

April 1997

JCT  
JOURNAL OF COATINGS TECHNOLOGY

**Rheological  
Changes During  
the Drying of a  
Waterborne Latex  
Coating**

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- 67** Synthesis and Characterization of Copoly(MMA-MA)-Cu Complex and Study on Its Leaching Behavior—A.B. Samui, V.R. Hande, and P.C. Deb  
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- 73** Unifying Model for Understanding HEUR Associative Thickener Influences on Waterborne Coatings: I. HEUR Interactions with a Small Particle Latex—M. Chen et al.  
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THE JOURNAL OF COATINGS TECHNOLOGY (ISSN 0361-8773) is published monthly by the Federation of Societies for Coatings Technology, 492 Norristown Rd., Blue Bell, PA 19422-2350, Phone (610) 940-0777; Fax: (610) 940-0292.

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

Subscription: U.S. and Canada - 1 year, \$60; 2 years, \$110; 3 years, \$170. Europe (Air Mail) - 1 year, \$90; 2 years, \$170; 3 years, \$260. Other Countries - 1 year, \$75; 2 years, \$140; 3 years, \$220.





## **Guide for Authors**

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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 All manuscripts will be assumed to be previously unpublished writing of the authors, not under consideration for publication elsewhere.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.

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### **SUBMISSION OF MANUSCRIPTS...**

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**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**

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#### **...for Roon Foundation Award Competition**

Ten complete copies of the manuscript are required, and should be submitted to Mike Bell at the address previously listed. (For complete details, see "Roon Awards" section of the JOURNAL in the January 1997 issue.)

### **MANUSCRIPT PREPARATION**

In general, authors are advised to use the "Handbook for Authors" published by the American Chemical Society as a guide to the preparation of manuscripts (ACS, 1155 Sixteenth St., Washington, D.C. 20036).

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

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

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

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

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

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

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

#### **Title**

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

#### **Authors' Biographies and Photographs**

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



## Abstracts

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

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

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## 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\* and subscripts, 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.

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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).

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

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# C O M M E N T

## Interactive Interaction ([www.coatingstech.org](http://www.coatingstech.org))



Those readers who are computer literate know that "http" is not the acronym for a new resin; that "url" is not the Southern colloquial of "oil"; and that the best place to find all about the FSCT, its activities, publications, and Societies can be found on the "web" (and we don't mean "spider").

First previewed at the 1996 International Coatings Expo in Chicago this past October, the Federation's world wide website, [coatingstech.org](http://www.coatingstech.org), has become a best-seller in the industry's access of the Internet, with over 51,000 "hits" since its introduction (through February). The response, frankly, has been overwhelming. Even American Online's recent problems have not kept people away!

What's it all about: Convenient Communication.

While the JCT publishes research articles and other editorial, such as the "Spotlight" features monthly, the Internet provides the forum to present information more succinctly, and on the users' time schedule. The website can and is used to inform and educate, as well as to promote the many activities and benefits of Federation membership.

The horizon is limitless, as is its use: From the 1997 JCT editorial calendar to program information on this month's FSCT seminar on Crosslinking; from a listing of the important international industry events this year to an up-to-date listing of the 1997 ICE exhibitors; from how to compete in the 1997 Roon Awards Competition to an on-line survey of your "web preferences."

Geographically, the FSCT is international — so is the web. In fact, many of the e-mails received are from international users seeking information on publications, seminars, and membership.

The FSCT is constantly looking to improve its services to its members. In the future the FSCT website will include on-line ICE Annual Meeting and seminar registration, on-line downloading of information for exhibitors, "hotlinks" to other industry organizations (including Society websites), JCT archival information, regulatory updates, and on-line publication ordering.

We invite you to participate, become interactive, and to contribute as well. Please e-mail, snail mail, or fax us with your comments and suggestions for new, different, and better ways of doing things on the web.

Log on and visit us at [www.coatingstech.org](http://www.coatingstech.org).

Robert F. Ziegler  
Executive Vice President

## Rheological Changes During the Drying of a Waterborne Latex Coating—F. Löfflath and M. Gebhard

JCT, Vol 69, No. 867, 55 (Apr. 1997)

Increases in the limiting low shear viscosity occurring during the initial drying stages of a water-based latex film were examined for two lattices formulated at varying pH's with a variety of cosolvents and neutralizing agents. Additionally, the rate of water and cosolvent evaporation were determined as a function of temperature and relative humidity. Water was found to evaporate from the films as if it were pure water with an activity coefficient of 1 and a heat of vaporization equivalent to pure water. To characterize the magnitude of the viscosity changes, the limiting low shear viscosities during drying of a water-based latex film were examined using a creep experiment at 0.1 Pa. The increase in viscosity during drying is explained by the volume packing models of Krieger and Dougherty or De Kruij. The viscosity measurements were used to determine the ratio between the volume and weight fraction. For several of the films in this study, the ratio between the volume and weight fraction was not a static parameter, and during the drying process, an abnormally large drop in the effective volume occupied by the latex was observed. This behavior was exaggerated for the samples containing either ethylene glycol monobutyl ether (EB) or  $\text{NH}_4\text{OH}$ . The former can be understood based on the high volatility of EB, while the latter can not be explained purely by the volatility of  $\text{NH}_3$ , and surprisingly indicates that  $\text{NH}_4\text{OH}$  substantially suppresses viscosity during drying.

## Cambios Reológicos Durante el Secado de un Recubrimiento de Latex Base Agua—F. Löfflath y M. Gebhard

Durante la etapa inicial de secado de una película de látex base agua ocurre un incremento de la viscosidad, en esta etapa fueron examinadas dos formulaciones típicas con diferentes PH y con una variedad de cosolventes y agentes de neutralización.

Además se determinó que la velocidad de evaporación de agua y de los cosolventes son una función de la temperatura y la humedad relativa.

Se encontró también que el agua se evapora desde la película como si fuera agua pura con un coeficiente de actividad de 1 y un calor de vaporización equivalente al del agua pura.

Para caracterizar la magnitud de los cambios de viscosidad, se limitó el estudio al valor de viscosidad a bajo efecto cortante, registrando la lenta variación experimental cada 0.1 Pa.

El incremento en la viscosidad durante el secado de una película de látex, es explicado por los modelos de Krieger y Dougherty o de Kruij.

La medida de la viscosidad fue utilizada para determinar la relación entre el volumen y la fracción peso. Para la mayoría de las películas analizadas, la relación entre el volumen y la fracción peso no es un parámetro estático y durante el proceso deseado se observó un agota anormalmente larga en el volumen efectivo ocupado.

Esta conducta fue exagerada en las muestras que contenían, ya sea etilenglicol monobutil éter (EB) o amoníaco  $\text{NH}_4\text{OH}$ . Este comportamiento puede ser entendido en base a la alta volatilidad del (EB), mientras que no podría ser explicado con la volatilidad de  $\text{NH}_3$ , y es necesario indicar que el  $\text{NH}_4\text{OH}$  sustancialmente detiene el incremento de viscosidad durante el secado.

## Synthesis and Characterization of Copoly(MMA-MA)-Cu Complex and Study on Its Leaching Behavior—A.B. Samui, V.R. Hande, and P.C. Deb

JCT, Vol 69, No. 867, 67 (Apr. 1997)

The most effective commercially available antifouling paint system is based on organotin, which is chemically attached to a long chain polymeric binder. Environmental studies have revealed that the proportion of organotin in sea water near the shores has reached an alarming level. Therefore, attempts are being made in multiple directions to eliminate tin from antifouling paint systems. Design of a highly toxic copper based paint system is one of the latest areas of research.

In the present work, a copper complex based on carboxyl containing polymer has been synthesized. Paints were formulated using the complexes as pigment. Critical pigment volume concentration is found to be around 35%. Both accelerated and normal leaching behavior were studied. The release of copper from complex is slower and steadier compared to that from cuprous oxide. The later part of leaching is very close to steady-state behavior.

## Síntesis y Caracterización de Cofolimeros Complejos De (MMA-MA)-CJ y Estudio en el Proceso de Li Xi Viación—A.B. Samui, V.R. Hande and P.C. Deb

Los productos antihongos más efectivos y comerciales disponibles para los sistemas de pinturas están basados en complejos órgano-estaño el cual es unido químicamente por una cadena polimérica larga a una resina.

Estudios ambientales han revelado que la porción en agua de mar cerca de las orillas, ha alcanzado un nivel alarmante. Por lo tanto, se han iniciado intentos en diferentes direcciones para eliminar el estaño de los sistemas de pintura antihongos.

El diseño de sistemas de pintura basados en cobre altamente tóxico es una de las últimas áreas de investigación.

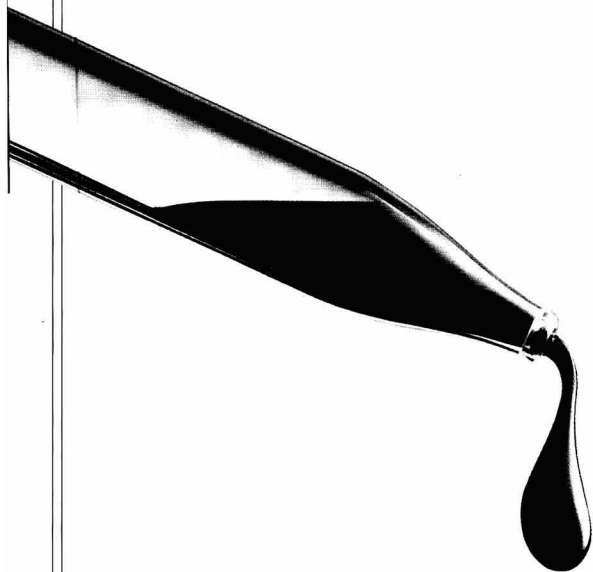
En el presente trabajo fueron sintetizados complejos de cobre basados en polímeros que contienen grupos carboxílicos. Fueron formuladas pinturas usando estos complejos como pigmentos. Se encontró una PVC crítica alrededor de 35%. Se sometieron a estudios acelerados y a condiciones normales del proceso de li xi viación.

Comparado con el óxido cuproso, el proceso de liberación del cobre de los nuevos complejos poliméricos de cobre se libera lenta y constantemente.

La última parte del proceso de li xi viación está muy ligado al proceso constante de liberación de cobre.



# Surfynol® grind aids make a little color go a long way.



Whether you make inks or coatings, pigment is the most expensive part of your waterborne formulation. If you want to stay in the black, you've got to get the most out of your color. That's why you should start with Surfynol grind aids. Surfynol grind aids make a little color go a long way. They provide excellent reduction of dynamic surface tension for rapid wetting of newly created pigment surfaces — so colors develop more quickly with greater intensity. And unlike traditional grind aids, foam problems are stopped before they start. Once

the pigment particles are wet out, Surfynol grind aids also act as superior dispersants, giving you excellent stability with lower working viscosities. In addition, all these benefits carry through into the letdown stage.

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**Unifying Model for Understanding HEUR Associative Thickener Influences on Waterborne Coatings—M. Chen et al.**

JCT, Vol 69, No. 867, 73 (Apr. 1997)

The structural features of associative thickeners influence their viscosifying properties in neat and surfactant containing aqueous solutions and in architectural coating formulations. Our understanding of the phenomena based on model associative thickener of the Hydrophobically modified Ethoxylate Urethane (HEUR) type are presented. These studies provide general concepts in aqueous solutions, but they do not provide a quantitative model for understanding the influence of associative thickeners in coating formulations. To provide a more quantitative description, the interactions of associative thickeners with the film forming latex are considered in this study. This requires a knowledge of the free surfactant concentration in the formulation that depends on the residual amount present in the latex and the amounts added with the pigment grind, colorant, etc. The competitive interaction of the surfactants and associative thickener types for the surface of both disperse phases is a key variable. These interactions with the latex will be discussed in this article in an effort to define an encompassing model for understanding how HEUR associative thickeners influence waterborne coatings.

**Un Modelo Unificador Para Entender La Influencia Del Espesante Asociativo: Uretano Etoxilado Modificado Hidrofobicamente (HEUR = Hydrophobically-Modified Ethoxylate Urethane)—M. Chen et al.**

Fueron estudiadas en una formulación de recubrimientos arquitectónico las características estructurales de los espesantes asociativos y la influencia en las propiedades de viscosidad, así como los efectos de las soluciones acuosas conteniendo surfactantes.

Los propietarios de materiales comerciales con conocimiento de las características estructurales. Proporcionan una lista de variaciones en el desempeño. Nuestra comprensión del fenómeno basado en el modelo del espesante asociativo tipo el "HEUR" y que estamos presentando.

Este estudio proporciona conceptos generales en soluciones acuosas, pero no proporciona un modelo cuantitativo para entender la influencia de los espesantes asociativos en fórmulas de recubrimientos o sobre propiedades de la película ya aplicada. Para proporcionar una mejor descripción cuantitativa de la interacción de los espesantes asociativos con las fases dispersas del recubrimiento, por ejemplo, se considera en este estudio la relación entre el formador de película y el  $TiO_2$ .

Para esto se requiere conocer la cantidad de surfactante libre en la formulación y que depende de la cantidad residual presente en el látex y la cantidad agregada en la molienda de pigmentos, colorantes, etc.

También depende del tipo de estabilizador absorbido en la superficie del formador de película y del  $TiO_2$ .



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

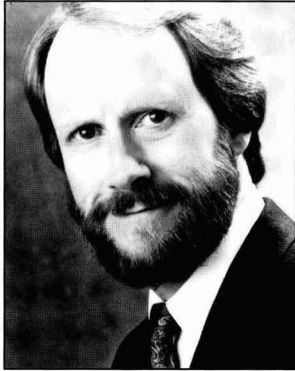
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**JCT**  
JOURNAL OF COATINGS TECHNOLOGY



## Futurist Daniel Burrus to Present Keynote Address at FSCT 75th Annual Meeting, Nov. 3-5, 1997

Celebrating 75 years as the premier technical organization in the coatings industry, the Federation of Societies for Coatings Technology is planning for ICE '97—to be held on November 3-5, 1997 at the Georgia World Congress Center, in Atlanta, GA. Combining the organization's 75th Annual Meeting, International Coatings Expo and the Technology Conference, ICE '97 will open with a Keynote Address by Daniel Burrus, one of the nation's leading science and technology forecasters.



In keeping with the theme "75 Years... Tradition... Discovery... Opportunity," ICE '97 will offer attendees insights into the coatings industry as it moves into the future—pre-viewing innovative technologies and solutions to current challenges.

### 1997 Keynote Address

During his Keynote Address on Monday, November 3, Mr. Burrus will dem-

onstrate how recent innovations in science and technology have provided us with a "new" set of tools to work with to greatly increase productivity and efficiency in all areas. Knowing what these tools are, and how to apply them creatively is rapidly becoming a matter of business survival and a key to personal gain.

His presentation, "Futureview®: A Look Ahead," is designed to offer valuable insight into present and future applications of recent advances, enabling attendees to positively influence

the future as they make sound future plans. Using down-to-earth terminology, insight and humor, Mr. Burrus provides an informative, provocative and fascinating look at the impact of scientific innovations on how we will live and work in the near future. Areas of emphasis include: Going Beyond Your Competition; Your Creative Edge; and Teaching the Future Today.

Daniel Burrus is Founder and President of Burrus Research Associates, a research and consulting firm that specializes in global innovations in science and technology, their creative application and future impact. His client list includes a wide range of industries, including many Fortune 500 companies, such as IBM, AT&T, Exxon, DuPont, Chrysler, Philip Morris, and Motorola.

In his timely presentations, Mr. Burrus helps audiences understand how to make a rapidly changing business environment a competitive advantage by getting all members of an organization involved in creatively utilizing the latest technology.

This is his second engagement with the FSCT; Mr. Burrus was Keynote Speaker at the Federation's Annual Meeting in 1994 in New Orleans.

### Annual Meeting Highlights

Participants of ICE '97 will have an opportunity to attend Annual Meeting technical sessions as part of their registration for all ICE events. Highlights of this year's technical program include:

#### Roon Award Competition Papers:

Representing the best technical work directly related to the protective coatings industry, the Roon Award Papers describe original work of high scientific caliber, not previously presented or published. Awards for the papers are determined on the basis of originality, scientific importance, practical value, and the quality of composition. The papers are presented by the authors during this session.

**International Papers:** Reflecting the global audience of ICE '97, papers are presented from international industry experts. These papers often report on technologies which may affect the global marketplace or detail some of the latest technical advances outside of North America.

**APJ/Voss Award Competition Papers:** These FSCT Constituent Society papers are developed and presented by the Societies' technical committees. Their work deals with the research, development, manufacture or application of the industry's products or raw materials entering into their preparation.

## CSI Organizations to Honor Technical Achievement at FSCT ICE '97

Coatings Societies International will sponsor an award honoring outstanding technical achievement in the presentation of papers at the FSCT Annual Meeting in Atlanta, on November 3-5, 1997. This award, first presented at the XXIII FATIPEC Congress in June 1996, is given at selected annual congresses of CSI-member organizations.

In addition to the Federation of Societies for Coatings Technology, member organizations of CSI include: FATIPEC (Federation d'Association des Techniciens des Peintures, Vernis, Emaux, et

d'Imprimerie de l'Europe Continentale; JSCM (Japan Society of Colour Materials; OCCA (Oil & Colour Chemists' Association; SLF (Skandinaviska Lackteknikers Forbund; SCAA (Surface Coatings Association Australia; and SCANZ (Surface Coatings Association New Zealand).

The award is a polished bronze medallion, inscribed with the CSI logo. Interested parties may contact the CSI General Secretariat at the Federation of Societies for Coatings Technology, 492 Norristown, Rd., Blue Bell, PA 19422-U.S.

(Continued on page 14)

# FSCT Presents Seminars on "Practical Paint Formulation for Raw Material Suppliers" and "Winning Technical Presentations"

Developed by the FSCT Professional Development Committee

Wednesday-Friday, June 25-27, 1997  
Park Hyatt at Bellevue Hotel • Philadelphia, PA



## **Practical Paint Formulation for Raw Material Suppliers** **Wednesday-Thursday, June 25-26**

### **Course Description**

The purpose of the course is to focus on the practical basics of paint formulation and manufacturing to give the staff of industry raw material suppliers a richer understanding of the processes involved in the development and production of coatings. The course is designed for individuals involved in research and development, technical service, and technical sales personnel employed by companies that supply materials to the coatings industry, and anyone else who would benefit from the knowledge of experienced paint formulators and production personnel.

### **Topics to be Covered**

Attendees will receive information on the following topics:

- How to build a paint formula
- How a paint plant operates
- How to make a pigment dispersion
- Performance, testing and applications for various coatings
- How to identify and correct paint defects

## **Winning Technical Presentations** **Friday, June 27**

### **Course Description**

One of the most popular workshops at the 1996 FSCT International Coatings Technology Conference, it is designed for laboratory and R&D personnel at all levels, in addition to marketing and sales staff and anyone else responsible for delivering technical presentations. Attendees will learn how to develop effective visuals; proper speaking techniques and data organization; how to handle question and answer sessions; tips on transferring written information to speaking terms; and how to communicate clearly to all audiences. This program offers a combination of lecture, interaction and small group projects.

### **Attendees will learn:**

- How to effectively develop visuals for technical presentations
- Learn proper speaking techniques
- How to organize data
- Tips to transfer written information to speaking terms
- How to handle question and answer sessions
- Presentation style and format
- How to effectively communicate to all audiences

### **Instructor**

Carter Johnson

Attendance for *Winning Technical Presentations* is limited to 25 attendees

### **Registration Information**

To register, simply complete the accompanying form in detail, attach your check or money order or provide credit card information, and return to: Federation of Societies for Coatings Technology, 492 Norristown Road, Blue Bell, PA 19422-2350— or — FAX your completed form (charges only) to: (610) 940-0292.

### **Registration Fees**

*Practical Paint Formulation (Wednesday-Thursday)*

- \$395 for FSCT members
- \$495 for nonmembers

*Winning Technical Presentations (Friday)*

- \$195 for FSCT members
- \$295 for nonmembers

Included with registration is the following: luncheons, refreshment breaks, and reference materials.

Payment by check must be made in U.S. funds.

### **Cancellation Policy**

If cancellation is necessary, written notification to FSCT is required on or before June 18, 1997. A \$25 processing fee will be applied. For cancellations received after June 18, a \$60 processing fee will be applied.

Attendance is limited and registrations will be accommodated on a first-come, first-served basis.

### **Hotel Information**

The Park Hyatt at the Bellevue Hotel will host the Seminar program. Located within the business and cultural district of Philadelphia, this national historic landmark hotel offers guests a health club, three restaurants and a lounge as well as shopping and a food court at the Shops of the Bellevue located below the hotel. Self or valet parking available.

A block of guest rooms is available at the group rate of \$145 single or double. To place accommodations, complete the hotel reservation form. The cut-off date to receive the FSCT rate is May 21. After

*(Continued on page 14)*





**"Practical Paint Formulation for Raw Material Suppliers" –  
June 25-26, 1997 and  
"Winning Technical Presentation" – June 27, 1997  
Park Hyatt at the Bellevue Hotel • Philadelphia, PA**

**Registration Form**

Name \_\_\_\_\_  
 Nickname (for Badge) \_\_\_\_\_  
 Company \_\_\_\_\_  
 Address \_\_\_\_\_  
 City \_\_\_\_\_ State \_\_\_\_\_ Zip \_\_\_\_\_  
 Phone \_\_\_\_\_ FAX \_\_\_\_\_

I am a member of the following FSCT Society \_\_\_\_\_  
**Free FSCT Monograph!** If we receive your registration by May 15, we'll mail you one of the following titles (check one):  Film Formation  Introduction to Polymers and Resins  Mechanical Properties

**PLEASE CHECK ONE BLOCK IN EACH OF THE TWO COLUMNS BELOW:**

- 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 \_\_\_\_\_

- 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 \_\_\_\_\_

**Method of Payment (payable to FSCT)**

**Registration Fees:**

Practical Paint Formulation (W-Th)  FSCT Member – \$395  Nonmember – \$495  
 Winning Technical Presentations (F)  FSCT Member – \$195  Nonmember – \$295

Check here if you are interested in becoming a member of FSCT.  
 Registration fee includes lunch, breaks, and copies of any support documentation from the speakers.  
 Payment is due with the registration form.

Total amount due \$ \_\_\_\_\_

Please check one:

- Enclosed is Check # \_\_\_\_\_ payable in U.S. Funds on a U.S. Bank to "FSCT"
- Charge to the following card:  MC  VISA  AMEX

Card No. \_\_\_\_\_ Expiration Date: \_\_\_\_\_/\_\_\_\_\_/\_\_\_\_\_  
 Mo. Yr.

Signature \_\_\_\_\_

Please print Cardholder's Name \_\_\_\_\_  
 If cancellation is necessary, written notification to FSCT is required on or before June 18, 1997. A \$25.00 processing fee will be applied. For cancellations received after June 18, a \$60.00 processing fee will be applied.

ATTENDANCE IS LIMITED AND REGISTRATIONS WILL BE ACCOMMODATED ON A FIRST-COME, FIRST-SERVED BASIS.

**Hotel Information (payable to Park Hyatt at the Bellevue)**

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

Room Requests:  Single  Double  Smoking  Non-Smoking

Special needs (please specify): \_\_\_\_\_

**Deposit**

- Check payable to Park Hyatt at the Bellevue for \$145
- Charge to the following card:  MC  VISA  AMEX  DISCOVER

Card No. \_\_\_\_\_ Expiration Date: \_\_\_\_\_/\_\_\_\_\_/\_\_\_\_\_  
 Mo. Yr.

Signature \_\_\_\_\_

Please print Cardholder's Name \_\_\_\_\_

The cut-off date to receive the FSCT rate is May 21, 1997. After that date, reservations will be accepted on a space available basis at the prevailing rate. Hotel check-in time is 3:00 pm and check-out time is 12 Noon. A one night's deposit is required to place a reservation. The deposit is refundable if cancelled 24 hours prior to arrival. Attendees paying the registration fee with a credit card can FAX the form to (610) 940-0292. Return completed form and check(s) to: Federation of Societies for Coatings Technology, 492 Norristown Rd., Blue Bell, PA 19422-2350. FSCT has the right to amend this program as necessary. In the event of a program cancellation, FSCT is not responsible for incidental costs incurred by registrants.



## Futurist Daniel Burrus to Present Keynote Address at FSCT 75th Annual Meeting, Nov. 3-5, 1997

Continued from Page 11

**Women in Coatings Roundtable:** Entitled, "Coatings 2000: Women Leading into the New Century," this panel discussion will feature female leaders of the coatings industry addressing a timely topic—the role of women in the paint and coatings industry, both now and in the future.

**Technical Focus Lecture:** One of the most popular features of the Annual Meeting, the Technical Focus Lecture kicks off the technical portion of the Annual Meeting technical program. The Lecturer is chosen by the Chairs of several

FSCT Committees, for on-going work in critical technical areas.

**Mattiello Memorial Lecture:** The Mattiello Lecturer is an individual who has made outstanding contributions to science, technology, and engineering, related to the coatings industry. The Lecturer embodies the standards of technical accomplishment, service to the coatings industry and leadership established by Joseph J. Mattiello, who did much to expand the application of science in the decorative and protective coatings field. This presentation, considered one of the most prestigious events of ICE '97, con-

cludes the technical programming of the Annual Meeting.

### ICE '97 Registration

Information on registering for ICE '97 will be sent to all FSCT members in May. Special conference pricing packages will be offered, including Early Bird Discounts, which will be in effect until June 30, 1997. For additional information, or non-member registration, contact FSCT, 492 Norristown Rd., Blue Bell, PA 19422-2350. Tel: (610) 940-0777; Fax: (610) 940-0292.

## FSCT Presents Seminars on "Practical Paint Formulation for Raw Material Suppliers" and "Winning Technical Presentations"

Continued from Page 12

that date, reservations will be accepted on a space-available basis at the prevailing rate.

Check-in time is 3:00 PM. Check-out time is 12 Noon.

A one-night's deposit is required to place a reservation. The deposit is refundable if the reservation is canceled 24 hours prior to arrival.

### Travel Arrangements

**Getting to Philadelphia:**

By Air: Philadelphia International Airport, eight miles from Center City is served by all major domestic carriers.

By Train: Amtrak operates rail service along the northeast corridor stretching from Boston to Washington, D.C.

Contact the FSCT Travel Desk for your transportation needs at 1-800-448-FSCT or 215-628-2549 and mention the FSCT June seminar for meeting discounts which may apply.

### About the PDC

The purpose of the FSCT Professional Development Committee is to promote and maintain individual technical competence, from basic techniques through state-of-the-art technology within coatings and related industries in a way that will meet the needs of the individuals through appropriate educational and training mechanisms (short courses, technical symposia and Annual Meeting sessions) so that coatings professionals can effectively contribute to the success of their respective employer within the global marketplace.

## Tentative Program Schedule

### Practical Paint Formulation for Raw Material Suppliers

#### Wednesday, June 25, 1997

- 9:00 AM ..... Building a Paint Formula, John Ballard, Burgess Pigment Co.
- 10:45 AM ..... Refreshment Break
- 11:00 AM ..... How a Paint Plant Operates, Parker Pace, Behr Process Corp.
- 12 NOON ..... Lunch
- 1:15 PM ..... How to Make a Pigment Dispersion, Steve Valente, Kronos
- 2:45 PM ..... Refreshment Break
- 3:00 PM ..... Architectural Coatings, Parker Pace
- 3:45 PM ..... Automotive/OEM Coatings, Phil Yaneff, DuPont Canada
- 4:30 PM ..... Round Table Discussion
- 5:00 PM ..... Recess

#### Thursday, June 26, 1997

- 8:00 AM ..... Industrial Wood Coatings, Gary Currier, Akzo Nobel
- 8:45 AM ..... Industrial Metal Coatings, Max Winkeler, Sigma Coatings
- 9:30 AM ..... Refreshment Break
- 9:45 AM ..... Waterborne/Solvent-Borne Coatings, Cliff Schoff, PPG
- 12 NOON ..... Lunch
- 1:30 PM ..... Case Studies—Identifying and Correcting Paint Defects
- 3:00 PM ..... Roundtable Discussion
- 3:30 PM ..... Program Concludes

### Winning Technical Presentations

#### Friday, June 27, 1997

- 8:00 AM ..... Program Begins
- 9:30 AM ..... Refreshment Break
- 11:30 AM ..... Lunch
- 12:30 PM ..... Program Continues
- 2:00 PM ..... Refreshment Break
- 4:00 PM ..... Program Concludes



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 Software 2000)  
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 Silverline Mfg. Co., Inc.  
 Software 2000, Inc. (see  
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 Southcorp Packaging USA, Inc.  
 NAMPAC/Bennett  
 The University of Southern  
 Mississippi  
 Specialty Minerals, Inc.  
 Spencer Machine & Tool Co.  
 Spraymatic, Inc.  
 Startex Chemical, Inc.  
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Tech Pak, Inc.  
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 Toyal America Inc.  
 Troy Corp.

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 U.S. Zinc Corp.  
 UCB Chemicals Corp.  
 Union Carbide Corp.  
 Union Process Inc.  
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 Versa-Matic Pump Co.  
 Vortis-Siv Div. MM Industries, Inc.  
 Wacker Silicones Corp.  
 Wilden Pump & Engineering Co.  
 Witco Corp.

X-Rite, Incorporated  
 Zemex Industrial Minerals  
 Zeneca Resins/Zeneca Biocides

ZPA  
ZPO  
ZMP  
ZCP  
ZPZ  
ZBZ

## HEUCOPHOS®

The cutting edge for  
Protective Coatings

ZAPP  
ZCPP  
SAPP  
SRPP  
CAPP

### for solvent based coatings

ZPA	ZPO	ZMP	ZCP	ZPZ/ZBZ		ZAPP	ZCPP	SAPP	SRPP	CAPP
↑	↑	↻	↑	↑	Alkyd resins	↑	↑	↻	↻	↻
↻	↻	↻	↻	↻	Polyesters	↻	↻	↑	↑	↻
↑	↻	↻	↻	↑	Epoxy resins	↑	↻	↑	↻	↻
↑	↻	↻	↻	↻	Polyurethanes	↑	↻	↑	↻	↻
↻	↻	↻	↑	↻	Chlorinated polymers	↻	↻	↻	↻	↻
↻	↑	↻	↻	↻	Silicone resins	↻	↻	↻	↻	↻
↻	↻	↻	↑	↻	Polyvinyl butyrale / Phenolic resins	↑	↑	↻	↻	↻

### for water based coatings

ZPA	ZPO	ZMP	ZCP	ZPZ/ZBZ		ZAPP	ZCPP	SAPP	CAPP
↑	↻	↻	↑	↻	Alkyd resins	↑	↻	↻	↻
↻	↻	↑	↑	↻	Alkyd emulsions	↻	↑	↻	↻
↑	↻	↑	↻	↑	Epoxy emulsions	↻	↻	↻	↻
↻	↻	↻	↻	↻	Epoxy dispersions	↻	↻	↑	↻
↑	↻	↻	↻	↻	Polyurethane dispersions	↻	↻	↑	↻
↑	↻	↻	↻	↻	Silicone emulsions	↑	↻	↻	↻
↻	↻	↻	↑	↑	Acrylate dispersions	↻	↑	↻	↻
↻	↻	↻	↑	↑	Butadiene dispersions	↻	↑	↻	↻

↑ very frequent application   
 ↻ frequent application   
 ↻ less frequent application

# HEUCOPHOS® - Active

## 2<sup>nd</sup> Generation

HEUCOPHOS ZPA, ZPO, ZMP, ZCP, ZPZ and ZBZ are active multi-level anticorrosive pigments. They differ from conventional zinc phosphate such as Zinkphosphat ZP 10 from Heubach by a modified chemical composition and optimized particle size, structure and distribution.

The following product brochures explain the technical properties and application options in detail:


**NEW**

**HEUCOPHOS® ZCP**

A modified zinc calcium strontium orthophosphate silicate hydrate

Guarantee for trace contents:  
Pb max. 10 ppm  
Cd max. 10 ppm

**BROCHURE AVAILABLE IN: MAY 1997**

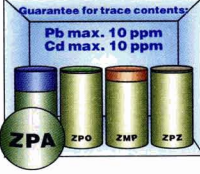


The image shows a collection of product brochures for HEUCOPHOS pigments. A red banner with the text 'BROCHURE AVAILABLE IN: MAY 1997' is overlaid on the brochures. The brochures are arranged in a grid, with each brochure featuring a different pigment product.

**HEUCOPHOS® ZPA**

A modified zinc aluminium orthophosphate hydrate

Guarantee for trace contents:  
Pb max. 10 ppm  
Cd max. 10 ppm

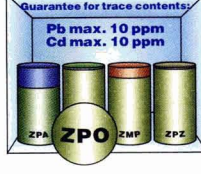


The image shows a collection of product brochures for HEUCOPHOS pigments. The brochures are arranged in a row, with each brochure featuring a different pigment product.

**HEUCOPHOS® ZPO**

A organically treated basic zinc orthophosphate hydrate

Guarantee for trace contents:  
Pb max. 10 ppm  
Cd max. 10 ppm



The image shows a collection of product brochures for HEUCOPHOS pigments. The brochures are arranged in a row, with each brochure featuring a different pigment product.

**HEUCOPHOS® ZMP**

A modified basic zinc molybdenum orthophosphate hydrate

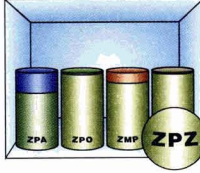
Guarantee for trace contents:  
Pb max. 10 ppm  
Cd max. 10 ppm



The image shows a collection of product brochures for HEUCOPHOS pigments. The brochures are arranged in a row, with each brochure featuring a different pigment product.

**HEUCOPHOS® ZPZ**

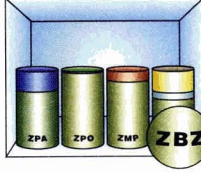
An organic/inorganic modified basic zinc orthophosphate hydrate



The image shows a collection of product brochures for HEUCOPHOS pigments. The brochures are arranged in a row, with each brochure featuring a different pigment product.

**HEUCOPHOS® ZBZ**

An organic/inorganic modified basic zinc phosphate silicate hydrate



The image shows a collection of product brochures for HEUCOPHOS pigments. The brochures are arranged in a row, with each brochure featuring a different pigment product.



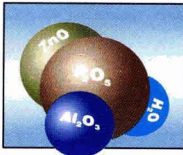
# Anticorrosive Pigments

The newly developed pigments of this polyphosphate series provide an altered chemical basis in comparison with the modified zinc orthophosphates and therefore a different electrochemical efficiency. These changes open new fields of application.

3<sup>rd</sup> Generation

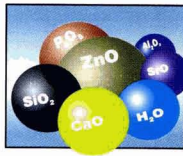
The following product brochures explain the technical properties and application options in detail:

**HEUCOPHOS® ZAPP**  
 A modified zinc aluminium polyphosphate hydrate



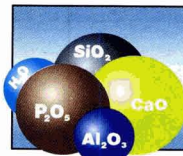
Guarantee for trace contents:  
 Pb max. 10 ppm, Cd max. 10 ppm

**HEUCOPHOS® ZCPP**  
 A modified zinc-calcium aluminium strontium polyphosphate silicate hydrate



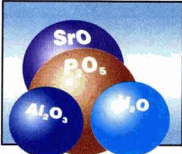
Guarantee for trace contents:  
 Pb max. 10 ppm, Cd max. 10 ppm

**HEUCOPHOS® CAPP**  
 A modified calcium aluminium polyphosphate silicate hydrate



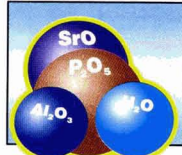
Guarantee for trace contents:  
 Pb max. 10 ppm, Cd max. 10 ppm

**HEUCOPHOS® SAPP**  
 A modified strontium aluminium polyphosphate hydrate

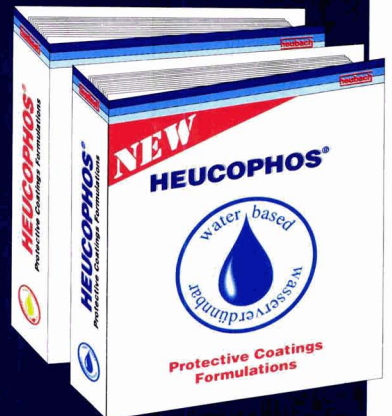


Guarantee for trace contents:  
 Pb max. 10 ppm, Cd max. 10 ppm

**HEUCOPHOS® SRPP**  
 An especially modified strontium aluminium polyphosphate hydrate



Guarantee for trace contents:  
 Pb max. 10 ppm, Cd max. 10 ppm



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**2<sup>nd</sup> Generation**

Sample Literature

**NEW**

- |                  |                          |                          |
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| 2. HEUCOPHOS ZPO | <input type="checkbox"/> | <input type="checkbox"/> |
| 3. HEUCOPHOS ZMP | <input type="checkbox"/> | <input type="checkbox"/> |
| 4. HEUCOPHOS ZCP | <input type="checkbox"/> | <input type="checkbox"/> |
| 5. HEUCOPHOS ZPZ | <input type="checkbox"/> | <input type="checkbox"/> |
| 6. HEUCOPHOS ZBZ | <input type="checkbox"/> | <input type="checkbox"/> |

**AVAILABLE  
MAY 1997**

**3<sup>rd</sup> Generation**

**NEW  
NEW**

- |                          |                          |                          |
|--------------------------|--------------------------|--------------------------|
| 7. HEUCOPHOS ZAPP        | <input type="checkbox"/> | <input type="checkbox"/> |
| 8. HEUCOPHOS ZCPP        | <input type="checkbox"/> | <input type="checkbox"/> |
| 9. HEUCOPHOS SAPP        | <input type="checkbox"/> | <input type="checkbox"/> |
| 10. HEUCOPHOS SRPP       | <input type="checkbox"/> | <input type="checkbox"/> |
| 11. HEUCOPHOS CAPP       | <input type="checkbox"/> | <input type="checkbox"/> |
| 12. Formulations Part I  | <input type="checkbox"/> | <input type="checkbox"/> |
| 13. Formulations Part II | <input type="checkbox"/> | <input type="checkbox"/> |
| 14. Product overview     | <input type="checkbox"/> | <input type="checkbox"/> |



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## Southern Society's Annual Meeting Highlights "Reaching Beyond the 21st Century" on May 13-15

On May 13-15, The King and Prince Beach and Golf Resort, on St. Simons Island, GA, will host the 61st Annual Southern Society for Coatings Technology Convention.

A group of speakers from the paint and coatings and related industries have been assembled to focus on this year's theme, "Reaching Beyond the 21st Century." The topics to be discussed include the following:

Keynote Address—"Encapsulation: A Method of Abating Leaded Paint in Housing"—Saul Spindel, D/L Laboratories, Inc.;

"Principles of Pigment Wetting and Dispersing"—Edward W. Orr, BYK-Chemie USA;

"Surface Tension—A Key to Coating Defect"—Joel Schwartz, Air Products and Chemicals, Inc.;

"New Developments in Acrylate Modified Epoxy-Amine Cure Coatings"—Michael Bailey, Sartomer Co.;

"Formulating with High Gloss Corrosion Resistant Emulsions"—George E. Ahrens, Engineered Polymers Solutions, Inc.;

"Analysis of Components of an Architectural Coating"—Eric A. Hayri, Huber EMD;

"The Paint Plant for the 21st Century"—Charles S.

Alack, Semi-Bulk Systems Inc. and Pat Lutz, Dunn-Edwards Corp.;

"Present and Future Methods of Coatings Analysis by Optical Microscopy, A Basic Approach"—Rich Brown, MVA, Inc.;

"One-Package Waterborne Crosslinking Finishes"—Gail Pollano, Zeneca Resins;

"Introduction to Mica Pigment in Coatings"—Michael T. Venturini, Engelhard Corp.;

"UV Curing Profile of Acrylate Resins"—Kip Sharp, the University of Southern Mississippi; and

"Photoinitiator Free Polymerization"—Garret Doucet, The University of Southern Mississippi.



### "Recent Advances in Additives and Modifiers" The Focus of New York Society's Symposium

The Technical Committee of the New York Society for Coatings Technology is sponsoring "Recent Advances in Additives and Modifiers for Modern Coatings" on April 30-May 1, at the Holiday Inn North, Newark Airport, NJ.

John L. Massingill, of the Coatings Research Institute, Eastern Michigan University, will serve as the dinner speaker. Mr. Massingill will discuss "University Perspective of Government, Universities, and Industry Working Together."

The following speakers have been selected by the committee:

"The Re-engineering of Wetting and Dispersing Performance Through Novel Pigment Control Techniques"—Edward W. Orr, BYK-Chemie;

"Defoamer Selection and Testing"—Chuck D'Amico, Ultra Additives Inc.;

"Use of Micronized Waxes in Waterborne Systems"—Warren Pushaw, Micro Powders Inc.;

"Non-Tin Metal Catalysts for Urethane Coatings"—John Florio, King Industries, Inc.;

"Rheology Modifiers: Formulating to Performance"—Eric A. Johnson, Rohm and Haas Co.;

"Dispersion Chemistry in Waterborne Systems"—Stanley J. Pruskowski Jr., Rohm and Haas Co.;

"The Effect of Synthetic Amorphous Silica on High-Solids, UV Cure, and

Water-Based Coatings"—Roy Seeman, Fuji Silysia Chemical Ltd.;

"Foam Control in Today's Waterborne Coatings"—Andrew A. Romano and Carl J. Cappabianca, Ashland Chemical Co.;

"Enhanced Coatings Performance with Polyethylene Wax"—Eric H. Erenrich, Allied Signal;

"Surface Wetting of Difficult Substrates"—Robert Miller, Pravin Patel, and Akheer Lateef, Troy Corp.;

"Polyaniline, Novel Additive Against Corrosion"—Kalle Levon, Polytechnic University;

"Compatibility Theory—How to Choose the Proper Silicone Additive for Your Needs"—Bob Ruckle, OSI Specialties, Inc.;

"Flow Modifiers for Surface Defect Control"—Marilyn A. Grolitzer and Dennis E. Erickson, Monsanto;

"Hydrophobic Dispersants Can Selectively Improve the Water Resistance, Gloss, and Rheological Properties of Architectural Coatings"—Bruce Matta, Henkel Corp.; and

"Advanced Polymers"—To be determined.

The registration fee of \$200 includes the lectures, lunches, and breaks, the cocktail hour, and dinner. Contact Mildred Leonard, NYSCT, 520 Westfield Ave., Elizabeth, NJ 07208; (908) 354-3200 for more information.

Another highlight of the event will be the unveiling of a plaque honoring the SSCT Past-Presidents. The plaque will be part of future SSCT conventions with the outgoing president's name added on each year. The University of Southern Mississippi will display this plaque year-round at the Polymer Science Department.

The SSCT Convention will also feature a golf outing on May 13. In addition, a charter fishing trip and Emerald Princess Dinner and Casino cruise have also been planned for the attendees. Spouses will have the opportunity shop and tour historic St. Simons and Sea Islands during the "Antiques, Boutiques, and Uniques" tour.

The member registration fee for the program is \$110, while the nonmember fee is \$145.

For more information, contact Peg Harshfield, Secretary, 5375 Fox Hill Dr., Norcross, GA 30092.

### Lehigh University to Conduct Corrosion Control Course

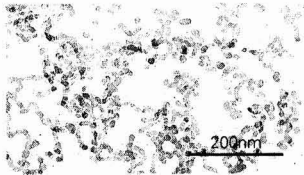
Lehigh University, Bethlehem, PA, will conduct a short course on "Corrosion and Its Control by Protective Coatings," May 19-23, 1997.

This course will concentrate on the control of corrosion through the use of metallic and organic coatings.

For more information, contact Richard Granata, Zettlemoyer Center for Surface Studies, Sinclair Laboratory, 7 Asa Dr., Bethlehem, PA 18015-3192.

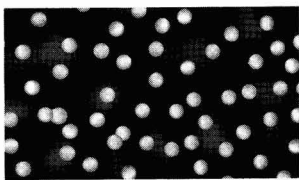
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Colloidal Silica dispersed in  
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Type	SiO <sub>2</sub> %	Dispersant
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<b>EG-ST</b>	20	Ethylene glycol
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<http://pubs.acs.org/Chemcy/cos/ds/593/index.html>

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## Service Life Prediction Topic of Symposium Scheduled for September 14-17 in Colorado

An international symposium on "A Systems Approach to Service Life Prediction of Organic Coatings," is slated for September 14-19, 1997 at The Village of Breckenridge: Resort, Breckenridge, CO. Six sessions highlight the event.

### SESSION I—OVERVIEW AND IMPORTANCE OF SERVICE LIFE PREDICTION PROBLEM IN THE COATINGS INDUSTRY

"Weather Cycles: Real or Imaginary"—William J. Burroughs;

"Accelerated Weathering: Science, Pseudo-Science, or Superstition"—George Pilcher, Akzo Nobel Coatings Inc.;

"Risk Management: The Real Reason for Long Product Development Time Cycles"—F. Louis Floyd, Duron, Inc.;

"A Systems Approach to the Service Life Prediction of Organic Coatings"—Jonathan W. Martin, NIST.

### SESSION II—QUANTITATIVE CHARACTERIZATION OF OUTDOOR EXPOSURE SITES

"Spectral UV-Radiation Monitoring and Biological Effects in Aquatic Environments"—Patrick Neale, Smithsonian Environmental Research Center;

"Panel Wetness"—Douglas Burch, NIST;

"Predicting Temperatures of Exposure Panels: Models and Empirical Data"—Daryl Meyers, NREL;

"Monitoring and Characterizing Air Pollutants and Aerosols"—Svein Haagenrud, Norwegian Institute for Air Research;

"A Survey of National and International Ultraviolet Monitoring Networks"—Elizabeth Weatherhead, National Oceanic and Atmospheric Administration;

### SESSION III—ACCELERATED TESTING

"Accelerated Aging Tests: Experimental Design and Analysis"—William Meeker, Iowa State University;

"Use of Reliability-Based Methodology for Appearance Measurements"—Patrick Schutyser, Coatings Research Institute of Belgium (CoRI);

"Appearance and Surface Defects Using Digital Image Analysis"—Fred Lee, Atlas Weathering Service Group;

"Supposition and Rumor About Cumulative Damage in Service Life"—Sam C. Saunders, Washington State University;

### SESSION IV—FUNDAMENTAL MECHANISTIC STUDIES

"Overview of Mechanical Property Changes During Coating Degradation"—Loren Hill, Monsanto;

"On Stress Development and Weathering of Organic Coatings"—Dan Perera, CoRI;

"Improved Service Life of Coated Metals by Engineering the Polymer Metal Interface"—Wym Van Oijj, University of Cincinnati;

"Prediction of Coating Lifetime Based on FTIR Microspectrophotometric Analysis of Chemical Evolutions"—Jacques Lemaire, Universite Blaise Pascal, France;

"Application of Failure Models for Predicting Weatherability in Automotive Coatings"—David Bauer, Ford;

### SESSION V—REPRESENTATION, INTEGRATION, AND USE OF SCIENTIFIC AND ENGINEERING KNOWLEDGE

"Data Quality Issues and the Development of Standard Formats for Representing Material Properties"—John Rumble, NIST;

"Uses and Delivery of Materials Information"—Gil Kaufman, The Aluminum Association;

"Case Study in Coatings Data Management: Collection, Processing, and Interpretation";

"Methods for Representing and Accessing Material Property Data and Its Use with Decision Support Systems"—Larry Kaetzel, NIST;

"Reliability Engineering: The Commonality between Airplanes, Light Bulbs, and Coated Steel"—Stephen Tait, Johnson Wax;

### SESSION VI: WRAP-UP

In addition, a poster session describing recent SLP research has been planned. To submit a poster for this session, send your name, company, and title, along with a brief abstract by August 1, 1997 to Karlis Adamsons, DuPont Automotive, Marshall R&D Laboratory, 3401 Grays Ferry Ave., Philadelphia, PA 19146; (215) 339-6345; or R. Sam Williams, USDA Forest Service, Forest Products Laboratory, One Gifford Pinchot Dr., Madison, WI 53705-2398; (608) 231-9412.

This symposium is a collaboration between the Polymeric Materials Science and Technology Division of the American Chemical Society, National Institute of Standards and Technology, National Renewable Energy Laboratory, Federal Highway Administration, Wright Patterson Air Force Base, and Forest Products Laboratory, Madison.

For more information contact Jonathan Martin, NIST, Bldg. 226, Rm. B350, Gaithersburg, MD 20899; (301) 990-6891.



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## Kent State University Coatings Short Courses Highlight Rheology, Dispersion, Adhesion, and Coatings Introduction

Four coatings related courses will be conducted by the Professional Development Institute and KSU Conference Bureau at Kent State University, Kent, OH. The courses are: "Applied Rheology for Industrial Chemists," April 14-18; "Introduction to Coatings Chemistry and Technology," April 28-May 1; "Dispersion of Pigments and Resins in Fluid Media," May 5-9; and "Adhesion Principles and Practice for Coatings and Polymer Scientists," May 12-16. The following is a day-by-day breakdown of each course.

### "Applied Rheology for Industrial Chemists"

**MONDAY, APRIL 14:** "Introduction to Rheology and Rheometry"—Irvin M. Krieger, Case Western Reserve University; "Fundamentals of Linear Viscoelasticity"—Irvin M. Krieger; "Rheological Instruments and Selection"—Richard M. Webber and Edward A. Collins, The Lubrizol Corp.; "Polymer Melt Rheology"—Edward A. Collins, E.A. Collins Inc.

**TUESDAY, APRIL 15:** "Meaningful Rheological Measurements"—Richard M. Webber and Edward A. Collins; "Rheology in the Protective and Decorative Coatings Industry, Part I"—Richard R. Eley, ICI Paints; "Rheology in the Protective and Decorative Coatings Industry, Part II"—Richard R. Eley; "Use and Performance of Rheological Additives for Water- and Solvent-Based Coatings"—Robert E. Van Doren, Rheox, Inc.

**WEDNESDAY, APRIL 16:** "Rheology of Dispersions"—Irvin M. Krieger; "Application of Rheology to Processing Problems"—Charles L. Rohn, Rohn and Associates, Inc.; "Application of Rheology to End-Use Performance Problems"—Charles L. Rohn; "Control and Rheological Measurement of Crosslink Density in Films"—Loren W. Hill, Monsanto Chemical Co.

**THURSDAY, APRIL 17:** "Rheology of Liquid Coatings: Defects and Quality Control"—Clifford K. Schoff, PPG Industries, Inc.; "Thermal Mechanical Properties of Coatings"—Daniel J. Skrovanek, Bayer Corp.; "Dynamic Mechanical Analysis Theory and Practice"—Edwin F. Meyer III, ICI Paints; "Chemorheology of Thermosetting Coatings"—Richard R. Eley.

**FRIDAY, APRIL 18:** "Rheological Measurements: Controlled Stress or Controlled Strain, Which to Use?"—Abel Gaspar-Rosas, Paar Physica USA, Inc.; "Application of Rheology to Engineering Problems"—Donald Bigg, R.G. Barry Corp.

### "Dispersion of Pigments and Resins in Fluid Media"

**MONDAY, MAY 5:** "Fundamentals of Surface and Colloid Chemistry I"—Donald L. Feke, Case Western Reserve University; "Dispersant Selection Based on Pigment Functionality"—Robert F. Conley, Mineral and Resource Technology; "Fundamentals of Surface and Colloid Chemistry II"—Donald L. Feke; and "Inorganic Pigment Processing Parameters and Their Influence on Polymer Properties"—Robert F. Conley.

**TUESDAY, MAY 6:** "White Pigments—Surface Character and Rheological Characteristics"—Robert F. Conley; "Dispersion of Organic Pigments"—Theodore Vernardakis, Sun Chemical Corp.; "Dispersion of Fumed Silica and Carbon Black for Optimum Performance"—Maria Nargiello, Degussa Corp.; "Wetting and Dispersing in Aqueous and Non-Aqueous Coatings Systems"—Robert W. Vash, Iron Chemicals Inc.

**WEDNESDAY, MAY 7:** "Introduction to Dispersion Rheology"—Richard R. Eley, ICI Paints; "Determining Dispersion Quality by Rheological and Related Means"—Richard Eley; "Overview of Dispersion Equipment for Inks and Coatings"—Ramon Pineiro, Daniel Products Co.; "Advances in Rotor-Stator Dispersion Technology"—David R. Ulrich, Ulrich and Associates; and "High Pressure Fluid Processing"—George Weckenbrock, Divtech Equipment Co.

**THURSDAY, MAY 8:** "Primary Mixing and Blending"—Leo Dombrowski, Gibraltar Chemical; "High Viscosity Dispersion and New Dispersion Techniques"—James White, White Chemical Equipment Co.; "Small Media Milling and Dispersion Technology"—Leo Dombrowski; "Principles of Ball and Pebble Milling"—Warren Fuller, Paul O. Abbe, Inc.; "Attritor Grinding and Dispersion Equipment"—Arno Szegvari, Union Process, Inc.

**FRIDAY, MAY 9:** "Assessing Pigment Dispersion Through Fineness, Tint Strength, and Transparency"—Leo Dombrowski; "Particle Size Analysis of Coating Systems, Part I"—Theodore Provder, ICI Paints; "Particle Size Analysis of Coating Systems, Part II"—Theodore Provder.

### "Adhesion Principles and Practice for Coatings and Polymer Scientists"

**MONDAY, MAY 12:** "Interfacial Energies and Their Role in Adhesion"—F.

James Boerio, University of Cincinnati; "General Rheology and Its Application to Adhesion"—Donald L. Hunston, National Institute of Standards and Technology; "Fracture Behavior of Glassy Adhesives"—Donald L. Hunston; "Deformation and Fracture of Elastomeric Adhesives"—Gary Hamed, Institute of Polymer Science, The University of Akron.

**TUESDAY, MAY 13:** "Fracture Mechanics and Bond Durability Considerations"—David A. Dillard, Virginia Tech; "Surface Preparation of Adherents"—John G. Dillard, Virginia Tech; "Plasma Surface Modification for Adhesion"—Ron Nickerson, Anatech, Ltd.; "Microscopic/Spectroscopic Studies in Adhesion Related to Durability of Adhesively Bonded Metals and Composites"—John G. Dillard.

**WEDNESDAY, MAY 14:** "Principles of Elastomer Tack"—Gary R. Hamed; "Plastic to Plastic Adhesion"—Rose Ann Ryntz, Ford Motor Co.; "Organofunctional Silanes as Adhesion Promoters and Crosslinkers"—Bruce A. Waldman, OSI Specialties, Inc.; "Adhesion Testing of Film-Formers"—James A. Miller, J. Miller Associates.

**THURSDAY, MAY 15:** "Corrosion at the Metal-Polymer Interface and Its Effect on Paint Adhesion and Adhesive Bond Durability"—Ray A. Dickie, Ford Motor Co.; "Surface Chemistry of Release"—Michael J. Owen, Dow Corning Corp.; "Application of Surface Analysis to Adhesion of Coatings"—Kenneth D. Bomben, Physical Electronics; "Bonding and Chemistry of Structural Adhesives"—Kurt C. Frisch, Jr., 3M Co.

**FRIDAY, MAY 16:** "Bonding Plastics and Elastomers"—Edward M. Petrie, ABB Transmission Technology Institute; and "Adhesive Application Methods"—Edward M. Petrie.

The "Introduction to Coatings Chemistry and Technology" course will be presented by Paul R. Baukema, of Akzo Nobel Coatings Inc. The course will focus on the composition of coatings, formulation principles, manufacture, application, and emerging technologies. In addition, the chemistry behind the binders and raw materials will be discussed.

These courses are designed for research and development personnel who are interested in coatings, adhesives, elastomers, inks, and composites.

For more information, contact Carl J. Knauss, Professional Development Institute, P.O. Box 1792, Kent, OH 44240; (330) 673-6993.

## Participants Experience "Riding the Wave of Technology" At 23rd Western Coatings Societies Symposium & Show

Providing a welcome respite from the winter doldrums, the 23rd Western Coatings Societies' Symposium & Show was held at the Disneyland Hotel in Anaheim, CA, on February 18-20. Attracting 1720 participants, the event focused on the theme, "Riding the Wave of Technology."

The West Coast has been a bellwether for regulatory trends in other parts of the country. In California, these trends have resulted in increased regulatory pressure and a reduction in the number of paint companies. The Symposium, hosted by the Los Angeles Society and co-sponsored by the Golden Gate, Rocky Mountain, and Pacific Northwest Societies, provided a forum for discussion on the effects of these trends. In addition, the trade show provided valuable information on the products and services of suppliers to the coatings industry.

The Keynote Speaker for the event was Kenneth L. Khachigian, an attorney in San Clemente, CA, and Senior Partner in the law firm of Smiland & Khachigian. Active in politics for many years with the Republican party, Mr. Khachigian served with the Dole campaign in California. During this presentation, he offered an interesting "backstage" look at the presidential campaign of 1996.

The WCSSS offered a variety of technical presentations, many of which attracted standing-room only crowds. These presentations included:

"Formulating with High Gloss Corrosion Resistant Emulsions"—Michael Wildman, EPS Inc.  
 "The Paint Plant for the 21st Century"—Charles S. Alack, Semi-Bulk Systems and Dr. Patrick Lutz, Dunn-Edwards Corp.  
 "When Policy Loses Touch with Science"—Robert Wendoll, EL-RAP

"Chemical Specification Profiles of Aerosol Coatings"—Dr. Dane Jones, Cal Poly San Luis Obispo

"Pigment Intermix Systems: A Cost Effective Approach to Formulate Industrial Coatings"—Dr. Romesh Kumar, Hoechst-Celanese Corp.

"Characteristics and Film Properties of Very Low VOC Coatings Based on Epoxy-Amine Technology"—Kalyan Ghosh, Shell Development Co.

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

"A Phenolic Ester Alcohol Reactive Diluent for High Solids Coatings"—Dr. Vijay Swarup, Exxon Chemical Co.

"New Technologies in Crosslinking Water-Based Acrylics and Polyurethanes for Industrial Wood Finishes"—Charles C. Shearer, Zeneca Resins

"Finding New Opportunities in the Coatings Industry: Lessons Learned from the Technology Assessment Process"—John Martin, Arthur D. Little, Inc.

Seminar and Panel Discussion on Masonry—Casey Seis, Tom Geary, Walt Gozdan and Frank Peters

"Decorative Interior Painting"—Debbie Zimmer, Rohm and Haas Co.

"Proposition 65: Ten Years After"—Christopher G. Foster, Smiland and Khachigian

"Effluence of Latex Paint"—Dr. Charles Kan, The Dow Chemical Co.

"Vinyl Acetate Based Latex Polymers for Architectural Coatings"—Robert J. Klein, Air Products and Chemicals, Inc.

"Wallstonite: Functionality in Paint and Coatings"—Sara Robinson, NYCO Minerals, Inc.

"Branched Ester Latexes for Interior and Exterior Applications"—Dr. Oliver Smith, Union Carbide Corp.

"A Novel Hydrophobically Modified Hydroethylcellulose for Latex Gloss Paints"—C. Warren Vanderslice, Hercules Incorporated

"Silicone Technologies Improve Cementitious Finishing Products"—Dr. Bruce A. Berglund, Wacker Silicones Corp.

"Ambient Cure Technology"—Gregory Monaghan, Rohm and Haas Co.

"Coating 2000: Women Leading into the New Century"—panel discussion, moderated by Melinda Rutledge, Rheox Inc.

"Zeta Potential and Paint Performance"—Dr. Bernhard Lieser, Dunn-Edwards Corp.

The following Symposium Committee Chairs are to be congratulated for their contributions: *General Chairman*—Robert Skarvan, Akzo Nobel Resins; *Exhibits*—John Long, Smiland Paint Co. and Roberta Garcia, ICI Paints; *Registration*—Keith Venia, Tavco Chemicals; *Technical*—Gil Mislund, Dunn-Edwards Corp.; *Entertainment*—Melinda Rutledge, Rheox Inc. and David Muggie, E. T. Horn Co.; *Publicity*—Roxanne Echevarria; *Executive Secretary*—Sheila Nothern, LASCT

### Western Coatings Societies' Show Exhibitors

3M Specialty Chemicals  
 ABO Industries  
 Air Products & Chemicals  
 Akzo Nobel Resins  
 Alnor Oil Co.  
 American Paint & Coatings Journal  
 ANGUS Chemical Co.  
 Aqualon Div., Hercules, Inc.  
 Atlas Electric Devices  
 BASF Corp.  
 Bayer Industrial Chemicals Div.  
 Brookfield Engineering Labs.  
 Buckman Laboratories  
 BYK-Chemie USA  
 BYK-Gardner, Inc.  
 Cal Poly University, Pomona  
 Cal Poly University, SLO  
 Calgon Corp.  
 CIBA Specialty Chemicals  
 CIMBAR Performance Minerals  
 Coatings World Magazine  
 Colortec Assoc., Inc.  
 Consolidated Color Corp.  
 Degen Oil & Chemical  
 Dorsett & Jackson, Inc.  
 Dowd & Guild, Inc.  
 Eagle Zinc  
 EL-RAP  
 Electronic Label Technology  
 EM Industries  
 EPS, Inc.  
 Epworth Morehouse-COWLES  
 Fawcett Company, Inc.  
 Federation of Societies  
 for Coatings Technology  
 Flash from the Past

Floridin Co  
 Fuji Sylisia Chemical Ltd.  
 BFGoodrich Specialty Chemicals  
 Grace/Davison Chemical Div.  
 Haake/Fisons Instruments  
 Hilton-Davis Company  
 Hockmeyer Equipment Corp.  
 Hoechst Celanese Corp.  
 Horiba Instruments, Inc.  
 E.T. Horn  
 Hüls America  
 P.T. Hutchins Company, Ltd.  
 Industrial Paint & Powder  
 Inter. Compliance Center, Ltd.  
 Inter. Performance Packaging Co.  
 LAST  
 Liquid Handling Systems  
 Macbeth  
 William F. McDonnell Co.  
 Manufacturing Business Systems  
 Michelmin, Inc.  
 C.B. Mills  
 Modern Paint & Coatings  
 Myers Engineering  
 New Way Packaging Machinery  
 Nichem  
 Norman International  
 Norton Packaging  
 Occidental Chemical Corp.  
 OSi Specialties  
 Pacific Resource Recovery Serv.  
 Paint and Coatings Industry  
 Paramount Can  
 Polar Minerals/The Kish Co.  
 Pumping Solutions  
 Rexam Mulox, Inc.

Rheox, Inc.  
 Rhone Poulenc  
 Rohm and Haas Co.  
 Romic Environmental  
 Ronning-Petter  
 Sartomer Company, Inc.  
 Schlumberger  
 Seegott  
 Semi-Bulk Systems, Inc.  
 SEPR  
 Silverline Manufacturing Co.  
 Southern Clay Products, Inc.  
 Southwest Mining Company  
 Specialty Minerals  
 Specialty Polymers  
 Spencer Machine & Tool  
 SRS Industrial Engineering  
 Stat-Ease  
 Summit Precision Polymers Corp.  
 Sun Chemical Corp., Pigments  
 Synergistic Performance Corp.  
 Tavco Chemical  
 Tego Chemie  
 Trans Western Chemical Inc.  
 Tri-ISO  
 UCB Chemicals/Rad cure  
 Ulah Clay Technology  
 Van Waters & Rogers  
 Vianova Resins  
 Vorti-Siv  
 Western Equipment Co.  
 Yamada America Inc.  
 Zeelan Industries, Inc./3M  
 Zemex Industrial Minerals  
 Zeneca Biocides  
 Zeneca Resins

# SPI Reports That EPA's Air Quality Proposals Baseless Due to Health Effects Data

Comments submitted by The Society of the Plastics Industry, Inc. (SPI), Washington, D.C., stated that the U.S. Environmental Protection Agency's (EPA) proposals for more stringent air quality standards for ozone and particulate matter are not supported by health effects data. According to SPI, EPA's own panel of experts found no health basis for the proposed revisions to the air quality standards, concluding that the current standards are sufficiently protective of human health.

SPI has urged the EPA to reassess the need for both proposed rules and conduct further research regarding exposure to and health effects from ozone

and particulate matter. In addition, SPI has recommended EPA undertake a formal evaluation of the impact of the proposals on small businesses.

Furthermore, SPI argued that the ozone proposal, which is expected to place large portions of the U.S. into non-attainment with the Clean Air Act and generate an onerous recordkeeping, reporting, and cost burden for businesses, is unjustified. In addition to the lack of data showing any adverse health effects, including effects from long-term exposure, the studies EPA used as the basis for stricter standards contain a significant number of flawed assumptions and methodologies. SPI said the studies overestimate ozone exposure and exaggerate the benefit of stricter ozone standards.

In addition, SPI noted the costs of the proposal far outweigh its benefits, and the regulation is in any case unnecessary because by EPA's own assessment, air quality has improved and will continue to do so with the new rule. Other Clean Air Act programs are already specifically addressing the emissions of ozone precursors.

SPI said the EPA's proposal to tighten air quality standards for particulate matter is "arbitrary" and "capricious" because there is no scientific support for the change. According to SPI, EPA lacks sufficient data to justify the revision and does not adequately consider flaws in the data it does have.

## ISO Certification

The RBH Pigment Dispersion business of **Reichhold Chemicals, Inc.**, Research Triangle Park, NC, has received ISO 9001 certification at the company's Bound Brook, NJ, facility.

**Air Quality Sciences (AQS), Inc.**, Atlanta, GA, has been registered as an ISO 9002 certified business.

**Sonoco Industrial Container Division**, Marietta, GA, has achieved ISO 9002 certification for its fibre drum production plant in Hightstown, NJ.

**Tate Andale Canada Inc.**, Concord, Ontario, has been granted ISO 9001 certification.

ISO 14001 Environmental Management System Standard certification has been awarded to **Plasticolors, Inc.**, Ashtabula, OH.

**Atlas Electric Devices Co.**, Chicago, IL, has been presented with ISO 9002 registration for establishing a quality management system for manufacturing and servicing of material test equipment.

**Crescent Electric Supply Co.**, East Dubuque, IL, has received ISO 9002 multi-site certification for the facilities located in Joliet, IL; St. Louis, MO; Appleton, WI; Elk Grove Village, IL; Greensboro, NC; McHenry, IL; and Salt Lake City, UT.

## Millennium Chemicals Announces Name Changes

In order to establish corporate identity, Millennium Chemicals Inc., Iselin, NJ, has announced that its three main operating units—Quantum Chemical, SCM Chemicals, and Glidco have changed their names—to Millennium Petrochemicals Inc., Millennium Inorganic Chemicals Inc., and Millennium Specialty Chemicals Inc., respectively.

Millennium Chemicals was formed as an independent company as a result of a spin-off from Hanson PLC, a UK public company.

Its three main component operations include: Millennium Petrochemicals Inc. (formerly Quantum Chemical), Cincinnati, OH—with business operations in polyethylene, acetyls and alcohol, and performance polymers; Millennium Inorganic Chemicals Inc. (formerly SCM

Chemicals), Baltimore, MD—produces titanium dioxide, cadmium-based pigments, and amorphous fine-particle silica gel; and Millennium Specialty Chemicals Inc. (formerly Glidco), Jacksonville, FL—produces terpene aroma chemicals, terpene aroma chemical intermediates, pinane hydroperoxide, and terpene solvents and manufactures pine oil.

## Methylene Chloride Rule Meets Opposition in Congress

According to a report published by the Halogenated Solvents Industry Alliance (HSIA), Inc., Washington, D.C., a resolution to disapprove the Occupational Safety and Health Administration's (OSHA) new methylene chloride standard has been introduced by Congressman Roger Wicker (R-MS). Congressman Wicker's resolution noted the significant differences of opinion within the scientific community about whether the standard will provide any health benefits for affected workers.

On January 10, OSHA promulgated a final rule lowering the permissible exposure limit (PEL) from 500 to 25 parts per million.

HSIA, which represents users and producers of methylene chloride, filed a petition for judicial review of the standard along with five of its members in the paint stripping and foam fabrication industries.

## Akzo Expands Whittaker's Distribution Responsibility

Akzo Nobel Resins, Louisville, KY, has named Whittaker, Clark & Daniels to represent its line of acrylic, alkyd, modified alkyd, epoxy ester, polyester, and urea resins in the Northeast United States. These resins are offered in conventional, waterborne, and high-solids formulations.

Whittaker, Clark & Daniels already serves as Akzo Nobel Resins' distribution agent on the West Coast.





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## NPCA Urges Industry to Challenge Massachusetts Bill #488

The National Paint and Coatings Association (NPCA), Washington, D.C., is urging coatings companies, customers, suppliers and vendors in Massachusetts to contact their state legislators to oppose Massachusetts Senate Bill #488.

The bill, called the "Massachusetts Citizens' Right-To-Know Act" would hold manufacturers responsible for ensuring that "reasonable and clear information about toxic chemicals contained in consumer products" is made avail-

able to the general public. If the Massachusetts attorney general is not "diligently pursuing" an action against an alleged violator within 60 days of a notice of violation, "any person in the public interest" can bring about an enforcement action.

The bill was introduced in response to a petition from the Massachusetts Public Interest Research Group.

To help defeat Massachusetts Senate Bill #488, concerned in-state parties should begin contacting their legislators immediately.

## ICI Expands Operations in Poland and Puerto Rico

ICI Paints, Cleveland, OH, has reached an agreement to buy a stake in Fabryka Farb I Lakierow Polifarb Pilawa SA, Pilawa, Poland. According to the agreement, ICI Paints will initially acquire a holding of around 40% stake which it anticipates increasing to 75% over the next three years.

The Pilawa paints business, with sales of more than £12m a year, was previously part of the state paint company Polifarb.

In other news, ICI Paints has completed a purchase transaction with Superior Paint Manufacturing Co., Inc. of Puerto Rico. The transaction includes the transfer of commercial activities and the purchase of certain assets by ICI Paints (Puerto Rico) Inc.

The recently acquired facility in Carolina, Puerto Rico, is being converted to produce 115,000 gallons per week. The plant will produce waterborne and solvent-borne paints.

## Ciba Introduces New Corporate Identity

Following the merger of Ciba and Sandoz, Ciba Specialty Chemicals, Tarrytown, NY, has been operating as an autonomous subsidiary within Novartis Inc. In conjunction with the merger, the company has unveiled a new corporate identity. Ciba Specialty Chemicals will be represented through a new logo in the shape of a butterfly. This original design, which is trademarked worldwide, utilizes six colors to repre-

sent the corporation as a whole—one color for the company and corporate services, five for the businesses.

Ciba Specialty Chemicals is comprised of the former Ciba-Geigy industrial businesses—Additives, Consumer Care Chemicals, Performance Polymers, Pigments, and Textile Dyes. As part of the merger agreement, Ciba Specialty Chemicals will be separated from Novartis to form an independent company.

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# AN INTRODUCTION TO ORGANIC PIGMENTS

by Peter Lewis, Sun Chemical Corp.\*

Significant progress in the technology associated with the chemistry of organic pigments has been made within the relatively recent past that has resulted in the introduction of new pigment forms offering increased value in use and, in a few cases, new pigment types offering new, improved properties from new color chemistry.

In 1856, an accomplishment took place that many at that time thought was impossible. A color that did not occur in nature was synthesized under laboratory conditions by William Henry Perkin. This 17-year-old Englishman, working in a basement laboratory at his home, was trying to oxidize aniline to produce guanine. Perkin combined aniline, containing toluidine as an impurity, with potassium dichromate and sulfuric acid. The resultant mauve dyestuff must have come as a considerable surprise to this young chemist.

Perkin's achievement ushered in a period of discovery often referred to as the "Dyestuffs Era," since the time between Perkin's synthesis and the start of the 20th Century saw both the invention and development of numerous dyestuffs based upon coal tar. In these early days of synthetic color chemistry, organic pigments were often produced as spin-offs from the major projects concerning the practical synthesis of dyestuffs.

Notable developments of this period are chronicled in *Table 1*, where pigments that have found use in the coatings industry are listed alongside the date of their discovery.

Less than 20 pigment types account for the major proportion of colors reported by specific Colour Index Name to the U.S. International Tariff Commission.† Of these specific pigments, few find major use within the coatings industry, most being key colors within both the paste ink and the fluid ink industries. In addition to these specifically reported organic pigments (monoarylide yellows, total monoarylides, diarylide yellows, total diarylides, miscellaneous oranges, naphthol reds, miscellaneous reds, total reds, total violets, total blues, miscellaneous greens, and total greens), closely related colors are also used, although in considerably less volume, to supplement and complement the color palette provided by the major pigments reported. Examples of such organic pigments are those based upon indanthrone, flavanthrone, anthosines, quinacridones, anthraquinone, and other similar, high priced, heterocyclic, high performance pigments. It is only in recent years that phthalocyanine blue is no longer reported specifically, rather it is listed under the generic heading of "organic blue toners."

Students of chemistry will notice that few, if any, organic pigments exist that are not associated with a benzenoid ring structure. In fact, it is the mobile cloud of pi electrons associated with this benzenoid structure that accounts for much of the coloristic features of the chemical. Other terms such as "chromophore," "auxochrome," "heterocyclic," and "azo," occur all too frequently in any in-depth discussion concerning organic pigments.

Additionally, terms are encountered such as "presscake," "toner," and "lake" that refer to the physical form in which the pigment is manufactured for sale. To better understand the complex world of organic pigments, an explanation of each of the previously mentioned terms is offered in this introduction. Further, the reader should be advised that certain pigment classes, while being major products within the pigment industry, find little use within the coatings industry and are produced primarily to fulfill the less demanding requirements of the printing ink marketplace. Many of the pigments used by the ink industry offer seductively

This introduction is reprinted, in part, from "Organic Pigments, Second Edition," *Federation Series on Coatings Technology*, Federation of Societies for Coatings Technology: Blue Bell, PA, March 1995. Readers are directed to this monograph for more complete information.

\* 5020 Spring Grove Ave., Cincinnati, OH 45232-1988.

† After 1996 it is no longer a requirement that pigment producers report their production to the International Tariff Commission.

Photo courtesy of Sun Chemical Corp.

attractive shades and economics; however, they fall far short when it comes to meeting the durability and weathering requirements of the coatings industry.

Before entering into any discussion relating to pigments, it is first necessary to clearly define what is meant by a pigment as opposed to a dyestuff since in many earlier texts on color the terms "pigment" and "dyestuff" are used almost interchangeably.

A definition of a pigment has been proposed by the Color Pigments Manufacturers Association (CPMA), formerly known as the Dry Color Manufacturers Association (DCMA), in response to a request from the Toxic Substances Interagency Testing Committee. This definition was developed specifically to enable differentiation between a dyestuff and a pigment with the intention of forever ending the confusion surrounding these two terms. As such, it is worthwhile reproducing this definition in its entirety:

*"PIGMENTS are colored, black, white or fluorescent particulate organic and inorganic solids which usually are INSOLUBLE in, and essentially physically and chemically UNAFFECTED by, the vehicle or substrate in which they are incorporated. They alter appearance by selective absorption and/or by scattering of light.*

*Pigments are usually DISPERSED in vehicles or substrates for application, as for instance in inks, paints, plastics or other polymeric materials. Pigments RETAIN a crystal or particulate structure throughout the coloration process.*

*As a result of the physical and chemical characteristics of pigments, pigments and dyes differ in their application; when a dye is applied, it penetrates the substrate in a SOLUBLE form after which it may or may not become insoluble. When a pigment is used to color or opacify a substrate, the finely divided INSOLUBLE solid remains throughout the coloration process."*

Differences occur between American and European terminology that may also cause confusion when pigments are classified as either toners or lakes. American terminology, as applied to pigments, defines a toner as an organic pigment that is free of inorganic extender pigments or carriers; as such, the pigment is unadulterated and exhibits maximum tinting capacity for the pigment type. A lake, conversely, is an organic colorant that has been combined with an inorganic substrate or extender such as barium sulfate (Blanc Fixe) or alumina. In European terminology, toners are considered to be water soluble acid or basic dyestuffs that are converted to insoluble pigmentary forms by appropriate precipitation with an inorganic compound. As such, Red Lake C (PR 53:1) and the PTMA based Rhodamine (PV 1) are considered toners. In the coatings industry the term toner may be used to refer to a secondary color that is added to alter the hue of the paint. The term lake now has an accepted definition as that used in America.

A most confusing European term which should be discouraged from use is "pigment dyestuff." This term is

meant to refer to insoluble organic pigments devoid of salt forming groups, for example, DNA Orange, Pigment Orange 5.

### International Nomenclature — the CI System

In this article, use is made of the coding system as published as a joint undertaking by the Society of Dyers and Colourists (SDC) in the United Kingdom and the Association of Textile Chemists and Colorists (ATCC)\* in the United States.

This system is known as the "Colour Index," and as such is a recognized trademark, hence the retention of the "u" in "colour" whenever reference is made to a "Colour Index" name or number.

The Colour Index provides valuable information on all classes of colored materials, irrespective of the compound's chemical composition or end use. As such, the publication extends to seven volumes. However, for the pigments industry, a single volume is available that covers only Pigments and Solvent Dyes together with a few fluorescent brightening agents. This single volume is a most useful and informative reference source to both producers and consumers of all classes of inorganic and organic pigments. The section on commercial trade names is particularly valuable in light of the number of companies who have discontinued pigment manufacture in the last 20 years.

The Colour Index (CI) identifies each pigment by giving the compound a unique "Colour Index Name" (CI name) and a "Colour Index Number" (CI number). In light of the recognition of the Colour Index by many government and state bodies, this description is proving to be most helpful to persons within the coatings industry responsible for assembling data on the composition of a coatings formulation for documents such as Material Safety Data Sheets or Hazard Data sheets. The identification of a pigment by mention of its CI name and number unequivocally identifies the chemical composition of the pigment in a manner acceptable to most government bodies. For example, DNA Orange has the Colour Index name of Pigment Orange 5 (PO 5) and the Colour Index number of 12075. Reference to the Colour Index under the number 12075 will

Table 1—Milestones in Pigment Synthesis

Year	Pigment Name	Year	Pigment Name
1858	.... Discovery of Synthetic Mauveine	1911	... Dianisidine Blue
1872	.... Phloxine	1921	... Pigment Green B
1876	.... Persian Orange	1924	... Perinone Orange
1884	.... Tetrazine Yellow	1925	... Basic Dye Complexes
1885	.... Para Red	1931	... Permanent Red 2B
1886	.... Alkali Blue	1935	... Phthalocyanine Blue
1896	.... Peacock Blue (Erioglaucine)	1938	... Phthalocyanine Green
1899	.... Lithol Red	1947	... Nickel Azo Yellow
1901	.... Indanthrone Blue	1949	... Red Lake C Homolog
1902	.... Pigment Scarlet	1954	... Azo Condensates
1903	.... Red Lake C	1955	... Quinacridones
1903	.... Lithol Rubine	1956	... Perylenes
1905	.... Toluidine Red	1958	... Salicyloyl Yellow
1907	.... BON Maroon	1960	... Benzimidazolones
1909	.... Hansa Yellows	1964	... Isoindolinones
1909	.... Pyrazolones	1964	... BON Red Homolog
1910	.... BON Red	1973	... Azomethines
1911	.... Diarylide Yellows	1974	... Quinophthalones
1911	.... Diarylide Oranges	1986	... Pyrrolo-pyrrole Red

\*Colour Index, American Association of Textile Chemists and Colorists, Research Triangle Park, NC, 1980. Pigments supplementary volume. The Colour Index is currently being fully revised and will be published some time in late 1998 after the input of all the pigment producers worldwide has been catalogued.



clearly illustrate the declared structure of DNA Orange, along with brief details of the pigment's properties and discovery.

The Colour Index name for a pigment is abbreviated as:

- PB = Pigment Blue
- PBk = Pigment Black
- PBr = Pigment Brown
- PG = Pigment Green
- PM = Pigment Metal
- PO = Pigment Orange
- PV = Pigment Violet
- PR = Pigment Red
- PW = Pigment White
- PY = Pigment Yellow

Additionally, the Colour Index constitution number conveys information regarding the structure of the compound, as shown in Table 2.

### Pigment Selection

Once a coatings formulator has decided upon the hue that is required for a particular application, the next most important criteria of any pigment or combination of pigments that achieves this required shade is the fastness properties of each pigment. It is useless to formulate an automotive coating with a pigment that will not withstand the increasingly stringent outdoor exposure specifications that the automotive industry places on all such high performance coatings. Such specifications can extend to requiring as many as five years' exposure data from test panels located in such states as Florida and Arizona where extremes of weather conditions prevail.

Due attention must be paid to the respective manufacturer's literature to ensure that a pigment has been chosen that will satisfy the end use criteria for fastness to light, solvents, heat, flocculation, crystallization, and chemicals.

Once a pigment class has been selected that will perform adequately in the end use application, the formulator can consider such other factors as economy, assuming the pigments are readily available. The formulator should always be aware that the fastness properties of a pigment will be affected by the medium into which it is dispersed and the substrate upon which it is applied. Thus, even though intrinsically the pigment may offer the required properties, it is still advisable, even necessary, for the final pigmented coating to be tested in the end use application. Fastness to light and heat are two of the pigment properties that are likely to be affected by the system. In many instances, especially when formulating away from the lead-containing inorganic pigments such as Molybdate Orange and Medium Chrome Yellow, the choice of pigments

has to be a compromise between what is available, economics of use, and marketplace requirements.

Fastness properties of pigments are most generally quoted in manufacturers' literature using one of two classification systems. The first uses words as a qualitative expression where properties are described as "Excellent," "Very Good," "Good," "Fair," and "Poor." These correspond to the second system, a numerical rating, where the qualitative expression is replaced by an attempt to quantify the property using a number from 1 through 5. The highest degree of fastness is always represented by 5 (i.e., 5 = "Excellent") except in the case of fastness to light and weathering where the scale is expanded to a 1 through 8 rating, a value of 8 signifying the maximum fastness. The use of figures is preferred and is becoming more widespread as the pigment marketplace truly expands to that of a global situation. Figures given for fastness to light are quoted based upon the 8-point Blue Wool scale as described in ISO 105, BSS 1006, and DIN 16525.

### Physical Forms

To understand the origin of the physical forms in which many pigments are available, an understanding of the basic manufacturing process is first necessary.

The majority of pigments available in today's marketplace are manufactured through an aqueous process. This results in a concentrated aqueous slurry of the pigment that must first be separated from the water before further processing is possible. The equipment generally in use for this isolation process is known as a "filter press." The aqueous pigment slurry is pumped through this filter press where the water and any soluble unwanted by-products, such as inorganic salts, pass through the press to effluent treatment. The press is fitted with a series of plates and frames, each plate being covered with a polypropylene, acid resistant filter cloth that is permeable to the water and dissolved salts but not to the insoluble pigment. Thus the pigment is isolated from the water and becomes sandwiched as a "cake" between the frames of the press. It is at this stage, while the pigment is tightly packed in between the plates of the press, that any necessary washing is

Table 2—Chemical Class and CI Number

Chemical Class	Colour Index Constitution Number
<b>Insoluble Azo:</b>	
1. Acetoacetyl	11640-11790
2. Heterocyclic hydroxyl	12600-12825
3. Disazo	20000-29999
4. 2-naphthol	12050-12211
5. 3-Hydroxy-2-naphthanilide	12300-12520
<b>Precipitated Azo:</b>	
1. 2-naphthol (sulfonic) acid	15500-16815
<b>Precipitated Non-Azo:</b>	
1. Xanthene	45000-45999
2. Triphenylmethane	42000-44999
<b>Insoluble Non-Azo:</b>	
1. Phthalocyanine	74000-74999
2. Anthraquinone	58000-72999
3. Quinacridone	73900-73999

accomplished. In practice, the pigment is washed with either hot or cold city water until the conductivity of the water leaving the press has reached a specified level. A prolonged wash with water will remove any residual, soluble by-products that are associated with the pigment as a result of the manufacturing chemistry. For example, a typical azo pigment produced by diazotization and coupling will likely contain sodium chloride as a by-product which is readily removed by washing.

Discharge of this filtered cake gives the pigment as a water wet form that is known as "presscake." At this stage, the product consists of pigment particles associated with water. The amount of water contained in a presscake is a variable that depends largely on the type of pigment rather than the mechanical efficiency of the filter press. A phthalocyanine blue pigment may, for example, contain 28-32% pigment, the balance being water, whereas it is not unusual for a barium lithol pigment presscake to contain less than 20% pigment. The pigment content of a presscake is normally estimated by drying out a known weight of a representative sample of the presscake and comparing the dried weight to that of the wet presscake. To the paint chemist working with a water-based formulation, this large amount of water can cause problems in pigmenting the paint at a level high enough to achieve the requisite tinting strength. The advantages to the formulator of using a presscake form of the pigment lie mainly in the fact that the pigment has not been dried out and thus has not been given the opportunity to sinter and form hard aggregates that are difficult, if not impossible, to wet out and fully disperse in the resin system.

Use of "Variable Chamber" filter or "Squeeze Frame" presses that mechanically squeeze additional water out of the presscake prior to its discharge from the press have resulted in products that are described as "high" or "medium" solids presscake and that may contain as much as 40% pigment when offered for sale.

A further type of presscake, also described as "high" solids, is available that is standardized for both shade and strength and supplied at 50% pigment. This physical form is achieved by subjecting the pigment to a further processing step after discharge from the filter press. The additional stage involves blending batches of presscake in an agitated dryer and drying this blend under carefully monitored conditions to give a product that is standardized at a pigment content of 50% as a norm. Such products are typically free flowing, dustless, and easier dispersed at the pre-mix stage than the pigment's dry counterpart. The formulator of water-based paints is thus presented with a high solids presscake that offers the necessary pigment concentration to achieve a correct formulation while also being a product that requires no additional wetting at the pre-milling stage since the product has never been fully dried.

The presscake discharged from the press can simply be dried to give a product described as dry "toner," a 100% pigment that is a dry, dusty, colored powder. Although the product is described as dry, it is rare that at least a small quantity of water is not associated with the pigment. The metallized azo reds, for example, may contain 1-2% water due to the tendency of such pigments, even after they have been completely dried, to absorb water from the atmosphere on storage. A point of interest about these metallized azo pig-

ments is the ease with which the pigment's dispersion characteristics can be negatively impacted if the pigment is completely dried. All classes of phthalocyanine blues and greens are regularly dried to a moisture content of less than 0.5% without apparent adverse effect on the pigment's properties.

While dry toner is the most common form in which organic pigments are marketed, it does have drawbacks, apart from the obvious dustiness of the product. One of the major problems associated with dry pigment is the difficulty in "rewetting" the pigment by driving out the air now associated with the dry powder and replacing this air with the solvent/resin system of concern. To this end, the careful selection of solvent/resin/vehicle system and wetting or dispersing aid is of paramount importance. Once the system thoroughly wets out the pigment, it is a relatively simple matter to achieve optimum dispersion using many of the modern media mills available to the coatings manufacturer.

Pigments are commonly available in two other physical forms, both of which try to address the situation surrounding the problem of redispersing dry toner. The first such form is simply a water-based "dispersion" in a resin system that is as widely compatible as possible to give levels approaching 50% solids as a stable aqueous dispersion. Glycol-based humectants, added to prevent the dispersion from skinning and drying out around the container walls, and organic, nonmercurial biocides are also added to confer increased stability and shelf life to the dispersion. Recently, the increasing need to produce coatings with low levels of compounds has resulted in further reformulation to remove even the glycol-based humectants.

The second physical form is known as "flush color" and is again manufactured from the water wet presscake. In this instance, the water is displaced from the pigment using a highly energy intensive process known as flushing to displace the water with, for example, an alkyd-based vehicle that finds a high degree of compatibility

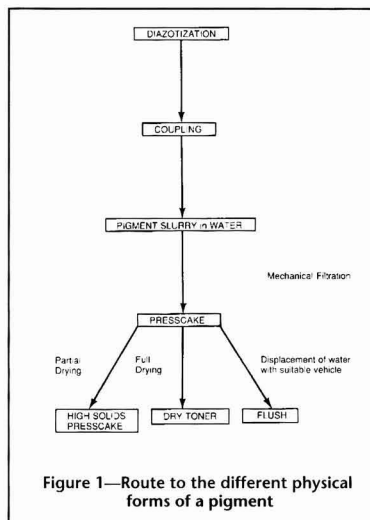


Figure 1—Route to the different physical forms of a pigment

with industrial paint formulations. This form can also contain as high a pigment loading as 50% and, being a very viscous and heavy bodied vehicle-based dispersion, is most certainly non-dusting.

The route to each of the physical forms discussed is presented schematically in Figure 1.

### Summary

As to future trends within the pigment industry as they relate to the coatings industry, I see research continuing to concentrate on providing the coatings industry with pigments that offer "value in use" by being more easy to disperse, more durable, more economical, faster wetting, more compatible with the common vehicle/solvent systems, and that are environmentally acceptable. The pressures on our environment are not likely to decrease as more and more pigments, both organic and inorganic, are withdrawn from use due to concerns over their effect on the environment.

On the other side, I see the coatings industry continuing to place stricter demands on the pigment manufacturer regarding improved quality control and product consistency, an increased requirement for economical high performance pigments to satisfy the demands of the ever-changing automotive industry as basecoat/clearcoat systems become more widespread.

Nothing is more sure than change itself but this change must be a change for the better or a change to meet a real need, not just change for the sake of change.

DR. PETER LEWIS, Coatings Industry Manager for the Pigments Division of Sun Chemical Corporation, is a graduate of the Royal Institute of Chemistry, London, England. He obtained his Ph.D. Degree in Colloid Chemistry at Bristol University, Avon, England, as a result of a two-year scholarship from his employer at the time, Imperial Chemical Industries (ICI).

Dr. Lewis began his career in the chemical industry when he joined ICI as a laboratory technician. In 1972, he entered the world of color chemistry at ICI's Dyestuff Div. at Huddersfield, Yorkshire.

In 1979, he emigrated from England and joined Sun Chemical Corp. Over the last 14 years he has held such positions as quinacridone product manager, technical service manager, dry color business manager, and marketing manager.

Dr. Lewis is a frequent lecturer to the pigments consuming marketplace as he presents his experiences with the manufacture, dispersion, and evaluation of colored organic pigments.

A member of the CDIC Society for Coatings Technology, he is editor of Volume I of the second edition of *The Pigment Handbook*, as published by John Wiley & Sons.

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P.O. Box 2544  
Corpus Christi, TX 78403-2544  
Phone: (512) 883-5591  
Fax: (512) 883-7619  
Roger Padden, National Sales Mgr.; Douglas Funk,  
Sales; Thomas A. Landshof, President & CEO

Black/Brown/Gray Pigments  
Blue Pigments  
Extender Pigments  
Green Pigments  
Iron Oxide Pigments  
Other Pigments  
Red Pigments  
White Pigments  
Yellow and Orange Pigments

### Hoover Color Corp.

P.O. Box 218  
State Highway 693  
Hiwassee, VA 24347  
Phone: (540) 980-7233  
Fax: (540) 980-8781  
Steve Haimann, Technical Sales Mgr.; Charles  
Hoover, Jr., Chief Operating Officer

Black/Brown/Gray Pigments  
Dyes  
Green Pigments  
Iron Oxide Pigments  
Yellow and Orange Pigments

### J.M. Huber Corp.

One Huber Rd.  
Macon, GA 31298  
Phone: (912) 745-4751  
Fax: (912) 750-5485  
Tom Anderskow, Business Director, Coatings  
Extender Pigments

### HÜLS AMERICA INC.

220 Davidson Ave.  
Somerset, NJ 08873  
Phone: (908) 560-6800  
Pigment Dispersions (Non-Aqueous)

### Ishihara Corp. (U.S.A.)

600 Montgomery St.  
San Francisco, CA 94111  
Phone: (415) 421-8207  
Fax: (415) 397-5403  
David Duenwald, General Mgr.; Keiko Watts,  
Marketing Mgr.  
White Pigments  
Yellow and Orange Pigments

### K-T Feldspar Corp.

Highway 226 North  
P.O. Box 309  
Spruce Pine, NC 28777  
Phone: (704) 765-9621  
Fax: (704) 765-6304  
Extender Pigments

### Kane International Corp.

411 Theodore Fremd Ave.  
Rye, NY 10580  
Phone: (914) 921-3100  
Fax: (914) 921-3180  
David Quinlan  
Pigment Dispersions (Aqueous)  
Pigment Dispersions (Non-Aqueous)

### Kemira Pigments Inc.

One Kemira Rd.  
P.O. Box 368  
Savannah, GA 31402  
Phone: (912) 652-1000  
Fax: (912) 652-1181  
G.L. Roberts, III, V.P. Sales/Marketing; Jeff Hyde,  
National Sales Mgr.; Billy Lee, Product Mgr., Rutile  
White Pigments

### Keystone Aniline Corp.

2501 W. Fulton St.  
Chicago, IL 60612

Phone: (312) 666-2015

Fax: (312) 666-8530

L. Bente, Product Mgr.

Black/Brown/Gray Pigments  
Blue Pigments  
Dyes  
Green Pigments  
Other Pigments  
Red Pigments  
Yellow and Orange Pigments

### Kohl Marketing, Inc.

14 Norcross St.  
Roswell, GA 30075  
Phone: (770) 642-0299  
Fax: (770) 642-1397  
Distributor of pigments

### Kowa American Corp.

342 Madison Ave., Ste. 710  
New York, NY 10173  
Phone: (800) 221-2076  
Fax: (212) 972-4625  
Mark K. Smith, Sales Mgr.; Taka Nagashima,  
Chemical Dept. Mgr.  
Other Pigments

### Kraft Chemical Co.

1975 N. Hawthorne Ave.  
Melrose Park, IL 60160  
Phone: (708) 345-5200  
Fax: (708) 345-4005  
Ron Weiland, Sales Mgr.; Stan Lewis, Industry  
Specialist

Corrosion-Inhibiting Pigments  
Extender Pigments  
Metallic Flakes and Powdered Pigments  
White Pigments

### Kronos, Inc.

P.O. Box 4272  
Houston, TX 77210  
Phone: (800) 866-5600  
Fax: (713) 423-3258  
White Pigments

### Landers-Segal Color Co., Inc.

90 Dayton Ave.  
Passaic, NJ 07055  
Phone: (201) 779-5001  
Fax: (201) 779-8948  
Donald Greenwald, CEO; Rick Campbell, V.P.  
Marketing & Sales; Michael Smith, V.P.  
Smithchem Div.

Black/Brown/Gray Pigments  
Blue Pigments  
Corrosion-Inhibiting Pigments  
Extender Pigments  
Green Pigments

### Laporte Pigments

7101 Muirkirk Rd.  
Beltville, MD 20705  
Phone: (301) 210-7800  
Fax: (301) 210-4967  
Dave Murphy, Sales Mgr.  
Black/Brown/Gray Pigments  
Blue Pigments  
Corrosion-Inhibiting Pigments  
Green Pigments  
Iron Oxide Pigments  
Yellow and Orange Pigments

### Luzenac America

8985 E. Nichols Ave.  
Englewood, CO 80112-3410  
Phone: (303) 643-0400  
Fax: (303) 643-0444  
Extender Pigments

### Magruder Color Co.

1029 Newark Ave.  
Elizabeth, NJ 07208  
Phone: (201) 242-1300  
Fax: (201) 242-4087  
Blue Pigments  
Pigment Dispersions (Aqueous)  
Red Pigments



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## PIGMENTS SPOTLIGHT: suppliers

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220 Runon St.  
P.O. Box 1238  
Hot Springs, AR 71902  
Phone: (501) 623-8893  
Fax: (501) 623-5113  
Sam Bristow, Plant Mgr.; Roger Moreland,  
Accounts Mgr.  
Extender Pigments

Manufacturing Business Systems  
1250 E. Walnut St., Ste. 150  
Pasadena, CA 91106  
Phone: (818) 585-0103  
Fax: (818) 585-0106  
Distributor of pigments

Mapico Inc.  
11116 S. Towne Sq.  
St. Louis, MO 63123  
Phone: (314) 845-2010  
Fax: (314) 845-3570  
Joseph Moramarco, Technical Mgr.  
Iron Oxide Pigments

Meadowbrook Co.  
30 Rockefeller Plaza, Ste. 2825  
New York, NY 10112  
Phone: (212) 582-0420  
Fax: (212) 582-3412  
Allen S. Perl, V.P.

Corrosion-Inhibiting Pigments  
Metallic Flakes and Powdered Pigments  
White Pigments  
Yellow and Orange Pigments

The Mearl Corporation  
320 Old Briarcliff Rd.  
P.O. Box 3030  
Briarcliff Manor, NY 10510  
Phone: (914) 923-8500  
Fax: (914) 923-9594  
(now part of Engelhard Corp.)  
Extender Pigments  
Other Pigments

Millennium Inorganic Chemicals  
200 International Circle, Ste. 5000  
Hunt Valley, MD 21030  
Phone: (410) 229-4400  
Fax: (410) 229-4488  
Gary L. Cianfichi, Marketing Mgr., Coatings  
Red Pigments  
White Pigments  
Yellow and Orange Pigments

Mineral Pigments Corp.  
7101 Muirkirk Rd.  
Beltsville, MD 20705  
Phone: (301) 210-3400  
Fax: (301) 210-4967  
Dave Murphy, Sales Mgr.; John Kurnas,  
Applications Chemist  
Black/Brown/Gray Pigments  
Blue Pigments  
Corrosion-Inhibiting Pigments  
Green Pigments  
Iron Oxide Pigments  
Yellow and Orange Pigments

Ming-Zu Chemical  
Raw Materials Div.  
1578 Barclay Blvd.  
Buffalo Grove, IL 60089  
Phone: (847) 419-1083  
Fax: (847) 419-1082  
Bob Yang, President  
Dyes

Mississippi Lime Co.  
7 Alby Street  
P.O. Box 2247  
Alton, IL 62002-2247  
Phone: (618) 465-7741  
Fax: (618) 465-7786  
David Viox, V.P. Sales; Mark DeGenova,  
Technical Service Mgr.  
Extender Pigments

Mitsubishi Chemical America  
1 North Lexington Ave.  
White Plains, NY 10601  
Phone: (914) 286-3600  
Fax: (914) 681-0760  
Kozo Hayashi, Mgr., Business Development; Paul  
Kreiter, Mgr., Business Development  
Dyes

Morton International  
100 N. Riverside Plaza  
Chicago, IL 60606  
Phone: (312) 807-2000  
Fax: (312) 807-2010  
Dyes  
Pigment Dispersions (Aqueous)  
Pigment Dispersions (Non-Aqueous)

NICHEM Corp.  
600 W. 52nd St.  
Chicago, IL 60609  
Phone: (312) 924-3700  
Fax: (312) 924-7760  
Blue Pigments  
Corrosion-Inhibiting Pigments  
Yellow and Orange Pigments

NYCO® Minerals, Inc.  
124 Mountain View Dr.  
Willsboro, NY 12996  
Phone: (518) 963-4262  
Fax: (518) 963-4187  
Dawn L. Revette, Marketing Communication Rep.  
Extender Pigments

Obron Atlantic Corp.  
72 Corwin Dr.  
Painesville, OH 44077  
Phone: (216) 352-0400  
Fax: (216) 352-6224  
Richard Thomas, V.P.; Henning Bunge, IM Paint/  
Plastics; Frank Passen, Industry/Mgr.-OEM  
Metallic Flakes and Powdered Pigments

OMYA, Inc.  
61 Main St.  
Proctor, VT 05765  
Phone: (802) 459-3311  
Fax: (802) 459-2125  
Extender Pigments

Peer Chemical Corp.  
1552 S. Abbott Dr.  
Wheeling, IL 60090  
Phone: (847) 459-5347  
Fax: (847) 459-5340  
L.J. Jones, V.P.  
Blue Pigments  
Green Pigments  
Other Pigments  
Red Pigments  
Yellow and Orange Pigments

Pflaumer Brothers, Inc.  
P.O. Box 309  
Norristown, PA 19404  
Phone: (610) 834-7400  
Fax: (610) 834-7404  
Harley R. McNair, President  
Pigment Dispersions (Aqueous)  
Pigment Dispersions (Non-Aqueous)

Polar Minerals, Inc.  
1703 Bluff Rd.  
Mt. Vernon, IN 47620  
Phone: (770) 934-4411  
Fax: (770) 934-4376  
Shawn Hays  
Extender Pigments

Potters Industries, Inc.  
P.O. Box 840  
Valley Forge, PA 19482  
Phone: (610) 651-4700  
Fax: (610) 408-9724

Customer Service  
Extender Pigments  
Metallic Flakes and Powdered Pigments  
Other Pigments

The PQ Corp.  
Specialty Div.  
P.O. Box 3720  
Chattanooga, TN 37404  
Phone: (423) 629-7160  
Fax: (423) 698-0614  
M.G. Ross, Marketing Development Project Mgr.  
Extender Pigments

PQ Corporation/ Potters Industries  
P.O. Box 840  
Valley Forge, PA 19482  
Phone: (610) 651-4317  
Fax: (610) 251-9060  
E. Myszak, Marketing Development Mgr.  
Extender Pigments

Purity Zinc Metals  
290 Arvin Ave.  
Stoney Creek, Ont. L8E 2M1  
Canada  
Phone: (905) 662-4802  
Fax: (905) 664-3944  
James E. Desroches, Dir. Sales  
Metallic Flakes and Powdered Pigments

Pyosa, S.A. de C.V.  
Ave. Industrias No. 1200 Pte.  
Col. Bella Vista  
Monterrey, NL 64410  
Mexico  
Phone: (52) 8 331 2600  
Fax: (52) 8 331 4632  
Alicia A. Lozano, Director; Pedro Tuerina, Sales  
Mgr., North America  
Blue Pigments  
Corrosion-Inhibiting Pigments  
Dyes  
Green Pigments  
Pigment Dispersions (Aqueous)  
Red Pigments  
Yellow and Orange Pigments

Radiant Color  
2800 Radiant Ave.  
P.O. Box 4019  
Richmond, CA 94804-0019  
Phone: (510) 233-9119  
Fax: (510) 233-9138  
Robert Hess, Dir. Marketing; Darren Bianchi,  
Technical Dir.  
Other Pigments  
Pigment Dispersions (Aqueous)  
Pigment Dispersions (Non-Aqueous)

RBH Dispersions, Inc.  
L-5 Factory Lane  
CN 2006  
Bound Brook, NJ 08805-1036  
Phone: (908) 356-1800  
Fax: (908) 356-8369  
John V. Mitzak, V.P.; Dennis H. Rice, Sales Mgr.;  
Bharat M. Parekh, Technical Mgr.  
Pigment Dispersions (Aqueous)  
Pigment Dispersions (Non-Aqueous)

Reade Advanced Materials  
P.O. Drawer 15039  
Providence, RI 02915-0039  
Phone: (401) 433-7000  
Fax: (401) 433-7001  
Charles Reade, Eastern Regional Sales Mgr.;  
Bethany Cochran, Western Regional Sales Mgr.  
Black/Brown/Gray Pigments  
Corrosion-Inhibiting Pigments  
Extender Pigments  
Green Pigments  
Iron Oxide Pigments  
Metallic Flakes and Powdered Pigments  
Red Pigments  
White Pigments



**Reichhold Chemicals, Inc.**

2400 Ellis Rd.  
P.O. Box 13582  
Durham, NC 27709  
Phone: (919) 990-7500  
Fax: (919) 990-7711

Steve Brechbiel, Corporation Communications  
Pigment Dispersions (Aqueous)  
Pigment Dispersions (Non-Aqueous)

**Reynolds Metals Co.**

Powder & Paste Div.  
Plant III, 4101 Camp Ground Rd.  
Louisville, KY 40211-2138  
Phone: (502) 775-4240  
Fax: (502) 775-4249

Dennis Malloy, Account Mgr.; Larry Pitchford,  
Technical Mgr.; Gary Wood, Account Mgr.  
Metallic Flakes and Powdered Pigments

**Ribelín Sales Inc.**

3857 Miller Park Dr.  
Garland, TX 75042  
Phone: (214) 272-1594  
Fax: (214) 272-1078

Michael Ribelin, President & CEO; Steve Stephens,  
V.P. Marketing; Robert Blackford, V.P. Sales  
Distributor of pigments

**Kenneth M. Rice Co.**

2200 E. Devon Ave., Ste. 193  
Des Plaines, IL 60018  
Phone: (847) 803-1030  
Fax: (847) 803-4358

Ken Rice; Frank Benson; Jerry Nowicki  
Distributor of pigments

**Rit-Chem Co., Inc.**

P.O. Box 435  
Pleasantville, NY 10570  
Phone: (914) 769-9110  
Fax: (914) 769-1408

Wayne J. Ritell, V.P. Sales; Gary S. Ritell, V.P.  
Marketing Development  
Extender Pigments

**RJ Chemical Sales, Inc.**

12 Galloway Ave., Ste. 1F  
Cockeysville, MD 21030  
Phone: (410) 666-2332  
Fax: (410) 666-0644

Bob Jortland, President; Peter Rehgel, V.P.  
Distributor of pigments

**Royale Pigments and Chemicals, Inc.**

12 Rt. 17 N., Ste. 309  
Paramus, NJ 07652  
Phone: (201) 845-4666  
Fax: (201) 845-0719

Lindsay A. Logue, President; Eric Percy, Sales  
Consultant

Black/Brown/Gray Pigments  
Blue Pigments  
Corrosion-Inhibiting Pigments  
Dyes  
Green Pigments  
Iron Oxide Pigments  
Metallic Flakes and Powdered Pigments  
Other Pigments  
Pigment Dispersions (Aqueous)  
Red Pigments  
White Pigments

**Royce Associates, ALP**

35 Carlton Ave.  
East Rutherford, NJ 07073  
Phone: (201) 438-5200  
Fax: (201) 438-5207

Jay Royce, President; Wylie Royce, V.P.; Terry  
Schierer, Comptroller  
Dyes

**Sachtleben Corp.**

520 Madison Ave.  
New York, NY 10022  
Phone: (212) 715-5236  
Fax: (212) 486-2742

Keith Standbridge; Paul Frazier

**Extender Pigments**

**White Pigments**

**SARTOMER CO.**

502 Thomas Jones Way  
Exton, PA 19341  
Phone: (800) SARTOMER  
Fax: (610) 363-4140

Blue Pigments  
Green Pigments  
Red Pigments  
Yellow and Orange Pigments

**Sherwin-Williams Chemicals**

101 Prospect Ave., NW  
Cleveland, OH 44115  
Phone: (216) 566-1294

Fax: (216) 566-1876  
Charles Simpson, Mgr., Technical Services  
Corrosion-Inhibiting Pigments

**Silberfine Manufacturing Co., Inc.**

P.O. Box B  
Lincoln Dr.  
Tamaqua, PA 18252-0420

Phone: (717) 668-6050  
Fax: (717) 668-0197  
Metallic Flakes and Powdered Pigments

**Sino-American Pigment Systems, Inc.**

1936 University Ave., Ste. 330  
Berkeley, CA 94704-1024

Phone: (510) 848-8890  
Fax: (510) 848-8889  
Kent Stelling, Dir. Administration; Michael Issel,  
President

Corrosion-Inhibiting Pigments  
Extender Pigments  
Green Pigments  
Red Pigments  
White Pigments  
Yellow and Orange Pigments

**Specialty Minerals Inc.**

The Chrysler Bldg.  
405 Lexington Ave.  
New York, NY 10174-1901

Phone: (212) 878-1900  
Fax: (212) 878-1903  
Extender Pigments

**Spectra Colors Corp.**

25 Rizzolo Rd.  
Kearny, NJ 07032  
Phone: (800) 527-8588

Fax: (800) 635-1811  
Sharon Auriemma, Customer Service Mgr.

Blue Pigments  
Dyes  
Iron Oxide Pigments  
Other Pigments  
Pigment Dispersions (Aqueous)

**Sun Chemical Corp.**

Color Group  
5020 Spring Grove Ave.  
Cincinnati, OH 45232

Phone: (513) 681-5950  
Fax: (513) 632-1537  
Ed Polaski, Sales Mgr.; Peter A. Lewis, Coatings  
Industry Mgr.

Blue Pigments  
Green Pigments  
Pigment Dispersions (Aqueous)  
Red Pigments  
Yellow and Orange Pigments

**Tayca Corp.**

K-White Div.  
1751 E. Lincoln Ave.  
Madison Heights, MI 48071

Phone: (810) 399-0035  
Fax: (810) 399-1340  
Nobuaki Kimizu, Sales Mgr.; Kimber Balch,  
Administrative Asst.

Corrosion Inhibiting Pigments

**Technical Industries, Inc.**

217 Church St.  
P.O. Box 65  
Peace Dale, RI 02883-0065

Phone: (401) 783-5887  
Fax: (401) 789-2270  
A.J. Rose, Jr., President; Eric A. Rose, V.P.;

F. Steven DiMasi, Plant/Quality Mgr.  
Black/Brown/Gray Pigments  
Blue Pigments  
Corrosion-Inhibiting Pigments  
Extender Pigments  
Pigment Dispersions (Aqueous)  
White Pigments

**Toxide Americas Inc.**

2001 Butterfield Rd., Ste. 601  
Downers Grove, IL 60515

Phone: (630) 663-4900  
Fax: (630) 663-4901  
Robert McComb, Communications & Marketing  
Information Mgr.

White Pigments

**Toyal America**

1717 N. Naper Blvd., Ste. 201  
Naperville, IL 60563-8838

Phone: (630) 505-2169  
Fax: (630) 505-2176  
Metallic Flakes and Powdered Pigments

**Toyo Ink America, Inc.**

910 Sylvan Ave.  
Englewood Cliffs, NJ 07632

Phone: (201) 568-8660  
Fax: (201) 568-2455  
Richard M. Skudera, Senior Sales Mgr.

Blue Pigments  
Green Pigments  
Pigment Dispersions (Aqueous)  
Pigment Dispersions (Non-Aqueous)  
Red Pigments  
Yellow and Orange Pigments

**Trans Western Chemicals, Inc.**

7766 Industry Ave.  
Pico Rivera, CA 90660

Phone: (310) 942-1833  
Fax: (310) 942-9412  
Henry J. Kirsch, V.P./ Sales & Marketing  
Distributor of pigments

**U.S. Aluminum, Inc.**

408 Rte. 202  
P.O. Box 2190  
Flemington, NJ 08822-2190

Phone: (800) 544-0186  
Fax: (908) 782-3489  
Bill Cwieka, V.P., Sales; Rhonda Kasler, Customer  
Service Mgr.

Metallic Flakes and Powdered Pigments

**Uhlich Color Company**

5620 North Kolb Rd.  
Tucson, AZ 85750

Phone: (520) 577-7705  
Fax: (520) 577-0038  
Blue Pigments  
Dyes  
Green Pigments  
Red Pigments  
Yellow and Orange Pigments

**Unimin Corp.**

258 Elm St.  
New Canaan, CT 06840

Phone: (203) 966-8880  
Fax: (203) 966-3453  
Extender Pigments

**United Color Technology, Inc.**

638 Newtown-Yardley Rd., Ste. 1E  
P.O. Box 480

Newtown, PA 18940  
Phone: (215) 860-2165  
Fax: (215) 860-8560

## PIGMENTS SPOTLIGHT : suppliers

Thomas Nowakowski, President; Robert Cwik,  
National Sales Mgr.

Blue Pigments  
Dyes  
Green Pigments  
Other Pigments  
Pigment Dispersions (Aqueous)  
Red Pigments  
Yellow and Orange Pigments

United Mineral & Chemical Corp.

1100 Valley Brook Rd.  
Lyndhurst, NJ 07071-3608  
Phone: (201) 507-3300  
Fax: (201) 507-1506

N. Nurhan Becidyan, V.P. & General Mgr.; Michael  
Sansoneetti, Mgr., Pigments; Sal Morreale, Mgr.,  
Chemicals; Irwin Drangel, Mgr., Metals

Blue Pigments  
Corrosion-Inhibiting Pigments  
Dyes  
Extender Pigments  
Green Pigments  
Other Pigments  
Red Pigments  
White Pigments  
Yellow and Orange Pigments

U.S. Bronze Powders, Inc.

408 Route 202  
P.O. Box 31  
Flemington, NJ 08822  
Phone: (908) 782-5454  
Fax: (908) 782-3489

William J. Cwieka, V.P. Sales; Rhonda G. Kasler,  
Mgr., Customer Service  
Metallic Flakes and Powdered Pigments

U.S. Silica Company

P.O. Box 187  
Highway 522 North  
Berkeley Springs, WV 25411  
Phone: (304) 258-2500

Fax: (304) 258-8295

Robert B. Calamari, V.P. Sales; Paul F. Guttman;  
John H. Wilson, Distribution Mgr.  
Extender Pigments

U.S. Zinc Corporation

6020 Navigation  
P.O. Box 611  
Houston, TX 77001  
Phone: (713) 926-1705

Fax: (713) 923-1783  
David Leggett, Sales Mgr.; Joe Hussein, Export  
Sales

Corrosion-Inhibiting Pigments  
White Pigments

R.T. VANDERBILT CO., INC.

30 Winfield St.  
P.O. Box 5150  
Norwalk, CT 06856-5150  
Phone: (203) 853-1400  
Fax: (203) 853-1452  
Extender Pigments

Wayne Pigments Corp.

306 N. Milwaukee St.  
Milwaukee, WI 53202  
Phone: (414) 225-2400  
Fax: (414) 225-2410

W. Thomas Pettijohn, President; James E. Boldt,  
V.P.

Corrosion-Inhibiting  
Other Pigments  
Yellow and Orange Pigments

Robert I. Webber Co., Inc.

35 Corporate Dr.  
Trumbull, CT 06611  
Phone: (203) 452-3080  
Fax: (203) 452-3085  
David Webber, V.P. Sales; Dee Whittaker, Secy-  
Treasurer/Office Mgr.  
Distributor of pigments

Zemex Industrial Minerals

1040 Crown Pointe Pkwy., Ste. 270  
Atlanta, GA 30338  
Phone: (770) 392-8664  
Fax: (770) 392-8670  
Lynn Kraniak, Dir. Marketing & Production Dev.;  
Patrick Carr, V.P. Sales, Specialty Products  
Extender Pigments

Zeneca, Pigments & Additives

8720 Red Oak Blvd., Ste. 2207  
Charlotte, NC 28217  
Phone: (704) 561-7340  
Fax: (704) 561-7353  
Robin Neaves, Mktg. & Sales Mgr.; Jan Weernik,  
Tech. Mgr.; Monica Grimes, Safety, Health, Envir.

Blue Pigments  
Dyes  
Green Pigments  
Pigment Dispersions (Aqueous)  
Red Pigments  
Yellow and Orange Pigments

Zinc Corp. of America, Inc.

Rt. 18, 300 Frankfort Rd.  
Monaca, PA 15061  
Phone: (412) 774-1020  
Fax: (412) 773-2269  
A.C. Hardies, V.P. Sales; S.L. Lewis, Technical  
Service Engineer

Corrosion-Inhibiting Pigments  
Metallic Flakes and Powdered Pigments  
White Pigments

Zochem, Division of Hudson Bay

P.O. Box 1120  
Brampton, Ont. L6V 2L8 Canada  
Phone: (905) 453-4100  
Fax: (905) 453-2920  
Scott A. Gilliard, Sales Mgr.  
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True one-coat hiding power in a high-gloss, water-based coating? Now it's possible, with DSX™ 2000 EXP rheology modifier from Henkel.

## Great hiding power for your toughest customers

DSX™ 2000 EXP is a high-solids associative thickener that's non ionic and urethane-free. In water-based coatings, DSX™ 2000 EXP provides increased brush drag, enhanced flow and leveling, and improved brush feel. With better performance properties, your coating will have:

- Excellent hiding power and gloss
- Improved spatter resistance during roller application
- Superior scrub and water resistance

What's more, you can achieve these results using smaller quantities of DSX™ 2000 EXP (typically 8-24 lbs./100 gal.) than with other less concentrated rheology modifiers. That means you can cut handling, transportation, and inventory costs, and that reduces your cost per unit. And DSX™ 2000 EXP has a longer shelf-life, too.

For more on DSX™ 2000 EXP, or any other Henkel rheology modifier or coating additive, call the Specialist in Applied Coatings Chemistry.

### **Henkel Corporation Coatings & Inks Division**

300 Brookside Avenue  
Ambler, PA 19002  
800-445-2207  
FAX: 215-628-1111  
In Canada 905-542-7550

**Coatings & Inks**



Circle No. 212 on the Reader Service Card

# PIGMENTS SPOTLIGHT : products

## **BLACK/BROWN/GRAY PIGMENTS**

ABCO Enterprises, Inc.  
Asbury Carbons, Inc., Div. of Asbury Graphite Mills, Inc.  
BASF CORP.  
Bayer Corporation  
Cabot Corp., Special Blacks Div.  
Cerdec Corp.  
Cleveland Pigment & Color Co.  
Columbian Chemicals Co.  
Degussa Corp.  
Ebonex Corporation  
ENGELHARD CORP.  
Ferro Corp.  
General Carbon Co.  
Harcros Pigments, Inc.  
Harcros Pigments-Canada  
HEUCOTECH LTD.  
Hilton Davis Co.  
Hitox Corp. of America  
Hoover Color Corp.  
Keystone Aniline Corp.  
Landers-Segal Color Co., Inc.  
Laporte Pigments  
Mineral Pigments Corporation  
Reade Advanced Materials  
Royale Pigments and Chemicals, Inc.  
Technical Industries, Inc.

### **Brown and Gray Pigments**

Cleveland Pigment & Color Co.  
ENGELHARD CORP.  
Harcros Pigments, Inc.  
Hitox Corp. of America  
Hoover Color Corp.  
Royale Pigments and Chemicals, Inc.

### **Carbon Black**

ABCO Enterprises, Inc.  
Asbury Carbons, Inc., Div. of Asbury Graphite Mills, Inc.  
Bayer Corporation  
Cabot Corp., Special Blacks Div.  
Columbian Chemicals Co.  
Degussa Corp.  
ENGELHARD CORP.  
Harcros Pigments-Canada  
Hilton Davis Co.  
Keystone Aniline Corp.  
Landers-Segal Color Co., Inc.  
Laporte Pigments  
Mineral Pigments Corporation  
Reade Advanced Materials

### **Complex Inorganic Color Pigments**

Cerdec Corp.  
Degussa Corp.  
ENGELHARD CORP.  
Ferro Corp.  
HEUCOTECH LTD.  
Hoover Color Corp.  
Landers-Segal Color Co., Inc.  
Royale Pigments and Chemicals, Inc.

### **Drop and Bone Blacks**

ABCO Enterprises, Inc.  
Cleveland Pigment & Color Co.  
Ebonex Corporation  
Hoover Color Corp.

### **Lampblack**

Columbian Chemicals Co.  
Degussa Corp.  
ENGELHARD CORP.  
General Carbon Co.  
Hoover Color Corp.  
Landers-Segal Color Co., Inc.  
Mineral Pigments Corporation  
Reade Advanced Materials

### **Misc. Black Pigments**

BASF CORP.  
Cleveland Pigment & Color Co.  
Columbian Chemicals Co.

ENGELHARD CORP.  
**HEUCOTECH LTD.**  
Hoover Color Corp.

## **BLUE PIGMENTS**

Aarbor International Corp.  
Atomergic Chemetals Corp.  
BASF CORP.  
Bayer Corporation  
Browning Chemical Corp.  
Cerdec Corp.  
CIBA SPECIALTY CHEMICALS  
Cleveland Pigment & Color Co.  
Degussa Corp.  
ENGELHARD CORP.  
Ferro Corp.  
Harcros Pigments-Canada  
HEUCOTECH LTD.  
Hilton Davis Co.  
Hitox Corp. of America  
Keystone Aniline Corp.  
Landers-Segal Color Co., Inc.  
Laporte Pigments  
Magruder Color Co.  
Mineral Pigments Corporation  
NICHEM Corp.  
Peer Chemical Corp.  
Pyosa, S.A. de C.V.  
Royale Pigments and Chemicals, Inc.  
SARTOMER CO.  
Spectra Colors Corp.  
Sun Chemical Corp., Colors Group Div.  
Technical Industries, Inc.  
Toyo Ink America, Inc.  
Uhlich Color Company  
United Color Technology, Inc.  
United Mineral & Chemical Corp.  
Zeneca, Pigments & Additives

### **Blue, Purple and Violet PMA & PTA Toners/Lakes**

ENGELHARD CORP.  
Keystone Aniline Corp.  
Peer Chemical Corp.  
Royale Pigments and Chemicals, Inc.  
Sun Chemical Corp., Colors Group Div.

### **Complex Inorganic Color Pigments**

Cerdec Corp.  
Degussa Corp.  
Ferro Corp.  
Harcros Pigments-Canada  
HEUCOTECH LTD.  
Landers-Segal Color Co., Inc.  
Royale Pigments and Chemicals, Inc.

### **Indanthrone Blue**

BASF CORP.  
Keystone Aniline Corp.  
Toyo Ink America, Inc.  
United Color Technology, Inc.  
Zeneca, Pigments & Additives

### **Iron Blue**

Aarbor International Corp.  
Degussa Corp.  
Keystone Aniline Corp.  
Landers-Segal Color Co., Inc.  
Mineral Pigments Corporation  
Pyosa, S.A. de C.V.

### **Phthalocyanine Blue**

Aarbor International Corp.  
Atomergic Chemetals Corp.  
BASF CORP.  
Bayer Corporation  
Browning Chemical Corp.  
CIBA SPECIALTY CHEMICALS  
Cleveland Pigment & Color Co.  
ENGELHARD CORP.  
HEUCOTECH LTD.  
Hilton Davis Co.  
Keystone Aniline Corp.

Landers-Segal Color Co., Inc.  
Magruder Color Co.  
NICHEM Corp.  
Peer Chemical Corp.  
Pyosa, S.A. de C.V.  
Royale Pigments and Chemicals, Inc.  
SARTOMER CO.  
Spectra Colors Corp.  
Sun Chemical Corp., Colors Group Div.  
Toyo Ink America, Inc.  
Uhlich Color Company  
United Color Technology, Inc.  
United Mineral & Chemical Corp.  
Zeneca, Pigments & Additives

### **Ultramarine Blue**

Atomergic Chemetals Corp.  
Browning Chemical Corp.  
Cleveland Pigment & Color Co.  
Ferro Corp.  
Hilton Davis Co.  
Landers-Segal Color Co., Inc.  
Royale Pigments and Chemicals, Inc.

### **Misc. Blue, Purple and Violet**

CIBA SPECIALTY CHEMICALS  
ENGELHARD CORP.  
Hilton Davis Co.  
Hitox Corp. of America  
Landers-Segal Color Co., Inc.  
Peer Chemical Corp.  
Spectra Colors Corp.  
Sun Chemical Corp., Colors Group Div.  
Uhlich Color Company

## **CORROSION-INHIBITING PIGMENTS**

Albright & Wilson U.K., Ltd.  
BASF CORP.  
Buckman Laboratories, Inc.  
CasChem, Inc.  
Cerdec Corp.  
Eagle Zinc Company  
HALOX PIGMENTS  
HEUCOTECH LTD.  
Kraft Chemical Co.  
Landers-Segal Color Co., Inc.  
Laporte Pigments  
Meadowbrook Co.  
Mineral Pigments Corporation  
NICHEM Corp.  
Pyosa, S.A. de C.V.  
Reade Advanced Materials  
Royale Pigments and Chemicals, Inc.  
Sherwin-Williams Chemicals  
Sino-American Pigment Systems, Inc.  
Tayca Corp., K-White Div.  
Technical Industries, Inc.  
U.S. Zinc Corporation  
United Mineral & Chemical Corp.  
Wayne Pigments Corp.  
Zinc Corp. of America, Inc.

### **Zinc Dust and Flakes**

Eagle Zinc Company  
Kraft Chemical Co.  
Meadowbrook Co.  
Reade Advanced Materials  
U.S. Zinc Corporation  
Zinc Corp. of America, Inc.

### **Zinc Yellow Pigments**

Landers-Segal Color Co., Inc.  
Laporte Pigments  
Mineral Pigments Corporation  
NICHEM Corp.  
Pyosa, S.A. de C.V.  
Royale Pigments and Chemicals, Inc.  
Wayne Pigments Corp.

### **Misc. Corrosion-Inhibiting Pigments**

BASF CORP.  
Buckman Laboratories, Inc.  
CasChem, Inc.



Cercdec Corp.  
Eagle Zinc Company  
HALOX PIGMENTS  
HEUCOTECH LTD.  
Landers-Segal Color Co., Inc.  
Laporte Pigments  
Meadowbrook Co.  
Mineral Pigments Corporation  
NICHEM Corp.  
Sherwin-Williams Chemicals  
Sino-American Pigment Systems, Inc.  
Tayca Corp., K-White Div.  
United Mineral & Chemical Corp.  
Wayne Pigments Corp.

#### **DYES**

**BASF CORP.**  
Bayer Corporation  
Captan Associates, Inc.  
Clariant Corp.  
Day-Glo Color Corp.  
Hilton Davis Co.  
Hoover Color Corp.  
Keystone Aniline Corp.  
Ming-Zu Chemical, Raw Materials Div.  
Mitsubishi Chemical America  
Morton International  
Pyosa, S.A. de C.V.  
Royale Pigments and Chemicals, Inc.  
Royce Associates, ALP  
Spectra Colors Corp.  
Uhlich Color Company  
United Color Technology, Inc.  
United Mineral & Chemical Corp.  
Zeneca, Pigments & Additives

#### **Organic**

**BASF CORP.**  
Keystone Aniline Corp.  
Pyosa, S.A. de C.V.  
Royale Pigments and Chemicals, Inc.  
Royce Associates, ALP  
Spectra Colors Corp.

#### **Solvent-Soluble**

**BASF CORP.**  
Bayer Corporation  
Keystone Aniline Corp.  
Ming-Zu Chemical, Raw Materials Div.  
Morton International  
Pyosa, S.A. de C.V.  
Royale Pigments and Chemicals, Inc.  
Royce Associates, ALP  
Spectra Colors Corp.  
United Color Technology, Inc.  
Zeneca, Pigments & Additives

#### **Water-Soluble**

**BASF CORP.**  
Hilton Davis Co.  
Hoover Color Corp.  
Keystone Aniline Corp.  
Ming-Zu Chemical, Raw Materials Div.  
Morton International  
Pyosa, S.A. de C.V.  
Royale Pigments and Chemicals, Inc.  
Royce Associates, ALP  
Spectra Colors Corp.  
United Color Technology, Inc.

#### **Misc. Dyes**

**BASF CORP.**  
Captan Associates, Inc.  
Day-Glo Color Corp.  
Hilton Davis Co.  
Keystone Aniline Corp.  
Ming-Zu Chemical, Raw Materials Div.  
Pyosa, S.A. de C.V.  
Royale Pigments and Chemicals, Inc.  
Royce Associates, ALP  
Spectra Colors Corp.  
Uhlich Color Company  
United Mineral & Chemical Corp.

#### **EXTENDER PIGMENTS**

Alcoa Industrial Chemicals  
Asbury Carbons, Inc., Div. of Asbury Graphite Mills, Inc.  
Atomergic Chemetals Corp.  
**BURGESS PIGMENT CO.**  
Cabot Corp., CAB-O-SIL  
Celite Corp., c/o World Minerals, Inc.  
Cimbar Performance Minerals  
Cleveland Pigment & Color Co.  
CR Minerals Corp.  
Dry Branch Kaolin Company  
ECC International  
**ENGELHARD CORP.**  
Franklin Industrial Minerals, Div. of KMG  
Fuji Silysia Chemical, Ltd.  
Harborlite Corp., c/o World Minerals, Inc.  
Harcros Pigments Inc.  
Harcros Pigments-Canada  
Hitox Corp. of America  
J.M. Huber Corp., Engineered Minerals Div.  
K-T Feldspar Corp.  
Kraft Chemical Co.  
Landers-Segal Color Co., Inc.  
Luzenac America  
Malvern Minerals Co.  
The Mearl Corporation  
Mississippi Lime Co.  
NYCO® Minerals, Inc.  
OMYA, Inc.  
Polar Minerals, Inc.  
Potters Industries, Inc.  
The PQ Corp., Specialty Div.  
PQ Corporation/ Potters Industries  
Reade Advanced Materials  
Rit-Chem Co., Inc.  
Sachtleben Corp.  
Sino-American Pigment Systems, Inc.  
Specialty Minerals Inc.  
Technical Industries, Inc.  
U.S. Silica Company  
Unimin Corp.  
United Mineral & Chemical Corp.  
**R.T. VANDERBILT CO., INC.**  
Zemex Industrial Minerals

#### **Aluminum Trihydrate**

Alcoa Industrial Chemicals  
Hitox Corp. of America  
J.M. Huber Corp., Engineered Minerals Div.  
Kraft Chemical Co.  
Landers-Segal Color Co., Inc.

#### **Barium Sulfate (Barytes, Blanc Fixe)**

Cimbar Performance Minerals  
Harcros Pigments Inc.  
Harcros Pigments-Canada  
Hitox Corp. of America  
J.M. Huber Corp., Engineered Minerals Div.  
Kraft Chemical Co.  
Landers-Segal Color Co., Inc.  
Polar Minerals, Inc.  
Rit-Chem Co., Inc.  
Sachtleben Corp.  
Sino-American Pigment Systems, Inc.  
Zemex Industrial Minerals

#### **Barium Sulfate**

Atomergic Chemetals Corp.  
Cimbar Performance Minerals  
Cleveland Pigment & Color Co.  
**ENGELHARD CORP.**  
Hitox Corp. of America  
J.M. Huber Corp., Engineered Minerals Div.  
Landers-Segal Color Co., Inc.

#### **Bentonite**

Asbury Carbons, Inc., Div. of Asbury Graphite Mills, Inc.  
Cimbar Performance Minerals  
Landers-Segal Color Co., Inc.

#### **Calcium Carbonate**

ECC International  
**ENGELHARD CORP.**

J.M. Huber Corp., Engineered Minerals Div.  
Landers-Segal Color Co., Inc.  
Mississippi Lime Co.  
OMYA, Inc.  
Polar Minerals, Inc.  
Specialty Minerals Inc.  
United Mineral & Chemical Corp.

#### **China Clay & Aluminum Silicate**

**BURGESS PIGMENT CO.**  
Dry Branch Kaolin Company  
ECC International  
**ENGELHARD CORP.**  
J.M. Huber Corp., Engineered Minerals Div.  
K-T Feldspar Corp.  
Landers-Segal Color Co., Inc.  
**R.T. VANDERBILT CO., INC.**

#### **Fillers**

**BURGESS PIGMENT CO.**  
CR Minerals Corp.  
Cimbar Performance Minerals  
Dry Branch Kaolin Company  
ECC International  
**ENGELHARD CORP.**  
Harborlite Corp., c/o World Minerals, Inc.  
J.M. Huber Corp., Engineered Minerals Div.  
K-T Feldspar Corp.  
Landers-Segal Color Co., Inc.  
NYCO® Minerals, Inc.  
Polar Minerals, Inc.  
The PQ Corp., Specialty Div.  
Reade Advanced Materials  
Specialty Minerals Inc.  
U.S. Silica Company  
Unimin Corp.  
Zemex Industrial Minerals

#### **Mica**

Asbury Carbons, Inc., Div. of Asbury Graphite Mills, Inc.  
**ENGELHARD CORP.**  
Franklin Industrial Minerals, Div. of KMG  
Landers-Segal Color Co., Inc.  
The Mearl Corporation  
Polar Minerals, Inc.  
Zemex Industrial Minerals

#### **Silica-Amorphous-Naturally Occurring**

CR Minerals Corp.  
**ENGELHARD CORP.**  
K-T Feldspar Corp.  
Landers-Segal Color Co., Inc.  
Unimin Corp.

#### **Silica-Amorphous-Synthetic**

Cabot Corp., CAB-O-SIL  
Celite Corp., c/o World Minerals, Inc.  
**ENGELHARD CORP.**  
Fuji Silysia Chemical, Ltd.

#### **Silica-Quartz and Diatomaceous**

Celite Corp., c/o World Minerals, Inc.  
CR Minerals Corp.  
**ENGELHARD CORP.**  
Landers-Segal Color Co., Inc.  
Malvern Minerals Co.  
U.S. Silica Company

#### **Talc or Magnesium Silicate**

Asbury Carbons, Inc., Div. of Asbury Graphite Mills, Inc.  
Celite Corp., c/o World Minerals, Inc.  
**ENGELHARD CORP.**  
Landers-Segal Color Co., Inc.  
Luzenac America  
Polar Minerals, Inc.  
**R.T. VANDERBILT CO., INC.**  
Zemex Industrial Minerals

#### **Misc. Extenders**

Alcoa Industrial Chemicals  
**BURGESS PIGMENT CO.**

# PIGMENTS SPOTLIGHT : products

## ENGELHARD CORP.

J.M. Huber Corp., Engineered Minerals Div.  
K-T Feldspar Corp.  
Landers-Segal Color Co., Inc.  
Luzenac America  
Malvern Minerals Co.  
NYCO® Minerals, Inc.  
Polar Minerals, Inc.  
PQ Corporation/ Potters Industries  
The PQ Corp., Specialty Div.  
Potters Industries, Inc.  
Specialty Minerals Inc.  
R.T. VANDERBILT CO., INC.  
Unimin Corp.

## GREEN PIGMENTS

Aarbor International Corp.  
Atomerig Chemetals Corp.  
BASF CORP.  
Bayer Corporation  
Browning Chemical Corp.  
Cerdec Corp.  
CIBA SPECIALTY CHEMICALS  
Cimbar Performance Minerals  
Cleveland Pigment & Color Co.  
ENGELHARD CORP.  
Ferro Corp.  
Harcros Pigments Inc.  
Harcros Pigments-Canada  
HEUCOTECH LTD.  
Hilton Davis Co.  
Hitox Corp. of America  
Hoover Color Corp.  
Keystone Aniline Corp.  
Landers-Segal Color Co., Inc.  
Laporte Pigments  
Mineral Pigments Corporation  
Peer Chemical Corp.  
Pyosa, S.A. de C.V.  
Reade Advanced Materials  
Royale Pigments and Chemicals, Inc.  
SARTOMER CO.  
Sino-American Pigment Systems, Inc.  
Sun Chemical Corp., Colors Group Div.  
Toyo Ink America, Inc.  
Uhlich Color Company  
United Mineral & Chemical Corp.  
Zeneca, Pigments & Additives

## Chrome Green

ENGELHARD CORP.  
Landers-Segal Color Co., Inc.  
Laporte Pigments  
Mineral Pigments Corporation  
Pyosa, S.A. de C.V.  
Royale Pigments and Chemicals, Inc.

## Chromium Oxide

Atomerig Chemetals Corp.  
Cleveland Pigment & Color Co.  
Harcros Pigments Inc.  
Harcros Pigments-Canada  
Hoover Color Corp.  
Landers-Segal Color Co., Inc.  
Laporte Pigments  
Mineral Pigments Corporation  
Pyosa, S.A. de C.V.  
Reade Advanced Materials

## Complex Inorganic Color Pigments

Cerdec Corp.  
Ferro Corp.  
HEUCOTECH LTD.  
Hoover Color Corp.  
Landers-Segal Color Co., Inc.  
Royale Pigments and Chemicals, Inc.

## Green PMA & PTA Toners/Lakes

Peer Chemical Corp.  
Royale Pigments and Chemicals, Inc.

## Barium Sulfate

Cimbar Performance Minerals  
Landers-Segal Color Co., Inc.

## Phthalocyanine Green

Aarbor International Corp.  
Atomerig Chemetals Corp.  
BASF CORP.  
Bayer Corporation  
Browning Chemical Corp.  
CIBA SPECIALTY CHEMICALS  
Cleveland Pigment & Color Co.  
ENGELHARD CORP.  
HEUCOTECH LTD.  
Hilton Davis Co.  
Keystone Aniline Corp.  
Peer Chemical Corp.  
Pyosa, S.A. de C.V.  
Royale Pigments and Chemicals, Inc.  
SARTOMER CO.  
Sun Chemical Corp., Colors Group Div.  
Toyo Ink America, Inc.  
Uhlich Color Company  
United Mineral & Chemical Corp.  
Zeneca, Pigments & Additives

## Misc. Green Pigments

CIBA SPECIALTY CHEMICALS  
ENGELHARD CORP.  
Hilton Davis Co.  
Hitox Corp. of America  
Peer Chemical Corp.  
Sino-American Pigment Systems, Inc.  
Toyo Ink America, Inc.

## IRON OXIDE PIGMENTS

Arizona Oxides Inc.  
BASF CORP.  
Cleveland Pigment & Color Co.  
Dynamic Color Solutions, Inc.  
ENGELHARD CORP.  
Harcros Pigments Inc.  
Harcros Pigments-Canada  
HEUCOTECH LTD.  
Hilton Davis Co.  
Hitox Corp. of America  
Hoover Color Corp.  
Laporte Pigments  
Mapico Inc.  
Mineral Pigments Corporation  
Reade Advanced Materials  
Royale Pigments and Chemicals, Inc.  
Spectra Colors Corp.

## Black Iron Oxide

Arizona Oxides Inc.  
Cleveland Pigment & Color Co.  
Dynamic Color Solutions, Inc.  
ENGELHARD CORP.  
Harcros Pigments Inc.  
Harcros Pigments-Canada  
HEUCOTECH LTD.  
Hoover Color Corp.  
Laporte Pigments  
Mapico Inc.  
Mineral Pigments Corporation  
Reade Advanced Materials  
Royale Pigments and Chemicals, Inc.  
Spectra Colors Corp.

## Burnt Sienna

Cleveland Pigment & Color Co.  
ENGELHARD CORP.  
Hilton Davis Co.  
Hoover Color Corp.  
Laporte Pigments  
Mineral Pigments Corporation

## Burnt Umber

Cleveland Pigment & Color Co.  
Dynamic Color Solutions, Inc.  
ENGELHARD CORP.  
Harcros Pigments Inc.  
Harcros Pigments-Canada  
Hilton Davis Co.  
Hoover Color Corp.  
Laporte Pigments  
Mineral Pigments Corporation

## Indian Red

Hoover Color Corp.  
Mineral Pigments Corporation

## Metallic Brown

Harcros Pigments Inc.  
Harcros Pigments-Canada  
Hoover Color Corp.  
Mineral Pigments Corporation

## Mineral Black

Hoover Color Corp.

## Ochre

Arizona Oxides Inc.  
Cleveland Pigment & Color Co.  
Dynamic Color Solutions, Inc.  
ENGELHARD CORP.  
Hoover Color Corp.  
Mineral Pigments Corporation

## Raw Sienna

ENGELHARD CORP.  
Hilton Davis Co.  
Hoover Color Corp.  
Laporte Pigments  
Mineral Pigments Corporation

## Raw Umber

ENGELHARD CORP.  
Harcros Pigments Inc.  
Harcros Pigments-Canada  
Hilton Davis Co.  
Hoover Color Corp.  
Laporte Pigments  
Mineral Pigments Corporation

## Red and Brown Iron Oxide—Natural

Arizona Oxides Inc.  
Cleveland Pigment & Color Co.  
Dynamic Color Solutions, Inc.  
ENGELHARD CORP.  
Harcros Pigments Inc.  
Harcros Pigments-Canada  
Hitox Corp. of America  
Hoover Color Corp.  
Laporte Pigments  
Mineral Pigments Corporation  
Royale Pigments and Chemicals, Inc.

## Red and Brown Iron Oxide—Synthetic

Arizona Oxides Inc.  
BASF CORP.  
Cleveland Pigment & Color Co.  
Dynamic Color Solutions, Inc.  
ENGELHARD CORP.  
Harcros Pigments Inc.  
Harcros Pigments-Canada  
HEUCOTECH LTD.  
Hilton Davis Co.  
Hitox Corp. of America  
Hoover Color Corp.  
Laporte Pigments  
Mineral Pigments Corporation  
Royale Pigments and Chemicals, Inc.  
Spectra Colors Corp.

## Spanish Type Oxide

Arizona Oxides Inc.  
Cleveland Pigment & Color Co.  
Harcros Pigments Inc.  
Harcros Pigments-Canada  
Hoover Color Corp.  
Laporte Pigments  
Mineral Pigments Corporation

## Van Dyke Brown

Hoover Color Corp.  
Laporte Pigments  
Mineral Pigments Corporation

# SER-AD™ ADDITIVES FOR WATERBORNES

Recommended for Leading Formulators and Environmentally Concerned Companies

SER-AD™ coatings additives were developed to be nature-friendly, much as the waterborne coatings in which they're used. When you formulate with these SER-AD products, you will improve finish quality and address issues such as odor, VOCs and harmful compounds.

**SER-AD FA 379** is the nitrite-free solution to flash rusting. This anti-corrosive additive forms a monomolecular barrier to protect the metal surface from water and improve coating adhesion. Effective during manufacturing, storage and application, SER-AD FA 379 permanently inhibits corrosion, long after the coating has dried.

**SER-AD FX 1070**, a VOC-free, unique PUR thickener, increases high-shear viscosity to provide improved brushing characteristics and higher film build for a better coating appearance.

**SER-AD FX 511**, a low-odor coalescing agent that promotes the formation of continuous films in a broad range of water-reducible resins, stays in the coating longer to help prevent cracking.

SER-AD Additives for Waterborne Formulations. Think of them as Mother Nature's assistants for your toughest formulation problems.

HÜLS AMERICA INC.  
Coatings Raw Materials  
220 Davidson Ave.  
Somerset, New Jersey 08873  
(800) FOR-HULS (367-4857)  
Fax (908) 560-6355  
In Canada: (905) 451-3810



**hüls**  
HÜLS AMERICA INC.

## PIGMENTS SPOTLIGHT : products

### Yellow Iron Oxide—Synthetic

Arizona Oxides Inc.  
BASF CORP.  
Cleveland Pigment & Color Co.  
Dynamic Color Solutions, Inc.  
Harcros Pigments Inc.  
Harcros Pigments-Canada  
HEUCOTECH LTD.  
Hilton Davis Co.  
Hoover Color Corp.  
Laporte Pigments  
Mapico Inc.  
Mineral Pigments Corporation  
Royale Pigments and Chemicals, Inc.

### Misc. Iron Oxide Pigments

Arizona Oxides Inc.  
Harcros Pigments Inc.  
Harcros Pigments-Canada  
Hilton Davis Co.  
Hoover Color Corp.  
Laporte Pigments  
Mapico Inc.  
Mineral Pigments Corporation  
Royale Pigments and Chemicals, Inc.

### METALLIC FLAKES AND POWDERED PIGMENTS

Aarbor International Corp.  
BASF Corp.  
Degussa Corp.  
Eagle Zinc Company  
Kraft Chemical Co.  
Meadowbrook Co.  
Obron Atlantic Corp.  
Potters Industries, Inc.  
Purity Zinc Metals  
Reade Advanced Materials  
Reynolds Metals Co., Powder & Paste Div.  
Royale Pigments and Chemicals, Inc.  
Silberline Manufacturing Co., Inc.  
Toyol America Inc.  
U.S. Aluminum, Inc.  
U.S. Bronze Powders, Inc.  
Zinc Corp. of America, Inc.

### Aluminum Pastes—Leafing

Aarbor International Corp.  
Obron Atlantic Corp.  
Reynolds Metals Co., Powder & Paste Div.  
Royale Pigments and Chemicals, Inc.  
Silberline Manufacturing Co., Inc.  
Toyol America Inc.  
U.S. Aluminum, Inc.  
U.S. Bronze Powders, Inc.

### Aluminum Pastes—Nonleafing

Obron Atlantic Corp.  
Reynolds Metals Co., Powder & Paste Div.  
Royale Pigments and Chemicals, Inc.  
Silberline Manufacturing Co., Inc.  
Toyol America Inc.  
U.S. Aluminum, Inc.  
U.S. Bronze Powders, Inc.

### Aluminum Powders—Leafing

Obron Atlantic Corp.  
Reade Advanced Materials  
Reynolds Metals Co., Powder & Paste Div.  
Toyol America Inc.  
U.S. Aluminum, Inc.  
U.S. Bronze Powders, Inc.

### Aluminum Powders—Nonleafing

Obron Atlantic Corp.  
Reade Advanced Materials  
Reynolds Metals Co., Powder & Paste Div.  
Toyol America Inc.  
U.S. Aluminum, Inc.  
U.S. Bronze Powders, Inc.

### Gold Bronze Powders

Degussa Corp.  
Obron Atlantic Corp.  
U.S. Bronze Powders, Inc.

### Zinc Dust and Flakes

Eagle Zinc Company  
Kraft Chemical Co.  
Meadowbrook Co.  
Obron Atlantic Corp.  
Purity Zinc Metals  
Reade Advanced Materials  
U.S. Bronze Powders, Inc.  
Zinc Corp. of America, Inc.

### Misc. Metallic Flakes

BASF CORP.  
Eagle Zinc Company  
Meadowbrook Co.  
Obron Atlantic Corp.  
Potters Industries, Inc.  
Reade Advanced Materials  
Silberline Manufacturing Co., Inc.  
U.S. Aluminum, Inc.  
U.S. Bronze Powders, Inc.

### OTHER PIGMENTS

AlliedSignal Inc.  
BASF CORP.  
CIBA SPECIALTY CHEMICALS  
Cleveland Pigment & Color Co.  
Day-Glo Color Corp.  
EM INDUSTRIES, INC.  
ENGELHARD CORP.  
HALOX PIGMENTS  
Hitox Corp. of America  
Keystone Aniline Corp.  
Kowa American Corp.  
The Mearl Corporation  
Peer Chemical Corp.  
Potters Industries, Inc.  
Radiant Color  
Royale Pigments and Chemicals, Inc.  
Spectra Colors Corp.  
United Mineral & Chemical Corp.  
Wayne Pigments Corp.

### Iridescent

ENGELHARD CORP.  
Kowa American Corp.  
The Mearl Corporation

### Luminescent and Fluorescent

AlliedSignal Inc.  
Cleveland Pigment & Color Co.  
Day-Glo Color Corp.  
ENGELHARD CORP.  
Keystone Aniline Corp.  
Radiant Color  
Royale Pigments and Chemicals, Inc.  
Spectra Colors Corp.  
United Mineral & Chemical Corp.

### Pearlescent

BASF CORP.  
EM INDUSTRIES, INC.  
ENGELHARD CORP.  
Kowa American Corp.  
The Mearl Corporation  
Royale Pigments and Chemicals, Inc.

### Misc. Other Pigments

BASF CORP.  
CIBA SPECIALTY CHEMICALS  
ENGELHARD CORP.  
HALOX PIGMENTS  
Hitox Corp. of America  
Keystone Aniline Corp.  
The Mearl Corporation  
Peer Chemical Corp.  
Potters Industries, Inc.  
United Mineral & Chemical Corp.  
Wayne Pigments Corp.

### Pigment Dispersions (Aqueous)

ABCO Enterprises, Inc.  
Allo Colouring Co.  
American Casein Co., Div. of Protein Polymer  
BASF CORP.  
Bayer Corporation  
Cardinal Color & Chemical Inc.  
CDI Dispersions  
Cimbar Performance Minerals  
Clariant Corp.  
Color Corporation of America  
Consolidated Color Corp.  
Daniel Products Co., Inc.  
Day-Glo Color Corp.  
Ebonex Corporation  
ENGELHARD CORP.  
Genesis Dispersions Inc.  
HEUCOTECH LTD.  
Hilton Davis Co.  
Kane International Corp.  
Magruder Color Co.  
Morton International  
Pflaumer Brothers, Inc.  
Pyosa, S.A. de C.V.  
Radiant Color  
RBH Dispersions, Inc.  
Reichhold Chemicals, Inc.  
Royale Pigments and Chemicals, Inc.  
Spectra Colors Corp.  
Sun Chemical Corp., Colors Group Div.  
Technical Industries, Inc.  
Toyo Ink America, Inc.  
United Color Technology, Inc.  
Zeneca, Pigments & Additives

### Color Concentrates

Allo Colouring Co.  
BASF CORP.  
Cardinal Color & Chemical Inc.  
CDI Dispersions  
Color Corporation of America  
Consolidated Color Corp.  
Daniel Products Co., Inc.  
Ebonex Corporation  
ENGELHARD CORP.  
Genesis Dispersions Inc.  
HEUCOTECH LTD.  
Hilton Davis Co.  
Kane International Corp.  
Pflaumer Brothers, Inc.  
Radiant Color  
RBH Dispersions, Inc.  
Sun Chemical Corp., Colors Group Div.  
Technical Industries, Inc.

### Machine Colorants

Color Corporation of America  
Daniel Products Co., Inc.  
ENGELHARD CORP.  
Genesis Dispersions Inc.  
Hilton Davis Co.

### Press Cakes

Bayer Corporation  
ENGELHARD CORP.  
HEUCOTECH LTD.  
Hilton Davis Co.  
Magruder Color Co.  
Pyosa, S.A. de C.V.  
Royale Pigments and Chemicals, Inc.  
Sun Chemical Corp., Colors Group Div.  
Toyo Ink America, Inc.  
United Color Technology, Inc.

### Solvent-Soluble Dyes

Spectra Colors Corp.  
United Color Technology, Inc.

### Tube Colorants

Color Corporation of America  
ENGELHARD CORP.  
Genesis Dispersions Inc.



### Water Soluble

Allo Colouring Co.  
American Casein Co., Div. of Protein Polymer  
Bayer Corporation  
Cardinal Color & Chemical Inc.  
CDI Dispersions  
ENGELHARD CORP.  
Morton International  
RBH Dispersions, Inc.  
Spectra Colors Corp.

### Misc.

ABCO Enterprises, Inc.  
Allo Colouring Co.  
Cardinal Color & Chemical Inc.  
CDI Dispersions  
Cimbar Performance Minerals  
Color Corporation of America  
Day-Glo Color Corp.  
ENGELHARD CORP.  
Genesis Dispersions Inc.  
Morton International  
Technical Industries, Inc.

### Pigment Dispersions (Non-Aqueous)

Allo Colouring Co.  
Cardinal Color & Chemical Inc.  
CDI Dispersions  
Cimbar Performance Minerals  
Color Corporation of America  
Consolidated Color Corp.  
Daniel Products Co., Inc.  
Day-Glo Color Corp.  
ENGELHARD CORP.  
Hilton Davis Co.  
HULS AMERICA INC.  
Kane International Corp.  
Morton International  
Pflaumer Brothers, Inc.  
Radiant Color  
RBH Dispersions, Inc.  
Reichhold Chemicals, Inc.  
Toyo Ink America, Inc.

### Acrylic Vehicle Pigment Dispersion

Cardinal Color & Chemical Inc.  
CDI Dispersions  
Consolidated Color Corp.  
Daniel Products Co., Inc.  
Day-Glo Color Corp.  
ENGELHARD CORP.  
Hilton Davis Co.  
HULS AMERICA INC.  
Kane International Corp.  
Morton International  
Pflaumer Brothers, Inc.  
Radiant Color  
RBH Dispersions, Inc.  
Toyo Ink America, Inc.

### Alkyd Vehicle Pigment Dispersion

Cardinal Color & Chemical Inc.  
CDI Dispersions  
Color Corporation of America  
Consolidated Color Corp.  
Daniel Products Co., Inc.  
Day-Glo Color Corp.  
Hilton Davis Co.  
HULS AMERICA INC.  
Pflaumer Brothers, Inc.  
Radiant Color  
RBH Dispersions, Inc.  
Toyo Ink America, Inc.

### Nitrocellulose Vehicle Pigment Dispersion

Consolidated Color Corp.  
Hilton Davis Co.  
Kane International Corp.  
RBH Dispersions, Inc.  
Toyo Ink America, Inc.

### Polyester Vehicle Pigment Dispersion

Cardinal Color & Chemical Inc.  
CDI Dispersions  
Consolidated Color Corp.  
Hilton Davis Co.  
HULS AMERICA INC.  
Morton International  
RBH Dispersions, Inc.  
Toyo Ink America, Inc.

### Universal Solvent Vehicle Dispersion

Cardinal Color & Chemical Inc.  
CDI Dispersions  
Color Corporation of America  
Consolidated Color Corp.  
ENGELHARD CORP.  
Hilton Davis Co.  
HULS AMERICA INC.  
Morton International  
Pflaumer Brothers, Inc.  
RBH Dispersions, Inc.

### Misc.

Allo Colouring Co.  
Cardinal Color & Chemical Inc.  
CDI Dispersions  
Cimbar Performance Minerals  
Color Corporation of America  
Consolidated Color Corp.  
Day-Glo Color Corp.  
ENGELHARD CORP.  
Hilton Davis Co.  
HULS AMERICA INC.  
Pflaumer Brothers, Inc.  
RBH Dispersions, Inc.  
Toyo Ink America, Inc.

### RED PIGMENTS

Aarbor International Corp.  
American Chemet Corp.  
Atomergic Chemetals Corp.  
BASF CORP.  
Bayer Corporation  
Cerdec Corp.  
CIBA SPECIALTY CHEMICALS  
Clariant Corp.  
Cleveland Pigment & Color Co.  
ENGELHARD CORP.  
HEUCOTECH LTD.  
Hilton Davis Co.  
Hitox Corp. of America  
Keystone Aniline Corp.  
Magruder Color Co.  
Millennium Inorganic Chemicals Inc.  
Peer Chemical Corp.  
Pyosa, S.A. de C.V.  
Reade Advanced Materials  
Royale Pigments and Chemicals, Inc.  
SARTOMER CO.  
Sino-American Pigment Systems, Inc.  
Sun Chemical Corp., Colors Group Div.  
Toyo Ink America, Inc.  
Uhlich Color Company  
United Mineral & Chemical Corp.  
Zeneca, Pigments & Additives

### Alizarine or Madder Lake

Uhlich Color Company

### Arylide Red and Maroon

Pyosa, S.A. de C.V.  
United Mineral & Chemical Corp.

### BON Red and Maroon

BASF CORP.  
ENGELHARD CORP.  
Hilton Davis Co.  
Magruder Color Co.  
Peer Chemical Corp.  
Pyosa, S.A. de C.V.  
Royale Pigments and Chemicals, Inc.  
Sun Chemical Corp., Colors Group Div.

Uhlich Color Company  
United Mineral & Chemical Corp.

### Cadmium Red

Atomergic Chemetals Corp.  
Cerdec Corp.  
ENGELHARD CORP.  
Millennium Inorganic Chemicals Inc.  
SARTOMER CO.  
United Mineral & Chemical Corp.

### Cadmium-Mercury Red, Maroon & Orange

Atomergic Chemetals Corp.  
ENGELHARD CORP.

### Cuprous Oxide

American Chemet Corp.  
Reade Advanced Materials

### Lithol Rubine

Aarbor International Corp.  
Bayer Corporation  
Cleveland Pigment & Color Co.  
ENGELHARD CORP.  
HEUCOTECH LTD.  
Hilton Davis Co.  
Keystone Aniline Corp.  
Magruder Color Co.  
Peer Chemical Corp.  
Pyosa, S.A. de C.V.  
Royale Pigments and Chemicals, Inc.  
Sun Chemical Corp., Colors Group Div.  
Toyo Ink America, Inc.  
Uhlich Color Company  
United Mineral & Chemical Corp.  
Zeneca, Pigments & Additives

### Metallized Azo Red

Hilton Davis Co.  
Keystone Aniline Corp.  
Royale Pigments and Chemicals, Inc.  
Sun Chemical Corp., Colors Group Div.

### Naphthol Red

Aarbor International Corp.  
BASF CORP.  
Clariant Corp.  
Cleveland Pigment & Color Co.  
ENGELHARD CORP.  
HEUCOTECH LTD.  
Hilton Davis Co.  
Keystone Aniline Corp.  
Magruder Color Co.  
Peer Chemical Corp.  
Pyosa, S.A. de C.V.  
Royale Pigments and Chemicals, Inc.  
Sun Chemical Corp., Colors Group Div.  
Toyo Ink America, Inc.  
Uhlich Color Company  
United Mineral & Chemical Corp.

### Pigment Scarlet

Bayer Corporation  
CIBA SPECIALTY CHEMICALS  
ENGELHARD CORP.  
Keystone Aniline Corp.  
Sun Chemical Corp., Colors Group Div.  
United Mineral & Chemical Corp.

### Pyrazolone Red and Maroon

ENGELHARD CORP.  
Keystone Aniline Corp.  
Sun Chemical Corp., Colors Group Div.

### Quinacridone Pigment

Bayer Corporation  
CIBA SPECIALTY CHEMICALS  
ENGELHARD CORP.  
Keystone Aniline Corp.  
Sun Chemical Corp., Colors Group Div.  
Uhlich Color Company

## PIGMENTS SPOTLIGHT : products

### Red Lake C

Aarbor International Corp.  
Cleveland Pigment & Color Co.  
ENGELHARD CORP.  
HEUCOTECH LTD.  
Hilton Davis Co.  
Keystone Aniline Corp.  
Magruder Color Co.  
Peer Chemical Corp.  
Pyosa, S.A. de C.V.  
Royale Pigments and Chemicals, Inc.  
Sun Chemical Corp., Colors Group Div.  
Uhlich Color Company  
United Mineral & Chemical Corp.

### Rhodamine

ENGELHARD CORP.  
Hilton Davis Co.  
Keystone Aniline Corp.  
Magruder Color Co.  
Royale Pigments and Chemicals, Inc.  
Sun Chemical Corp., Colors Group Div.

### Sodium Lithol, Calcium Lithol, and Barium Lithol Toner

Hilton Davis Co.  
Peer Chemical Corp.  
Pyosa, S.A. de C.V.  
Sun Chemical Corp., Colors Group Div.  
Toyo Ink America, Inc.  
United Mineral & Chemical Corp.

### Thioindigo Red and Maroon

Keystone Aniline Corp.

### Toluidine Red

Aarbor International Corp.  
Atomergic Chemetals Corp.  
BASF CORP.  
Cleveland Pigment & Color Co.  
ENGELHARD CORP.  
Hilton Davis Co.  
Peer Chemical Corp.  
Pyosa, S.A. de C.V.  
Royale Pigments and Chemicals, Inc.  
Sun Chemical Corp., Colors Group Div.  
Uhlich Color Company  
United Mineral & Chemical Corp.

### Misc. Red & Maroon Toners/Lakes

Cleveland Pigment & Color Co.  
ENGELHARD CORP.  
Hilton Davis Co.  
Hitox Corp. of America  
Keystone Aniline Corp.  
Sino-American Pigment Systems, Inc.  
Toyo Ink America, Inc.  
Uhlich Color Company  
United Mineral & Chemical Corp.

### WHITE PIGMENTS

Aarbor International Corp.  
American Chemet Corp.  
Browning Chemical Corp.  
DuPont Co., White Pigment & Mineral Products  
Eagle Zinc Company  
ENGELHARD CORP.  
Hilton Davis Co.  
Hitox Corp. of America  
Ishihara Corp. (U.S.A.)  
Kemira Pigments Inc.  
Kronos, Inc.  
Meadowbrook Co.  
Millennium Inorganic Chemicals Inc.  
Reade Advanced Materials  
Royale Pigments and Chemicals, Inc.  
Sachtleben Corp.  
Sino-American Pigment Systems, Inc.  
Technical Industries, Inc.  
Tioxide Americas Inc.  
U.S. Zinc Corporation  
United Mineral & Chemical Corp.

Zinc Corp. of America, Inc.  
Zochem, Div. of Hudson Bay

### Antimony Oxide

Reade Advanced Materials  
United Mineral & Chemical Corp.

### Titanium Dioxide—Anatase

Aarbor International Corp.  
Browning Chemical Corp.  
ENGELHARD CORP.  
Ishihara Corp. (U.S.A.)  
Kemira Pigments Inc.  
Kronos, Inc.  
Millennium Inorganic Chemicals Inc.  
Royale Pigments and Chemicals, Inc.  
Technical Industries, Inc.  
Tioxide Americas Inc.  
United Mineral & Chemical Corp.

### Titanium Dioxide—Rutile

DuPont Co., White Pigment & Mineral Products  
ENGELHARD CORP.  
Hilton Davis Co.  
Hitox Corp. of America  
Ishihara Corp. (U.S.A.)  
Kemira Pigments Inc.  
Kronos, Inc.  
Millennium Inorganic Chemicals Inc.  
Royale Pigments and Chemicals, Inc.  
Technical Industries, Inc.  
Tioxide Americas Inc.  
United Mineral & Chemical Corp.

### Zinc Oxide

American Chemet Corp.  
Eagle Zinc Company  
ENGELHARD CORP.  
Meadowbrook Co.  
Reade Advanced Materials  
Technical Industries, Inc.  
U.S. Zinc Corporation  
United Mineral & Chemical Corp.  
Zinc Corp. of America, Inc.  
Zochem, Div. of Hudson Bay

### Zinc Sulfide

ENGELHARD CORP.  
Sachtleben Corp.  
Sino-American Pigment Systems, Inc.

### Misc. White Pigments

Keystone Aniline Corp.  
Sino-American Pigment Systems, Inc.

### YELLOW AND ORANGE PIGMENTS

Aarbor International Corp.  
Atomergic Chemetals Corp.  
BASF CORP.  
Bayer Corporation  
Cerdec Corp.  
CIBA SPECIALTY CHEMICALS  
Clariant Corp.  
Cleveland Pigment & Color Co.  
Eagle Zinc Company  
ENGELHARD CORP.  
Ferro Corp.  
HEUCOTECH LTD  
Hilton Davis Co.  
Hitox Corp. of America  
Hoover Color Corp.  
Ishihara Corp. (U.S.A.)  
Keystone Aniline Corp.  
Laporte Pigments  
Meadowbrook Co.  
Mineral Pigments Corporation  
Millennium Inorganic Chemicals Inc.  
NICHEM Corp.  
Peer Chemical Corp.  
Pyosa, S.A. de C.V.  
SARTOMER CO

Sino-American Pigment Systems, Inc.  
Sun Chemical Corp., Colors Group Div.  
Toyo Ink America, Inc.  
Uhlich Color Company  
United Mineral & Chemical Corp.

Atomergic Chemetals Corp.  
Cerdec Corp.  
ENGELHARD CORP.  
Millennium Inorganic Chemicals Inc.  
SARTOMER CO  
United Mineral & Chemical Corp.

ENGELHARD CORP.  
Pyosa, S.A. de C.V.  
Wayne Pigments Corp.

Chrome Yellow

ENGELHARD CORP.  
Ishihara Corp. (U.S.A.)  
Laporte Pigments  
Mineral Pigments Corporation  
NICHEM Corp.  
Pyosa, S.A. de C.V.  
Wayne Pigments Corp.

Complex Inorganic Color Pigments

Cerdec Corp.  
CIBA SPECIALTY CHEMICALS  
ENGELHARD CORP.  
Ferro Corp.  
HEUCOTECH LTD  
Hoover Color Corp.  
Sino-American Pigment Systems, Inc.

Diarylide Orange Toner

ENGELHARD CORP.  
Hilton Davis Co.  
Peer Chemical Corp.  
Pyosa, S.A. de C.V.  
Sino-American Pigment Systems, Inc.  
Sun Chemical Corp., Colors Group Div.  
United Mineral & Chemical Corp.  
Zeneca, Pigments & Additives

Diarylide Yellow Toner

BASF CORP.  
ENGELHARD CORP.  
HEUCOTECH LTD  
Hilton Davis Co.  
Peer Chemical Corp.  
Pyosa, S.A. de C.V.  
Sun Chemical Corp., Colors Group Div.  
Toyo Ink America, Inc.  
Uhlich Color Company  
United Mineral & Chemical Corp.

Hansa Yellow

Aarbor International Corp.  
BASF CORP.  
Cleveland Pigment & Color Co.  
ENGELHARD CORP.  
HEUCOTECH LTD  
Hilton Davis Co.  
Peer Chemical Corp.  
Pyosa, S.A. de C.V.  
Sino-American Pigment Systems, Inc.  
Sun Chemical Corp., Colors Group Div.  
United Mineral & Chemical Corp.

Metallized Azo Yellow

Bayer Corporation  
ENGELHARD CORP.  
Keystone Aniline Corp.  
Sino-American Pigment Systems, Inc.



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## PIGMENTS SPOTLIGHT : products

### Molybdate Orange

Keystone Aniline Corp.  
Pyosa, S.A. de C.V.  
Wayne Pigments Corp.

### Zinc Oxide, Orthonitraniline Orange, Dinitraniline Orange

Aarbor International Corp.  
Eagle Zinc Company  
Meadowbrook Co.  
Pyosa, S.A. de C.V.  
United Mineral & Chemical Corp.  
Zochem, Div. of Hudson Bay

### Misc. Yellow and Orange Toners/Lakes

BASF CORP.  
CIBA SPECIALTY CHEMICALS  
ENGELHARD CORP.  
Hilton Davis Co.  
Peer Chemical Corp.  
United Color Technology, Inc.  
United Mineral & Chemical Corp.

### Misc. Yellow Pigments

BASF CORP.  
Bayer Corporation  
CIBA SPECIALTY CHEMICALS  
Cleveland Pigment & Color Co.

### ENGELHARD CORP.

Hilton Davis Co.  
Hitox Corp. of America  
Ishihara Corp. (U.S.A.)  
Keystone Aniline Corp.  
Peer Chemical Corp.  
Sino-American Pigment Systems, Inc.  
Sun Chemical Corp., Colors Group Div.  
Toyo Ink America, Inc.  
Uhlich Color Company  
United Color Technology, Inc.  
United Mineral & Chemical Corp.  
Zeneca, Pigments & Additives



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There are other good reasons for using these low viscosity talcs. They give excellent tint retention, scrub and

stain resistance and rapid dispersion in both water-based and solvent-based formulations.

In addition, NYTAL 3300 and 7700 resist "frosting" better than nepheline syenite and calcium carbonate extenders because of lower soluble salts content. Coatings remain more stable and deterioration is less.

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# Regulatory Update April 1997

**T**his digest of current regulatory activity pertinent to the coatings industry is published to inform readers of actions which could affect them and their firms, and is designed to provide sufficient data to enable those interested to seek additional information. Material is supplied by National Paint and Coatings Association, Washington, D.C. The Regulatory Update is made available as a service to 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.

**Environmental Protection Agency  
February 19, 1997—62 FR 7502**  
**Land Disposal Restrictions: Correction  
of Tables; Treatment Standards for  
Hazardous Wastes and Universal  
Treatment Standards**

**Action: Technical amendment of final rule**

The Environmental Protection Agency (EPA) has published technical amendments to its final rule on phase III land disposal restrictions, originally published on April 8, 1996. The final rule contained tables on "Treatment Standards for Hazardous Wastes" and "Universal Treatment Standards." This notice provides updated and corrected versions of these two tables, which are intended to eliminate confusion as to what levels of treatment must be achieved by the regulated community.

This regulation was effective Feb. 19, 1997. For general information on the rule, contact the Resource Conservation and Recovery Act Hotline at (800) 424-9346. For technical information, contact Shaun McGarvey, EPA, (703) 308-8603.

**Environmental Protection Agency  
February 24, 1997—62 FR 8314**  
**Credible Evidence Revisions**  
**Action: Final rule**

The EPA has issued a final rule which eliminates language from its regulations that has been read to provide for exclusive reliance on reference test methods (e.g. Method 24 to determine the volatile organic compound (VOC) content of coatings) as the means of demonstrating compliance with various emission limits under the Clean Air Act.

These "credible evidence" revisions were designed to clarify that non-reference test data, such

as facility operating data and coatings formulation data, can be used in enforcement actions and to remove any ambiguity regarding this data's use for compliance certifications. This rule finalizes the previously proposed credible evidence amendments to the Clean Air Act.

This regulation will go into effect on April 25, 1997. For additional information, Contact Gregory Jaffe, EPA, (202) 564-2260.

**Surface Coatings Workshop  
Planned**—The EPA has scheduled a special "Surface Coatings Regulations Workshop" on April 8-9, 1997 in Durham, NC. This workshop will act as the official start of development of a new series of hazardous air pollutant regulations for eight major categories of surface coatings operations. The categories included in this new rulemaking effort are: Metal Furniture; Large Appliances; Plastic Parts; Flat Wood Paneling; Miscellaneous Metal Parts; Fabric; Metal Can; and Metal Coil.

In addition, EPA will undertake an effort to develop new controls for VOC emissions for the first six of these source categories. This will result in either the issuance of a new national VOC rule or a revised control technique guideline. EPA's regulatory agenda calls for all of these new standards to be completed by November 2000.

For additional information on the workshop agenda, contact Kim Teal, EPA, (919) 541-5580.

**EPA Sponsors Compliance  
Workshops**—The Environmental Protection Agency (EPA) Regions 5 and 7 are sponsoring a series of

compliance assistance workshops in anticipation of the July 1, 1997 reporting deadline for annual certification statements, as required under the Emergency Planning and Community Right-to-Know Act (EPCRA), Section 313. The workshops, which are open to industry, will provide a discussion of Section 313 requirements. The following workshops have been scheduled:

**Region 5**

April 30 – Bloomington, MN;  
May 14 – Grand Rapids, MI;  
May 28 – Terre Haute, IN; and  
June 4 – Chicago, IL.

**Region 7**

April 22 – Wichita, KS;  
April 30 – Lenexa, KS;  
May 7 – Bridgeton, MO;  
May 13 – Omaha, NE; and  
May 15 – Cedar Rapids, IA.

To date, only EPA Regions 5, 7, and 9 have scheduled compliance workshops, but the agency is planning a nationwide series during the spring. To receive a registration form or for more information, contact EPA Region 5 at (312) 886-4348, or Region 7 at (913) 551-7389 or (913) 551-7098. For general information on EPCRA, contact the EPA Hotline at (800) 424-9346.

**Risk Assessment Document**

**Available**—The Commission on Risk Assessment and Risk Management, established as an advisory committee under the Clean Air Act Amendments, has released the second volume of its final report, "Risk Assessment and Risk Management in Regulatory Decision-Making." (The first volume was published in January 1997.)

To receive a copy of the final report, fax your request to (202) 233-9540 or by mail to the Commission on Risk Assessment and Risk Management, 529 14<sup>th</sup> Street N.W., Room 420, Washington, D.C. 20045. Include a complete mailing address and a contact phone number. Copies may also be obtained through the Internet at <http://www.riskworld.com>. For more information on the report, contact the Commission at (202) 233-9537.

Controversy is continuing in Congress over the Environmental Protection Agency's proposed national ambient air quality standards for ozone and particulate matter. Several leading members of both parties have expressed their concern that the science behind the particulate matter limits is faulty or that the cost of implementation is prohibitive. Additionally, documents have surfaced that indicate that EPA may have unduly influenced an Office of Management and Budget's review of the proposal in response to a Congressional committee inquiry. EPA is maintaining its position that the standard is necessary to protect

human health under Clean Air Act requirements.

In the Senate, supporters of product liability reform (S. 5) are beginning their push to pass the measure in hearings held by the Senate Commerce Committee. S. 5 is identical to product liability legislation that passed both houses of Congress last session, but was vetoed by President Clinton. The bill would place limits on damage amounts awarded to victims injured due to a faulty consumer product.

Informal meetings are being held between select members of Congress and administration officials concerning the fiscal 1998 budget. The two sides are trying to reconcile a budget plan using differing figures provided by the Office of Management and Budget (OMB) and the Congressional Budget Office (CBO). Republicans support the CBO's budget projection, which shows President Clinton's budget proposal would generate a \$69 billion deficit by 2002; Democrats are following the OMB figures, under which the president's budget would show a surplus of \$17 billion by 2002.

On March 6, the House Small Business Committee approved a bill (H.R. 852) designed to ease the paperwork burden for small businesses that must file extensive documentation with the federal government. The measure would require federal agencies to make the option available to small businesses to submit certain information through e-mail, fax or any other electronic means. It is scheduled for a vote in the House in late-March.

During a hearing of a Senate Environment and Public Works subcommittee on Superfund, Environmental Protection Agency Administrator Carol Browner testified against the Republican's Superfund reform bill (S.8). The Clinton administration's opposition stems primarily from provisions in the measure that would exempt up to 75% of current responsible parties from cleanup costs. Both parties want to substantially reform the program, but disagree on the issue of who should pay to clean up waste sites. Browner urged Congress to convene broad, multi-stakeholder meetings to work out a compromise.

## States Proposed Legislation and Regulations

### ALABAMA

*Environmental Audits*—AL S. 388 (McClain) encourages environmental audits by creating a qualified audit privilege. On Feb. 18, the bill was reported favorably out of the Senate Committee on Conservation, Environment, and Natural Resources.

*Lead*—AL H. 535 (Minnifield) provides for a tax credit for lead-based paint abatement. The bill, which was introduced on Feb. 18, was sent to the House Ways and Means Committee.

AL H. 680 (Johnson) creates a program relating to indoor lead hazard abatement. On March 6, the measure was reported favorably out of the House Health Committee.

*Toxic Substances*—AL S. 245 (Smitherman) requires a person who possesses a permit to release pollution to post a conspicuous sign near the point of release notifying the public of any toxic pollutants. The legislation was introduced on Feb. 4 and sent to

the Senate Committee on Economic Expansion and Trade.

### ARIZONA

*Air Quality (Regulation)*—The Arizona Department of Environmental Quality (DEQ) adopted a final rule (3 AZAR 317; 1/31/97) which amends the definition of volatile organic compound (VOC) by exempting several chemicals, including acetone, from consideration as a VOC. The regulation went into effect Jan. 10. Contact Martha Seaman, DEQ, (602) 207-2230.

*Lead*—AZ H. 2155 (Gerard and Kyle) relates to the abatement of lead-based paint hazards. On Feb. 17, the House Committee on Health released the legislation with a favorable report.

### ARKANSAS

*Hazardous Materials Transportation*—AR S. 572 (Boozman) eliminates the requirement that

transporters of hazardous materials obtain a permit. On March 7, the measure was released with a favorable report from the Senate Committee on Public Health, Welfare, and Labor.

*Lead*—AR S. 214 (Walker and Stalnaker) authorizes the licensing and certification of lead-based paint activities training programs, procedures and requirements. On Feb. 28, the legislation was signed by the governor.

### CALIFORNIA

*Air Quality*—CA S. 987 (Sher) relates to regulations requiring the maximum feasible reduction in VOCs emitted from the use of aerosol paints. The legislation was introduced on Feb. 27 and sent to the Senate Committee on Environmental Quality.

*Graffiti*—CA S. 325 (Maddy) requires the state to adopt standards for the removal of graffiti from certain property. The bill was introduced on Feb. 12 and sent to



the Senate Committee on Local Government.

**Hazardous Waste**—CA A. 256 (Cunneen) requires the establishment of a new code system for tracking the shipment of hazardous waste subject to manifest requirements. The bill was introduced on Feb. 12 and referred to the Assembly Committee on Environmental Safety and Toxic Materials.

CA A. 770 (Margett) relates to existing law which subjects recyclable materials to requirements of the hazardous waste control laws unless exempted by the state. The bill was introduced on Feb. 26.

CA S. 660 (Sher) makes legislative findings concerning the state's hazardous waste management program and existing fee mechanisms. The measure was introduced on Feb. 25.

**Hazardous Waste (Proposed Regulation)**—A proposed rule (97 CARR 277; 2/7/97) of the California Department of Toxic Substances Control (DTSC) would amend assessment and secondary containment for non-RCRA regulated tank systems at facilities used to manage hazardous waste generated on-site. Contact Dave Remick, DTSC, (916) 324-3111.

**Lead**—CA A. 481 (Kuehl) provides guidance for property owners, contractors, tenants and insurers on how to evaluate and control lead hazards. On Feb. 24, the legislation was introduced.

CA S. 718 (Leslie) authorizes an income tax credit for voluntary lead abatement activities. The measure was introduced on Feb. 25 and sent to the Senate Committee on Revenue and Taxation.

**Occupational Safety and Health**—CA S. 370 (Solis) includes painters within those persons for whom cancer occurring during employment is deemed an injury under the workers' compensation law. The legislation was introduced on Feb. 13 and referred to the Senate Committee on Industrial Relations.

**Proposition 65 (Notice)**—The California Office of Environmental Health Hazard Assessment (OEHHA) plans (97 CARR 147; 1/24/97) to add nine chemicals to the list of substances known to the state to cause cancer or reproductive toxicity, as required by the Safe Drinking Water and Toxic Enforcement Act (Proposition 65).

The chemicals to be added are nitromethane, tetrafluoroethylene, vinyl fluoride, spironolactone, stanozolol, clarithromycin, dihydroergotamine mesylate, hydroxyurea, and oxymetholone. Contact Cynthia Oshita, OEHHA, (916) 445-6900.

**Solid Waste (Proposed Regulation)**—A proposed regulation (97 CARR 93; 1/17/97) issued by the California Department of Toxic Substances Control (DTSC) would clarify permit requirements concerning tank cleaning and closure procedure for underground and aboveground storage tanks. Contact Diana Peebler, DTSC, (916) 324-4754.

**Tort Reform**—CA S. 143 (Kopp) requires unfair business practice actions brought by private parties on behalf of the general public to comply with certain requirements. The bill, which was introduced on Jan. 13, was sent to the Senate Judiciary Committee.

**Toxic Substances**—CA S. 658 (Sher) repeals provisions of law enacted in 1996 requiring the state to conduct a review of "California-only" hazardous waste policies followed by the state for the identification and assessment of chemical toxicity. The bill was introduced on Feb. 25.

## COLORADO

**Graffiti**—CO H. 1125 (S. Williams) makes mandatory revocation of a driver's license one of the penalties for defacing property by graffiti. On Feb. 18, the legislation passed the House and was sent to the Senate Transportation Committee.

**Lead**—CO S. 136 (Blickensderfer) requires the establishment of a comprehensive plan to reduce elevated blood lead levels in children and control exposure to lead-based paint hazards. On March 7, the bill was amended and released from the Senate Appropriations Committee.

## CONNECTICUT

**Lead**—CT S. 1131 (Committee on Insurance) makes lead poisoning liability insurance available to tenants and homeowners. Introduced on Feb. 25, the bill was referred to the Joint Committee on Insurance and Real Estate.

CT S. 1206 (Insurance Committee) clarifies that health directors,

in response to reports of a child with an elevated blood lead level, may order occupants to exercise reasonable measures to prevent continued exposure. The bill was introduced on March 5 and referred to the Joint Committee on Insurance and Real Estate.

**Product Liability**—CT S. 1008 (Judiciary Committee) extends the statute of limitations for any person injured by a product to bring an action against that party. Introduced on Feb. 11, the bill was referred to the Joint Judiciary Committee.

## FLORIDA

**Graffiti**—FL S. 936 (Gutman) provides that a county is not preempted by state law from establishing ordinances which prohibit graffiti-related offenses. The bill was introduced on March 4 and sent to the Senate Committee on Community Affairs.

**Hazardous Waste (Proposed Regulation)**—A proposed regulation (23 FLAR 841; 2/14/97) of the Florida Department of Environmental Protection (DEP) would incorporate by reference recent amendments to federal standards governing hazardous waste. Contact Diane Hunt, DEP, (904) 488-0300.

## GEORGIA

**Lead**—GA H. 580 (Thomas and Pelote) makes it unlawful to rent or lease any building if any portion is painted with lead-based paint or poses any other lead hazard. The legislation was introduced on Feb. 14 and referred to the House Committee on Health and Ecology.

**Solid Waste**—GA H. 647 (Dobbs and Lane) prohibits the placing of certain substances in underground storage tanks. The bill was introduced on Feb. 18 and sent to the House Committee on Natural Resources.

**Water Quality (Regulation)**—A final rule adopted by the Georgia Department of Natural Resources (DNR) amends water quality standards dealing with waste treatment, permit requirements, surface water withdrawals, pretreatment programs, variance procedures, and storm water permits. The regulation went into effect July 30, 1996. Contact DNR, (404) 656-4713.

## HAWAII

*Hazardous Waste*—HI S. 449 (Ihara and McCartney) requires the state to publish annually the names of each small and large quantity generator of hazardous waste. Introduced on Jan. 17, the bill was sent to the Senate Committee on Health and Environment.

*Spray Paint Restrictions*—HI S. 955 (Ige) prohibits the sale or possession of spray paint by minors. The measure, which was introduced on Jan. 17, was sent to the Senate Judiciary Committee.

## IDAHO

*Hazardous Waste*—ID S. 1208 (Judiciary Committee) imposes fees on hazardous wastes stored or treated at commercial hazardous waste facilities. On March 5, the legislation was amended and released from the House Environmental Affairs Committee.

## ILLINOIS

*Air Quality*—IL H. 2166 (Brosnahan) imposes a fee on facilities that emit toxic air pollutants. Introduced on March 10, the bill was referred to the House Committee on Rules.

*Graffiti*—IL H. 661 (Scott) provides that a municipality may remove graffiti from private property but may not recover the cost from the owner. On March 6, the measure was reported out of the House Committee on Local Government.

*Hazardous Materials Transportation*—IL S. 378 (Mahar) requires persons engaged in the transportation of hazardous materials to register and obtain a permit. On March 6, the Senate Environment Committee amended and released the bill.

*Lead*—IL H. 1536 (M. Davis) provides that physicians may screen children for lead poisoning when the child is potentially at risk of lead poisoning. Introduced on March 6, the measure was referred to the House Rules Committee.

IL S. 247 (Syverson) provides that only positive results, rather than all results, of a blood lead analysis must be reported to the state within 48 hours of receipt. On March 6, the Senate approved the legislation.

## INDIANA

*Hazardous Waste (Regulation)*—The Indiana Solid Waste Management Board (SWMB) adopted a final regulation (20 INR 1111; 2/1/97) which updates provisions governing the hazardous waste management permit program and hazardous waste transportation requirements to conform with recent federal amendments. The rule was effective Feb. 8. Contact Steven Mojonnier, SWMB, (317) 233-1655.

IN S. 478 (Simpson) provides that an industrial or manufacturing byproduct that is listed as a hazardous waste but is capable of being recycled in a different process with no additional threat to health and the environment may be excluded from hazardous waste regulations. The legislation was approved by the Senate on March 4.

*Lead*—IN H. 1181 (Crawford) requires health care providers to conduct periodic blood lead testing on children between the ages of six months and six years. On March 4, the bill passed the House and was sent to the Senate Committee on Health and Environmental Affairs.

## IOWA

*Lead (Regulation)*—The Iowa Department of Public Health (DPH) adopted a final rule (19 IAAB 1318; 1/29/97) which establishes requirements for the voluntary certification of lead inspectors. The regulation became effective March 5. Contact DPH, (515) 281-5787.

## KANSAS

*Air Quality (Proposed Regulation)*—A proposed regulation (16 KSR 157; 2/6/97) of the Kansas Department of Health and Environment (DHE) would incorporate by reference federal standards governing emissions standards for hazardous air pollutants. Contact Ralph Kieffer, DHE, (913) 296-6428.

*Air Quality (Regulation)*—A final rule (16 KSR 176; 2/6/97) adopted by the Kansas DHE postpones an increase in air emission fees from \$15 to \$18 per ton of pollutant through the year 2001. The regulation went into effect Feb. 21. Contact Ralph Kieffer, DHE, (913) 296-6428.

## KENTUCKY

*Transportation (Proposed Regulation)*—The Kentucky Transportation Cabinet (KTC) plans to amend current regulations (23 ARKY 2944; 2/1/97) to incorporate by reference federal safety requirements concerning the safe operation of commercial motor carriers. Contact Sandra Pullen, KTC, (502) 564-4890.

## MARYLAND

*Graffiti*—MD H. 1169 (Klausmeier) requires a court to order a person committing an act of graffiti to pay restitution or perform community service. On Feb. 11, the bill was introduced and sent to the House Judiciary Committee.

*Hazardous Waste (Proposed Regulation)*—A proposal (24 MDR 305; 2/14/97) issued by the Maryland Department of the Environment (DOE) would amend requirements for the reporting of hazardous waste activity by generators who ship waste off-site and for treatment, storage and disposal facilities. Contact Deanna Miles-Brown, DOE, (410) 631-3602.

*Lead (Regulation)*—The Maryland Department of Housing and Community Development (DHCD) adopted a final rule which establishes procedures for making grants and loans to owners of residential property or child care centers for the purpose of lead abatement. The regulation went into effect Feb. 24. Contact Vance Morris, DHCD, (410) 514-7565.

MD H. 229 (Brinkley) alters the definition of "affected property" in provisions of the insurance law relating to lead paint hazards. The legislation was approved by the House on Feb. 28 and sent to the Senate Committee on Judicial Proceedings.

MD H. 712 (Workman) repeals a provision of law authorizing a lessee to deposit rent in a rent escrow account if a lessor fails to eliminate lead-based paint within a dwelling. On Feb. 17, the legislation was withdrawn from further consideration.

MD H. 1138 (Hubbard) requires the establishment of a lead screening program to monitor children for lead poisoning. On March 6, the bill was approved by the House.

MD H. 1231 (Guns) alters the date by which rental dwelling units must be registered under the Lead Poisoning Prevention Program. The House approved the legislation on Feb. 28.

MD S. 772 (Baker) repeals the two provisions of law authorizing a lessee to invoke rent escrow remedies if the lessor fails to remove lead-based paint from a residential dwelling unit. On March 11, the Senate Committee on Judicial Proceedings amended and released the bill.

## MASSACHUSETTS

*Air Quality (Proposed Regulation)*—A proposed rule (809 MAR 10; 1/24/97) of the Massachusetts Department of Environmental Protection (DEP) would amend the state implementation plan for ozone by amending the VOC plan; eliminating unnecessary control strategies; and modifying the 1999 target emissions, the 1999 projected emissions inventory, and the contingency plan. Contact Leah Weiss, DEP, (617) 292-5520.

*Hazardous Materials Transportation (Regulation)*—A final regulation (808 MAR 69; 1/10/97) adopted by the Massachusetts Board of Fire Prevention Regulations (BFPR) amends current requirements governing the transportation of flammable and combustible liquids to conform with national safety standards. The rule went into effect Jan. 10. Contact Maura Ware, BFPR, (508) 567-3181.

MA H. 3679 (Larkin) provides for an exemption from hazardous waste transporter fees for waste that is to be reused or recycled. Introduced on Jan. 1, the measure was referred to the Joint Committee on Natural Resources and Agriculture.

*Household Hazardous Waste*—MA H. 2352 (Local Sponsor) establishes a household hazardous waste collection grant program. On Jan. 1, the bill was introduced and referred to the Joint Committee on Natural Resources and Agriculture.

MA H. 3767 (Cahir) establishes a retail hazardous products identification program. Introduced on Jan. 1, the bill was sent to the Joint Committee on Commerce and Labor.

*Lead*—MA H. 2254 (Bosley and Koczera) relates to the Occupa-

tional Blood Lead Registry. The bill was introduced on Jan. 1 and sent to the Joint Committee on Commerce and Labor.

MA H. 2682 (Travis and Murray) provides for the health and safety of children from all sources of lead exposure. The legislation was introduced on Jan. 1 and sent to the Joint Committee on Health Care.

MA H. 3601 (Paulsen) establishes an occupational lead poisoning registry fund. On Jan. 1, the legislation was introduced and sent to the Joint Committee on Commerce and Labor.

*Toxics-in-Packaging*—MA H. 2901 (S. Angelo) reduces the presence of heavy metals in consumer packaging. The bill was introduced on Jan. 1.

## MICHIGAN

*Air Quality (Proposed Regulation)*—The Michigan Department of Environmental Quality (DEQ) proposed a regulation (1996 MIR 46; 1/31/97) which would amend air quality standards to make compliance and recordkeeping requirements for coatings and graphic arts lines more flexible. Contact DEQ, (517) 373-7069.

## MINNESOTA

*Hazardous Materials*—MN H. 1126 (Jennings) repeals the hazardous materials labeling law. On March 3, the bill was introduced and sent to the House Committee on Environment and Natural Resources.

*Lead*—MN H. 843 (Clark) establishes a lead hazard reduction advisory task force to propose provisions for lead-safe residential rental property certification, essential management practices, and legal issues surrounding lead poisoning. Introduced on Feb. 20, the bill was referred to the House Committee on Financial Institutions.

*Pollution Prevention*—MN H. 837 (Munger) modifies toxic pollution prevention plan requirements to cover the reduction or elimination of toxic pollutants that are treated, recycled or subject to energy recovery. On Feb. 20, the bill was introduced and sent to the House Committee on Environment and Natural Resources.

*Toxics-in-Packaging*—MN H. 947 (Wagenius) modifies toxics-in-

packaging requirements; and requires biennial reports to identify exemptions. Introduced on Feb. 24, the bill was sent to the House Committee on Environment and Natural Resources.

MN H. 707 (Rukavina) modifies requirements relating to toxics-in-products. The measure, which was introduced on Feb. 13, was referred to the House Committee on Environment and Natural Resources.

## MISSISSIPPI

*Hazardous Waste*—MS S. 2797 (Dearing) sets an annual schedule of fees for commercial hazardous waste management facilities. On Feb. 8, the bill died in committee.

*Lead*—MS S. 2496 (Dearing) allows the establishment of certification requirements for lead abatement workers and sets up lead hazard work standards. The measure was approved by the House on March 6.

## MISSOURI

*Hazardous Waste*—MO H. 151 (Smith) establishes a new fee for hazardous waste treatment, storage and disposal facilities. On Feb. 20, the House approved the bill.

## MONTANA

*Hazardous Waste (Regulation)*—A final regulation (1997 MTAR 208; 1/27/97) of the Montana Department of Environmental Quality (DEQ) incorporates by reference federal standards concerning hazardous waste and universal waste management. The rule became effective Jan. 28. Contact Mark Stahly, DEQ, (406) 444-3742.

*Labeling*—MT H. 35 (DeBruycker) eliminates obsolete consumer protection provisions pertaining to paint labeling. On Feb. 20, the bill was signed by the governor.

## NEBRASKA

*Hazardous Materials Transportation*—NE L.B. 722 (Transportation Committee) updates state adoption of federal motor carrier safety requirements concerning hazardous materials. On March 6, the bill was sent to the governor.

*Water Quality (Regulation)*—The Nebraska Department of Environ-

mental Quality (DEQ) adopted a final regulation which amends current water quality standards; clarifies acute toxicity criteria; revises use designation standards; and modifies toxic substance requirements. The rule was effective retroactively to March 6, 1996. Contact Thomas Lamberson, DEQ, (402) 471-2186.

## NEVADA

*Hazardous Materials Transportation*—NV A. 179 (Committee on Natural Resources) authorizes the state to designate highly hazardous substances by regulation; and clarifies the motor vehicles for which a permit to transport hazardous materials must be obtained. The measure was introduced on Feb. 18 and sent to the Assembly Natural Resources Committee.

## NEW HAMPSHIRE

*Air Quality (Regulation)*—A final regulation (17 NHHR 14; 2/7/97) of the New Hampshire Department of Environmental Services (DES) establishes two types of open market trading programs that sources may use to trade emissions reductions credits to ensure compliance with Clean Air Act requirements. The rule was effective Jan. 21. Contact Joseph Fontaine, DEP, (603) 271-6794.

*Lead*—NH S. 49 (Fraser) allows unlicensed individuals to conduct low risk lead abatement activities and the use of certain alternative abatement methods. The bill was approved by the Senate on Feb. 20.

## NEW JERSEY

*Air Quality (Notice)*—The New Jersey Department of Environmental Protection (DEP) has published eight draft state of the art manuals for air quality permits. The manuals, which outline methods and performance levels for air pollution control, are designed to help air permit applicants demonstrate that their proposal incorporates advances in air pollution control technology. For more information or contact Eleonora Kats, DEP, (609) 633-2970.

*Community Right-to-Know (notice)*—The New Jersey Department of Health (DOH) is holding a hearing (29 NJR 706; 2/18/97) to discuss implementation of the

Worker and Community Right-to-Know Act and amendments to the hazardous substance lists. The hearing will be held on April 11 in Trenton; comments are due April 26. Contact Richard Willinger, DOH, (609) 984-2202.

## NEW MEXICO

*Lead*—NM H. 668 (Miera) creates a program to prevent lead poisoning in children, and provides for training and certification for lead hazard activities. The measure was released with a favorable recommendation from the House Appropriations Committee March 10.

## NEW YORK

*Graffiti*—NY A. 3945 (Nolan) makes the act of graffiti punishable by community service. On Feb. 10, the bill was introduced and sent to the Assembly Codes Committee.

NY A. 4539 (Labriola) provides for driver's license suspension upon the second conviction of creating graffiti. The bill, which was introduced on Feb. 20, was sent to the Assembly Committee on Codes.

NY A. 4915 (McLaughlin) prohibits conduct resulting in graffiti on any public transportation facility. Introduced on Feb. 26, the legislation was sent to the Assembly Transportation Committee.

NY A. 5326 (Hochberg) makes the act of graffiti punishable by community service or a fine. The bill, which was introduced on March 3, was sent to the Assembly Codes Committee.

*Hazardous Materials*—NY A. 4728 (Clark) provides that any person storing a hazardous substance must furnish the state with information on the storage facility, type of substance, handling practices, monitoring and inspections. The measure was introduced on Feb. 24 and referred to the Assembly Committee on Environmental Conservation.

*Household Hazardous Waste*—NY A. 3824 (McGee) establishes a household hazardous waste disposal program. Introduced on Feb. 6, the legislation was sent to the Assembly Committee on Environmental Conservation.

NY A. 4716 (Tokasz) establishes a plan for the management of household hazardous waste,

including a program to educate consumers regarding the proper disposal of waste. On Feb. 24, the measure was introduced and sent to the Assembly Committee on Environmental Conservation.

*Lead*—NY A. 3872 (Dinowitz) requires the state to take action when areas of lead poisoning are designated. The bill, which was introduced on Feb. 10, was sent to the Assembly Health Committee.

NY A. 4735 (Clark) increases the penalty for the failure to comply with a notice and demand for the discontinuance of a paint condition conducive to lead poisoning. The bill was introduced on Feb. 24 and referred to the Assembly Committee on Health.

NY A. 6222 (Eve) provides that policies insuring against liability for injury shall not exclude coverage for exposure to lead-based paint. Introduced on March 4, the bill was sent to the Assembly Committee on Insurance.

NY A. 6241 (Eve) makes provisions regarding lead inspection and abatement. On March 4, the bill was introduced and sent to the Assembly Health Committee.

NY S. 395 (Volker) establishes a program to reduce the risks of residential lead-based paint hazards. On Feb. 11, the bill was reported out of the Senate Health Committee.

NY S. 2118 (Mendez) establishes requirements for the prevention and recognition of lead poisoning in children. Introduced on Feb. 4, the measure was sent to the Senate Committee on Health.

*Packaging*—NY A. 4629 (Brodsky) requires packaging to be reusable or recyclable. On Feb. 20, the bill was introduced and sent to the Assembly Committee on Environmental Conservation.

*Recycling*—NY A. 4838 (Colton) requires municipalities to enact a local law requiring all recyclable materials be collected for recycling unless exempted by the state. The legislation was introduced and sent to the Assembly Committee on Environmental Conservation on Feb. 25.

*Tort Reform*—NY A. 1620 (Brodsky) authorizes any private citizen who has an interest which is or may be adversely affected to commence civil judicial actions to remedy environmental harms. On Feb. 5, the bill passed the assembly and was sent to the Senate



Committee on Environmental Conservation.

*Toxic Substances*—NY A. 4034 (Wright) prohibits the use of non-waterbased or flammable paint in any stair well of a dwelling unit owned or operated by the Public Housing Authority; and provides that any existing non-waterbased paint found in such housing shall be overcoated. Introduced on Feb. 10, the measure was referred to the Assembly Committee on Housing. At presstime, no further action on the bill was scheduled.

NY A. 4355 (Thiele) continues the common law actions for recovery of damages for personal injury or property damage caused by the latent effects of exposure to a toxic substance. The bill, which was introduced on Feb. 18, was sent to the Assembly Codes Committee.

NY S. 2973 (Leichter) provides information to consumers concerning household hazardous products at the point of retail sale using labels and pamphlets. On Feb. 27, the measure was introduced and referred to the Senate Committee on Environmental Conservation.

## NORTH CAROLINA

*Solid Waste (Proposed Regulation)*—A proposed regulation (11 NCR 1639; 2/3/97) of the North Carolina Department of Environment, Health and Natural Resources (DEHNR) would specify risk-based criteria for the assessment and cleanup of discharges resulting from releases from underground storage tanks. Contact David Hance, DEHNR, (919) 715-6189.

## OHIO

*Air Quality (Proposed Regulation)*—A proposed rule issued by the Ohio Environmental Protection Agency (EPA) would amend regulations concerning particulate matter; establish visible particulate emission limits; update language regarding continuous emission monitoring requirements; and revise compliance time schedules. Contact Ohio EPA, (614) 644-3037.

*Solid Waste (Regulation)*—A final regulation (1996 OHMR 1002; 12/31/96) of the Ohio Department of Commerce (DOC) amends underground storage tank (UST) standards by implementing uniform permit and inspection

fees; requiring certain inspections; and establishing application, renewal and decertification procedures for UST inspectors. The rule became effective Jan. 1. Contact Ray Roe, DOC, (614) 752-7079.

## OKLAHOMA

*Graffiti*—OK S. 290 (Leftwich) authorizes certain procedures for the removal of graffiti by municipalities. On Feb. 19, the Senate approved the legislation.

*Hazardous Materials Transportation (Proposed Regulation)*—The Oklahoma Department of Public Safety (DPS) proposed a regulation (14 OKR 510; 2/3/97) which would incorporate by reference federal standards regarding motor carrier safety and hazardous materials transportation, and would extend the exemption cut-off date for cargo tanks. Contact Bill Hughes, DPS, (405) 521-6103.

*Lead*—OK S. 315 (Easley) removes requirements for certain lead management certification. On March 4, the bill was approved by the Senate.

## OREGON

*Air Quality (Regulation)*—The Oregon Department of Environmental Quality (DEQ) adopted a final regulation (36 ORRB 52; 2/1/97) which amends current air quality requirements by incorporating national emissions standards for hazardous air pollutants for specific sources. The rule became effective Dec. 19. Contact DEQ, (503) 229-6775.

*Community Right-to-Know*—OR S. 585 (Ferrioli) changes the basis for assessing hazardous substances fees to fund community right-to-know programs. The bill was introduced on March 7.

*Hazardous Materials Transportation (Proposed Regulation)*—A proposal (36 ORRB 174; 2/1/97) issued by the Oregon Department of Transportation (DOT) would adopt by reference federal requirements concerning hazardous materials transportation; motor carrier safety; and hazardous material out-of-service standards. Contact Brenda Trump, DOT, (503) 945-5278.

*Solvent Tax*—OR H. 3036 (Roberts) imposes a fee on cleaning solvents, which are

defined as a "substance composed of the same chemicals as dry cleaning solvent, but not used in a dry cleaning facility." The bill was introduced on March 4 and referred to the House Committee on Environment and Energy.

## RHODE ISLAND

*Graffiti*—RI S. 607 (Roberts) relates to sanctions against juveniles charged with graffiti-related offenses. On Feb. 11, the legislation was introduced and sent to the Senate Judiciary Committee.

RI S. 608 (Palazzo) makes the act of creating graffiti punishable by fines or community service. The measure, which was introduced on Feb. 11, was sent to the Senate Judiciary Committee.

*Hazardous Waste*—RI H. 6119 (Palumbo) relates to hazardous waste management. Introduced on Feb. 4, the measure was referred to the Joint Committee on Environment and Energy.

*Occupational Safety and Health*—RI S. 259 (Ruggerio) entitles employees to refuse a work assignment within an area where a violation of the state Health and Safety Code has been reported until the violation has been corrected. On Jan. 29, the legislation was introduced and referred to the Senate Labor Committee.

## SOUTH DAKOTA

*Hazardous Materials Transportation*—SD H. 1053 (Committee on Transportation) revises certain provisions pertaining to the regulation of motor carriers transporting hazardous materials. On Feb. 7, the governor signed the legislation.

*Solid Waste (Regulation)*—A final regulation (23 SDR 131; 2/10/97) adopted by the South Dakota Department of Environment and Natural Resources (DENR) updates underground storage tanks standards for reporting releases to make them consistent with federal requirements. The rule went into effect Feb. 24. Contact Doug Miller, DENR, (605) 773-3296.

## TENNESSEE

*Toxic Substances*—TN S. 1307 (Cohen) requires annual reports from emitters of toxic substances

on alternative technology available to reduce or eliminate emissions. The bill was introduced on Feb. 6.

## TEXAS

*Air Quality (Proposed Regulation)*—The Texas Natural Resource Conservation Commission (NRCC) proposed a regulation (22 TXR 1065; 1/31/97) which would clarify, among other things, reporting procedures for unauthorized emissions occurring during maintenance, startup or shutdown; and compliance criteria. Contact Beecher Cameron, NRCC, (512) 239-1495.

*Air Quality*—A proposed rule (22 TXR 1070; 1/31/97) of the Texas Natural Resource Conservation Commission (NRCC) would amend new source review permit requirements to eliminate provisions governing transfers of permits and licenses. Contact Catherine Collins, NRCC, (512) 239-0389.

*Graffiti*—TX H. 1264 (Dukes) relates to the disposition of a juvenile who damages property with graffiti. The bill was introduced on Feb. 13 and sent to the House Committee on Juvenile Justice and Family Issues.

*Lead*—TX H. 2219 (Dukes) relates to lead poisoning screening and lead inspection. The measure was introduced on March 6.

*Spray Paint Restrictions*—TX H. 1714/S. 758 (Serna/Shapleigh) increases the penalties for acts of graffiti and restricts customer access to spray paint. On Feb. 25, the House version was sent to the House Committee on Juvenile Justice and Family Issues; the Senate version was referred to the Senate Committee on Criminal Justice.

## UTAH

*Air Quality (Regulation)*—A final regulation (97 UTSB 63; 1/15/97) of the Utah Department of Environmental Quality (DEQ) streamlines the process for obtaining approval for construction and modification of industrial sources of pollution, including specifying exemptions and establishing inventory information requirements for emission sources. The rule was effective Dec. 1. Contact Jan Miller, DEQ, (801) 536-4042.

A final rule (97 UTSB 73; 2/1/97) adopted by the Utah DEQ reduces the inventory reporting requirements for very small sources of air pollution that are located in attainment areas and removes provisions which trigger contingency measures by ozone inventory. The regulation went into effect Jan. 15. Contact Jan Miller, DEQ, (801) 536-4042.

*Hazardous Materials Transportation (Regulation)*—The Utah Department of Transportation (DOT) adopted a final rule (97 UTSB 74; 2/1/97) which, among other things, (1) extends the effective date for the implementation of the Intermodal Safe Container Transportation Act until Jan. 2, 1997; (2) incorporates changes to the classification of materials that are poisonous by inhalation into hazardous materials regulations; and (3) amends provisions for the manufacture, use, and reuse of hazardous materials packaging. The regulation became effective Jan. 14. Contact Shirleen Hancock, DOT, (801) 965-4781.

*Lead (Regulation)*—The Utah Department of Health (DOH) adopted a final rule (97 UTSB 63; 1/15/97) which amends lead poisoning reporting requirements to include all persons with whole blood lead concentrations greater than 10 micrograms per deciliter. The regulation went into effect Jan. 1. Contact Craig Nichols, DOH, (801) 538-6191.

## VERMONT

*Lead*—VT H. 281 (Valsangiacomo) reduces the burden on landlords for abatement of lead paint hazards in rental housing and child care centers. Introduced on Feb. 11, the legislation was sent to the House Committee on Health and Welfare.

## VIRGINIA

*Air Quality (Proposed Regulation)*—A proposed regulation (13 VAR 1057; 2/3/97) of the Virginia State Air Pollution Control Board (SAPCB) would develop a general permit which would allow stationary sources subject to the federal operating permit program to be exempted from the program as long as they maintain actual annual emissions at a level that is 75 percent of the major source,

potential-to-emit thresholds. Contact Robert Mann, SAPCB, (804) 698-4419.

*Household Hazardous Waste*—VA H. 2814 (Moore) changes the definition of household hazardous waste to include solvent-based paint, paint stripper, and paint thinner. The bill was sent to the governor on Feb. 27.

*Lead (Regulation)*—A final rule (13 VAR 1084; 2/3/97) adopted by the Virginia Department of Professional and Occupational Regulation (DPOR) reduces the fees charged to applicants for late renewal penalties for lead certifications. The rule will go into effect April 1. Contact Thomas Perry, DPOR, (804) 367-2176.

VA S. 1004 (Lambert) authorizes regulations for lead training and certification, and standards for performing lead-based paint activities that are no more stringent than the federal requirements. On Feb. 22, the Conference Committee report on the measure was approved by the House and Senate.

VA S.J.M. 227 (Lambert) continues to require the joint subcommittee to monitor lead-poisoning and abatement issues. On Feb. 20, the House approved the bill.

*Spray Paint Restrictions*—VA H. 1663 (Hull) makes it unlawful for any juvenile to possess any paint implement, except under an adult's supervision. On Feb. 18, the legislation died in committee.

## WASHINGTON

*Recycling*—WA S. 5474 (Hargrove) adopts federal standards for purposes of state and local agency purchases of recycled products, including latex paint. On Feb. 21, the Senate Agriculture Committee amended and released the bill.

## WEST VIRGINIA

*Hazardous Waste*—WV S. 165 (Ross) authorizes the promulgation of rules relating to hazardous waste management. The bill was introduced on March 3 and sent to the Senate Judiciary Committee.

## WYOMING

*Solid Waste*—WY H. 78 (Luthi) amends fees charged for storage tank installation or modification. On Feb. 24, the governor signed the legislation.

## Rheological Changes During the Drying of a Waterborne Latex Coating

Frank Löfflath—PPG Industries (France) S.A.\*  
 Matthew Gebhard—Rohm and Haas Co.†

### INTRODUCTION

Rheological changes during drying have a profound effect on final film properties. In particular, these changes affect the ultimate gloss and distinctness of image of the dried film. Rheological changes accompanying drying are due to the effects of evaporation and the concomitant change in dispersion-volume-solids. The rate of evaporation and the relation between viscosity and dispersion-volume-solids have been studied separately but, to our knowledge, there is no work investigating the impact of evaporation on viscosity increases in a drying film comprised of a water-based latex dispersion. Thus, a study of this rather complicated behavior seems appropriate.

From a rheological standpoint, the drying process can be divided into three regions (Figure 1). In the first region, immediately following application, water evaporates at a constant rate and the coating builds viscosity but still behaves as a liquid. At an effective volume fraction of ~65%, the coating enters a second transition region and develops solid-like behavior (yield value). The yield value increases until the film is essentially a solid. In this transition region, polymer particles come into contact, the liquid/air interface is dominated by latex particles, and the rate of water evaporation decreases dramatically. The last stage involves the slow diffusion of solvents out of the film. At this point the film behaves like a solid; however, some creeping flow may take place. The rates at which these processes occur can affect the final film properties, such as flow and leveling, sag resistance, microfoam entrapment, gloss, film formation, mudcracking, and pin holing.<sup>1</sup> In particular, if the coating passes into the second phase very quickly, all of the imperfections introduced during the film application process are frozen in place.

An important aspect of the drying process is water evaporation. Evaporation rates have received much attention<sup>2</sup> over the years. Dillon<sup>2a</sup> derived a very useful mathematical model which includes relative humidity and temperature effects. This model is based on Langmuir-Knudsen<sup>2b,c</sup> and Gardner<sup>2d</sup> treatments of evaporation. While Dillon provides an excellent treat-



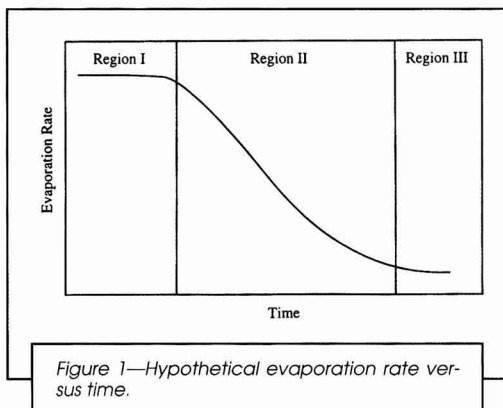
*Increases in the low shear viscosity occurring during drying of a water-based latex film were examined as a function of pH, cosolvents, and base. The water and cosolvent evaporation rates were determined as a function of temperature and humidity. Water was found to evaporate with an activity coefficient of 1 and a  $\Delta H_v$  equivalent to pure water. The viscosity changes were determined from a creep measurement. The data is explained by the volume packing model of De Kruif. For several of the films, the ratio between volume and weight fraction was not a static parameter, and an abnormally large drop in the effective volume and weight fraction was observed. This was exaggerated for the samples with ethylene glycol monobutyl ether (EB) or  $\text{NH}_4\text{OH}$ . The high volatility of EB explains the former, while the latter result indicates that  $\text{NH}_4\text{OH}$  suppresses viscosity during drying.*

ment for the case of single or mixed solvents, the model does not include effects due to soluble components in the liquid such as salts, surfactants, and cosolvents. These components are present in a water-based latex coating and may impact evaporation; however, there are conflicting reports in the literature<sup>3</sup> on such effects. Thus, a comparison between experimental measurements in water-based latex coatings and existing theories is of interest.

Another crucial aspect of the drying process is the volume-solids effect on viscosity. There have been sev-

Presented at the 69th Annual Meeting of the Federation of Societies for Coatings Technology on October 23, 1996, in Chicago, IL.

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eral treatments of this, the most notable of which are the theories of Dougherty-Krieger<sup>4</sup> and De Kruif.<sup>5</sup> The theoretical and experimental studies on solvent loss and volume solids effects are very useful and, to a first approximation, it is possible to couple the two effects for a composite theory; however, this strategy overlooks compositional changes in the serum phase which can have an impact on viscosity. Thus, an important question is what effects pH changes, cosolvent evaporation, and increases in salt concentration have on viscosity.

To address these questions, we undertook a study of viscosity changes occurring during drying of two model latex dispersions in which parameters such as starting pH, neutralizing agent, and cosolvents were varied. Water evaporation rates were determined under controlled environmental conditions and evaluated in light of existing theories. This allowed determination of the activity coefficient for water evaporation. Only the viscosity changes of the coatings during the first region of drying were considered. To eliminate complications due to pigments, this study focused on clear coatings. The viscosity was measured in the creep mode using a Carri-Med-CSL 100 controlled stress rheometer. This technique gives the limiting low shear viscosity, thus allowing comparison to the theories<sup>4</sup> relating limiting low shear viscosity to dispersion-volume solids. In addition, the intrinsic viscosity and evaporation rates of the cosolvents were evaluated. Lastly, a dry-time recorder was constructed to measure open-times,\* which were compared to the Carri-Med rheological data.

## THEORETICAL BACKGROUND

### Evaporation Process

There is much work in the literature on measuring evaporation rates of solvents and, in particular, evaporation rates of water from paint films. These studies by Hansen,<sup>6</sup> Sletmoie,<sup>7</sup> and Doolittle<sup>8</sup> employed test methods like the Evapocorder,<sup>9</sup> Evapograph<sup>10</sup> or Evaporometer.<sup>11</sup>

The theoretical basis for much of this work is the kinetic gas theory of Knudsen<sup>2c</sup> and Langmuir.<sup>2b</sup> Knudsen treated the case where the only gas present in the vapor phase is the evaporating solvent. At a temperature,  $T$ , the number of molecules evaporating out of the liquid,  $E_{\max}$ , depends on the surface area,  $A$ , a mass transfer factor,  $k$ , the vapor pressure of the liquid,  $P_v$ , the molecular weight,  $M$ , and the gas constant  $R$ . This is given in equation (1).

$$E_{\max} = kP_v \sqrt{\frac{M}{2\pi RT}} \quad (1)$$

Evaporation in the presence of other gases (e.g., air) is more complicated. Gardner<sup>2d</sup> derived equation (2) for the absolute rate based on diffusion theory.<sup>12</sup>

$$E_L = \frac{KDMp_v}{RTp_x} \quad (2)$$

In equation (2),  $E_L$  is the absolute evaporation rate,  $k$  is a mass transfer constant,  $D$  is the diffusion coefficient of the evaporating gas molecules through the ambient gas,  $p$  is the ambient pressure, and  $x$  is an effective boundary layer film thickness at the liquid surface. If the diffusion coefficient is not known, it can be estimated from the molecular weight and molar volume using Gilliland's equation.<sup>9</sup>

Gilbert<sup>2e</sup> extended the kinetic theory approach to the case where air is present. Not surprisingly, he arrived at an equation for the absolute rate of evaporation in air ( $E_L$ ) similar to the Langmuir-Knudsen equation.

$$E_L = e^{-f} P_v \sqrt{\frac{M}{2\pi RT}} \quad (3)$$

$$f = \frac{S}{Y} \quad (3.1)$$

In this equation,  $f$  is a factor which depends on  $S$ , the height of the stagnant air column above the liquid, and  $Y$ , the mean free path of the molecules in the vapor phase.

A much more useful model is that of Dillon<sup>2a</sup> which includes a treatment for relative humidity. In the Dillon model, the evaporation rate of a given component is assumed to follow first order kinetics with modification for relative humidity.<sup>2e,13</sup> According to Dillon, the evaporation rate is given by equation (4).

$$\frac{dm}{dt} = -AK^{v,T}P_i\sqrt{T}(a - \phi) \quad (4)$$

Here,  $dm/dt$  is the evaporation rate,  $A$  is the surface area,  $K^{v,T}$  is a mass transfer coefficient which depends on air flow and temperature,  $T$  is the absolute temperature,  $p_i$  is the vapor pressure,  $a$  is an activity coefficient, and  $\phi$  is the relative vapor saturation (e.g., relative humidity). Several of the factors in equation (4) are temperature dependent and can be combined in one factor,  $C^{v,T}$ .

$$C^{v,T} = K^{v,T}P_i\sqrt{T} \quad (5)$$

\*In this context the open time is defined as the point where coating flow ceases.

Thus equations (4) and (5) can be rewritten as equation (6). If  $dm/dtA$  is determined at constant temperature and air flow then the activity coefficient of the evaporating solvent can be determined.

$$\frac{dm}{Adt} = -C^{v,T}(a - \phi) \quad (6)$$

The air speed over the surface of the evaporating liquid is a very important factor. In Dillon's treatment, this effect is present in the mass transfer coefficient,  $K^{v,T}$ , as given in equation (7).

$$K^{v,T} = K^0 + \frac{V}{\alpha V + \beta} \quad (7)$$

In this equation,  $V$  is the air speed,  $K^0$  is the mass transfer coefficient in the absence of air flow, and  $\alpha$  and  $\beta$  are the correction factors for air flow which depend on the evaporating liquid; these correction factors are given by Dillon<sup>2a</sup> for several solvents. In actuality, air flow turns out to be the most important parameter for determining absolute rates and, unfortunately, it is the hardest to control or measure.

As can be seen from this model, in order to determine the rate of evaporation, parameters like air speed, temperature, and humidity must be controlled. In addition, film thickness effects must also be considered. Film thickness effects may be important because all of the models described earlier assume that the rate limiting step for evaporation is the transport of the evaporating solvent through the vapor phase and away from the drying film. However, at some point during the drying process, solvent diffusion through the film is the rate limiting step, and the Dillon model is no longer valid. Experience shows<sup>6</sup> that, in the constant evaporation region (I), the rate limiting step is diffusion through the vapor phase, and this assumption can be checked by verifying that the evaporation rates are independent of film thickness.

At constant temperature and air flow, the evaporation rate should be a linear function of humidity [equation (6)]. The slope of the line is  $C^{v,T}$ , and the intercept is a  $C^{v,T}$ . Measurement of these evaporation rates allows the determination of both  $C^{v,T}$  and  $a$ . If  $C^{v,T}$  is determined at constant humidity and air flow and different temperatures, the temperature dependence of  $C^{v,T}$  can be measured. This is given in equation (8), where equation (6) is expanded using the Clausius-Clapeyron equation for vapor pressure, and  $\Delta H$  is the enthalpy of vaporization for the solvent.

$$C^{v,T} = K^{v,T} \sqrt{T} e^{-\frac{k_2}{T}} \quad (8)$$

$$k_2 = \frac{\Delta H}{R} \quad (8b)$$

The effect of temperature on the mass transfer coefficient,  $K^{v,T}$ , is assumed to be constant.

### Viscosity and Volume Fraction

As with evaporation rates, there are several excellent treatments of the viscosity dependence on volume frac-

tion of a dispersion. At dilute concentrations ( $< \sim 5\%$  volume solids) the viscosity of a latex suspension depends only on the volume fraction. Factors such as interparticle forces are unimportant. A theoretical treatment [equations (9) and (10)] for the viscosity in this regime was derived by Einstein and has since been verified using synthetic mono-disperse particles.<sup>14</sup>

$$\eta = \eta_0(1 + 2.5\phi) \quad (9)$$

$$\eta_r = \frac{\eta}{\eta_0} \quad (10)$$

In this equation,  $\eta$  is the viscosity of the suspension,  $\eta_0$  is the viscosity of the medium,  $\eta_r$  is the relative viscosity, and  $\phi$  is the volume fraction of latexes. The resulting equation is useful because it is independent of the latex size. Deviations from equation (9) can occur in situations where flocculation or agglomeration exist; however, such deviations are evident in a nonlinear viscosity dependence on  $\phi$ .

As the volume fraction of latexes is increased, significant deviation from equation (9) occurs. In particular, the viscosity increases rapidly as  $\phi$  increases. A very useful treatment [equation (11)] is the model given by Dougherty and Krieger,<sup>11</sup> where  $p_k$  is the volume packing fraction, and  $[\eta]$  is the intrinsic viscosity.

$$\eta_r = \left[ 1 - \frac{\phi}{p_k} \right]^{-[\eta]p_k} \quad (11)$$

There is much debate about the value of these parameters, and they are known to be dependent upon the shear rate. A useful equation is the very low shear rate limit as derived by De Kruif [equation (12)]. Equation (12) predicts that at a volume fraction of 0.63 the viscosity at low shear goes to infinity.

$$\eta_r = \left[ 1 - \frac{\phi}{0.63} \right]^{-2} \quad (12)$$

Equations (9-12) are very useful for predicting the viscosity of latex suspensions; however, they are all given in terms of latex volume fraction. This presents a problem because volume fractions are ill defined and, in practice, only the weight fraction is known. Therefore, equations (9-12) are most useful for determining effective volume fractions at high concentrations. An important parameter then becomes the ratio of the volume ( $\phi_v$ ) to the weight fraction ( $\phi_m$ ).

$$v_r = \frac{\phi_v}{\phi_m} \quad (13)$$

If equation (13) is inserted into equation (9) the result is equation (14).

$$\eta_r = (1 + 2.5V_r\phi_m) \quad (14)$$

Thus, the intrinsic viscosity can be used to determine the effective hydrodynamic volume,  $V_r^1\phi_m$ , of the latex at low volume fractions. In practice,  $V_r^1 > 1$  for an acrylic latex ( $\rho \approx 1.1 \text{ g/cm}^3$ ). This is due to physical swelling of



**Table 1—Physical Parameters of Latexes Used in this Study**

Physical Parameters	Latex A	Latex B
Composition (wt%) .....	64% BA/31%MMA/5%MAA	38%BA/57%MMA/5%MAA
Solid content as supplied .....	41.4%	42.6%
Particle size .....	95 nm	95 nm
$T_g^b$ .....	0°C	50°C

(a) As measured with a Brookhaven BI-90, Brookhaven Instruments Corp., Ronkonkoma, NY.  
 (b) Calculated using the Fox equation<sup>17</sup>

the latex and electric double layer contributions. Determination of  $V_f^i$  allows an assessment of the effective volume fraction in the dilute regime. It is also indicative of the volume fraction present at the beginning of the drying process for a latex film.

By combining equation (12) and equation (13) the result is equation (15).

$$\eta r = [1 - V_f(t)\phi_m/0.63]^{-2} \tag{15}$$

Therefore, the viscosity during drying is not only a function of the weight fraction, but it is also a function of the time dependent  $V_f$  factor. During the drying of a latex film, several events cause the  $V_f$  factor to change. Due to physical swelling of the latex by cosolvents and base and to electric double layer effects which arise from the anionic charge, the effective volume fraction of a typical anionic water-based latex dispersion may be anywhere from 10% to several times larger than its weight fraction. In addition, the electric double layer is affected by the ionic strength of the formulation. Thus, the nature and amount of cosolvents used in the formulation influence the  $V_f$  factor, as will the amount and type of base and changes in the ionic strength. During the drying process, cosolvents and ammonia evaporate from the drying film and the ionic strength typically increases, causing a decrease in  $V_f$ . It is the magnitude of these effects which we tried to characterize in the work presented here. If equation (15) is used to fit the viscosity versus weight % solids data then the  $V_f$  factor at the instant that the coating develops an infinite low shear viscosity ( $V_f^h$ ) is determined. In this context,  $V_f^h\phi_m = 0.63$  at the point that an infinite low shear viscosity is achieved.

### Combination of Evaporation and Volume-Fraction/Viscosity Equations

During the early drying stages of a latex film, the rate of water evaporation is assumed to be constant. In light of this assumption, the weight fraction at time  $t$ ,  $\phi_m$ , is given by equation (16).

$$\phi_m = \frac{\phi_m(t=0)}{(1-E't)} \tag{16}$$

$$E' = \frac{E}{m(t=0)} \tag{16b}$$

In this equation,  $E$  is the absolute rate of solvent evaporation (g/min),  $E'$  is the relative rate of evaporation (1/min),  $\phi_m(t=0)$  is the initial weight fraction, and  $m$  is the initial mass of the film. Combining equation (16a) with equation (15) gives equation (17), which gives the time dependence of the viscosity in terms of the parameters  $\eta_0$ ,  $V_f$ ,  $\phi_m(t=0)$ , and  $E'$ . In practice,  $\phi_m(t=0)$ , and  $E'$  are known and the viscosity data are used to determine  $V_f$  and  $\eta_0$ .

$$\eta_r = \left[ 1 - \frac{V_f}{0.63} \left( \frac{\phi_m(t=0)}{1-E't} \right) \right]^{-2} \tag{17}$$

$E'$  is a particularly useful parameter because it allows data collected at different evaporation rates and film thicknesses to be compared. In principle, the viscosity versus time data is confounded by differences in absolute evaporation rates, making comparison between dif-

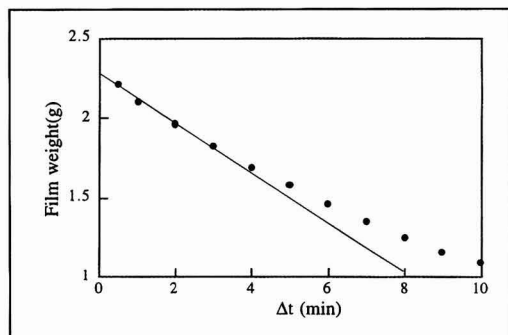


Figure 2—Weight change during drying of latex A, at 308K/20% humidity.

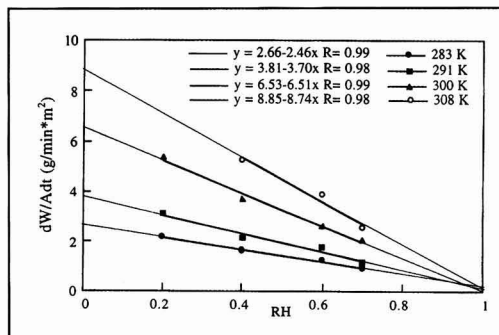


Figure 3—Influence of climate conditions on water evaporation from a latex A.

Table 2—Evaporation Rates Measured at 300K/40% Humidity, Air Flow (0.5m/sec)

1. Influence of film thickness: Latex A, pH 7.5		
Film thickness ( $\mu\text{m}$ )	Evaporation Rate ( $\text{g}/\text{min}$ ) $\cdot 10^{-1}$	Evaporation Rate Per Unit Area ( $\text{g}/\text{min}/\text{cm}^2$ ) $\cdot 10^{-4}$
40 .....	1.10	4.07
50 .....	1.09	4.04
90 .....	1.12	4.15
150 .....	1.12	4.15
2. Influence of pH: Latex A, (80 $\mu\text{m}$ )		
Base/pH	Evaporation Rate ( $\text{g}/\text{min}$ ) $\cdot 10^{-1}$	Evaporation Rate Per Unit Area ( $\text{g}/\text{min}/\text{cm}^2$ ) $\cdot 10^{-4}$
$\text{NH}_4\text{OH}/\text{pH } 8.5$ .....	1.11	4.11
$\text{NH}_4\text{OH}/\text{pH } 9.5$ .....	1.08	4.00
$\text{NaOH}/\text{pH } 9.5$ .....	1.10	4.07
3. Influence of cosolvents: Latex B, (80 $\mu\text{m}$ ), pH 8/ $\text{NH}_4\text{OH}$		
Latex B + cosolvent	Evaporation Rate ( $\text{g}/\text{min}$ ) $\cdot 10^{-1}$	Evaporation Rate Per Unit Area ( $\text{g}/\text{min}/\text{cm}^2$ ) $\cdot 10^{-4}$
neat Latex B .....	1.10	4.07
Latex B + EB .....	1.09	4.04
Latex B + DB .....	1.10	4.07
Latex B + PNB .....	1.09	4.04
Latex B + DPnB .....	1.10	4.07
Latex B + DM .....	1.09	4.04
Latex B + DPM .....	1.11	4.11

ferent samples impossible; however, by comparing data as a function of  $E't$  this complication can be avoided.  $E't$  is the relative amount of solvent that has left the film, and is independent of absolute evaporation rate, time, and film thickness.

## EXPERIMENTAL DATA

### Raw Material and Sample Preparation

The measurements of viscosities were performed on two model acrylic latexes (Table 1). Both latexes were made by standard polymerization procedures employing a thermal, persulfate-initiated semi-continuous monomer emulsion addition process; methacrylic acid and one percent sodium dodecyl benzenesulfonate (based on monomer) were used to stabilize the latexes.

### Evaporation Measurements

Evaporation rates (i.e., weight loss as a function of time) were determined at several temperatures and relative humidities. In addition, the effects of film thickness, initial pH, neutralizing base, and cosolvents on evaporation rates were determined. The samples were drawn down over a glass plate at a film thickness of 180  $\mu\text{m}$  and a total area of 270  $\text{cm}^2$ . The temperature and humidity which varied by  $\pm 5\%$ , were determined by a sling psychrometer, model WE 1330P (Gardner). Air flow was kept relatively constant using a box to shield the samples from stray drafts, and was determined using an Anemometer, Model Velometer Jr. range (0-10) m/sec (Gardner).

To check reproducibility, evaporation rates were determined at the same temperature and humidity on 10 different days. An analysis of the results indicated that the experimental error was about 8.5% which is reasonable considering the potential sources of error such as air flow and temperature-humidity fluctuations.

### Viscosity Increase During Evaporation

**Sample Preparation:** Samples of latex A were prepared at pH values of 8.5 and 9.5 using  $\text{NH}_4\text{OH}$  or  $\text{NaOH}$  as the neutralizing agent. In addition, latex A was used as supplied at pH 7.3. During the synthesis of latex A and B,  $\text{NH}_4\text{OH}$  was added as the neutralizing agent for stability. Thus, the control experiment with latex A at pH 7.3 was actually carried out with  $\text{NH}_4\text{OH}$  as the neutralizing agent. Latex B was prepared with 20% cosolvent (Dowanol<sup>TM</sup> EB, DB, PnB, DPnB, DM, and DPM)\* based on polymer solids. The pH of the samples was adjusted to 8.0 using  $\text{NH}_4\text{OH}$ .

These samples were drawn down over a glass panel at a film thickness of 180  $\mu\text{m}$ . This was done in a controlled environmental room at constant temperature (298 $\pm$ 2K) and humidity (50 $\pm$ 5%). The air flow was controlled using a box to shelter the panels from stray breezes. A small fan was placed in the back of the box to generate a small but relatively constant air flow. At set time intervals, the samples were removed from the panel using a rubber squeegee. The time intervals were chosen based on the observed open time. Typically five viscosity/time data points were obtained for each sample.

\*Dowanol is a trademark of the Dow Chemical Company. EB—ethylene glycol monobutyl ether, DB—diethylene glycol monobutyl ether, DM—diethylene glycol monomethyl ether, PnB—propylene glycol monobutyl ether, DPnB—dipropylene glycol monobutyl ether, DPM—dipropylene glycol monomethyl ether.

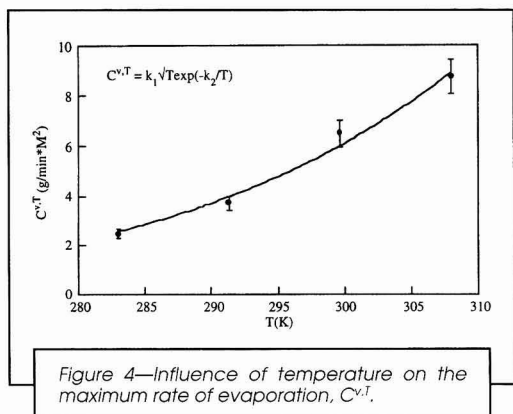


Figure 4—Influence of temperature on the maximum rate of evaporation,  $C^{v.T}$ .

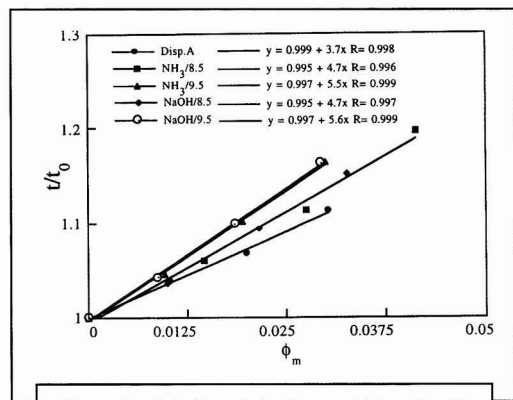


Figure 5—Relative drain times of latex A with  $NH_4OH$  or  $NaOH$ .

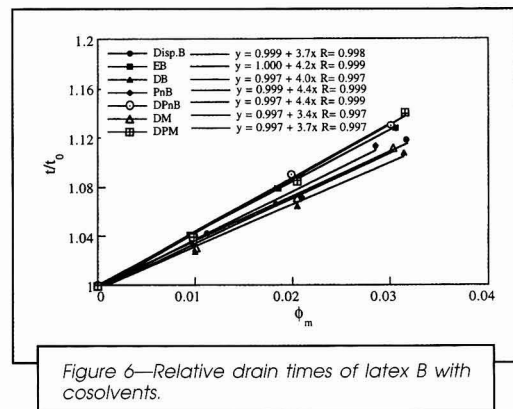


Figure 6—Relative drain times of latex B with cosolvents.

Prior to viscosity measurement, all the samples were filtered to remove any dried polymer which could become lodged between the cone and plate of the rheometer.

**Viscosity Measurements:** The previously mentioned models for viscosity are valid in the low shear rate limit. Therefore, in order to get data which can be used in these models, a very low shear measurement is required. By far, the best way to extract the data is through a creep measurement. In this experiment a constant and low stress is applied and the amount of deformation [compliance (J)] is measured. The viscosity is given by the reciprocal of the rate of compliance (dt/dJ).

Viscosity was determined using the Carri-Med CSL 100 controlled-stress cone and plate rheometer, with a 6 cm diameter 2° cone at a stress of 0.1 Pa at 20°C. The data was obtained as compliance versus time. All the samples were presheared at 15Pa for 30 sec and allowed to equilibrate for one minute prior to the creep measurement. The rheometer was calibrated using a standard oil. Data is only presented for those samples which did not display an elastic component.

**Additional Sample Data:** In addition to measuring viscosity, the pH, cosolvent levels, and weight solids were also determined. The solid content was measured by drying the samples for 24 hr at 120°C. pH was measured with the Corning 240 pH meter. Also, the effect of pH and neutralizing agent on the viscosity of latex A was determined at 35% weight solids. The cosolvent level in the samples was determined using the gas chromatograph Model 5890 from Hewlett Packard, with a flame ionization detector. The determinations were done in THF, and compared against known standards.

### Intrinsic Viscosity

The measurement of intrinsic viscosity of a latex is complicated by salt effects on the electric double layer. To perform the experiment, samples need to be diluted to low solids (< 5%); however, if deionized water is used, the serum composition changes dramatically, impacting the intrinsic viscosity. To circumvent this problem, a sample of the serum phase of each of the formulations was isolated using ultrafiltration. The samples were first prepared with the desired cosolvent and base neutralization and allowed to equilibrate for 24 hr. The serum was isolated using an Amicon Model 8200 ultrafiltration cell. The membrane had a 300,000  $M_w$  cutoff, which at 1 g/cm corresponds to a 5 nm pore size. The back pressure was 5 psi. The use of a low back pressure keeps the filter from clogging. This serum was then used to dilute the latex formulations back to the desired concentration.

The viscosities at 0, 1, 2, and 3% solids by weight were determined using a capillary viscometer at 25°C in a water bath, controlled by a thermostat (VWR, Model 1110). This technique provides drain times for each sample; however, since these times are proportional to the kinematic viscosity and we are only concerned with relative viscosities, no further attempt was made to convert these times into viscosities. The relative drain time,

Table 3— $V_f^1$  from Intrinsic Viscosity and Fits to Equation (15)

Sample	$V_f^1$	$V_f^1/\text{Latex A or B}$	$V_f^h$	$V_f^h/\text{Latex A or B}$
Neat Latex A .....	1.47	1.00	1.36	1.00
Latex A + $\text{NH}_4\text{OH}$ to pH 8.5 .....	1.87	1.27	1.33	0.978
Latex A + $\text{NH}_4\text{OH}$ to pH 9.5 .....	2.20	1.50	1.29	0.949
Latex A + $\text{NaOH}$ to pH 8.5 .....	1.87	1.27	1.34	0.985
Latex A + $\text{NaOH}$ to pH 9.5 .....	2.23	1.52	1.41	1.04
Neat Latex B .....	1.46	1.00	1.33	1.00
Latex B + EB .....	1.68	1.15	1.24	0.932
Latex B + DB .....	1.58	1.08	1.34	1.01
Latex B + PnB .....	1.76	1.21	1.39	1.05
Latex B + DPnB .....	1.77	1.21	1.53	1.15
Latex B + DM .....	1.37	0.983	1.31	0.985
Latex B + DPM .....	1.48	1.01	1.37	1.03

$t/t_0$ , should be a linear function of  $\phi_w$ , and should have a slope of 2.5. Deviations of the slope from 2.5 give the  $V_f^1$  factor discussed in the theoretical section.

### Determination of Open Time

The cessation of flow of the liquid is an important physical phenomenon during the drying of a latex. In this context, open time ( $t$ ) is defined as the time between application and cessation of flow. In order to compare data generated under different film thickness and environmental conditions it is necessary to determine the dimensionless parameter  $E't$  (i.e., the relative amount of water that has left the film). Based on equation (17), flow ceases in the low shear rate region at a given  $E't$ . In order to determine the open time for each of the samples, a dry time recorder was used. The majority of commercial dry time recorders are designed to track the drying of alkyd paints and thus are much too slow for this application. Therefore, a suitable dry time recorder was constructed. For this test a stylus is dragged through the film at  $\sim 2.5$ -5cm/min. As long as the coating is fluid it flows back and no mark is left. Once the open time is reached, the coating stops flowing and a permanent mark is left. The distance the stylus traveled without leaving a mark gives the time.

The measurements were done at 300 K, 40% humidity, an air speed of 0.5m/s, and a film thickness of  $80 \pm 5$   $\mu\text{m}$ . The stylus speed was 3.8 cm/min. The glass panel was weighed immediately after application to get an actual film thickness. In addition, the relative evaporation rate was determined ( $E'$ ), allowing the dimensionless open time to be determined.

## RESULT AND ANALYSIS

### Evaporation Rates

A typical weight loss versus evaporation time is given for latex A in Figure 2. The data is for the sample dried at 308 K, and 20% RH. The data shows that even at fairly long times the weight loss remains constant. As a reference, the open time of this sample under these conditions was about two minutes. This means that for the purposes of the experiments presented here, the evaporation rate is constant.

The data at different temperatures are plotted versus relative humidity (RH) in Figure 3, and a straight line is fit at each temperature. The fits were not constrained to 0 at 100% RH. From the slope and intercept, the activity coefficients were all within experimental error ( $\sim 10\%$ ) of being 1. Thus, during the early stages of drying the water is evaporating as if it was pure water. This result is consistent with those of Hansen.<sup>15</sup>

As set forth in the theoretical section, the slope of the lines gives the maximum evaporation rate which is dependent on temperature among other things. The temperature dependent  $C^{v,T}$  values are shown in Figure 4, along with a fit to equation (8). To within the error of the measurements, the measured  $\Delta H_v$  is equivalent to pure water.

These results indicate that at least during the early stages of drying the temperature and humidity dependence of the evaporation of water is completely unaffected by the presence of the latex. This result is consistent with results obtained by Pramoganey<sup>16</sup> and Kornum.<sup>36</sup> However, the results do not address the fact that the latex may reduce the absolute rate by affecting the effective evaporative surface area. Additional results on samples at different film thickness, different starting pH values, and in the presence of cosolvent (Table 2) reveal the surprising result that none of these components have an effect on the evaporation rate. In other words, in the early stages of drying, the evaporation of water from a latex film depends on temperature, air flow, and humidity.

### Intrinsic Viscosity

The relative drain times for the samples prepared from latex A or latex B are plotted in Figures 5 and 6, respectively. The best fit of a line through the points is also provided. Using the Einstein relation, the correction factors,  $V_f^1$ , were determined (Table 3). As a reference, all of the  $V_f^1$  factors were divided by the value obtained for the neat latex (column 3).

As expected, samples at high pH display the greatest volume increase and little difference is noted between  $\text{NH}_4\text{OH}$  and  $\text{NaOH}$ . Thus, the degree to which each of these bases swell the latex is quite similar. Also, the cosolvents elicited varying degrees of latex swelling, in accord with their relative hydrophobic or hydrophilic

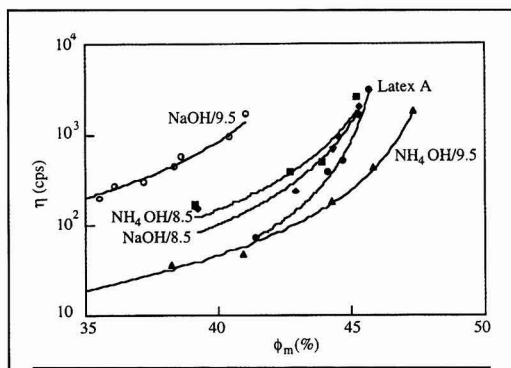


Figure 7—Viscosity versus weight solids content for Latex A with  $\text{NH}_4\text{OH}$  or  $\text{NaOH}$ .

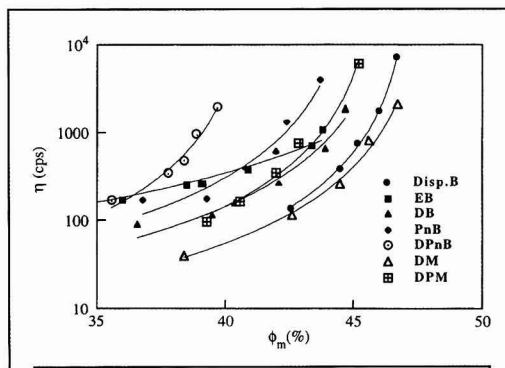


Figure 8—Viscosity versus weight solids content for latex B with cosolvents.

character. The two hydrophobic cosolvents (PnB and DPnB) were found to swell latex B the most. EB and DB give the intermediate swelling and are known to only partially partition into the latex. Lastly both DPM and DM cause little swelling and are expected to predominantly remain in the water phase.

Based on the intrinsic viscosity data, the assumption that the  $V_f$  factors determined remain constant during the drying process, and the assumption that the volume fraction at which gelation occurs (infinite low shear viscosity) is a fixed value ( $\phi = 0.63$ ); the samples with the highest pH are expected to display gelation at the lowest weight percent. There would also be no difference between  $\text{NH}_4\text{OH}$  and  $\text{NaOH}$ . A similar statement could be made for the samples containing PnB and DPnB. If a comparison is made between samples at the same initial starting weight percent solids, this data would indicate that high pH and PnB or DPnB gives the shortest open time. However, as shown in the following, this is based on the invalid assumption that the  $V_f$  factor is constant during the drying process.

### Viscosity Increase During Drying

The wt% solids versus viscosity data is plotted in Figures 7 and 8. A useful and simple way of interpreting the data is estimated, based on the shape of the curve, at what wt% solids the viscosity becomes infinite. For example, latex A neutralized to pH 9.5 with  $\text{NaOH}$  has a much higher viscosity at a given solids than the control sample (Latex A with no added base). This difference is present throughout the drying process, and amounts to a shift to the left in the wt% solids versus viscosity curve. Curves which lie to the left of the control indicate that the ratio between the volume and weight fractions ( $V_f$ ) is larger than the control, and this condition persists throughout the drying process. Curves which lie to the right of the control indicate that  $V_f$  is smaller than the control, or at least that at some point during the drying process,  $V_f$  becomes smaller. It is important to remember that during the drying process  $V_f$  is a dynamic parameter, and that only relative comparisons are valid

(i.e., Latex A with different bases and different pH values).

As expected, the viscosity is much higher at a given wt% solids for the high pH sample containing  $\text{NaOH}$  (Figure 7,  $\text{NaOH}/9.5$ ). However, the data for the pH 9.5 sample with  $\text{NH}_4\text{OH}$  reveals a much lower viscosity at a given wt% solids. In fact, it is seen that this sample has a lower viscosity than even the control sample (latex A initially at pH 7.3). Versus the latex A control, the presence of the added  $\text{NH}_4\text{OH}$  to latex A allows the sample to achieve a significantly higher wt% solids during drying, before reaching an infinite viscosity. This is completely counterintuitive, especially since the measurement of the final pH of the samples reveals that the sample starting at pH 9.5 winds up at pH 7.9, while the control sample at pH 7.3 winds up at pH 7.1.

In general, as the pH is raised through addition of a base like  $\text{NH}_4\text{OH}$ , the viscosity will increase due to a neutralization of carboxylic acid groups and a concomitant swelling of the latex; however, the viscosity/wt solids data provided earlier indicates that it is possible to prepare a sample that has a higher pH, a higher wt% solids, and yet a significantly lower viscosity. This means that the route by which the sample is prepared can impact the viscosity. The act of adding  $\text{NH}_4\text{OH}$  to latex A, then allowing water and  $\text{NH}_3$  to evaporate during drying brings the system to a different state than if water was first removed from the latex and then  $\text{NH}_4\text{OH}$  was added to bring the pH to 7.9.

The data for the cosolvent series also reveals some interesting trends. In general, the addition of a cosolvent to latex B causes it to develop an infinite viscosity at lower wt% solids than for the control sample (latex B with no cosolvents); however, some solvents actually suppress viscosity during drying.

DPnB causes latex B to develop an infinite viscosity at the lowest wt% solids. This is expected based on the hydrophobic low-volatility nature of DPnB. Because of the low solubility of DPnB in water, an overwhelming fraction of DPnB partitions into the latex particle. This causes a physical swelling of the latex and an increase in



the effective volume fraction occupied by the latex and an increase in the viscosity. Because of the low volatility of DPnB, virtually none of it evaporates during the time scale of the drying process studied here.

Interestingly, PnB, like DPnB, has a low water solubility and also swells the latex significantly; however, it has a much higher evaporation rate, and thus the PnB can evaporate during drying. At the beginning of the drying process both the sample with PnB and the sample with DPnB have very similar viscosities at the same wt% solids. This indicates that both PnB and DPnB initially swell latex B to the same extent; however, the volatilization of PnB during drying leads to a reduction in effective volume fraction, and a shift in the wt% solids/viscosity curve to higher weight fractions relative to DPnB, as evidenced in Figure 8 (DPnB versus PnB).

DB and DPM are both completely miscible in water, but they also partition into the latex, and cause an increase in the effective volume fraction and the viscosity. As expected, this causes a shift relative to the control in the wt% solids/viscosity curve to lower wt% solids. When compared to DPnB and PnB, this shift is not as large, and can be explained based on the incomplete partitioning into the latex. This partitioning effect is also seen in the intrinsic viscosity data ( $V_f^1$  in Table 3). During the time scale of the drying process studied here, neither DB or DPM are volatile enough to leave the coating in any significant amount.

While most of the cosolvents in the series cause an increase in viscosity upon addition, the addition of DM to latex B actually causes a drop in viscosity and this translates into lowered viscosity throughout the drying process. DM is so hydrophilic that it does not partition into the latex and, in fact, it tends to cause the latex to shrink slightly. This effect is also seen in the intrinsic viscosity data ( $V_f^1$  in Table 3). By virtue of this shrinking effect, a shift to the right is seen in the wt% solids/viscosity curve. It should be noted that DM does not evaporate significantly during the time scale of the drying process studied here.

The effect of EB on the viscosity is quite unique among these cosolvents. Although it is completely water miscible, a significant fraction partitions into the latex, initially increasing the effective volume fraction and the viscosity. However, the high volatility of EB causes it to evaporate from the film at a rate comparable to the evaporation of water, and the effective volume of the EB swollen latex is decreasing during the drying process. This effect translates into lower viscosities later in the drying process, such that the sample, when compared to the control, can achieve a higher weight % solids before reaching an infinite viscosity. At high volume fractions EB appears to have an effect not unlike that of DM. It is also very interesting to compare the behavior of EB with that of PnB. Both have comparably high volatilities, but very different behaviors during drying. A possible explanation is that the PnB is trapped in the latex and its ability to evaporate is significantly reduced, while on the other hand EB, by virtue of its miscibility with water, can more easily evaporate.

A useful way of comparing the data is through the  $V_f^h$  factors, and these are given in Table 3. The  $V_f^h$  factor was

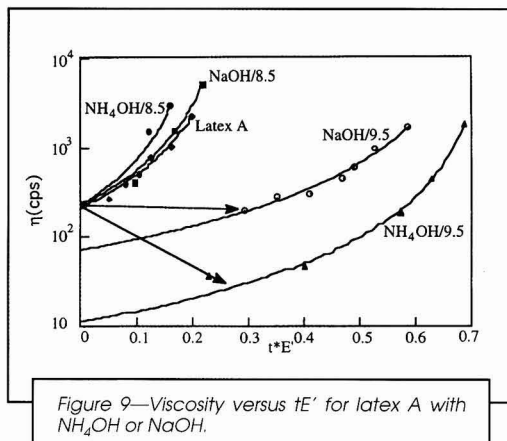


Figure 9—Viscosity versus  $tE'$  for latex A with  $NH_4OH$  or  $NaOH$ .

obtained by fitting the viscosity versus wt% solids data (Figures 7 and 8) to equation (15). The fits were performed by letting both the zero point viscosity [ $\eta_i(\phi_m=0)$ ] and the  $V_f^h$  factor float as free parameters. The  $V_f^h$  factor, as defined in the theoretical section, is the ratio of the volume to weight fraction at the instant that the coating develops an infinite low shear viscosity (i.e.,  $V_f^h \phi_m = 0.63$ , when  $\eta_r = \infty$ ). Column 4 gives  $V_f^h$ , and column 5 gives  $V_f^h$  relative to the control. A quick scan of column 5 reveals that several of the factors are less than one, and of particular note are the materials which give the lowest factors:  $NH_4OH$  pH 9.5, and EB.

Another useful comparison between the drying curves comes from adjusting the data so that all the samples start at the same initial viscosity. This amounts to a minor shift along the time axes for the curves. To facilitate the comparison, the data must be plotted as a function of  $t^*E'$  for the reasons discussed previously. The data are plotted in Figures 9 and 10. When plotted in this way the high initial pH samples stand out as being significantly different from the other samples; however, it should be remembered that the starting solids of the

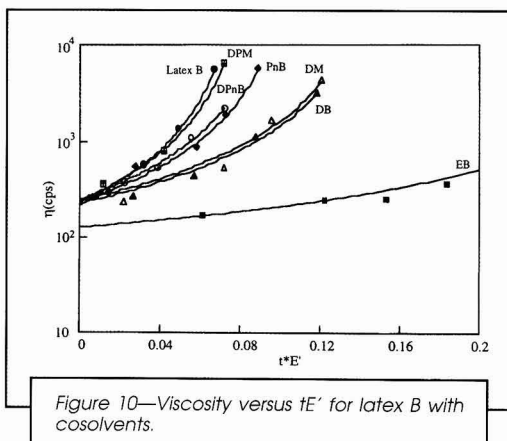


Figure 10—Viscosity versus  $tE'$  for latex B with cosolvents.

**Table 4—Percentage of Cosolvent Remaining in the Film**

EB	t (min)	0	2	4	6	7	8
	%C BOP1	18.8	16.0	15.6	14.8	14.5	13.9
DB	t (min)	0	2	3	4	5	6
	%C BOP	21.3	21.7	22.3	20.8	21.8	23.0
PnB	t (min)	0	2	3	4	4.5	5
	%C BOP	22.6	19.9	19.9	19	18.1	16.1
DPnB	t (min)	0	1	1.5	2	2.5	
	%C BOP	26.4	22.9	21.9	21.6	20.6	
DM	t (min)	0	3	5	6	7	
	%C BOP	21.0	21.3	21.7	21.0	20.8	21.7
DPM	t (min)	0	1	2	3	4	
	%C BOP	19.8	20.8	20.5	18.6	21.4	

(1) Percentage of cosolvent based on polymer

NaOH sample are much lower. The plots for the cosolvent series also show that EB provides a significant effect on the development of the viscosity. Thus, open time is significantly extended for samples which contain EB.

### Physical Changes in the Sample Upon Drying

The data previously mentioned clearly shows that during the drying process, the amount of swelling ( $V_i$ ) is a dynamic variable and changes significantly. The two effects contributing to this change are evaporation of cosolvents (latex B) and  $NH_4OH$ . Data were obtained for both of these effects and can give some insight into their origin.

**Cosolvent Evaporation:** The amount of cosolvent left in the samples at the various dry times was determined by GC. This data is given in Table 4 in terms of percent cosolvent based on polymer solids in the film. As expected, the highly volatile EB and PnB, show a decrease in level as the drying proceeds. This data explains why the  $V_i$  factors, for both EB and PnB are changing during the drying process. For all of the other cosolvents, the level is seen to remain constant when compared to experimental error.

### pH Changes and the Effect of $NH_4OH$ on Viscosity:

The pH of latex A with added  $NH_4OH$  or NaOH is plotted versus drying time in Figure 11. All of the samples show a drop in pH in the first few minutes during the drying process. Even the samples neutralized with NaOH show a decrease in pH. At first, this may seem a little odd until it is remembered that all of the samples contain some  $NH_4OH$  which was carried along from the synthesis of the latex. Evaporation of  $NH_3$  could explain this pH drop. The adsorption of atmospheric  $CO_2$  could also be playing a role. Interestingly, the sample which starts at pH 9.5 with  $NH_4OH$  drops quickly in pH such that within 3-4 min it is at the same pH as the sample that started at pH 8.5.

Figure 12 shows that pH dependence of the viscosity of latex A at constant wt% solids. The viscosity of latex A is highly dependent on pH, showing a rapid rise between pH 8 and 9. Also, the increase is much more significant for the NaOH sample, and while the NaOH sample plateaus at pH 9.5, the sample with  $NH_4OH$  drops in viscosity as the pH is increased above 9.5. The viscosity decrease indicates that the presence of  $NH_4OH$  suppresses viscosity. A separate titration of latex A reveals that at pH, 9.5, 97% of the polymer acid is ionized. This is consistent with the plateau observed in the NaOH viscosity data.

One possible explanation is that the  $Na^+$  ions contribute to latex swelling more than  $NH_4^+$ ; however, the intrinsic viscosity data indicates that at low solids the swelling of latex A is the same for both NaOH and  $NH_4OH$ . Taken together, these results indicate that  $NH_4OH$  somehow reduces the interaction between the latex particles at high volume solids. The most plausible reason for this viscosity reduction is the effect that  $NH_4^+$  ions have on shielding the charge on the latex, causing a reduction in viscosity. Another important consideration is the differences in molar equivalents of the two bases needed to achieve a given pH.

This data gives insight into the origin of the  $NH_4OH$  behavior. An important effect is the drop in pH which causes a large viscosity drop in the initial drying stages. In the first few moments during the drying process, the pH drops and the system resembles the lower initial pH sample, but with a lower weight-solids and a lower

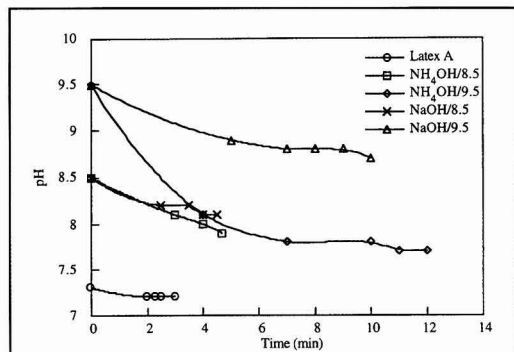
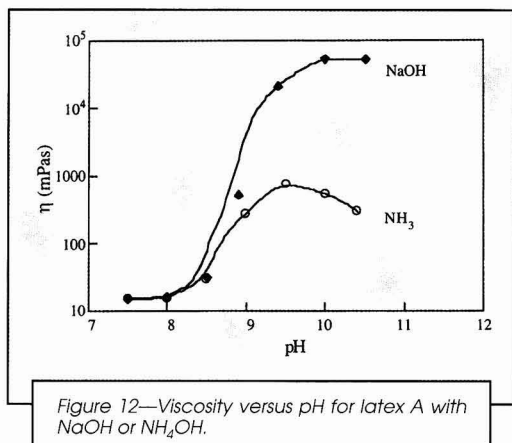


Figure 11—pH versus time for latex A with  $NH_4OH$  or NaOH.



viscosity. Additionally, the presence of the initial  $\text{NH}_4\text{OH}$  suppresses the viscosity, allowing it to achieve a significantly higher solids before cessation of flow.

#### Correlation Between Drying Curve Data and Open-Time

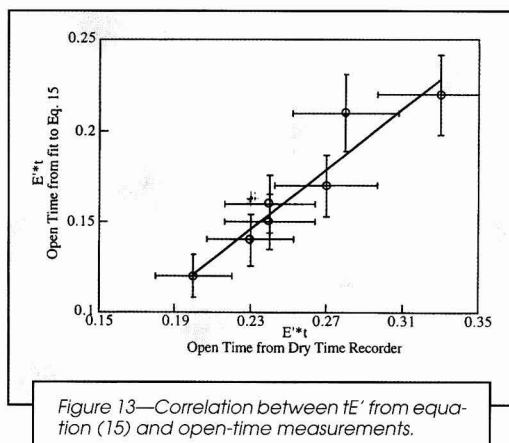
Throughout this paper it is assumed that there is a correlation between the rheology changes that occur during the drying of a latex film and the open time. In addition, it is assumed that the rheological changes which occur for the film can be understood in terms of a particle packing model. Implicit in this last assumption is the belief that the latex film dries uniformly from top to bottom (i.e., skinning is not important) and from edge to center.

A pragmatic test of these assumptions is the existence of a correlation between the point of infinite viscosity as determined from the drying curves, and the open time as measured with the dry time recorder. If these two values are correlated, then at the very least, the physical model is consistent with observations, and the D-K model and the drying rate model can be combined to predict relative trends in the open time. Lastly, if air flow rate can be kept constant, it allows open time data obtained at different temperatures and RH to be directly compared.

To test this assumption, the open time was measured for the same series of samples used for the drying study. Open time is given in terms of the dimensionless parameters  $E't$ . Figure 13 gives a plot of the dimensionless open time versus the time to reach infinite viscosity as predicted by equation (15), and a reasonably good correlation is observed.

## DISCUSSION

This work shows that the rates of evaporation from a latex, as well as the accompanying rheological changes can be measured with uncomplicated and practical methods. The Dillon model can be used to determine the



effects of temperature and humidity on the drying process. In the early stages of drying the water can be assumed to evaporate from a latex as if it were pure water. This result is extremely useful in that many of the complicating factors can be ignored. In addition, the Dougherty-Krieger and De Kruif models were found to give a physical understanding for the viscosity increase. These two models could be combined to give an expression for the time evolution of the viscosity as a function of the dimensionless parameter  $E't$ . Because these models work and can be correlated with actual open time measurements, the working theoretical model can be comfortably assumed valid. However, at this point it is unclear whether this treatment can be extended into pigmented systems or latexes thickened with rheology modifiers. This is an obvious extension of this study.

One of the key findings of this study is the fact that the relationship between the volume fraction occupied by the latex and weight fraction is anything but constant during the drying process. As a first approximation, the density of the polymer could be used to obtain  $V_f$ ; however, as clearly shown by the intrinsic viscosity data this assumption leads to a gross underestimation of this parameter. In some cases, the latex is more than twice the volume predicted from the density. Moreover, the data presented here shows that  $V_f$  is anything but constant during the drying process. This is not contrary to experience; however, the level of the effect is surprising. Factors such as neutralizing agent, initial pH, and cosolvent choice can have significant impact on the rheology during drying.

The effect that  $\text{NH}_4\text{OH}$  has on the viscosity of the drying film is very intriguing. In essence, our work shows that it is possible to prepare a latex sample which has a higher solid content and a higher pH than the control, and yet has a substantially lower viscosity. This effect can not be explained simply on the basis of the volatility of  $\text{NH}_4\text{OH}$  and the concomitant drop in pH. This means that the method by which a sample arrives at a given pH and weight-solids greatly impacts the viscosity. At this point we have no further insight into why the viscosity is suppressed in the  $\text{NH}_4\text{OH}$  samples, but we strongly

suspect that the effect is due to the contribution that  $\text{NH}_4^+$  has on shielding the double layer. In addition, we suspect that the macroscopically measured pH does not probe subtler effects that are happening on the latex surface.

**SUMMARY**

The rheological changes during the initial stages of drying of a water-based latex film were examined for two lattices formulated at varying pH's with a variety of cosolvents, and different neutralizing agents. Water was found to evaporate from the films as if it were pure water with an activity coefficient of one and a heat of vaporization equivalent to pure water. The increase in viscosity during drying is explained by the volume packing models of Krieger and Dougherty or De Kruijff. For several of the films in this study, the ratio between the volume and weight fractions was not a static parameter, and an abnormally large drop was observed in the effective volume occupied by the latex. This was exaggerated for the sample containing EB or  $\text{NH}_4\text{OH}$ . The former can be understood based on the high volatility of EB, while the latter effect indicates the surprising result, that  $\text{NH}_4\text{OH}$  substantially suppresses viscosity.

**ACKNOWLEDGMENT**

The authors would like to thank Rohm and Haas for providing the funding for this work. We are also grateful for the contribution of R.P. Lauer and S.L. Tecce in synthesizing the latexes and measuring the accessible MAA in the latexes, and for the contribution of W. Thompson in measuring the cosolvent levels in the films. We are also grateful for the contribution of R.P. Lauer for help in editing this manuscript.

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**Symbol list**

T .....	Absolute temperature
$E_{max}$ .....	Number of molecules evaporating out of the liquid
A .....	Surface area of evaporating liquid
k .....	Mass transfer factor
$P_v$ .....	Vapor pressure of the evaporating liquid
M .....	Molecular weight of the evaporating molecules
R .....	Ideal gas constant
$E_L$ .....	Absolute evaporation rate
D .....	Diffusion coefficient of the evaporating gas molecules through the ambient gas
p .....	Ambient pressure
$x$ .....	Effective boundary layer film thickness at the liquid surface
f .....	Factor which is dependent on S
S .....	Height of the stagnant air column above the liquid
Y .....	Mean free path of the molecules in the vapor phase
$dm/dt$ .....	Evaporation rate
$K^{v,T}$ .....	Mass transfer coefficient which depends on air flow (v) and temperature
$p_i$ .....	Vapor pressure
a .....	Activity coefficient
$\phi$ .....	Relative vapor saturation (relative humidity)
$C^{v,T}$ .....	Combination of temperature dependent factors from equation (4)
V .....	Air speed over evaporating liquid
$K_0$ .....	Mass transfer coefficient in the absence of air flow
$\alpha, \beta$ .....	Correction factors for air flow
$\Delta H$ .....	Enthalpy of vaporization for the solvent
$\eta$ .....	Viscosity of the dispersed lattices
$\eta_0$ .....	Viscosity of the dispersing medium
$\eta_r$ .....	Relative viscosity
$\phi_v$ .....	Volume fraction of dispersed latex
$\phi_m$ .....	Weight fraction of dispersed latex
$P_k$ .....	Volume packing fraction
$V_f$ .....	Ratio of volume to weight fraction of dispersed latex
$V_f(t)$ .....	Time dependent ratio of the volume fraction to the weight fraction
$V_f^l$ .....	Ratio of volume to weight fraction of dispersed latex at low volume fractions
$V_f^h$ .....	Ratio of volume to weight fraction of dispersed latex at critical packing
E' .....	Relative rate of evaporation (1/min)
m .....	Initial mass of the film

# Synthesis and Characterization of Copoly(MMA-MA)-Cu Complex and Study on Its Leaching Behavior

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## INTRODUCTION

Underwater surfaces exposed to sea water are prone to settlement or fouling by fouling organisms.<sup>1</sup> With time this settlement results in the formation of a thick, uneven, and hard crust and poses several problems in maintenance and operational availability. Thus prevention of fouling is of direct concern.

One of the more common and widely used biocides for fouling prevention is cuprous oxide. Tributyltin species are among the most effective organotin biocides and their worldwide use as active agents in antifouling coatings, especially on ships' hulls, is rapidly expanding.<sup>2</sup>

The main difference between these two biocides is in the mode of leaching from the paint matrix to the surrounding sea water. Leaching of copper takes place by simple uncontrolled diffusion,<sup>3</sup> whereas that of tin occurs in a controlled manner by breaking the chemical bond and subsequent diffusion.<sup>4</sup> Another point of difference is the high threshold value of leaching. The threshold value for copper is  $10 \mu\text{g}/\text{cm}^2/\text{day}$ <sup>5</sup> which is about 25 times greater than that of tin ( $0.4 \mu\text{g}/\text{cm}^2/\text{day}$ ).<sup>4</sup> As the leaching of copper is uncontrolled, paints based on cuprous oxide throw large amounts of unnecessary copper into sea water. The concentration of copper in the Suez Canal was found to be several times higher than the threshold value for deterioration of water quality.<sup>6</sup> Similarly, the increasing use of tributyltin-based antifouling coatings has raised concerns about their environmental effects, and the effects on non-target organisms of the toxic tributyltin species released from the coatings.<sup>7-10</sup> Bioassays with algae,<sup>2</sup> oyster,<sup>7</sup> crab,<sup>11</sup> mussel larva,<sup>8</sup> mysid shrimp,<sup>12</sup> copepods,<sup>13</sup> and fish<sup>14</sup> have shown sub-lethal and lethal effects of tributyltin at parts per billion and lower levels in water. Consequently, some nations have issued regulations to control the use of tributyltin-based antifouling coatings on small crafts in an attempt to protect marine life near harbors.<sup>15</sup>

There have been numerous attempts to develop effective alternate systems so that either a non-toxic or less toxic surface will be maintained. Some of the recent systems developed are based on silicone elastomers, complex organic compounds, etc.<sup>16-25</sup> Attention has also been

*The most effective commercially available antifouling paint system is based on organotin, which is chemically attached to a long chain polymeric binder. Environmental studies have revealed that the proportion of organotin in sea water near the shores has reached an alarming level. Therefore, attempts are being made in many directions to eliminate tin from antifouling paint systems. Design of a highly toxic copper based paint system is one of the latest areas of research.*

*In the present work, a copper complex based on carboxyl containing polymer has been synthesized. Paints were formulated using the complexes as pigment. Critical pigment volume concentration is found to be around 35%. Both accelerated and normal leaching behavior were studied. The release of copper from complex is slower and steadier compared to that from cuprous oxide. The later part of leaching is very close to steady-state behavior.*

paid to copper-based biocides, such as lipid soluble copper complexes, so that a low leaching rate would be enough to prevent fouling.<sup>26</sup> It will also be worth trying to develop a controlled leaching or self polishing copper based antifouling paint system.

In the present work, polymer-based copper complex was synthesized and characterized. The complex was incorporated as pigment in paint matrix. The paint films were characterized for their mechanical properties. The leaching behavior of the paints was studied under both normal and accelerated conditions.

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Table 1—Glossary of Materials

Chemicals	Specification	Source
Polymethyl methacrylate .....	Mn	:1,20,000
Chlorinated rubber .....	Chlorine	:65% (w/w)
	Viscosity (20% soln. in Toulene)	:18-24 cp (27°C)
Chlorinated paraffin wax .....	Chlorine	:40 ± 1% (w/w)
	Viscosity	:30-35 poise (27°C)
Gum rosin .....	Acid value	:160
Glycine .....	A.R. Grade	M/s BTS Pvt. Ltd., India
Cupric chloride .....	A.R. Grade	BDH, India
Sulphuric acid (conc.) .....	A.R. Grade	BDH, India
Nitric acid (conc.) .....	A.R. Grade	S.D. Fine Chemicals, India
Zinc oxide .....	Pigment Grade	—do—
Cuprous oxide .....	Pigment Grade	M/s Indian Minerals Corp., India
	Copper	:93%
Xylene .....	A.R. Grade	M/s Gomati Chemicals Ltd., India
		BHD, India

## EXPERIMENTAL

### Materials

All chemicals used in this study, as listed in Table 1, were used without further purification.

### Methods

**Synthesis of Copoly (Methyl Methacrylate-Methacrylic Acid)—Cu Complex [Copoly(MMA-MA)—Cu]:** Copoly (methyl methacrylate-methacrylic acid) [copoly(MMA-MA)] was synthesized by using the method of Deb et al.<sup>27</sup> Polymethyl methacrylate (PMMA) was hydrolyzed by dissolving it in concentrated sulphuric acid and stirring at 60°C for a predetermined period. The solution was precipitated in crushed ice. The solid separated was filtered, washed thoroughly till free from sulphate, and dried at 80°C under vacuum to constant weight. The degree of hydrolysis was determined by dissolving the dried powder in aqueous ethanol and titrating the solution with aqueous sodium hydroxide solution.

Copper salt of copoly(MMA-MA) was prepared by reacting it first with a stoichiometric amount of aqueous sodium hydroxide solution (10%, w/v) at ambient temperature. The resulting aqueous solution of the sodium salt was taken in flask and kept stirred at ambient temperature. A stoichiometric amount of aqueous cupric chloride solution (10%, w/v) was added slowly to this solution. Blue precipitate appeared instantaneously. The temperature was raised to 60°C and stirring continued for another three hours.

The precipitate was filtered and washed thoroughly until the filtrate turned colorless.

**Estimation of Copper:** The estimation of copper was done by using gravimetric, volumetric, and atomic absorption spectroscopic methods respectively. In the gravimetric method, the complex (0.3–0.5 gm) was digested with concentrated nitric acid in a silica crucible. The complex was moistened with few drops of nitric acid and heated over a low flame with lid slightly open. The digestion was repeated twice and finally the mass was heated on a strong flame with lid wide open. The residue was weighed as cupric oxide.

In the volumetric method, the sample (0.2–0.3 gm) was digested with conc. nitric acid over low flame. The solution was diluted with distilled water and filtered. It was titrated by using iodometric method.

In the spectroscopic method, the previously mentioned solution was diluted further and estimated by using an atomic absorption spectrophotometer (M/s Elec. Corp. of India Ltd., Model No. AAS4127).

### Characterization

**FTIR Study:** Powders of the complexes were dispersed in potassium bromide and compressed to pellets. IR spectra was recorded by using FTIR spectrophotometer (Perkin-Elmer, USA, Model 1650).

**Formulation of Antifouling Paints:** Specific amounts of chlorinated rubber (CR), chlorinated paraffin wax, powdered copoly(MMA-MA)-Cu complex/zinc oxide and xylene were premixed and the

Table 2—Paint Formulation

Comp. No.	Chlorinated Rubber	Gum Rosin	Chlorinated Paraffin Wax	Pigment		Aluminum Stearate	Xylene
				Cu- Compl.	Cu <sub>2</sub> O		
Parts by Weight							
1 .....	10	10	4	10	—	0.7	35
2 .....	10	10	4	20	—	0.7	35
3 .....	10	10	4	25	—	0.7	35
4 .....	10	10	4	40	—	0.7	35
5 .....	10	10	4	—	25	0.7	35

grinding was performed in a laboratory ball mill for about eight hours. Requisite amount of rosin solution in xylene was added to the paint and stirred thoroughly for one hour. Table 2 shows the formulations of copper complex based paint.

**Panel Preparation/Paint Application:** Experimental panels for leaching were made of glass ( $12.5 \times 5 \times 0.2$  cm). They were abraded thoroughly, cleaned with water and methanol, and dried in air. Mild steel panels were grit blasted and paint was applied on both sides and all the edges, leaving an interval of 15-16 hr for drying. The total average dry film thickness was maintained at  $100 \pm 10$   $\mu\text{m}$ .

**Tensile Properties:** Free standing films were made by solvent casting of the paint compositions on glass plate using film applicator. The tensile strength and elongation at break were determined by using ASTM Method D2370. The specimens were cut in the form of strips and fixed between the grips of universal testing machine. The specimens were strained at a rate of 20 mm/min. An average of five readings were taken.

**Adhesive Strength:** Adhesive strength of the samples was measured by using a universal testing machine (Instron, Model No. 1123). Chromic acid etched aluminum alloy test cylinders were glued coaxially on both sides of the painted panel, using epoxy (GY 250/HY 848, M/s Ciba-Geigy, India), and allowed to cure for seven days at ambient temperature. The test was performed by pulling apart the glued cylinders in opposite directions. The force at which the cylinder was detached from the paint surface was taken as the adhesive strength.

**Determination of Leaching Rate:** The leaching rate apparatus consisted of an assembly of 12 vertically rotating shafts (60 rmp) each provided with a clamp. The experimental panels in triplicate were fixed to the shafts and immersed in 500 ml of sodium glycinate solution/sea water. Leachate was replaced with fresh sodium glycinate solution/sea water at the end of every eight hours for accelerated leaching and every 10 days for normal leaching.

### Estimation of Copper

**Accelerated Leaching:** 25 ml of leachate was taken in 50 ml of volumetric flask and the volume was made up by adding sodium glycinate solution. Two milliliters of this solution was transferred to a quartz cell. The optical density was measured by using UV/VIS Spectrophotometer (Spectronic 710) at 660 nm. Copper concentration was determined by matching the optical density with a standard curve which was obtained by using copper solutions of known concentrations.

**Leaching in Sea Water:** The estimation of copper was done by using the method of Jedlinski et al.<sup>28</sup> To 50 ml of leachate, 10 ml 20% citric acid, 10 ml 6N ammonia solution, 2 ml 0.1% aqueous sodium dithiocarbamate solution were added sequentially. The yellow complex formed was extracted three times with 10 ml carbon tetrachloride and the volume was made up to 50 ml. The optical density of the solution was measured at 435 nm

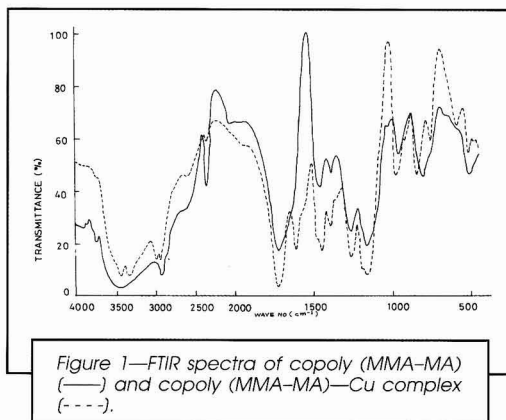


Figure 1—FTIR spectra of copoly (MMA-MA) (—) and copoly (MMA-MA)—Cu complex (---).

using UV/VIS spectrophotometer. The concentration was calculated by using the method previously mentioned.

## RESULT AND DISCUSSION

**Composition:** Copper complexes obtained were found to be insoluble. The amount of copper in the complex was estimated by using gravimetric, volumetric, and atomic absorption spectroscopic methods, respectively. The amount of copper was found to be the same by all the methods. Table 1 shows the proportion of copper and carboxyl in the complexes as a function of carboxyl con-

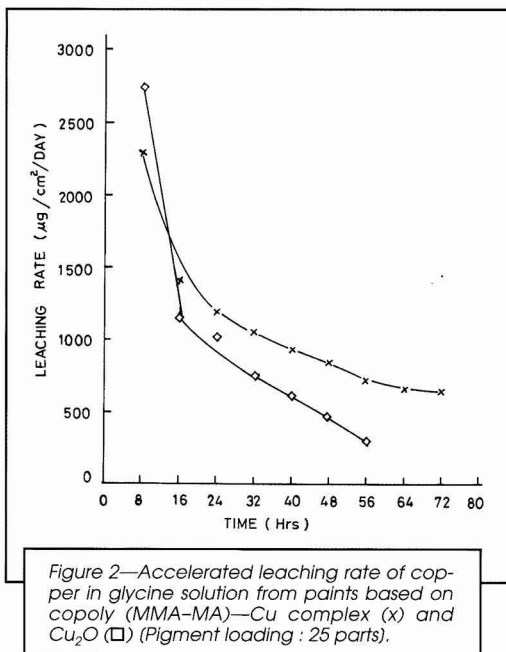


Figure 2—Accelerated leaching rate of copper in glycine solution from paints based on copoly (MMA-MA)—Cu complex (x) and  $\text{Cu}_2\text{O}$  (□) (Pigment loading : 25 parts).

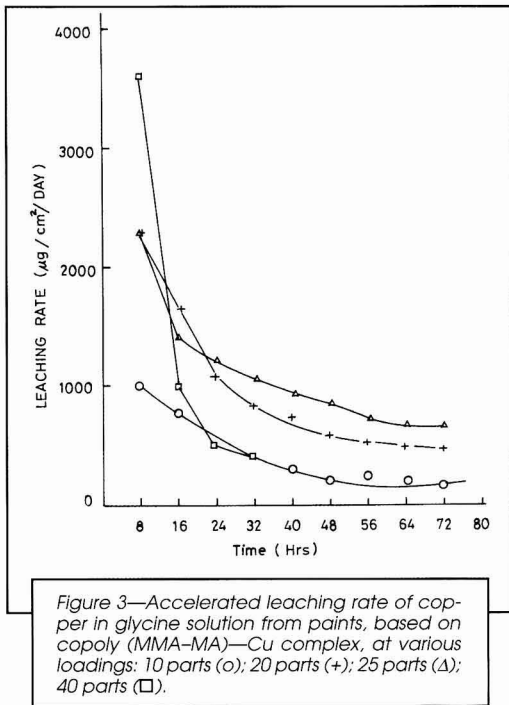


Figure 3—Accelerated leaching rate of copper in glycine solution from paints, based on copoly (MMA-MA)—Cu complex, at various loadings: 10 parts (o); 20 parts (+); 25 parts ( $\Delta$ ); 40 parts ( $\square$ ).

Table 3—Variation of COOH : Cu Ratio with Copolymer Composition

Copoly (MMA-MA) MMA : MA (mole ratio)	Copoly (MMA-MA)—Cu complex COOH : CU (mole ratio)
90 : 10	5.6
80 : 20	2.8
70 : 30	2.3
60 : 40	2.3
50 : 50	2.8
0 : 100	4.0

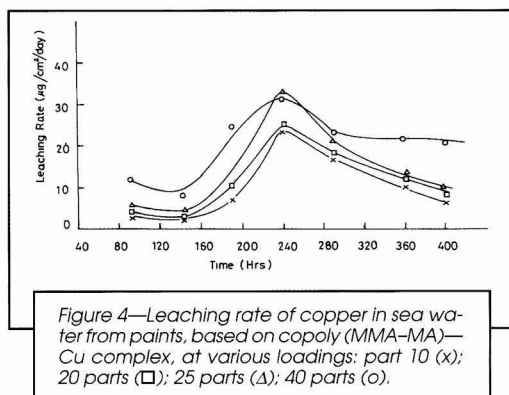


Figure 4—Leaching rate of copper in sea water from paints, based on copoly (MMA-MA)—Cu complex, at various loadings: part 10 (x); 20 parts ( $\square$ ); 25 parts ( $\Delta$ ); 40 parts (o).

tent, i.e., methacrylic acid unit in the copolymer. As expected, the amount of copper increases with carboxyl content. It can be seen that COOH : Cu ratio decreases from 5.6 to 2.8 as the carboxyl content increases from 10 to 20 mole percent. Thereafter, the ratio remains constant around 2.5 up to 50 mole percent and increases to 4 at 100 mole percent of carboxyl group, i.e., in the case of poly(methacrylic acid). It has been reported that for polymers containing carboxyl side groups, the ratio lies in the range of 2 to 4.<sup>29,30</sup> In the present study, the very low value 5.6 obtained at 10 mole percent of carboxyl may be attributed to incomplete complex formation. Copoly (MMA-MA) has limited solubility at 10 mole percent of MA. During complex formation there may be premature precipitation leading to incomplete reaction and thus a very high COOH : CU ratio is obtained.

**Infrared Spectra:** Representative Infrared spectra of copoly(MMA-MA) and copoly(MMA-MA)—Cu complex are shown in Figure 1. A broad peak around 1723  $\text{cm}^{-1}$  having a shoulder around 1660  $\text{cm}^{-1}$  in the copolymer indicate the presence of ester and carboxyl group, respectively. The shoulder disappears and the ester peak shifts to 1728  $\text{cm}^{-1}$  in the complex. This indicates the complex formation between carboxyl and copper. The broadness of the peak around 3300  $\text{cm}^{-1}$  decreases after formation of the complex. This can be attributed to the lowering of the extent of hydrogen bonding. It is also observed that the peaks at 1457  $\text{cm}^{-1}$  and at 1263  $\text{cm}^{-1}$ , assigned to stretching vibration of C—O, are shifted to 1446  $\text{cm}^{-1}$  and 1259  $\text{cm}^{-1}$ , respectively. A new peak appearing at 1624  $\text{cm}^{-1}$  is attributed to ionized carboxyl group.

**Mechanical Properties of Paint Films:** All the paint compositions are based on chlorinated rubber resin, water-soluble rosin, and copoly(MMA-MA)—Cu complex (50 mole percent MA) as pigment.

**Tensile Strength:** Table 4 shows the ultimate tensile strength and percent elongation at break. It can be seen that the tensile strength increases up to 35 pigment volume concentration (PVC). However, a decreasing trend is observed beyond this pigment loading. Increase of loading of hard pigment increases the tensile strength due to reinforcing effect. The elongation, as expected, follows the reverse trend. The decrease of tensile strength beyond 35 PVC can be attributed to the insufficient covering of the pigment particles resulting in imperfect films. This result suggests that the critical pigment volume concentration (CPVC) lies at 35%. The maximum tensile strength was found to be 0.578  $\text{kg}/\text{cm}^2$ . Attempts have been made to find out tensile strength of the paints based on vinyl resin (U.S. Navy formulations)<sup>32</sup> and chlorinated rubber.<sup>32</sup> The PVC maintained in the former was 95.7% and that in the latter was 28%. It was not possible to obtain free standing film. Therefore, no tensile data is available for these paints. However, the tensile strength of organotin based antifouling paint<sup>4</sup> was found to be 22.2  $\text{kg}/\text{cm}^2$ . The system is altogether different and the high strength is originated from the resin itself.

**Adhesive Strength:** Table 5 lists the adhesive strength of the paint films at various PVC. It is observed that the

adhesive strength increases with pigment loading up to 35 PVC and a reversal is observed after that. The result again indicates that CPVC is around 35%. The maximum adhesive strength was found to be 44 kg/cm<sup>2</sup>. The adhesive strengths of standard paints described were also measured and found to be lower than this value. The value for both vinyl resin-based and chlorinated rubber-based paints is 19.5 kg/cm<sup>2</sup>.

**Accelerated Leaching:** Leaching behavior under accelerated condition was studied by rotating the painted panels in glycine solution. Copper gradually dissolves in glycine forming copper glycinate complex. Figure 2 shows the comparative leaching behavior of copper from cuprous oxide (Cu<sub>2</sub>O) and copoly(MMA-MA)-Cu complex based paints, respectively. The paint formulation of Cu<sub>2</sub>O based paint is given in Table 2 (Composition No. 5). Loading of pigment was kept identical in both systems. However, the percentage of copper in Cu<sub>2</sub>O is 87% as compared with 13% in complex. It can be seen that leaching from complex-based paint is slower than Cu<sub>2</sub>O-based paint. A slow and near-steady behavior is observed at the later part of leaching of complex based paint whereas a faster leaching is observed throughout in the case of Cu<sub>2</sub>O based paint. It has been observed that the near-steady leaching rate increases with loading. These phenomenon can be explained by the fact that the leaching of copper from the complex occurs by breaking of the complex which is followed by the dissolution of copper. So a rate controlling step, i.e., breaking of complex, is involved in the process. The same is not true for Cu<sub>2</sub>O based paint. Leaching behavior of antifouling paint, based on Cu<sub>2</sub>O has been reported by De et al.<sup>33</sup> It has been observed that the leaching rate remains much higher than the threshold value (Accelerated : 650 µg/cm<sup>2</sup>/day) for a considerable period. This indicates unnecessary loss of toxin. The leaching from complex is controlled to some extent and a low copper content can extend the effective leaching for a longer period. This also decreases the unnecessary loss of toxin and can extend the antifouling life for a longer period. In essence, this will reduce the toxic burden to the flora and fauna of the sea.

Plots of accelerated leaching rate, at various loading, as a function of time are shown in Figure 3. It can be seen that the leaching rates are very high at the initial phase. However, the leaching at 10-25 parts loading becomes slower after about 40 hrs. Initial high value may be due to leaching from surface. Subsequently, the leaching occurs via diffusion of medium into the matrix, breaking of complex and dissolution of copper. The leaching au-

**Table 5—Variation of Adhesion Strength with Pigment Volume Concentration for Copoly (MMA-MA)—Cu Based Paints on Mild Steel Substrate**

Pigment Volume Concentration (%)	Adhesion Strength kg/cm <sup>2</sup>
20 .....	15
25 .....	28
30 .....	35
35 .....	44
40 .....	43
45 .....	26
50 .....	21

tomatically becomes diffusion controlled and hence slower. As expected, the leaching rate increases with loading. The leaching behavior at 40 parts loading is somewhat different from others; the initial high rate is followed by rapid fall commencing after 32 hr.

**Leaching in Sea Water:** Leaching behavior of the paint systems, under actual conditions, i.e., in sea water, was also studied. Figure 4 shows the plot of leaching rate, at various copoly(MMA-MA)-Cu complex loading, as a function of time. It is observed that initial leaching rate is low. A slight decrease is observed up to 143 hrs. Further, it increases to maximum at 240 hrs and declines steadily after that. The initial decrease probably indicates the onset of diffusion/dissolution phenomenon. As the diffusion/dissolution continues the rate increases until it reaches a point when the total complex available for leaching starts declining. The steadier leaching observed at the later stage of leaching may be attributed to attainment of semi-equilibrium stage. In the 40 parts loading case, the leaching at the end is quite slow and steady. At the same time it is maintaining a leaching rate which is higher than the threshold value. It has already been observed that CPVC is around 35% pigment loading. Therefore, the high leaching rate may be attributed partly to imperfect paint film. On the other hand, it is observed that at 25 parts loading, the near-steady leaching is maintained around threshold value. However, initial rate is lower than the threshold value. It seems that a loading around CPVC will be most ideal in respect of leaching rate as well as mechanical strength.

**CONCLUSION**

Antifouling paint compositions were made using copoly(MMA-MA)-Cu complex as pigment. Critical pigment volume concentration (CPVC) was found to be around 35% pigment loading. Complex-based paint exhibits slower and steadier leaching compared to Cu<sub>2</sub>O-based paint. At identical concentration of copper, the former continues effective leaching for a longer duration. Under accelerated condition, the leaching rate increases with pigment (copper complex) loading. Initial faster leaching is followed by slower and steadier leaching.

Leaching in sea water shows a small dip at the initial phase followed by rapid increase. However, after the maximum is attained, the leaching rate decreases and exhibits near steady leaching.

**Table 4—Variation of Tensile Properties with Pigment Volume Concentration for copoly (MMA-MA)—Cu Complex Based Films**

Pigment Volume Concentration (%)	Tensile Strength kg/cm <sup>2</sup>	Elongation (%)
25 .....	0.542	10.6
30 .....	0.546	8.6
35 .....	0.578	5.3
40 .....	0.384	3.3
45 .....	0.347	2.0
50 .....	0.194	0.9

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# Unifying Model for Understanding HEUR Associative Thickener Influences on Waterborne Coatings: I. HEUR Interactions with a Small Particle Latex

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## INTRODUCTION

Associative thickeners are noted for their sensitivity to variations in formulations, and there are a variety of structurally undefined, commercial associative thickeners available for use in architectural and original equipment manufacturing (OEM) coating formulations. To date, studies have presented mechanisms of association that are unrealistic in a coating due to the high concentrations used in aqueous solution studies. The amounts of associative thickener used in a coating formulation are much lower. This study attempts to provide a more unified concept of the contribution of associative thickener in coatings by considering viscosity contributions from their self-association, the interaction of surfactants in the formulation with the thickener, and the interaction of the HEUR thickeners with the latex.

Our initial studies<sup>1,2</sup> were conducted with model Hydrophobically modified, Ethoxylated URethane (HEUR) polymers. This family of associative thickeners was chosen for it is the only family that allows well-defined models to be studied. They are prepared by the direct addition of a monoisocyanate, such as octadecylisocyanate to a polyether diol or by the reaction of a telechelic polyether diisocyanate with an alkyl amine or alcohol. The thickeners prepared by either of these procedures are referred to as uniHEURs. Our study also will include both uniHEURs and HEURs prepared by a step-growth (S-G HEUR) polymerization,<sup>3</sup> the type used commercially. The influence of the synthesis procedures on the solution properties of both types of thickeners are reviewed in chapter 10 of reference (4).

The concentrations used in these previous aqueous solution studies are well above those used in coating formulations, and in general, the amount of surfactant present in a coating formulation is not at a concentration that would promote an optimum viscosity maximum [chapter 17 in reference (4)]. In addition to any viscosity contribution, the HEUR associative thickeners also serve

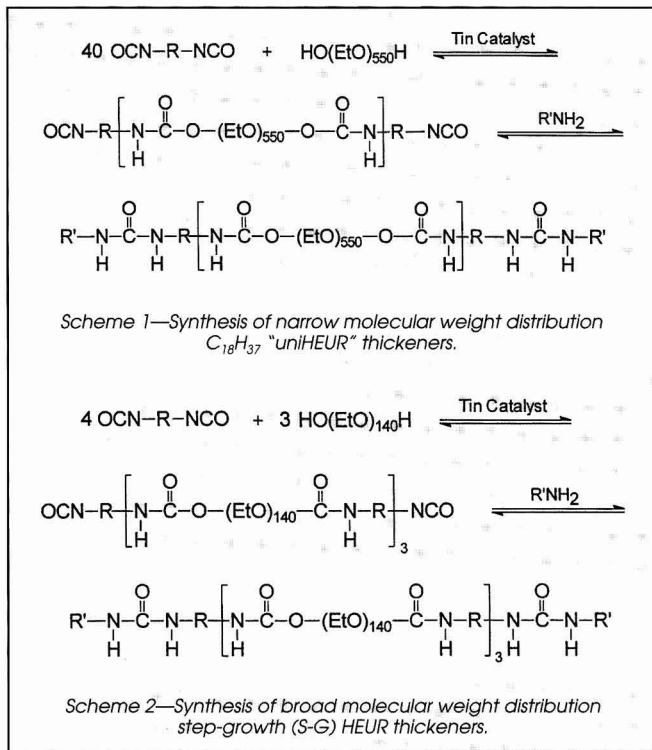
*The structural features of associative thickeners influence their viscosifying properties in neat and surfactant containing aqueous solutions and in architectural coating formulations. Our understanding of the phenomena based on model associative thickener of the Hydrophobically modified Ethoxylate URethane (HEUR) type are presented. These studies provide general concepts in aqueous solutions, but they do not provide a quantitative model for understanding the influence of associative thickeners in coating formulations. To provide a more quantitative description, the interactions of associative thickeners with the film forming latex are considered in this study. This requires a knowledge of the free surfactant concentration in the formulation that depends on the residual amount present in the latex and the amounts added with the pigment grind, colorant, etc. The competitive interaction of the surfactants and associative thickener types for the surface of both disperse phases is a key variable. These interactions with the latex will be discussed in this article in an effort to define an encompassing model for understanding how HEUR associative thickeners influence waterborne coatings.*

to increase the stability of the disperse phases (i.e., titanium dioxide (TiO<sub>2</sub>) and the latex), and these disperse phases contribute to the dispersion's viscosity through their "increased" volume fraction.<sup>5,6</sup> The objectives of

\*Presented at 69th Annual Meeting of Federation of Societies for Coatings Technology, on October 23, 1996, in Chicago, IL.

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the current study examine how the adsorption of the HEURs on the latex influences their rheology in the presence of surfactants. A key parameter in this study is the role of the free surfactant in the coating formulation.

## EXPERIMENTAL

The materials used in these studies and procedures for measuring adsorption, individually and competitively, have been described previously.<sup>5</sup> Procedures used in rheological measurements and in formulating pigment grinds, latex dispersions, and coatings formulations also have been described.<sup>1,3,7</sup>

## RESULTS AND DISCUSSIONS

In traditional cellulose ether thickened latex coatings, there is a competition for waters of hydration among the surfaces of  $\text{TiO}_2$ , the latex, and the thickener. In the depletion flocculation<sup>8,9</sup> concept the competition is compromised by liberation of water from and flocculation of the disperse phases, if they are not properly stabilized. Replacement of the cellulose ether thickeners with surfactant-modified, water-soluble polymers (W-SPs) provides a means for stabilization through adsorption of the thickener's hydrophobes on the disperse phases with displacement of or participation with the adsorbed, con-

ventional surfactants. In addition to stabilizing the disperse phase, an association of the surfactant-modified W-SP with the disperse phases could influence dispersion rheology.

For significant adsorption to occur on the latex, the concentration of the conventional surfactants (arising from the residual amounts left from the latex synthesis and from that added to the pigment grind) should be relatively low. It also requires that the hydrophobes of the associative thickener be equivalent or larger in size than the hydrophobes of these conventional surfactants.

### Adsorption on Small Particle Latexes

Both surfactants and HEUR thickeners will adsorb on a latex surface; it is a simple hydrophobic interaction between the surface of the latex and the hydrophobes of the surfactant or the thickener. It would be truly simple if the latexes were not complex. To achieve stability to salinity gradients in urban water supplies and to mechanical and thermal variations, latexes are synthesized with oligomeric acids or polymer fragments grafted to their surfaces.<sup>10</sup> These surface structures influence the amount of surfactant and associative thickener adsorbed. In addition, latexes, unlike  $\text{TiO}_2$ , are synthesized in various median particle sizes and particle size distributions, and latexes are often blended to obtain bi- and multimodal particle size distributions. For simplicity, our adsorption studies will be restricted to a small monodisperse, methyl methacrylate latex, with  $1.418 \times 10^{-3}$  meq/m<sup>2</sup> of methacrylic acid on the latex's surface, which in most of the studies to follow, was dialyzed free of the synthesis surfactant.

If a uniHEUR (Scheme 1) with large terminal hydrophobes is added to the model 121 nm, dialyzed latex, the adsorbed HEUR layer enlargement of the latex's effective volume fraction can be quantified. In this dialyzed latex, stabilized by the ionized oligomeric methacrylic acid segments, the influence of the uniHEUR on the viscosity with increasing latex volume fraction is evident (Figure 1), and Kreiger's dimensionless parameter approach<sup>11</sup> could be used to calculate the effective volume fraction increase due to the adsorption of the uniHEUR. This approach, however, would not really relate to the meaningful use of associative thickener in higher quality latex coating. The uniHEUR with  $\text{C}_{18}\text{H}_{37}$  hydrophobes is very efficient in viscosifying latex coatings, and the formulations are very shear thinning (Figure 2). It is more appropriate to use a smaller hydrophobe S-G HEURs, synthesized by a slightly different approach (Scheme 2).

The general adsorption behavior of S-G HEURs on model MMA latexes with surface acids is illustrated in

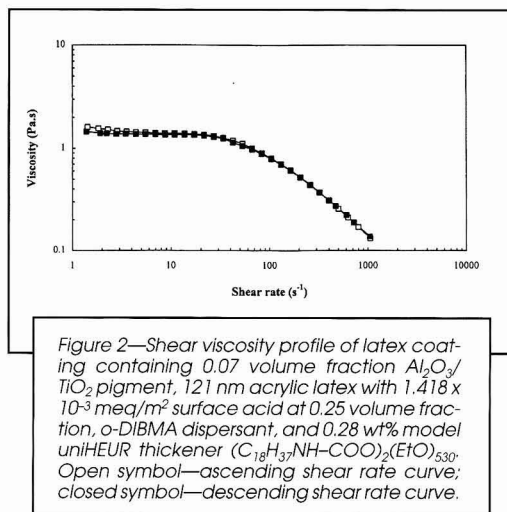
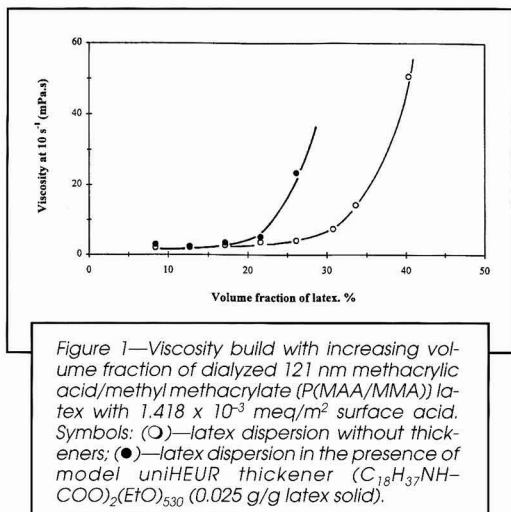


Figure 3. The adsorption of the thickeners containing small terminal hydrophobes follows a Langmuir adsorption isotherm (from a pH = 9.3 medium). As the terminal size of the S-G HEUR is increased, the adsorption behavior follows a more complex profile suggesting multilayer adsorption.

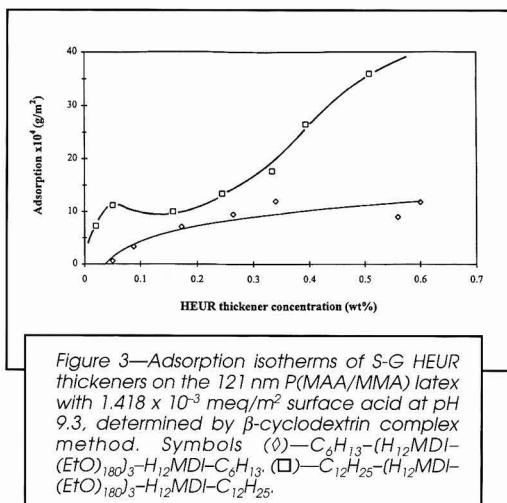
Commercial latexes are not dialyzed free of the synthesis surfactant, and in formulating a coating, nonionic surfactant is added with the pigment. Prior studies have shown that 1.0 wt% sodium dodecyl sulfate (SDS) will displace an S-G HEUR from the surface of a 140 nm acrylic latex<sup>12</sup>; however, SDS generally introduced with a colorant may not be the dominant surfactant in a coating formulation. An ethoxylated anionic surfactant (i.e.,  $C_6H_{19}-C_6H_4-O(EtO)_{20}SO_3NH_4$ ) is the surfactant we have used in synthesizing monodisperse methacrylate latexes. In the coating formulations that we have used, an ethoxylated, nonionic surfactant added to the pigment grind has been the dominant surfactant, and our emphasis has been on the competition of the terminal hydrophobes of the S-G HEURs and the hydrophobes of the nonionic surfactant for the latex surface. The chemical compositions of the surfactant and HEUR thickeners are very close; this makes quantification of the adsorbed species difficult. The aromatic unit in  $C_8H_{17}-C_6H_4O(EtO)_{10}H$  permits quantification of the nonionic surfactant distribution in the aqueous phase; therefore, the dialyzed latex is titrated with the surfactant at a given thickener concentration. If the hydrophobes of the thickener are competitive with the surfactant, the adsorption density of the surfactant from the UV analysis will be less, and it is these types of studies reported in the following.

With increasing surfactant concentration, the HEUR thickener is displaced from the surface of the latex if there are no terminal hydrophobes (e.g., polyethylene glycol) or if they are small (Figure 4). This occurs at a relatively low surfactant concentration for HEURs with small terminal hydrophobes, but this displacement is

only partial when the hydrophobe is large. In the latter case, the adsorption of the model uniHEURs on the latexes is noted to decrease the zeta potential of the latex. The stability of these dispersions is increased, despite the drop in electrical charge, due to the stability arising from the osmotic stabilization of the latex. This is a plus in media of increasing salinity. With these results in mind, we will turn to the rheology of such dispersions.

### Rheology of Thickened Dispersions

The viscosity of a coating could be increased by increasing the volume fraction of the latex and  $TiO_2$ . With a soft, film-forming latex this would be courting disaster. Nevertheless, there is little question that the major viscosity contribution in a coating formulation



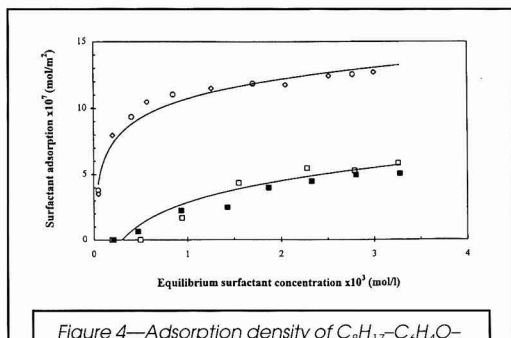


Figure 4—Adsorption density of  $C_6H_{17}-C_6H_4O-(EtO)_{10}H$  on a 121 nm P(MAA/MMA) latex with  $1.418 \times 10^{-3}$  meq/m<sup>2</sup> surface acid in the presence of S-G and uniHEUR associative thickeners with  $H_{12}MDI$  internal hydrophobes at pH 9.3 using a cyclodextrin complex method. (O)—without thickener; (□)—0.4 wt%  $C_6H_{13}-(H_{12}MDI-(EtO)_{14O})_3-H_{12}MDI-C_6H_{13}$ ; (□)—0.4 wt%  $C_{12}H_{25}-(H_{12}MDI-(EtO)_{14O})_3-H_{12}MDI-C_{12}H_{25}$ ; (■)—0.4 wt%  $(C_{18}H_{37}NH-COO)_2(EtO)_{180}$ .

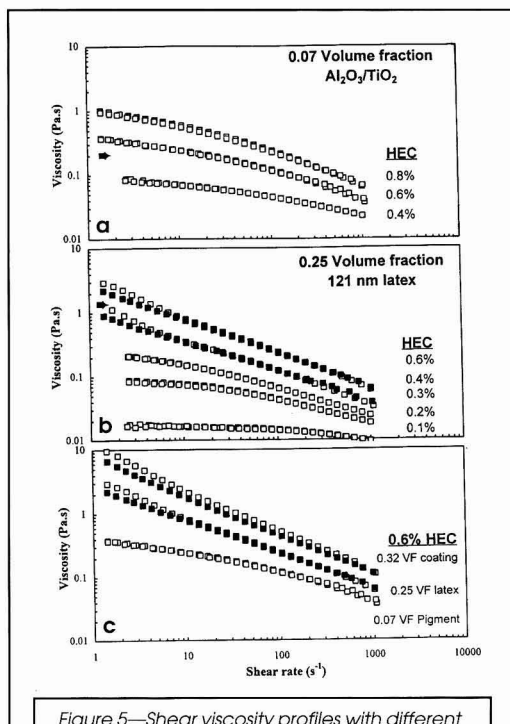


Figure 5—Shear viscosity profiles with different hydroxyethyl cellulose (HEC) concentrations: (a)—In a pigment dispersion (b)—Latex dispersion (c)—Coating formulation. Arrow indicates location of viscosity profile in 90 KU. Open symbol—ascending shear rate curve; closed symbol—descending shear rate curve.

comes from the volume fraction contribution of the latex and  $TiO_2$ . The volume fraction one assumes when preparing a formulation is not the same as the actual volume fraction in the formulation due to the hydration of the disperse phases. For example, a latex formulation at the 0.32 volume fraction with a 5 nm hydration layer is effectively at a volume fraction of 0.42 for a 100 nm latex, and 0.36 for a 220 nm latex.<sup>6</sup> This is one of the reasons that small particle latexes require less water-soluble polymer as thickener to achieve a given KU viscosity. Even if an increase in the volume fraction achieved a given viscosity, without mass flocculation of the disperse components, it would not provide the viscosity profile necessary over the shear rate range approximating formulation, storage, and application. This is most economically done with a water-soluble polymer.

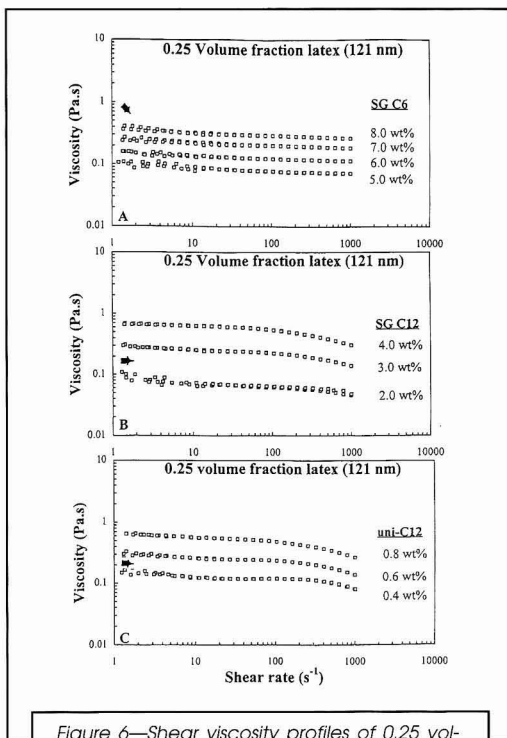


Figure 6—Shear viscosity profiles of 0.25 volume fraction 121 nm P(MAA/MMA) latex with  $1.418 \times 10^{-3}$  meq/m<sup>2</sup> surface acid (containing 0.86 wt% EP-115 ( $C_9H_{19}-C_6H_4-O(EtO)_{20}SO_3NH_2$ )) and 0.07 volume fraction pigment dispersion with model HEUR thickeners. Arrow indicates location of viscosity profile for 90 KU. (a)—( $C_6$ -SG HEUR):  $C_6H_{13}-(H_{12}MDI-(EtO)_{14O})_3-H_{12}MDI-C_6H_{13}$  (b)—( $C_{12}$ -SG HEUR):  $C_{12}H_{25}-(H_{12}MDI-(EtO)_{14O})_3-H_{12}MDI-C_{12}H_{25}$  (c)—( $C_{12}$ -uniHEUR):  $C_{12}H_{25}-(H_{12}MDI-(EtO)_{550}-H_{12}MDI)-C_{12}H_{25}$

The viscosities of model HEURs, most commercial associative thickeners, and hydroxyethyl cellulose solutions are Newtonian or nearly so over a broad shear rate range at moderate concentrations. Slurries of  $\text{TiO}_2$  or the latex, at the volume fractions used in coating formulations, are Newtonian in flow; however, when the thickeners and the disperse phases are blended together in a coating, the formulation can be markedly non-Newtonian. Our approach to understanding the complexities in a coating formulation is to examine the rheology of the disperse phases, individually and together, in the presence of the thickener, and in the presence of surfactants. The thickeners studied in the following discussion include HEC, two S-G HEURs, and a uniHEUR mentioned previously and in reference (4).

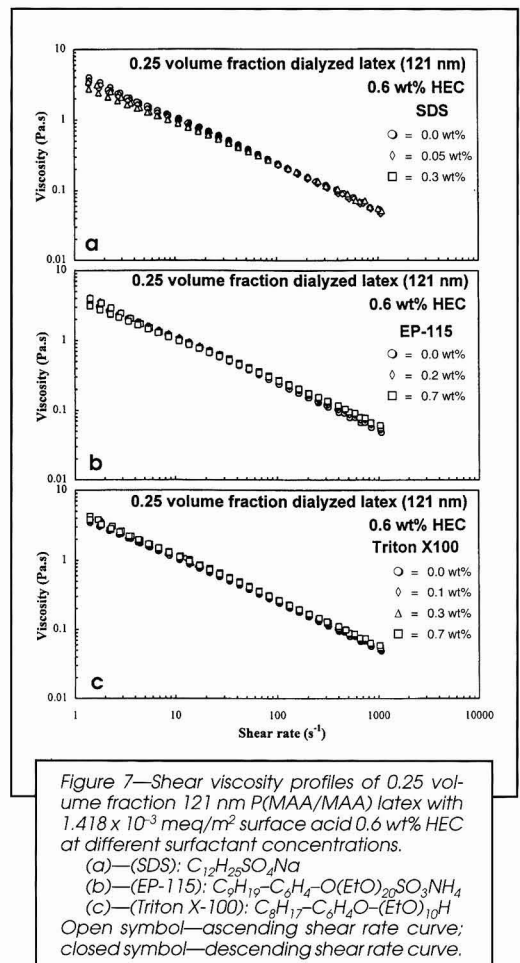
The pigment and latex volume fraction in a coating is generally 0.07 and 0.25, respectively. At this level with a 121 nm latex, the effective volume fraction of the latex is ca. 0.32, and significant shear viscosity increases, with thixotropy in the case of the latex, are observed at low shear rate viscosities at HEC concentrations below that required to thicken the formulation of 90 KU (Figures 5a-b). Clearly, depletion flocculation of the latex is the primary source of the extreme shear thinning in HEC thickened formulations. An excess of surfactant is required in the synthesis of a 121 nm latex, and it was not removed by dialysis in this initial study. The relative viscosity profiles of an HEC thickened 0.07 V.F.  $\text{TiO}_2$  slurry, of an HEC thickened, 0.25 V.F. 121 nm latex, and of an HEC thickened architectural coating formulation containing 0.07 V.F.  $\text{TiO}_2$  and 0.25 latex are illustrated in Figure 5c. Clearly, the individual viscosity of the coating is not a sum of the two thickened disperse phases. The higher viscosities at low shear rates are due to the additional "effective" increase in volume fraction, due to the inclusion of the aqueous phase in the depletion flocculated disperse phases in the higher solids (0.32 V.F.) formulation.

The three HEUR thickeners were also added to the latex, before dialysis, and all exhibited Newtonian flow, irrespective of the amount of HEUR used (Figures 6a-c). Significantly more of the  $\text{C}_{12}\text{H}_{25}\text{-SG-HEUR}$  is required (2.5 wt%) to thicken the formulation to a 90 KU than is required of the uniHEUR (0.5 wt%). This would be expected since the spectrum of products in a step-growth HEUR (i.e., ca. 20% of the polyethylene glycol PEG) remains unreacted and a significant amount is hydrophobe-modified, but unextended PEG are part of the synthetic mixture [chapters 10 and 17 in reference (4)]. Decreasing the terminal hydrophobe size to  $\text{C}_6\text{H}_{13}$  in the SG-HEUR also decreases the thickening efficiency and 8.0 wt% of this thickener is required to formulate a 90 KU, 121 nm latex coating.

In the next series of studies, the synthesis surfactant was removed from the latex and incremental amounts of  $\text{C}_{12}\text{H}_{25}\text{SO}_4\text{Na}$ ,  $\text{C}_9\text{H}_{19}\text{-C}_6\text{H}_4\text{-O(EtO)}_{20}\text{SO}_3\text{NH}_4$  and  $\text{C}_8\text{H}_{17}\text{-C}_6\text{H}_4\text{O(EtO)}_{10}\text{H}$  were added to simulate the type of surfactant that might be present in a coating as a result of addition of a colorant, the pigment grind or remaining from the synthesis of the latex. The concentrations of the surfactant added back to the dialyzed latex dispersion approximates the range that would be used in a latex

coating. In the surfactant addition studies, the amount of thickener used approximates that added to achieve a formulation 90 KU viscosity. None of the three different surfactants influenced the rheology of the HEC thickened 121 nm latex (Figure 7) significantly, as was expected for the non-associating HEC thickener.

The HEURs also were added to the dialyzed 121 nm latex stabilized by the oligomeric surface acids. In the absence of surfactant, the HEUR thickeners will adsorb on the surface of the latex similar to the low volume solids data illustrated in Figure 3. With an increase in the effective volume solids, due to the adsorption, the viscosity of the dispersion will increase, as demonstrated in Figure 1. With the small hydrophobe SG-HEUR, the large amount of thickener required to obtain a 90 KU formulation viscosity, and weak hydrophobic association of the thickener would be expected to promote interparticle bridging.<sup>13</sup> This would explain the thixotropy in this formulation (Figure 8a) and higher viscosities at low





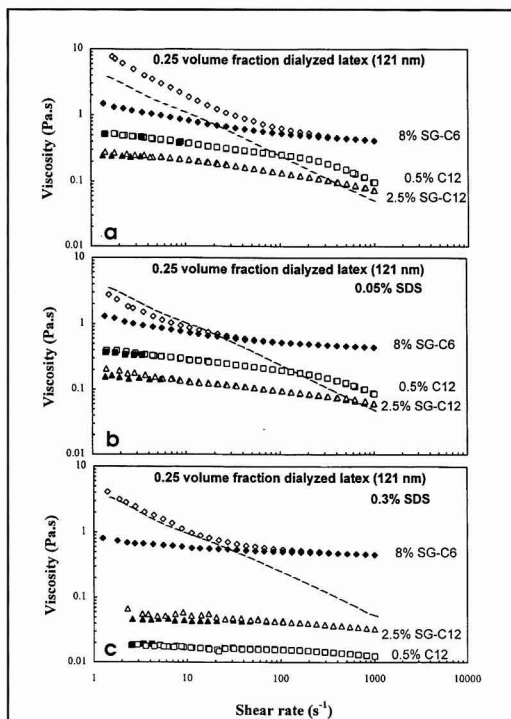


Figure 8—Shear viscosity profiles of 0.25 volume fraction 121 nm P(MAA/MMA) latex with  $1.418 \times 10^{-3}$  meq/m<sup>2</sup> surface acid with model HEUR thickeners at different SDS ( $C_{12}H_{25}SO_4Na$ ) concentrations. The dashed line represents the corresponding HEC thickened latex. ( $C_6$ -S-G HEUR):  $C_6H_3$ -( $H_{12}$ MDI-( $EtO$ )<sub>140</sub>)<sub>3</sub>- $H_{12}$ MDI- $C_6H_{13}$ ; ( $C_{12}$ -S-G HEUR):  $C_{12}H_{25}$ -( $H_{12}$ MDI-( $EtO$ )<sub>140</sub>)<sub>3</sub>- $H_{12}$ MDI- $C_{12}H_{25}$ ; ( $C_{12}$ -uniHEUR):  $C_{12}H_{25}$ -( $H_{12}$ MDI- $EtO$ )<sub>550</sub>- $H_{12}$ MDI)- $C_{12}H_{25}$ .  
 (a)—No SDS  
 (b)—0.05% SDS  
 (c)—0.3% SDS

shear rates than observed in the depletion flocculation (HEC thickened) dispersion; however, the addition of the hard surfactant, SDS, does not notably influence latex rheology (Figures 8b-c) with this high HEUR loading.

With SDS addition, the viscosities drop dramatically (Figures 8b-c) in the larger  $C_{12}H_{25}$ -HEURs thickened latex dispersions. In a previous study,<sup>12</sup> the addition of 0.5 wt% SDS resulted in complete displacement of a  $C_{10}H_{21}$ -HEUR from a similar size acrylic latex. In our latex, partially covered with methacrylic acid surface segments, the  $C_{12}H_{25}$ -HEURs also would be displaced completely from the surface of the latex. With the addition of 0.3 wt% SDS, the viscosity has fallen dramatically, except for the smaller hydrophobe HEUR thickened latex, at all shear rates. At this SDS concentration (slightly over one critical micelle concentration, CMC), there is no contri-

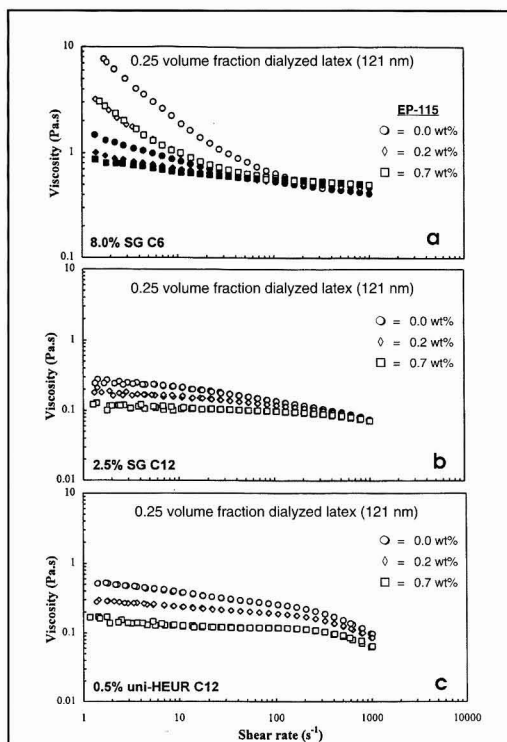


Figure 9—Shear viscosity profiles of 0.25 volume fraction 121 nm P(MAA/MMA) latex with  $1.418 \times 10^{-3}$  meq/m<sup>2</sup> surface acid with model EP-115 ( $C_6H_{19}$ - $C_6H_4O$ -( $EtO$ )<sub>20</sub> $SO_3NH_4$ ) concentrations.  
 (a)—8.0% ( $C_6$ -SG HEUR):  $C_6H_{13}$ -( $H_{12}$ MDI-( $EtO$ )<sub>140</sub>)<sub>3</sub>- $H_{12}$ MDI- $C_6H_{13}$   
 (b)—2.5% ( $C_{12}$ -SG HEUR):  $C_{12}H_{25}$ -( $H_{12}$ MDI-( $EtO$ )<sub>140</sub>)<sub>3</sub>- $H_{12}$ MDI- $C_{12}H_{25}$   
 (c)—0.5% ( $C_{12}$ -uniHEUR):  $C_{12}H_{25}$ -( $H_{12}$ MDI-( $EtO$ )<sub>550</sub>- $H_{12}$ MDI)- $C_{12}H_{25}$   
 Open symbol—ascending shear rate curve;  
 closed symbol—descending shear rate curve.

bution to viscosity that is attributable to surfactant/HEUR interactions and all of the HEUR has been displaced from the surface of the latex. The viscosities (Figure 8c) are due to the volume fraction of the latex and the volume fraction of the thickener, determined in the absence of hydrophobic interactions, by the molecular weight and the amount of thickener added.

The surfactant present in the highest wt% in a coating is the nonionic surfactant added to the pigment grind. Adding this surfactant in greater amounts does not influence the rheology of the HEC thickened latex (Figure 7c), but the influence is notably different from SDS with the  $C_{12}H_{25}$ -HEURs. This is best illustrated by examining the surfactant concentration influences, collectively, with each individual HEUR thickener (Figures 9 and 10).

The surfactant,  $C_6H_{19}-C_6H_4-O(EtO)_{20}SO_3NH_4$ , added to the HEURs in Figure 9 is of intermediate hardness. With the smaller hydrophobe HEUR, the variations in rheology with surfactant addition are not dramatically different from those noted with SDS additions. With the larger  $C_{12}H_{25}$ -HEURs, the viscosity decreases are not as large at the higher surfactant concentrations, as were noted in the SDS additions. However, the addition of the nonionic surfactant,  $C_8H_{17}-C_6H_4O(EtO)_{10}H$ , to the dialyzed latex containing the small  $C_6H_{13}$ -terminal hydrophobe S-G HEUR (Figure 10a) dramatically decreases the viscosity at low shear rates and eliminates the dispersion's thixotropy. At 0.7 wt%  $C_8H_{17}-C_6H_4O(EtO)_{10}H$ , the viscosity has dropped, not quite to the level reached with the addition of 0.3 wt% SDS, but unlike SDS, the thixotropy is absent with 0.7 wt% nonionic surfactant. The small  $C_6H_{13}$ -terminal hydrophobe S-G HEUR does not form strong associations. With the dialyzed latex stabilized with only the surface acid segments, adsorption of the  $C_6H_{13}$ -S-G HEUR will occur (Figure 3). The 8.0 wt% HEUR concentration used with surfactant addition is well above that legitimately used in adsorption studies, and multilayer adsorption could occur at 8.0 wt%. In any event the interactions with the latex surface are weak, as are hydrophobe interactions among the different HEUR chains. In the presence of even the nonionic surfactant the small hydrophobe HEUR is not adsorbed on the latex.

This is not true with the terminal  $C_{12}H_{25}$ -S-G HEUR and uniHEUR; they are not completely displaced from the latex surface with nonionic surfactant (Figure 4). The real distinction in these latex dispersions is the increase in viscosity with continued nonionic surfactant addition in both  $C_{12}H_{25}$ -HEUR thickened dispersions (Figures 10b-c). The nonionic surfactant does not displace all of the  $C_{12}H_{25}$ -HEURs from the latex surface, and the dispersions are not thixotropic. With SDS addition (Figures 8b-c), the viscosities decrease. The amount of  $C_8H_{17}-C_6H_4O(EtO)_{10}H$  used in our coating formulations is 0.65 wt%. This corresponds to 34 CMCs of surfactant relative to the 0.3 wt% SDS, that corresponds to 1.3 CMC. This high  $C_8H_{17}-C_6H_4O(EtO)_{10}H$  concentration, leading to higher viscosities, corresponds to the surfactant's micelle transformation from spheres to rods in the aqueous phase.

Based on the data in Figures 6 through 10, it is clear that the viscosities at higher shear rate ( $10^4 \text{ s}^{-1}$ ), important to hiding, are determined by the hydrodynamic volume contributions (related to the amount) of thickener, of a given MW, added to achieve a given KU formulation viscosity, just as it is in an HEC formulation.<sup>14</sup> In the  $C_6H_{13}$ -S-G HEUR thickened dispersion, this weakly associating HEUR is displaced (Figure 4 for data with  $C_8H_{17}-C_6H_4O(EtO)_{10}H$ ) from the surface of the latex. This is reflected in Figure 8 at an intermediate shear rate of  $20 \text{ s}^{-1}$  in SDS solutions and at  $200 \text{ s}^{-1}$  in  $C_8H_{17}-C_6H_4O(EtO)_{10}H$  (Figure 10) solutions. With lesser amounts of the larger  $C_{12}H_{25}$ -HEURs, SDS is effective in displacing both the S-G and uniHEURs from the surface of the latex, and significant viscosity decreases are observed (Figure 8). Given the other surfactants present in a coating formulation and their possible synergies with SDS, hard surfactants should be avoided in HEUR thickened

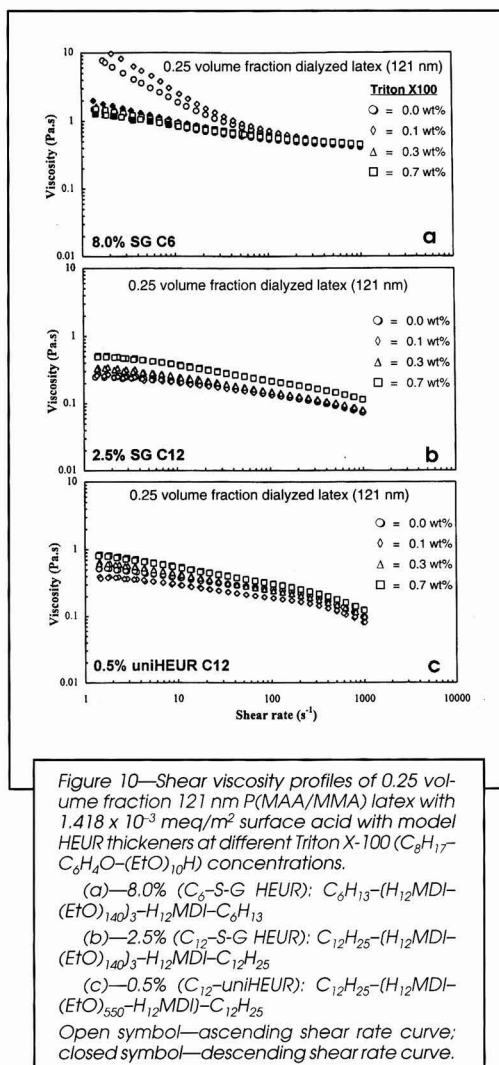


Figure 10—Shear viscosity profiles of 0.25 volume fraction 121 nm P(MAA/MMA) latex with  $1.418 \times 10^{-3} \text{ meq/m}^2$  surface acid with model HEUR thickeners at different Triton X-100 ( $C_8H_{17}-C_6H_4O-(EtO)_{10}H$ ) concentrations.

(a)—8.0% ( $C_6$ -S-G HEUR):  $C_6H_{13}-(H_{12}MDI-(EtO)_{140})_3-H_{12}MDI-C_6H_{13}$

(b)—2.5% ( $C_{12}$ -S-G HEUR):  $C_{12}H_{25}-(H_{12}MDI-(EtO)_{140})_3-H_{12}MDI-C_{12}H_{25}$

(c)—0.5% ( $C_{12}$ -uniHEUR):  $C_{12}H_{25}-(H_{12}MDI-(EtO)_{550}-H_{12}MDI)-C_{12}H_{25}$

Open symbol—ascending shear rate curve; closed symbol—descending shear rate curve.

coatings. With increasing softness of the surfactant, the dramatic viscosity decreases are reversed with  $C_{12}H_{25}$ -HEURs. At levels typically used in the nonionic formulation surfactant, the viscosity of the dispersions increase, due to the participation of the HEURs in the rod-shaped nonionic surfactant micelles, and to the retention of a significant amount of these larger hydrophobe HEURs on the latex surface in the presence of nonionic surfactants (Figure 4).

## CONCLUSIONS

To understand the influence of associative thickeners on the film properties and rheology of the formulation,

our studies have centered on the adsorption of Hydrophobically modified, Ethoxylated Urethane (HEUR) thickeners on the primary disperse phase components of a latex coating, the film forming binder, and the hiding pigment,  $\text{TiO}_2$ . The latter are discussed in Part II of this series. The data in this study are interpreted in terms of the interaction and displacement of HEURs from the latex surface by three types of surfactants found in a coating formulation, an anionic, an ethoxylated anionic, and a nonionic formulation surfactant.

It is clear that the viscosities at higher shear rate ( $10^4 \text{ s}^{-1}$ ), important to hiding, are determined by the hydrodynamic volume contributions (related to the amount of MW) of the thickener added to achieve a given KU formulation viscosity, just as it is in a HEC formulation. The examination of both Step-Growth HEUR and narrow molecular weight uniHEUR model thickeners revealed different sensitivities to the variety of surfactants in a latex coating. In the  $\text{C}_6\text{H}_{13}$ -S-G HEUR thickened dispersion, this weakly associating HEUR is displaced by the surfactants from the surface of the latex at an intermediate shear rate,  $20 \text{ s}^{-1}$  in SDS solutions;  $200 \text{ s}^{-1}$  in  $\text{C}_8\text{H}_{17}$ - $\text{C}_6\text{H}_4\text{O}(\text{EtO})_{10}\text{H}$  solutions. With lesser amounts of the larger  $\text{C}_{12}\text{H}_{25}$ -HEURs required to thicken latex dispersions, SDS is effective in displacing both the S-G and uniHEURs from the surface of an acrylic latex, and significant viscosity decreases are observed. Given the other surfactants present in a coating formulation and its possible synergy with SDS, hard surfactants should be avoided in HEUR thickened coatings. With increasing softness of the surfactant (i.e., transition from anionic to nonionic), dramatic viscosity decreases are reversed. At levels typically used for the nonionic formulation surfactant in a coating, the viscosity of the dispersions increase, due to the participation of the  $\text{C}_{12}\text{H}_{25}$ -HEURs in rod-shaped nonionic micelles, and retention of a significant fraction of the  $\text{C}_{12}\text{H}_{25}$ -HEURs on the latex's surface.

HEUR associative thickener influences on the rheology of latex coatings are complex, but the mechanisms are understandable based on structural differences of the products and an understanding of basic surface chemistry principles.

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# Self-Opacifying Aluminum Phosphate Particles for Paint Film Pigmentation

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## Introduction

Titanium dioxide is the most common white pigment due to its strong ability to backscatter visible light, which is in turn dependent on its refractive index.<sup>1</sup> Substitutes for titanium dioxide have been sought, but the refractive indexes of both the anatase and rutile forms of this oxide are much higher than those of any other white powder, for structural reasons.

Although many efforts to replace TiO<sub>2</sub> have been made, currently there is not a competitive replacement. Other solids (barite, kaoline, CaCO<sub>3</sub>) are used as extenders replacing part of the white pigment and aiming at the preservation of the optical properties of the finished products (paints, coatings, paper) but at significantly lower prices.

It is known that the inclusion of closed pores of sub-micrometric dimensions within film pigments causes an increase in their light scattering ability.<sup>2,3</sup> It was shown that the addition of microvoids offers greater hiding efficiency than does an increase in the prime pigment content within the film.<sup>4</sup>

A theoretical study on pigmented microvoid coatings was made by Kerker, Cooke, and Ross.<sup>5</sup> Models are presented for three void types: (1) voids within the pigment particles; (2) voids in between pigment particles and resin matrix; and (3) voids within the resin. There is synergism between particle and microvoid scattering, within the pigmented resin films. Microvoid effect does not seem to differ significantly among the three models studied, but the authors are very cautious about their results. They indicate the need for further studies, including pigment polydispersion and the effect of polychromatic visible light, which are certainly relevant in real systems.

In spite of the three possibilities presented by Kerker et al.,<sup>5</sup> there are still

only a few processes for making void filled films.

Closed-pore formation within the resin was described by Rankin<sup>6</sup> in the process of making a thermoset film, by reaction of epoxy resin particles on a substrate. The irregular shapes of the particles allow the retention of interstitial air bubbles within the film. However, the films thus obtained present some problems: the irregular surface is responsible for a low film brightness, and the coalescence or collapse of bubbles during the reaction reduces the number of closed pores.

Studies on the thermal stability of microvoid coatings prepared from thermoplastic and alkyd resins using a solvent-non-solvent technique were done by Ramaiah and Funke.<sup>7</sup>

Processes in which void formation occurs within a resin filled with solids are also scarce. An example of a study on voids trapped between pigment particles or at the pigment-resin interface is given by Fishman, Kurtze, and Bierwag.<sup>8</sup> This study evaluates the consequences of void formation on organic coatings, when PVC exceeds a critical concentration.

On the other hand, there are many publications which describe the synthesis of hollow particles, but most discuss

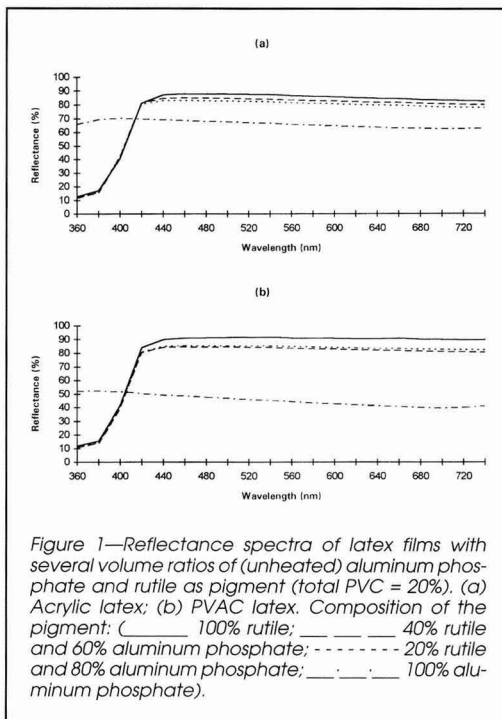


Figure 1—Reflectance spectra of latex films with several volume ratios of (unheated) aluminum phosphate and rutile as pigment (total PVC = 20%). (a) Acrylic latex; (b) PVAC latex. Composition of the pigment: (—) 100% rutile; (---) 40% rutile and 60% aluminum phosphate; (· · · ·) 20% rutile and 80% aluminum phosphate; (— · —) 100% aluminum phosphate).

polymeric spheroidal particles, which are used as paint and paper whiteners. Only a few examples of inorganic hollow particles available exist in the literature.

The introduction of hollow polymeric particles in the coatings industry led many paint manufacturers to successfully use this technology to lower their total raw materials costs, while maintaining the quality of their formulation. This trend has accelerated recently due to increased prices for titanium dioxide, improvements in hollow polymer pigment technology, and the move towards pricing paint by volume rather than

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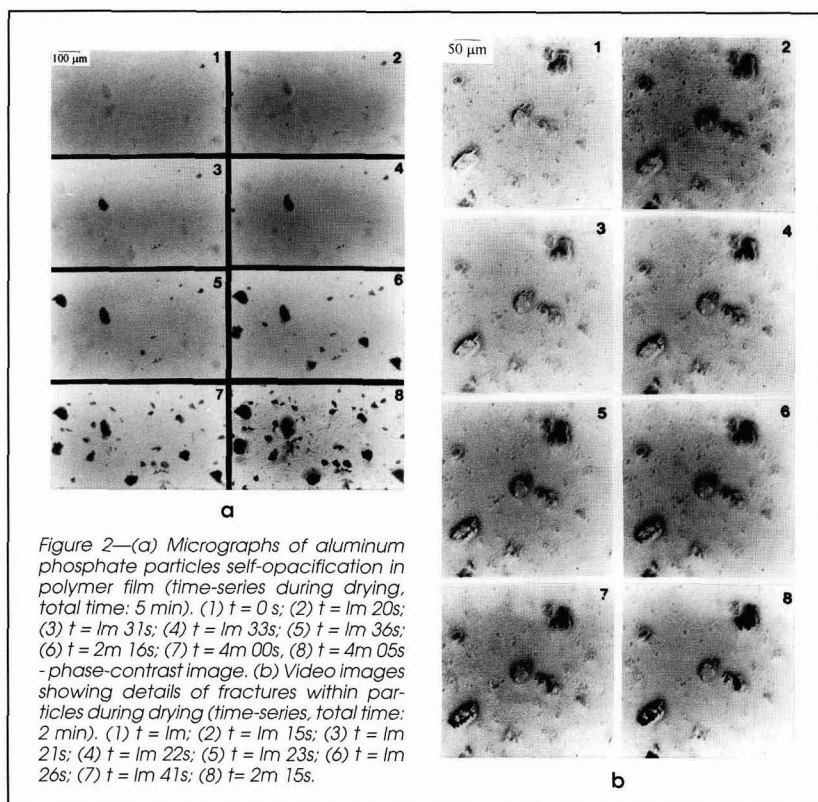


Figure 2—(a) Micrographs of aluminum phosphate particles self-opacification in polymer film (time-series during drying, total time: 5 min). (1)  $t = 0$  s; (2)  $t = 1$  m 20 s; (3)  $t = 1$  m 31 s; (4)  $t = 1$  m 33 s; (5)  $t = 1$  m 36 s; (6)  $t = 2$  m 16 s; (7)  $t = 4$  m 00 s; (8)  $t = 4$  m 05 s. (b) Video images showing details of fractures within particles during drying (time-series, total time: 2 min). (1)  $t = 1$  m; (2)  $t = 1$  m 15 s; (3)  $t = 1$  m 21 s; (4)  $t = 1$  m 22 s; (5)  $t = 1$  m 23 s; (6)  $t = 1$  m 26 s; (7)  $t = 1$  m 41 s; (8)  $t = 2$  m 15 s.

weight. Fasano<sup>3</sup> studied the application of hollow opaque polymer particles in paints without losing mechanical resistance; Hermenway, Latimer, and Young described similar studies obtaining improved gloss and opacity<sup>9</sup> in paper coatings. Ramig and Ramig studied the effect of plastic pigment composition on latex paint performance as a novel approach to microvoid hiding.<sup>10</sup> Improved scrub resistance can be obtained using microvoid coatings under particular conditions.<sup>11</sup> The making of polymer particles for microvoid coatings is described in the open literature as well as in the patent literature.<sup>12-18</sup>

Braun's review on white pigment technology stresses the importance of void hiding by three mechanisms: (1) voids which scatter light; (2) very small voids, which reduce the refractive index of the binder/air combination; this process increases the light scattering ability from any pigments; and (3) foams which scatter light at the air/polymer interfaces. The author also lists some commercially available hollow plastic pigments.<sup>19</sup> Renell and Rigdahl<sup>20</sup> confirm that the scattering ability of some coat-

ings can be considerably enhanced and also controlled by the use of monodisperse hollow pigment particles. This enhancement is positively or negatively affected by many factors, and some compromises may have to be made.

There are also some examples of hollow inorganic pigments: Kawahashi, Persson, and Matijevic obtained zirconia<sup>21</sup> and yttria<sup>22</sup> hollow spheres by deposition of zirconium compounds on cationic and anionic polystyrene lattices followed by calcination.

Kaneko et al.<sup>23</sup> presents a procedure to make microporous silica microballoons, for use in adsorption studies. Roth and Köbrich<sup>24</sup> also produced hollow spheres by a sophisticated apparatus which involves electrodeposition, heating, and spinning. Other studies have reported on inorganic materials.<sup>25,26</sup>

Theoretical studies on the optical properties of coatings containing hollow pigments<sup>27</sup> are available. The appearance and growth of voids within solids under several conditions were studied<sup>27-28</sup>; a more specific study was done by Strawbridge and Hallett on the application of Mie theory to hollow latex

spheres<sup>29</sup>; the scattering by low-refractive index dielectric spheres and cylinders was compared with rigorous calculations for hollow particles by Jazbi and Wickrasinghe.<sup>30</sup>

Past work from this laboratory described making hollow particles of amorphous phosphate and polyphosphate compounds, and their use as white pigments.<sup>31-33</sup>

According to our previous studies, closed pores are formed within non-crystalline, hydrated aluminum phosphate and polyphosphate particles under heating. This is due to the simultaneous occurrence of two phenomena: (1) solid matrix softening; and (2) release of low molecular weight, volatile components from the matrix. When the hydrated particles are heated, water vapor is released and bubbles are formed and kept within the particles provided the viscosity of the matrix is neither too high or too low.

More recently, we found that polymer films prepared with transparent, unheated, dense

amorphous aluminum phosphate particles could also be highly opaque. This result was at first rather surprising, but we found that these particles underwent some morphological transformation during polymer film formation. Voids were formed within these particles and they account for film opacification.

In this work we describe the characterization and evaluation of amorphous aluminum phosphate as a white pigment in self-opacifying polymer films. Also, a morphogenetic mode is proposed for the formation of voids within particles dispersed in a polymer film, leading to self-opacification.

## Experimental

Aluminum phosphates were precipitated by admixture of aqueous solutions of aluminum nitrate, sodium dihydrogen phosphate, and ammonium hydroxide. After centrifugation, washing, drying, and milling the precipitate, we obtained white powders with different chemical compositions depending on the initial concentration of the



**Table 1—Optical Properties of Pigmented Latex Films**

Pigment Composition/Latex	K/S	Whiteness Index	Opacity Index	Tinting Strength	Film Thickness ( $\mu\text{m}$ )
100% rutile-acrylic .....	0.0777	80.62	99.60	80.62	90.7
40% rutile, 60% aluminum phosphate - acrylic .....	0.1004	85.00	99.63	104.2	88.9
20% rutile, 80% aluminum phosphate - acrylic .....	0.2442	86.00	98.29	253.4	91.7
100% aluminum phosphate - acrylic .....	3.1647	71.84	78.21	3284	98.7
100% rutile - PVAC .....	0.0841	86.38	99.60	87.24	85.6
40% rutile, 60% aluminum phosphate - PVAC .....	0.1987	83.88	78.37	206.2	91.4
20% rutile, 80% aluminum phosphate - PVAC .....	0.2618	82.37	97.66	271.7	88.4
100% aluminum phosphate - PVAC .....	3.9282	76.13	74.24	4076	94.6

reagent solutions. These powders are transparent when immersed in paraffin oil, as observed in an Olympus CBA-K optical microscope. Detailed chemical and thermogravimetric (TGA) analyses, X-ray diffraction, IR spectra, and other characterization data on these compounds are presented elsewhere<sup>31</sup> and are not repeated here.

Two samples were used in the present work: one, in which the P/Al mol ratios are respectively 1.52 and 1.04. These correspond to samples 3 and 8 in reference 31.

Polymeric latex films (PVAC or acrylic latex) were prepared using rutile and/or aluminum phosphate. This was used in two forms: (1) as prepared; and (2) heated at 500°C for 5 min (in the case of a sample for which the atom ratio was P/Al = 1.52) or 600°C for 1 min, (for a P/Al = 1.04 sample). A total 20% pigment volume concentration (PVC) was used, which is lower than that used in many industrial products but is suitable for discrete particle optical examination in the microscope.

Film preparation was performed following these steps:

(a) the required amounts of pigments (rutile and aluminum phosphate, in the desired proportion), and latex were weighed; PVAC (poly(vinyl acetate)) was from Rhodia and Albri (Campinas), acrylic latex from Albri, and rutile from Tibrás (Bahia);

(b) pigments were mixed with the latex, together with two drops of a silicone anti-foam and water as required to have a suitable viscosity;

(c) the mixture was homogenized for five minutes in a tissue homogenizer;

(d) the mixture was sonicated in an ultrasonic cleaning bath for 1.5 min; and

(e) the pigmented latex was spread with a glass stick on a glass plate (7.5 cm x 2.5 cm), with 185  $\mu\text{m}$  spacers to determine the film thickness.

Films were dried at room temperature for a minimum of 40 hr. Thickness of dried films was measured using a micrometer according to the ASTM D1005-84 standard. Reflectance of films was measured in a 1020 Macbeth instrument, using a D-65 light source (except for the whiteness index measurement, which was done using C light), and an angle of observation of 10° (CIE 1954).<sup>34,35</sup> Whiteness index was measured by Macbeth software using the equation described in ASTM E-313-73 (1979). Opacity index or contrast ratio was calculated using the same software, according to ASTM D 2805-88 method. Tinting strength was determined using Kubelka-Munk (K/S) parameters,<sup>35-37</sup> as described in the ASTM D 2745-93 standard.

The aluminum phosphate particles were also observed by transmission electron microscopy (TEM), in a Zeiss CEM-902 instrument. Sample particles were spread on copper screens coated with carbon and parlodion.

Fracture surfaces of particles which underwent thermal treatment and from

pigmented latex films were observed by SEM, in a JEOL T-300 microscope fitted with a Noran X-ray spectrometer.

For two months storage tests were done on PVAC and acrylic emulsions containing rutile and/or unheated aluminum phosphate in several proportions as a pigment. They were stored in closed glass vials and placed in a closet protected from handling and moving. Reflectances of films formed by aged emulsions were compared to those of freshly-made emulsion films.

Oil absorption of aluminum phosphate and rutile were performed by the Gardner-Coleman procedure (ASTM D 1483-84) using an oil in conformity with ASTM D 234-82 (1987).<sup>37</sup>

Density of aluminum phosphate was measured using a helium pycnometer from Micromeritics, model 1305 and surface area was measured with FlowSorb (Micromeritics) 2300 equipment using the BET method.

Particle size analysis was done in a Coulter Counter TA-II instrument,<sup>38</sup> using a microfiltered two percent NaCl solution as the electrolyte and by microscopic observation in accordance to the ASTM E20-85 method using a CBA-K Olympus optical microscope and water as a dispersant.<sup>37,39</sup>

**Table 2—Density, Oil Absorption and Surface Area Values for Two Different Samples of Aluminum Phosphate**

Aluminum Phosphate	Density g/cm <sup>3a</sup>	Surface Area (m <sup>2</sup> /g)	Oil Absorption (ml oil/100 g pigment) <sup>a</sup>
P/Al = 1.52	2.83±0.3	76.0±0.4	132±5
P/Al = 1.04 .....	2.51±0.3	77.0±0.4	145±5

(a) Errors are calculated from replicates.

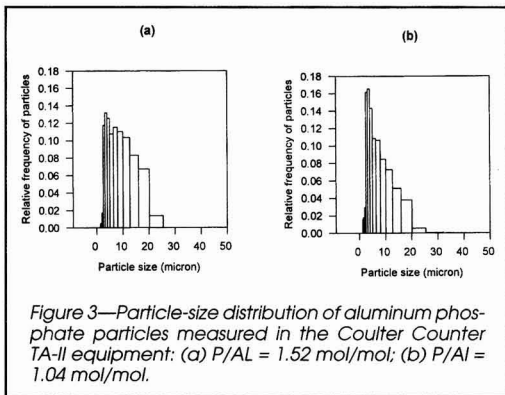


Figure 3—Particle-size distribution of aluminum phosphate particles measured in the Coulter Counter TA-II equipment: (a) P/Al = 1.52 mol/mol; (b) P/Al = 1.04 mol/mol.

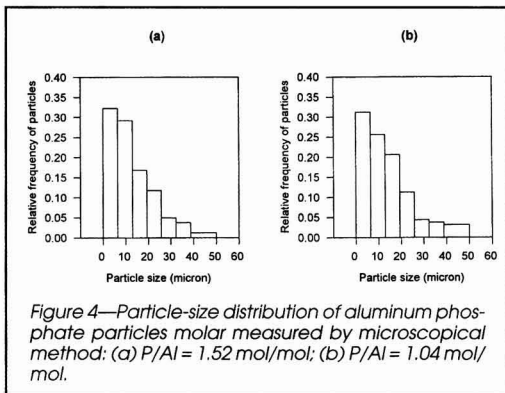


Figure 4—Particle-size distribution of aluminum phosphate particles molar measured by microscopical method: (a) P/Al = 1.52 mol/mol; (b) P/Al = 1.04 mol/mol.

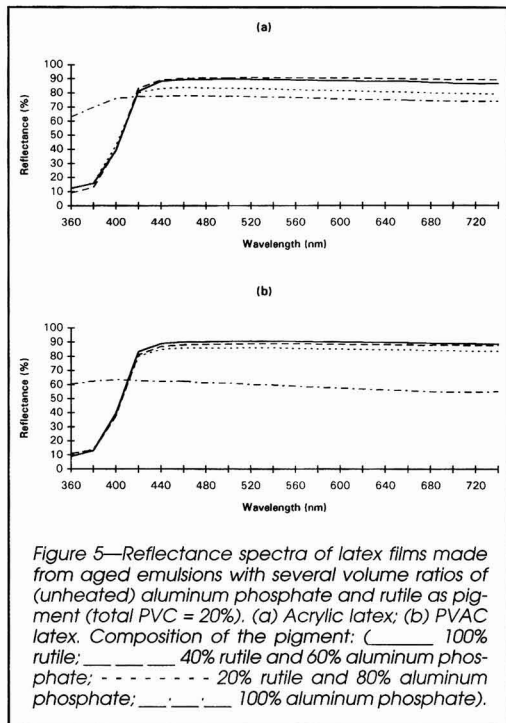


Figure 5—Reflectance spectra of latex films made from aged emulsions with several volume ratios of (unheated) aluminum phosphate and rutile as pigment (total PVC = 20%). (a) Acrylic latex; (b) PVAC latex. Composition of the pigment: (—) 100% rutile; (---) 40% rutile and 60% aluminum phosphate; (- · - ·) 20% rutile and 80% aluminum phosphate; (· · ·) 100% aluminum phosphate.

## Results

### SELF-OPACIFICATION OF FILMS CONTAINING ALUMINUM PHOSPHATE PARTICLES

Reflectance spectra of PVAC and acrylic latex films containing different amounts of aluminum phosphate and titanium dioxide particles are shown in Figure 1. Reflectance of films containing unheated amorphous aluminum phosphate particles is above 60%, showing that there is significant opacification of the films. This is remarkable, since the refractive index of the phosphate is 1.57, below that of solids like calcium carbonate (1.66) and barium sulfate (1.65). This observation suggests that some of the light-scattering structure was formed within the films during drying.

Reflected light spectra were obtained (Figure 1) and used to calculate the optical parameters of Table 1. We can notice that K/S parameter of rutile is lower than that for mixed-pigment films. On the other hand, whiteness and opacity

indexes are all fairly close. When aluminum phosphate is used alone as a pigment, the film does not present a good level of reflectance, but if phosphate replaces up to 60% (v/v) rutile, the film still presents a reflectance comparable to that of films pigmented with rutile only. Tinting strength is lost with this substitution and this is due to the higher value of K/S for aluminum phosphate.<sup>41</sup>

The formation of opaque structures within the dispersion during film drying can be observed visually, in a transmission optical microscope. A time-series of micrographs showing particle opacification during film drying is in Figure 2. In the earlier times, the film is translucent (it contains a low particle concentration, to make observation easier) and the wet particles are perceived but only with little contrast. As drying proceeds, dark spots are formed (in the transmission mode of observation), which account for film opacification.

However, opacification of aluminum phosphate particles was not observed

while the particles were kept in a curing epoxy resin or when they were dispersed and left standing in paraffin oil. This shows that this phenomenon is associated with water removal from the film.

We have also taken powder samples, wetting them with water and aqueous surfactant solutions and allowed them to dry, under air. The dried particles were then dispersed in paraffin oil and examined in the optical microscope. They always appeared transparent, showing that the opacification was not achieved by particle drying, outside the latex films. However, in two related circumstances we have observed the formation of light-scattering interfaces, but in aluminum polyphosphate monoliths of various compositions. First, when large (ca. 5 cm diameter, 1 cm tall) flat cylinders made of aluminum polyphosphate gels were allowed to dry, under some conditions, we observed that a hard skin was formed and bubbles were obtained within the cookie-shaped solid, as drying progressed. Second, in some other cases we found that polyphosphate

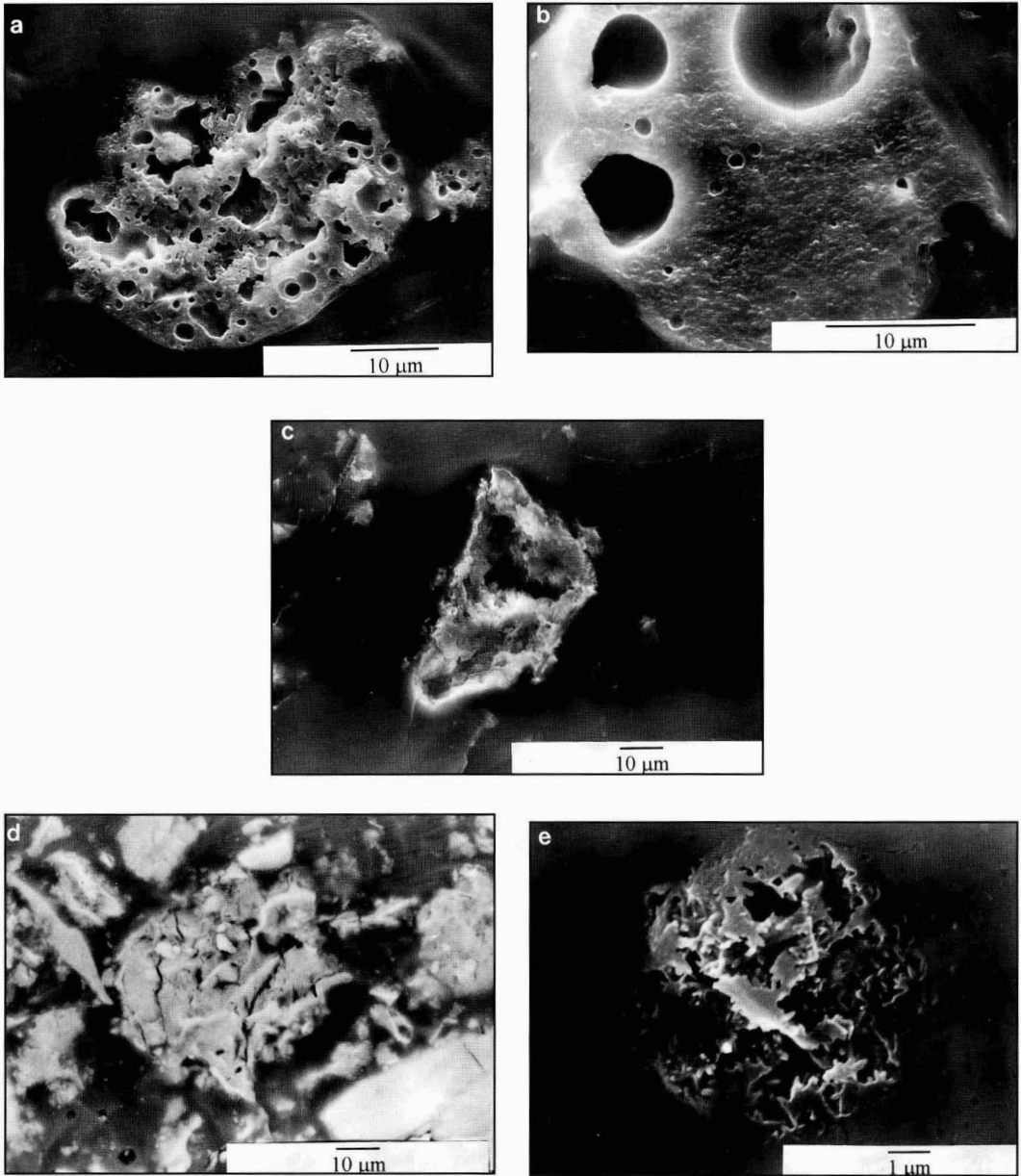
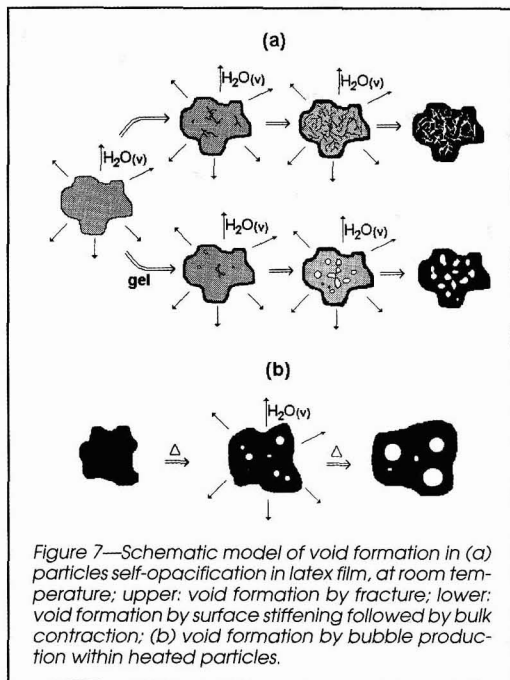


Figure 6—Scanning electron micrographs of aluminum phosphate and polyphosphate particles fracture surfaces: (6a and 6b) aluminum phosphate sample ( $P/Al = 1.52$  mol/mol) heated at  $500^{\circ}C$  for 5 min; (6c) (unheated) aluminum phosphate sample ( $P/Al = 1.04$  mol/mol) in PVAC film (secondary electron image); (6d) (unheated) aluminum phosphate sample ( $P/Al = 1.04$  mol/mol) in acrylic film (back scattered electron image - BEI); (6e) (unheated) aluminum polyphosphate sample ( $P/Al = 1.50$  mol/mol) in PVAC film (secondary electron image).



gel film drying causes massive fracturing, which impairs light propagation throughout the film. These observations are reported in detail elsewhere.<sup>40</sup>

Oil absorption results for two different samples of aluminum phosphate are described in Table 2 for both an aluminum-rich sample and a phosphate-rich sample. The values are three times higher than that for TiO<sub>2</sub> (which is ca. 40 ml oil/100g pigment). In the same table, we can observe density and surface area values. Again, the numbers are very different from those for TiO<sub>2</sub>: the density for aluminum phosphate is close to one-half the value for rutile, and its surface area is lower than that of conventional pigments.

Particle size distribution is shown in Figures 3 and 4. We can observe that the results from both techniques used (microscopy and Coulter Counter) are in fair agreement. Although microscopy shows more large particles (> 20 μm) than the Coulter Counter, both indicate that most particle diameters are within, 0, 1-10 μm range.

#### PARTICLES SELF-OPACIFICATION AND EMULSION AGING

Aged emulsions (at room temperature, for two months) were also used to make films, from which the reflectance

spectra were obtained (Figure 5). They show that the self-opacification ability of particles is unaltered for this storage time. Redispersibility and roughness problems associated to particle aggregation or coalescence were not observed.

Reversibility of the self-opacification phenomenon was observed when we immersed some dried, fresh films in water. The wet films gradually lose opacity, but when the film dries again, it recovers its opacity. This is understood if we consider that film opacification is due to particle contraction and void formation, as described in the Discussion Section. This reversibility is

not observed in more extensively dried films.

#### PARTICLE MORPHOLOGY

Fracture surfaces of aluminum phosphate particles from a heated sample (P/Al atom ratio = 1.52, heated at 500°C for 5 min) and of aluminum phosphate particles opacified within drying latex films are presented in Figure 6. The differences are clear: in the first case, most voids within particles are roughly spherical, as expected considering that they are formed as expanding bubbles, within a viscous matrix<sup>31</sup>; in the second case, the voids are rather the result of fracture formation within the particles, shaped as broken lines. A micrograph from an aluminum polyphosphate particle (4e) obtained under analogous conditions<sup>40</sup> is also given, for comparison.

#### Discussion

Previous work from this laboratory showed that non-crystalline aluminum phosphate particles can be transformed into opaque particles, under heating.

A novel property of the amorphous, hydrated aluminum phosphate particles was discovered during the present work: the ability to undergo void formation at

room temperature. This is an unprecedented behavior, which can be exploited in the making of opaque polymer films.

This property will probably be very useful, because it avoids the need for the heating step in the making of opaque particles, at least when these are to be used as water-based paint opacifiers.

The model for void formation by particles within polymer films is schematically represented in Figure 7. It is consistent with other, macroscopic observations made on polyphosphate gel drying in this laboratory.<sup>40,42</sup>

According to this model, particle drying is non-uniform from surface to bulk. This causes the formation of a rigid external layer while the core is still wet at an intermediate drying state. The gradual core drying and volume contraction leads to the formation of voids within the particle. This is possible due to the ability of the external skin to maintain the initial particle volume. This behavior is similar to void formation by macroscopic shrinkage, in the solidification process of molded ceramics<sup>43</sup> or during the cooling of alloys,<sup>44</sup> and differs from the microvoid formation in polyester composites under a high strain rate<sup>45</sup> as well as from the models considered in other theoretical studies emphasizing the same topic.<sup>27,28</sup>

Another type of event leading to void formation is particle gel cracking during drying, which is well known in the sol-gel literature. This is quite different from bubble formation described in the previous paragraph, but it does also result in film opacification.

In Figure 2, the opacification is initiated in some particle sites, then proceeds discretely to other parts. This is clearly caused by sudden morphological changes (formation of voids) in these locations and not by local changes in refractive index caused by solvent evaporation, as could be suggested. This later process would produce a smaller, gradual, and fairly homogeneous increase in the contrast among particles and matrix film.

The comparison between acrylic and PVAC lattices is also interesting. We assume that the formation of a more rigid interfacial layer in the acrylic film than in PVAC is responsible for the differences of opacification observed in these two films. This hypothesis may be further substantiated by future work using lattices with well-defined surfaces.

An open question at this time is related to the possibility of full TiO<sub>2</sub> replacement by aluminum polyphosphate. At present, films exempt of TiO<sub>2</sub> present insufficient opacity, which is due to the poor packing of the polyphosphate par-

ticles within the film, thus leaving clear areas easily observed in the microscope. This problem may well be solved by optimization of aluminum polyphosphate particle size distribution, which is currently in progress in this laboratory.

We should also observe that aluminum phosphate particles have a large size as compared to conventional pigments such as rutile. This is needed considering that the scattering structures are the particle voids, which dimensions and shape determine scattering. Perhaps the polydispersity of aluminum phosphate particle sizes can also be used to improve the dispersion of pigments and to optimize optical properties.<sup>46</sup>

In summary, aluminum polyphosphate can be used to make opaque particles in two different ways: by heating, as described in previous articles, and by *in-situ* void formation, as described in this paper. Both ways to make opaque particles (heating and *in-situ*) are useful, depending on the prospective application. Heating produces opaque powders which can be used in most pigmented systems, such as paints, papers, and thermoplastic polymers, while the *in-situ* formation of voids is a more practical way to opacify water-based paints, avoiding the heating step in particle making.

Further work is currently being done in this laboratory, to verify to which extent the properties of the polyphosphates can be extended to other amorphous solids and to verify the morphogenetic models suggested here. Work on the void size and shape characterization, and on its effect on scattering power, as well as on the film resistance to weathering is also under way.

Note: The preparation of aluminum phosphates studied in the present paper is protected under INPI 9400745 patent.<sup>47</sup>

## Conclusion

Opaque particles of aluminum phosphate can be obtained in two ways: self-opacification within drying latex films and thermal treatment at 500-700°C (which was previously described). Self-opacification is easily achieved and allows for extensive replacement of TiO<sub>2</sub> as a white pigment, with a gain (in an acrylic latex) in the optical properties of the pigmented film.

## Acknowledgment

This project was supported by FAPESP, CNPq and PADCT/FINEP. M.M. Beppu was a fellow from CNPq and FAPESP. The use of image digitalization equip-

ment from TELECINE (Campinas) is gratefully acknowledged.

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FERNANDO GALEMBECK serves as the Head of the Institute of Chemistry and as Professor of Physical Chemistry at the State University of Campinas, where he has been since 1980. His areas of research include surfactants, pigments, and polymers. Dr. Galembeck has authored approximately 100 research papers in refereed journals.

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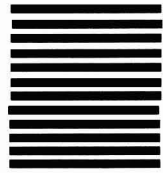
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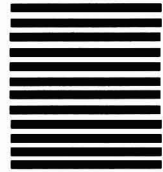


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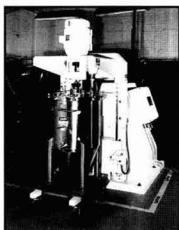
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## HSD Milling System

HOCKMEYER EQUIPMENT CORP.

New standards for the technology of milling via the HSD Milling System are presented by Hockmeyer Equipment Corp. The HSD unit reportedly provides lower operating costs, higher yield, and ease of operation. Batch volumes range from portable tanks up to 1,200 gallon stationary tanks, while viscosity ranges exceed conventional bead milling technology.

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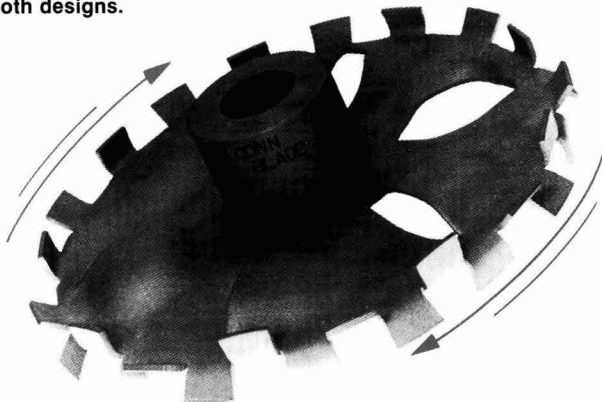
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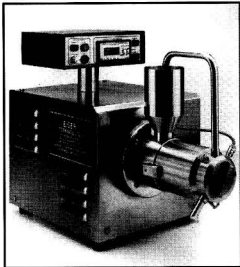
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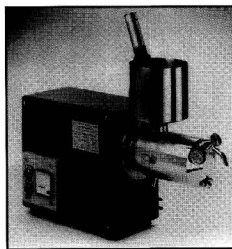
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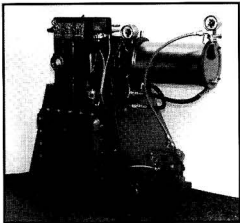
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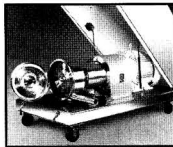
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## X-Series Mixer Emulsifiers

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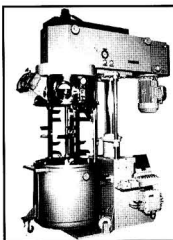


Charles Ross and Son has introduced its newest addition to the line of X-Series Mixer Emulsifiers. The 430-X mixer emulsifier, which produces sub-micron emulsions and dispersions, features an interchangeable rotor/stator generator and offers an accelerated particle size reduction. With tip speeds as high as 17,000 fpm, this mixer forces the mix material through a matrix of interlocking channels. Many options, including sanitary construction are available.

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## Hidrobat Mixers

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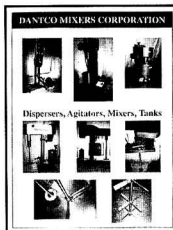


Premier Mill is distributing the Hidrobat Mixers, a complete line of mixers designed for medium and high viscosity pastes. Specially designed vertical mixing blades provide a double rotating motion while a scraping blade constantly renews the product that adheres to the vessel wall. In addition, a high speed dispersing blade is positioned in the center of the vessel between the vertical mixing blades.

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## Product Catalog

DANTCO MIXERS CORP.



Dantco Mixers Corp. has published a new catalog that describes their line of mixers, dispersers, agitators, and tanks, as well as high speed blades and low speed turbines. The catalog provides detailed descriptions of these standard products used in a variety of applications including drug and cosmetics, chemicals, food, textile, and paints and coatings.

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## Liquid Mixing Equipment

BRAWN MIXER, INC.



Brawn Mixer, Inc. manufactures a line of liquid-mixing equipment for chemical, food, pharmaceutical, pulp and paper, and water/wastewater applications. The product line ranges from small, sub-fractional horsepower mixers for laboratory use to massive high-torque-transmitting, gear-reduced mixers exceeding 200 horsepower (150kw). These mixers feature a range of both metric and U.S. standard motors.

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## BIRMINGHAM—OCTOBER

### General Business Meeting

It was determined that the Oil and Colour Chemists' Association (OCCA) will assist the Birmingham Paint, Varnish & Lacquer Club with the Symposium "Transatlantic Coatings Technology—Diverging or Converging" which will be held in conjunction with the FSCT Spring Board of Directors Meeting in May. In addition, the fees for the event were discussed.

The Program Committee has proposed 11 subjects for next year's meetings.

Roland Staples, of Nortax discussed the Technical Committee's Ironbridge project. Mr. Staples stated that OCCA would like to be involved in the project.

In addition, the VOC paper has been completed.

JOE BROWN, *President*

## BIRMINGHAM—JANUARY

### "Mergers and Acquisitions"

The evening's speaker, Peter Vercoe, Consultant, presented "MERGERS AND ACQUISITIONS—SOME FINANCIAL ASPECTS."

Mr. Vercoe outlined the pitfalls that are likely to occur when a merger or acquisition is under consideration. He stressed caveat emptor. According to the speaker, a full investigation into the quality of staff and the veracity of accounts is crucial when considering an acquisition.

Mr. Vercoe stated that profits must be capable of being increased. He also noted that 75% of transactions fail to meet expectations.

In addition, the speaker discussed premium re-capture.

JOE BROWN, *President*

## CHICAGO—MARCH

### "Acrylate Modified Epoxy-Amine Cure Coatings"

A moment of silence was observed for the passing of Beatrice Schwahn, the late wife of CSCT 50-year Member Cliff Schwahn.

Educational Chair Susan DiSantis, of Fitz Chem, reported that applications for the Joint Grant in Aid and CSCT Merit Scholarship are due by March 11, 1997.

She read a thank you letter from DePaul University for the 1997 Grant from the CSCT for the DePaul Coatings Lab.

Ms. DiSantis also stated that the "Introductory Session I Coatings Course" begins March 19, 1997, at Elmhurst College.

Mike Bailey, of Sartomer Co., discussed "NEW DEVELOPMENTS IN ACRYLATE MODIFIED EPOXY-AMINE CURE COATINGS."

WILLIAM BELLMAN, *Secretary*

## KANSAS CITY—FEBRUARY

### FSCT Officer Visit

FSCT Secretary-Treasurer Forest Fleming, of Akzo Nobel Coatings, Inc., reviewed the activities of the FSCT Executive Committee and Staff members with the attendees.

Victoria Graves, FSCT's Director of Meetings and Conventions, was also in attendance.

Program Committee Chair Curry Sanders, of Tnemec Co., Inc., reported that a tour of CCP labs will be held during the March meeting.

In another matter, Mr. Sanders proposed that the Technical Committee should have a Vice Chair as well. The Vice Chair will then become the Chair of the Committee the following year. Mr. Curry nominated Yasmin Sayed-Sweet, of Cook Composites and Polymers, to serve as Co-Chair with David Hazlett, of Tnemec Co., Inc., the current Technical Committee Chair.

President Randy Ehmer, of Walsh and Associates Inc., announced that the Joint Meeting with the St. Louis Society will take place on May 3-4 at the Four Seasons Lodge.

Educational Committee Chair, Kim Nee, of Mozel Inc., is seeking volunteers to judge the April Science Fair.

It was reported that the American Chemical Society has invited the KCSCST to participate in the technical meeting at the Lake of the Ozarks in October. Mr. Sanders will research the feasibility of this meeting since it occurs near the time of the FSCT Annual Meeting.

DEBBIE KOSS, *Secretary*

## Cleveland Society March meeting



Attending the March meeting of the Cleveland Society was FSCT President-Elect Thomas Hill and FSCT Director of Meetings and Conventions Victoria Graves.



## LOUISVILLE—FEBRUARY

### "Solvent Selection"

A moment of silence was observed in remembrance of Bill Klapper and Dave Anderson who passed away recently.

The members of the FSCT Technical Advisory Committee were in attendance. They included the following: Mike Bell, FSCT, Director of Educational Services; Fred Anwari, of BFGoodrich Co.; Noel Harrison, of Jones-Blair Co.; Nellie Moretz, of Lilly Industries Inc.; and Walter Naughton, of Scott Paint Corp.

William Leightner, of C.L. McGuire, Co., encouraged all members to solicit applications for the LSCT Educational Grant.

Technical Committee Chair, Ilona Duvall, of Red Spot Paint and Varnish Co., reminded the members that the LSCT Spring Symposium "Spectrum of Coatings" will be held on April 16, 1997 at the Executive West Hotel, Louisville, KY.

In addition, Ms. Duvall stated that the Committee has narrowed the topic of its study to include the viscoelastic properties of a waterborne paint when various pigments are utilized in the formula.

Environmental Committee Chair Roy Funkhouser, of Law Environmental, reported that the Kentucky Paint Council's 1997 Spring Technical Seminar is slated for April 8, 1997. The seminar will focus on air quality issues and NPCA's Coatings Care™ program.

In addition, Mr. Funkhouser noted that the U.S. EPA has proposed stringent revisions to the National Ambient Air Quality Standards for ozone and par-

ticulate matter. This proposal could have an impact on the paint and coatings industry. The Chair encouraged the members to write letters to Sen. John Chafee.

Mr. Funkhouser stated that anyone having sons or daughters interested in the field of environmental science are encouraged to obtain information about college internships by contacting him.

Don Sullivan, of Shell Chemical Co., presented "SOLVENT SELECTION IN TODAY'S REGULATORY ENVIRONMENT."

Mr. Sullivan reviewed the history and regulations involved in solvent selection. He stated that new and evolving regulations are having a greater impact on the use and selection of solvents for every industrial process. Recent regulatory efforts have been designed to address tropospheric ozone issues, stratospheric ozone depletion, and reduction of hazardous air pollutant emissions.

According to Mr. Sullivan, VOC reductions have laid the groundwork for further reduction of hazardous air pollutants (HAPs). HAPs have been restricted and further reductions are targeted at some long standing universal solvents including methyl ethyl ketone, methyl isobutyl ketone, toluene, and xylene.

A study has been conducted to evaluate the reduction or elimination of HAPs in polyester baked coatings. The aromatic content of Cypar 7 and Cypar 9 is <5 and .01, respectively. KB values are moderate at 46 and 41 and may be incorporated as diluents utilizing the hydrocarbon base. Cypar 7 is currently a commercial product and Cypar 9 will be introduced to the market shortly.

In a comparative study using Cypar 7 and Cypar 9 at 35% total weight of formula, replacing xylene and acetone, Mr. Sullivan said that significant improvement was observed. HAPs were reduced from 35% to <0.1%.

Mr. Sullivan noted that when utilized in wood coatings, these non-HAP sol-

vents give good dry-to-touch properties. When used in conjunction with aromatic hydrocarbons, good film properties are achieved. N-butyl propionate can replace methyl ethyl ketone or n-butyl acetate and still provide good viscosity reduction. Formulations that have utilized this property of retarded solvent evaporation are wood coatings and baked finishes.

The speaker also discussed a computer simulation program designed to help formulators reformulate existing products with the need to try all possible solvent blends.

*Q. In an epoxy system containing n-butyl propionate, is the solvent retarded longer than n-butyl acetate?*

A. Yes. In this system n-butyl propionate is retarded longer than n-butyl acetate due to the addition of one more carbon. Properties of impact resistance will improve over time.

CHRIS A. LOCKHART, *Secretary*

## MONTREAL—MARCH

### "Adhesion of Coatings"

The evening's speaker, Krishnan C. Sehgal, of UCAR Emulsion, spoke on "ADHESION OF COATINGS TO DIFFERENT SUBSTRATES."

Mr. Sehgal reported on recent findings on the role of various parameters upon the adhesion of polymeric coatings to some substrates differing in surface energy and morphology.

According to the speaker, the strength of adhesion was determined by practical lab tests, e.g., direct pull-off, 180° pull and tape tests under varying temperature, humidity, drying conditions, and rates of separation.

Mr. Sehgal used wettability studies plus SEM and ESCA techniques to characterize the nature of various substrates. The influence of both the surface and polymer bulk effects upon the quality of adhesion were highlighted by the speaker. The practical relevance of these results in terms of coatings performance properties important to the coatings chemist were also mentioned.

HORACE PHILIPP, *Society Representative*

## PACIFIC NORTHWEST (VANCOUVER SECTION)— JANUARY

### "Reducing Milling Costs"

Technical Committee Chair, Yoichi Seo, of Flecto Coatings Ltd., updated the



Louisville Society Past Presidents in attendance at the January meeting included (from left): John Ballard (1977), Tim Fortney (1994), Bill Leightner (1996), John Lanning (1978), Larry Pitchford (1989), Paul Nilles (1976), and Herb Wilson (1975).

members on the video project. The completion date was delayed due to the Spring Symposium on May 8-10, 1997, in Vancouver.

Educational Committee Chair, Tom Fairley, of Calcoast Labs Canada Inc., announced that the Kwantlen course, "Formulation of Architectural and Trade Sale Paints," is scheduled to begin on February 19, 1997.

Yvon Poitras, of Horizon Chemicals Ltd., has issued a final call for papers for the Spring Symposium.

Paul Andreassen, of Consolidated Coatings Corp., has agreed to go through the Society Chairs by becoming the new member-at-large.

Herman Hockmeyer, of Hockmeyer Equipment Corp., spoke on "RESTRUCTURING THE BASICS OF PROFITABILITY BY REDUCING MILLING COSTS."

KELVIN J. HUGET, *Treasurer*

## PHILADELPHIA—DECEMBER

### "Amine Chemistries for Isocyanate-Based Coatings"

Technical Committee Chair, Bernadette Corujo, of Zeneca Resins, is seeking members to join the committee. They are studying adhesion in a broad spectrum of product types and substrates.

Educational Committee Chair, Rich Granata, of Lehigh University, announced that a study group will meet to discuss corrosion and rheology. The sessions will be based on the FSCT's monograph series.

Douglas Wicks, of Bayer Corp., spoke on "AMINE CHEMISTRIES FOR ISOCYANATE-BASED COATINGS."

Mr. Wicks discussed the trend in reactive coatings to lower VOCs and the effects it has on the application properties and characteristics of these systems including: shorter pot life and higher viscosities. He noted that lower molecular weight oligomers make for lower viscosities, and decreasing the solvent content increases the value of coatings to the end user.

The speaker defined low molecular weight syndrome as the phenomenon where these systems have extremely short pot-lives and very long cure times.

Higher-solids co-reactants displace higher viscosity resins and can reduce and sometimes eliminate solvents. Acrylic polyols have a limitation of about 50% solids, while polyesters are better at 60-70% with adequate properties. Ac-

## Constituent Society Meetings and Secretaries

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

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

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

**CHICAGO** (First Monday—Embassy Suites Hotel, Hwy. 56, Lombard, IL). WILLIAM C. BELLMAN, The Valspar Corp., 300 Gilman, Wheeling, IL 60090-5808.

**CLEVELAND** (Third Tuesday—meeting sites vary). JENNIFER L. RUMBERG, The Mahoning Paint Corp., P.O. Box 1282, Youngstown, OH 44501-1282.

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

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

**GOLDEN GATE** (Monday after second Wednesday—Francesco's, Oakland, CA). DON MAZZONE, Dowd & Guild, Inc., 14 Crow Canyon Ct., #200, San Ramon, CA 94583.

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

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

**LOS ANGELES** (Second Wednesday—Maggies Pub, Santa Fe Springs, CA). JOSEPH C. REILLY, Rohm and Haas Co., 432 Cienega Dr., Fullerton, CA 92635.

**LOUISVILLE** (Third Wednesday—Executive West Motor Hotel, Louisville, KY). CHRIS A. LOCKHART, Reynolds Metals Co., 4101 Camp Ground Rd., Louisville, KY 40211.

**MEXICO** (Every fifteen days—Gabriel Mancera, Mexico City, Mexico). MANUEL MAESTRO, DuPont, S.A. de C.V., Km. 9.5 via Dr. Gustavo Baz, Co. Barrientos, 54110 Tlalhepantla, Edo de Mexico, Mexico.

**MONTREAL** (First Wednesday—Restaurant Le Bifhèque, St. Laurent, Quebec). ROBERT BENOIT, Kronos Canada Inc., 3390 Marie Victorin, Varennes, Que., J3X 1T4 Canada.

**NEW ENGLAND** (Third Thursday—Best Western TLC, Waltham, MA). DAVID GORVINE, RSM Sales, 79 Park Rd., Lynn, MA 01904.

**NEW YORK** (Second Tuesday—Landmark II, East Rutherford, NJ). LARRY WAELE, Troy Corp., 8 Vreeland Rd., Florham Park, NJ 07932.

**NORTHWESTERN** (Second Tuesday—Jax Cafe, Minneapolis, MN). GLEN VETTER, The Valspar Corp., 1101 S. Third St., P.O. Box 1461, Minneapolis, MN 55440.

**PACIFIC NORTHWEST** (PORTLAND SECTION—Tuesday before third Wednesday—Tony Roma's, Mall 205, Portland, OR; SEATTLE SECTION—Third Wednesday—Wyndham Gardes Hotel, Sea-Tac, WA; VANCOUVER SECTION—Thursday after third Wednesday—Abercorn Inn, Richmond, B.C.). BEVERLY SPEARS, Synergistic Performance Corp., 5950 6th Ave., St., Ste. 109, Seattle, WA 98108.

**PHILADELPHIA** (Second Thursday—DoubleTree Guest Suites, Plymouth Meeting, PA). SUE M. NIELSEN, Best Bros. Paint Manufacturing Co., Inc., 172 Shillington Rd., Sinking Spring, PA 19608-2056.

**PIEDMONT** (Third Wednesday—Ramada Inn Airport, Greensboro, NC). CLARENCE D. HOFFMAN, Kohl Marketing, Inc., 4 Tarrywood Ct., Greensboro, NC 27455.

**PITTSBURGH** (Second Monday—Montemurro's Restaurant, Sharpsburg, PA). JOSEPH E. HUNT, Palmer Supplies Co. of Pittsburgh, 8980 Perry Hwy., Pittsburgh, PA 15237.

**ROCKY MOUNTAIN** (Monday following first Wednesday—DelMonico Hall, Denver, CO). JOHN ELVERUM, Hauser Chemical Research, 5555 Airport Blvd., Boulder, CO 80301.

**ST. LOUIS** (Third Tuesday—The Salad Bowl Restaurant, St. Louis, MO). LOU L. VOIT, Cemsac Chemicals Corp., P.O. Box 6427, Chesterfield, MO 63006.

**SOUTHERN** (GULF COAST SECTION—third Thursday; CENTRAL FLORIDA SECTION—third Thursday after first Monday; ATLANTA SECTION—third Thursday; MEMPHIS SECTION—bi-monthly on second Tuesday; and SOUTH FLORIDA SECTION—Tuesday prior to Central Florida Section). GREG SCHARFETTER, Thompson Minwax Co., 10136 Magnolia Dr., P.O. Box 667, Olive Branch, MS 38654.

**TORONTO** (Second Monday—Speranza Restaurant & Banquet Hall Convention Centre, Brampton, Ont., Canada). ALEXANDER KING, Tioxide Canada, Inc., 350 Burnhamthorpe Rd., W., Ste. 210, Mississauga, Ont. L5B 3J1, Canada.



cording to Mr. Wicks, conventional co-reactants are where the solvents are brought into polyurethane systems, so higher solids co-reactants can be a good way to reduce VOCs.

Amine systems are one way to accomplish this, but they are limited in coatings usage because of their very short gel times. Mr. Wicks stated that they can basically only be used in plural component application systems and do not weather very well at all. In addition, the reactivity of these systems is extremely sensitive to humidity.

Another approach, according to Mr. Wicks, is high-solids polyamines. Here reactivity can be reduced and they can also be made to be non-crystalline forming.

Polyspartic esters hinder or block the amines and there is increased bonding between the amine and the ester. The reactivity of the amine is moderated significantly by the presence of the ester. When these groups react with the isocyanate, they generate an asymmetric urea which is not prone to crystallization.

According to the speaker, other variations include the addition of DBTD (dibutyl tin dilaurate) and oxazolindines to high-solids formulations. DBTD speeds up the rate of reaction in polyurethanes and suppresses viscosities (the opposite of hydroxyl catalysis). It also scavenges acids produced by the amines.

Oxazolindines is a chemistry which is non-reactive in urethane systems until moisture is present. Hydrolysis yields difunctional species which are very low in viscosity. These chemistries have long pot lives but cure rates are humidity dependent so are often slow cure and cannot be thermally driven. They do, however, produce coatings which have excellent durability.

Mr. Wicks stated that bisoxazolindines on the market give a functionality of greater than two on average. These tend to be "exact" compounds, meaning their purity is very high. The viscosity here depends on the linking group. All of these aforementioned chemistries depend to a large extent on the presence of moisture in order to react and form tight films.

Imines, on the other hand, exhibit blocked amine functionality with very low viscosities because there are no hydrogen bonding sites. They also give long potlife, yet cure relatively quickly. They will show good (though not excellent) durability and will yellow when reacted.

Aldehydes are very quick to gel and will generate 60+ degrees reaction temperatures. The VOCs in these systems indicate the retention of aldehydes in the finished film. These are also sensitive to humidity.

Aspartates, as stand-alone co-reactants, exhibit long potlife yet give fast cure and excellent durability. These compounds, though, tend to yellow.

The speaker noted that other factors which influence reactivity are the presence of alcohols and carboxylic acids, as well as temperature increases the rate of reaction. Tin compounds tend to inhibit cure.

*Q. What is the relative reactivity with oxazolindines?*

*A. The amines have much higher reactivity.*

SUE NIELSEN, *Secretary*

## PHILADELPHIA—FEBRUARY

### "High-Speed Dispersion Techniques"

The evening's technical speaker was Harry Way of Netzsch Inc. He discussed "AN OVERVIEW OF NEW-HIGH SPEED DISPERSION TECHNIQUES."

Mr. Way reported on some of the drawbacks of older technologies of dispersion equipment such as horizontal and other types of media mills. He noted that these types require fairly large batch sizes, they are difficult to clean, they generate more waste, and because there are so many variables, more operator training is required.

The speaker focused on the basket mill. He stated that this equipment reportedly is easier to operate, cleans quickly, produces repeatable performance with high production rates and low waste. Mr. Way also said this technology is designed to reduce solvent emissions, is competitively priced, and requires low installation costs.

The technology was developed 25 years ago and entails a two-piece shaft. The outer shaft rotates with a basket filled with 80-90% media. The only variable is agitator speed.

SUE NIELSEN, *Secretary*

## PHILADELPHIA—MARCH

### "Failure Analysis of Coatings"

Bob Thomas reported on the Society's constitution. Upon reviewing the constitution, he discovered that some of the wording is gender specific. Mr. Thomas read a resolution to amend in 72 places wording that is gender specific.

Bud Senkowski, of KTA-Tator, presented "FAILURE ANALYSIS OF COATINGS."

Mr. Senkowski stated that most failures are due to improper application either because of a lack of understanding of the products used or poor surface preparation.

The speaker outlined the steps to failure analysis: (1) acquire project documentation; (2) conduct field investigations; (3) perform lab analyses; (4) conduct personnel interviews; and (5) make a final report. According to Mr. Senkowski, sometimes these steps can be time consuming and often facilities must be shut down until they are complete and repairs are made.

Some of the elements involved in field investigations are visual observation, substrate measurement of failed and/or unfailed areas, coatings measurements, sample collection, photographs or videos, and personnel interviews. Commonly used field instruments include thickness gauges, the Tooke gauge for examining individual layers of coatings and various adhesion test methods.

There are a number of causes of failure, Mr. Senkowski said. They include improper coating selection, improper coating formulation, surface preparation problems, coating application problems, and poor structural design. Analytical techniques used in failure analysis are as varied as the causes of failure. They run from optical microscopy to infrared spectroscopy and gas chromatography.

In summary, Mr. Senkowski elaborated on some of the consequences of coating failures. He said there are often extensive and expensive repairs which must be made, sometimes to the point of substrate replacement. There is also often facility downtime involved, lost revenue, or costly rework. Sometimes products are contaminated and must be replaced and/or disposed of. And, finally, poor aesthetics are a less important but quite obvious consequence.

SUE NIELSEN, *Secretary*

## TORONTO—NOVEMBER

### "High-Speed Dispersion Techniques"

Gerry Kunihiro, of St. Lawrence Chemical, has agreed to serve as the Society's Bylaws and Archives Chair.

The Educational Committee will conduct a course on "Latex Technology and Applications."

A. Coomarasamy, of the Ontario Ministry of Transportation, discussed "PAVEMENT MARKINGS AND STRUCTURAL STEEL COATINGS, EXPECTATIONS, AND EVALUATION METHODS."

ALEXANDER KING, *Secretary*

# New FSCT Members

## CDIC

### Active

*Anin, Jacqueline A.*—Delphi Interior & Lighting, Vandalia, OH.  
*Wallace, Elah P.*—Southwest Research Institute, Miamisburg, OH.

### Associate

*Rapach, John N.*—Zemex Industrial Minerals, Cincinnati, OH.  
*Smith, Ed D.*—Procter & Gamble, Cincinnati.

## CLEVELAND

### Active

*Gray, Penny L.*—Goodyear Tire & Rubber Co., Akron, OH.

### Associate

*Jewitt, Jeff B.*—JB Jewitt Co., Inc., North Royacton, OH.  
*Kay, Gary M.*—Technical Resources, Twinsburg, OH.

## DETROIT

### Educator/Student

*Bodenham, Timolee M.*—Eastern Michigan University, Ypsilanti, MI.  
*Dewitt, Julie A.*—Eastern Michigan University, Ypsilanti.  
*Dudzic, Mark A.*—Eastern Michigan University, Ypsilanti.  
*Fletcher, Jason C.*—Eastern Michigan University, Ypsilanti.  
*Guck, Carl C.*—Eastern Michigan University, Ypsilanti.  
*Haskell, Brad A.*—Eastern Michigan University, Ypsilanti.  
*Hinderer, Brian J.*—Eastern Michigan University, Ypsilanti.  
*Husty, Jennifer L.*—Eastern Michigan University, Ypsilanti.  
*LaForest, Jacob J.*—Eastern Michigan University, Ypsilanti.  
*Mallery, William E.*—Eastern Michigan University, Ypsilanti.  
*Mania, Daniel J.*—Eastern Michigan University, Ypsilanti.  
*McClain, Justin L.*—Eastern Michigan University, Ypsilanti.  
*Mohagheghli, Mehrdad*—Eastern Michigan University, Ypsilanti.  
*Parsons, Matthew J.*—Eastern Michigan University, Ypsilanti.  
*Steinmetz, Kimberly A.*—Eastern Michigan University, Ypsilanti.  
*Thompson, James E.*—Eastern Michigan University, Ypsilanti.  
*Wilcox, Richard P.*—Eastern Michigan University, Ypsilanti.

## KANSAS CITY

### Active

*Hon, Kenneth A.*—Tnemeck Co., Inc., N. Kansas City, MO.

## LOUISVILLE

### Active

*Bhattacharya, Shubho*—Trinity Industrial Corp., Georgetown, KY.

### Associate

*Burns, Paul A.*—Technical Products, Louisville, KY.

## NEW YORK

### Active

*McGovern, Paula M.*—Benjamin Moore & Co., Flanders, NJ.  
*Niak, Ashwin*—Cardinal Color Co., Paterson, NJ.

### Associate

*Herd, Thomas P.*—Wm. Barr & Co., Montville, NJ.  
*Kassner, Jessica D.*—Ciba Specialty Chemical, Newport, DE.  
*Miller, Marguerite J.*—J.M. Huber Corp., Stamford, CT.  
*Mittal, Kashmiri L.*—Hopewell Jct., NY.

### Retired

*Kaplan, Meyer*—Edison, NJ.

## NORTHWESTERN

### Active

*Chong, Ceelia*—Winnipeg, MB.  
*Luketic, Amy*—Harcros Organics, Lombard, IL.

## PACIFIC NORTHWEST

### Active

*Stinson, Laura A.*—Gaco Western, Seattle, WA.

### Associate

*Board, Charles L.*—DuPont, San Ramon, CA.  
*Bloomfield, Susan*—Ashland Chemical Co., Portland, OR.

## PHILADELPHIA

### Active

*Hutt, Robert J.*—Harris Specialty Chemical, Richboro, PA.  
*Kubanoff, Ryan S.*—Kurz-Hastings, Philadelphia, PA.  
*Nelson, Ronald R.*—Nutech Corp., Bethlehem, PA.

### Associate

*Canavan, Daniel T.*—D.B. Becker Co., Inc., Clinton, NJ.  
*Reminger, Jennifer L.*—Premier Mill, Reading, PA.  
*Zaborsky, Herbert J.*—Heucotech Ltd., Fairless Hills, PA.

## TORONTO

### Active

*Jackson, David Reid*—R.M. Ferguson Co., Inc., Brampton, Ont.  
*Levy, Roger H.*—Standard Products, Stratford, Ont.  
*Loyst, Brian M.*—Para Paints, Brampton, Ont.  
*Tarnate, Florendo C.*—Kub Coatings Corp., Kingston, Ont.  
*Veresuk, John A.*—SWT Specialty Product, Tecumseh, Ont.  
*Wolde, Biftu*—Sico, Etobicoke, Ont.

### Associate

*Lomas, Rand A.*—L.V. Lomas Ltd., Brampton, Ont.  
*Morris, Spence*—L.V. Lomas Ltd., Brampton, Ont.  
*Samuel, Derick J.*—Hoechst Canada, Markham, Ont.  
*Wright, Eva E.*—BDH Inc., Toronto, Ont.

## Future Society Meetings

### Baltimore

(May 15)—Election of Officers.

### Chicago

(May 30)—Annual Awards Banquet.

### Los Angeles

(May 14)—“THE USE OF POLYOLS A ‘NEW GENERATION’ IN HIGH PERFORMANCE COATINGS”—Steve Seneker, Arco Chemical Co.

(June 11)—Annual Meeting and Election of Officers.

### New York

(May 13)—PaVac Awards Night. “CHEMISTRY OF IRON OXIDES”—George Poldosky, Harcos.

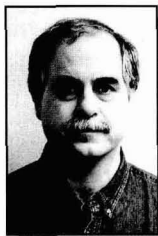
### Philadelphia

(May 8)—“DISPERSANTS FOR INDUSTRIAL COATINGS”—Peter Hibbert, ICI.

### Rocky Mountain

#### Denver/Arizona

(May 12/13)—“THE USE OF POLYOLS A ‘NEW GENERATION’ IN HIGH PERFORMANCE COATINGS”—Steve Seneker, Arco Chemical Co.



F. Viguerie

Frank Viguerie has been named Applications and Marketing Manager—Hydrate Chemicals for Alcoa Industrial Chemicals/North America, Bauxite, AR. Mr. Viguerie will provide technical/applications support for the company's onyx/solid surface and paper coating/filler markets.

In addition, Eddie Black has been appointed Hydrate Chemicals Plant Manager. In this capacity, Mr. Black will be responsible for the production of all hydrate chemical products at the Bauxite operations, including those products for the onyx/solid surface, paper coatings and filler, and paint and coatings markets.

Laurence L. Williams has received the Coating and Resin Products Lifetime Achievement Award from Cytec Industries Inc., West Paterson, NJ. Dr. Williams, Vice President, Global Technical Development, Coating and Resins Products, holds 19 patents and has authored or co-authored numerous technical articles.

Randy Golenberg has been appointed National Marketing Manager, Shur-Stik®, Dynamite® Products, for The Gibson-Homas Co., Twinsburg, OH. In this capacity, Mr. Golenberg will be responsible for the marketing efforts behind these products.

A. David Harbourne has assumed the Presidency of RadTech International North America, Northbrook, IL. Mr. Harbourne, who is President of Fusion UV Systems Inc., has served as President-Elect of RadTech for the past two years.

Stephanie L. Kwolek, a retired chemist from DuPont, Wilmington, DE, is the 1997 recipient of the Perkin Medal by the Society of Chemical Industry (SCI) American Section. Ms. Kwolek was acknowledged for her discoveries, inventions, and development work that supplied the basis for DuPont's Kevlar® brand fiber.



E. Black

Hercules Resins, Wilmington, DE, has appointed Juan J. Magrans as Worldwide Business Director of Rosins, Terpenes and Co-Products Strategic Business Unit. Mr. Magrans will manage the unit's contribution to Rosin's five-year strategic plan and safety record.

The Inter-Society Color Council will honor Henry Hemmendinger with the Godlove Award during its Annual Meeting slated for September 14-17, 1997 in Baltimore, MD.

Dr. Hemmendinger's career has focused on quantifying performance errors in colorimetry, incurred by photometric equipment and also by human observers. In addition, he has worked to establish and to publish methods for precision spectrophotometry of reflecting materials.

The Godlove Award is given in recognition of a lifetime of distinguished service to the color community.

National Starch and Chemical Co., Bridgewater, NJ, has appointed Leonard J. Berlik to the newly created position of Executive Vice President, Adhesives. Mr. Berlik will continue to report to James A. Kennedy.

In addition, Walter F. Schlauch was named Executive Vice President, Specialty Chemicals and Electronic Materials. Mr. Schlauch will retain the responsibility for the overall corporate purchasing function.

Kashmiri L. Mittal, Educator and Consultant, has been awarded the Adhesives Age Award, presented by *Adhesives Age* magazine; and the American Society for Testing and Materials (ASTM) Adhesives Award, given by ASTM Committee D-14 on Adhesives.

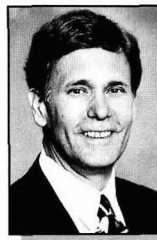
The Adhesives Age Award is presented to a person who has performed outstanding work for the science of adhesion and the technology of adhesives, and who has significantly added to the adhesive body of knowledge or has significantly upgraded the research, development, or application of adhesive technology.

ASTM Committee D-14's Adhesives Award recognizes continuous and outstanding work in the science of adhesion or the technology of adhesives or both.



K.L. Mittal

Ranbar Electrical Materials Inc., Manor, PA, has appointed Tom King as Regional Sales Manager. Mr. King was previously Vice President of Triangle Specialty Resins and the Sterling Varnish Co.



T. King

In addition, John Conroy was named Technical Director. Mr. Conroy will be responsible for all new product development and technical service.

American Colors, Inc., Sandusky, OH, has announced the promotion of Connie L. Ward to the position of Manager of Quality Operations. In addition, Ms. Ward has been appointed to serve as a member of the company's Executive Committee.

George R. Hennigan, Senior Vice President/Chemical Operations at Kerr-McGee Corp., Oklahoma City, OK, has announced his retirement. Mr. Hennigan joined the company in 1979 and was promoted to Executive Vice President in 1983. He was named to his current position in 1991.

S.P. Morell and Co., Armonk, NY, has announced the appointment of Christopher Mangano as Technical Representative in the New England region. Mr. Mangano brings 10 years of chemical sales experience to this position.

The Steel Shipping Container Institute (SSCI), Washington, D.C., has selected Dan Gilligan to serve as Executive Director. Mr. Gilligan brings to the position trade association management experience at both the state and national level.

Craig A. Rogerson has been elected President of Wacker Silicones Corp., Adrian, MI. Mr. Rogerson was previously Vice President and General Manager of the Fibers Division of Hercules Specialty Chemical Co, a subsidiary of Hercules, Inc.

## Obituary

Douglas John Kier, of Asahipen America Inc., Seattle, WA, died on March 1, 1997. He was 60-years old.

Mr. Kier was a member of the Pacific Northwest Society.

The Chemical Fabrics and Film Association, Cleveland, OH, has elected **James L. Tremoulis**, of O'Sullivan Corp., as President. In addition, **Philip J. Tarullo**, of Product Specialties Inc., was elected First Vice President and **John K. Given**, of Sandusky Ltd., was elected Second Vice President.

The Polymers and Resins business of Rohm and Haas, Philadelphia, PA, has announced a reorganization of its seven business units into three worldwide businesses: Coatings, Specialty Polymers, and Building Products. As a result of the reorganization, **Alan Barton** will serve as Worldwide Business Director—Coatings; **Nick Gutwein** will be Worldwide Business Director—Specialty Polymers; and **Rob Andrew** will serve as Worldwide Business Director—Building Products.

WYKO Corp., Tucson, AZ, has announced the promotion of **Matthew Abbene** to Manager/North American Sales. In his new position, Mr. Abbene will oversee all sales activities in the United States and Canada, including the management of sales engineers, key accounts, and sales forecasts.

**Paul Rocheleau** will succeed **Robin Paul** as Chief Executive of Albright & Wilson plc. Dr. Paul will retire in July 1997.

**Terry Pierce** has joined the staff of Fitz Chem Corp., Elmhurst, IL, as an Account Manager. In this capacity, Mr. Pierce will provide technical and sales support to Fitz Chem's customers at select accounts in Chicago, IL, Indiana, and Michigan.

The Colors Group of Sun Chemical Corp., Cincinnati, OH, has announced the addition of three new representatives to its National Sales staff. They are **Thomas D. DeSanto**, **George S. Lloyd**, and **Jason Stout**.

Mr. DeSanto will be responsible for the Southern sales region which includes Mississippi, Alabama, Georgia, and Florida. Mr. Lloyd will represent Sun across Canada, upper New York State, and Michigan. Mr. Stout will be responsible for the group's Chicago sales territory.

**Karen L. Royce** has joined the Environmental Services Group at TolTest Inc., Toledo, OH, as Project Manager. Ms. Royce brings 13 years of project experience with industrial, commercial, and government clients to this position.

The National Board of Registration for Nuclear Safety Related Coating Engineers and Specialists, Leola, PA, have certified **Robert Howard**. Mr. Howard is a Nuclear Coating Specialist with TVA, Chattanooga, TN.



**F.C. Hughes**



**K. Littell**

ANGUS Chemical Co., Buffalo Grove, IL, has promoted **Freeman C. Hughes** to the position of Director of Chemical Feedstocks. In his new position, Mr. Hughes will be responsible for all marketing activities relating to the use of ANGUS' products for chemical synthesis.

In addition, **Ken Littell** was named Senior Manager, Sales and Market Development/India. Mr. Littell will manage current sales of the company's products in the pharmaceutical industry in India as well as sales and market development of ANGUS' products into industrial markets, including coatings, metalworking fluids, and water treatment.

The Institute of Materials, London, England, has appointed **Bernard Rickinson** as its new Chief Executive. Dr. Rickinson joins the Institute from Bodycote International plc. He succeeds **J.A. Catterall**, who is retiring.

Hüls America Inc., Somerset, NJ, has promoted **Michael C. Spangler** to Director, Colorant Systems, Worldwide. In this position, Mr. Spangler will direct all marketing and promotional activities for Mundial™ color system; Unipearl™ pearlescent dispersions; Covon® no-VOC universal colorants; as well as existing and custom color systems.

In other news, **Patricia A. Johnson** was named Controller for the company's Coatings Raw Materials Division. Ms. Johnson will oversee operating and capital budgets, manage all financial analysis services and prepare the division's five-year financial plan.



**M.C. Spangler**



**P.A. Johnson**

## Literature Review

### Powder Coatings Terms and Definitions

#### Published by:

**The Powder Coating Institute**  
**2121 Eisenhower Ave., Ste. 401**  
**Alexandria, VA 22314**  
**1996, 57 pages, \$10**



#### Reviewed by: **Stanley LeSota,** **Horsham, PA**

Powder coatings, an elegant method of solventless coatings application, now has its own official language in print. The Powder Coating Institute has published the first edition of *Powder Coating Terms and Definitions* in a handsome, soft cover, reader friendly booklet.

The terms and definitions defined are in large bold type and starting with capitals. It would have been handier if they started with either lower case or capital letters so that the reader would know which words should be capitalized. The terms and definitions are also in large readable type, much appreciated by se-

nior citizens like myself. There are over 600 succinct, simplified entries in this 57-page booklet.

Twenty-one individuals from different organizations wrote and edited these entries. This type of consensus establishes these terms and definitions as the official terminology of their industry. Some of these entries are specific powder coating jargon, others are allied coating terms, abbreviations, equipment descriptions, and some cross references. This booklet should be useful for those in the powder coatings industry.

## New Products



### Raw Materials

#### Red 170 Pigments

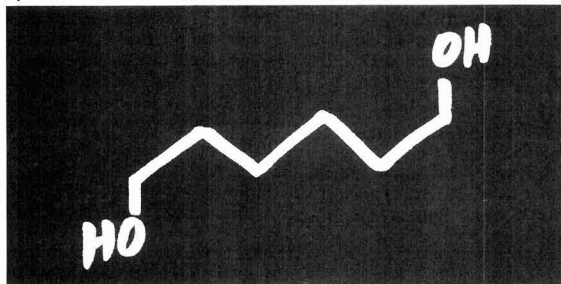
Engelhard Corp. has extended the color space and performance of the two traditional naphthol red 170 pigments. Pigment 3169 matches the shade as the traditional yellow shade red, but has value,

lightfastness, opacity, and rheology. Pigment 3170 is a mid-shade yellow usually made by mixing the two traditional 170 pigments for use in Toro and Case reds, but reportedly enhance opacity, gloss, gloss retention, and heat stability. Pigment 3172 matches the traditional blue shade 170 and features a heat stability of 550°F. Pigment 3175 has a strong blue shade and can act as a quinacrinone diluent or replacement.

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##### Look at some applications in Polyurethanes:

- Automotive coatings
- Epoxy adhesives
- Personal care

##### In Polyesters:

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

##### In Acrylics:

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Circle No. 166 on Reader Service Card

#### Chemical Additives

Information from the Drew Industrial Division of Ashland Chemical Co. highlights specialty waxes and rheology modifiers. Drewax™ specialty waxes offer slip, anti-slip, abrasion resistance, mar resistance, water repellency, and wet-rub resistance. These waxes may be used in industrial coatings, overprint varnishes, flexo ink, wood furniture and parquet lacquers, and stains. The Drewthix™ rheology modifiers line, which currently consists of three urethane and four acrylic types, provides sag resistance, leveling control, film build, spatter resistance, and antisetling.

Circle No. 31 on Reader Service Card

#### Chemical Intermediates

The CD-570 series—chemical intermediates for coatings are available from Sartomer Co. The CD-570 series provides formulators with variations in ethoxylation: CD-570 (2EI), CD-571 (5EO), and CD-572 (10EO). These intermediates offer low toxicity and low-odor replacements of hydroxy ethyl methacrylates.

Circle No. 32 on Reader Service Card

#### Surfactants

Air Products and Chemicals, Inc., highlights Surfynol® 502 and 504 surfactants. These surfactants promote defect-free coverage of medium- to low-energy surfaces under high-speed spraying, coating, saturation, dispersion, or similar processes. This product's reported rapid migration to newly formed interfaces reduces surface tension and produces defect-free coatings by preventing film retraction, craters, and other surface defects.

Circle No. 33 on Reader Service Card

#### Fluorescent Pigments

A line of Panax™ fluorescent pigments—UFB series, is introduced by United Mineral and Chemical Corp. The UFB pigments provide color strength, solvent resistance, hiding power, a full palette, and narrow particle size distribution.

Circle No. 34 on Reader Service Card

#### Polymer Emulsions

Nacan Products Ltd. announces the availability of Nacrythane 2420, a polyurethane modified acrylic emulsion. Designed for the manufacture of clear and pigmented systems, this product reportedly protects the natural elegance of wood while delivering performance benefits. Due to its water-based technology, Nacrythane 2420 is an environmentally compliant coating.

Circle No. 35 on Reader Service Card





## Laboratory Apparatus

### Rolling Oil Coatings

Information from ASI SensIR Technologies describes a new method for the FTIR analysis of rolling oil coatings on metal surfaces. The AmpliIR accessory provides rapid infrared data on thin and residual oils on metals, polymer and paint coatings, semi-conductor surface properties, and new technology sensor surfaces using organic receptor films. This product uses a compact, multiple reflection optical design to produce high sensitivity spectra for unusually small sample areas on reflective surfaces.

Circle No. 36 on Reader Service Card

### Rheometer

The Physica MC1 rheometer is now available from Paar Physica to measure viscosity as a function of rate, time, stress, or temperature for fluids and semisolids. This instrument features a dual post design and user exchangeable control systems. A variety of applications may be utilized including: Peltier lower plate for heating/cooling from -20 to -130°C; resistance heated/air cooled lower plate operating from 25-300°C; and circulating fluid controlled lower plate for use from -30 to 180°C.

Circle No. 37 on Reader Service Card

### Potentiostat/Galvanostat

EG&G Instruments Princeton Applied Research has introduced the VersaStat™ potentiostat/galvanostat. Designed for basic research electrochemistry and corrosion experiments, the new VersaStatII offers 200 mA maximum current output and 20V compliance voltage. Additionally, the unit 1 µA current range reportedly provides good sensitivity with nanoamp resolution.

Circle No. 38 on Reader Service Card

### Scanning Probe Microscope

The AutoProbe® VP2 scanning probe microscope is available from Park Scientific Instruments. Designed for atomic-scale surface analysis in ultra-high vacuum (UHV), this instrument combines the benefits of high temperature imaging with 3-D probe positioning, advanced spectroscopy functions, and self-sensing AFM probes. AutoProbe VP@ is available in three system configurations—standard, extended y-translation, and high temperature.

Circle No. 39 on Reader Service Card



## Books/ Publications

### Reactive Diluents

A brochure published by Henkel Corp. highlights Photomer® acrylate reactive diluents and their use with epoxy resins and curing agents. This publication explains how to use these products in Michael Addition chemistry to formulate no-blush or low-blush high-solids coatings. The coatings are designed for industrial applications such as road stripping, chemical plants, manufacturing facilities, and petroleum plants.

Circle No. 40 on Reader Service Card

### Graphics Coatings

Sequa Chemicals, Inc., has published a brochure on specialty chemicals for graphics high-performance coatings, adhesives, and other applications. The eight-page publication features information on the company's line of polyamide and aqueous vehicles, plus specialty additives, for a wide range of ink and coating applications.

Circle No. 41 on Reader Service Card

### NACE Product Catalog

NACE International has released its 1997 products catalog. The catalog features more than 1,000 books, standards, and software and other products to help operations and maintenance personnel in all industries control corrosion. The 1997 edition features many new corrosion reference books such as *Corrosion Resistant Alloys in Oil & Gas Production and Wet H<sub>2</sub>S Cracking of Carbon and Weldments*.

Circle No. 42 on Reader Service Card



## Services

### Surface Treatment Technology

The Surface Treatment Technology Center has been formed by Concurrent Technologies Corp. to provide a shared resource for investigations, application demonstrations, and interactive communications among those that apply coatings or require surface treatments, and those that develop technology, or manufacture and supply the necessary equipment and materials. The Center will inform and keep its members abreast of the latest technology development, applications, and user needs.

Circle No. 43 on Reader Service Card

## Misc. Miscellaneous Misc.

### Corrugated Eliminator

Stretch-O-Seal Corp. has introduced a stretch wrap machine which applies standard stretch film under tension to multiple containers such as cans, bottles, and jars. This product holds the containers so that they can be palletized without boxes, and in many cases, without any corrugated. The machine can bundle two to four round containers and up to twelve square or rectangular containers ranging in size from one pint to three gallons of up to 25 bundles per minute.

Circle No. 44 on Reader Service Card

### Component Siloxirane

Advanced Polymer Sciences has announced the availability of a 20-minute videotape outlining the capabilities of siloxirane. The video explains the basic chemical background behind siloxirane and shows the product's many uses and applications. The program details a comparison of the properties and chemical structure of siloxirane with epoxies, phenolics, rubber, and stainless steel.

Circle No. 45 on Reader Service Card

### Leak Proof Hose Assemblies

The Hereen Co. has introduced the Squeezelock®, a portable tool that eases hose assembly for Push-Lok and Bar-Lok style hose fittings. The ergonomically designed tool can be used with one hand and creates leakproof assemblies for fittings in hoses of 1/4 in., 5/16 in., and 3/8 in. inside hose diameter. The tool is made of an aluminum alloy for maximum strength and durability and has coated handles. A small push pin and drive pin accommodate hose fittings in a wide variety of sizes.

Circle No. 46 on Reader Service Card

### Pigment Blacks

Degussa Corp. has compiled technical information on disk that offers paint and coatings formulators a convenient method of selecting pigment blacks. The disk covers everything the formulator needs to make purchasing decisions regarding the company's specialized furnace blacks, channel-type blacks, and lamp blacks for the coatings market. In addition, an array of graphs and charts compare the particle size distribution and structure of various Degussa pigment blacks.

Circle No. 47 on Reader Service Card

# Calendar of Events

## FEDERATION MEETINGS



For information on FSCT meetings, contact Federation of Societies for Coatings Technology, 492 Norristown Rd., Blue Bell, PA 19422 (610) 940-0777, FAX: (610) 940-0292.

### 1997

(Apr. 23-25)—"Crosslinking for the Coatings Chemist: Understanding Crosslinking for Improved Performance." Symposium sponsored by the FSCT Professional Development Committee. Orlando Airport Marriott, Orlando, FL.

(May 17-18)—FSCT Spring Board of Directors Meeting, May 17—Social Tour; May 18—Board Meeting. Hyatt Regency, Birmingham, England.

(June 20-21)—FSCT Incoming Society Officers Meeting, June 20—FSCT Headquarters Visit, Meeting, and Reception; June 21—Society Officers Meeting, Marriott West, Conshohocken, PA.

(June 25-26)—"Practical Paint Formulation for Raw Material Suppliers." Symposium sponsored by the FSCT Professional Development Committee. Park Hyatt, Philadelphia, PA.

(June 27)—"Winning Technical Presentations." Symposium sponsored by the FSCT Professional Development Committee. Park Hyatt, Philadelphia, PA.

(Nov. 3-5)—ICE '97—FSCT Annual Meeting and International Coatings Expo and Technology Conference (Formerly Annual Meeting and Paint Industries' Show). Georgia World Congress Center, Atlanta, GA.

### 1998

(Oct. 14-16)—FSCT Annual Meeting and International Coatings Expo and Technology Conference (Formerly Annual Meeting and Paint Industries' Show). Ernest N. Morial Convention Center, New Orleans, LA.

## SPECIAL SOCIETY MEETINGS

### 1997

(Apr. 24)—"The Pulse of the Coatings Industry: Compliance, Processability & Performance." 22nd Annual FOCUS Conference sponsored by the Detroit Society. Michigan State University Management Education Conference Center, Troy, MI. (Rosemary Brady, Akzo Nobel Coatings Inc., P.O. Box 7062, Troy, MI 48007-7062).

(Apr. 30-May 1)—"Additives and Modifiers for Modern Coatings." Symposium sponsored by the New York Society. Holiday Inn North, Newark Airport, NJ. (Paul Mazer, Troy Corp., 8 Vreeland Rd., P.O. Box 955, Florham Park, NJ 07932-0955; (201) 443-0003; fax: (201) 443-0257).

(May 8-10)—50th Annual Spring Symposium. Sponsored by the Pacific Northwest Society. Pan-Pacific Hotel, Vancouver, British Columbia. (Kelvin J. Huget, Imasco Minerals Inc., 19287-98A Ave., Surrey, B.C. V4N 4C8; (604) 888-3848; fax: (604) 888-5671).

(May 13-15)—Southern Society Annual Meeting. King and Prince Beach and Golf Resort, St. Simons Island, GA. (Eve Irvine, J.M. Huber Corp., One Huber Rd., Macon, GA 31298; (912) 750-5433).

(May 15-16)—"Transatlantic Coatings Technology—Diverging or Converging." Sponsored by the Birmingham Paint, Varnish and Lacquer Club. Solihull, N. Birmingham, England. (Joe Brown, Blagden Chemicals Ltd., Piperell Way, Haverhill, Suffolk, CB9 8PH; Telephone: 01440 62821).

(May 22-23)—40th Annual Technical Symposium. "Waterborne Coatings: Sink or Swim." Symposium sponsored by the Cleveland Society. Case Western Reserve University, Cleveland, OH. (Vicki Fisher, Jamestown Paint Co., 108 Main St., Jamestown, PA 16134; (412) 932-3101).

(June 13-15)—RMSCT's June Outing. Steamboat Sheraton, Steamboat Springs, CO. (Charlie Schroeder, Fel-Pro Chemical Products, L.P., 6120 E. 58th Ave., Commerce City, CO 80022; (303) 289-5651).

(Sept. 12)—"Corrosion Control Through Coatings." Conference co-sponsored by the Los Angeles Society and California State Polytechnic University at Pomona. Kellogg West Conference Center, Pomona, CA. (LASCT, 11278 Los Alamitos Blvd., #104, Los Alamitos, CA 90720; fax: (310) 594-6862).

### 1998

(May 11-14)—Eastern Training Conference II. Sponsored by the Philadelphia Society. Valley Forge Convention Center, King of Prussia, PA. (Wayne Kraus, Hercules Incorporated, Research Center, 500 Hercules Rd., Wilmington, DE 19808).

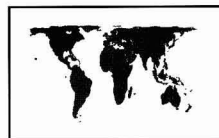
## OTHER ORGANIZATIONS

### 1997—North America

(May 1-2)—"VOCs in Paints and Other Products." Training course sponsored by the American Society for Testing and Materials (ASTM). Chicago, IL. (Kristina Falkenstein, ASTM, 100 Barr Harbor Dr., West Conshohocken, PA 19428-2959).

(May 4-6)—"Pollution Prevention: Tools for Making It Really Happen." Sponsored by the American Institute of Chemical Engineers (AIChE). Sheraton Meadowlands, East Rutherford, NJ. (AIChE, 345 E. 47th St., New York, NY 10017).

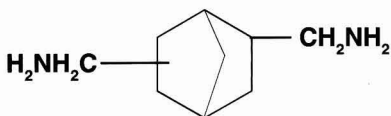
(May 4-8)—43rd Annual Technical Meeting and Exposition. Sponsored by Institute of Environmental Sciences. Los Angeles Airport Hilton, Los Angeles, CA. (Institute of Environmental Sciences, 940 E. Northwest Highway, Mt. Prospect, IL 60056).



## Mitsui Toatsu Chemicals

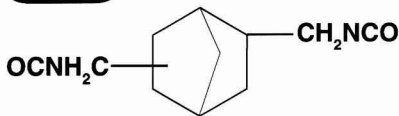
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Fax: +81-3-359 242 81



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(May 5-7)—"Introduction to Emulsion Polymers/Polymer Colloids." Sponsored by the Institute of Materials Science—State University of New York. Orlando, FL. (Angelos V. Patsis, Institute of Materials Science, State University of New York, New Paltz, NY 12561).

(May 5-7)—"Adhesion and Coating Adhesion." Sponsored by the State University of New York. Orlando, FL. (Angelos V. Patsis, Institute of Materials Science, State University of New York, New Paltz, NY 12561).

(May 5-7)—"Thermal Analysis in Polymer Research and Production." Sponsored by Polytechnic University. Conference Center, Newark Airport Marriott Hotel, Newark, NJ. (Eli M. Pearce, Polymer Research Institute, Polytechnic University, Six Metrotech Center, Brooklyn, NY 11201).

(May 5-9)—"Dispersion of Pigments and Resins in Fluid Media." Short course sponsored by the Professional Development Institute. Kent State University, Kent, OH. (Carl J. Knauss, Professional Development Institute, P.O. Box 1792, Kent, OH 44240).

(May 7-9)—"Frontiers in Polymer Chemistry." Short course sponsored by the American Chemical Society. University of Akron, Akron, OH. (American Chemical Society, Dept. of Continuing Education, Meeting Code AKR9705, 1155 Sixteenth St., N.W., Washington, D.C. 20036).

(May 7-9)—"Block and Graft Copolymer Blends." Course sponsored by the State University of New York. Orlando, FL. (Angelos V. Patsis, Institute of Materials Science, State University of New York, New Paltz, NY 12561).

(May 8)—"Viscoelastic Properties of Polymers." Short course sponsored by Polytechnic University. Conference Center, Newark Airport Marriott Hotel, Newark, NJ. (Eli M. Pearce, Polymer Research Institute, Polytechnic University, Six Metrotech Center, Brooklyn, NY 11201).

(May 8-10)—50th Annual Spring Symposium. Sponsored by the Pacific Northwest Society. Pan-Pacific Hotel, Vancouver, British Columbia. (Kelvin J. Huget, Imasco Minerals Inc., 19287-98A Ave., Surrey, B.C. V4N 4C8; (604) 888-3848; fax: (604) 888-5671).

(May 12-13)—"Spectroscopy Instrumentation and Application Seminars." Sponsored by Labsphere, Inc. North Sutton, NH. (Labsphere, Inc., P.O. Box 70, Shaker St., North Sutton, NH 03260).

(May 12-14)—"Fundamentals of Corrosion and Its Control." Sponsored by LaQue Corrosion Services, Wrightsville Beach, NC. (Sherree Darden, LaQue Center for Corrosion Technology, Inc., P.O. Box 656, Wrightsville Beach, NC 28480).

(May 12-16)—"Adhesion Principles and Practice for Coatings and Polymer Scientists." Short course sponsored by the Professional Development Institute. Kent State University, Kent, OH. (Carl J. Knauss, Professional Development Institute, P.O. Box 1792, Kent, OH 44240).

(May 12-16)—"Short Course on Spray Technology." Sponsored by the Spray Systems Technology Center of Carnegie Mellon University. Pittsburgh, PA. (Norman Chigier, Mechanical Engineering, Carnegie Mellon University, Pittsburgh, PA 15213-3890).

(May 13-14)—"Inventory/Production Training Course." Sponsored by BatchMaster Software Corp. Chicago, IL. (BatchMaster Software Corp., 13001 Seal Beach Blvd., Seal Beach, CA 90740).

(May 13-15)—Southern Society Annual Meeting. King and Prince Beach and Golf Resort, St. Simons Island, GA. (Eve Irvine, J.M. Huber Corp., One Huber Rd., Macon, GA 31298; (912) 750-5433).

(May 13-16)—"Practical Emulsion Polymerization." Short course sponsored by The University of Southern Mississippi (USM). Hattiesburg, MS. (Dr. Shelby F. Thames, Director, USM, Box 10037, Hattiesburg, MS 39406-0037).

(May 14-16)—"Spray Finishing Technology Workshop." Sponsored by Bowling Green State University and ITW DeVilbiss. ITW DeVilbiss Training Center, Maumee (Toledo), OH. (Richard A. Kruppa, Bowling Green, OH 43403-0301).

(May 19-21)—"Waterborne Short Course." Sponsored by The Adhesive and Sealant Council, Inc. Quaker Square Hilton, Akron, OH. (The Adhesive and Sealant Council, Inc., 1627 K St., N.W., Ste. 1000, Washington, D.C. 20006).

(May 19-22)—"Finishing '97 Conference and Exposition." Sponsored by the Society of Manufacturing Engineers (SME). Rosemont

Convention Center, Rosemont, IL. (SME, One SME Dr., P.O. Box 930, Dearborn, MI 48121-0930).

(May 19-23)—"Corrosion and Its Control by Protective Coatings." Short course sponsored by Lehigh University. Bethlehem, PA. (Richard Granata, Lehigh University, Sinclair Laboratory, 7 Asa Dr., Bethlehem, PA 18015-3192).

(May 19-23)—"Physical Testing of Paints & Coatings." Short course sponsored by University of Missouri-Rolla (UMR), Rolla, MO. (UMR Coatings Institute, 1870 Miner Circle, Rolla, MO 65409).

(May 20-23)—"Coatings Science for Coatings Technicians." Short course sponsored by The University of Southern Mississippi (USM). Hattiesburg, MS. (Dr. Shelby F. Thames, Director, USM, Box 10037, Hattiesburg, MS 39406-0037).

(May 22-23)—40th Annual Technical Symposium. "Waterborne Coatings: Sink or Swim." Symposium sponsored by the Cleveland Society. Case Western Reserve University, Cleveland, OH. (Vicki Fisher, Jamestown Paint Co., 108 Main St., Jamestown, PA 16134; (412) 932-3101).

(June 2-4)—"Advances in Flame Retardancy of Polymeric Materials: Applications, Materials, Industry Developments, Markets." Conference sponsored by Business Communications Co., Inc. Holiday Inn Select, Stamford, CT. (Business Communications Co., Inc., 25 Van Zant St., Norwalk, CT 06855).

(June 2-4)—"Quality Assurance Management for the Chemical and Allied Industries." Conference sponsored by The Center for Professional Advancement. New Brunswick, NJ. (Registrar, The Center for Professional Advancement, P.O. Box 1052, East Brunswick, NJ 08816).

(June 2-6)—"Advances in Emulsion Polymerization and Latex Technology." Short course sponsored by Lehigh University. Emulsion Polymers Institute, Bethlehem, PA. (Mohamed S. El-Aasser, Emulsion Polymers Institute, Lehigh University, 111 Research Dr., Bethlehem, PA 18015).

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(June 2-13)—Summer Coatings Course. Sponsored by North Dakota State University (NDSU), Fargo, ND. (Debbie Shasky, Program Coordinator, NDSU, Dept. of Polymers and Coatings, 54 Dunbar Hall, Fargo, ND 58105).

(June 3-5)—“Marine and Offshore Coatings Conference '97.” Sponsored by the National Paint and Coatings Association (NPCA). Ramada Plaza Resort Oceanfront, Virginia Beach, VA. (Melina Jimenez, NPCA, 1500 Rhode Island Ave., N.W., Washington, D.C. 20005-5597).

(June 8-13)—“Adhesion Science Short Course.” Sponsored by The Adhesive and Sealant Council, Inc. Blacksburg Marriott, Blacksburg, VA. (The Adhesive and Sealant Council, Inc., 1627 K St., N.W., Ste. 1000, Washington, D.C. 20006).

(June 13-15)—RMSCT's June Outing. Steamboat Sheraton, Steamboat Springs, CO. (Charlie Schroeder, Fel-Pro Chemical Products, L.P., 6120 E. 58th Ave., Commerce City, CO 80022; (303) 289-5651).

(June 17-20)—“Coatings Science for Coatings Formulators.” Short course sponsored by The University of Southern Mississippi (USM), Hattiesburg, MS. (Dr. Shelby F. Thames, Director, USM, Box 10037, Hattiesburg, MS 39406-0037).

(June 22-25)—ASTM Committee D-1 on Paint and Related Coatings, Materials, and Applications. Sponsored by The American Society for Testing and Materials (ASTM). Holiday Inn on King, Toronto, Ontario, Canada. (Scott Orthey, ASTM, 100 Barr Harbor Dr., West Conshohocken, PA 19428-2959).

(June 23-27)—“Applied Pump Technology.” Conference sponsored by The Center for Professional Advancement. San Francisco Bay area, CA. (Registrar, The Center for Professional Advancement, P.O. Box 1052, East Brunswick, NJ 08816).

(June 24)—ASTM D01.51 on Powder Coatings. Sponsored by the American Society for Testing and Materials (ASTM). Holiday Inn at the King, Toronto, Ontario, Canada. (Jeffrey Hagerlin, O'Brien Powder Products, 9800 Genard Rd., Houston, TX 77041-7624).

(June 24-25)—“Purchasing/Order Entry Course.” Sponsored by BatchMaster Software Corp. Chicago, IL. (BatchMaster Software Corp., 13001 Seal Beach Blvd., Seal Beach, CA 90740).

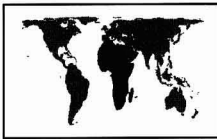
(June 24-27)—“Coatings Science for Coatings Chemists.” Short course sponsored by The University of Southern Mississippi (USM), Hattiesburg, MS. (Dr. Shelby F. Thames, Director, USM, Box 10037, Hattiesburg, MS 39406-0037).

(June 25-27)—“Practical Paint Formulation for Raw Material Suppliers” and “Winning Technical Presentations,” Seminars sponsored by the FSCT Professional Development Committee. Park Hyatt, Philadelphia, PA. (FSCT, 492 Norristown Rd., Blue Bell, PA 19422; (610) 940-0777).

(July 14-16)—“Layman's Introduction to Coatings.” Short course sponsored by University of Missouri-Rolla (UMR). St. Louis Airport Marriott Hotel, St. Louis, MO. (UMR Coatings Institute, 1870 Miner Circle, Rolla, MO 65409).

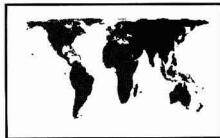
## 1998—Africa

(Mar. 6-8)—“Coatings for Africa '98.” Sponsored by The Oil & Colour Chemists' Association's (OCCA) South African Division, the Natal Section, and Surfex Ltd. International Convention Centre, Durban, South Africa. (Christopher Pacey-Day, OCCA, 967 Harrow Rd., Wembley, Middlesex, England HA0 2SF).



## 1997—Asia

(Oct. 22-24)—“New Developments in Colour Material Science and Technology.” 70th Anniversary Conference on Colour Materials Tokyo sponsored by the Japan Society of Colour Material. Arcadia Ichigaya (Shigaku Kaikan), Tokyo, Japan. (Shuichi Hamada, Japan Society of Colour Material, Kitamura Bldg. 5F, 9-12, 2-chome, Iwamoto-cho, Chiyoda-ku, Tokyo 101, Japan).



## 1997—Australia

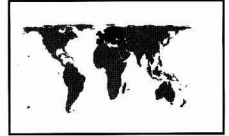
(July 17-19)—“Asset Protection Through Surface Coatings.” 39th Annual Conference sponsored by Surface Coatings Association Australia, Inc. Burswood Resort Convention Centre, Perth, Western Australia. (Surface Coatings Association Australia Inc., P.O. Box 1109, Canning Vale, Western Australia, 6155).



(July 24-27)—“Replacement, Refurbishment & Renewal.” SCANZ '97. Sponsored by Surface Coatings Association, New Zealand, Inc. Wairakei Resort. (Derek Taylor, c/-Coates NZ Ltd., P.O. Box 12748 Penrose).

## 1997—Europe

(May 15-16)—“Transatlantic Coatings Technology—Diverging or Converging.” Sponsored by the Birmingham Paint, Varnish and Lacquer Club. Solihull, N. Birmingham, England. (Joe Brown, Blagden Chemicals Ltd., Piperell Way, Haverhill, Suffolk, CB9 8PH; Telephone: 01440 62821).



(May 17-18)—FSCT Spring Board of Directors Meeting. May 17—Social Tour; May 18—Board Meeting. Hyatt Regency, Birmingham, England.

(May 19-22)—“Paint Technology.” Training course sponsored by the Paint Research Association. Teddington, Middlesex, United Kingdom. (Heena Mehta, PRA, 8 Waldegrave Rd., Teddington, Middlesex, TW11 8LD, United Kingdom).

(May 29-June 1)—15th SLF-Congress. Sponsored by the Skandinaviska Lackteknikers Förbund (SLF). Lillehammer, Norway. (Bent Haflan, Jotun A/S, P.O. Box 2021 Hasle, N-3235 Sandefjord, Norway; or Svein Singstad, Scanox A/S, P.O. Box 42 Ainabru, Norway).

(June 2-4)—“Printing Ink Technology.” Training course sponsored by the Paint Research Association. Teddington, Middlesex, United Kingdom. (Heena Mehta, PRA, 8 Waldegrave Rd., Teddington, Middlesex, TW11 8LD, United Kingdom).

(June 9-11)—19th Annual International Conference on the Degradation and Stabilization of Polymers. Sponsored by the State University of New York. Luzern, Switzerland. (Angelos V. Patsis, Institute of Materials Science, State University of New York, New Paltz, NY 12561).

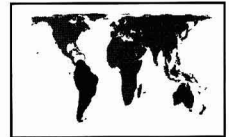
(June 9-11)—“Radiation Curing Technology.” Training course sponsored by the Paint Research Association. Teddington, Middlesex, United Kingdom. (Heena Mehta, PRA, 8 Waldegrave Rd., Teddington, Middlesex, TW11 8LD, United Kingdom).

(June 16-18)—RadTech Europe '97. Sponsored by Vincentz Verlag. Palais de Congrès, Lyon, France. (Esther Schwencke, Vincentz Verlag, P.O. Box 67 42, D-30062 Hanover, Germany).

(June 17-20)—International Intensive Short Course on the Science and Technology of Pigment Dispersions. Sponsored by the State University of New York. Luzern, Switzerland. (Angelos V. Patsis, Institute of Materials Science, State University of New York, New Paltz, NY 12561).

## 1997—South America

(Sept. 15-17)—Fifth International Paint Congress and Exhibition on Paint Industry Suppliers. Sponsored by the Brazilian Association of Paint Manufacturers (ABRAFATI). Palácio de Convenções do Anhembi, São Paulo, Brazil. (Congress Organization Secretariat, Especifica S/C Ltda., Rua Augusta, 2516-2 and-ar-cj. 22, 01412-100-São Paulo, SP-Brazil).



(Oct. 6-9)—“Latin-American Interfinish.” Hotel Transamerica's Convention Center, São Paulo, Brazil. (Associação Brasileira de Tratamentos de Superfície, Av. Paulista, 1313, 9ªa., conj. 913, CEP 01311-923 São Paulo, SP-Brazil).

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# Humbug from Hillman

**H**umbug welcomes Patience Merriman, a devotee of nonsense research, our friend, and a popular local journalist. An advocate of the need for improvement in higher education, Patience recommends the courses below for students seeking advanced degrees.

## Self-Improvement

- 1100—Creative Suffering
- 1101—Overcoming Peace of Mind
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## Business & Career

- BC1—"How I Made \$100 in Real Estate"
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- BC3—Packaging & Selling Your Child
- BC4—How to Profit from your Body
- BC5—The Underachiever's Guide to Very Small Business Opportunities
- BC6—Tax Shelters for the Indigent
- BC7—Mortgage Reduction Through Arson

Of course, there are more . . . for another time.

Patience tells me that her Dad is devoted to composing "palindromes." Devoted?? . . . He's an addict!! Anyone who spends his time this way belongs in this column.

"What is a palindrome?" you ask. Well, typical of "Humbug," it makes as much sense reading it backwards. I quote the following out of the hundreds in his file:

- A Santa at NASA.
- A Toyota! Race fast, sa'z car. A Toyota.
- A man, a plan, a canal, Panama!
- A slut nixes sex in Tulsa.
- Able was I ere I saw Elba.
- Dennis and Edna sinned.
- Drat Saddam, a mad dastard.
- Ed. I saw Harpo Marx ram Oprah W. aside.
- He did, eh?
- Zeus was deified, saw Suez.

Enough???? . . . Enough!!!!

★★★★★★

**I**t takes Dick Stewart to discover "50 Fun Things to Do in an Elevator." Well we won't list all of them in this issue but enough to give you some inspiration. Some of these may be rated "R" for ridiculous. In fact, they all are. But then, so is Dick!

- (1) Grimize painfully, while smacking your forehead and muttering, "Shut up dammit, all of you just shut UPI!"
- (2) Stare at another passenger for a while, then announce "You're one of THEM!" and move to the far corner of the elevator.
- (3) Crack open your briefcase or purse, and while peering inside ask, "Got enough air in there?"
- (4) Stand silent and motionless in the corner, facing the wall, without getting off.
- (5) Stare, grinning at another passenger and then announce, "I've got new socks on!"

(6) When at least 8 people have boarded, moan from the back, "Oh no, not now, damn motion sickness."

(7) Frown and mutter "gotta go, gotta go" then sigh and say "oops."

(8) Walk on with a cooler that says "human head" on the side.

(9) Say "Ding!" at each floor.

(10) Start a singalong.

(11) Take a bite out of a sandwich and ask another passenger, "Wanna see wha in muh mouf?"

(12) Stare at your thumb and say, "I think it's getting larger."

(13) Shave.

(14) Greet everyone getting on the elevator with a warm handshake and ask them to call you "Admiral."

★★★★★★

**T**hrough the thoughtful courtesy of Bob Athey, we again offer to the frustrated gardeners the advice of his mentor, Dr. Chlorophyll, Murphy's Laws of Gardening

- The Jacaranda Principle: If anything goes wrong with your garden, it goes wrong with your favorite plant.

- O'Clarke's Law: The heaviest frost of the winter will occur on the first night that you forget to cover a tender plant.

- The Rainfall Rule: Rainfall is concentrated on weekends and public holidays.

- Noah's Hypothesis: The planting of a new garden will be followed by a flood unless there's a drought.

- The Phantom Breeze Enigma: If spraying is carried out in calm conditions, weedkillers will be blown towards the shrubs but insecticide will be blown in your face.

- The Catastrophe Theory: Cats find newly planted seed beds superior to kitty litter.

- Canine Corollary: Dogs find lovely plants superior to lamp posts.

- And apropos of nothing: "Everything you see I owe to spaghetti." —Sophia Loren

★★★★★★

**D**ick Kiefer offers proof how wrong you can be no matter who you are:

"Computers in the future may weigh no more than 1.5 tons.

*Popular Mechanics* (1949).

"I think there is a world market for maybe five computers."

Thomas Watson, Chairman of IBM (1943)

"There is no reason anyone would want a computer in their home."

Ken Olson, Chairman and Founder of Digital Equipment (1977).

—"640K ought to be enough for anybody."

Bill Gates (1981)

—Herb Hillman, *Humbug's Nest*, P.O. Box 135, Whitingham, VT 05361.

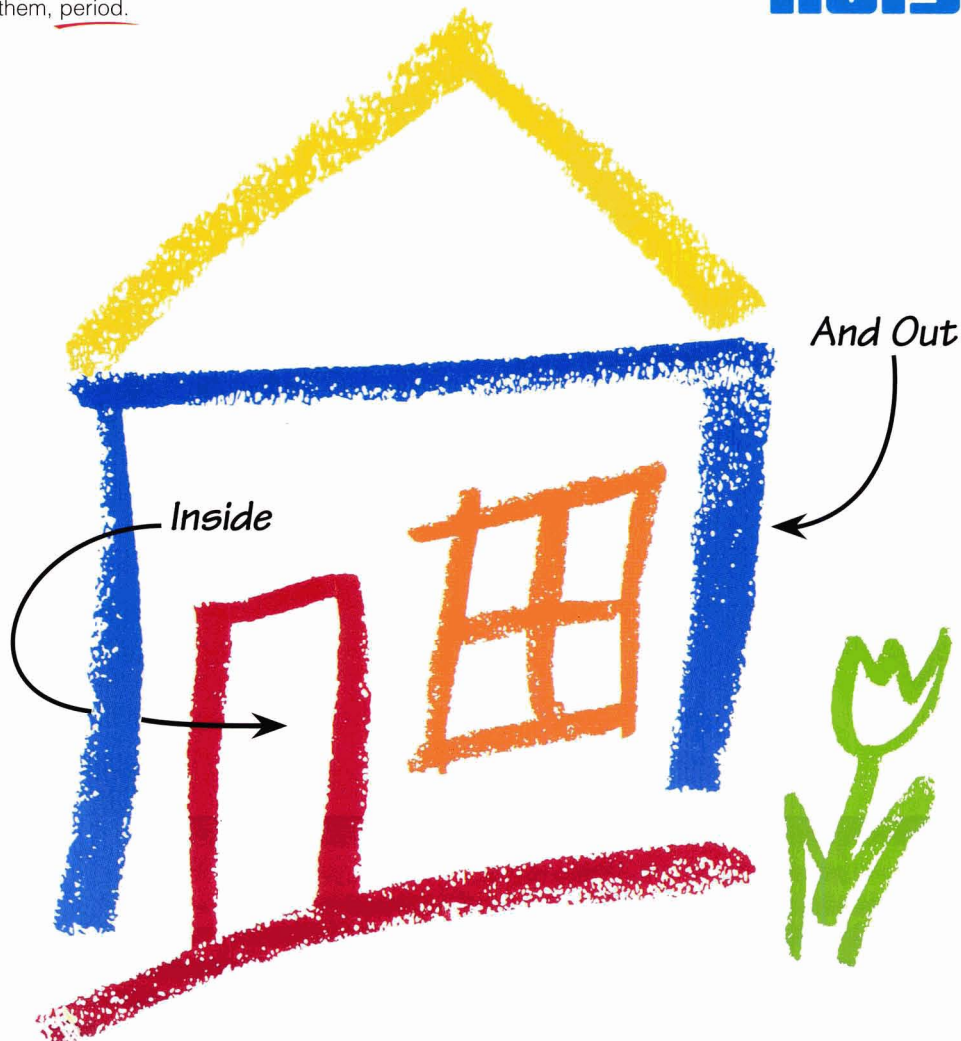
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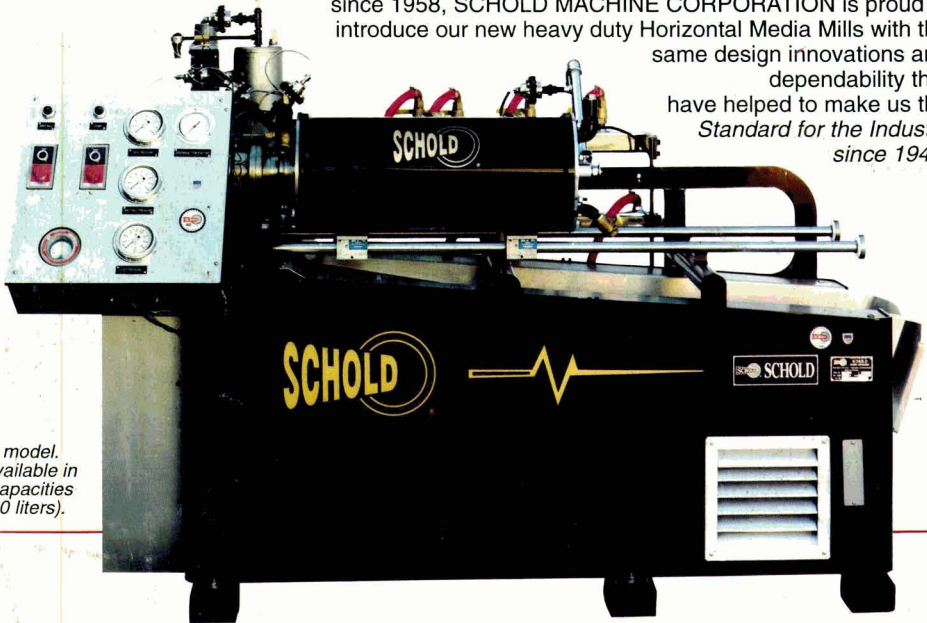
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