 14)—Speaker—Saul Spindel, D/L Laboratories.
- (Feb. 13)—Legislative Update.
- (Mar. 4)—Mini Workshop—"APPLICATIONS EQUIPMENT, HVLP, ELECTROSTATIC, ETC."—Dennis Stephens, ITW Ransburg; "TOOLS PC SOFTWARE"—

T. Wu, Formu; "PAINT TECHNOLOGY SUMMARY FOR THE NEW PEOPLE IN THE INDUSTRY"—George Schmitz, S.P. Morell, Inc.; and "SURFACTANT CHEMISTRY SUMMARY"—speaker from Rhone-Poulenc Co.

(Apr. 8)—"OPERATING VARIABLES ON MILLING EFFICIENCY AND MATERIAL WEAR"—Gerald Amback, SEPR.

(May 13)—PaVac Awards Night. "CHEMISTRY OF IRON OXIDES"—George Poldosky, Harcros.

Philadelphia

- (Jan.)—Joint meeting with PPCA.
- (Feb.)—Manufacturers' Night.
- (Mar. 13)—"FAILURE ANALYSIS OF COATINGS"—Bud Senkowski, KTA-Tator.
- (Apr.)—Awards Night.
- (May 8)—"DISPERSANTS FOR INDUSTRIAL COATINGS"—Peter Hibbert, ICI.

Rocky Mountain

Denver/Arizona

- (Jan. 6/7)—"INTRODUCTION OF A 'NEW' BASKETMILL DISPERSION TECHNOLOGY"—Herman Hockmeyer, Hockmeyer Equipment Corp.
- (Mar. 10/11)—"EFFICIENT USE OF TiO₂ IN ARCHITECTURAL FINISHES"—DuPont White Pigments & Mineral Products
- (Apr. 7/8)—"RHEOLOGY TESTING FOR THE PAINT INDUSTRY"—Scott Crane, Haake Instruments.
- (May 12/13)—"THE USE OF POLYOLS A 'NEW GENERATION' IN HIGH PERFORMANCE COATINGS"—Steve Seneke, Arco Chemical Co.



24th Annual International Waterborne, High-Solids, and Powder Coatings Symposium

Co-Sponsored by the Southern Society for Coatings Technology and The University of Southern Mississippi

**February 5-7, 1997
Hyatt Regency Hotel
New Orleans, LA**

**For more information, contact:
Robson Storey or Shelby F. Thames, WBHS&PC
Symposium, Dept. of Polymer Science, USM,
Box 10076, Hattiesburg, MS 39406-0076**

Complete program will appear in the January 1997 issue of the JCT.

BALTIMORE

Active

Burns, Laura L.—SCM Chemicals, Baltimore, MD.
 Heble, Milind S.—SCM Chemicals, Baltimore.
 Koban, Mary E.—SCM Chemicals, Baltimore.
 Stogran, Tracy L.—Duron, Inc., Beltsville, MD.
 Tong, Lot—Farboil Co., Baltimore.
 White, Scott R.—Duron, Inc., Beltsville.

Associate

Rothenberg, Stephanie E.—Thornley Co., Inc., Wilmington, DE.

BIRMINGHAM

Active

Griffiths, Craig E.—Rollacolor Ltd., Bloxwich, W. Midlands.
 Hill, Paul C.—Black Country Paints, Wolverhampton.

Associate

Simpson, Keith E.—Rhône-Poulenc Chemical, Stockport, Cheshire.

CDIC

Active

Bachman, Russell R.—C.L. Zimmerman, West Chester, OH.
 Heemann, Charles J.—Cintech Ind. Coatings, Cincinnati, OH.
 Loudermilk, Dan S.—Armco Inc., Middletown, OH.
 Paskoff, Philip—U.S. Chemical & Plastics, Massillon, OH.
 Pfetscher, Donald J.—Challenge Inc., Indianapolis, IN.
 Sparks, Angela M.—Challenge Inc., Indianapolis.

Associate

Kratzer, Sam—Seegott Inc., Richmond, IN.
 Pineault, Paul—Flanagan Associates Inc., Cincinnati, OH.
 Wright, Michael W.—D.A. Campbell and Co., West Chester, OH.

CHICAGO

Active

Allen, Jodi B.—Union Carbide Corp., Alsip, IL.

Associate

Clennon, Jack J.—Van Waters & Rogers, Oak Brook, IL.
 Rucker, Tammy, L.—Union Carbide Corp., Alsip, IL.

DALLAS

Associate

Jensen, Bill—Gary-Williams Energy Corp., Oklahoma City, OK.

KANSAS CITY

Active

Ryer, Dennis—CCP, Kansas City, MO.

Associate

Kaza, Mike—CCP, Kansas City, MO.

LOS ANGELES

Active

Burdette, David L.—Akzo Nobel Coatings, Orange, CA.
 Camarillo, Paul J.—Delta Technical Coatings, Whittier, CA.
 Carrere, Norvell G.—Delta Technical Coatings, Whittier.
 Dances, William B.—AC Products, Inc., Placentia, CA.
 Dancy, Gregory—Courtaulds Aerospace, Burbank, CA.
 Delamerced, Gricelda C.—Behr Process Corp., Santa Ana, CA.
 Delgado, Gonzalo—Akzo Nobel Inc., Orange.
 Desai, Snehal S.—National Ink Inc., Santee, CA.
 Diaz, Mark A.—AC Products Inc., Placentia.
 Dickinson, Sandra L.—Tri-Iso, Inc., Claremont, CA.
 Dow, William—Smiland Paint Co., Los Angeles, CA.
 Durand, Roy—ICI Paints, Los Angeles.
 Espinoza, Rudy—Ameron PCD, Brea, CA.
 Francisco, Renante A.—Dunn-Edwards Corp., Los Angeles.
 Garcia, Donna M.—Ashland Chemical Co., Santa Ana.
 Gallant, Loretta C.—Lab Support, Diamond Bar, CA.
 Harmon, Meldean—Fineline Paint, Sante Fe Springs, CA.
 Iacoli, Alex S.—EPS, Commerce, CA.
 Jones, Chris E.—Frazee Industries, San Diego, CA.
 Kota, Prakash R.—Kemikomp Inc., Hayward, CA.

Lautchang, Nel A.—Ellis Paint Co., Los Angeles.
 Lutz, Patrick B.—Dunn-Edwards Corp., Los Angeles.
 Mann, Michael E.—Sherwin-Williams Co., Victorville, CA.
 Park, Roger—Dura Coat Products, Riverside, CA.
 Peshek, William B.—Frazee Industries, San Diego.
 Pompeo, Bill—Behr Process Corp., Santa Ana.
 Rymarczyk, Mark J.—Behr Process Corp., Santa Ana.
 Salomon, Robert L.—Custom Printing Inks Ltd., San Diego.
 Scholler, James R.—The Norac Co., Inc., Azusa, CA.
 Smith, Marcl.—Morton International, Colton, CA.
 Tanjuaquio, Edward S.—Custom Printing Inks, Chula Vista, CA.
 Waite, Alvin, J.—Behr Process Corp., Santa Ana.
 Vuelvas Galindo, Antonio—Pinturas y Barnices Calette, San Diego.

Associate

Ahn, Bob—E.T. Horn Co., La Mirada, CA.
 Brooks, Terri—Ashland Chemical Co., Santa Ana, CA.
 Busch, Jayson—Ashland Chemical Co., Santa Ana.
 Campbell, Thomas R.—AC Products Inc., Placentia, CA.
 Crow, Sean S.—EPS, Commerce, CA.
 Gleason, Elizabeth S.—Ashland Chemical Co., Santa Ana.
 Gomez, Margarita M.—Dowd and Guild, Cerritos, CA.
 Gray, Daniel—John K. Bice Co., Inc., Los Angeles, CA.
 Hanley, Joseph T.—H.M. Royal of California, Inc., Buena Park, CA.
 Hermann, Spencer M.—MRI, Laguna Hills, CA.
 Holmes, Brian—Ashland Chemical Co., Santa Ana.
 Jurivich, Jeanne—Ashland Chemical Co., Santa Ana.
 Kellner, Michael J.—Nampac, Lake Forest, CA.
 Langenbach, Fern M.—Delta Technical Coatings, Whittier, CA.
 Lee, Calvin G.—Rose Cooperage, Montebello, CA.
 McDonald, Thomas A.—William F. McDonald Co., Los Angeles.

75th Annual Meeting of the Federation of Societies for Coatings Technology and International Coatings Expo

November 3-5, 1997
 Georgia World Congress Center
 Atlanta, GA



Pennacchi, Manlio—Harwick Chemical Corp., Pico Rivera, CA.
Reeder, Ron L.—Greneker, Los Angeles.
Reilly, Kevin J.—C.P. Hall Co., Torrance, CA.
Rogers, Larry—Ashland Chemical Co., Santa Ana.
Roth, Doris R.—Specialty Minerals, Los Angeles.
Segala, Lorraine M.—Amazon Environmental, Fullerton, CA.
Settle, Phillip—Total-Western Inc., Paramount, CA.
Shulman, Saul L.—Leonard Engineered Products, N. Hollywood, CA.
Starr, Don E.—Starr Engerprise, Carson, CA.
Strayer, John I.—C.P. Hall Co., Torrance.
Thies, Jim—Pacific Coast Chemical, Los Angeles.
Wellman, Clem—Brockway Standard, Atlanta, GA.
Whitney, Dave—Ashland Chemical Co., Santa Ana.
Wivoeil, Judith A.—Monsanto Co., Richardson, TX.

Educator/Student

Bourque, Donald—Claremont High School, Claremont, CA.
Konick, Michael—Emerson Middle School, Corona, CA.
Park, John—Diamond Bar High School, Diamond Bar, Ca.
Salehpour, Phyllis—Calvary Baptist School, Laverne, CA.
Stockwell, Shari—Cajon High School, Crestline, CA.
Tamminga, Denise—Valley Christian High School, Cerritos, CA.
Tamminga, Scott—Ontario Christian High School, Ontario, CA.

LOUISVILLE

Associate

Howard, Jesse M. III—Howard Consulting, Louisville, KY.

NEW YORK

Active

Bialas, Kamila A.—William Zinsser & Co., Somerset, NJ.
Billington, Andy J.—Courtaulds Coatings, Union, NJ.
Crowley, Stephen J.—Courtaulds Coatings, Union.
Fox, Paul M.—Ultra Additives Inc., Paterson, NJ.
Jones, Robert T. Jr.—Fabricolor, Inc., Paterson.
Merrin, Alex G.—Insl-X Products Corp., Stony Point, NY.
Percarpio, James M.—Courtaulds Coatings, Union.

Associate

Onacki, Jerry—Westtec Industries, Plainfield, NJ.
Shannahan, Mark O.—Witco Corp., New Fairfield, CT.
Smith, Joy A.—Zeneca Inc., West Chester, PA.

NORTHWESTERN

Active

Carlson, Eugene H.—Valspar Corp., Minneapolis, MN.
Thorson, Teresa M.—Van Technologies Inc., Duluth, MN.
Tomlinson, Tricia A.—Van Technologies Inc., Duluth.
Werner, Todd A.—Circuit Supply Inc., Plymouth, MN.

Associate

Fitch, John J.—Anchor, Minneapolis, MN.
Ruda, Robert C.—Reichhold Chemicals, Burr Ridge, IL.

PACIFIC NORTHWEST

Active

LaGrange, Anthony J.—Quantum Technical Services Ltd., St. Albert, Alberta.

PHILADELPHIA

Active

Russell, Randall L.—Ranbar Electrical Materials, Manor, PA.

PIEDMONT

Active

Barthel, Ralph E.—Lord Corp., Cary, NC.
Fonda, James B.—Lord Corp., Cary.
Heinze, Richard E.—Lord Corp., Cary.
Howe, Stephen E.—Lord Corp., Cary.
May, Clifton C.—Lord Corp., Cary.
Quarmby, Ian C.—Lord Corp., Cary.
Waters, C. Donald—Savannah Paint Manufacturing, Savannah, GA.
Zietlow, Miriam H.—Lord Corp., Cary.

Associate

Wallace, Peter D.—Borden Chemical Inc., Morganton, NC.

PITTSBURGH

Active

Amorose, Adam J.—R & D Coatings Inc., Wexford, PA.
Edmundson, Ronald Dean—Sony Chemical Corp., Mount Pleasant, PA.
Hart, Donald P.—R & D Coatings Inc., McKees Rocks, PA.

ROCKY MOUNTAIN

Active

O'Neill, Michael E.—Mobile Mini Inc., Maricopa, AZ.

Associate

Sutherland, Richard C. II—E.T. Horn Co., La Mirada, CA.

SOUTHERN

Active

Bright, Bradley A.—Delta Industrial Coatings, Arlington, TN.
Clark, Gary Mark—Masonite Corp., Laurel, MS.
Johnson, Lewis H.—Avery Dennison Corp., Crossville, TN.
McCammon, Jimmy L.—Masonite Corp., Laurel.

Associate

Badejo, Ibraheem T.—Bayer Corp., Charleston, SC.
Sandri, Joseph M.—Callaway Chemical Co., Columbus, Ga.

TORONTO

Active

Arnott, John S.—Westglen Industries Inc., Milton, Ont.
Ciente, Ioan C.—Harcros Pigments, Toronto, Ont.
Deng, Xiadming—K-G Packaging, Concord, Ont.
Fulton, Tara J.—Nacan Products Ltd., Brampton, Ont.
Hamel, Michel—Sherwin-Williams, Brampton.
Horne, Kent W.—K-G Packaging, Concord.
Kabakian, Leon—Van Waters & Rogers, Lachine, Que.
Kelly, Heather L.—Uniroyal Chemical, Guelph, Ont.
Loncar, Joseph—Tri-Tex Co., Inc. Georgetown, Ont.
Prins, Arnold—Progress Plastics, Toronto.
Robbins, Scott K.—Autosystems Mfg. Inc., Belleville, Ont.
Spencer, Chris R.—Autosystems Mfg. Inc., Belleville.
Tinamisan, Judie Mae—Nacan Products Ltd., Brampton.
Wilson, Caroline J.—Hüls Canada, Brampton.

Associate

Bebbington, C. David—Stanchem Inc., Etobicoke, Ont.
Coleman, J. Scott—Ashland Chemical, Mississauga, Ont.
Painchaud, Lisa M.—Quadra Chemicals, Burlington, Ont.
Turnbull, Richard B.—St. Lawrence Chemical, Rexdale, Ont.
Yu, Zuoxing Steven—Standard Products (Canada) Ltd., Stratford, Ont.





T.R. Poe

G.A. Ward

CDIC Society member, **Thomas R. Poe**, has been named Sales Representative for Palmer Supplies Co., Cleveland, OH. Mr. Poe most recently served Seegott, Inc. as a Sales Representative.

In addition, **George A. Ward** has been named Regional Manager of Containers and Equipment Sales. A member of the Louisville Society, Mr. Ward previously worked for Davies Can Co.

Michael Winters has joined the Southwestern sales force of Seegott Inc., Streetsboro, OH. Based in Houston, TX, Mr. Winters will be responsible for specialty raw material sales in Louisiana, as well as the Dallas and Houston areas. He is a member of the Houston Society.

Robert Stoner has accepted the position of Technical Sales Representative for P.T. Hutchins Co., Ltd., Alameda, CA. Mr. Stoner is a member of the Los Angeles Society.

UCB Chemicals, Smyrna, GA, has promoted **Richard A. Mackiewicz** to Sales Manager, Central Region. Based in Chicago, IL, Mr. Mackiewicz is responsible for the company's sales activities and personnel in the Central U.S. He is a member of the Chicago Society.

Also, **William R. Cox** has been named Sales Manager, Eastern Region. Serving the company since 1995, Mr. Cox will handle the sales activities and personnel in the Eastern United States.

Obituary

Robert H. Purnell, Technical Director—Sun Chemical (Bowers Printing Ink Division), died in September 1996. He was 56 years old.

Mr. Purnell spent nearly 40 years in the printing ink industry, including 30 years with the Sun Chemical/Bowers Printing Ink. Prior to joining Bowers Ink Group, he had been with the Sinclair & Valentine organization.

Mr. Purnell is survived by his wife Iris, and two daughters.

Three sales executives from Sun Chemical Corp.'s Colors Group, Cincinnati, OH, have received awards for outstanding performance. **Brian Leen**, Chicago District Sales Manager, was named recipient of the Sales Manager Award, presented to the individual showing the highest annual increase in dollar sales volume. Mr. Leen is a member of the Chicago Society.

Doug Evans, an Account Executive, received the President's Award for excellence in salesmanship.

In addition, **Jim Wilson**, Nashville Sales Representative, earned the company's Seymour Stetzer Award as the Color Group salesperson demonstrating the greatest career sales potential.

SCJohnson Polymer, Racine, WI, has awarded its annual Innocircle Award to District Accounts Manager **Elizabeth Anne Wrobel**. Based in Chicago, IL, Ms. Wrobel handles the company's line of Joncryl® water-based acrylic and styrenated acrylic polymers and solvent-borne oligomers within the Midwest. She is a member of the Chicago Society.

Elf Atochem North America, Inc., Philadelphia, PA, has promoted **Gary Dennis** to Marketing Manager, Chemical Processing Industry. Mr. Dennis is responsible for Pebax® copolyamide resins, Rilsan® polyamide resins, and Kynar® PVDF resins in semiconductor, pharmaceutical, and chemical processing industries.

Charles "Chip" Bisignaro was promoted to Demand Manager of Fluoropolymers. Mr. Bisignaro will implement the company's sales and operations planning process for the Kynar product line.

Columbian Chemicals Co., Atlanta, GA, has named **John T. Walsh** as President. Mr. Walsh will be responsible for the company's worldwide operations. He replaces **Jim A. Cederna**, who resigned to pursue opportunities outside the company.



J.T. Walsh

COATEGRITY AFFORDABILITY FRADELITY

COATEGRITY PORTABILITY SIMPLICITY

COATING PROBLEMS?

Eliminate unwanted coating problems before they occur. Gamry Instruments' EIS90 Impedance System can determine a coating's performance characteristics by measuring the properties of the coating itself. Use that information to detect application problems, specification deviations, or potential coating failure before it is visible. Unlike salt spray tests, EIS is repeatable and can be performed under varying conditions to allow you to chose the optimal coating. Think how a longer and more predictable service life can lower your coating costs.



HOSPITALITY OCTOPICITY FRADELITY

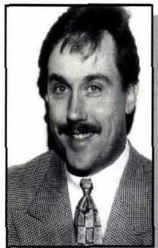


Gamry Instruments, Inc.

607-C1 Easton Road
Willow Grove, PA 19090
Tel: 215-830-9886 Fax: 215-830-9877

FLEXIBILITY PORTABILITY HOSPITALITY

Circle No. 295 on Reader Service Card



J.D. Davis



F. Alley

The E.T. Horn Co., La Mirada, CA, has appointed **Jeffrey D. Davis** to the position of Pacific Northwest Account Manager. Mr. Davis will service the coatings, composites, adhesives, and ink and graphics industries. He is a member of the Pacific Northwest Society.

Frank Alley was named Account Manager in Southern California. A Los Angeles Society member, Mr. Alley will focus on the construction industry, as well as the coatings, composites, adhesives, and ink and graphics industries.

POLYURETHANE PAINT FOR SALE

Various colors VOC Compliant
Other Coatings Available
One's—Five's—55 Gallon Drums
Kits (1's) \$15.00
Five's \$58.00
MSDS/Data On Request
Unicoat Technology, Inc.
So. Houston, Texas 77587
713-947-2545
Prices F.O.B. Houston, Texas

Quality

Used

Equipment

For Sale

High speed dispersers, pebble mills, horizontal and vertical media mills, pumps, chillers, filling and packaging machinery, laboratory instruments, safety, material handling equipment. Call for complete listing. We also buy your surplus equipment.

Western Equipment Co.
(510) 820-8883
FAX: (510) 820-9188

Cook Composites and Polymers, Kansas City, MO, has announced the following two new executive management appointments. **George Kunkle** was promoted to the newly created position of Vice President, Logistics. Mr. Kunkle will be responsible for customer service, planning, transportation, inventory control, and manufacturing resource planning.

Erwoan Pezron was named CCP's Vice President of Technology. Dr. Pezron will be responsible for the company's research and development activities.

Ciba Polymers, Brewster, NY, has promoted **Rick Irizarry** to Director of Sales, Coatings, and Distributors. Mr. Irizarry will manage the direct coatings sales force and the resins distributor network.

In other news, **Vipul Joshi** was named Marketing Manager, Industrial Maintenance and Marine Coatings.

Jean L. Luck has joined the staff of Color Communications, Inc., Chicago, IL, as Senior Color Stylist. Working in The Institute for Color Research, Ms. Luck will plan and implement color consulting, color training and education courses, as well as color research and color development.

Fusion UV Systems, Inc., Rockville, MD, has appointed **Edmund Shockey** as Direct Sales Representative for the mid-south territory. In his new position, Mr. Shockey will develop new business for the company's equipment, and service existing customers in his region and territory.

Brian C. Sanders has joined ABC Dispensing Technologies, Akron, OH, in dual positions Director of Marketing and Vice President of Engineering-Paint and Industrial Division. Mr. Sanders was the Founder and President of Ultrablend Systems, Inc.

Zeneca Resins, Wilmington, MA, has appointed **Robert J. Seidewand** Vice President of Technology and Strategic Development. In his newly created position, Dr. Seidewand will be responsible for long-term growth, oversee the company's strategic plan, and formulate and implement all merger and acquisition growth opportunities.

In other personnel changes, **Susan Anderson** will be in charge of Industry and Customer Strategic Development.

John Kibbee has been promoted to Business Manager for Architectural Coatings and Graphics Arts.

In addition, **John Abrahamson** was named Manager of Purchasing.

Anthony Mazzarella, Jr., has joined Ruco Polymer Corp., Hicksville, NY, as Sales Director for the firm's powder-coating resins and curatives business. Mr. Mazzarella will be responsible for sales, pricing, profitability, and other business strategies in all territories.



A. Mazzarella Jr.

Deborah L. Oberst was appointed Director of Urethanes R&D for ARCO Chemical Co., Newtown Square, PA. Dr. Oberst will coordinate all urethanes R&D worldwide, including direct responsibility for the South Charleston, WV, Technical Center and all urethanes R&D at the company's main research center.

In other news, **E. Kent Damon, Jr.** has relinquished his seat on ARCO's Board of Directors, while **Marie L. Knowles** has rejoined the Board after a short absence.

W.R. Bonsal Co., Charlotte, NC, has named **Jacob J. Ferro** to the position of President. Mr. Ferro will work with **William R. Bonsal, III** Chairman and Chief Executive Officer of the company, during an 18-month transition period. Mr. Bonsal will retire in December 1997.

Sheryl Will has been promoted to Controller for Raabe Corp., Menomonee Falls, WI. Ms. Will is responsible for the company's financial operations.

CVI Laser Corp., Putnam, CT, has named **John McCasland** to the position of Sales and Marketing Manager. Mr. McCasland will be responsible for the sales and marketing of the company's line of PC-based spectrophotometers.

Hüls America Inc., Somerset, NJ, has appointed **Harrison Finney** as its North-eastern Regional Account Representative for the Coatings Raw Materials Division. In his new position, Mr. Finney will be responsible for the sales of Vestanat® IPDI and TMDI, Vestamin® IPD, Vestagon® powder coatings hardeners, Dynapol polyester resins, and other specialty materials.

Al Dekock has joined the staff of Ronningen-Petter, Portage, MI, as Marketing Manager for the chemical process industry. In this position, Mr. Dekock will identify market segments and applications that represent potential for the company's products.



Equipment

IBC/Tank Mixer

The Drum-Mates® DM-600TAS/A is designed to improve quality control for liquid compounds that tend to stratify or settle out. Liquid movement is maximized at all RPM with five tiers of adjustable turbine impellers giving a mixing range of 250-950 gallons, with 300-300 rpm (unloaded) at 4 HP (@100 psi), using 10-130 cfm. A new "IBC Mixing Quality Control Program Guideline" has also been issued with the unit.

Circle No. 30 on Reader Service Card

Tempering Furnace

A tempering furnace, electrically heated to a maximum operating temperature of 1400°F, features a rear-mounted, heat resisting alloy circulating fan. Forty-two KW of total power are installed in alloy wire heating elements supported by a stainless steel frame. The six-inch insulated walls on the Grieve Corp.'s No. 778 comprise three inches of 2,300°F ceramic fiber and three inches of block insulation.

Circle No. 31 on Reader Service Card

Poly Liner

Barnhill Enterprises introduces the Poly Liner, bucket bags and paint tray sleeves. This product is designed to eliminate the cleaning of five-quart buckets and paint trays by using these disposable bags and sleeves. These liners can be used with latex-based paints.

Circle No. 32 on Reader Service Card

Recirculation Mill

A lab size recirculation mill is used to qualify applications, formulas, and new products. Designed for developers, formulators, and researchers, the air-driven mill is designed for safety and easy cleaning. All wetted parts of this Netzsch Inc. product are constructed of stainless steel, and the adjustable position chamber rotates to the up position for media fill and to the down position for media discharge.

Circle No. 33 on Reader Service Card

Tank Line

Birchwood Casey's BC-40 tank line with Presto® black coating, designed as a cleaner, safer, alternative to hot oxide, is highlighted. The tank system is engineered to provide consistent finish results without red or brown discoloration or white salt leaching. This process is in-

tended for departments having a need for blackening on an occasional basis.

Circle No. 34 on Reader Service Card

High Pressure Pumps

AR North America, Inc., introduces a four-page catalog featuring Spaggiari pumps with complete specifications on five models. This catalog lists features of each pump along with their uses. The pumps range in size from 9 to 70 gpm at 1,450 to 10,000 psi. Typical uses of these pumps include military, mining, and municipal applications, offshore drilling, and pipe and sewer cleaning.

Circle No. 35 on Reader Service Card

Disperser

The Daymax® disperser, a cavitation processor features a high-shear principle for dissolving, emulsification, and dispersion and is ideal for processing varnishes, inks, pigments, and pharmaceuticals. This disperser line offers seven models for a range of capacities from 10 to 1,000 gal. and up to 300 HP. The Daymax disperser is developed by Littleford Day, Inc., and also features custom engineering as required by the customer.

Circle No. 36 on Reader Service Card



Books/ Publications

Product and Industry Brochure

A brochure by National Starch and Chemical Co. describes the diverse end uses of plant products that fall into these groupings: hot melt adhesives and pressure-sensitive solution polymers, resin emulsion polymers, specialty chemical intermediates, and specialty polymers. Major industries served in this 16-page brochure include chemicals, packaging, paper, personal care, textiles, and wood-working.

Circle No. 37 on Reader Service Card

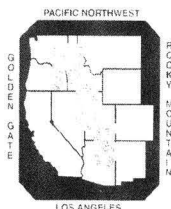
Dehumidification Handbook

The Cargocaire Div. of Munters Corp. introduces the second edition of *The Dehumidification Handbook*. The handbook serves as a guide to system designers by illustrating and describing the fundamental principles of dehumidification technology and by citing specific examples. *The Dehumidification Handbook* features informative text, reference charts, calculation worksheets, and a guide for minimizing project costs.

Circle No. 38 on Reader Service Card

Plan Now to Attend . . .

23rd Western Coatings Societies' Symposium and Show



Disneyland Hotel and Convention Center
February 18-20, 1997

Robert J. Skarvan, EPS, Inc., 5501 E. Slauson Ave.,
Los Angeles, CA 90040; (800) 642-7077.

New Zealand Trade Directory

The third edition of the "New Zealand Trade Directory 1996/97" is now available. A reference guide for those who wish to do business in New Zealand, this publication lists the country's 6,000 major and active firms and organizations, including manufacturers and exporters, importers and distributors, professional services, tourism and trade-related industries, and publicly listed companies.

Circle No. 39 on Reader Service Card

ASCA Performance Standards

A revised set of high-performance specifications for architectural spray painting was issued by the Architectural Spray Coaters Association (ASCA). Called ASCA 96, the standard is subtitled "Voluntary Specification for Superior Performance of Organic Coatings on Architectural Aluminum Curtainwall, Extrusions, and Miscellaneous Aluminum Components." ASCA 96 replaces ASCA Specifications 1.0.90, which called for alignment with American Architectural Manufacturers Association's 605.2.

Circle No. 40 on Reader Service Card

Viscosity Technical Papers

A catalog with 70 definitive papers on viscosity measurement published by scientists and engineers around the world is available from Brookfield Engineering Laboratories. Among the products covered are asphalts, candy lubricants, paints and coatings, glasses, titanium slags, clays and muds, pharmaceuticals and cosmetics, plastics, inks, food processing and industrial process control.

Circle No. 41 on Reader Service Card

Instrument Catalog

Fischer Technology offers a catalog describing the company's line of coating thickness measurement and materials testing equipment. Photos and illustrations depict each instrument and its capabilities are also described. A section on how to integrate measuring systems into a quality control system, and a convenient flow chart and table are also included.

Circle No. 42 on Reader Service Card

Pump Catalog

A line of Nemo® progressing cavity pumps are featured in a 28-page, full color product catalog. This Netzsch publication includes a step-by-step selection guide, photographs, and performance and dimensional data.

Circle No. 43 on Reader Service Card



Reaction Information System

InfoChem announces the release of COGNOS, a chemical reaction search system based on a new concept for reaction indexing. COGNOS is designed for the Macintosh and includes a database of more than 390,000 chemical reactions. This reaction information system is capable of operating on several databases in real time and permits post-search modifications.

Circle No. 44 on Reader Service Card

Materials Software Directory

ESM Software has published a materials software directory on its home page on the world wide web. This directory includes descriptions of Macintosh, Windows, and DOS programs that relate to science, ceramics, and polymers. Demonstration copies of several of the programs can be downloaded. This site also links to materials software developers and other materials sites on the Internet.

Circle No. 45 on Reader Service Card

Viscosity Software

A new software package from Brookfield Laboratories allows R&D, QC, and other lab personnel to automate viscosity testing and data collection/analysis. Rheocalc for Windows™ is a multi-tasking package that will allow users to program and collect background data while analyzing previously recorded data. Rheocalc records up to 1,000 data points per test and up to six flow curves can be plotted simultaneously—shear rate, rotational speed, temperature, etc.

Circle No. 46 on Reader Service Card

STIR

A CD-ROM version of the Sartomer Technical Information Resource (STIR) is now available. STIR provides an indexed collection of over 230 product bulletins, applications, and technical data sheets for the company's products used in coatings, inks, adhesive, elastomer, and sealant applications. This Windows™ based software allows the user to browse on-screen and print any document from their PC.

Circle No. 47 on Reader Service Card

Color Index

The Society of Dyers & Colourists offers the Colour Index International on CD-

ROM. Users of the index can search by colour index generic name, manufacturers code, or commercial name. All routes lead to details of origin together with technical properties of each dye or pigment including, where appropriate, chemical structures.

Circle No. 48 on Reader Service Card

Archived Articles

Technology Publishing Co. has released JPCL Archives II on CD-ROM, an updated and upgraded collection of the *Journal of Protective Coatings & Linings*' articles published from June 1984 through December 1995. This new Windows-based program has better on-screen appearances and is capable of printing the graphics as well as the articles. JPCL Archives II allows users to find information from key words, phrases, issues, topics, or titles.

Circle No. 49 on Reader Service Card



IR Cards

3M disposable IR cards are available in 250 count packages from Spectra-Tech Inc. These cards fit into the standard slide mount of a spectrometer and can be used for qualitative IR transmission analysis of organic liquids, materials that are soluble in organic solvents, semi-solids, and pastes. The cards reportedly require small volumes of sample to achieve spectral results.

Circle No. 50 on Reader Service Card

Brush Holder

The paint brush cleaner and holder is an accessory that fits into the top of a paint can. It provides a place for a brush when not in use and also includes a means to scrape excess paint off the brush. This brush holder is available from International Product Design.

Circle No. 51 on Reader Service Card

Ink Delivery

A centralized ink delivery system, for use with the PEL series ink jet system, is available from Diagraph Corp. The system is designed for printing applications that require two or more print-heads. The system allows all the print-heads to operate from a single ink source.

Circle No. 52 on Reader Service Card

FEDERATION MEETINGS



For information on FSCT meetings, contact Federation of Societies for Coatings Technology, 492 Norristown Rd., Blue Bell, PA 19422 (610) 940-0777, FAX: (610) 940-0292.

1997

(May 17-18)—FSCT Spring Board of Directors Meeting, May 17—Social Tour; May 18—Board Meeting, Hyatt Regency, Birmingham, England.

(June 20-21)—FSCT Incoming Society Officers Meeting, June 20—FSCT Headquarters Visit, Meeting, and Reception; June 21—Society Officers Meeting, Marriott West, Conshohocken, PA.

(Nov. 3-5)—FSCT Annual Meeting and International Coatings Technology Conference and Expo (Formerly Annual Meeting and Paint Industries' Show), Georgia World Congress Center, Atlanta, GA.

1998

(Oct. 14-16)—FSCT Annual Meeting and International Coatings Technology Conference and Expo (Formerly Annual Meeting and Paint Industries' Show), Ernest N. Morial Convention Center, New Orleans, LA.

SPECIAL SOCIETY MEETINGS

1997

(Feb. 5-7)—24th Annual International Waterborne, High-Solids, and Powder Coatings Symposium. Sponsored by the Southern Society and The University of Southern Mississippi (USM), New Orleans, LA. (Robson F. Storey or Shelby F. Thames, Co-Organizers, WBHS&PC Symposium, Dept. of Polymer Science, USM, Box 10076, Hattiesburg, MS 39406-0076).

(Feb. 18-20)—Western Coatings Societies' 23rd Biennial Symposium and Show. Sponsored by the Golden Gate, Los Angeles, Pacific Northwest, and Rocky Mountain Societies, Disneyland Hotel and Convention Center, Anaheim, CA. (Robert J. Skarvan, EPS, Inc., 5501 E. Slauson Ave., Los Angeles, CA 90040; (800) 642-7077 or for exhibit space: Roberta Garcia, ICI Paints, 6100 S. Garfield Ave., Los Angeles, CA 90040; (213) 888-8888, ext. 8343).

(Mar. 19)—Mini-Trade Show & Symposium. Sponsored by the Piedmont Society. Showplace on the Park, High Point, NC. (Nellie Moretz, Lilly Industries, 2147 Brevard Rd., High Point, NC 27263; (910) 889-6344).

(Apr. 2-4)—Southwestern Paint Convention. "AIM for the Future—NOW!" Co-sponsored by the Dallas and Houston Societies. Hyatt Regency Reunion, Dallas, TX. (General Chairman Bruce Bridges, Texas Resin Co., 2728 Empire Central, Dallas, TX 75235; (800) 492-9400).

(Apr. 30-May 1)—"Additives and Modifiers for Modern Coatings." Symposium co-sponsored by the New York Society for Coatings Technology and the Polytechnic University. Holiday Inn-North Conference Center, Newark, NJ. (Paul Mazer, Troy Corp., 8 Vreeland Rd., P.O. Box 955, Florham Park, NJ 07932-0955; (201) 443-0003; fax: (201) 443-0257).

(May 8-10)—50th Annual Spring Symposium. Sponsored by the Pacific Northwest Society. Pan-Pacific Hotel, Vancouver, British Columbia. (Kelvin J. Huget, Imasco Minerals Inc., 19287-98A Ave., Surrey, B.C. V4N 4C8; (604) 888-3848; fax: (604) 888-5671).

(May 12-14)—Southern Society Annual Meeting. King and Prince Beach and Golf Resort, St. Simons Island, GA. (Eve Irvine, J.M. Huber Corp., One Huber Rd., Macon, GA 31298; (912) 750-5433).

(May 22-23)—40th Annual Technical Symposium. "Waterborne Coatings: Sink or Swim." Symposium sponsored by the Cleveland Society. Case Western Reserve University, Cleveland, OH. (Vicki Fisher, Jamestown Paint Co., 108 Main St., Jamestown, PA 16134; (412) 932-3101).

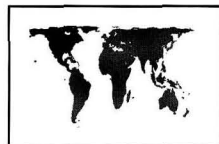
1998

(May 11-14)—Eastern Training Conference II. Sponsored by the Philadelphia Society. Valley Forge Convention Center, King of Prussia, PA. (Wayne Kraus, Hercules Incorporated, Research Center, 500 Hercules Rd., Wilmington, DE 19808).

OTHER ORGANIZATIONS

1997—North America

(Jan. 8-10)—"Spray Finishing Technology Workshop." Cosponsored by Bowling Green State University and ITW DeVilbiss. ITW DeVilbiss Training Center, Maumee (Toledo), OH. (Richard A. Kruppa, Bowling Green State University, Bowling Green, OH 43403-0301).



(Jan. 20-22)—"Composites '97 Manufacturing & Tooling." Conference and Exhibition sponsored by Society of Manufacturing Engineers (SME), Marriott, Anaheim, CA. (SME Customer Service, One SME Dr., P.O. Box 930, Dearborn, MI 48121-0930).

(Jan. 21-24)—"Environmentally Compliant Coatings." Short course sponsored by North Dakota State University (NDSU), Crowne Plaza Resort, Hilton Head Island, SC. (Debbie Shasky, Program Coordinator, NDSU, Dept. of Polymers and Coatings, 54 Dunbar Hall, Fargo, ND 58105).

(Jan. 26-28)—Meeting of the National Board of Registration for Nuclear Safety Related Coating Engineers and Specialists. Sheraton Yankee Trader, Ft. Lauderdale, FL. (D.M. Berger, Executive Director, P.O. Box 56, Leola, PA 17540-0056).

(Jan. 26-29)—ASTM Committee D-1 on Paint and Related Coatings, Materials, and Applications. Sponsored by the American Society for Testing and Materials. Crown Sterling Suites, Ft. Lauderdale, FL. (Scott Orthey, ASTM, 100 Barr Harbor Dr., West Conshohocken, PA 19428-2959).

(Jan. 28)—PCI Technical Subcommittee on Test Methods and ASTM D01.51 on Powder Coatings. Sponsored by the American Society for Testing and Materials (ASTM), Embassy Suites, Ft. Lauderdale, FL. (Jeffrey Hagerlin, O'Brien Powder Products, 9800 Genard Rd., Houston, TX 77041-7624).

(Feb. 1-5)—SPFA Annual Meeting. Sponsored by the Steel Plate Fabricators Association. Westin Mission Hills Resort, Rancho Mirage, CA. (SPFA, 3158 Des Plaines Ave., Des Plaines, IL 60018).

(Feb. 3-5)—Fifth Bridge Congress on Coatings Systems for Bridges and Steel Structures. Cosponsored by University of Missouri-Rolla (UMR) and the Steel Structures Painting Council. St. Louis Airport Marriott, St. Louis, MO. (UMR Coatings Institute, 1870 Miner Circle, Rolla, MO 65409).

(Feb. 5-7)—24th Annual International Waterborne, High-Solids, and Powder Coatings Symposium. Sponsored by the Southern Society and The University of Southern Mississippi (USM), New Orleans, LA. (Robson F. Storey or Shelby F. Thames, Co-Organizers, WBHS&PC Symposium, Dept. of Polymer Science, USM, Box 10076, Hattiesburg, MS 39406-0076).

(Feb. 10-15)—"Spray Foam '97." Sponsored by The Society of the Plastics Industry, Inc. Disneyland Hotel, Anaheim, CA. (SPI/SPFD, 1275 K St. N.W., Ste. 400, Washington, D.C. 20005).

(Feb. 14-15)—"Spring Decor '97: Paint & Decorating Show." Sponsored by the National Decorating Products Association (NDPA). Charlotte Convention Center, Charlotte, NC. (Teri Flotron, NDPA, 1050 N. Lindbergh Blvd., St. Louis, MO 63132-2994).

(Feb. 18-20)—Western Coatings Societies' 23rd Biennial Symposium and Show. Sponsored by the Golden Gate, Los Angeles, Pacific Northwest, and Rocky Mountain Societies, Disneyland Hotel and Convention Center, Anaheim, CA. (Robert J. Skarvan, EPS, Inc., 5501 E. Slauson Ave., Los Angeles, CA 90040; (800) 642-7077 or for exhibit space: Roberta Garcia, ICI Paints, 6100 S. Garfield Ave., Los Angeles, CA 90040; (213) 888-8888, ext. 8343).

(Feb. 22-24)—"Interiors Decor Showcase '97." Sponsored by the National Decorating Products Association (NDPA). Toronto Congress Centre, Toronto, Ontario, Canada. (Teri Flotron, NDPA, 1050 N. Lindbergh Blvd., St. Louis, MO 63132-2994).

(Feb. 24-26)—"Basic Coatings for Sales, Marketing, and General Personnel." Short course sponsored by University of Missouri-Rolla (UMR). St. Louis Airport Marriott, St. Louis, MO. (UMR Coatings Institute, 1870 Miner Circle, Rolla, MO 65409).

(Mar. 1-2)—"Degradation and Stabilization of Polymers." Sponsored by the State University of New York. Hilton Head Island, SC. (Angelos V. Patsis, Institute of Materials Science, State University of New York, New Paltz, NY 12561).

(Mar. 3-5)—"Polymer Stabilizers and Modifiers '97: Conference and Exhibit." Sponsored by the State University of New York, Institute of Materials Science and the Division of Polymeric Materials: Science and Engineering of the American Chemical Society (ACS). Hilton Head Island, SC. (Angelos V. Patsis, Institute of Materials Science, State University of New York, New Paltz, NY 12561).

(Mar. 3-5)—"International Seminar on the Technology of Inherently Conductive Polymers." Short course sponsored by Advanced Polymer Courses. Princess Resort, San Diego, CA. (M. Aldissi, Advanced Polymer Courses, 536 Main St., Unit 1, Falmouth, MA 02540).

(Mar. 10-12)—"Introduction to Polymer Colloids/Emulsion Polymers." Sponsored by the State University of New York. Hilton Head Island, SC. (Angelos V. Patsis, Institute of Materials Science, State University of New York, New Paltz, NY 12561).

(Mar. 10-13)—"Pigment Dispersions: Science and Technology." Sponsored by the State University of New York. Hilton Head Island, SC. (Angelos V. Patsis, Institute of Materials Science, State University of New York, New Paltz, NY 12561).

(Mar. 14-15)—"Paint Volatile Organic Compounds (VOCs)." Training course sponsored by the American Society for Testing and Materials (ASTM). Atlanta, GA. (Kristina Falkenstein, ASTM, 100 Barr Harbor Dr., West Conshohocken, PA 19428-2959).

(Mar. 19)—"Mini-Trade Show & Symposium. Sponsored by the Piedmont Society. Showplace on the Park, High Point, NC. (Nellie Moretz, Lilly Industries, 2147 Brevard Rd., High Point, NC 27263; (910) 889-6344).

(Mar. 19-21)—"Carbon Black World '97." Sponsored by Intertech Corp. La Mansion del Rio Hotel, San Antonio, TX. (Melanie Searle, Intertech Conferences, 411 U.S. Route One, Portland, ME 04105).

(Apr. 2-4)—"Southwestern Paint Convention. "AIM for the Future—NOW!" Cosponsored by the Dallas and Houston Societies. Hyatt Regency Reunion, Dallas, TX. (General Chairman Bruce Bridges, Texas Resin Co., 2728 Empire Central, Dallas, TX 75235; (800) 492-9400).

(Apr. 7-8)—"Practical Chemistry of Polyurethanes and Diisocyanates." Seminar sponsored by Technomic Publishing Co., Inc. Crowne Plaza, Hasbrouck Heights, NJ. (Program Division, Technomic Publishing Co., Inc., 851 New Holland Ave., Box 3535, Lancaster, PA 17604).

(Apr. 7-10)—"12th Annual Advanced Composites Conference and Exposition. Sponsored by The Engineering Society (ESD) and SAE International. Westin Hotel, Renaissance Center, Detroit, MI. (Wael Berrached, ESD, 29355 Northwestern Hwy., Ste. 200, Southfield, MI 48034).

(Apr. 7-11)—"Basic Composition of Coatings." Short course sponsored by University of Missouri-Rolla (UMR), Rolla, MO. (UMR Coatings Institute, 1870 Miner Circle, Rolla, MO 65409).

(Apr. 8-10)—"Sixth Annual Advanced Coatings Technology Conference & Exposition. Sponsored by The Engineering Society (ESD) and SAE International. Westin Hotel, Renaissance Center, Detroit, MI. (Wael Berrached, ESD, 29355 Northwestern Hwy., Ste. 200, Southfield, MI 48034).

(Apr. 9-10)—"Polyurethane Coatings." Seminar sponsored by Technomic Publishing Co., Inc. Crowne Plaza, Hasbrouck Heights, NJ. (Program Division, Technomic Publishing Co., Inc., 851 New Holland Ave., Box 3535, Lancaster, PA 17604).

(Apr. 9-11)—"Advances in Polyurethane Foam Formulation." Seminar sponsored by Technomic Publishing Co., Inc. Crowne Plaza,

Hasbrouck Heights, NJ. (Program Division, Technomic Publishing Co., Inc., 851 New Holland Ave., Box 3535, Lancaster, PA 17604).

(Apr. 16-18)—"Medical Adhesives: Materials, Technology and Applications." Seminar sponsored by Technomic Publishing Co., Inc. Back Bay Hilton, Boston, MA. (Program Division, Technomic Publishing Co., Inc., 851 New Holland Ave., Box 3535, Lancaster, PA 17604).

(Apr. 17-18)—"Thermoplastic Foams." Seminar sponsored by Technomic Publishing Co., Inc. Crowne Plaza, Hasbrouck Heights, NJ. (Program Division, Technomic Publishing Co., Inc., 851 New Holland Ave., Box 3535, Lancaster, PA 17604).

(Apr. 21-24)—"Introduction to Paint Formulation." Short course sponsored by University of Missouri-Rolla (UMR), Rolla, MO. (UMR Coatings Institute, 1870 Miner Circle, Rolla, MO 65409).

(Apr. 23-26)—"Coverings '97." Flooring exhibition sponsored by TSI, Inc. Orange County Convention Center, Orlando, FL. (Coverings, 900 E. Indiantown Rd., Ste. 207, Jupiter, FL 33477).

(Apr. 24-25)—"Electroactive Polymers." Seminar sponsored by Technomic Publishing Co., Inc. Meadowlands Hilton, Secaucus, NJ. (Program Division, Technomic Publishing Co., Inc., 851 New Holland Ave., Box 3535, Lancaster, PA 17604).

(Apr. 30-May 1)—"Additives and Modifiers for Modern Coatings." Symposium cosponsored by the New York Society for Coatings Technology and the Polytechnic University. Holiday Inn-North Conference Center, Newark, NJ. (Paul Mazer, Troy Corp., 8 Vreeland Rd., P.O. Box 955, Florham Park, NJ 07932-0955; (201) 443-0003; fax: (201) 443-0257).

(May 1-2)—"Paint Volatile Organic Compounds (VOCs)." Training course sponsored by the American Society for Testing and Materials (ASTM). Chicago, IL. (Kristina Falkenstein, ASTM, 100 Barr Harbor Dr., West Conshohocken, PA 19428-2959).

(May 7-9)—"Adhesive and Coating Adhesion." Sponsored by the State University of New York. Orlando, FL. (Angelos V. Patsis, Institute of Materials Science, State University of New York, New Paltz, NY 12561).

(May 7-9)—"Block and Graft Copolymer Blends." Sponsored by the State University of New York. Orlando, FL. (Angelos V. Patsis, Institute of Materials Science, State University of New York, New Paltz, NY 12561).

(May 8-10)—"50th Annual Spring Symposium. Sponsored by the Pacific Northwest Society. Pan-Pacific Hotel, Vancouver, British Columbia. (Kelvin J. Hugel, Imasco Minerals Inc., 19287-98A Ave., Surrey, B.C. V4N 4C8; (604) 888-3848; fax: (604) 888-5671).

(May 12-13)—"Polyurethane Catalysis." Seminar sponsored by Technomic Publishing Co., Inc. Sheraton Colony Square, Atlanta, GA. (Program Division, Technomic Publishing Co., Inc., 851 New Holland Ave., Box 3535, Lancaster, PA 17604).

(May 12-14)—"Southern Society Annual Meeting. King and Prince Beach and Golf Resort, St. Simons Island, GA. (Eve Irvine, J.M. Huber Corp., One Huber Rd., Macon, GA 31298; (912) 750-5433).

(May 13-14)—"Thermoplastic Polymers for Medical and Pharmaceutical Applications." Seminar sponsored by Technomic Publishing Co., Inc. Meadowlands Hilton, Secaucus, NJ. (Program Division, Technomic Publishing Co., Inc., 851 New Holland Ave., Box 3535, Lancaster, PA 17604).

(May 19-21)—"Hydrogels: Specialty Plastics for Biomedical and Pharmaceutical Applications." Seminar sponsored by Technomic Publishing Co., Inc. Crowne Plaza, Hasbrouck Heights, NJ. (Program Division, Technomic Publishing Co., Inc., 851 New Holland Ave., Box 3535, Lancaster, PA 17604).

(May 19-23)—"Physical Testing of Paints & Coatings." Short course sponsored by University of Missouri-Rolla (UMR), Rolla, MO. (UMR Coatings Institute, 1870 Miner Circle, Rolla, MO 65409).

(June 2-3)—"Fire Retardant Polymer Markets: Developments in U.S. and Europe." Seminar sponsored by Technomic Publishing Co., Inc. Renaissance Harborplace Hotel, Baltimore, MD. (Program Division, Technomic Publishing Co., Inc., 851 New Holland Ave., Box 3535, Lancaster, PA 17604).

(June 2-4)—"Advances in Flame Retardancy of Polymeric Materials: Applications, Materials, Industry Developments, Markets." Con-

ference sponsored by Business Communications Co., Inc. Holiday Inn Select, Stamford, CT. (Business Communications Co., Inc., 25 Van Zant St., Norwalk, CT 06855).

(June 2-6)—“Advances in Emulsion Polymerization and Latex Technology.” Short course sponsored by Lehigh University. Emulsion Polymers Institute, Bethlehem, PA. (Mohamed S. El-Aasser, Emulsion Polymers Institute, Lehigh University, 111 Research Dr., Bethlehem, PA 18015).

(June 2-13)—Summer Coatings Course. Sponsored by North Dakota State University (NDSU). Fargo, ND. (Debbie Shasky, Program Coordinator, NDSU, Dept. of Polymers and Coatings, 54 Dunbar Hall, Fargo, ND 58105).

(June 24)—ASTM D01.51 on Powder Coatings. Sponsored by the American Society for Testing and Materials (ASTM). Holiday Inn at the King, Toronto, Ontario, Canada. (Jeffrey Hagerlin, O'Brien Powder Products, 9800 Genard Rd., Houston, TX 77041-7624).

(July 14-16)—“Layman's Introduction to Coatings.” Short course sponsored by University of Missouri-Rolla (UMR). St. Louis Airport Marriott Hotel, St. Louis, MO. (UMR Coatings Institute, 1870 Miner Circle, Rolla, MO 65409).

(Sept. 8-12)—“Basic Composition of Coatings.” Short course sponsored by University of Missouri-Rolla (UMR), Rolla, MO. (UMR Coatings Institute, 1870 Miner Circle, Rolla, MO 65409).

1997—Asia

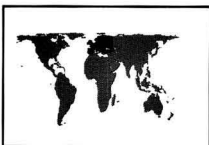
(Mar. 9-11)—India International Coatings Show '97. Sponsored by FMJ International Publications Ltd. World Trade Centre, Bombay, India. (Jane Malcolm-Coe, PR & Publicity Dept., FMJ International Publications Ltd., Queensway House, 2 Queensway, Redhill, Surrey, RH1 1QS, England).



(Oct. 22-24)—“New Developments in Colour Material Science and Technology.” 70th Anniversary Conference on Colour Materials Tokyo sponsored by the Japan Society of Colour Material. Arcadia Ichigaya (Shigaku Kaikan), Tokyo, Japan. (Shuichi Hamada, Japan Society of Colour Material, Kitamura Bldg. 5F, 9-12, 2-chome, Iwamoto-cho, Chiyoda-ku, Tokyo 101, Ja-

1997—Europe

(Feb. 3-5)—“Co-Mold '97.” Sponsored by Maack Business Services. Zürich, Switzerland. (Maack Business Services, Moosacherstrasse 14, CH-8804 AU/Zürich, Switzerland).



(Apr. 8-10)—European Coatings Show '97. Exhibition and conference sponsored by Vincentz Verlag, Nürnberg, Germany. (Vincentz Verlag, Postfach 6247, D-30062 Hannover, Germany).

(Apr. 14-19)—Hannover Fair '97. Industrial fair sponsored by Hannover Fairs USA, Inc. Hannover Fairgrounds, Hannover, Germany. (Andrea Anderson, Project Director, Hannover Fairs USA, Inc., 103 Carnegie Center, Princeton, NJ 08540).

(May 6-7)—“PE '97.” Sponsored by Maack Business Services. Milano, Italy. (Maack Business Services, Moosacherstrasse 14, CH-8804 AU/Zürich, Switzerland).

(May 12-14)—“Epoxy Technologies for Ambient Cure Protective Coatings.” Sponsored by Paint Research Association. Brussels, Belgium. (Conference Secretary, Paint Research Association, 8 Waldegrave Rd., Teddington, Middlesex, TW11 8LD England).

(May 29-June 1)—15th SLF-Congress. Sponsored by the Skandinaviska Lackteknikers Förbund (SLF). Lillehammer, Norway. (Bent Haflan, Jotun A/S, P.O. Box 2021 Hasle, N-3235 Sandefjord, Norway; or Svein Singstad, Scanox A/S, P.O. Box 42 Ainabru, Norway).

(June 9-11)—19th Annual International Conference on the Degradation and Stabilization of Polymers. Sponsored by the State University of New York. Luzern, Switzerland. (Angelos V. Patsis, Institute of Materials Science, State University of New York, New Paltz, NY 12561).

(June 16-18)—RadTech Europe '97. Sponsored by Vincentz Verlag. Palais de Congrès, Lyon, France. (Esther Schwencke, Vincentz Verlag, P.O. Box 67 42, D-30062 Hanover, Germany).

(June 17-20)—International Intensive Short Course on the Science and Technology of Pigment Dispersions. Sponsored by the State University of New York. Luzern, Switzerland. (Angelos V. Patsis, Institute of Materials Science, State University of New York, New Paltz, NY 12561).

(July 7-11)—23rd Annual International Conference on Organic Coatings: Waterborne, High-Solids, and Powdered Coatings. Sponsored by the State University of New York. Athens, Greece. (Angelos V. Patsis, Institute of Materials Science, State University of New York, New Paltz, NY 12561).

(Sept. 15-17)—“PP '97.” Sponsored by Maack Business Services. Zürich, Switzerland. (Maack Business Services, Moosacherstrasse 14, CH-8804 AU/Zürich, Switzerland).

(Nov. 3-5)—“PET '97.” Sponsored by Maack Business Services. Zürich, Switzerland. (Maack Business Services, Moosacherstrasse 14, CH-8804 AU/Zürich, Switzerland).

(Dec. 1-3)—“SP '97.” Sponsored by Maack Business Services. Zürich, Switzerland. (Maack Business Services, Moosacherstrasse 14, CH-8804 AU/Zürich, Switzerland).

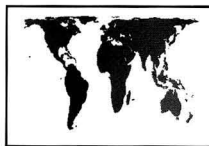
1998—Europe

(Jan. 20-22)—Powder Coating Europe 98. Sponsored by Vincentz Verlag. Amsterdam Exhibition Centre, Amsterdam, The Netherlands. (Vincentz Verlag, Postfach 6247, D-30062 Hannover, Germany).

(Feb. 2-4)—“ETP '98.” Sponsored by Maack Business Services. Zürich, Switzerland. (Maack Business Services, Moosacherstrasse 14, CH-8804 AU/Zürich, Switzerland).

1997—South America

(Sept. 15-17)—Fifth International Paint Congress and Exhibition on Paint Industry Suppliers. Sponsored by the Brazilian Association of Paint Manufacturers (ABRAFATI). Palacio de Convenções do Anhembi, São Paulo, Brazil. (Congress Organization Secretariat, Especifica S/C Ltda., Rua Augusta, 2516-2° andar-cj. 22, 01412-100-São Paulo, SP-Brazil).



(Oct. 6-9)—“Latin-American Interfinish.” Hotel Transamerica's Convention Center, São Paulo, Brazil. (Associação Brasileira de Tratamentos de Superfície, Av. Paulista, 1313, 9°a., conj. 913, CEP 01311-923 São Paulo, SP-Brazil).

Advertisers' Index

BASF Corp.	12, 13
Federation of Societies for Coatings Technology	Cover 2
Gamry Instruments, Inc.	75
Omnimark Instrument Corp.	65
Unicoat Technology, Inc.	76
R.T. Vanderbilt Co., Inc.	Cover 4
Westerlins Maskinfabrik AB	11
Western Equipment Co.	76

NOTE: The Advertisers' Index is published for the convenience of our readers and as an additional service to our advertisers. The publisher assumes no liability for errors or omissions.

Way back in July, Jeff Sturm sent me his copy of the *Yetter Letter* and in it I was pleased to find: Artistic License: When the Communist Party ruled Poland, its leaders commissioned a local artist to do a painting of Lenin. It was to be called "Lenin in Poland." The artist despised Lenin, but took the job for a large fee with a guarantee of complete artistic freedom. At the unveiling, he pulled a cord and the painting's cover fell away.

The crowd gasped. Before them was a rendering of a middle aged man and a plump peasant woman in a passionate embrace. The Kremlin was visible through a window.

"Who is that man?" the Party chairman angrily demanded.

"That is Trotsky," said the artist.

"And who is that vulgar woman?"

"That is Lenin's wife."

"And where is Lenin?" demanded the official.

The artist replied, "Lenin is in Poland."

Two inhabitants of hell were taking a walk when a frigid breeze blew by. Then a storm dumped several inches of snow. The men looked around in amazement.

"What's going on?" one asked.

"Only thing I can figure," replied his companion, "is that the Cubs just won the World Series."

* * * * *

Helpful Bob Athey has supplied Humbug in the past with several items, but this year he has outdone himself. Here are a couple:

When Harry was a young man in Louisiana, he was always getting in trouble. One morning while waiting for the school bus, he shoved the outhouse into the bayou and went off to school as if nothing happened.

When he returned his father was waiting for him. He said, "Son, did you push the outhouse into the bayou?"

"Yes, Dad," replied Harry, "like George Washington, I cannot tell a lie."

Harry's Dad took off his belt and said, "Alright son, bend over, I'm whipping you."

Harry tried to explain that Mr. Washington didn't spank George when he admitted chopping down the cherry tree.

"Yes, son," said Harry's Dad, "but George's father wasn't in the tree."

Bob's friend, Richard Loeffler, relates this: "Having purchased new appliances for our house, my wife and I decided to give our old refrigerator to my parents. When I spoke to my mother on the phone a few days later, she announced, "We want to pay for the refrigerator."

"No, Mom it's a gift," I said, "We want you to have it."

"But you could have sold it," she persisted.

"Look, Mom," I replied "Just consider it as repayment for all those days that you took care of me when I was in diapers."

After a slight pause, she answered, "In that case, the refrigerator doesn't cover it."

Longtime contributor, Dick Kiefer, asks, "How many personal injury attorneys does it take to change a light bulb?"

And answers, "Three. One to turn the bulb. One to shake him off the ladder. One to sue the ladder manufacturer."

"How many corporate attorneys does it take to change a light bulb?"

"Who knows? You need 250 just to lobby for the research grant."

"How many defense attorneys does it take to change a light bulb?"

"How many can you afford?"

"How many divorce attorneys does it take to change a light bulb?"

"It takes only one divorce attorney to change YOUR light bulb to HIS light bulb."

Please Note—To all attorneys and their relatives and friends: Dick goes on to say, "The above were dragged home by my wife, Gwen, from the law office where she is still gainfully employed as a legal secretary."—Send all complaints to Kiefer!!

* * * * *

From the *News Graphic* (Mequon-Thiensville Edition) of Ozaukee County (sic) sent in by Humbug's anonymous friend in Milwaukee:

Mequon—A man toasting marshmallows inside a friend's home ended with police and firefighters being called to put out a fire on August 22. Emergency personnel arrived just minutes after 5:30 a.m. at West Pinehurst Circle. The man told the police that while toasting marshmallows they started on fire and he ended up throwing them into a bathroom wastebasket, along with his underwear.

* * * * *

And a few recent gems from the indefatigable Dick Stewart:

Question—What is the difference between a psychotic and a neurotic?

Answer—A psychotic thinks that 2 plus 2 equals 5. A neurotic knows that 2 plus 2 equals 4, but it really bothers him.

The trouble with talking too fast is that you may say something you haven't thought of yet

My daughter recently presented me with another grandchild; she gave birth in a state-of-the-art delivery room. It was so high tech that the baby came out cordless.

—Herb Hillman, *Humbug's Nest*, P.O. Box 135, Whitingham, VT 05361.



Reader Service Card
December 1996 Issue

Your Company

(Check One Block)

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

Your Position

(Check One Block)

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

Circle the numbers of the items you would like more information on, and mail it—postage paid!

Grid of item numbers from 001 to 300 for selection.

Name, Company, Address, City, State, Zip, Phone, FAX form fields.



Reader Service Card
December 1996 Issue

Your Company

(Check One Block)

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

Your Position

(Check One Block)

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

Circle the numbers of the items you would like more information on, and mail it—postage paid!

Grid of item numbers from 001 to 300 for selection.

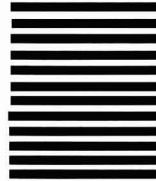
Name, Company, Address, City, State, Zip, Phone, FAX form fields.



NO POSTAGE
NECESSARY
IF MAILED
IN THE
UNITED STATES

BUSINESS REPLY MAIL
FIRST CLASS PERMIT NO. 12522 CHICAGO, ILLINOIS

POSTAGE WILL BE PAID BY ADDRESSEE



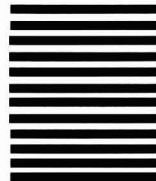
Journal of Coatings Technology
Reader Service Center
650 S. Clark St.
Chicago, IL 60605-9960



NO POSTAGE
NECESSARY
IF MAILED
IN THE
UNITED STATES

BUSINESS REPLY MAIL
FIRST CLASS PERMIT NO. 12522 CHICAGO, ILLINOIS

POSTAGE WILL BE PAID BY ADDRESSEE



Journal of Coatings Technology
Reader Service Center
650 S. Clark St.
Chicago, IL 60605-9960



Tearing Out This Ad Can Improve Your Career

The Federation's Series on Coatings Technology Has the Facts to Make You Succeed

The Federation of Societies for Coatings Technology gives you the tools you need to enhance your career with its Series on Coatings Technology, an innovative series of booklets on various phases of coatings technology and manufacturing. Each booklet is authored by a coatings expert, and thousands of copies have been sold to coatings manufacturers, chemists, suppliers and students worldwide.

From the Introduction to Coatings Technology and Film Formation to Corrosion Protection and Coatings Film Defects, each booklet in the ever-expanding series provides an authoritative and comprehensive insight into an important industry subject – information vital to you in today's changing environment. For coatings professionals, the Series on Coatings Technology is just a phone call away.

A Must for Every Reference Library, Perfect for Educating Sales Representatives

Complete sets of the Series can be used as reference tools for any laboratory or library. Many are also useful for sales representatives – teaching them more about various aspects of the industry and its products.

Make Your Move – Start Building Your Career One Volume at a Time

To order single booklets or the complete Series, call today to place your order.

(610) 940-0777

All Federation members receive special member discount pricing!

Automotive Coatings
by
Bruce N. McBane

Pigments

Coil Coatings
by
Joseph E. Gas

Mechanical Properties
Of Coatings
by
Loren W. Hill



**Federation of Societies for
Coatings Technology**

492 Norristown Road, Blue Bell, PA, 19422-2350
(610) 940-0777, Fax (610) 940-0292



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



Our new bulk bagging capability eliminates dusty paper bag disposal problems for good. Bulk bags have 40 times the weight capacity of paper bags. Their tough, woven polypropylene construction gives them a recyclable life of 10 times or more.

Storage problems are reduced too. Storage areas stay cleaner and annoying dust due to leakage is minimized. In the long run bulk bags are labor saving and money saving.

Bulk bag shipments are now available for NYTAL® and I.T. Talcs as well as Vansil® wollastonite, Pyrax® pyrophyllite and kaolin clays.

Request bulk bag shipments of our consistent, high quality minerals and reduce disposal/cleanup problems. Call the Minerals Group R. T. Vanderbilt Company, Inc., 30 Winfield Street, P.O. Box 5150, Norwalk, CT 06856; Tel. (203)853-1400, FAX (203)853-1452.



R. T. Vanderbilt Company, Inc.
INDUSTRIAL MINERALS AND CHEMICALS

