

jct JOURNAL OF COATINGS TECHNOLOGY

JCTAX 60 (758) 1-92 (1988)

March 1988



New Heterocyclic Pigments



HALF THIS AD IS FOR THE BENEFIT OF OUR COMPETITION.

In times like these, it's rather difficult to double your savings.

But that's exactly what you can do when you use *their* opaque polymer and *our* UCAR Acrylic 522.

If you're worried that switching to a lower cost pigment technology may shortchange you on performance, forget it.

In test after test, UCAR Acrylic 522 ranked number one in wet adhesion for interior semigloss paints.

It was also right on the money when it came to associative thickener response, and gloss and

color development.

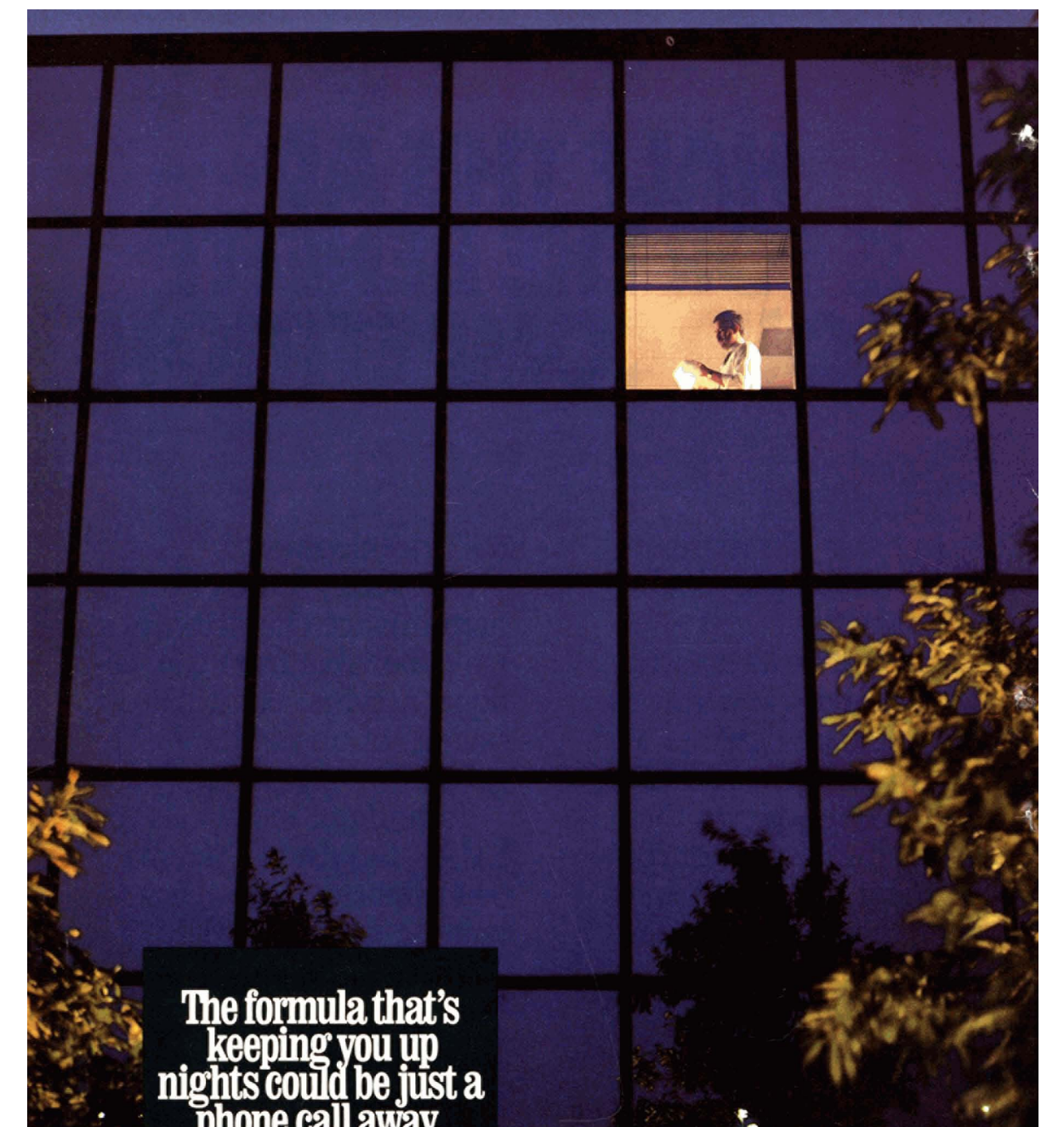
Of course, some of these performance characteristics are obtainable from conventional acrylics. But not at a savings of up to 50¢ a gallon.

To find out more, call your UCAR Emulsion Systems Sales Representative, or write to us at Dept. L4488, 39 Old Ridgebury Road, Danbury, CT 06817.

Half of this ad may be for our competition. But all of the savings are for you.



UCAR Emulsion Systems



**The formula that's
keeping you up
nights could be just a
phone call away.**

If you have a radiation curing project that's as slippery as a high-gloss finish, it's time to call in some expert help.

And there's no one more expert than Radcure

Specialties. Because no one concentrates on UV and electron beam curing products like we do — offering a full spectrum of monomers, photoinitiators, epoxy acrylates, urethane acrylates, polyester acrylates, additives and straight acrylics.

In fact, as a member of UCB Group, we can offer over 80 different raw materials for radiation curing. We will be glad to help you design the formulation you need. So call on us for technical assistance, service, or even the use of our fully-equipped radcure laboratory.

Why spend another sleepless night? Call toll-free 1-800-426-3820.

Radcure Specialties

The Name Says It All.

5365-A Robin Hood Road, Norfolk, VA 23513



Technical Articles	37	New Heterocyclic Pigments—A. Iqbal, et al.
	47	Positron Implantation and Annihilation in Protective Organic Coatings—Cs. Szeles, et al.
	53	How to Calculate Crosslink Structure in Coatings—D.R. Bauer
	67	Crowding and Spacing of Titanium Dioxide Pigments—J.H. Braun

Federation News	24	Plans Underway for 1988 Annual Meeting and Paint Show
	22	Current 1988 Paint Industries' Show Exhibitors
	24	"Spring Week '88" Registration Forms and Program

Departments

Comment	7	Don't Miss the Main Event on the Midway
Abstracts	10	
JCT Editorial		
Review Board	12	
Regulatory UPDATE	17	
JCT Guide for Authors	27	
Government & Industry	32	Concerns of Managers and Planners Focus of Battelle Study
Society Meetings	73	
Elections	77	
Future Society Meetings	78	
People	79	Joseph Koleske Retires from Union Carbide Corp.
Obituary	81	Harold Spitzer, 1977 George Baugh Heckel Award Winner
Meetings/Education	83	Missouri-Rolla Offers Spring Coatings Classes
Literature	86	
CrossLinks	86	Solution to February Puzzle
Coming Events	88	
Humbug from Hillman	92	Kindergarten Lessons and More Ahlfisms

1988年3月出版

HOW TO MAKE G ON A FAST FO



ROPAQUE® OP-62 Opaque Polymer. Maintains quality and hiding while reducing costs.



ACRYSOL® RM-825 Rheology Modifier. Highly efficient; excellent flow and leveling, thickening efficiency and film build; low viscosity for easy handling.



TRITON® CA Surfactant. Newest wetting agent; solves color acceptance problems.



ACRYSOL TT-935 Rheology Modifier. Low-cost HEC substitute; provides improved spatter resistance and film build.

Like the perfect spice that makes a gourmet dish, Rohm and Haas additives can help you maintain the high quality of your paints...and trim some fat from your costs at the same time. The secret is in our variety. No one offers as many additives that save you so much. Each is designed to perform better and more economically. Just add a pinch here, a dash there... and voila!

And that goes for all your paints. In fact, the more paint you produce using Rohm and Haas

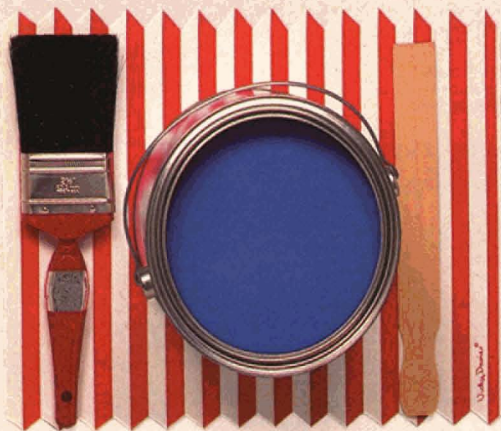
GOURMET PAINTS ON A BUDGET.



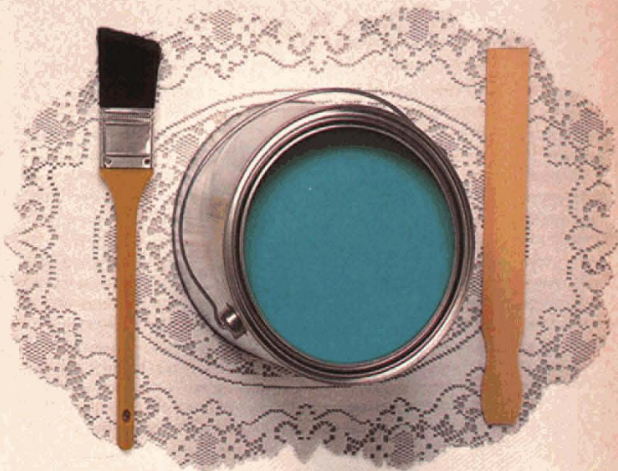
TAMOL® 963 Dispersant. Lowers costs; aids stability, color acceptance and hiding; contributes less foam and color.



TAMOL 983 Dispersant. All the features of TAMOL 963 as well as the added benefit of zinc oxide stability.



SKANE® M-8 Mildewcide. Highly effective; liquid form for easy incorporation into water or solvent-based paints.



KATHON® LX Microbicide. Emulsion storage preservative; can substantially reduce biocide costs.

additives, the more significant the savings. And when purchased in combination with our RHOPLEX® acrylic vehicles, you have the potential to save even more.

To learn more about all the ways you can make gourmet paints on a fast food budget, contact your Rohm and Haas technical representative. Or write our Marketing Services Department, Independence Mall West, Philadelphia, PA 19105.

**ROHM
AND
HAAS** 
PHILADELPHIA, PA. 19105

jct JOURNAL OF COATINGS TECHNOLOGY

1315 Walnut St., Phila., PA 19107

THE JOURNAL OF COATINGS TECHNOLOGY is published monthly by the Federation of Societies for Coatings Technology at 1315 Walnut St., Philadelphia, PA 19107. Phone: (215) 545-1507.

Annual dues for Active and Associate Members of the Federation of Societies for Coatings Technology is \$20.00. Of this amount, \$13.50 is allocated to a membership subscription to this publication. Membership in the Federation is obtained through prior affiliation with, and payment of dues to, one of its 26 Constituent Societies. Non-member subscription rates are:

	U.S. and Canada	Europe (Air Mail)	Other Countries
1 Year	\$27.00	\$ 55.00	\$ 40.00
2 Years	\$51.00	\$107.00	\$ 77.00
3 Years	\$73.00	\$157.00	\$112.00

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

Staff

ROBERT F. ZIEGLER PUBLISHER
 PATRICIA D. VIOLA EDITOR
 THOMAS J. MIRANDA TECHNICAL EDITOR
 THOMAS A. KOCIS CONTRIBUTING EDITOR
 SAMUEL M. AMICONE ASSOCIATE EDITOR
 KATHLEEN WIKIERA ASSISTANT EDITOR
 LORRAINE LEDFORD ADVERTISING SERVICES MANAGER

Publications Committee

THOMAS J. MIRANDA, Chairman
 TAKI ANAGNOSTOU THOMAS A. KOCIS
 DARLENE BREZINSKI PERCY E. PIERCE
 PAUL R. GUEVIN, JR. PATRICIA D. VIOLA
 LOREN W. HILL ROBERT F. ZIEGLER

Editorial Review Board

THOMAS J. MIRANDA, Chairman
 T. ANAGNOSTOU G.D. CHEEVER T. HOCKSWENDER
 H.E. ASHTON R.A. DICKIE J.V. KOLESKE
 R.D. BAKULE G.D. EDWARDS H. LOWREY
 G.P. BIERWAGEN F.L. FLOYD P.E. PIERCE
 R.F. BRADY, JR. P.R. GUEVIN, JR. F. SHUSTER
 A.H. BRANDAU H.E. HILL R. STANZIOLA
 D. BREZINSKI L.W. HILL

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

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

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

Copyright 1988 by the Federation of Societies for Coatings Technology. All rights reserved. No portion of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying, recording, or by any information storage or retrieval system without permission in writing from the publisher. Authorization to photocopy items for internal or personal use, or the internal or personal use of specific clients is granted by the Federation of Societies for Coatings Technology for users registered with the Copyright Clearance Center (CCC) Transactional Reporting Service, provided that the base fee of \$1.00 per copy, plus .25 per page is paid directly to CCC, 27 Congress St., Salem, MA 01970. For those organizations that have been granted a photocopy license by CCC, a separate system of payment has been arranged. The fee code for users of the Transactional Reporting Service is: 0032-3352/86 \$1.00 + .25.



FEDERATION OF SOCIETIES FOR COATINGS TECHNOLOGY BOARD OF DIRECTORS 1987-88

PRESIDENT

*DERYK R. PAWSEY
 Rohm and Haas Can. Inc.
 1099 W. 8th St.
 Vancouver, B.C., Canada
 V6H 1C3

*NORMAN A. HON
 Cook Paint & Varnish Co.
 Kansas City, MO

CARLTON R. HUNTINGTON
 Chemical Distributors Inc.
 Portland, OR

PRESIDENT-ELECT

*JAMES E. GEIGER
 Sun Coatings, Inc.
 12295 75th St. N
 Largo, FL 33540

TERRYL F. JOHNSON
 Cook Paint & Varnish Co.
 Kansas City, MO

BERGER JUSTEN
 Justen & Associates
 Tampa, FL

TREASURER

*JOHN C. BALLARD
 Kurpees Coatings, Inc.
 201 E. Market St.
 P.O. Box 1093
 Louisville, KY 40201

JOAN B. LAMBERG
 Horton-Earl Co.
 St. Paul, MN

MAUREEN LEIN
 Davidson Rubber Co.
 Dover, NH

BARRY ADLER
 Royelle, Inc.
 Menlo Park, CA

JAMES A. MCCORMICK
 LCI, Inc.
 Baltimore, MD

JAMES N. ALBRIGHT, JR.
 Lilly Co.
 High Point, NC

DONALD R. MONTGOMERY
 The O'Brien Corp.
 Houston, TX

RONALD R. BROWN
 Unoca Corp.
 Charlotte, NC

WILLIAM W. PASSENO
 Mercury Paint Co.
 Detroit, MI

*CARLOS E. DORRIS
 Jones-Blair Co.
 Dallas, TX

JAMES E. PETERSON
 Peterson Paints
 Pueblo, CO

VAN G. FALCONE
 Koppers Co.
 Irving, TX

HORACE S. PHILIPP
 Ottawa, Ont., Canada

JOHN FOLKERTS
 Futura Coatings, Inc.
 Hazelwood, MO

ANTONIO PINA
 Mexicana de Pinturas Intl.
 Ixtapalapa, Mexico

RICHARD L. FRICKER
 Valspar Corp.
 Minneapolis, MN

LLOYD REINDL
 Flanagan Associates, Inc.
 Cincinnati, OH

CARL W. FULLER
 U.S. Oxides
 Morrisville, PA

FRED G. SCHWAB
 Coatings Research Group, Inc.
 Cleveland, OH

JOSEPH D. GIUSTO
 Lenmar, Inc.
 Baltimore, MD

SAUL SPINDEL
 D.L. Laboratories, Inc.
 New York, NY

L. LLOYD HAANSTRA
 Decratrend Paints
 City of Industry, CA

RAYMOND B. TENNANT
 Carrs Paints Ltd.
 Birmingham, England

*THOMAS HILL
 Pratt & Lambert, Inc.
 Buffalo, NY

RAYMOND C. UHLIG
 PPG Industries, Inc.
 Allison Park, PA

JAN P. VAN ZELM
 Byk-Chemie USA
 Castaic, CA

RICHARD M. HILLE
 General Paint & Chemical Co.
 Cary, IL

*KURT WEITZ
 Indusmin Ltd.
 Toronto, Ont., Canada

JAMES A. HOECK
 Reliance Universal, Inc.
 Louisville, KY

*Executive Committee Members

EXECUTIVE VICE-PRESIDENT

ROBERT F. ZIEGLER
 FSCT Headquarters
 1315 Walnut St.
 Philadelphia, PA 19107

WILLIAM R. HOLMES
 DeSoto, Inc.
 Garland, TX 75046

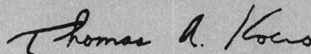
Don't Miss the Main Event on the Midway

The Ides of March have not yet arrived, the blossoms of Spring are still some weeks away, and the dog days of summer must come and go before the Federation Annual Meeting and Paint Show convenes this October. Nonetheless, it's not too early to begin making plans to attend.

The "Sold Out" sign just went up for this year's Paint Show (display space will again set a record), and the exhibit hall at McCormick Place will literally bulge with the wares of industry supplier companies.

In the meeting rooms, sessions will feature presentations addressing various aspects of the program theme, "Performance *and* Compliance: The Challenge Intensifies." Speakers will focus on such areas as corrosion protection, aerosol coatings, "high tech" coatings research, and major regulatory issues affecting coatings formulation and manufacture, all underscoring the impact of regulatory restrictions on the coatings industry, which must respond to the dual challenges of producing quality coatings while meeting increasingly restrictive compliance standards.

In the exhibit hall and the meeting rooms, there will be much of interest for coatings technical personnel to savor and ponder. So plan now to take part in the big 1988 twin bill in Chicagoland, Oct. 19-21—all signs point to a truly memorable event!



Thomas A. Kocis
Contributing Editor

กองบรรณาธิการ วารสารสีเคลือบ

John Massingill helped a contract. Yet he still needs help



can coater keep a \$1 million matching his ties and shirts.



There are two things about John Massingill that people soon learn. He is a very good chemist. And a very bad dresser. It's gotten to the point around the Massingill home that his wife labels which ties go with which shirt—which is a pretty good solution since most colors appear alike to John's eyes. (The blue tie goes with the yellow shirt in the photo at left.)

Fortunately, fancy ties are not in fashion in the Dow lab where John works—but creative chemistry is. Here John excels.

A few months ago, for example, John helped a Dow customer hold onto a one million dollar can coating contract when its customer put on the squeeze. The problem: The resin viscosity range had to be cut in half while all other performance characteristics had to remain the same.

"It sounds simple," says John. "But it took weeks to work out the details. At one point we had six functions at Dow involved—from research to marketing to production. We ran the Freeport, Texas plant around the clock for five days during production. We virtually customized the resin, but it finally helped our customer out of a tight jam."

John is just one of the more than 150 people in Dow's Resin Products coatings group working with coating formulators and makers of can coatings like yours.

In the coming months, you will see more of John and his colleagues—visiting labs, attending trade shows and delivering papers at conferences. Wherever you see them, they are there to answer your questions, listen to your needs and respond with products and technical insights.

If you'd like, you can call John right now to discuss your technical needs in epoxy resins for can coatings. Just call toll-free 1-800-258-2436, ext. 21, Coatings, or send in the coupon below.

Oh yes, and please feel free to suggest some clothing ensembles for John—his family is running out of ideas.

To: The Dow Chemical Company, Resin Products Department, P.O. Box 1206, Midland, MI 48641-9940

- Please send me your brochure on epoxy resins for can and coil coatings.
 Please send brochures on epoxy resins for:
 Automotive coatings Flooring
 Powder coatings Marine and maintenance coatings.
 Please have a sales representative call.

Name _____

Position _____

Company _____

Address _____

City/State/Zip _____

Phone _____



Abstracts of Papers in This Issue

NEW HETEROCYCLIC PIGMENTS—A. Iqbal, et al.

Journal of Coatings Technology, 60, No. 758, 37 (Mar. 1988)

Following introductory remarks on the discovery of a novel family of heterocyclic compound pigments, 1,4-diketopyrrolo(3,4-c)pyrrole, called the DPP, an attempt is made to rationalize their properties in terms of their solid state structures. Various mechanisms of formation of DPP are described and the chemistry, especially bearing on the synthesis and development of pigmentary forms of DPP, also is briefly outlined.

POSITRON IMPLANTATION AND ANNIHILATION IN PROTECTIVE ORGANIC COATINGS—Cs. Szeles, K. Süvegh, A. Vértes, M.L. White, and H. Leidheiser, Jr.

Journal of Coatings Technology, 60, No. 758, 47 (Mar. 1988)

Positron implantation and annihilation were studied in two polymeric coatings, one pigmented and the other unpigmented, deposited on steel substrates. Positron lifetime spectra recorded on the coatings exhibited three components and closely resembled characteristic lifetime spectra of bulk polymers, but they were strongly dependent on the coating thickness. It was shown that the lifetime spectra could well be described as a sum of two contributions: spectra of the coating and the steel substrate. The fraction of positrons stopped in the coatings and in the steel were determined, and the effective mass absorption coefficients of positrons were extracted. The thickness dependence of the mean positron lifetime and the intensities of different lifetime components were described with an exponential positron implantation profile. The mixing of the lifetime parameters of the coating and steel spectra was studied as a function of thickness. Simulated lifetime spectra were generated using the experimental lifetime spectra and implanted fractions in the coatings and steel. Differences

between the measured and simulated lifetimes and intensities at low thickness values were associated with an inhomogeneous size and depth distribution of open volumes in the coatings.

HOW TO CALCULATE CROSSLINK STRUCTURE IN COATINGS—D.R. Bauer

Journal of Coatings Technology, 60, No. 758, 53 (Mar. 1988)

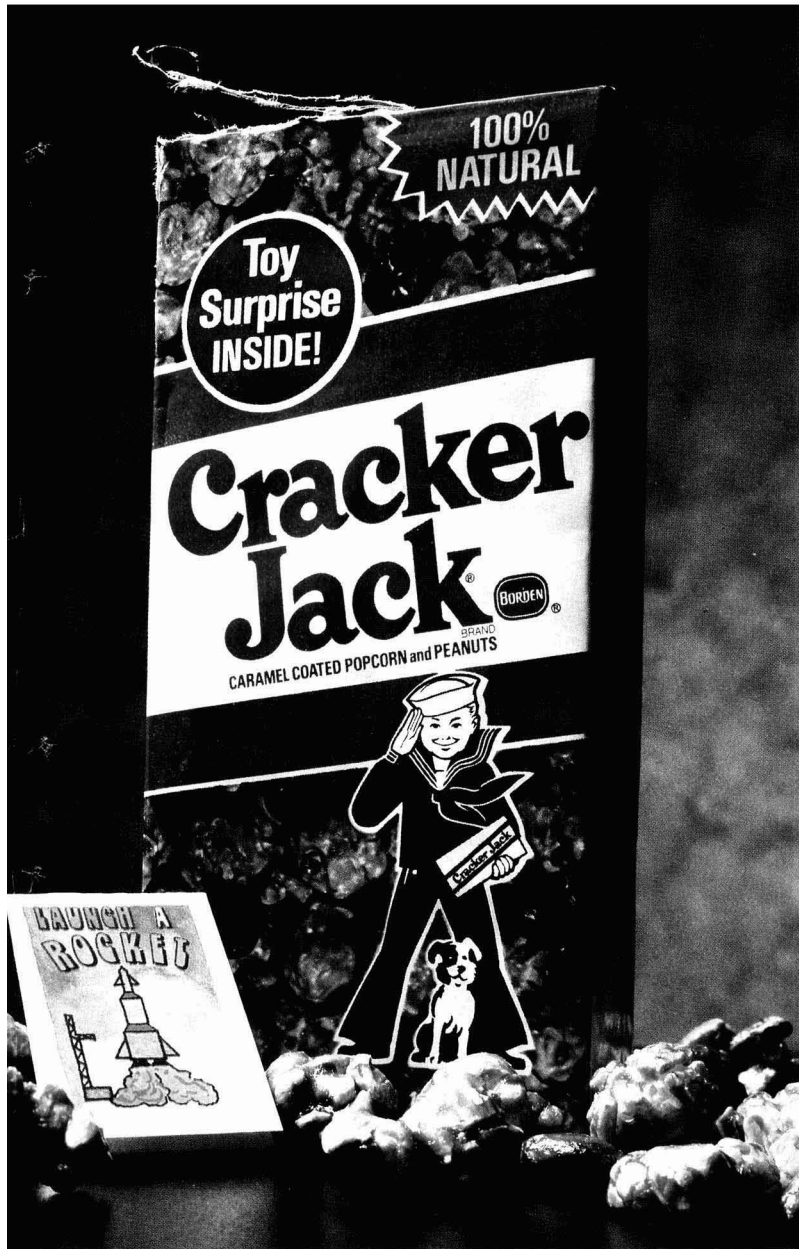
Two simple programs are presented for calculating both pre-gel and post-gel network structure properties in thermoset coatings. The programs are based on the theories of Miller and Macosko. The coating components can be mixtures of oligomeric species or random copolymers. The pre-gel program calculates the weight average molecular weight as a function of coating variables and extent of reaction. The post-gel model calculates the weight of the sol fraction and the effective crosslink density. The programs are written in BASIC and run on IBM-PC compatible computers. Various applications of these programs are described.

CROWDING AND SPACING OF TITANIUM DIOXIDE PIGMENTS—J.H. Braun

Journal of Coatings Technology, 60, No. 758, 67 (Mar. 1988)

Considerations of geometry and hiding power show that "spacing" of rutile particles can improve the hiding of non-porous paint films. The improvements are small, only a few percent, and limited to paints formulated at high pigment concentrations.

Commercial extenders are too large to improve hiding by spacing of rutile particles. Coatings on the rutile, however, can be thin enough to meet geometric requirements for hiding improvement and not affect paint rheology.



CRACKER JACK, the design of SAILOR JACK, and BINGO are registered trademarks of Borden, Inc. Used with permission of Borden, Inc.

Unlike some products, we don't provide a surprise in every container.

We know you're looking for three things in a quality kaolin clay and mica source: consistency, consistency, consistency.

So at Huber, SPC (Statistical Process Control) is an integral part of every plant. It's the best system we know to shave the peaks and valleys off performance charts. To deliver minerals you can count on to be right on target, every time.

Add to that SQC (Statistical Quality Control), a system Huber pioneered in the clay industry to ensure we meet your quality control standards.

But all those numbers won't add up to much without the human equation. So we put in hundreds of hours of training to make SPC and SQC user-friendly and results-oriented.

Contact your cracker jack Huber sales representative, or call us at 912/745-4751 and ask about all the ways we can deliver consistency. Over and over. Every time. Et cetera.



Our Quality Runs Deep.™



Editorial Review Board

This is the second part of a two-part series which highlights the professional accomplishments of the members of the JCT Editorial Review Board. Part One appeared in the January 1988 issue.

Taki J. Anagnostou

A member of the coatings industry for 31 years, Dr. Anagnostou is a Professor and the Program Coordinator of Polymers and Coatings Technology at Eastern Michigan University, Ypsilanti, MI.



He received his undergraduate degree from Miami University of Ohio in 1952, and the M.S. Degree from Roosevelt University in 1960. In 1963, Dr. Anagnostou received the Ph.D. Degree

from North Dakota State University and, in 1969, initiated the coatings program at the University of Detroit. He is a past-Chairman of the Federation's A.F. Voss/American Paint & Coatings Journal Award Committee and past-Chairman of the Detroit Society Technical Committee (1976-79). Dr. Anagnostou received the Fourth Prize in the 1980 Roon Foundation Awards competition. He has been a member of the Editorial Review Board since 1984 and currently serves on the FSCT Publication Committee.

Percy E. Pierce

Dr. Pierce received the B.S. Degree in Chemistry from Case Institute of Technology in 1953. In 1956, he attained the M.S. Degree and, in 1958, the Ph.D. Degree in Physical Chemistry from Yale University.

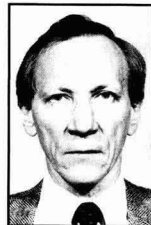


He began his professional career as an Assistant Professor of Chemistry at Case. In 1963, he joined the Glidden Co. where he carried out research on various aspects of the physical chemistry of coatings. Presently, Dr. Pierce is Manager of Physical

Dr. Koleske recently retired from Union Carbide Corp., Charleston, WV, where he was employed as a Corporate Research Fellow. He has 65 U.S. patents and 75 papers, books, and book chapters to his credit. Dr. Koleske was instrumental in developing the Cyra-cure®, Envibar®, and Tone® M-100 products. In 1958, he received the B.S. Degree in Chemistry from the University of Wisconsin. In 1960, he received the M.S. Degree and, in 1963, the Ph.D. Degree from Lawrence University. Dr.

Joseph V. Koleske

Koleske is a member of the Pittsburgh Society and formerly served as a member of the Federation's Publications Committee. His areas of interest include polymer physics, and powder, high-solids, and radiation coatings.



Gordon Dale Cheever, Sr.

Dr. Cheever is a Staff Research Scientist, General Motors Research Labo-



ratories, Warren, MI. He has been associated with GM for 22 of his 29 years in

the coatings industry. Dr. Cheever received the A.B. Degree in 1955 and M.A. Degree in 1958 from Johns Hopkins University. In 1963, he accepted the Ph.D. Degree from Case Institute of Technology (now Case Western Reserve University). Dr. Cheever received Federation's Roon Foundation Awards in 1966 (Fifth Prize) and 1982 (Fourth Prize). He is a member of the Detroit Society.

Ralph Stanziola

Mr. Stanziola is President, Industrial Color Technology, Neshanic Station, NJ. He received the B.S. Degree in Chemistry and Dyeing from the Philadelphia College of Textiles and Science and currently is an Adjunct Professor of Color Science at the school. Mr. Stanziola is Chairman of the Federation's Armin J. Bruning Award



Committee and received the Award at the Annual Meeting in 1981. The Philadelphia Society member has been in the coatings field for 25 years and specializes in industrial color control.

Finally, emulsions as forgiving as your mother

Not since you were a kid has anything been as forgiving as Joncryl® R.C. Emulsions.

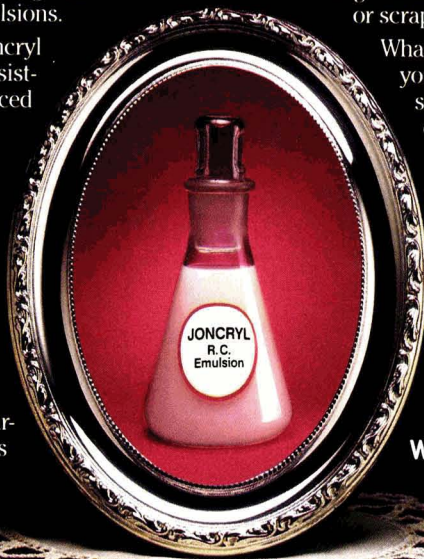
Unlike most other emulsions, Joncryl R.C. Emulsions have excellent resistance to solvent shock and pH-induced viscosity drift. So they provide outstanding shelf and diptank stability. Plus, their unusual mechanical shear stability, coupled with inherent pigment dispersing ability, allow for direct use in a Cowles or sand mill grind. These unique properties permit wide formulating and production latitude.

Joncryl R.C. Emulsions are less touchy throughout the manufacturing process. And since there's less

to go wrong, you don't run the risk of ruined or scrapped batches.

Whatever the use or finish, we think you'll find Joncryl R.C. Emulsions superior to the conventional acrylic emulsions you're now using.

See what Joncryl R.C. Emulsions can do for you. For samples call 1-414-631-3920 or write: Specialty Chemicals Group, Worldwide Innochem, Johnson Wax, Racine, WI 53403.



**Johnson
wax**

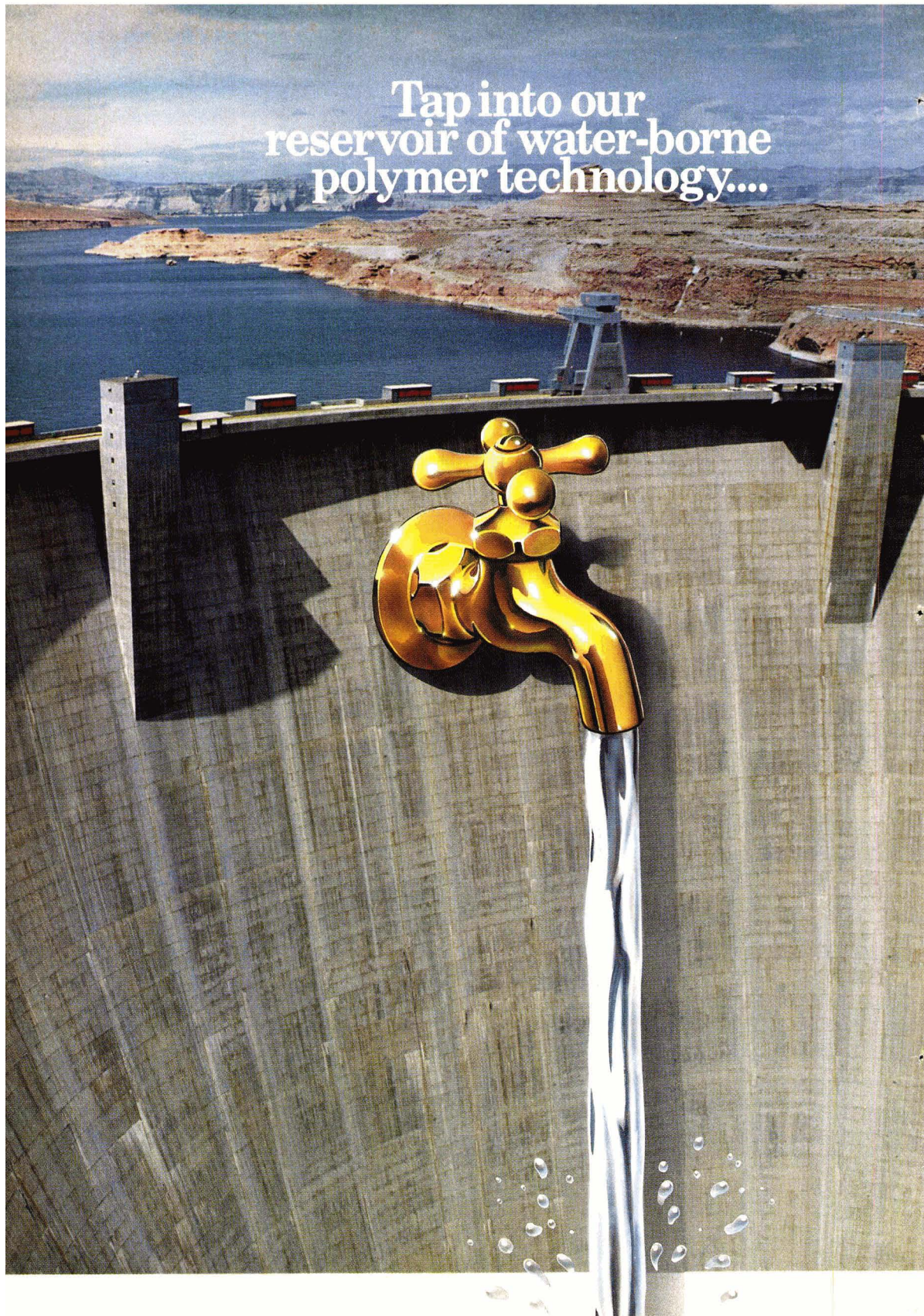
SPECIALTY CHEMICALS
Racine, Wisconsin 53403

We do much more than floors.

Joncryl is a trademark. © 1987
S.C. Johnson & Son, Inc.,
Racine, WI 53403

International: Mijdrecht, Netherlands;
Brantford, Ontario, Canada; Oiso, Japan.

Tap into our
reservoir of water-borne
polymer technology...



Get proven water-borne solutions for your maintenance coating problems.

For more than 30 years, Polyvinyl has pioneered in developing special-purpose water-borne polymers to replace solvent-borne resins in industrial coatings.

Now we're offering water-borne **Haloflex**[®] vinylidene chloride/vinyl chloride/acrylic terpolymers for maintenance coating formulations. These resins provide corrosion resistant performance that is equivalent—and sometimes superior—to high-performance solvent-borne resins.

The zero VOC potential of these Haloflex resins makes them suitable for all compliance-sensitive markets.

Coatings formulated with Haloflex resins have unique barrier properties. In salt-fog testing to 2,000+ hours and extended on-site trials, Haloflex primers and primer/top coat systems have demonstrated their durability for applications such as bridges and open-structure plants.

For more information about Haloflex[®] resins for maintenance coatings, call our Market Development Group at 800-225-0947 (in MA 617-658-6600), or write Dept. GR3, 730 Main Street, Wilmington, MA 01887.



Polyvinyl Chemicals

a member of the ICI Group



A TRUE MEASURE OF A FINE CLAY

Georgia Kaolin announces the development of two new clays as companions to its Hydrite® kaolins, the industry standard for water-washed specialty clays. These new clays permit smoother, faster dispersion in water based coatings, as well as in traditional non-aqueous paint systems.

The benefits of Hydrite PXH clay include high brightness and controlled particle sizing with a 5+ Hegman grind. The high degree

of pulverization of Hydrite PXH clay allows quick and efficient makedown in a variety of mixing equipment. Its ease of dispersion is well suited to solvent based coatings where good gloss and controlled rheology are important.

Likewise, Hydrite RH clay features a Hegman grind of 5+. However, the unique particle size of Hydrite RH clay contributes to lower binder demand and reduced viscosity, allowing higher

loading levels and more economical filler usage.

Please contact Georgia Kaolin or your GK distributor for more information on these finer-grind clays—Hydrite RH and Hydrite PXH.

Georgia Kaolin. We help you make better paint.™

Georgia Kaolin Company
2700 US Highway 22 East
Union, NJ 07083
201-851-2800

COMBUSTION  ENGINEERING

Regulatory UPDATE

MARCH 1988

This digest of current regulatory activity pertinent to the coatings industry is published to inform readers of actions which could affect them and their firms, and is designed to provide sufficient data to enable those interested to seek additional information. Material is supplied by Roy F. Weston, Inc., Washington, D.C.

Hazardous Chemical Inventory Due—Owners and operators of facilities that are required to prepare or have available a material safety data sheet (MSDS) for a hazardous chemical under Occupational Safety and Health Administration (OSHA) regulations must file emergency and hazardous chemical inventory forms with local authorities by March 1, 1988. The emergency and hazardous chemical inventory form must be submitted to the local emergency planning committee, state emergency response commission, and local fire department.

The emergency and hazardous chemical inventory form requires an estimate of the maximum amount of hazardous chemicals present during the preceding year, an estimate of the average daily amount of hazardous chemicals at the facility, and their location. See 52 Federal Register 38344 (Oct. 15, 1987).

The inventory submission requirements are imposed by the Emergency Planning and Community Right-to-Know Act of 1986, enacted as part of the Superfund Amendments and Reauthorization Act (SARA). Contact Kathleen Brody, Program Analyst, Preparedness Staff, Office of Solid Waste and Emergency Response, WH-5262A, U.S. EPA, 401 M Street, S.W., Washington, D.C. 20460, or The Chemical Emergency Preparedness Program Hotline 1-(800) 535-0202.

Chemical Release Form To Be Issued—A form for reporting toxic chemical releases is awaiting the signature of the EPA's administrator and is expected to be released soon. Section 313 of the Emergency Planning and Community Right-to-Know Act (enacted as part of the 1986 Superfund Amendments, SARA) requires that owners and operators of certain facilities that manufacture, import, or process certain toxic chemicals report their releases of those chemicals annually. Standard Industrial Classification codes 20-39 are required to report annually on releases of certain toxic chemicals as a result of normal business operations. The first reporting date is July 1, 1988. The reports are to be sent to both EPA and the State in which the facility is located. The purpose of the report is to make toxic chemical release information available to the public. See 52 Federal Register 21152 (June 4, 1987). Contact Edward A. Klein, Director, TSCA Assistance Office (TS-799), Office of Toxic Substances, U.S. EPA, 401 M Street, S.W., Washington, D.C. 20460 (202) 382-4355.

EPA Supplements Underground Tank Proposal—EPA has issued a supplement to its proposed rules for hazardous substance and petroleum underground storage tanks (UST) and is considering comments on several specific issues. Among them is whether to list substances that would be subject to the proposed petroleum UST system standards rather than the standards for hazardous substance UST systems. See 52 Federal Register 48638 (Dec. 23, 1987). EPA originally proposed to categorize substances as petroleum or hazardous based on the relative concentration of each type of substance in mixtures containing both. See 52 Federal Register 12662 (Apr. 17, 1987).

EPA is also considering changes to its proposed definition of flow through process tanks that would be excluded from the proposed underground storage tank regulations. EPA has proposed to define the excluded tanks as ones that are integral to a production process through which there is a steady or uninterrupted flow of materials during the operation of a process. The change in the proposed definition is intended to clarify that the exclusion does not apply to tanks used to store regulated substances prior to their introduction into the industrial and commercial process, or to storage of regulated substances as intermediates, by-products, or finished products of the process. For more information, contact the RCRA/Superfund Hotline, 1-(800) 424-9346.

Small Quantity Waste Exception Rule Takes Effect—Beginning March 23, 1988, generators of between 100 and 1000 kilograms of hazardous waste per month will have to file with the EPA, an exception report if the generator does not receive confirmation that his hazardous waste shipment has been received at the designated facility. See 52 Federal Register 35894 (Sept. 23, 1987). The exception reporting requirement has been modified to reduce for small quantity generators any burden associated with the full reporting requirement.

For general information, contact the RCRA/Superfund Hotline at 1-(800) 424-9346, or call the Small Business Hotline at 1-(800) 368-5888. For information on specific aspects of the exception reporting rule, contact Paul Mushovic, Office of Solid Waste (WH-562B), U.S. EPA, 401 M Street, S.W., Washington, D.C. 20460 (202) 475-7736.

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.

Warnings Required for California Proposition 65 Chemicals—Requirements to provide "clear and adequate" exposure warnings for products containing listed chemicals took effect on February 27, 1988, for the first set of chemicals listed under California's Safe Drinking Water and Toxic Enforcement Act. Popularly known as Proposition 65, the law requires exposure warnings for listed chemicals known to the state to cause cancer or reproductive toxicity. A prohibition on discharge of the listed chemicals takes effect in November of 1988.

The next meeting of the California Scientific Advisory Panel, that recommends additions to the Proposition 65 list, will be April 29, 1988. Listing of ethyl alcohol is expected to be the main topic.

Chemicals subject to the February 27 warning requirement are: 4-Aminodiphenyl; Analgesic mixtures containing phenacetin; Arsenic (inorganic compounds); Asbestos; Azathioprine; Benzene; Benzidine (and salts); Chloronapazine; Bis(chloromethyl)ether; Myleran; Certain combined chemotherapy for lymphomas; Chlorambucil; Chloromethyl methyl ether (technical grade); Chromium (hexavalent compounds); Coke oven emissions; Conjugated estrogens; Cyclophosphamide; Diethylstilbestrol; Melphalan; Methoxsalen with ultraviolet A therapy (PUVA); Mustard Gas; 2-Naphthylamine; Soots, tars, and lubricant base oils and derived products; Thorium dioxide; Treosulfan; Vinyl chloride; 1,2-Dibromo-3-chloropropane (DBCP); Ethylene oxide; and Lead.

VOC-Plastic Coating Rule Issued—EPA has issued the final rule to limit volatile organic compound (VOC) emissions from facilities that surface coat plastic parts for business machines. The rule is intended to require new and reconstructed plants to control VOC emissions to the level achievable by the best system of continuous emission reduction. Limits are set at 1.5 kg voc/l of coating solids applied for prime and color coats and 2.3 kg voc/l of coating solids applied for texture and touchup coats. The rule took effect January 29, 1988. See 53 Federal Register 2672 (Jan. 29, 1988).

For policy questions, contact Doug Bell or Laura Butler, Standards Development Branch, Emission Standards and Engineering Division (MD-13), U.S. EPA, Research Triangle Park, NC 27711 (919) 541-5578. For technical questions, contact James C. Berry, Chemicals and Petroleum Branch, Emission Standards and Engineering Division (MD-13), U.S. EPA, Research Triangle Park, NC 27711 (919) 541-5605.

Pretreatment Clarifications Expected—Proposed revisions to EPA's General Pretreatment Regulations are expected to receive final approval from the Office of Management and Budget near the beginning of April, 1988, according to sources within EPA. The rule, as submitted to OMB, contains only minor alterations and does not change the framework of the pretreatment program. The proposed modifications are intended to clarify existing regulations; respond to recommendations of the Pretreatment Implementation Review Task Force; and conform the pretreatment regulations, where appropriate, to National Pollutant Discharge Elimination System (NPDES) permit regulations. See 51 Federal Register 21454 (June 12, 1986). Contact Permits Division (EM-336), U.S. EPA, 401 M Street, S.W., Washington, D.C. 20460 (202) 475-9533.

Comment Period Reopened On Unsubstituted Phenylenediamines—The comment period for a proposed rule on unsubstituted phenylenediamines (PDAS) has been reopened to permit public comment on modifications and additions EPA is proposing in the testing program for neurotoxic, mutagenic, oncogenic, and aquatic toxicity effects. EPA is restructuring the proposed aquatic toxicity testing for meta-phenylenediamine (M-PDA), ortho-phenylenediamine (O-PDA), and para-phenylenediamine (P-PDA) and the proposed mutagenicity and oncogenicity testing, and is now proposing that neurotoxicity testing be conducted on all three isomers. M-PDA is used in the manufacture of dyes, corrosion inhibitors, urethanes, decolorizing resins, and ion exchange resins. O-PDA and P-PDA are used in the manufacture of dyes and azo dyes, respectively. See 53 Federal Register 913 (Jan. 14, 1988).

Comments due in triplicate by February 29, 1988, at Document Control Number OPTS-42008D, TSCA Public Information Office (TS-793), Office of Pesticides and Toxic Substances, U.S. EPA, Rm. NE-G004, 401 M Street, S.W., Washington, D.C. 20460. Contact Edward A. Klein, Director, TSCA Assistance Office (TS-799), Office of Toxic Substances, Rm. E-543, 401 M Street, S.W., Washington, D.C. 20460 (202) 554-1404.

EPA to Remove 49 Substances from TSCA Inventory—EPA intends to remove 49 chemical substances from the Toxic Substances Control Act Chemical Substance Inventory and is soliciting public comment on the appropriateness of that removal. After reviewing requests to correct certain previously submitted inventory reports, EPA concluded that the 49 chemical substances were incorrectly reported and listed. In reviewing the total body of inventory submissions, EPA discovered that each of the incorrectly listed substances was reported only by one submitter who subsequently requested that EPA correct the chemical identity originally reported. See 53 Federal Register 949 (Jan. 14, 1988).

Comments are due in triplicate by February 29, 1988, at Document Control Office (TS-790), U.S. EPA, Office of Toxic Substances, 401 M Street, S.W., Washington, D.C. 20460. Contact Edward A. Klein, Director, TSCA Assistance Office (TS-799), Office of Toxic Substances, U.S. EPA, Rm. E-543, 401 M Street, S.W., Washington, D.C. 20460 (202) 554-1404.

EPA Seeks Diisocyanate Adverse Reaction Reports—EPA is requiring manufacturers, processors, and distributors of specified members of the categories "diisocyanates" and "Tri(alkyl/alkoxy)phosphates" to submit records of allegations that these substances cause significant adverse reactions to health or the environment. This action is required by the Toxic Substances Control Act (TSCA) to help EPA evaluate the risks of exposure to these substances. See 53 Federal Register 1408 (Jan. 19, 1988). Regulations specifying these recordkeeping and reporting requirements can be found in 40 CFR Part 717.

Records are due by March 4, 1988 at Docket Number 8cF-0188-0002, Document Processing Center (TS-790), Rm. L-100, Office of Toxic Substances, Attention: Section 8(c) Report, U.S. EPA, 401 M Street, S.W., Washington, D.C. 20460. Contact Edward A. Klein, Director, TSCA Assistance Office (TS-799), Office of Toxic Substances, U.S. EPA, Rm. E-543, 401 M Street, S.W., Washington, D.C. 20460 (202) 554-1404.

Four Substances Deleted From Right-To-Know List— EPA has issued final rules removing four substances from the list of extremely hazardous substances published under section 302 of the Emergency Planning and Community Right-to-Know Act. These substances, dimethyl phthalate, diethyl phthalate, dibutyl phthalate, and bacitracin, were incorrectly listed due to clerical error and, in response to a court order requiring their removal, have been delisted effective December 17, 1987. These four substances were part of an original list of 40 substances EPA proposed to delete from the list of extremely hazardous substances in November, 1986. EPA believes that the remaining 36 substances are similar to the four substances with respect to their status on the list. Therefore, EPA intends to soon issue a final rule deleting the other 36 substances. See 52 Federal Register 48072 and 52 Federal Register 48073 (Dec. 17, 1987). Contact Carrie Wehling, Office of General Counsel, LE-1325, U.S. EPA, 401 M Street, S.W., Washington, D.C. 20460 (202) 382-7706.

Containerized Hazardous Waste Rule Delayed— Publication of the final rule concerning the disposal of containerized hazardous liquids in hazardous waste landfills has been postponed by the EPA at least until June. The rules are expected to prohibit free liquids, prohibit the use of biodegradable absorbants, and require absorbant mixtures to be tested for liquid release. See 51 Federal Register 46824 (Dec. 24, 1986). Contact Paul Cassidy, Office of Solid Waste (WH-565), Land Disposal Branch, U.S. EPA, 401 M Street, S.W., Washington, D.C. 20460 (202) 382-4654.

OSHA Proposes Rule for Ethylene Oxide Exposure— The Occupational Safety and Health Administration (OSHA) has proposed a short-term permissible exposure (excursion) limit for ethylene oxide. OSHA is proposing to amend its existing standard that regulates occupational exposure to ethylene oxide, to include an excursion limit of five parts ethylene oxide per million parts of air (5 ppm) averaged over a maximum sampling period of fifteen minutes. OSHA is seeking comment on whether the proposed limit would reduce the significant risk faced by workers at the current eight-hour time-weighted average permissible exposure. Where the proposed short-term limit is exceeded, employers would have to reduce exposure. See 53 Federal Register 1724 (Jan. 21, 1988).

Comments on the proposed standard are due in quadruplicate, postmarked by February 22, 1988, at Docket Officer, Docket No. H-200, Rm. N-3670, U.S. Department of Labor, 200 Constitution Avenue, N.W., Washington, D.C. 20210. Contact James F. Foster, Occupational Safety and Health Administration, Division of Consumer Affairs, Rm. N-3649, U.S. Department of Labor, 200 Constitution Avenue, N.W., Washington, D.C. 20210 (202) 523-8157.

A public hearing on the proposed standard has been tentatively scheduled for March 3, 1988 in Washington, D.C. Notice of intention to appear must be postmarked by February 22, 1988. Documentary evidence to be introduced into the record is due in quadruplicate February 22, 1988, at Occupational Safety and Health Administration, Division of Consumer Affairs, Attn: Tom Hall, Rm. N-3649, 200 Constitution Avenue, N.W., Washington, D.C. 20210 (202) 523-8615.

SUMMARY CALENDAR OF REGULATORY ACTIONS

- | | |
|-------------------|---|
| February 27, 1988 | Warnings required for first chemicals listed under Calif. Proposition 65. (See this issue.) |
| February 29, 1988 | Comments due on EPA removal of 49 substances from TSCA Inventory. (See this issue.) |
| February 29, 1988 | Comments due on proposed modifications to testing program of unsubstituted phenylenediamines. (See this issue.) |
| March 1, 1988 | Material safety data sheets for hazardous chemicals due to local emergency planning committee, state emergency response commission, and local fire department. (See this issue.) |
| March 4, 1988 | Diisocyanate adverse reaction reports due to EPA. (See this issue.) |
| March 14, 1988 | CPSC Policy on labeling household products containing methylene chloride takes effect. (See February 1988 issue.) |
| March 18, 1988 | Petitions due for judicial review of EPA organic chemicals, plastics, and synthetic fibers category effluent limitation guidelines, pretreatment standards, and new source performance standards. (See January 1988 issue.) |
| March 23, 1988 | Generators of 100-1000 kg/month of hazardous waste must file exception reports when wastes are shipped but delivery is not confirmed. (See this issue.) |
| March 28, 1988 | Comments due on EPA's expanded Good Laboratory Practice standards. (See February 1988 issue.) |
| April 1988 | Comments due on New York State Proposed Regulation for Architectural Coatings. (See February 1988 issue.) |
| April 29, 1988 | Meeting of Calif. Scientific Advisory Panel to consider additions to Proposition 65 list. (See this issue.) |
| May 9-11, 1988 | EPA sponsored hazard waste symposium. (See February 1988 issue.) |

House Committee Proposes Compromise On Tin Paint Bill—The House Merchant Marine and Fisheries Committee has suggested to the Senate a compromise version of a bill to curb pollution from tributyltin and other organotin based paints. The House and Senate have been at odds over harbor refuge and water quality provisions.

The organotin based paints are used to prevent barnacles, algae, and other encrusting organisms from attaching to the bottom of vessels. The compromise would prohibit organotin paints on boats 25 meters or less in length, but provides an exemption for aluminum boats and outboard motors because the alternative to organotin paints are copper based paints which corrode aluminum surfaces. The compromise would also establish a release rate of four micrograms per centimeter per day (originally the Senate set the release rate at three micrograms, the House, at five). A ban on sale of organotin paints for larger ships would be in effect until EPA issued final regulations on the use of organotin chemicals. Willful violations would result in criminal penalties of up to \$25,000 or up to one year in prison or both. Civil penalties would be set at up to \$5,000. The compromise would not preempt States' authority to adopt stricter standards.

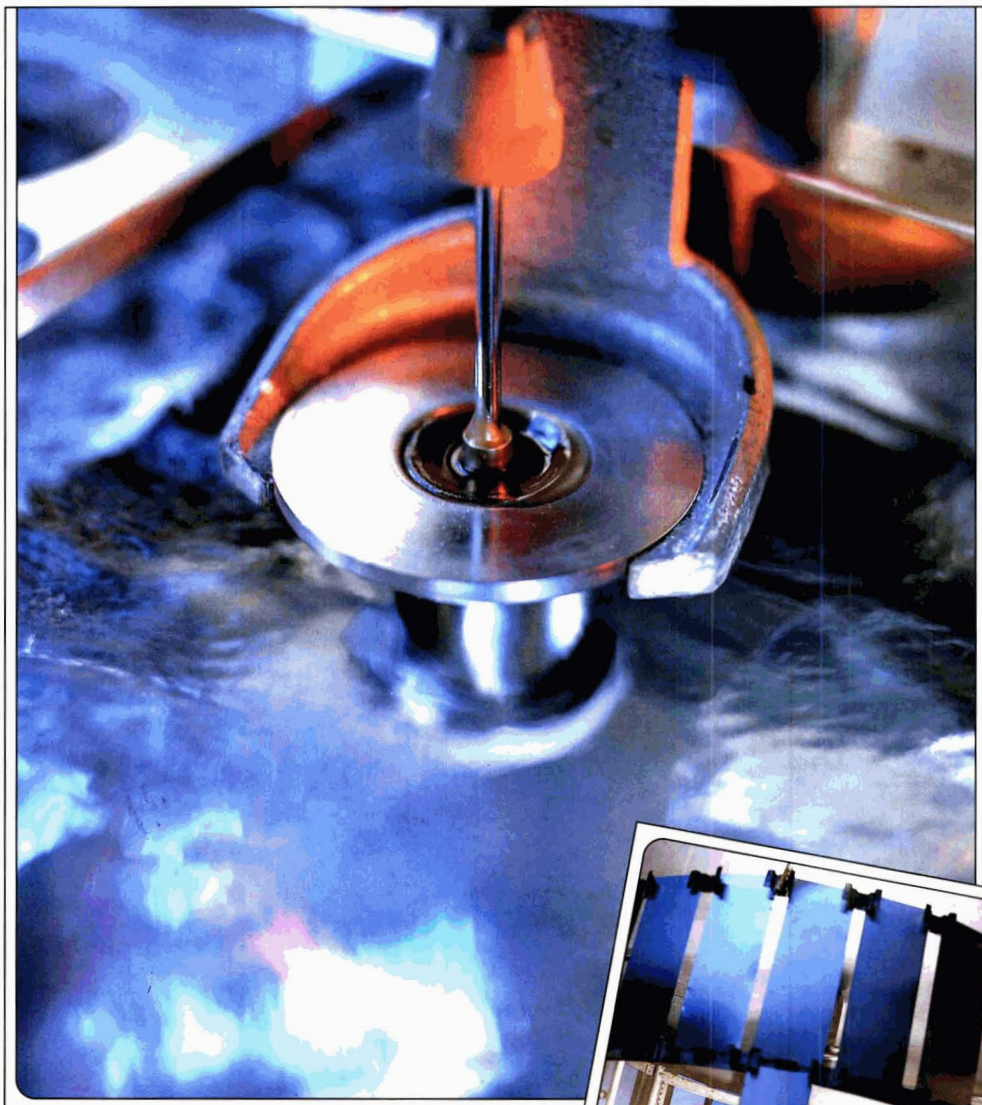
Contact Committee on Merchant Marine and Fisheries, 1334 Longworth House Office Building, Washington, D.C. 20515 (202) 225-4047.

EPA Calls For Chlorendic Acid/Anhydride Records—

EPA is requiring manufacturers, importers, processors, and distributors of chlorendic acid and chlorendic anhydride, used in the preparation of polyester resins, to submit records and reports of allegations that these substances cause significant adverse reactions to health or the environment. EPA requested the reports by February 4, 1988. Under the authority of section 8(c) of the Toxic Substances Control Act (TSCA), chemical manufacturers, processors, importers, and distributors must maintain records of significant adverse reactions to health or the environment alleged to have been caused by chemical substances or mixtures, and to make these records available to EPA. Regulations specifying these record keeping and reporting requirements are codified at 40 CFR Part 717. This call for data is being issued to help EPA evaluate the risk of exposure to these substances. EPA is also seeking information that suggests that significant adverse reactions could be attributable to a synergistic reaction of these chemicals with other substances. See 52 FR 48321 (Dec. 21, 1987).

Contact Edward A. Klein, Director, TSCA Assistance Office (TS-799), Office of Toxic Substances, U.S. EPA, Rm. E-543, 401 M Street, S.W., Washington, D.C. 20460 (202) 554-1404.

For paints that perform brilliantly



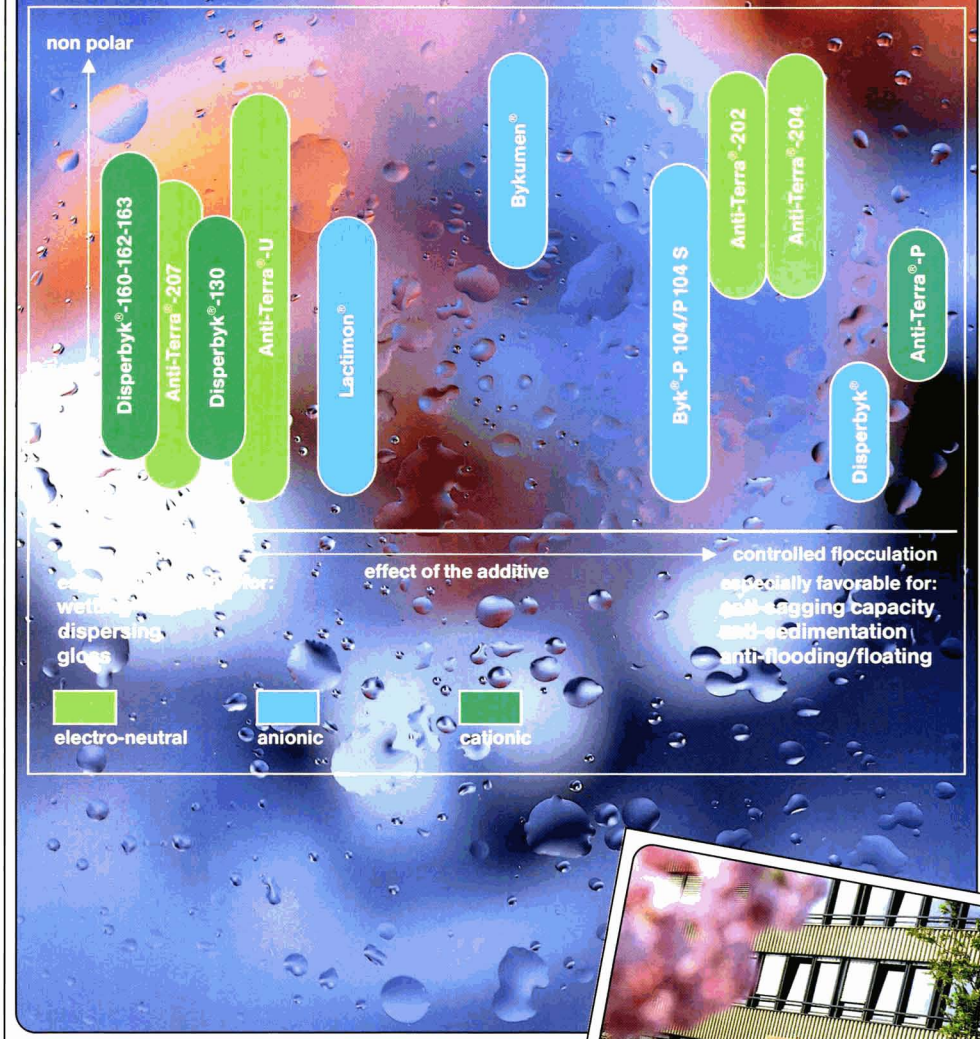
Every one of our additives is conceived, developed, manufactured and tested under practical conditions in our own facilities. Our worldwide distribution network is supported by our technical advisory service with direct focus on application technology. In addition to being responsible for the training of our sales representatives, our laboratories are also available for customer support and can be called on for problem-solving and technical advice regarding the use of the wide range of BYK additives.



Our Quality Assurance Policy ensures the highest possible standards by continuous monitoring of all production processes using sophisticated test equipment, often of our own design.

 **Chemie**
Additives + Instruments

Effectiveness of BYK wetting and dispersing additives

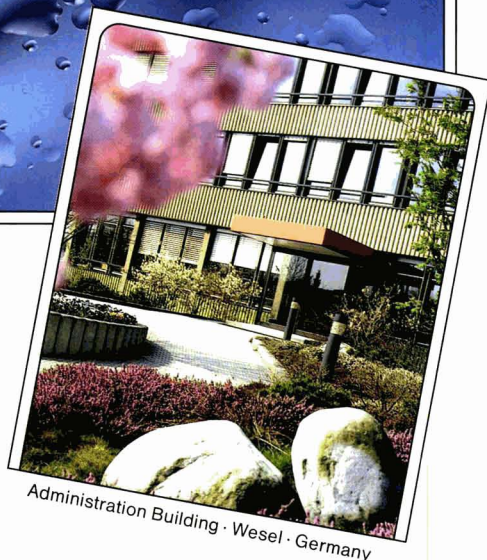


W. HK-Düsseldorf 11989

Our wetting and dispersing additives wet and disperse pigments and extenders, offering stable adsorption layers and making them more compatible with their surrounding media. The results are shorter dispersion times and stable systems.

BYK-Chemie USA · Wallingford · Connecticut

BYK Chemie
 Additives + Instruments



Preparations Underway for 1988 Annual Meeting And Paint Industries' Show in Chicago, Oct. 19-21

The 1988 Annual Meeting of the Federation will be held on October 19-21 at McCormick Place, Chicago, IL. The theme of the meeting is "Performance and Compliance: The Challenge Intensifies." This theme underscores the impact of regulatory restrictions on the coatings industry, which must respond to the dual challenges of producing quality products while meeting increasingly restrictive compliance standards. Programming will focus on such areas as corrosion protection, aerosol coatings, "high tech" coatings research, and major regulatory issues affecting coatings formulation and manufacture. Also included in the program will be the Mattiello Memorial Lecture, Roon Awards Papers, Society Papers, and Seminars.

Program Chairman Richard M. Hille, of General Paint & Chemical Co., Cary, IL, and his committee are developing a schedule of presentations. Serving on the committee are: George R. Pilcher (Vice-Chairman), Hanna Chemical Corp., Columbus, OH; Adrian Adkins, Olympic Homecare Products Co., Pleasanton, CA; Jay Austin, Halox Pigments Corp., Hammond, IN; Gary Gardner, Tnemec Co., Inc., N. Kansas City, MO; Richard J. Himics, Daniel Products Co., Jersey City, NJ; Gus W. Leep, Seymour of Sycamore, Inc., Sycamore, IL; and Joseph P. Walton, Jamestown Paint & Varnish Co., Jamestown, PA.

Paint Industries' Show

To be held in conjunction with the 66th Annual Meeting, the Paint Show will feature the products and services of the suppliers of the coatings industry. More than 215 exhibitors—utilizing over 67,000 net square feet of space—will be in the show. For a current list of exhibitors, see page 22 in this issue.

Currently, all available exhibit space is contracted, and over 7000 industry personnel are expected to attend. Exhibit hours will be 11:00 to 5:30 on Wednesday, October 19; 9:00 to 5:30 on Thursday, October 20; and 9:00 to 3:00 on Friday, October 21.

Hotels and Reservations

Federation headquarters will be the Chicago Hilton. Other cooperating hotels will be: Hyatt Regency Chicago; The Congress; Palmer House; Essex Inn; Best Western Inn; Days Inn; and McCormick Center

Hotel. All housing will be processed by the Chicago Convention Bureau, which will accept only the official housing form furnished by the Federation.

Special Air Fares

United Airlines and Delta Air Lines, in cooperation with the FSCT, are offering a special discount fare which affords passengers a 40% minimum savings off their round trip, undiscounted day coach fares for travel to the Annual Meeting on the airlines' domestic systems. The discount from Canada is 35%.

To take advantage of the United Airlines discount, you must (1) travel between October 16-24, 1988; (2) phone 1-800-521-4041 for reservations. Immediately reference the FSCT file number: **8002D**. The special fares are available only through this number.

For those traveling on Delta Air Lines, the discount will be given if you: (1) travel between October 14-23, 1988; (2) purchase tickets at least seven days in advance; (3) phone 1-800-241-6760 for reservations. Immediately reference the FSCT file number: **U0235**. The special fares are available only through this number. For Delta Frequent Flyers, triple mileage is available if tickets are purchased with an American Express card.

Discounts on either airline are good for both direct and connecting flights to Chicago. If you use travel agents, have them place your reservation through the toll-free number to obtain the same fare advantages. Both Delta and United have a variety of other promotion fares, some of which may represent even greater savings. When you phone for reservations, ask for the best discount applicable to your itinerary.

Spouses Activities

The Spouses Program of Activities will begin on Wednesday, October 19, with a get-acquainted wine and cheese social in the Williford Room of the Chicago Hilton.

On Thursday, the spouses will tour the University of Chicago with a visit to the Museum of Science and Industry. The group will be treated to a private organ recital at the University's Rockefeller Chapel.

Luncheon will be served at the Ambassador West Hotel's elegant Guildhall. Following lunch, the attendees will be enter-

tained by "Jan Hobson and Her Bad Revue," featuring local harmony and flashy piano, with songs spotlighting the '20's, and '30's.

Host Committee

Co-chairmen of the 1988 Annual Meeting Host Committee are Audrey LeNoble, of Emco Chemical Distributors, Inc. and Rudolph Albrecht, of Ace Paint Div., Ace Hardware Corp. Assisting them are the following subcommittee chairmen: *Information Services*—Thomas Drucker, Graham Paints & Varnish Co., Inc.; *Registration*—Thomas Yates, of United Coatings Inc.; *Program*—Natu Patel, Ace Paint Div.; *Federation Booth*—Victor Willis, Ace Paint Div.; and *Spouses' Program*—Audrey LeNoble, Emco Chemical Distributors.

NPCA to Meet Same Week

The National Paint & Coatings Association will hold its annual meeting on October 17-19, at the Palmer House in Chicago. Persons wearing the NPCA registration and who sign up at a special FSCT registration desk will be admitted to the Paint Show on Wednesday only, with the compliments of the Federation.

1988 Paint Industries' Show Exhibit Space Sold Out

With nearly eight months remaining before the 53rd Paint Industries' Show to be held on October 19-21 at the McCormick Center in Chicago, IL, 215 companies have signed up to participate and available booth space is sold out in another record-setting event.

Held in conjunction with the 66th Annual Meeting of the Federation, the Paint Show is the largest coatings manufacturing industry exhibit of its kind. Over 7,000 industry personnel are expected to attend the event.

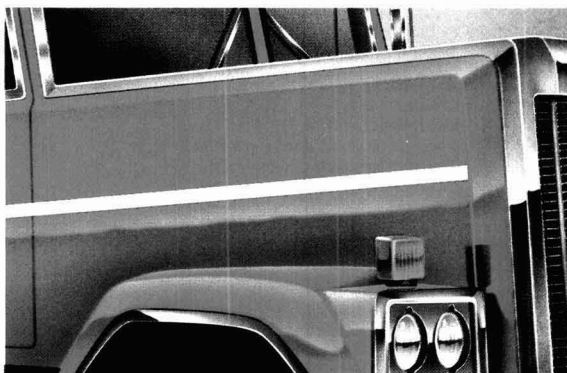
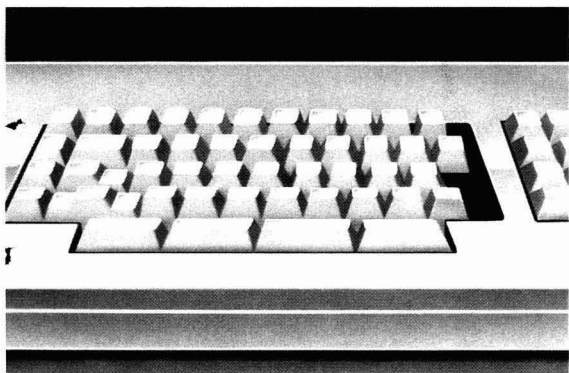
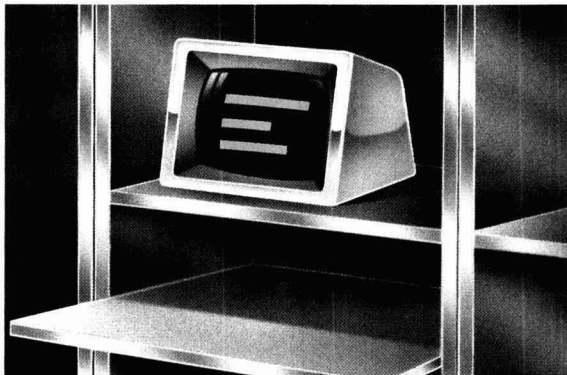
Exhibitors will feature products and services used in coatings formulation and manufacture. A complete listing of the companies who have applied for exhibit space is included on the opposite page.

1988 Paint Show Exhibitors

(As of February 5, 1988)

- Accurate, Inc.
Aceto Corp.
Advanced Coating Technologies, Inc.
Advanced Software Designs
Air Products & Chemicals, Inc.
Alcan-Toyo America, Inc.
Alpine American Corp.
C.M. Ambrose Co.
American Cyanamid Co.
Amoco Chemical Co.
Angus Chemical Co.
Applied Color Systems, Inc.
Aqualon Co.
Aroco Chemical Co.
Aries Software Corp.
Ashland Chemical Co., IC&S Div.
- B&P Environmental Resources, Inc.
BASF Corp., Chemicals Div.
T.J. Bell, Inc.
Berol Chemicals, Inc.
Blackmer Pump Div., Dover Resources Co.
Bohlin Reologi, Inc.
Brinkmann Instruments
Brookfield Engineering Labs., Inc.
Brookhaven Instruments Corp.
BTL Specialty Resins Corp.
Buckman Laboratories, Inc.
Buhler-Miag, Inc.
Bulk Lift International
Burgess Pigment Co.
Byk-Chemie USA
- Cabot Corp., Cab-O-Sil Div.
Calgon Corp., Div. of Merck & Co., Inc.
Cardolite Corp.
Cargill, Inc.
CasChem, Inc.
Catalyst Resources, Inc.
Chemical & Engineering News
Chemical Week
Chemolimpex, Hungarian Trading Co.
Chicago Boiler Co.
CIBA-GEIGY Corp.
Clawson Tank Co.
Coatings Magazine
Colloids, Inc.
Color Corp. of America
Columbian Chemicals Co.
Cook Resins & Additives
Cosan Chemical Corp.
Coulter Electronics, Inc.
CPI Purchasing
Cray Valley Products, Inc.
Crosfield Chemicals, Inc.
Cuno Process Filtration Products
Cyprus Industrial Minerals Co.
- D/L Laboratories
Daniel Products Co.
Datacolor
DataLogix Formula Systems, Inc.
Day-Glo Color Corp.
Degussa Corp.
University of Detroit
Dow Chemical USA
Dow Corning Corp.
Draiswerke, Inc.
Drew Chemical Corp.
DSA Consulting, Inc.
DSET Laboratories, Inc.
Du Pont Coatings Resource Network
- E.C.C. America
Eastern Michigan University
Eastman Chemical Products, Inc.
Ebonex Corp.
Ecometer, Inc.
Elmar Industries, Inc.
- Engelhard Corp.
Epworth Manufacturing Co., Inc.
Erdco Engineering
Expancel, Nobel Industries Sweden
Exxon Corp.
- Fawcett Co., Inc.
Federation of Societies for Coatings Tech.
H.B. Fuller Co.
- GAF Chemicals Corp.
Georgia Kaolin Co., Inc.
Goodyear Tire & Rubber Co., Chemical Div.
Gorman-Rupp Co.
W.R. Grace & Co., Davison Chemical Div.
Grefco, Inc., Dicaprel & Dicalite Depts.
- Halox Pigments, Div. Hammond Lead Prods.
Harshaw/Filtrol Partnership
HBI-Haake Buchler Instruments, Inc.
Henkel Corp., Process Chemicals
Heubach, Inc.
Hilton-Davis Co.
Hitox Corp. of America
Hockmeyer Equipment Corp.
Hoechst Celanese Corp.
Horiba Instruments, Inc.
J.M. Huber Corp.
Hunter Associates Lab., Inc.
- ICI Americas, Inc.
Ideal Manufacturing & Sales Corp.
Illinois Minerals Co.
Indusmin Inc.
Industrial Finishing Magazine
Interez, Inc.
Itasco Industries Div., I.W.I., Inc.
ITT Marlow Pumps
- S.C. Johnson & Son, Inc.
- Kenrich Petrochemicals, Inc.
Kent State University
King Industries, Inc.
Kraft Chemical Co.
KTA-Tator, Inc.
- Labelette Co.
Liquid Controls Corp.
Logicom, Inc.
The Lubrizol Corp., Diversified Prod. Group
- 3M, Industrial Chemicals Div.
Macbeth Div. of Kollmorgen Corp.
Magnesium Elektron, Inc.
Malvern Minerals Co.
Manchem, Inc.
Manville Corp.
The McCloskey Corp.
McWhorter, Inc.
The Mearl Corp.
Micro Powders, Inc.
Micromeritics Instrument Corp.
Mid-States Eng. & Mfg. Co., Inc.
Miller Paint Equipment, Inc.
Milliken Chemical, Div. of Milliken Co.
Milton Roy Co.
Mineral Pigments Corp., Davis Colors
MiniFIBERS, Inc.
Minolta Corp.
University of Missouri-Rolla
Mitech Corp.
Mobay Chemical Corp.
Modern Paint & Coatings Magazine
Monsanto Co.
Montana Talc Co.
Morehouse Industries, Inc.
Mozel Chemical Products Co.
Myers Engineering
- National Assn. of Corrosion Engineers
National Paint & Coatings Assn.
Netzsch Incorporated
Neupak, Inc.
Neville Chemical Co.
NL Chemicals, Inc.
North Dakota State University
Nuodex, Inc., A Huls Co.
NYCO
- Orb Industries, Inc.
Ontario Research Foundation
- P.A. Industries
Pacific Micro Software Engineering
Pacific Scientific Co., Instrument Div.
Packaging Service Co., Inc.
Permuthane, Inc.
Phillips 66 Co., Specialty Chemicals
Pico Chemical Corp.
Plastican, Inc.
Pleuss-Staufner Int'l, Inc., Omya Group
Poly-Resyn, Inc.
Polyvinyl Chemicals, Inc.
PPG Industries, Inc.
Premier Mill Corp.
Progressive Recovery, Inc.
- Q-Panel Co.
- Raabe Corp.
Radtech International
Red Devil, Inc.
Reichhold Chemicals, Inc.
Renzmann Inc.
Rheometrics, Inc.
Rhone-Poulenc Inc.
Rohm and Haas Co.
Rosedale Products, Inc.
Russell Finex, Inc.
- Sandoz Chemicals Corp.
Sanyo-Kokusaku Pulp Co., Ltd.
Semi-Bulk Systems, Inc.
Serac, Inc.
Shamrock Chemicals Corp.
Shell Chemical Co.
Sherwin-Williams Chemicals Co.
Silberline Manufacturing Co., Inc.
Sonoco Fibre Drum, Inc.
Steel Structures Painting Council
Sub-Tropical Testing Service
Sun Chemical Corp.
- Tammco, Inc.
Tego Chemie Service GmbH
Tekmar Co.
Texaco Chemical Co.
Thiele Engineering Co.
Tokheim Corp., Process Controls Div.
Troy Chemical Corp.
- U.S. Silica Co.
Union Carbide Corp.
Union Process, Inc.
United Catalysts, Inc.
Universal Color Dispersions
Unocal Chemicals Div., Unocal Corp.
- R.T. Vanderbilt Co., Inc.
Viking Pump-Houdaille, Inc.
Vorti-Siv Div. of M&M Machine, Inc.
- Wacker Silicones Corp.
Warren Rupp-Houdaille, Inc.
Wilden Pump & Engineering Co.
Witco Chemical Corp.
- Zeelan Industries, Inc.

Are Your Urethane Finishes **TOUGH ENOUGH?**



ACRYLOID® Polyols Come Shining Through The Toughest Applications.

Today's urethane finishes have to handle a lot of different jobs and hold up to heavy use under less-than-ideal conditions. That's why Rohm and Haas offers a large selection of high performance acrylic polyols for urethane coatings—all backed by extensive testing and technical support. ACRYLOID polyols can help you meet your specifications—*durability . . . high gloss with excellent retention . . . solvent resistance . . . fast tape times, good pot life . . . low VOC and more.*

Our current product line includes: ACRYLOID AU-608X, ACRYLOID AU-608S, and RESIN QR-999—the newest members of our best

known polymer line; RESINS QR-1003 and QR-1004—for improved chemical and solvent resistance; RESINS QR-1033 and QR-1102—for fast lacquer dry and reduced isocyanate demand; RESIN QR-946, new RESIN QR-1166, and REACTIVE MODIFIER QM-1007—for high solids coatings.

So get tough. Go with Rohm and Haas for acrylic polyols that come shining through. For samples and technical literature, contact your local

Rohm and Haas representative today, or write Rohm and Haas Inquiry Response Center—682A4, P.O. Box 8116, Trenton, NJ 08650.

**ROHM
AND
HAAS** 
PHILADELPHIA, PA. 19105

Prevention and Cure of Coatings Defects to Be Focus of FSCT Seminar in Orlando, May 17-18

"Coatings Defects: Their Prevention and Cure" is the subject of the 1988 Federation Spring Seminar, to be held May 17-18 at the Orlando Marriott, Orlando, FL.

Eliminating defects can be a trying task even for the most experienced coatings chemist; often, for example, changes which eliminate one type of defect lead to other problems. But the elimination of defects is essential if the decorative and protective functions of the coating are to be achieved.

Programming for the 1½ day seminar will cover a variety of coatings defects that develop in different coatings systems (including the newer technologies, such as water-based, powder coatings, and radiation cured systems), and well-known industry speakers will discuss the many aspects of dealing with the problem.

Several open forum sessions will be featured, at which registrants will have the opportunity to question speakers on specific problem areas.

Program

Included on the program will be the following presentations.

Keynote Speaker will be Dr. Percy E. Pierce, Manager of Physical Research PPG Industries, Inc., Research Center, Allison Park, PA. He will discuss "The Mechanism of Coating Defect Formation and Strategies for Defect Prevention" (The driving force for many coating defects is surface tension variations along the coating surface. The main force that retards defect formation is the viscous force arising from the viscosity of the coating. A knowledge of the role of these forces in defect formation, along with insight into the effect of coating composition on surface tension and viscosity can provide a systematic approach to the cure and prevention of coating defects).

"Techniques for Characterizing Coatings Defects"—Clifford K. Schoff, PPG



Industries, Inc., Research Center, Allison Park, PA (Accurate analysis of specific problem being faced usually leads to an explanation of the cause and points the way to a solution; the many characterization techniques available are described in their application illustrated with series of real-life coatings defects).

"Pigmented Coating Problems and Solutions Associated with Particle Size Reduction"—Richard J. Himics and Ramon E. Pineiro, Daniel Products Co., Jersey City, NJ (Particle size has great influence on properties of a coating, and problems thought to be due to poor resin or pigment selection can usually be corrected or improved by altering or reducing the particle size of the pigment(s) used).

"Color Non-Uniformity as a Film Defect"—Marvin J. Schnell, Troy Chemical Corp., Newark, NJ (Pigment floating and flocculation are two mechanisms which are primary causes of color non-uniformity defects; factors involved in both mechanisms are described, as well as methods of improving uniformity through formulation modifications and additive usage).

"Defects in Coatings and Polymers Caused by Microorganisms"—William B. Woods, Nuodex, Inc., Piscataway, NJ (Biodeterioration of a coating film can lead to embrittlement, cracking, and loss of ad-

hesion; additionally, microbial growth and staining often deface coating surfaces. This presentation discusses the microorganisms responsible, mechanisms of biodeterioration and defacement, and recommended practices for prevention of microbial mediated coating failure).

"Fourier Transform Infrared Spectroscopic Studies of Surface Defects"—Daniel J. Skrovaneck, PPG Industries, Inc., Research Center, Allison Park, PA (Application of FTIR spectroscopic techniques to the study of surface defects are presented; capabilities and limitations of the various techniques are discussed as they apply to study of surface defects, and practical lab examples are given).

"Surface Chemistry of Surfactants Used to Prevent Coatings Defects"—Paul D. Berger, Witco Corp., Organics Div., Houston, TX (The surface chemistry of various additives used to prevent surface defects is discussed. Among the additives studied are defoamers, leveling agents, wetting agents, and spreading agents. The influence of dynamic and static surface tensions on the effectiveness of these surfactants is explored. The effect of varying the structure of these additives on their performance and surfactant properties is also discussed).

"Coating Defects as They Pertain to Wood Coatings"—Donald W. Waltrip, Reliance Universal, Inc., Robertson Research and Development Center, Louisville, KY (This presentation reviews potential coatings defects in kitchen cabinets and furniture finishes, including orange peel, film cracking, and veneer cracking; methods for eliminating these defects are reviewed).

"Appliance Coatings: Defects and Their Prevention"—Thomas J. Miranda, Whirlpool Corp., R&D Center, Benton Harbor, MI (Appliance industry uses a variety of coating processes, and each is designed to meet the requirements of ultimate use of the product. Priming is done by flowcoating or electrocoating; topcoating is done with powders, high solids polyesters, and acrylics. Curing is carried out in gas, steam-heated ovens, or electrically-heated ovens. Problems encountered include metal treatment, cleanliness of substrate, surfaces such as patterned steel, and undercuring of curing. Finished coatings are subjected to fabric softeners and stains, particularly in dryer drums and refrigerators. These are reviewed, and methods for assuring quality finishing are discussed).

"Silicones Can Cause or Overcome Many Coating Defects"—Robert Vash,

1988 Membership Directory Available from Federation

The 1988 Annual Membership Directory (Year Book) of the Federation of Societies for Coatings Technology has been published.

Listed in the 328-page directory are the names, companies, addresses and telephone numbers of the 7000 Federation members by Society affiliation. The publication also provides an alphabetical index of members and includes informative details on FSCT Officers,

the Board of Directors, Committee Members, and By-Laws.

The Year Book, included with membership in the Federation, is available to non-members for \$20 per copy. To place an order, contact Meryl Cohen, Federation of Societies for Coatings Technology, 1315 Walnut St., Suite 832, Philadelphia, PA 19107, or call (215) 545-1506.

Byk Chemie USA, Inc., Mantua, OH (The oldest of the many classes of compounds called silicones are the poly di methyl siloxanes, commonly called silicone fluids or oils, which have been major culprits in causing defects. Compounds have been developed recently in which various groups are substituted for the methyls along the siloxane backbone to yield desired properties and overcome many of the silicone oil defects. This presentation describes the various silicones and modifications, explaining effects of the chemical structures in coatings).

"Factors Influencing Surface Appearance in Powder Coatings"—Joseph S. Puglisi, CIBA-GEIGY Corp., Ardsley, NY (Since a powder coating does not contain any liquid solvent or diluent, surface appearance is predominantly influenced by the binder polymer. This presentation discusses the properties of flow, edge coverage, cratering and void formation, as a function of binder rheology, compatibility, reactivity, and other factors).

"Radiation Curable Coatings—Defects and Possible Solutions"—Morris A. Johnson, Interez, Inc., Louisville, KY (In this presentation, a brief historical background to development of radiation curable coatings is accompanied by a summary of advantages and perceived disadvantages. Defects can result from poor technique as well as from difficulties inherent in the technology. Possible solutions to such problems as poor adhesion, air entrapment, shrinkage, and pigmentation are discussed).

Registration

To register, fill out the accompanying form and return with payment to Federation of Societies for Coatings Technology, 1315 Walnut St., Suite 832, Philadelphia, PA 19107. Registration fee is \$125 for FSCT members, and \$155 for non-members. After May 1, registration fee is \$165 for everyone. (Payment must be in U.S. funds, payable in U.S. banks.)

Included in the registration fee is continental breakfast, luncheon, coffee breaks, and copies of talks, as well as bus transportation to Orlando International Airport at completion of seminar. *Please note reference to bus on registration form, and check appropriate box.*

Note: No refund for cancellations received after May 12.

Housing

Headquarters hotel is the Orlando Marriott, located 20 minutes from downtown Orlando and 15 minutes from Orlando International Airport, Walt Disney World, and Epcot Center.

To obtain complete program information contact Federation headquarters (1315 Walnut St., Suite 832, Philadelphia, PA 19107—Phone: (215) 545/1506).

COATING DEFECTS SEMINAR

REGISTRATION FORM

Registration fees: \$125 (FSCT members); \$155 (non-members)
\$165 for everyone after May 1

Check must accompany registration form. Make checks payable to Federation of Societies for Coatings Technology. (Payment must be made in U.S. funds payable in U.S. banks.)

NICKNAME (For Registration Badge) _____

FULL NAME _____

JOB TITLE _____

COMPANY _____ PHONE _____

ADDRESS _____

CITY _____ STATE _____ ZIP _____

Name of Federation Society
Of Which You Are A Member _____

I will will not use the Federation bus to Orlando International Airport at conclusion of seminar.

No refund for cancelled registrations received after May 12.

Return form and check to: Federation of Societies for Coatings Technology
1315 Walnut Street, Suite 832
Philadelphia, PA 19107

IF YOU REQUIRE HOUSING AT THE ORLANDO MARRIOTT COMPLETE FORM BELOW

HOUSING FORM Orlando Marriott

NAME _____

ADDRESS _____

CITY _____ STATE _____ ZIP _____

Arrival Date _____ Before 6 pm
 Late* Departure Date _____

Please reserve: Single _____ Room rate is \$70 single/double
occupancy (per night).

Double/Twin _____

*Reservations will be held until 6:00 pm. If arrival is after 6:00 pm, hotel requires deposit for one night's lodging to guarantee availability. Make check payable to "Orlando Marriott."

Note: Reservations must be made no later than April 15 to guarantee availability and rates.

Return this form to: Federation of Societies for Coatings Technology
1315 Walnut Street, Suite 832, Philadelphia, PA 19107

PICTORIAL STANDARDS OF COATINGS DEFECTS

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

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

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

Complete manual . . . \$90 (includes shipping charges)*
Individual Standards . . . \$3 each, plus \$3 for each photograph.
Record Sheets (pad of 100 sheets) . . . \$3.50

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

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

Send orders to: Federation of Societies for Coatings Technology
1315 Walnut St., Suite 832, Philadelphia, PA 19107

Federation of Societies for Coatings Technology

GENERAL

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

The Editors invite the submission not only of regular research papers, but also *Open Forum* comments on subjects of relevant interest, and *Letters to the Editor*. All manuscripts will be assumed to be original work and to have been unpublished elsewhere; not under consideration for such publication; not copyrighted; and to have been submitted for appropriate clearance by the organization with which the author is affiliated if such clearance is necessary. 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 or regional meetings or symposia of the Constituent Societies. *Papers in which proprietary products or processes are promoted for commercial purposes are specifically non-acceptable for publication.*

SUBMISSION OF MANUSCRIPTS . . .

. . . for the Journal

Technical Papers: Four complete copies should be sent to the Editor, JOURNAL OF COATINGS TECHNOLOGY, 1315 Walnut St., Philadelphia, PA 19107.

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 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.

Papers originally composed for oral presentation may have to be revised or rewritten by the author to conform to the style suitable for written publication.

Open Forum: Three complete copies should be sent to the Open Forum Editor, at the address listed above.

The same general rules as given for technical papers should be followed in the preparation of an Open Forum manuscript. However, the subject may be informally approached. Topics may be nontechnical in nature, dealing with any aspect of the coatings industry.

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

. . . by Constituent Societies For Annual Meeting Presentation

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

. . . for Roon Foundation Award Competition

Ten complete copies of the manuscript are required, and should be submitted to the Chairman of the 1988 Roon Awards Committee, Gary Gardner, Tnemec Co., Inc., P.O. Box 1749, Kansas City, MO 64141. (For complete details, see "Roon Awards" section of the JOURNAL for January 1988.)

MANUSCRIPT PREPARATION

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

Manuscripts should be typed with double spacing on one side of 8½ × 11 inch (22 × 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 × 7 inch (13 × 18 cm) black-and-white photograph with glossy or smooth high sheen surface, for each author. See later section on photographs for further details.

Abstracts

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

Text

The headings and sub-headings in this Guide illustrate their use to divide the text into sections to improve readability for comprehension, and to break up typographical monotony; they may be used as a model for preparation of the text of a manuscript for publication. The text should *not* be presented as an alphanumeric outline.

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

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

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

Metric System

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

Tables, Graphs, and Drawings

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

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

Graphs should be on good quality white or non-photographic blue-lined 8½ × 11 inch paper. Each graph should be drawn on a separate sheet, numbered, and the captions listed on a *copy* of the original graph. Graph captions and legends should also be typed on a separate sheet for typesetting.

Graphs should not be used if they merely duplicate the data given in tables, or vice versa.

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

Photographs

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

Color prints and slides are unacceptable.

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

Nomenclature

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

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

Nomenclature of chemical compounds should conform to the style of *Chemical Abstracts* and the IUPAC rules.

Equations

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

Summary

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

Acknowledgment

If used, it should follow the summary.

References

These should be listed in the numerical order in which they are cited in the text, and should be placed at the end of the manuscript. Names of authors may or may not be shown in the text with reference numbers. If possible, include titles of articles referenced in the literature. The following are examples of acceptable reference citations for periodicals^{1,2,3}, books⁴ and patents.⁵

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

OTHER INFORMATION

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

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

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

VELATE™

coalescing aid

**Just
a drop
in the bucket
can make barrels
of difference on
your bottom line!**



VELATE™, the coolest, coalescing film-former for all latex paints:
Interior Flat, Semi-Gloss, High Gloss and Exterior Latex Paint Formulations.

Provides:

Low Odor
Cost Effective
Good Washability
Good Gloss Retention

Excellent Color Acceptance
Excellent Scrub Resistance
Less Flocculation

WRITE OR CALL FOR VELATE™ TESTING SAMPLES & DATA



VELSICOL CHEMICAL CORPORATION
CHATTANOOGA PRODUCTS DIVISION

5600 N. River Road, Rosemont, IL 60018-5119
Toll Free: Outside IL 1-800-826-4449
In IL 1-800-654-8599



**CIBA-GEIGY is giving them
lots of things to agree on.
Things like low VOC epoxy
resins and hardeners.**





**Industry wants performance.
America wants clean air.
We are developing products
responsive to both needs.**

CIBA-GEIGY technology helps solve the problems of performance vs. pollution. Now, with CIBA-GEIGY low viscosity epoxy resins and hardeners, you can formulate low-solvent and solvent-free coatings with superior chemical, solvent, heat, abrasion, and corrosion resistance, as well as good mechanical properties.

Here are a few examples.

Product	Viscosity Range, cP @ 25° C
Resin	
Araldite® PY 306 (XB 3336)	1,200 - 2,000
Araldite GY 281	5,000 - 7,000
Araldite GY 6008	7,000 - 9,000
Hardener XU HY 360	200 - 300
*Hardener XU HY 283	3,000 - 5,000

*Polyamidoamine

**VOC is just one of the
problems we are solving.**

But low VOC and solvent-free resins and hardeners are just one of the areas on which we are focusing our technological resources. We are also developing epoxies to stand

up to higher temperatures and harsher environments. We have tough, flexible epoxy resins and others that are weatherable. We are highly regarded for the technical support we can provide our customers and the responsiveness of our sales representatives.

For information on our new products, simply call Mike Preston at (800) 431-1900 (in New York (914) 347-4700). Or write Plastics Department, CIBA-GEIGY Corporation, Three Skyline Drive, Hawthorne, New York 10532.

CIBA-GEIGY



Chief Concerns of Managers and Planners Worldwide Are Focus of Battelle Program Planning Survey

Battelle Columbus Division, Columbus, OH, has just completed a survey of managers and planners at 82 major companies which will be used to gauge client interests for program planning purposes.

The survey was conducted by the Battelle Technical Inputs to Planning (B-TIP) Office. B-TIP stated the chief concerns among managers of industrial research and development organizations worldwide are: identifying new manufacturing technologies; planning for implementation of new technology; and reducing risk in technology and new product development.

The survey, which included 58 companies in the U.S. and 17 in Japan, covered 164 topics in six major technology categories. Members in the 150 B-TIP client companies showed greatest interest in topics in the manufacturing technology, advanced materials, and information and engineering systems categories. Beyond the consistently strong interest in new technologies and their commercial application, the results indicated high interest in automation, sensors, quality control, and process efficiency.

The highest ranking topics in each of the six technology areas were:

- **Manufacturing Technology**—Identifying new technologies or processes, planning for implementation of new technology, and sensors for improved process control.

Coil and Container Treatment Div. Formed by Betz Labs

Betz Laboratories, Inc., Trevose, PA, has announced the creation of the new Betz Coil and Container Treatment Division. The division is charged with servicing exclusively the coil and container industries.

The division, which provides a full range of products and services, is staffed with specialists who have a detailed knowledge of conversion coating technology and extensive experience in the coil and container industries. Field representatives will be supported with comprehensive technical services that include engineers, chemists, microbiologists, technicians, and production facilities throughout the country.

In addition, Betz recently broke ground for a new state-of-the-art manufacturing facility which will produce some specialized products for the coil and container industries.

- **Advanced Materials**—Advances in coating technology, especially powder; advances in adhesives and their use in structural packaging, and construction applications; and advances in ceramics and glass.

- **Information and Engineering Systems**—Reducing risk in technology and new product development, integrating research and development and business planning, and methods for assessing new product performance and potential markets.

- **Electronics and Defense Systems**—Overall advances in sensors, electronic sensors, and advances in superconductive materials.

- **Biological and Chemical Services**—Compliance with government health, safety, environmental, and efficacy regulations; and fate and effects of product and byproducts in various environments, especially groundwater and the atmosphere.

- **Biotechnology**—Technical and business trends in biotechnology, developments in separation technologies and their industrial implementation, and advances in sensors and instruments for monitoring biological processes.

For more information on the B-TIP program, contact S.R. Simon, Battelle, 505 King Ave., Columbus, OH 43201-2693.

Engelhard Corporation Announces Kaolin Expansion

Engelhard Corp., Edison, NJ, broke ground for a more than \$80 million expansion of its Middle Georgia facilities located in McIntyre and Gordon. The expansion will add 300,000 tons of additional capacity to produce high-performance, kaolin-based materials used by the paper, paint, plastics, rubber, and allied industries.

The expansion is expected to be completed by the fourth quarter of the year. It will incorporate state-of-the-art design and computerized process control systems. Plans include a new calciner, which physically alters the kaolin structure using temperatures in excess of 1500 °F.

In addition, the expansion will enable a significant increase in the production of non-calcined products which are used in paper, paint, plastics, and other industrial applications. New facilities to centralize and enhance engineering and technological capabilities will also be added.

Pennwalt Finishes Expansion Of Organosulfur Plant

Pennwalt Corp.'s, Organic Chemicals Div., Philadelphia, PA has completed a major expansion of its methane sulfonic acid/methane sulfonyl chloride plant in Wyandotte, MI.

The plant is also capable of producing ethane sulfonyl chloride and other specialty organosulfur products.

An earlier expansion quadrupled Pennwalt's capacity to manufacture anhydrous methane sulfonic acid. The Wyandotte facility is the world's largest organic specialty plant producing these products. The plant expansion, which also includes additional storage capacity, was completed on schedule.

Specialty acids and chlorides are used in a number of growing markets, including electrochemical applications, agricultural intermediates, photographic chemicals, catalysts, and other specialty applications.

In addition to Wyandotte, the Organic Chemicals Div. has plants in Houston and Beaumont, TX; Rotterdam, Holland; and through a joint venture in Japan.

New Regional QA Lab Established by Goodyear

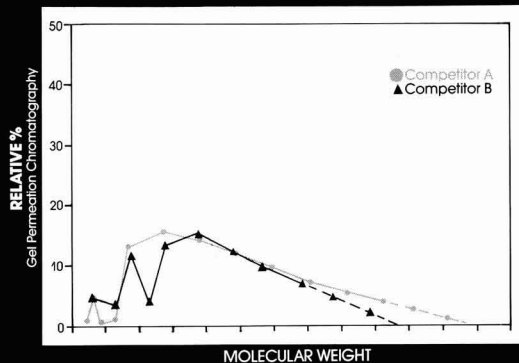
The Goodyear Tire & Rubber Co., Akron, OH, has established a new regional quality assurance laboratory for testing materials used in the company's North American tire production. The Akron lab will serve as a central clearinghouse for testing all supplier materials.

The lab employs the latest state-of-the-art testing equipment to analyze the components of tires to ensure they meet Goodyear specifications. At the present time, the lab will only be testing rubber and chemical materials used in tire construction.

In addition, the lab will act as a backup for troubleshooting problems at the production level and will receive samples of shipments sent to company tire plants from other Goodyear plants as well as external suppliers.

If you think narrow molecular weight distribution is important when formulating high solids coatings,

YOU'RE RIGHT!



POLYOL MOLECULAR WEIGHT DISTRIBUTION
K-FLEX 188 VERSUS COMPETITOR POLYOLS

That's why we developed K-FLEX® 188 polyester polyol for aminoplast and isocyanate crosslinked compliance coatings. K-FLEX® 188 optimizes the combination of low viscosity, low VOC, resin compatibility and coating performance by building in the ideal molecular weight (MW) distribution.

As the GPC* curves indicate, K-FLEX® 188 has a very narrow molecular weight distribution — controlled by a unique process which provides performance advantages by • Maximizing the desired low MW polyester components for low viscosity, excellent compatibility and the best balance of hardness and flexibility • Minimizing free glycol and volatile lower MW fractions to provide lower VOC • Excluding the high MW tail for faster cure, improved

crosslinking efficiency and higher application solids • Eliminating haze problems associated with prolonged storage and/or cold temperatures • Providing a uniform and consistent product batch after batch.

K-FLEX® 188 linear, aliphatic, saturated polyester polyol provides these additional benefits

- Excellent optical clarity • Very low color
- Rapid viscosity reduction in a wide variety of standard solvents • 100% reactive non-volatile
- Enhanced gloss • Low temp. cure
- Excellent adhesion to numerous substrates including most plastics • Excellent resistance properties (QUV, Cleveland humidity and salt spray).

Send for the K-FLEX® Formulating Guide and be right — right from the start.

*GPC Gel Permeation Chromatography

USA
Science Rd., Norwalk, CT 06852 Tel: 203-866-5551 TWX: 710-468-0247

EUROPE
Kattensingel 7, 2801 Ca Gouda, Holland. Tel: 01820-28577 Telex: 62411



Chemical Manufacturers Association Survey Indicates Industry Sales and Profits Increased During 1987

A survey conducted by the Chemical Manufacturers Association indicates that, for the second consecutive year, chemical industry sales and profits moved upward during 1987. The industry will post record sales and profits for 1987 according to the annual survey of its member companies.

The CMA survey predicts that 1987 chemical sales will be \$214.5 billion—8% above sales for 1986 and significantly better than the 4.7% annual growth rate for the years 1982-86.

The survey also predicts that the industry should continue to recover profits from a dismal performance of the decade's first five years. Based on information supplied to CMA by its members, industry sales should rise 8.5% this year.

In addition, the survey anticipates the industry's export performance and trade balance will be much improved for 1987. In keeping with the survey, chemical exports will be a record \$26 billion—14% above 1986. Chemical imports also are expected to reach a record level for 1987—\$15.8 billion, or 5% above 1986.

The industry's trade balance—or the difference between exports and imports—is

expected to be \$10.3 billion, or 32% better than 1986. The trade surplus is about what it was in 1982 and is nearly \$2 billion less than the record surplus of \$12.2 billion of 1979.

Other findings in the annual survey indicate that capital expenditures for new plants and equipment are expected to be \$16.5 billion for 1987—about the same level of the years 1985-86. Capital spending is expected to surge 14% for 1988.

Research and development spending by the industry should be approximately \$9.6 billion for 1987—a record amount. Research and development spending should rise 7% during 1988.

Chemical industry employment stabilized during 1987. According to the survey, total industry employment was 1,024,000 million. Chemical executives expect employment to rise this year—perhaps by 2%.

World Olympiad of Knowledge Slated for 1990

The first World Olympiad of Knowledge, scheduled for 1990, is now accepting official entries. The object of the competition is to discover human minds having unusual creative and innovative potential so that they may be maximized for the benefit of everyone.

The intellectual competition is open to all, irrespective of academic (or no academic) training and degrees (or no degrees).

Entries may cover any proposal that may assist humanity in a most significant way with benefits that clearly outweigh potential risks. All entrants in the competition must submit their proposals only on Official Entry Forms.

For more information, write to: 1990 Knowledge Olympiad, Knowledge Park, 3863 SW Loop 820, Suite 100, Fort Worth, TX 76133-2076.

Sherex Purchases Assets Of AZS Corporation

Sherex Polymers, Inc., Dublin, OH, a wholly-owned subsidiary of Sherex Chemical, Inc., has purchased the assets and business of AZS Corp., Atlanta, GA, a wholly-owned subsidiary of Toyo Soda (America).

The traditional AZS product line for the resin, mining, and chemical intermediate markets will be continued. The marketing activities will be concentrated at the headquarters of Sherex Chemical Co., Columbus, OH.

Ruco Adds Reactor System; Increases Polyester Capacity

A new reactor system was brought online by the Ruco Polymer Corp., Hicksville, NY. The new system adds 15 million pounds of polyester capacity to the company's current production facilities.

The new reactor is a state-of-the-art vessel equipped with digital program controls for heating (by multi-zone hot oil), cooling, vacuum, and reflux. The agitator has been designed to handle high viscosities, as well as those more typical of polyester oligomers. The column and agitator are of a special design to allow Ruco to manufacture the newer specialty thermoplastic polyesters.

PPG Obtains JME Chemicals; Expands Metal Pretreatment

PPG Industries, Pittsburgh, PA, has announced the purchase of JME Chemicals, Chicago, IL, a supplier of metal pretreatment chemicals to the coil coating industry.

The purchase of JME provides PPG, in the pretreatment products business since 1986, the opportunity to expand within the pretreatment business beyond the automotive market.

JME will remain based in Chicago.

J.M. Huber to Construct Calcium Carbonate Plant

The Calcium Carbonate Div., J.M. Huber Corp., Quincy, IL, has announced plans to construct a new calcium carbonate plant at Nolanville, TX. The start-up for the new operation is planned for the third quarter of this year.

The new operation will be highly automated and will utilize statistical process control techniques currently being used by the corporation's Marble Falls, TX plant.

ICI Polyurethanes Group Relocates Headquarters

The ICI Polyurethanes Group, a division of ICI Americas Inc., has announced the relocation of its North American headquarters from Wilmington, DE, to West Deptford, NJ. The site already contains the Group's research and development staff, physical and analytical testing facilities, and manufacturing capabilities for fully formulated systems.

The new location features 30 plus acres for physical expansion of the facility and proximity to major transportation routes on the East Coast.

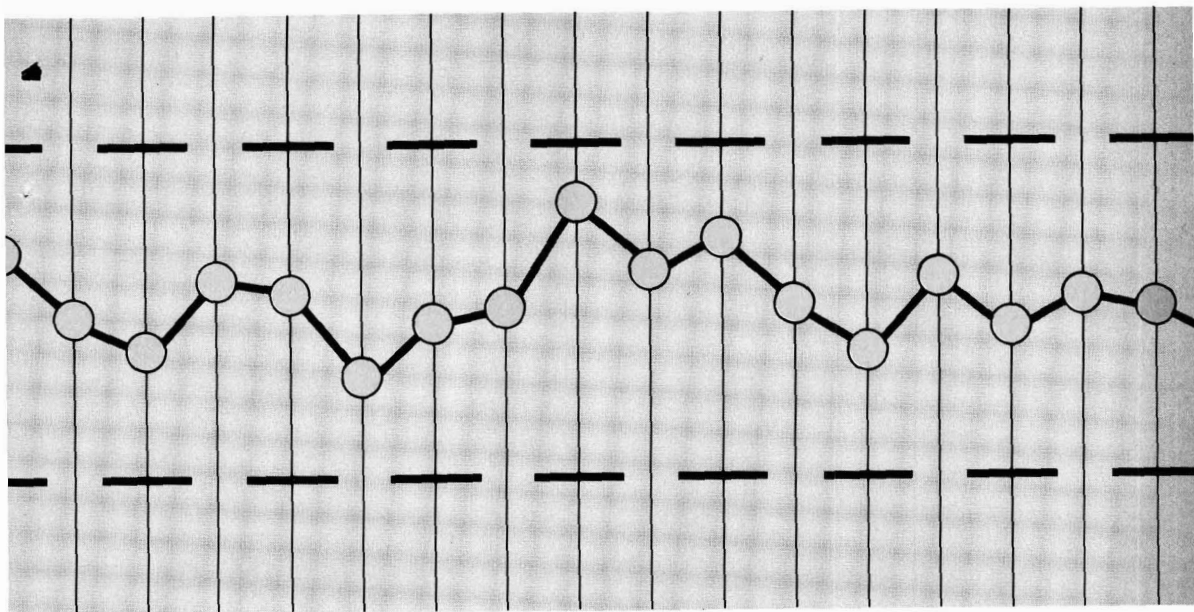
Personnel involved in the relocation include all administrative staff as well as the operations group of the Chemicals Division.

Air Products To Expand Pressure Emulsion Facility

Air Products and Chemicals, Inc., Allentown, PA, plans to expand its pressure emulsion capacity by 150 million wet pounds. The \$30 million expansion, targeted for completion by early 1990, will take place at the company's chemicals facility in Calvert City, KY.

The project will incorporate the latest developments in process technology to reduce significantly unit operating costs and improve product quality.

In addition to the Calvert City facility, Air Products also manufactures emulsions at its South Brunswick, NJ; Elkton, MD; Cleveland, OH; and City of Industry, CA, plants.



We're plotting to improve the consistency of your products.

The quality and consistency of your vendor's products directly affect the quality and profitability of your products. For higher levels of quality, you need a vendor that employs more than ordinary quality control programs.

That's why Engelhard has used Statistical Process Quality Control (SPQC) longer and better than anyone else in the kaolin-based products industry.

Ordinary quality control programs only test the product for acceptance. SPQC goes further by using statistical methods to control quality *throughout* the manufacturing process, including the quality of raw materials.

With our SPQC process, we chart

each of the key production variables, and apply statistics to analyze the data. We control the quality of our products by controlling the consistency of the processes used to produce them. This increases your confidence in Engelhard's specialty kaolin products. It also reduces the need for testing at your facility, saving you time and expense.

SPQC consists of two parts: Statistical Process Control (SPC) and Statistical Quality Control (SQC). We use SPC to keep our processes consistently within statistical control limits to meet desired specifications and to control the quality of incoming raw materials.

SQC ensures our final products meet customer quality control stand-

ards. Whether you need quality kaolin products for paint, plastics, rubber or other applications, our SPQC program can enhance your product performance and profitability.

Our technical service representatives welcome the opportunity to meet with you to discuss a SPQC program to meet your requirements.

For more information on what SPQC can do for you, call 1-800-932-0444, in New Jersey 1-800-624-0818. Or write Engelhard Corporation, Performance Minerals Group, Menlo Park, CN 28, Edison, NJ 08818.

Let our SPQC program give your products a consistent advantage.

© Copyright 1987 Engelhard Corporation

ENGELHARD
EXCEPTIONAL TECHNOLOGIES

Less gives you More

(with Slip-Ayd SL 600).

LESS WAX - MORE SLIP AND RUB RESISTANCE

Slip-Ayd SL 600 is highly effective. It can be used at lower levels than other dry micronized powder slip additives and still provide lower coefficient of friction and better resistance to rubbing, marring and scuffing.

LESS TROUBLE WITH ADDITION - MORE CHOICES

Slip-Ayd SL 600 mixes in easily. Standard high shear dispersion techniques are all you need to get this dry micronized powder into your system. For even greater convenience, SL 600 is also available predispersed in four carriers to let you stir it in with simple low energy mixing.



LESS INVENTORY - MORE FUNCTION

Slip-Ayd SL 600 can replace combinations of slip additives based on PTFE and other waxes. SL 600 is a unique blend of halogenated polyolefins, polyethylenes and other synthetic waxes. It will give you the slip and rub you need in just about any water-thinned, solvent-thinned, or solvent-free coating or ink you make.

LESS ADDITIVE - DOES MORE FOR YOU

Would you like to have LESS slip additive do MORE for you? Drop us a line or give us a call, and we will send you technical information on the complete Slip-Ayd SL 600 line.



DANIEL PRODUCTS COMPANY

400 Claremont Avenue Jersey City, New Jersey 07304
201/432-0800; TELEX: 126-304

THIS PAPER WAS AWARDED THIRD PRIZE IN THE
1987 ROON AWARDS COMPETITION

New Heterocyclic Pigments

A. Iqbal, L. Cassar, A.C. Rochat, J. Pfenninger, and O. Wallquist
CIBA-GEIGY Ltd.*

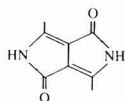
Following introductory remarks on the discovery of a novel family of heterocyclic compound pigments, 1,4-diketo-pyrrolo(3,4-c)pyrrole, called the DPP, an attempt is made to rationalize their properties in terms of their solid state structures. Various mechanisms of formation of DPP are described and the chemistry, especially bearing on the synthesis and development of pigmentary forms of DPP, also is briefly outlined.

INTRODUCTION

The days are far and gone when the world was used to registering the birth of a new class of colorants every five or ten years. Increasing toxicological and environmental constraints, demanding price-performance requirements, primarily dictated by a highly competitive market, and the extensive exploratory work already performed have led to a drastic reduction in the number of products that are being added to the pigment manufacturers' selling ranges.

Thus, the dominant pigment chromophores on the market today, such as the azos and the phthalocyanines, have been known for 50 years or longer. Even the commercialization of the quinacridone pigments, which indeed belong to the most recent developments of significance in the pigment sector, dates back nearly 30 years.

A novel family of heterocyclic pigments, 1,4-diketo-pyrrolo(3,4-c)pyrrole (DPP), incorporating a completely new chromophoric system, is disclosed in the following. The designation DPP stems from the color-imparting substructure:



DPP: 1,4-diketo-pyrrolo(3,4-c)pyrrole

Presented at the 65th Annual Meeting of the Federation of Societies for Coatings Technology, in Dallas, TX, on October 5, 1987.

*P&A Research Center, CH-1701 Fribourg, Switzerland.

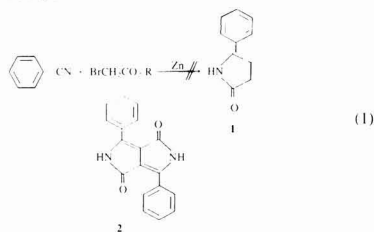
The present paper describes this new class of pigments, which shows enough promise to be considered one of the most important breakthroughs in organic red pigment chemistry since the introduction of the quinacridones.

In the following, the discovery of the DPP chromophore is briefly described and the properties of such pigments rationalized in terms of their solid state structure. Finally, various mechanisms of formation, and especially the chemistry bearing on the synthesis and development of pigmentary forms of DPP, are discussed.

DISCOVERY

In 1974, Farnum, et al.¹ briefly reported on the attempted synthesis of 2-azetionones, in accordance with equation (1).

However, the proposed reaction failed to produce the target lactam **1**. Instead, the authors isolated in 5-20% yield the diphenyl-DPP derivative **2**, in addition to several other byproducts.



We first became aware of the reaction [equation (1)] six years later in 1980, while scrutinizing a compilation of interesting chemical transformations published by Ranganathan, et al.²

Equation (1) is conspicuous by the fascinating molecular symmetry and challenging mechanistic aspects of formation of **2**.

While incorporating indigo-like cross-conjugated vinylous amidic chromophore units embedded in a rigid planar structural frame, DPP **2** also bears a strong resemblance to the well-known isoindolinone structure (com-

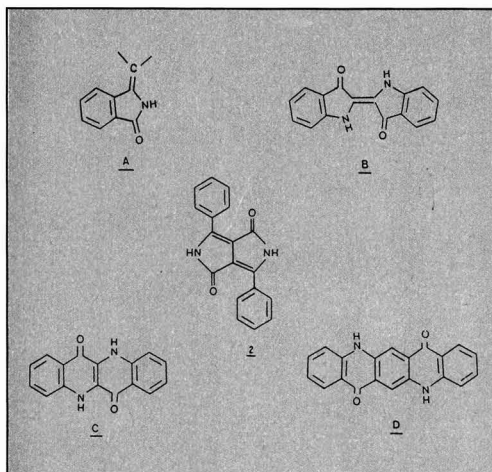
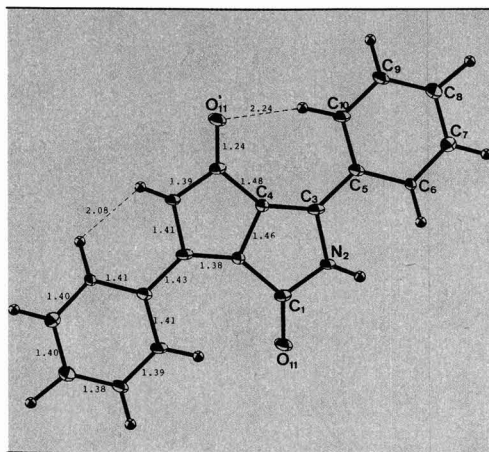


Figure 1—Structural analogy of DPP with a few commercial pigment molecules

pare with **A** and **B** in Figure 1). The imaginative color chemist, upon discerning the concealed vinylogous hydrazine and α -diketone substructures, may further be tempted to view DPP **2** as a five-ring equivalent of the epindolindione and quinacridone chromophoric systems.

Such structural analogies with commercially established classes of pigments, backed up by the fact that DPP **2** indeed is described in the literature as a highly insoluble, brilliant red crystalline compound melting beyond 350°C , prompted an investigation of its performance as a pigment.

In spite of the poor yield indicated in the work, several laboratory-scale experiments were performed to obtain the first gram amounts of the product for preliminary



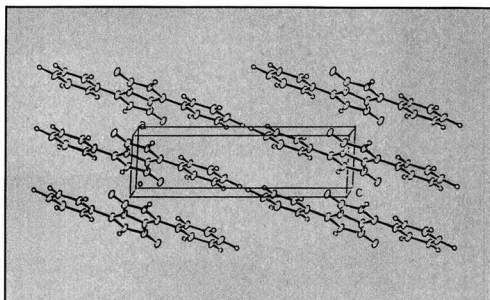


Figure 3—Projection of diphenyl-DPP crystal on the (a,c)-plane

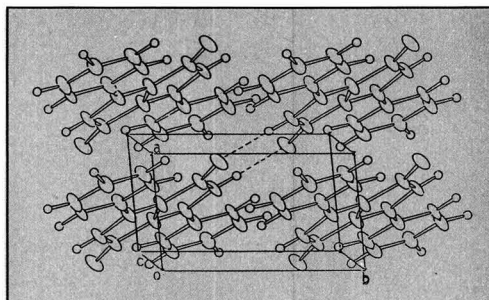


Figure 4—Projection of diphenyl-DPP crystal on the (a,b)-plane

As we soon found out, a broad spectrum of shades ranging from orange-yellow via blue-red to violet could be accomplished by simply exchanging the substituents at the p- and m-position of the two phenyl rings attached to the DPP chromophore unit (compare *Table 1*).

The average level of light- and weatherfastness of such pigments is appreciable. Despite their low molecular weights, the diaryl pyrrole-pyrroles are highly insoluble and remarkably resistant to migration, even when carrying otherwise solubilizing alkyl substituents, such as the tertiary butyl substituent (compare *Table 2*). Such behavior may be attributed, above all, to the presence of strong intermolecular bonding forces in the pigment solid state, as was also corroborated by x-ray structure analyses of individual members of this family of pigments.

Figure 2, for example, offers a perspective view of the diphenyl-DPP molecule **2**, including bond lengths and appropriate numbering of various non-hydrogen atoms. The molecule **2** is practically planar, with the phenyl

rings being twisted out of the heterocyclic chromophore plane by merely 7°. The distance between the two hydrogen atoms at N₂ and C₆ is 2.08 Å, while that between the hydrogen atom at C₁₀ and O₁₁ is 2.44 Å. For both cases, the sum of the corresponding van der Waals radii are substantially larger, 2.4 Å and 2.6 Å, respectively, thus implying resonance interaction between the DPP chromophore unit and the phenyl rings. This appears to be confirmed by a C₃-C₅ bond length of 1.43 Å, which is shorter, and hence possesses even more pronounced double bond character than the bond (1.496 Å) between the two aromatic rings of biphenyl. Such resonance interactions, among others, would explain the electronic influence of substituents on the earlier mentioned wave length shifts (see *Table 1*) of maximum absorption, and hence of color of different diaryl DPP derivatives in solution, at least.

Figures 3-5 represent three different projections of the crystal packing on the three crystallographic planes.

Table 2—Fastness Properties of a Few DPP Pigments

Compound	R =	Lightfastness ^a of Pigmented PVC (Grey Scale)	Weatherfastness ^b of Pigmented Alkyd-Melamine Enamel (Δ E CieIab)	Migration Fastness ^c of Pigmented PVC (Grey Scale)
2	H	5	1,6	5
3	m-CF ₃	5	2,2	5
4	m-Cl	5	1,6	5
5	p-Br	5	0,5	5

(a) Measured according to DIN 54001 on flexible PVC foil, pigmented after DIN 53775 with 0.2% DPP, and exposed for 1000 hr to light [Weather-Ometer-600, Atlas Electric Devices Co., Chicago, IL]. Set at 29-35°C and 40-50% relative humidity; energy of light (340-700 nm): 180 joules/cm²h.

(b) Determined according to DIN 6174 on pigmented alkyd-melamine enamel (DPP: TiO₂: binder = 0.8: 0.2: 10 parts, thickness of enamel film: 50 μm) after artificial weathering for 1000 hr [Weather-Ometer-600; cycle: 108 min of light, followed by 12 min of light and rain, energy of light (340-700nm): 180 joules/cm²h].

(c) Measured according to DIN 54002 on flexible PVC foil pigmented after DIN 53775 with 0.2% DPP.

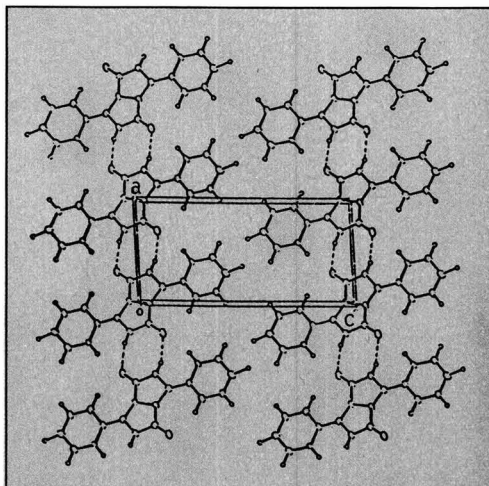


Figure 5—Projection of diphenyl-DPP crystal on the (b,c)-plane indicating intermolecular hydrogen bonding

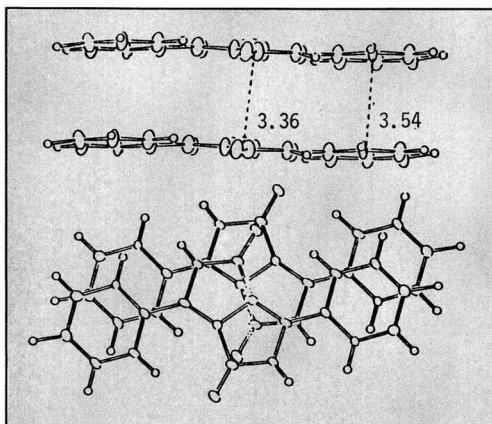


Figure 6—Overlapping of two diphenyl-DPP molecules

Figure 3 represents the projection of the crystal packing on the crystallographic (a,c)-plane. The crystal system is triclinic, the space group being centrosymmetrical $P\bar{1}$, with only one DPP molecule in the unit cell (C_1 molecular symmetry). All molecules are hence parallel to each other. Intermolecular van der Waals contacts between the terminal phenyl group atoms determine the packing along the crystallographic c-axis.

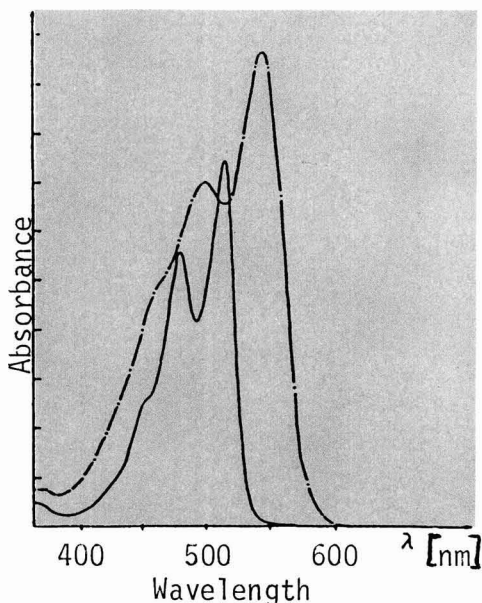


Figure 7—Absorption spectrum of diphenyl-DPP 2 (— solution; - - - solid)

The crystal packing along the a-axis is determined by π - π interactions between the layers. The overlapping of two neighboring molecules along a-axis is shown by Figure 6.

The optimum interlayer distances between chromophore planes (3.36 Å) and phenyl ring planes (3.54 Å) are short enough to warrant π - π interactions via molecular orbital overlapping, the growth of crystals investigated being also the strongest along this direction.

Figure 5 depicts the projection of the crystal packing on the crystallographic (b,c)-plane, highlighting the intermolecular hydrogen bonding between neighboring lactam NH and carbonyl O atoms. This in turn determines the molecular packing along the a-b diagonal of the crystal lattice.

Electronic, atomic, and molecular interactions of the previously mentioned type, in sum, lead to rearrangements of the frontier molecular orbital energy levels, in general, with consequent bathochromic wavelength shift of maximum absorption in the solid state vis-à-vis in solution. This is a commonly observed phenomenon in pigment physics, manifesting itself in the case of 2, for example, in a manner set forth by Figure 7.

Moreover, as can be seen from Figure 7, the visible absorption bands (particularly the bathochromic arm of the curve) feature ideally steep profiles with negligible residual absorption. This explains the high chroma or purity of shade often displayed by the DPP pigments.

The absorption maxima differences between solution and the solid state, denoted as $\Delta\lambda_{\max}$ values in Table 1, diverge widely within the series of compounds shown. Most DPP pigments generally possess high color strength, the relatively high ϵ_{\max} values additionally bearing testimony to this (see Table 1). This latter property is a major potential of this pigment class and deserves to be commercially exploited.

A further manifestation of the strong intermolecular forces (hydrogen bonding, π - π interactions, and van der Waals forces) present in the pigment solid state of diaryl DPP derivatives is reflected by the high thermal stability of such compounds, shown by thermo-gravimetric measurements on selected samples (see Figure 8). DPP compounds which are stable up to 500°C and higher are known. Such products are, hence, ideally suitable for pigmentation of plastics.

Also, probably because of the more or less pronounced tendency of such pigment crystals to grow in all three directions, as governed by the prior mentioned forces, the DPP crystals frequently lend themselves to transformation into small transparent, as well as into large—in particular, isometric—and, hence, hiding forms by selected procedures (*vide infra*).

CHEMISTRY

The early recognition of the high pigment potential of DPP compounds stimulated a deeper investigation of reaction 1 [equation (1)] with a view to evaluating its commercial feasibility. This process was chosen primarily because equation (1), at this point, not only appeared to be the only known, hopeful route of access to a DPP

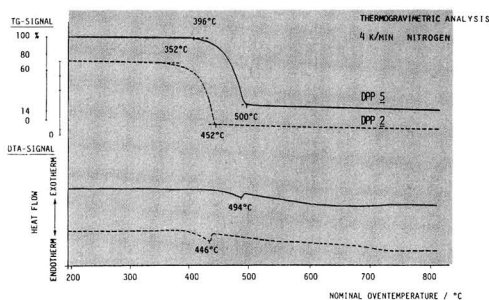


Figure 8—Thermal stability of DPP-derivatives

pigment, but it also represented a one-pot process starting with available raw materials, requiring no eco-toxicologically questionable amines or hydrazines.

Footing on Farnum's¹ original mechanistic proposal for the formation of **2** via oxidative dimerization of the amino cinnamic acid intermediate **7A** (Figure 9), initial attempts at improving pigment yields by this method unfortunately met with no noteworthy success. This, hence, called for a reinvestigation of the reaction, step by step.

Appropriate crossing experiments, with increasing amounts of amino cinnamic acid derivative **7A** being added to a Reformatsky reaction mixture of p-tolynitrile, bromo acetate, and zinc (Figure 10), showed a corresponding increase in the formation of the asymmetric DPP **9**, as well as of the symmetric DPP **2**, as determined by mass spectroscopic and high temperature thin-layer chromatographic analyses of the resultant pigment mixtures. A second interesting observation made was the high selectivity to the asymmetric DPP **9**, when working in the presence of amino cinnamic ester **7A**.

Such results were considered as sufficiently coercive evidence in support of the intermediacy of cinnamic acid derivative **7A** and its Zn-salt **7B**, respectively, in the formation of DPP **2** according to equation (1). Both the enaminoester and its corresponding Zn-salt, prepared independently, however, failed to yield any pyrrolopyrroles upon thermal reaction, be it in the presence of a Lewis acid, a base, air, or other oxidizing agents.

On the other hand, when to the independently prepared Zn-salt **7B** (Figure 11) was added a mixture of benzonitrile and bromo acetate only, the ensuing reaction furnished DPP **2** even at lower temperatures than reported by Farnum.¹ This led to the postulation of a unified mechanistic rationale (Figure 12) for the formation of DPP via the Reformatsky reaction, that makes adequate allowance for the various findings, so far.

Unfortunately, however, even after months of intensive experimentation based on these observations, no major breakthrough was possible. Although we did succeed in developing a procedure ultimately affording reproducible yields of DPP, somewhat higher than previously reported, the results were still too poor to warrant commercial viability of the process given by equation (1).

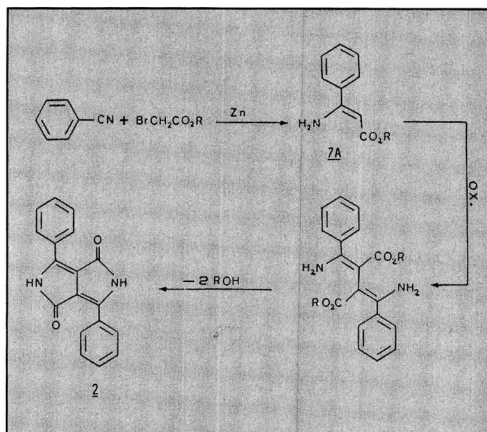


Figure 9—DPP formation mechanism proposed by Farnum, et al.¹

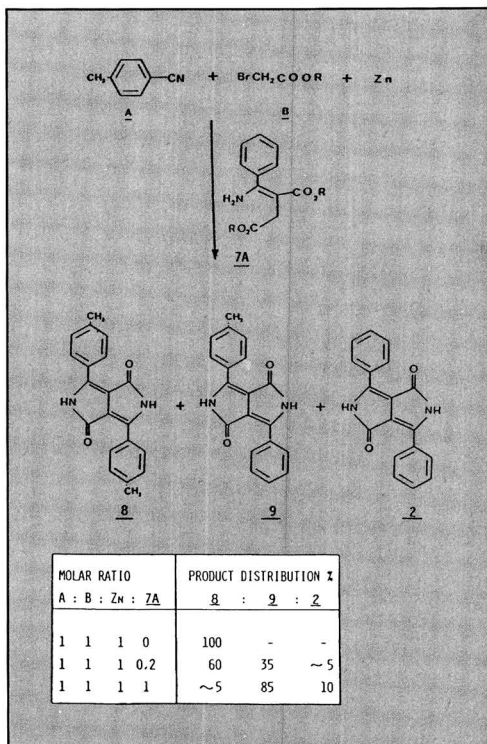


Figure 10—DPP crossing experiment in the presence of β -amino cinnamic ester

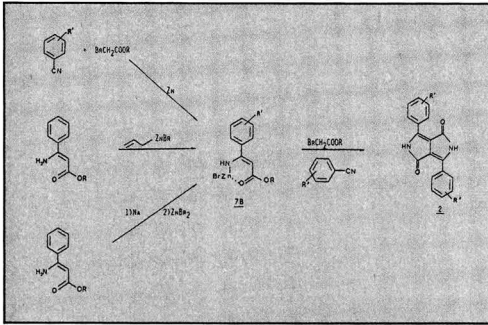


Figure 11—Independent synthesis and conversion of β -amino cinnamic ester (Zn-salt) to DPP

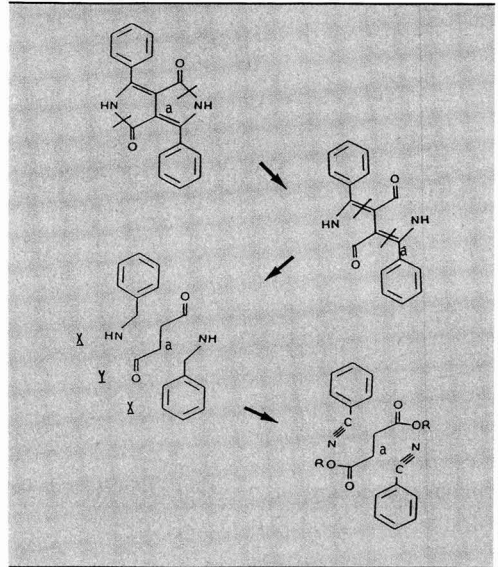


Figure 13—Retrosynthetic analysis of the DPP molecule

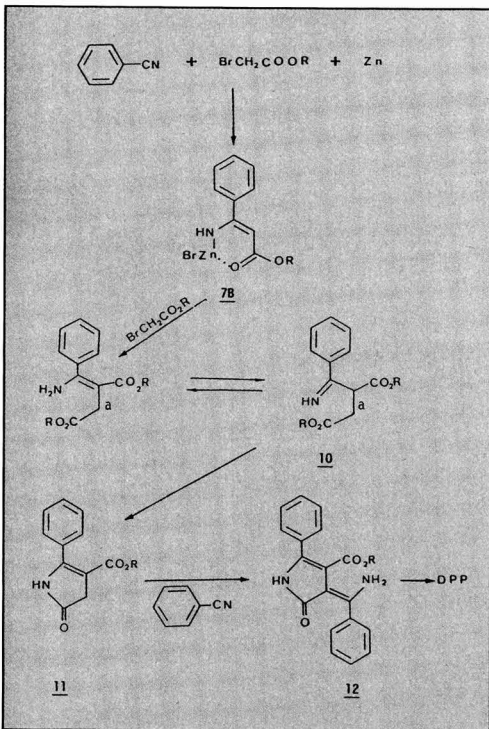


Figure 12—Mechanism of DPP formation via the Reformatsky reaction of nitriles

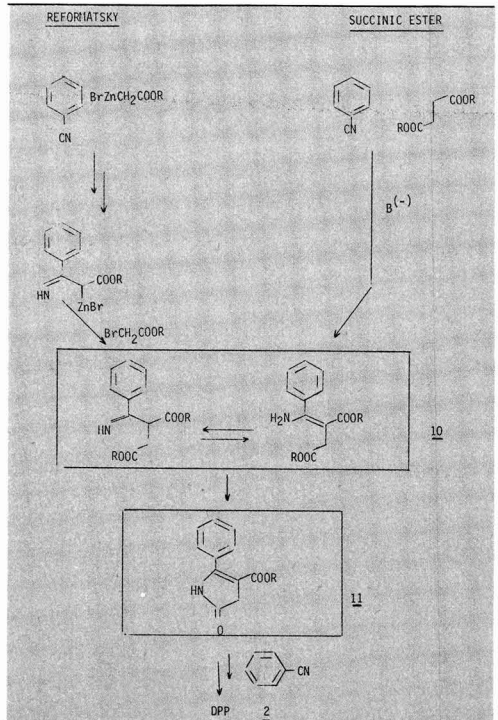


Figure 14—Mechanistic comparison between the Reformatsky and the succinic ester routes to DPP

Keeping in mind the important criteria of availability of starting materials, least number of reaction steps, and technologically feasible chemistry, the search for alternative approaches to the DPP system, which would allow one to circumvent the disadvantages associated with the original Reformatsky route [equation (1)], was therefore continued.

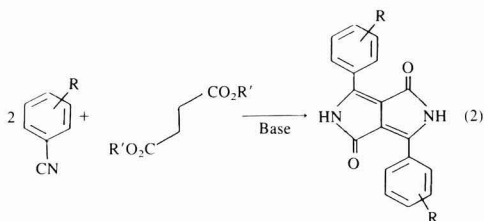
A closer inspection of the mechanistic scheme depicted in *Figure 12*, backed up by appropriate experimental verification, soon revealed that the overall low yield of DPP **2** was in strong contrast to: the observed high yields (over 80%) of formation of the Zn-salt **7B** via Reformatsky reaction of benzonitrile, and the practically quantitative cyclization of a preprepared sample of compound **12**, as immediate progenitor of DPP **2**.

In the formation of DPP according to *Figure 12*, the C-alkylation of Zn-salt **7B** was hence concluded to be the crucial yield-determining step, which very likely was accompanied by such side reactions as self-hydrogenation, reductive dimerization, N-alkylation, N-, and C-acylation of **7B**.

The implied C-alkylation would lead to the formation of the bond **a**, which both rings of the fused bicyclic DPP chromophore have in common. In developing an alternative synthetic concept, it was decided to conserve the said bond in any one of the many educts that might come in question for construction of the DPP unit.

Figure 13 shows one possible variant of sequential retrosynthetic analysis of the DPP molecule **2** with retention of the crucial bridging C-C bond **a**, but involving consecutive rupture of the remaining cyclic lactam bonds, in symmetrical pairs, to ultimately yield the three fragments **X**, **Y**, and **X**. Assuming a symmetrical formation step, of the many possible combinations of synthetic equivalents of the three fragments, the one indicated at the bottom of *Figure 13* was considered to be the most promising.

In other words, the following synthesis, starting from succinic esters and aromatic nitriles [equation (2)]



appeared to be the most attractive one for reasons of it directly affording the desired pigment in a one-step process from available raw materials. Generation of the crucial C-C bond required by the Reformatsky route (see Steps **7B** \rightarrow **10**, *Figure 12*) is here obviated by its advance presence in the succinic ester component.

In spite of initial failures, we persisted in this approach, embarking on a detailed study of the reaction given by equation (2). Systematic and laborious optimization of reaction parameters ultimately led to success via this route. The initial poor yields of the reaction were

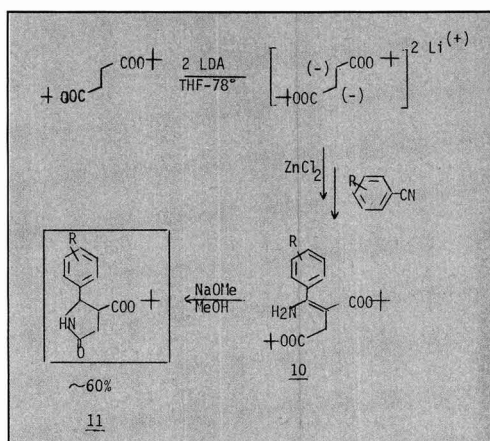


Figure 15—Synthesis of enamino(**10**) and pyrrolinone (**11**) esters

significantly improved by appropriate choice of reactants and conditions,⁴ thus making it amenable to scale-up, providing optimum product yield, consistent with good process economics.

Mechanistically, the formation of the DPP unit from succinic esters is believed to proceed along pathways shown in *Figure 14*. Of the hitherto elusive crucial intermediates **10** and **11**, as postulated previously for both the Reformatsky and the succinic ester route, the **10** analogue could recently be isolated and characterized⁵ via the low temperature condensation of succinic esters and nitriles in the presence of appropriate bases as shown by *Figure 15*. Transformation to lactam analogue of **11** occurred upon treatment of the intermediate enamine with sodium methy- late in methanol.⁶

The lactam ester, or its non-cyclized precursor, when used instead of succinic ester in the normal DPP synthesis

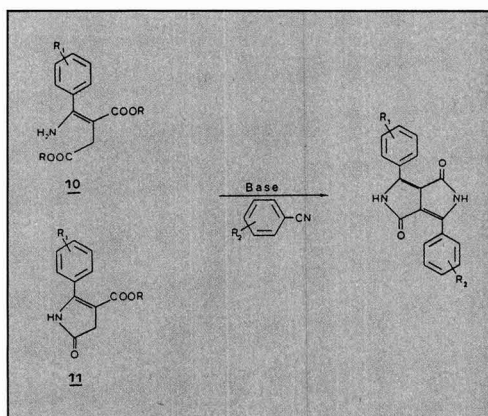


Figure 16—Conversion of enaminoester (**10**) or pyrrolinone ester (**11**) to DPP

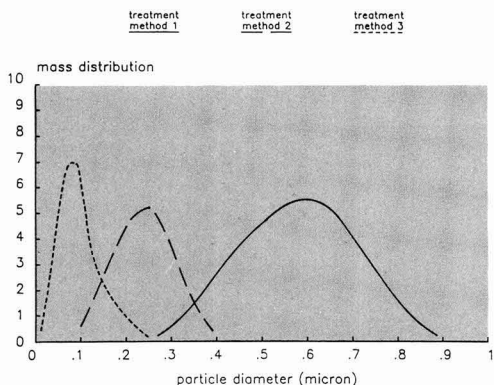


Figure 17—In-synthesis control of DPP particle-size (disc centrifuge with photodensitometer)

procedure, gave rise to excellent yields of the desired pigment according to Figure 16. The formation of DPP under the conditions described previously adds to the evidence that these two compounds—enamine and lactam—are possible intermediates in both the succinic ester and the Reformatsky route, as indicated in Figure 14.

PARTICLE SIZE CONTROL

A pigment is not only characterized by its chemical structure, but also by its crystallinity and especially by its

morphology. Important properties like color strength, shade chroma, hiding power, flow, and even light- and weatherfastness are strongly influenced by such physical and geometrical parameters. Recrystallization stability and particle size control are often serious problems in pigment chemistry.

Fortunately, the formation and growth of DPP pigment particles may be controlled, in particular, by *in situ* chemical methods both during and after the pigment formation step. Thus, thermal treatment during post-hydrolytic work-up of one and the same DPP pigment in specific solvent systems under defined conditions of pH, in many cases, can furnish a wide range of particle sizes (Figure 17) of varying color, strength, crystallinity, flow, fastness, and hiding properties.

On the other hand, for a strong, transparent, and recrystallization stable version, such as is normally required in high temperature plastics applications, it is often expedient to perform a so-called mixed synthesis⁷ of DPP with succinic ester. Instead of one nitrile, a mixture, for example, of two different nitriles is employed in the standard succinic ester route (Figure 18), which should be yielding a mixture of symmetrical and asymmetrical DPPs.

Figure 19 impressively illustrates how, by mere incorporation of 5% of m-phthalonitrile in the synthesis of the DPP derivative 13 by the succinic ester route (Figure 20), one can obtain a mixed synthesis product 14 with not only higher color strength and transparency (due to smaller particle size), but also with significantly improved recrystallization stability, while essentially retaining the inherent shade of the standard synthesis product 13.

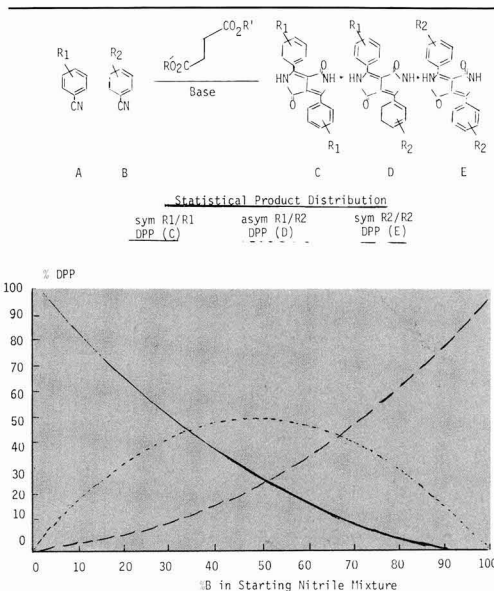


Figure 18—DPP mixed synthesis

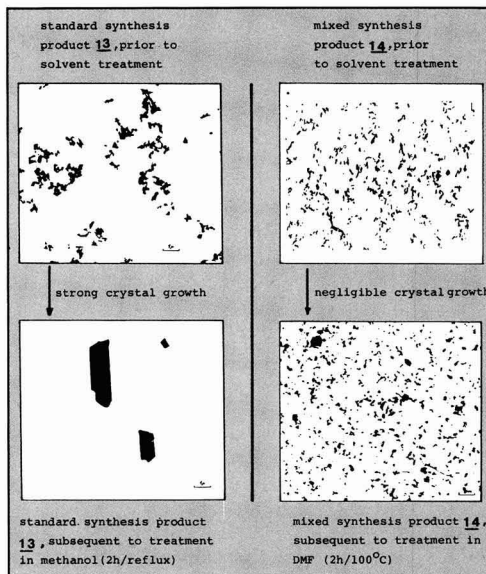


Figure 19—Photomicrograph (transmission electron microscopy) of DPP pigments 13 and 14

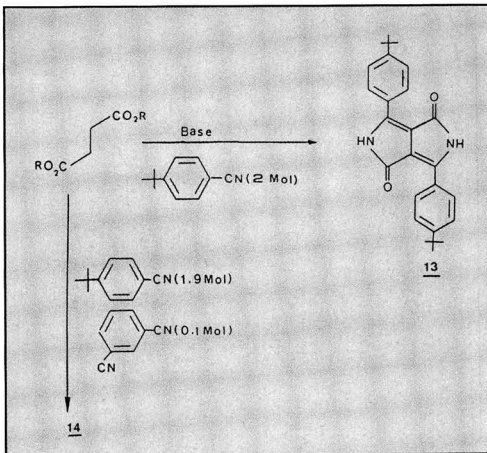


Figure 20—Mixed synthesis of DPP 13

The aforementioned examples, and several similar ones which remain unmentioned here, demonstrate the versatility of the mixed synthesis technique as a tool for controlling particle size in DPP synthesis without additional cost.

CONCLUSION

For their manufacture, the DPP pigments require raw materials which are either commercially available or are amenable to synthesis from simple precursors.

A major potential of this new class of chromophore resides in its ability to furnish a wide range of strong,

saturated shades of variable opacity. As pigments, the DPP's feature, in general, a high level of light- and weatherfastness. They are intrinsically characterized by outstanding heat, bleed, and chemical resistance. Optimum exploitation of such properties is rendered possible by *in situ* particle size control during synthesis.

The exceptional combination of these properties should therefore make the DPP pigments ideally suitable for industrial and automotive paints, as well as for applications in plastics and man-made fibers.

ACKNOWLEDGMENT

The present work embodies the fruits of endeavors of many colleagues at CIBA-GEIGY. Their active participation at various interdisciplinary levels of product development has helped to enhance our understanding of the chemistry and physics of DPP pigments, and is here gratefully acknowledged.

References

- (1) Farnum, D.G., Metha, G., Moore, G.G.I., and Siegal, F.P., *Tetrahedron Letters*, 29, 2549 (1974).
- (2) Ranganathan, D. and Ranganathan, S., "Further Challenging Problems in Organic Reaction Mechanisms," Academic Press, New York, 1980, page 206.
- (3) Iqbal, A. and Cassar, L. (to CIBA-GEIGY Corp.), U.S. Patent 4,415,685 (Nov. 15, 1983).
- (4) Rochat, A.C., Cassar, L., and Iqbal, A. (to CIBA-GEIGY Corp.), Europ. Patent 9 4911 (Nov. 23, 1983).
- (5) Pfenninger, J., Iqbal, A., and Rochat, A.C. (to CIBA-GEIGY Corp.), Europ. Patent Application 184-981 (June 18, 1986).
- (6) Pfenninger, J., Iqbal, A., Rochat, A.C., and Wallquist, O. (to CIBA-GEIGY Corp.), Europ. Patent Application 184-982 (June 18, 1986).
- (7) Iqbal, A., Pfenninger, J., Rochat, A.C., and Bähler, F. (to CIBA-GEIGY Corp.), Europ. Patent Application 181-290 (May 4, 1986).

CONVENTION CASSETTES

that let you hear what
you may have missed.

***Cassettes of the convention seminars will be
available for purchase from AVW Audio Visual, Inc.***

Here's how the convention seminar cassettes can be valuable long after the Federation of Societies for Coatings Technology Convention is over:

- Provides an excellent 'refresher course' for the future.
- Provides an invaluable educational and training tool.
- Provides access to important information for those unable to attend.

Get your AVW seminar cassettes by using the handy order form below.

Federation of Societies for Coatings Technology
October 5 - 7, 1987
Dallas, Texas

TUESDAY, OCTOBER 6, 1987

_____	COAT-01	Tools for Professional Success in the Coatings Industry . . .	\$18.00
_____	COAT-02	Reactive and Non-Reactive Resins and Electrodeposition	\$18.00
_____	COAT-03	Innovation — The Key to Survival and Growth	\$18.00
_____	COAT-04	Seminar on Dispersion/From the Stone Mill to the Horizontal Mill: 250 Yrs.	\$18.00
_____	COAT-05	Solvents and Testing	\$18.00

WEDNESDAY, OCTOBER 7, 1987

_____	COAT-06	Sales/People	\$9.00
_____	COAT-07	Mattiello Memorial Lecture	\$9.00
_____	COAT-08	Powder Coatings	\$9.00

COAT

c/o AVW Audio Visual, Inc.
Tape Duplication
2254 Valdina, Suite 100
Dallas, Texas 75207
214/638-0024

By Mail Order:

(After Convention) Add \$3.50 per order for handling charges.

Allow 2 weeks for delivery.

Payment Method:

VISA _____
Mastercharge _____ American Express _____
Check (Payable to AVW) _____

Card Number _____ Expiration Date _____

Signature Required on all Mail orders _____

Amount of Tapes:

Binder(s): _____ (6 Cassettes
Binder @ \$4.00 ea.)
_____ (12 Cassettes
Binder @ \$5.00 ea.)

Sales Tax (8%)

Texas Residents Only: _____

Total: _____

NAME: _____

COMPANY: _____

ADDRESS: _____

(CITY) _____ (STATE) _____ (ZIP CODE) _____

Positron Implantation and Annihilation In Protective Organic Coatings

Cs. Szeles, K. Süvegh, and A. Vértes
Eotvos University*

M.L. White and H. Leidheiser, Jr.
Lehigh University†

Positron implantation and annihilation were studied in two polymeric coatings, one pigmented and the other unpigmented, deposited on steel substrates. Positron lifetime spectra recorded on the coatings exhibited three components and closely resembled characteristic lifetime spectra of bulk polymers, but they were strongly dependent on the coating thickness. It was shown that the lifetime spectra could well be described as a sum of two contributions: spectra of the coating and the steel substrate. The fraction of positrons stopped in the coatings and in the steel were determined, and the effective mass absorption coefficients of positrons were extracted. The thickness dependence of the mean positron lifetime and the intensities of different lifetime components were described with an exponential positron implantation profile. The mixing of the lifetime parameters of the coating and steel spectra was studied as a function of thickness. Simulated lifetime spectra were generated using the experimental lifetime spectra and implanted fractions in the coatings and steel. Differences between the measured and simulated lifetimes and intensities at low thickness values were associated with an inhomogeneous size and depth distribution of open volumes in the coatings.

INTRODUCTION

Protection of metal surfaces from corrosion is among the more important applications of organic coatings. Five major subject areas in which many questions relative to corrosion protection are unanswered have been described in a recent publication.¹ One of these subject areas relates to the size and number of voids present at the metal/

organic coating interface. Means for determining the presence of these voids are not obvious because optical measurements are impractical with opaque coatings. Recent success²⁻⁴ in the application of positron annihilation to the study of protective organic coatings led us to initiate research on the use of this technique for studying voids in organic coatings since positron annihilation is sensitive to vacancies and voids in solid materials.

Experimental methods based on the annihilation properties of positrons injected into materials have been widely used to study open volume defects in a range of materials.^{5,6} It has also been successfully applied to study the structure of molecular materials and the structural changes that occur upon phase transitions, ion uptake, radiation damage, etc.⁷ New experimental methods based on controlled energy, monoenergetic positron beams have been developed for the study of surfaces and interfacial phenomena.^{8,9} These methods hold great promise for the study of the interface between thin organic coatings and a metal, but they do not appear applicable to the study of protective organic coatings whose thickness is in the 25-600 μm range. The more conventional methods for studying positron annihilation appear to have more promise in the area of our present interest.^{2-4,10,11}

Positrons, when injected into a solid, tend to be localized at regions of lower than average ionic charge density. Since the electron distribution and the density are different at such sites, the annihilation properties of the positrons may be completely different in these trapped states. The annihilation probability of the trapped positron depends largely on the average electron density in the free volume, and it is thus sensitive to both the volume and geometry of the free volumes. If the size of the free volume is large and consequently the electron density therein is low, positronium formation and localization may take place within these free voids. The chemical nature of the boundaries of the free volumes influences the positronium lifetime since the annihilation

*Laboratory of Nuclear Chemistry, Budapest, H-1088 Hungary.

†Department of Chemistry and Zettlemoyer Center for Surface Studies, Bethlehem, PA 18015.

Table 1—Lifetime Spectra of the Coatings And the Cold-Rolled Steel Substrate^a

Material	τ_1 (ps)	τ_2 (ps)	τ_3 (ps)	I_1 (%)	I_2 (%)	I_3 (%)
Alkyd. . .	178 ± 3	480 ± 8	2520 ± 30	48.8 ± 1.3	42.5 ± 1.3	8.8 ± 0.2
Epoxy . . .	188 ± 4	520 ± 20	1830 ± 23	43.7 ± 1.6	34.0 ± 1.3	22.3 ± 0.5
Steel. . .	136 ± 3	276 ± 10	—	78.0 ± 1.0	22.0 ± 1.0	—

(a) Data given in the table are somewhat different from results published earlier.⁴ The differences are due to a more precise treatment of the resolution function and more consistent analysis of the steel spectra in terms of two lifetime parameters. The statistically most reliable parameters, mean lifetimes and I_1 , are not appreciably influenced by the differences in the data treatment.

properties of the positronium atoms, as well as the electron density, are sensitive to the polarization effects of atoms at the boundary. Experimental methods based on positron annihilation are particularly fruitful when relatively small changes in the ionic or electronic structure of free volumes and their surroundings are studied.

Recently we have studied the positron annihilation properties in protective organic coatings before, after, and during exposure of the coated metal to water.^{2,3} The ability to draw correlations between the positron lifetimes and the protective properties of the coatings in an aggressive environment encouraged us to pursue this work further. An important shortcoming of the prior work was the poor knowledge of the depth distribution of positrons in the metal/coating system. The reported lifetime spectra represented the sum of the lifetime distributions in the coating and in the metal, weighted by the fraction of positrons stopped in the two layers. Therefore, in order to interpret lifetime spectra recorded on protective coatings, it is essential to know the positron stopping profile in the metal/coating system.

The work reported herein was designed to clarify the role of different contributions to the measured lifetime spectra, to advance the analysis of such spectra, and to gain additional insight useful in interpreting the spectra. To achieve these goals, we have determined the effective mass absorption coefficients and implantation profiles of positrons in two coatings, one a fully formulated, commercial system and the other a neat resin system without pigments or fillers. The major parameter that was varied was the coating thickness. The thickness dependence of the positron lifetime spectrum parameters was studied on computer-generated spectra. These were obtained using

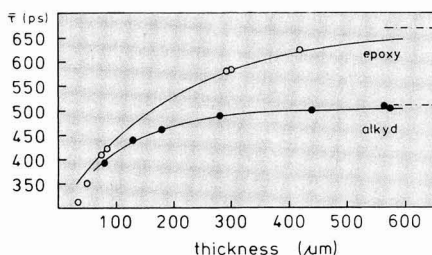


Figure 1—Mean positron lifetime as a function of coating thickness for the alkyd and epoxy coatings

the experimental fractions of positrons stopped in the coatings and in the metal. It will be shown in the discussion that follows that differences in the measured and calculated spectra may be accounted for by a change in the defect structure in the vicinity of the metal/coating interface.

EXPERIMENTAL

The alkyd based coating was a formulated, commercial material (Rust-Oleum Flat White #7790). It was applied as received to discs of cold-rolled steel 1⁵/₁₆ in. (3.3 cm) in diameter and 32 mils (0.80 mm) thick by spinning at 1000 rpm. Sample thicknesses between 3 mils (0.08 mm) and 23 mils (0.58 mm) were obtained by multiple spinning, with a 45 min air dry between coats and a final bake at 60°C for about 1 hr.

The epoxy coating was a novolac resin cured with a mixed aromatic/aliphatic amine (2:1 ratio, by weight) obtained from CIBA-GEIGY Corporation. The mixed resin/hardener material was applied to cold-rolled steel by a draw down procedure, using an adjustable Gardner knife. The thickness varied from 2.5 mils (0.063 mm) to 17.7 mils (0.44 mm). Curing was done at room temperature. The coated steel was then cut into 1¹/₂ in. (3.8 cm) squares. The surface finish on the steel substrates for both coatings was 35-50 microinches (0.89-1.27 μm).

The lifetime spectrometer was a conventional fast-slow coincidence system based on NE 111 plastic scintillators, XP 1021 photomultipliers, and ORTEC electronics. The time-resolution of the system was around 300 ps full width at half maximum. In most cases, it was reliably described with a single or eventually two Gaussians. The positron source was made by deposition of carrier-free ²²NaCl solution between 1 mg/cm² thin Kapton foils. The lifetime spectra were measured at room temperature and normal pressure, and were collected within one day. The RESOLUTION and POSITRONFIT computer programs were used¹² to evaluate the lifetime spectra. The spectra were fitted with three components which are described in terms of the lifetime (τ) and the intensity (I).¹⁰

There are several experimental methods to determine positron depth distribution in a given material.^{13,14} Here we have applied the method developed in the 1960's,^{15,16} which uses a simple sandwich geometry and is based on the large differences between the lifetime spectra of polymers and steel (see Table 1). The measured spectra were assumed to be linear superpositions of these two contributions weighted by the relative fraction of positrons stopped in the two materials. The positron implantation profile and effective mass absorption coefficients were determined from positron lifetime spectra on coatings of increasing thickness.

RESULTS

Lifetime spectra of the coatings and the steel substrate are given in Table 1. The coatings data were obtained from spectra recorded on the thickest alkyd coating, as this coating absorbed almost all the injected positrons, and on a stack of detached epoxy coatings of total thickness about 1800 μm.

Figure 1 shows the mean positron lifetimes, while Figures 2 and 3 show extracted lifetimes and intensities versus coating thickness for the alkyd and epoxy, respectively. The lifetime parameters show the expected saturation behavior. Spectra converge toward the spectra of the coatings with increasing coating thickness due to an increased positron absorption in the coatings and a decreased fraction of positrons reaching the metal.

Three major differences in the spectral features of the two coatings may be noted. First, there is a striking difference between the long-lived components. The epoxy coating exhibits a much higher intensity and shorter lifetime for this component. Second, saturation of the parameters takes place at a much lower thickness value in the case of the alkyd coating because of its higher density. Third, the value for the long lifetime increases considerably with increasing thickness for the alkyd coating while it is almost constant in the case of the epoxy coating.

DISCUSSION

Positron Implantation

The lifetime parameters depicted in Figures 1-3 tend towards saturation above 300 μm and 600 μm in the case of alkyd and epoxy, respectively. This is most clearly seen in the behavior of the mean positron lifetime (Figure 1) which is the most statistically reliable parameter. As the density of the pigmented alkyd coating, δ = 2.03 g/cm³ is almost a factor of two higher than the density of the unpigmented epoxy coating, δ = 1.13 g/cm³, the above thickness values roughly correspond to 60 mg/cm² reduced thickness value in both cases. Below this value, the thickness of the coatings is insufficient to stop all the positrons, and a fraction of the positrons traverses the coating and reaches the metal. Any lifetime spectrum below this coating thickness contains a significant contribution from positrons decaying in the steel beneath the coating. The measured lifetime spectra are then summations of the spectra of the coating and the steel.

The large differences between the lifetime spectra of the coatings and the steel give us the opportunity to estimate the fraction of positrons implanted and transmitted through the coating, as well as the value of the effective mass absorption coefficients and implantation profiles of the positrons in the coatings.^{14,15} Any linear annihilation parameter A (e.g., mean lifetime or intensity) is given as: $A = A_c f_c + A_m f_m$, where A_c and A_m are the characteristic values of A in the coating and in the metal, respectively. In addition, f_c and f_m are the fractions of positrons stopped in the coating and in the metal, respectively. Thus, measuring A as a function of the coating thickness, x, the transmitted fraction, i.e., the relative number of positrons decaying in the steel, can be calculated as:

$$f_m(x) = \frac{A(x) - A_c}{A_m - A_c} \tag{1}$$

while the implanted fraction in the coating is: $f_c = 1 - f_m$.

The transmitted fractions $f_m(x)$ have been determined by equation (1) using measured values of the mean lifetime and I_3 since these were the most reliable annihilation

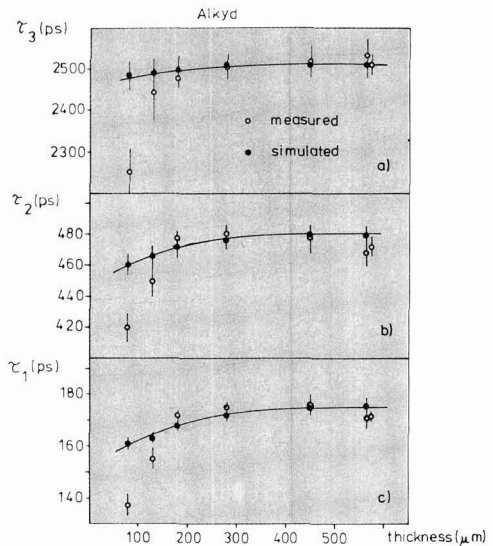


Figure 2A—Positron lifetimes of the three components as a function of thickness for the alkyd coatings. Full curves are the best exponential fits to the data points

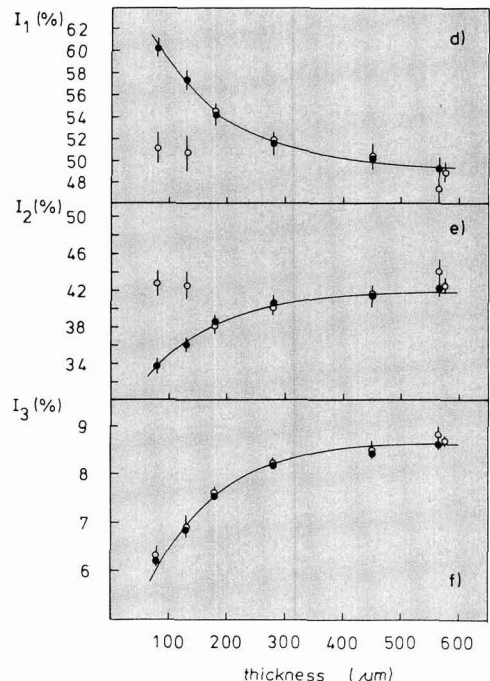


Figure 2B—Positron intensities for the three components as a function of thickness for the alkyd coating. Open circles are the measured values and the solid circles are the simulated values

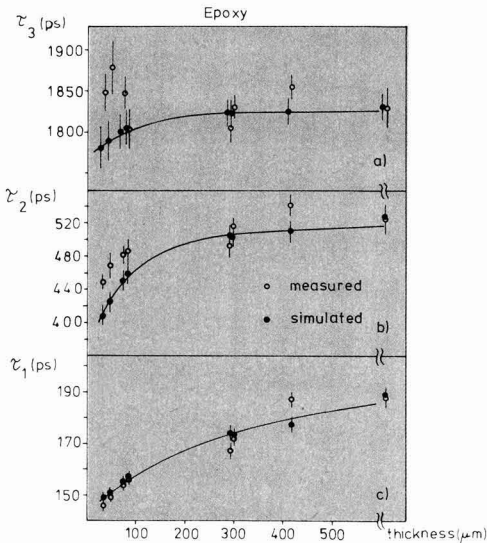


Figure 3A—Positron lifetimes of the three components as a function of thickness for the epoxy coating. Open circles are the measured values and the solid circles are the simulated values

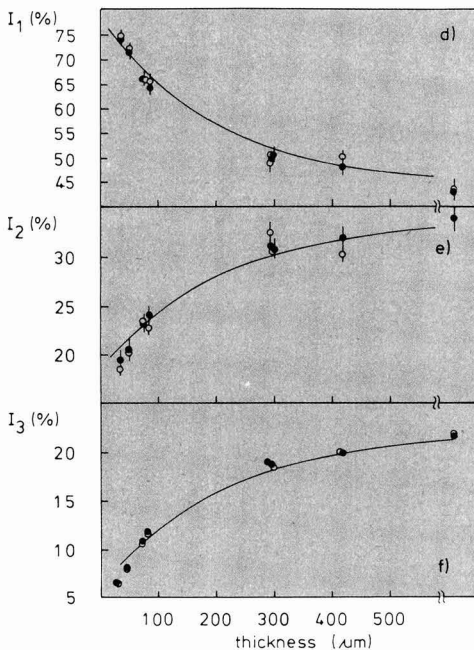


Figure 3B—Positron intensities for the three components as a function of thickness for the epoxy coating. Open circles are the measured values and the solid circles are the simulated values

Table 2—Effective Mass Absorption Coefficients Of Positrons in the Coatings

Material	α (cm^2/g)	$\delta\alpha$ (cm^{-1})
Alkyd	42.8 ± 2.8	86.9 ± 5.7
Epoxy	43.2 ± 1.8	48.8 ± 2.0

parameters. The results are plotted in *Figure 4* for both coatings. Transmitted fractions $f_m(x)$ show nearly exponential behavior common to such experiments,^{14,15} characterized by an effective mass absorption coefficient (α). Then, to a good approximation:

$$\alpha = \frac{d \ln f_m(x)}{dx} \quad (2)$$

Below a certain thickness value (x_0), the transmitted fraction differs significantly from pure exponential and equation (2) loses its validity. The value of x_0 for ²²Na positrons was found to be $5.7 \text{ mg}/\text{cm}^2$ ¹⁴ corresponding to coating thicknesses of approximately $30 \text{ }\mu\text{m}$ and $60 \text{ }\mu\text{m}$ for the alkyd and epoxy coatings, respectively. The effective mass absorption coefficients estimated by equation (2) are listed in *Table 2*.

Equation (2) is useful if we want to determine the practical value of the effective mass absorption coefficient of positrons emerging from a ²²Na source for a given absorber (coating), reflector (steel), and geometry. The extracted value, however, may differ significantly from the intrinsic mass absorption coefficient of the absorber (coating) itself due to positron backscattering at the absorber-reflector interface which tends to increase the implanted and decrease the transmitted positron fractions.¹⁷ Backscattering effects are also clearly manifested in our data. Neither mean lifetime nor I_3 converge towards the value of uncoated steel with decreasing thickness. The effect could be accounted for, in an approximate way, by introduction of an effective backscatter coefficient of positrons B at the coating/metal interface. B is that fraction of positrons reaching the metal surface which is reflected back into the polymer. The fraction of positrons stopping in the coating is then

$$f_c(x) = 1 - (1 - B) \cdot \exp(-\alpha \cdot x) \quad (3)$$

if $x > x_0$. The mean lifetime and I_3 are then to a good approximation

$$\tau(x) = \tau_m + (\tau_c - \tau_m) \cdot f_c(x) \quad (4)$$

$$I_3(x) = I_3(\infty) \cdot f_c(x) \quad (5)$$

respectively, where τ_m and τ_c are the mean positron lifetimes for the metal and coating, while $I_3(\infty)$ is the asymptotic value of I_3 for high thickness values.

Curves in *Figures 1-3* of τ and I_3 are the best fits to the data points with α and B as parameters. Extracted values of B ($B = 0.41$ and 0.26 for the alkyd and epoxy coatings, respectively) are in reasonable agreement with its value estimated according to Mackenzie, et al.,¹³ $B = 0.338$ for steel. It should be pointed out that this approximation strongly overestimates backscattering below x_0 , which is clearly seen as a deviation of the epoxy data from the fitted curve below $60 \text{ }\mu\text{m}$ as shown in *Figure 1*. More detailed discussion of the backscattering effects

was given elsewhere.⁴ Transmitted fractions of positrons may be used to determine the positron implantation profile in the coatings:

$$P(x) = -\frac{1}{I-B} \cdot \frac{d I_m(x)}{dx} \quad (6)$$

Figure 5 shows the derived implantation profiles.

Positron Annihilation

The positron lifetime spectra of the coating, as discussed previously, contains contributions both from the coating itself and from the metal substrate, unless the coating is thick enough to absorb all the injected positrons. Since the lifetime spectrum of the steel substrate can be described in terms of two lifetime components, the effect of the substrate shows up largely in the two shorter lifetime components of the coating. The contributions from the substrate diminish with increasing coating thickness and the spectrum converges towards that of the coating itself. The decreasing contribution from the steel is clearly shown by the decreasing intensity of the short-lived component and the concomitant increase of the intensities of the longer lifetime components. Since the shortest lifetime component is a sum of the contributions from the coating and the steel substrate, the measured lifetime value is sensitive to the coating thickness. Indeed, it has been possible to model the thickness dependence of the short lifetime value, assuming it is a linear superposition of the short lifetime component of the coating and the mean lifetime characterizing the substrate.⁴

An important question arising from these results is whether the variation in the lifetime of the longer lifetime components is a consequence of the simple superposition of the spectra of the coating and the substrate, or is due to a change in the nature of the coating with decreasing thickness. In order to address this question, computer-derived spectra have been compared with the measured spectra. The computer-derived spectra were generated using the experimental spectra of Table 1 and the experimental values of the implanted and transmitted positron fractions as determined from equation (1). The calculated five-component spectra were analyzed to three components characteristic of the coating, and the resulting lifetime and intensity values are shown as black dots in Figures 2 and 3. It is apparent from the simulated data that significant mixing of the steel lifetime components occurs in the case of τ_2 and even τ_3 . This effect causes a systematic decrease of τ_2 and τ_3 from their values in the coating with decrease in coating thickness. These results show the importance of a knowledge of the positron depth distribution when studying coatings.

In the case of the epoxy coating, there was an excellent agreement between the measured and simulated values of the intensities and the short lifetime component over the entire thickness range as well as for τ_2 and τ_3 above 100 μm thickness. This result may be considered to support the concept that the measured spectra are simple linear superpositions of the coating and the metal spectra for coatings exceeding 100 μm in thickness.

Measured and simulated parameters, particularly τ_2 and τ_3 , significantly deviate for thinner coatings. These

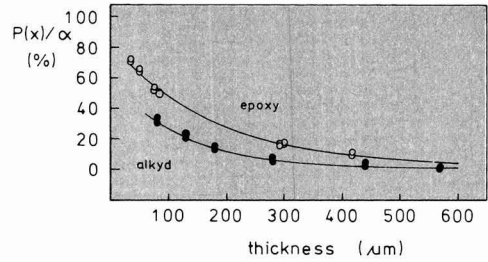


Figure 4—Transmitted intensities as a function of coating thickness for the alkyd and epoxy coatings

observations cannot be ascribed to backscattering effects since the experimental implanted and transmitted fractions, which already contain the backscattered contributions, were used in calculating the simulated spectra. The disagreement between the measured and simulated spectra at low thicknesses are tentatively associated with changes in the coating morphology at thicknesses below 100 μm .

The lower calculated values of τ_2 and τ_3 for the thinner coatings in the case of the epoxy coating suggests an increase in the average size of both positron and positronium trapping sites with decreasing thickness. This effect is speculated to be caused by an inhomogeneous distribution of voids in the coating with a high concentration of voids existing in the vicinity of the metal/coating interface. Positrons sample this interfacial region, presumably containing the larger or more numerous voids, with higher probability as the coating is decreased in thickness.

The behavior of the lifetime parameters in the case of the alkyd coating is more complicated than in the case of the epoxy coating in that the values of τ_1 , τ_2 , τ_3 , I_1 , and I_2 deviate from the simulated values below 130 μm thickness. An increase in I_2 at the expense of I_1 for the thinner coatings suggests an increase of the free volume density at the metal/coating interface. The decrease in τ_1 is also in accord with this interpretation. The low values of τ_2 and τ_3 moreover suggest a decrease in the average size of free volumes near the interface with decrease in coating thickness.

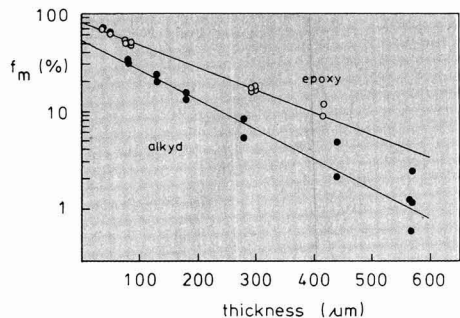


Figure 5—Positron implantation profiles in the alkyd and epoxy coatings

The main difference between the annihilation properties of positrons in the alkyd and epoxy coatings arises in the long lifetime component. The value of this lifetime ($\tau_3 = 1800\text{-}2600$ ps) shows that its origin is the formation of positronium in the coatings. The intensity values show that a much larger amount of positronium is formed in the epoxy coating than in the alkyd coating. Two interpretations are considered, either a more open structure (higher void content) in the epoxy coating or by a considerable inhibition of positronium formation in the alkyd coating.

ACKNOWLEDGMENT

Appreciation is expressed to the Office of Naval Research for partial support of the U.S. portion of the research.

References

- (1) Leidheiser, H. Jr., *Proc. Intern. Conf. Localized Corrosion*, Orlando, FL, June 1-5, 1987, Isaacs, H. (Ed.), Natl. Assoc. Corrosion Engrs., Houston, TX, in press.
- (2) Leidheiser, H. Jr., Szeles, Cs., and Vértés, A., *Nucl. Instr. Meth. Phys. Res.*, A255, 606 (1987).
- (3) Szeles, Cs., Vértés, A., White, M.L., and Leidheiser, H. Jr., submitted to *Nucl. Instr. Meth. Phys. Res.*
- (4) Suvegh, K., Szeles, Cs., Vértés, A., White, M.L., and Leidheiser, H. Jr., *J. Radioanal. Nucl. Lett.*, 117, 183 (1987).
- (5) "Positron Solid State Physics," Brandt, W. and Dupasquier, A., (Eds.), North-Holland: Amsterdam, 1983.
- (6) "Positron Annihilation," Jain, P.C., Singru, R.M., and Gopinathan, K.P. (Eds.), World Scientific: Singapore, 1985.
- (7) Eldrup, M. in reference (6), p. 644.
- (8) Mills, A.P. Jr., in reference (6), p. 432.
- (9) Dupasquier, A. and Zecca, A., *Riv. Nuovo Cimento*, 8, 1 (1985).
- (10) Jilek, J.H., *Progr. Org. Coat.*, 5, 97 (1977).
- (11) Singh, J.J., Holt, W.H., and Mock, W., Jr., *Nucl. Instr. Meth. Phys. Res.*, 201, 485 (1982).
- (12) Kirkegaard, P., Eldrup, M., Mogensen, O.E., and Pedersen, N.J., *Comp. Phys. Commun.*, 23, 307 (1981).
- (13) Mackenzie, I.K., Schulte, C.W., Jackman, T., and Campbell, J.L., *Phys. Rev.*, A7, 135 (1973).
- (14) Hansen, H.E., Linderoth, S., and Petersen, K., *Appl. Phys.*, A 29, 99, (1982).
- (15) Bisi, A. and Braicovich, L., *Nucl. Phys.*, 58, 171 (1964).
- (16) Bertolaccini, M. and Zappa, L., *Nuovo Cimento*, 52B, 487 (1967).
- (17) Linderoth, S., Hansen, H.E., Nielsen, B., and Petersen, K., *Appl. Phys.*, A 33, 25 (1984).

How to Calculate Crosslink Structure In Coatings

David R. Bauer
Ford Motor Company*

Two simple programs are presented for calculating both pre-gel and post-gel network structure properties in thermoset coatings. The programs are based on the theories of Miller and Macosko. The coating components can be mixtures of oligomeric species or random copolymers. The pre-gel program calculates the weight average molecular weight as a function of coating variables and extent of reaction. The post-gel model calculates the weight of the sol fraction and the effective crosslink density. The programs are written in BASIC and run on IBM-PC compatible computers. Various applications of these programs are described.

INTRODUCTION

The final physical properties of thermoset coatings depend primarily on the network structure that is developed during cure. Development of improved coatings has been hampered by the lack of quantitative relationships between coating variables and final physical properties. This is particularly true in the case of the development of high solids coatings which exhibit substantially different cure behavior from low solids coatings. The development of a mathematical relationship between coating formulation and final cure properties is a formidable task requiring detailed characterization of the coating components, an understanding of the cure chemistry and a model of the cure kinetics, determination of cure process variables (air temperature, heat transfer, etc.), a relationship between cure chemistry and network structure, and the existence of a network structure parameter that correlates with physical properties. There are now a wide range of tech-

niques available to the coatings chemist to characterize coating components and cure chemistry including GPC and NMR (for characterizing structure and molecular weight distributions), and FTIR and thermal analysis (for characterizing cure chemistry and kinetics).

The lack of quantitative relationships between coating composition, cure, and performance seems to be limited by the availability of general, easy-to-use network models which can take the kinetic and coating characterization inputs and calculate parameters to correlate with physical properties. Network structure models which are easy-to-use tend not to be general enough to handle complex coating formulations. More complicated models are often mathematically forbidding. It is the purpose of this paper to present network models which can be used to calculate network properties in a relatively straightforward manner. The model is based on the approach of Miller and Macosko.¹⁻⁵ This approach and the reasons for its selection are described. The relations derived by Miller and Macosko are used in two relatively simple IBM-PC BASIC programs to calculate pre-gel and post-gel properties. These derivations and listings of the programs are provided, and various applications of these calculations are given.

NETWORK STRUCTURE USING MILLER-MACOSKO

The Miller-Macosko approach uses basic laws of probability and the recursive nature of the crosslinking process to calculate average network properties. Formally, this approach is a subset of the more general cascade theory of Gordon.⁶ The advantage of the Miller-Macosko approach is that it readily lends itself to calculating properties of complex systems including mixtures of polydisperse polymers and crosslinkers typical of many coatings. The approach assumes that the polymer contains func-

*P.O. Box 2053, Dearborn, MI 48121.

tional groups, "A," which react with functional groups, "B," on the crosslinker. The A groups react only with B groups. No other side reactions take place. The key inputs are the extent of reaction and the distribution of molecular weight and functionality of the crosslinking components. Separate programs have been written for the pre-gel and post-gel cases since the type of calculation required in the two cases is quite different even though the inputs are similar.

Below the gel-point, the Miller-Macosko approach^{1,4} calculates the weight average molecular weight of the crosslinking mixture. The calculation involves determining the average weight looking out from and in to a group selected at random. The concept of out and in is critical to the use of the Miller-Macosko approach. Looking out from a group means to look away from the chain to which the group is attached. Looking in means to look back at the chain to which the group is attached. Thus, looking out from a reacted A group is the same as looking in to a reacted B group. Also, the weight looking in to a group is the same as the weight of the starting component plus the weight looking out from all the other branches on that component. These recursive relationships are used to determine the molecular weight.

Another critical concept in the Miller-Macosko approach is the concept of how quantities are selected "at random." Three ways are used in the model: chains can be selected at random yielding number averages (also termed expectation values); units of mass can be selected at random yielding weight averages; or functional groups

can be selected at random yielding site averages.⁴ The exact definitions of these quantities are given in *Appendix I*. Above the gel-point, the weight average molecular weight is formally infinite. The Miller-Macosko approach calculates the probability that looking out from or in to a group selected at random is a finite chain. This quantity is calculated using the recursive nature of the branching process and the site distribution of functional groups on the polymer and crosslinker. This probability is used to calculate such network parameters as sol fraction and effective crosslink density. For a more complete discussion of the Miller-Macosko approach, see references (1-5), and the derivations in *Appendices I, III, and IV*.

PRE-GEL MODEL AND APPLICATIONS

In the pre-gel calculation, the expected weights looking out from and in to the A and B functional groups are calculated. These weights are then used to derive an expression for the weight average molecular weight of the mixture in terms of the extent of reaction and various expectation values (averages) of the functionality and mass determined from the input data. The weight average molecular weight derivation and definitions of the expectation values are given in *Appendix I*. The required inputs are as follows: the weight fraction of polymer (solids basis); information about the functionality and molecular weight of the polymer and crosslinker; and the extent of reaction.

A listing of a program which calculates the weight average molecular weight is given in *Appendix II*. The possible compositions of the species which make up the reacting mixture are quite general. The components are divided into polymer (containing the A groups) and crosslinker (B groups). In the case of the pre-gel calculation, the distinction is arbitrary since both components may either be a collection of oligomers (up to 20 unique species) or a random copolymer with an arbitrary ratio of M_w/M_n . In the case of the random copolymer, a single oligomeric reactive diluent can also be included. The program first asks for the weight fraction of the "polymer" component (group A) (line 90). In the case of a hydroxy functional polymer reacting with an aminoplast crosslinker at a 70:30 weight ratio, the weight fraction of the hydroxy (A) component would be 0.7. The program then requests specification as to component type (line 190). If the polymer component is oligomeric, the program asks for the number of unique species (line 250). The program then asks for the amount, functionality, and molecular weight of each species (lines 310-560). The amount can be expressed in terms of either the weight or mole fraction of each component. The program then computes the number, site, and mass expectation values of the functionality and molecular weight (lines 570-670; equations (1) and (2), *Appendix I*). If the polymer component is a random copolymer, the program asks for the fraction and monomer weight of the reactive monomer in the polymer (line 730). The calculations assume that the reactive and nonreactive monomers have the same weight. The program then asks for the number and weight

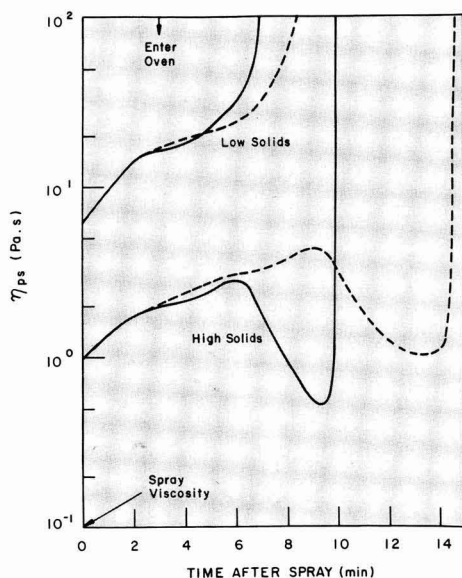


Figure 1—Coating solution viscosity vs time after spray for the high solids and low solids coatings at low (---) and high (—) heat transfer rates. Figure reprinted from reference (7)

average molecular weights (line 790). The program asks for the weight fraction of diluent (as a fraction of the amount of polymer). If there is no diluent, enter 0. If there is a diluent, the program asks for the functionality and molecular weight of the diluent. The program then computes the necessary expectation values (lines 870-950; equation (3), *Appendix I*). The program then asks the same questions for the "crosslinker" component. From the calculated expectation values, the program calculates the ratio of A to B groups (line 1060; equation (4), *Appendix I*) and the gel point (percent reaction of A groups at gel, line 1080; equation (11), *Appendix I*). The program prints the various expectation values along with the gel point and the ratio of crosslinker to polymer functionality (1/R; line 1280). The program finally asks for the percent of reaction of A groups (line 1340) and proceeds to calculate the weight average molecular weight (lines 1400-1470; equation (10), *Appendix I*). This weight is printed out and the program asks for a new percent reaction. To stop the program, enter percent reaction greater than 100. If the percent reaction is greater than the gel point, the program prints out "the mixture has gelled!" and asks for a new percent reaction.

An attempt has been made to make the input requirements convenient and self-explanatory. The output data are simply printed out at the terminal. No special output programming, such as graphics, have been supplied since the output requirements will vary strongly with the specific application. The program will run on any IBM-PC or compatible clone using BASICA (note: for those users unfamiliar with BASICA, real constants are written with a !; this does not indicate a factorial expression).

The main applications of the pre-gel part of network structure modeling in coatings involve studies of the coating viscosity either prior to or in the initial stages of cure. One such study, which used an earlier version of this program, calculated the viscosity of a high and low solids coating as a function of time after application.⁷ The study measured the viscosity of polymer solutions as a function of solids level and temperature in the absence of crosslinking. It was also found that, in the initial stages of cure, the viscosity at constant temperature and solids level was proportional to the increase in molecular weight. A kinetic model, together with oven temperature data, was used to calculate the extent of reaction which was used to calculate the weight average molecular weight and thus the effect of crosslinking on viscosity. The calculated viscosities (*Figure 1*) agree well with measured results on similar systems.⁸ A more complete discussion of this work is presented in reference (7). It should be noted that the approach used essentially breaks up the problem into a number of components or modules. The modules serve as input for one another which helps to simplify the problem. With the generalization of the pre-gel model presented here, the effects on coating rheology of a number of different variables (crosslinker functionality, diluent type and concentration, catalyst level, etc.) could be studied.

Another area where the pre-gel calculation can be useful is in estimating the long term stability of coatings. When coatings are stored for long periods of time, the functional groups can react causing an increase in viscos-

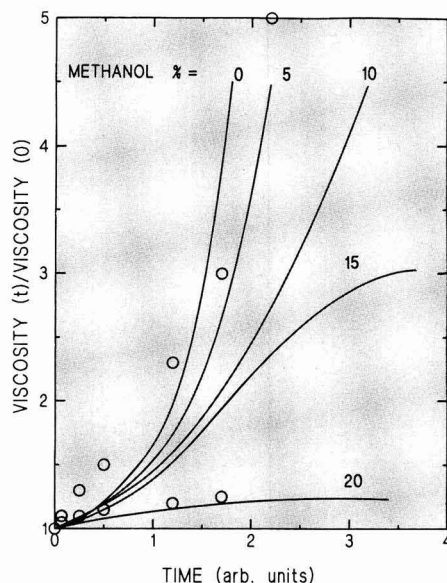
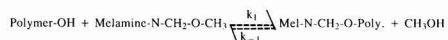


Figure 2—Viscosity increase vs time for a typical high solids acrylic-melamine coating as a function of methanol concentration. The solid lines are calculated data while the (O) indicate experimental data for 0 and 20% methanol

ity. If a kinetic model is available to determine the reaction kinetics, the pre-gel model can be used to determine the rate of viscosity increase and the time to gel. As an example of this application, consider the following coating: a hydroxy functional polymer, hexamethoxymethylmelamine, and varying quantities of methanol. The methanol competes with the polyol to limit the reaction according to the following reaction scheme:



The kinetics of this reaction can be calculated using this expression. The equilibrium constant (k_1/k_{-1}) has been found by Meijer to be 0.67.⁹ The increase in viscosity has been calculated (*Figure 2*) for a typical high solids coating (gel point = 24% reaction) as a function of methanol concentration. The calculated increase in viscosity agrees reasonably well with experimental measurements. It can be seen that large concentrations of methanol are required to prevent the coating from gelling.

POST-GEL MODEL AND APPLICATIONS

As previously stated, the weight average molecular weight is infinite past the gel-point. This does not mean that all of the functional groups are connected to the infinite network. In the post-gel model, the probability that a given group is attached to a finite chain (i.e., not

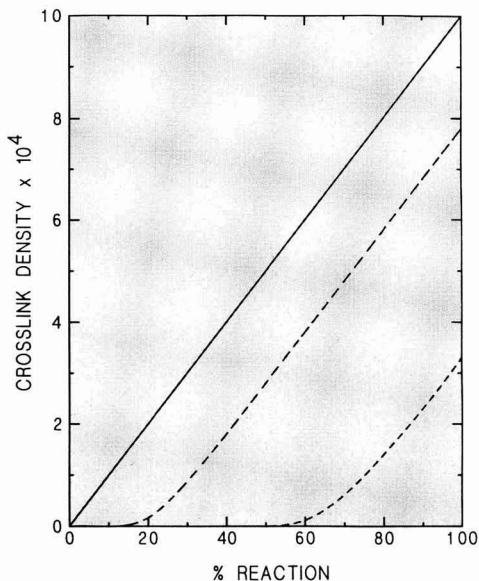


Figure 3—Weighted concentration of effective strands vs extent of reaction for a simple three functional condensation (---) and nine functional condensation (—). The total number of chemical bonds formed is also shown (— · —)

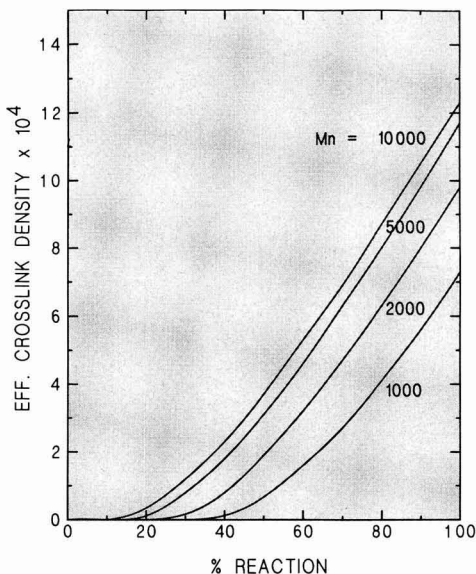


Figure 4—Weighted concentration of effective strands vs extent of reaction for a most probable polymer (30% hydroxyethylacrylate) crosslinked with 25% hexamethoxymethylmelamine. The number average molecular weight of the polymer ranged from 1000 - 10,000

connected to the infinite network) is calculated. This probability is then used to calculate network structure parameters such as sol fraction and crosslink density. The calculation requires that sites be chosen at random. Thus, the site distribution functions of functional groups on the polymer and crosslinker must be specified.⁵ These data can be derived from the oligomer data used in the pre-gel model, however, the specification of the ratio of M_w/M_n for a random copolymer is insufficient to establish the necessary distribution. For this reason, the polymer is limited to being either an oligomer or a random copolymer with either a most probable or a monodisperse weight distribution. The crosslinker is assumed to be oligomeric. The possibility of including a reactive diluent in the mixture is still available. The derivation of the probability that the mass attached to an A and B group are finite is given in Appendix III. This probability does not uniquely define a crosslink density.

It is possible to calculate a number of different kinds of "effective" crosslink densities. Bauer, et al., have used a quantity they termed the elastically effective crosslink density to correlate cure with solvent resistance.¹⁰⁻¹² The correlation was basically empirical. Miller and Macosko have used the model to calculate the crosslink density which in principal correlates with the rubbery modulus of the coating.^{2,5} This crosslink density has been termed the

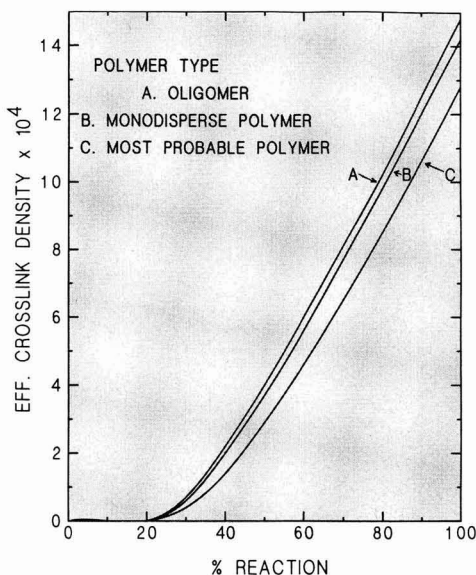


Figure 5—Weighted concentration of effective strands vs extent of reaction are compared for an oligomer, a monodisperse polymer, and a most probable polymer all crosslinked with 25% hexamethoxymethylmelamine. The weight average molecular weights of the "polymer" components were all 3900. The site expectation values of the functionality was ~ 12 in all cases. The lower value of the crosslink density for the most probable polymer reflects the effect of low functional materials on the effective crosslink density

weighted concentration of effective strands. The approach used here is an extension of the approach used in reference (2) incorporating the new expressions for polydispersity. The derivation used by Miller and Macosko in reference (5) is somewhat different. The final expressions for the weighted concentration of effective strands are equivalent numerically. The theory that relates this effective crosslink density to the rubbery modulus requires that the chains between links be Gaussian. This is only true at low crosslink density and breaks down at the high crosslink densities typical of coatings. Hill and Kozlowski have measured the rubbery modulus for model systems and practical coating formulations.¹³ Their measurements indicate that both calculated crosslink densities are proportional to the measured modulus though the proportionality constant does not agree with theory. The agreement is, in fact, closer for the elastically effective crosslink density than it is for the weighted concentration of effective strands, even though the latter value is "more correct" in theory. At this point, relations between any calculated crosslink density and coating performance must be considered. In practice, the two calculated crosslink densities are roughly proportional to one another and more experimental data are required to determine which of the two will give better overall correlation with coating properties. For convenience, both quantities are calculated. The derivation of the equations relating crosslink density to the probabilities are given in *Appendix IV*.

A listing of the BASICA program which calculates the crosslink densities is given in *Appendix V*. The input section (lines 10-1400) is similar in structure to that for the pre-gel program. The "polymer" component (*A* groups) can be either oligomeric or a random copolymer. The "crosslinker" component (*B* groups) must be oligomeric. This covers the most common coating cases. If the polymer is a random copolymer, it must have either a most probable or a monodisperse mass distribution. The program calculates the necessary expectation values (equations (1) and (3), *Appendix I*) and distributions (equation (3), *Appendix III*). The program calculates the ratio of crosslinker to polymer functionality and the gel point using expressions from the pre-gel program. The program then asks for the percent reaction of *A* groups and then proceeds to calculate $P(F_A^{out})$ and $P(F_B^{out})$ using a binary search method (lines 1630-1830; equations (6) and (7), *Appendix III*). This method is more convenient than the earlier approach of Bauer and Budde¹⁰ who used Newton's method since derivatives of these functions are not required. Expressions for the relevant probability generating functions (sums) are given by equations (3), (5), (8), and (9), *Appendix III*. The program also calculates other probability generating functions used to calculate sol fractions and the two crosslink densities (lines 1860-2160; equations (2), (4), (5), and (9), *Appendix IV*). Finally the sol fraction and crosslink densities are calculated and printed out (using lines 2180-2280; equations (2), (3), and (8), *Appendix IV*). The program then asks for a new percent reaction. To quit, enter a percent reaction of 0.

If coating performance simply correlated with the amount of chemical reaction, these calculations would not be necessary. Unfortunately, the extent of chemical

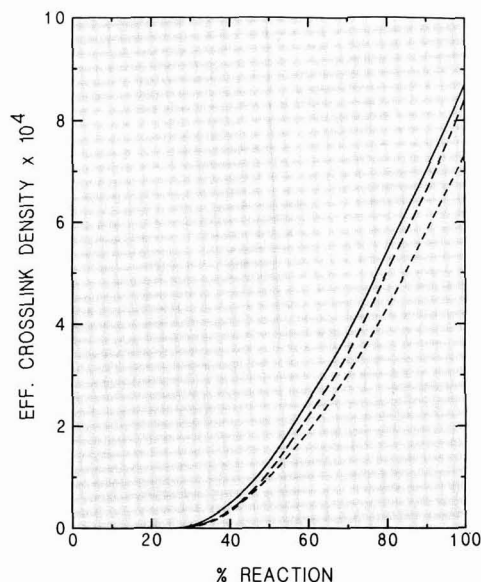


Figure 6—Weighted concentration of effective strands vs extent of reaction for a most probable polymer (30% hydroxyethylacrylate) crosslinked with 30% by weight biuret triisocyanate with and without diluents (concentration = 10%). The (—) indicates no diluent; the (---) indicates a monofunctional diluent (weight = 300); and the (- - -) indicate a difunctional diluent (weight = 600)

reaction by itself does not give good correlation with coating performance. It is necessary in high solids coatings to have a much higher level of chemical links formed to achieve the same state of cure as in low solids coatings. The reason for this can be seen in *Figure 3* where the number of chemical crosslinks formed is compared with an effective crosslink density (the weighted concentration of effective strands) for simple condensation of a three functional and of a nine functional species. The lower the functionality, the smaller the ratio of effective crosslinks to chemical bonds consistent with the observation that high solids (low functional) coatings require higher levels of chemical bond formation to achieve the same effective crosslink density. It is also important to note that the bulk of the formation of effective crosslinks in the low functional material occurs in the last stages of reaction, and that small changes in reaction extent cause proportionally larger effects on the effective crosslink density.

Probably the most important application of the network structure programs is to determine the effect of various formulation changes on effective crosslink density. For example, the effect of molecular weight (*Figure 4*), polydispersity (*Figure 5*), and diluent (*Figure 6*) can all be investigated rapidly. Similar variations in crosslinker structure or cure kinetics can be studied. A key conclusion of these and earlier studies is that relatively small changes in formulation can have large effects on the

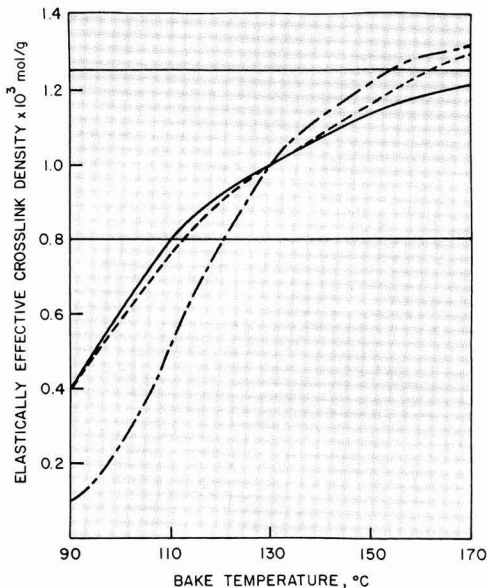


Figure 7—Elastically effective crosslink density vs bake temperature for a high solids acrylic-urethane (—), a high solids acrylic-melamine (---), and a low solids acrylic-melamine (-.-). The horizontal lines indicate the range of acceptable effective crosslink density. Reprinted from reference (14)

effective crosslink density.¹⁰ In addition, small changes in effective crosslink density can have large effects on coating performance (e.g., less than a 5% change in crosslink density can cause intercoat adhesion failure).¹¹

Although the network programs will never replace physical testing of formulations, they allow the formulator to more closely zero in on promising approaches and to avoid poor ones. They may also aid in determining how to reformulate in the face of changes in raw materials and to determine quality requirements on incoming materials.

A final key concept in network modeling is that of the cure window.¹¹ It has been shown that there exists a range of network structure which provides acceptable properties. This can be translated into a bake window using the network models and kinetic models. This allows for the determination as to whether or not a given coating will be acceptably cured with given bake conditions.¹² For this approach to work, the network structure parameter that is calculated must correlate with the physical property being measured independent of changes in cure conditions. This can be a very powerful technique for comparing coatings and baking processes. For example, in Figure 7, the cure response of low and high solids melamine crosslinked coatings are compared with a high solids two component urethane coating.¹⁴ The urethane coating has a wider cure window due to differences in cure kinetics and a lower activation energy. These exam-

ples serve to illustrate only a few of the possible applications of network structure calculation.

CONCLUSION

In this paper, two simple BASIC programs for calculating pre-gel and post-gel properties of thermoset coatings have been presented. The programs are based on the work of Miller and Macosko. In the pre-gel case, the program calculates the increase in weight average molecular weight of the mixture. This can be used to study coating chemorheology and stability. The post-gel program calculates sol fractions and effective crosslink density. The effective crosslink density is used to predict state of cure in thermoset coatings. A wide variety of different kinds of coatings can be studied with these programs. The only significant limitation to the programs is that they assume only one crosslinking reaction occurs. In many practical cases, more than one crosslinking reaction occurs although usually there is one main reaction and one or more side reactions. Incorporation of multiple crosslinking reactions into the model is in progress.

References

- (1) Macosko, C.W. and Miller, D.R., *Macromolecules*, 9, 199 (1976).
- (2) Miller, D.R. and Macosko, C.W., *Macromolecules*, 9, 206 (1976).
- (3) Miller, D.R., Valles, E.M., and Macosko, C.W., *Polymer Eng. Sci.*, 19, 272 (1979).
- (4) Miller, D.R. and Macosko, C.W., *J. Polymer Sci.*, Polymer Phys., in press.
- (5) Miller, D.R. and Macosko, C.W., *J. Polymer Sci.*, Polymer Phys., in press.
- (6) Gordon, M., *Proc. Roy. Soc. (London)*, A268, 240 (1962).
- (7) Bauer, D.R. and Briggs, L.M., "Rheological Models for Predicting Flow in High Solids Coatings," *JOURNAL OF COATINGS TECHNOLOGY*, 56, No. 716, 87 (1984).
- (8) Otsubo, Y., Amari, T., Watanabe, K., and Nakamichi, T., *J. Rheol.*, 31, 251 (1987).
- (9) Meijer, E.W., *J. Polymer Sci.*, Polymer Chem., 24, 2199 (1986).
- (10) Bauer, D.R. and Budde, G.F., *Ind. Eng. Chem., Prod. Res. Develop.*, 20, 674 (1981).
- (11) Bauer, D.R. and Dickie, R.A., "Cure Response in Acrylic Copolymer/Melamine Formaldehyde Crosslinked Coatings," *JOURNAL OF COATINGS TECHNOLOGY*, 54, No. 685, 57 (1982).
- (12) Bauer, D.R. and Dickie, R.A., "Development and Application of Network Structure Models to Optimization of Bake Conditions for Thermoset Coatings," *JOURNAL OF COATINGS TECHNOLOGY*, 58, No. 738, 41 (1986).
- (13) Hill, L.W. and Kozlowski, K., "Crosslink Density of High Solids MF-Cured Coatings," *JOURNAL OF COATINGS TECHNOLOGY*, 59, No. 751, 63 (1987).
- (14) Bauer, D.R., Dickie, R.A., and Koenig, J.L., *Ing. Eng. Chem., Prod. Res. Develop.*, 25, 289 (1986).

APPENDIX I: Derivation of Pre-Gel Equations

The Miller-Macosko pre-gel model calculates the weight average molecular weight of a crosslinking mixture by calculating various expected weights attached to

APPENDIX I (Continued)

the different functional groups. These calculations require the number, site, and mass expectation values of the functionality and weight of the starting components. For a mixture of oligomeric species, these expectation values can be expressed in terms of the mole fraction (X), functionality (F), and molecular weight (M) of each component:

$$\begin{aligned} E_n(F) &= \sum X_i F_i & E_s(M) &= \sum X_i F_i M_i / E_n(F) \\ E_n(M) &= \sum X_i M_i & E_m(F) &= \sum X_i F_i M_i / E_n(M) \\ E_s(F) &= \sum X_i F_i^2 / E_n(F) & E_m(M) &= \sum X_i M_i^2 / E_n(M) \end{aligned} \quad (1)$$

If the weight fraction (W) is specified rather than the mole fraction, the mole fraction of each component can be determined by the following:

$$X_i = (W_i/M_i) / \sum (W_i/M_i) \quad (2)$$

For a random copolymer, the expectation values are as follows:

$$\begin{aligned} E_n(F) &= p M_n/m & E_s(M) &= E_m(M) = M_w \\ E_n(M) &= M_n & E_m(F) &= p M_w/m \\ E_s(F) &= p M_w/m + (1-p) \end{aligned} \quad (3)$$

where m is the monomer weight and p the fraction of reactive groups. If α is the extent of reaction of A groups, then $r\alpha$ is the extent of reaction of B groups where r is given by:

$$r = \frac{E_n(F_A)/E_n(M_A)}{E_n(F_B)/E_n(M_B)} \cdot \frac{w_A}{w_B} \quad (4)$$

The Miller-Macosko model calculates the expectation value of the weight looking out from a given functional group, $E(W_A^{\text{out}})$. For the A group, this is just the expectation value of the weight looking in to B provided that A

has reacted:

$$E(W_A^{\text{out}}) = \alpha E_s(W_B^{\text{in}}) \quad (5)$$

The site expectation value is required since sites are chosen at random. This site expectation value is given by the sum of the site expectation value for the mass of the crosslinker and the expectation values for the weights looking out on all the other B arms:

$$E_s(W_B^{\text{in}}) = E_s(M_B) + (E_s(F_B) - 1)E(W_B^{\text{out}}) \quad (6)$$

Similar expressions can be written for $E(W_B^{\text{out}})$ and $E_s(W_A^{\text{in}})$:

$$\begin{aligned} E(W_B^{\text{out}}) &= r\alpha E_s(W_A^{\text{in}}) \\ E_s(W_A^{\text{in}}) &= E_s(M_B) + (E_s(F_A) - 1)E(W_A^{\text{out}}) \end{aligned} \quad (7)$$

The above equations can be solved for $E(W_A^{\text{out}})$ and $E(W_B^{\text{out}})$. The weight average molecular weight is given by:

$$M_w = w_A E_m(W_A) + w_B E_m(W_B) \quad (8)$$

where,

$$\begin{aligned} E_m(W_A) &= E_m(M_A) + E_m(F_A)E(W_A^{\text{out}}) \\ E_m(W_B) &= E_m(M_B) + E_m(F_B)E(W_B^{\text{out}}) \end{aligned} \quad (9)$$

yielding the following expression for M_w :

$$\begin{aligned} M_w &= w_A E_m(M_A) + E_m(F_A) \frac{\alpha E_s(M_B) + r\alpha^2 E_s(M_A)(E_s(F_B) - 1)}{1 - r\alpha^2(E_s(F_A) - 1)(E_s(F_B) - 1)} \\ &+ w_B E_m(M_B) + E_m(F_B) \frac{r\alpha E_s(M_A) + r\alpha^2 E_s(M_B)(E_s(F_A) - 1)}{1 - r\alpha^2(E_s(F_A) - 1)(E_s(F_B) - 1)} \end{aligned} \quad (10)$$

The gel point is given by:

$$\alpha_{\text{gel}} = r(E_s(F_B) - 1)(E_s(F_A) - 1)^{-1/2} \quad (11)$$

APPENDIX II:
Pre-Gel Program

```

10 PRINT "THIS PROGRAM CALCULATES THE WEIGHT AVERAGE MOLECULAR WEIGHT"
20 PRINT "OF A CROSSLINKING MIXTURE BELOW THE GEL POINT. THE MIXTURE"
30 PRINT "CONSISTS OF A POLYMER WITH 'A' FUNCTIONAL GROUPS AND A CROSSLINKER"
40 PRINT "WITH 'B' FUNCTIONAL GROUPS. A GROUPS REACT ONLY WITH B GROUPS."
50 PRINT
60 PRINT
70 PRINT
80 DIM X (20), F (20), M (20), W(20)
90 INPUT "THE SOLIDS WEIGHT FRACTION OF THE 'A' FUNCTIONAL POLYMER =";WA
100 PRINT
110 PRINT
120 WB = 1! - WA
130 PRINT "INPUT POLYMER TYPE."
140 PRINT "THIS COMPONENT CAN EITHER BE A MIXTURE OF OLIGOMERS WITH UP"
150 PRINT "TO 20 SEPARATE SPECIES OR IT CAN BE A RANDOM COPOLYMER WITH"
160 PRINT "KNOWN VALUES OF MW AND MN. A DILUENT CAN ALSO BE INCLUDED."
170 PRINT
180 PRINT
190 INPUT "TYPE 0 IF OLIGOMERIC, 1 IF RANDOM COPOLYMER ";N%
200 PRINT
210 PRINT
220 IF N% GOTO 690

```

```
230 ENF = 0! : ENM = 0! : ESF = 0! : EX = 0!
240 EMF = 0! : ESM = 0! : EMM = 0!
250 INPUT "THE NUMBER OF OLIGOMERIC SPECIES IS"; NN%
260 PRINT
270 PRINT
280 PRINT "THE AMOUNT OF EACH OLIGOMERIC SPECIES MUST BE EXPRESSED IN"
290 PRINT "EITHER MOLE OR WEIGHT FRACTIONS."
300 PRINT
310 INPUT "TYPE 0 IF WEIGHT FRACTION, 1 IF MOLE FRACTION  ", NF%
320 PRINT
330 PRINT
340 IF NF% GOTO 490
350 PRINT "INPUT THE WEIGHT FRACTION, FUNCTIONALITY, AND MOLECULAR"
360 PRINT "WEIGHT OF EACH SPECIES. THE SUM OF THE WEIGHT FRACTIONS"
370 PRINT "MUST EQUAL 1.0."
380 PRINT
390 PRINT
400 FOR I = 1 TO NN%
410 INPUT "WEIGHT FRAC., FUNCT., AND MOLE WT. ="; W(I), F(I), M(I)
420 X(I) = W(I)/M(I)
430 EX = EX + X(I)
440 NEXT I
450 FOR I = 1 TO NN%
460 X(I) = X(I)/EX
470 NEXT I
480 GOTO 540
490 PRINT "INPUT THE MOLE FRACTION, FUNCTIONALITY, AND MOLECULAR"
500 PRINT "WEIGHT OF EACH SPECIES. THE SUM OF THE MOLE FRACTIONS"
510 PRINT "MUST EQUAL 1.0."
520 PRINT
530 PRINT
540 FOR I = 1 TO NN%
550 IF NF%-1 GOTO 570
560 INPUT "MOLE FRAC., FUNCT., AND MOLE WT.="; X(I), F(I), M(I)
570 ENF = ENF + (X(I) * F(I))
580 ENM = ENM + (X(I) * M(I))
590 ESF = ESF + (X(I) * (F(I)^2))
600 ESM = ESM + (X(I) * F(I) * M(I))
610 EMM = EMM + (X(I) * (M(I)^2))
620 NEXT I
630 EMF = ESM
640 ESF = ESF/ENF
650 ESM = ESM/ENF
660 EMF = EMF/ENM
670 EMM = EMM/ENM
680 GOTO 960
690 PRINT "INPUT THE WEIGHT FRACTION AND MONOMER WEIGHT OF THE"
700 PRINT "REACTIVE MONOMER IN THE COPOLYMER."
710 PRINT
720 PRINT
730 INPUT "FRAC. REACT. AND MON. WT. ="; P, MON
740 PRINT
750 PRINT
760 PRINT "INPUT THE NUMBER AND WEIGHT AVERAGE MOLECULAR WEIGHT."
770 PRINT
780 PRINT
790 INPUT "MN AND MW ="; MN, MW
800 PRINT
810 PRINT
820 INPUT "THE WEIGHT FRACTION OF DILUENT = "; WD
830 IF WD>.0001 THEN PRINT
840 IF WD>.0001 THEN INPUT "THE FUNCTIONALITY AND MOLE WT. OF DILUENT ="; FD, MD
850 IF WD<.0001 THEN FD=1!
860 IF WD<.0001 THEN MD=1!
```

```

870 FF = (1!-WD)/MN + WD/MD
880 XD = WD/(MD*FF)
890 ENM = MN*(1!-XD) + MD*XD
900 EMM = MW*(1!-WD) + MD*WD
910 ENF = (1!-XD)*P*MN/MON +XD*FD
920 EMF = (1!-WD)*P*MW/MON +WD*FD
930 SD = XD*FD/ENF
940 ESF = (1!-SD)*(P*MW/MON+1!-P) + SD*FD
950 ESM = (1!-SD)*MW + SD*MD
960 IF AORB% GOTO 1040
970 AENF = ENF : AESF = ESF : AEMF = EMF
980 AENM = ENM : AESM = ESM : AEMM = EMM
990 AORB% = 1
1000 PRINT
1010 PRINT
1020 PRINT "INPUT CROSSLINKER TYPE"
1030 GOTO 140
1040 BENF = ENF : BESF = ESF : BEMF = EMF
1050 BENM = ENM : BESM = ESM : BEMM = EMM
1060 R = (AENF * WA * BENM)/(BENF * WB * AENM)
1070 GEL = R * (AESF - 1!) * (BESF - 1!)
1080 GELS = 100!/SQR(GEL)
1090 PRINT
1100 PRINT
1110 PRINT "THE WEIGHT FRACTION OF POLYMER IN THE MIXTURE = ";WA
1120 PRINT
1130 PRINT "THE EXPECTATION VALUES FOR POLYMER FUNCTIONALITY ARE:"
1140 PRINT "NUM. = "; AENF, "SITE = "; AESF, "MASS = "; AEMF
1150 PRINT
1160 PRINT "THE EXPECTATION VALUES FOR POLYMER WEIGHT ARE:"
1170 PRINT "NUM. = "; AENM, "SITE = "; AESM, "MASS = "; AEMM
1180 PRINT
1190 PRINT
1200 PRINT "THE WEIGHT FRACTION OF CROSSLINKER IN THE MIXTURE = ";WB
1210 PRINT
1220 PRINT "THE EXPECTATION VALUES FOR CROSSLINKER FUNCTIONALITY ARE:"
1230 PRINT "NUM. = "; BENF, "SITE = "; BESF, "MASS = "; BEMF
1240 PRINT
1250 PRINT "THE EXPECTATION VALUES FOR CROSSLINKER WEIGHT ARE:"
1260 PRINT "NUM. = "; BENM, "SITE = "; BESM, "MASS = "; BEMM
1270 PRINT
1280 RR = 1!/R
1290 PRINT "THE RATIO OF CROSSLINKER TO POLYMER FUNCTIONALITY = "; RR
1300 PRINT
1310 PRINT "THE % REACTION OF 'A' GROUPS AT THE GEL POINT = ";GELS
1320 PRINT
1330 PRINT
1340 INPUT "THE PERCENT REACTION OF 'A' GROUPS = "; XRA
1350 IF XRA>100! THEN END
1360 XRA = XRA/100!
1370 PRINT
1380 PRINT
1390 PRINT
1400 DENOM = 1! - XRA^2*GEL
1410 IF DENOM<0! THEN PRINT "MIXTURE HAS GELLED!"
1420 IF DENOM<0! THEN GOTO 1320
1430 TOPA = XRA *BESM + R*XRA^2*AESM*(BESF-1!)
1440 TOPB = R*XRA*AESM + R*XRA^2*(AESF-1!)*BESM
1450 MWA = WA*(AEMM +(AEMF*TOPA/DENOM))
1460 MWB = WB*(BEMM +(BEMF*TOPB/DENOM))
1470 MWW = MWA + MWB
1480 PRINT "THE WEIGHT AVERAGE MOLECULAR WEIGHT OF THE MIXTURE = "; MWW
1490 PRINT
1500 GOTO 1320

```

APPENDIX III: Post-Gel Equations

The post-gel Miller-Macosko model determines network properties by first calculating the probability that looking out from an A group is a finite chain, $P(F_A^{out})$. This probability is equal to the probability that A has not reacted $(1-\alpha)$ plus the probability that it has reacted times the probability that looking into a B group is finite:

$$P(F_A^{out}) = 1 - \alpha + \alpha P_s(F_B^{in}) \quad (1)$$

The probability that looking into B is finite is the sum over all possible functionalities of the crosslinker (weighted by the site probability distribution function) of the probability that looking out from B is finite raised to the $g-1$ power (g being the functionality):

$$P_s(F_B^{in}) = \sum_{g=1}^{\infty} P_s(F_B=g) P(F_B^{out})^{(g-1)} = \tau_{F-1,s}(P(F_B^{out})) \quad (2)$$

The site probability distribution function is required since sites are chosen at random. The term τ defines a probability generating function. The site and mass distribution functions are related to the number distribution function (determined from the input mole fraction) by the following:

$$\begin{aligned} P_s(F=g) &= g P_n(F=g)/E_n(F) \\ P_m(F=g) &= M_g P_n(F=g)/E_n(M) \end{aligned} \quad (3)$$

Similar expressions can be written for $P(F_B^{out})$ and $P_s(F_A^{in})$:

$$P(F_B^{out}) = 1 - r\alpha + r\alpha P_s(F_A^{in}) \quad (4)$$

$$P_s(F_A^{in}) = \sum_{f=1}^{\infty} P_s(F_A=f) P(F_A^{out})^{(f-1)} = \phi_{F-1,s}(P(F_A^{out})) \quad (5)$$

These expressions can be simplified to:

$$P(F_B^{out}) = 1 - \alpha + \alpha \tau_{F-1,s}(P(F_B^{out})) \quad (6)$$

$$P(F_B^{out}) = 1 - r\alpha + r\alpha \phi_{F-1,s}(P(F_A^{out})) \quad (7)$$

Equation (7) can be inserted into (6) and the resulting expression solved numerically. For oligomers, the probability generating functions are defined by the appropriate sums. For random copolymers analytical expressions for ϕ can be written for most probable and monodisperse polymers:

Monodisperse copolymers:

$$\phi_{F-1,s}(x) = (1 - p + px)^{L-1} \quad (8)$$

Most probable copolymers:

$$\phi_{F-1,s}(x) = q^2 / (1 - (1-q)(1 - p + px))^2 \quad (9)$$

where L is the monodisperse chain length and $q = m/M_n$. If a diluent is present, the expressions are modified using equation (3). These analytical expressions greatly simplify the calculations required when a random copolymer is employed.¹⁰

APPENDIX IV: Crosslink Density Calculations

A given polymer or crosslinker will be part of the sol only if all of its groups are attached to finite chains. The weight of the sol is given by:

$$\begin{aligned} w_s &= w_A \sum_{f=0}^{\infty} P_m(F_A=f) P(F_A^{out})^f + w_B \sum_{g=0}^{\infty} P_m(F_B=g) P(F_B^{out})^g \\ &= w_A \phi_{F,m}(P(F_A^{out})) + w_B \tau_{F,m}(P(F_B^{out})) \end{aligned} \quad (1)$$

The probability generating function for random copolymer is given by:

Monodisperse:

$$\phi_{F,m}(x) = (1 - p + px)^L \quad (2)$$

Most probable distribution:

$$\phi_{F,m}(x) = (1 - p + px) \phi_{F-1,s}(x)$$

As previously noted, several different "effective" crosslink densities can be calculated. The elastically effective crosslink density of Bauer and Budde is in fact a calculation of the number of functional groups that are attached to the infinite network and for which there are at least two other paths to the network on the given polymer or crosslinker. This essentially attempts to correct the crosslink density for dangling ends (one bond to the infinite network) and chain extension (two bonds to the infinite network). Based on this definition, the following expression can be written for the elastically effective crosslink density:

$$\begin{aligned} C_{el} &= \frac{w_A E_n(F_A)}{2 E_n(W_A)} \{ (1 - P(F_A^{out})) [1 - \phi_{F-1,s}(P(F_A^{out}))] - (1 - P(F_A^{out})) (\phi'_{F-1,s}(P(F_A^{out}))) \} \\ &+ \frac{w_B E_n(F_B)}{2 E_n(W_B)} \{ (1 - P(F_B^{out})) [1 - \tau_{F-1,s}(P(F_B^{out}))] - (1 - P(F_B^{out})) (\tau'_{F-1,s}(P(F_B^{out}))) \} \end{aligned} \quad (3)$$

The functions τ' and ϕ' are first derivatives of the probability generating functions τ and ϕ :

$$\tau'_{F-1,s}(x) = \sum_{g=1}^{\infty} P_s(F_B=g) (g-1) x^{g-2} \quad (4)$$

ϕ' is defined in an analogous manner for oligomers; for random copolymers, ϕ' can be given by:

Monodisperse copolymers:

$$\phi'_{F-1,s}(x) = p(L-1)(1-p-px)^{L-2} \quad (5)$$

Most probable polymer:

$$\phi'_{F-1,s}(x) = q^2(1-q)p / \{1 - (1-q)(1-p+px)\}^3$$

Another "effective" crosslink density that can be defined is the weighted concentration of effective strands. This quantity is related to the rubbery modulus at low crosslink density. This quantity can be defined as follows:

$$\begin{aligned} \text{Link} &= \frac{w_A}{E_n(W_A)} \sum_{f=3}^{\infty} \sum_{m=3}^f \frac{m-2}{2} P(X_{f,m}) P_n(F_A=f) \\ &+ \frac{w_B}{E_n(W_B)} \sum_{g=3}^{\infty} \sum_{m=3}^g \frac{m-2}{2} P(X_{g,m}) P_n(F_B=g) \end{aligned} \quad (6)$$

APPENDIX IV (Continued)

where,

$$P(X_{f,m}) = \binom{f}{m} P(F_A^{\text{out}})^{f-m} (1 - P(F_A^{\text{out}}))^m \quad (7)$$

$$P(X_{g,m}) = \binom{f}{m} P(F_B^{\text{out}})^{g-m} (1 - P(F_B^{\text{out}}))^m$$

This calculation treats every polymer and crosslinker molecule as a crosslinking junction with 'm' paths to the infinite network. The m-2/2 term provides the proper weighting function. Number probability distribution functions are required since chains are chosen at random. The sums can be simplified to the following expression:

$$\text{Link} = \frac{w_A}{2 E_d(W_A)} \{E_d(F_A) (1 - P(F_A^{\text{out}})) + 2\phi_{1,d}(P(F_A^{\text{out}})) + (1 - P(F_A^{\text{out}}))\phi'_{1,d}(P(F_A^{\text{out}})) - 2\} \\ + \frac{w_B}{2 E_d(W_B)} \{E_d(F_B) (1 - P(F_B^{\text{out}})) + 2\tau_{1,d}(P(F_B^{\text{out}})) + (1 - P(F_B^{\text{out}}))\tau'_{1,d}(P(F_B^{\text{out}})) - 2\} \quad (8)$$

The probability generating functions in equation (8) are defined in an identical manner to those used in equation (2), Appendix III, and equation (4), Appendix IV, except that the number probability distribution (P_n ($F = f$)) is used rather than the site probability distribution in the appropriate sums. For random copolymers the probability generating functions are as follows:

Monodisperse copolymers:

$$\phi_{F,n}(x) = (1 - p + px)^l \phi_{F,n}^*(x) = pL (1 - p + px)^{l-1}$$

Most probable copolymers:

$$\phi_{F,n}(x) = q(1 - p + px)/(1 - (1 - q)(1 - p + px)) \\ \phi_{F,n}^*(x) = qp/(1 - (1 - q)(1 - p + px))^2 \quad (9)$$

The above expressions are used in the post-gel program to calculate sol fractions and crosslink densities.

APPENDIX V:
Post-Gel Program

```

10 DIM AX(20), AF(20), AM(20), AXF(20), AXM(20)
20 DIM BX(20), BF(20), BM(20), BXF(20), BXM(20)
30 PRINT "THIS PROGRAM CALCULATES THE CROSSLINK DENSITY AND THE SOL FRACTION"
40 PRINT "OF A CROSSLINKING MIXTURE PAST THE GEL POINT USING THE MILLER-"
50 PRINT "MACOSKO FORMALISM. THE MIXTURE CONSISTS OF A POLYMER WITH 'A'"
60 PRINT "FUNCTIONAL GROUPS AND A CROSSLINKER WITH 'B' FUNCTIONAL GROUPS."
70 PRINT "THE 'A' GROUPS REACT ONLY WITH 'B' GROUPS."
80 PRINT
90 PRINT "CROSSLINK DENSITIES ARE CALCULATED IN TWO WAYS. THE FIRST USES"
100 PRINT "THE OLD ELASTICALLY EFFECTIVE CROSSLINK DENSITY EXPRESSION OF BAUER"
110 PRINT "AND BUDDE. THE SECOND CALCULATES A CROSSLINK DENSITY WHICH IN"
120 PRINT "THEORY SHOULD BE PROPORTIONAL TO THE RUBBERY ELASTIC MODULUS."
130 PRINT "THIS CROSSLINK DENSITY IS CALLED THE WEIGHTED CONCENTRATION OF"
140 PRINT "EFFECTIVE STRANDS."
150 PRINT
160 PRINT
170 INPUT "THE SOLIDS WEIGHT FRACTION OF THE 'A' FUNCTIONAL POLYMER = "; WA
180 PRINT
190 PRINT
200 WB = 1! - WA
210 PRINT "INPUT 'A' FUNCTIONAL POLYMER TYPE. THE 'A' FUNCTIONAL POLYMER"
220 PRINT "CAN BE ONE OF THREE TYPES: 1) A MIXTURE OF OLIGOMERS WITH UP TO 20"
230 PRINT "SEPARATE SPECIES; 2) A RANDOM COPOLYMER WITH A MOST PROBABLE"
240 PRINT "WEIGHT DISTRIBUTION; 3) A RANDOM COPOLYMER WITH A MONODISPERSE"
250 PRINT "WEIGHT DISTRIBUTION. A REACTIVE DILUENT MAY ALSO BE INCLUDED."
260 PRINT
270 PRINT
280 INPUT "TYPE 0 IF OLIGOMER; 1 IF MOST PROB. COPOLY.; 2 IF MONODISP."; NN%
290 PRINT
300 PRINT
310 IF NN% GOTO 760
320 INPUT "THE NUMBER OF 'A' FUNCTIONAL OLIGOMERIC SPECIES = "; AN%
330 PRINT
340 PRINT
350 PRINT "THE AMOUNT OF EACH OLIGOMERIC SPECIES MUST BE EXPRESSED IN"
360 PRINT "EITHER MOLE OR WEIGHT FRACTIONS."
370 PRINT
380 INPUT "TYPE 0 IF WEIGHT FRACTION, 1 IF MOLE FRACTION "; NF%
390 PRINT
400 PRINT
410 AEX = 0!
420 IF NF% GOTO 570

```

```
430 PRINT "INPUT THE WEIGHT FRACTION, FUNCTIONALITY, AND MOLECULAR"
440 PRINT "WEIGHT OF EACH SPECIES. THE SUM OF THE WEIGHT FRACTIONS"
450 PRINT "MUST EQUAL 1.0."
460 PRINT
470 PRINT
480 FOR I = 1 TO AN%
490 INPUT "WEIGHT FRAC., FUNCT., AND MOLE WT. ="; AXM(I), AF(I), AM(I)
500 AX(I) = AXM(I)/AM(I)
510 AEX = AEX + AX(I)
520 NEXT I
530 FOR I = 1 TO AN%
540 AX(I) = AX(I)/AEX
550 NEXT I
560 GOTO 620
570 PRINT "INPUT THE MOLE FRACTION, FUNCTIONALITY, AND MOLECULAR"
580 PRINT "WEIGHT OF EACH SPECIES. THE SUM OF THE MOLE FRACTIONS"
590 PRINT "MUST EQUAL 1.0."
600 PRINT
610 PRINT
620 ANF = 0! : ANM = 0! : ASF = 0!
630 FOR I = 1 TO AN%
640 IF NBF%-1 GOTO 660
650 INPUT "MOLE FRAC., FUNCT., MOLE. WT. ="; AX(I), AF(I), AM(I)
660 ANF = ANF + AX(I)*AF(I)
670 ANM = ANM + AX(I)*AM(I)
680 ASF = ASF + AX(I)*AF(I)*AF(I)
690 NEXT I
700 ASF = ASF/ANF
710 FOR I = 1 TO AN%
720 AXF(I) = AX(I)*AF(I)/ANF
730 AXM(I) = AX(I)*AM(I)/ANM
740 NEXT I
750 GOTO 960
760 INPUT "THE NUMBER AVERAGE MOLECULAR WEIGHT OF THE COPOLYMER = "; ANM
770 PRINT
780 INPUT "THE MOLECULAR WEIGHT OF A REACTIVE MONOMER UNIT = "; MON
790 PRINT
800 Q = MON/ANM
810 INPUT "THE WEIGHT FRACTION OF REACTIVE MONOMER = "; P
820 ANF = P/Q
830 IF NN%-1 THEN ASF = 1! + P*(1!/Q-1!) ELSE ASF = 1! + 2!*P*(1!/Q-1!)
840 PRINT
850 PRINT
860 INPUT "THE WEIGHT FRACTION OF DILUENT = "; WD
870 IF WD>.0001 THEN PRINT
880 IF WD>.0001 THEN INPUT "THE FUNCTIONALITY AND MOLE WT. OF DILUENT = "; FD, MD
890 IF WD<.0001 THEN FD = 1! : MD = 1!
900 FF = (1!-WD)/ANM + WD/MD
910 XD = WD/(MD*FF)
920 ANM = ANM*(1!-XD) + MD*XD
930 ANF = ANF*(1!-XD) + FD*XD
940 SD = FD*XD/ANF
950 ASF = ASF*(1!-SD) + SD*FD
960 PRINT
970 PRINT
980 INPUT "THE NUMBER OF OLIGOMERIC CROSSLINKER SPECIES = "; BN%
990 PRINT
1000 PRINT
1010 PRINT "THE AMOUNT OF EACH OLIGOMERIC SPECIES MUST BE EXPRESSED IN"
1020 PRINT "EITHER MOLE OR WEIGHT FRACTIONS."
1030 PRINT
1040 INPUT "TYPE 0 IF WEIGHT FRACTION, 1 IF MOLE FRACTION ", NBF%
1050 PRINT
1060 PRINT
```

```

1070 IF NBF% GOTO 1230
1080 PRINT "INPUT THE WEIGHT FRACTION, FUNCTIONALITY, AND MOLECULAR"
1090 PRINT "WEIGHT OF EACH SPECIES. THE SUM OF THE WEIGHT FRACTIONS"
1100 PRINT "MUST EQUAL 1.0."
1110 BEX = 0!
1120 PRINT
1130 PRINT
1140 FOR I = 1 TO BN%
1150 INPUT "WEIGHT FRAC., FUNCT., AND MOLE WT. = "; BXM(I), BF(I), BM(I)
1160 BX(I) = BXM(I)/BM(I)
1170 BEX = BEX + BX(I)
1180 NEXT I
1190 FOR I = 1 TO BN%
1200 BX(I) = BX(I)/BEX
1210 NEXT I
1220 GOTO 1270
1230 PRINT "INPUT THE MOLE FRACTION, FUNCTIONALITY, AND MOLECULAR"
1240 PRINT "WEIGHT OF EACH SPECIES. THE SUM OF THE MOLE FRACTIONS"
1250 PRINT "MUST EQUAL 1.0."
1260 PRINT
1270 BNF = 0! : BNM = 0! : BSF = 0!
1280 PRINT
1290 FOR I = 1 TO BN%
1300 IF NBF%-1 GOTO 1320
1310 INPUT "MOLE FRAC., FUNCT., MOLE WT. = "; BX(I), BF(I), BM(I)
1320 BNF = ENF + BX(I)*BF(I)
1330 BNM = ENM + EX(I)*BM(I)
1340 BSF = BSF + BX(I)*BF(I)*BF(I)
1350 NEXT I
1360 BSF = BSF/BNF
1370 FOR I = 1 TO BN%
1380 EXF(I) = EX(I)*BF(I)/BNF
1390 EXM(I) = EX(I)*BM(I)/BNM
1400 NEXT I
1410 PRINT
1420 PRINT
1430 R = (ANF*WA*BNM)/(BNF*WB*ANM)
1440 RR = 1!/R
1450 GELO = R*(ASF-1!)*(BSF-1!)
1460 GELO = 100!/SQR(GELO)
1470 PRINT "THE RATIO OF CROSSLINKER TO POLYMER FUNCTIONALITY = ";RR
1480 PRINT
1490 PRINT "THE % REACTION OF 'A' GROUPS AT THE GEL POINT = ";GELO
1500 PRINT
1510 PRINT
1520 INPUT "THE % REACTION OF 'A' GROUPS = ";XRA
1530 XRA = XRA/100!
1540 XRR = XRA*R
1550 IF XRA < .001 THEN END
1560 PRINT
1570 IF XRR > 1! GOTO 1590
1580 GOTO 1630
1590 PRINT "THE CONVERSION OF B GROUPS IS GREATER THAN 100%, TRY AGAIN!"
1600 PRINT
1610 PRINT
1620 GOTO 1500
1630 PFBOUT = .5 : DELTA = .5
1640 FOR I = 1 TO 20
1650 DELTA = DELTA/2!
1660 PSI = 0!
1670 FOR J = 1 TO BN%
1680 PSI = PSI + BXF(J)*PFBOUT^(BF(J)-1!)
1690 NEXT J
1700 PFAOUT = 1!-XRA+XRA*PSI
1710 IF NN% GOTO 1770

```

```

1720 PHI = 0!
1730 FOR J = 1 TO AN%
1740 PHI = PHI + AXF(J)*PFAOUT^(AF(J)-1!)
1750 NEXT J
1760 GOTO 1800
1770 PZ = 1!-P+P*PFAOUT
1780 IF NN%-1 THEN PHI=PZ^(1!/Q-1!) ELSE PHI=Q^2/(1!-(1!-Q)*PZ)^2
1790 PHI = PHI*(1!-SD) + SD*PFAOUT^(FD-1!)
1800 H = 1!-XRR+XRR*PHI-PFBOUT
1810 PFBOUT = PFBOUT +DELTA*SGN(H)
1820 NEXT I
1830 PRINT "PFAOUT = "; PFAOUT, "PFBOUT = "; PFBOUT
1840 PRINT
1850 PRINT
1860 PSIM = 0! : PSIX = 0! : PSIXD = 0! : PSIFD = 0!
1870 FOR J = 1 TO BN%
1880 PSIM = PSIM + BXM(J)*PFBOUT^BF(J)
1890 PSIX = PSIX + BX(J)*PFBOUT^BF(J)
1900 PSIXD = PSIXD + BX(J)*BF(J)*PFBOUT^(BF(J)-1!)
1910 PSIFD = PSIFD + BXF(J)*(BF(J)-1!)*PFBOUT^(BF(J)-2!)
1920 NEXT J
1930 IF NN% GOTO 2020
1940 PHIM = 0! : PHIX = 0! : PHIXD = 0! : PHIFD = 0!
1950 FOR J = 1 TO AN%
1960 PHIM = PHIM + AXM(J)*PFAOUT^AF(J)
1970 PHIX = PHIX + AX(J)*PFAOUT^AF(J)
1980 PHIXD = PHIXD + AX(J)*AF(J)*PFAOUT^(AF(J)-1!)
1990 PHIFD = PHIFD + AXF(J)*(AF(J)-1!)*PFAOUT^(AF(J)-2!)
2000 NEXT J
2010 GOTO 2170
2020 FP = 1!-P+P*PFAOUT
2030 IF NN%-1 GOTO 2090
2040 PHIM = FP*Q^2/(1!-(1!-Q)*PP)^2
2050 PHIX = Q*PP/(1!-(1!-Q)*PP)
2060 PHIXD = Q*P/(1!-(1!-Q)*PP)
2070 PHIFD = Q^2*(1!-Q)*P/(1!-(1!-Q)*PP)^3
2080 GOTO 2130
2090 PHIM = PP^(1!/Q)
2100 PHIX = PHIM
2110 PHIXD = (P/Q) * PP^(1!/Q-1!)
2120 PHIFD = P*(1!/Q-1!)*PP^(1!/Q-2!)
2130 PHIM = PHIM*(1!-WD) + WD*PFAOUT^FD
2140 PHIX = PHIX*(1!-XD) + XD*PFAOUT^FD
2150 PHIXD = PHIXD*(1!-XD) + XD*FD*PFAOUT^(FD-1!)
2160 PHIFD = PHIFD*(1!-SD) + SD*(FD-1!)*PFAOUT^(FD-2!)
2170 WS = WA*PHIM + WB*PSIM
2180 CROSSA = ANF*(1!-PFAOUT) + 2!*PHIX + (1!-PFAOUT)*PHIXD - 2!
2190 CROSSA = CROSSA*WA/(2!*ANM)
2200 CROSSB = BNF*(1!-PFBOUT) + 2!*PSIX + (1!-PFBOUT)*PSIXD - 2!
2210 CROSSB = CROSSB*WB/(2!*ENM)
2220 LINK = CROSSA + CROSSB
2230 PRINT "THE WEIGHT FRACTION OF SOL = ";WS
2240 PRINT
2250 PRINT
2260 CELA = (1!-PFAOUT)*(1!-PHI-(1!-PFAOUT)*PHIFD)*WA*ANF/(2!*ANM)
2270 CELB = (1!-PFBOUT)*(1!-PSI-(1!-PFBOUT)*PSIFD)*WB*BNF/(2!*ENM)
2280 CEL = CELA+CELB
2290 PRINT "THE OLD ELASTICALLY EFFECTIVE CROSSLINK DENSITY =";CEL
2300 PRINT
2310 PRINT "THE WEIGHT CONCENTRATION OF EFFECTIVE STRANDS =";LINK
2320 PRINT
2330 PRINT
2340 GOTO 1500

```

Crowding and Spacing Of Titanium Dioxide Pigments

Juergen H. Braun
E.I. du Pont de Nemours & Co., Inc.*

Considerations of geometry and hiding power show that "spacing" of rutile particles can improve the hiding of nonporous paint films. The improvements are small, only a few percent, and limited to paints formulated at high pigment concentrations.

Commercial extenders are too large to improve hiding by spacing of rutile particles. Coatings on the rutile, however, can be thin enough to meet geometric requirements for hiding improvement and not affect paint rheology.

INTRODUCTION

In 1949, W.K. Asbeck and M. VanLoo explained paint performance in terms of film geometry.¹ Numerous investigators have elaborated on the subject.² The scientific approach to paint formulation based on packing considerations of pigment and extender particles is now widely accepted.

Extenders predate titanium dioxide pigments; early titanium dioxide grades contained extenders, generally calcium sulfate. Extended titanium dioxides became obsolete for lack of merit and incompatibility with water-based paints (calcium sulfate recrystallizes in water).

It has also been established that crowding of rutile[†] particles diminishes their scattering power^{3,4} and it has been suggested that nonscattering particles placed between the rutile particles can reduce hiding loss from crowding.

The literature on extension, crowding, and spacing is extensive, but much of it is empirical and involves investigations into multidimensional spaces: extender characteristics (composition, shape, size, size distribution, and surface), formulating parameters (PVC, additives), pigments, and resins. In this situation, the number of experiments required for unambiguous conclusions is enormous, and merit rarely can be proven with only a few experiments.^{5,6} Matters are further complicated because the experimental error of hiding measurements is large and expected benefits are small. Bierwagen proposed approaches to deal effectively with the multiplicity of formulating variables.^{2,7} Stieg reviewed white pigment technology and published semiempirical analyses of spacing, crowding, and dilution of the pigmentation.⁸ Recent publications and letters have elevated the subject of spacing and crowding to controversy.⁹⁻¹³ Theoretical analyses of the packing of spheres were conducted by D.G. Tsimboukis.¹⁴

Doubts about the merits of extenders caused us to examine the issues of rutile "spacing" theoretically and experimentally. We conclude that some hiding advantage may indeed accrue from spacing of rutile in nonporous paint films, but commercial extenders are too large for the geometric requirements of paint films. Coatings on rutile particles can deliver hiding advantage because they can be thin enough for the film geometry, but do not thicken the paint the way very small particles would.

GEOMETRIC CONSIDERATIONS

Particles that can space rutile uniformly in practical paint films to optimal hiding must be small—much smaller than the dispersed particle size of commercial extenders. The restrictions which apply include:

Presented at the 65th Annual Meeting of the Federation of Societies for Coatings Technology, in Dallas, TX, on October 6, 1987.

*Chemicals & Pigments Department, Jackson Laboratory, Wilmington, DE 19898.

†The opacifying pigment is referred to as "rutile" (R), but all considerations would apply to any opacifying pigment.

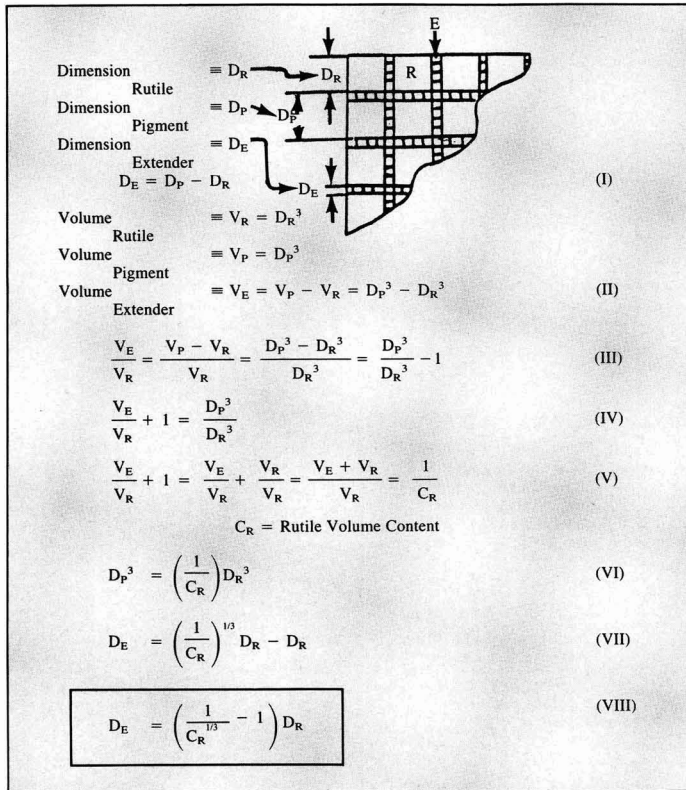


Figure 1—Optimal extender dimension. Relationship between extender size and pigment composition

(1) In a nonporous paint film, the combined volume concentrations of rutile and extenders cannot exceed the Critical Pigment Volume Concentration (CPVC).

(2) Up to the CPVC, a paint film is composed only of pigment, extender, and vehicle including a small volume fraction of additives; thus, the sum of the volumes of pigment, extender, and vehicle is constant and the sum of their volume fractions is one:

$$\text{Vol fraction(rutile)} + \text{Vol fraction(extender)} + \text{Vol fraction(vehicle)} = 1 \quad (1)$$

(3) The mean spacing between the rutile particles, and thus, the maximum extender size that can be used for uniform spacing, is dictated by volume fraction and size of rutile (Figure 1):

$$\text{Diameter(extender)} = \left[\left(\frac{1}{\text{Concentr. (rutile)}} \right)^{1/3} - 1 \right] \times \text{Diameter(rutile)} \quad (2)$$

Equation (2) was derived from theoretical, i.e., space filling packing, and for cubic geometry. Pigments cannot fill space to theoretical density and equation (2) becomes:

$$\text{Diameter(extender)} = \left[\left(\frac{A}{\text{Concentr. (rutile)}} \right)^{1/3} - 1 \right] \times \text{Diameter(rutile)} \quad (3)$$

where:

- A = 1 for identical cubes in perfect array;
- = 0.74* for identical spheres in densest packing;
- = 0.64 for identical spheres in natural packing; and
- < 0.6[†] for pigment particles in natural packing.

Because a cube root is involved, the effect of "A" on the spacing of pigment particles is secondary.

Equations (2) and (3) apply to any isometric shape because shape-specific terms cancel. Nonisometric geometry requires corrective terms only in the case of very thin plates or very long needles.

HIDING POWER CONSIDERATIONS

The effect of extender coatings on rutile was calculated as shown in Table 1 using experimental data³ from Figure 2. Results are plotted in Figures 3 and 4. Figure 3 shows results in terms of gains and losses vs the case of rutile

*A value of 0.74 is preferred by Steig¹⁵ in a similar calculation.

[†]The densest packings of rutile pigment we could attain were 59 vol% (87 wt%) in low and high density polyethylenes and 56 vol% (85 wt%) in acrylonitrile butadiene styrene. Dispersions had to be ground exhaustively in a Banbury mill.

Table 1 (Excerpt)—Scattering and Hiding Effects Of Extended Rutile

Pigment (PVC), %		Scattering Coefficient, Per $\mu\text{m TiO}_2$	Relative Hiding Power		
Rutile	"Extender"		III ^a	IV ^b	V ^c
1.00	0	2.22	2.22	o ^d	"100"
.95	.05	2.22	2.11	x ^e	95
.85	.15	2.22	1.89	x	85
.75	.25	2.22	1.67	x	75
10	0	2.16	21.6	o	"100"
9.5	.5	2.17	20.6	x	96
8.5	1.5	2.20	18.7	x	87
7.5	2.5	2.22	16.6	x	77
20	0	1.59	31.8	o	"100"
19	1	1.66	31.5	x	99
17	3	1.78	30.3	x	95
15	5	1.91	28.6	x	90
30	0	1.04	31.1	o	"100"
28.5	1.5	1.10	31.4	x	101
25.5	4.5	1.23	31.2	x	101
22.5	7.5	1.43	32.2	x	104
21	9	1.53	32.1	x	103
15	15	1.90	28.5	x	92
9	21	2.19	19.7	x	63
3	27	2.22	6.7	x	21
40	0	.72 ^f	28.8	o	"100"
38	2	.78 ^f	29.6 ^f	x	103 ^f
34	6	.90	30.6 ^f	x	106 ^f
30	5	1.04	31.2 ^f	x	108 ^f
28	12	1.13	31.6 ^f	x	110 ^f
20	20	1.59	31.8 ^f	x	110 ^f
12	28	2.06	24.7 ^f	x	86 ^f
4	36	2.22	8.9 ^f	x	31 ^f
50	0	.50 ^f	25.0	o	"100"
45	5	.65 ^f	28.4 ^f	x	113 ^f
40	10	.72 ^f	28.8 ^f	x	115 ^f
35	15	.86	30.1 ^f	x	120 ^f
25	25	1.26	31.4 ^f	x	126 ^f
15	35	1.92	28.7 ^f	x	115 ^f
5	45	2.22	11.1 ^f	x	44 ^f

(a) III = From Figure 2.
 (b) IV = 1 x III.
 (c) V = (IV_s + IV_e) x 100.
 (d) o ~ IV_o.
 (e) x ~ IV_x.
 (f) Extrapolation.

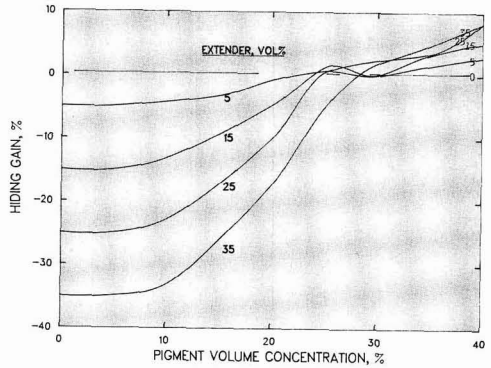


Figure 3—Hiding power effects of extension

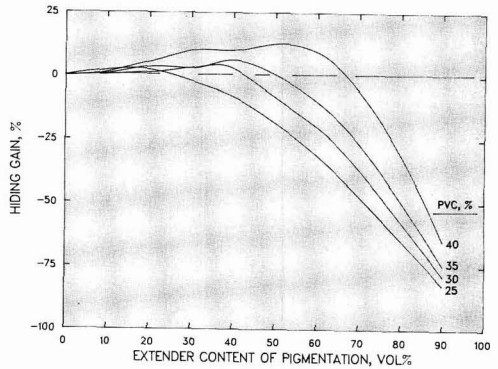


Figure 4—Hiding power effects of extension

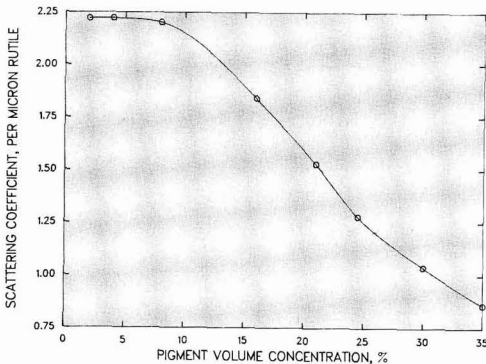


Figure 2—Scattering coefficient of rutile

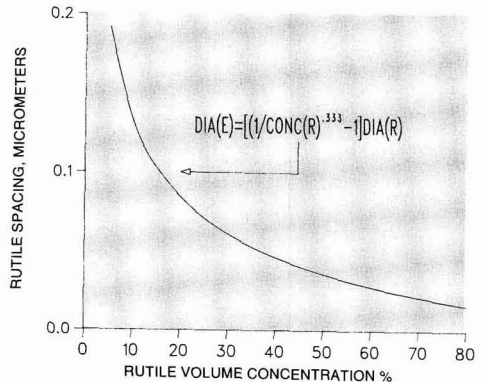


Figure 5—Rutile spacing and volume concentration

Table 2—Typical Extenders

Type	Size*, μm
CaCO ₃	
(Ground)	0.6
(Precipitated)	0.8
Clays	
(Ground)	0.1-0.3
(Calcined)	0.9-1.0
Talc	0.8
Silicas	
(Ground)	1.8
(Precipitated)	0.5
BaSO ₄	
(Ground)	12
(Precipitated)	0.3
Boehmite	
(Precipitated)	0.005
Mica	5 × 0.5

(a) Advertised equivalent spherical diameter (median by weight).

alone for a range of Pigment Volume Concentrations (PVC). The plot identified the PVC range in which extended pigment could offer advantages:

(1) At low PVC, the substitution of some of the rutile by extender causes hiding loss equal to the dilution of rutile;

(2) Between 10-20% PVC, crowding diminishes the effectiveness of rutile. Spacing of rutile particles counteracts the detrimental effects of dilution and increases hiding, but not enough to make up for the dilution loss; and

(3) Above 25% PVC, the hiding gain from spacing overcomes the loss from dilution; the combination of extender with rutile can hide better than an equal volume of rutile. The threshold of advantage shifts only slightly with changes in the extender/rutile composition.

The same data of hiding gain of extender/rutile combinations over rutile alone are replotted in *Figure 4*—this time vs composition of the extender/rutile combination rather than PVC. The plot shows that at practical PVC, hiding gain is best attained at extender/rutile combinations with 20-30 vol % extender. At PVC of 22-30%, pigmentation with combinations of 30 vol% extender and

70 vol% rutile could hide up to 10% better than rutile alone; higher pigment volume concentrations show somewhat higher extender contents.

Extender rutile combinations with more than 40 vol% extender would cause hiding loss at PVC below 30%.

IMPLICATIONS

Given the composition of the extender/pigment mix (about 30/70 volumes extender/rutile), the target PVC (about 25%), and the geometric formula [Equation (2)], we can calculate optimal spacings. Larger than optimal spacings do, of course, occur, but they cannot be uniform and must be compensated for by crowding elsewhere in the paint film.

Figure 5 shows the results in a graph of extender content vs spacing between rutile particles. For the best extender/rutile composition, uniform spacings between rutile particles could be no larger than 0.1 μm. Rutile could be spaced either by discrete extender particles or by coatings on the rutile. For particles, spacing equals particle size. Optimal extender size is much smaller than the particle size to which commercial extenders can be dispersed (*Table 2*).

Spacings that small are attained easier by coatings than by discrete particles. Because each pair of particles is spaced by two coatings, the appropriate coating thickness is one half of a corresponding particle size or spacing. Optimal coating thickness equivalent to particle size of 0.1 μm for 25% PVC would be 0.05 μm.

EXPERIMENTAL VERIFICATION

To verify the predictions, we used coated rutile pigments in an acrylic paint. The pigments were evaluated in a semigloss trade sales paint, modified to 28% rutile volume concentration and 34% PVC. These are concentrations higher than typical to accentuate effects.

R-960 and R-960-Experimental were coated with a dense coating of silica (*Table 3*). The coatings of R-960 were, however, slightly thinner than optimal for the PVC of the experiment. Results (*Table 3*) confirm the model. R-960-Experimental averaged 7% higher in hiding and tinting strength than R-902. R-960, intermediate in coating thickness between R-902 and R-960-Experimental, was intermediate in hiding power and tinting strength.

Table 3—Evaluation Results

Rohm and Haas Co. XW-64-2 (Modified) Semigloss Trade Sales Paint 34% PVC; 28% TiO₂ VC

Pigment Grade	Composition		Coating Thickness μm*	Relative Hiding Power/ Tinting Strength			Gloss, %		Shear Strength Uniformity
	Wt % TiO ₂	Vol % Coating		Drawdown		Brushout TS	60°	85°	
				HP	TS				
R-960—Experimental									
#6267	87	22	0.018	103	105	103	3	40	97
R-960									
#5883	93	12	0.009	100	100	100	6	68	96
R-902									
#11163	96	7	0.005	96	96	97	12	77	95

(a) On nominally 0.2 μm rutile.

PRACTICAL CONSEQUENCES

The considerations outlined previously have important implications on formulation of nonporous paints:

(1) Extenders larger than about 0.1 μm do not space rutile for hiding advantage; instead they contribute to crowding.

(2) Particulates small enough to increase the hiding of a paint film decrease its CPVC and thicken the paint.

(3) Effective spacing can be achieved without detriment to paint rheology by coatings on rutile particles.

(4) At suitably high PVC, coatings on the pigment can more than make up for diminished rutile content.

SUMMARY

For geometric reasons, the maximum size of extender particles intended to improve hiding is limited by rutile size and volume concentration. Maximum size of hiding effective extender is small, less than commercial products and dispersion processes can deliver. Hiding improvements can, however, be obtained through uniform spacing of rutile by coatings on rutile particles. The following requirements should be met:

(1) Composition—"Extender"/rutile combinations should be less than 40 vol% extender/60 vol% rutile;

(2) Configuration—Extender should be present as a coating of less than 0.05 μm thickness on rutile; and

(3) Application—The concept is applicable to paints of pigment volume concentration greater than 20%.

The hiding power advantage of such product over conventional rutile could be as much as 10%.

ACKNOWLEDGMENT

P.G. Schmidt, D.W. Hoppenjans, and A. Launder have contributed significantly with good ideas, constructive criticism, and thought-provoking discussions.

References

- (1) Asbeck, W.K. and VanLooy, M., "Critical Pigment Volume Relationships," *Ind. Eng. Chem.*, **41**, 1470 (1949).
- (2) Bierwagen, G.P. and Hay, T.K., "Reduced Pigment Volume Concentration as an Important Parameter in Interpreting and Predicting the Properties of Organic Coatings," *Progr. Org. Coatings*, **3**, 281 (1975).
- (3) Bruehlman, R.J., Thomas, L.W., and Gonick, E., "Effect of Particle Size and Pigment Volume Concentration on Hiding Power of Titanium Dioxide," *Official Digest*, **33**, No. 433, 252 (1961).
- (4) Fitzwater, S. and Hook, J.W. III, "Dependent Scattering Theory: A New Approach to Predicting Scattering in Paints," *JOURNAL OF COATINGS TECHNOLOGY*, **57**, No. 721, 39 (1985).
- (5) Ritter, H.S., Blöse, W.A., and Dembski, T.A., "Influence of Fine Particle Extenders on Hiding Pigment Performance in Latex Paints," *JOURNAL OF PAINT TECHNOLOGY*, **38**, No. 500, 508 (1966).
- (6) Los Angeles Society for Coatings Technology, "Surface Area/PVC Relationships for Various Extender Pigments," *Official Digest*, **33**, No. 442, 1461 (1961).
- (7) Bierwagen, G.P., "Computer Prediction of Latex Paint Properties," *Proceedings, XVI FATIPEC Congress*, Vol. II, 13, 1982.
- (8) Stieg, F.B., "Opaque White Pigments in Coatings," *ACS Symposium Series* No. 285, American Chemical Society, 1249, 1985.
- (9) Stieg, F.B., "Dilution Efficiency of Extenders," *JOURNAL OF COATINGS TECHNOLOGY*, **53**, No. 680, 75 (1981).
- (10) Stieg, F.B., "Avoiding Excessive Titanium Costs," *JOURNAL OF COATINGS TECHNOLOGY*, **53**, No. 682, 65 (1981).
- (11) Cutrone, L., "Influence of Fine-Particle Size Extenders on the Optical Properties of Latex Paints," *JOURNAL OF COATINGS TECHNOLOGY*, **58**, No. 736, 83 (1986).
- (12) Hook, J., "Conclusions on 'Crowding/Spacing Theory' Clarified," *JOURNAL OF COATINGS TECHNOLOGY*, **58**, No. 742, 81 (1986).
- (13) Steig, F.B., "Ending the 'Crowding/Spacing Theory' Debate," *JOURNAL OF COATINGS TECHNOLOGY*, **59**, No. 748, 96 (1987).
- (14) Tsimboukis, D.G., "The Packing of Spherical Particles: Analytical Approximations," *Proceedings, Sixth International Conference in Organic Coatings Science and Technology*, Athens, Greece, Vol. 4, 189 (1980).
- (15) Stieg, F.B. Jr., "Pigment/Binder Geometry," in "Pigment Handbook," Patton, T.E. (Ed.), Vol. III, p. 203, John Wiley & Sons, Inc., New York, 1973.

ORDER FORM

Quantity		Price	Total
Journal of Coatings Technology:			
	U.S. and Canada	Europe (Air Mail)	Other Countries
_____ 1 Yr.	\$27	\$55	\$40
_____ 2 Yrs.	51	107	77
_____ 3 Yrs.	73	157	112
New Federation Series on Coatings Technology		(\$5.00 ea.)	
_____	"Film Formation"—Z.W. Wicks, Jr.		_____
_____	"Radiation Cured Coatings"—J.R. Costanza, A.P. Silveri, and J.A. Vona		_____
_____	"Introduction to Polymers and Resins"—J. Prane		_____
_____	"Solvents"—W.H. Ellis		_____
_____	"Coil Coatings"—J.E. Gaske		_____
_____	"Corrosion Protection by Coatings"—Z.W. Wicks, Jr.		_____
_____	"Mechanical Properties of Coatings"—L.W. Hill		_____
_____	"Automotive Coatings"—B.N. McBane		_____
_____	"Coating Film Defects"—P.E. Pierce and C.K. Schoff		_____
Audio/Visual Presentations (Slide/tape except where noted)			
_____	Causes of Discoloration in Paint Films	(\$40)	_____
_____	The Setafash Tester	(\$100)	_____
_____	High Speed Dispersion	(\$65)	_____
_____	Introduction to Resin Operation	(\$65)	_____
_____	A Batch Operated Mini-Media Mill	(\$60)	_____
_____	Operation of a Vertical Sand Mill	(\$75)	_____
_____	Laboratory Test Procedures (VHS format)	(\$50)	_____
_____	Federation Training Series on Test Methods	(\$70)	_____
_____	Paint/Coatings Dictionary	(Mbr.—\$30; Non-Mbr.—\$50)	_____
_____	Infrared Spectroscopy Atlas	(Mbr.—\$75; Non-Mbr.—\$100)	_____
_____	Color-matching Aptitude Test Set	(\$400)	_____
Pictorial Standards of Coatings Defects			
_____	Complete Manual	(\$90)	_____
_____	Individual Standards (\$3 ea., plus \$3 per photo as noted)		_____
_____	Adhesion (1)	Blistering (4)	Chalking (1)
_____	Checking (1)	Cracking (1)	Erosion (1)
_____	Fillform Corrosion (3)		Flaking (2)
_____	Mildew (3)	Print (1)	Rust (4)
_____	Traffic Paint Abrasion (2)	Traffic Paint Chipping (2)	
_____	Record Sheets (pad of 100 sheets)	(\$3.50)	_____
_____	Glossary of Color Terms	(\$6.00)	_____
Subtotal			_____
Pa. Residents please add 6% Sales Tax			_____
Total			_____

ALL INFORMATION BELOW MUST BE COMPLETED

Signed _____ Date _____

YOUR COMPANY:

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

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

YOUR POSITION:

Check the one block which best describes your position in your company or organization.

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

Name _____

Title _____

Company _____

Address _____

City & State _____

Country _____ Mail Code _____

Make checks payable to: Federation of Societies for Coatings Technology

Postage and handling charges will be added to all orders requiring billing.

FSCT Member

Non-Member

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

Federation of Societies for Coatings Technology
1315 Walnut St. • Philadelphia, PA 19107 • 215/545-1506

Society Meetings

CDIC NOV.

"Anticorrosive Pigment"

The meeting's technical speaker was Baltimore Society member Leon Kutik, of W.R. Grace & Co., Davison Div. Mr. Kutik discussed "A NEW ION EXCHANGE NON-TOXIC ANTICORROSIVE PIGMENT."

Mr. Kutik began his presentation by reviewing the unique properties of synthetic amorphous silica gel. He stated that the product has a number of significant applications such as a flattening agent, a desiccant, and a corrosion control inhibitor.

The speaker then described, in detail, the manufacturing of the pigment. He highlighted the desirable properties of the several possible grades of finished products. These grades of materials have different areas and pore diameters and can be used to remove moisture from aluminum paint, explained the speaker.

Flattening grade products are the intermediate products in both surface area and pore size, he stated. Flattening is done by the reduction in reflectivity of the surface. A good rule of thumb is to select a pigment that is 25% of the average particle size of the total film thickness. For dispersion of the product, he added, typical high speed equipment is acceptable as long as it is set up and operated in accordance with standard engineering principles of high speed equipment.

Mr. Kutik also reported on a new area of technology which is based on silica chemistry that has been further modified, calcium exchange silica. The need for this is due to the increased concern for lead and chromate based industrial coatings, which are currently considered toxic. He pointed out that the new non-toxic calcium exchange pigment eliminates the problem. Mr. Kutik went on to discuss several results of actual exposure data for testing the corrosion inhibiting pigments and the specific techniques of formulation.

Q. Will these calcium type silicas work in a variety of vehicles?

A. Yes. They will work equally well in most systems tested to date.

Q. How much do you suggest be used?

A. Use 75-80% of the CPVC of the total pigment system. Of course, this is a ball park figure, but it should get the formula started.

The educational speaker for the evening was Tom Hissong, of the Dayton Museum

of Natural History. He spoke on "OHIO'S NATURAL HERITAGE."

N.J. HUBER, JR., Secretary

CDIC DEC.

"Carbon Black Pigments"

The guest technical speaker was Maria Nargiello, of Degussa Corp., whose presentation was titled "CARBON BLACK PIGMENTS FOR COATINGS: PRODUCTION PROPERTIES, APPLICATION, AND DISPERSION."

Ms. Nargiello addressed the four major types of carbon black: (1) Furnace Process; (2) Channel Process (historic); (3) Channel Process; and (4) Lamp Black Process. She stated that they differ in method and in yield, and that all, with the exception of the second process, are currently being used to produce carbon black in the coatings industry.

Using visual aids, Ms. Nargiello described the actual mechanics of production for each process. She reported that due to the variation in production technique the particle size of the black is varied. She pointed out that the smaller the particle size, the higher the jettness, and the larger the particle size, the bluer the tone.

The speaker then discussed the surface characteristics of the carbon black. The oxidative process coats the surface and this allows for less reagglomeration of the pigments when used by the coatings formulator. The oxidized particles wet out much faster than the non-oxidized, she reported.

Q. Can you get as good a grind using aluminum oxide as when using steel ball?

A. Yes, but a lot depends on the vehicle that you are using and the end result desired.

Q. Is the better black, lamp black or channel black in terms of blueness?

A. As we discussed, the particle size determines the blueness and the lamp black has the largest particle size.

Bob Hellebush, of OMNI Investment Management, Inc., was the educational speaker of the evening. His presentation was "IS THERE LIFE AFTER THE CRASH OF '87 OR WHERE SHOULD I PUT MY MONEY NOW?"

N.J. HUBER, JR., Secretary

HOUSTON DEC.

"Color Matching"

Society Representative Donald R. Montgomery, of O'Brien Corp., presented Loren Odell, Technical Consultant, with an Honorary Federation Membership plaque.

Guest speaker for the evening was Malcolm Lloyd, of Applied Color Systems. His topic was "COLOR MATCHING, FACT OR FICTION?"

Mr. Lloyd introduced his presentation with an abstract of a paper published in 1944 giving a mathematical approach to colorant formulation based on the Kubelka-Munk constant theory. He then discussed the limitations and benefits of a computer color matching system, and gave a detailed report on what is involved in setting up the system. When considering a system, he



1987-88 NORTHWESTERN SOCIETY OFFICERS are: President—Joan B. Lamberg; Vice-President—Richard Karlstad; Secretary—Mark W. Uglem; and Treasurer—Terry Strom

advised remembering the three S's: support, software, and spectrophotometer.

SANDRA SWIFT GIDLEY, *Secretary*

LOUISVILLE NOV.

"On-Site Solvent Recovery"

1986-87 Federation Environmental Committee Chairman Joyce Specht St. Clair was presented a plaque in recognition of her services on behalf of the committee.

President Ken Hyde, of Reliance Universal, Inc. presented Howard Ramsay, of Du Pont Co. with a Past-Presidents' Pin. Mr. Ramsay then recognized Jim Duggins, of Argus Co. who presented the Nuodex gavel to Mr. Hyde.

Fred Slack, of Disti Environmental Systems, Inc., spoke on "ON-SITE SOLVENT RECOVERY." He discussed cost justification, current environmental regulations, and available methods relating to on-site solvent recovery.

RAYMOND L. MUDD, *Secretary*

NEW YORK NOV.

"A New Industry Challenge"

William J. Greco, retired, was awarded a plaque in recognition of his many accomplishments over the years.

Fred Daniel, retired, was elected to Society Honorary Membership.

Guest speaker was Rad Mead, whose presentation was entitled "A NEW INDUSTRY CHALLENGE." Mr. Mead reviewed Title III, Emergency Planning, and Right-to-Know Acts. Among the topics covered were: the public's perception of the chemical industry; SARA regulations; Chemical Manufacturing Act of 1975; and CAER program. He also discussed: FEMA association; MSDS; hazardous chemicals; target dates for compliance; and community awareness.

ARTHUR A. TRACTON, *Secretary*

NORTHWESTERN DEC.

"Color"

The meeting's first talk was given by Terry Downes, of Applied Color Systems. Mr. Downes' subject was "COLOR: HOW CLOSE IS CLOSE ENOUGH."

The speaker explained that, when measuring color, most people still use the age-old technique of doing it by eye, and that current instruments can never measure

color this way. The problem with this type of measurement, he added, is simply that no two people see a color exactly the same. That is where color computers can help. They can set a standard that will be acceptable to all parties without the personal bias that a "by eye" match often generates. Color computers eliminate the human factor and generate color standards by precise mathematical formulas, he stated.

The speaker explained why people buy color computers. He stated that computers save time in tinting and money, and they can improve consistency from batch to batch, or consistency in color from plant to plant.

Mr. Downes then explained future developments in color computer applications. He felt that, on the whole, spectrophotometers are becoming more and more consistent and accurate. The new software applications and the ability to network some of the newer computers will provide the customer unique input into final color approval, he said. Improvements in hardware, with video display of up to 16,000 different colors, provides an obvious advantage for color computer applications both for the lab and production departments. Finally, with increased memory storage, it is now possible to have complete color files on matches made many years ago.

In conclusion, Mr. Downes felt that, as technology advances, the question of how close is close enough will get easier to answer, and make color computers a must for color matching.

The second speaker was Ray Chimberly, of United Telephone, who gave a brief update on telephone deregulation and expected rate increases for local services.

MARK W. UGLEM, *Secretary*

PACIFIC NORTHWEST— PORTLAND SECTION SEPT.

"Coalescing Agents"

Society member Rich Branchik, of Forest Paint Co., reported on a regulatory meeting which he attended concerning SARA, hazardous waste, and worker communication. Mr. Branchik said to presently satisfy OSHA inspectors, a company needs to have a written hazard communication plan and adequate labels for raw materials. A documented training and education program must be available for the inspectors review, he concluded.

The evening's speaker was Dennis Guthrie, of The Dow Chemical Co., who spoke on "EVALUATION OF COALESCING AGENTS FOR INDUSTRIAL LATEXES."

STEVE REARDEN, *Secretary*

PACIFIC NORTHWEST— SEATTLE SECTION NOV.

"Industrial Latexes"

Committee Chairmen for 1987-1988 were announced. They are: Manufacturing—Ross West, of Preservative Paint Co.; Environmental—Glenn Carlson, of Cordano Chemical; and Educational—Dan Jarvie, of Jarvie & Associates.

Dennis Guthrie, of The Dow Chemical Co., spoke on "EVALUATION OF COALESCING AGENTS FOR INDUSTRIAL LATEXES."

JOHN BARTLETT, *Secretary*

PACIFIC NORTHWEST— VANCOUVER SECTION NOV.

"Coalescing Agents"

George Shaffer, of Uniplast Products Ltd., reported that the Kwantlen course was going well, and he intends to run the advanced course in February, 1988.

Members were urged to actively participate in committee activities, in particular the Environmental Committee.

It was announced that the 1988 Symposium will be held at the Hotel Vancouver, April 28-30.

The evening's first talk was "EVALUATION OF COALESCING AGENTS FOR INDUSTRIAL LATEXES," presented by Dennis Guthrie, of The Dow Chemical Co.

B. Benoit and A. Wray, of the Dale Carnegie Institute gave the second presentation on "LEARNING CYCLE AND PUBLIC SPEAKING."

JOHN BERGHUIS, *Secretary*

PHILADELPHIA NOV.

"Use of Coalescing Aid In Latex Paints"

A moment of silence was observed in memory of Society member Joseph A. Vasta, of DuPont Co., who died recently.

Francis P. Gaffney, of Harry W. Gaffney Co., Inc., presented the Nuodex gavel to President Thomas L. Peta, of C.J. Osborn Chemical Co.

As a result of the resignation of Treasurer Fred J. Lipson, of LPC Ltd., the following members were elected to the Board of Directors: Treasurer—Christopher H. Huhn, of Loos and Dilworth, Inc.; Assistant Treasurer—Peter C. Kuzma, of V.I.P. Chemical Corp.; Senior Member-at-Large—William F. Fabiny, of Sermatech International, Inc.; and Junior Member-

at-Large—Brian O'Conner, of The McCloskey Corporation.

Mr. Fabiny, Technical Committee Chairman, announced that Past-President Donald F. Denny, of E.W. Kaufmann Co., will be the Chairman of the 1988 Technical Seminar to be held on May 2.

Julio Aviles, of NL Chemicals, Inc., was named Chairman of the committee which is to prepare a paper on "High Solids Solvent Diffusion" for the 1988 Annual Meeting in Chicago, IL.

The By-Laws change to more evenly distribute responsibilities between the Secretary, Treasurer, and Assistant Treasurer was unanimously approved.

William D. Arendt, of Velsicol Chemical Corp., presented a paper on "USE OF VELATE™ 262 COALESCING AID IN LATEX PAINTS."

ORVILLE E. BROWN, *Secretary*

PIEDMONT NOV.

"Latex Paint Spoilage"

A moment of silence was observed for FSCT Educational Committee Chairman, Joseph A. Vasta, of DuPont Co., who died recently.

The evening's speaker was William B. Woods, of Nuodex, Inc. Mr. Woods' presentation was on "LATEX PAINT SPOILAGE VS PLANT HOUSEKEEPING."

The speaker's discussion centered around the practices that are used in preventing microbial spoilage of latex paint. Mr. Woods emphasized the importance of good plant hygiene practices and the proper use of anti-microbials to control microbial growth and spoilage.

Mr. Woods talked about the causes, characteristics, sources, preventive maintenance, and commercial products that are used in controlling microbial growth. Also highlighted were the various nutrients that are necessary for the growth of aerobic and anaerobic organisms and their effects on paint stability.

FOREST G. FLEMING II, *Secretary*

PIEDMONT DEC.

"Steel, The Preferred Container"

Society President Charles Howard, of DeSoto, Inc., presented an honorarium to Past-President Michael Davis, of Sadolin Paint Products, Inc., for his many years of outstanding service to the Society.

It was announced that those interested in participating in the 1988 MMA Awards

are to contact President Charles Howard, so a letter of intent can be submitted by March 31.

The evening's guest speaker was Arthur J. Schultz, Jr., of Steel Shipping Container Institute (SSCI) who spoke on "STEEL, THE PREFERRED CONTAINER."

Mr. Schultz's presentation was centered on manufacturing steel shipping containers (e.g. pails and drums) for the coatings industry. He also emphasized the importance of quality control testing in accordance with DOT regulations and the recent improvements in the steel containers.

Q. What can be done with reconditioned or used drums?

A. The SSCI and Nevada Institute has developed a Responsible Container Management Program; beginning in 1988, a recovery network will be instituted to pick up and recondition used drums. A toll-free telephone number will be available to contact your nearest drum reconditioner.

Q. What can be done about the steel pail containers being "dumped" in the United States by Mexico?

A. Nothing can be done unless it is proven that Mexico is exceeding its 25% quota and illegally dumping thousands of five gallon pails in the United States.

FOREST G. FLEMING, II, *Secretary*

PITTSBURGH DEC.

"How Close Is Close Enough"

Society Vice-President Richard Marci, of Royston Laboratories, updated the progress of the Environmental Committee's Hazardous Waste Seminar scheduled for April 11.

The meeting's speaker was Norman Uress, of Applied Color Systems, who talked on "HOW CLOSE IS CLOSE ENOUGH."

Mr. Uress reported that color computers are designed to give an accurate and a reproducible number to a given color, and not to tell you if you have a "match." All color measuring equipment on the market reads color in a slightly different way, he said. The problem in color tolerance is to learn how to correctly interpret the information obtained from the equipment.

The speaker stated two new approaches presently being used to attempt to set up standards for color tolerance: 1) Society of Automotive Engineers J-1545, and 2) Color Measurement Committee CMC (1:C). According to Mr. Uress, both methods seem to offer certain advantages, but the test of time will determine how reliable they are.

The speaker stressed that one important thing to remember is that color tolerances must differ depending on the color that is being measured regardless of the type of equipment that is being used. Color tolerance can be based on the acceptability of a series of colors matched to a given standard, by a customer. Once the range of acceptability is determined for a customer, color matches should be directed toward the center of the range.

Mr. Uress reported that color tolerance is much improved today because better instrumentation, software, and hardware provide better repeatability, reproducibility, and stability. Establishing a good color tolerance program, he concluded, is beneficial by minimizing rejection and returns, minimizing inventory and tinting requirements, and minimizing the need for testing and inspection.

Q. How does color drift, over time, affect color tolerance?

A. With values being stored in the computer, color drift of a standard is much less significant than when having to rely on the standard itself.

Q. What is the next generation of color matching hardware coming on line?

A. The hardware is made up of two components—the computer and the spectrophotometer. The computers will only get smaller, cheaper, and faster, and the spectrophotometers are already advanced far beyond what is capable of being done by eye.

JAMES LORE, *Secretary*

PITTSBURGH JAN.

"Preservative Treatments for Wood"

President Richard Marci announced that the dinner speaker for the Hazardous Waste Seminar, April 11, 1988 will be Robert Foreman, Director of Governmental Affairs, of the National Paint and Coatings Association.

Alan Ross, of Koppers Company, Inc., was the evening's speaker. The Pittsburgh Society member spoke on "PRESERVATIVE TREATMENTS FOR WOOD AND SUCCESSFUL COATING TECHNIQUES."

Mr. Ross reported that the use of pressure-treated wood, particularly in deck construction, has grown rapidly over the last 10-15 years. This has created a large market for wood preservative coatings. Presently, this type of treated wood is widely used for railroad ties, utility poles, all-weather wood foundations, landscape timbers, marine pilings, and dimensional lumber.

The speaker stated the three most widely used preservative chemicals for pressure

Constituent Society Meetings and Secretaries

BALTIMORE (Third Thursday—Snyder's Willow Grove, Linthicum, MD). DONALD HILLIARD, Unocal, 1500 Carbon Ave., Baltimore, MD 21226. **VIRGINIA SECTION** (Fourth Wednesday—Ramada Inn-East, Williamsburg, VA).

BIRMINGHAM (First Thursday—Strathallan Hotel, Birmingham, England). D.A.A. WALLINGTON, Macpherson Drynamels Ltd., Westgate, Aldridge, West Midlands WS9 8YH England.

CDIC (Second Monday—Sept., Jan., Apr., June in Columbus; Oct., Dec., Mar., May in Cincinnati; and Nov., Feb. in Dayton). N. JAY HUBER, JR., Paint America Co., 1501 Webster St., Dayton, OH 45404.

CHICAGO (First Monday—meetings alternate between Como Inn in Chicago, IL and Sharko's West in Villa Park, IL). KEVIN P. MURRAY, DeSoto, Inc., 1700 S. Mt. Prospect Rd., Des Plaines, IL 60018.

CLEVELAND (Third Tuesday—meeting sites vary). ILONA NEMES-NEMETH, Sherwin-Williams Co., Cleveland Technical Center, 601 Canal Rd., Cleveland, OH 44113.

DALLAS (Thursday following second Wednesday—Harvey Hotel, North Dallas, TX). STEVE STEPHENS, Ribelin Sales, Inc., P.O. Box 461673, 3857 Miller Park Dr., Garland, TX 75046.

DETROIT (Second Tuesday—Ukrainian Cultural Center, Warren, MI). LIANA CALLAS ROBERTS, A.T. Callas Co., 1985 W. Big Beaver, Suite 308, Troy, MI 48043.

GOLDEN GATE (Monday before third Wednesday—Alternate between Francesco's in Oakland, CA and Holiday Inn in S. San Francisco). GORDON PROCH, Triangle Coatings, Inc., 1930 Fairway Dr., San Leandro, CA 94577.

HOUSTON (Second Wednesday—Look's Sir-Loin Inn, Houston, TX). SANDRA SWIFT, Cron Chemical Corp., P.O. Box 14042, Houston, TX 77221.

KANSAS CITY (Second Thursday—Cascone's Restaurant, Kansas City, MO). NICK DISPENSA, Davis Paint Co., P.O. Box 7589, N. Kansas City, MO 64116.

LOS ANGELES (Second Wednesday—Steven's Steak House, Commerce, CA). JAMES F. CALKIN, E.T. Horn Co., 16141 Herron Ave., La Mirada, CA 90638.

LOUISVILLE (Third Wednesday—Executive West Motor Hotel, Louisville, KY). RAYMOND L. MUDD, Porter Paint Co., Coatings Div., P.O. Box 1439, 400 S. 13th St., Louisville, KY 40201-0439.

MEXICO (Fourth Thursday—meeting sites vary). ARTURO ITA, Pinturas Auro- lin, S.A. De C.V., Poniente 150 No. 750, Nueva Industrial Vallejo, 02300 Mexico, D.F.

MONTREAL (First Wednesday—Bill Wong's Restaurant, Montreal). ROBERT BENOIT, NL Chemicals Canada Inc., 4 Place Ville-Marie, Ste. 500, Montreal, Que., Canada H3B 4M5.

NEW ENGLAND (Third Thursday—LeChateau Restaurant, Waltham, MA). JOSEPH T. SCHRODY, Unocal Chemicals Div., 90 Cumberland Rd., Leominster, MA 01453.

NEW YORK (Second Tuesday—Landmark II, East Rutherford, NJ). ARTHUR A. TRACTON, Hempel Coatings, Inc., Foot of Curie Ave., Wallington, NJ 07057.

NORTHWESTERN (Tuesday after first Monday—Jax Cafe, Minneapolis, MN). MARK W. UGLEM, Hirschfeld's Paint Mfg., Inc., 4450 Lyndale Ave., N., Minneapolis, MN 55412. **WINNIPEG SECTION** (Third Tuesday—Marigold Restaurant, Winnipeg). NEIL WEBB, Phillips Paint Products Ltd., 95 Paquin Rd., Winnipeg, MB, Canada R2J 3V9.

PACIFIC NORTHWEST (PORTLAND SECTION—Tuesday following second Wednesday; SEATTLE SECTION—the day after Portland; BRITISH COLUMBIA SECTION—the day after Seattle). EMIL IRAOLA, Olympic Home Care Products Co., 1141 N.W. 50th, Seattle, WA 98107.

PHILADELPHIA (Second Thursday—Williamson's, GSB Bldg., Philadelphia, PA). ORVILLE E. BROWN, M.A. Bruder & Sons Inc., 52nd & Grays Ave., Philadelphia, PA 19143.

PIEDMONT (Third Wednesday—Americana Inn, Greensboro, NC). FOREST G. FLEMING, Reliance Universal, Inc., P.O. Box 2124, High Point, NC 27261.

PITTSBURGH (Second Monday—Montemurro's, Sharpsburg, PA). JAMES LORE, Watson Standard Co., P.O. Box 11250, Pittsburgh, PA 15238.

ROCKY MOUNTAIN (Monday following first Wednesday—Holiday Inn North, Denver, CO). PAUL D. SILVA, Kwal Paints, Inc., 3900 Joliet St., P.O. Box 39485, Denver CO 80239.

ST. LOUIS (Third Tuesday—Salad Bowl, St. Louis, MO). HOWARD JEROME, Mozel Equipment Co., 4003 Park Ave., St. Louis, MO 63110.

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; MIAMI SECTION—Tuesday prior to Central Florida Section). KENNETH W. ESPEUT, Jim Walter Research, 10301 9th St. N., St. Petersburg, FL 33702.

TORONTO (Second Monday—Cambridge Motor Hotel, Toronto). ROY A. DONNELLY, St. Lawrence Chemical Co. Ltd., 321 Humberline Dr., Rexdale, Ont., Canada M9W 5T6.

WESTERN NEW YORK (Third Tuesday—meeting sites vary). MARKO K. MARKOFF, 182 Farmingdale Rd., Cheektowaga, NY 14225.

treatment are: 1) creosote and creosote solutions, 2) pentachlorophenol, and 3) chromated copper arsenate (CCA). Only CCA is used for lumber in home deck construction. Mr. Ross explained that CCA, a mixture of the oxides of copper, chromium, and arsenic, does not adversely affect wood finishing characteristics, although some evidence shows that CCA actually promoted the life of certain finishes that are applied over it.

Mr. Ross continued by discussing why CCA pressure-treated wood is coated in the first place. Many manufacturers recognize that the treatment alone may not provide the full range of protection that today's consumers require, he stated. Coating pressure-treated wood helps to prevent water damage, resists mildew and algae growth, and prevents the graying caused by exposure to sunlight. CCA pressure-treated wood is prone to these conditions since it usually consists of Southern Pine with flat grain characteristics and wide late wood bands, he maintained.

Mr. Ross also reported that proper surface preparation is important to good coating performance for CCA pressure-treated wood. To prevent early weather exposure damage, new wood should be coated soon after construction. Weathered wood can be prepared by the use of commercially available painting pre-treatment cleaning solutions, followed by painting. The main criteria, he described, are that the surface of the wood be dry and that the coating be able to penetrate the surface. If the wood is wet or damp, it should be allowed to air dry for a few days before coating. If new wood is burnished, resulting in a "tight" grain and evidenced by a tendency to repel water droplets, it should be weathered for a short period before coating.

Mr. Ross recommended that semi-transparent coatings, wood stains, and clear water repellants be used on CCA pressure-treated wood if they are recommended for wood applications by the manufacturer. In all cases, he concluded, the label instructions should be followed.

Q. After using a wood-brightener on weathered CCA pressure-treated wood, how long should you wait before applying a clear water repellent?

A. As soon as the surface is dry to the touch, and this will depend on weather conditions.

Q. What are the different retention levels that are referred to with the treated lumber sold for commercial use?

A. The two retention levels commonly sold are .25 pounds per cubic foot—which is recommended for above ground applications, and .40 pounds per cubic foot—used for direct ground contact applications.

JAMES LORE, Secretary

Elections

C-D-I-C

Active

- BANSCH, PAMELA A.—Lilly Industrial Coatings, Indianapolis, IN.
BURDICK, STEPHEN D.—Hanna Chemical Coatings Co., Columbus, OH.
CROMWELL, MICHAEL J.—Lilly Industrial Coatings, Indianapolis.
CUNNINGHAM, PATRICIA D.—Lilly Industrial Coatings, Indianapolis.
GRIDER, RALPH A.—Lilly Industrial Coatings, Indianapolis.
KRETSCHMAIER, DAVID G.—DeSoto Inc., Columbus.
LAYMAN, RICHARD E.—Ashland Chemical Co., Columbus.
MERRITT, MICHAEL H.—Akzo Coatings America, Springfield, OH.
MONTJOY, TONY L.—Yenkin-Majestic Paint Co., Columbus.
PARADEE, SIDNEY A.—Akzo Coatings America, Springfield.
PASKOFF, PHILIP H.—Yenkin-Majestic Paint Co., Columbus

Associate

- POE, THOMAS R.—Seegott Inc., Florence, KY.
SIMS, MARILYN S.—Flanagan Associates, Inc., Cincinnati, OH.

Educator/Student

- DANTIKI, SUDHAKAR—Univ. of Dayton Research Institute, Dayton, OH.

CHICAGO

Active

- PETTY, JOHN L.—Consultant, Homewood, IL.
VAN HEULE, JAMES G.—Moline Paint Manufacturing Co., Moline, IL.
YOUSUF, MOHAMMED K.—S.C. Johnson & Son, Inc., Racine, WI.

Associate

- BYRNE, CINDY S.—Angus Chemical Co., Northbrook, IL.
ZWICKER, BRUCE M.—Unocal Chemicals Div., Lemont, IL.

HOUSTON

Active

- DAVIS, M. LLOYD—Isotec International, Houston, TX.
SANHUEZA, MANUEL C.—Potter Paint of Texas, Brownsville, TX.
WISSMAN, HARRY G.—Reliance Universal, Houston, TX.

Associate

- BROWNHILL, ROBERT S.—Raw Materials Corp., Houston, TX.
HAMMERLE, JOSEPH J.—R.T. Vanderbilt Co., Inc., Plano, TX.

- HUEMMER, THOMAS F.—Real Craft, Houston.
LOMBARDI, LORI A.—Unocal Chemicals Div., Houston.
STEWART, DONALD L.—Raw Materials Corp., Houston.

NEW ENGLAND

Active

- KAPPOCK, PAUL S.—Dryvit System Inc., West Warwick, RI.

NEW YORK

Active

- KENNEDY, JOHN F.—Standard Coating Corp., Ridgefield, NJ.
MARTIN, FELIPE L.—Degen Oil & Chemical, Jersey City, NJ.
MICCIO, ALBERT—Mercury Paint Corp., Brooklyn, NY.
OLANDER, FINN—Degen Oil & Chemical, Jersey City.
SOLDATOS, ANTHONY C.—BP Chemicals America, Rye, NY.

Associate

- ARONSON, STUART M.—S.P. Morell & Company, Scarsdale, NY.
HOPSON, WILLIAM S.—Whittaker, Clark, & Daniels, Inc., So. Plainfield, NJ.
HORNBERG, MARIA D.—Alnor Oil Co., Valley Stream, NY.
KACPEROWSKI, KENNETH R.—Rhône-Poulenc, Inc., Monmouth Junction, NJ.
RUSSO, ROBERT F.—Daipolymer Div., Clifton, NJ.

PACIFIC NORTHWEST

Active

- CUMMINGS, LARRY C.—Lawrence-David Inc., Eugene, OR.
GETZIN, DANIEL L.—Wood-Kote Products, Portland, OR.
GREEN, ALLAN—General Paint, Vancouver, British Columbia.
JEAL, ROBERT C.—Ames Paints, Victoria, British Columbia.
KNOX, RON—General Paint, Vancouver.
KRUEGER, ALLAN—Technical Industrial Sales, Inc., Oregon City, OR.
KRUEGER, KIRT—Technical Industrial Sales, Inc., Oregon City.
SEVERSON, DEBORAH J.—Wiltech Corp., Longview, WA.
VALDEZ, ANTONIO D.—ADV Consulting, Portland.
VELDHUIS, KEITH—Nero Acrylic Paint & Plastics, Nobleford, Alberta.
WONG, FLORA—Polymer Engineering, New Westminster, British Columbia.

Associate

- ADAMS, DAVID M.—Progressive Services, Coquitlam, British Columbia.
GUNNING, DONALD F.—Washington Stone Corp., Richmond, British Columbia.
HOWE, DONALD—Reichhold Ltd., Port Moody, British Columbia.
NICOL, PAT—Reichhold Ltd., Port Moody.

WESTERN NEW YORK

Active

- DAVIS, MARLENE L.—Spencer Kellogg/NL Chemicals, Buffalo, NY.
SCHINDLER, MARK S.—Pratt and Lambert, Inc., Buffalo.

SPRING WEEK '88

Sponsored by
Federation of Societies for Coatings Technology

May 17-20
Orlando Marriott Hotel • Orlando, FL

Featuring
FSCT Seminar on
"Coatings Defects: Prevention
and Cure"
May 17-18

Future Society Meetings

Birmingham

(Apr. 7)—"IMPROVING DISPERSION OF PIGMENTS"—Allen Cowley, ICI Chemicals and Polymers Ltd.

(May 5)—59th ANNUAL GENERAL MEETING.

(May 12)—"BRITISH STANDARD BS 5750 QUALITY ASSURANCE AND THE PAINT INDUSTRY"—J. Cauthorpe, Sonneborn & Rieck Ltd.

C-D-I-C

(Apr. 11)—"EVALUATING COATINGS FOR LONG TERM PROTECTION"—Bernard Appleman, Steel Structures Painting Council.

Chicago

(Apr. 4)—"IMPROVED FLOW AND OPACITY WITH ORGANIC PIGMENTS"—Gary Jordan, Hoechst Corp. and "DISPERSION OF ORGANIC PIGMENTS"—Ted Vernardakis, Sun Chemical Corp. Sharko's.

(May)—AWARDS NIGHT.

Cleveland

(Apr. 19)—AWARDS NIGHT. "PLASMA SURFACE TREATMENT FOR ENHANCED ADHESION OF COATINGS FOR PLASTICS"—Peter Rose, Plasma Science Inc. Independence Brown Derby.

(May 17)—"EFFECT OF COATINGS ON ACOUSTIC QUALITIES OF MUSICAL INSTRUMENTS"—Speaker to be announced. Harley Hotel.

Golden Gate

(Apr. 18)—"MODERN TRENDS IN ORGANIC PIGMENT TECHNOLOGY"—Hugh M. Smith, Sun Chemical Corp. Holiday Inn.

(May 16)—"UNDER UTILIZED KAOLIN"—Dan Dixon, Engelhard Minerals & Chemicals Corp. Francesco's Restaurant.

(June 13)—MANUFACTURING COMMITTEE PROGRAM. Holiday Inn.

Houston

(Mar. 16-18)—SOUTHWEST PAINT CONVENTION—Speaker to be announced. Hyatt Regency Hotel, Houston, TX.

(Apr. 13)—"ADVANTAGES OF PRE-DISPERSED POLYETHERS AND WAXES IN HIGH PERFORMANCE COATINGS"—Elio Cohen, Daniel Products Co.

(May 11)—Speaker to be announced.

Los Angeles

(Apr. 13)—BOSSSES' NIGHT. "MODERN TRENDS IN ORGANIC PIGMENT TECHNOLOGY"—Hugh M. Smith, Sun Chemical Corp.

(May 11)—AWARDS NIGHT. "UNDER UTILIZED KAOLIN"—Dan Dixon, Engelhard Minerals & Chemicals Corp.

(June 8)—ANNUAL MEETING AND ELECTION OF OFFICERS.

Montreal

(Apr. 6)—TECHNICAL COMMITTEE PRESENTATION—John E. Hall, Tioxide of Canada Ltd.

(May 4)—MANUFACTURING COMMITTEE PRESENTATION—Ladislav Krivanek, International Paints Ltd.

New York

(Apr. 12)—Speaker to be announced.

(May 10)—PAST-PRESIDENTS' AND PAVAC AWARDS NIGHT.

Pacific Northwest— Portland, Seattle, & Vancouver Sections

(Mar. 15-17)—"PRODUCTION MANAGEMENT, FORMULA ANALYSIS AND COMPLIANCE USING THE PERSONAL COMPUTER"—Christy Ausman, Pacific Micro.

(Apr. 19-21)—"MODERN TRENDS IN ORGANIC PIGMENT TECHNOLOGY"—Hugh M. Smith, Sun Chemical Corp.

(May 17-19)—"UNDER UTILIZED KAOLIN"—Dan Dixon, Engelhard Minerals & Chemicals Corp.

Philadelphia

(Apr. 8)—AWARDS NIGHT.

(May 12)—Speaker to be announced.

Pittsburgh

(Apr. 11)—SYMPOSIUM ON HAZARDOUS WASTE LAWS—Speaker to be announced.

Rocky Mountain

(Apr. 11)—"MODERN TRENDS IN ORGANIC PIGMENT TECHNOLOGY"—Hugh M. Smith, Sun Chemical Corp.

(May 9)—"UNDER UTILIZED KAOLIN"—Dan Dixon, Engelhard Minerals & Chemicals Corp.

Western New York

(Apr. 19)—FEDERATION OFFICERS' VISIT and "TOOLS AND RULES OF ADHESION SCIENCE"—Doug Rahrig, S.C. Johnson Co. Daffodil's Restaurant, Amherst, NY.

(May 17)—"ISOPARAFFINS IN COATINGS"—Jack T. DiPiazza, Exxon Corp. Jamaica Joe's Dockside Inn. Amherst, NY.

Philadelphia Society Technical Committee Seminar

Airport Hilton, Philadelphia, PA
May 2, 1988

"Computers and the Paint Plant— From Formulation through Production"

For information, contact Donald Denny, E.W. Kauffman Co., P.O. Box 529, Southampton, PA 18966.

People

Furane Products Company, a CIBA-GEIGY company, Los Angeles, CA, has appointed **Robert R. Adams** to the position of Senior Sales Engineer, Electrical/Electronic Products for the Midwest. Mr. Adams brings over 15 years of experience in the electronic chemicals business to this position.

William Rosenthal has accepted a position with The O'Brien Corporation, Elkhart, IN, as Vice-President, Technology, headquartered in South Bend, IN. He replaces **James Kelly** who was named Vice-President and General Manager for the firm's Venture Business Group.

Gloria Miller recently joined the staff of The O'Brien Corporation, S. San Francisco, CA, as Manager of Trade Sales Computer Services. In her new position, Ms. Miller will be responsible for the development and execution of demonstrations and training programs.

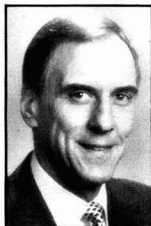
Ruco Polymer Corporation, Hicksville, NY, has announced the appointment of three new technical staff personnel. Joining the engineering staff is **George Chrysanthopoulos**; Chemists **Mark Doyle** and **Andrew France** have joined Ruco's production staff.

Rheometrics, Inc., Piscataway, NJ, has appointed **Ignatius Chan**, Sales Engineer for the Mid-Atlantic district including New Jersey, Pennsylvania, Delaware, Washington, D.C., Virginia, and West Virginia.

Also, **Richard Sader** has assumed the position of Technical Support Sales Engineer. His responsibilities include being a liaison between the applications lab and sales engineers, and providing technical support to customers.

Henkel Polymers Division, Henkel Corporation, La Grange, IL, has announced the following appointments: **Ronald E. Weiland, Jr.**—Manager of Market Development; **Joyce Ko**—Project Chemist; **Donald A. Van Beek, Jr.**—Senior Development Chemist; and **Marcel C. Ugoagwu**—Business Development Manager of Thermoplastics.

Mr. Weiland is a member of the Chicago Society.



R.R. Adams



W. Rosenthal



P.M. Boehler



R.C. Ross

Paul M. Boehler has been named Midwest Regional Sales Manager for Troy Chemical Corporation, Newark, NJ. In his new position, Mr. Boehler will be responsible for the sales of the firm's additives and biocides to the coatings and building materials industries in the Midwest.

Dean M. Berger has retired from Gilbert Associates, Inc., Reading, PA, where he was employed as a Coating Consultant for the past 14 years. Mr. Berger, a member of the Philadelphia Society, will work as a Coating Consultant with Berger Associates, Leola, PA.

Mr. Berger is a Past-President of the Pittsburgh Society and Past-Chairman of the Federation's Corrosion Committee.

William A. Bomball has been promoted to Group Manager, Chemical Intermediates Research and Development for the Horizon Chemical Division of Staley Continental, Inc., Decatur, IL. In this new position, Mr. Bomball will be responsible for applications research and technical service for methyl glucoside and intermediates.

In addition, **Patrick M. McCurry** has been named Staley Research Fellow for Horizon Chemical Division. Dr. McCurry will continue in his current assignment as Manager of Carbohydrate Chemistry for Horizon Research and Development.

Crown Metro Aerospace Coatings, Inc., Greenville, SC, has named **Philip T. O'Dell** Technical Director in charge of Research. Also, **Ed Brannfors** has been appointed Director of Technical Service, and will be located at the company's Seattle office.

Robert C. Ross has been named Chemicals Marketing Representative, Southwest District, for Eastman Chemicals Products, Inc., Kingsport, TN. Prior to this appointment, Mr. Ross was a Resource Analyst in the Business Team Management Group.

Terry Crabtree has joined the staff of Fusion UV Curing Systems, Rockville, MD, as National Sales Manager. Prior to this appointment, Mr. Crabtree was Regional Sales Manager for Loctite Corporation.

The Board of Directors of Dexter Chemical Corporation, New York, NY, has appointed **Leonard A. Sitver** Executive Vice-President. He joined Dexter in 1973 as Product Manager.

Joseph V. Koleske has retired from Union Carbide Corp., S. Charleston, WV, after 25 years of service. He is now a Consultant for the coating and polymer industries.

Mr. Koleske received the B.S. Degree in Chemical Engineering from the University of Wisconsin and M.S. and Ph.D. Degrees from Lawrence University (The Institute of Paper Chemistry) in the field of polymer and materials science. At Union Carbide, he worked in the area of polymer and coating research. Author of over 70 papers, book chapters, and books, Mr. Koleske has been granted over 70 U.S. patents.

Active in the Federation for many years, Mr. Koleske serves on the JCT Editorial Review Board. He is a member of the Pittsburgh Society.

Hercules Incorporated, Wilmington, DE, has appointed **Reid J. Frazier** to the position of Manager of Business Development for its Coatings & Additives Group. Mr. Frazier previously served as Area Controller for Hercules Asia Pacific, headquartered in the Far East.

In addition, **John M. DeStefano** has been named Director, Business Development for the Organics Group. He was formerly Vice-President and General Manager of Ross Pulp and Paper, a subsidiary of Hercules Canada Inc.

Michael Ribelin has been appointed President of Ribelin Sales, Inc., Garland, TX. Among his many responsibilities, Mr. Ribelin will oversee all operations at the organization's four locations: Garland; Houston, TX; New Orleans, LA; and Tempe, AZ. He is a member of the Dallas Society.

In addition, **Arlen Cornett** has been named Vice-President, Sales and Marketing. Prior to joining Ribelin in 1979, Mr. Cornett was Business Manager of the Goodyear Chemical Division.

Grow Group, Inc., New York, NY, has appointed **Les W. Wilde** to the newly-created position of President, Consumer and Professional Products Group. Located in City of Commerce, CA, Mr. Wilde will oversee all of the Group's operations.

Polychrome Corporation, Yonkers, NY, has announced the following promotions: **Donald O. Wheeler**—Executive Vice-President/Chief Operating Officer for Printing Products; **Paul V. Reilly**—Vice-President/General Manager for Domestic Printing Products; and **Robert W. Hallman**—Vice-President for Plate Research and Development.

Barbara Ulrich has been appointed Customer Service Manager for Unichema Chemicals, Inc., Chicago, IL. Ms. Ulrich joined Unichema in 1986; prior to this promotion she was Customer Service Supervisor.

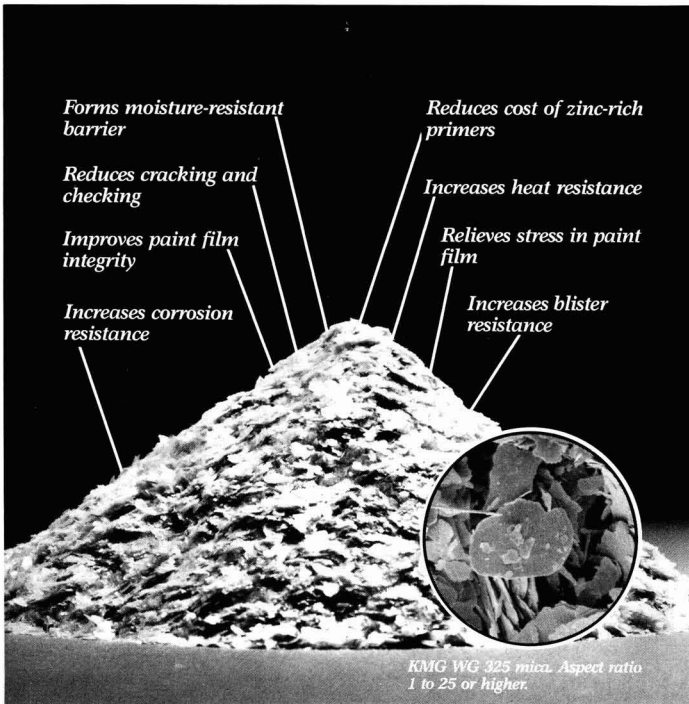
Liquid Carbonic Industries Corporation, Chicago, IL, has named **Robert J. Daniels** President and Chief Executive Officer, replacing **James P. Gage** who will retire on June 30.

Jacob J. Ferro has been elected Vice-President, Clay Division by the Board of Directors of the J.M. Huber Corp., Macon, GA. He succeeds retiring Vice-President **Jack A. Rogers**.

Mr. Ferro will be responsible for directing 770 employees in the Division's marketing, research, exploration, planning and development, finance, personnel, and production sections. He joined the J.M. Huber Corp., Clay Division in 1986 as General Operations Manager. Prior to joining Huber, Mr. Ferro was Plant Manager for the Inland Steel Co.

Michael J. Hanrahan has joined the staff of EM Industries, Inc., Hawthorne, NJ. Before joining EM, Mr. Hanrahan was a Development Chemist with Beacon Chemical Company.

Hoechst Celanese Corporation, Somerville, NJ, has announced the following appointments to its managerial staff: **Ernie Drew**—President and Chief Executive Officer; **Dieter zur Loye**—Chairman; **Richard M. Clarke**—Vice-Chairman and "Direktor" of Hoechst AG; **Harry R. Benz**—Executive Vice-President and Chief Financial Officer; and **Juergen Dornmann**—Chairman and Chief Executive Officer of Hoechst Corporation.



KMG WG 325 mica. Aspect ratio 1 to 25 or higher.

Protect your good name in the paint industry

KMG white muscovite mica improves the physical properties of your paints. KMG **wet ground**, **dry ground**, and **micronized** micas provide consistent, controllable results, serving as a functional secondary pigment. Custom grinding and blending available.

Specify with confidence. KMG is the world's largest ground mica producer. Half-century proven

reserve. Distributors worldwide.

Call or write for technical data and samples.

KMG
MINERALS, INC.

PO Box 729
Kings Mountain, North Carolina 28086
Telephone: (704) 739-1321 Telex: 703063

 KMG...worldwide

KMG1272

Gary L. Fulk has been promoted to President and Chief Executive Officer of Reliance Universal Inc., Louisville, KY. He replaces **Charles J. Fisher**, who recently retired. Mr. Fulk has been affiliated with Reliance for 19 years.

Mark Mueller has been appointed Manager, Western Region for Volstatic, Inc.'s, Florence, KY, electrostatic powder coating equipment. Mr. Mueller brings twelve years of experience in the industrial finishing industry to this new position.

In addition, the firm has named **Bruce N. Kazich** to the position of Sales Engineer for Volstatic's line of electrostatic powder coating equipment.

CIBA-GEIGY Corporation, Hawthorne, NY, has appointed **Kirk Johnson**, Regional Sales Manager, South Central, for the Probimer business of the firm based in Austin, TX. Prior to joining CIBA-GEIGY, Mr. Johnson worked at W.R. Grace as Senior Technical Sales Representative.

Douglas E. Olesen has been elected President and Chief Executive Officer of Battelle Memorial Institute, Columbus, OH. He joined Battelle in 1967, and recently served as Executive Vice-President and Chief Operating Officer. Dr. Olesen succeeds **Ronald S. Paul**, who is retiring after 22 years of service.

In an effort to better serve the markets covered by the *American Paint & Coatings Journal* and *American Painting Contractor*, the American Paint Journal Co., St. Louis, MO, has announced the following changes. In addition to his continued responsibilities as Editor of the APJ, **Chuck Reitter** has been named Vice-President of the company. His new activities in the area of general management are a result of his continuing educational training toward his master's degree and the company's desire to build management succession. A member of the St. Louis Society, Mr. Reitter has been Editor since 1982.

This appointment increases the editorial and production responsibilities of Assistant Editor **Maria Minowitz** and Production Manager **Kelley Devine**. In addition, the independent publishing company has named **Monica Tower** Circulation Manager for the two magazines. She succeeds **Bill Lindsey**, who will retire.

Dieter J. Stein, Director of the Coatings Operating Division of the BASF Group, Parsippany, NJ, has been appointed to the Board of Executive Directors of BASF Aktiengesellschaft, the parent company of the BASF Group. Effective May 1, Dr. Stein will also become President and Chief Executive Officer of BASF Corporation, and, additionally, Chairman on July 1. In these positions, he will succeed **Juergen F. Strube** who, as a member of the BASF AG Board of Executive Directors, will assume in mid-1988 the responsibilities for the Foam Plastics, Polyolefins, and PVC Operating Divisions, as well as the Brazil and Latin America Regional Divisions, all of which, except Foams, have been directed by **Herbert Willersinn**, a Board member, who is retiring in mid-1988. Dr. Strube will retain his responsibilities for the Group's Information Systems Operating Division.

Also, **Frederick W. Bernthal**, Executive Vice-President Finance of BASF Corporation, has been elected Vice Chairman of the company.

Arthur T. Lichtenberger has been named President of Westfield Coatings Corporation, Westfield, MA, a division of RPM Inc., Medina, OH. Mr. Lichtenberger has 36 years of experience in the coatings and graphic arts industries and has served Westfield as Vice-President of Research and Development for the past 17 years.

John T. Marvel has been named Vice-President—Research and Development for Ethyl Corporation, Richmond, VA. Dr. Marvel joins Ethyl following 19 years of service with the Monsanto Company where he most recently served as General Manager, Science and Technology for Europe and Africa.

Robert S. Steele has joined the staff of Colorgen, Inc., Billerica, MA, as Senior Vice-President for Business Development. Mr. Steele will be involved with the direction of current sales and marketing activities in the coatings industry, and responsible for pursuing other market opportunities for the firm's products.

SCM Chemicals, Baltimore, MD, has announced the appointment of **Jon A. Sikora** as Sales Representative for southwestern Ohio, southeastern Indiana, and Kentucky. Mr. Sikora will be responsible for the sales and service support of titanium dioxide and fine particle silica. Prior to his Cincinnati area appointment, Mr. Sikora was a Sales Representative in the Atlanta area, serving the southeast region.

Nalco Chemical Company, Naperville, IL, recently announced two promotions within the firm's Operations Staff. They are: **Richard E. Myers**—Vice-President, Corporate Sales, and **Anthony J. Sadowski**—Vice-President, Environmental Health and Safety. Mr. Sadowski succeeds **E. Hamilton Hurst**, who retired in February after serving Nalco in a variety of capacities for 35 years.

Morris L. Owen has accepted the position of Market Manager for Ashland Chemical Company's IC&S Division, Columbus, OH. Mr. Owen joined Ashland Petroleum Company's Branded Marketing Department in 1972, and in 1974 he transferred to the IC&S Division. In this new position, he will be joining current IC&S Market Managers **Roy L. Bever** and **Richard E. Hunter**.

Obituary

Harold Spitzer, Vice-President and Technical Director of the Coatings Group at The Sherwin-Williams Co., Cleveland, OH, died on January 2.

Mr. Spitzer began his career with Sherwin-Williams in 1937 after earning a B.S. Degree in Chemistry from North Dakota State University. He advanced through successive supervisory positions until becoming Associate Technical Director of coatings at the company's Cleveland headquarters in 1968. Five years later, he was named to the post of Vice-President and Technical Director—a position he maintained until his retirement in 1978.

Mr. Spitzer served on many committees of the Federation and was a Trustee and Vice-President of the Paint Research Institute. In 1977, he was awarded the highest honor of the FSCT, the George Baugh Heckel Award.

Rosemary D. Boehle, a Director of the family-owned Boehle Chemical, Inc., Southfield, MI, died on December 26. She was 59.

Mrs. Boehle was a regular attendee of both the FSCT and NPCA Annual Meetings and conventions. She also actively participated in the national and regional meetings of the National Association of Chemical Distributors.

NOW AVAILABLE

The NEW Federation Series on Coatings Technology

Quantity

— **Radiation Cured Coatings**

*by J.R. Costanza, A.P. Silveri,
and J.A. Vona*

— **Film Formation**

by Zeno W. Wicks, Jr.

— **Introduction to
Polymers and Resins**

by Joseph W. Prane

— **Solvents**

by William H. Ellis

— **Coil Coatings**

by Joseph E. Gaske

— **Corrosion Protection
by Coatings**

by Zeno W. Wicks, Jr.

— **Mechanical Properties
of Coatings**

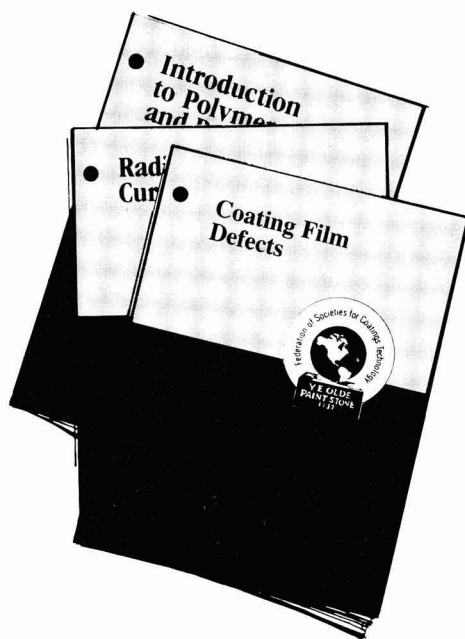
by Loren W. Hill

— **Automotive Coatings**

by Bruce N. McBane

— **Coating Film Defects**

*by Percy E. Pierce and
Clifford K. Schoff*



\$5.00 each

PLEASE MAKE ALL CHECKS PAYABLE IN U.S. FUNDS

Federation of Societies for Coatings Technology • 1315 Walnut Street, Philadelphia, PA 19107

Pennsylvania residents please add 6% sales tax

AVAILABLE IN THE U.K. FROM:

Birmingham Paint, Varnish and Lacquer Club

c/o Mr. Ray Tennant, Carrs Paints Limited, Westminster Works, Alvechurch Rd.
Birmingham B31 3PG, England

Meetings/Education

Missouri-Rolla Offers Spring Coatings Classes

The Coatings and Polymer Science Program at the University of Missouri-Rolla, Rolla, MO, is offering three short courses this spring. UMR has been conducting short courses since the 1950's and has offered over 100 short courses in that time.

The three courses to be conducted include: "16th Introductory—Paint Formulation"—March 14-18; "Conformal Coatings"—April 18-20; and "Physical Testing of Paints and Coatings from Classic Methods to Modern Instrumental Techniques"—May 16-20.

The "Paint Formulation" introductory course is for persons interested in the basic fundamental concepts of paint formulation. Some of the topics to be included are: basic raw materials and their influences on the performance characteristics of the finished coating; manufacturing and testing of coatings in the laboratory to meet the state requirements of the job to be done with a minimum of inventory complication; limitations of plant production equipment and the variables that can be introduced when a coating is moved from the laboratory to the plant; systems for reducing variables in screening series; and modern chemical instrumentation as applied to coatings.

"Conformal Coatings" is designed for those involved in the use, formulation, se-

lection, manufacture, or sales of conformal coatings used in electronics. Subject matter includes: selection of criteria needed for proper circuit protection; quality control needs; compatibility of board and components with the coating; performance limitations of each resin type; application of the coating to the board; curing or drying for the coating; masking and demasking; and when should the board be coated.

The "Physical Testing" course is devised to improve quality control protocol for paints and coatings. The course benefits those working in quality assurances for coatings or raw materials, a newcomer to the paint industry in a quality control lab, those supervising or who expect to supervise a quality control lab, and purchasing

agents/quality control for large volume end users.

In addition, the UMR fall coatings short course schedule has been announced. The courses and dates are as follows: "Estimating for Painting Contractors and Maintenance Engineers"—September 5-7; "57th Introductory Short Course—The Basic Composition of Coatings"—September 12-16; "17th Introductory—Paint Formulation"—October 3-7; and "Introduction to Polymer Chemistry"—October 31-November 4.

For more information, write the Coatings and Polymer Science Program, Dept. of Chemistry, University of Missouri-Rolla, Rolla, MO 65401-0249.

George R. Pilcher Scheduled as Keynote Speaker At Washington Paint Technical Group Symposium

"Problems-Solutions-Results" is the theme of the 28th Annual Symposium sponsored by the Washington Paint Technical Group, Washington, D.C., at the Marriott Twin Bridges Hotel, on April 11-12, 1988.

Papers in four sessions will focus on this theme, covering topics on the latest research being conducted to solve problems, existing VOC problems, use of computers, and problems and solutions for handling hazardous and toxic materials.

The keynote speaker will be George R. Pilcher, of Hanna Chemical Coatings Co. Mr. Pilcher's presentation will center on "Chemical Coatings in the 80's: Trials, Tribulations and Triumphs."

Technical sessions and speakers scheduled for April 11 include: "Problems Associated with Removal of Lead-Based Paints on Bridges"—Tom Neal, of the Virginia Department of Transportation; "Antifouling Paint—Reformulating Formula 121"—Karen Poole, of David Taylor Research Center; "OSHA Maritime Painting Standards—Update"—Susan Herbert, of the U.S. Department of Labor, OSHA; current regulatory topic—NPCA representative; "Environmental and Electrochemical Test Methods for the Evaluation of Protective Organic Coatings"—Abbie Alavi, of Sherwin-Williams Co.; "Coating Problems Regarding Historic Structures and Objects"—Nick Veloz, of National Park Service; "Effects of Weathering and Acid Rain on Performance of Coatings on Wood"—Sam Williams, William C. Feist, and Jerry

Winandy, of Forest Products Laboratory; "Application of FTIR for Characterization and Degradation Studies of Protective Coatings on Steel"—Tinh Nguyen, of the National Bureau of Standards; and "Effect of Surface Contamination on Performance of Coatings on Steel"—Gerald Soltz, of GCS, Inc.

The slate for April 12 is: "What's New or Expected in Environmental VOC Regulations"—Richard G. Rhoads, of EPA; "NAVSEA Policy for Meeting VOC Regulations"—Mike Chan, of NAVSEA Systems Command; "Transfer Efficiency Regulations"—Eugene Prashan, of General Motors; "Review of VOC Measurements—U.S. EPA RM 24"—Hiro Fujimoto, of Immont Corp.; "DoD Policy for Meeting VOC Regulations in Facilities Painting"—Bruce Flowers, of NAVFAC Engineering Command; "Condition Assessment of Existing Coatings Using Computer Image Processing"—Jonathan Martin, of the National Bureau of Standards; "Specifications on Laser Disk/Read Only Memory"—Roger Seaman, of U.S. Army, Office, Chief of Engineers; "Computer-Based Expert Systems for Use in Engineering, Design and Manufacturing"—Peter Brown, of the National Bureau of Standards; and "Using PC's for Preparing Painting Contracts"—Armand Herraras, of The Problem Solver.

For further information, contact Mary E. McKnight, Program Chairwoman, at (301) 975-6714.

Kent State Univ. Presents Dispersion Course, May 9-13

Kent State University, Kent, OH, will be offering the course "Dispersion of Pigments and Resins in Fluid Media," on May 9-13. The program is designed especially for individuals in the coatings and polymer industries interested in the chemistry and mechanics of dispersion and stabilization of particulates in fluids.

Lecturers include both academic and industrial scientists who will discuss the surface chemistry and physics relative to dispersion, selection of dispersants for various pigments, methods for measuring size of dispersed particles, and means of measuring quality of the dispersion.

The mechanics of dispersion will relate to pigments, resins, and latexes in classic solvent and water media. Dispersion equipment and its proper selection will be presented during the last portion of the course. The use of mixers, ball and pebble, horizontal, sand, and related small media mills are among those that will be discussed.

For more information, contact Carl J. Knauss, Chemistry Dept., Kent State University, Kent, OH 44242.

SSPC Conference and Expo Scheduled for Nov. 13-17; Convention to Feature Seminars and Tutorials

Over 140 suppliers of materials and services for the protective coatings industry are expected to exhibit as part of the Steel Structures Painting Council (SSPC) National Conference and Exposition, on November 13-17, at the Baltimore Civic Center, Baltimore, MD.

The symposium's theme is "The Economics of Protective Coating Systems for Structures." The SSPC is seeking abstracts for papers on this topic. Papers should identify the cost and effectiveness of various coating systems and strategies.

Technical seminars will be held on the following topics: water and waste treatment, painting galvanized steel, coatings for concrete, bridge coatings forum, low VOC coatings, regulations and litigation, repair of lining systems, coatings for power generation facilities, and research and development. Seminars consist of four/five informal papers and a panel discussion.

Tutorials (sessions designed to educate those who attend on various aspects of topics associated with protective coatings) under consideration include: developing applicator training programs, establishing and managing a corporate maintenance painting program, conducting laboratory and field coating evaluations, developing inspection programs, and estimating painting and coating costs.

To further the SSPC's work for the protective coatings industry, approximately 25 SSPC technical committees will address the need for standards and guides in areas such as surface preparation, application,

coating materials, and methods for improved performance.

For more information, write SSPC, 4400 Fifth Ave., Pittsburgh, PA 15213.

CALL FOR PAPERS

"The Economics of Protective Coating Systems for Structures" Steel Structures Painting Council

November 13-17, 1988
Baltimore Civic Center
Baltimore, MD

The Steel Structures Painting Council (SSPC) is currently seeking papers for presentation at the SSPC National Convention on November 13-17, in Baltimore, MD. The SSPC is searching for papers on such issues as initial costs, lifetime costs, and degrees of effectiveness of protective coating systems and strategies.

Possible topics include the economics of surface preparation and application procedures (alternate techniques and equipment, and new recovery and recycling systems), alternate cost-effective coating materials (one-coat systems, and low-solvent, surface-tolerant, and high technology coatings), economic strategies for new construction and maintenance (single source responsibility, full shop application, corporate coatings programs, and estimating coating lifetimes), and cost-effectiveness of inspection and quality control (training and certification programs, and evaluation and inspection procedures).

Submit a title and brief abstract no later than April 1 to Gary Tinklenberg, 1988 Symposium Chairman, SSPC, 4400 Fifth Ave., Pittsburgh, PA 15213.

Southern Society Hosts 52nd Annual Meeting: Focuses on "Managing Quality," April 13-15

The Southern Society for Coatings Technology will hold its 52nd annual meeting at The Omni at Charleston Place, Charleston, SC, on April 13-15. Highlighting the meeting will be technical presentations focused on the theme, "Managing Quality—The New Frontier."

To introduce this topic, a Keynote Address will be presented by J.R. Desjardins, President and Executive Officer of Devoe & Reynolds, Louisville, KY. He will discuss "Quality." Additional presentations include "Managing in a Competitive Industry," by Ron Hiltunen, of the Tennessee Valley Authority and "Applying Statistical Process Control to Coating Manufacturing," by Dr. Peter Hunt, Management Consultant.

Federation President Deryk R. Pawsey and Executive Vice-President Robert F. Ziegler also will address participants.

Special events planned include tennis and golf outings scheduled for Wednesday,

April 13; Spouses' Program for Thursday, April 14 and Friday, April 15; and a Harbor Cruise and Dinner on Friday.

Delta Airline will offer a savings of up to 70% for registrants using their services. When making reservations, call 1-800-241-6760 and immediately reference the

file number U0523. Taxi and limousine service will be available from Charleston Airport to The Omni at Charleston Place.

For additional registration information, contact Ken Espeut, 920 Springville Court, Tampa, FL 33613.

Pittsburgh Society Schedules Seminar, Apr. 11

The Pittsburgh Society will hold a half-day seminar on hazardous waste legislation and minimization on April 11, at the Sheraton Hotel, Station Square, in Pittsburgh. The seminar, intended to help provide information to paint companies and their customers, will cover such topics as federal and state hazardous waste laws, compliance and noncompliance situations, hazardous waste minimization strategies, and waste treatment technologies.

The seminar is scheduled to coincide with the monthly meeting of the Society and seminar registrants are invited to attend the evening meeting. Robert Foreman, Director of Governmental Affairs for the NPCA, is the scheduled speaker for the Society meeting.

Additional information may be obtained by contacting Richard Marci, Royston Laboratories, Inc., 128 First St., Pittsburgh, PA 15238.

George Brown College Features Courses In Chemical Technician-Coatings

George Brown College of Applied Arts and Technology, Toronto, Ont., is currently conducting evening and Saturday part-time courses in coatings and plastics technology at the St. James campus, convenient to downtown Toronto.

The courses are approved and certified jointly by George Brown College and the Toronto Society for Coatings Technology. The courses are designed to be taken separately with accumulated credits going toward the Chemical Technician Coatings Certificate.

Courses of interest being offered include: "Polymer Chemistry," "Organic Coatings," "Coatings Laboratory," "Resins—C," and "Paint Flow and Pigment Dispersion."

The course in "Polymer Chemistry" features the classification of polymers, the functionality molecular weight theory and its distribution, configurations and conformations of polymer chains, morphology, polymerization conditions, addition-condensation polymerization, copolymerization, degradation, stabilization, and prop-

erties of polymers, polymer solutions, and solvent-pigment-binder interactions.

"Organic Coatings" focuses on raw materials including: oils, resins, solvents, driers, additives, and prime and extender pigments. The course also highlights the formulation and properties of organic coatings.

Quality control of raw materials, preparation and evaluation of lacquers, varnishes, and water-borne coatings, and report writing are the scope of the "Coatings Laboratory" course.

The course on "Resins—C" is a study of the raw materials, manufacturing methods, chemistry, film formation, properties and the uses of lacquers, hydrocarbon, phenolic, amino, silicone, and water-borne resins in coatings.

The "Paint Flow and Pigment Dispersion" course deals with the viscosity viscometer, interconversion of viscosity units, factors affecting viscosity, brushing, leveling, sagging, and settling. Pigment dispersion using the ball and pebble mill, sand mill, attritor, three-roll mill, and high

speed disperser are discussed. The assessment of pigment dispersion, and millbase and let down stages are also studied.

George Brown College offers other courses during the first year of the Chemical Technician—Coatings Program including: "Inorganic Chemistry," "Organic Chemistry," "Analytical Chemistry," "Industrial Plant Tours," "Inorganic Chemistry Lab," "Organic Chemistry Lab," and "Analytical Chemistry Lab."

During the second year of the program, "Resins—A," "Principles of Color Technology," "Industrial Plant Tours," "Resins—A Lab," "Resins—C Lab," "Polymer Chemistry Lab," and the "Paint Flow and Pigment Dispersion Lab" may be taken.

Exemptions may be granted to students who have completed the same or equivalent courses at other educational institutions.

For further information, contact P. Rodak, George Brown College of Applied Arts and Technology, St. James Campus, 200 King St. E., P.O. Box 1015, Station B, Toronto, Ont., Canada M5T 2T9.

Paints, Coatings and Inks

**Whatever your need
R & D, Production & Product Evaluation, Failure Analysis,
Specification Testing. . .**

We provide the following professional technical services:

Product Development

New product development and existing product enhancement to help increase your market penetration.

Production Improvement

Solve your problems to increase your profitability.

Failure Analysis

Investigate the cause of failure with the assistance of a wide range of instrumentation.

Rapid Turnaround

Meeting your expectation is our priority.

Business Integrity

All work is performed in strict confidence. All new technology is assigned to the client.

Complementary Capabilities

Laboratories specializing in adhesives, sealants and polymer chemistry.

Quality

Projects are carried out by technical professionals using state-of-the-art equipment.

**For an initial, no obligation consultation,
please contact:
Dr. John Flack**

Ontario Research Foundation
Sheridan Park Research Community
Mississauga, Ontario L5K 1B3

Telephone (416) 822-4111
or 1-800-268-5390 (in Canada only)

Canada's Largest Independent Contract Research Organization

ONTARIO RESEARCH
FOUNDATION

Literature

Glycol Ethers

A new brochure provides an overview of the applications of glycol ethers in solvent-based coatings. The brochure includes individual data sheets which contain useful information such as physical properties, resin solubility, and evaporation rates. The publication also includes information on an interactive computer service which offers a solvent modeling program to assist customers in reformulating solvent blends. For a copy of "Advance Technology for Solvent-Based Coatings," write Chemicals & Metals, The Dow Chemical Co., 2020 Willard H. Dow Center, Midland, MI 48674.

Paint Testing Instruments

A 92-page catalog describes 40 new instruments including wet film applicators, wet and dry film thickness gauges, glossmeters, a pencil hardness gauge, hot plate/stirrers, mixers, and circular chart recorders for temperature and humidity. For a copy of the catalog, write Paul N. Gardner Co., Inc., P.O. Box 10688, Pompano Beach, FL 33061-6688.

UV Curing Agent

A new UV curing agent, a photoinitiator developed especially for pigmented systems, is the topic of a product bulletin. The photoinitiator can be used alone or in combination with a suitable coinitiator, such as thioxanthenes or amines, for UV-curable inks and varnishes for application on paper, metal, or plastic materials. For more information on Irgacure® 907, write Coatings, Radiation Curing and Photography Group, Additives Dept., CIBA-GEIGY Corp., Ardsley, NY 10502.

Software Module

Literature introduces a new software module which will project material, container, production, equipment, and manpower requirements based on sales and production forecasts. The forecast can cover up to three periods and its profitability analysis determines which product(s) contribute most to overall sales and margin. For a free demonstration of the Planning Subsystem, write Pacific Micro Software Engineering, 6511 Salt Lake Ave., Bell, CA 90201.

Low Volatile Alcohols

A new line of alcohols has been introduced in a technical bulletin. The alcohols can be of use for formulators of products such as lubricants, specialty surfactants, and personal care products. The low volatile alcohols are liquid at temperatures as low as -69°F and exhibit lubricity and emolliency. For details on Exxal® Guerbet Alcohols C16 and C20, write Exxon Chemical Co., Dept. L3-314, P.O. Box 3272, Houston, TX 77253-3272.

Epoxy Primer

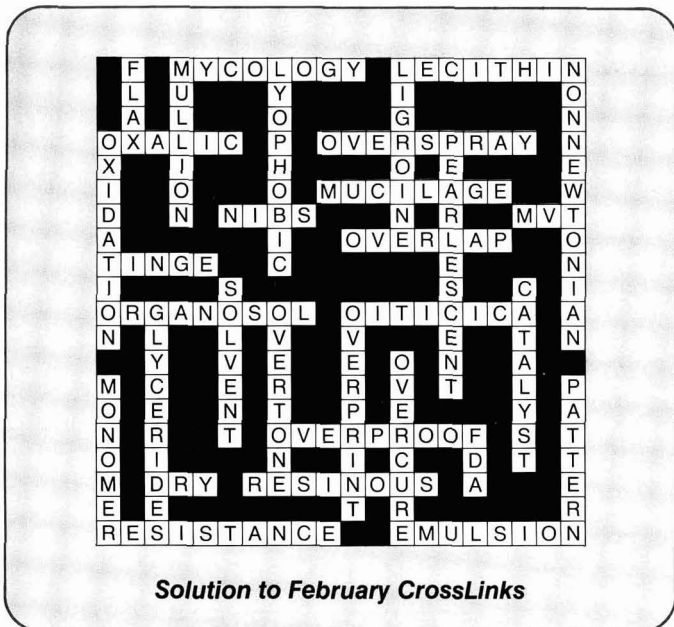
A two-component, zinc-rich epoxy primer which can be topcoated after only 30 minutes air dry at standard cure conditions of 72°F and 50 ± 5% relative humidity is the subject of a data sheet. The primer is approved to MIL-P-26915B, Class I, Type B and to USAF Drawing 7545352, Revision N. For more information on primer 10-P3-2, contact Janet Hurley, Crown Metro Aerospace Coatings, Inc., P.O. Box 5695, Greenville, SC 29606.

Electrophoresis

A full literature package details a complete line of electrophoresis systems, equipment, and supplies. Each specification sheet in the package describes, in detail, each piece of electrophoresis equipment and available systems. For more data, contact Loretta Scheel or Mary J. Greenway, Haake Buchler Instruments, Inc., 244 Saddle River Rd., Saddle Brook, NJ 07662-6001.

Chemicals and Plastics

A new, 16-page brochure details a complete line of chemical and plastic products as well as extensive technology and development and support services. Highlighted in the guide are oxygenates, industrial and specialty chemicals for merchant markets, expandable polystyrene resins, specialty moldable foams for packaging and cushioning applications, and engineering resins. Also described are technology and development facilities along with sales, customer, technical, and distribution services. A copy of the "Product Guide" is available from ARCO Chemical Co., Marketing Communications Dept., 3801 West Chester Pike, Newtown Square, PA 19073.



Aromatic Amine Hardener

A product bulletin features an aromatic amine epoxy resin hardener which provides physical properties very similar to methylene dianiline-based hardeners. The hardener also has low viscosity (400-1000 Cps at 25°C) and is nonstaining. For more details on Epotuf® 95-447, write Epoxy Technical Service, Reichhold Chemicals, Inc., Chemical Coatings Div., P.O. Box 1433, Pensacola, FL 32596.

Corrosion Software

Two software products which provide data search capability and give the user a selection of corrosion performance, concentration, and temperature limits are the topic of technical literature. The software features graphical and tabular formats, hard copy output, transference of data to an ASCII file for use with other software, and IBM compatibility. For details on Cor*Sur™ and Cor*Sur2,™ contact Sheila T. Brann, Marketing Coordinator, Technical Services Div., NACE, P.O. Box 218340, Houston, TX 77218.

Standards Catalog

A catalog describes the 67 volumes in the 1988 "Annual Book of ASTM Standards." For a copy of the catalog, contact Jackie Nolden, ASTM, 1916 Race St., Philadelphia, PA 19103.

Flexible Epoxy Resin

An internally modified flexible epoxy resin which features adhesion properties is the subject of a product bulletin. The resin possesses low viscosity (1000 cP at 25°C) and is suited for use in solventless and high solids coatings requiring combinations of toughness, versatility, corrosion, and abrasion resistance. To receive a sample and a laboratory data sheet with extensive formulations testing results of Epoxy Resin XB 4122, write CIBA-GEIGY Corp., Three Skyline Dr., Hawthorne, NY 10532.

Coating Thickness Gauge

Literature details a coating thickness gauge which can be programmed to accommodate various sizes and configurations of probes. The gauge measures any nonferrous coating over either a ferrous or nonferrous metal substrate. A technical product brochure on the Minitest 3000, along with a brochure highlighting over 70 coating inspection instruments, is available from KTA-Tator, Inc., 115 Technology Dr., Pittsburgh, PA 15275-1085.

Mechanical Spectrometer

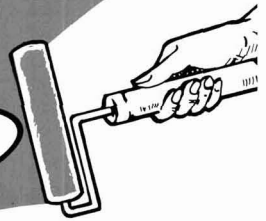
Literature highlights an extended temperature range mechanical spectrometer which is ambient to 500°C. The spectrometer provides comprehensive capabilities for rheological characterization of a material's linear viscoelastic behavior, suitable for fundamental research as well as in product and process development. For additional features on the RMS-800, contact Jason Livneh, Rheometrics, Inc., One Possumtown Rd., Piscataway, NJ 08854.

Wet Film Thickness Gauge

A product bulletin describes a hexagonal shaped wet film thickness gauge which can be used for measuring wet film thickness of paints, enamels, lacquers, varnishes, adhesives, and many other coatings. The reusable, aluminum gauge has a wet measuring range of 1-80 mils and from 25 to 2000 microns. For more facts on the Model 395/181 gauge, contact Frank Rueter, Marketing Mgr., Zorelco Ltd., P.O. Box 25500, Dept. H-19, Cleveland, OH 44125-0500.

For multi-purpose
surfactants in water based
and water reducible
coatings
choose-

dexter



STRODEX PK-90
STRODEX PK-95G
STRODEX PK-80A
STRODEX SEK-50

STRODEX MOK-70
STRODEX PSK-28
STRODEX MRK-98
STRODEX P-100

DEXTROL OC-50

Dexter surfactants are being successfully and widely used for the many and exceptional benefits they provide, among them

- improved gloss
- enhanced color acceptance
- increased package stability
- rust inhibition
- reduced blocking
- and other valuable advantages offered by their strong wetting and dispersing properties.

Write or call for complete details and samples:

dexter Chemical Corporation

845 Edgewater Rd., Bronx, N.Y. 10474, (212) 542-7700 • Telex 127061

Coming Events

FEDERATION MEETINGS

For information on FSCT meetings, contact FSCT, 1315 Walnut St., Philadelphia, PA 19107 (215-545-1506).

1988

(Mar.)—Federation Seminars on Statistical Process Control. Level I: Mar. 4-5, Mexico City, Mexico; Mar. 14-15, Philadelphia Airport Marriott, Philadelphia, PA; Mar. 21-22, Chicago O'Hare Marriott, Chicago, IL; and Mar. 28-29, Cleveland Airport Marriott, Cleveland, OH. Level II: Mar. 16-18, Philadelphia Airport Marriott; Mar. 23-25, Chicago O'Hare Marriott.

(May-June)—Federation Seminars on "Project Management for the Coatings Chemist." May 9-10, Nordic Hills Resort & Conference Center, Itasca, IL; June 6-7, Holiday Inn-International Airport, S. San Francisco, CA; June 13-14, Orlando Marriott, Orlando, FL; and June 20-21, Days Inn, Airport, Philadelphia, PA.

(May 17-20)—Federation "Spring Week." Seminar on the 17th and 18th; FSCT Society Officers Meeting on the 19th; FSCT Board of Directors Meeting on the 20th. Orlando Marriott Hotel, Orlando, FL.

(Oct. 19-21)—66th Annual Meeting and 53rd Paint Industries' Show. McCormick Place, Chicago, IL.

1989

(Nov. 8-10)—67th Annual Meeting and 54th Paint Industries' Show. Rivergate, New Orleans, LA.

1990

(Oct. 19-21)—68th Annual Meeting and 55th Paint Industries' Show. Convention Center, Washington, D.C.

SPECIAL SOCIETY MEETINGS

1988

(Mar. 16-18)—Southwestern Paint Convention of Dallas and Houston Societies. Hyatt Regency Hotel, Houston, TX. (J. Harrell, Buckman Labs., 5127 Wightman Ct., Houston, TX 77069).

(Apr. 5)—"Creative Management With A Personal Touch." Management Workshop. Chicago Society and Chicago Paint and Coat-

When you need a pigment extender, you need GENSTAR.

CAMEL-WITE® & CAMEL-WITE SLURRY® The industry standard. Exceptionally white, fine particle size, wet-ground product produced from high-grade calcite limestone.

CAMEL-TEX® Fine ground general purpose grade of calcium carbonate produced from extremely white Calcite. Low vehicle demand, rapid dispersibility.

CAMEL-CARB® A quality extender that's economically priced. Produced from white Calcite. Provides uniform low vehicle demand, good color, high brightness.

CAMEL-CAL® & CAMEL-CAL SLURRY® New from Genstar. Ultra-fine ground calcite limestone with extender efficiency and hiding power of precipitated calcium carbonate.

GENSTAR

Genstar Stone Products
Hunt Valley, Md. 21031

ings Association. Knickers Restaurant, Des Plaines, IL. [Jerry Cuca, (312) 736-1800].

(Apr. 11)—Pittsburgh Society Seminar on Hazardous Waste Legislation and Minimization. Sheraton Station Square, Pittsburgh, PA. (R. Marci, Royston Laboratories, Inc., 128 First St., Pittsburgh, PA 15238).

(Apr. 13-15)—Southern Society. Annual Meeting. Omni Hotel, Charleston, SC. (Scott McKenzie, Southern Coatings Co., P.O. Box 160, Sumter, SC 29150).

(Apr. 19)—Detroit Society. 13th Annual FOCUS Conference. "International Trends in Automotive Coatings." Management Education Center, Troy, MI.

(Apr. 28-30)—Pacific Northwest Society. Annual Symposium. Hotel Vancouver, Vancouver, B.C., Canada. (Yvon Poitras, General Paint Corp., 950 Raymur Ave., Vancouver, B.C., Canada V6A 3L5).

(May 2)—Philadelphia Society Seminar, "Computers and the Paint Plant—From Formulation through Production." Airport Hilton, Philadelphia, PA. (Donald Denny, E.W. Kauffman Co., P.O. Box 529, Southampton, PA 18966.)

(May 11-12)—New England Society. 1988 Tech Expo. Sheraton Boxborough Hotel, Boxborough, MA. (G. Pollano, Polyvinyl Chemicals, 730 Main St., Wilmington, MA 01887).

(June 1-2)—Cleveland Society. 31st Annual Conference on Advances in Coatings Technology. John Carroll University, Cleveland, OH.

(June 9-11)—Rocky Mountain Society. Paint and Coatings Symposium. Vail, CO. (Dick Mullen, G-3 Industries, 17554 E. Bellevue Place, Aurora, CO 80015).

(June 10-12)—Joint meeting of St. Louis and Kansas City Societies. Holiday Inn, Lake of the Ozarks, MO.

1989

(Mar. 13-15)—Western Coatings Societies Symposium and Show. Disneyland Hotel, Anaheim, CA. (Andy Ellis, NL Industries, Inc., 200 N. Berry St., Brea, CA 92621).

(Apr. 5-7)—Southern Society. Annual Meeting. Hyatt Regency Westshore, Tampa, FL.

OTHER ORGANIZATIONS

1988

(Mar. 14-17)—"Spray Applications for Furniture Finishing" Seminar followed by workshop, sponsored by Society of Manufacturing Engineers. High, N.C. (Jody Pickens, SME, Professional Education Dept., One SME Dr., P.O. Box 930, Dearborn, MI 48121).

(Mar. 14-18)—"16th Introductory—Paint Formulation." Course sponsored by the University of Missouri-Rolla, Rolla, MO. (Coatings and Polymer Science Program, Dept. of Chemistry, UMR, Rolla, MO 65401-0249).

(Mar. 16-17)—Regional "Color and Appearance" Seminar sponsored by HunterLab. Dallas, TX. (Hunter Associates Laboratory, Inc., 11491 Sunset Hills Rd., Reston, VA 22090).

(Mar. 17-18)—"The Fundamentals of Color" Seminar sponsored by Macbeth, a division of Kollmorgen Corp. Bloomington, MN. (Jeanne Dolan or Karen Degnan, Macbeth, Little Britain Rd., P.O. Box 230, Newburgh, NY 12550-0382).

(Mar. 21-24)—Spring National Plant Engineering & Maintenance Show and Conference. Sponsored by the Plant Engineering and Maintenance Division of the American Society of Mechanical Engineers. McCormick Place North, Chicago, IL. (Show Manager, Spring National Plant Engineering & Maintenance Show & Conference, 999 Summer St., Stamford, CT 06905).

(Mar. 21-25)—Corrosion '88 sponsored by the National Association of Corrosion Engineers. Cervantes Convention & Exhibition Center, St. Louis, MO. (Allison Mayer, NACE Exhibits Dept., P.O. Box 218340, Houston, TX 77218).

(Mar. 22)—Color and Appearance Seminar. Sponsored by Pacific Scientific. Marriott at Perimeter Center, Atlanta, GA. (Paul Barnes, Pacific Scientific, 2431 Linden Lane, Silver Spring, MD 20910).

(Mar. 24)—Color and Appearance Seminar. Sponsored by Pacific Scientific. Charlotte Marriott Executive Park, Charlotte, NC.

(Paul Barnes, Pacific Scientific, 2431 Linden Lane, Silver Spring, MD 20910).

(Mar. 26-27)—Western Decorating Products Show sponsored by the National Decorating Products Association. Brooks Hall, San Francisco, CA. (Lillian Smysor, NDPA, 1050 N. Lindbergh Blvd., St. Louis, MO 63132-2994).

(Mar. 28-29)—"New Specialty Polymer Products Through Interpenetrating Polymer Network (IPN) Technology" Seminar sponsored by Technomic Publishing Co., Inc. Colony Square Hotel, Atlanta, GA. (Lisa Shirk, Program Div., Technomic Publishing Co., Inc., 851 New Holland Ave., Box 3535, Lancaster, PA 17604).

(Mar. 29-31)—"Engineering for Electroplating." Seminar sponsored by Products Finishing magazine. Sheraton at Bradley International, Windsor Locks, CT. (Julianne Hall, Products Finishing, 6600 Clough Pike, Cincinnati, OH 45244-4090).

(Mar. 30-31)—Regional "Color and Appearance" Seminar sponsored by HunterLab. Denver, CO. (Hunter Associates Laboratory, Inc., 11491 Sunset Hills Rd., Reston, VA 22090).

(Apr. 4-5)—"The Fundamentals of Color" Seminar sponsored by Macbeth, a division of Kollmorgen Corp. Grand Rapids, MI. (Jeanne Dolan or Karen Degnan, Macbeth, Little Britain Rd., P.O. Box 230, Newburgh, NY 12550-0382).

(Apr. 5-8)—Fabtech East Conference and Exposition. Sponsored by the Society of Manufacturing Engineers (SME) and the American Fabricating Institute of Technology (AFIT). Baltimore Convention Center, Baltimore, MD. (Jean Schroeder or Dave Kanagy, AFIT, 5411 E. State St., Rockford, IL 61108 or Dale Mason or Darcy Cliff-Coon, SME, One SME Drive, P.O. Box 930, Dearborn, MI 48121).

(Apr. 6-7)—"Formulating Urethane Foams" Seminar sponsored by Technomic Publishing Co., Inc. Colony Square Hotel, Atlanta, GA. (Lisa Shirk, Program Div., Technomic Publishing Co., Inc., 851 New Holland Ave., Box 3535, Lancaster, PA 17604).

(Apr. 9-10)—Eastern Decorating Products Show sponsored by the National Decorating Products Association. World Trade Center, Boston, MA. (Lillian Smysor, NDPA, 1050 N. Lindbergh Blvd., St. Louis, MO 63132-2994).

(Apr. 9-13)—National Coil Coaters Association Annual Meeting. Marriott's Rancho Las Palmas, Palm Springs, CA. (NCCA, 1900 Arch St., Philadelphia, PA 19103).

(Apr. 11-12)—28th Annual Symposium sponsored by the Washington Paint Technical Group. Marriott Twin Bridges Hotel, Washington, D.C. (Mildred A. Post, Publicity Chairwoman, Washington Paint Technical Group, P.O. Box 12025, Washington, D.C. 20005).

(Apr. 11-12)—"The Fundamentals of Color" Seminar sponsored by Macbeth, a division of Kollmorgen Corp. Neenah, WI. (Jeanne Dolan or Karen Degnan, Macbeth, Little Britain Rd., P.O. Box 230, Newburgh, NY 12550-0382).

(Apr. 13-14)—Regional "Color and Appearance" Seminar sponsored by HunterLab. Cleveland, OH. (Hunter Associates Laboratory, Inc., 11491 Sunset Hills Rd., Reston, VA 22090).

(Apr. 13-14)—ASTM Coordinating Committee on Flash Point. API, Washington, D.C. (Earl Sullivan, 1916 Race St., Philadelphia, PA 19103).

(Apr. 13-15)—"Radiation Curing." Course sponsored by The Center for Professional Advancement. San Mateo, CA. (The Center for Professional Advancement, 46 W. Ferris St., East Brunswick, NJ 08816).

(Apr. 18-20)—"Conformal Coatings." Course sponsored by the University of Missouri-Rolla, Rolla, MO. (Coatings and Polymer Science Program, Dept. of Chemistry, UMR, Rolla, MO 65401-0249).

(Apr. 18-20)—ASTM Committee B-8 on Metallic and Inorganic Coatings. ASTM Headquarters, Philadelphia, PA. (Peggy Loughran, 1916 Race St., Philadelphia, PA 19103).

(Apr. 20-21)—Regional "Color and Appearance" Seminar sponsored by HunterLab. Minneapolis, MN. (Hunter Associates Laboratory, Inc., 11491 Sunset Hills Rd., Reston, VA 22090).

(Apr. 20-27)—Surface Treatment '88 at Hannover Fair Industry '88. Hannover Fairgrounds, Hannover, W. Germany. (Joachim Schafer, Hannover Fairs USA Inc., 103 Carnegie Center, P.O. Box 7066, Princeton, NJ 08540).

(Apr. 24-28)—RadTech '88. New Orleans Fairmont Hotel, New Orleans, LA. (John Waxman, Director of Conferences and Exhibits,



Do your plastics and paints withstand sunlight ?

SUNTEST can help you provide for long lasting surface quality !

SUNTEST, the desk top "XENON-ARC" light and weatherfastness tester, enables you to check the quality of your products

- easily anywhere and at low cost
- with excellent correlation to sunlight
- in short testing times

today, more than ever, international success depends on **quality**

United States Representatives: DSET Laboratories, Inc.

SUNTEST - Your way to quality



COUPON

-
- Please call for an appointment
- Please send us more information on your SUNTEST equipment

Name _____

Company _____

Street _____

City, State, ZIP _____

Phone _____

Please send inquiries to: Heraeus Inc. Equipment Division
18662 Mac Arthur Blvd. Suite 200
Irvine, California 92715

Heraeus



Product Division Original Hanau

RadTech International, 60 Revere Dr., Suite 500, Northbrook, IL 60062).

(Apr. 25-26)—"Advances in Polyurethanes—Elastomers & Coatings, Adhesives & Sealants" Seminar sponsored by Technomic Publishing Co., Inc. Colony Square Hotel, Atlanta, GA. (Lisa Shirk, Program Div., Technomic Publishing Co., Inc., 851 New Holland Ave., Box 3535, Lancaster, PA 17604).

(Apr. 26-27)—"Innovations with Plastic Films Technology" Seminar sponsored by Technomic Publishing Co., Inc. Colony Square Hotel, Atlanta, GA. (Lisa Shirk, Program Div., Technomic Publishing Co., Inc., 851 New Holland Ave., Box 3535, Lancaster, PA 17604).

(Apr. 26-28)—Aluminum Finishing '88 Conference sponsored by Products Finishing Magazine. Drawbridge Inn, Greater Cincinnati Airport area, OH. (Aluminum Finishing '88, c/o Products Finishing, 6600 Clough Pike, Cincinnati, OH 45244-4090).

(Apr. 28)—Color and Appearance Seminar. Sponsored by Pacific Scientific. Toronto Airport Marriott, Toronto, Ont., Canada. (Paul Barnes, Pacific Scientific, 2431 Linden Lane, Silver Spring, MD 20910).

(May 2-4)—International Seminar sponsored by the Ford Motor Co. Dearborn, MI. (A. Golovoy, Ford Motor Co., Box 2053/SRL 3198, Dearborn, MI 48121).

(May 4-5)—Regional "Color and Appearance" Seminar sponsored by HunterLab. Boston, MA. (Hunter Associates Laboratory, Inc., 11491 Sunset Hills Rd., Reston, VA 22090).

(May 8-10)—Inter-Society Color Council Annual Meeting. Sheraton Inner Harbor Hotel, Baltimore, MD. (Paula J. Alessi, 10 Bay Park, Webster, NY 14580).

(May 9-11)—Federation of Scandinavian Paint and Varnish Technologists. 12th Congress, Helsinki, Finland. (Arja Saloranta, Tikkurila Oy, PB 53, SF 01301 Vanda, Finland).

(May 9-11)—"Crosslinked Polymers: Chemistry, Properties and Applications." Course sponsored by the State University of New York at New Paltz. (A.V. Patsis, Chemistry Dept., State University of New York, New Paltz, NY 12561).

(May 9-13)—"Dispersion of Pigments and Resins in Fluid Media." Course sponsored by Kent State University, Kent, OH. (Carl J. Knauss, Chemistry Dept., Kent State Univ., Kent, OH 44242).

(May 10)—Color and Appearance Seminar. Sponsored by Pacific Scientific. St. Louis Airport Marriott, St. Louis, MO. (Paul Barnes, Pacific Scientific, 2431 Linden Lane, Silver Spring, MD 20910).

(May 10-12)—"Process Safety Management" Seminar sponsored by Du Pont Co., Wilmington, DE. (Du Pont Safety Services, Barley Mill Plaza, P19-1104, Wilmington, DE 19898).

(May 11-13)—"Radiation Curing." Course sponsored by The Center for Professional Advancement. Chicago, IL. (The Center for Professional Advancement, 46 W. Ferris St., East Brunswick, NJ 08816).

(May 12)—Color and Appearance Seminar. Sponsored by Pacific Scientific. Hyatt Regency Memphis, Memphis, TN. (Paul Barnes, Pacific Scientific, 2431 Linden Lane, Silver Spring, MD 20910).

(May 12-13)—Third International Symposium on "Theory and Trends in Electrostatic Painting Technology." Sponsored by The University of Western Ontario and the University of Southampton. Toronto, Ont., Canada. (I.I. Inculat, Director, Applied Electrostatics Research Centre or Jacquie Taylor, Dept. of Electrical Engineering, The University of Western Ontario, Faculty of Engineering Science, London, Ont., Canada N6A 5B9).

(May 16-17)—"The Fundamentals of Color" Seminar sponsored by Macbeth, a division of Kollmorgen Corp. Cherry Hill, NJ. (Jeanne Dolan or Karen Degnan, Macbeth, Little Britain Rd., P.O. Box 230, Newburgh, NY 12550-0382).

(May 16-20)—"Physical Testing of Paints and Coatings." Course sponsored by the University of Missouri-Rolla, Rolla, MO. (Coatings and Polymer Science Program, Dept. of Chemistry, UMR, Rolla, MO 65401-0249).

(May 17-18)—"Markets and Technologies of Specialty High Performance Elastomers" Seminar sponsored by Technomic Publishing Co., Inc. Colony Square Hotel, Atlanta, GA. (Lisa Shirk,

Program Div., Technomic Publishing Co., Inc., 851 New Holland Ave., Box 3535, Lancaster, PA 17604).

(May 17-19)—"Advances in Medical Plastics" Seminar sponsored by Technomic Publishing Co., Inc. Holiday Inn North, Newark International Airport, Newark, NJ. (Lisa Shirk, Program Div., Technomic Publishing Co., Inc., 851 New Holland Ave., Box 3535, Lancaster, PA 17604).

(May 18-19)—"Basic Principles: Polymeric Foams, Preparation, Processes and Properties" Seminar sponsored by Technomic Publishing Co., Inc. Colony Square Hotel, Atlanta, GA. (Lisa Shirk, Programs Div., Technomic Publishing Co., Inc., 851 New Holland Ave., Box 3535, Lancaster, PA 17604).

(May 18-20)—"Measurement of Appearance" Workshop sponsored by HunterLab. Sheraton Hotel, Tysons Corner, VA. (Hunter Associates Laboratory, Inc., 11491 Sunset Hills Rd., Reston, VA 22090).

(May 19-20)—"The Fundamentals of Color" Seminar sponsored by Macbeth, a division of Kollmorgen Corp. Boston, MA. (Jeanne Dolan or Karen Degnan, Macbeth, Little Britain Rd., P.O. Box 230, Newburgh, NY 12550-0382).

(May 23-25)—"Radiation Curing" Course sponsored by The Center for Professional Advancement. East Brunswick, NJ. (The Center for Professional Advancement, 46 W. Ferris St., East Brunswick, NJ 08816).

(May 23-27)—"Adhesion Principles and Practice for Coatings and Polymer Scientists." Course sponsored by Kent State University. Kent, OH. (Carl J. Knauss, Chemistry Dept., Kent State Univ., Kent, OH 44242).

(May 24-25)—Regional "Color and Appearance" Seminar sponsored by HunterLab. Charlotte, NC. (Hunter Associates Laboratory, Inc., 11491 Sunset Hills Rd., Reston, VA 22090).

(May 24-26)—"Engineering for Electroplating" Seminar. Sponsored by Products Finishing magazine. Drawbridge Inn, Ft. Mitchell, KY (Cincinnati Airport area). (Julianne Hall, Products Finishing, 6600 Clough Pike, Cincinnati, OH 45244-4090).

(May 25-27)—10th International Conference on "Advances in the Stabilization and Controlled Degradation of Polymers." Sponsored by the State University of New York. Luzern, Switzerland. (Angelos V. Patsis, Director, Materials Research Laboratory, CSB 209, State University of New York, New Paltz, NY 12561).

(May 30-June 1)—Second International Conference on "Cross-linked Polymers." Sponsored by the State University of New York. Luzern, Switzerland. (Angelos V. Patsis, Director, Materials Research Laboratory, CSB 209, State University of New York, New Paltz, NY 12561).

(June 1-2)—Regional "Color and Appearance" Seminar sponsored by HunterLab. Cherry Hill, NJ. (Hunter Associates Laboratory, Inc., 11491 Sunset Hills Rd., Reston, VA 22090).

(June 5-9)—Robots 12/Vision '88 Conference. Sponsored by the Society of Manufacturing Engineers. Cobo Conference/Exhibition Center, Detroit, MI. (Robotic Industries Association, 900 Victors Way, P.O. Box 3724, Ann Arbor, MI 48106).

(June 5-11)—American Chemical Society. 195th National Meeting and Third Chemical Congress of North America. Toronto, Ont., Canada. (B.R. Hodson, ACS, 1155—16th St. NW, Washington, D.C. 20036).

(June 6-10)—19th Annual Short Course "Advances in Emulsion Polymerization and Latex Technology." Sponsored by Lehigh University, Bethlehem, PA. (Mohamed S. El-Aasser, Dept. of Chemical Engineering, Sinclair Lab #7, Lehigh University, Bethlehem, PA 18015).

(June 9)—Color and Appearance Seminar. Sponsored by Pacific Scientific. Hyatt Regency Flint, Detroit, MI. (Paul Barnes, Pacific Scientific, 2431 Linden Lane, Silver Spring, MD 20910).

(June 9-10)—"The Fundamentals of Color" Seminar sponsored by Macbeth, a division of Kollmorgen Corp. Cincinnati, OH. (Jeanne Dolan or Karen Degnan, Macbeth, Little Britain Rd., P.O. Box 230, Newburgh, NY 12550-0382).

(June 13-14)—"The Fundamentals of Color" Seminar sponsored by Macbeth, a division of Kollmorgen Corp. Rexdale, Ontario, Can. (Jeanne Dolan or Karen Degnan, Macbeth, Little Britain Rd., P.O. Box 230, Newburgh, NY 12550-0382).

(June 13-17)—International Conference on Composite Interfaces II. Case Western Reserve University, Cleveland, OH. (Professor H. Ishida, General Chairman, ICCI-II, Dept. of Macromolecular Science, Case Western Reserve University, 10900 Euclid Ave., Cleveland, OH 44106-1727).

(June 13-17)—"Applied Rheology for Industrial Chemists." Course sponsored by Kent State University, Kent, OH. (Carl J. Knauss, Chemistry Dept., Kent State Univ., Kent, OH 44242).

(June 15-16)—Surfex '88. Oil and Colour Chemists' Association. Harrogate International Conference Center, Yorkshire, England. (R.H. Hamblin, OCCA, Priory House, 967 Harrow Rd., Wembley, Middlesex HA0 2SF England).

(June 19-22)—62nd Colloid and Surface Science Symposium. Pennsylvania State University, State College, PA. (R. Nagarajan, 161 Fenske Laboratory, University Park, PA 16802).

(July 11-15)—14th International Conference on "Organic Coatings Science & Technology." Sponsored by the State University of New York. Athens, Greece. (Angelos V. Patsis, Director, Materials Research Laboratory, CSB 209, State University of New York, New Paltz, NY 12561).

(July 14-16)—30th Annual Convention of the Oil and Colour Chemists' Association Australia. The Surfers, Queensland. (D. Corless, SCM Chemicals Ltd., P.O. Box 465, Auburn, NSW 2144, Australia).

(Aug. 8-11)—Color in Environmental Design Symposium sponsored by the International Color Association (AIC). Winterthur Polytechnic, Dept. of Architecture, Winterthur, Switzerland. (Allan Rodrigues, E.I. Du Pont de Nemours & Co., 945 Stephenson Highway, P.O. Box 2802, Troy, MI 48007-2802).

Advertisers Index

BYK CHEMIE	19-20
CIBA GEIGY CORP.	30-31
DANIEL PRODUCTS CO.	36
DEXTER CHEMICAL CORP.	87
DOW CHEMICAL, RESINS DIV.	8-9
ENGELHARD CORP.	35, Cover 3
GENSTAR STONE PRODUCTS CO.	88
GEORGIA KAOLIN CO., INC.	16
W.C. HERAEUS GmbH	90
J.M. HUBER CORP.	11
S.C. JOHNSON & SON	13
KING INDUSTRIES, INC.	33
KMG MINERALS, INC.	80
ONTARIO RESEARCH FOUNDATION	85
POLYVINYL CHEMICALS	14-15
RADCURE SPECIALTIES, INC.	2
ROHM AND HAAS CO.	4-5, 23
SHAMROCK CHEMICALS CORP.	Cover 4
UNION CARBIDE CORP.	Cover 2-1
VELSICOL CHEMICAL CORP.	29

NOTE: The Advertisers' Index is published for the convenience of our readers and as an additional service to our advertisers. The publisher assumes no liability for errors or omissions.

'Humbug' from Hillman

It is hoped that a month has been sufficient time for you to recover from February's Bob Ahlfisms. In the event that you can handle some more of them—he-e-e-ere's Ahlfie—

- I'm tired, someone else will have to screw things up today.
- Theoretically, there's no limit to your ability to slow down.
- Their problem is not implementing technology; it's finding out what technology is.
- Once you're successful, you'll find out just how much help you had.
- Value analysis is a method of lowering quality with a clear conscience.
- It's tough when an engineer has to weigh his sense of good engineering against his need for employment.
- Don't pick up anything you can't carry.
- There comes a time when all you can do is stand there and say, "Isn't this ridiculous?"
- Space is expanding but we don't know what into.

In the newsletter of the ACS Division of Chemical Health and Safety, Dick Kiefer found a quote by Robert Fulghum, which originally appeared in *Church and Public Education*.

All I Ever Needed to Know I Learned in Kindergarten

Most of what I really need to know about how to live, and what to do, and how to be, I learned in kindergarten. Wisdom was not at the top of the graduate school mountain, but there in the sandbox.

These are the things I learned: Share everything. Play fair. Don't hit people. Put things back where you found them. Clean up your own mess. Don't take things that aren't yours. Say you're sorry when you hurt somebody. Wash your hands before you eat. Flush! Warm cookies and cold milk are good for you. Live a balanced life. Learn some and think some and draw and paint and sing and dance and play and work every day some.

Take a nap every afternoon. When you go out into the world, watch for traffic, hold hands, and stick together. Be aware of wonder. Remember the little seed in the plastic cup. The roots go down and the plant goes up and nobody really knows why or how, but we are all like that. Goldfish and hamsters and white mice and even the little seed in the plastic cup—they all die. So do we.

And remember the book about Dick and Jane and the first word you learned, the biggest word of all: LOOK. Everything you need to know is in there somewhere. The Golden Rule and love and basic sanitation. Ecology and politics and sane living.

Think of what a better world it would be if we all—the whole world—had cookies and milk about 3 o'clock every afternoon and then lay down with our blankets for a nap. Or, if we had a basic policy in our nation and other nations to always put things back where we found them and cleaned up our own messes. And it is still true, no matter how old you are, when you go out into the world, it is best to hold hands and stick together.

Humbug's legal mentor, Dr. Barbara Lauren, sent us some quotes from the *ABA Journal*, which still leaves it open to some question as to lawyers' sense of the hilarious.

— A city bus was damaged and there was a hearing to assess the amount of damages. The opposing counsel, during cross examination, showed the mechanic who repaired the bus an unidentifiable close-up of the wreckage.

"Please identify this," the counsel asked. It showed a mess of mangled wires and hydraulic tubing.

After a period of silence, the mechanic said, "Picaso-so?"

* * *

Two lawyers were arguing a personal injury case where a driver struck a pedestrian.

"Your honor," said the driver's attorney, "The man who was injured must have been negligent. My client is an experienced driver of more than 30 years."

"If experience is the issue here," said the other lawyer, "my client has been walking for over 50 years!"

* * *

A judge in New York's Family Court was presiding at a child support hearing. The judge was attempting to ascertain the man's weekly income. He asked the man what he did for a living.

"I'm a cook in a restaurant," the man answered.

The judge asked, "And what do you take home?"

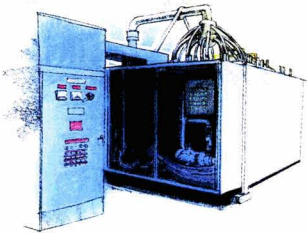
"Oh, some leftovers and soup."

Taxation without representation might have been cheaper!

— Herb Hillman
Humbug's Nest
P.O. Box 135
Whitingham, VT 05361

We're banking \$80,000,000 on our reputation.

Engelhard is expanding its annual kaolin output by 300,000 tons to better meet your kaolin needs.



You've always been able to count on Engelhard for the finest quality kaolin-based products available. And now you can get more of the kaolin you need, when you need it.

We've just committed over \$80 million to a state-of-the-art expansion of our U.S.A. facilities that will add 300,000 tons a year to our output by the second half of 1988. This will mark the biggest capacity expansion ever made in the U.S. kaolin industry.

For over 75



years, Engelhard has been a kaolin industry leader. We were the first with calcined and delaminated products, the first with premium brightness kaolin products and the first with SPQC (Statistical Process Quality Control).

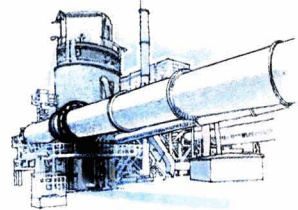
Engelhard's SPQC goes far beyond conventional product acceptance testing. We use statistical methods to control quality throughout the manufacturing process — from raw materials to finished product. Which reduces your need to test and increases your confidence in our quality.

Our three Georgia kaolin plants in McIntyre, Gordon and Gardner are state-of-the-art facilities that employ the most sophisticated equipment and processing methods. Our kaolin-based products

include performance and specialty pigments for the paper, paint, plastic, rubber, ink and allied industries. And we

back it all up with the largest technical support in the industry.

Find out how our new expanded kaolin capacity can help your business. Call 1(800)932-0444, in New



Jersey 1(800)624-0818, or write: Engelhard Corporation, Performance Minerals Group, Menlo Park, CN28, Edison, NJ 08818.

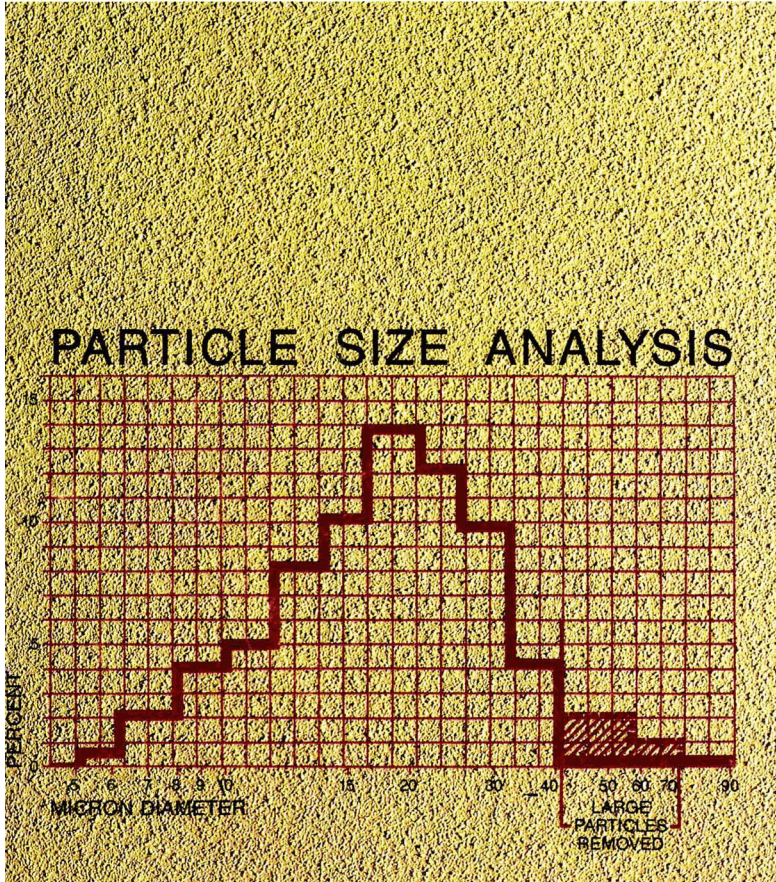
Get your kaolin-based products from the company that's fully committed to your needs — Engelhard.

© Engelhard Corporation 1988

ENGELHARD
EXCEPTIONAL TECHNOLOGIES

New Texture Series. Even-sized 25, 40, 55 and 75 micron stir-in textures.

unretouched photo shown at 3x actual size



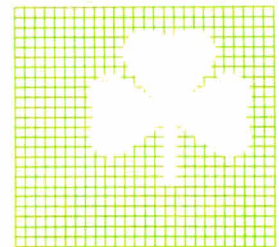
When your coating is being utilized for easy-care textured finishes, and an even suede-like texture is your goal... the new Texture series is your answer. In carefully configured particle ranges (see Coulter diagram at left) we screen out the oversize particles to eliminate any abrasive "feel" to the end product. Offered in 4 sizes—25, 40, 55 and 75 microns, they are compatible to solvent and water-base formulations. With a high melt viscosity useful for bake or air dry systems. It will not lose particle definition at 350° F. bake cycles. Manufactured of crystalline polypropylenes, the stir-in powders disperse easily under high-speed mixing equipment. A small quantity of the selected micron size will provide uniform texture.

Call our coatings lab for more details, specs, samples.

Sales Regions:

Florida	R.H. Wells Co. Lakeland, FL (813) 646-6470
Georgia	Kinsmen Corp. Atlanta, GA (404) 355-9550
Illinois	Shamrock Regional Office Chicago, IL (312) 629-4652
Michigan	A.T. Callas Co. Troy, MI (313) 643-9280
Missouri	Cemsac Chemical St. Louis, MO (314) 532-4330

Ohio	Sexton & Co. Cincinnati, OH (513) 542-1925
Pennsylvania	S.E. Firestone Associates Philadelphia, PA (215) 635-1366
Texas	J.M. Gillen Co. Cuddy, PA (412) 257-3300 M.D. Chemicals Grand Prairie, TX (214) 937-9914
Canada	Industrial Colours & Chem. Brampton, ONT (416) 453-7131
Europe	Shamrock Technologies S.A. Neuchatel, Switzerland (038) 25 27 67



Shamrock Chemicals Corporation Phone: (201) 242-2999
Foot of Pacific St., Newark, N.J. 07114 Fax: 201-242-8074/Telex: 138691

Shamrock

77247