

**jct** JOURNAL OF  
COATINGS  
TECHNOLOGY

JCTAX 65 (818) 1-92 (1993)  
**March 1993**

Development  
of High  
Performance,  
Water-Based  
Emulsion  
Coatings for  
Can Coatings  
Application





**Technical Articles**

- 25 **Development of High Performance, Water-Based Emulsion Coatings for Can Coating Application—S. Kojima, Y. Wantanbe, and T. Moriga**
- 39 **Interactions of HEUR Associative Thickeners with Waterborne Polyurethanes—J.P. Kaczmarek, R.H. Fernando, and J.E. Glass**
- 47 **AC Impedance Analysis and Factorial Designs of an In-Situ Phosphatizing Coating—D.A. Meldrum and C-T. Lin**
- 59 **Amine-ene Technology III: Investigation of Properties of Some Branched Maleate Oligomers in Ultraviolet Light Curable, Amine-ene Coatings—G.K. Noren**
- 67 **Behavior of Some Anticorrosive Epoxy-Polyamide Primers of Lead and Chromate and in the Presence of Chloride Ions—A. Ruvolo-Filho and E.S. da Costa**

**Federation News**

- 13 **FSCT and NPCA Lay Groundwork for Closer Ties**
- 13 **Focus Is on Atlanta, Oct. 27-29, as FSCT Prepares for Annual Meeting and Paint Industries' Show**
- 16 **Current List of 1993 Paint Industries' Show Exhibitors**
- 19 **1993 Spring Week Registration and Hotel Reservation Form**
- 20 **Spring Week Seminar Program Highlights**

**Departments**

JCT Guide for Authors . . . . .	4	People . . . . .	78
Comment . . . . .	7	Meetings/Education . . . . .	79
Abstracts . . . . .	8	Literature . . . . .	81
Regulatory UPDATE . . . . .	17	Letter to the Editor . . . . .	86
Government & Industry . . . . .	22	CrossLinks . . . . .	86
Society Meetings . . . . .	71	Book Review . . . . .	88
Future Society Meetings . . . . .	76	Coming Events . . . . .	89
Elections . . . . .	77	Humbug from Hillman . . . . .	92

ห้องสมุดกรมวิทยาศาสตร์บริการ

11 ส.ช. 2536



© 1993 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. Phone: (215) 940-0777.  
 Second class 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.  
 Subscriptions: U.S. and Canada—1 year, \$30; 2 years, \$57; 3 years, \$82. Europe (Air Mail)—1 year, \$60; 2 years, \$117; 3 years \$172. Other Countries—1 year, \$45; 2 years, \$87; 3 years, \$127.

## GENERAL

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

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

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

**Papers in which proprietary products or processes are promoted for commercial purposes are specifically unacceptable 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 Annual Meeting Presentation

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

### ...for Roon Foundation Award Competition

Ten complete copies of the manuscript are required, and should be submitted to the Chairman of the 1993 Roon Awards Committee, Louis J. Sharp, Dexter Corp., 1 E. Water St., Waukegan, IL 60085. (For complete details, see "Roon Awards" section of the JOURNAL in January 1993 issue.)

# GUIDE FOR AUTHORS

## 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 8½ x 11 inch (22 x 28 cm) paper, with at least one-inch (2.5 cm) margins on all four sides. All paragraphs should be indented five spaces, and all pages should be numbered at the top center, or upper right corner.

## Title

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

## Authors' Biographies and Photographs

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

## Abstracts

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

## Text

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

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

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

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

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

## Metric System

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

## 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<sup>a</sup> and subscripts<sub>s</sub> 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,<sup>1,2,3</sup> books,<sup>4</sup> and patents.<sup>5</sup>

- (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: (215) 940-0777. FAX: (215) 940-0292.

Annual dues for Active and Associate Members of the Federation of Societies for Coatings Technology is \$20.00. Of this amount, \$13.50 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 .....	\$30.00	\$60.00	\$45.00
2 Years .....	\$57.00	\$117.00	\$87.00
3 Years .....	\$82.00	\$172.00	\$127.00

When available, single copies of back issues of the JOURNAL OF COATINGS TECHNOLOGY are priced as follows: \$3.00 each for current calendar year issues; \$4.00 each for all other issues.

#### Staff

ROBERT F. ZIEGLER .....	PUBLISHER
PATRICIA D. VIOLA .....	EDITOR
ROBERT F. BRADY, JR. ....	TECHNICAL EDITOR
SAMUEL M. AMICONE .....	ASSOCIATE EDITOR/ MARKETING COORDINATOR
KATHLEEN M. WIKIERA .....	ASSISTANT EDITOR
AUDREY E. BOOZER .....	SUBSCRIPTION FULFILLMENT MANAGER

#### Publications Committee

ROBERT F. BRADY, JR., Chairman

PERCY E. PIERCE .....	LOREN W. HILL
DARLENE R. BREZINSKI .....	PATRICIA D. VIOLA
PAUL R. GUEVIN, JR. ....	ROBERT F. ZIEGLER

#### Editorial Review Board

ROBERT F. BRADY, JR., Chairman

D.R. BAUER .....	C.R. HEGEDUS .....	J.L. MASSINGILL .....
A.H. BRANDAU .....	H.E. HILL .....	P.E. PIERCE .....
J.H. BRAUN .....	L.W. HILL .....	G.R. PILCHER .....
D.R. BREZINSKI .....	T. HOCKSWENDER .....	T. PROVDER .....
R.A. DICKIE .....	S. KIA .....	R.A. RYNTZ .....
F.L. FLOYD .....	J.V. KOLESKE .....	C.K. SCHOFF .....
P.R. GUEVIN, JR. ....	H. LOWREY .....	R. STANZIOLA .....
	J.W. MARTIN .....	

The JOURNAL OF COATINGS TECHNOLOGY has first rights to the publication of papers presented at the Annual Meeting 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 1993 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.



## FEDERATION OF SOCIETIES FOR COATINGS TECHNOLOGY BOARD OF DIRECTORS 1992-93

#### PRESIDENT

\*COLIN D. PENNY  
Kapsulkote, Inc.  
228 Patterson Ave.  
Hampton, VA 23669

#### PRESIDENT-ELECT

\*JOHN LANNING  
Courtaulds Coatings, Inc.  
Porter Paints Div.  
400 S. 13th St.  
Louisville, KY 40201

#### SECRETARY-TREASURER

\*JOSEPH P. WALTON  
Jamestown Paint Co.  
108 Main St.  
Jamestown, PA 16134

#### EVANS ANGELOS

Orny, Inc.  
Clarendon Hills, IL

#### JOHN C. BALLARD

Burgess Pigments Co.  
Sandersville, GA

#### \*LARRY BRANDENBURGER

The Valspar Corp.  
Minneapolis, MN

#### DARLENE R. BREZINSKI

Consolidated Research Inc.  
Mount Prospect, IL

#### ORVILLE E. BROWN

Courtaulds Coatings, Inc.  
Porter International Div.  
Louisville, KY

#### BRENDA L. CARR

Coatings Development Co.  
Painesville, OH

#### JOHN DELMONICO

Old Western Paint Co., Inc.  
Denver, CO

#### DAN DIXON

Engelhard Corp.  
Gordon, GA

#### TIMOTHY J. DONLIN

Synergistic Performance Corp.  
Emeryville, CA

#### FOREST FLEMING

Akzo Coatings, Inc.  
High Point, NC

#### JAMES E. GEIGER

Largo, FL

#### TERRY GELHOT

Carboline Co.  
St. Louis, MO

#### \*JOSEPH D. GIUSTO

Lenmar, Inc.  
Baltimore, MD

#### GERRY J. GOUGH

Holden Surface Coatings Ltd.  
Birmingham, England

#### ARTHUR K. HAGOPIAN

ICI Paints, Inc.  
Concord, Ont., Canada

#### RICHARD J. HIMICS

Daniel Products Co.  
Jersey City, NJ

#### PETER A. HISCOCKS

Ashland Chemicals  
Mississauga, Ont., Canada

#### WILLIAM M. HOLLIFIELD

Perry & Derrick Co.  
Norwood, OH

#### \*WILLIAM F. HOLMES

National Pigments & Chemicals, Inc.  
Garland, TX

#### NORMAN A. HON

The Sherwin-Williams Co.  
Kansas City, MO

#### ARTURO ITA

BASF Pinturas & Tintas, S.A. de C.V.  
Mexico, D.F., Mexico

#### GERALD F. IVANCIE

Pratt & Lambert, Inc.  
Buffalo, NY

#### CHARLES KAPLAN

Gillespie Coatings  
Longview, TX

#### WAYNE A. KRAUS

Aqualon Co.  
Wilmington, DE

#### MAUREEN M. LEIN

Davidson/Textron  
Dover, NH

#### ARTHUR R. McDERMOTT

Sugar Land, TX

#### J. DICK MULLEN

G-3 Industries  
Aurora, CO

#### WILLIAM W. PASSENO

Red Spot Westland, Inc.  
Westland, MI

#### HORACE S. PHILLIP

Supply & Services Canada  
Hull, Que., Canada

#### LARRY PITCHFORD

Reynolds Metals  
Louisville, KY

#### WILLIAM E. SHACKELFORD

Gaco-Western, Inc.  
Tukwila, WA

#### WILLIAM C. SPANGENBERG

Hammond Lead Products, Inc.  
Pittsburgh, PA

#### \*JAN P. VAN ZELM

Byk-Chemie USA  
Castaic, CA

\*Executive Committee Members

#### EXECUTIVE VICE PRESIDENT

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

# Comment

## FSCT & NPCA Cooperative Efforts—An Update

In the lengthy "Comment" published in the December 1992 JCT, we reviewed the background, status, and future hopes regarding the FSCT/NPCA cooperative efforts. We congratulate those readers who persevered through the summary and we thank those members who took the time to give us their thoughts on the topic.

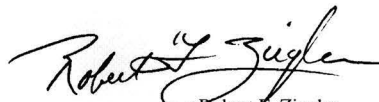
Since that writing, the NPCA Executive Committee approved the recommendations of the FSCT on representative and accountability of grant funding. And, following discussion of the NPCA vote, the Federation's Executive Committee authorized the implementation of the grant. The current status of the cooperation is presented in the news story on page 13 of this issue.

Also since that writing, we have had the pleasure of addressing the joint meetings of several Constituent Societies and local Paint & Coatings Associations, notably in Kansas City, Cleveland, and New York. In company with J. Andrew Doyle, NPCA's Executive Director, we discussed the need for cooperation and the direction, at least initially, of these efforts.

But, probably most importantly, the mission and programs of the Federation were detailed to the Association attendees. The response was gratifying, for the feedback indicated that coatings management knew very little about either the FSCT or Society activities. It was also interesting to learn that the move toward closer cooperation at the national level has led to similar discussions locally. Suffice to say that those who took part were surprised to learn of how lacking their knowledge was of the other organization; that their missions were essentially different, but contained many areas where cooperation could be explored.

Both nationally and locally, these discussions in no way eroded the sovereignty of the Federation or the Societies; they are independent and will remain so. Indications are, however, that the possibilities for synergism with NPCA and its constituents are good.

Generally speaking, it would appear that rather than familiarity, ignorance breeds contempt, and that familiarity plus communication breeds progress.



Robert F. Ziegler  
Executive Vice President

# Abstracts of Papers in This Issue

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

## Development of High Performance, Water-Based Emulsion Coatings for Can Coating Application—S. Kojima, Y. Watanabe and T. Moriga

JCT, 65, No. 818, 25 (Mar. 1993)

A new manufacturing process for high performance, waterborne coatings for can coating application was developed, which includes emulsification of an epoxy resin by the phase inversion method with or without a hardener by incorporation of an acrylic resin. It is possible by this new process to emulsify a variety of resins with minimum effects of the surfactant (acrylic resin) on the film properties of the cured coating. Thus, the latitude to design a formulation is widened and the performances of the epoxy resin and hardener are fully developed. It was found that the composition of the solvents in the resin solution prior to emulsification is critical to obtaining a stable emulsion with a fine particle size. The effects of surfactant and neutralizer on adhesion performance was also studied and found that the effect of the acrylic resin concentration was relatively small, but that the effects of the neutralizer were significant. It was confirmed that the usage of ammonia or amines with a branched alkyl group is required to achieve balanced dry and wet adhesion. It was also found, by the characterization of the emulsion and the cured films, that there exists a layer of acrylic polymer near the substrate and that most of the acrylic polymer forms a dispersed phase in the epoxy/phenolic polymer matrix.

## Interactions of HEUR Associative Thickeners with Waterborne Polyurethanes—J.P. Kaczmarek, R.H. Fernando, and J.E. Glass

JCT, 65, No. 818, 39 (Mar. 1993)

Polyurethane aqueous dispersions are examined with a variety of water-soluble polymers, and are compared with waterborne acrylic latices. Two particle size polyurethane aqueous dispersions are studied, the smaller size gives higher viscosities, in parallel with acrylic latices. Hydroxyethyl cellulose and hydrophobically-modified hydroxyethyl cellulose thicken surface-acid-stabilized acrylic latices. In contrast, polyurethane aqueous dispersions are not thickened effectively with cellulose ethers. The latter cause phase separation of the polyurethane dispersions, which increases with increasing particle size, in agreement with

## Développement de Revêtements Aqueux à Haute Performance pour une Application de Revêtement de Conserve—S. Kojima, Y. Watanabe and T. Moriga

JCT, 65, No. 818, 25 (Mar. 1993)

Un nouveau procédé de fabrication a été développé pour l'application des revêtements aqueux pour les revêtements de conserve, qui implique l'émulsification d'une résine époxydique par une méthode d'inversion de phase avec ou sans agent durcisseur par l'incorporation d'une résine acrylique. Il est possible avec l'aide de ce nouveau procédé d'émulsifier une gamme de résines avec un minimum d'effets des tensio-actifs (résine acrylique) sur les propriétés du feuillet du revêtement durci. Donc, la latitude pour le design d'une formulation est élargie et les performances de la résine époxydique et de l'agent durcisseur sont développés au maximum. Il a été trouvé que la composition des solvants dans la solution de résine avant l'émulsification est critique pour obtenir une émulsion stable avec une taille de particule fine. L'effet des tensio-actifs et neutralisants sur la performance d'adhésion a aussi été étudiée, où il a été trouvé que l'effet de la concentration de la résine acrylique était relativement petite mais que l'effet du neutralisant était significatif. Il a été confirmé que l'utilisation de l'ammoniac et des amines avec un groupe branché alkyl est requis pour obtenir un compromis entre l'adhésion sèche et humide. Il a également été trouvé, par la caractérisation de l'émulsion et des feuillets durcis, qu'il existe une couche de polymère acrylique près du substrat et qu'une grande partie du polymère acrylique forme une phase dispersée dans la matrice polymérique époxydique/phénolique.

## Les Interactions des Epaisissants Associatifs HEUR avec des Polyuréthanes Aqueux—J.P. Kaczmarek, R.H. Fernando, and J.E. Glass

JCT, 65, No. 818, 39 (Mar. 1993)

Des dispersions aqueuses de polyuréthane sont examinées avec une variété de polymères solubles à l'eau, et sont comparés avec des émulsions acryliques. Deux dispersions aqueuses de polyuréthane possédant deux grosseurs de particules différentes ont été étudiées, la plus petite particule donnant des viscosités plus hautes, en parallèle avec les émulsions acryliques.

## Desarrollo de Recubrimiento en Emulsion Base Agua de Alto Comportamiento Para Aplicación en Recubrimiento de Latas—S. Kojima, Y. Watanabe, and T. Moriga

JCT, 65, No. 818, 25 (Mar. 1993)

Se desarrolló un nuevo proceso de manufactura para recubrimientos en emulsión base agua, de alto comportamiento, para aplicación en latas, dicho proceso incluye la emulsificación de una resina epóxica mediante el método de inversión de fase con o sin un endurecedor por incorporación de una resina acrílica. Mediante este método es posible emulsificar una variedad de resinas con efectos mínimos del surfactante (resina acrílica) en las propiedades de película del recubrimiento curado. De esta manera, la libertad para diseñar una formulación se extiende y el desempeño de las resinas epóxicas y el endurecedor son totalmente desarrollados. Se encontró que la composición de los solventes en la solución de la resina, previa a la emulsificación, es crítica para obtener una emulsión estable con un tamaño fino en la partícula. Los efectos del surfactante y el neutralizador, en el desempeño de la adhesión, también se estudiaron, y se encontró que el efecto de la concentración de la resina acrílica, fué relativamente pequeño, pero los efectos del neutralizador fueron significativos. Se confirmó que se requiere el uso de amoníaco o de aminas ramificadas con un grupo alkyl para poder llevar a cabo el balance de la adhesión en seco y húmedo. También se encontró, mediante la caracterización de la emulsión y de las películas curadas, que existe una capa de polímero acrílico cercana al sustrato y que la mayoría de los polímeros acrílico forman una fase dispersa en la matriz epoxy/polímero fenólico.

## Las Interacciones de Espesantes Asociativos HEUR con Poliuretanos Base Agua—J.P. Kaczmarek, R.H. Fernando, and J.E. Glass

JCT, 65, No. 818, 39 (Mar. 1993)

Se examinaron las dispersiones acuosas de poliuretano con una variedad de polímeros solubles y se compararon con latex acrílicos base agua. Se estudiaron en forma paralela con latex acrílicos, dispersiones acuosas de poliuretano de 2 tamaños de partículas, la de menor tamaño da viscosidades mas altas. La hidroxietil celulosa y la hidroxietil celulosa hidro-

# FSCT PUBLICATIONS ORDER FORM

Quantity	Price	Total
----------	-------	-------

## Journal of Coatings Technology

	U.S. and Canada	Europe (Air Mail)	Other Countries
1 Year	\$30	\$60	\$45
2 Years	57	117	87
3 Years	82	172	127

## New Federation Series on Coatings Technology

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

(Mbr. \$7.50 ea., or  
\$5 ea. with order of full  
set;  
List-\$15 ea., or \$10 ea.  
with order of full set)

## Technical Volumes

_____ Paint/Coatings Dictionary		
_____ Infrared Spectroscopy Atlas (1991 Edition)		
_____ Glossary of Color Terms		

(Mbr.- \$30; List-\$50)  
(Mbr.-\$150; List-\$200)  
(\$6.00)

## Audio/Visual Presentations

(Slide/tape except where noted)

_____ Causes of Discoloration in Paint Films		
_____ The Setflash Tester		
_____ High Speed Dispersion		
_____ Introduction to Resin Operation		
_____ A Batch Operated Mini-Media Mill		
_____ Operation of a Vertical Sand Mill		
_____ Laboratory Test Procedures (VHS Format)		
_____ Federation Training Series on Test Methods		

(\$40)  
(\$100)  
(\$65)  
(\$65)  
(\$60)  
(\$75)  
(\$50)  
(\$70)

## Pictorial Standards of Coatings Defects

_____ Complete Manual		
_____ Individual Standards (\$3 ea., plus \$3 per photo as noted)		
_____ Adhesion (1)	_____ Blistering (4)	_____ Chalking (1)
_____ Checking (1)	_____ Cracking (1)	_____ Erosion (1)
_____ Fillform Corrosion (3)	_____ Flaking (2)	_____ Mildew (3)
_____ Print (1)	_____ Roller Spatter (5)	_____ Rust (4)
_____ Traffic Paint Abrasion (2)	_____ Traffic Paint Chipping (2)	
_____ Record Sheets (pad of 100 sheets)		

(\$100)  
(\$3.50)

Subtotal

Pa. Residents please add 6% Sales Tax

Total

Available in the U.K. from: Birmingham Paint, Varnish and Lacquer Club, c/o Robert McD. Barrett  
B.I.P. Chemicals Ltd., P.O. Box 6, Warley, West Midlands, England

Available in Mexico from: Ms. Margarita Aguilar, Mexico Society, Gabriel Mancera 309, Col. Del Valle, 03100 Mexico, D.F., Mexico

### ALL INFORMATION BELOW MUST BE COMPLETED

#### YOUR COMPANY

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

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

Signed \_\_\_\_\_ Date \_\_\_\_\_

Name \_\_\_\_\_

Title \_\_\_\_\_

Company \_\_\_\_\_

Address \_\_\_\_\_

City & State \_\_\_\_\_

Country \_\_\_\_\_ Mail Code \_\_\_\_\_

**Make Checks payable to: Federation of Societies for Coatings Technology**  
Postage and handling charges will be added to all orders requiring billing.

FSCT Member     Non-Member     Please send membership information

All checks must be payable on a U.S. Bank



the concept of depletion or volume restricted flocculation. Polyurethane aqueous dispersions are more effectively thickened with hydrophobe-modified, ethoxylated urethanes (HEURs) than corresponding particle size acrylic latices. HEURs that are very inelastic in acrylic latex dispersions become very elastic in polyurethane dispersions. In a series of designed step-growth polymerization, HEURs, synthesized in our laboratories, the viscosity increase is noted to depend on the "effective hydrophobe size" of the terminal positions in HEUR thickeners. The effective terminal hydrophobe size is determined by the alkyl chain of the hydrophobic amine and the alkyl group of the diisocyanate with which it reacts. When the size of the hydrophobic amine is kept constant, but the alkyl units of the diisocyanate is increased in hydrophobicity, larger increases in viscosity are realized.

### AC Impedance Analysis and Factorial Designs of an In-Situ Phosphatizing Coating—D.A. Meldrum and C-T. Lin

JCT, 65, No. 818, 47 (Mar. 1993)

A full factorial experiment designed to obtain formulation factor effects of a single-step polyester-melamine enamel/ $H_3PO_4$  system has been conducted. The designs consist of five factors (%  $H_3PO_4$ , VOC type, CLA/VEH ratio, DFT, and bake schedule) at two levels each. Electrochemical impedance spectroscopy was used to obtain quantitative performance of the formulated paint coatings on Q-panels. The results manifested that %  $H_3PO_4$  has the largest main effect, suggesting that  $H_3PO_4$  in the single-step paint system tends to diffuse to and react with the metal surface, providing a corrosion protective layer on the substrate. Under standard and "real world" test environments, the in-situ phosphatizing paint performed with equivalent ranking to that of the multi-step process.

### Amine-ene Technology III': Investigation of the Properties of Some Branched Maleate Oligomers in Ultraviolet Light Curable, Amine-ene Coatings—G.K. Noren

JCT, 65, No. 818, 59 (Mar. 1993)

Photocrosslinking utilizing the amine-ene reaction with benzophenone (BP) as the hydrogen abstraction photoinitiator was investigated using the Simplex Experimental Design technique. Coating formulations consisting of three basic components: an allyl terminated polyester, a polymer bound amine synergist, and a branched maleate

Le cellulose hydroxyéthyl et la cellulose hydroxyéthyl modifiée hydrophobiquement épaississent les émulsions acryliques stabilisées en surface par de l'acide. Par contre, les dispersions aqueuses de polyuréthane ne sont pas épaissies de façon efficace avec les éthers cellulosiques. Ces dernières causent des séparations de phase de dispersions de polyuréthane, qui augmentent avec une augmentation de la taille de particule, en accord avec le concept de la floculation restreinte de volume. Des dispersions aqueuses de polyuréthane sont épaissies plus efficacement avec des uréthanes éthoxylée modifiée hydrophobiquement (HEUR) que les émulsions acryliques de taille de particules équivalentes. Les HEUR qui sont très inélastiques dans des émulsions acryliques, deviennent très élastiques dans des dispersions de polyuréthanes. Dans une série d'étapes de croissance de polymérisation HEUR, synthétisés en laboratoire, l'augmentation de viscosité dépend de la "taille effective hydrophobe" des positions terminales dans les épaississants HEUR. La taille du terminal hydrophobe est déterminée par la chaîne alkyl de l'amine hydrophobique et du groupe alkyl du diisocyanate avec lequel il réagit. Quand la taille de l'amine hydrophobique est gardée constante, mais que les unités alkyl du diisocyanate est augmentée en hydrophobicité, de plus grandes augmentations de viscosité sont réalisées.

### Analyse d'Impédance AC et Design Factoriel d'un Revêtement de Phosphatation In-Situ—D.A. Meldrum and C-T. Lin

JCT, 65, No. 818, 47 (Mar. 1993)

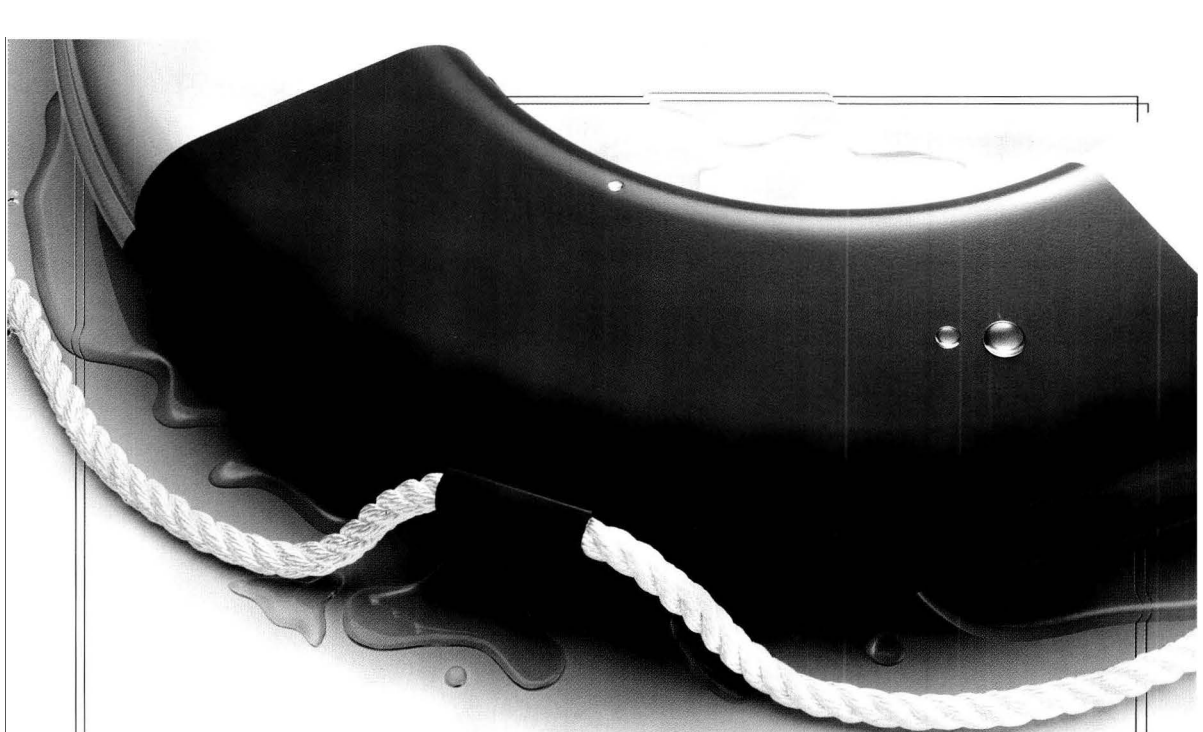
Une analyse factorielle complète a été effectuée pour obtenir les facteurs affectant la formulation d'un système polyester-melamine/ $H_3PO_4$ . Le design consiste en cinq facteurs (%  $H_3PO_4$ , type COV, rapport CLA/VEH, DFT et cédule de cuisson) à deux niveaux chacun. La spectroscopie d'impédance électro-chimique a été utilisée pour quantifier la performance de divers revêtements sur des panneaux "Q". Les résultats démontrent que le pourcentage de  $H_3PO_4$  a le plus grand effet, suggérant que le  $H_3PO_4$  dans le système de revêtement a tendance à diffuser et à réagir avec la surface métallique, pourvu qu'il y a une couche protectrice de corrosion sur le sujet. En présence de tests environnementaux "normaux," la phosphatation *in-situ* du revêtement accomplit sa tâche de façon équivalente à un procédé multi-étapes.

fómicamente modificada, espesan estos latex acrílicos estabilizados con ácidos. En contraste, las dispersiones acuosas de poliuretano no se espesan efectivamente con éteres de celulosa. Esto último causa separación de fases de las dispersiones de poliuretano, lo cual se incrementa con el aumento del tamaño de la partícula, de acuerdo con el término de depleción o floculación restringida por volumen. Las dispersiones acuosas de poliuretano son espesadas mas efectivamente con uretanos etoxilados modificados con Hidrófobos (HEURs) que los correspondientes latex acrílicos, con cierto tamaño de partícula. Los HEURs que son muy inelásticos en las dispersiones de latex acrílicos, se vuelven muy elásticos en dispersiones de poliuretano. En una serie de HEURs polimerizados con crecimiento diseñado en etapas, sintetizados en nuestros laboratorios, se notó un incremento de viscosidad dependiendo del tamaño de hidrófobo efectivo en la posición terminal de los espesantes HEURs. El tamaño efectivo de la terminal hidrófoba se determina por la cadena alquímica de la amina hidrófoba y el grupo alquilo del diisocianato con el cual reacciona. Cuando el tamaño de la amina hidrófoba se mantiene constante, pero se aumentan las unidades alquímicas del diisocianato, se tiene un incremento en hidrofobicidad y se obtienen incrementos mayores en la viscosidad.

### Análisis de la Impedancia AC y Diseños Factoriales de un Recubrimiento Fosfatizante In-Situ—D.A. Meldrum and C-T. Lin

JCT, 65, No. 818, 47 (Mar. 1993)

Se condujo un experimento completamente factorial para obtener los efectos de factores de formulación de un sistema barniz—poliéster-melamina/ $H_3PO_4$  de una sola etapa. Los diseños consisten de 5 factores (%  $H_3PO_4$ , tipo de VOC, relación CLA/VEH, espesor seco de película (DFF) y ciclo de horneado) en dos niveles cada uno. Para obtener el desempeño cuantitativo de los recubrimientos de pinturas formuladas en paneles Q, se empleó la técnica de espectroscopía de impedancia electroquímica. Los resultados manifestaron que el porcentaje de  $H_3PO_4$  presenta el mayor efecto principal, sugiriendo que el  $H_3PO_4$  en el sistema de pintura de un solo paso tiende a difundirse hacia la superficie metálica y a reaccionar con ella, proporcionando una capa protectora de corrosión en el sustrato. Bajo pruebas en medios estándares y "reales," la pintura fosfatizante in-situ desarrolló en grado equivalente al del proceso múltiple.



## There's only one thing that works better in water than Surfynol<sup>®</sup> surfactants.

When it comes to formulating water-based systems, Air Products' Surfynol surfactants are real lifesavers. They're multifunctional, so they make formulating or reformulating in water as easy as the systems you're used to.

And with Surfynol surfactants, your coatings perform the way they should, with improved flow and leveling, and better wetting with reduced foam—including microfoam.

How can we be sure? Because we test our products in our own lab, under real-world application settings. So you can be sure our entire line of surfactants do what they promise. Work. For more information, or to order a sample, call us at 1-800-

345-3148 or 215-481-6799, Fax 215-481-4381. Europe

31-30-511828. Surfynol surfactants. Take the plunge.



*More than chemicals. Chemistry.*

oligomer (BMO) were prepared. The chemical structure of the BMO component was varied by introducing four different saturated difunctional carboxylic acids into an oligomer backbone containing tris-(2-hydroxyethyl) isocyanurate as a branching agent. The average double bond functionality of the oligomers was held constant at four and the equivalent weight was maintained between 400 and 425. Some structure-property dependence was observed for the solvent resistance and pencil hardness data at a cure dose of 3 J/cm<sup>2</sup>. These oligomers were compared with a BMO which contained no saturated dicarboxylic acid component and had an equivalent weight of 340. In spite of the lower functionality, cure rate (MEK double rub resistance) increased with the decreased double bond equivalent weight at a cure dose of 1 J/cm<sup>2</sup>. Comparison of a linear internal maleate unsaturated polyester oligomer with a BMO indicated an advantage for the use of the BMO. The average crosslink density for the BMO systems, as determined from the equilibrium modulus data, was about 10<sup>20</sup> crosslinks per cc. Of the three intramolecular cleavage photoinitiators evaluated, only 2-hydroxy-2-methyl-1-phenylpropan-1-one (HMPP) produced a faster cure rate than BP.

#### **Behavior of Some Anticorrosive Epoxy-Polyamide Primers Free of Lead and Chromate and in the Presence of Chloride Ions—A. Ruvolo-Filho and E.S. da Costa**

JCT, 65, No. 818, 67 (Mar. 1993)

A series of new generation primers has been developed and characterized by measurements of ionic resistance, salt permeability, and salt absorption. Their utilization as replacements for zinc chromate and red lead in conventional anticorrosive systems is proposed.

#### **Technologie Amine-Ene III: Investigation des Propriétés d'Oligomères Maléate Branchés dans des Revêtements Ultraviolets à Base d'Amine-Ene—G.K. Noren**

JCT, 65, No. 818, 59 (Mar. 1993)

La photoréticulation utilisant la réaction amine-ene avec le benzophénone (BP) comme photoinitiateur a été étudiée avec l'aide de la technique de Design Experimental Simplex. Les formules de revêtements consistent en trois composés de base, un polyester avec terminaisons allyl, un synergiste à base d'amine, et un oligomère maléate branché (BMO) ont été préparés. La structure chimique du composé BNO a été variée en introduisant quatre acides carboxyliques bi-fonctionnels saturés différents dans le squelette d'un oligomère contenant le tris-(2-hydroéthyl) isocyanate comme agent de branchement. La fonctionnalité du lien double des oligomères a été maintenu constant à quatre et le poids équivalent a été maintenu entre 400 et 425. Une relation structure-propriété a été observée pour la résistance au solvant et la dureté au crayon pour une dose de cuisson de 3J/cm<sup>2</sup>. Les oligomères ont été comparés avec un BNO ne contenant aucun composé acide carboxylique saturé et ont un poids équivalent de 340. Malgré la plus basse fonctionnalité, le degré de durcissement (résistance au MEK) a augmenté avec la diminution du poids équivalent du lien double pour une dose de cuisson de 1J/cm<sup>2</sup>. La comparaison d'un oligomère polyester non-saturé linéaire avec un BMO indique un avantage pour l'utilisation du BMO. La densité moyenne de réticulation pour les systèmes BMO, tel que déterminé à partir des données du module d'équilibre, était environ 10<sup>20</sup> réticulations par cc. De ces trois photoinitiateurs évalués, seulement le 2-hydroxy-2-méthyl-1 phénylpropan 1-one (HMPP) a produit un degré de cuisson plus rapide que le BP.

#### **Comportement d'Apprêts Anti-Corrosif Epoxy/Polyamide sans Plomb et Chromate en Présence d'Ions Chlorures—A. Ruvolo-Filho and E.S. da Costa**

JCT, 65, No. 818, 67 (Mar. 1993)

Une nouvelle génération d'apprêts a été développée et caractérisée à l'aide de mesures de résistance ionique, perméabilité et absorption saline. Leurs utilisations pour remplacer le chromate de zinc et le rouge de plomb dans les systèmes anti-corrosifs conventionnels est proposé.

#### **Tecnologia Amine—Ene III<sup>1</sup>: Investigación de las Propiedades de Algunos Oligomeros Maleato Ramificados, en Recubrimientos Amine—Ene Curables con Luz Ultravioleta—G.K. Noren**

JCT, 65, No. 818, 59 (Mar. 1993)

Utilizando la técnica simplex de diseño experimental se investigó la fotoreticulación de la reacción de amino-eno, empleando benzofenona (BP) como fotoiniciador para abstracción de hidrógeno. Se prepararon formulaciones de recubrimiento, las cuales consistieron de tres componentes básicos: un alyl poliéster, un polímero sinergista unido a una amina y un oligómero maléato ramificado (BMO). La estructura química del BMO se varió mediante la introducción de cuatro ácidos carboxílicos difuncionales saturados, distintos, en la cadena a de un oligómero que contenía tris-(2-hidroxiethyl isocianuro) como agente ramificante. El promedio de funcionalidad del doble enlace de los oligómeros se mantuvo constante a 4 y el peso equivalente se mantuvo entre 400 y 425. Se observaron algunas relaciones estructura-propiedad para la resistencia al solvente y los datos de dureza de lápiz a un curado de 3 J/cm<sup>2</sup>. Estos oligómeros fueron comparados con un BMO, el cual contenía un componente de ácido dicarboxílico no saturado y tuvo en peso equivalente de 340. A pesar de la menor funcionalidad, el curado (resistencia al doble frotoado con MEK) aumento con el descenso del peso equivalente del doble enlace a un curado de 1 J/cm<sup>2</sup>.

#### **Comportamiento de Algunos Recubrimientos Epoxi-Poliamidicos Anticorrosivos, Libres de Plomo y Cromatos en Presencia de Algunos Iones Cloruro—A. Ruvolo-Filho and E.S. da Costa**

JCT, 65, No. 818, 67 (Mar. 1993)

Se ha desarrollado y caracterizada una nueva generación de primarios, caracterizada por mediciones de resistencia iónica, permeabilidad y absorción de sal. Se propone su utilización como reemplazo del cromato de zinc y plomo rojo en sistemas convencionales anticorrosivos.

## FSCT and NPCA Lay Groundwork for Closer Ties

The Executive Committees of the Federation of Societies for Coatings Technology (FSCT) and the National Paint and Coatings Association (NPCA) have approved a number of measures aimed at enhancing cooperation and fostering joint efforts between the two organizations.



In a joint announcement, Robert F. Ziegler, FSCT Executive Vice President, and J. Andrew Doyle, NPCA Executive Director, said that discussions over the past year between the organizations' leadership have been successful in developing several

areas in which mutual cooperation can benefit the industry.

Communication between FSCT and NPCA will continue with each organization providing the other with a seat on their respective Boards of Directors, and representatives will be invited guests at meetings of the other's Executive Committee and Budget and Finance Committee.

FSCT will provide financial support with a grant of \$100,000 to NPCA for 1993 to fund programs of common interest. This grant will be used to fund the NPCA state paint council network and further expansion of the NPCA state affairs program. Members of FSCT Constituent Societies will be placed on each state paint council roster and be represented on council steering committees. An FSCT representative will also be placed on the NPCA State Affairs Com-

mittee and the Strategic Planning Subcommittee on State Affairs.

"We believe the technical support offered by FSCT members will be very beneficial to our state-level efforts," Doyle said. "The Federation encourages its membership to become involved in the state programs whenever possible," added Ziegler.



In a move to better coordinate the industry's support of educational activities, NPCA will close the Ernest T. Trigg Foundation and donate assets to the Federation's Coatings Industry Educational Fund (CIEF).

The organizations will also cooperate in the co-sponsorship of two projects. NPCA will support and co-sponsor the FSCT project on compiling Material Safety Data Sheets on CD-ROM. The system will provide coatings manufacturers with a compact, highly durable, yet easily accessible format for MSDS document information. Also, the NPCA Manufacturing Management Committee's Plant Operation Seminar, scheduled for April 1993, will be co-sponsored by the FSCT's Manufacturing Committee.

In addition, both groups will consider eliminating or combining certain of their committees to avoid duplication of effort and to foster synergistic opportunities.

Ziegler said that one of the goals of the discussions had been to better coordinate NPCA and FSCT Annual Meetings, and added, "We believe this can be accomplished." NPCA will hold its 1999 Annual Meeting in Dallas, TX, in conjunction with the FSCT Annual Meeting and Paint Industries Show. All future Annual Meetings of the two groups (with the exception of the 1995 meetings) will be held in the same city. "We are considering the possibility of holding joint theme sessions, and perhaps jointly sponsoring forum sessions with FSCT," Doyle said.

Both organizations emphasized that because the move toward a closer relationship is a recent one, strategies for additional joint efforts are still being formulated. "We are looking forward to working with the Federation in any areas that will further our common goal of strengthening the industry," Doyle said.

## Focus is on Atlanta, Oct. 27-29, as FSCT Prepares For Annual Meeting & Paint Industries' Show

Atlanta—the Gateway to the South, the city that combines old southern hospitality and is the center for the latest in modern technology—will host the 71st Annual Meeting and 58th Annual Paint Industries' Show of the Federation of Societies for Coatings Technology, on October 27-29. It is a fitting location for an event which has a long history of successful service to the coatings industry by providing opportunities to learn about the very latest technologies, materials, and equipment used in the manufacture of paints and related decorative and protective coatings.

### Annual Meeting Theme

Plans are currently underway for the three-day program. The theme of the FSCT Annual Meeting is "Today's Competitive Coatings: Lean, Mean, and Green."

The 1993 theme recognizes these goals in the terms:

LEAN: Cost effective . . . process efficient . . . waste free

MEAN: Consistent . . . tough . . . durable . . . resistant

GREEN: Environmentally friendly . . . renewable . . . recyclable . . . safe.

Success in the coatings industry, now, and in the future, belongs to those who take the lead by blending long-term profitability,

coatings performance, and environmental protection.

Programming will be geared to this theme. In addition, sessions will be held on such topics as: corrosion, manufacturing, advanced technologies in coatings research, radiation curing, latex technology, polymer science, environmental impact/constraints and physical property characterization.

All sessions will be held at the newly-expanded Georgia World Congress Center, beginning with the Opening Session on Wednesday, October 27 and ending with the Mattiello Memorial Lecture on Friday, October 29.

### Program Committee

Clifford Schoff, of PPG Industries, Inc., Allison Park, PA, is serving as Chairman of the Program Committee which is involved in the program development. Assisting Dr. Schoff on the steering committee are: Ronda Miles (*Vice-Chair*), Union Carbide Corp., Garland, TX; Darlene Brezinski, Consolidated Research, Inc., Mt. Prospect, IL; Loren W. Hill, Monsanto Co., Springfield, MA; Richard J. Himics, Daniel Products Co., Inc., Jersey City, NJ; Louis F. Holzknecht, Devoe Coatings Co., Louisville, KY; Louis J. Sharp,

(Continued on page 14.)

# Atlanta to Host Annual Meeting & Paint Show, Oct. 27-29

(Continued from page 13)

Dexter Packaging Products, Waukegan, IL; and Roger Woodhull, California Products Corp., Cambridge, MA.

## Hotels and Reservations

Seven hotels have reserved blocks of rooms for the Federation event. The Atlanta Marriott Marquis will serve as headquarters for the Annual Meeting and Paint Industries' Show.

Other cooperating hotels include the Atlanta Hilton and Towers, Atlanta Hyatt Regency, Omni at CNN Center, Radisson, Ritz-Carlton, and the Westin Peachtree Plaza. All hotel reservations will be processed through the Atlanta Convention & Visitors Bureau. Housing information will be mailed to all members in April.

## Registration Fees

Advance registration forms and information will be sent to all members in April. Advance fees are \$75 for members and \$80 for non-members. The fee for guest activities is \$60 in advance. Retired members and their spouses may register for the special advance fee of \$25 each.

On-site registration will be \$90 for full time and \$70 for one-day for members. Non-member fees will be \$125 for full-time and \$90 for one day.

## Host Committee

Serving as Chairman of the Annual Meeting Host Committee is Jeff Shubert, of Shubert Paints, Inc., Tucker, GA. Assisting on the committee are: Stan Harshfield, of Watty Paint Corp., Tampa, FL; Philip Aultman, of Whittaker, Clark & Daniels, Norcross, GA; Thad T. Broome, of J.M. Huber Corp., Macon, GA; Sal Sanfilippo,

of SGC Coatings Consultants, Tuscaloosa, AL; and Stephen Cantrell, of Kerr-McGee Chemical Corp., Tucker, GA.

## NPCA to Meet Same Week

The National Paint & Coatings Association will hold its annual meeting on October 25-27, in the Hilton Hotel & Towers, in Atlanta.

## FSCT Seeks Authors for Manufacturing Digest

The Manufacturing Committee of the FSCT is seeking authors to contribute articles for its Manufacturing Digest. The Digest will be in loose-leaf format consisting of articles from industry publications, academic sources, and articles from industry suppliers. The intent is to have the Digest used as a reference/training tool for manufacturers of coatings.

The primary focus of the Digest is the production/manufacturing process, rather than the technical/formulation aspect. Papers are invited from raw material suppliers on preferred or recommended techniques for handling or processing, as well as safeguards specific to their materials. Submissions are also encouraged from academic

sources, and individuals from other segments of the industry related to manufacturing.

The Digest will include chapters on the following subjects: Quality Management; Material Handling; Paint Production Procedures; Inventory/Warehouse; Safety/Environmental; and Waste Management. Authors are encouraged to contact FSCT for the complete "Authors Kit," which includes a Guide for Authors, and a complete list of the Table of Contents.

The deadline for the submission of papers is June 30, 1993. For your copy of the "Authors Kit," please contact Michael G. Bell, Director of Educational Services, FSCT, 492 Norristown Road, Blue Bell, PA 19422.

## PAINT INDUSTRIES' SHOW

### 256 Supplier Companies Reserve Booth Space At 1993 Paint Industries' Show; 95% Sold Out

Running concurrent with the FSCT Annual Meeting, the 58th Annual Paint Industries' Show will be held October 27-29, at the Georgia World Congress Center. The Paint Show provides the largest and most complete exhibition of raw materials, manufacturing equipment, instrumentation, containers and filling equipment, and services in the coatings industry—worldwide.

Currently, 256 exhibiting companies have reserved 95% of available booth space in Atlanta. Of these, seven companies are first-time exhibitors: Coatings Laboratory, Inc.; LaQue Center; Praxair, Inc.; Rohm Tech, Inc.;

Ronnigen-Petter; Schuller Filtration; and U.S. Sack Corp.

Companies interested in reserving the remaining booth space should contact Robert F. Ziegler or Lisa Torrens at FSCT Headquarters Office.

Show hours are: 12 noon to 5:00 pm on Wednesday, October 27; 9:00 am to 5:00 pm on Thursday, October 28; and 9:00 am to 12 noon on Friday, October 29. Shuttle service will be available to the World Congress Center from participating hotels.



Georgia World Congress Center  
Atlanta, GA  
October 27-28-29, 1993

No alkaline pH problems.  
No amine incompatibility.  
No safety margin concerns.  
No stabilizers required.  
No formaldehyde released.  
And no experience gap  
between what we make and  
what we know



Not with PROXEL® GXL preservative.  
When you protect your products with PROXEL GXL, it's not just what you get that counts. It's what you don't get: Worry.

You don't worry about performance in the challenging chemical environment of your coatings. Or about falling short of your safety or stability requirements. Or about any incompatibility with your raw materials.

Instead, you get over a decade of experience in coatings preservation. A decade that's proven how cost-effective PROXEL's long term protection is. A decade that's established PROXEL GXL as the standard of antimicrobial performance in the industry.

But beyond unmatched performance is unrivaled service. By an experienced team

of microbiologists, chemists, and technical sales representatives.

If you'd like to learn more, just call 1-800-523-7391, Ext. 112.

**PROXEL® GXL**

Preserving Your Products.  
And Your Reputation.™



**Biocides**

Wilmington, Delaware 19897

PROXEL is a registered trademark of Imperial Chemical Industries PLC. © 1992, ICI Americas Inc. All Rights Reserved.

Part of ICI Specialties A business unit of ICI Americas Inc.

**Circle No. 105 on the Reader Service Card**

# 1993 PAINT INDUSTRIES' SHOW

## Current List of Exhibitors

Aceto Corp.  
Advanced Coating Technologies  
Advanced Software Designs  
Air Products & Chemicals, Inc.  
Alcan-Toyo America, Inc.  
Alcoa Industrial Chemicals  
Allied Signal Corp.  
Alt-Chem International  
ACS/C&E News  
American Felt & Filter Co.  
American Paint Journal Co.  
ANGUS Chemical Co.  
Anker Labelers USA, Inc.  
Aqualon Co.  
Arco Chemical Co.  
Atlas Electric Devices Co.  
Aztec Catalyst Co.

B.A.G. Corp.  
BASF Corp.  
Blackmer Pump  
Bohlin Instruments, Inc.  
Brookfield Engineering Labs, Inc.  
Brookhaven Instruments Corp.  
Buckman Laboratories  
Buhler Inc.  
Bulk Lift International  
Burgess Pigment Co.  
BYK-Chemie USA  
BYK-Gardner, Inc.

Cabot Corp., Cab-O-Sil & Special  
Blacks Div.  
Caframo Ltd.  
Calgon Corp.  
Cappelle Inc.  
The Carborundum Co., Fibers Div.  
Cardolite Corp.  
Cargill, Inc.  
Carri-Med Americas, Inc.  
Carroll Scientific, Inc.  
CB Mills, Div. Chicago Boiler Co.  
CCP Polymers  
Celite Corp.  
Chemical Marketing Reporter  
Chemical Week Associates  
CIBA-GEIGY Corp.  
The Coatings Laboratory Inc.  
Coatings Magazine  
Color Corp. of America  
Colorgen, Inc.  
Colortec Associates Inc.  
Columbian Chemicals Co.  
Compliance Services, Inc.  
Consolidated Research, Inc.  
Cookson Pigments Inc.  
Coulter Corp.  
CPI Purchasing Magazine  
CPS Chemical Co., Inc.  
CR Minerals Corp.  
Cray Valley Products  
Crosfield Co.  
Cuno, Inc., Process Filtration Prods.  
CYTEC Industries

D/L Laboratories  
Daniel Products Co., Inc.  
Datacolor International  
DeFelsko Corp.  
Degussa Corp.  
University of Detroit-Mercy

Distil-Kleen, Inc.  
Dominion Colour Corp.  
Dow Chemical  
Dow Corning Corp.  
Draiswerke, Inc.  
Drew Industrial  
Dry Branch Kaolin Co.  
DSA Consulting, Inc.  
Du Pont Co.

Eagle-Picher Minerals, Inc.  
Eagle Zinc Co.  
Eastern Michigan University  
Eastman Chemical Co.  
Ebonex Corp.  
ECC International  
Eiger Machinery, Inc.  
Elektro-Physik USA, Inc.  
Elf Atochem  
Elmar Worldwide  
EM Industries, Inc.  
Engelhard Corp.  
Epworth Mfg. Co., Inc.  
Etna Products, Inc., Specialty  
Chemical Div.  
Exxon Chemical Co.

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

Paul N. Gardner Co., Inc.  
The BFGoodrich Co., Specialty  
Polymers & Chemicals Div.  
The Goodyear Tire & Rubber Co.,  
Chemical Div.  
Grace Davison (W.R. Grace & Co)  
Guertin Polymers

Haake Inc.  
Halox Pigments  
Harcros Pigments, Inc.  
Henkel Corp., Coatings & Inks Div.  
Heraeus DSET Laboratories, Inc.  
Hilton Davis Co.  
Hitox Corp. of America  
Hockmeyer Equipment Co.  
Hoechst Celanese Corp., Pigments  
Hoechst Celanese Corp., Waxes,  
Lubricants & Polymers  
J.M. Huber Corp.  
Hüls America Inc.  
Hunter Associates Laboratory, Inc.

Ideal Manufacturing & Sales Corp.  
Industrial Finishing Magazine  
International Compliance Center  
International Resources, Inc.  
International Specialty Products  
ISP Filters, Inc.  
ITT Marlow/ITT A-C Pump

SC Johnson Polymer  
**Journal of Coatings Technology**

K-T Feldspar Corp.  
Kenrich Petrochemicals, Inc.  
Kinetic Dispersion Corp.  
King Industries, Inc.  
KRONOS, Inc.  
KTA-Tator, Inc.

Labsphere, Inc.  
LaQue Center for Corrosion  
Technology, Inc.  
Leeds & Northrup/Microtrac Div.  
Liquid Controls Corp.  
The Lubrizol Corp.  
Luzenac America

3M, Industrial Chemicals Prod. Div.  
3M/Zeelan Industries, Inc.  
Macheth, Div. of Kollmorgen, Corp.  
Magnesium Elektron Inc.  
Malvern Instruments, Inc.  
Malvern Minerals Co.  
McWhorter, Inc.  
The Mearl Corp.  
Michelman, Inc.  
Micro Powders, Inc.  
Micromeritics Corp.  
Mid-States Eng. & Mfg.  
Millipore Corp.  
Mineral Pigments  
MiniFIBERS, Inc.  
Minolta Corp.  
Mississippi Lime Co.  
University of Missouri-Rolla  
Modern Paint & Coatings  
Morton International, Inc.,  
Universal Color Dispersions  
Mountain Minerals Co., Ltd.  
Myers Engineering

Nacan Products Ltd.  
National Chemical Co., Inc.  
Netzsch Inc.  
Neville Chemical Co.  
New Way Packaging Machinery Inc.  
North Dakota State University  
NYCO Minerals, Inc.

Obron Atlantic Corp.  
Ohio Polychemical Co.  
Olin Chemicals  
Opticolor, Inc.  
Ortech International

Pacific Micro Software Engineering  
Paint & Coatings Industry  
Magazine

Pen Kem Inc.  
Peninsula Polymers  
Philips Container Co.  
Physica USA  
Pioneer Packaging Machinery, Inc.  
Plastican, Inc.  
Polar Minerals  
Poly-Resyn, Inc.  
PPG Industries, Inc., Silica Prods.  
PPG Industries, Inc., Spec. Chems.  
PQ Corp.  
Praxair, Inc.  
Premier Mill Corp.  
Progressive Recovery, Inc.  
Pyosa, S.A de C.V.

Q-Panel Co.

Raabe Corp.  
RadTech International North  
America  
Ranbar Technology, Inc.  
Reichhold Chemicals Inc.  
RHEOX, Inc.  
Rhone-Poulenc Inc.  
Rohm and Haas Co.  
Rohm Tech Inc.  
Ronningen-Petter  
Rosedale Products, Inc.  
Charles Ross & Son Co.  
Russell Finex Inc.

Sandoz Chemicals Corp.  
Sannor Industries, Inc.  
Sartomer Co.  
Schold Machine Corp.  
Schuller Filtration  
SCM Chemicals  
Semi-Bulk Systems, Inc.  
Serac, Inc.  
Shamrock Technologies, Inc.  
Sheen Instruments Ltd.  
Shell Chemical Co.  
Sherwin-Williams Co.  
Shimadzu Scientific Inst., Inc.  
Silberline Manufacturing Co., Inc.  
South Florida Test Service  
Southern Clay Products, Inc.  
University of Southern Mississippi  
Spartan Color Corp.  
Specialty Minerals Inc.  
Steel Structures Painting Council  
Sub-Tropical Testing Service  
Sullivan Chemical  
Sun Chemical Corp.  
Systech Environmental Corp.

Taber Industries  
Tego Chemie Service USA  
Texaco Chemical Co.  
Thiele Engineering  
Troy Corp.  
21st Century Containers, Ltd.

U.S. Silica Co.  
Union Carbide Corp.  
Union Process Inc.  
United Catalysts, Inc.  
United Mineral & Chemical Corp.  
United States Testing Co.

Van Waters & Rogers Inc.  
R.T. Vanderbilt Co., Inc.  
Velsicol Chemical Corp.  
Versa-Matic Pump Co.  
Vorti-Siv Div., of M&M Ind., Inc.

Wacker Silicones Corp.  
Warren Pump, Inc., a Unit of Idex  
Wilden Pump & Engineering Co.  
Witco Corp.

X-Rite, Inc.

Zeneca Resins

# Regulatory UPDATE

MARCH 1993

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. and edited by members of the FSCT Environmental Affairs Committee.

---

## Legislation—Lead

**House**—Legislation that would impose an excise tax on lead is expected to be introduced by Representative Ben Cardin (D-MD). The revenue generated from the tax would be used to establish a trust fund for lead hazard abatement in low income housing. The bill will be introduced pending a determination from the Joint Tax Committee on what level of excise tax would be needed based on revenue estimates. Rep. Cardin offered similar legislation last year, but the bill never cleared the House Ways and Means Committee because of objectives to a two-part tax schedule instead of a flat tax.

Under the proposal, lead produced or recycled in the United States would be taxed by weight, as would foreign-produced lead exported to the United States. While products containing trace amounts of lead would be exempt from the tax, other products containing more than trace amounts would be taxed under a soon-to-be-determined schedule. Proposals under consideration for this latter tax are similar to the tax on ozone-depleting chemicals such as chlorofluorocarbons. Revenue from the excise tax, which would amount to approximately 50 cents per pound of lead, is expected to generate about \$1 billion per year.

**Senate**—Senator Harry Reid (D-NV) also plans to resurrect his bill, the Lead Exposure Reduction Act of 1991 (S. 391). This bill would amend the Toxic Substances Control Act (TSCA) by banning a number of uses of lead.

Senator Reid, chairman of the Senate Energy and Public Works Subcommittee on Toxic Substances, Environmental Oversight, Research and Development, which has jurisdiction over TSCA, has indicated he will introduce an identical

bill to S. 391, with the exception of the lead based paint abatement provisions. Those provisions were incorporated into Title X of last year's Housing and Community Development Act.

Reportedly, the measure will focus on controlling existing uses of lead, banning certain non-essential uses of lead and requiring firms to report certain lead production and use information to the EPA.

The House has not yet determined whether they will pursue lead legislation under TSCA.

In related activity, the Alliance to End Childhood Lead Poisoning has released a comprehensive national action plan. The plan stresses action on four key issues that must be addressed during the implementation of the Residential Lead-based Paint Hazard Reduction Act of 1992 (Title X), which passed in October.

According to the plan, EPA must immediately develop minimum national criteria to which state programs can refer when certifying abatement contractors; federal agencies should train 25,000 workers in 1993 and at least 100,000 in 1994 for lead abatement; the Department of Health and Human Services must ensure that all children under the age of six must have their blood screened for lead poisoning and referred for appropriate followup; and the federal government must set an example for private landlords by preventing lead poisoning in children who live in federally funded housing.

Reportedly, the Alliance to End Childhood Lead Poisoning has discussed this issue with a number of Clinton transition teams and are claiming that EPA and the Department of Housing and Urban Development (HUD) will jointly increase their efforts to end lead hazards.

---

**Solid Waste**—A bill to allow states to determine whether they will accept and/or export waste to other states for disposal, recycling or incineration was reintroduced in the House at the end of January.

Rep. Paul Kanjorski (D-PA) has proposed legislation, HR 599, that is identical to bills he introduced during the two previous Congresses. The bill would allow states to develop their own policies with other states as to whether they would accept or restrict shipments of solid waste. The bill deviates

from legislation advocated by Senator Dan Coats (D-IN) last year in that it does not provide for a flat restriction of interstate solid waste shipments.

During the second session of the 102nd Congress, the interstate waste issue caused a controversial debate during the attempted reauthorization of the Resource Conservation and Recovery Act. Frustrated with the lack of action on the reauthorization, Sen. Coats introduced a free standing bill which would have given states limited powers to block out of

---

The Regulatory Update is made available as a service to FSCT members, to assist them in making independent inquiries about matters of particular interest to them. Although all reasonable steps have been taken to ensure the reliability of the Regulatory Update, the FSCT cannot guarantee its completeness or accuracy.



state trash. The bill passed the full Senate but died at the end of the session because the House failed to take action.

Rep. Kanjorski's decision to reintroduce his bill stemmed from pressure from the rural communities in his district that are forced to accept garbage for land disposal from New York and New Jersey simply because they do not have the resources to fight such shipments. The bill has been referred to the House Energy and Commerce Committee.

**Clean Water Act**—The reauthorization of the Clean Water Act could be in jeopardy if Congress decides to push a comprehensive wastewater treatment funding program as part of a Clinton administration plan to improve the country's infrastructure.

House Public Works and Transportation Chairman Norman Mineta (D-CA) and House Merchant Marines and Fisheries Chairman Gerry Studds (D-MA) have been holding meetings with "officials" of the new administration regarding the inclusion of a funding increase for water treatment projects in the "economic stimulus" program the administration is expected to offer.

Because an increase in wastewater treatment funding would satisfy short-term needs in many congressional districts, the impetus for a comprehensive reauthorization of the act could be somewhat depleted. Reportedly, some members of Congress would prefer to settle for a temporary resolution rather than take up an issue that is expected to be very time-consuming and controversial.

On the other hand, congressional staff and state wastewater treatment officials are pushing for a full reauthorization of the Clean Water Act to resolve such controversial issues as wetlands regulation, municipal stormwater compliance deadlines and watershed planning. It has also been reported that since Representatives Studds and Mineta are looking to go beyond a public works program for wastewater, they intend to begin hearings on the reauthorization late this year.

**Department of Labor  
Occupational Safety and Health Administration  
January 14, 1993—58 FR 4462  
Permit-Required Confined Spaces  
Action: Final rule**

The Occupational Safety and Health Administration (OSHA) has promulgated final rules regarding safety requirements for those entering permit-required confined spaces, which pose certain dangers because their configurations hamper efforts to protect against toxic, explosive or asphyxiating atmospheres. The new standard includes a complete regulatory scheme, including a permit system for entry into confined spaces, within which employers can use to effectively protect employees who work in permit spaces from injury or death.

Promulgation of the rules are based on a determination by OSHA that existing standards do not adequately protect workers in confined spaces from "atmospheric, mechanical and other hazards." It was also OSHA's determination that the only way to continually monitor, test, and communicate these workplace hazards is to implement a comprehensive confined space entry program.

The rules become effective on April 15, 1993. For further information, contact James Foster U.S. Department of Labor, Occupational Safety and Health Administration, Washington, D.C. (202) 523-8151.

**Department of Transportation  
Research and Special Programs Administration  
January 22, 1993—58 FR 5850  
Training for Safe Transportation of Hazardous Materials**

**Action: Final rule; revisions and response to petitions for reconsideration**

The Research and Special Programs Administration (RSPA) has revised a final rule published on May 15, 1992 (57 FR 20944) regarding training requirements for hazardous materials (hazmat) employees.

In response to petitions for reconsideration, RSPA has extended the compliance date for training under HM 126F; Training for the Safe Transportation of Hazardous Materials. The effective date will be October 1, 1993, to coincide with the compliance date of the new hazard communication and classification requirements under HM-181.

Because the extension to the final rule does not affect the Hazardous Materials Transportation Uniform Safety Act (HMTUSA) requirement for commencement of training, each hazmat employer must begin training each hazmat employee within six months (i.e., by November 15, 1992) after issuance of the May 15, 1992 final rule.

For further information, contact Jackie Smith, Office of Hazardous Materials Standards, RSPA, Department of Transportation, Washington, D.C. (202) 366-4488.

**Department of Transportation  
Research and Special Programs Administration  
February 2, 1993—58 FR 6864  
Oil Spill Prevention and Response Plans  
Action: Interim final rule with request for comments**

The Research and Special Programs Administration is amending the Hazardous Materials Regulations to include specific minimum standards for the safe transportation of oil that is currently unregulated. The amendments also include requirements for transporters of oil to develop plans for the prevention of and response to oil spills. This particular interim rule is applicable to bulk-packaging containing oil, specifically cargo tanks (tank trucks), railroad tank cars and portable tanks. The rule also implements provisions from the Federal Water Pollution Control Act as amended by the Oil Pollution Act of 1990.

Those persons subject to this rule must be in compliance with the requirements by October 1, 1993.

RSPA will accept comments on the rule until April 5, 1993. Comments should be identified by Docket No. HM-214; Amendment Nos. 171-119, 172-128, 173-232, 174-71, and 176-32, and sent in triplicate to Dockets Unit, RSPA, Department of Transportation, Room 8412, 400 Seventh Street, S.W., Washington, D.C. 20590-0001. For further information, contact Thomas Allan, Office of Hazardous Materials Standards, RSPA, Washington, D.C. (202) 366-4488.

## States Proposed Legislation and Regulations

### California

**Lead (Regulatory Activity)**—The California Department of Health Services (DHS) has issued emergency regulations to implement the Childhood Lead Poisoning Prevention Act of 1991. The regulations center around a fee structure that is to collect over 16 million dollars each year to fund a program to screen children under six for elevated blood lead levels and to provide case management for chronic exposures. The initial drafts of the regulation proposed to collect 7.5 million dollars each year from both the paint and petroleum industries.

When promulgating the regulations, DHS took into consideration a proposal by the California Paint Council (CPC) and the Western States Petroleum Association (WSPA) to assess a percentage of the total fees to be collected from industries that continue to use lead in their product formulations or industrial processes and a percentage from industries, including paint and petroleum, that have discontinued lead use. CPC and WSPA argued that their proposal more closely fulfills the mandate of the statute that fees be assessed on the basis of a manufacturer's past and present responsibility for environmental lead contamination.

The result is a structure that collects fees from the paint and petroleum industries for past environmental lead contamination and from all facilities reporting releases of lead into ambient air in California pursuant to SARA Title III for present environmental lead contamination. In doing so, DIIS assigned approximately 16% of the responsibility for past environmental lead contamination to the paint industry and 84% to the petroleum industry. The exact formula for assessing fees is complicated and will result in an annual adjustment of fees for all entities involved.

The paint industry's share of the total fees will be assessed against distributors on the basis of their market shares in the calendar year two years prior to the annual assessment. In other words, 1994 fees will be assessed using 1992 data. While regulations state that the first year fees will be due April 1, 1993, DHS has yet to collect the individual company data necessary to make the assessments.

Meanwhile, the California Manufacturers Association, along with CPC and WSPA, is still looking into the possibility of filing a lawsuit against DHS to block implementation of the regulations. A separate lawsuit is being considered to challenge the validity of the statute itself. The point of contention is whether the fees to be collected by the department to fund the program are actually taxes. Under California law, any bill that imposes a tax must be approved by a two thirds vote of both houses of the legislature. A court ruling that the funds to be collected are indeed taxes would be fatal to the funding portion of the statute, which passed only by a simple majority. For further information, contact CPC's Matt Dustin at (916) 443-5095.

**Air Quality (Regulation)**—The California Bay Area Air Quality Management District (BAAQMD) has adopted amendments to air district rules to reduce volatile organic compound (VOC) emissions from surface coating operations.

The amendments to the air district's Regulation 8, Rules 19, 29 and 31 limit VOC's from metal, aerospace and plastic parts surface coating operations and from aerospace stripping operations. They do not deal with ozone depleting compounds.

The amendments implement objectives contained in the Bay Area's Clean Air Plan and its Toxic Air Contaminants Reduction Plan, and they will affect over 200 firms. Report-

edly, affected facilities include 119 firms that use metal parts coatings, 53 involved in aerospace coatings operations, and seven that utilize plastic parts coatings.

All three rules require high transfer-efficiency spray application equipment, which must be in place by July 1, 1994. Companies that control emissions to an overall abatement efficiency of at least 85 percent will be exempt from the requirement. For further information, contact California Paint Council's Matt Dustin at (916) 443-5095.

**Graffiti**—CA A. 169 (Horcher) provides, in addition to existing penalties, that a person under the age of 18 years possessing an aerosol container of paint for the purpose of defacing property may be required to perform community service of not more than 100 hours. The bill was referred to the Assembly Committee on Public Safety on January 28.

Note—The California Paint Council has endorsed this legislation as a step in the right direction to combat graffiti.

### Colorado

**Environmental Labeling**—CO H. 1142 (Gordon) concerns environmental labeling for products. Introduced on January 14, the bill was released from the House Committee on Business Affairs and Labor on January 29 but was postponed indefinitely.

**Hazardous Painting**—CO H. 1117 (June) concerns the regulation of professional painters who engage in hazardous painting and makes an appropriation. The bill was released from the House Committee on Business Affairs and Labor on January 29 but was postponed indefinitely.

**Recycling**—CO H. 1146 (Gordon) concerns the mandatory use of recycled paper. The bill was reported favorably with amendments from the House Committee on State, Veterans and Military Affairs on January 29.

### Connecticut

**Recycling**—CT H. 5951 (Mushinsky) concerns improvement of recycling markets, increases the use of recycled materials in the marketplace and alleviates marketing problems of municipal recycling facilities. Introduced on January 19, the bill has been referred to the Joint Committee on Environment.

**Lead**—CT H. 5468 (Dillon) provides funds to property owners for lead abatement. Introduced on January 12, the bill has been referred to the Joint Committee on Planning and Development.

CT H. 6127 (Caruso, C.) reduces mercury and lead contamination in the environment. Introduced on January 20, the bill has been referred to the Joint Committee on Environment.

CT H. 6221 (Dyson and Villano) appropriates funds for a lead paint inspection and abatement assistance program. Introduced on January 20, the bill has been referred to the Joint Committee on Public Health.

CT. H. 6242 (Dillon) makes school construction funds available to municipalities for the replacement of lead paint contaminated pipes in public schools; protects school children from lead paint contaminated pipes in public schools. Introduced on January 20, the bill has been referred to the Joint Committee on Education.

CT. H. 6290 (Dillon) authorizes a civil action against persons who knowingly used lead-based paint. Introduced on January 20, the bill has been referred to the Joint Committee on Judiciary.

CT. H. 6332 (Dyson) provides funds for low interest loans to homeowners for lead paint abatement, thereby facilitating a corrective measure. Introduced on January 20, the bill has been referred to the Joint Committee on Public Health.

CT. H. 6335 (Dyson) reduces the incidence of lead poisoning in children by insuring comprehensive environmental investigations along with educational outreach. Introduced on January 20, the bill has been referred to the Joint Committee on Public Health.

CT H. 6462 (Donovan) controls lead-poisoning in children. Introduced on January 21, the bill has been referred to the Joint Committee on Public Health.

CT H. 6765 (Dillon) concerns state payments in lieu of taxes for property used by the state for lead paint safe houses; recognizes the fiscal loss borne by municipalities due to the creation of lead paint safe houses. The bill was introduced on January 25, 1993 and referred to the Joint Committee on Planning and Development.

CT H. 6816 (Committee on Public Health) concerns financial assistance for lead abatement activities in residential structures. Introduced on January 27, the bill has been referred to the Joint Committee on Public Health.

CT H. 6819 (Committee on Public Health) concerns recommendations of the Lead Poisoning Prevention Task Force. Introduced on January 27, the bill has been referred to the Joint Committee on Public Health.

CT S. 385 (Colapietro) concerns lead paint poisoning; establishes a lead paint poisoning program to "protect the rights of innocent infants who suffer latent permanent damage from exposure to poisonous lead-based substances, particularly paints." The bill was introduced on January 19, 1993 and referred to the Joint Committee on Planning and Development.

CT S. 419 (Penn) concerns lead poisoning; identifies and remedies cases of lead poisoning among school children. Introduced on January 20, the bill has been referred to the Joint Committee on Public Safety.

## Florida

*Occupational Safety and Health*—FL H. 189 (Greene) revises provisions of the law relating to occupational health and safety; provides that toxic substances labeled or amended pursuant to certain federal acts are governed by such provisions of the law; requires described employers to post a notice in English and Spanish informing employees of their rights with respect to occupational health and safety. The bill was introduced on February 2, 1993 and referred to the House Committee on Commerce and the House Committee on Appropriations.

## Indiana

*Hazardous Materials Transportation*—IN S. 295 (Weatherwax) adds the safety and maintenance requirements for containers used to transport hazardous materials to the list of federal regulations informed in Indiana. The bill was released from the Senate Committee on Transportation and Interstate Cooperation on February 2, 1993.

## Kansas

*Labeling*—1993 KS S. 133 (Oleen) requires certain labeling of plastic bottles and containers; provides remedies for violations. The bill was introduced on January 29 and referred to the Senate Committee on Energy and Natural Resources.

*Solid Waste (Regulation)*—The Kansas Department of Health and Environment has proposed rules that would formalize the solid waste disposal permit fee procedures and make changes to the fee structure for certain types of disposal facilities. For further information, contact the Department of Health and Environment at (913) 296-1540.

## Maryland

*Toxics in Packaging*—MD H. 111 (Perry) specifies that persons who violate provisions relating to toxics-in-packaging are liable to the State for designated civil penalties; requires the State to recover the civil penalties in civil actions in any county. The bill was reported favorably from the House Committee on Environmental Matters on February 1, 1993.

*Manufacturers-Distributors Relations*—MD H. 600 (Taylor), The Maryland Fair Distributor Act, would permit termination and non-renewal of manufacturer/distributor relationship for "good cause" only. This was introduced on February 3 and referred to the House Economic Matters Committee. The Senate introduced identical legislation (S. 505—Miller) on February 2, which was referred to the Senate Finance Committee. Hearings in both committees are scheduled for late February.

## Massachusetts

*Community-Right-to-Know (Regulation)*—The Massachusetts Department of Public Health has proposed rules to make additions to the Massachusetts Substance List (MSL). The list is the primary foundation for compliance with state right-to-know requirements. Under the proposal, substances suggesting an acute or chronic risk to human health or safety, that have already been added to the National Toxicology Program list of chemicals and the American Conference of Governmental Industrial Hygienists' list of threshold limit values for chemicals, will be added to the MSL. For further information, contact the Department of Public Health at (617) 727-7170.

*Lead*—MA H. 680 (Local Sponsor) increases availability of lead-safe housing and reduces chronic childhood lead poisoning. The bill was referred to the Joint Committee on Health Care on January 29.

MA H. 681 (Local Sponsor) encourages accurate testing methods for lead paint. On January 29, the bill was referred to the Joint Committee on Health Care.

## Michigan

*Environmental Labeling*—MI S. 187 (Bouchard) requires labeling for degradable, biodegradable, or photodegradable bags or containers to meet standards for decomposition. The bill was introduced on January 26 and referred to the Senate Committee on Natural Resources and Environmental Affairs.

## Missouri

*Lead*—MO. H. 193 (Dougherty) relates to the prevention of lead poisoning; creates a "Missouri Commission to Prevent and Control Lead Poisoning." The commission operating within the Department of Health would develop a lead inspector training and certification program for contractors, supervisors and workers engaged in lead abatement activities. Requires the department to develop various support activities. The bill was referred to the House Committee on Public Health and Safety on January 14.

MO S. 232 (Banks and Wiggins) relates to prevention of lead poisoning, with penalty provisions. The bill was introduced on January 28 and referred to the Senate Committee on Public Health and Welfare.

*Packaging*—MO S. 100 (Goode) prohibits the selling of packages, packing material or components containing specified concentrations of lead, cadmium, mercury or hexavalent chromium. The bill was introduced on January 6 and referred to the Senate Committee on Commerce, Consumer Protection and Elections.

MO H. 510 (Dougherty) establishes a Source Reduction Advisory Board to provide recommendations and implement a comprehensive program that will reduce the quantity of packaging material in the waste stream; maximizes the recycling and reuse of packaging materials; discourages the use of toxic materials in packaging; and reduces litter. The bill was introduced on January 19 and referred to the House Committee on Energy and Environment on January 28, 1993.

### Nebraska

*Lead*—NE L.B. 648 (McKenzie and Rasmussen) relates to public health and welfare; provides for comprehensive environmental lead inspections; restricts certain transfers of property. The bill was introduced on January 20 and referred to the Legislative Committee on Health and Human Services.

*Packaging*—NE L.B. 63 (Elmer) creates the Plastic Container Coding Act to prohibit the manufacture or distribution of any plastic bottle or rigid plastic container unless it is imprinted with a code identifying the appropriate resin type used to produce the structure of the container. Adopted as a committee amendment on the legislative floor on February 3.

### New Hampshire

*Lead*—NH S. 231 (Shaheen) relates to lead poisoning and control and continually appropriates a fund to the Director of Public Health Services; concerns lead paint laws. The bill was referred to the Senate Committee on Public Institutions, Health and Human Services on January 28.

### New Jersey

*Lead Paint Abatement Certification*—NJ S. 1135 (Bassano) requires certification of lead inspectors and lead abatement workers by the Department of Health. This bill was introduced in September 1992. It passed the Senate in October and was amended on the Assembly floor on February 1, 1993.

*VOC Content (Regulation)*—NJ S.A. 7:27-23.3 Architectural Coatings. The "grandfather clause" for sales in New Jersey of architectural coatings manufactured prior to January 1, 1990 for Group I coatings and February 1, 1990 for Group II coatings no longer applies as of February 28, 1993. All architectural coatings must meet Group I and II VOC content rules (except sales for shipment and use out of state and sales of containers with a capacity of less than one quart). For further information, contact NPCA's Jim Sell.

### New York

*Lead*—NY A. 615 (Grannis) enacts the lead-free parks act; directs the Department of Environmental Conservation to do a study of certain parks to identify the level of lead contamination at such parks; provides for the posting of

warning signs at parks identified as potential hazards; provides for grants to localities to clean up lead-contaminated parks. The bill was introduced on January 6 and referred to the Assembly Committee on Environmental Conservation.

### Oklahoma

*Lead*—OK H. 1118 (Paulk) creates an "Oklahoma Asbestos and Lead Paint Control Act"; designates the Department of Labor as the proper state agency to perform on-site inspection for the federal program relating to demolition and renovation of asbestos facilities pursuant to the National Emissions Standards for Hazardous Air Pollutants and authorizes the Labor Department to contract with the Department of Environmental Quality for such inspection; includes lead paint abatement licensure requirements; sets penalties for violations. The bill was introduced on February 3 and referred to the House Committee on Commerce, Industry and Labor.

### Oregon

*Hazardous Painting Certification*—OR H. 2610 (Local Sponsor) allows Director of Department of Insurance and Finance to establish hazardous painting certification programs for painting activities other than painting of single-family or multiple-family private residences. The bill was introduced and referred to the House Committee on Commerce on January 27, 1993.

### Pennsylvania

*Lead*—PA H. 66 (Petrarca) provides for the prevention, detection, treatment and follow-up of cases of undue lead absorption and lead poisoning among certain children. Makes an appropriation. The bill was referred to the House Committee on Rules on January 27, 1993.

PA S. 70 (Holl) establishes a lead poisoning control program. Provides for the powers and duties of the Department of Health with respect to lead poisoning control. Grants limited civil immunity to physicians and certain other persons. Requires reports of cases of lead poisoning. The bill was introduced on January 5 and referred to the Senate Committee on Public Health and Welfare.

*Toxics-in-Packaging*—PA H. 337 (Vitali) regulates toxic materials used in packaging and components thereof. Provides for additional duties of the Department of Environmental Resources, for certain procedures, for remedies, for enforcement and for civil and criminal penalties. The bill was introduced on February 3, 1993.

### Tennessee

*Hazardous Waste (Regulation)*—Under final rules issued by the Tennessee Department of Environment and Conservation, transporters, storers, treaters, disposers and certain generators of hazardous wastes will have to pay new fees. Effective December 28, 1992, the rule establishes fees for permit applications and modifications, yearly permit maintenance, closure and post-closure plans, and annual generator registration. For further information, contact the Department of Environment and Conservation at (615) 741-3424.

### Texas

*Lead*—TX S. 91 (Truan) relates to the identification of children suffering from lead poisoning and to control measures for lead contamination. The bill was introduced on

January 12 and referred to the Senate Committee on Health and Human Services.

### **Vermont**

*Lead*—VT S. 30 (Ready) proposes to establish a program for training and certification of lead hazard abatement workers; to make blood lead screening and testing of children available upon request of parents; provides for inspection and testing of child care facilities; ensures that lead-based paint hazards are disclosed in the sale or lease of pre-1978 housing. The bill was referred to the Senate Committee on Health and Welfare on January 19, 1993.

VT H. 169 (Ross and Babcock) establishes a program for training, certification and licensing of lead hazard abatement workers; makes blood lead screening and testing of children available upon request of parents and mandatory if warranted; provides for inspection and testing of child care facilities; ensures that lead-based paint hazards are disclosed in the sale or rental of housing; establishes a standard of reasonable care on the part of owners of rental housing and day care facilities. The bill was introduced on January 28 and referred to the House Committee on Health and Welfare.

*Environmental Labeling*—VT H. 117 (Schaefer and McCormack) enacts in conjunction with other states in the northeastern region of the country, standards that would apply to certain representations made on consumer products sold at retail in the state. Establishes standards for the use of the term "reusable," for the use of the term "recyclable," and the related symbol, and for the use of the term "recycled

materials." The bill was referred to the House Committee on Natural Resources and Energy on January 19, 1993.

*Packaging*—VT S. 50 (Ready) encourages recycling and reuse of packaging material by prohibiting, by January 1, 1995, the retail sale within the state of certain products that are in packaging that is not recyclable and either reusable or made of recycled materials. The bill was introduced on January 28, 1993 and referred to the Senate Committee on Natural Resources and Energy.

### **Washington**

*Hazardous Painting Certification*—WA H. 1546 (Heavey) trains and educates workers who handle paint and other coatings. Develops a program to educate, test, and certify paint and coatings applicators in handling hazardous materials. Requires applicators to be certified. Establishes monetary penalties for violations. Creates the paint and coatings applicators account. The bill was introduced on February 1 and referred to the House Committee on Commerce and Labor. An identical bill (S. 5412—Prentice) was introduced in the Senate on January 27 and referred to the Senate Committee on Commerce and Labor.

*Storm Water*—WA S. 5454 (Fraser) imposes taxes on sewage collection and storm and surface water drainage control. The bill was introduced on January 29 and referred to the Senate Committee on Trade, Technology and Economic Development.

---

---

**“THE INFLUENCE OF SUBSTRATES AND APPLICATION METHODS/TECHNIQUES  
ON COATINGS PERFORMANCE”**

**REGISTRATION FORM**

May 18-19, 1993 • South Shore Harbour Resort and Conference Center  
League City (Houston), TX

NAME \_\_\_\_\_  
NICKNAME (for badge) \_\_\_\_\_  
JOB TITLE \_\_\_\_\_  
COMPANY \_\_\_\_\_  
ADDRESS \_\_\_\_\_  
CITY \_\_\_\_\_ STATE \_\_\_\_\_ ZIP \_\_\_\_\_  
PHONE \_\_\_\_\_

I am a member of the following Federation Society: \_\_\_\_\_

Registration Fees:   FSCT members   \$175  
                          PDCA members   \$175  
                          Non-members     \$225

Your check for the seminar fee must accompany the registration form. Please make check payable to: Federation of Societies for Coatings Technology. Payment must be made in U.S. Funds, payable in U.S. Banks.

PLEASE CHECK ONE BOX IN EACH OF THE TWO COLUMNS BELOW:

**YOUR COMPANY IS**

AA  Manufacturers of Paints, Varnishes,  
Lacquers, Printing Inks, Sealants, etc.  
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 IS**

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

**HOTEL INFORMATION**

Arrival Date \_\_\_\_\_ Departure Date \_\_\_\_\_

Sharing Room With \_\_\_\_\_

Room Rate: \$110 (single or double occupancy)

Special Room Requests:    Single Occupancy    Double Occupancy

Courtesy Van (from Hobby Airport):   Airline \_\_\_\_\_ Arrival Time \_\_\_\_\_  
(to Hobby Airport):                    Airline \_\_\_\_\_ Departure Time \_\_\_\_\_

*Note: Hotel does not assume responsibility for alternate transportation due to missed shuttle.*

One night's deposit enclosed (**Separate check payable to South Shore Harbour Resort and Conference Center**) or enter credit card number and expiration date below:

Credit Card:    AMEX                    VISA                    MASTERCARD

Card # \_\_\_\_\_ Expiration Date \_\_\_\_\_

Room Reservations Guaranteed only with deposit or major credit card.

CHECK IN TIME IS 3:00 PM, CHECK OUT TIME IS 12:00 NOON.

Reservations must be made no later than **April 16** to guarantee availability and rates.

Return completed form and check(s) to: **Federation of Societies for Coatings Technology**  
492 Norristown Rd., Blue Bell, PA 19422-2350

# "THE INFLUENCE OF SUBSTRATES AND APPLICATION METHODS/TECHNIQUES ON COATINGS PERFORMANCE"

**FSCT**  
**Spring**  
**Seminar**

Many factors come into play in the process of coating a substrate, including the method of application, the substrate, the coating to be applied and other conditions. Each of these factors also has a lasting effect on the performance of the coatings. A panel of experts has been assembled to present information on the variety of considerations which must be examined in order to develop coatings for architectural substrates, and the effects various application methods have on the process. You will examine and discuss what you must allow for when developing coatings for architectural substrates, and learn time honored solutions to improve your formulating operation for these coatings.

## PROGRAM

### Tuesday, May 18

9:00 AM - 9:15 AM

**"Welcome Remarks"**—Colin Penny, (President, Federation of Societies for Coatings Technology) Senior Vice President, Research and Development, Kapsulkote, Hampton, VA

**"Introduction/Overview"**—Dan Dixon, Englehard Corp., Gordon, GA

9:15 AM - 10:15 AM

**"Coating of Concrete/Masonry"**—Eric S. Kline or Richard Burgess, KTA-Tator, Inc., Houston, TX

The coating of concrete/masonry requires special surface preparation procedures that, when improperly performed or omitted altogether, may result in premature coating failure. The presentation will consist of detailed procedures related to the coating of concrete/masonry, and will illustrate catastrophic coating failures that have occurred over concrete/masonry surfaces.

10:15 AM - 10:45 AM

Refreshment Break

10:45 AM - 11:45 AM

**"Sheet Rock"**—Dave Evans, Evans Paint Store, Traverse City, MI

11:45 AM - 1:00 PM

Luncheon

1:00 PM - 2:30 PM

**"The History of Paint Applicators"**—Dave Rowekamp, The Wooster Brush Co., Wooster, OH

This presentation is based on the evolution of paint applicators, from the introduction of brushes and rollers to the history of raw materials used. The reasons why changes in materials and manufacturing procedures have occurred as paints have changed will also be reviewed.

2:30 PM - 3:00 PM

Refreshment Break

3:00 PM - 4:30 PM

**"Application Methods"**—John Price, EZ Paint, Milwaukee, WI

Paint as it is sold is a raw material. Of all types of wallcoverings that can

be used, paint is the one and only one that must undergo both chemical and physical changes before a customer obtains the benefits promised by the merchandiser of the paint. The customer, or more properly, the ultimate user, actually processes the raw material. The satisfaction to the customer, therefore, comes not only from the product (paint, the raw material), but from its processing as well. Thus, the customer's technique and the tools (applicators) used are vitally important, and the paint formulator must be concerned with the manner of applying the paint as well as the applicator used, especially since the applicator determines many of the properties of the applied film, like thickness, smoothness, and uniformity. The selection and proper use of rollers, brushes and pads are the keys to the customer's satisfaction with the paint product.

4:30 PM - 6:00 PM

**Open Forum**—Panel discussion gives you the chance to question the speakers on your particular needs.

6:30 PM - 7:30 PM

Attendee Reception (Cash Bar)

### Wednesday, May 19

8:00 AM - 9:00 AM

**"The Role and Importance of Basic Wood Properties and Surface Preparation in the Durability of Wood Coatings"**—Bill Feist, USDA Forest Products Lab, Madison, WI

Wood has the ability to take and hold a variety of finishes (paints, stains,

etc.). These finishes include clear ones that reveal and accentuate the natural beauty of wood, stains that impart a rustic appearance, and paint of every conceivable color. This presentation will detail the characteristics and surface preparation requirements of the different solid and reconstituted wood products available from today's new forest. More particularly, it will focus

on detailing the characteristics of different kinds of wood, manufacturing and construction practices that affect surfaces to be finished, and the ways in which various types of finishes interact with the effects of those characteristics and practices. Even with the best finishes and finishing procedures, some coatings remain serviceable much

longer on some woods than others. The different types of finishes, their compatibility with different wood products, and surface preparation procedures for these products will be outlined.

#### 9:00 AM - 10:00 AM

**"Finishing Alternatives for Exterior Wood Products"**—Charles Jourdain, California Redwood Association, Novato, CA

Wood, a product of nature, has been used by man for fuel, shelter and furnishings for centuries. Not only is wood a natural composite material with many unique properties, but it is also a renewable resource, thoroughly recyclable and energy efficient in terms of both production and utilization. Nearly all uses for wood can be enhanced by the application of properly specified quality finishing systems. A wide range of exterior wood products: siding, decking, trim and fascia, furniture, roofing, etc., can be finished with an equally wide variety of products such as wood preservatives, water repellents, transparent and semitransparent stains, varnishes, solid color stains and paint systems. The changing nature of both wood products and finish formulations creates a tremendous need for these associated industries to enhance consumer education efforts.

#### 10:00 AM - 10:30 AM

Refreshment Break

## HOUSING

Requests for seminar room accommodations at the South Shore Harbour Resort and Conference Center must be made on the **Seminar Registration Form** and returned to FSCT Headquarters.

The seminar room rate is \$110 for either single or double occupancy. The reservation cut-off date is April 16, 1993.

A 20-minute trip from Houston's Hobby Airport, the South Shore Harbour

#### 10:30 AM - 11:30 AM

**"The Successful Coatings of Pressure-Treated Wood"**—Alan Ross, Kop Coat, Inc., Pittsburgh, PA

Wood which has been pressure treated with chemicals to prevent decay and insect attack is widely used in residential and commercial decking—prime substrates for surface finishes. Unfortunately, little information has been published on the compatibility of pressure-treated wood with surface finishes, and many misconceptions exist.

This presentation will review the effects of pressure treatment on wood and on subsequently applied surface coatings. Also discussed are the proper application techniques for the successful coating of pressure-treated wood.

#### 11:30 AM - 1:00 PM

Luncheon

#### 1:00 PM - 2:00 PM

**"Finishing Characteristics of Plywood, OSB, and Com-Ply Panels"**—Dick Carlson, American Plywood Association, Tacoma, WA

The natural growth characteristics of trees and the manufacturing characteristics of various wood-based panel products are reviewed in this presentation. Interdependency between these characteristics and the properties of coatings influence both the appearance and the performance of the substrate/coating composite. The interactions between these materials are discussed

Resort and Conference Center features 250 elegantly appointed rooms with water views, and is located near the NASA/Johnson Space Center.

**The hotel operates a complimentary shuttle to and from Houston's Hobby Airport. To use the service, be sure to include your arrival and departure times on the registration form.**

## AIR TRANSPORTATION

Discounted airline travel arrangements to the Spring Week seminar can be made by contacting the Federation Travel Desk at 1-800-448-FSCT. An agent will

make your reservations, write your ticket using your credit card number, and mail the tickets directly to you. Be sure to mention the Code: FSCT-SW.

as they relate to coating performance and finishing recommendations for wood-based panels. Understanding these variables and identifying the architectural intent of the user are necessary for proper finish selection and realistic performance expectations. The importance of proper finish application is also stressed to help assure optimum performance of the coated wood surface.

#### 2:00 PM - 3:00 PM

**"Hardboard Siding as a Substrate for Coatings"**—Louis Wagner, American Hardboard Association, Palatine, IL

This paper describes how hardboard siding is manufactured and used. The characteristics which make hardboard different from other wood-based products are discussed. How these characteristics are developed during manufacture is explained. Factory priming, factory prefinishing, and field applied coatings are described with the objective of maximizing durability of both substrate and coatings.

#### 3:00 PM - 3:30 PM

**Open Forum/Wrap-Up**—Your opportunity to hear the speakers of the day answer your questions.

• • •

Complete program information is available by contacting the Federation of Societies for Coatings Technology, 492 Norristown Rd., Blue Bell, PA 19422-2350.

## REGISTRATION

The registration fee for the event is \$175 for FSCT members and \$225 for non-members. In addition, a special arrangement has been made with the Painting and Decorating Contractors of America for registration at the member rate. (The registration fee is to be paid in U.S. funds, payable on U.S. banks.)

The registration fee includes continental breakfasts, luncheons, refreshment breaks, and a portfolio containing copies of the papers presented at the event.

*Note:* If cancellations are received less than five days prior to the seminar, a \$50 charge per registration will apply.



## ICI Resins US Renamed ZENECA Resins; New Singapore-Based Operation Is Formed

As of January 1, ZENECA Resins is the name for what had been known as ICI Resins US, a producer and marketer of advanced polymers for the paints and coatings, adhesives, and graphic arts markets.

The name change reflects the creation of a separate entity within the worldwide ICI Group, which is organizing its biosciences and specialties chemicals interests under the

ZENECA name. The new name was developed from the word "zenith," which reflects the company's intentions to position itself among the front rank of science-based companies in its chosen business sectors.

ZENECA Resins, a business unit of ZENECA Inc. and a member of the ICI Group, is a producer of waterborne acrylic and urethane polymers, copolymers, vinyl-acrylic terpolymers, and other special purpose polymers. The company's North American headquarters are in Wilmington, MA. ZENECA Resins operates production facilities at the Wilmington site, as well as in Frankfort, IN, and Vallejo, CA.

In addition, a new Singapore-based company, ZENECA Resins Pte Ltd., has

been formed by the ICI Group to spearhead the growth of its specialty resins activities in the Asian Pacific region. The company will assume full responsibility for ICI Resins' existing business interests in Singapore immediately. Significant new investment plans involving manufacturing and R&D include a new resins manufacturing plant and associated R&D facility in the Jurong industrial area of Singapore. The plant, expected to be operational by July 1994, will initially manufacture a range of acrylic emulsions, urethane dispersions, and urethane-acrylic copolymers with a combined annual capacity of about 10,000 metric tons. The initial investment is expected to be approximately \$7.8 million (U.S.).

---

### National Rule Proposed at Reg-Neg Meeting

An initial proposal that would control the volatile organic compound (VOC) content of architectural and industry maintenance (AIM) coatings was presented by paint industry representatives to the full AIM Coatings Reg-Neg Committee in Raleigh-Durham, NC, in January.

The AIM Reg-Neg Committee was established last year to pursue regulatory negotiations between the coatings industry, the U.S. Environmental Protection Agency (EPA), and other interested parties to develop a national regulatory program for AIM coatings. Its purpose is to develop a consensus regulation with representatives of interested parties to minimize the controversy, litigation, and delay that is often part of traditional rulemaking. After a consensus rule is drafted through negotiations, it then undergoes traditional regulatory public notice and comment procedures.

The initial proposal, sponsored by the Paint Industry Caucus Group, which counts the National Paint and Coatings Association (NPCA) among its representatives, contains suggested VOC limits for AIM coatings based on the results of a recently tabulated industry-wide emissions survey.

Responding to the Paint Industry Caucus Group's proposal, other members of the AIM Reg-Neg Committee, including representatives from environmental organizations, state regulatory agencies, and EPA, developed a list of some 25 issues and questions concerning the proposal that they would like the industry group to address. The industry group prepared responses to these questions and was expected to present its findings at the Reg-Neg meeting, scheduled for February 11-12, in Newport Beach, CA.

For further information on the initial proposal and the meeting, contact Bob Nelson at NPCA, (202) 462-6272.

---

### 1992 Survey on Color Choice for Vehicles Shows Increase of Greens in Popularity

While the number one vehicle color choice in 1992 continued to be white, dark and medium greens made significant gains in North America, according to an annual survey conducted by DuPont Automotive Products, Troy, MI.

An average of 23% of consumers chose white for luxury cars, full/intermediate cars, sport/compact cars, and light trucks/vans. White got high marks in the truck/van segment, but lost some ground in the three passenger car categories.

However, the big news in 1992 vehicle colors was the momentum of green. "Green, on average, jumped to the top five consumer color selections for all four vehicles categories," said Robert S. Daily, Finishes Color Marketing Manager for DuPont Automotive.

Last popular in the late 1960s and early 1970s, the greens of 20 years ago were yellow green. Rich, dark, blue greens are the color of choice today.

As green gained ground, however, other colors faltered. While medium and dark shades of both red and blue retained their ranking as favorites, they lost percentage points as a result of increased interest in green. Likewise, neutral colors, like silver and gray, also dropped somewhat.

In line with greens, 1992 saw a marked increase in greenish blue hues of turquoise/aqua for sport/compact cars.

Based on research, the following trends are predicted. Greens will retain their popular position for several years. Growth may continue, but in smaller increments than the

1992 jump. Color in the light truck/van category will continue as a high priority in consumer purchase decisions, as these vehicles continue to move from strictly utilitarian use to the mainstream. In addition, colors will tend to be somewhat less chromatic in the full/luxury category. Instead, a dustier/chalkier look that will appear first with various shades of blue will be seen.

Red shades will shift from blue/reds to warmer appearance yellow/reds and will maintain their vibrance and chroma in straight shades, as well as metallics.

Dark, rich purples and mid to reddish yellows (both pale and chromatic) will emerge in the next three to five years. Change will be seen in 1993, the survey predicts.

---

### Reichhold Expands Waterborne Polyurethane Capacity

Reichhold Chemicals, Inc., Research Triangle Park, NC, recently initiated a multimillion dollar program to expand its capacity for manufacturing waterborne polyurethane dispersions at its Baltimore, MD facility. Slated for completion in September 1993, the expansion will more than double the company's capacity to produce its line of waterborne polyurethane dispersions. The new facility will also support the production of new products the company plans to commercialize, such as novel solvent-free and self-crosslinked waterborne polyurethane dispersions.

# Construction Contracts Ease Three Percent in December Set Seven Percent Gain for 1992 to Total \$247 Billion

New construction contracts slipped three percent in December, according to a survey conducted by the F.W. Dodge Division of McGraw-Hill, New York, NY, in another indication of the construction industry's uncertain recovery. With the modest retreat at the end of 1992, total construction contract value still finished up seven percent at \$246.9 billion, the first annual gain since 1989.

For December the seasonally adjusted Dodge Index came in at 90 (1987=100), down from November's revised 94 and the recent high of 103 reported in October. Residential construction, climbing 11% in the latest month, reasserted its role as the leading edge of recovery following a pause in November. Offsetting the strength in homebuilding was a 14% decline for nonresidential construc-

tion and an 18% plunge for the often volatile nonbuilding construction sector (public works and utilities).

When compared to the performance of 1990 and 1991, which posted declines of nine and six percent, respectively, the total construction turnaround represented a positive change.

December's 11% gain for residential construction was due entirely to strength in single family housing, with the multifamily side of the market remaining weak. This corresponded to the pattern for the year as a whole—residential contract value was up 17% in 1992 because of single family improvement. Meanwhile, the overbuilt apartment segment continued to weaken in 1992, unlike its behavior in the first years of previous cycles.

Nonresidential construction in December fell 14% to its weakest volume of the year, due to further slippage by the institutional building sector and a retreat by stores from the resilient volume of recent months.

For 1992 as a whole, nonresidential construction dropped one percent in value. Commercial and industrial building posted a third year-to-year loss, falling to a dollar amount about 40% below what was reported in 1989.

Institutional building, which performed counter to the general downward trend in 1990-91, finally succumbed to growing fiscal pressures with a slight decline in 1992.

Nonbuilding construction decreased 18% in December, with lower contracting reported for a majority of the public works categories as well as utilities. Overall in 1992, nonbuilding construction managed a modest three percent rise.

Geographically, the North Central region led the growth in total construction with a 13% rise, followed by the South Central's nine percent improvement. The South Atlantic matched the national average at seven percent; while lagging behind were the Northeast, up four percent, and the West, up three percent.

---

## Cyanamid Plans Expansion Of Polymer Additives Plant

A multimillion dollar plant investment program that includes expansion, new process technology, and facility modernization has been announced by American Cyanamid Company's chemicals business unit, Wayne, NJ. The program is for the company's polymer additives product line at its Willow Island, WV, facility.

The multi-year program, scheduled to be completed by the end of 1994, is designed to increase the plant's capacity, enhance manufacturing processes, and significantly improve all process environmental control systems.

---

## Union Carbide Sells Phenoxy Resins Business to Partnership

Sale of the phenoxy resins business of Union Carbide, Danbury, CT, to Phenoxy Associates (PA) was announced by the two companies. PA is a partnership which includes a group of former Union Carbide employees, with additional private financing from a trust associated with United

Kingdom chemical industrialist, Ken Schofield.

Provisions of the sale include transfer of Union Carbide's phenoxy unit at Bound Brook, NJ, to a site in Rock Hill, SC. Contracts have been offered to customers assuring them of supply continuity from inventory accumulated for that purpose during the transition to the partnership.

---

## Dry Color Manufacturers' Association Changes Name To Color Pigments Manufacturers Association

The membership of the 70-year-old Dry Color Manufacturers' Association (DCMA) recently voted to change its name to the Color Pigments Manufacturers Association, Inc. (CPMA), effective January 1, 1993.

Among the oldest color pigments industry associations in the world, the association's board felt that, although the former name and acronym, DCMA, had a long history, were very well-known by those associated with the industry, and had significant name recognition, it was important that the words "color pigments" be included in the name of the organization in order to better reflect both the products and members that the association represents.

It was noted that many people not directly associated with the color pigments or related industries did not know what "dry color" was, often mistaking it for dyes, powder coatings, artists materials, or other incorrect identifications.

Color pigments are widely used in product compositions of all kinds, including

paints, inks, plastics, glass, synthetic fibers, and ceramics.

Although sometimes confused with dyes, color pigments are distinct from those chemicals. Pigments retain a crystalline or particulate structure and remain insoluble throughout the coloration process. Also, they are usually insoluble in the material in which they are incorporated.

The CPMA is an industry trade association representing small, medium, and large pigment color manufacturers throughout Canada, Mexico, and the United States, accounting for approximately 95% of the production of color pigments in these countries. Foreign pigment manufacturers with sales in Canada, Mexico, and the United States, and suppliers of intermediates to the pigments industry are also members of the association.

The association remains at its offices at 300 N. Washington St., Suite 102, Alexandria, VA 22314 (mail address: P.O. Box 20839, Alexandria, VA 22320-1839).

---

## Degussa Opens World-Scale Hydrophobic Fumed Silica Plant

Degussa Corporation, Ridgefield Park, NJ, has announced that its hydrophobic fumed silica plant in Waterford, NY, is on stream. The first of its kind in the United States, the \$40 million facility will serve the growing domestic market for fumed silica, an ingredient in silicone rubber sealants, coatings, printing inks, and other industry applications.

In addition to providing the general market with hydrophobic fumed silica (AEROSIL® R972), the Degussa Waterford plant will meet the fumed silica requirements of the adjacent General Electric Company silicone manufacturing facility.

Degussa imported fumed silica from its worldwide facilities for over 25 years. Today, Degussa plants in Waterford and Mobile, AL, manufacturing hydrophobic and hydrophilic versions of the fumed silica, respectively, qualify the product as American-made.

## Tioxide North America Announces Conversion Of Tracy Plant and Joint Venture with NL/Kronos

Tioxide North America, Montreal, Quebec, announced that as of April 2, the company's titanium pigment plant in Tracy,

Quebec will be converted solely to a finishing operation. This conversion will involve the shutdown of the front-end production part of the plant, resulting in the complete elimination of waste acid discharge from the site.

## Hüls America Dedicates New Isophorone Derivatives Unit

Hüls America Inc., Piscataway, NJ, recently dedicated its new \$100 million plus isophorone derivatives plant in Theodore, AL.

The plant, which employs 90 people, produces a proprietary group of raw materials used in high performance coatings, adhesives, and sealants. These include isophorone diamine, diisocyanate, and derivatives.

Hüls pioneered isophorone derivatives chemistry some 25 years ago and until now has produced these materials solely at plants in Herne, Germany. The Theodore plant marks a major transfer of Hüls technology from Germany to the United States.

In addition to the new isophorone derivatives unit, Hüls operates three other manufacturing units at the Theodore site that produce orthoesters, cyanoacetates, and organosilanes. Products made at these units are used in the agricultural, pharmaceutical, adhesives, and photographic industries.

Tioxide also announced that it has reached an agreement in principle with NL/Kronos to establish a manufacturing joint venture based on the assets and associated technology at Kronos' chloride titanium pigment plant in Lake Charles, LA. The proposed joint venture with NL/Kronos would give Tioxide immediate access to North American pigment production and would enable the company to maintain a reliable supply of high quality product for its customers. Completion of the transaction, anticipated during the second quarter of this year, is subject to finalization of definitive agreements and review by the U.S. antitrust authorities.

As a result of this agreement, Tioxide has decided to suspend construction of its titanium pigment plant in Becancour, Quebec.

The closure of the front-end section of Tracy will mean the loss of 60 jobs and the suspension of the Becancour project will affect approximately 400 construction jobs.

## Akzo Begins Construction Of Organic Peroxide Plant

Akzo's Polymer Chemical business unit will construct a new multimillion dollar organic peroxide manufacturing plant at the company's Pasadena (Bayport), TX site. The new plant will be a multi-purpose liquids unit designed to produce selected dialkyl peroxides, peroxyketals, specialty peroxyesters (t-butyl, t-amyl and trimethylpentyl products) and hydroperoxides.

Construction will begin in the first quarter of 1993 with mechanical completion estimated in the fourth quarter of 1994. The plant will be a state of the art facility incorporating advanced safety technology and statistical process control. The new production capacity is being added to keep up with the growing demand for organic peroxides used for polymerization of PVC, polyethylene, polystyrene, acrylics, modification of polypropylene, the curing of unsaturated polyester resins and the crosslinking of synthetic rubber. A significant portion of the capacity of the plant will be used to produce products currently imported from Europe.

## 71st Annual Meeting & 58th Annual Paint Industries' Show



*"Today's Competitive Coatings:  
Lean, Mean and Green"*

Georgia World Congress Center  
Atlanta, Georgia

Wednesday • Thursday • Friday,  
October 27 • 28 • 29, 1993

Sponsored by the  
**Federation of Societies for Coatings Technology**  
492 Norristown Road, Blue Bell, PA 19422

# Development of High Performance, Water-Based Emulsion Coatings For Can Coatings Application

Shunji Kojima and Toshinori Moriga  
Toyo Seikan Group\*

Yoshiki Watanabe  
Toyo Seikan Kaisha, Ltd.†

---

A new manufacturing process for high performance, water-based emulsion coatings for can coating application was developed, which includes emulsification of an epoxy resin by the phase inversion method with or without a hardener by incorporation of an acrylic resin. It is possible by this new process to emulsify a variety of resins with minimum effects of the surfactant (acrylic resin) on the film properties of the cured coating. Thus, the latitude to design a formulation is widened and the performances of the epoxy resin and hardener are fully developed. It was found that the composition of the solvents in the resin solution prior to emulsification is critical to obtaining a stable

emulsion with a fine particle size. The effects of surfactant and neutralizer on adhesion performance were also studied, it was found that the effect of the acrylic resin concentration was relatively small, but that the effects of the neutralizer were significant. It was confirmed that the usage of ammonia or amines with a branched alkyl group is required to achieve balanced dry and wet adhesion. It was also found, by the characterization of the emulsion and the cured films, that there exists a layer of acrylic polymer near the substrate and that most of the acrylic polymer forms a dispersed phase in the epoxy/phenolic polymer matrix.

---

## INTRODUCTION

There are several advantages of using water-based emulsion coatings, such as:

- (1) Reduced volume of organic solvents emitted from the plant, thus reducing the adverse effects on the environment.
- (2) Reduced levels of organic solvents in the working environment, thus improving the standards of occupational health and safety.
- (3) Reduced risks of fire.
- (4) Reduced usage of organic solvents, thus saving resources.
- (5) No necessity to install after-burners to save energy.

For these reasons, great efforts have been made to develop water-based emulsion coatings for a variety of

industries. Currently, water-based emulsion house paints and repair paints are commonly used. In the automobile industry, it has become common to use a water-based emulsion primer applied by electrocoating. These trends were precisely reviewed by Bauer<sup>1</sup> and Emch.<sup>2</sup>

In the can manufacturing industry, the use of water-based emulsion coatings is also desirable, and many ideas have been proposed.<sup>3-5</sup> Some efforts were successful and a majority of drawn and wall ironed cans are coated with water-based emulsion coatings, both inside and outside. Robinson<sup>6</sup> and his colleague developed the first generation of water-based emulsion coatings for inside spray of drawn and wall ironed cans using an acrylic-grafted epoxy resin, and they concluded that it was impossible to obtain an acceptable dispersion from a mixture of an epoxy resin and an acrylic resin and that grafting had to take place in order to produce a satisfactory dispersion.

Industry trends toward higher performance in container applications have shown a need for properties characteris-

---

\*Corporate Research and Development, 22-4, Okazawa, Hodogaya, Yokohama, 240 Japan.  
†Technical Headquarters, 1-1-70, Yako, Tsurumi, Yokohama, 230 Japan.

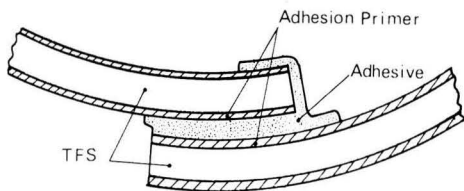


Figure 1—Cross-sectional view of bonded portion of Toyo Seam Can

tic of the component resins, epoxy and hardeners, and improvements of these resins have been effectively carried out.<sup>7-9</sup> These resins show excellent performance when used as a component of solvent-borne coatings, however, their performances are not fully developed when used in water-based emulsion coatings made by conventional processes.

The adhesion performance of the primer coating is critically important for the production of the side-seam bonded cans, e.g., Toyo Seam Cans (Figure 1), where the side-seam structure is shown.<sup>10,11</sup> To promote reliable adhesion, all three components have been improved, the tin free steel (TFS), the adhesive, and the adhesive primer. An epoxy/phenolic, solvent-borne coating has been used as the adhesion primer. It is strongly desirable to develop a new water-based emulsion primer for this application by the reasons previously mentioned.

Thus, despite of Robinson's conclusion,<sup>6</sup> we started a program to develop a new manufacturing process for water-based emulsion coatings, which consisted of blending the component resins and emulsifying them in a water/amine mixture. We were successful in developing such a process. It widened the design latitude of water-based emulsion epoxy resin formulations. Thus, it has become possible to obtain a water-based emulsion coating with excellent adhesion performance to be used as an adhesive primer for the side-seam bonded cans.

In this paper, we discuss the emulsification process, factors affecting emulsification stability, factors affecting adhesion performance, and the structure of the emulsions and the cured films.

## EXPERIMENTAL

### Materials

The acrylic resin used in this study was prepared by free radical polymerization, using benzoyl peroxide as the initiator. The polymerization procedure is shown elsewhere.<sup>4</sup> The monomer composition was methacrylic acid (MAA)/methyl methacrylate (MMA)/ethyl acrylate (EA)/styrene = 40/20/20/20, unless otherwise noted. The acrylic resin was prepared as a 40% nonvolatile solution in a mixture of *n*-butanol/butylacetate = 40/20 by weight. Weight average molecular weight (Mw) of the resultant polymer was determined to be about 80,000 using gel permeation chromatography (GPC) calibrated

using polystyrene standards. The glass transition temperature ( $T_g$ ) of the polymer calculated from the monomer composition was about 110°C.

The epoxy resin used was an experimental grade solid epoxy resin supplied by the Dow Chemical Co. The Mw of the resin was about 15,500, and the epoxide equivalent weight was about 3,600. Characterization procedures of the resin are described elsewhere.<sup>7</sup>

The phenol/formaldehyde resole (phenolic resin) used (proprietary supplied by Toyo Ink Mfg. Co., Ltd., Tokyo, Japan) was made from *p*-cresol and bisphenol A. The phenolic resin was supplied as a solution at 40% nonvolatile in a mixed solvent of methyl isobutyl ketone (MIBK)/methyl isobutyl carbinol (MIBC)/*i*-butanol = 35/35/30.

The solvent-borne epoxy/phenolic coating was used (proprietary supplied by Toyo Ink Mfg. Co., Ltd.) at 40% nonvolatile and contained less than 25% water-soluble solvents. The solvent-borne coatings counterpart was made with the experimental epoxy resin and the phenolic resin.

### Emulsification Procedure to Study the Process

A 40% nonvolatile solution of the epoxy resin was made using a mixed solvent. The solvent composition will be noted in each case.

The epoxy resin solution was blended with the acrylic resin solution at a predetermined ratio with or without the phenolic resin hardener, to give a total of 1,000 g. Aqueous ammonia (450 g) was prepared, which contained 2.0 equivalents of  $\text{NH}_3$  based on the carboxyl group content of the acrylic resin.

The resin mixture was vigorously agitated in a stainless steel vessel by a Homodisper produced by Tokushu Kika

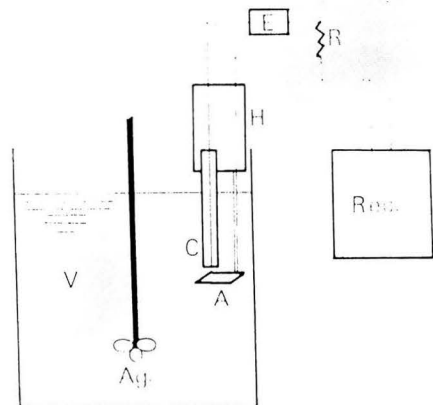


Figure 2—Schematics of an apparatus to measure electrical current: A—copper anode; C—platinum cathode; E—electrical source of 5.0 VDC; R—standard resistor of 1.00  $\Omega$ ; Rec.—recorder; H—holder; Ag—agitator; and V—emulsification vessel

Kogyo Co., Ltd., Osaka, Japan, and the aqueous ammonia was added stepwise in 50 mL aliquots at 1 min intervals. Then, 550 g of deionized water was added in the same manner. The emulsification was carried out at ambient temperature. A water-in-oil (W/O) emulsion was formed at first by the addition of the aqueous ammonia, and then by the addition of the deionized water, an oil-in-water (O/W) emulsion was formed by phase inversion.

### Preparation of Water-based Emulsion Coatings to Study the Effects of Component Materials

To study the effects of solvents on the emulsification stability, namely the effects of ethylene glycol monobutyl ether (EGB), mixed resin solutions of epoxy/phenolics/acrylics = 85/15/15 were prepared as follows with various EGB contents. First, 200 g of the solid epoxy resin and phenolic resin solution were charged into a four-necked flask at a predetermined ratio. Next, a mixed solvent with a predetermined amount of EGB and butyl acetate was added to produce a 40% nonvolatile solution of the epoxy/phenolics. The agitated mixture was heated up to the boiling temperature of n-butanol to dissolve the epoxy resin and then cooled down to ambient temperature. The acrylic resin solution was added and mixed with the epoxy/phenolics solution at a predetermined ratio. At this stage, the mixture contained MIBK, MIBC, n-butanol, i-butanol, EGB, and butyl acetate.

The mixed resin solution was put in a stainless steel vessel and 450 g of aqueous ammonia containing 2.0 equivalents of  $\text{NH}_3$  based on the carboxyl groups in the acrylic resin was added in one shot to the mixture while it was being vigorously agitated. Agitation was continued until a homogeneous W/O emulsion was formed. Then, 550 g of deionized water was added stepwise, about 50 g each time, until the phase inversion took place. After phase inversion, the residue of the deionized water was added at once.

To study the effects of the monomer composition of the acrylic resin, ammonia was used as the neutralizer. Ten acrylic resins were prepared with different monomer compositions by the process previously described. The acrylic resin solution and epoxy/phenolic coating were first mixed at a ratio of epoxy-phenolic coating/acrylic resin = 100/15 on a solid basis. Emulsification was carried out as previously described.

To study the effects of the acrylic resin content, the acrylic resin with a monomer composition of MAA/MMA/EA/Styrene = 40/20/20/20 was used. Ammonia was used as the neutralizer.

To study the effects of the neutralizer, the same acrylic resin was used as was used in the acrylic resin content study. The amines examined are listed in the text.

For the characterization of the emulsion and the cured films, the previously mentioned resin was neutralized with ammonia.

The solvent in the emulsion was stripped off using a rotary vacuum evaporator until the solvent content, based on nonvolatile, was 1% or less. The emulsion was then diluted using deionized water to give a 30% by weight nonvolatile emulsion, and characterized as a water-based emulsion coating.

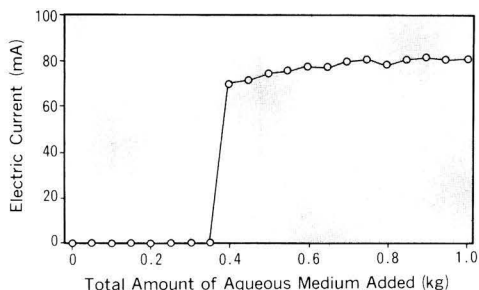


Figure 3—Electrical conductivity change during emulsification process

### Monitoring of Emulsification Process

Viscosity change during the emulsification process was monitored using a spiral viscometer PC-ITL (Malcom Co., Tokyo, Japan) with a B rotor. Shear rate was set at  $108 \text{ sec}^{-1}$  throughout the measurement.

Electrical conductivity during emulsification was monitored using the apparatus shown in Figure 2. This apparatus is composed of an electricity source of 5.0 (volts direct current) VDC, a platinum cathode of 3 mm diameter, a copper anode of  $5 \times 5 \text{ mm}$ , a standard resistance of  $1.00 \Omega$ , and a recorder. Electrodes are placed facing each other at a distance of 10 mm. The voltage drop between the resistor was recorded to monitor the electric current between the electrodes.

### Characterization of Emulsions and Water-based Emulsion Coatings

Particle size and particle size distribution of the dispersed phase of the resultant O/W emulsions were characterized using a laser light scattering type particle size analyzer Microtrac SPA (Nikkiso Co., Ltd., Tokyo, Japan), before and after solvent stripping at ambient temperature. By this particle size analyzer, it is only possible to characterize particles larger than  $0.12 \mu\text{m}$  and less than  $42.21 \mu\text{m}$  because of instrumental restrictions. In some cases, a Microtrac SRA produced by the same company was used, because it has capability to analyze particles up to 300

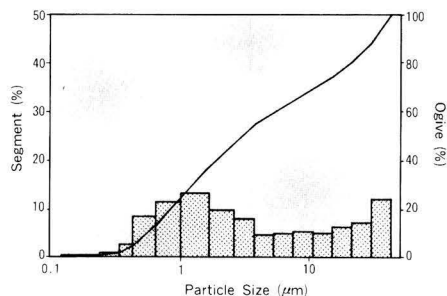


Figure 4—Particle size distribution pattern of an epoxy emulsion—mean particle size  $3.11 \mu\text{m}$

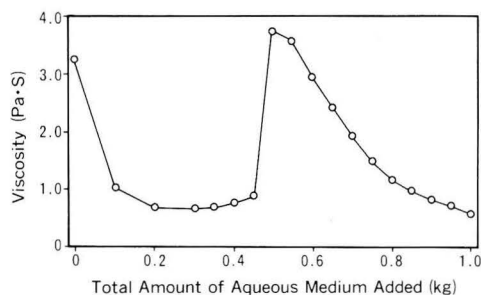


Figure 5—Viscosity change during emulsification process

$\mu\text{m}$ . All of the particles out of this range were excluded from the data.

The water-soluble components in the water-based emulsion coating were analyzed as follows. The water-based emulsion coating sample was centrifuged to separate the dispersed particles from the aqueous medium using an ultra-high gravity centrifuge. A clear aqueous solution was obtained on the top of the sample tube. The nonvolatile portion of the aqueous solution was analyzed to determine the ratio of the acrylic polymer in the particles versus polymer in the aqueous medium. The polymer was then analyzed by infrared (IR) spectroscopy.

Stability of the stripped emulsion, namely change of viscosity, mean particle size, and appearance, was observed after storage for one month at  $50^\circ\text{C}$  in a sealed glass bottle.

### Preparation and Characterization of Cured Film

Water-based emulsion coatings were coated on TFS (Toyo Kohan Co., Tokyo, Japan), which is an electrochemically surface-treated steel that has a layer of chromium oxide on the surface and a layer of metallic chromium between the steel substrate and the chromium oxide layer, using a #8 coating bar. The coated panel was baked in a gas forced air oven at  $185^\circ\text{C}$  for 12 min and then  $215^\circ\text{C}$  for 12 min to give a dry film thickness of about  $2\ \mu\text{m}$ .

All adhesion data was measured by the T-peel test (ASTM D 1876-72) using an Instron type tensile tester. The T-peel test strips were prepared by first cutting the coated and cured TFS panel into 5 mm wide strips. Next, a strip of thermoplastic adhesive of  $40\ \mu\text{m}$  thickness (supplied by Toray) was placed between the two panel strips with the coating facing the adhesive. Each unit was then heat bonded under a pressure of 25 kPa at a temperature of  $200^\circ\text{C}$  for 30 sec. The panels were tested for dry adhesion using the tensile tester to run a T-peel test. Wet adhesion was measured in the same manner after the test specimens were soaked in  $90^\circ\text{C}$  water for four days.

Gel content was measured by methyl ethyl ketone (MEK) extraction. Coated and cured TFS panels were first cut into  $4 \times 15$  cm width strips and weighed (W1). Next, the specimens were soaked in boiling MEK for 1 hr, rinsed in MEK, dried in an electric forced air oven at  $200^\circ\text{C}$  for 10 min, and weighed (W2). It was then soaked

in concentrated sulfuric acid for 5 min to remove the coating film from the substrate, then dried, rinsed, and weighed again (W3). Gel content was calculated from the following equation.

$$\text{Gel Content} = (W2 - W3)/(W1 - W3) \times 100 \quad (1)$$

To characterize the mechanical and thermal properties of the cured films, each coating was coated on a tin plate using a #30 coating bar to give a dry film thickness of about  $20\ \mu\text{m}$ . The coated panels were baked under the conditions previously noted. The dry film was removed from the substrate using mercury to form an amalgam with tin and to solubilize the tin layer, when a free film was required for characterization by transmission electron microscope (TEM) observation of a cross section, dynamic mechanical measurements, and differential scanning calorimetry (DSC) measurements.

On the other hand, when a coated panel was to be directly used for a coating evaluation, namely TEM observation of a coated surface or thermomechanical analysis (TMA), each coating was coated on a TFS panel using a #12 coating bar to give a dry film thickness of about  $5\ \mu\text{m}$  after baking.

The interface layer between substrate and coating was analyzed as follows: the coated and baked TFS panel was immersed in concentrated sulfuric acid for 5 min to decompose the epoxy/phenolic polymer, rinsed in water, dried, and analyzed by IR spectroscopy.

The surface structure of the cured films was observed by TEM using the double-stage replica method. The cross section of the cured films was observed by TEM as follows: a free film of cured coating was embedded in styrene polymer, cut vertically to the film plane by an ultra-microtome, and stained by ruthenium tetroxide.

Dynamic mechanical properties of cured films were analyzed by a mechanical spectrometer, Toyo Baldwin (Orientec Corp. at present) Rheovibron DDV-II-EA at 110 Hz. Thermomechanical properties were analyzed using a thermomechanical analyzer, Rigaku Thermoflex TAS 200 TMA 8140C by a penetration technique. DSC measurements were carried out using a Perkin-Elmer DSC-2C. Heating rate employed in these measurements was  $10^\circ/\text{min}$ .

## RESULTS AND DISCUSSION

### Emulsification of Epoxy Resin

It is important to select proper surfactants in order to obtain a stable emulsion and to achieve the inherent properties of the resultant cured film of the coatings. It would be possible to use a simple surfactant to obtain a stable emulsion, however, such a surfactant will remain in the cured film and be soaked into the cans, which should be avoided. In addition, the existence of such a water-soluble component in the cured film can be a possible reason for poor water resistance. Thus, we decided to use a polymeric surfactant, an acrylic resin, which could be crosslinked by baking, as shown in the later sections.

An epoxy resin was dissolved in a mixture of n-butanol/butyl acetate/EGB = 40/40/20 to give a 40% non-volatile solution and 15 parts per hundred resin (PHR) of

the acrylic resin was added based on the epoxy resin. The mixed resin solution had an opaque appearance.

Figure 3 shows the change of electrical conductivity during the emulsification process. Electrical current was not detected at first, because the continuous phase was composed of the epoxy resin solution, and its electrical conductivity is low. At the moment when a certain amount of aqueous ammonia was added, the electrical current increased instantaneously, which indicated the occurrence of a phase inversion, because the electrical conductivity of the aqueous medium is much higher than that of the epoxy resin solution. The increase of electrical current was observed after an induction period following the addition of aqueous ammonia. It was thought that the delay was caused simply by a physical phenomenon, i.e., the delay to achieve homogeneity. The electrical current recorded slightly increased with further addition of aqueous ammonia and then of deionized water.

The particle size distribution of the resultant emulsion is shown in Figure 4. Using the particle size analyzer, Microtrac SPA, all the particles larger than 42.21  $\mu\text{m}$  were excluded from the data. The excluded portion was determined not to be very great, using Microtrac SRA which can analyze particles up to 300  $\mu\text{m}$ .

Although this emulsion contained a significant amount of coarse particles which are not desirable in a water-based emulsion coating, it was confirmed that emulsification of epoxy resins was possible without any chemical modification of epoxy resin. Epoxy resin and acrylic resin blends can be emulsified by the phase inversion method, from the fact that there exists a peak in the distribution in the fine particle size region. It was found that the phase inversion of the system occurs instantaneously, which may allow the development of a continuous emulsification process. It was also confirmed that any hydrophobic resin can be emulsified if suitable solvents and compatible dispersants for the resin are found, which widens the design latitude of formulation and the possibility of developing higher performance water-based emulsion coatings.

### Emulsification of Epoxy/Phenolics

An epoxy resin was dissolved in a mixture of n-butanol/butyl acetate = 50/50 to give a 40% nonvolatile

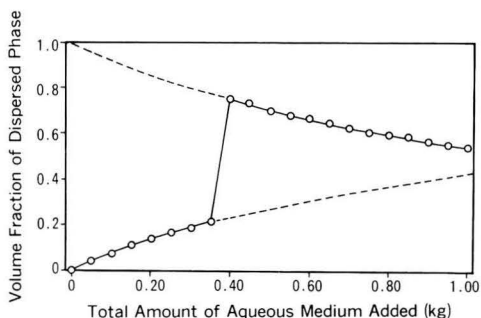


Figure 6—Volume fraction of dispersed phase during emulsification process

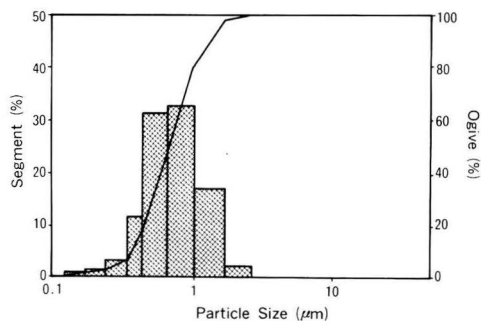


Figure 7—Particle size distribution pattern of an epoxy/phenolic emulsion—mean particle size 0.68  $\mu\text{m}$

solution, and the phenolic resin solution and the acrylic resin solution were added at a ratio of epoxy resin/phenolic resin/acrylic resin = 85/15/15 based on solids. The mixed resin solution was then agitated until homogeneous. Emulsification was carried out as previously described.

Figure 5 shows the viscosity change during the emulsification process. The viscosity of the system decreased rapidly at first. At this stage, neutralization occurs and ionized groups are introduced in the acrylic resin. It is thought that the viscosity of the system is mainly governed by the amount and nature of the acrylic resin, the largest molecular weight component in the system. It is thought that the conformation of the acrylic resin will change to the hard coil or micelle-like one from the relatively extended random coil with the introduction of polar groups and the migration of the poor solvent, water, which will result in a decrease of the viscosity of the continuous phase. By phase inversion, the viscosity of the system increased instantaneously, because the volume fraction of dispersed phase increases by about three folds as shown in Figure 6. In this figure, volume fraction of the dispersed phase was plotted against the amount of aqueous ammonia and deionized water, which was calculated assuming that the density of the solution phase is 0.80, and that the water and solvents do not dissolve each other.

The particle size distribution of the resultant emulsion is shown in Figure 7. This emulsion has a single peak in its particle size distribution and does not contain any coarse particles larger than 3  $\mu\text{m}$ . The mean particle size of this emulsion is a little greater than that of conventional water-based emulsion coatings<sup>6</sup> but much smaller than that of an aqueous powder suspension.<sup>13</sup> The particle size distribution was found to be reasonably narrow and the largest size particles are in an acceptable range to use the emulsion as a water-based emulsion coating.

By stripping off the solvents from the emulsion, a water-based emulsion coating with 30% nonvolatile was prepared. The mean particle size and particle size distribution did not show any difference when characterized with or without solvents. Furthermore, it was found that after storage at 50°C for one month in a sealed glass bottle, that the stability of the water-based emulsion coat-



**Table 1—Effects of Ethylene Glycol Monobutyl Ether on the Emulsification of Epoxy/Phenolic Resin**

Solvents EGBE/Others	Emulsification	Mean Particle Size ( $\mu\text{m}$ )
0/100	+	0.90
10/90	+	0.81
25/75	+	0.56
35/65	+	0.85
40/60	+	0.88
45/55	—	—
50/50	—	—

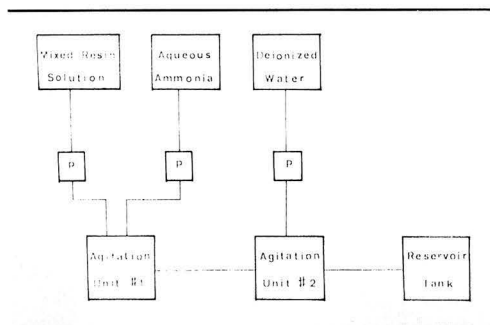
ing is excellent, i.e., very little change in viscosity, particle size, and appearance was observed.

### Construction of Continuous Emulsification Process

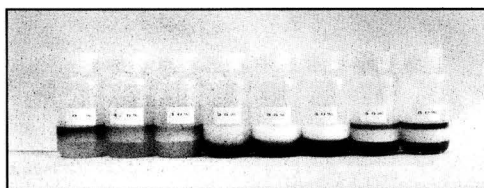
Based on the results previously obtained, a scaled-up, continuous emulsification was tried, using a mixed resin solution of epoxy/phenolic/acrylic = 100/15/15. The resin solution was prepared to be 40% nonvolatile by weight. The main solvents incorporated were n-butanol and butyl acetate, and contained a minor amount of MIBK and MIBC.

Figure 8 shows the flow chart of the emulsification system. The system consisted of two agitation units, supply tanks, and a reservoir. The agitation units used were T.K. Homomix Line Flow model 100 (Tokushu Kika Kogyo Co., Ltd., Osaka, Japan). The agitation unit is very compact and efficient agitation is possible. It is also possible to work under pressure, which helps to control cavitation and to improve agitation efficiency.

Twenty-three kg of the mixed resin solution were charged into tank 1, 7.2 kg of deionized water and 0.8 kg of 25% aqueous ammonia were put in tank 2, and 15 kg of deionized water into tank 3. The flow rate of the pumps was adjusted to 1.00 kg/min. for Pump 1, 0.45 kg/min. for Pump 2, and 0.55 kg/min. for Pump 3, and the agitation was started. Products obtained in the first few minutes were disposed of until a stable emulsion was continuously obtained. The gauge pressure in the agitation unit 1 was controlled to be 0.12 MPa (1.2 kg/cm<sup>2</sup>) throughout the operation.



**Figure 8—Schematic diagram of the continuous emulsification apparatus**



**Figure 9—Phase separation of epoxy/phenolics solution and deionized water mixture at varying ethylene glycol monobutyl ether content**

Mean particle size of the dispersed phase was characterized to be 0.56  $\mu\text{m}$ , both before and after solvent removal. Stability of the stripped emulsion was tested and no practical changes were observed in the mean particle size, viscosity, and appearance after one month storage at 50°C.

### Effects of Solvents

It was found that emulsification of an epoxy resin solution in EGB was not possible. EGB is a good solvent for an epoxy resin and it is possible to mix it with water at any ratio. The mechanism is thought to be that the aqueous ammonia added is dissolved in the epoxy resin solution, and does not form a dispersed phase as in a W/O emulsion. Thus, the resin solution becomes highly viscous because the EGB/aqueous ammonia mixture dissolves the acrylic resin and finally forms a separate water phase by further addition of deionized water because the highly viscous solution no longer dissolves water. In such cases, it was impossible to emulsify the system.

Water-soluble solvents are widely used in the coatings industry because they dissolve epoxy resins and other resins used as film forming components, and the solvents that dissolve both epoxy/hardener mixture and acrylics should be chosen for the present emulsification process. It seems preferable to use water-insoluble solvents for emulsification, because some water-soluble solvents such as EGB have adverse effects on the emulsification process as previously mentioned. So, it is worthwhile to examine the effects of solvents, to determine which solvents have an adverse effect on the emulsification process. As stated, these experiments were conducted to find what quantity of water-soluble solvent is acceptable for this process. For this purpose, a series of emulsification experiments was carried out using the resin mixture, described in the experimental section, dissolved in a series of mixed solvents which included EGB. The results are shown in Table 1.

The mean particle size of the dispersed phase in the resultant emulsions is given for experiments where emulsification was successfully carried out. It was found that emulsification became difficult when the EGB content in the mixed solvent exceeded 45%. In the cases when the EGB content was 45% or more, an oily component was formed in the resultant emulsion, which was the part of the resin solution which failed to form dispersed particles.

It is thought that both water and the water-soluble solvents are distributed in both the aqueous phase and the

resin solution phase. To determine the distribution of water and water-soluble solvents, an additional experiment was carried out. The mixture of mixed resin solution of epoxy/phenolics (50 g) and deionized water (50 g) was violently shook in a sealed plastic bottle, and then centrifuged to separate out the aqueous phase. The results are shown in Figure 9. As in the case of the emulsification experiments, an oily component was formed when the EGB content was 45% or more (see Figure 9). For the samples with 45 and 50% of EGB, the mixtures separated into three phases. Analysis showed that the upper phase was the phenolic resin solution of the mixed solvents, the middle phase was a resin solution of mainly epoxy resin and acrylic resin in which minor amounts of water were dissolved. In the cases where the EGB content was 40% or less, the mixture separated into two phases, however, the composition was different depending on the EGB content. When EGB content was 25, 35, and 40%, the upper phase was an aqueous phase and the lower phase was the resin solution in which a minor amount of water was dissolved. On the other hand, when the EGB content was 10% or less, the upper phase was a resin solution and the lower phase was an aqueous phase. It was assumed that the resin solution does not dissolve a large amount of water when EGB content is lower, and the density of the resin solution phase is low compared to the aqueous phase.

The mechanism of phase separation is not well understood. However, it was found that the resin solution in hydrophobic solvents was preferable for obtaining an emulsion with a fine particle size.

**Effects of Acrylic Resin Content on Emulsification**

The epoxy resin was dissolved in a mixture of n-butanol/butyl acetate = 50/50 to give a 40% nonvolatile material. Fifteen PHR of the phenolic resin solution was added on a solids basis. The acrylic resin solution was diluted with n-butanol, MIBK, and MIBC to give the same solvent composition as the epoxy/phenolic solution. These solutions were then blended at a predetermined ratio and emulsified by the process previously described.

Figure 10 shows the influence of the acrylic resin content on the mean particle size of the dispersed phase for the resultant O/W emulsions before stripping the solvents. It was found that the mean particle size of the dispersed phase decreases slightly with increasing acrylic resin content. It is thought that the excess amount of acrylic resin (surfactant) helps to stabilize the emulsification process, although the amount of acrylic resin required to emulsify and to obtain dispersions with fine particle size is relatively small. Additionally, it is surprising that a stable emulsion could be obtained with only 3 PHR of acrylic resin based on the epoxy/phenolic resins, because it is well known that conventional dispersion type water-based emulsion coatings, aqueous dispersions of acrylic modified epoxy resin, contain 20 to 40 PHR of the acrylic component so as to obtain stable dispersions.<sup>4,5</sup> Although emulsions with lower amounts of acrylic resin produced larger particle sizes, it was confirmed that it would be possible to produce emulsions

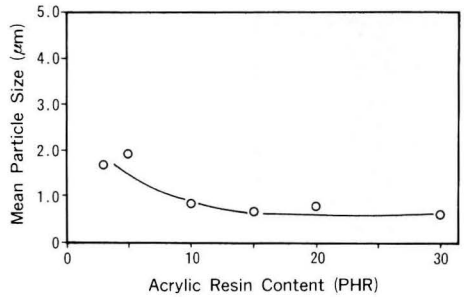


Figure 10—Effect of acrylic resin content on the mean particle size of the dispersed phase

with a fine particle size by precise control of the emulsification process. The reduction of acrylic resin incorporated will help to develop the excellent performance of the epoxy resin and hardeners, because the influence of acrylic resin will be minimized. The acrylic resin content, however, should be adjusted as to give excellent emulsification stability, preferable rheological properties for application and excellent film performance. The influence of the acrylic resin content on adhesion performance will be discussed in the following section.

**Effects of the Monomer Composition of the Acrylic Resin on Emulsification and Adhesion Performance**

The monomer composition of the acrylic resin employed as a surfactant is thought to be important in view of emulsification stability and also adhesion performance. The acrylic resin has to possess some compatibility with the epoxy/phenolics and also carboxyl function-

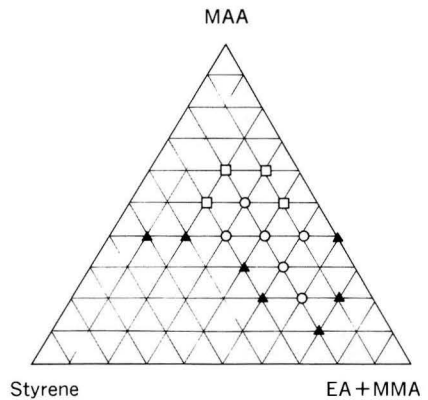


Figure 11—Effects of the monomer composition of the acrylic resin on the emulsion stability and adhesion performance. ○—good adhesion, good emulsion stability; □—inferior adhesion, good emulsion stability; and ▲—inferior emulsion stability

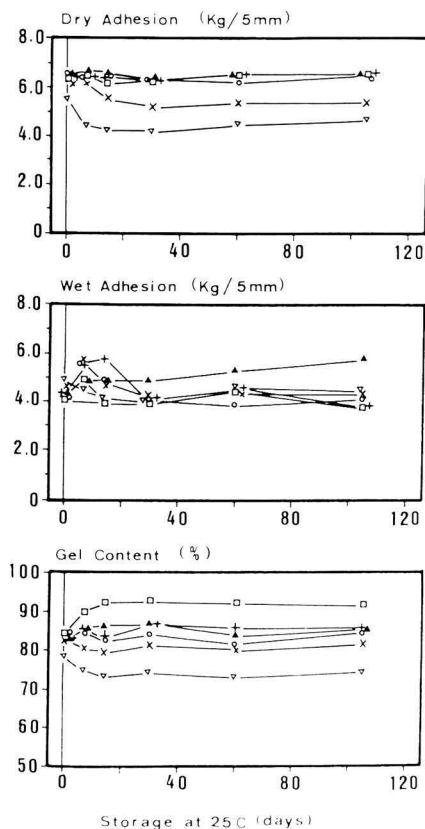


Figure 12—Effects of the stabilizing amine on the gel content of the cured film and the adhesion performance when the emulsions were stored at 25°C. □—no stabilizing amine; +—0.5 equivalents of ammonia per carboxyl group in the acrylic resin; ○—1.0 equivalents of ammonia; ▲—0.2 equivalents of morpholine; X—equivalents of morpholine; and ▽—1.0 equivalents of morpholine

ality to be neutralized in order to emulsify the resin mixture. On the other hand, adverse effects of the acrylic resin on adhesion performance should be avoided.

A series of acrylic resins was prepared using different monomer composition (see Figure 11). The ratio of MMA and EA was set to be equal, i.e., MMA/EA = 1/1. The molecular weight of these polymers was controlled around 80,000.

From the emulsification experiments and the evaluation of the resultant emulsions, these acrylic resins were classified into three categories: (1) both the emulsification stability and adhesion performance of resultant water-based emulsion coating are good; (2) the emulsification stability is good, but the wet adhesion is poor; and (3) the emulsification stability is poor, therefore a stable water-based emulsion coating was not obtained. As seen, styrene-rich systems and EA + MMA rich systems tend to show poor emulsification stability. The reason is assumed

to be that the surface activity of the acrylic resin is reduced because of their low carboxyl functionality and/or the compatibility with the epoxy/phenolics is reduced. On the other hand, wet adhesion tends to decrease for the systems with high MAA content. The reason is assumed to be that the hot-water resistance of the cured films is reduced by the introduction of too much carboxyl functionality.

Thus, for the epoxy/phenolics used in this study, preferable monomer composition of acrylic resin was found and used throughout the study. However, minor adjustments will need to be made for different resin systems.

### Effects of Acrylic Resin Concentration on Adhesion Performance

Six water-based emulsion coatings were prepared with different amounts of acrylic resin, ranging from 3 to 30 PHR based on solid epoxy/phenolic resin. Mean particle size of the dispersed phase for each water-based emulsion coating is listed in Table 2 with the dry film gel content and adhesion.

Little influence of the acrylic resin content on the gel content was observed. The molecular weight of the acrylic resin is much higher than that of the epoxy resin or the phenolic resin, which seems to help the acrylic resin to form an insoluble network structure. Because of the reduction of the hardener (phenolic resin) content in the resin mixture, a slight reduction of the gel content was observed with increasing acrylic resin content.

Dry and wet adhesion of water-based emulsion coatings was excellent, even better than the solvent-borne coating counterpart in many cases. Wet adhesion at higher acrylic resin content tends to be lower, possibly because of the introduction of the hydrophilic acrylic component. Thus, it is concluded that the acrylic resin content should not be too high in order to obtain the ultimate adhesion performance. On the other hand, it has been observed that the lower the acrylic resin (surfactant) content is, the better the adhesion is. The acrylic resin content should be selected to achieve the optimum balance of adhesion performance and ease of emulsification.

### Effects of Neutralizer on Adhesion Performance

A series of water-based emulsion coatings was prepared using ammonia and variety of amines as the neu-

Table 2—Effects of Acrylic Resin Content on the Mean Particle Size of the Dispersed Phase of Emulsions, the Gel Content of Cured Films, and the Adhesion Properties

Acrylic Resin Content (PHR)	Mean Particle Size (μm)	Gel Content (%)	Dry Adhesion (Kg/5mm)	Wet Adhesion (Kg/5mm)
3	1.69	72.2	5.5	4.7
5	1.93	72.6	5.5	3.9
10	0.86	73.2	5.4	4.2
15	0.70	74.6	5.4	4.3
20	0.83	76.5	5.7	4.4
30	0.65	77.6	5.7	4.0
None <sup>a</sup>	—	81.2	5.5	3.9

(a) Solvent-borne counterpart.

tralizer (see Table 3). It was possible to produce an emulsion independent of neutralizer, however, it was found that the gel content of the cured film and the adhesion performance were very dependent on the neutralizer. It was also found that wet adhesion tends to be lower in water-based emulsion coatings whose gel content is higher than that of the solvent-borne coating counterpart.

It is well known that amines are classified as a hardener for epoxy resins. In fact, when an EGB solution of an epoxy resin was mixed with ammonia and stored in a sealed glass bottle, gelation of the system was observed. Thus, it would be reasonable to assume that some amines work as a hardener for epoxy resins at the stoving condition, which results in the increase of gel content. We do know that the adhesion performance of epoxy coatings crosslinked by an amine is inferior compared with that of epoxy coatings crosslinked by a phenolic resin.<sup>14</sup> This is the reason why epoxy/phenolic coatings are widely utilized as an adhesive primer for side-seam bonded cans. It is suggested that the occurrence of amine crosslinking should be avoided to achieve superior adhesion performance by the selection of proper amines. The difference in the gel content produced by the different amines used as a neutralizer will help for selection of the proper one. We found that the best balance of dry and wet adhesion was obtained by the use of ammonia, amines with branched alkyl groups such as iso-propyl amine, sec.-butyl amine and tert.-butyl amine, or cyclic amines such as morpholine. It is assumed that ammonia does not work as a hardener because of its fast evaporation at the stoving condition and that the reactivity of amines with branched alkyl groups or cyclic amines is much lower because of steric hindrance.

### Effects of the Stabilizing Amines on Adhesion Performance

It is well known that the pH value of deionized water or an aqueous dispersion tends to decrease during storage because of the absorption of carbon dioxide. This should be avoided to insure stability of the emulsion when an anionic surfactant is employed. To keep the system in the basic region, it is a common practice to add some amine. As previously described, some amines react with epoxy resins, which should be avoided to achieve ultimate adhesion performance. It is also known that crosslinking of epoxy resin by some amines occurs at relatively low temperatures.<sup>15</sup>

Ammonia and morpholine were selected as the stabilizing amines, because they had no adverse effects when used as neutralizers. Various levels of stabilizing amine were added to the water-based emulsion coating prepared with 10 PHR of acrylic resin. The mixtures were stored at ambient temperature and at 50°C in sealed glass bottles. Appearance, gel content of the cured film, and adhesion performance were checked periodically. Results are shown in Figures 12 and 13.

At the higher level of ammonia addition, gel content of the cured film gradually increased with storage, which suggests that crosslinking proceeded at the storage condition. On the other hand, gel content of the cured film did

not increase as much in water-based emulsion coatings with lower levels of ammonia or morpholine. Dry adhesion was not influenced by the change of gel content, however, wet adhesion decreased with increasing gel content, which is assumed to be the result of amine crosslinking. Coagulation of dispersed particles was also observed in water-based emulsion coatings with higher levels of ammonia after storage for one month at 50°C.

Thus, it was concluded that the addition of stabilizing amines should be minimized to obtain optimum storage stability, and that an alkyl-branched amine or ammonia should be used.

### Adhesion Strength of Side-Seam Bonded Cans

The side-seam structure of side-seam bonded cans,<sup>11</sup> Toyo Seam Cans (Toyo Seikan Kaisha, Ltd., Japan), is shown in Figure 1. The cans are widely used for hot

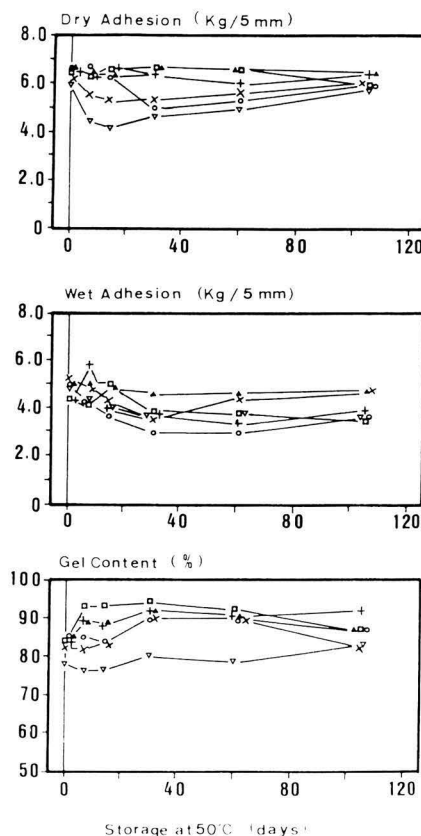


Figure 13—Effects of the stabilizing amine on the gel content of the cured film and the adhesion performance when the emulsions were stored at 50°C. □—no stabilizing amine; +—0.5 equivalents of ammonia per carboxyl group in the acrylic resin; ○—1.0 equivalents of ammonia; ▲—0.2 equivalents of morpholine; X—0.4 equivalents of morpholine; and ▽—1.0 equivalents of morpholine

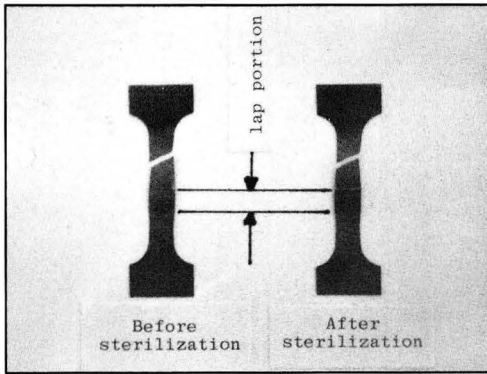


Figure 14—Fractured test pieces of bonded portion of a Toyo Seam Can by tensile test before and after the sterilization process

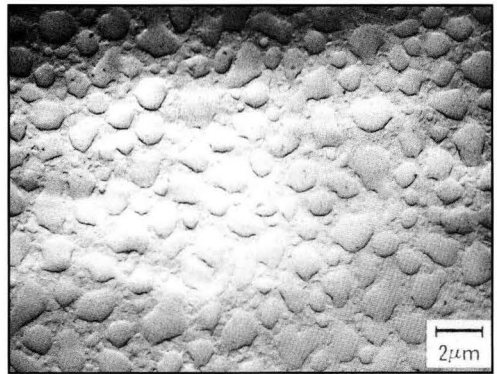


Figure 17—TEM image of the cured film surface of the new water-based emulsion coating

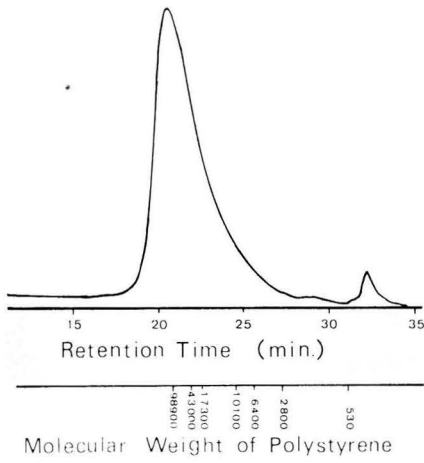


Figure 15—GPC pattern of the water-soluble component

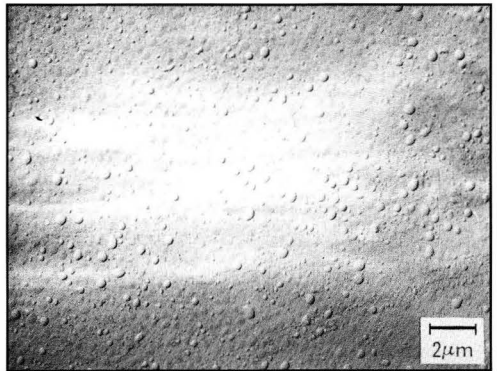


Figure 18—TEM image of the cured film surface of a conventional water-based emulsion coating

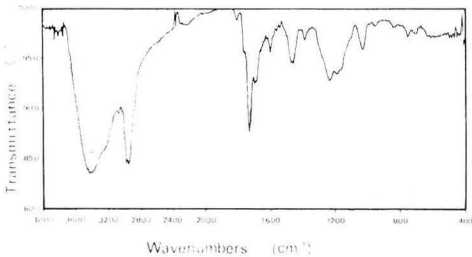


Figure 16—IR spectrum of the organic substance remaining on the TFS surface after removing the epoxy/phenolic polymer by decomposition using concentrated sulfuric acid

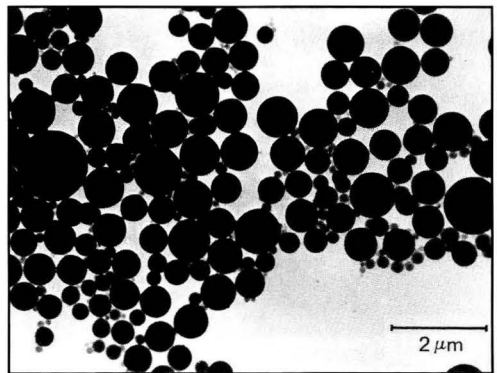


Figure 19—TEM image of the dispersed particles of the new water-based emulsion coating

**Table 3—Effects of Neutralizer on Gel Content of Cured Film and Adhesion Properties. Baked at 185°C, 215°C, and then 170°C for 12 min Each**

Amines	Gel Content (%)	Dry Adhesion <sup>a</sup>	Wet Adhesion <sup>a</sup>
Monomethylamine	84.8	7.0	3.3
Dimethylamine	89.1	8.1	3.2
Trimethylamine	93.8	5.2	2.4
Monoethylamine	81.6	6.9	3.6
Diethylamine	82.5	6.3	3.9
Triethylamine	92.0	7.6	3.2
n-Propylamine	80.8	6.7	3.7
i-Propylamine	80.2	6.8	5.8
n-Butylamine	89.2	7.0	3.3
sec-Butylamine	82.6	6.7	5.0
tert-Butylamine	83.0	6.5	4.9
Morpholine	79.8	6.3	5.5
Ammonia	83.8	6.8	6.1
Dimethylaminoethanol	90.2	4.9	2.8

(a) Kg/5mm.

drinks, retort sterilized drinks, processed food, meat and fish, and so on. The adhesive structure is designed to withstand a severe sterilization process after the cans are filled.<sup>10</sup>

All the constituent materials play an important role in promoting reliable adhesion: the adhesive, TFS, and the adhesive primer. A thermoplastic polyamide is utilized as the adhesive. The surface treatment of the TFS is important to achieve strong adhesion and specially designed electrochromium coated steel is utilized. The adhesive primer is the subject of discussion in this article.

The adhesive strength is usually measured by T-peel, however, the cans have to withstand shear force by circular expansion during the sterilizing process. The shear strength of the side-seam structure is impossible to measure because it is stronger than TFS, i.e., steel strip of 0.22 mm thickness (see *Figure 14*). It has also been demonstrated that the adhesive strength is maintained even after a sterilization process of 30 min in an autoclave at 130°C. Thus, T-peel strength is measured to monitor the adhesion performance instead of measuring shear strength.

Solvent-borne epoxy/phenolic coatings have been utilized as the adhesive primer for this purpose since the can was first developed. It is well demonstrated that the water-based emulsion coatings described in this paper possess superior adhesion performance. These high performance solvent-borne coatings are conventionally used.

### Characterization of Water-Soluble Components in Water-based Emulsion Coatings

It has been shown that the amount of acrylic resin necessary to emulsify was relatively small, and the addition of excess amounts of acrylic resin made it easy to obtain dispersions with a fine particle size. It was also shown that the adhesion performance was not greatly affected by an excess amount of acrylic resin. However, it is important to know where such acrylic resin exists, in

the dispersed particles or in the aqueous medium, to understand the morphology of the cured film.

The water-based emulsion coating was centrifuged to separate the dispersed particles from the aqueous medium, as described in the experimental section. The clear, aqueous medium obtained on the top of the sample tube was characterized as follows: first the nonvolatile percent was determined and then the nonvolatile component was characterized by GPC and IR spectroscopy.

It was found that the amount of polymer in the aqueous phase was equivalent to that of the acrylic resin added to the system. If all of the acrylic resin is dissolved in the aqueous phase, and no acrylic resin covers the dispersed particles, it is peculiar that a stable dispersion is obtained.

To analyze the polymer in the aqueous phase, hydrochloric acid was added to the aqueous solution to convert the ammonium salt of acrylic acid to its acid form and then it was dried. The dried residue was dissolved by tetrahydrofuran (THF) and filtered to remove the ammonium chloride. The solution was then characterized by means of GPC. The result is shown in *Figure 15*. Two peaks were observed on the chart. These fractions were further analyzed by IR spectroscopy and it was found that the higher molecular weight fraction corresponds to the acrylic resin and the lower molecular weight fraction corresponds to the phenolic resin. Comparing the peak areas, it was found that 90% of the polymer dissolved in the aqueous medium was acrylic resin.

Because the amount of polymer dissolved in the aqueous medium is equivalent to the amount of acrylic resin added as previously noted, it was concluded that 90% of acrylic resin added is dissolved in the aqueous medium

### Nomenclature

TFS	tin free steel
MAA	methacrylic acid
MMA	methyl methacrylate
EA	ethyl acrylate
Mw	weight average molecular weight
GPC	gel permeation chromatography
T <sub>g</sub>	glass transition temperature
MIBK	methyl isobutyl ketone
MIBC	methyl isobutyl carbinol
W/O emulsion	water-in-oil emulsion
O/W emulsion	oil-in-water emulsion
EGB	ethylene glycol monobutyl ether
IR spectroscopy	infrared spectroscopy
MEK	methyl ethyl ketone
TEM	transmission electron microscope
DSC	differential scanning calorimetry
TMA	thermomechanical analysis
PHR	parts per hundred resin
THF	tetrahydrofuran

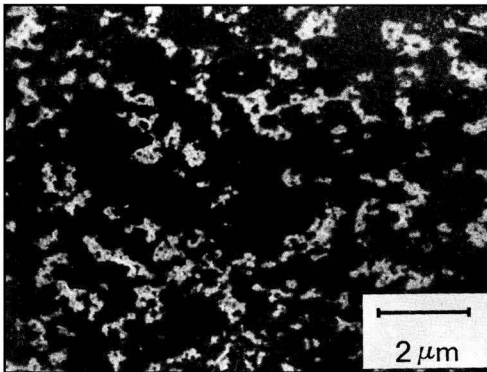


Figure 20—TEM image of the cross section of a cured film of the new water-based emulsion coating

Table 4— $T_g$  of Acrylic Resin/Phenolic Resin Mixture Baked at 215°C for 12 min

Phenolic Resin Content (%)	$T_g$ (°C)
0	150.4
1	152.7
3	148.7
5	148.1
7.5	150.4
10	149.9
15	151.6
20	148.8
25	149.6

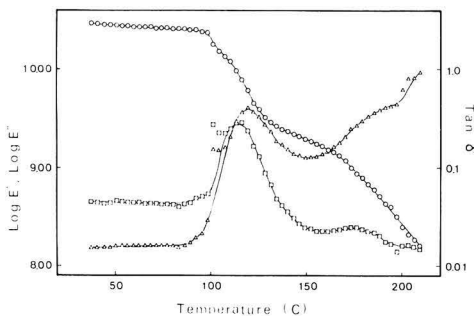


Figure 21—Temperature dependence of dynamic storage modulus ( $E'$ —○); loss modulus ( $E''$ —□); and loss tangent ( $\tan \delta$ —△) for the new water-based emulsion coating

and the rest covers the dispersed particles to stabilize them.

### Characterization of Interface Layer between Substrate and Coating Film

As noted, it was found that the majority of the acrylic resin added is dissolved in the aqueous, continuous phase, and that the rest covers the dispersed particles to stabilize them. Then, it is presumed that there exists a layer of acrylic resin in the interface between the substrate and the epoxy/phenolic polymer when the water-based emulsion coatings are coated and baked.

The interface layer was analyzed by IR spectroscopy as described in the experimental section. Figure 16 shows the IR spectrum of the organic substance that remained on the TFS surface. The spectrum is characteristic of the acrylic resin employed here, although trace amounts of epoxy resin were also found. Thus, it is confirmed that the acrylic resin exists at the interface between substrate and the epoxy/phenolic polymer after the water-based emulsion coating is baked.

These findings can be expressed, in other words, that the substance which contacts with substrate is the acrylic resin and not the epoxy/phenolic polymer. In the case of the solvent-borne coatings, the epoxy/phenolic polymer contacts the substrate and shows excellent adhesion performance. However, in the new water-based emulsion coatings, it is presumed that the adhesion to the substrate is totally due to the acrylic resin, and the epoxy/phenolic polymer plays the role of improving the cohesive strength of the film.

### Observation of Surface and Cross Section of the Cured Film

The surface of the cured film was observed by TEM using the double stage replica method (see Figure 17) which is compared with the photograph for a conventional water-based emulsion coating (see Figure 18). It is clearly demonstrated that the surface of the coated film with a dispersion type water-based emulsion coating is not as flat and smooth when compared with a coating from a conventional water-based emulsion coating with a fine particle size.<sup>4</sup> The size of the island phase for the conventional water-based emulsion coating is similar to that of the dispersed particles. However, the size of the island phase for the new water-based emulsion coating is much larger than the size of the dispersed particles (see Figure 19) which shows the TEM image of the dispersed particles for the new water-based emulsion coating. The reason is assumed to be that the dispersed particles are flattened during the precipitation and baking process by flowing out.

Figure 20 shows the TEM image for a cross section of the cured film. As can be seen, the acrylic component (bright portion) forms a separate phase from the epoxy/phenolic component (dark portion). However, it is not clear if the acrylic component forms a continuous phase or not. Moreover, it seems as if the epoxy/phenolic component forms the continuous phase, fusing the particles of the epoxy/phenolic resin by the baking operation. It is

assumed that the acrylic component, covering the particles or dissolved in the aqueous medium, gathers together to form a dispersed phase.

### Mechanical and Thermal Properties

Figure 21 shows the results of the characterization of the new water-based emulsion coating by a mechanical spectrometer. As shown, two shoulders were observed on the storage modulus ( $E'$ ) data, which suggests that there exists two separate components. This is consistent with the TEM observation as shown in Figure 20.

The storage modulus of the new water-based emulsion coating is compared with that of a solvent-borne coating counterpart with the same epoxy/phenolic composition without acrylic resin and a conventional water-based emulsion coating with a different composition in Figure 22. Both the conventional water-based emulsion coating and solvent-borne coating counterpart possess only one shoulder, which suggests that the structure is homogeneous, even though a hybrid polymer is employed for the conventional water-based emulsion coating. From the comparison of the results with that of the solvent-borne coating counterpart, the shoulder in the lower temperature region is thought to correspond to the epoxy/phenolic polymer, and in the higher temperature region to the acrylic resin. Thus, the unique morphology of the new water-based emulsion coating is again demonstrated.

The cured film was further analyzed by TMA by a penetration technique. Figure 23 shows the results of the evaluation with a solvent-borne coating counterpart for comparison. Two shoulders were observed for the cured film of the new water-based emulsion coating, whereas the solvent-borne coating counterpart possessed a single shoulder. This result is consistent with the TEM observation and the dynamic mechanical characterization results.

The results of DSC measurements for the new water-based emulsion coating, the solvent-borne counterpart, and a conventional water-based emulsion coating are shown in Figure 24. Unlike the TEM observation and mechanical characterization results, only a single transition was observed for each sample. The  $T_g$  for each sample shown in the figure are the onset temperature of the glass transition. The result for the conventional water-based emulsion coating was consistent with that reported elsewhere.<sup>6</sup>

To understand the reason for the discrepancy, additional experiments were carried out, i.e., DSC measurement using more sample and at a lower heating rate, so as to obtain more precise results. The result was as expected, however, the signal of  $T_g$  for the acrylic component was equivalent to the level of noise and it was difficult to determine the  $T_g$ .

It was found that  $T_g$  for the acrylic component determined by dynamic mechanical measurement was much higher than that estimated from the monomer composition. It is well known<sup>16</sup> that  $T_g$  increases by the introduction of crosslinking. If crosslinking is introduced into the acrylic resin, then it is assumed that the phenolic resin will play the role of crosslinking agent. To make sure, an additional experiment was carried out. A phenolic resin

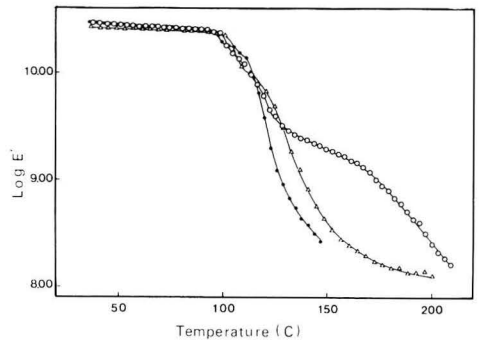


Figure 22—Temperature dependence of dynamic storage modulus ( $E'$ ); for the new water-based emulsion coating (O); a conventional water-based emulsion coating ( $\Delta$ ); and the solvent-borne coating counterpart ( $\bullet$ )

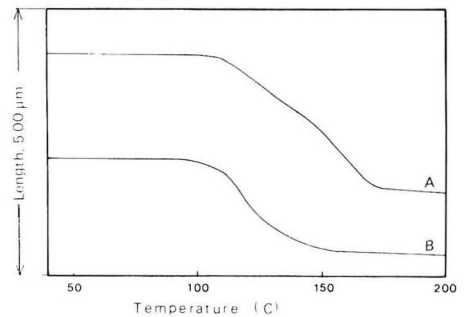


Figure 23—TMA data for new water-based emulsion coating (A); and the solvent-borne coating counterpart (B)

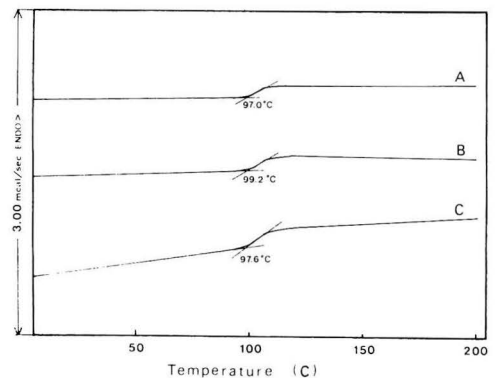


Figure 24—DSC trace of the new water-based emulsion coating (A); a conventional water-based emulsion coating (B); and the solvent-borne coating counterpart (C)



solution was added to the acrylic resin solution at a predetermined ratio, coated and baked at 215°C for 12 min. The results of  $T_g$  measurement by DSC are summarized in Table 4. The  $T_g$  values scattered around 150°C are independent of the phenolic resin content. However, these values of  $T_g$  are consistent with that observed by dynamic mechanical measurement. Moreover, hot water resistance of the coating film, i.e., blushing by retort sterilization in an autoclave at 130°C for 30 min, showed pronounced difference; coating film without phenolic resin showed severe blushing, whereas those with phenolic resin showed no blushing.

Thus, it is confirmed that crosslinking is introduced into the acrylic resin and that some phenolic resin dissolved in the aqueous medium reacts with the acrylic resin when baked. Also, it is assumed that the brittle nature of the acrylic resin is reduced by the introduction of crosslinking to give a tough film, which helps to improve the adhesion performance at the interface layer between the substrate and the epoxy/phenolic polymer.

## CONCLUSION

A new generation of water-based emulsion coatings for can coating applications has been developed. These coatings possess excellent adhesion performance and can be used as an adhesive primer for side-seam bonded cans.

Despite the previous conclusions, it has become possible to emulsify epoxy resins without any chemical modification by acrylics but just by blending them, by the phase inversion method. This widened the design latitude of the formulations, thus making it possible to develop the optimum properties of the component resins.

It was found, from the study on emulsification, that the critical factors to be controlled are the solvent composition prior to emulsification, the monomer composition of the acrylic resin, and the amount of acrylic resin added to achieve a stable emulsion. Thus, a continuous emulsification process has been established. It was also found that, to achieve optimum adhesion performance of the component epoxy/phenolic resins, the choice of acrylic resin and its amount, the neutralizer and the stabilizing amine are all important. From the characterization of the emulsions and the cured films, the unique structure of the new water-based emulsion coatings was demonstrated; the acrylic resin is dispersed in the epoxy/phenolic matrix and there exists a layer of acrylic resin at the interface between the substrate and the epoxy/phenolic matrix. The

formation of these unique structures was supported by the mechanical and thermal characterization of the cured films.

## ACKNOWLEDGMENTS

The authors wish to acknowledge the permission of Dr. Y. Kuwahara, Chief of Corporate Research and Development, of Toyo Seikan Group, to publish this article, the contributions of Dr. H. Gotoh, and the contributions of Miss M. Kondo, of Japan Synthetic Rubber Co., on TEM observation of emulsion particles.

The authors also wish to acknowledge the kind advice and discussion of Professor S. Hibi, of Nagoya Institute of Technology, Japan.

## References

- (1) Bauer, R.S., *J. Water Borne Coating*, 5, 5 (November 1982).
- (2) Emch, D., *Tech. Pap. Soc. Manuf. Eng.*, FC-83-629 (1983).
- (3) Demmer, C.G. and Moss, N.S., *J. Oil & Colour Chemists' Assoc.*, 65, 249 (1982).
- (4) Suzuki, H., Kuno, T., Yoshimura, Y., Okugami, K., Hotta, H., and Otsuka, S., U.S. Patent 4,458,040.
- (5) Woo, J.T.K., Ting, V., Evans, J., Ortiz, C., Carlson, G., and Marcincio, R., ACS Symp., Ser. No. 221, 283 (1983).
- (6) Robinson, P.V., "Design of Water Reducible Polymers for Use in Food Contact Applications," *JOURNAL OF COATINGS TECHNOLOGY*, 53, No. 674, 23 (1981).
- (7) Sheih, P.S. and Massingill, J.L., "Fundamental Studies of Epoxy Resins for Can and Coil Coatings I. Adhesion to Tin Free Steel," *JOURNAL OF COATINGS TECHNOLOGY*, 62, No. 781, 25 (1990).
- (8) Massingill, J.L., Sheih, P.S., Whiteside, R.C., Benton, D.E., and Morisse-Arnold, D.K., "Fundamental Studies of Epoxy Resins for Can and Coil Coatings II. Flexibility and Adhesion of Epoxy Resins," *JOURNAL OF COATINGS TECHNOLOGY*, 62, No. 781, 31 (1990).
- (9) Whiteside, R.C., Sheih, P.S., and Massingill, J.L., "High Performance Epoxy Resins for Container Coating Applications Based on In-Situ Advancement Technology," *JOURNAL OF COATINGS TECHNOLOGY*, 62, No. 788, 61 (1990).
- (10) Kishimoto, A., Ueno, H., Kobayashi, S., Tsurumaru, M., and Otsuka, S., *Prep. Polymer Soc. Japan*, 29(4), 679 (1975).
- (11) Kojima, S. and Ueno, H., *J. Metal Finishing Soc. Japan*, 37, 455 (1986).
- (12) Kojima, S., Watanabe, Y., Goto, H., and Moriga, T., U.S. Patent 5,068,266.
- (13) Gaschke, M. and Lauterbach, H., *Proceedings Water-Borne Higher Solids Coat. Symp.*, 107 (1980).
- (14) Hotta, H., Ph.D. Dissertation, Kyushu University, Japan (1974).
- (15) Vratsanos, M.S. and Farris, R.J., *Polymer Eng. Sci.*, 29, 806 (1989).
- (16) Nakagawa, T. and Kanbe, H., *Rheology*, Misuzu Shobo, Tokyo, Japan (1959).

# Interactions of HEUR Associative Thickeners with Waterborne Polyurethanes

J. Philip Kaczmariski, Raymond H. Fernando and J. Edward Glass  
North Dakota State University\*

Polyurethane aqueous dispersions are examined with a variety of water-soluble polymers, and are compared with waterborne acrylic latices. Two particle size polyurethane aqueous dispersions are studied, the smaller size gives higher viscosities, in parallel with acrylic latices. Hydroxyethyl cellulose and hydrophobically-modified hydroxyethyl cellulose thicken surface-acid-stabilized acrylic latices. In contrast, polyurethane aqueous dispersions are not thickened effectively with cellulose ethers. The latter cause phase separation of the polyurethane dispersions, which increases with increasing particle size, in agreement with the concept of depletion or volume restricted flocculation. Polyurethane aqueous dispersions are more effectively thickened with hydrophobe-modified, gthoxylated urethanes

(HEURs) than corresponding particle size acrylic latices. HEURs that are very inelastic in acrylic latex dispersions become very elastic in polyurethane dispersions. In a series of designed step-growth polymerization HEURs, synthesized in our laboratories, the viscosity increase is noted to depend on the "effective hydrophobe size" of the terminal positions in HEUR thickeners. The effective terminal hydrophobe size is determined by the alkyl chain of the hydrophobic amine and the alkyl group of the diisocyanate with which it reacts. When the size of the hydrophobic amine is kept constant, but the alkyl units of the diisocyanate is increased in hydrophobicity, larger increases in viscosity are realized.

## INTRODUCTION

Polyurethanes, with the proper composition,<sup>1-3</sup> provide high abrasion resistance with good low temperature flexibility in maintenance and original equipment manufacturing (OEM) coatings. Conversion of conventional solvent-based polyurethanes to low volatile organic content (VOC) aqueous dispersions involves structuring these step-growth polymers into a disperse phase particle, much like a chain-growth polymer latex used in architectural coatings. The stabilizers for polyurethane aqueous dispersions (PURADs) are monomeric,<sup>1-2</sup> in contrast to the oligomeric stabilizers of neutralized methacrylic acid and/or hydroxyethyl cellulose (HEC) fragment on acrylic latices. Acrylic latices also contain adsorbed synthesis surfactant not chemically bonded, whereas PURADs may have a large amount of organic cosolvent and no surfactant.

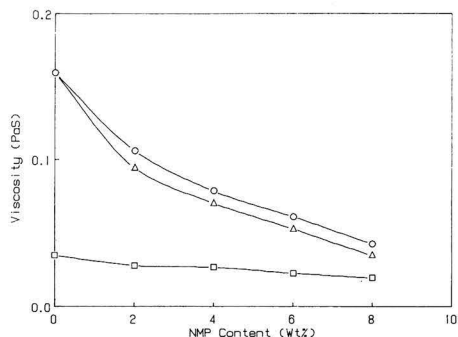
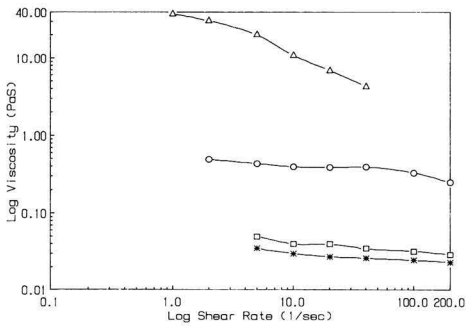


Figure 1—The low shear rate viscosity (steady rate) dependence of commercial HEURs on NMP content. Key: O—2.5% HEUR 708;  $\Delta$ —1.5% HEUR 270;  $\square$ —1.5% HEUR 200

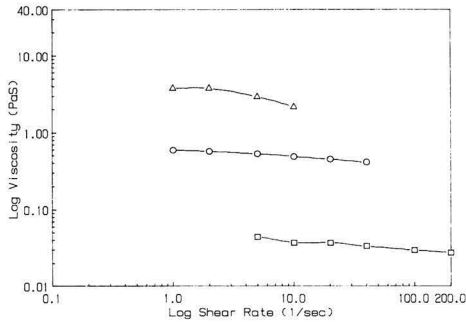
\*Presented at the 70th Annual Meeting of the Federation of Societies for Coatings Technology, in Chicago, IL, on October 21-23, 1992.

\*Polymers and Coatings Dept., Fargo, ND 58105.

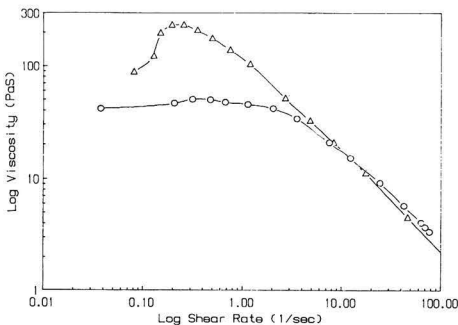
\*Armstrong World Industries, P.O. Box 3511, Lancaster, PA 17604.



**Figure 2**—The log viscosity (steady rate) vs log shear rate for 20% Baybond 121 with commercial HEURs. Key: O—0.254% HEUR 708; Δ—0.353% HEUR 270; □—0.307% HEUR 200; \*—0.284% HMHEC



**Figure 3**—The log viscosity (steady state) vs log shear rate for 20% Baybond 123 with commercial HEURs. Key: O—0.519% HEUR 708; Δ—0.470% HEUR 270; □—0.481% HEUR 200



**Figure 4**—The log viscosity vs log shear rate for 20% Baybond 121 with commercial HEURs (scan completed in 3 min). Key: O—0.51% HEUR 708; Δ—0.470% HEUR 270

The concept of volume restriction or depletion layer flocculation,<sup>4</sup> developed over the past several decades, has been cited for the phase separation of acrylic latices thickened with aqueous HEC.<sup>5-7</sup> In previous studies from our laboratories, with acrylic latices containing oligomeric methacrylic acid surface segments and synthesis surfactant, phase separation is not observed in HEC thickened dispersions. Phase separation has been observed in hydrophobe-modified, ethoxylated urethane (HEUR) thickened latices that do not have full surfactant surface coverage.<sup>8</sup> When HEUR thickeners are added, the hydrophobes of the HEUR polymers can adsorb on the hydrophobic surface of the colloid, resulting in gels and pastes of various types.<sup>9</sup> The addition of nonionic surfactant to these dispersions to obtain complete surface coverage affects one phase, free flowing latex dispersions, suggesting competition between HEUR and surfactant for adsorption sites.

In concept, depletion flocculation occurs more readily with larger latices.<sup>3-7</sup> Commercially, such latices for architectural coatings are commonly stabilized by chemically grafted HEC surface fragments, and thus flocculation of the larger latices also is unlikely. Therefore, there is little likelihood of depletion flocculation occurring in HEC thickened latices of the type commonly used in architectural coating formulations.

The literature is deficient with respect to rheological studies of aqueous PURADs; however, several papers<sup>10-13</sup> discuss mechanical properties of unpigmented polyurethane coatings. High viscosities at low shear rates are required to inhibit pigment settling,<sup>14</sup> thus, the viscosity of aqueous PURADs must be increased for proper pigmentation. As discussed later in this manuscript, when PURADs are thickened with HEC, phase separation, a phenomenon associated with nonadsorbing polymer, is observed.

It has been reported that a commercially available step-growth polymerized (SGP) thickener (HEUR, QR-708, Rohm and Haas) is adsorbed and then displaced by sodium dodecyl sulfate from acrylic latex surfaces,<sup>15</sup> and later from the same lab, that SGP HEURs with terminal pyrene groups adsorbed on latex surfaces.<sup>16</sup> Recently, it has been demonstrated that QR-708 is displaced from a 200 nm latex, containing surface acid groups, by a conventional formulation surfactant.<sup>17</sup> Both components, QR-708 and the formulation surfactant, were at concentrations commonly used in acrylic latex coatings.

The influence of commercial HEURs, HEC, and hydrophobe modified HEC, on the rheology and phase separation of PURADs is described in the initial part of this manuscript. The increase in viscosity observed upon addition of HEURs to PURADs is compared with previous results obtained with surfactant-free and surfactant-stabilized acrylic latices. In the second part, insights into structural influences of model HEURs on PURAD viscosities are ex-

**Table 1**—Characteristics of Waterborne Polyurethanes

Dispersion	Solids %	Particle Size (nm)	Cosolvent % <sup>a</sup>
Baybond 121 .....	35.6	50-70	15
Baybond 123 .....	36.1	125-170	12

(a) The cosolvent used is N-methyl pyrrolidinone and ther percentage reported is based on the total system weight.

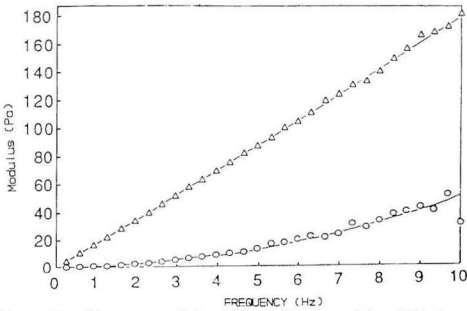


Figure 5a—Storage modulus ( $G'$ ) and loss modulus ( $G''$ ) dependence on frequency of 4 wt% HEUR 708 with 1.015 wt% sodium dodecyl sulfate (from reference 18). Key: O—storage modulus;  $\Delta$ —loss modulus

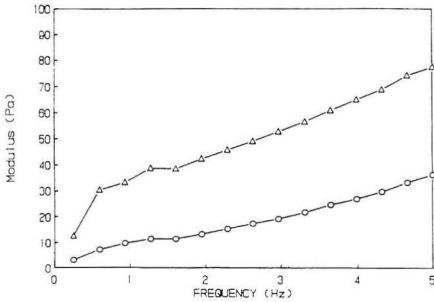


Figure 5b—Storage modulus ( $G'$ ) and loss modulus ( $G''$ ) dependence on frequency of 0.75 wt% HEUR 708 with 0.32 volume fraction dispersion of 220 nm latex containing 0.00648 meq/m<sup>2</sup> surface acid at pH=9 with 0.138 wt% free surfactant (from reference 8). Key: O—storage modulus;  $\Delta$ —loss modulus

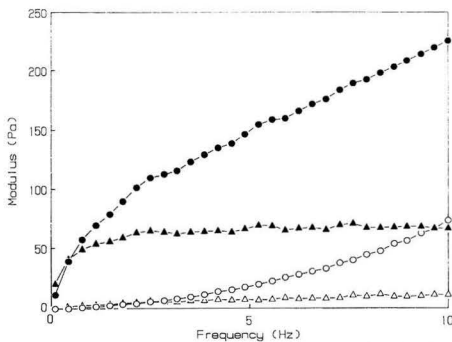


Figure 5c—Storage modulus ( $G'$ ) and loss modulus ( $G''$ ) dependence on frequency of HEUR 708 with 20% Baybond 121: open symbols, 0.254%; closed symbols, 0.513%. Key: O—storage modulus;  $\Delta$ —loss modulus

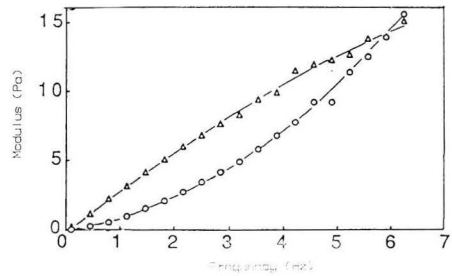


Figure 6a—Storage modulus ( $G'$ ) and loss modulus ( $G''$ ) dependence on frequency of 1.5 wt% HEUR 270 with 0.0805 wt% sodium dodecyl sulfate (from reference 18). Key: O—storage modulus;  $\Delta$ —loss modulus

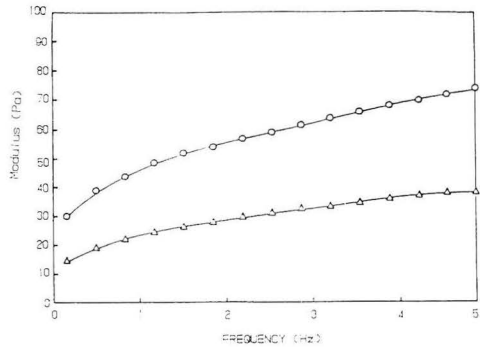


Figure 6b—Storage modulus ( $G'$ ) and loss modulus ( $G''$ ) dependence on frequency of 0.5 wt% HEUR 270 with 0.32 volume fraction dispersion of 220 nm latex containing 0.00648 meq/m<sup>2</sup> surface acid at pH=9 with 0.138 wt% free surfactant (from reference 8). Key: O—storage modulus;  $\Delta$ —loss modulus

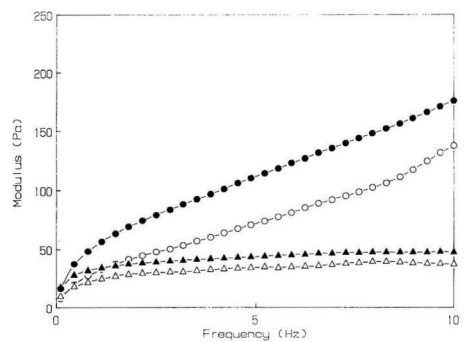
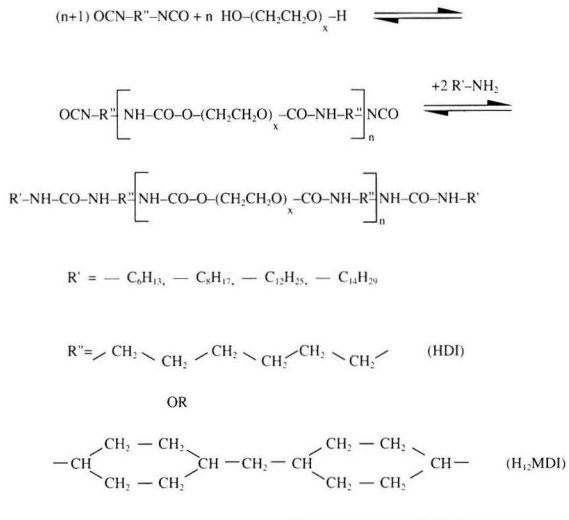


Figure 6c—Storage modulus ( $G'$ ) and loss modulus ( $G''$ ) dependence on frequency of HEUR 270 with 20% Baybond 121: open symbols, 0.353%; closed symbols, 0.457%. Key: O—storage modulus;  $\Delta$ —loss modulus



**Scheme 1 — Synthetic route to model associative thickeners**

aminated, so that thickeners can be designed to achieve high viscosities at low shear rates that are required to inhibit pigment settling. A future manuscript will discuss the interactions of HEURs with pigmented PURADs.

**EXPERIMENTAL**

**Materials**

The waterborne PURADs, Baybond 121 and Baybond 123, were supplied by Miles and their characteristics are listed in Table 1. HEC was supplied by Aqualon and a small amount of phenyl mercuric acetate was added to aqueous HEC solutions. Four associative thickeners, HEUR 200 (Union Carbide), HEUR 270 (Union Carbide), HEUR 708 (Rohm and Haas), and hydrophobe-modified hydroxyethyl cellulose (HMHEC, Aqualon), were used in the solid form. Isolation of these materials from their commercial solutions

has been described.<sup>18</sup> All aqueous solutions were prepared with distilled, deionized (DDI) water and all dispersions, without thickener, exhibited shear thinning behavior. Synthesis of the broad molecular weight model HEURs are described in detail in a dissertation.<sup>19</sup>

**Solution Preparation**

Aqueous thickener solutions were prepared by adding the solid thickener to DDI water and rolling on a two-roll mill for 48 hr (HEUR 200 and HEUR 270 were 3 wt% solutions, HEC 4 wt%, and HMHEC and HEUR 708 5 wt%). The HEC solution had a small quantity of phenyl mercuric acetate added to inhibit enzymatic degradation. The dispersions were supplied at approximately 35% solids and required dilution before associative thickener solutions could be added. The PURADs were diluted with DDI water to various solids content and mixed with varying thickener levels. These solutions were mixed on a two-roll mill overnight. Viscosities were recorded after 24 hr (and before observable phase separation was noted with HMHEC).

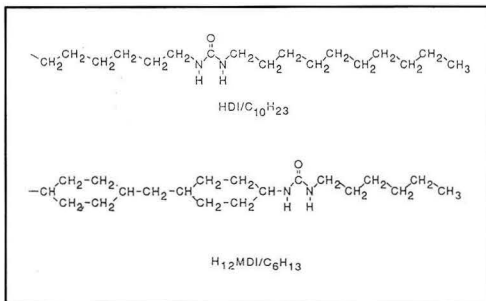
**Viscosity Measurement**

Viscosities were recorded with cone and plate viscometers; primarily with a Rheometrics oscillatory rheometer.

**RESULTS AND DISCUSSION**

**Parallels to Latex Technology**

The initial observations in this study relate to similarities in HEUR behavior in waterborne latex architectural coatings with PURAD dispersions. For example, PURADs may be synthesized with small amounts of organic solvents (i.e., N-methyl pyrrolidinone, NMP) to reduce the viscosity of the



**Figure 7—Comparison of terminal hydrophobe sizes of model HEUR thickeners**

prepolymer before dispersing in water.<sup>1,2</sup> This cosolvent may also serve as a coalescing aid to improve freeze-thaw stability similar to the action of glycol ethers in acrylic latices. The decreasing viscosity with increasing NMP concentration (Figure 1) parallels similar losses in HEUR viscosity with increasing glycol ether content.<sup>15</sup> HEUR-200, noted to be the most surfactant sensitive<sup>20</sup> and thereby ineffective in most latex coating formulations, is ineffective in viscosifying PURADs that are supplied with 15 wt% NMP.

With the addition of a hydration layer, the layer thickness will contribute more to an effective volume fraction increase of a smaller particle than a larger particle, resulting in greater viscosity of the small particle dispersion.<sup>9</sup> The smaller size particle also possesses a greater area for potential adsorption of hydrophobic species. HEUR thickeners adsorb to a greater extent on dialyzed, smaller particle size latices than larger particle size latices and affect greater viscosity increases due to the greater surface area.<sup>15</sup>

A particle size influence, similar to that observed with acrylic latices, is observed with PURADs. With lower amounts of commercial HEURs, the smaller particle dispersion, Baybond 121 with a particle size of 50-70 nm (Figure 2), is more viscous than the larger particle size PURAD, Baybond 123 with a particle size of 125-175 nm (Figure 3). In these studies, when HMHEC and HEC were used to thicken PURADs, the solutions exhibited phase separations. In the HMHEC dispersions, this occurred with the smaller, Baybond 121 PURAD after one week, with the larger, Baybond 123, after 24 hr. When thickened with HEC, phase separation was observed in 24 hr (Baybond 121) and 1 hr (Baybond 123). When the PURADs/HMHEC blends phase separate, both layers are viscous. This follows depletion layer concepts that describe the effect of nonadsorbing polymers. Larger particles possess a greater force of attraction and are more prone to flocculation<sup>4-5</sup> if they are not properly stabilized.

### Influence of Commercial HEURs on PURAD Rheology

The unique aspect of this study with PURADs is the contrasting behavior of HEUR-708 with acrylic latices. Shear thickening and shear thinning are observed with low levels of HEUR-708 (Figure 4); acrylic latices do not exhibit the shear thickening character. Oscillatory studies<sup>21</sup> of latex paints have provided insights into the role of the elastic and viscous parts of the viscosity reflected by a storage modulus ( $G'$ , elastic solid-like character) and a loss modulus ( $G''$ , viscous liquid-like character), respectively, on the flow behavior of coatings in brush<sup>22</sup> and roll<sup>23</sup> applications. This type of analysis also provides an insight into the type of interactions in these studies.

Oscillatory data from HEUR 708 and HEUR 270 solutions and dispersions are given in Figures 5 and 6. HEUR-708 (the lower molecular weight polymer) at 4 wt%, and in the presence of an amount of sodium dodecyl sulfate that facilitates a maximum in the viscosity, data are presented in Figure 5a. The response of HEUR 708 added to a model, monodisperse poly(methyl methacrylate) latex, with neutralized, oligomeric methacrylic acid surface segments and an excess of synthesis surfactant is illustrated in Figure 5b. Data from the HEUR-708 dispersions containing one of the

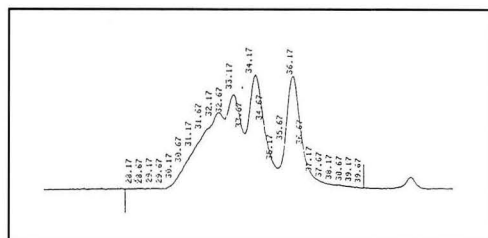


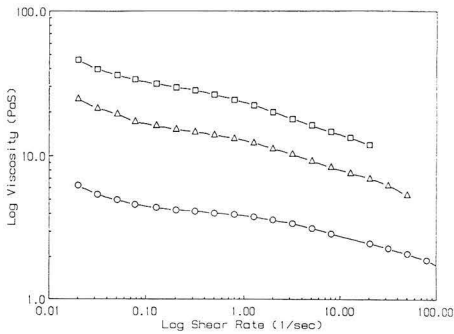
Figure 8—SEC chromatograph of  $C_{12}H_{25}-[H_{12}MDI-(CH_2CH_2O)_{185}]_x-H_{12}MDI-C_{12}H_{25}$  [thickener  $M_n=24, 138$ ,  $M_w=34, 231$ ,  $PDI=1.42$ ] peak at 36.2 min corresponds to  $HO(CH_2CH_2O)_{185}H$

PURADs is illustrated in Figure 5c. Results from a parallel series containing HEUR-270 are illustrated in Figures 6a-c. In the absence of a disperse phase or in the acrylic latex dispersion containing excess surfactant, the major contribution to the viscosity of HEUR-708 solutions is the loss modulus,<sup>24</sup>  $G''$ . In the presence of the PURAD dispersions, with no surfactant for competitive displacement of the thickener from the dispersion particles, the primary contributor to the dispersion's viscosity is the elastic function, the storage modulus. HEUR-270 has sufficiently large hydrophobes to displace formulation and synthesis surfactants from the surface of the acrylic latices,<sup>17</sup> and this is reflected in an elastic response (Figure 6b), contrasting with HEUR 708 (Figure 5b). In the noncompetitive PURAD dispersions, both HEURs adsorb on the PURAD, and through the build-up of a more structured network, the storage modulus is the main contributor to the viscosity build.

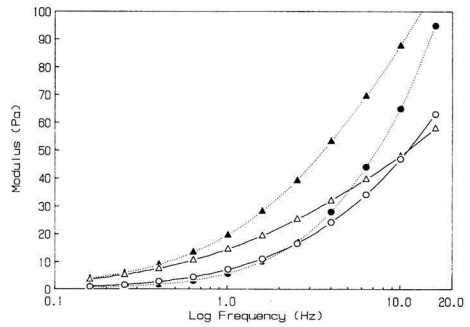
Adsorption of the HEURs onto the PURADs could not be measured because the PURADs could not be centrifuged to remove the dispersed phase and adsorbed species. Our examination of PURADs is therefore redirected from commercial materials to model HEUR thickeners synthesized in our laboratories to examine structural features that influence HEUR associations and infer a mechanism. It is inappropriate to designate the SGP HEURs synthesized in our laboratories as models because there are a multitude of species with different molecular weight in each thickener, but this will distinguish them from the commercial products with unknown composition.

### Influence of Structure of Model HEURs on PURAD Rheology

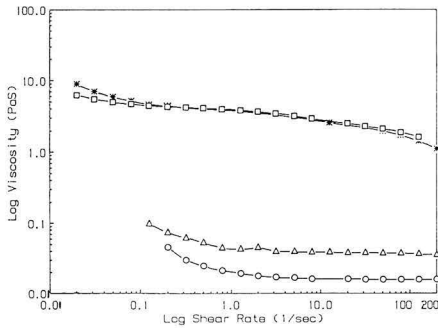
In our previous study of HEUR polymers<sup>25</sup> with terminal hydrophobes and narrow molecular weight distribution, isophorone urethane linkages did not appear to contribute to the hydrophobicity and increase the viscosity of the aqueous thickener solutions. In this study two series of HEURs with terminal isocyanate groups are prepared by step-growth polymerization of 3 moles of diisocyanate with 2 moles of poly(ethylene glycol), [ $M_n = 8,878$ , by hydroxyl titration], followed by reaction with amines with variable size alkyl groups (Scheme 1). Dicyclohexylmethane diisocyanate ( $H_{12}MDI$ ) was selected because it represented the largest branched alkyl group among the aliphatic diisocyanates commercially available; hexamethylene diisocyanate (HDI)



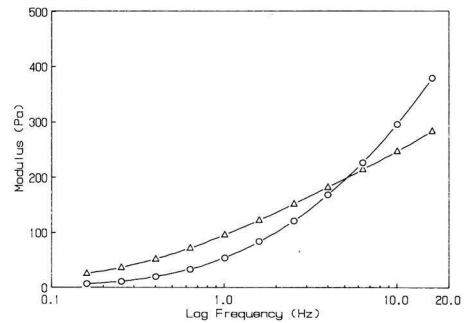
**Figure 9**—The log viscosity vs log shear rate for 20% Baybond 121 with different  $C_{12}H_{25}$ -[HDI-( $CH_2CH_2O$ ) $_{185}$ ] $_x$ -HDI- $C_{12}H_{25}$  content (scan completed in 11 min). Key: O—0.6%;  $\Delta$ —0.9%;  $\square$ —1.2%



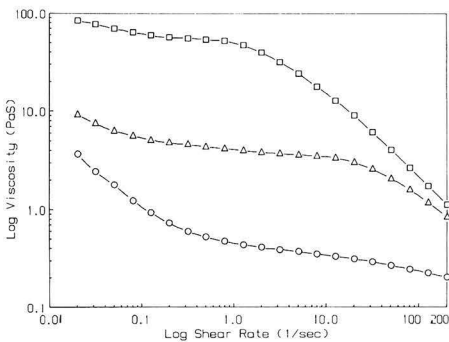
**Figure 12**—Storage modulus ( $G'$ ) and loss modulus ( $G''$ ) dependence on frequency of 20% Baybond 121 with 0.6%  $R'$ -[DI-( $CH_2CH_2O$ ) $_{185}$ ] $_x$ -DI- $R'$ : closed symbols,  $C_{12}H_{25}$ -HDI; open symbols,  $C_8H_{17}H_{12}$ MDI. Key: O—storage modulus;  $\Delta$ —loss modulus



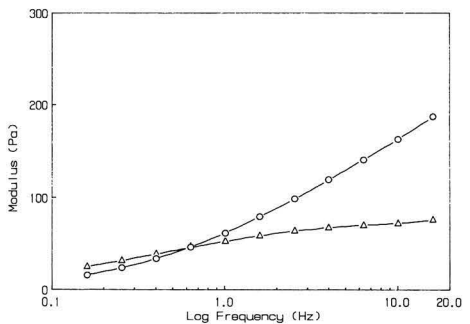
**Figure 10**—The log viscosity vs log shear rate for 20% Baybond 121 with 0.6% model  $R'$ -[HDI-( $CH_2CH_2O$ ) $_{185}$ ] $_x$ -HDI- $R'$  thickener content (scan completed in 11 min). Key: O— $R'=C_6H_{13}$ ;  $\Delta$ — $R'=C_8H_{17}$ ;  $\square$ — $R'=C_{12}H_{25}$ ; \*— $R'=C_{14}H_{29}$



**Figure 13**—Storage modulus ( $G'$ ) and loss modulus ( $G''$ ) dependence on frequency of 20% Baybond 121 with 1.2%  $C_{12}H_{25}$ -[HDI-( $CH_2CH_2O$ ) $_{185}$ ] $_x$ -HDI- $C_{12}H_{25}$ . Key: O—storage modulus;  $\Delta$ —loss modulus



**Figure 11**—The log viscosity vs log shear rate for 20% Baybond 121 with 0.6% model  $R'$ -[ $H_{12}MDI$ -( $CH_2CH_2O$ ) $_{185}$ ] $_x$ - $H_{12}MDI$ - $R'$  thickener content (scan completed in 11 min). Key: O— $R'=C_6H_{13}$ ;  $\Delta$ — $R'=C_8H_{17}$ ;  $\square$ — $R'=C_{12}H_{25}$



**Figure 14**—Storage modulus ( $G'$ ) and loss modulus ( $G''$ ) dependence on frequency of 20% Baybond 121 with 0.6%  $C_{12}H_{25}$ -[ $H_{12}MDI$ -( $CH_2CH_2O$ ) $_{185}$ ] $_x$ - $H_{12}MDI$ - $C_{12}H_{25}$ . Key: O—storage modulus;  $\Delta$ —loss modulus

because it was linear and more flexible (Figure 7). These HEURs, similar to the commercial HEURs, are a mixture of multiple molecular weight species, including unreacted poly(ethylene glycol)<sup>26</sup> (Figure 8) due to the nature of the polymerization mechanism.

Increasing the concentration of the model HEUR with C<sub>12</sub>H<sub>25</sub>-HDI terminal hydrophobes to the small particle size PURAD (Baybond 121) increases the viscosity of the system (Figure 9). The viscosity dependence on shear rate at 0.6 wt% of two series of HEURs, varying in terminal hydrophobe size, are illustrated in Figure 10 for the HDI series and in Figure 11 for the H<sub>12</sub>MDI series. Aqueous solutions of these model HEURs at concentrations of 0.6 wt% do not exhibit the high viscosities observed in the presence of the PURADs and an association between the HEUR and the PURAD must occur to account for the viscosity change.

Previous literature reports<sup>27-29</sup> neglect the contribution of the alkyl group of the diisocyanate to the size of the external hydrophobe when reporting external hydrophobe size, and in many of these studies, the HEURs were highly degraded materials. It becomes immediately obvious (Figures 10 and 11) that the size of the alkyl group of the diisocyanate contributes to the "effective size of the terminal hydrophobe." For example, the C<sub>8</sub>H<sub>17</sub>-H<sub>12</sub>MDI HEUR builds viscosity of the PURAD dispersion to the same degree as the C<sub>12</sub>H<sub>25</sub>-HDI HEUR at intermediate shear rates, despite the fact that the endcapping alkyl amine is shorter for the C<sub>8</sub>H<sub>17</sub>-H<sub>12</sub>MDI. On a total carbon count (including the alkyl groups of the diisocyanate) the two compared are equal in hydrophobicity.

As with the commercial materials, oscillatory studies provide a more quantitative description. For example, the C<sub>12</sub>H<sub>25</sub>-HDI HEUR/PURAD dispersion does not exhibit a dominant storage modulus (elastic) response (Figure 12) whereas the C<sub>8</sub>H<sub>17</sub>-H<sub>12</sub>MDI HEUR/PURAD solution has a slightly more elastic behavior at concentrations of 0.6 wt% HEUR. If the concentration of the C<sub>12</sub>H<sub>25</sub>-HDI HEUR is increased two-fold, a more elastic network is formed (Figure 13), reflected by a longer relaxation time (i.e., the reciprocal of the shear rate at the crossover point). This phenomenon, at a given concentration, also is observed in C<sub>8</sub>H<sub>17</sub>-H<sub>12</sub>MDI and C<sub>12</sub>H<sub>25</sub>-H<sub>12</sub>MDI HEUR thickened solutions. When the terminal group added to the H<sub>12</sub>MDI is increased from C<sub>8</sub>H<sub>17</sub> to C<sub>12</sub>H<sub>25</sub> the terminal hydrophobe effective size is sufficient to promote a greater elastic network with the PURAD (Figure 14). The dynamic viscosity versus frequency of PURAD/HEUR solutions exhibit an upturn at low frequencies (Figure 15) which is indicative of flocculated structures.<sup>30</sup>

PURADs are thickened by HEUR thickeners without phase separation; two mechanisms could be proposed. An increase in the effective volume fraction due to flocculation or to an increase in the effective radius of the PURAD particle due to adsorption. As the size of the terminal hydrophobe is increased, greater viscosity increases are observed. To a first approximation, this phenomenon has been correlated with a greater adsorption of model HEURs on dialyzed acrylic latices as the terminal hydrophobe size is increased. An increase in viscosity due to depletion flocculation results in an increase in loss modulus.<sup>31</sup> The major contributor to the HEUR/PURADs increase in viscosity is the storage modulus. The data suggest that the hydrophobes of the HEUR polymers, attached by a large number of

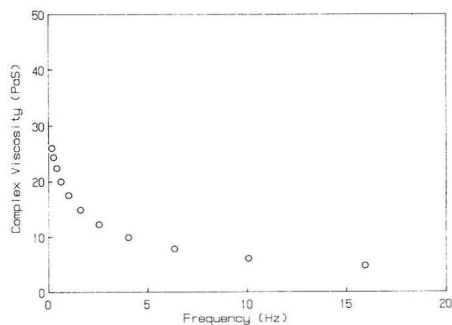


Figure 15—Complex viscosity vs frequency for 1.2% C<sub>12</sub>H<sub>25</sub>[HDI-(CH<sub>2</sub>CH<sub>2</sub>O)<sub>185</sub>]<sub>x</sub>-HDI-C<sub>12</sub>H<sub>25</sub>

oxyethylene units (>200), interact with the PURAD surface. Through interactions of these adsorbed polymers with other HEUR polymers, a network of associations are built via hydrophobic domains in the aqueous phase to form an elastic network, even with associative thickeners with smaller hydrophobes.

## CONCLUSIONS

The behavior of model and commercial acrylic latices in the presence of HEC and HEUR thickeners are reviewed in the Introduction and Results and Discussion sections. PURADs are distinctly different from acrylic latices in their behavior with thickeners. When thickened by HEC or hydrophobically-modified-HEC, phase separation occurs to a greater extent in large 150 nm dispersion than with 60 nm average particle size dispersion. These observations follow the general criteria of depletion flocculation.

The stabilizers in PURADs are internal, small, and not prepared in a manner to ensure total surface coverage. Under these conditions, it would be expected that the ethoxylated HEUR hydrophobes would adsorb on the surface of the PURAD particle. HEURs with large hydrophobes, such as HEUR-270, have been observed to adsorb and displace surfactant on acrylic latices, and such dispersions have significant elastic character. The behavior of HEUR-270/PURADs follow this behavior. Although HEURs adsorb onto dialyzed latices and effect large viscosity increases, in real acrylic resins with excess surfactant, HEURs with smaller hydrophobes, such as HEUR-708, do not adsorb competitively. Their dispersions are inelastic. The HEUR-708/PURAD dispersions are elastic.

The diisocyanate used in the step-growth synthesis influences rheological properties. In a series of designed step-growth polymerization HEURs, synthesized in our laboratories, the viscosity increase through the interaction of HEURs with the PURAD depends on the "effective hydrophobe size" of the terminal positions. The effective hydrophobe size is determined by the hydrophobicity of the hydrophobic amine and the terminal hydrophobe isocyanate group with which it reacts (i.e., when the size of the hydrophobic amine is kept constant, but the alkyl units of the diisocyanate is



increased in hydrophobicity, larger increases in viscosity are realized).

## ACKNOWLEDGMENT

The financial support of these studies by the E.I. du Pont de Nemours & Company is gratefully acknowledged. Appreciation is also expressed to Drs. Stephen Seneker and Douglas Wicks for the PURAD samples.

## References

- (1) Dieterich, D., *Progr. in Organic Coat.*, 9, p 281-340, 1981.
- (2) Rosthauser, J.W., and Nachtkamp, K., *Advances in Urethane Science and Technology*, Frisch, K.C. and Klempner, D. (Eds.), 10, p 121, Technomic, Westport, CT.
- (3) Yang, W.P., *ACS Div. Polym. Mater.: Sci. Eng.*, 66, 217, 1992.
- (4) For discussion of the concept see, Napper D.N., *Polymer Stabilization & Dispersion Stability*, Academic Press, New York, Chapter 15, 1983.
- (5) Sperry, P.R., Hopfenberg, H.B., and Thomas, N.L., *J. Colloid Interfac. Sci.*, 82, 1, 1981.
- (6) Sperry, P.R., *J. Colloid Interface Sci.*, 87, 2, 1982.
- (7) Sperry, P.R., *J. Colloid Interface Sci.*, 99, 97, 1984.
- (8) Karunasena, A. and Glass, J.E., *Prog. Org. Coatings*, 17(3), 301-320 (1989).
- (9) Karunasena, A. and Glass, J.E., "The Effect of Latex Particle Size on the Rheology of Thickened Dispersions," *Prog. Org. Coatings*, 21(1), 53-67 (1992).
- (10) Tirpak, R.E. and Markusch, P.H., *Proceedings of the Twelfth Waterborne and Higher Solids Coatings Symposia*, February 13-15, 1985, p 159.
- (11) Kim, B.K., and Kim, T.K., *J. Appl. Polym. Sci.*, 43, 393, 1991.
- (12) Kim, T.K. and Kim, B.K., *Colloid Polym. Sci.*, 269, p 889, 1991.
- (13) Kim, C.K., Kim B.K., and Jeong, H.M., *Colloid Polym. Sci.*, 269, 1991, p. 895.
- (14) For a discussion of pigment settling see Patton, T.C., *Paint Flow and Pigment Dispersion*, 2nd Ed., John Wiley & Sons Inc., New York, Chapter 27, 1979.
- (15) Thibeault, J.C., Sperry, P.R., and Schaller, E.J., *Advances in Chemistry Series, No. 213, Water-Soluble Polymers: Beauty with Performance*, Glass, J.E. (Ed.), American Chemical Society, Washington, D.C., Chapter 20, 1986.
- (16) Richey, B., Kirk, A.B., Eisenhart, E.K., Fitzwater, S., and Hook, J., "Interactions of Associative Thickeners with Paint Components as Studied by the Use of a Fluorescently Labeled Model Thickener," *JOURNAL OF COATINGS TECHNOLOGY*, 63, No. 798, 31 (1991).
- (17) Ma, Z., Kaczmariski, J.P., and Glass, J.E., *Proc. ACS Div. Polym. Materials: Sci. & Engin.*, 66, 11 (1992), and in greater detail in *Prog. Org. Coatings*, 21(1), 69-77 (1992).
- (18) Lundberg, D.J., Glass, J.E., and Eley, R.R., "Viscoelastic Behavior Among HEUR-Thickeners" *J. Rheol.*, 35(6), 1255 (1991).
- (19) Kaczmariski, J.P., Ph. D. Thesis, North Dakota State University, 1993.
- (20) Bergh, J.S., Lundberg, D.J., and Glass J.E., "Rheology of Associative Thickener Pigment and Pigmented Commercial Latex Dispersions," *Prog. Org. Coatings*, 17, 155-173 (1989).
- (21) Ferry, J.D., *Viscoelastic Properties of Polymers*, John Wiley & Sons, New York, 1970.
- (22) Glass, J.E., "The Role Played by Water-Soluble Polymers in Paint Performance. Part II: Chemical Modeling Studies," *J. Oil & Colour Chemists' Assoc.*, 59, 86-94 (1976).
- (23) Glass, J.E., "Dynamics of Roll Spatter and Tracking. Part IV, Importance of G\* Recovery and N<sub>i</sub> in Tracking," *JOURNAL OF COATINGS TECHNOLOGY*, 50, No. 641, 72 (1978).
- (24) Lundberg, D.J., Ma, Z., Alahapperuna, K., and Glass, J.E., "Surfactant Influences on Hydrophobically-Modified Thickener Rheology," *ACS Symposium Series 462: Polymers as Rheology Modifiers*, Glass, J.E. and Schulz, D.N. (Eds.), American Chemical Society, Washington, D.C., Chapter 14 (1991).
- (25) Lundberg, D.J., Glass, J.E., and Eley, R.R., "Model-HEUR/Surfactant/Model Latex Matrix Rheology Studies," *Proceedings ACS Div. Polym. Materials: Sci. & Engin.*, 61, 533-538 (1989).
- (26) Glass, J.E. and Kaczmariski, J.P., "Complexities in Evaluating Behavior of Associative Thickeners," *Proceedings ACS Div. Polym. Materials: Sci. & Engin.*, 65, 175 (1991).
- (27) Wang, Y. and Winnik, M.A., *Langmuir*, Vol. 6(9), 47 (1990).
- (28) Jenkins, R.D., Silebi, C.A., and El-Asser, M.S., *Polymers as Rheology Modifiers*, Schulz, D.N. and Glass, J.E. (Eds.), ACS Symposia Series 462, American Chemical Society, Washington, D.C., Chapter 13, 1991.
- (29) Howard, P.R., Leasure, E.L., Rosier, S.T., and Schaller, E.J., "Formulating with Combinations of HEUR Associative Thickeners," *JOURNAL OF COATINGS TECHNOLOGY*, 64, No. 804, 87 (1992).
- (30) Lundberg, D.J. and Glass, J.E., "Pigment Stabilization Through Mixed Associative Thickener Interactions," *JOURNAL OF COATINGS TECHNOLOGY*, 64, No. 807, 53 (1992).
- (31) Prestidge, C. and Tadros, Th. F., *Colloids Surf.* 1, 325 (1988).

# AC Impedance Analysis and Factorial Designs of an *In-Situ* Phosphatizing Coating

Dean A. Meldrum  
Finishes Unlimited Inc.\*

Chhiu-Tsu Lin  
Northern Illinois University†

A full factorial experiment designed to obtain formulation factor effects of a single-step polyester melamine enamel/H<sub>3</sub>PO<sub>4</sub> system has been conducted. The designs consist of five factors (% H<sub>3</sub>PO<sub>4</sub>, VOC type, CLA/VEH ratio, DFT, and bake schedule) at two levels each. Electrochemical impedance spectroscopy was used to obtain quantitative performance of the formulated paint coatings on Q-panels. The results manifested that % H<sub>3</sub>PO<sub>4</sub> has the largest main effect, suggesting that H<sub>3</sub>PO<sub>4</sub> in the single-step paint system tends to diffuse to and react with the metal surface, providing a corrosion protective layer on the substrate. Under standard and "real world" test environments, the *in-situ* phosphatizing paint performed with equivalent ranking to that of the multistep process.

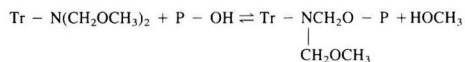
## INTRODUCTION

Protective coatings on metal surfaces<sup>1</sup> represent a major portion of the investment of material, cost, time, and labor in the manufacturing process. In order to assure optimal performance of the coating, a process known as phosphating is applied to the metal just before painting. The phosphate process is used in industry for two primary reasons<sup>2</sup>: to improve the adhesion of paint and to enhance the resistance to corrosion thereby achieving a longer finish life. The phosphate process is applied to metal in a number of ways and is produced via various treatment steps. The metal substrate is normally cleaned by one of

several possible pretreatment steps, phosphated, dried, and then painted.

Recently, we have successfully formulated a stable and compatible single-step phosphate/paint system comprising a one-pack composition of polymer resin, crosslinker, and H<sub>3</sub>PO<sub>4</sub>,<sup>3</sup> e.g., a polyester-melamine enamel/H<sub>3</sub>PO<sub>4</sub> system. It is expected that phosphate chemistry and polymer chemistry in the uncoat system may proceed independently yet simultaneously. The simplicity of the application of a single coat phosphate paint over the current multistep methods will make this product attractive to many manufacturers of metal products as the result of its increased quality without the capital expense of a separate phosphate line.

For a polyester-melamine enamel/H<sub>3</sub>PO<sub>4</sub> system, a small portion of phosphoric acid is used as a catalyst, for the thermal curing of a polyester-melamine enamel in the single-step phosphate/paint system. Using hexakis(methoxymethyl) melamine resins (HMMM), the predominant cocondensation reaction with polyester has been proposed<sup>4</sup> as



where Tr represents the triazine ring of HMMM and P represents the polymer being crosslinked. When the uncoat paint system is applied on a Q-panel, it is expected that the major portion of H<sub>3</sub>PO<sub>4</sub> in the paint formula should diffuse to and react with a metal surface, providing a corrosion protective layer on the substrate and simultaneously making available the proper functionality to form chemical bonding with polymer resins. Recent experimentation<sup>5</sup> has revealed the paint formulation factors that may govern the *in-situ* formation of a metal phos-

Presented in part at the 19th Waterborne, Higher-Solids, and Powder Coatings Symposium, February 26-28, 1992, New Orleans, LA.

\*Wheeler Rd., P.O. Box 69, Sugar Grove, IL 60554.

†Department of Chemistry, DeKalb, IL 60115-2862.

phate interfacial layer. These factors are the concentration of acid, film thickness, temperature/time related to crosslinking event, ratio of crosslinking agent to vehicle, and volatile organic solvent type. The  $H_3PO_4$  diffusion mechanisms as a function of crosslink density or polymer functionality are related to percent solids content of the resin solution and their acid numbers. Tests also show<sup>3</sup> that solvent as represented in the mobile phase for transporting the phosphoric acid to the substrate may play as important a role in the *in-situ* process as any of the other factors.

Good formulations are the foundation of any coatings business. The factorial design<sup>6,7</sup> allows the interactive effects to be generated, which permits the calculation of the true effect of each separate ingredient. In this paper, a full  $2^5$  factorial experiment consisting of five factors at two levels each is reported. Electrochemical impedance, pencil hardness, and the presence or absence of exudation measurements were used to study the effects that each individual factor has on the performance of the formulated coatings. A mathematical model<sup>7</sup> relating the response value to the levels of one or more factors was adopted to interpret the results of experimental design. A general procedure known as the method of contrasts<sup>7</sup> was introduced to the estimation of main effects, interactions, and curvature effects. An optimized coating composition is then established for a single-step polyester-melamine enamel/ $H_3PO_4$  system. The nature of the chemical mechanism of a unicoat system is illustrated by probing the qualities of the paint film and corrosion process at the interface for a paint composition with acid concentrations below, at, and above its optimal value. The optimum single-step phosphate/paint coating on a Q-panel was exposed to the standard salt spray, humidity, and outdoor fence testings. The visually observed deprecation results were compared to those of commercial coatings on a bare

DEAN A. MELDRUM received the B.A. Degree from North Texas State University in 1980 where he began his chemistry career as a Technician at the university's Institute of Applied Science in 1978. Working for Radian and SumX Corporations in Austin, TX, and then as a Chemical Consultant in northern Illinois, he has performed research in photooxidation, corrosion inhibition, and, beginning in 1988 at Finishes Unlimited, coatings development. The emphasis of his work has been to coordinate industrial manufacturing processes with advanced treatment techniques for the cost effective and product quality oriented reduction or elimination of hazardous materials to the environment.

CHHIU-TSU LIN is a Professor of Chemistry at Northern Illinois University (NIU). After receiving his Ph.D. Degree in 1974 from the University of California, Los Angeles (UCLA), he joined the faculty of the State University of Campinas, São Paulo, Brazil. In 1984, he returned to the United States and taught at UCLA, before moving in 1985 to NIU. In 1981-82 he spent a year at the Thomas J. Watson Research Center, where he was an IBM World Trade visiting scientist. His current research interests include: (1) development of an *in-situ* phosphatizing coating, (2) production of layered ceramic thin films using the deposition from aqueous acetate solutions (DAAS) technique, and (3) optical and electrochemical characterizations of optically active molecules embedded in sol-gel matrices.

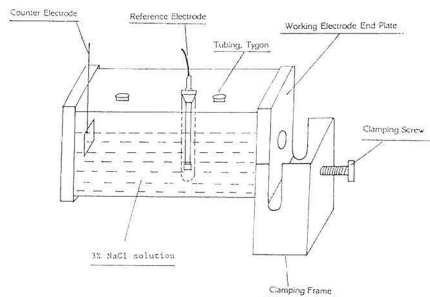


Figure 1—Flat cell, EG & G Princeton Applied Research model KO 235

Q-panel or a commercially prepared Bonderite panel (Bonderite 1000, Parker-Amchem). The significance and benefit of the *in-situ* phosphatizing coatings are demonstrated.

## EXPERIMENTAL DETAILS

Water-extendable polyester (resin #5778, Cargill), crosslinking resin [hexakis(methoxymethyl) melamine, Resimene #745 referred as HMMM], 85% phosphoric acid, water, and organic solvents (e.g., butyl Carbitol, isopropyl alcohol) were used to formulate a single-step phosphate/paint system. The five factors at two levels each chosen in the factorial design are as follows: (1)  $H_3PO_4$  acid concentration, (+) = 6%, (-) = 2%; (2) volatile organic compound (VOC) type, (+) = butyl Carbitol, (-) = isopropyl alcohol; (3) ratio of crosslinking agent to vehicle (CLA/VEH), (+) = 0.22, (-) = 0.18; (4) dry film thickness (DFT): there are two sets of DFT, one, (+) = 1.5 mil and (-) = 1.0 mil; the other, (+) = 1.5 mil and (-) = 0.5 mil; and (5) bake schedule, (+) = the curing temperature was increased gradually from 160° to 325°F in 13 min and then held at 325°F for 10 min, (-) = the curing temperature was raised gradually from 200° to 300°F in 13 min and then held at 300°F for 10 min. There is also a center point of all of the levels that was run once for the estimation of overall curvature.<sup>7</sup> The acid/water ratio was kept the same in all formulas, i.e., when % acid is 6%, the water is at 1.5% and when % acid is 2%, the water is at 0.5%. Moreover, the % total solids was kept the same in all formulas, 61.3%, even though the CLA/VEH was not.

The uncoated mild steel panels [Q-panel, SAE 1010: C 0.08-0.13%, Mn 0.3-0.6%, P(max) 0.04%, S(max) 0.05%] were used to cast the single-step coatings (0.5 mil, 1.0 mil, and 1.5 mil) using a spray gun. The DFT was determined using ASTM D 1186 method.<sup>8</sup> Pencil hardness testing and visual observation of the presence of exudation were performed in accordance with Finishes Unlimited's quality control manual.<sup>8</sup>

Data from electrochemical impedance spectroscopy (EIS) were obtained by using a Potentiostat/Galvanostat

Model 273 (EG&G Princeton Applied Research), PAR Model 5210 lock-in amplifier, IBM PS/2-30 computer, and Epson FX-850 printer. The software of a Model 388 electrochemical impedance system (EG&G Princeton Applied Research) measures the response of an electrochemical system to ac excitations at frequencies from 100 kHz to 5 Hz using the single-sine technique and 11 Hz to 10 mHz using the multi-sine technique in this case. Figure 1 shows the Model K0235 Flat Cell (EG&G Princeton Applied Research) which consists of a glass cylinder clamped horizontally between two end plates was used in this study. One end plate houses the working electrode and the other houses the center electrode. The reference electrode is housed in a Luggin well, with a fixed Teflon Luggin capillary protruding from the bottom of the well. The exposed area of the working electrode (coated Q-panel) to the cell solution (3% NaCl solution) is 1.13 cm<sup>2</sup>. This area was presoaked in the cell solution for 72 hr before the measurement. The reference electrode is silver in silver chloride/saturated potassium chloride solution and the counter electrode is platinum/rhodium (8 cm<sup>2</sup>). Data was stored in the computer and analyzed by using Bode and Nyquist plots.

In order to gain a perspective towards the *in-situ* phosphating concept in actual service, comparative samples were prepared representing a waterborne polyurethane (Bayhydrol #121, Miles), a solvent-borne epoxy (resin #1170, Cargill), a solvent-borne phenolic modified alkyd (resin #5354, Cargill) and a water-reducible alkyd (resin #7450, Cargill) as bake enamels. These systems were formulated in a simple manner so that the comparison from system to system would be consistent to the polymer resin type rather than other optimal or otherwise performance enhancing factors. The CLA/VEH ratios were controlled to the degree that mechanical properties, e.g., hardness and impact, would represent cure completeness and would be consistent in all systems at a bake schedule of 10 min and 325°F. HMMM was used as the crosslinker in every case. Appropriate solvents and catalysts were incorporated only as were determined necessary to meet these ends. All coating systems were applied on both Q-panels and Bonderite panels, except the single-step phosphate/paint systems optimized in this study which were applied on Q-panels only. All panels were sprayed and confirmed to be a consistent DFT of 1.00 ± 0.05 mil. The panels were replicated in sets of two and exposed to humidity (ASTM D 4585, condensation), salt spray (ASTM B 117), and outdoor fence (ASTM D 1014 & 1006, Annex: Fence Construction, 45° South) conditions over a period of time long enough to rank the performance in accordance to each exposure mode.

## RESULTS AND DISCUSSION

### Response Variables

The response variables constitute the observation value or data obtained from the experimental run. Responses can be classified as quantitative, qualitative, or quantal types. In this experimental run on the formulation of a single-step polyester-melamine enamel/H<sub>3</sub>PO<sub>4</sub> system,

the total impedance,  $|Z|$  ohms-cm<sup>2</sup> presented in log  $|Z|$  scale (quantitative), pencil hardness (qualitative), and exudation (quantal) were used as the response variables. The results are listed in Table 1. Two sets of low level(-) dry film thickness were used: DFT = 0.5 mil(-) corresponding to runs 1-8 and 17-24, and DFT = 1.0 mil(-) corresponding to runs 1A-8A and 17A-24A. Each set of low level(-) DFT is then combined separately with the high level(+) DFT = 1.5 mil corresponding to runs 9-16 and 25-32 to form a 2<sup>5</sup> factorial design of five factors at two levels each. The hardness of the uncoat film was rated according to the hardness of a lead (graphite) pencil, i.e., a qualitative response. In general, an organic finish with a pencil hardness of 2H is considered good and acceptable in the paint industry. The degree of hardness shown in Table 1 as a decreasing order is 2H, H, F, B, <B (a slightly less than B), where B is classified as a soft paint coating. The appearance of exudation on the dry paint film is either yes = Y or no = N. An extremely small amount of exudation is marked as N> in Table 1. The electrochemical impedance spectroscopy (EIS) measurements  $|Z|$  should have a unit of ohms-cm<sup>2</sup>, i.e., a quantitative response. The values reported in Table 1 are a log  $|Z|$  scale, or powers of 10. These experimentally measured results must be multiplied by the area of exposed surface (area = 1.13 cm<sup>2</sup>).

The high and low values measured for both the runs that were done at DFT = 1.0 mil, and the runs that were done at DFT = 0.5 mil(-) and 1.5 mil(+) are quite distinguishable. For the runs that were performed at DFT

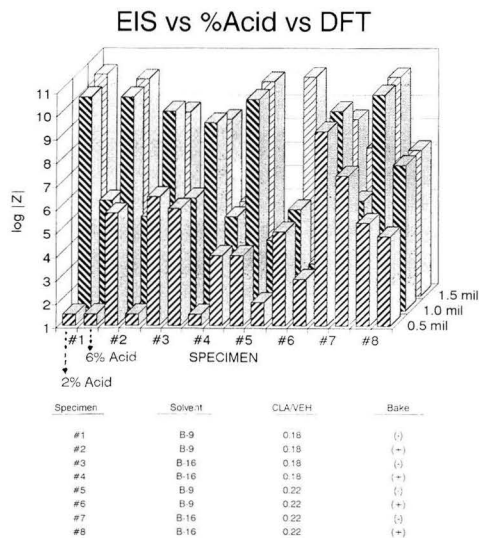


Figure 2—EIS in log  $|Z|$  vs % acid vs DFT for a polyester-melamine enamels/H<sub>3</sub>PO<sub>4</sub> system on Q-panel with fixed VOC type (B-9: isopropyl alcohol and B-16: butyl Carbitol), CLA/VEH and bake schedule. Left and right block-bar graphs of each specimen represent acid concentration = 2% and 6%, respectively

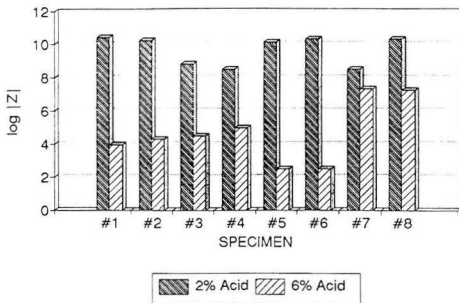
**Table 1—Factors, Levels and Responses of 2<sup>5</sup> Factorial Designs in a Single-Step Phosphate/Paint System**

Run	Factors and Levels				Responses			
	% Acid	VOC Type	CLA/VEH	DFT(mil)	Bake Schedule	Hardness	Exudation	EIS Log Z
1	-	-	-	0.5(-)	-	H	Y	1.5
1A	-	-	-	1.0(-)	-	F	Y	10.1
2	+	-	-	0.5(-)	-	<B	Y	1.5
2A	+	-	-	1.0(-)	-	<B	Y	5.7
3	-	+	-	0.5(-)	-	B	Y	6.5
3A	-	+	-	1.0(-)	-	B	Y	9.5
4	+	+	-	0.5(-)	-	<B	Y	6.0
4A	+	+	-	1.0(-)	-	<B	Y	5.8
5	-	-	+	0.5(-)	-	2H	N>	4.0
5A	-	-	+	1.0(-)	-	2H	N>	10.0
6	+	-	+	0.5(-)	-	B	Y	2.0
6A	+	-	+	1.0(-)	-	B	Y	4.0
7	-	+	+	0.5(-)	-	2H	N	9.3
7A	-	+	+	1.0(-)	-	H	N	9.5
8	+	+	+	0.5(-)	-	B	Y	7.4
8A	+	+	+	1.0(-)	-	<B	Y	5.7
9	-	-	-	1.5(+)	-	F	Y	10.4
10	+	-	-	1.5(+)	-	<B	Y	3.9
11	-	+	-	1.5(+)	-	<B	Y	8.8
12	+	+	-	1.5(+)	-	<B	Y	4.5
13	-	-	+	1.5(+)	-	H	N>	10.1
14	+	-	+	1.5(+)	-	B	Y	2.5
15	-	+	+	1.5(+)	-	H	N	8.5
16	+	+	+	1.5(+)	-	<B	Y	7.3
17	-	-	-	0.5(-)	+	H	Y	5.8
17A	-	-	-	1.0(-)	+	F	Y	10.1
18	+	-	-	0.5(-)	+	<B	Y	1.5
18A	+	-	-	1.0(-)	+	<B	Y	5.0
19	-	+	-	0.5(-)	+	<B	N	1.5
19A	-	+	-	1.0(-)	+	<B	N	9.0
20	+	+	-	0.5(-)	+	<B	Y	4.0
20A	+	+	-	1.0(-)	+	<B	Y	5.0
21	-	-	+	0.5(-)	+	2H	N	5.0
21A	-	-	+	1.0(-)	+	2H	N	5.3
22	+	-	+	0.5(-)	+	<B	Y	3.0
22A	+	-	+	1.0(-)	+	<B	Y	3.0
23	-	+	+	0.5(-)	+	2H	N	5.4
23A	-	+	+	1.0(-)	+	H	N	10.2
24	+	+	+	0.5(-)	+	<B	Y	4.8
24A	+	+	+	1.0(-)	+	<B	Y	7.2
25	-	-	-	1.5(+)	+	F	Y	10.2
26	+	-	-	1.5(+)	+	<B	Y	4.3
27	-	+	-	1.5(+)	+	<B	Y	8.5
28	+	+	-	1.5(+)	+	<B	Y	5.0
29	-	-	+	1.5(+)	+	H	N	10.3
30	+	-	+	1.5(+)	+	<B	Y	2.5
31	-	+	+	1.5(+)	+	2H	N	10.3
32	+	+	+	1.5(+)	+	<B	Y	7.2
33		center point		0.5(-)	center point	B	Y	6.8
34		center point		1.0(-)	center point	B	Y	6.8
35		center point		1.5(+)	center point	F	Y	8.9

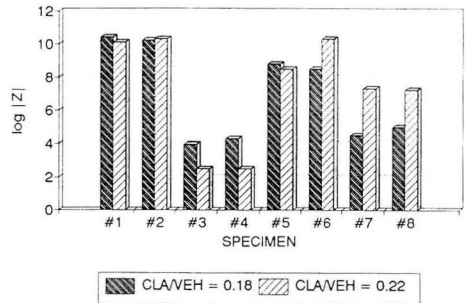
= 1.0 mil, the highest EIS results,  $\log |Z|$  is 10.2, which can be translated into a  $|Z| = 1.79 \times 10^{10}$  ohms-cm<sup>2</sup> for the single-step phosphate/paint film. The levels of each factor for this run are as follows: % acid = 2%(-), VOC type = butyl Carbitol(+), CLA/VEH = 0.22(+), and bake schedule = 160 to 325°F(+). This was run 23A in *Table 1* and the pencil hardness was H with no exudation. The lowest EIS result, however, is  $\log |Z| = 3.0$  (or  $1.13 \times 10^3$  ohms-cm<sup>2</sup>). The levels of each factor for this run are as follows: % acid = 6%(+), VOC type = isopropyl alcohol(-), CLA/VEH = 0.22(+), and bake schedule = 160 to 325°F(+). This was run 22A in *Table 1* and the pencil hardness was <B with exudation.

For the runs that were measured at DFT = 0.5 mil(-) and 1.5 mil(+), the highest EIS result is  $\log |Z| = 10.4$  (or  $2.84 \times 10^{10}$  ohms-cm<sup>2</sup>). The levels of each factor for this run are as follows: % acid = 2%(-), VOC type = isopropyl alcohol(-), CLA/VEH = 0.18(-), bake schedule = 200 - 300°F(-), and DFT = 1.5 mil(+). This was run 9 in *Table 1*. The pencil hardness was F and there was exudation present on the coated panel. The lowest EIS result, on the other hand, is  $\log |Z| = 1.5$  (or 35.7 ohms-cm<sup>2</sup>). Four runs gave this experimental response. They are as follows: run 1 at (-)% acid, (-)VOC type, (-)CLA/VEH, (-)bake schedule, and DFT = 0.5 mil(-); run 2 at (+)% acid, (-)VOC type,

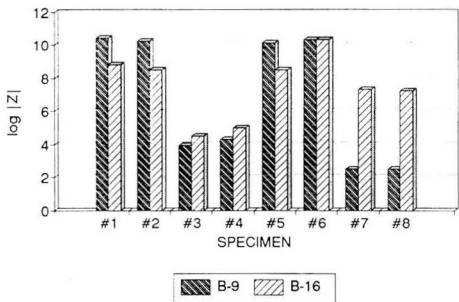
EIS vs %Acid  
DFT held constant @ 1.5



EIS vs CLA/VEH  
DFT held constant @ 1.5



EIS vs VOC Type  
DFT held constant @ 1.5



EIS vs Bake Schedule  
DFT held constant @ 1.5

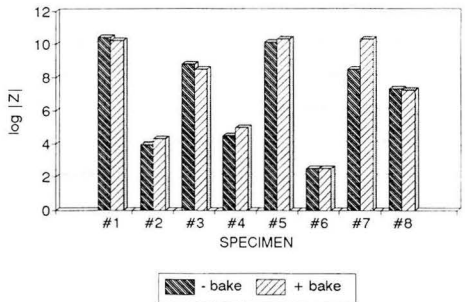


Figure 3—EIS in log |Z| vs % acid, VOC type, CLA/VEH, and bake schedule while DFT was kept constant at 1.5 mil for a single-step phosphate/paint system on Q-panel

(-)CLA/VEH, (-) bake schedule, and DFT = 0.5 mil (-); run 18 at (+)% acid, (-)VOC type, (-)CLA/VEH, (+)bake schedule, and DFT = 0.5 mil (-); and run 19 at (-)% acid, (+)VOC type, (-)CLA/VEH, (+)bake schedule, and DFT = 0.5 mil (-). Run 1 had a hardness of H with exudation. Both runs 2 and 18 had a paint film hardness of <B with exudation, and run 19 had a hardness of <B with no exudation.

In order to better visualize the responses for various factors at different levels, the data in Table 1 are shown graphically in Figure 2 which displays EIS, log |Z| versus % acid versus DFT, for a fixed VOC solvent type, CLA/VEH, and bake schedule. Note that B-9 is isopropyl alcohol [or level (-) in VOC type] and B-16 is butyl Carbitol [or level (+) in VOC type]. For each paint specimen, the block bar on the left represents a 2% acid (-) and that on the right indicates a 6% acid (+) formulation. It is evidenced that many EIS measurements taken at DFT = 0.5 mil are very low and not accurate because for many of these formulas it was impossible to spray an even film at 0.5 mil. For paint specimens of the

same % acid level, the electrical impedance values are quite similar for DFT = 1.0 mil and 1.5 mil. It is shown in Figure 2 that log |Z| is much larger at 2% acid than that at 6% acid for all levels of DFT.

It is interesting to correlate electrical impedance results versus the other four factors while keeping DFT constant. As an example, Figure 3 displays EIS in log |Z| versus % acid, VOC type, CLA/VEH and bake schedule while DFT was kept constant at 1.5 mil. The top left block-bar graph indicates that higher EIS results are obtained when 2% acid is used instead of 6% acid in all cases. Specimen 6 has the following levels of each factor: VOC type = B-9, isopropyl alcohol, CLA/VEH = 0.22, DFT = 1.5 mil, and bake schedule = 160-325°F which shows as having the greatest difference in EIS value at 2% acid as compared to that at 6% acid. This suggests that % acid has more of an effect at these factor levels in the unicat system developed here.

Although VOC type is a qualitative factor, in these factorial designs it was perceived as a quantitative factor as a function of its boiling points. B-9 is a "low boiler"

Table 2—2<sup>5</sup> Design—Estimation of Main Effects (X<sub>1</sub>: % acid, X<sub>2</sub>: VOC Type, X<sub>3</sub>: CLA/VEH, X<sub>4</sub>: DFT, X<sub>5</sub>: Bake Schedule) and Two-Factor Interactions, Y = Log |Z|

Run	X <sub>1</sub>	X <sub>2</sub>	X <sub>1</sub> X <sub>2</sub>	X <sub>3</sub>	X <sub>1</sub> X <sub>3</sub>	X <sub>2</sub> X <sub>3</sub>	X <sub>4</sub>	X <sub>1</sub> X <sub>4</sub>	X <sub>2</sub> X <sub>4</sub>	X <sub>3</sub> X <sub>4</sub>	X <sub>5</sub>	X <sub>1</sub> X <sub>5</sub>	X <sub>2</sub> X <sub>5</sub>	X <sub>3</sub> X <sub>5</sub>	X <sub>4</sub> X <sub>5</sub>	Y
1A	-	-	+	-	+	+	-	+	+	+	-	+	+	+	+	10.1
2A	+	-	-	-	-	-	-	-	-	-	-	-	+	+	+	5.7
3A	-	+	-	-	+	-	-	+	-	+	-	+	-	+	+	9.5
4A	+	+	+	-	-	-	-	-	+	-	-	-	-	+	+	5.8
5A	-	-	+	+	-	-	-	+	+	-	-	+	+	-	+	10.0
6A	+	-	-	+	+	-	-	-	+	-	-	+	+	-	+	4.0
7A	-	+	-	+	-	+	-	+	-	-	-	-	-	-	+	9.5
8A	+	+	+	+	+	+	-	-	-	-	-	-	-	-	+	5.7
9	-	-	+	-	+	+	+	-	-	-	-	+	+	+	-	10.4
10	+	-	-	-	-	+	+	+	-	-	-	-	+	+	-	3.9
11	-	+	-	-	+	-	+	-	+	-	-	+	-	+	-	8.8
12	+	+	+	-	-	-	+	+	+	-	-	-	-	+	-	4.5
13	-	-	+	+	-	-	+	-	-	+	-	+	+	-	-	10.1
14	+	-	-	+	+	-	+	+	-	+	-	-	+	-	-	2.5
15	-	+	-	+	-	+	+	-	+	-	-	+	-	-	-	8.5
16	+	+	+	+	+	+	+	+	+	+	-	-	-	-	-	7.3
17A	-	-	+	-	+	+	-	+	+	+	+	-	-	-	-	10.1
18A	+	-	-	-	-	+	-	-	+	+	+	+	-	-	-	5.0
19A	-	+	-	-	+	-	-	-	+	+	-	+	+	-	-	9.0
20A	+	+	+	-	-	-	-	-	+	+	+	+	+	-	-	5.0
21A	-	-	+	+	-	-	-	+	+	-	+	-	-	+	-	5.3
22A	+	-	-	+	+	-	-	-	+	+	+	+	-	+	-	3.0
23A	-	+	-	+	-	+	-	+	-	-	-	-	+	+	-	10.2
24A	+	+	+	+	+	+	-	-	-	-	+	+	+	+	-	7.2
25	-	-	+	-	+	+	+	-	-	-	+	-	-	-	+	10.2
26	+	-	-	-	-	+	+	+	-	-	+	+	-	-	+	4.3
27	-	+	-	-	+	-	+	-	+	-	+	-	+	-	+	8.5
28	+	+	+	-	-	-	+	+	-	-	+	+	+	-	+	5.0
29	-	-	+	+	-	-	+	-	-	+	+	-	-	+	+	10.3
30	+	-	-	+	+	-	+	+	-	+	+	+	-	+	+	2.5
31	-	+	-	+	-	+	+	-	+	+	+	+	+	+	+	10.3
32	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	7.2
<+ level>	4.91	7.63	7.76	7.10	7.25	7.85	7.14	6.93	7.08	7.43	7.07	7.26	7.44	7.17	7.41	
<- level>	9.43	6.71	6.58	7.24	7.09	6.49	7.19	7.41	7.26	6.91	7.27	7.08	6.90	7.17	6.93	
Diff.	-4.52	0.92	1.18	-0.14	0.16	1.36	-0.05	-0.48	-0.18	0.52	-0.20	0.18	0.54	0.00	0.48	

with a boiling point at 180°F while B-16 is a “high boiler” with a boiling point at 447.1°F. This allowed us to assign B-9 as (-) level and B-16 as (+) level relative to the other quantitative factors. Unlike EIS versus % acid, the effect of VOC type on log |Z| in the single-step polyester-melamine enamel/H<sub>3</sub>PO<sub>4</sub> system shown in the bottom left of Figure 3 is smaller and nonuniform when compared to the block-bar graph shown in the top left of Figure 3. Specimens 1, 2, and 5 show higher EIS value using B-9 solvent as compared to those using B-16 solvent while specimens 3, 4, 7, and 8 show a reversed effect. Specimen 6 has the same log |Z| value for both VOC type solvents. Specimens 7 and 8 have the following levels of each factor: % acid = 6%, CLA/VEH = 0.22, DFT = 1.5 mil, and bake schedule = 160-325°F for specimen 8 and = 200-300°F for specimen 7, which display the largest differences in EIS values using B-16 solvent as compared to those using B-9 solvent. This points to the fact that VOC type has more of an effect at these factor levels in the paint system formulated.

At DFT = 1.5 mil, the EIS versus CLA/VEH (top right graph in Figure 3) and EIS versus bake schedule (bottom right graph in Figure 3) show only a small variation. In fact, within the ranges examined, bake schedule is the factor out of all five factors with the least effect. The greatest difference in EIS value at CLA/VEH = 0.22 as compared to that at CLA/VEH = 0.18 has the following

levels of each factor: % acid = 6%, VOC type = B-16, DFT = 1.5 mil, and bake schedule = 200-300°F. This implies that CLA/VEH has the greatest effect at these levels.

### Estimation of Main Effects and Interactions

A mathematical model relating the response value to the levels of one or more factors is an indispensable aid in the interpretation of results from an experimental design. A general procedure known as the method of contrasts<sup>7</sup> was used to calculate the main effects and two-factor interaction for 2<sup>5</sup> factorial designs of a single-step phosphate/paint system. The electrochemical impedance spectroscopy (EIS) results were used in these calculations, since EIS was the sole quantitative response factor in this report. It was shown in Table 1, that pencil hardness results and the absence or presence of exudation correlated well with the EIS measurements. As an example, the coating (run 31) with a high EIS measurement of log |Z| = 10.3 has a 2H pencil hardness and no exudation, while the coating (run 30) with a low EIS value of log |Z| = 2.5 has <B pencil hardness and exudation. It has been noted in the previous section that it was impossible to spray an even film at 0.5 mil for many of the formulas. This was due to the differences in viscosities from one formula to another. Because of this, many of the EIS measurements taken at 0.5 mil are not accurate as was shown in Figure

2. Therefore, the main effects and two-factor interactions were calculated using two sets of DFT levels: set one, 1.0 mil as the low(-) DFT level and 1.5 mil as the high(+) DFT level; and set two, 0.5 mil as the low(-) DFT level and 1.5 mil as the high(+) DFT level.

The procedures for calculating the main effects and two-factor interactions using both sets of DFT levels are the same. Table 2 only illustrates one set, 1.0 mil as (-) and 1.5 mil as (+) DFT level. The factor main effects are calculated as the difference between the average responses at the high and low factor levels, i.e.,  $\langle (+) \text{ level} \rangle - \langle (-) \text{ level} \rangle$ . For the main effect of  $X_1$  (% acid) listed in Table 2,

$$\langle (+) \text{ level} \rangle = \frac{\sum Y_i}{16}$$

where  $i = (+)$  level of column  $X_1$ , and

$$\langle (-) \text{ level} \rangle = \frac{\sum Y_j}{16}$$

where  $j = (-)$  level of column  $X_1$

The two factor interaction effect for  $X_1$  (% acid) and  $X_2$  (VOC type) is the difference between the average responses at the high(+) and low(-) levels of the cross product  $X_1X_2$ . In Table 2, the  $X_1X_2$  column is the algebraic cross product of columns  $X_1$  and  $X_2$ . A similar procedure can be extended to calculate other main effects,  $X_2$  (VOC type),  $X_3$  (CLA/VEH),  $X_4$  (DFT), and  $X_5$  (bake schedule), and other two-factor interactions. Moreover, the main effects and two-factor interactions for set two, 0.5 mil as (-) and 1.5 mil as (+) DFT level can also be calculated. This is done by using the data of runs 1-32 listed in Table 1. The average EIS response of the  $2^5$  factorial points,  $\bar{X}_f = 5.7$ . The average EIS response of the center points (i.e., run 34 in Table 1),  $\bar{X}_c = 6.8$ . Thus, the estimated overall curvature for set two is  $\bar{X}_c - \bar{X}_f = 1.1$ .

Table 3 lists the calculated results on  $2^5$  factorial design using DFT = 1.0 mil(-) and 1.5 mil(+) for the polyester-melamine enamel/ $H_3PO_4$  paint system. These results are compared with those in Table 4 obtained by using DFT = 0.5 mil(-) and 1.5 mil(+). Tables 3A and 4A list the average EIS measurements for each factor at both levels. Tables 3B and 4B summarize the five factors in a decreasing order of main effect. The numbers were obtained by subtracting the average EIS measurement of the lower level from the average EIS measurement of the higher level for each factor, i.e.,  $\langle (+) \text{ level} \rangle - \langle (-) \text{ level} \rangle$ . The positive or negative sign indicates which level, on the average, gave the higher electrical impedance results. The level with higher EIS values is listed in the last column of Tables 3B and 4B. Tables 3C and 4C give two-factor interactions in a decreasing order from the greatest interaction to the least interaction. It is important to remember that the main effects and two-factor interaction calculations were done using the levels that were picked for each of the five factors. If different higher and lower levels were picked for any of the factors, the order of main effect and two-factor interactions would change.

To demonstrate the use of information listed in Tables 3 and 4 and obtain a better coating formula, the results of each table (Table 3 vs Table 4) are compared. As mentioned earlier, many of the paint films sprayed at 0.5 mil were not continuous and perhaps quite porous, therefore, accurate EIS measurements were not obtained. These EIS values were very low because the solution electrolyte in the experimental arrangement of substrate/paint film/3% NaCl solution was in a direct (or indirect) contact with the Q-panel during the entire paint film soaking time of the EIS test. As a consequence, every average EIS measurement in Table 4A is lower than the corresponding EIS measurement in Table 3A, with the exception of that of DFT level = 1.5 mil. This is because all of the low EIS values from the DFT = 0.5 mil coatings were incorporated in the averages for Table 4A. It is noted that an analysis of variance was conducted on the EIS measurements. The results of these calculations are included in Tables 3A and 4A.

In both Tables 3B and 4B, % acid has the largest main effects on EIS results. Table 4B shows that bake schedule has the least main effect and DFT displays the second largest main effect. Once the DFT = 1.0 mil is used as the low(-) DFT level, DFT drops down to the least main effect as listed in Table 3B. This suggests that once the DFT is equal or greater than 1.0 mil, the DFT is no longer an important factor for the EIS results of the formulated paint coating. Table 3B shows that % acid has a much greater main effect on EIS results than the rest of the factors. Moreover, % acid has a main effect that is almost five times greater than the factor with the next largest main effect, VOC type. In Table 4B, the main effect of % acid and the two factors (DFT and VOC type) with the next two largest main effects are fairly close together. Once the DFT = 0.5 mil is replaced with DFT = 1.0 mil

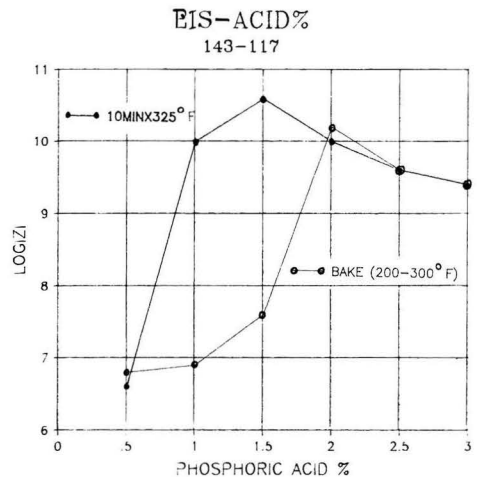


Figure 4—EIS in  $\log |Z|$  vs % acid (0.5%-3%) for a paint formula, 143-117 (VOC type = isopropyl alcohol, DFT = 1.0 mil, and CLA/VEH = 0.22) cured at two bake schedules on Q-panel



**Table 3—Results on 2<sup>5</sup> Factorial Design Using DFT = 1.0 mil(-) and 1.5 mil(+)**

A. Average EIS Results		
Factor Level	Average EIS Result <sup>a</sup>	
2% Acid (-)	9.43	
6% Acid (+)	4.91	
B-9 VOC (-)	6.71	
B-16 VOC (+)	7.63	
.18 CLA/VEH (-)	7.24	
.22 CLA/VEH (+)	7.10	
1.0 mil DFT (-)	7.19	
1.5 mil DFT (+)	7.14	
200-300°F Bake (-)	7.27	
160-325°F Bake (+)	7.07	

B. Main Effects		
Factor (X <sub>i</sub> )	Main Effect	Level w/Higher EIS Value
% Acid	-4.52	2%
VOC type	+ .92	B-16
Bake	- .20	200-300°F
CLA/VEH	- .14	.18
DFT	- .05	1.0

C. Two-Factor Interactions		
Two Factors	Interaction	
VOC Type and CLA/VEH	+ 1.36	
% Acid and VOC type	+ 1.18	
VOC type and bake	+ .54	
CLA/VEH and DFT	+ .52	
% Acid and DFT	- .48	
DFT and bake	+ .48	
% Acid and bake	+ .18	
VOC type and DFT	- .18	
% Acid and CLA/VEH	+ .16	
CLA/VEH and bake	0.00	

(a) From analysis of variance, 95% reliability limit = 2.02.

as the low DFT level(-), all main effects indicated in Table 3B are better defined and % acid stands out as having the largest main effect on EIS results.

Table 4C lists % acid and DFT as the largest two-factor interaction that affects EIS results. This suggests that the DFT has a large effect on the diffusion of phosphoric acid to the surface of the metal substrate. The degree of acid diffusion could enhance the formation of a corrosion protective metal phosphate layer to affect the EIS results. In Table 3C, the two-factor interaction of % acid and DFT drops down to the middle of the column. This might indicate that once the DFT value is equal to or thicker than 1.0 mil, the DFT does not have a large effect on the diffusion of the phosphoric acid and it seems unnecessary to use more than 1.0 mil thickness of paint. The two factors with the least interaction are CLA/VEH and bake schedule in both Tables 3C and 4C.

### Optimal Formulas, Coating Characteristics, and Underfilm Corrosion

Table 1 listed two sets of 2<sup>5</sup> factorial designs for a single-step phosphate/paint system and also a center point, that was run once, for all of these levels. Since both factors DFT and bake schedule are not formulation variables, but processing factors, there are only nine formulas (2<sup>3</sup> + 1 center point) that need to be prepared to

**Table 4—Results on 2<sup>5</sup> Factorial Design Using DFT = 0.5 mil(-) and 1.5 mil(+)**

A. Average EIS Results		
Factor Level	Average EIS Result <sup>a</sup>	
2% acid (-)	7.26	
6% acid (+)	4.21	
B-9 VOC (-)	4.91	
B-16 VOC (+)	6.56	
.18 CLA/VEH (-)	5.24	
.22 CLA/VEH (+)	6.23	
1.0 mil DFT (-)	4.32	
1.5 mil DFT (+)	7.14	
200-300°F Bake (-)	5.89	
160-325°F Bake (+)	5.58	

B. Main Effects		
Factor (X <sub>i</sub> )	Main Effect	Level w/Higher EIS Value
% Acid	- 3.05	2%
DFT	+ 2.82	1.5
VOC type	+ 1.65	B-16
CLA/VEH	+ .99	.22
Bake	- .31	200-300°F

C. Two-Factor Interactions		
Two Factors	Interaction	
% Acid and DFT	- 1.95	
% Acid and VOC type	+ 1.47	
VOC type and bake	- 1.15	
VOC type and CLA/VEH	+ .95	
VOC type and DFT	- .91	
DFT and bake	+ .59	
CLA/VEH and DFT	- .59	
% Acid and CLA/VEH	- .23	
% Acid and bake	- .05	
CLA/VEH and bake	- .01	

(a) From analysis of variance, 95% reliability limit = 2.89.

run this factorial experiment. Two of the nine formulas gave EIS results of log |Z| around 10 with 2H pencil hardness and little or no exudation. These two paint formulas are: one (referred to as 143-117), 2% acid concentration, B-9 VOC type, and 0.22 CLA/VEH ratio; and two (referred to as 143-119), 2% acid concentration, B-16 VOC type, and 0.22 CLA/VEH ratio. These formulas were used to conduct an experiment with different phosphoric acid concentrations, around 2%, to further optimize the paint formulations. It was evidenced that it seems unnecessary to use a DFT of more than 1.0 mil paint layer. So a DFT = 1.0 mil was used for % acid level optimization. Also, since the bake schedule has such a small effect on the EIS values, a more simple bake schedule at one temperature (325°F) for 10 min was conducted. Figure 4 shows the results of EIS versus % acid (0.5-3%) for a single-step phosphate paint formula, 143-117 cured at two bake schedules, one at 325°F for 10 min (referred as bake schedule A) and the other one is the original (-) bake schedule (referred as bake schedule B, i.e., the curing temperature was raised gradually from 200 to 300°F in 13 min and then held at 300°F for 10 min). For the phosphoric acid concentration greater than 2%, both bake schedules gave similar EIS results. This confirms the findings shown in the bottom right graph of Figure 3 that EIS values are quite insensitive to the bake

schedule. Surprisingly, bake schedule A increases the order of magnitude by three in EIS values at 1.5% acid ( $|Z| = 4.50 \times 10^{10}$  ohms-cm<sup>2</sup>) and at 1.0% acid ( $|Z| = 1.13 \times 10^{10}$  ohms-cm<sup>2</sup>) as compared to those using bake schedule B. Bake schedule B gives  $|Z| = 4.50 \times 10^7$  ohms-cm<sup>2</sup> at 1.5% acid concentration. At 0.5% phosphoric acid concentration, both bake schedules again gave almost the same EIS values. These observations clearly point to the important nature of chemical mechanisms in a single-step phosphate/paint system, and implies the potential for accelerated diffusion rates at significantly elevated cure schedule. For a single-step coating to be successful, upon the application of a paint formula on a Q-panel, the H<sub>3</sub>PO<sub>4</sub> needs to diffuse to and then react with the substrate surface to form a corrosion protective metal phosphate layer. This metal phosphate interfacial layer together with a good moisture barrier film provides a high EIS measurement. The baking temperature dependence in the rate of diffusion of H<sub>3</sub>PO<sub>4</sub> for the paint formula 143-117 is illustrated in Figure 4 at both 1% and 1.5% acid concentrations. At a low H<sub>3</sub>PO<sub>4</sub> concentration of 0.5%, the amount is not enough to complete and form a unique corrosion protective phosphate layer, thus a low EIS value is expected. For an acid concentration greater than 2%, a metal phosphate interfacial layer is formed but the excess amount of H<sub>3</sub>PO<sub>4</sub> could be trapped and encapsulated in the paint film as an electrolyte. The entrapped H<sub>3</sub>PO<sub>4</sub> tends to deteriorate the paint coating, and it tends to decrease the EIS value linearly with respect to the amount of excess H<sub>3</sub>PO<sub>4</sub> electrolyte encapsulated in the dry paint film. The supposition can be further supported by modeling the general electrical equivalent circuits<sup>9</sup> in the EIS measurements.

Electrical impedance is an important tool for predicting the relative performance of organic coatings on metal. A frequency dependent impedance can be described mathematically as

$$Z(\omega) = V(t)/I(t) = Z'(\omega) + Z''(\omega)$$

where  $t$  = time;  $\omega$  = frequency in radians per second =  $2\pi f$  (where  $f$  = frequency in Hertz);  $Z(\omega)$  = frequency dependent impedance,  $V(t) = V_o \sin(\omega t)$ , voltage excitation signal or response;  $I(t) = I_o \sin(\omega t + \delta)$ , current excitation signal or response;  $Z'(\omega)$  = real component of impedance; and  $Z''(\omega)$  = complex component of impedance. The frequency dependence of magnitude of the impedance  $|Z|$ , and the phase shift in radians  $\delta$  can be defined as

$$|Z| = [(Z')^2 + (Z'')^2]^{1/2}, \quad \delta = \text{Arc Tan}(Z''/Z')$$

For instance, in a Bode plot ( $\log |Z|$  vs  $\log f$  in Hertz and  $\theta$  in degree vs  $\log f$  in Hertz), the impedance of a "perfect capacitance" can be represented as a straight line with a slope of  $-1$  and a phase angle of  $-90^\circ$  (referred to as case I). A pure resistor will plot as a horizontal line (frequency independent) for the  $\log |Z|$  with a phase angle of  $0^\circ$  (referred to as case II). A Bode magnitude Warburg impedance plot is a straight line with a slope of  $-1/2$  and a phase angle of  $-45^\circ$  (referred to as case III).

To completely characterize the impedance behavior of organic coated metals<sup>10,11</sup> under corroding conditions, a

broad bandwidth frequency (e.g., 100 KHz to 10 mHz) modulating measurement must be performed. In general, information about the coating is obtained at the higher frequencies, whereas corrosion process information is obtained at the lower frequencies. Figure 5 shows the Bode plot,  $\log |Z|$  vs  $\log f$  (top) and  $\theta$  vs  $\log f$  (bottom) for a single-step phosphate/paint system (143-117) at an acid concentration = 0.5% [curve (a)], 1.5% [curve (b)] and 3% [curve (c)]. At 1.5% acid concentration,  $\log |Z|$  vs  $\log f$  shows a straight line with a slope of almost  $-1$  and a phase angle of almost  $-90^\circ$  is displayed in the  $\theta$  vs  $\log f$  plot. The straight line characteristic is identical to the case I previously mentioned as a "perfect capacitance," where coating capacitance  $C_c$  can be determined by following the line of curve (b) in Figure 5 (top) to the frequency where  $\log \omega = 0$  (i.e.,  $f = 0.16$  Hz). The result gives  $C_c = Z^{-1} = 1.6$  nanoFarads/cm<sup>2</sup>. This result indicates that paint formula 143-117 at the acid concentration = 1.5%, DFT = 1.0 mil, and bake schedule = 325°F for 10 min should be considered as one of

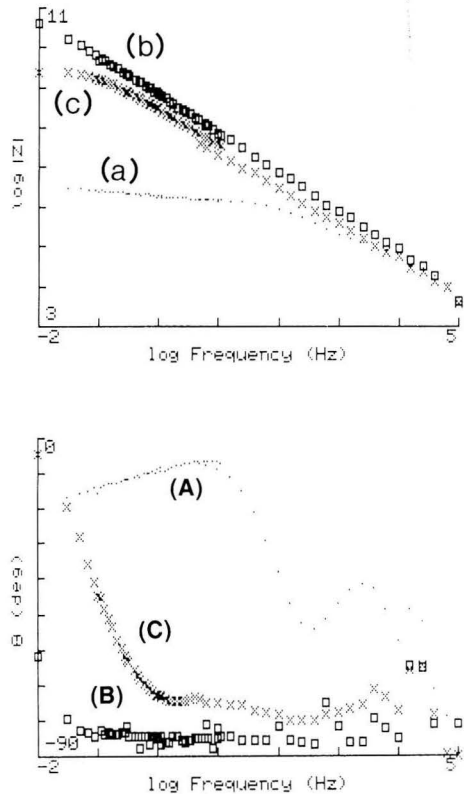
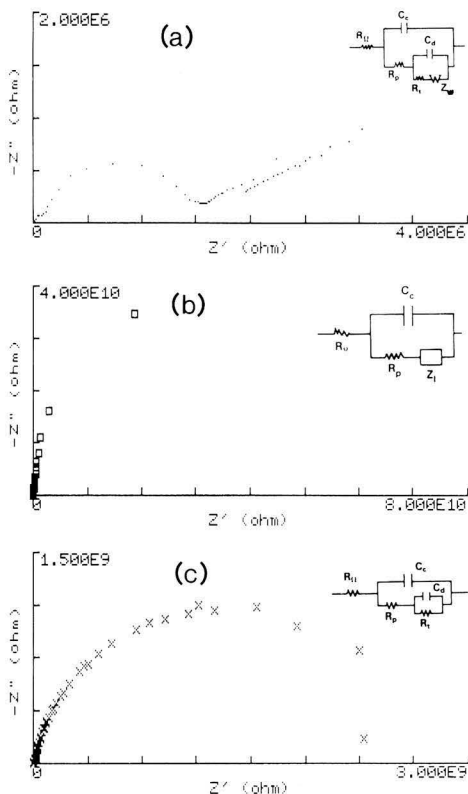


Figure 5—A Bode plot for a paint formula, 143-117 (VOC type = isopropyl alcohol, DFT = 1.0 mil, CLA/VEH = 0.22, and bake schedule = 325°F for 10 min) on Q-panel. H<sub>3</sub>PO<sub>4</sub> acid concentration = 0.5% for curves (a) and (A), 1.5% for curves (b) and (B), and 3% for curves (c) and (C).



**Figure 6**—The Nyquist plots and their corresponding electrical equivalent circuits for paint films applied on Q-panel by using formula 143-117 at an acid concentration = 0.5% (a), 1.5% (b), and 3% (c)

the optimal paint formulations for the single-step polyester-melamine enamels/H<sub>3</sub>PO<sub>4</sub> system.

Besides the paint film capacitance previously calculated, another parameter of importance that is normally generated by impedance testing is the paint film resistance. The film capacitance is a function of the coating dielectric whereas the film resistance is a function of the insulating properties of the paint. The impedance responses can be summarized for coatings that are intact with very high impedance responses [curve (b)] and that have minor or major defects with complex behavior [curves (a) and (c) of Figure 5]. The curve (a) (acid concentration = 0.5%) on the top graph (log |Z| vs log f) of Figure 5 shows a composite of three frequency ranges for log |Z|: a slope of almost -1 for log f = 2 - 5; a frequency independent range for log f = 0.5 - 1.5; and a slope of almost -1/2 for log f = -2 - 0.5. The medium frequency range of slope ≈ 0 reflects the metal/electrolyte corrosion potential and the low frequency range of slope ≈ -1/2 describes the diffusion-related impedance of the rate-limiting species. The complex EIS behavior of

curve (a) on the top graph is also reflected on the curve (A) (0.5% acid) of the bottom graph (θ vs log f) of Figure 5. A broad transition with a wide range of scattering data may be described as θ = -90° at log f = 5, -45° at log f = 4-2, -10° at log f = 1-0, and -20° at log f = -2. These results strongly suggest that the electrochemical reactions are quite active at the metal/coating interface for a paint film on Q-panels coated by 143-117 formula with an acid concentration = 0.5%. It is expected that at this low acid concentration, there is not sufficient H<sub>3</sub>PO<sub>4</sub> in the paint formulas to diffuse to and the formation of a corrosion protective layer on Q-panels. At a high acid concentration (3% acid), curve (c) in log |Z| vs log f graph, and curve (C) in θ vs log f graph of Figure 5 are quite similar to those of curve (b) and curve (B), respectively, except in the low frequency range. The differences may be summarized as: (1) the curve (c) becomes a frequency independent, and (2) the curve (C) goes from θ = -90° to θ = 0° in the low frequency range. The changes in the EIS behavior can be attributed to the coating penetration by electrolyte as resulting from the entrapment of excess amounts of H<sub>3</sub>PO<sub>4</sub> in the paint films.

The Nyquist plots and their corresponding electrical equivalent circuits for paint films applied on Q-panels by using formula 143-117 at an acid concentration = 0.5% (a), 1.5% (b), and 3% (c) are presented and tentatively assigned in Figure 6. The possible electrical equivalent circuits consist of the solution resistance R<sub>Ω</sub>, for the bulk solution between the coated metal surface and the reference electrode and electrical leads; the coating capacitance, C<sub>c</sub> for the dielectric coating; the double layer capacitance or pseudo-capacitance, C<sub>d</sub>; the “pore” resistance, R<sub>p</sub> (near 10<sup>6</sup> to 10<sup>10</sup> ohms-cm<sup>2</sup>), for typical coatings describing the coating penetration by electrolyte; and Z<sub>1</sub> corresponding to the electrochemical reactions occurring at the metal/coating interface as shown in Figure 6b. For many systems, Z<sub>1</sub> can be described by a transfer resistance, R<sub>t</sub>, in parallel with a pseudo or double-layer capacitance as described in Figure 6c. For others, Z<sub>1</sub> is best represented by R<sub>t</sub> in series with a Warburg impedance W (model II)<sup>12</sup> as presented in Figure 6a, where R<sub>t</sub> describes the metal/electrolyte corrosion rate when determined at open circuit, or the corrosion potential, and Z<sub>w</sub>

**Table 5**—Performance Comparison in a Decreasing Order of Single-Step vs Multistep Coatings after Exposure to Laboratory Accelerated and Outdoor Test Conditions

@164 hr Salt Spray	@309 hr Humidity	@1600 hr Fence
Epoxy B	143-119 <sup>a</sup>	Ureth B
Ureth B	143-166	143-119 <sup>a</sup>
143-119	Ureth B	Alkyd B
Alkyd B	Alkyd B <sup>a</sup>	Phen B
Alkyd Q	Epoxy B	Alkyd Q
Phen B	Phen B	143-166
Phen Q	Alkyd Q	Epoxy B
143-166	Epoxy Q	Ureth Q
Ureth Q	Phen Q	Phen Q
Epoxy Q	Ureth Q	Epoxy Q

(a) The rankings are tied.

describes the diffusion-related impedance of the rate-limiting species. It is evidenced that a Nyquist plot of  $-Z''$  vs  $Z'$  in Figure 6b shows only the presence of a high frequency response indicative of a purely capacitive dielectric for the unicoat paint formula, 143-117 at an acid concentration = 1.5%. At 3% acid concentration as shown in Figure 6c, a simple restrictive charge transfer process is obtained. Only at 0.5% acid concentration as displayed in Figure 6a, the incompletely phosphated unicoat paint film on a Q-panel shows a possible presence of the diffusion-controlled ( $Z_w$ ) corrosion process.

### Exposure Performance

A comparative study was conducted to determine the ranking order of coating protection offered by four different resin systems with (on a Bonderite 1000 panel) and without (on a Q-panel) metal phosphate in comparison with two formulations (143-119 and 143-166) of a single-step phosphate/paint system as derived from the factorial design and stability tests. Formulation 143-166 is a version of 143-117 formulated with 1.5% acid concentration and reduced by butyl Carbitol. The polymer resin types of these clear bake enamel systems are indicated as follows: waterborne polyurethane (urethane Q and urethane B), solvent-borne phenolic modified alkyd (phenolic Q and phenolic B), solvent-borne epoxy (epoxy Q and epoxy B), and water-reducible alkyd (alkyd Q and alkyd B). Q and B referred to paint coatings on a Q-panel and a Bonderite 1000 panel, respectively.

The outdoor testing was conducted over a period of 2½ months in Sugar Grove (~50 miles northwest of Chicago), Illinois, from February 24, 1992 to May 15, 1992. This period is representative of real world performance under extreme conditions where early Illinois spring weather provided considerable high humidity, i.e., fog, freeze/thaw, snow, rain, ice, and on a few spectacular days, all of the above and a little sunshine and temperatures in the 60s and 70s.

Table 5 lists the ranking order, system type, and duration of exposure performed in order to conduct the comparative ranking. Rankings are based upon determinations specific to the testing mode as described in the ASTM standards. Factors considered were scribe corrosion, creep, delamination, wet adhesion, recovery, blistering, filiform corrosion, surface corrosion, fading, pitting, spotting, and any other effects which were considered pertinent to the general performance. It should be noted that in order to rank these systems it is not necessary to expose the samples to the degree that they fail, only to the degree that scribe and surface changes may be measured. The test duration should not be considered as a measure of performance, especially the results that were conducted in real time, where true failure would probably be measured in years and would consist of greater variance of climate than what these samples represented. In fact, the best ranked outdoor exposure specimen on Bonderite had no discernible corrosion or other weathering effects at all. The next best had minimal scribe corrosion, and the third best had a little more and so forth. On the Q-panels of the lower ranking specimen, however, as much as 10 mm scribe effect and other surface effects and

spotting were quite noticeable. It is clearly shown that in each of the exposure cases the single-step system 143-119 performed with equivalent ranking with the Bonderite 1000 coated samples and significantly better than the Q-panel comparisons.

### CONCLUSION

A single-step polyester-melamine enamel/ $H_3PO_4$  paint system has been successfully formulated. Nine paint formulas were prepared to run a  $2^5$  full factorial experiment. Electrical impedance response, pencil hardness, and exudation were used to probe and optimize the paint formulation. The optimal factors and levels for the single-step unicoat paint film (i.e., formula 143-117) are  $H_3PO_4$  acid concentration = 1.5%, VOC type = B-9, isopropyl alcohol, CLA/VEH = 0.22, DFT = 1.0 mil, and bake schedule = 325°F for 10 min. The optimized paint film on a Q-panel displays a purely capacitive dielectric of  $|Z| = 4.50 \times 10^{10}$  ohms-cm<sup>2</sup> with a pencil hardness of 2H and no exudation. The visually observed degradation of the *in-situ* phosphatizing paint system, upon salt spray, humidity, and outdoor fence testings, ranks high among the systems tested. A marketable "pigmented" single-step phosphate/paint system using these optimized factors and levels is currently under development in our laboratory. Recently, we have achieved the formulation of both "carbon black" and "TiO<sub>2</sub> white" pigmented single-step phosphate/paint systems using both water-extendable polyester and water-reducible alkyd resins.

Electrical equivalent circuit models were adopted to investigate the nature of chemical phosphatizing mechanisms in a single-step phosphate/paint system. The paint film on a Q-panel coated by using formula 143-117 with a  $H_3PO_4$  concentration above, at, and below the optimal levels shows a charge transfer process, a high frequency response and a diffusion-controlled corrosion process, respectively. This result indicates that  $H_3PO_4$  in the single-step paint system tends to diffuse dynamically to and react with a metal surface, and provide a corrosion protective layer on the substrate.

### ACKNOWLEDGMENTS

Financial support from the Illinois Department of Commerce and Community Affairs, a State of Illinois Technology Challenge Grant, Finishes Unlimited, Inc., Cargill and Northern Illinois University Graduate School, College of Liberal Arts and Sciences, and Technology Commercialization Center is gratefully acknowledged. The authors would like to thank Mr. Fernando Quitian-Puello, Ms. Ping Lin, Ms. Sharon L. Burd and Dr. Meen-Woon Hsiao for their technical assistance.

### References

- (1) Hare, C.H., "Corrosion and the Preparation of Metallic Surfaces for Painting," *Federation Series on Coating Technology*; Federation of Societies for Paint Technology, Philadelphia, PA, Unit 26, 5 (1978).
- (2) Hall, W.S., "Theory and Practice of Coating by Autodeposition," *J. Water Borne Coat.*, 2 (August 1978).

- (3) Lin, C.T., Lin, P., Hsiao, M.W., Meldrum, D.A., and Martin, F.L., "Chemistry of a Single-Step Phosphate/Paint System," *Ind. Eng. Chem. Res.*, 31, 424 (1992).
- (4) Gan, S., Solimeno, R.D., Jones, F.N., and Hill, L.W., "Recent Studies of the Curing of Polyester-Melamine Enamels: Possible Causes of Overbake Softening," *Proc. of the Sixteenth Water-Borne and Higher-Solids Coatings Symposium*, New Orleans, LA, 87 (1989).
- (5) Lin, C.T., Lin, P., and Quitian-Puello, F., "Interfacial Chemistry of a Single-Step Phosphate/Paint System," *Ind. Eng. Chem. Res.*, accepted for publication.
- (6) Rooney, C., "Using Designed Experiments for Complex Formulations," *Mod. Paint and Coat.*, 44 (May 1991).
- (7) Eckert, R.E., "Design and Optimization, Applied Techniques in Statistics for Selected Industries: Coatings, Paints, and Pigments," Hill, H.E. and Prane, J.W. (Eds.), John Wiley & Sons, Inc., New York, Chap. 13, 379 (1984).
- (8) *1988 Annual Book of ASTM Standards*, Section 6, "Paints, Related Coatings, and Aromatics," ASTM, Philadelphia, PA, 1988.
- (9) Scully, J.R., "Electrochemical Impedance Spectroscopy for Evaluation of Organic Coating Deterioration and Under Film Corrosion: A State of the Art Technical Review," David W. Taylor Naval Ship Research and Development Center Report, DTNSRDC/SME86/006, September 1986.
- (10) Epelbion, I., Gabrielli, C., Keddam, M., and Takenouti, H., "Alternating Current Impedance Measurements Applied to Corrosion Studies and Corrosion Rate Determination, Electrochemical Corrosion Rate Determination, Electrochemical Corrosion Testing," ASTM, STP 727, Mansfeld, F. and Bertocci, U. (Eds.), 150 (1981).
- (11) Mansfeld, F. and Kendig, M., "Evaluation of Protective Coatings with Impedance Measurements," *Proceedings of the Int. Cong. Metal. Cor.*, Toronto, Canada, 74 (June 1984).
- (12) Bard, A.J. and Faulkner, L.R., "Electrochemical Methods, Fundamentals and Applications," Wiley & Sons, New York, 320-352 (1980).

# Amine-ene Technology III<sup>1</sup>: Investigation Of the Properties of Some Branched Maleate Oligomers in Ultraviolet Light Curable, Amine-ene Coatings

Gerry K. Noren  
DSM Desotech, Inc.\*

---

Photocrosslinking utilizing the amine-ene reaction with benzophenone (BP) as the hydrogen abstraction photoinitiator was investigated using the Simplex Experimental Design technique. Coating formulations consisting of three basic components: an allyl terminated polyester, a polymer bound amine synergist, and a branched maleate oligomer (BMO) were prepared. The chemical structure of the BMO component was varied by introducing four different saturated difunctional carboxylic acids into an oligomer backbone containing tris-(2-hydroxyethyl)isocyanurate as a branching agent. The average double bond functionality of the oligomers was held constant at four and the equivalent weight was maintained between 400 and 425. Some structure-property dependence was observed for the solvent resistance and

pencil hardness data at a cure dose of 3 J/cm<sup>2</sup>. These oligomers were compared with a BMO which contained no saturated dicarboxylic acid component and had an equivalent weight of 340. In spite of the lower functionality, cure rate (MEK double rub resistance) increased with the decreased double bond equivalent weight at a cure dose of 1 J/cm<sup>2</sup>. Comparison of a linear internal maleate unsaturated polyester oligomer with a BMO indicated an advantage for the use of the BMO. The average crosslink density for the BMO systems, as determined from the equilibrium modulus data, was about 10<sup>20</sup> crosslinks per cc. Of the three intramolecular cleavage photoinitiators evaluated, only 2-hydroxyl-2-methyl-1-phenylpropan-1-one (HMPP) produced a faster cure rate than BP.

---

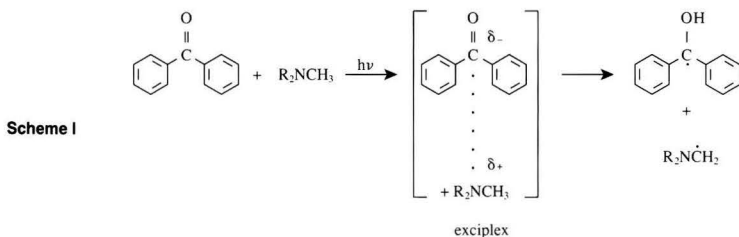
## INTRODUCTION

During the last 15 to 20 years, considerable growth has been accomplished in the development of ultraviolet curable coating systems. Five useful resin systems that can be cured by the ultraviolet light initiated free radical mechanism are: 1) unsaturated polyester resin/styrene; 2) thiol-ene; 3) multifunctional (meth)acrylates; 4) maleate/vinyl ether; and 5) amine-ene. Polyester/styrene systems are low in price and are used primarily in wood finishing. They cure slowly and present environmental and health problems due to the high volatility of the

styrene monomer. Thiol-ene systems are high priced and are used in PVC flooring, printing plates, and in gaskets. They cure much faster than the polyester/styrene systems but also present health problems due to the thiol component in the system. Acrylate systems are moderately priced; they are also fast curing and have been known to cause skin irritation. They have recently come under scrutiny for possible long-term toxicity effects. Their methacrylate counterparts are very slow curing and are not considered to create health problems. (Meth)acrylate materials have been useful in many application areas. The new maleate/vinyl ether systems have about the same cure speed as acrylates, are about the same price, and are generally less toxic.<sup>2</sup>

---

\*1122 St. Charles St., Elgin, IL 60120.



The initiation of photocrosslinking by the use of the intermolecular hydrogen abstraction (*Scheme I*) is well known.<sup>3</sup>

Diaryl ketones such as benzophenone (BP) are used as the photoinitiator and a coinitiator consisting of a low molecular weight tertiary amine having at least one abstractable hydrogen atom on a carbon atom that is alpha to the nitrogen is required. These amine synergists or photoactivators form an exiplex with the excited state of the diaryl ketone and subsequently transfer a hydrogen atom to the diaryl ketone producing a ketyl radical and an alpha-amino radical. The ketyl radical has been shown to be inefficient as an initiator, while the alpha-amino radical has been proven to be an effective initiator for acrylate polymerization.<sup>4</sup>

Amine-ene technology offers the opportunity for the formulation of economical radiation curable systems with broad versatility for use in high-solids and/or water-based applications. We have previously reported studies of this crosslinking system with various formulations consisting of allyl functional oligomers, polymeric or oligomeric tertiary amines, and linear unsaturated polyester oligomers containing maleate functionality as an integral part of the backbone.<sup>1-5</sup> We now wish to report an investigation of the substitution of branched maleate oligomers

(BMO) for linear internal maleate oligomers and the effects of some chemical structure changes in the BMO on some of the physical properties of clear UV-cured coatings. The overall goal of this research was to produce amine-ene systems with improved cure rate at increased solids levels while maintaining a reasonable application viscosity.

## EXPERIMENTAL

**TERTIARY AMINE FUNCTIONAL ACRYLIC COPOLYMER (TAFAC):** In a 500 ml four-necked flask, equipped with a mechanical stirrer, nitrogen inlet, thermometer, condenser, and a dropping funnel was placed 165 g of n-butyl acetate. The reaction was stirred and heated to 85-90°C approximately 30 min while being purged with nitrogen. Then a solution of 120 g (1.2 m) of methyl methacrylate, 51 g (0.3 m) of dimethylaminopropyl methacrylamide, 3.9 g (0.05 m) of 2-mercaptoethanol, and 4.3 g (0.022 m) of 2,2'-azobis(2-methylbutanenitrile) (VAZO 67, Du Pont Co.) was added over 1 hr. The nitrogen purge was switched to a nitrogen blanket and the reaction temperature was held at 90°C for 3 hr. Then, 1 g of VAZO 67 was added and the temperature was held at 90°C for an additional 3 hr. The resultant copolymer solution was about 52.9% NVM and had a viscosity of about 1600 cP at room temperature. The theoretical equivalent weight was 583 g/nitrogen.

**ALLYL-TERMINATED OLIGOMER (ATO):** In a 500 ml four-necked flask, equipped with a mechanical stirrer, nitrogen inlet, thermometer, and a Dean-Stark trap with condenser was placed 63 g (0.25 m) of tris-(2-hydroxyethyl) isocyanurate (THEIC, Allied Chemical Co.), 129 g (0.75 m) of cyclohexane dicarboxylic acid (Eastman Chemical Co.), 171 g (0.40 m) of trimethylolpropane diallyl ether (National Starch and Chemical Corp.), 0.3 g of Fascat 4100 (M & T Chemicals Inc.), and 40 ml of xylene. The mixture was heated to 160°C under a nitrogen blanket and after about 45 min the azeotropic distillation of water began. The temperature was held at 160°C for about 2 hr and then slowly raised to 200°C over a period of about 4 hr. After an additional 5 hr at 200°C, the xylene was removed. The final acid value was 23.6 mg KOH/g and the viscosity was 3130 cP (#6 spindle; 20 RPM) at room temperature. The theoretical equivalent weight of this oligomer was 201 g/double bond.

**Table 1—Composition and Properties of Branched Maleate Oligomers Used in This Study**

Raw Material (moles)	BMO 1	BMO 2	BMO 3	BMO 4	BMO 5
Maleic anhydride	1.00	0.80	0.80	0.80	1.00
Succinic anhydride	0.25	—	—	—	—
Azelaic acid	—	0.20	—	—	—
Dodecanedioic acid	—	—	0.20	—	—
Phthalic anhydride	—	—	—	0.20	—
Butyl carbitol	1.05	0.84	0.84	0.84	1.05
THEIC <sup>a</sup>	0.50	0.40	0.40	0.40	0.34
<b>Properties</b>					
Viscosity (cP)	47,600	33,040	22,800	136,400	6,800
Acid value (mg KOH/g)	11.2	16.7	12.3	10.4	17.2
<b>Unsaturation</b>					
Equivalent wt.	400	415	425	410	340
Functionality	4.0	4.0	4.0	4.0	3.0
Percent NVM	100	100	100	100	100

(a) THEIC = Tris-(2-hydroxyethyl)isocyanurate.

Table 2—Composition and Viscosities of Simplex Experimental Design Formulations Varying the Branched Maleate Oligomer

Component	Simplex Formulation Number (SFN)									
	1	2	3	4	5	6	7	8	9	10
TAFAC <sup>a</sup> (g)	124.5	9.6	9.6	67.0	67.0	9.6	47.9	86.3	28.8	28.8
ATO <sup>b</sup> (g)	5.0	65.0	5.0	35.0	5.0	35.0	25.0	15.0	45.0	15.0
BMO <sup>c</sup> (g)	30.0	30.0	90.0	30.0	60.0	60.0	50.0	40.0	40.0	70.0
BP <sup>d</sup> (g)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
<b>Percent NVM</b> (theo.)	64	96	96	77	77	96	82	72	89	89
<b>Viscosity</b> (cP × 10 <sup>-4</sup> )										
BMO 1	1.73	3.28	4.57	1.38	5.07	2.76	2.41	1.97	2.17	5.21
BMO 2	2.03	0.80 <sup>e</sup>	2.58 <sup>f</sup>	5.91 <sup>e</sup>	1.16 <sup>f</sup>	3.02	3.11 <sup>f</sup>	2.02	2.06 <sup>f</sup>	5.53 <sup>f</sup>
BMO 3	1.93	1.15	3.50	1.28	2.46	2.62	2.06	1.88	1.69	3.64
BMO 4	2.43	2.63 <sup>g</sup>	13.6	1.96	2.88 <sup>g</sup>	4.72	3.47	2.64	2.97	7.95
BMO 5	2.16	0.35	1.14	1.80	1.33	2.75	2.62	2.16	2.06	3.66

(a) TAFAC = Tertiary amine functional acrylic resin.

(b) ATO = Allyl terminal oligomer.

(c) BMO = Branched maleate oligomer.

(d) BP = Benzophenone.

(e) 1 g of methyl ethyl ketone added.

(f) 2 g of methyl ethyl ketone added.

(g) 0.5 g of methyl ethyl ketone added.

**BRANCHED MALEATE OLIGOMERS 1-4:** In a 500 ml four-necked flask, equipped with a mechanical stirrer, nitrogen inlet, thermometer, and a Dean-Stärke trap with a condenser was placed 78.4 g (0.8 m) of maleic anhydride (Aldrich Chemical, Inc.), 136.1 g (0.84 m) of 2-(2-butoxyethoxy) ethanol (Union Carbide Chemical Co.), and 0.3 g of Fascat 4100. The mixture was heated to 75°C under a nitrogen blanket and an exothermic reaction began which caused the temperature to rise to about 120°C where it was held for 2 hr. Then, 104.4 g (0.4 m) of THEIC, 0.2 m of the desired dibasic acid (see Table 1), and 40 ml of xylene were added. Additional heating brought the temperature up to 160°C. After 1 hr at 160°C, the temperature was slowly raised to 200°C over approximately 7 hr and held at that temperature for 1 hr. Then the xylene was removed to give the product BMO. The compositions and properties of these branched maleate oligomers are given in Table 1.

**BRANCHED MALEATE OLIGOMER 5:** In a 500 ml four-necked flask, equipped with a mechanical stirrer, nitrogen inlet, thermometer, and a Dean-Stärke trap with a condenser was placed 196.0 g (2.0 m) of maleic anhydride, 340.0 g (2.1 m) of 2-(2-butoxyethoxy) ethanol, and 0.3 g of Fascat 4100. The mixture was heated to 75°C under a nitrogen blanket and an exothermic reaction began which caused the temperature to rise to about 120°C where it was held for 2 hr. Then, 174.0 g (0.67 m) of THEIC and 40 ml of xylene were added. Additional heating brought the temperature up to 160°C. After 1 hr at 160°C, the temperature was slowly raised to 200°C over about 7 hr and held at that temperature for 1 hr. Then the xylene was removed to give the product BMO. The properties of this branched maleate oligomer are given in Table 1.

**FORMULATIONS:** The formulations were prepared by blending the allyl terminated polyester, the tertiary amine

functional copolymer, and the appropriate branched maleate oligomer with 4% BP based on solid resins in a dark bottle. The mixtures were heated in a 150°F oven for 30 min to obtain complete solution. A ten-sample simplex experimental design was used for the evaluation of each of the branched maleate oligomers. The compositions of the formulations and their viscosities are shown in Table 2.

**PANEL PREPARATION:** The coating formulation was coated on an acetone-wiped aluminum Q-Panel using a #40 wire-wound rod and allowed to air dry for 30 min to

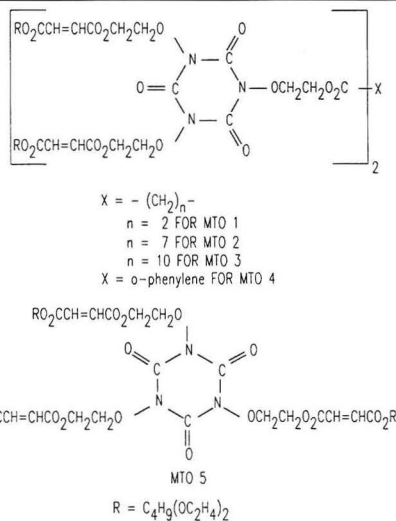


Figure 1—Idealized chemical structures of oligomers studied



Table 3—MEK Double Rub Data for Formulations Cured at 1 J/cm<sup>2</sup>

BMO Number	Simplex Formulation Number (SFN)									
	1	2	3	4	5	6	7	8	9	10
BMO 1	30	0	0	15	0	0	26	25	35	0
BMO 2	14	c <sup>a</sup>	c	14	c	15	22	24	22	18
BMO 3	17	12	c	18	25	c	18	20	18	17
BMO 4	15	c	c	20	c	12	26	16	c	c
BMO 5	38	12	c	40	c	c	40	25	40	c

(a) c = "cheesy" film.

remove the n-butyl acetate. The coatings were then cured by exposure to ultraviolet light from a pulsed xenon lamp in a UV curing unit (IST America Div. of Syndicate Sales Inc.).

GENERAL: All chemicals were used as received from the suppliers unless otherwise noted. The gel permeation chromatography data was obtained using a styrene-divinylbenzene column with a Waters Model 590 pump, a Waters Model 410 refractometer, and a Waters Model 840 data station. The molecular weights are based on polystyrene standards. The thermal mechanical analysis was performed on a Rheometrics Linear Rheometer.

## RESULTS AND DISCUSSION

### Oligomer Synthesis and Properties

Previous studies of the amine-ene curing system have used maleate functional linear unsaturated polyester resins.<sup>1,5</sup> Branched maleate functional polyester oligomers have not been investigated. The previous work indicated that faster cure rates could be obtained with the higher functionality (e.g., four or greater), linear polyesters. Thus, it would be necessary to synthesize branched multifunctional maleate oligomers with a functionality of at least four.

The synthesis of branched multifunctional maleates with an average functionality of four was conducted in a step-wise manner which involved the synthesis of the half ester of maleic acid first by the reaction of 2-(2-butoxyethoxy)ethanol with maleic anhydride. Then a trifunctional alcohol, THEIC, and a saturated dicarboxylic acid were added and esterification was continued to an acid value of less than 20 meq KOH/g. The four dicarboxylic acids that were evaluated as received included succinic acid (BMO 1), azelaic acid (BMO 2), dodecanedioic acid (BMO 3), and phthalic acid (BMO 4). The idealized structure of BMOs 1 to 4, as well as, the structure of BMO 5 which was prepared without the saturated dicarboxylic acid and had a functionality of only three, are shown in *Figure 1*. The composition and properties of these oligomers are summarized in *Table 1*.

With the exception of BMO 5, these oligomers were much higher in viscosity than the linear unsaturated polyesters which we had studied earlier. As might be expected, the viscosities generally decreased as the flexibility of the dicarboxylic acid increased. The equivalent weights of BMOs 1-4 ranged from 400 to 425 and the equivalent weight of BMO 5 was 340.

The BMO 2 sample was analyzed in greater detail. The GPC curve for BMO 2 is shown in *Figure 2*. By comparison with authentic samples, peak 1 was identified as 2-(2-

Table 4—Coating Property Data for Formulations Cured at 3 J/cm<sup>2</sup>

MEK Double Rubs:	Simplex Formulation Number (SFN)									
	1	2	3	4	5	6	7	8	9	10
BMO 1	40	25	10	100	105	85	175	95	>200	>200
BMO 2	85	20	15	>200	>200	175	132	100	162	160
BMO 3	34	65	17	75	170	82	97	67	136	109
BMO 4	>200	30	28	>200	180	>200	>200	>200	80	>200
BMO 5	75	65	12	166	>200	>200	>200	125	>200	>200
<b>Pencil Hardness:</b>										
BMO 1	B	4B	4B	2B	4B	4B	2B	B	B	B
BMO 2	F	4B	4B	HB	HB	F	F	F	F	F
BMO 3	HB	4B	4B	HB	3B	HB	F	HB	HB	B
BMO 4	B	4B	4B	B	B	B	F	F	F	F
BMO 5	F	4B	4B	F	F	F	F	F	F	HB
<b>Adhesion:</b>										
BMO 1	Good	Good	Good	Poor	Poor	Poor	Poor	Poor	Poor	Poor
BMO 2	Fair	Good	Good	Fair	Poor	Poor	Poor	Fair	Poor	Poor
BMO 3	Fair	Fair	Fair	Fair	Poor	Poor	Poor	Fair	Poor	Poor
BMO 4	Fair	Fair	Good	Fair	Poor	Fair	Poor	Fair	Poor	Poor
BMO 5	Fair	Fair	Good	Poor	Poor	Poor	Poor	Fair	Poor	Poor

butoxyethoxy)ethanol, peak 2 was identified as mono-2-(2-butoxyethoxy)ethyl maleate, peak 3 was identified as di-2-(2-butoxyethoxy)ethyl maleate, and peak 4 was identified as di-2-(2-butoxyethoxy)ethyl azelate with peak 5 accounting for the oligomer portion. The number average molecular weight of peaks 3-5 was 1800 (theoretical molecular weight = 1660) with a PDI of 5.17. Therefore, the maleate functionality should be predominantly located at the terminal position of the oligomer as indicated by the idealized structures shown in *Figure 1*. Nuclear magnetic resonance analysis of BMO 2 showed that about 50% of the maleate had isomerized to fumarate.

### Simplex Design Formulations and Results

A three-component mixture study consisting of ten different compositions was prepared and used to evaluate the five different BMO samples in amine-ene formulations. The experimental region is shown in *Figure 3*. In this region, the tertiary amine concentration provided by the tertiary amine functional acrylic copolymer (TAFAC) varied from  $8.5 \times 10^{-5}$  to  $1.11 \times 10^{-3}$  equivalents per gram of formulation which completely brackets the optimum range of  $10^{-4}$  equivalents per gram of the coating formulation.<sup>1,5</sup> The TAFAC used was a simple copolymer containing 70% methyl methacrylate and 30% dimethylaminopropyl methacrylamide and had an equivalent weight of 583 g per nitrogen. Also within this region, the level of the double bond concentration contributed by the allyl terminated oligomer (ATO) was varied from about  $7.14 \times 10^{-4}$  to  $1.19 \times 10^{-3}$  equivalents per gram of the coating formulation.<sup>1,5</sup> The ATO was an ester type oligomer prepared from THEIC, cyclohexane 1,4-dicarboxylic acid (CHDA), and trimethylolpropane diallyl ether (TMPDAE). The ATO had an equivalent weight of 201 g per double bond. Finally, for this region, the double bond concentration from the BMO samples varied from  $7.5 \times 10^{-4}$  to  $2.1 \times 10^{-3}$  equivalents per gram of the coating formulation for BMO samples 1-4 and from  $8.8 \times 10^{-4}$  to  $2.65 \times 10^{-3}$  equivalents per gram of coating formulation for BMO 5.

Formulations were prepared and assigned numbers from 1 to 10. Simplex Formulation Numbers (SFN). The formulations were prepared without regard to solvent content so that the total resin solids would add up to 100% as required by Simplex Experimental Designs. This resulted in a variation of actual sample solids from about 64 to 96%. The compositions of the formulations and their viscosities are summarized in *Table 2*. Due to the higher viscosities of the branched oligomers compared to the linear oligomers, the formulations had correspondingly higher viscosities and in some cases additional solvent (MEK) had to be added to reach a reasonable application viscosity.

Each formulation was evaluated as a clear coating on aluminum Q-panels. Before cure, the panels were allowed to air dry for 30 min to permit the evaporation of the n-butyl acetate/(MEK). Since all films were prepared with a #40 wire-wound rod, some differences in film thickness would be anticipated due to solvent loss. Curing was accomplished by exposure to a pulsed xenon ultraviolet light source with a broad band spectral output

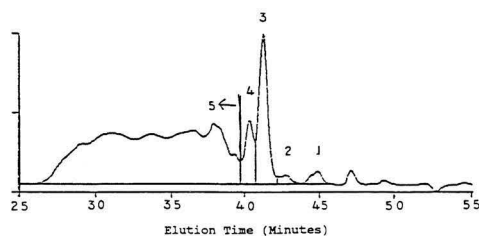


Figure 2—Gel permeation chromatograph of BMO 2

and peak radiation in the 200-400 nm region. *Table 3* summarizes the results of the evaluation of the degree of cure of the coatings by the MEK double rub test after curing at a dosage of  $1 \text{ J/cm}^2$ . Cure response, pencil hardness, and adhesion measurements at a dosage of  $3 \text{ J/cm}^2$  were also performed and *Table 4* shows these results.

From *Table 3* it can be seen that several of the formulations gave films that were "cheesy" with no MEK double rubs. This is especially true for formulation number 3 which contained the largest amount of the BMO. No correlation between these results and the percent NVM (film thickness) of the original coating was observed. There also appears to be very little advantage for the use of a specific dicarboxylic acid. For all BMOs, the fastest cure at the  $1 \text{ J/cm}^2$  dose level was observed within an area bounded by a line connecting formulations 1, 4, 9, 7, 8, and back to 1 again. This is the shaded area in *Figure 3*. BMO 5, with the lowest equivalent weight and a functionality of 3, proved to be the fastest curing material in the sample region. Since BMOs 1-4 all have a functionality of four, lowering the equivalent weight may be the more effective method of increasing the cure speed at low dosages than increasing the oligomer functionality.

While the MEK double rub results at  $1 \text{ J/cm}^2$  revealed little relationship with BMO structure, the data from the  $3 \text{ J/cm}^2$  dose in *Table 4* varied substantially as the dicarboxylic acid structure was changed. First, useful or completely cured ( $>200$  MEK double rubs) formulations can be prepared from all of the BMOs studied with the excep-

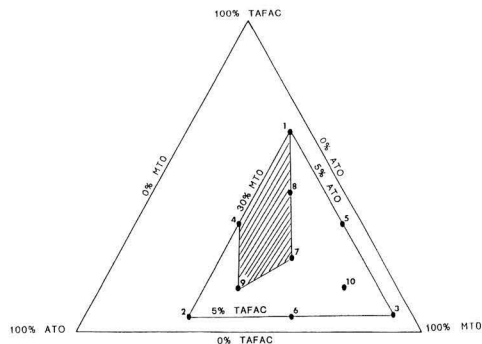


Figure 3—Simplex experimental design showing region of interest and region of fastest cure at  $1 \text{ J/cm}^2$

**Table 5—Comparison of BMO 5 with Sample B of Reference 1**

	BMO 5	Sample B <sup>1</sup>
Structure of oligomer.....	Branched maleate	Internal maleate
Equivalent weight .....	340	315
Functionality .....	3	2.6
Brookfield viscosity (cP) .....	6800	3050
Number of simplex formulae that had:		
(1) >20 MEKDR at 1 J/cm <sup>2</sup> .....	5	1
(2) >200 MEKDR at 3 J/cm <sup>2</sup> .....	5	0
(3) Pencil hardness > B at 3 J/cm <sup>2</sup> .....	8	2
(4) Good adhesion at 3 J/cm <sup>2</sup> .....	1	1

**Table 6—Thermal Mechanical Properties of Branched Maleate Oligomers in SFN 7**

BMO Number	T <sub>g</sub> (°C)	Equilibrium Modulus (MPa)	Crosslink Density (crosslinks/cc)
BMO 1 .....	62	4.6	1.45 × 10 <sup>20</sup>
BMO 2 .....	61	5.0	1.58 × 10 <sup>20</sup>
BMO 4 .....	66	5.0	1.58 × 10 <sup>20</sup>
BMO 5 .....	65	5.9	1.86 × 10 <sup>20</sup>

**Table 7—Comparison of Cure Speed (MEK Double Rubs) of Cleavage Type Photoinitiators in BMO 5 Based Simplex Formulations**

	MEK Double Rubs at Dosage (J/cm <sup>2</sup> )		
	1	2	3
<b>Photoinitiators:</b>			
<b>4% Benzophenone</b>			
SFN 1 .....	38	—	75
SFN 7 .....	40	—	>200
SFN 8 .....	25	—	125
SFN 9 .....	40	—	>200
<b>4% Deoxybenzoin</b>			
SFN 1 .....	15	23	130
SFN 7 .....	5	42	>200
SFN 8 .....	10	40	>200
SFN 9 .....	8	42	>200
<b>4% 2-Hydroxy-2-methyl-1-phenylpropan-1-one</b>			
SFN 1 .....	8	25	85
SFN 7 .....	52	>200	—
SFN 8 .....	21	100	>200
SFN 9 .....	65	>200	—
<b>4% 2,4,6-Trimethylbenzoyl-diphenylphosphine oxide</b>			
SFN 1 .....	25	30	80
SFN 7 .....	25	75	>200
SFN 8 .....	13	40	85
SFN 9 .....	30	75	>200

tion of BMO 3 which was based on dodecandioic acid. When rated by the number of formulations giving >200 MEKDRs, the order is BMO 4 > BMO 5 > BMO 2 > = BMO 1 > BMO 3. This order is not related to the functionality, equivalent weight, or viscosity of the oligomer but is roughly the same order observed for decreasing heat distortion temperatures of cast unsaturated polyester systems containing these dicarboxylic acids. It is also interesting that the formulations which give >200 MEK double rubs are not the same for each oligomer and each BMO appears to have its own individual performance maximum in the trilinear plot. This was also observed with linear internally unsaturated polyesters amine-ene systems.<sup>1</sup> This indicates that a different degree of synergistic behavior exists between the three main ingredients of the formulation which depends on the structure of the BMO used.

The pencil hardness data ranges from 4B to HB with SFNs 2 and 3 giving the softest films and SFN 7 yielding the hardest films. Surprisingly, BMO 3 which has the longest carbon chain in the dicarboxylic acid had several formulations with HB hardness. This could be the result of association between the long carbon chains from the dodecandioic acid molecule. The adhesion data seemed to be inversely related to the degree of cure. Formulations which had >200 MEK double rubs had poor adhesion while those with <50 MEK double rubs had good adhesion.

In an effort to compare a predominantly terminal maleate functional BMO system with a linear internally unsaturated polyester we summarized the results from sample B of reference 1 and compared them to those of BMO 5 in Table 5. While sample B has a slightly lower functionality, it also has a lower equivalent weight. In all categories compared, the BMO was better or equivalent to the UPE.

### Thermal Mechanical Analysis

The films of SFN 7 containing four different BMOs were chosen for thermal mechanical analysis. The results are summarized in Table 6. Generally, a glass transition temperature of between 61 and 66°C and an equilibrium modulus of around 5.0 MPa was observed. The crosslink density calculated from this data was on the order of 10<sup>20</sup> crosslinks per cc which is an order of magnitude less than that observed earlier with a linear, internally unsaturated polyester.<sup>1</sup> This suggests that maleate terminated materials would be a little more flexible than the internal maleates.

### Evaluation of Intramolecular Cleavage Photoinitiators

Photoinitiators for free radical polymerization of double bonds can be divided into two groups based on their mechanism of radical formation. These groups consist of intermolecular hydrogen abstraction photoinitiators and intramolecular cleavage photoinitiators. Our previous studies with amine-ene systems have concentrated on common intermolecular hydrogen abstraction photoinitiators.<sup>1,5</sup> It is also known that both aromatic and aliphatic

tertiary amines can be utilized to reduce oxygen inhibition when intramolecular cleavage photoinitiators are used.<sup>6</sup> Three additional photoinitiators were investigated as replacements for benzophenone (BP). Deoxybenzoin (DOB) is unique in that it has been shown to operate by intramolecular cleavage in nonhydrogen-donating solvents and by intermolecular hydrogen abstraction in hydrogen-donating solvents. In fact, it has been shown that tertiary amines are very active in quenching the triplet state of DOB.<sup>6</sup> Both 2-hydroxy-2-methyl-1-phenylpropan-1-one (HMPP) and 2,4,6-trimethylbenzoyldiphenylphosphine oxide (MBPO) are recognized as reactive intramolecular cleavage photoinitiators.<sup>7,8</sup> Low molecular weight amines have been used as oxygen scavengers to promote efficient curing of unsaturated polyesters when MBPO is used as a photoinitiator.<sup>8</sup> A comparison of these photoinitiators with BP using the four Simplex Design Formulations containing BMO 5 is shown in *Table 7*.

The DOB did not improve cure speed at the low dosage (1 J/cm<sup>2</sup>), however, it did exhibit better cure at 3 J/cm<sup>2</sup> than obtained with BP for SFNs 1 and 8. The best cure at 1 J/cm<sup>2</sup> was observed with HMPP which also generally improved the cure speed of SFNs 7, 8, and 9. The MBPO generally did not show improvement over BP in these systems and in the case of SFN 8 appeared to be detrimental to cure. The overall order of reactivity at 1 J/cm<sup>2</sup> is HMPP > BP > MBPO > DOB. Finally, tests of pencil hardness and adhesion revealed no significant advantages could be obtained by changing the photoinitiator.

## CONCLUSIONS

Five oligomers (BMOs) containing predominantly terminal maleate functionality were synthesized and evaluated as components in ultraviolet light curing amine-ene systems. The BMOs and their corresponding coating formulations were somewhat higher in viscosity than previously studied linear unsaturated polyesters. In BMOs designed to have a functionality of four, very little difference in cure speed was observed at 1 J/cm<sup>2</sup> when changing the dicarboxylic acid structure. However, the order of reactivity observed at 3 J/cm<sup>2</sup> as measured by the number

of formulations giving >200 MEK double rubs was BMO 4 > BMO 5 > BMO 2 > BMO 1 > BMO 3. One BMO proved to be better or equal to a linear unsaturated polyester in all categories measured. Thermal mechanical analysis studies indicated that the BMO based formulations had a crosslink density on the order of 10<sup>20</sup> while previous studies showed a formulation with a linear unsaturated polyester had crosslink density of about 10<sup>21</sup>. In an investigation of some intramolecular cleavage type photoinitiators one, 2-hydroxy-2-methyl-1-phenylpropan-1-one (HMPP), appeared to give faster curing coating formulations than benzophenone.

## ACKNOWLEDGMENT

The author would like to thank DSM Desotech, Inc. for the opportunity to publish this research. The author would also like to acknowledge the helpful discussions of S. Lapin and E. Murphy, as well as R. Johnson for obtaining the thermal mechanical analysis data.

## References

- (1) Noren, G.K., "Non-acrylate Curing Mechanisms: Investigation of the Reactivity of Unsaturated Polyesters in the Amine-ene Reaction," RadTech '90-North America, *Radiation Curing Conference and Exposition Proceedings*, Vol. 1, p 191, March 25-29, 1990, Chicago, IL.
- (2) Noren, G.K., Tortorello, A.J., and Vandenberg, J.T., "New Non-Acrylate Free Radical Radiation Cure Technology, New Maleate End-Capped Oligomers," RadTech '90-North America, *Radiation Curing Conference and Exposition Proceedings*, Vol. 2, p 201, March 25-29, 1990, Chicago, IL.
- (3) Pappas, S.P., *J. Radiation Curing*, p 6 (July 1987).
- (4) Sander, M.R., Osborn, C.L., and Trecker, T.J., *J. Polymer Sci., Polymer Chem. Ed.*, 10, 3173 (1972).
- (5) Noren G.K., and Murphy, E.J., "Radiation Curing of Polymeric Materials," *ACS Symposium Series No. 417*, Hoyle, C.E. and Kinstle, J.F. (Eds.) American Chemical Society, Washington, D.C., p 151, 1990.
- (6) Hoyle, C.E., Cranford, M., Trapp, M., No, Y.G., and Kim, K.J., *Polymer*, 29(11), 2033 (1988).
- (7) Ohngemach, J., Neisius, K.H., Eichler, J., and Herz, C.P., *Kontakt-Reagents, Laboratory Chemicals and Methods*, No. 3, 15, 1980.
- (8) Baxter, J.E., Davidson, R.S., and Hageman, H.J., *Eur. Polymer J.*, 24(5), 419 (1988).

# PICTORIAL STANDARDS OF COATINGS DEFECTS

Revised and updated edition of this manual (previously titled "Exposure Standards Manual") has been compiled in conjunction with the American Society for Testing and Materials, and includes definition, description, and photographic standards for each of the following defects: Adhesion; Blistering; Chalking; Checking; Cracking; Erosion; Filiform Corrosion; Flaking; Mildew; Print; Rust; Traffic Paint Abrasion and Chipping.

Also included is reference information on supplementary standards, along with sample record sheets for compiling exposure data.

Bound in handsome 10" × 11½" × 1½" three-ring, vinyl-covered binder which readily accommodates additional material as it is developed.

**Complete manual . . . \$100**  
**Individual Standards . . . \$3 each, plus \$3 for each photograph**  
**Record Sheets (pad of 100 sheets) . . . \$3.50**

*Please make all checks payable in U.S. funds.*

*\*Pennsylvania residents add 6% sales tax.*

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

Federation of Societies for Coatings Technology

# Behavior of Some Anticorrosive Epoxy Polyamide Primers Free of Lead and Chromate and In the Presence of Chloride Ions

A. Ruvolo-Filho and E.S. da Costa  
Universidade Federal de São Carlos\*

---

A series of new generation primers has been developed and characterized by comparative measurements of ionic resistance, salt permeability, and salt absorption. Their utilization as replacements for zinc chromate and red lead in conventional anticorrosive systems is proposed.

---

## INTRODUCTION

Red lead is one of the oldest anticorrosive pigments used for the protection of iron. Red lead ( $2\text{PbO}\cdot\text{PbO}_2$ ) is an orange-red, highly toxic pigment which is reactive in nature when dispersed in linseed oil or other oxidizable medium. Lead soaps are formed by the reaction of PbO and acidic by-products formed during the oxidation processes. These soaps are thought to play an important role in the protection of iron and steel by red lead primers.<sup>2</sup>

Zinc chromate ( $\text{ZnCrO}_4\cdot\text{Zn}(\text{OH})_4$ ) is another anticorrosive pigment used in primers for steel. Although zinc chromate contains very little water-soluble chromate, the metal protection is thought to result from the presence of water-soluble chromate ions inside the primer. Moisture permeating the film carries chromate ions to the metal surface where they induce iron oxide ( $\text{Fe}_2\text{O}_3$ ) formation and become incorporated in the passive iron oxide film.

According to recent toxicological studies,<sup>3-5</sup> zinc chromate and red lead pigments are classified as toxic materials because the former causes dermatitis, skin sensitization, and asthma, and has carcinogenic properties, and

the latter causes lead poisoning and mental retardation in children.

The objective of this investigation was to study anticorrosive pigments with the same performance as zinc chromate and red lead, but without the health and toxicity factors associated with them.

Many types of anticorrosive pigments have been examined during the last seven years in an attempt to substitute for zinc chromate in an effective manner. Several newly developed pigments based on phosphates, phosphites, silicates, and oxides were tested.<sup>4-6</sup> These pigments resist water and salt permeation, and are protective primarily because of a barrier effect.<sup>7</sup>

## EXPERIMENTAL

The experiments described in this work were carried out at 25°C and at least in triplicate to ensure reproducibility.

### Materials and Films Preparation

Eight different primers based on an epoxy polyamide (EPDA) were prepared by Sumaré Indústria Química S.A.—Tintas e Sistemas Anticorrosivos and are shown in Table 1.

In these formulations the free define binder and a ratio  $Q = \frac{\text{PVC}}{\text{CPVC}} = 0,8$  are always the same so the different types of pigments could be compared. The CPVC values were determined by the oil absorption method.

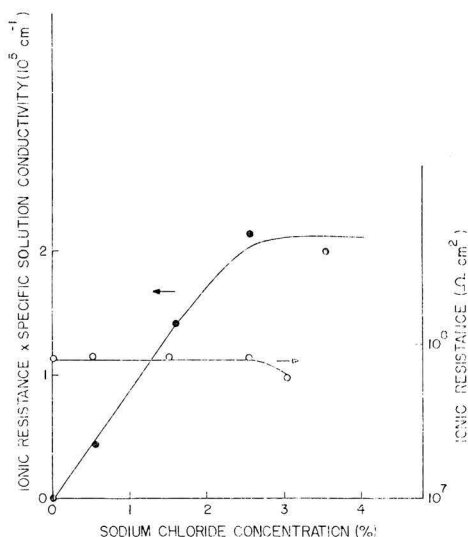
The films were applied either on an iron surface previously treated by sandblasting or on polyester using a doctor blade. The films were kept in a thermostated chamber at 30°C and 50-60% relative humidity for five

---

\*Grupo de Eletroquímica e Polímeros, DQ-UFSCar, Caixa Postal 676, 13560, São Carlos, SP, Brazil.

**Table 1—Epoxy-Polyamide Primers (EPDA)**

No.	Paint System	Thickness Free film (μm)	Applied film (μm)
1.....	EPDA/zinc chromate	127	60
2.....	EPDA/calcium silicate	135	96
3.....	EPDA/iron oxide	155	77
4.....	EPDA/zinc phosphite	150	67
5.....	EPDA/zinc oxide	150	65
6.....	EPDA/red lead	130	83
7.....	EPDA/zinc phosphate	150	98
8.....	EPDA/barium metaborate	150	75
9.....	Pure EPDA	110	114



**Figure 1—Ionic resistances ( $R_i$ ) of EPDA/iron oxide paint system and the product  $R_iK_s$  against the concentration of NaCl solutions. Applied film:  $l = 77 \mu\text{m}$ ;  $A = 15.9\text{cm}^2$ ; and  $T = 25^\circ\text{C}$**

**Table 2—Free Area of Diffusion ( $A_D^0$ ) and Permeability Coefficient ( $P^0$ ) Calculated from Measurements in 3.5% NaCl Solutions and Normalized to a Unit Film Thickness**

No.	Paint System	$A_D^0(\mu\text{m}^2)$	$P^0(\text{cm}^2 \text{ s}^{-1})$	
			Via Ionic Resistance	Via Salt Flux
1...	EPDA/zinc chromate	391.4	$5.9 \times 10^{-13}$	$1.1 \times 10^{-10}$
2...	EPDA/calcium silicate	8.6	$4.4 \times 10^{-14}$	$1.2 \times 10^{-10}$
3...	EPDA/iron oxide	35.1	$1.4 \times 10^{-14}$	$9.7 \times 10^{-11}$
4...	EPDA/zinc phosphite	422	$7.9 \times 10^{-13}$	$1.7 \times 10^{-10}$
5...	EPDA/zinc oxide	712	$1.6 \times 10^{-12}$	$1.2 \times 10^{-10}$
6...	EPDA/red lead	393	$1.1 \times 10^{-12}$	$7.1 \times 10^{-11}$
7...	EPDA/zinc phosphate	—	$6.2 \times 10^{-13}$	$1.2 \times 10^{-10}$
8...	EPDA/barium metaborate	1037	$2.3 \times 10^{-12}$	$1.4 \times 10^{-9}$
9...	EPDA Pure	5.5	$8.4 \times 10^{-14}$	$9.2 \times 10^{-11}$

days in order to ensure cure. Free films were obtained by peeling off the polyester 24 hr after application.

As shown in *Table 1*, the free and applied films had a thickness range between 100 to 150 μm and 60 to 120 μm, respectively. Because the films thickness range is very large, all measurements were normalized to a unit film thickness (pure EPDA as a reference primer) in order to compare the results.

**Measurements**

**IONIC RESISTANCE MEASUREMENTS:** The resistance of the applied films against direct current was measured with a Labo Model FR1515;1.5V;1.5A potential source, and a Keithley Model 642 electrometer current detector in series with the film and the potential source. To avoid polarization, the other electrode used was a platinum wire. The applied potential was 0.5 V and previous tests indicated that around this value a linear current-voltage response exists. The film resistances were in the range of  $10^5$  to  $10^7 \Omega\text{cm}^2$ , while the solution resistances measured without the film were approximately  $10^3 \Omega\text{cm}^2$ . Thus, the total resistance was considered equal to the film resistance.

These experiments were carried out in NaCl solutions of various concentrations (0-3.5% W/W).

The value of the equilibrium ionic resistance was obtained after seven to 10 days.

**PERMEABILITY MEASUREMENTS:** The free paint films were held between two compartments of nylon cells; these compartments could be pressed against each other causing the paint film to act as a diaphragm separating the two halves of the cell.

The permeability of NaCl, in terms of flux, was determined by filling one of the cell compartments with 3.5% NaCl solution. The other compartment was filled with distilled and deionized water having a conductance less than  $2.10^{-6} \text{ S}\cdot\text{cm}^{-1}$ . The amount of NaCl diffusing through the film was established by conductivity measurements of the water in the compartment originally containing pure water. The conductivity cell consisted of two closely spaced plates of platinum in the water compartment. The cell constant was about  $0.101\text{cm}^{-1}$ .

It was possible to detect less than 0.015% of diffused NaCl. The steady state NaCl flux took 5 to 100 hr to be established.

The film was conditioned in water for three days prior to the measurements.

**WATER CONTENT MEASUREMENTS:** The water absorbed by the paint films was determined after the equilibrium of the free-film samples in the NaCl solutions was reached. The film was dried at  $100^\circ\text{C}$  and the amount of water (as a percentage of the dry film weight) was calculated. Previous tests indicated that the drying temperature did not affect, in the experiment time, the thermal stability of the binder. The film samples were weighed on a Mettler H-20 balance. The equilibrium and desorption times were 20 days at  $25^\circ\text{C}$  and 40 hr at  $100^\circ\text{C}$ , respectively.

**CHLORIDE ION CONCENTRATION INSIDE THE FILMS:** The chloride ion concentration in the film was measured after

the free-film samples in NaCl solutions reached equilibrium. After 20 days, the paint-film samples were removed from the solution, the surface washed with distilled and deionized water, quickly blotted between sheets of filter paper, and then immersed in distilled and deionized water in order to promote ion desorption. The measurements of the desorbed ions concentration was made by a selective chloride electrode. The salt concentrations inside the film were calculated by using the water amount absorbed.

## RESULTS AND DISCUSSIONS

Figure 1 shows typical curves of stationary-ionic resistance ( $R_i$ ) and of the product  $R_i K_s$  (where  $K_s$  is the specific conductivity of the solution) as a function of the concentration of NaCl solutions for applied films.

From this figure, it was possible to calculate a hypothetical cell constant by extrapolating  $R_i K_s$  values for high concentrations of NaCl solutions and then a free area of diffusion ( $A_d$ ) using the thickness of the film. These values, normalized to an unit film thickness ( $A_d^0$ ), are given in Table 2 for all paint films studied.

The behavior presented in Figure 1 is the same for all paint films studied. The constant value of  $R_i$  with external salt concentration is a typical behavior and is related to that of a charged membrane, with almost constant  $R_i$  until the external salt concentration is great enough to overcome Donnan exclusion. Therefore,  $R_i$  decreases with the salt concentration. This interpretation is supported by the fact that the measured concentration of positive fixed charges in pure EPDA<sup>8</sup> was 0.2 meq/g of polymer at pH = 6.5.

At this stage, and based on the values of  $A_d^0$  in the range of 8.6 to 1037  $\mu\text{m}^2$  for the primers containing pigments, it is plausible to determine the main contribution of these pigments in the paint formulation, if the value of  $A_d$  found for the EPDA pure was only 5.5  $\mu\text{m}^2$ .

A possible interpretation is that the free area for diffusion is not concentrated in a single diffusion channel but rather due to a large number of small microvoids throughout the film area. These microvoids could be concentrated in the interface between binder and pigment, and an increase would be directly related to the degree of interaction (wetting) between the binder and the pigment.

Taking into account all the results discussed, if ionic transport takes place through microvoids flooded by the external salt solution, it would be expected that ionic conductivity would yield a value of the permeability coefficient ( $P_i$ ) close to the observed value employing the Nernst-Einstein relationship.<sup>9,10</sup> The calculated and normalized values ( $P_i^0$ ) obtained either via permeability experiments (using the measured salt flux) or employing the Nernst-Einstein relationship (using the measured ionic resistance) are shown in Table 2.

Figure 2 illustrates a typical curve of permeability experiments through free films.

As shown in Table 2, the calculated values of permeability coefficient ( $P_i^0$ ) from measured ionic resistance were 10 to 10,000 times smaller than those observed in the permeability experiments. The fact that the Nernst-Einstein relationship does not hold in this case is evidence

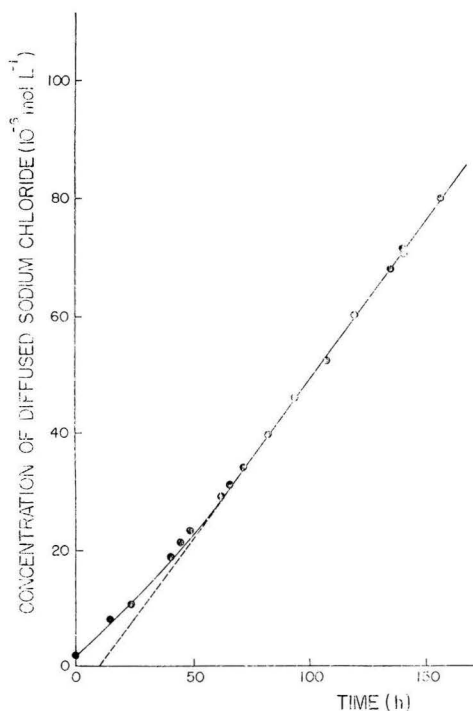


Figure 2—Sodium chloride concentration ( $C_{\text{NaCl}}$ ) diffused through EPDA/zinc phosphate against time. Free film: 1 = 150  $\mu\text{m}$ ; A = 17.4  $\text{cm}^2$ ; and T = 25°C

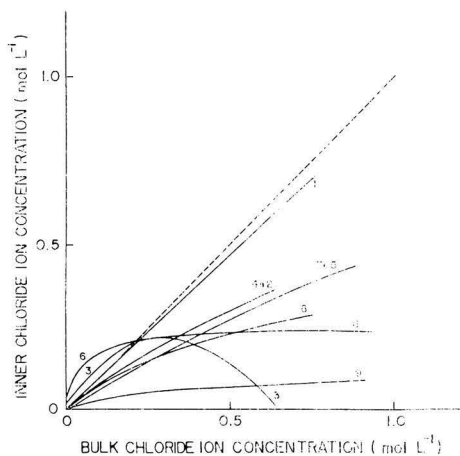
in favor of the view that there must be a strong interaction between the charged epoxy matrix either with the diffusing species or the external electric field.<sup>10</sup> At present, it is not possible to distinguish between these two alternatives, because the heterogeneous nature of the paint films makes quantitative comparison possible only within the same film section.

Taking into account these interpretations and the measurements of the free area for diffusion and the permeability coefficients, it is possible to make a first qualitative prediction for the anticorrosive behavior of the paint systems. Film performance, in decreasing order is: 2,3,7 > 5 > 1,4,6 > 8.

Figure 3 illustrates the chloride ions concentration inside the free films ( $\bar{C}$ ) against its concentration in the bulk (C) for all paint systems studied. In order to compare these results with those of a film without exclusion and pigments, a dashed line representing the first and the results obtained for pure EPDA were added in Figure 3.

The fact that the partition coefficient ( $K = \bar{C}/C$ ) is between 0.1 and 1.0 is clear evidence that there is a Donnan exclusion. This means that the amount of the fixed charge in the epoxy matrix does not affect the amount of charge of the chloride ion content. The higher values of  $\bar{C}$  for paint systems when compared to that of





**Figure 3—Inner chloride ion concentration (C) against bulk chloride ion concentration (C) for free films of epoxy primers. Numbers on the lines correspond to the paint system of Table 1. The dashed line corresponds to a theoretical result for a film without exclusion**

pure EPDA seem to be evidence in favor of the view that the inner salt concentration is related to the microvoids concentration in the interface between binder and pigment. When comparing these results with those of ionic resistance (see Figure 1), the shift from a straight line, without Donnan exclusion, could be attributed to the fact that while the equilibrium time of chloride was 20 days the experimental extraction time was only 10 days.

An interesting phenomenon that shows the results of Figure 3 is that in the specific case of the EPDA/iron oxide system the inner chloride concentrations increase up to a bulk chloride concentration of  $0,3 \text{ mol}^{-1}$ , and decrease for higher values. A possible interpretation for this phenomenon could be related to the specific interaction between the iron oxide and the absorbed water,

resulting in insoluble products which could reduce the water activity inside the film, and then the ion solubility.

Finally, another important and qualitative result could be detected by direct observation after 30 days of the exposed area of the applied films which remained immersed in the different salt concentrations where the ionic resistance measurements were made. The results in terms of corrosion are shown in Table 3.

Based on all the results present and discussed, an expected anticorrosive behavior for these alternative primers systems is proposed. The film performance decreasing order is  $3,7,5 > 2 > 6,1,4 > 8$ .

**CONCLUSIONS**

(1) Based on the results obtained via ionic resistance permeability and ion absorption measurements, a new generation of primers with promising use in anticorrosive systems can be obtained by replacing conventional systems containing zinc chromate and red lead. In order, they are as follows: EPDA/iron oxide, EPDA/zinc phosphate, EPDA/zinc oxide, and EPDA/calcium silicate.

(2) The presence of heterogeneities in paint systems seems to be a general feature of paint films and a likely cause of deterioration of the coatings.

(3) This work indicates the need for further study of the chemical stability of iron oxide pigments in electrolyte solutions, in order to obtain quantitative information.

These measurements must be performed either with the films in equilibrium with the liquid medium, if its results are intended to explain the protective paint function for immersed structures, or in environments with higher humidity.

**References**

- (1) Patton, T.C. (Ed.), *Pigment Handbook*, Vol. 1, John Wiley & Sons, New York, pp 838-839, 1973.
- (2) Morgans, W.M., *Outlines of Paint Technology Materials*, 2nd Ed., Vol. 1, Charles Griffin, England, pp 95-96, 1982.
- (3) Gomoa, A.Z. and Gad, H.A., *J. Oil & Colour Chemists' Assoc.*, 2, 50 (1988).
- (4) Adrian, G. and Bittner, A., "Second Generation Phosphate Anti-Corrosive Pigments. Formulating Rules for Full Replacement of the New Anti-Corrosive Pigments," *JOURNAL OF COATINGS TECHNOLOGY*, 58, No. 740, 59 (1986).
- (5) Brady, R.F. Jr., Field, D.E., Griffith, J.R., and Love, K.S., "Nontoxic Alternatives to Antifouling Paints," *JOURNAL OF COATINGS TECHNOLOGY*, 59, No. 755, 113 (1987).
- (6) Bittner, A., "Advanced Phosphate Anticorrosive Pigments for Compliant Primers," *JOURNAL OF COATINGS TECHNOLOGY*, 61, No. 777, 111 (1989).
- (7) Biegańska, B., Zubielewicz, M., and Śmieszek, E., *Prog. Org. Coat.*, 16, 219 (1988).
- (8) Ruvolo-Filho, A., Ribeiro da Silva, D., and D'Alkaine, C.V., *Proceedings 10th International Congress on Metallic Corrosion*, Madras, India, p 1207, 1987.
- (9) Robinson, R.A. and Stokes, R.H., *Electrolyte Solutions*, 2nd Ed. Butterworths, London, 1959.
- (10) Lakshminarayanaiah, N.K., "Electrochemistry," *Specialist Periodical Report*, Vol. 5, The Chemical Society, 1972.

**Table 3—Corrosion Observations of the EPDA Primers after 30 days of Immersion in Sodium Chloride Solutions**

No.	Paint System	Corrosion
1. ....	EPDA/zinc chromate	CA <sup>a</sup>
2. ....	EPDA/calcium silicate	NC <sup>b</sup>
3. ....	EPDA/iron oxide	NC
4. ....	EPDA/zinc phosphite	CA
5. ....	EPDA/zinc oxide	NC
6. ....	EPDA/red lead	CA
7. ....	EPDA/zinc phosphate	PPC <sup>c</sup>
8. ....	EPDA/barium metaborate	CA
9. ....	EPDA Pure	PPC

(a) CA: corrosion generalized.  
 (b) NC: absent of corrosion.  
 (c) PPC: few corrosion points.

# Society Meetings

## BIRMINGHAM ..... NOV.

### "Tioxide and the Environment"

David Moulton, of Tioxide (Europe) Ltd., presented the meeting's technical talk. His topic was "TIOXIDE AND THE ENVIRONMENT."

The speaker reviewed the sulphate and chloride processes, the two main reactions used in the production of titanium dioxide. He discussed the types and amounts of by-products produced.

Mr. Moulton stated that the dumping of solid by-products, via pipeline, below the low water mark at sea, has been reduced significantly. Also, he noted that the pipeline has been lengthened. The speaker said the majority of by-products are sold off.

*Q. Is the chloride process ousting the sulphate process technically?*

A. It depends on your point of view. Tioxide is increasing chloride process capacity worldwide, because it can give a slightly whiter product. Also, we can make a profit from selling the by-products.

DAVID C. MORRIS, *Secretary*

## CLEVELAND ..... NOV.

### "Good Tests-Bad Testing"

Technical Committee Chairman Ben J. Carlozzo, of Mameco International, announced that the Society had won First Prize (\$450) in the A.F. Voss/*American Paint and Coatings Journal* Award competition for the paper, "Changes in Hiding During Latex Film Formation—Part V: Effect of Opaque Polymer." Mr. Carlozzo presented the \$450 check to President Roy A. Glover, of The Mahoning Paint Corporation.

Members of the Technical Committee were recognized for their contribution to the Society's paper. Receiving Certificates of Merit were: Jeff Andrews, of Montana Products; Freidun Anwari, Philip Slifko, and Walter I. Stipkovich, of Coatings Research Group, Inc.; Mr. Carlozzo; Kalpesh Chokshi; Mark S. DiLorenzo, of Engelhard Corporation; Norm Headlow; Carl Knauss, of Kent State University; Joseph F. McCarthy, of Plasti-Kote Company, Inc.; Rene A. Patterson, of The Sherwin-Williams Company; Phil Rozick, of Day-Glo Color Corporation; John Weaver, of Case Western Reserve University; and Michael A. Wolfe, of Seegott, Inc.

Mr. Carlozzo announced that any questions or nominations concerning the Tech-

nical Achievement Awards (2) and the Annual Distinguished Service Award should be directed to him.

The videotape, "Good Tests-Bad Testing," prepared by the New York Society, was presented. The tape began with an introduction by Richard Himics, of Daniel Products Company. The speaker on the tape was Saul Spindel, of D/L Laboratories.

According to Mr. Spindel, the purpose of the video was "to stimulate an awareness for the need to perform tests carefully and in accordance with specified methodology."

From the tests presented, it was concluded that the industry as a whole does not adhere to test procedures. To improve test procedures, the following recommendations were made: (1) Read and follow test procedures, exactly as written; (2) Calibrate laboratory instruments on a regular schedule; (3) Maintain instruments; and (4) Participate in a proficiency program.

CONSTANCE F. WILLIAMS, *Secretary*

## HOUSTON ..... NOV.

### "Titanium Dioxide"

The meeting's technical presentation was delivered by Juergen H. Braun, of Dupont Chemicals. His talk focused on "TITANIUM DIOXIDE'S CONTRIBUTION TO THE DURABILITY OF PAINT FILMS."

The speaker discussed the titanium dioxide dilemma, chalking mechanisms, chalking chemistry, chalking control, and durability testing.

Dr. Braun stated that titanium dioxide is the best white pigment. Titanium dioxide possesses the best scattering power and the highest refractive index of pigments known to man. In addition, he said that titanium dioxide happens to be a catalyst for degradation of paint films.

The speaker noted that ultraviolet (UV) is the only degrading portion of light due to the energy of the photon. UV can break chemical bonds where infrared and visible light cannot. According to Dr. Braun, this breakage is usually irreversible.

He reviewed how titanium dioxide protects paint films by UV absorption, and how it transfers UV energy to water and oxygen through the generation of free radicals.

Dr. Braun also discussed control of chalking and how the understanding of the mechanism of failure has outpaced the ability to measure durability.

*Q. How tight is silica shell bonded to titanium dioxide?*

A. Silica shell is bonded extremely tightly. Standard paint grinding techniques cannot displace this shell. One can increase durability by a factor of 10 by switching from anatase to rutile grades. Encapsulation increases durability by a factor of five.

*Q. How well do the new zirconia surface treatments perform?*

A. These types of treatments do not work as well as the silica encapsulation.

THOMAS W. FITZGERALD JR., *Secretary*

## HOUSTON ..... DEC.

### "Surface Smoothness"

Becky Butler, of BYK-Gardner, Inc., presented a talk on "SURFACE SMOOTHNESS AND ITS INFLUENCE ON PAINT APPEARANCE, HOW TO MEASURE AND CONTROL IT."

Ms. Butler stated that the surface appearance of a coating is especially important in the automotive industry. She said the problems with coatings are significant due to the wide variety of substrates used, such as, sheet metal, plastic, and steel. Many of the substrates have different profile charac-



DETROIT SOCIETY OFFICERS (from left)—Scot J. Westerbeek, Latoska Price, Ron Andrus, and Jane Allen

## Constituent Society Meetings and Secretaries

BALTIMORE (Third Thursday—Martins West, Baltimore, MD). HELENE J. RANFONE, Duron, Inc., 10460 Tucker St., Beltsville, MD 20705.

BIRMINGHAM (First Thursday—Strathallan Hotel, Birmingham, England). D.C. MORRIS, PPG Industries (UK) Ltd., P.O. Box 359, Birmingham, B16 0AD, England.

CDIC (Second Monday—Location alternates between Columbus, Cincinnati, Dayton, and Indianapolis). JEFFERY I. BUCHMAN, Akzo Coatings, Inc., P.O. Box 147, Columbus, OH 43216-0147.

CHICAGO (First Monday—Sharko's Restaurant, Villa Park, IL). NATU C. PATEL, Ace Hardware Corp., Paint Div., 21901 S. Central Ave., Matteson, IL 60443.

CLEVELAND (Third Tuesday—Brown Derby, Independence, OH in Nov., Mar., and Apr.; Cleveland Hilton, Cleveland, OH, in Feb.; Landerhaven, Mayfield Heights, OH, in May). CONSTANCE F. WILLIAMS, The Glidden Co., 801 Canterbury Rd., Westlake, OH 44145.

DALLAS (Thursday following second Wednesday—Holiday Inn Crowne Plaza, Dallas, TX). BENNY PUCKETT, Kelly-Moore Paint Co., Inc., 301 W. Hurst Blvd., Hurst, TX 76053.

DETROIT (Second Tuesday—meeting sites vary). JANE ALLEN, Reichhold Chemicals, Inc., 814 Commerce Dr., Oakbrook, IL 60521.

GOLDEN GATE (Monday before third Wednesday—alternates between Francesco's in Oakland, CA, and Holiday Inn in S. San Francisco). RICHARD COOPER, Synergistic Performance Corp., 5801 Christie Ave., #590, Emeryville, CA 94608.

HOUSTON (Second Wednesday—Hobby Airport Hilton, Houston, TX). TOM FRITZGERALD, Monarch Paint Co., P.O. Box 55604, Houston, TX 77255.

KANSAS CITY (Second Thursday—Cascone's Restaurant, Kansas City, MO). LAWRENCE J. MURPHY, Tnemec Co. Inc., 123 W. 23rd Ave., N. Kansas City, MO 64116.

LOS ANGELES (Second Wednesday—Steven's Steakhouse, Commerce, CA). JOHN C. KULNANE, Ameritone Paint Corp., 18414 S. Santa Fe Ave., P.O. Box 190, Long Beach, CA 90801.

LOUISVILLE (Third Wednesday—Executive West Motor Hotel, Louisville, KY). WILLIAM LEIGHTNER, C.L. McGuire & Co., 8134 Newlagrange Rd., Louisville, KY 40222.

MEXICO (Every fifteen days—Gabriel Mancera, Mexico City, Mexico). SERGIO ROJAS, Pinturas International, S.A. De C.V., Ganaderos 234, Col. Granjas Esmeralda, 09810 Mexico, D.F., Mexico.

MONTREAL (First Wednesday—Le Bifhèque Steakhouse, Ville St. Laurent, Quebec). ESTHER ROULEAU MCCARTHY, Stochem Inc., 1455 32nd Ave., Lachine, Que. H8T 3J1, Canada.

NEW ENGLAND (Third Thursday—Sheraton Lexington Hotel, Lexington, MA, and other locations in Massachusetts and Rhode Island). CHARLES SHEARER, ICI Resins US, 730 Main St., Wilmington, MA 01887.

NEW YORK (Second Tuesday—Landmark II, East Rutherford, NJ). GEORGE M. AMRICH JR., Benjamin Moore & Co., 134 Lister Ave., Newark, NJ 07105.

NORTHWESTERN (Jax Cafe, Minneapolis, MN). MICHAEL GRIVNA, Hirschfield's Paint Mfg., Inc., 4450 Lyndale Ave., N., Minneapolis, MN 55412.

PACIFIC NORTHWEST (PORTLAND SECTION—Third Tuesday; PUGET SOUND SECTION—Third Wednesday; VANCOUVER SECTION—Third Thursday). JOHN WESTENDORF, Lipscomb Chemical Northwest, 2627 NW Nicolai, Portland, OR 97210.

PHILADELPHIA (Second Thursday—Williamson's Restaurant, GSB Bldg., Bala Cynwyd, PA). ROBERT D. THOMAS, M.A. Bruder & Sons, Inc., 52nd & Grays Ave., Philadelphia, PA 19143.

PIEDMONT (Third Wednesday—Ramada Inn Airport, Greensboro, NC). DALE BAKER, Kohl Marketing, Inc., 3859 Battleground Ave., Ste. 203, Greensboro, NC 27410.

PITTSBURGH (Second Monday—Montemurro's Restaurant, Sharpsburg, PA). MARK A. HARLEY JR., PPG Industries, Inc., 4325 Rosanna Dr., P.O. Box 9, Allison Park, PA 15101.

ROCKY MOUNTAIN (Monday following first Wednesday—Zangs Brewery, Denver, CO). CHRISTINE LES-CAMELA, Luzenac America, Inc., 8985 E. Nichols Ave., Englewood CO 80112.

ST. LOUIS (Third Tuesday—Salad Bowl Cafeteria, St. Louis, MO). CHUCK REITTER, American Paint Journal Co., 2911 Washington Ave., St. Louis, MO 63103.

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). JEFF SHUBERT, Shubert Paints, Inc., 2157 Mountain Industrial Blvd., Tucker, GA 30084.

TORONTO (Second Monday—Cambridge Motor Hotel, Toronto). BOB C. NG, Hoechst Canada Inc., 100 Tempo Ave., Willowdale, Ont. M2H 2N8, Canada.

WESTERN NEW YORK (Third Tuesday—meeting sites vary). MARKO MARKOFF, 182 Farmingdale Rd., Cheektowaga, NY 14225.

teristics. The speaker discussed some of these characteristics.

An explanation of the theories behind surface appearance was presented. Also, Ms. Butler talked about a new orange peel meter which is used to measure surface smoothness.

THOMAS W. FITZGERALD, *Secretary*

## NEW YORK .....NOV.

### "ISO-9000"

Technical Committee Chairman Larry Waelde, of Troy Corporation, announced that the Society will be conducting a two-day technical symposium.

In other news, Mr. Waelde announced that two of the Technical Subcommittees are approaching completion of their testing procedures which will go into the technical writing phase, for publication next year.

Environmental Affairs Committee Chairman Sidney J. Rubin, of Empire State Varnish Company, Inc., said the Society and the MYNPCA was planning a small (25-30 people) seminar on HMI181.

The meeting's technical presentation was given by R.J. Scanlon, of Kemira, Inc. His topic of discussion was "ISO-9000."

It was noted that the ISO-9000 system is a quality management system comprised of five standards, ISO-9000 through ISO-9004. Mr. Scanlon said that companies certified for ISO-9000 are actually certified under ISO-9001, 9002, or 9003.

The speaker gave a brief history of the ISO-9000 system.

Mr. Scanlon said that the ISO-9000 system is for managing business. The system is based on two fundamental principles: do things right the first time and make quality.

According to the speaker, to make the ISO-9000 system work, management has to be totally committed to it. The standards deal with systems, which must be documented, written procedures. Workers that are trained in the ISO-9000 system must be documented to show what they are doing. Each worker must know what their job is, and there must be internal and external audits.

Mr. Scanlon explained the differences between the three different certification standards. The ISO-9001 system is very comprehensive and covers a lot of areas. ISO-9002 deals with procurement, manufacturing, total quality control, and shipments. The ISO-9002 system is the most commonly used of the certification standards. ISO-9003 is used primarily by people involved in simple manufacturing and minor assembling.

In conclusion, the speaker stated that the ISO-9000 system is a "write what you do and make sure you do it system."

*Q. How much does certification cost?*

A. It depends on the size of the organization. For example, Kemira's whole cost for one single plant will be over \$100,000. Ongoing costs will be much less.

*Q. How long does certification take? Were your own people involved in the writing procedures?*

A. Kemira has one full-time individual that is in charge of the operation. The person also coordinates that operation with part-time personnel. The certification process will take approximately three years.

GEORGE M. AMRICH JR., *Secretary*



**MEXICO SOCIETY OFFICERS (from left)—Standing: Jorge Esquivel, Sergio Rojas, Eduardo Aviles, and Jorge Hijuelos Jr. Seated: Gustavo Vero, Lucio Huerta, Martha Colin, Julieta Lucio, and Raquel Cortes**

## NEW ENGLAND ..... NOV.

### *"Rheological Additives"*

The meeting featured two speakers. The first talk was given by Ellen Kaplan, of New England Memorial Hospital/Center for Health Promotion, who discussed "STRESS MANAGEMENT."

The speaker began by defining two types of stress: eustress or positive stress, and distress or negative stress.

According to Dr. Kaplan, the key to stress management is to turn around the way we look at stressors, or the events which cause stress. Attempting to find positive aspects of the negative stressors is a technique which can be used, and is referred to as cognitive restructuring.

Also discussed were other methods of reducing stress at work and home, including: setting goals, prioritizing time, personal growth, and relaxation response.

The evening's technical presentation was delivered by Wayne N. Coffey, of United Catalysts, Inc., who spoke on "RHEOLOGICAL ADDITIVES FOR COATINGS." Mr. Coffey is a member of the Louisville Society.

The speaker reviewed common rheological terms, definitions, and equations. This was followed by a discussion on organoclays as rheological modifiers.

Mr. Coffey talked about conventional organoclays. He said the three important factors to consider when working with organoclays are: the polar activator, the order of addition, and the shear environment. A description of the second generation organoclay, the "self-activating" organoclays, was given. An explanation of castor-based thixotropes was presented.

Mr. Coffey concluded his presentation with a review of anti-settling agents as a separate type of rheological additive.

*Q. What impact do organoclays have on storage stability of a paint?*

A. Organoclays are very stable in most paint systems. Paints made with castor derivatives, however, must be stored away from heat, or seeding will be a problem.

WILLIAM LEIGHTNER, *Secretary*

Two presentations were scheduled for the meeting. The first was "OPTIMIZING MATERIAL DEVELOPMENT THROUGH TEST PANEL SELECTION," by Ronald J. Swinko, of Advanced Coating Technology. Mr. Swinko is a member of the Detroit Society.

The speaker talked about the properties of test panels and what they are used for. He said the test panels are used to qualify coatings. In addition, testing procedures are designed to duplicate field results and highlight a particular quality. Also, Mr. Swinko reported that the panels are standardized and prepared in a controlled process, which includes identifying the key factors that influence performance. Standardized panels provide consistent performance and can be a reference point for data analysis.

According to the speaker, the substrate, as well as the pretreatment, affect end performance. He stated that the substrate must represent the real world in properties such as cleanliness, roughness, and hardness with consistent performance. The pretreatment concerns are as follows: alloy composition, purity, coating weight, and surface condition as far as oxidation and porosity. The substrate and the pretreatment both interact with the coating system. Mr. Swinko said together the substrate and pretreatment dictate the coating structure, crystal structure, and performance profile.

In conclusion, the speaker reviewed the various types of pretreatments.

The second presentation was by Neil Hailstone and Timothy Herwig, of the University of Minnesota YMCA. Their talk was entitled "CORPORATE SOCIAL RESPONSIBILITY/METRO INTERNSHIP PROGRAM."

It was explained that the Metro Internship Program places 25 students annually in a 10-week seminar on ethics, leadership, and power organizations. The seminar is followed by a 10-week internship.

The objective of the program is to explore personal, social, and organizational ethics while being a responsible member of a group contributing towards a common goal.

MICHAEL GRIVNA, *Secretary*

## NORTHWESTERN ..... NOV.

### *"Optimizing Material Development"*

Society member James W. Alseth, of Hüls America, Inc., presented the President's Gavel to Joseph Wirth, of Consolidated Container Corporation.



**KANSAS CITY SOCIETY OFFICERS (from left)—Norman Hon, Craig Hughes, Yvonne D'Arcy, Lawrence J. Murphy, and William Porter**

**NORTHWESTERN ..... DEC.**

**"Alternatives to Dioctyl Phthalate"**

Environmental Affairs Committee Chairman Mark Uglem, of Hirschfield's Paint Mfg., Inc., updated the Society on Paint Council activities. His topics included the Solid Waste Management focus group, the Department of Public Health rules on lead, the Federal HP 334 Housing and Redevelopment Bill, and the Ohio Referendum.

The meeting's first speaker was Philadelphia Society member Harold Haag, of Aqualon Company. His topic was "ALTERNATIVES TO DIOCTYL PHTHALATE IN A NITROCELLULOSE LACQUER."

The speaker compared 13 alternate plasticizers as replacements for dioctyl phthalate in a wood lacquer comprised of nitrocellulose, coconut oil alkyd, modified rosin ester, and dioctyl phthalate. Replacement levels versus dioctyl phthalate required to pass 20 cold-check cycles on birch veneer plywood were established, and the overall relative performance of each of the alternate plasticizers was discussed.

In conclusion, Mr. Haag said when evaluating plasticizer migration, all of the alternatives performed similar or better than dioctyl phthalate.

The second speaker was Dian Emerson, of the Minnesota Horticulture Society, who spoke on, "PRIVATE EDENS: THE BEST GARDENS IN MINNESOTA."

MICHAEL GRIVNA, *Secretary*

**PHILADELPHIA ..... NOV.**

**"Corrosion Resistant Emulsions"**

It was announced that Membership Committee Chairman A. Marshall Jones III, of Van Horn, Metz & Company, Inc., has been awarded the Society Membership Award (200-300 members) for increasing membership 11%. The award was presented during the FSCT Annual Meeting on October 21-23, 1992, in Chicago, IL.



**PHILADELPHIA SOCIETY OFFICERS (from left)—Standing: A. Marshall Jones III, Julio I. Aviles, Patricia M. Peterson, Thomas G. Brown, J. Richard Kiefer Jr., Howard J. Salmon, and Neil R. Shearer. Seated: Lawrence J. Kelly, Robert D. Thomas, J. Brian O'Connor, William J. Fabiny, Barrett C. Fisher III, and Wayne A. Kraus**

In addition, it was announced that J. Brian O'Connor, of McWhorter, Inc., was awarded First Prize in the Society Secretaries Award competition.

The technical presentation was delivered by Mike Wildman, of McWhorter, Inc.. His topic was "NEW GENERATION HIGH GLOSS, CORROSION RESISTANT EMULSIONS."

The speaker spoke about Aquamac 700, including its properties and some of the findings of the testing program during its development.

According to Mr. Wildman, during the development of Aquamac 700, it was determined that drop-in resin replacements rarely were successful. During these studies, the competitive resins were exposed using the manufacturer's recommended formula. The studies provided evidence that salt spray performance is dependant on the film thickness. Also, data from a thickener evaluation indicated that cellulosic thickeners are detrimental to performance.

The speaker said that prohesion tests tend to correlate better with exterior exposure than salt spray tests do. Also, he stated that while most of the work with Aquamac 700 to date has been in high gloss systems, results from a PVC study indicate that small particle size calcium carbonate extenders perform best in the salt spray tests.

In conclusion, Mr. Wildman said there are recommended starting point formulations available for gloss spray topcoat, primer, and gloss brush/roll systems.

ROBERT D. THOMAS, *Secretary*

**PHILADELPHIA ..... DEC.**

**"Corrosion Properties of Coatings"**

New York Society member Edward W. Orr, of BYK-Chemie USA spoke on "IMPROVEMENT OF CORROSION PROPERTIES OF COATINGS USING WETTING AND DISPERSION ADDITIVES."

The structural and functional characteristics of available additives that enhance performance were divided into groups and discussed. Also, the speaker defined some of the terms used in the field, and talked about environmentally preferred pigments. It was explained that most of the effective additives were neutral or anionic and are controlled flocculants. Most of the additives are present in the 0.5-2.5% range by weight. Mr. Orr commented that the polycarboxylic acid types seem more often than not to show significant reduction of corrosion in salt spray evaluations.

Also, the speaker pointed out that the pigment-resin-additive complexes were key elements for improving performance.

*Q. Why does performance decrease at higher levels of additives?*

A. Unoccupied pigmentary adhesion sites disappear at a logarithmic rate not a linear rate. Consequently, the proper levels are very system specific and need to be determined on a case to case basis.

*Q. Did you only use salt spray evaluations to assess the performance?*

A. Some outdoor exposures are in progress now, but it is too early to make any conclusions from them. It is important to choose the most appropriate test for the product being investigated.

ROBERT D. THOMAS, *Secretary*



**NORTHWESTERN SOCIETY OFFICERS (from left)—Joseph Wirth, Sarah E. Oebser, Michael Grivna, and Harold H. Christhill**

**PIEDMONT .....OCT.**

**"Natural Iron Oxides"**

Herbert J. Zaborsky, of Hoover Color Corporation, presented a talk entitled "NATURAL IRON OXIDES AND MINED PIGMENTS." Mr. Zaborsky is a member of the Southern Society.

According to the speaker, world mine production of pigment ores is approximately 300,000 metric tons with consumption in the U.S. about 50,000 metric tons.

Mr. Zaborsky explained that natural iron oxide pigments are derived from limonite, hematite, and magnetite ores. From these ores the following products are derived: limonite—ochre, sienna, and umber pigments; hematite—natural red oxides, metallic browns, and red ochre; and magnetite—natural black iron oxide.

It was noted that over the past four years, significant quality improvements in color consistency, strength, and dispersibility have been achieved by manufacturers of these pigments. As a result, new areas of application have been expanded.

DALE BAKER, *Secretary*

**PIEDMONT .....NOV.**

**"Metal Sulfonates"**

The meeting's technical presentation was given by New York Society member Benjamin J. Dent, of King Industries, Inc. His topic was "THE EFFECT OF METAL SULFONATES ON THE CORROSION RESISTANCE AND OTHER PROPERTIES OF INDUSTRIAL COATINGS."

The focus of the talk was on corrosion resistant coatings for the protection of metal substrates. According to Mr. Dent, there are four essential elements for rusting of metal substrates: anode (for oxidation), cathode (for induction of oxygen and water), electrolyte (water or moisture), and conductor (metal substrate).

The speaker stated that hydrophobic metal sulfonates in coatings are effective in preventing corrosion without negative effects regarding toxicity. A comparison of panels utilizing combinations of barium salts, calcium salts, zinc salts, and magnesium salts in various formulas was provided.

DALE BAKER, *Secretary*

**ST. LOUIS ..... NOV.**

**"Low Molecular Weight Diols"**

Chicago Society member Patrick Gorman, of Hüls America, Inc., presented the Hüls Gavel to President Dennis Cahill, of Archway Sales.

It was announced that Michael Van De Mark, of University of Missouri-Rolla, received the First Prize in the Society Speaker Award competition at the FSCT Annual

Meeting, on October 21-23, 1992, in Chicago, IL.

Mr. Cahill noted that plans are underway for the joint annual meeting of the Kansas City and St. Louis Societies, in June, at Lake of the Ozarks, MO.

Members of the committee responsible for putting the event together include: Chairman Michael Schnurman, of Kop-Coat Carboline; Mr. Cahill; Terry Gelhot, of Carboline Company; James McKittrick, of Archway Sales; Jim Mitchell, of Mozel, Inc.; Robert B. Phelps, of P.D. George Company; Chuck Reitter, of American Paint Journal Company; and Lou L. Voit, of Cemsac Chemicals Corporation.

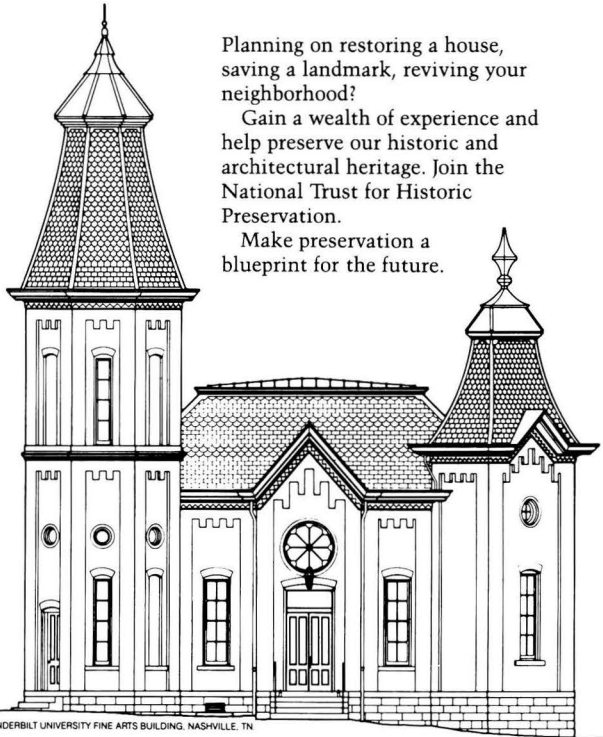
The meeting's technical speaker was New York Society member Richard Shain, of King Industries, Inc. His topic was entitled, "LOW MOLECULAR WEIGHT DIOLS FOR HIGH SOLIDS COATINGS."

According to the speaker, the reasons for the popularity of high solids are regulations and the costs of solvents and energy.

The four major requirements of high-solids resins, low molecular weight, a narrow molecular weight distribution, solubility and compatibility, and a large amount of crosslinking, were discussed. Also reviewed were two materials: a polyester diol and a polyurethane material. The benefits of each of the materials were examined.

CHUCK REITTER, *Secretary*

# PRESERVATION PLAN ON IT



VANDERBILT UNIVERSITY FINE ARTS BUILDING, NASHVILLE, TN

Planning on restoring a house, saving a landmark, reviving your neighborhood?

Gain a wealth of experience and help preserve our historic and architectural heritage. Join the National Trust for Historic Preservation.

Make preservation a blueprint for the future.

Write:



**National Trust for Historic Preservation  
Department PA  
1785 Massachusetts Ave., N.W.  
Washington, D.C. 20036**

# Future Society Meetings

## Baltimore

(Apr. 15)—Educational Committee. Nominations.

(May 20)—Manufacturing Committee. Elections.

## Birmingham

(Apr. 1)—"RECENT ADVANCES ON THE ISSUE OF CHROME VI REPLACEMENT IN METAL PRETREATMENT PROCESSES"—J. Roberts, Henkel Metal Chemicals Ltd.

(May 6)—64th Annual General Meeting.

## CDIC

(Apr. 12)—"WATERBORNE RESINS"—Richard Johnson, Cargill, Inc.

(May 10)—Speaker to be announced, King Industries, Inc.

## Chicago

(Apr. 5)—"SOLVENT SELECTION FOR WATERBORNE INDUSTRIAL COATINGS"—Ronald K. Litton, Eastman Chemical Products.

(May 7)—Annual Awards Banquet.

## Cleveland

(Mar. 16)—"FORMULATING COLOR WITHOUT HEAVY METAL PIGMENTS"—Jim Delaney, CIBA-GEIGY.

(Apr. 20)—"CARBON BLACK MICRODISPERSION—EFFECT ON JETNESS AND UNDERTONE

IN COATINGS"—Jerry Rogers, Columbian Chemicals.

(May 18)—To be announced—Richard Ressmeyer, Intermuseum Conservatory.

## Dallas

(Apr. 15)—"COMPLYING WITH EMISSIONS REGULATIONS—A RAW MATERIAL SUPPLIERS' VIEW"—Daniel N. King, Exxon Chemical Company.

(May 13)—"COLOR PERCEPTION AND MEASUREMENT"—Romesh Kumar, Hoechst Celanese Corporation.

## Golden Gate

(Mar. 15)—"SILICONES IN THE COATINGS INDUSTRY: THE INFLUENCE OF CHEMICAL STRUCTURE UPON PROPERTIES"—Edward Ott, Byk-Chemie USA.

(Apr. 19)—"THE FOAM STORY"—Jay W. Adams, Tego Chemie.

(May 17)—"STATISTICAL DESIGN IN HIGH SOLIDS POLYURETHANE COATINGS"—Sherri L. Bassner, Air Products and Chemicals, Inc.

(June 14)—Manufacturing Committee Seminar.

## Houston

(Apr. 14)—"COMPLYING WITH EMISSIONS REGULATIONS—A RAW MATERIAL SUPPLIERS' VIEW"—Daniel N. King, Exxon Chemical Company.

(May 12)—"COLOR PERCEPTION AND MEASUREMENT"—Romesh Kumar, Hoechst Celanese Corporation.

## Montreal

(Apr. 7)—Technical Committee Presentation—Daniel Letourneau, Chateau Paints.

(May 5)—Past-Presidents' Night. Manufacturing Committee Presentation—Gerard Paradis, BASF Canada.

## New England

(Mar. 18)—"MEETING THE CHALLENGE OF THE NINETIES WITH VOC COMPLIANT SILICONES"—Lee Hertz, Wacker Silicones.

(May 25-26)—Tech Expo '93. Sheraton Tara, Danvers, MA.

## New York

(Apr. 13)—"MODERN TRENDS IN ORGANIC PIGMENT TECHNOLOGY"—Hugh M. Smith, Sun Chemical.

(May 11)—PaVaC Meeting. To be announced—Frank Jones, Eastern Michigan University.

## Philadelphia

(Apr. 16)—Awards Night Dinner Dance.

(Mar. 11)—"FILTERING THOSE DIFFICULT HIGH SOLIDS PAINTS"—Pete Scovic, Ronnigen Petter.

(May 13)—Manufacturing Committee Presentation. "ISO 9000"—Speaker to be announced.

## Pittsburgh

(Apr. 13)—Environmental Symposium. "AN ENVIRONMENT RESPONSIBLE 90s." Airport Marriott, Pittsburgh, PA.

(May 10)—"PSYCHOLOGY OF COLOR"—Andrea Piontelc, PPG Industries, Inc.

## St. Louis

(Mar. 16)—Manufacturing Night.

(May 18)—"PIGMENTS FOR HIGH SOLIDS AND WATER BORNE COATINGS"—Speaker from CIBA-GEIGY.

(June 4-5)—Joint Meeting with Kansas City Society, Holiday Inn, Lake of the Ozarks, MO.

## Southern

(Apr. 21-23)—Annual Meeting. "WATERBORNE COATINGS—RIDING THE WAVE TO THE FUTURE." Opryland Hotel, Nashville, TN.

## CLASSIFIED ADVERTISING

### Development Chemist

*Thermal Transfer/Hot Stamp*—Coding Products, a rapidly growing division of ITW, a Fortune 500 company, seeks a Development Chemist, with at least 3-5 years of experience in formulating thermal transfer inks (or related experience). Background also should include web coatings and gravure printing presses.

The selected individual will work on a variety of development projects, in-

cluding development strategy, lab bench formulating/evaluation, plant trials, scale-up, and investigation to production.

Competitive salary and full benefits with relocation assistance to our pleasant, smaller, upper Midwest community.

Please submit resume to: Coding Products, 111 W. Park Dr., Kalkaska, MI 49464, Attn: Jerry Bernard.

## Elections

### CHICAGO

#### Active

*Antos, Cheryl A.*—Crosfield Co., Joliet, IL.  
*Orchowski, Eugene R.*—Benjamin Moore & Co., Melrose Park, IL.  
*Schlichting, James P.*—McWhorter Inc., Carpentersville, IL.  
*Shah, Kanu G.*—Dana Corp., Lisle, IL.

#### Associate

*Gwik, James E.*—Kemira Inc., St. Charles, IL.  
*Haller, Michael C.*—Macbeth, St. Charles.  
*Marvel, David A.*—Kemira Inc., St. Charles.  
*O'Connor, J. Brian*—McWhorter Inc., Carpentersville, IL.  
*Schlecker, Claude O.*—Great Lakes Systems, Lombard, IL.

#### Educator/Student

*Kharas, Gregory B.*—DePaul University, Chicago, IL.

### CLEVELAND

#### Active

*Christman, Elizabeth A.*—Ferro Corp., Cleveland, OH.  
*Dick, John Stewart*—Monsanto Corp., Akron, OH.  
*Grossman, Steven J.*—Q-Panel Co., Westlake, OH.  
*Humbert, Kurt A.*—Jamestown Paint Co., Jamestown, PA.  
*Nabar, Shreerang N.*—Tamms Industries, Mentor, OH.  
*Nemunaitis, Bradley R.*—Tamms Industries, Mentor.  
*Sedler, Kevin L.*—Thermoclad, Erie, PA.  
*Shuck, Ronald L.*—Benjamin Moore & Co., Cuyahoga Hts., OH.  
*Smith, Jan E.*—Jamestown Paint Co., Jamestown.

#### Educator/Student

*Crawford, Derek L.*—Westminster College, New Wilmington, PA.  
*Hunt, Todd M.*—Mount Union College, Alliance, OH.  
*Obermeier, Keith A.*—Kent State University, Ravenna, OH.  
*Paris, Pamela L.*—John Carroll University, University Hts., OH.  
*Rossini, Michael M.*—Ashland University, Ashland, OH.

#### Retired

*Held, Merle D.*—Cleveland, OH.

### HOUSTON

#### Active

*Arrache, Alex A.*—ISK Biotech, Houston, TX.  
*Chambliss, James D.*—Monarch Paint Co., Porter, TX.

*Crozier, Collins B.*—Southern Clay Products Inc., Gonzales, TX.  
*Haynes, Scott A.*—Benjamin Moore & Co., Houston.  
*Hutton, Kent M.*—Shell Chemical Co., Houston.  
*Johnson, Deborah K.*—Rothe Development, Houston.  
*Lewis, David*—Courtaulds Coatings/International Paints, Houston.  
*Michaud, Kenneth J.*—Courtaulds Coatings/International Paints, Houston.  
*Mills, George D.*—GM & A International, Humble, TX.  
*Montgomery, Donald R.*—Hempel Coatings USA, Houston.  
*Price, Leonard L.*—Rothe Development, Houston.  
*Simmons, Charles E.*—Rothe Development, Houston.  
*Sullivan, Michael S.*—Sea-Master Marine, Channelview, TX.  
*Wilke, Carson W.*—M-B Companies Inc., Mustang Ridge, TX.

#### Associate

*Brunnerhop, John C.*—Shell Chemical Co., Houston, TX.  
*Limon, Edward*—Texaco Chemical Co., Houston.  
*Mueller, Douglas R.*—Somson & Associates, Houston.  
*Siller, David*—Rohm Tech Inc., Sugar Land, TX.

### NEW ENGLAND

#### Active

*Brooks, Lamar E.*—A.T. Cross Co., Lincoln, RI.  
*DeWitt, Kimberly S.*—Morton International, Chicopee, MA.  
*Golding, William T.*—W.T. Golding Co., Inc., Nashua, NH.  
*Kadokia, Surendra*—Guardsman Products Inc., Rocky Hill, CT.  
*King, Gregory S.*—Senergy Inc., Warwick, RI.  
*Spazian, Thomas R.*—Guardsman Products Inc., Rocky Hill.  
*Teng, Ganghli*—Polaroid Corp., Waltham, MA.  
*White, H. James*—Whitman Polymers, Arlington, MA.

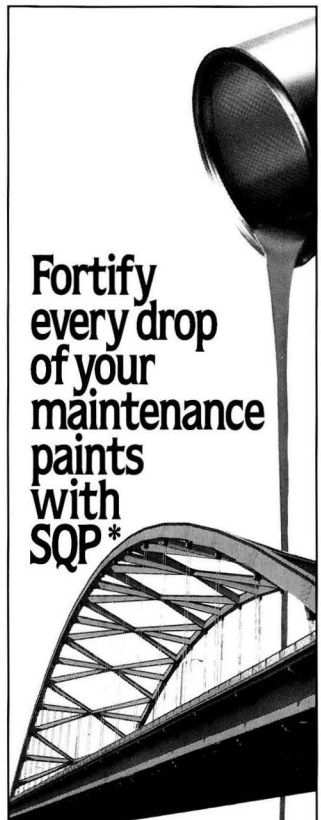
#### Associate

*Cullinan, Brendan M.*—Eastech Chemical, Philadelphia, PA.  
*Hicks, Robert C. Jr.*—R. Hicks & Associates, Brookline, MA.  
*Paul, Sankar Kumar*—Arkwright Inc., Fiskeville, RI.

### PIEDMONT

#### Active

*Love, Joel Conn*—Akzo Coatings, High Point, NC.



**Fortify every drop of your maintenance paints with SQP\***

#### \*Service. Quality. Performance.

HALOX Pigments provides effective non-toxic corrosion inhibitors for heavy duty maintenance coatings.

Does your present inhibitor source meet your SQP requirements? HALOX Pigments with SQP fortifies your coatings against corrosion and fortifies you against your competition. And our combination of dependable SERVICE, unsurpassed QUALITY, and time-proven PERFORMANCE gives you the reliability you need for your paint formulations.

Call or write for detailed product information.

**Advanced technology applied against corrosion**



#### HALOX PIGMENTS

2340 165th Street, Hammond, IN 46320; (219) 945-4599  
Telex: 72-5481 HMD; LEAD HM; Fax: (219) 845-7138  
A DIVISION OF HAMMOND LEAD PRODUCTS, INC.

Circle No. 106 on the Reader Service Card



## People

**Jere W. McKenny** is retiring as President and Chief Operating Officer of Kerr-McGee Corporation, Oklahoma City, OK, after 40 years of service to the company. The company's directors will name a successor for Mr. McKenny at a future date. In the interim, **Frank A. McPherson**, Chairman and Chief Executive Officer, will assume the responsibilities as President. Mr. McKenny has been with Kerr-McGee since 1953.

The position of Vice President and General Manager for Blue M. Electric, a General Signal Company, Blue Island, IL, has been accepted by **Charles P. Andersen**. Mr. Andersen brings to this position an extensive background in marketing, strategic planning, engineering, and manufacturing.

**Alison M. Azar** has been named "Sales Representative of the Year" for Seegott Inc., Solon, OH. Ms.



A.M. Azar

Azar joined the company in 1989 after serving as a Sales Representative for Arizona/Sylva-chem and for Union Carbide. She is a member of the Chicago and Northwestern Societies.

**Steve Kushnir** has joined the sales team of Hunter Associates Laboratory, Inc. Reston, VA. Mr. Kushnir will represent HunterLab products and services in Illinois, Missouri, and Indiana.

Man-Gill Chemical, Cleveland, OH, has named **Jim Coe** as Sales Manager/Appliance Market. Mr. Coe, who has been with Man-Gill for nearly four years, most recently served as West Coast Account Manager headquartered in San Diego, CA.

The National Board of Registration for Nuclear Safety-Related Coating Engineers and Specialists has certified **Jerry Byrd**, of Corrosion Control Consultants and Labs, Jensen Beach, FL as a Nuclear Coatings Engineer and **Gerald Calpin**, of S.G. Pinney and Associates, Inc., Port St. Lucie, FL as a Nuclear Coatings Specialist.

**Philip C. Bremenstuhl** has been appointed West Coast Sales Representative for ZENECA Resins (formerly ICI Resins US), Wilmington, MA. Based in Southern California, Mr. Bremenstuhl will sell the company's complete line of advanced polymers to the paints and coatings, adhesives and sealants, graphic arts, and toner markets in California, Nevada, and Arizona. He was previously employed with Ashland Chemical Company in Orange, CA, and before that, Fredericks-Hansen Paint Company, San Bernardino, CA. Mr. Bremenstuhl currently serves as Treasurer and Membership Chairman of the Los Angeles Society.

**Erik Pfanku** has been named Western Regional Sales Manager/Color Measurement and Control Products for the Macbeth Division of Kollmorgen Instruments Corporation, Newburgh, NY. Based in Westminster, CO, Mr. Pfanku will assume sales responsibilities for Macbeth in the western United States and Mexico.

**George Schmitz** has joined the staff of S.P. Morell and Company, Tarrytown, NY, as Technical Representative. In this capacity, Mr. Schmitz will be in charge of the metropolitan New York area.

Witco Corporation, New York, NY, has promoted **Newton E. Brightwell III** to Corporate Group Vice President/Petroleum Specialties Business. Prior to this appointment, Dr. Brightwell served as Corporate Vice President and General Manager of the company's Sonneborn Division. He has been with Witco since 1977.

The Chemicals Group of PPG Industries, Inc., Pittsburgh, PA, has elected **Donald W. Bogus** Vice President/Specialty Chemicals. Mr. Bogus will oversee the surfactants business unit and PPG's joint venture, Transitions Optical, Inc. In addition, the following units will continue to report to him as they did for the past two years while he served as Vice President/Performance Chemicals: fine chemicals and optical products, silicas and Teslin synthetic sheet products, calcium hypochlorite, and polymer products. He has been with the company since 1970.

In addition, the election of **Rae R. Burton** to Vice President/Chlor-Alkali and Derivatives of PPG's Chemicals Group has been announced. Prior to this appointment, Mr. Burton served as General Manager since 1991.

Ashland Chemical, Inc., has named **Leonard R. Gelsosa** as Vice President/General Manager for its Drew Industrial Division, Boonton, NJ. In this capacity, Mr. Gelsosa will spearhead worldwide operations for Drew Industrial.

**William Bryce** has accepted the promotion to Vice President/Sales and Marketing for Liquid Carbonic Bulk Gases, Chicago, IL. Since joining the company in 1975, Mr. Bryce has held a variety of sales positions, most recently serving as Regional Sales Manager/Mid-Atlantic Region.

In addition, **Marvin Shipps** has joined the company as Regional Manager/East Coast. Mr. Shipps brings 20 years of managerial experience in the industrial gases industry to this position.

Flow International Corporation, Kent, WA, has named **William A. Keadle** to the position of Senior Vice President/Construction Products and Services Group. In this capacity, Mr. Keadle will spearhead the consolidation of all marketing and sales activities to the construction and related services industries.

Hüls America Inc., Piscataway, NJ, has named **Peter Purwien** to Executive Vice President. In this capacity, Mr. Purwien will be responsible for corporate development and strategy for the company, and he will also serve on the Hüls' Executive Committee. Prior to joining Hüls America, he served on the management board for Hüls Troisdorf AG, in Troisdorf, Germany.



P. Purwien

## 21st Western Coatings Societies' Symposium and Show To Feature Exhibits, Technical Program, and Entertainment

The 21st Western Coatings Societies' Symposium and Show (WCSSS) will be held on March 23-25, at the Disneyland Hotel & Convention Center, in Anaheim, CA. The event is sponsored by the Golden Gate, Los Angeles, Pacific Northwest, and Rocky Mountain Societies for Coatings Technology.

Currently, 102 companies have contracted 14,300 square feet of exhibit space for the three-day show.

In addition, the symposium on "Visions—Opportunities—Challenges," will feature three days of two concurrent sessions of technical presentations. A total of 23 papers are scheduled for presentation during the symposium, including:

"New Catalysts for High Solids Coatings"—Robert Middlemiss, of OMG Group;

"Plant Housekeeping Considerations with Nonmercurial Biocides"—Jeffrey Hinkle, of Hüls America, Inc.;

Presentation by the National Paint and Coatings Association (NPCA), Southern California Paint and Coatings Association (SCPCA), and California Paint Council (CPC)—J. Andrew Doyle, of NPCA, Sandra Skomesa, of SCPCA, and Mathew Duston, of CPC;

"Exterior Studies of Exterior Latex House Paints Containing Kaolin Clay Pigments"—Thad T. Broome, of J.M. Huber Company;

"Approach to Formulation of Architectural and Maintenance Coatings"—John Ballard, of Burgess Pigment Company;

"Optimizing Lightfastness of Organic Pigments through Particle Size Control"—Romesh Kumar, of Hoechst Celanese Corporation;

"Gloss: Factors Influencing Gloss Development and Formulating Guidelines to Achieve Gloss in Paint"—Rebecca Craft Tulloch, of E.I. du Pont de Nemours & Company, Inc.;

"Ion Exchanged Alternatives to Chromate for Corrosion Inhibition"—Michael Maule, of W.R. Grace Company;

"Waterborne Epoxy Resin Emulsion"—Marcel Gaschke, of CIBA-GEIGY Corporation;

"High Solids Solvent Free Baking Enamels"—Richard Farmer, of Cargill Resin Products Division;

"Optical Brighteners—More Than Just Clean Laundry"—Timothy Geran, of CIBA-GEIGY Corporation;

"HVLP Spray Gun Technology"—Glen L. Muir, of Graco Inc.;

"Graffiti Abatement and Prevention Handbook"—V.C. "Bud" Jenkins, of the Los Angeles Society for Coatings Technology;

"The Cal Poly Polymers and Coatings Program: From Dream to Reality"—Dane Jones, James D. Westover, and Max T. Willis, of California Polytechnic State University;

"ELRAP: Environmental, Legislative, and Regulatory Advocacy Program of the Southern California Paint and Coatings Association"—Robert Wendoll and Raymond Robinson, of SCPCA;

"Aqueous Suspensions of Cellulosic Thickeners: Function and Mechanisms in Water Based Coatings"—C.W. Vanderslice, H.F. Haag, and C.L. Burdick, of Aqualon Company;

"Ultrafine Titanium Dioxide: Its Properties and Applications in Coatings"—Stuart G. Heyes, of Tioxide Specialties, Inc.;

"The Utility of Glycol Based Ethers as Cosolvents in Water Based"—Douglas K. Pollack, of Dow Chemical Company;

"Safe Paint Biocides"—Judith Ross and Angela Downey, of Rohm and Haas Company;

"System Design Considerations for Powder Coatings Operations"—Michael Cravens, of Powdercoat Services, Inc.;

"Investigation of Long-Term Yellowing of Architectural Enamels as a Function of Coating Composition"—Jeffrey H. Danneman and Arthur C. Smith, of Reichhold Chemicals Inc.;

"Developments in the European Low VOC Architectural Coatings Market"—

(Continued on next page.)

### 21st Biennial WCSSS Exhibitors

- |   |   |  |
|---|---|--|
| Alar Engineering Corp.  | Federation of Societies for Coatings Technology (donated by TCR Industries) | PPG Industries, Inc., Silica Products                            |
| Alcoa Industrial Chemicals  | Grace Davison   | PPG Industries, Inc., Specialty Chemicals                        |
| American Paint Journal Co.  | Greyhound Exposition Services   | Premier Mill Pychem, Inc.  |
| ANGUS Chemical Co.  | Hilton Davis Co.  | P.T. Hutchins Co., Ltd.  |
| Aqualon Co.   | Hockmeyer Equipment Corp.   | Reichhold Chemicals, Inc.  |
| Armenco Engineering Inc.  | Hüls America, Inc.  | RHEOX, Inc.  |
| Armstrong Containers, Inc.  | ZENECA Resins   | Rhone-Poulenc  |
| Brookfield Engineering Labs.  | Ideal Manufacturing & Sales Corp.   | Rohm and Haas Co.  |
| Buckman Laboratories, Inc.  | <i>Industrial Finishing Magazine</i>  | R.T. Vanderbilt Co., Inc.  |
| BYK-Chemie USA  | John K. Bice Co., Inc.  | Sandoz Chemicals Corp.   |
| BYK-Gardner, Inc.   | J.R. Elliott, Inc.  | Sannor Industries, Inc.  |
| CB Mills, Div. of Chicago Boiler Co.  | J.M. Huber Corp., Chemical Div.   | Sartomer Co., Inc., Cray Valley Products, and CCP Polymers       |
| California Polytechnic State University, Chemistry Dept. (donated by Du Pont Co.) | J.M. Huber Corp., Clay Div.   | SC Johnson Polymers  |
| Cargill, Inc.   | Kemira, Inc.  | Shamrock Technologies, Inc.                                      |
| Contico Container   | Manufacturing Business Systems  | Shell Chemical Co.   |
| CR Minerals Corp.   | McWhorter, Inc.   | Silverline Manufacturing Co., Inc.                               |
| Crosfield Chemicals, Inc.   | The Mearl Corp.   | Synergistic Performance Corp.                                    |
| Daniel Products Company, Inc.   | Message Center (donated by E.T. Horn Co.)                                   | Tavco Chemicals  |
| Datacolor International   | Michelman, Inc.   | Tego Chemie  |
| Day-Glo Color Corp.   | Microfluidics Corp.   | Tikkurila Oy   |
| Disposal Control Service, Inc.  | Miles, Inc., Industrial Chemicals Div.                                      | Tioxide Specialties, Ltd.  |
| Disti-Kleen   | <i>Modern Paint &amp; Coatings</i>  | Trans Western Chemicals, Inc.                                    |
| DK Container, Inc.  | Morehouse-Cowles, Inc.  | UCB-Radure, Inc.   |
| Dowd & Guild, Inc.  | Morton International, Inc.  | Union Carbide  |
| Drew Industrial Div.  | Myers Engineering   | United Catalysts, Inc., Rheological & Performance Minerals Group |
| Eagle Zinc Co.  | National Chemical Company, Inc.   | United States Can Co.  |
| Eastman Chemical Co.  | Netzsch Inc.  | U.S. Borax   |
| El Rap (donated by Kronos, Inc.)  | Norman International  | U.S. Silica Co.  |
| EM Industries, Inc.   | Norton Containers   | Van Waters & Rogers, Inc.  |
| Environmental Science & Engineering, Inc.   | Pacific Micro Software Engineering  | Wacker Silicones Corp.   |
| Epworth Mfg. Co., Inc.  | Pacific Resource Recovery Services  | Western Coatings Societies (donated by SCM Chemicals)            |
| E.F. Whitmore & Co.   | Paint Chemicals, Inc.   | X-Rite, Inc.   |
| E.I. du Pont de Nemours & Co., Inc.   | <i>Paint &amp; Coatings Industry</i>  | Zeelan Industries, Inc./3M Co.                                   |
| Fawcett Co., Inc.   | Poly-Resyn, Inc.  |  |

## New England Society for Coatings Technology To Sponsor Coatings Tech Expo '93, June 8-9

The New England Society for Coatings Technology will sponsor the Fifth Biennial Convention and Exposition, Coatings Tech Expo '93, on June 8-9, at the Sheraton Tara Hotel and Resort, Danvers, MA.

The theme for this year's event is "Compliance-Options for the 21st Century." The exposition will include exhibits featuring machinery, equipment, containers, accessories, raw materials, and other industrial equipment and services.

In addition, the convention will introduce a unique seminar program which will not conflict with exhibit hours. Prominent industry leaders, environmental specialists, and factory technicians will deliver presentations during the scheduled technical sessions.

The New England Society's goal is to produce an event that educates people connected with the coatings, inks, plastics, and steel structure painting industries. Their mission is introduce the new developments,

products, and proper methods of utilization of new equipment, and to raise the general level of knowledge of the individuals within these industries.

An estimated attendance of approximately 1,000 qualified bench chemists, suppliers, technicians, buyers, and executives from manufacturing and marketing are expected to attend the event.

Tech Expo '93 also will feature the Annual Society Dinner. The guest speaker is Loretta LaRoche, acclaimed speaker, educator, and well-known personality. Ms. LaRoche will talk on "How to Prevent Hardening of the Attitude."

For more information on the convention, contact Chairman Joanne Monique, Ashland Chemicals, Inc., 400 Main St., Tewksbury, MA 01876; (800) 962-5388.

Dame Associates, Inc., the Boston-based exhibit management firm, has been designated as Show Management. All exhibitor inquiries should be directed to Frank Netherwood, National Sales Manager, Dame, 51 Church St., Boston, MA 02166-5493; (800) 843-3263.

## Brazilian Paint Manufacturers to Sponsor Third International Paint Congress

The Brazilian Association of Paint Manufacturers (ABRAFATI) Third International Paint Congress and Exhibition will

be conducted on September 8-10, at the Palácio de Convenções do Anhembi, in São Paulo, Brazil.

The purpose of the Congress is to present a broad overview of the paint industry. Also, the event will feature the presentation of new ideas, facts, and techniques.

The technical program will feature three plenary lectures and 60 presentations in the following subject areas: raw materials, production and testing equipment; product and technology innovations; cure and application technologies; environmental issues; total quality management and productivity; and health and safety.

Simultaneously, an exhibition featuring more than 100 participating companies and covering more than 35,000 square meters will be held. Suppliers of raw materials, packaging materials, equipment, and other services related to the paint and coatings industry will be included among the exhibitors.

For more details on the Third ABRAFATI Congress, contact Congress Organization Secretariat, Especifica S/C Ltda, Rua Augusta, 2516-2nd Floor, Suite 22, 01412-100, São Paulo, SP, Brazil.

## Papers Sought for Symposium On Inverse Gas Chromatography

All prospective authors are invited to submit papers for presentation at the "Advances in Inverse Gas Chromatography for Surface Characterization" Symposium, on March 13-18, 1994, in San Diego, CA. The symposium will be held as part of the ACS Division of PMSE program.

Invited topics include, but are not limited to, the following areas: interactions in polymer systems, finite concentration IGC, surface heterogeneity of solids by IGC, and IGC for biopolymers.

Titles, authors, and an abstract on an ACS form are due by August 1. A short paper, following ACS guidelines, is due by October 31.

For information, contact H.P. Schreiber, Chemical Engineering, Ecole Polytechnique, Box 6079, Stn. A, Montreal, Quebec H3C 3A7, Canada.

## Pacific Northwest Society's 46th Annual Symposium Scheduled for April 29-May 1, in Bellevue, WA

The Pacific Northwest Society for Coatings Technology's 46th Annual Spring Symposium will be held on April 29-May 1, at the Red Lion Hotel, in Bellevue, WA.

"Understanding the Fundamentals" is the theme of this year's symposium. Nine technical papers are scheduled to be presented during the technical sessions.

The event also will feature the following activities: golf, the Spirit of

Washington dinner train, the Annual Business Meeting, a suppliers' cocktail party, the dinner dance, and the international competition.

For more information on the Pacific Northwest Symposium and all of its activities, contact Kristin L. Soliday, J.F. Shelton Company, 1108 Andover Park West, Tukwila, WA 98188; (206) 575-9377.

## 1993 West Coast Show To Feature 102 Exhibitors

*(Continued from previous page.)*

David Sykes, of Rohm and Haas Company; and

"Economic Outlook: 1993-1994"—Richard A. Stuckey, of E.I. du Pont de Nemours and Company, Inc.

\*\*\*\*\*

The Western Coatings Societies' Symposium and Show Industry Luncheon will be held on Wednesday, March 24, and feature guest speaker Daryl F. Gates, retired Chief of the Los Angeles Police Department. He had served the LAPD for 43 years prior to his retirement last March, the last 14 years as Chief.

A dinner and show will take place on Thursday, March 25, the final evening of the event. Featured will be Danny Gans, impressionist, comedian, singer, and actor. He has been hailed as the "Sammy Davis Jr. of the 90s." Mr. Gans' repertoire includes well over 100 voice impersonations.

Concluding the WCSSS festivities will be Marie Osmond and the Joe Diamond Orchestra. Ms. Osmond will perform the hit songs from her album, "There's No Stopping Your Heart."

\*\*\*\*\*

For more information on the 21st Western Coatings Societies' Symposium and Show, contact: Sam A. Rumpfola, c/o TCR Industries, 26 Centerpointe Dr., #105, La Palma, CA 90623; (714) 521-5222.

## Rheology Tests

A product release introducing operating software and firmware designed to run rheological test around-the-clock without operator intervention has been printed. The systems can measure the rheological properties of materials in solid, melt, and liquid form. Additional information on the Rheometrics Dynamic Analyzer (RDA II) is obtainable from Thomas A. Luckenbach, Rheometrics Technical Marketing, One Possumtown Rd., Piscataway, NJ 08854.

Circle No. 200 on Reader Service Card

## Paints and Coatings

A new line of water-based, environmentally friendly paints and coatings is highlighted in literature. Applications for the crystal-clear water-based acrylic polyurethane coatings include wood floors, cabinets, tables, doors, paneling, trim, and furniture. For more in-depth details on Envirocare paints and coatings, write InSI-X Products Corp., 50 Holt Dr., P.O. Box 694, Stony Point, NY 10980.

Circle No. 201 on Reader Service Card

## Coating Thickness Gage

A coating thickness gage that reportedly combines the full capabilities of ferrous and nonferrous gages by employing both the magnetic and eddy current principles is the subject of a data sheet. The device can measure paint and other coatings on metals with one integral probe. Contact DeFelsko Corp., P.O. Box 676, Ogdensburg, NY 13669-0676 for more information on the new PosiTector 6000-FN coating thickness gage.

Circle No. 202 on Reader Service Card

## Color Software

A new four-page, full-color bulletin describing software designed for use with computerized color measurement systems has been released. The literature details the key features and capabilities of the software, provides complete specification data, and illustrates sample display formats. For a copy of the bulletin on the 1500 Series color QC software, write Macbeth, P.O. Box 230, Newburgh, NY 12551-0230.

Circle No. 203 on Reader Service Card

## Mixing System

A high efficiency mixer and impeller mixing system is the subject of a new eight-page brochure. A composite construction allows this system to be used for applications where stainless steel or exotic metal mixers are required. Write Betty Felix, Lightnin, 135 Mt. Read Blvd., P.O. Box 1370, Rochester, NY 14603 for more information on the SX™ mixer and A6000™ impeller mixing system.

Circle No. 204 on Reader Service Card

## Colorimeter

A multi-angle colorimeter which reportedly allows metallic paint measurements to be made on the factory floor is detailed in a product sheet. Data memory allows for the storing of 1,000 measurements and an interface permits the colorimeter to be connected to a PC. For further details on the CR-354 multi-angle colorimeter, write Minolta Corp., Instrument Systems Div., 101 Williams Dr., Ramsey, NJ 07446.

Circle No. 205 on Reader Service Card

## Functional Fillers

Industrial applications for fiber functional fillers are presented in an eight-page pamphlet. The pocket-sized folder describes typical applications for the following: animal (pet) food, plastic (including thermoset and thermoplastic), asphalt mixtures, building products, latex paints, rubber, asbestos-free friction linings, and welding electrodes (rutile-electrodes). For a copy of the Fibracel® functional fillers folder pamphlet (#FF-570), contact Celite Information Center, 1601 Park Ave. W., Denver, CO 80216.

Circle No. 206 on Reader Service Card

## Additives

Two new additives, a defoamer and dispersant, have been introduced through literature. The products are designed for use in solvent-borne coatings. Further information on Defoamer Colloid PH-87 and Dispersant Manomet 10 can be obtained by contacting Dick Marsh, Rhone-Poulenc Inc., Paints, Inks, and Adhesives, 311 Marble Mill Rd., Marietta, GA 30060.

Circle No. 207 on Reader Service Card

## Aqueous Dispersions

A line of aqueous dispersions suited for the protection of metal parts in storage is the topic of a product release. The dispersions can also be used for temporary protection in spray paint booths, transit, and masking coatings. Write Art De Monte, Allied-Signal Inc., P.O. Box 2332R, Morristown, NJ 07962-2332, for further information on ACqua™ 220, 240, and 250 aqueous dispersions.

Circle No. 208 on Reader Service Card

## Additives Brochure

Water-based or water-dispersible additives suited for low- or no-VOC systems in a wide-range of industrial applications are described in a six-page brochure. Defoamers, wax emulsions, cationic resins, and rosin soaps are highlighted. For a copy of "Industrial Specialties—Performance Additives," selection guide, contact Product Inquiry, Paper Technology Group, Hercules Incorporated, Wilmington, DE 19894.

Circle No. 209 on Reader Service Card

## Defoamer

A new data sheet focusing on the physical properties and performance of a defoamer has been issued. The literature details test results which demonstrate the defoamer's dewebbing efficiency and wetting performance in the manufacture of natural rubber latex dipped goods. For a copy of the data sheet, "Surfynol® DF-37 Defoamer," contact Air Products and Chemicals, Inc., Performance Chemicals Div., 7201 Hamilton Blvd., Allentown, PA 18195-1501.

Circle No. 210 on Reader Service Card

## SITUATIONS WANTED

Coatings Chemist experienced in formulation of water and solvent systems. Experience in formulation and application of pigment dispersions and color for multi-product end use. Has hands-on plant and quality control management experience for large as well as small volume production sites. Environmental reporting for federal and state agencies including generation of MSDSs and other materials. Northern and central New Jersey locations preferred. Edward Baird, 160 Linden Ave., Verona, NJ 07044.

## Label Printing System

A fully integrated, on-site label production system is the topic of a data sheet. The system features software that drives a wide variety of printers including dot matrix impact, direct thermal/thermal transfer, and continuous form laser. For further details on the Allegro™ Thermal/Thermal Transfer printer, contact Steve Kersey, Labeling Systems Product Manager, Diagraph Corp., 3401 Rider Trail South, St. Louis/Earth City, MO 63045-1110.

Circle No. 211 on Reader Service Card

## Emulsion

A data sheet discussing a newly developed emulsion for architectural coatings has been published. Included in the literature are physical properties and low VOC formulations for 65 PVC flat, 60 PVC flat, semigloss, and eggshell enamel paints. For a copy of publication, "Airflex® 738 Emulsion for Architectural Coatings," contact Air Products and Chemicals, Inc., Polymer Chemicals Div., 7201 Hamilton Blvd., Allentown, PA 18195-1501.

Circle No. 212 on Reader Service Card

## Corrosion Inhibitor

A corrosion inhibitor containing no lead, barium, strontium, or chromate has been introduced through a data sheet. The product can be post-added to primer and topcoats, or formulated into transparent coatings. For additional details on COTROL® 18-8, write CasChem, Inc., 40 Avenue A, Bayonne, NJ 07002.

Circle No. 213 on Reader Service Card

## Pipe Coating

A technical sheet focusing on three-layer pipe coating materials and application technology for the U.S. oil and gas transmission and distribution market has been printed. The system incorporates an epoxy primer, and intermediate adhesive layer, and a polyethylene topcoat. More information is obtainable from Karen Baka, Marketing Manager, Elf Atochem North America, Inc., Three Parkway, Philadelphia, PA 19102.

Circle No. 214 on Reader Service Card

## Flowmeter

A flowmeter, designed for use in the process, food and beverage, energy, pulp and paper, chemical, and steel industries, is highlighted in literature. The instrument is available in line sizes ranging from 2 in. to 72 in. For more information on the MAGFLO™ magnetic flowmeter, write Romy Deutchman, EMCO, 600 Diagonal Hwy., Longmont, CO 80501.

Circle No. 215 on Reader Service Card

## Acrylic Polymers

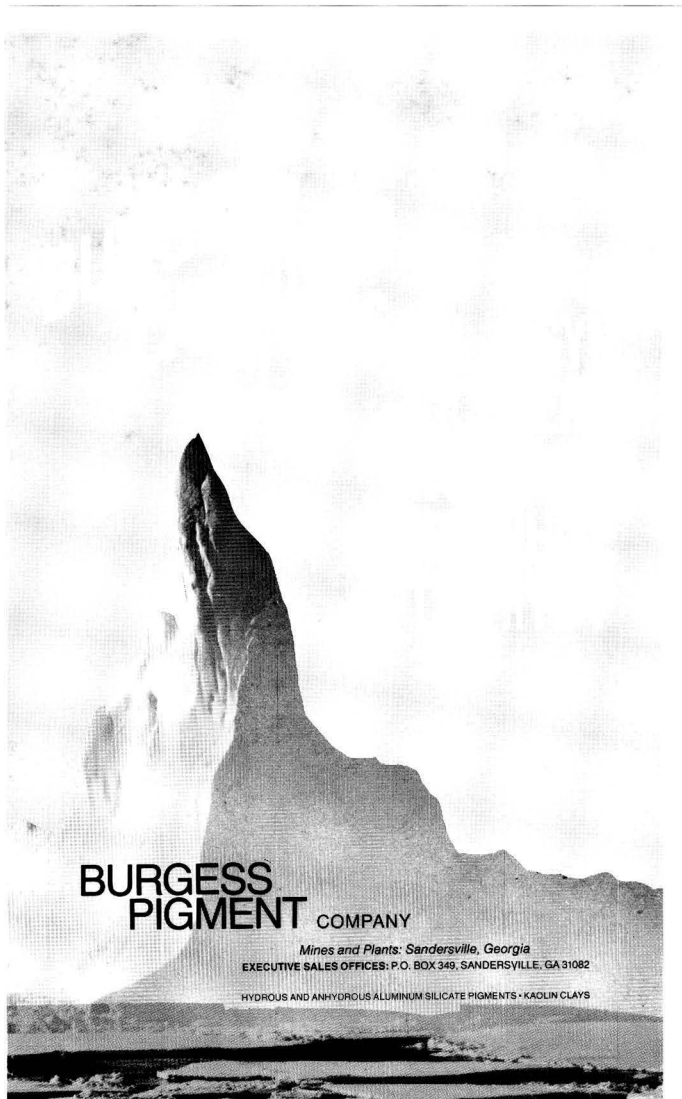
A new product guide providing technical information on a line of thermoplastic acrylics, advanced nonyellowing emulsions, solution acrylics, standard self-crosslinking polymers, and formaldehyde-free products has been released. The publication uses a spreadsheet format to list product specifications by product family. Inquiries may be sent to John Kolackovsky, Rohm Tech Inc., 83 Authority Dr., Fitchburg, MA 01420.

Circle No. 216 on Reader Service Card

## Polyurethane Latexes

Two new polyurethane latexes have been introduced through literature. One is a high-solids anionic dispersion of a fully reacted light-stable urethane polymer, and the other is a high-solids dispersion of a fully reacted, light-stable urethane polymer. For technical information on RUCOTHANE® 2018L and 2019L, respectively, contact Michael McCann, Ruco Polymer Corp., New South Rd., Hicksville, NY 11802.

Circle No. 217 on Reader Service Card



Circle No. 107 on the Reader Service Card

**jet** Journal of  
Coatings  
Technology  
Reader Service Card  
February 1994 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!

001	021	041	061	081	101	121	141	161	181	201	221	241	261	281
002	022	042	062	082	102	122	142	162	182	202	222	242	262	282
003	023	043	063	083	103	123	143	163	183	203	223	243	263	283
004	024	044	064	084	104	124	144	164	184	204	224	244	264	284
005	025	045	065	085	105	125	145	165	185	205	225	245	265	285
006	026	046	066	086	106	126	146	166	186	206	226	246	266	286
007	027	047	067	087	107	127	147	167	187	207	227	247	267	287
008	028	048	068	088	108	128	148	168	188	208	228	248	268	288
009	029	049	069	089	109	129	149	169	189	209	229	249	269	289
010	030	050	070	090	110	130	150	170	190	210	230	250	270	290
011	031	051	071	091	111	131	151	171	191	211	231	251	271	291
012	032	052	072	092	112	132	152	172	192	212	232	252	272	292
013	033	053	073	093	113	133	153	173	193	213	233	253	273	293
014	034	054	074	094	114	134	154	174	194	214	234	254	274	294
015	035	055	075	095	115	135	155	175	195	215	235	255	275	295
016	036	056	076	096	116	136	156	176	196	216	236	256	276	296
017	037	057	077	097	117	137	157	177	197	217	237	257	277	297
018	038	058	078	098	118	138	158	178	198	218	238	258	278	298
019	039	059	079	099	119	139	159	179	199	219	239	259	279	299
020	040	060	080	100	120	140	160	180	200	220	240	260	280	300

Name \_\_\_\_\_  
 Company \_\_\_\_\_  
 Address \_\_\_\_\_  
 City \_\_\_\_\_ State \_\_\_\_\_ Zip \_\_\_\_\_  
 Phone \_\_\_\_\_ FAX \_\_\_\_\_

**jet** Journal of  
Coatings  
Technology  
Reader Service Card  
February 1994 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!

001	021	041	061	081	101	121	141	161	181	201	221	241	261	281
002	022	042	062	082	102	122	142	162	182	202	222	242	262	282
003	023	043	063	083	103	123	143	163	183	203	223	243	263	283
004	024	044	064	084	104	124	144	164	184	204	224	244	264	284
005	025	045	065	085	105	125	145	165	185	205	225	245	265	285
006	026	046	066	086	106	126	146	166	186	206	226	246	266	286
007	027	047	067	087	107	127	147	167	187	207	227	247	267	287
008	028	048	068	088	108	128	148	168	188	208	228	248	268	288
009	029	049	069	089	109	129	149	169	189	209	229	249	269	289
010	030	050	070	090	110	130	150	170	190	210	230	250	270	290
011	031	051	071	091	111	131	151	171	191	211	231	251	271	291
012	032	052	072	092	112	132	152	172	192	212	232	252	272	292
013	033	053	073	093	113	133	153	173	193	213	233	253	273	293
014	034	054	074	094	114	134	154	174	194	214	234	254	274	294
015	035	055	075	095	115	135	155	175	195	215	235	255	275	295
016	036	056	076	096	116	136	156	176	196	216	236	256	276	296
017	037	057	077	097	117	137	157	177	197	217	237	257	277	297
018	038	058	078	098	118	138	158	178	198	218	238	258	278	298
019	039	059	079	099	119	139	159	179	199	219	239	259	279	299
020	040	060	080	100	120	140	160	180	200	220	240	260	280	300

Name \_\_\_\_\_  
 Company \_\_\_\_\_  
 Address \_\_\_\_\_  
 City \_\_\_\_\_ State \_\_\_\_\_ Zip \_\_\_\_\_  
 Phone \_\_\_\_\_ FAX \_\_\_\_\_

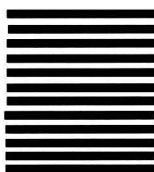


NO POSTAGE  
NECESSARY  
IF MAILED  
IN THE  
UNITED STATES

**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

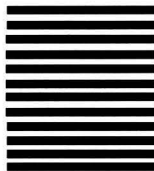


NO POSTAGE  
NECESSARY  
IF MAILED  
IN THE  
UNITED STATES

**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



### Microsampling Device

Data has been released on a device designed for microsampling forensic-size samples of inks, toner, correction fluid, adhesive, body fluids, or any other media resting on this surface. The uniform dimension and sharp cutting edge of the tip reportedly allows for quick, repetitive sampling without risk of damage to the substrate, producing samples of uniform size for quantitative studies. For more in-depth details on the Micro-Punch, contact Premier Scientific, P.O. Box 42057, Ottawa, Ontario, Canada, K1K 3B0.

Circle No. 218 on Reader Service Card

### Viscosity Sensor

A new addition to a family of in-line viscosity sensors for process control has been announced through a product release. The sensor features: 1/4 in. inlet and outlet ports; internal RTD temperature probe; temperature capability to 190°C; all stainless steel construction; and temperature compensated viscosity. Contact Sandy Precht, Cambridge Applied Systems Inc., 57 Smith Pl., Cambridge, MA 02138, for more in-depth details on the SPC371 Flow Thru Viscosity Sensor.

Circle No. 219 on Reader Service Card

### Precipitated Silica

A 22-page publication detailing the manufacture, properties, and application of a line of precipitated silica has been printed. The brochure features a reference guide that provides suggestions to various industries regarding how to use precipitated silica and also includes sections on regulatory compliance, health and safety, and other subjects. Contact Degussa Corp., 425 Metro Park North, Ste. 450, Dublin, OH 43017, for information on how to obtain a copy of "Precipitated Silicas."

Circle No. 220 on Reader Service Card

### Waxes

The release of a four-color brochure on the applications of polyethylene and montan waxes in color masterbatches and concentrates for plastics has been announced. The 36-page booklet offers a wide-range of illustrations including graphs, charts and four-color photographs focusing on masterbatches made from a variety of plastics, in particular the polyolefins, polystyrene, and PVC. A free copy of the brochure, "Luwax Polyethylene and Montan Waxes," can be obtained by writing BASF Corp., Performance Chemicals, 100 Cherry Hill Rd., Parsippany, NJ 07054.

Circle No. 221 on Reader Service Card

### Hand Cleaner

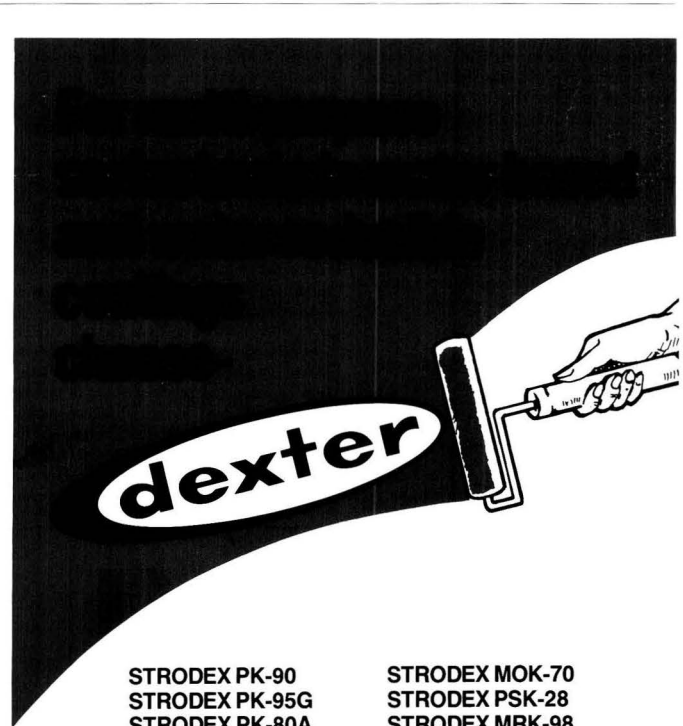
A new, nontoxic hand cleaner designed to remove substances like polyurethane, stain, enamel, varnish, adhesives, and sealants without water and without drying the skin has been introduced through literature. The cleaner is fortified with four premium skin conditioners—aloe, lanolin, jojoba oil, and vitamin E. For a free sample of PARR™ Paint and Resin Removing Hand Cleaner, contact Permatex Industrial, 705 N. Mountain Rd., Newington, CT 06111.

Circle No. 222 on Reader Service Card

### Rust Preventor

A free-flowing powder that can be incorporated into coatings at the grind stage for long-term corrosion protection is highlighted in a product release. Typically used at levels ranging from 4.0 to 15.0%, the product may be employed in water-reducible and high-solids alkyds, conventional and high-solids epoxies, and latex emulsions. Write CasChem, Inc., 40 Avenue A, Bayonne, NJ 07002, for further details on COTROL® 316 rust preventor.

Circle No. 223 on Reader Service Card



STRODEX PK-90  
STRODEX PK-95G  
STRODEX PK-80A  
STRODEX SEK-50

STRODEX MOK-70  
STRODEX PSK-28  
STRODEX MRK-98  
STRODEX P-100

DEXTROL OC-50

Dexter surfactants are being successfully and widely used for the many and exceptional benefits they provide, among them

- improved gloss
- enhanced color acceptance
- increased package stability
- rust inhibition
- reduced blocking
- and other valuable advantages offered by their strong wetting and dispersing properties.

Write or call for complete details and samples:

**dexter** Chemical Corporation  
845 Edgewater Rd., Bronx, N.Y. 10474, (212) 542-7700 • Telex 127061

Circle No. 108 on the Reader Service Card



# Letters to the Editor

## "On the Shoulders of Giants"

TO THE EDITOR:

The coatings industry is the oldest segment of the chemical process industry tracing its beginning to Noah's Ark where he coated the ark with pitch—a high solids coating with the unique properties of excellent adhesion and water resistance.

For centuries, the coatings industry relied upon art, trade secrets, and trial and error in the formulation of paints and in the development of vehicles. The first real attempt to put science into polymer chemistry came in 1907, with the systematic researches of Leo Baekeland, who studied the phenol-formaldehyde resin system—a copolymer still in use today. Other developments followed slowly until the pioneering work of Staudinger and Carothers who provided the foundation upon which to build and understand polymers. The applications of these giant's contributions to the coatings industry followed many years later.

I am writing to review the work of the "giants"—great corporate assets, the abuse of these assets, and what we might do to "Beware of Giants."

### Some Examples of Giants

In the early 1930s, Dr. Roy Kienle developed the alkyd resin, which was to be the

work horse of the coatings industry for over 25 years until Dr. Roger Christenson developed the practical thermosetting acrylic. This ushered in a period of intense technical progress—new technologies in metal treatment, radiation curing, electrocoating, powder and coil coating, and high solids coatings. If we trace back, we should most surely meet a giant who was responsible for unlocking the door, freeing the technology. Let's look at four advances.

**TEFLON:** One of the great developments in polymer chemistry came about as a result of a giant who refused to give up once he noted something unusual in a gas cylinder. Dr. Roy Plunkett, at DuPont, was testing tetrafluoroethylene's toxic effect upon mice, when he noted that no gas came from the opened cylinder. He weighed the cylinder and found that his weight determination showed no loss of its contents.

When he tried to have the cylinder cut open, he was rebuked, since the cylinder cost \$50 and it would be simple to just take another gas cylinder. His persistence led to the discovery of Teflon® and his subsequent pursuit of the events leading to the formation of the gunk in the cylinder showed how Teflon had been produced, by a redox reaction. This was caused by the cleaning process used to prepare

these cylinders. His discovery had a monumental impact on the coatings and materials industries.

**ELECTROCOATING:** Two persistent major problems in coating practice were the poor corrosion resistance of automotive primers which were applied by flow coating, and the fire hazard of the solvent dilutable primers. The latter reached a dramatic point with a disastrous fire in Wixom, Michigan.

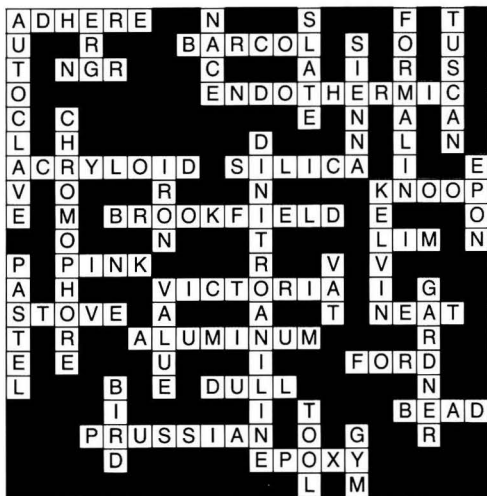
This is where another giant stepped in. Dr. George E.F. Brewer, a Staff Scientist at Ford Motor Co., recognized the need to improve corrosion resistance and reduce the fire hazard associated with flow coat priming. In his pioneering work, he turned to the technology used in making latex gloves and found that by using electrophoresis, he could coat recesses and edges with a water dilutable paint. With the help of Alan Gilchrist of Glidden, maleic modified linseed oil was synthesized to demonstrate the viability of his concept. Today, electrocoating is practiced around the world!

**RADIATION:** With the increased use of plastics in automobiles, it became evident that the high baking temperatures of automobile primers and topcoats would have a deleterious effect upon these materials. In addition, there was a growing concern for the high energy consumed in the baking operation.

Enter another giant, Dr. William Burlant. While at Ford Motor Co., he conceived a process for curing unsaturated polyesters using electron beams. One can envision the struggle he had in introducing the concept and reducing it to practice. Eventually, a radiation curable coating was developed for curing a coating on ABS plastic and a coil coating line using electron beam curing was operated to prove the process. Today radiation curing, electron beam, and UV are finding their place in low VOC, low energy curing processes.

**URETHANES:** The idea of curing automotive touchup and repaint systems at ambient temperatures captured the imagination of another giant, Joseph A. Vasta, at Du Pont. He realized the importance of developing high quality coating for repaint shops, where high temperatures are not easily achieved as on a production line.

He came to the conclusion that two component urethanes would be effective in this application and set out to prove the idea and develop the coating system. At the time he



Solution to February's "CrossLinks"

was doing this, aliphatic urethane prepolymers were in short supply. He then travelled to Europe to convince manufacturers to make these precursors available so that the coating could be commercialized.

Today, we have IMRON<sup>®</sup>, an automotive and aircraft finish which has excellent wear, durability, and quality.

### Giants as Assets

These few examples should illustrate the importance of giants who contribute to landmark developments. Others make contributions less noteworthy, but still of great value to any firm and to the welfare of the economy. In the past, these and other giants have been well rewarded for their effort; financially, in peer recognition, through technical societies and in other ways supportive of their creativity.

But what about giants of less note?

How are they treated in today's firms?

Let me cite a recent example from my own experience. Upon taking over a group a few years ago, I examined the records of two individuals, an adhesives expert and a metallurgical engineer. I found that, based upon their consistent performance records, they should be promoted to the senior level. When I reviewed the promotional criteria with a newly appointed Vice President, he was shocked that I would even consider these individuals for promotion.

I then arranged for these two individuals to review their contributions to the Technical Managers in the Engineering Center. During their presentations, they showed how they had contributed to several million dollars worth of innovations, productivity, and quality improvements and in preventing the shutdown of a major production facility.

They were both promoted!

How are giants treated today?

### Asset Abuse

We hear a lot about abuse today. The media is constantly reminding us about child, drug, environmental, spouse and other abuse that unfortunately has become a part of our society. One of the most neglected areas of abuse today is Asset Abuse. This is a sinister practice conducted by upper management and encouraged by the gurus of our business schools.

Here's how it works.

During the 1950s and 1960s, management found that, using the principles of management taught by people like Maslow and others, by treating people fairly, they encouraged high morale, a sense of belonging, commitment, reward and praise. The net result was that people felt they were part of a team, worked for the common goal, and were rewarded for their efforts through bonuses, promotions, and other recognition of their efforts.

With the philosophy now being taught by the business schools and adopted by management, those sound principles have been

discarded in favor of worshiping the current bottom line and doing whatever is necessary to show a profit in each quarter. This short-term goal has become the norm, regardless of the long-term effects on the business and more importantly with little regard for their most important asset—people.

Think about it! In a highly motivated organization, people will work as a team, put in extra hours and apply creativity to improve the company's competitive position.

Just how much money is a firm losing in man hours, creativity, enthusiasm and return on assets by such poor people management?

With the new thinking, using subjective appraisal systems, forced ratings and disregard for people, management is throwing away a valued asset. For example, most firms will seek out the best qualified candidates for a position, generally the top 10 percentile. Yet, in the forced rating systems, performance is rated on and force fitted to a specific curve. This has a negative impact on motivation, team work, enthusiasm and, more importantly, on people's contributions to the welfare of the firm.

Another example, which can be found in many firms, is the disregard for people performance. There are numerous examples of outstanding performers, who now, because of the new thinking, are rated as average or below average with subsequent loss or merit bonuses, pay increases, and promotions just to satisfy a management goal such as "Managing-to-One" or some other form of Human Resource "Doublespeak." Unfortunately, managers who mistreat this most important asset are frequently hailed by business publications and cited as "CEO of the Year."

How can management be so foolish?

Are they aware of this loss of assets; don't care or both? What will happen to the giants who are still working for a firm and how will they be encouraged to do their best?

### The Sandbox

Today we are busy working or perhaps playing in the new management sandbox. Some of the toys in the sandbox include:

#### QUALITY:

We hear a lot about quality, quality circles, and if you check, many companies will cite the percentage of their efforts going into quality management. Yet, one such firm produced a line of autos whose door hinges were corroding such that the doors fell off. They advised their customers that they would fix the doors, because they wanted to treat the customer right.

They should have done it right the first time!

#### THE STORYBOARD:

Another wasteful management practice is the Storyboarding Technique. The intent of this is great, but people soon forget what the real objective is and spend their assets as slaves to the process.

I recall an effort we had, in which I had identified a concept whereby we would increase the sales of one of our products by perhaps a million units. We wanted to tell the Chairman of the plan, but unfortunately, the "Sandboxes" (a business version of a bureaucrat) got into the act; then started a long series of Storyboard sessions to "get the data." After many sessions, and a particular full day of story boarding, I found the leader completely bogged down. I then asked him what the objective was and he indicated that he needed to fill in some critical steps in the story board. I responded by pointing out that I thought that the objective was to tell the Chairman how we could increase our market share. This was followed by an enthusiastic silence.

### Beware of Giants

These examples, while depressing, clearly illustrate the problems facing business today and how we are discouraging the giants among us. There are still companies out there which promote teamwork, creative atmospheres, who encourage and reward their giants. I can name a few, but you can read of their successes in business publications and by talking to their employees. I can remember calling one such firm recently, where the enthusiasm of the secretary was overwhelming. I asked her if she liked her job and her company and her answer was an enthusiastic yes!

To continue our progress in coatings and materials science and engineering we must "Beware of Giants" and:

- (1) Create an environment where teamwork is given more than lip service.
- (2) Identify and nurture the giants in a firm.
- (3) Provide the opportunity for the giant to perform, to be adequately rewarded, and recognized.
- (4) Remove the encumbrances which stifle creativity, such as meaningless and numerous meetings and activities which produce a lot of smoke, but no fires (i.e., storyboarding).
- (5) Get back to basics.

What we have discovered today is not new. Petronius Arbiter, in 210 B.C., must have had similar problems when he said:

*"We trained hard . . . but it seemed that every time we were beginning to form up into teams, we would be reorganized. I was to learn late in life that we tend to meet any new situation by reorganizing; and a wonderful method it can be for creating the illusion of progress while producing confusion, inefficiency and demoralization."*

Perhaps Sir Isaac Newton said it best:

*"If I have seen farther than Descartes, it is because I have stood on the shoulders of giants."*

—THOMAS J. MIRANDA  
Granger, IN

## Book Review

### ORGANIC COATINGS: SCIENCE AND TECHNOLOGY Volume 1: Film Formation, Components, and Appearance

By  
Zeno W. Wicks, Jr., Frank N. Jones, and S. Peter Pappas

Published by  
John Wiley & Sons, Inc.  
605 Third Ave.  
New York, NY 10158-0012 (1992)  
xxiv + 343 Pages, \$85.00

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

This book presents clear and concise descriptions of the physical and chemical principles which are needed for an understanding of modern coatings technology. The historical roots of coatings are described, and limitations in our current understanding are made clear. The reader learns that coat-

ings formulation is still very much of an art, but that the systematic application of the principles taught in this book will speed the development and production of modern coatings. Basic science is linked directly to practical applications, and the jargon of coatings technology is introduced at appropriate points.

This text is an outgrowth of coatings science courses taught for many years at North Dakota State University, and has been polished by use in these classes. The authors are experienced teachers who are highly qualified to write on this subject. Readers who have had two years of college chemistry, including organic but not polymer chemistry, will find that this book is lucid and easy to use.

This book, the first of two volumes, contains introductory chapters on fundamental concepts and film formation. It covers all of the resins commonly used in coatings (10 chapters), solvents (two chapters), and pigments, color, and gloss (one chapter each). A very useful appendix lists sources of information in coatings science which the reader can use to pursue topics in more

depth. In addition, each chapter lists general references and many specific references to the coatings literature. There is also an extensive subject index.

Volume 2 will treat flow, pigment dispersion, and pigment-volume relationships in separate chapters. It will also contain nine chapters describing the characteristics of all modern coatings types, three chapters on coatings properties, and chapters on application processes, film defects, and coatings design. It is expected that Volume 2 will maintain the high standards of the first volume.

When completed, this two-volume set will be the best available introduction which covers the broad scope of all of coatings technology. It will be the text of choice for an introductory course in coatings science for upper undergraduate or beginning graduate students. It should also be on the desk of all those who formulate and test coatings in governmental and industrial laboratories, and it will be an essential reference for production, marketing, and sales personnel in the coatings and allied industries.

# We Won't Leave You Holding The Bag.



Order semi-bulk calcium carbonates from Genstar, and you won't have 40 empty bags lying around for every ton you order.

You'll also save \$5 a ton. Because we won't make you pay for bags you didn't order in the first place. And we'll process your order in 24 hours or less.

So if you'd like to give bags the boot, give Genstar a call: 301-527-4221.

Calcium Carbonates in  
Semi-Bulk Bags From **GENSTAR**

# Coming Events

## FEDERATION MEETINGS

For information on FSCT meetings, contact Federation of Societies for Coatings Technology, 492 Norristown Rd., Blue Bell, PA 19422 (215) 940-0777, FAX: (215) 940-0292.

### 1993

(May 16-19)—Federation "Spring Week." Board of Directors Meeting on the 16th; Incoming Society Officers Meeting on the 17th; Spring Seminar on the 18th and 19th, "The Influence of Substrates and Application Methods/Techniques on Coatings Performance." South Shore Harbour Resort and Conference Center, League City (Houston), TX.

(Oct. 27-29)—71st Annual Meeting and 58th Paint Industries' Show. World Congress Center, Atlanta, GA.

### 1994

(May 12-15)—Federation "Spring Week." Spring Seminar on the 12th and 13th; Incoming Society Officers Meeting on the 14th; Board of Directors Meeting on the 15th. Marriott City Center Hotel, Minneapolis, MN.

(Oct. 12-14)—72nd Annual Meeting and 59th Paint Industries' Show. New Orleans Convention Center, New Orleans, LA.

### 1995

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

## SPECIAL SOCIETY MEETINGS

### 1993

(Mar. 17-19)—Southwestern Paint Convention. "Back to the Future." Dallas and Houston Societies. Four Seasons Resort and Club, Las Colinas (Irving), TX. (Steve Stephens, Ribelin Sales, Inc., P.O. Box 461673, Garland, TX 75046-1673; (214) 272-1594).

(Mar. 23-25)—Western Coatings Societies' 21st Biennial Symposium and Show. "Visions—Opportunities—Challenges." Golden Gate, Los Angeles, Pacific Northwest, and Rocky Mountain Societies. Disneyland Hotel and Convention Center, Anaheim, CA. (Donald I. Jordan, Cargill, Inc., 2801 Lynwood Rd., Lynwood, CA 90262; (213) 537-9935; or Sandra L. Dickinson, Synergistic Performance Corp., 17821 E. 17th St., Ste. 190, Tustin, CA 92680; (714) 544-8200).

(Apr. 13)—Pittsburgh Society Symposium. "An Environment Responsible 90s." Airport Marriott, Pittsburgh, PA. (William C. Spangenberg, Hammond Lead Products Inc., 1910 Cochran Rd., Pittsburgh, PA 15220; (412) 344-5811).

(Apr. 21-23)—Southern Society Annual Meeting. "Waterborne Coatings—Riding the Wave to the Future." Opryland Hotel, Nashville, TN. (Mary Finnigan, McCullough & Benton, Inc., 2900 G Carolina Center, Charlotte, NC 28208; (704) 392-2101).

(Apr. 27)—Detroit Society FOCUS Conference. "Waterborne Technology for the Millennium." University of Detroit-Mercy, Detroit, MI. (Valerie E. Gunn, L&L Products Inc., P.O. Box 308, 74100 Van Dyke, Romeo, MI 48065-0308; (313) 752-4571).

(Apr. 29-May 1)—Pacific Northwest Society Symposium. "Understanding the Fundamentals." Red Lion Hotel, Bellevue, WA. (Richard C. Tomczak, Van Waters & Rogers, Inc., 8201 S. 212th, Kent, WA 98032; (206) 872-5097).

(May)—Philadelphia Society Seminar. "Waterborne Coatings Formulations." Airport Hilton, Philadelphia, PA. (Peter C. Kuzma, V.I.P. Products Corp., 3805 Frankford Ave., Philadelphia, PA 19124; (215) 535-3025).

(May 4-5)—New York Society Symposium. "Recent Advances in Additives & Modifiers for Coatings." Holiday Inn North, Newark Airport, Newark, NJ. (Mildred Leonard, 520 Westfield Ave., Rm. 208, Elizabeth, NJ 07208; (908) 354-3200).

(May 25-26)—New England Society. Coatings Tech Expo '93. "Compliance—Options for the 21st Century." Sheraton Tara Hotel & Resort, Danvers, MA. (Joanne Monique, Ashland Chemical, Inc., 400 Main St., Tewksbury, MA 01876; (800) 962-5388).

(June 4-5)—Joint Meeting of the Kansas City and St. Louis Societies. Holiday Inn, Lake of the Ozarks, MO.

(June 14)—Golden Gate Society. Manufacturing Committee Seminar.

## OTHER ORGANIZATIONS

### 1993

(Mar. 20-21)—Eastern Decorating Products Show. Sponsored by the National Decorating Products Association (NDPA). World Trade Center, Boston, MA. (Teri Flotron, NDPA, Marketing Communications Director, 1050 N. Lindbergh Blvd., St. Louis, MO 63132-2994).

(Mar. 21-23)—"Polymer Blends and Alloys." Course sponsored by the State University of New York (SUNY) at New Paltz. New Orleans, LA. (Angelos Patsis, Institute of Materials Science, SUNY, New Paltz, NY 12561).

(Mar. 21-24)—"Pigment Dispersion." Course sponsored by the State University of New York (SUNY) at New Paltz. New Orleans, LA. (Angelos Patsis, Institute of Materials Science, SUNY, New Paltz, NY 12561).

(Mar. 22-23)—"Industrial Lead Paint Removal and Abatement." Tutorial sponsored by Steel Structures Painting Council (SSPC). Sheraton Inn Bossier City, Shreveport, LA. (SSPC, 4516 Henry St., Pittsburgh, PA 15213-3728).

(Mar. 22-24)—"Emulsion Polymerization." Course sponsored by State University of New York (SUNY) at New Paltz. New Orleans, LA. (Angelos Patsis, Institute of Materials Science, SUNY, New Paltz, NY 12561).

(Mar. 22-26)—Davos Recycle '93 Forum and Exhibition. Sponsored by Maack Business Services. Davos, Switzerland. (Maack Business Services, Moosacherstr. 14, CH-8804, AU/Zürich, Switzerland).

(Mar. 23-25)—International Symposium on Advanced Infrared Spectroscopy (AIRS). Sponsored by The Spectroscopic Society of Japan. Sanjo Conference Hall, The University of Tokyo, Tokyo, Japan. (Hirokazu Toriumi, AIRS Organizing Committee, Dept. of Chemistry, College of Arts and Sciences, The University of Tokyo, Komaba, Meguro, Tokyo 153, Japan).

(Mar. 27-31)—American Chemical Society (ACS) Spring Seminar on "Raw Materials." Pittsburg, PA. (ACS, 1627 K St., N.W., Suite 1000, Washington, D.C. 20006).

(Mar. 28-31)—Adhesive and Sealant Council, Inc. Spring Convention. Pittsburgh Hilton, Pittsburgh, PA. (The Adhesive and Sealant Council, Inc., 1627 K St., N.W., Ste. 1000, Washington, D.C. 20006).

(Apr. 12-15)—Surface Coating '93. The Chemical Coaters Association International's (CCAI) Annual Conference and Exhibition. Amway Grand Plaza Hotel and Grand Center, Grand Rapids, MI. (CCAI, P.O. Box 54316, Cincinnati, OH 45254).

(Apr. 12-16)—Spring Meeting of the Materials Research Society. San Francisco Marriott Hotel, San Francisco, CA. (Materials Research Society, Meetings Dept., 9800 McKnight Rd., Pittsburgh, PA 15237).

(Apr. 13-14)—"Facing the Future . . . Technology for the 90s." Washington Paint Technical Group 33rd Annual Symposium. Ramada Hotel, Tyson's Corner, VA. (Mark Padow, National Paint and Coatings Association, 1500 Rhode Island Ave., N.W., Washington, D.C. 20005).

(Apr. 14-15)—"Industrial Lead Paint Removal and Abatement." Tutorial sponsored by Steel Structures Painting Council (SSPC), Airport Hilton and Towers, Los Angeles, CA. (SSPC, 4516 Henry St., Pittsburgh, PA 15213-3728).

(Apr. 18-21)—Inter-Society Colour Council (ISCC) Annual Meeting and Symposium. Doubletree Hotel, Newport, RI. (Romesch Kumar, Program Chairman, 1993 ISCC Annual Meeting, Hoechst Celanese Corp., 500 Washington St., Coventry, RI 02816).

(Apr. 18-23)—"Durability of Coatings." Symposium sponsored by American Chemical Society, Division of Polymeric Materials: Science Engineering, Denver, CO. (Jonathan W. Martin, NIST, Bldg. 226, Rm. B348, Gaithersburg, MD 20879; David Bauer, Ford Motor Co., SRL-E3198, P.O. Box 2053, Dearborn, MI 48121; F. Louis Floyd, Glidden Research Ctr., 16651 Sprague Rd., Strongsville, OH 44136).

(Apr. 20-21)—"Color Pigments, Regulations, and the Environment." Symposium cosponsored by the Dry Color Manufacturers' Association (DCMA) and the Inter-Society Color Council. Newport, RI. (DCMA, P.O. Box 20839, Alexandria, VA 22320-1839).

(Apr. 20-22)—Surface Treatment '93. "Computer Methods and Experimental Measurements for Surface Treatment Effects." International Conference sponsored by Wessex Institute of Technology, Novotel, Southampton, United Kingdom. (Sue Owen, Conference Secretariat, Wessex Institute of Technology, Ashurst, Southampton, Hants, United Kingdom So4 2AA).

(Apr. 26-30)—"Applied Rheology for Industrial Chemists." Short course sponsored by Kent State University (KSU), Kent, OH. (Carl J. Knauss, Director, Cooperative & Continuing Education—Chemistry, KSU, P.O. Box 5190, Kent, OH 44242-0001).

(Apr. 27-30)—Architectural Spray Coaters Association (ASCA) 8th Annual Conference. Sheraton San Marcus Resort & Conference Center, Chandler, AZ. (ASCA, 230 W. Wells St., Ste. 311, Milwaukee, WI 53203).

(Apr. 28-29)—"Paint Technology—Surviving the '90s, Part II." 47th Annual and 20th "Back to Back" Symposium. Sponsored by The Chemical Institute of Canada, Protective Coatings Division. Hélène de Champlain Restaurant, Montreal, Que., Canada; and The Old

Mill, Toronto, Ont., Canada. (For Montreal, contact: Martin Ménard, Produits Nacan Ltee., 50 Boul. Marie-Victorin, Boucherville, Que. J4B 1V5, Canada; for Toronto, contact: Robert D. McComb, Tioxide Canada Inc., 350 Burnhamthorpe Rd., W., Suite 210, Mississauga, Ont. L5B 3J1, Canada).

(May 2-6)—RadTech Europe '93. Third Annual RadTech conference. Sponsored by RadTech Europe. Italian vessel T/S Eugenio Costa. (RadTech Europe, Business Office, Pérolles 24, CH-1700 Fribourg, Switzerland).

(May 3-7)—11th Annual Atlas School of Natural and Accelerated Weathering. Sponsored by Atlas Electric Devices Co. Miami, FL. (Margaret MacBeth, Atlas Electric Devices Co., 4114 N. Ravenswood Ave., Chicago, IL 60614).

(May 4-6)—Hazardous Materials and Environmental Management Conference and Exhibition (HazMat West/Spring). Sponsored by Tower Conference Management Company, Long Beach Convention Center, Long Beach, CA. (Tower Conference Management Co., 800 Roosevelt Rd., Bldg. E—Ste. 408, Glen Ellyn, IL 60137-5835).

(May 4-6)—Plasticcoat '93 Conference and Exhibition. Sponsored by Products Finishing. Drawbridge Estate & Convention Center, Ft. Mitchell, KY (Greater Cincinnati, OH area). (Cindy Goodridge, Gardner Management Services, 6600 Clough Pike, Cincinnati, OH 45244).

(May 4-6)—"Continuous Steel Strip Plating" Symposium. Sponsored by American Electroplaters and Surface Finishers Society (AESF). Ritz-Carlton Dearborn, Dearborn, MI. (AESF, Central Florida Research Park, 12644 Research Pkwy., Orlando, FL 32826-3298).

(May 4-6)—"Fundamentals of Corrosion and Its Control." Training course sponsored by LaQue Center for Corrosion Technology. Holiday Inn, Wrightsville Beach, NC. (LaQue Center for Corrosion Technology, Inc., P.O. Box 656, Wrightsville Beach, NC 28480).

(May 9-14)—"Polymer Characterization: Thermal, Mechanical, and Optical." Short course sponsored by American Chemical Society (ACS). Virginia Tech University, Blacksburg, VA. (ACS, Dept. of Continuing Education, Meeting Code VPI93, 1155 Sixteenth St., N.W., Washington, D.C. 20036).

(May 10-14)—"Dispersion of Pigments and Resins in Fluid Media." Short course sponsored by Kent State University (KSU), Kent, OH. (Carl J. Knauss, Director, Cooperative & Continuing Education—Chemistry, KSU, P.O. Box 5190, Kent, OH 44242-0001).

(May 16-21)—"Polymer Synthesis: Fundamentals and Techniques." Short course sponsored by American Chemical Society (ACS). Virginia Tech University, Blacksburg, VA. (ACS, Dept. of Continuing Education, Meeting Code VPI93, 1155 Sixteenth St., N.W., Washington, D.C. 20036).

(May 17-19)—Styrenics '93. Sponsored by Maack Business Services. Zürich Hotel International, Zürich, Switzerland. (Maack Business Services, Moosacherstr. 14, 8804 Au/Zürich, Switzerland).

(May 17-20)—"Coatings Science for Coatings Technicians." Short course sponsored by University of Southern Mississippi (USM), Hattiesburg, MS. (Debbie Ballard or Shelby Thames, USM, Dept. of Polymer Science, Southern Station, Box 10076, Hattiesburg, MS 39406-0076).

(May 17-21)—"Introduction to Roll Formulation." Short course sponsored by University of Missouri-Rolla (UMR), Rolla, MO. (UMR Coatings Institute, 142 Schrenk Hall, Rolla, MO 65401).

(May 17-22)—"Interpretations of IR and Raman Spectroscopy." Course sponsored by Fisk Infrared Institute. Vanderbilt University, Nashville, TN. (Fisk Infrared Institute, P.O. Box 265, French Village, MO 63036).

(May 24-28)—"Adhesion Principles and Practice for Coatings and Polymer Scientists." Short course sponsored by Kent State University (KSU), Kent, OH. (Carl J. Knauss, Director, Cooperative & Continuing Education—Chemistry, KSU, P.O. Box 5190, Kent, OH 44242-0001).

(May 25-28)—Annual Conference in Science and Technology of Pigment Dispersion. Luzern, Switzerland. (Angelos Patsis, Institute of Materials Science, State University of New York at New Paltz, New Paltz, NY 12561).

(June 2-4)—15th Annual International Conference on Advances in the Stabilization and Degradation of Polymers. Luzern, Switzerland. (Angelos Patsis, Institute of Materials Science, State University of New York at New Paltz, New Paltz, NY 12561).

(June 6-7)—"Industrial Lead Paint Removal and Abatement." Tutorial sponsored by Steel Structures Painting Council (SSPC), Marriott Astrodome, Houston, TX. (SSPC, 4516 Henry St., Pittsburgh, PA 15213-3728).

## CALL FOR PAPERS

### "WATERBORNE TECHNOLOGY FOR THE MILLENNIUM"

18TH ANNUAL **FOCUS** CONFERENCE  
FUTURE OF COATINGS UNDER STUDY

The Detroit Society for Coatings Technology

April 27, 1993

University of Detroit/Mercy Conference Center

Detroit, Michigan

The 1993 Annual FOCUS Conference for the Detroit Metropolitan Area will focus on waterborne technology for the future. Those wishing to participate are urged to submit a letter of intent including a tentative title of the paper, and a 200 word abstract by February 28, 1993.

Please forward all communications to Dr. Valerie E. Gunn, Senior Research Scientist, L & L Products Inc., P O Box 308, 74100 Van Dyke, Romeo, Michigan 48065-0308 or telephone 313-752-4571.

(June 7-9)—"Engineering Solutions to Industrial Corrosion Problems." Conference cosponsored by the National Association of Corrosion Engineers (NACE) and Norsk Korrosjonsteknisk Forening (NKF). Rica Park Hotel, Sandefjord, Norway. (NKF, Rosenkrantzgate 7, 0159 Oslo, Norway).

(June 7-10)—"Coatings Science for Coatings Formulators." Short course sponsored by University of Southern Mississippi (USM), Hattiesburg, MS. (Debbie Ballard or Shelby Thames, USM, Dept. of Polymer Science, Southern Station, Box 10076, Hattiesburg, MS 39406-0076).

(June 7-11)—"Fundamentals of Chromatographic Analysis." Short course sponsored by Kent State University (KSU), Kent, OH. (Carl J. Knauss, Director, Cooperative & Continuing Education—Chemistry, KSU, P.O. Box 5190, Kent, OH 44242-0001).

(June 14-17)—"Coatings Science for Coatings Chemists." Short course sponsored by University of Southern Mississippi (USM), Hattiesburg, MS. (Debbie Ballard or Shelby Thames, USM, Dept. of Polymer Science, Southern Station, Box 10076, Hattiesburg, MS 39406-0076).

(June 21-22)—"Thin Film Coatings: Topics in Coating and Drying Technology." Short course sponsored by the University of Minnesota, Minneapolis, MN. (Jackie O'Brien, Dept. of Chemical Engineering & Materials Science, University of Minnesota, 421 Washington Ave. SE, Minneapolis, MN 55455).

(June 21-23)—International Colouristic Symposium. Sponsored by the Colouristic Section of the Hungarian Chemical Society, Balatonszéplak (by Lake Balaton), Hungary. (Hungarian Chemical Society, Colouristic Symposium Organizing Committee, H-1027 Budapest Fo u. 68, Hungary).

(June 22-24)—"Predictive Technology" Symposium. Sponsored by American Defense Preparedness Association. Twin Tower Hotel and Convention Center, Orlando, FL. (Frank A. Gagliardi, U.S. Army Armament Research and Development Center, Bldg. 92, Picatinny Arsenal, NJ 07806-5000).

(June 23-25)—Tecnopinturas '93. First Argentine Congress on the Technology of Coatings, Resins, Varnishes, Printing Inks, and Related Products. Sponsored by the Argentine Chemical Association. Buenos Aires, Argentina. (TAL Organizaciones y Servicios, A.J. de Sucre 1552, 8vo. Piso "A" (1428) Buenos Aires, Argentina).

(June 23-25)—"Coating Process Fundamentals." Short course sponsored by University of Minnesota, Minneapolis, MN. (Jackie O'Brien, Dept. of Chemical Engineering & Materials Science, University of Minnesota, 421 Washington Ave. SE, Minneapolis, MN 55455).

(June 27-July 2)—ORGABROM '93. 2nd International Symposium. Sponsored by the Dead Sea Bromine Group in cooperation with the Casali Institute of Applied Chemistry, The Hebrew University of Jerusalem. (Secretariat, P.O. Box 50006, Tel Aviv 61500, Israel).

(July 11-14)—Sixth International Symposium on Polymer Analysis and Characterization. Crete, Greece. (Judith A. Sjoberg, Professional Association Management, 815 Don Gaspar, Santa Fe, NM 87501).

(July 12-16)—19th International Conference in Organic Coatings Science and Technology. Athens, Greece. (Angelos Patsis, Institute of Materials Science, State University of New York at New Paltz, New Paltz, NY 12561).

(July 25-29)—Conference on "Lead in Paint, Soil, and Dust." Cosponsored by ASTM Committees D-22, E-6, D-1, and D-18. University of Colorado, Boulder, CO. (ASTM, 1916 Race St., Philadelphia, PA 19103).

(July 28-30)—"Basic Coatings for Sales and Marketing Personnel." Short course sponsored by University of Missouri-Rolla (UMR), Rolla, MO. (UMR Coatings Institute, 142 Schrenk Hall, Rolla, MO 65401).

(Aug. 3-5)—"Fundamentals of Corrosion and Its Control." Course sponsored by LaQue Center for Corrosion Technology. Blockade Runner Hotel, Wrightsville Beach, NC. (LaQue Center for Corrosion Technology, Inc., P.O. Box 656, Wrightsville Beach, NC 28480).

(Aug. 9-12)—"Coatings Science of Powder Coatings." Short course sponsored by University of Southern Mississippi (USM), Hattiesburg, MS. (Debbie Ballard or Shelby Thames, USM, Dept. of Polymer Science, Southern Station, Box 10076, Hattiesburg, MS 39406-0076).

(Sept. 5-10)—3rd International Congress on Polymer Photochemistry. Sponsored by Manchester Metropolitan University and University of Milan. Genova, Italy. (Emmezeta SRL, Via C. Farini, 70, I-20159, Milano, Italy).

(Sept. 8-10)—3rd International Paint Congress and Exhibition on Paint Industry Suppliers. Sponsored by the Brazilian Association of

Paint Manufacturers. Palácio de Convenções do Anhembi, São Paulo, Brazil. (Especifica S/C Ltda, Rua Augusta, 2516-2nd, Cj 22, 01412-100 São Paulo SP, Brazil).

(Sept. 8-11)—Conference on "Innovative Responses from an Industry under Siege." Sponsored by the Skandinaviska Lacteknikers Forbund (SLF) Congress. Copenhagen, Denmark. (Michael Symes, President, SLF, Strandboulevarden 38, DK-2100, Copenhagen, Denmark).

(Sept. 12-14)—"Back to Basics." 81st Annual Convention of the Canadian Paint and Coatings Association (CPCA). Queen's Landing Inn, Niagara-on-the-Lake, Ontario, Canada. (CPCA, 9900 Cavendish Blvd., Ste. 103, St-Laurent, Quebec H4M 2V2, Canada).

(Sept. 14-17)—Eurocoat '93. (AFTPV-5, rue Etex, 75018 Paris-France).

(Sept. 23)—Detroit Colour Council Meeting. Michigan State Management Education Centre, Troy, MI. (James Hall, General Motors Corp., 30009 Van Dyke, Warren, MI 48090).

(Sept. 29-Oct. 1)—"Accelerated and Natural Weathering Techniques for Coatings and Polymers." Short course sponsored by Kent State University (KSU), Kent, OH. (Carl J. Knauss, Director, Cooperative & Continuing Education—Chemistry, KSU, P.O. Box 5190, Kent, OH 44242-0001).

(Oct. 4-6)—"Polyethylene '93." Conference sponsored by Maack Business Services, Swissôtel Zürich, Switzerland. (Maack Business Services, Moosacherstrasse 14, CH 8804, AU/ZH Switzerland).

(Oct. 5-8)—"Introduction to Coatings Technology." Short course sponsored by Kent State University (KSU), Kent, OH. (Carl J. Knauss, Director, Cooperative & Continuing Education—Chemistry, KSU, P.O. Box 5190, Kent, OH 44242-0001).

(Oct. 12-14)—"Industrial Painting: Application Methods." Short course sponsored by Kent State University, Kent, OH. (Carl J. Knauss, Director, Cooperative & Continuing Education—Chemistry, KSU, P.O. Box 5190, Kent, OH 44242-0001).

(Oct. 25-27)—"Polypropylene '93." Conference sponsored by Maack Business Services, Swissôtel Zürich, Switzerland. (Maack Business Services, Moosacherstrasse 14, CH 8804, AU/ZH Switzerland).

## Advertisers Index

<b>AIR PRODUCTS AND CHEMICALS, INC.</b> .....	<b>11</b>
<b>AQUALON</b> .....	<b>COVER 2</b>
<b>BURGESS PIGMENT COMPANY</b> .....	<b>82</b>
<b>DEXTER CHEMICAL CORPORATION</b> .....	<b>85</b>
<b>GENSTAR STONE PRODUCTS COMPANY</b> .....	<b>88</b>
<b>HALOX PIGMENTS</b> .....	<b>77</b>
<b>HÜLS AMERICA INC.</b> .....	<b>COVER 4</b>
<b>ICI AMERICAS INC.</b> .....	<b>15</b>
<b>S.C. JOHNSON POLYMER</b> .....	<b>COVER 3</b>
<b>R.T. VANDERBILT COMPANY, INC.</b> .....	<b>2</b>
*****	
<b>CLASSIFIED</b> .....	<b>76</b>
<b>SITUATIONS WANTED</b> .....	<b>81</b>

\*\*\*\*\*

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.

## 'Humbug' from Hillman

In their holiday greetings to me, longtime contributors Owen and Helen Carpenter included excerpts from a column published in the *Chicago Tribune* headlined, "A Procrastinator Never Delays Having Fun." Here are some excerpts from the excerpts:

PHILADELPHIA—When Hap Holiday saw an article about the Procrastinators Club of America, he thought, "Anybody who belongs to a club like that must be a lot of fun." He decided to join. "I joined a year later," said Holiday, "I just didn't get around to it."

Another procrastinator, Valerie Jones of Kokomo, IN, wrote, "The other day I went to change my baby's diaper and I found out that he was enlisted in the U.S. Army."

Another potential member wrote to the club, "I put so many things off that if tomorrow ever comes, I'm sunk."

Among other things, the club has organized trips to England to protest to the makers of the Liberty Bell about its cracking; to Holland to relieve the boy with his finger in the dike; and to Italy to watch the Christians battle the lions. A group from Chicago, a few years ago, arrived with buckets of water to help put out the Great Chicago Fire. The effort was a complete success reported a Mr. Wass, the founder of the club in 1956. (Humbug planned to learn his first name but didn't get around to it.)

As for celebrating New Year's, Wass won't uncork any champagne until September or October. "Otherwise, I might be celebrating a bad year." Wass soon will release the club's annual predictions—for 1992.

Jeff Sturm kindly sent me some choice items from the *Yetter Letter*, published by the Walter E. Yetter Company, Wilmington, DE, which, appropriate to the above, contained this tidbit,—"A critic never procrastinates."

Further in the *Yetter Letter*, for its customers:

"The story goes that a minister sold a horse to a fellow and told him the critter was trained to go when the rider said, "Praise the Lord," and to stop when the rider said, "Amen."

The prospective purchaser mounted the beast, said "Praise the Lord," and the horse raced away. Becoming excited, the rider kept saying "Whoa" with no effect on the animal. Then he remembered and said, "Amen."

And the horse stopped abruptly. The rider looked down and found the animal had stopped right at the edge of a gigantic cliff. Wiping his brow, he gratefully declared, "Praise the Lord."

During an auction, proceedings were halted and the auctioneer announced, "A fellow in the room had just lost his wallet containing one thousand dollars. He offers two hundred bucks for its return."

Came a voice from the rear: "Two hundred and ten."  
(Source—H. Matty Simmons)

A lawyer was browbeating a witness. "Isn't it true that you went to the home of the defendant?" the attorney shouted, "Isn't that so?"

"Yes," replied the witness.

"What did he say?" the lawyer asked.

The defendant's attorney objected. "Any conversa-

tion between this witness and my client on that night is not relevant," he said.

A lengthy discussion about relevance ensued. The judge summoned both attorneys to the bench for more discussion. Fifteen minutes went by and no agreement had been reached. The judge declared a recess and summoned the attorneys to his chambers.

Sometime later, the judge and the attorneys emerged and the judge ruled the question proper.

"What did he say?" repeated the lawyer. His smile was confident.

"He wasn't home," said the witness.

—*Soundings Magazine*

Friend Dick Kiefer found this in the November 22nd issue of the *Philadelphia Inquirer*:

### Our Language Never Seems to Get Much Past 1984

This just in. The Committee on Public Doublespeak of the National Council of Teachers of English, which announced its 1992 Doublespeak Awards has ample examples of doublespeak this year:

- Contained depression: economic recession.
- High-velocity, multi-purpose air circulator: electric fan.
- Immediate permanent incapacitation: death.
- Mental activity at the margins: insanity.
- Monitored retrievable storage site: nuclear fuel dump.
- Synthetic glass: plastic.
- Unique retail biosphere: farmers market.
- Waste water conveyance facility: sewage plant.
- Wet deposition: acid rain.

The committee also found several terms to define firing employees: payroll adjusting, permanently downsizing, releasing resources, and repositioning.

And here we thought permanently downsizing meant going on a diet.

John Gardon joins Perrott Philipps and Mike Shoup who discovered those signs abroad where the message may get lost in the translation. The following excerpts, not published before in *Humbug*, were found by John in the *Wall Street Journal* and written by Charles Goldsmith from Brussels:

Such tortured English-language signs are being featured here (Brussels) until December 2, 1992 in an exhibit organized by the European Community's translation service.

Hungry? From a Polish menu, select "roasted duck let loose" or perhaps "beef rashers beaten up in the country people's fashion." By any and all means, avoid the Acapulco hotel that gives new meaning to quality control: "The manager has personally passed all the water served here."

A Budapest zoo puts people first: "Please do not feed the animals. If you have any suitable food, give it to the guard on duty." At a Hong Kong dentist, teeth are "extracted by the latest Methodists."

"Drop your trousers here for best results," suggests a Bangkok dry cleaner. And there is a doctor in Rome with manifold talents: "Specialist in women and other diseases."

—Herb Hillman

*Humbug's Nest*

P.O. Box 135

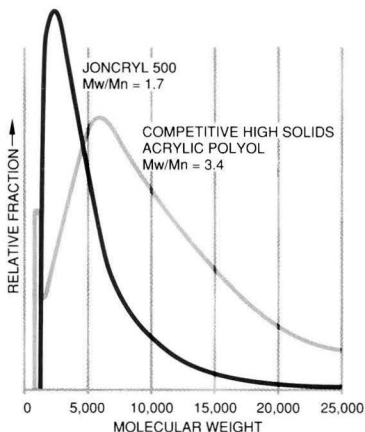
Whitingham, VT 05361

# ▶ A Tall, Slender Curve Makes Joncryl Hi-Solids Acrylic Polyols The Most Attractive In The Industry.

*Route*

Our curve is turning heads. That's because Joncryl high-solids acrylic polyols, like Joncryl 500, are the only ones produced with our patented SGO technology. This process yields acrylic oligomers with unusually narrow molecular weight distributions, eliminating or minimizing the problems normally associated with high-solids coatings—oven smoking, excessive sag, high viscosity and high VOC's.

As a modifying resin for polyester and other acrylics, Joncryl high-solids oligomers can improve application properties and reduce film defects. Add these



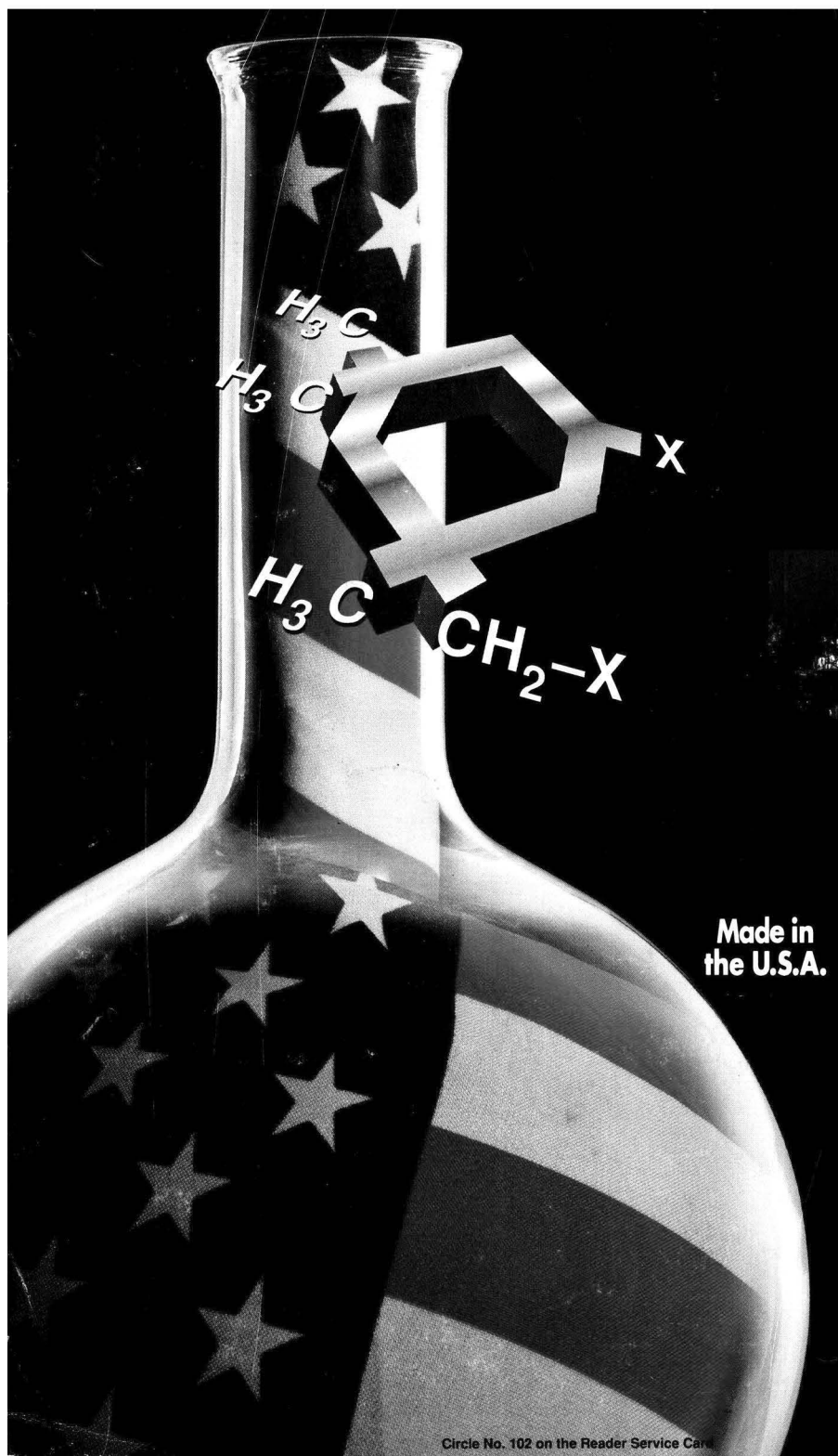
advantages to its broad compatibility with resins, solvents and additives and you'll find Joncryl high-solids oligomers to

have far more versatility than other competitive products.

In the 90's, the paint market will turn to producers of low VOC coatings—so it is important now to take a good hard look at how you can best be prepared. Joncryl SGO technology can be your *best available control technology*. For more information, write to S.C. Johnson Polymer, S.C. Johnson & Son, Inc., Racine, WI 53403, or call 1-800-631-3920.

**SC Johnson  
Polymer**





## The Domestic Source

Hüls pioneered Isophorone Derivatives chemistry in the late 1960's and since then has been perfecting the technology. Now we can assure a constant domestic supply of these quality coatings raw materials through our new plant in Theodore, Alabama.

Call us for more information on the following top quality, high performance products — all supported by our expanded technical service team.

**Made in  
the U.S.A.**

- VESTAMIN® – Diamines
- VESTANAT® – Diisocyanates & polyisocyanates
- VESTICOAT® – Polyurethane systems
- VESTAGON® – Crosslinking agents for powder coatings

HÜLS AMERICA INC.,  
P.O. Box 456,  
80 Centennial Avenue,  
Piscataway, New Jersey  
08855-0456,  
Tel.: (908) 980-6929  
Fax: (908) 980-6970  
In Canada:  
(416) 451-3810

# hüls

# LIQUID NATROSOL FPS

*You asked for it...we listened!*

The Natrosol<sup>®</sup> hydroxyethylcellulose line of paint thickeners has always had the best balance of properties. But you wanted more. Now you can have the added benefits of a new liquid form.

As a Fluidized Polymer Suspension, Natrosol FPS can be added at any step in the paint-making process. It makes viscosity post-adjustment much easier. The bottom line is that this new delivery system can mean more gallons of paint from your present facilities.

And you still get all the film build, spatter resistance, color acceptance, and bioreistance you've come to expect from the Natrosol family of HEC products: Natrosol, Natrosol B, and Natrosol Plus.

Call or write for a demonstration and for an economic analysis.

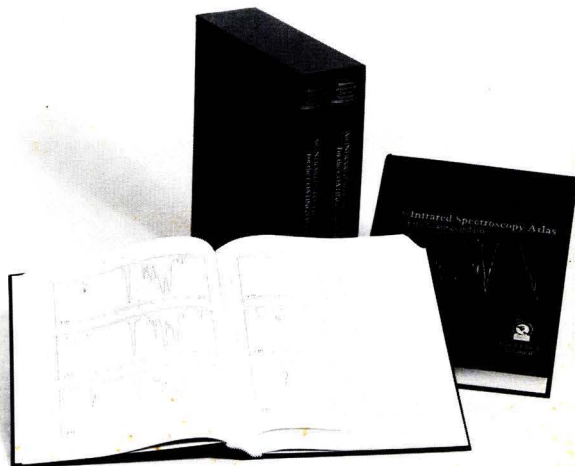


## Aqualon

AQUALON  
1313 N. Market St.  
Wilmington, DE 19879-1740  
Phone 800-345-5704

A Division of Hercules Company

# 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  $\text{cm}^{-1}$ .

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

(215) 940-0777 • FAX: (215) 940-0292

# High bright, uniform and reliable — that's NYTAL<sup>®</sup> talc!



● Before a shipment of NYTAL talc leaves our mines it is carefully tested for viscosity in a paint base, brightness of pigment in resin and particle size fineness. These tests are controlled through SPC and SQC methods. Quality and uniformity are maintained at high levels.

Further testing has shown that this extender pigment is very compatible with all other ingredients in both water and solvent base coatings. Its complete inertness, easy dispersion and excellent suspension characteristics have made it the standard of the industry.

Paint manufacturers know that NYTAL brings the best in talc to their formulations. But, their confidence in NYTAL begins with its handling in the plant. OSHA has recently removed non-asbestiform tremolite, which is found in NYTAL, from its Asbestos Standard.

There are several grades of NYTAL available up to 5 Hegman fineness. For samples and further information, contact R.T. Vanderbilt Company, Inc., Paint Department, 30 Winfield Street, P.O. Box 5150, Norwalk, CT 06856-5150. (203) 853-1400. Fax: (203) 853-1452.



**R. T. Vanderbilt Company, Inc.**  
INDUSTRIAL MINERALS AND CHEMICALS

Photographed at Keeler & Long, Inc., Watertown, CT.

Circle No. 103 on the Reader Service Card