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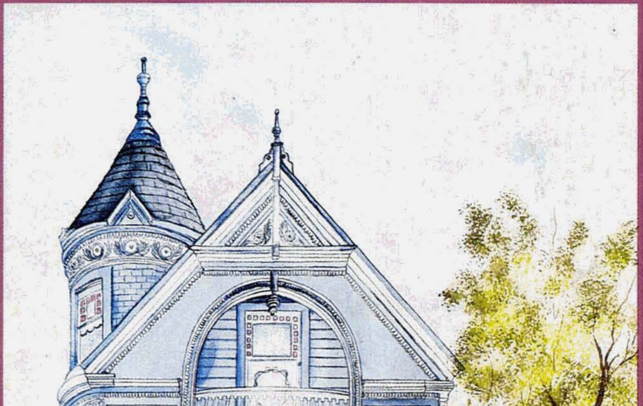

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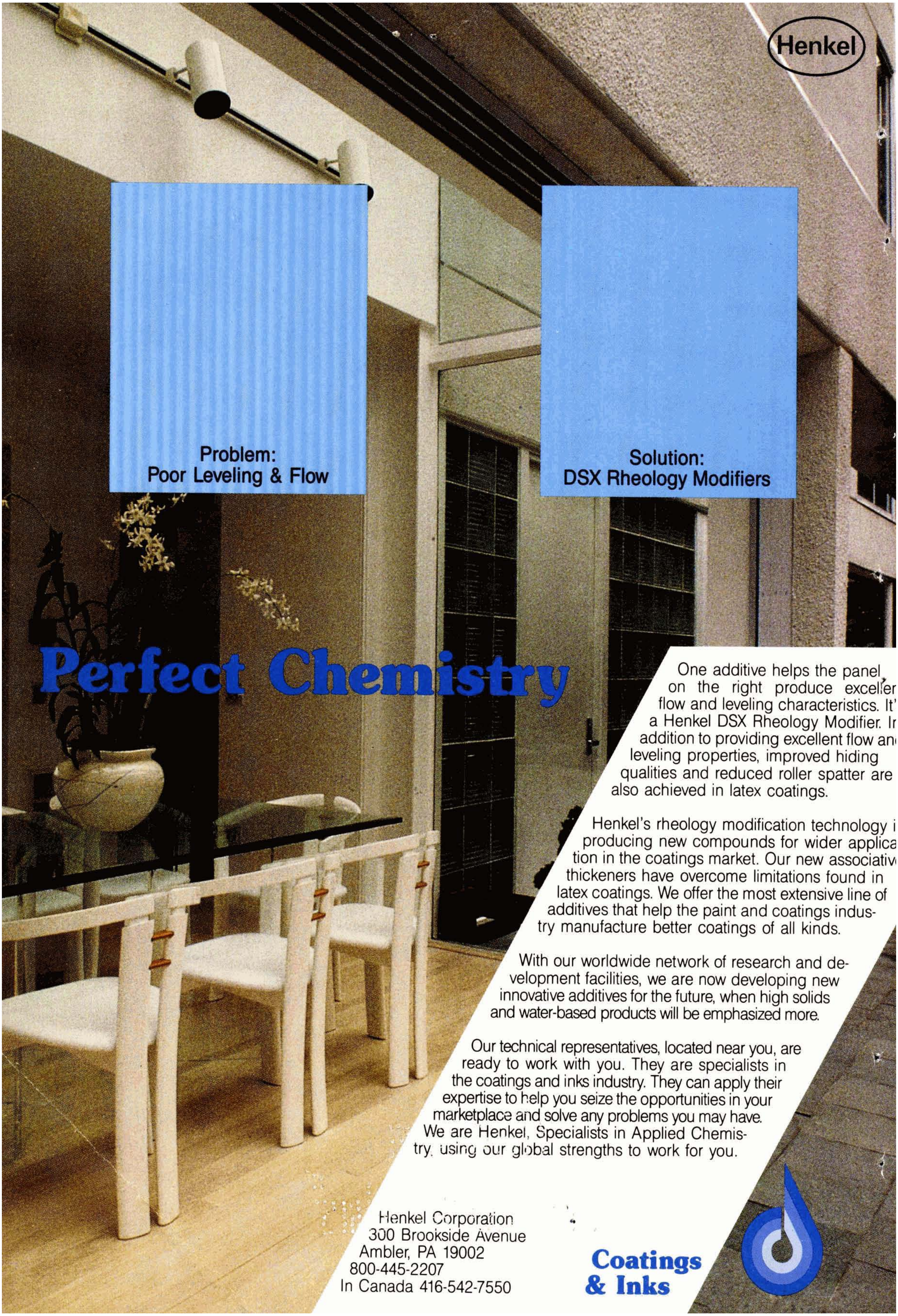
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VOLUME 63 NUMBER 800

Technical Articles

Federation News

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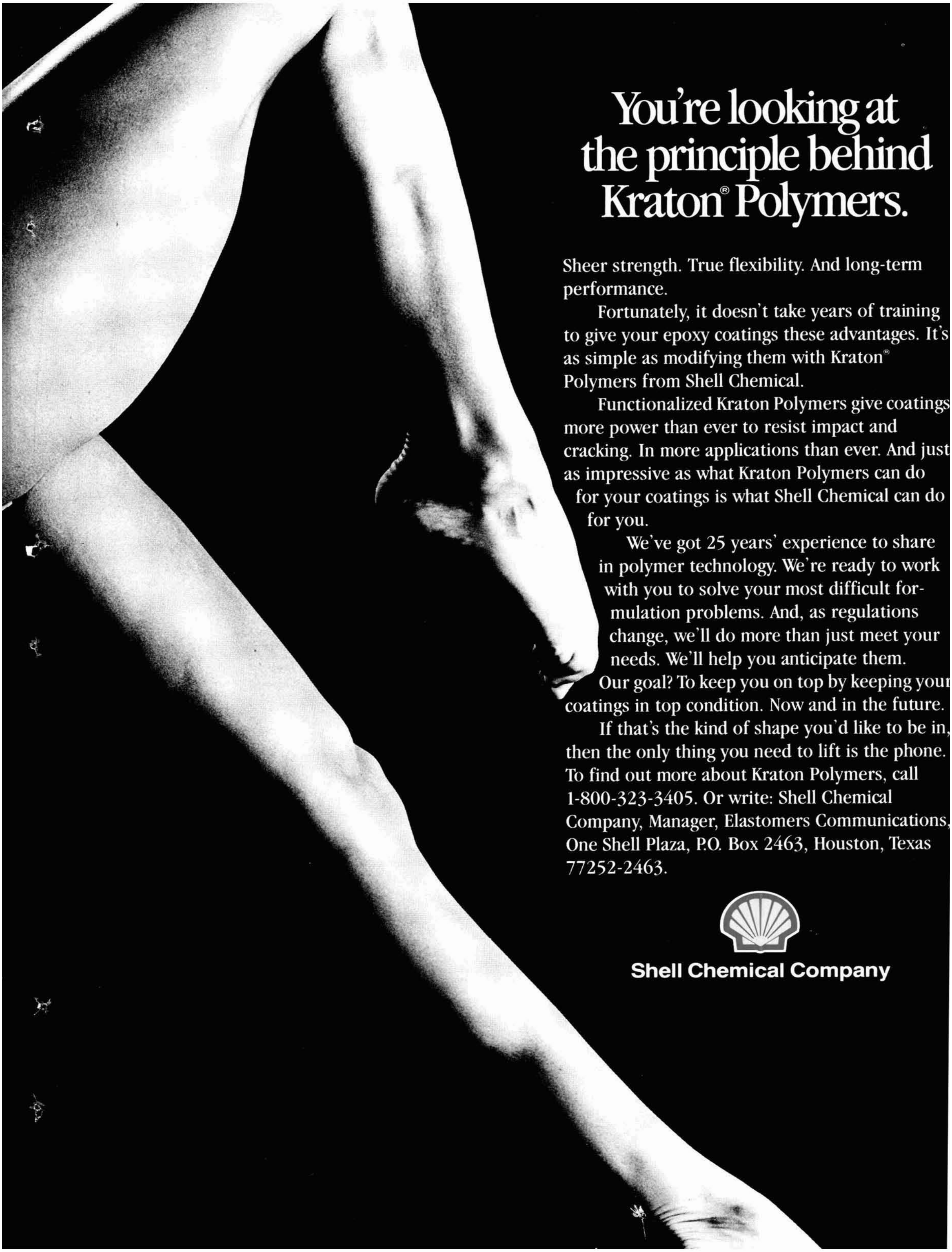

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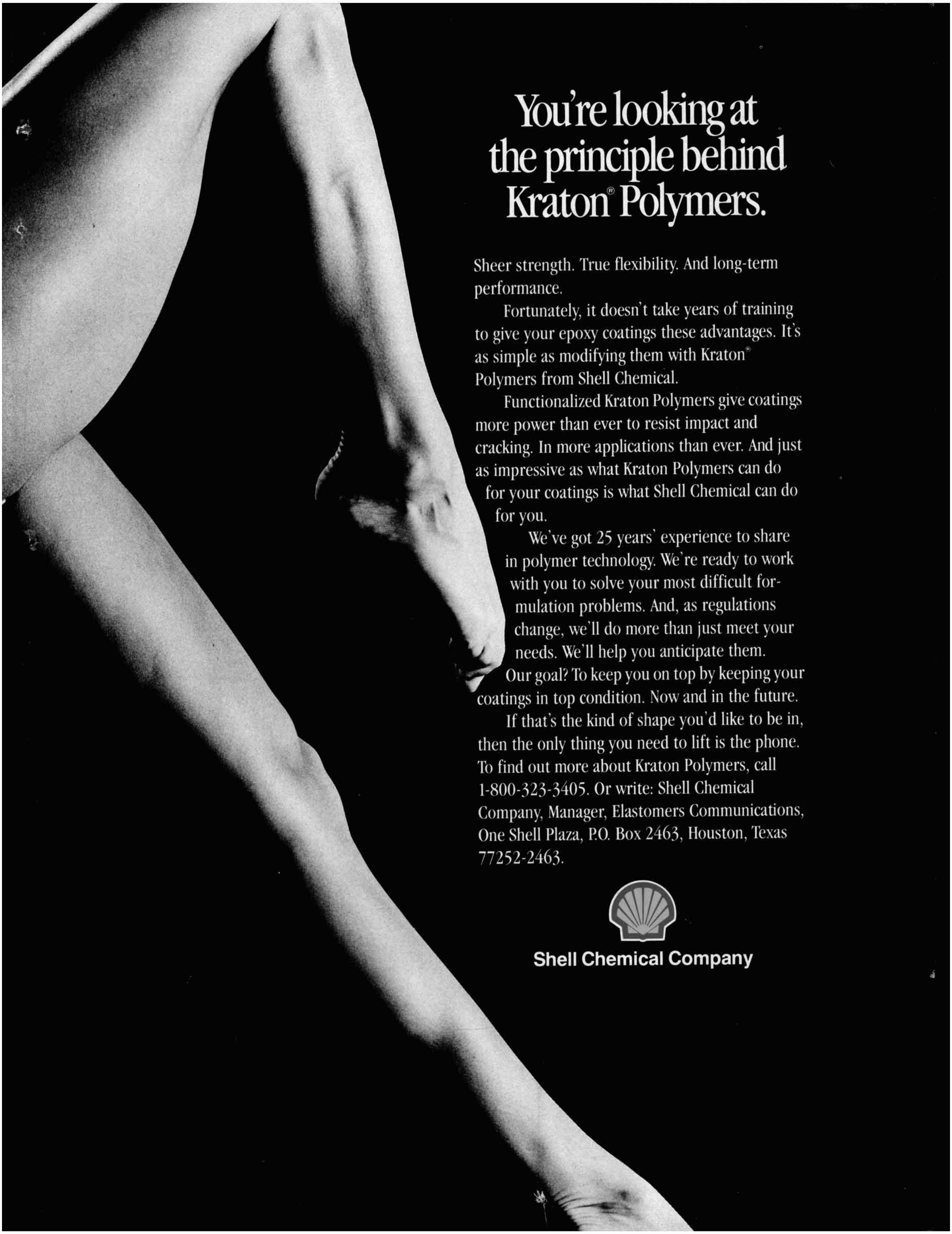

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Comment

Pride Goeth Before ??

The ancient Greeks had a name for it—*hubris*—the sin of excessive pride. Punishment by the gods for this transgression was swift, destructive, and, usually, eternal. Centuries later, Christian theology named pride as the first of the seven "deadly" sins and warned of excruciating tortures to be endured in the afterlife by those guilty of committing this sin.

Therefore, it is with extremely cautious modesty that we highlight some of the features of the JOURNAL OF COATINGS TECHNOLOGY.

The JCT has built its reputation presenting technical papers which focus on various aspects of the development, manufacture, and use of protective and decorative coatings. The articles by Kastanek and Hajek (beginning on page 75) and Erciyes, et al. (on page 83), illustrate the solid technical information which is categorized by the JCT Editorial Review Board as *original research*. To broaden its scope and offer greater benefits to a wider readership, the JCT also features papers from three additional categories.

Review articles, exemplified by the paper authored by Sam Williams (page 53), organize and prepare data from numerous sources to provide new insights. Papers which show how advances from other fields can be applied to the coatings industry are also included in this category.

The "how to" of coatings technology is the focus of papers presented in the "*Back to Basics*" section featured in some issues. These articles are designed to serve as useful guides to readers interested in such topics as process and production, paint manufacture, and calculations for coatings formulation. They benefit readers by re-examining and re-evaluating some of the essential fundamentals of the industry.

In the *Open Forum* section of the JCT, nontechnical papers are featured. Appropriate topics include the presentation of problems and their solutions, as well as other aspects of the industry approached in an informal manner. Papers in which proprietary products or processes are promoted for commercial purposes are not acceptable for publication in this, or any other, category.

All papers submitted to the JOURNAL for publication consideration are subject to review by selected members of the Editorial Review Board. This highly qualified 22-member committee carefully considers the merits of each submission and ranks the papers in 10 specific areas. The category of the paper is then designated and a final decision regarding publication is made by the JCT Technical Editor.

It is through this process that the JCT continues to meet the needs of its readership by providing the most up-to-date, practical and technical information. At the risk of eternal retribution, it is a process in which we take great pride!

Patricia D. Viola

Patricia D. Viola,
Editor

Abstracts of Papers in This Issue

EFFECTS OF ACIDIC DEPOSITION ON PAINTED WOOD: A REVIEW—R.S. Williams

Journal of Coatings Technology, 63, No. 800, 53 (Sept. 1991)

Acidic deposition has captured the attention of many researchers during the last decade and considerable knowledge has been gained in many disciplines including forestry, limnology, atmospheric sciences, and materials science. The study of the degradation of materials by acidic deposition has included the effects on wood, paint, and painted wood. The literature pertinent to the effects of acidic deposition and its precursors on these materials is critically reviewed. The subjects include transport properties of paints and polymers, the reactions of acids with paint components, and the degradation of wood. The research on acidic effects on paint degradation leaves many questions unanswered and the review forms the basis of future research recommendations.

A STUDY OF THIXOTROPIC FLOW BEHAVIOR OF ALKYD SOLUTIONS—A. Kaštánek and K. Hájek

Journal of Coatings Technology, 63, No. 800, 75 (Sept. 1991)

The thixotropic flow behavior of alkyl solutions was investigated with a Model RV 100 Haake Rotovisco viscometer equipped with a coaxial cylinder sensor system. The variation of shear stress and viscosity with changes in shear rate was studied. The thixotropic structure of 60% solids alkyd solutions was markedly affected over a broad range of shear rates including low shear rates. Thixotropic structure recovery was usually realized after about five hours at rest.

USE OF METHYLOLATED ABIETIC ACID AND TOLUENE DIISOCYANATE IN THE MODIFICATION OF TRIGLYCERIDE OILS—A.T. Erciyes, O.S. Kabasakal, and F.S. Erkal

Journal of Coatings Technology, 63, No. 800, 83 (Sept. 1991)

In this study, methylolated abietic acid and toluene diisocyanate were used together in the modification of some triglyceride oils, such as poppy seed oil, tobacco seed oil, sunflower oil, and linseed oil. For this purpose, preformed partial glyceride mixtures of each oil were, initially, partly esterified with methylolated abietic acid. Subsequently, the remaining hydroxyl groups were combined with toluene diisocyanate. In addition, toluene diisocyanate and abietic acid were reacted separately with the partial glyceride mixtures of each oil and the resulting products were used as control samples for the comparison of film properties. Another comparative sample was also prepared by reacting ester gum with linseed oil. An investigation of the film properties indicated that methylolated abietic acid could be utilized together with toluene diisocyanate as a modifier for binders based on drying and semi-drying oils.

NEW HORIZONS IN COATINGS TECHNOLOGY: 1990—R.B. Seymour

Journal of Coatings Technology, 63, No. 800, 89 (Sept. 1991)

The worldwide coatings sales in 1990 exceeded $55 billion. U.S. coatings firms accounted for almost 40% of this market which was divided almost equally between architectural and product finishes. The U.S. tonnage of powder coatings increased to over 65,000 tons with a dollar volume of $13.5 million. Sherwin-Williams continues to be the dominant paint producer in the U.S. The worldwide trend towards the increased use of waterborne coatings continues and trends toward reduced volume of solvents is being enhanced by the use of blends of carbon dioxide and organic solvents.


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Resumenes de Artículos en este Número

EFECTOS DE LA DEPOSITACION ACIDA EN MADERA PINTADA: UNA REVISION—R.S. Williams

Journal of Coatings Technology, 63, No. 800, 53 (Sept. 1991)

La depositación de Acida ha llamado la atención de muchos investigadores durante la ultima década y se ha ganado un conocimiento considerable en muchas disciplinas, incluyendo la Silvicultura, y las ciencias Atmosféricas y de materiales. El estudio de la degradación de materiales debido a la depositacion de Acida tomó en consideración los efectos en madera, pintura y madera pintada. Se revisó profundamente la literatura enfocada a los efectos de la depositación Acida y sus antecedentes sobre estos materiales. Los temas incluyen propiedades de transporte de pintura y polímeros. Las reacciones de los ácidos con los componentes de las pinturas, y la degradación de la madera. La investigación de los efectos del ácido en la degradación de la pintura dejó muchas preguntas sin respuesta y la revision creo la bases para recomendaciones de investigación futura.

ESTUDIO DEL COMPORTAMIENTO DEL FLUJO TIXOTROPICO DE SOLUCIONES ALQUIDALICAS—A. Kastánek and K. Hájek

Journal of Coatings Technology, 63, No. 800, 75 (Sept. 1991)

Se investigó el comportamiento de flujo tixotrópico de soluciones alquidalicas con un viscosimetro Modelo Rv 100 Haake Rotovisco, equipado con un sistema sensor de cilindro coaxial. Se estudiaron las variaciones de la viscosidad y del esfuerzo de corte con los cambios en la velocidad de corte.

La estructura tixotrópica de las soluciones alquidalicas con 60% de sólidos estuvo marcadamente afectada en un amplio rango de velocidades de corte, incluyendo velocidades de corte bajas. La estructura tixotrópica se recuperó usualmente después de 5 horas en reposo.

Spanish translation of abstracts was provided by Mexico Society Member, Ing. Gustavo Sanchez, Technical Chief, Instituto Mexicano de Técnicos en Pinturas Tintas, Mexico

USO DEL ACIDO ABIETICO METILOLADO Y DE TOLVEN DISOCIANATO EN LA MODIFICACION DE ACEITES TRIGLICERIDOS—A.T. Erciyes, O.S. Kabasakal, and F.S. Erkal

Journal of Coatings Technology, 63, No. 800, 83 (Sept. 1991)

En este estudio, el ácido abietico metilolado y el tolven disocianato fueron usados juntos en la modificación de algunos aceites, tales como el aceite de semilla de adormidera, aceite de semilla de tabaco, aceite de girasol y aceite de linaza. Para este propósito, primero se esterificaron parcialmente, mezclas de gliceridos formadas previamente de cada aceite, con ácido abietico metilonado. Posteriormente, se combinaron los grupos hidroxilo remanentes con tolven disocianato. En adición el tolven disocianato y el ácido abietico se hicieron reaccionar separadamente con las mezclas parciales de gliceridos decada aceite y los productos resultantes se usaron como muestras de control para la comparación de propiedades de película. Fue también preparada otra muestra comparativa por la reacción de "ester gum" con aceite de linaza. Las investigaciones de las propiedades de película indicaron que el ácido abietico metilolado puede ser usado junto con el tolven disocianato cumo unmodificante para ligantes basados en aceites semisecantes y secantes.

NUEVOS HORIZONTES EN LA TECNOLOGIA DE RECUBRIMIENTOS: 1990—R.B. Seymour

Journal of Coatings Technology, 63, No. 800, 89 (Sept. 1991)

Las ventas mundiales de recubrimientos en 1990, sobrepasaron los $55 billones de dólares. Las firmas de recubrimientos de U.S.A. contaron, por lo menos, para el 40% de este mercado, el cual se dividió, casi en partes iguales, entre los recubrimientos arquitectónicos y los productos para acabado. La cantidad en toneladas para los recubrimientos en polvo en U.S.A. se incrementó a cerca de 65,000 ton. con un volumen ed dólares de $13.5 millones. Sherwin-Williams continua siendo el productor de pinturas dominante en U.S.A. La tendencia mundial se encamina al uso de recubrimientos base agua e igualmente continua la tendencia de reducir el volumen de solventes, lo que ha venido a acrecentar el uso de mezclas de dioxido de carbono y solventes orgánicos.

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Sam Donaldson and Robert Fulghum to Be Speakers At NPCA Annual Meeting, in San Francisco, on Oct. 21-23

Sam Donaldson, co-anchor of ABC News' "PrimeTime Live," will be the Keynote Speaker at the Opening Session of the National Paint and Coatings Association's (NPCA) 104th Annual Meeting, on October 21, at the San Francisco Hilton, San Francisco, CA.

Mr. Donaldson was ABC's chief White House correspondent from 1977 to 1989. He reported on the administrations and policies of Presidents Jimmy Carter and Ronald Reagan, covering Presidential activity at the White House and on domestic and foreign trips.

He has covered every national political convention since 1964, as well as such national and international crises as the Vietnam War, Watergate, the Iran hostage crisis, the assassination attempt on President Reagan, and the recent Operation Desert Storm in the Persian Gulf.

Washington Journalism Review named him "best television White House correspondent" in 1984, and "best television correspondent" in 1985, 1986, 1987, and 1988.

In addition to his "PrimeTime Live" assignment as co-anchor with correspondent Diane Sawyer, Mr. Donaldson is an interviewer and roundtable participant on "This Week with David Brinkley."

He began his television career at KRLD-TV in Dallas in 1959, and joined WTOP-TV in Washington, D.C. two years later.

Mr. Donaldson's early years and his career as a Washington and White House correspondent are described in his best-selling autobiography, *Hold On, Mr. President.*

Author Robert Fulghum will be the featured speaker at the Final Breakfast session of NPCA's 1991 Annual Meeting, on October 23.

The author's first book, *All I Really Need to Know I Learned in Kindergarten*, topped the *New York Times* bestseller list for over 90 weeks. Mr. Fulghum's second book is entitled *It Was on Fire When I Lay Down on It.*

While he first attracted worldwide attention through his books, Mr. Fulghum is more than an author. In his time, he has been a newsboy, ditch-digger, singing cowboy, rodeo rider, IBM salesman, musician and artist, bartender, teacher, and ordained minister.

Most of all, Mr. Fulghum is a philosopher who sweetens his existential philosophy with anecdotes and leavens it with humor.

He tells stories of people who experience victory when they expected defeat, stories of people whose unstructured lives turn out perfectly well, and stories of truly humane actions.

Mr. Fulghum says he has no "canned speech." Rather, he sees every appearance as "living an hour or two of my life with a large group of people, but it's real life, not a repeating."

According to the author, *Kindergarten* was not originally meant to be a book, but grew out of excerpts from his journals and newsletters that, as a part-time Unitarian minister, he distributed to his congregation. Mr. Fulghum's material came to the attention of his publisher, Random House, through what he terms a kind of "underground press—you send it to your Mom who sends it to a friend who sticks it on the refrigerator."

Mr. Fulghum's third book, entitled *Uh-Oh*, is scheduled to appear this fall.

Amoco Co. to Expand Isophthalic Acid Line

Amoco Chemical Company, Chicago, IL, plans to expand and improve its isophthalic acid product line through an increase in capacity and the conversion of its worldwide production to a purified grade of isophthalic acid.

The plant modification and expansion work is scheduled for completion in the second quarter of 1992 at Amoco's Joliet, IL facility, and in the fourth quarter of 1992 at the company's Geel, Belgium plant.

The expansion in capacity will use Amoco's proprietary oxidation, purification, and environmental technologies, and will increase the company's isophthalic acid production capabilities by about 60%.

NPCA Announces Forum Sessions and Speakers For 104th Annual Meeting, in San Francisco, CA

The National Paint and Coatings Association (NPCA), Washington, D.C., has announced that forum sessions on topics of major concern to the paint industry will be held during its 104th Annual Meeting in San Francisco, CA, on October 21-23.

Forum topics will include such subjects as improved waste management, competing in a global market, environmental labeling, analysis of emerging coatings technologies, the work of NPCA's state paint councils, and the pros and cons of proactive communication with the media and the public.

Scheduled forums and featured speakers include:

"Profit from Waste"—participants will present several actual case examples of paint and coatings firms that have achieved dramatic profit improvement through waste management methods. Specific improvement actions will be discussed;

"Coatings in the 1990s and Beyond: Identifying Prime Technology, Raw Materials, and Formulated Coatings Opportunities"—Howard Ellerhorst and Phil Phillips, of Chemark Consulting Group, Inc.;

"Partnering and Global Technology: Prescription for Progress"—Adolph Posnick, retired, Ferro, Inc.; and Ernest S. Micek, of The Corn Milling Division, Cargill, Inc., and the Coca-Cola Company;

"World Class Marketing: Competing in Today's Global Marketplace"—Thomas Billesbach, of the University of Nebraska/Omaha; and Thomas Daly, of the Packaging Products Division, The Dexter Corporation;

"Communications—The Forgotten Management Tool?"—panel discussion featuring: Jim Lovejoy, of Gerber Products Company; Jeff Raimundo, of Townsend & Company; Timothy Harker, of The Harker Firm; and Bernice Bolek, of The Glidden Company;

"Impacting through State Coalitions"—panel discussion featuring chairmen of existing state paint councils: Marvin Wager, of California; Peter Tepperman, of New Jersey; James O'Conner, of Illinois; Van Stogner, of Massachusetts; and David Lloyd, of NPCA; and

"Environmental Labeling Here and Abroad"—Chris Harris, of ICI; and Denis Hayes, of Green Seal.


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F.W. Dodge Reports Midyear Construction Contracting Decline

A 4% decline of construction contracting was experienced in June according to a report compiled by the F.W. Dodge Division of McGraw-Hill, New York, NY.

June's decline followed an earlier setback in May, and took some strength out of the recent recovery of the building sector.

Construction contracting for new construction of all kinds increased an average of 2% during the second quarter of 1991 as compared to the same period of one year ago. This recent increase in construction contracting reversed a six-quarter slide which began in 1989.

In June, declines in contracting for nonresidential buildings and for "nonbuilding construction" (public works and utilities) more than offset a small but encouraging improvement in homebuilding.

According to officials at Dodge, because June's setback was limited to nonresidential construction, the results for construction contracting for the month should not be viewed as threatening. It was stated that housing construction is where recovery takes hold first. Officials predicted that a revival of nonresidential building is at least one year away.

The value of newly started residential units advanced another 2% (seasonally adjusted) in June, extending the uninterrupted improvement which began in February. Since January's low point, residential building value has risen by nearly 20%.

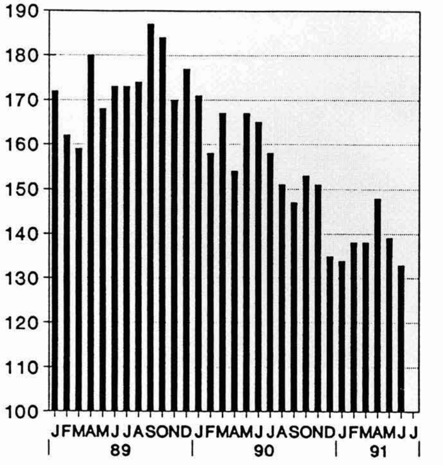
In June, the gain in residential buildings was confined to one-family homes. At midyear, starts of apartments and condos were below their already depressed January rate.

Contracting for nonresidential buildings declined 6% in June, as starts of commercial and industrial projects sank to the lowest rate since the 1982 recession. However, a small gain was reported for institutional buildings.

A sharp decline of utility projects was responsible largely for June's 11% drop in nonbuilding construction contracting. Public works construction, buoyed by continuing strength in highway and bridge projects, but lacking the support of sewer and waste treatment facilities, slipped 3% in June.

At midyear, 1991's unadjusted value of total newly started construction reached $108 billion, 16% less than in the first half of 1990. The year-to-date comparison, which stood at -19% at the end of the first quarter, narrowed during the second quarter.

By region, the West showed the biggest decline in 1991's first half, down 21%. The Northeast was down 15%, the North Central was down 17%, and the South Atlantic was down 16%, all very close to the national average. The South Central declined only 3%.



The Dodge Index (1982=100) of construction contract value

Ethyl Petroleum Division To Relocate to Richmond

Ethyl Corporation, Richmond, VA, has announced that it will relocate its Petroleum Additives Division headquarters from St. Louis, MO, to Richmond.

The move is scheduled to take place in July 1992 and is expected to involve approximately 100 administrative employees.

The division's engine-testing facility will remain in St. Louis. Any expansion of the division's research facilities most likely will be constructed in Richmond. A final decision has not been made regarding relocation of any of the employees now in the St. Louis laboratory to a new laboratory. A new facility is expected to take two to three years to construct.

Representatives from Ethyl stated that the relocation will result in a further consolidation of administrative and support functions at its corporate headquarters.

According to officials at Ethyl, the company will take a $3 million after-tax charge (three cents per share) against its second-quarter 1991 earnings to cover the estimated costs of the move.

Plastics Resins Production Figures For April and May Released by SPI

The production of plastics resins totaled more than 4.3 billion pounds in April and nearly 4.5 billion pounds in May, according to final statistics released by The Society of the Plastics Industry (SPI), Washington, D.C.

The April 1991 totals were down 5.7% from the same month in 1990, while the May 1991 totals decreased less than 1% from May of 1990.

The production year-to-date totaled 21.6 billion pounds, down 1.8% from the same period in 1990.

Sales and captive (internal) use of plastics resins in April and May exceeded 4.6 billion pounds, respectively. As of May, sales and captive use year-to-date are running 3.6% below the same time period in 1990.

The April and May 1991 figures are based on final data on selected major plastics materials as compiled by Ernst & Young for SPI's Committee on Resin Statistics.

SCM's Australian Operations Gains ISO Accreditation

SCM Chemicals in Australia has achieved accreditation under the International Quality Standard ISO 9002-1987. The accreditation covers the TiONA® brand of titanium dioxide.

The accreditation of SCM's Australian operation marks the third site approved under ISO 9002 for SCM Chemicals worldwide. The United Kingdom and Baltimore, MD, locations have already achieved approval.

ISO 9902 is the internationally recognized standard for quality management.

Quantum to Shut Down Production Units; Tuscola, IL, and Port Arthur, TX, Plants Affected

The USI Division of Quantum Chemical Corporation, New York, NY, has announced that it will close, either permanently or temporarily, three of its production units.

The company will shut down some of its less efficient units at Tuscola, IL, and Port Arthur, TX. These units include ethylene and polyethylene manufacturing facilities.

The 400 million-pound ethylene unit at Tuscola will be closed permanently. The facility began production in 1952 and is one of the oldest in the U.S. The plant's ethylene requirements will be supplied by the company's Morris, IL, ethylene plant, via a pipeline. Quantum will continue to produce ethyl alcohol, ethyl ether, vinyl acetate-ethylene copolymers, and powdered polyethylene at the Tuscola facility.

The company also will shut down permanently two reactors with an aggregate 100 million pounds of high density polyethylene capacity at its Port Arthur plant. These two reactors came on stream in the early 1960s.

Quantum will suspend temporarily operation of one of its 300 million pound per year linear low density polyethylene units at Morris. The unit will remain closed down until there is significant improvement in the linear low density polyethylene supply/demand balance.

The shut down of production units by Quantum is expected to result in the reduction of approximately 300 employees, primarily at the Tuscola facility.

Dow to Convert Sarnia Plant To Produce Acrylic Latexes

The Dow Chemical Company, Midland, MI, will convert its latex facility in Sarnia, Ont., Canada to produce acrylic latexes.

The conversion, which will change the plant from styrene butadiene production to exclusive acrylic latex production, is scheduled to be completed in early 1993.

When the conversion is complete, the dedicated acrylic facility will produce acrylic latexes for architectural and industrial coatings, paper coatings, adhesives, and textiles. The conversion also will incorporate new process equipment, raw material storage facilities, and environmental controls.

During the changeover, acrylic latexes will be produced at Dow's Midland plant. Current customers for the company's styrene butadiene latexes produced at the Sarnia facility will be supplied from Dow plants in Varennes, Que., Canada; Midland; or other existing latex facilities.

Synergistic Performance Corp. Acquires Harcros Assets

Synergistic Performance Corporation (SPC), Emeryville, CA, has acquired the assets of four Harcros Chemicals Company locations, including: Tustin, CA; Emeryville, CA; Portland, OR; and Seattle, WA.

All four of the acquisitions were former Harrisons & Crosfield locations.

Leon Persson will serve as President of the newly acquired sites. Mr. Persson has over 30 years of experience in the industry.

According to officials at SPC, all former Harcros employees were retained. Additional sales personnel have been added to the staff.

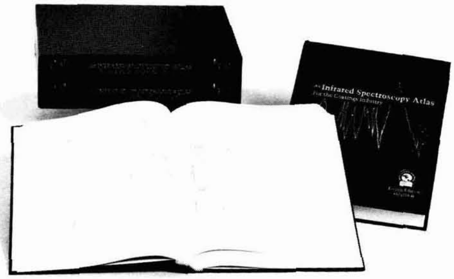
Fourth Edition of Infrared Atlas for the Coatings Industry Published by Federation of Societies for Coatings Technology

The Federation of Societies for Coatings Technology is pleased to announce the publication the newly revised and expanded fourth edition of "An Infrared Spectroscopy Atlas for the Coatings Industry." The use of infrared spectroscopy has experienced a renaissance in technology in its use in coatings analysis since the third edition was published by the Federation in 1980. Completely new coatings systems have evolved. These new frontiers within the industry and in the field of analytical chemistry firmly established the need to replace the previous Atlas with a more current reference source for the coatings industry.

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

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

A fully indexed literature survey represents the most complete bibliography published in this type of text. It is organized into sections, such as theory, general information, reviews, instrumentation, experimental techniques, compilation of spectra, quantitative analysis, coatings, polymers applications and pigment applications. Each section is in chronological order.



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

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

Development of the current Atlas was under the overall direction of the Federation Infrared Spectroscopy Atlas Advisory Committee consisting of Darlene R. Brezinski, Glen P. Cunningham, Loren W. Hill, Joseph V. Koleske, Stan LeSota, Percy E. Pierce, and Harold D. Swafford. Samples were prepared and spectra were generated by a five-member "Working Committee," headed by James M. Julian, consisting of Dennis G. Anderson, Alan H. Brandau, John R. McGinn, and Anne M. Millon. Darlene Brezinski edited the text for the edition.

The cost of the Atlas is $150 for Federation members and $200 for non-members.

To order copies, contact Meryl Cohen, FSCT, 492 Norristown Rd., Blue Bell, PA 19422-2350, telephone: 215-940-0777.

For additional information regarding the Nicolet Coatings Technology Database, call 1-800-232-1472, or write Nicolet Instruments Corporation, 5225-1 Verona Rd., Madison, WI 53711-0508.

Rosemary Falvey Retires from Federation Staff; Victoria Graves Promoted to Director of Meetings

Rosemary Falvey, Director of Meetings and Conventions for the Federation, has retired from the FSCT staff, as of July 31. Assuming the position of Director is Victoria (Tori) Graves, who had been Meetings and Conventions Coordinator.

Mrs. Falvey joined the Federation staff in 1959 as Secretary/Receptionist and moved into the Publications Department in 1960 as Associate Editor of the, then, *Official* DIGEST. In 1974, she was promoted to Managing Editor of the JOURNAL OF PAINT TECHNOLOGY.

Mrs. Falvey was named Director of Administration in 1977. Her subsequent promotion to the concurrent positions of Director of Meetings and Conventions and Director of Membership Services, as well as Editor of the FSCT Membership Directory (*Year Book*), brought her into contact with many FSCT members and industry personnel. In addition, she served as Office Manager of the FSCT staff.

An active member of the Philadelphia Chapter of Meetings Planners International, Mrs. Falvey has served on their Board of Directors for the past 10 years. She served as Treasurer of the group for three years and, most recently, was its Secretary. She was named "Meeting Planner of the Year" by that Chapter in 1990.

A graduate of the College of St. Elizabeth in Morristown, NJ, Mrs. Falvey resides in the Philadelphia suburb of Lafayette Hill, PA.

Tori Graves, who joined the Federation staff in 1984 as Assistant Editor of publications, has been promoted to succeed Mrs. Falvey. She will work with hotels and industry regarding FSCT meeting arrangements. Ms. Graves has served as Meetings Coordinator since 1987. In her additional function as Director of Membership Services, she will coordinate production of the FSCT *Year Book*, as well as serve as liaison with the Constituent Societies of the FSCT for member services as well as promotion of membership.

A graduate of Millersville State College, with a degree in Business Administration, Ms. Graves is a member of the Delaware Valley Society of Association Executives and serves on the Board of Directors of the Philadelphia Chapter of Meeting Planners International.

PACIFIC NORTHWEST PAINTMAKING

Volume 1, No. 3—September, 1991

THE BROAD WORLD OF SURFACE COATINGS

All of us, at various times, are exposed to a variety of types of paints or surface coatings. From very early days with finger paints, to touching up rust spots on our first car, to painting our homes and possibly refinishing antique furniture, we have learned some of the more common uses of paints. These applications of paint are in the everyday public eye and usually represent consumers' first impressions of our industry.

Not all paints are so obvious, however, in their use, and many offer some very unique properties for specific end uses. Paints can be formulated to offer extreme ranges in performance. Examples present themselves everyday in our kitchens. Teflon is a coating applied to cooking utensils for non-stick purposes. Most of our food and beverage cans have a painted liner to prevent discoloration, rusting and tainting by metal contact. Also, the exterior of beverage containers has a painted surface.

Industrial applications for specialty coatings range from coatings able to withstand 600°C temperatures on a continuous basis, to coatings which change colors at different temperatures to indicate temperature change. Paints can be formulated to adhere tenaciously to such substrates, for example, as tank liners and pipe coatings. There are also strippable coatings which are used as base coats in areas such as paint spray booths for easy removal of subsequent layers of paint. Coatings can range from very high "slip" or lubricity to very low slip for safety flooring around hazardous machinery.

Some applications for paint require extremely low electrical conductivity. Examples are insulating varnishes for motor windings and protective coatings for circuit boards. Other uses require high electrical conductivity such as satellite dish coatings and coatings which convey electrical conductivity to non-conductive materials to permit electrostatic grounding.

Other unique applications are intumescent or fire retardant coatings which swell up to many times their original thickness on exposure to fire. This forms a non-flammable insulating barrier over the substrate to retard the spread of flames. In some areas of the world, roof coatings play a major role in reflecting heat and reducing energy costs of air conditioning. Other tropical areas use their roofs to collect drinking water, so these coatings must be completely non-toxic as well as weather resistant.

Coatings are used to control biological growth in a variety of applications. Examples are wood preservative coatings for the lumber industry and anti-fouling coatings for application to ships and underwater structures to prevent marine growth.

These examples represent but a very few of the many varied and unique products our industry produces. We certainly don't have to look very hard to find examples!

—Stuart Eaton,
Cloverdale Paint

PRINCIPLES OF MIXING

The art of mixing is a subject in the chemical processing industry that is often misunderstood and misapplied. An understanding of the mechanics and techniques can mean the difference between a success or a failure. A basic definition of mixing is the attempt to incorporate different components into a homogeneous blend with the correct physical and chemical properties for that product; the correct grind, viscosity, color, and consistency.

To reach the final homogeneous product there are a number of factors that affect the production of a good product, including but not limited to:

Mixer Design—Is it correct for the application?

Mixer Repair—Is it capable of operating at its designed level?

Operator Training—Does the operator understand what is required of him?

Mixing Blades—Are the mixing blades applicable to the process and are they worn?

Batch Formulation—Are the correct raw materials being used and are they being added to the process in the correct order?

Raw Materials—Is the quality of the raw materials correct and consistent from batch to batch?

All those factors must be taken into account when producing a finished product. If one of the factors is incorrect the end result will be a poor quality batch or excessive batch time.

If we make some basic assumptions like the mixer is designed correctly, the machine is in good repair, and the formulation is correct, we are left with the operator as one of the most important links. If the operator does not understand the proper techniques of mixing then he cannot be expected to compound a consistent batch.

The area that the operators must control and understand are:

•Blade Speed—If the blade is operating too slowly then the batch will take much longer to reach its finished stage and may not have the correct viscosity, color, or grind. If the blade is operating too fast there is a risk that the batch will be over mixed or sheared and become too hot. Running the mixer too fast consumes extra electricity and puts undue strain on the power transmission components.

•Batch Vortex—The creation of a vortex in the batch is critical to the success of the batch. If the operator is not running the mixer properly and a vortex has not been created there will be dead spots in the flow that will create inconsistencies in the final product. Without a proper vortex, incorporating powders into the batch will take too long.

•The operator can inspect the blade for wear. Fifty percent of the fins on the blade should be left. Anything less than 50% indicates that a blade change is in order.

•Powder being added to the batch and dispersed should be added at a slow even rate. If the powders are added too quickly lumps of unmixed powders may form. Large lumps of unmixed powders are a different density than the mixed product; as the mixing blade hits these pockets it can cause considerable shock load in the power transmission components.

•The operator should follow the batch formula as prepared. Failure to follow the formula makes it difficult to determine if the formula is correct when poor quality control results are detected. It is very difficult to determine if the formula or the operator is at fault.

•The operator should be aware of any inconsistencies in the raw materials that he is using. If the operator feels that something is not correct he should report the findings to his supervisor.

The key to producing a good finished product is understanding the process and the dynamics in the batch itself. That understanding makes the job of the formulator easier because it reduces the variables. A batch that passes the QC test is compounded in an acceptable amount of time represents profits for the company.

—Clinton Van Zyverden,
Hockmeyer Equipment Corporation

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Hockmeyer has a travelling road show that they will take to any production facility to teach operators the fine points of mixing technology. The show which consists of a film, slides, and a lecture is approximately two hours long.

If you would like further details, please contact: Clinton Van Zyverden, Hockmeyer Equipment Corporation, (201) 482-0225.

THE ROLE OF SOLVENTS IN COATINGS

A wide variety of solvents are used in coatings manufacture either to dissolve the binder or to dilute the paint and make it more flowable prior to its use. The amount of solvent in the paint depends on the method of application. For example, a spray-gun needs a thinner solvent than a brush or roller. In fact, the paint has to be sufficiently thin to be pushed through the spray-gun nozzle.

Solvents also play a role in the film formation, the consistency of the film, the way the paint levels out, and the drying time. This is why a paint often contains several solvents mixed together in a "solvent blend." Selection of the solvent blend components is a critical part of paint formulation. Each component in a blend has a special function, for example, a "true solvent" dissolves the binder (film forming material) and keeps it in solution. The term "solvency" is often used as a measure of dissolving by the true solvent. The higher the solvency, the less solvent is needed to dissolve the same amount of binder material. Other components in the solvent blend can be diluent, latent solvent, and thinner. None of these components can dissolve the binder. However, diluent and latent solvent can increase a binder's solubility in the true solvent. The "thinner" is used to control paint "thickness" or flowability. It can be a pure or mixed solvent.

Most oil based paints and varnishes can be thinned with mineral spirits made from petroleum distillates. Many of the alkyds can also be thinned with mineral spirts. Shellac is thinned with alcohol (ethyl or methyl alcohol). Thinners other than alcohol will damage the shellac.

Improper thinning is a major cause of inferior or unsatisfactory product. This is because painting materials are delicately balanced formulations designed to produce correct hiding, luster, color retention, drying, and durability. Incorrect or excessive thinning upsets the balance of a formula causing a poor paint job. The right solvent combination in a blend can compensate for local conditions such as temperature, humidity, application and curing, equipment design, line speed, etc.

The most important solvent properties to be considered are evaporation rate, viscosity, and safety. Evaporation rate refers to the volatility of the solvent. The right choice of a solvent depends on the curing schedule. If oven bake is required, the solvent blend should contain a "tail-end solvent" with an evaporation rate that leaves the paint slowly during the baking cycle. Rapid loss of solvent during baking can cause blistering. The oven cured paints also contain the "middle solvent," which evaporates from the paint gradually during the oven warm-up cycle. A small percentage of "front-end solvent" is also present. The term refers to a solvent which will evaporate from the paint as soon as coating is applied onto the surface. Under certain conditions, a very heavy solvent (retarder) is needed to prolong paint drying time. It is often used to prevent blushing or orange peel. The viscosity of solvents affects paint flow properties and atomization ability. It is therefore an important factor for solvent selection. For example, if two solvents have very similar evaporation rates but different viscosities, the lower viscosity solvent would be the right choice for spray-gun paint application.

Solvent toxicity and flowability are also very important selection criteria. Naphtha-like solvents are quite flammable and chlorinated hydrocarbons so toxic that extreme care must be exercised in their use. All chemicals may affect your health if you breathe their vapors, get them on your skin, or ingest them.

Safe handling of chemicals of any kind is necessary and important for prevention of ill effects. Specific health and safety information about each chemical used in paint is available from the paint or solvent manufacturer.

—Olga Puzic,
Esso Chemical

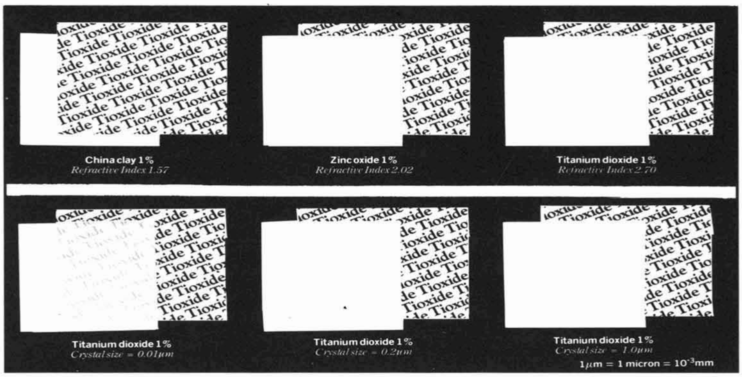
"Success in life is to never let
your ego outstrip your talent."

—Don Shebib

TITANIUM DIOXIDE—THE PRIME PIGMENT

Titanium dioxide is the most important white pigment currently produced commercially; world production being in the region of 2.9 mt/year. It is used in a wide range of applications including paint, inks, plastics, rubber, paper, textiles, food, and pharmaceuticals. It is the most widely used prime pigment in the paint industry (95% of all white pigment sold) due to its outstanding opacifying ability, high whiteness, high durability, and low toxicity.

The photographs below illustrate that while china clay, zinc oxide, and titanium dioxide are all white powders, when included in a paint, it is only titanium dioxide that has high opacity and tinting strength.



Pigment Grades

Commercial grades of titanium dioxide are made in two crystal forms: anatase and rutile. While "pure" anatase pigments were first developed in the early 1920s, they have been steadily replaced in paint applications by rutile grades, due to the latter's improved opacity and durability. Today about 85% of the total titanium dioxide pigments sold are of the rutile type.

In addition to changing the form, it is possible to apply various chemical treatments to the pigment. This has resulted in specialized grades being developed for some of their many applications. In the paint industry, three basic types are common.

Enamel Grades—These lightly coated grades are suitable for use both in gloss and flat paints. They are readily dispersible using a high speed mixer, give good gloss development, and can be used in interior/exterior finishes.

Superdurable Grades—These are moderately coated grades where the coating has been applied to reduce photoactivity and prolong the exterior performance of the paint. Such grades are used in paints which require the maximum possible durability such as automotive applications and coil coatings.

Flat Grades—Such grades are moderately to heavily coated and designed for use in flat paints, particularly interior latex paints. The coating level is designed to maximize "dry hiding" and give the highest opacity possible.

Pigment Dispersion

Without a doubt, the level of pigment dispersion has a significant effect on the properties of any paint. Studies in our laboratories have demonstrated its influence on opacity, tinting strength, gloss, durability, metal marking, and rheology.

In relative terms, titanium dioxide pigments are easily dispersed, and as a result of their surface treatment, can be processed using a wide variety of modern machinery provided correct millbase formulating procedures have

(Continued on next page.)

(Continued from previous page.)

been followed. However, it should not be assumed that apparently similar pigments can automatically be substituted in existing millbase formulations. Despite the efforts of the pigment manufacturer, differences in binder demand may occur and caution is advised if efficient milling conditions are to be consistently obtained. Once an acceptable fineness of grind is achieved, care must be taken during the millbase let down. A stabilization step is often useful; where the millbase is reduced from a high concentration to a more moderate level before being let down to the final paint. When millbases are prepared using high speed impeller mills, stabilization can be easily controlled. However, when sandmilling is used, it is more difficult and the millbase has to be designed with enough pigment, resin, and solvent to give adequate stability, as well as an efficient grinding action. Reagglomeration of pigment, known as colloidal or pigment shock, is liable to occur if a relatively concentrated resin is added to a millbase low in resin solids. Even if shock does not occur, flocculation may result which has a detrimental effect on important optical properties like opacity, tinting strength, and gloss.

We have seen many cases where the presence of too many additives can cause problems. These situations occur when paint formulations are developed over a period of years, often with input from numerous sources. In paints where flooding/floatation, sedimentation, poor gloss or opacity development occur, it is often a good idea to remove all of the existing additives and begin again. We once saw an alkyd paint formulation which contained *11* additives, many of which had conflicting properties, so one had been added to offset the other. An expensive way of producing an unsatisfactory paint.

Pigment Manufacture

Two methods are currently used for the commercial manufacture of titanium dioxide: the sulphate process and the chloride process. At the moment, it is the sulphate process which predominates globally, but moving towards a 50/50 split by about 1995.

Environmental considerations have resulted in significant expenditures by both sulphate and chloride producers to meet legislative requirements.

—John Hall,
Tioxide Canada

MANUFACTURING ITEM

Use Powers of Observation

When paintmaking, try to make use of your powers of observation. A strong odor, a different shade of pigment, skin on a drum of resin, any little thing you might notice different from the usual could be a warning sign of a problem in the finished product.

Familiarize yourself with how the products you use and make should look, smell, and handle. When you notice a change you can draw your supervisor's attention to it and record what you notice on the formulation card. This will help save a lot of time and money investigating if a batch develops problems.

—Valerie Braund,
General Paint Ltd.

> "Every story has three sides,
> yours, mine, and the facts."
>
> *—Rene Fumoleau*

A Newsletter
For the Exchange
Of Ideas On Safety
And Manufacturing . . .

SAFETY ITEMS

Cowles Blades Safety

Always be certain that the dispersion blade is securely attached to the shaft before you use it. If the blade requires a support plate, be certain it also is in place. Never use a bent or warped blade, as it creates an off balance vibration putting the shaft out of alignment and creating the potential for serious accident or injury.

Never leave the dispersion unit in the raised position with the blade exposed, someone could hit the exposed blade with their head and injure themselves.

—Ross West,
Preservative Paint Company

When lifting, carrying, or moving objects, remember these rules:

- Only lift, carry, or move what you can manage safely.
- Use the correct technique, particularly when you have to move heavy objects.
- Take a firm grip before lifting.
- Make sure you can see where you are going.
- If mechanical aids are provided, use them.

Use your brain and save your back!

Rules and Fools

- Know the rules which apply to you.
- Always follow them.
- Be prepared to advise others if you think they are doing wrong.

The Pacific Northwest Paintmaking (PNP) is intended for the exchange of ideas on safety and manufacturing. First published and distributed independently by the Manufacturing Committee of the Pacific Northwest Society for Coatings Technology, the newsletter will be published periodically in the JCT. The editors would like your participation. Send your comments, ideas, safety or manufacturing tips, and articles to: PNP Editor, Valerie Braund, General Paint, 950 Raymur Ave., Vancouver, B.C., Canada V6A 3L5.

The PNP is made available as a service to FSCT members. Although all reasonable steps have been taken to ensure the reliability of the PNP, the FSCT cannot guarantee its completeness or accuracy.

Regulatory UPDATE

September 1991

This digest of current regulatory activity pertinent to the coatings industry is published to inform readers of actions which could affect them and their firms, and is designed to provide sufficient data to enable those interested to seek additional information. Material is supplied by National Paint and Coatings Association, Washington, D.C. and edited by members of the FSCT Environmental Affairs Committee.

Lead—On August 1, the Senate Environment and Public Works Committee favorably reported S. 391, The Lead Exposure Reduction Act. The bill restricts the use of lead in a variety of products, and includes a ban on its use in virtually all paints and coatings by limiting the allowable amount to 0.06 percent dry weight.

One of several amendments adopted by the Committee allows a renewable exemption for electrocoat and electrodeposition primers that are applied by original equipment manufacturers to motor vehicle parts. At the end of a five year period, the Administrator of the Environmental Protection Agency (EPA) will re-evaluate the health and environmental effects of the lead content level in those products. The bill also requires the EPA to develop a model lead paint abatement accreditation plan for state use.

Republican panel members used a procedural tactic to try to stop the markup of S. 391, arguing that the bill would devastate the lead-mining industry. Senator Symms (R-ID), a leading opponent of the legislation, expressed deep concern over the future of the domestic lead industry, especially the loss of jobs. He also argued that the legislation would, "put a stranglehold on business by restricting development and forcing industries offshore." Senator Dave Durenberger (R-MN), also objecting to continuation, said he wanted more Republicans present when he offered a provision to delete parts of the bill that would ban the sale of leaded gasoline in urban areas. The delay only lasted 24 hours, and the Committee ultimately agreed to the Durenberger amendment by a vote of 9 to 7.

Committee members also approved an amendment that requires the labeling of certain lead-containing products (excluding those with incidental levels below 100 p.p.m.), and one that requires data on new uses of lead to be submitted to EPA prior to production. The full Senate is expected to debate the legislation in September.

Environmental Crimes—An amendment to the Senate Crime bill, which passed the Senate in mid-July contains language that would give the courts broad authority to require companies convicted of environmental crimes to develop pollution prevention measures in addition to paying fines.

The amendment, sponsored by Senator Harris Wofford (D-PA), would require any "organization found guilty of a felony environmental crime to hire an independent auditor to evaluate the criminal damage, suggest solutions, and recommend further steps to prevent future harm to the environment. The audit report would then be submitted to the court, and the judge could require the defendant to comply with the suggestions of the auditor.

Environmental groups joined Senate Majority Leader George Mitchell (D-ME) and Judiciary Committee Chairman Joseph Biden (D-DE) in supporting the measure. However, industry groups have raised serious concerns regarding costs and judicial authority. A frequently mentioned concern is a section of the bill that is so vague, it is unclear as to whether the audit requirement covers all facilities owned by a company or just the offending facility.

The House is still undecided on whether it will consider the Wofford Amendment in its deliberations of the crime bill, scheduled to begin after Labor Day.

Toxic Release Inventory Reporting—Representative Gerry Sikorski (D-MN) has introduced legislation that would expand chemical use reporting requirements under the Toxic Release Inventory Program (TRI). H.R. 2880, The Community-Right-to-Know-More Act of 1991, would not only require companies to report chemicals they release, but also to report the toxics they use and produce.

Currently, under the Emergency Planning and Community-Right-to-Know Act (EPCRA), federally operated sites, mines, electric utilities and incinerators are exempt from reporting requirements. The new legislation would expand the requirements to cover those facilities. The bill would also broaden the list of substances under section 313 (SARA) to include chemicals already deemed hazardous under the Clean Air Act, the Solid Waste Disposal Act, the Federal Insecticide, Fungicide, and Rodenticide Act, and the Safe Drinking Water Act.

H.R. 2880 also changes the thresholds for off-site waste transfers. Companies would have to report to EPA wastes that are transferred to offsite waste management facilities in amounts that exceed 100 pounds per year for metals and 2000 pounds per year for chemicals. According to Rep. Sikorski, the new threshold would assist in the collecting of data from incinerators and utilities that produce large amounts of toxic emissions, but manufacture few chemicals. Additionally, the bill connects the TRI data base (chemical emissions) with the RCRA Inventory data base (hazardous waste stream generation) in an effort to discourage businesses from cutting their

TRI emissions by adding extensively to their waste stream generation.

Although not formally introduced, the Senate has been circulating a similar draft.

Resource Conservation and Recovery Act—Legislation that would attempt to expand the market for recycling by placing a moratorium on new incinerators and require the separation of certain hazardous materials has been introduced in the House.

The Pollution Prevention, Community Recycling and Incinerator Control Act of 1991 (H.R. 3253), sponsored by Representative Pete Kostmeyer (D-PA) requires hazardous materials that produce toxic emissions (batteries, household hazardous wastes, plastics and yard waste) to be separated from the waste stream before incineration. The bill is a complement to Rep. Sikorksi's Community-Right-to-Know-More Act.

The legislation provides that incinerator ash be considered hazardous under RCRA Subtitle C. Fly Ash and combined ash would be tested to determine whether it is toxic or contains dangerous chemical constituents. The bill also mandates an eight-year moratorium on the construction of new incinerators, reportedly to "allow for the development of recycling markets." Kostmeyer's bill has 14 co-sponsors and is supported by several major national environmental organizations.

Activity also continues on the development of a comprehensive RCRA reauthorization bill by the House Energy and Commerce Transportation and Hazardous Materials Subcommittee. To date, the committee, chaired by Rep. Al Swift (D-WA), has reached a general agreement on interstate waste transport and underground storage tank issues, but has failed to agree on municipal recycling.

Rep. Swift has set a deadline of July 31 for the committee members and staff to prepare a concept paper outlining the preferred options for a reauthorization bill. At press time, the paper had not been released. Hearings on the proposed legislation are scheduled to begin September 23.

Indoor Air Quality—The Indoor Air Act of 1991 appears to be on a fast track in the Senate as it passed the Superfund, Ocean and Water Protection Subcommittee on July 29, and the full Environment and Public Works Committee on August 1. However, the companion legislation in the House (H.R. 1066) ran into trouble in the House Science Committee.

Both bills would create an interagency council on indoor air quality, and would establish a research office for indoor air at the Environmental Protection Agency (EPA). The Indoor Air Quality Council would take the lead in developing a federal plan to reduce indoor air pollution. Also included in the legislation is a provision to establish grant programs for state agencies, and a requirement for EPA to issue health advisories on listed indoor air contaminants. Lead is among the listed contaminants.

The House version also contains a provision for a research program to determine the causes of lead poisoning in children. The program includes studies on the effect of lead-based paint and paint dust.

The House Science Committee sent its bill back to the Environment Subcommittee for re-drafting after a bi-partisan group of members raised a number of objections. Some members were concerned about the language being so vague that federal agencies could misinterpret the intent of the bill. Other members felt that the bill should focus only on scientific research, and not involve enforcement activities.

Occupational Safety and Health—Legislation that would broaden the scope of the Occupational Safety and Health Act was introduced in both Houses of Congress on August 1. The Comprehensive Occupational Safety and Health Reform Act (S. 1622 and H.R. 3160) is sponsored by Senators Edward Kennedy (D-MA), Howard Metzenbaum (D-OH), Representative William Ford (D-MI), and Representative Joseph Gaydos (D-PA).

The new package shifts the focus of the current act to encourage employers and employees to play an active part in identifying hazards in the workplace before an injury or illness can occur. Provisions in the bill include a requirement for employers to develop and maintain health and safety programs to "reduce or eliminate hazards and prevent injuries and illness to employees. Employers with 11 or more employees would also be required to establish joint committees with an equal number of employees and employer representatives. The committee would be authorized to review the company's health and safety program, conduct inspections, and make advisory recommendations to the employer. The employees would also be protected from employer "discharge or retaliation" should the employee report an unsafe condition or refuse to perform a specific task because he fears a health or safety risk.

The legislation would also require OSHA to target "high-risk" industries and operations; require employers to report work-related deaths immediately, and accidents resulting in hospitalization within 24 hours; require employers to take immediate corrective action if OSHA determines an "imminent danger of death or serious harm; and protects from discrimination employees who refuse to perform work that might expose them to danger.

The bill also incorporates language from S. 445, the OSHA Criminal Penalties Act, and H.R. 1190, the High Risk Occupational Disease Notification and Prevention Act. No further action has been scheduled.

Environmental Protection Agency
July 22, 1991—56 FR 33490
Hazardous Waste Treatment, Storage, and Disposal Facilities, Organic Air Emission Standards for Tanks, Surface Impoundments, and Containers
Action: Proposed rule

Under a regulation proposed by the U.S. Environmental Protection Agency (EPA), over 2000 new and existing facilities operating under Resource Conservation and Recovery Act permits would have to substantially reduce emissions of volatile organic compounds (VOCs). Within two years after the date of final promulgation, hazardous waste treatment, storage, and disposal facilities would be required to install new equipment that would reportedly reduce VOC emissions by 90% from tanks, surface impoundments, and containers.

The proposal is the second of a three phase implementation plan. The first phase regulated process vents and equipment leaks by an EPA final rule announced in 1990. During the third phase, EPA will determine whether there is a need for further regulation. The Agency estimated that because this rule covers a significantly larger percentage of emissions than the first phase, it is expected that the nationwide reduction of VOC emissions will be at least seven percent.

According to EPA, in addition to the $360 million per year in labor, maintenance, and capitol costs, industry would need to make a capitol investment of approximately $960 million.

Written comments will be accepted by EPA until September 20. Comments should be sent to the Docket Clerk (OS-305), U.S. Environmental Protection Agency, 401 M Street, Washington, DC 20460. Refer to Docket number F-91-CESP-FFFF, Air Emission Standards for Organics Control.

For further information, contact the RCRA Hotline (800) 424-9346. For specific information on the regulatory aspects of the proposal, contact Ms. Gail Lacy at (919) 541-5261. For technical information on the industry and control technology, contact Ms. Michele Aston (919) 541-2363.

Department of Transportation
Research and Special Programs Administration (RSPA)
August 1, 1991—56 FR 36922
Amendments to the Hazardous Materials Program Procedures
Action: Notice

The Hazardous Materials Transportation Act of 1975 (HMTA) was amended in November, 1990, by the enactment of the Hazardous Materials Transportation Uniform Safety Act of 1990 (HMTUSA). Section 105 of the HMTA was amended by section 4 of the HMTUSA to reflect the establishment of a new preemption standard for state and political subdivision requirements.

The Research and Special Programs Administration (RSPA) has requested comments on recommendations for the definition of the new standard. Additionally, RSPA has proposed to "streamline the preemption determination and waiver of preemption processes."

Comments will be accepted until September 3, 1991, and should be sent, if possible, in quintuplicate. Address comments to the Docket Unit, Research and Special Programs Administration, U.S. Department of Transportation, 400 Seventh Street, SW, Washington, DC 20590. (Docket No. HM-207A; Notice No. 91-2). For further information, contact Mary Crouter, Hazardous Materials Safety and Research and Technology Division, Office of the Chief Counsel, RSPA, (202) 366-4400.

Environmental Protection Agency
August 16, 1991—56 FR 40948
National Pollution Discharge Elimination System (NPDES) General Permit and Reporting Requirements for Storm Water Discharges Associated with Industrial Activity.
Action: Proposed rule and Notice of draft general NPDES permits for Storm Water Discharges Associated with Industrial Activity.

On November 16, 1990 , the U.S. Environmental Protection Agency published a final rule that established permit application requirements for storm water discharges associated with industrial activity. The term "storm water discharge associated with industrial activity" was comprehensively defined by EPA to cover a wide variety of facilities. Under the definition, the number of industrial facilities required to comply with the NPDES program was significantly expanded.

EPA has to implement a permitting strategy that will cover the large number of industrial storm water discharges, and is now requesting comments on proposed regulatory changes to existing minimum requirements for NPDES permits with regard to annual monitoring reports. Comments are also being requested on changes to the current minimum requirements for filing notices of intent for authorization to discharge under NPDES general permits.

Additionally, EPA is accepting comments on separate general permits for industrial storm water discharges in 12 states (MA, ME, NH, FL, LA, TX, OK, NM, SD, AZ, AK, ID) and 6 territories (District of Columbia, Puerto Rico, Guam, American Samoa, the Commonwealth of the Northern Mariana Islands, and the Trust Territory of the Pacific Islands). Those who wish to address factors or issues which are specific to one or several permits (i.e. specific requirements for the general permit in Idaho) should clearly indicate that the comment applies to that particular state.

Comments on the proposed rule and permits must be received on or before October 15, 1991. Two copies of comments addressing any aspect of this notice should be sent to Kevin Weiss, Permits Division (EN-336), Environmental Protection Agency, 401 M Street, SW, Washington, DC 20460.

The public hearing schedule to discuss specific state general permits (for the state in which the hearing is held) is as follows:

September 23, 1991, Dallas, TX
September 20, 1991, Oklahoma City, OK
September 24, 1991, Baton Rouge, LA
September 25, 1991, Albuquerque, NM
September 26, 1991, Seattle, WA
September 16, 1991, Boise, ID
September 19, 1991, Juneau, AK
September 30, 1991, Pierre, SD
September 18, 1991, Phoenix, AZ
September 10, 1991, Orlando, FL
September 12, 1991, Tallahassee, FL
September 25, 1991, Augusta, ME
September 24, 1991, Boston, MA
September 26, 1991, Manchester, NH

States Proposed Legislation and Regulations

California

Lead—CA S. 240 (Torres) requires the State Department of Health Services to establish and maintain an occupational lead poisoning prevention program; authorizes the Department to adopt implementing regulations; requires a fee to be paid by those employers involved in industries which present a potential source of occupational lead poisoning; requires the fee to be paid annually to the State Board of Equalization; provides that the cost of the program shall not exceed the amount of revenue collected. (Note—paint manufacturers would be among the 63 SIC #'s affected, with the minimum "employer-paid" fee being $175.00 The California Paint Council will continue to monitor this legislation).

Solid Waste—CA A. 1475 (Tanner) requires that a person recycling the recyclable materials excluded from the hazardous waste control law provide specified information to the local health officer or public officer by July 1, 1992 and annually thereafter. (Note—the California Paint Council is monitoring this legislation).

CA. A.2178 (Brulte) defines the term recyclable latex paint and generally prohibits any person from disposing of latex paint, unless authorized. Allows recyclable latex paint to be accepted at any location if specified requirements are met concerning the management of that paint. Exempts a person transporting recyclable latex paint from the manifest and hazardous waste hauler requirements, but requires the transporter to use a specified bill of lading. (Note—the California

Paint Council was successful in getting legislators to adopt amendments that make this bill acceptable to the industry).

Household Hazardous Waste—CA A. 2092 (Sher) extends the dates when the source reduction and recycling element is required to be prepared and adopted to July 1, 1992, in the case of a city element, and January 1, 1992, in the case of a county element. Extends the date when the city and the county household hazardous waste element is required to be prepared to January 1, 1992. Specifies related duties if the city or county determines it is unable to comply with the deadline and requirements of the Act. (Note—the California Paint Council is monitoring this legislation).

CA A.304 (Wright) imposes additional eligibility requirements on small quantity waste generators participating in a household hazardous waste program. Requires compliance with specified federal regulations. Deletes a limitation on acceptance of halogenated organic compounds and revises the definition of small quantity commercial sources. Specifies a lower facility permit fee for a variance with no significant changes and exempts from fee variances granted as specified. (Note—the California Paint Council is monitoring this legislation).

Graffiti—CA A.446 (Boland) provides that any person who writes, sprays, scratches, or otherwise affixes graffiti on any real or personal property not his/her own is guilty of an infraction punishable by a fine not to exceed a specified amount of money if the amount of the defacement, damage, or destruction is less than the specified amount. Authorizes the court to require the defendant to provide the labor necessary to clean, repair, or replace the damaged property only at the victim's option.

CA S.224 (Watson) permits any territory, whether incorporated, contiguous, or whether within one or more counties, or not, to be included in a graffiti abatement district. Includes graffiti abatement as a specified purpose and enacts procedures for establishing graffiti abatement districts with specified powers. Requires a district to include the territory of an entire city plus some other incorporated or unincorporated territory and defines abatement. Allows the levying of a tax against marking instruments.

Hazardous Waste (Tax)—CA S.194 (Torres) includes the collection of fees and taxes related to the handling of hazardous waste and substances within the Hazardous Substances Tax Law; defines the term "feepayer" for purposes of this law and makes various changes concerning statutory references. Imposes the fee on a business concern which conducts activities related to hazardous material and hazardous waste, thereby imposing a tax for purposes of Article XIIIA of the California Constitution. (Note—the California Paint Council opposes this bill in its present form).

Environmental Issues—CA S.51 (Torres) enacts the Pollution Prevention Act of 1991. Creates the California Environmental Protection Agency and will transfer the State Air Resources Board, the California Integrated Waste Management Board, the State Water Resources Control Board, and the California regional water quality control boards to the agency. (Note—the California Paint Council has reservations about this legislation).

CA A.144 (Sher) ("Environmental Truth in Labelling") provides that it is unlawful for any person to represent that any consumer good, or any part, ingredient, or packaging of a consumer good, which he or she manufactures or distributes is describable by certain terms unless it meets definitions established in regulations which have the full force and effect of law adopted by the Environmental Protection Agency for specified purposes.

CA A.1122 (Sher) makes a statement of legislative intent and creates the California Environmental Protection Agency. Includes within that agency the State Air Resources Board, the California Integrated Waste Management Board, the State Energy Resources Conservation and Development Commission, the State Water Resources Control Board, each California regional water quality control board, and the Department of Toxic Substances Control, created by this bill.

Air Quality—CA A.158 (Roybal-Allard) would authorize an air pollution control officer to review a permit applicant's history of compliance with air pollution laws and regulations and would authorize the officer to deny or refuse to renew a permit if the applicant has a history of violating air pollution control laws. The bill also pertains to the issuance of hazardous waste facility permits. (Note—the California Paint Council is monitoring this bill).

CA A.157 (Roybal-Allard) authorizes an air pollution control officer to require specified information from a supplier, wholesaler, distributor, or manufacturer of volatile organic compounds or chemical substances, and would require the supplier, wholesaler, distributor, or manufacturer to disclose that information to the district. Imposes a state-mandated local program by creating a new crime since failure to comply would be a misdemeanor. Prohibits disclosure of trade secrets, except as specified.

Illinois

Hazardous Waste—IL S.388 (Karpiel) amends the Environmental Protection Act; requires the same kind of manifests for shipment of nonhazardous special waste as is required for hazardous waste.

Solid Waste—IL H.2253 (Kulas et al) amends Solid Waste Planning and Recycling Act; includes encouragement of source reduction among the purposes of the act.

IL S.1296 (Macdonald) amends various acts regarding solid waste; standardizes definition of certain terms; bans sale of certain plastic containers that are not coded recycling; other changes.

Louisiana

Air Quality—LA S.875 (Crain and Thompson) relates to the comprehensive toxic air pollutant emission control program; provides for consistency with federal standards.

Environmental Issues—LA S.825 (Fields) relates to environmental quality; provides for a moratorium on new incinerators; provides for powers of the secretary of the Department of Environmental Quality; provides for permits for incineration facilities; provides for rules; provides for notification to legislators.

Massachusetts

Packaging—MA H.5202 (Mass PIRG) proposes a gradual packaging ban on various "non-recyclable" containers.

Minnesota

Toxics in Packaging—MN H.303 (Wagenius et al.) relates to waste management; amended to include reduction of toxics in packaging and a prohibition on the use of lead, mercury, cadmium and hexavalent chromium in all paints (except artists) by July 1, 1994.

Missouri

Air Quality—The Department of Natural Resources/Air Conservation Commission adopted a regulation (3735) on

July 1 that specifies the air quality standards, definitions, sampling and reference methods, and air pollution control regulations for the state. The rule became effective on July 11. For further information contact, Roger D. Randolph, Staff Director, Air Pollution Control Program, Division of Environmental Quality, Department of Natural Resources, P.O. Box 176, Jefferson City, MO 65102 (314) 751-4817.

New Jersey

Hazardous Substances—NJ S.2220 (Dalton) establishes a regulatory program in the Department of Environmental Protection designed to prevent pollution through the reduction in the use and discharge of hazardous substances. Establishes as a statewide goal a 50% reduction over five years in the use of hazardous substances, in the discharge of hazardous substances into the air and water and in the generation of hazardous waste. Requires owners and operators of certain facilities to inventory the substances that they use or discharge.

New York

Aerosols—NY A.3620 (Weprin) Companion to S.B. 2369. Authorizes the NYC Departments of Consumer Affairs, Sanitation, Environmental Protection and Transportation and the NYC Police Department to issue summons for violations involving the sale of aerosol spray paint cans and broad tipped indelible markers.

NY S. 2369 (Padavan et al.) Companion to A.B. 3620. Authorizes the New York City Departments of Consumer Affairs, Sanitation, Environmental Protection and Transportation and the NYC Police Department to issue summons for violations involving the sale of aerosol spray paint cans and broad tipped indelible markers.

Packaging (Toxic)—NY A.8887 (Committee on Rules) provides a two to four-year delay in implementation of reduction of toxics-in-packaging requirements relative to "tin cans" used to contain paint and chemicals and nonfood products with lead components.

North Carolina

Environmental Crimes—NC S.51 (Daniel) improves the investigation and enforcement of crimes against the environment, declares unlawful discharges to be crimes and establishes a three-year statute of limitation for the collection of certain environmental civil penalties.

Air Quality—The Department of Environment, Health and Natural Resources/Environmental Management Commission adopted a rule (1464) on July 15 that establishes new source performance standards for hazardous air pollutants; requires compliance with the standards by automobile and light-duty truck manufacturers, coatings operations and incinerators; sets forth rules for the control of the emissions of air pollutants from incinerators; requires owners/operators of incinerators to test equipment for emission compliance. For further information, contact Thomas C. Allen, Division of Environmental Management, P.O. Box 27687, Raleigh, NC 27611-76867, (919) 733-3340.

Pennsylvania

Air Quality—On August 2, the Environmental Quality Board adopted an amendment (1664) to the Environmental Quality Board Air Resources Regulations pertaining to Volatile Organic Compounds (VOCs). The amendment defines regional boundaries; extends the applicability of emission limitations: surface coating and pneumatic rubber tire manufacturer; revises leak check requirements for synthetic organic chemical and polymer manufacturing and clarifies emission control system efficiency requirements for surface active agent manufacturing facilities. Clarifies that "clean-up" solvent use is to be considered in determining applicability of graphic arts regulatory requirements. Adds a recordkeeping requirement for regulated sources of VOCs. Brings Environmental Quality Control Board regulations in conformance with EPA requirements. For further information, contact Gary L. Triplett, Chief, Division of Air Resources Management, Board of Air Quality Control, P.O. Box 2357, Harrisburg, PA 17120, (717) 787-4310.

Wisconsin

Aerosols—The Department of Natural Resources Adopted a regulation (6259) on July 31 that pertains to the establishment of an emission limitation for certain sources of volatile organic compounds (aerosol can filling operations). The effective date is September 1, 1991. For further information, contact Donald Theiler, Bureau of Air Management, P.O. Box 7921, Madison, WI 53707.

Issues Recap

Arizona

The Arizona legislation adjourned at the end of April. Existing bills will not carry into the next session.

AZ S. 1259—would have provided that interior finish and trim products and structural members could not be used until it was tested for combustion toxicity. Introduced in February, no further action.

AZ S. 1379—would have added a wide-ranging general-purpose "pollution prevention" chapter to the Environment Code. Referred to Environment Committee in February, no further action.

AZ H. 2401—pertains to hazardous products tax (replaced by S. 1170 which repealed the 8.5% hazardous waste surtax and implements in its place, a flat $12.00 per establishment retailer fee. Signed by the Governor on June 3, 1991.

California

CA A. 1609—enacts the Heavy Metal Packaging Waste Act of 1991. No further action.

CA S. 428—requires any business which sells or delivers any hazardous material to accept back the empty container used to transfer that material. Passed Senate on June 10. Sent to Assembly Committee on Environmental Safety and Toxic Materials on June 13. Note—the California Paint Council is working to amend or defeat this bill.

CA A. 1565—imposes a tax on paint (to be deposited in the Lead Based Paint Fund). No further action to report. Note—the California Paint Council is working to defeat this bill.

Florida

The Florida legislation adjourned in May. Existing bills will not be carry into the next session.

FL H. 1827—would have imposed restrictions on aerosol spray paint cans and broad-tipped markers. Introduced on March 11 with no further action.

Georgia

The Geogia legislation adjourned in May. All existing bills will carry over into the next session.

GE H. 124—provides for the regulation of toxic heavy metals in packaging. Reported with substrate from House Committee on Natural Resources and Environment on February 21. No further action.

Illinois

The Illinois legislature adjourned at the end of June. All existing bills will carry over into the next session.

IL H. 463—imposes a 15 cent per pound fee on certain toxic emissions.

IL H. 2196—prohibits the sale of spray paint. Remains dormant. No action since introduction. The Illinois Paint Council successfully lobbied against this bill.

IL H. 2451—pertains to toxic automobile paint and hazardous waste identification numbers. Subsequent amendments modified the bill to narrow its focus.

IL H. 1852—creates the Lead Poisoning and Lead Abatement Act. Author agreed to withdraw the bill in exchange for co-sponsorship of IL H. 2295.

IL H. 2295—amends the Lead Poisoning Prevention Act. Passed the Senate on June 27.

Maine

The Maine legislature adjourned in mid-June. All existing bills will carry over into the next session.

ME H. 1317—would implement an educational program regarding disposal of household hazardous products; establish collection center. The bill would have imposed a ¢.25 tax on certain household hazardous products, including paint, but it died in the Joint Committee on Taxation.

Maryland

The Maryland legislature adjourned in mid-April. Existing bills will not carry over into the next session.

Massachusetts

MA H. 1982—reduces heavy metals in packaging. Reported from Join Committee on Natural Resources and Agriculture on May 13. No further action.

MA H. 4864—provides for a paint recycling program. Reported from Joint Committee on Commerce and Labor on June 12. No further action.

New Jersey

NJ A. 2916 and S. 2261—pertains to toxic substances and packaging. Amended to delay impact on paint industry suppliers. No action since April.

New York

NY A. 5818—would require statewide lockup of aerosol paint cans and broad-tipped markers. No action since introduction in March. (Sponsor has indicated no interest in moving this bill.)

Oregon

The Oregon legislature adjourned at the end of June. Existing bill will not carry over.

OR H. 3431—would have prohibited the sale of toxic packaging or packing components.

OR S. 1108—would have prohibited the sale of toxic packaging or their components.

Pennsylvania

PA H. 81—provides for the establishment of a Lead Poisoning Program in the Department of Health; imposes a tax on sale/use of paint. A public hearing was held on June 6. No further action.

Vermont

The Vermont legislature adjourned in mid-May. All existing bills will carry over.

VT H. 39—prohibits landfilling of paint, paint thinners, paint remover, stains, and varnishes, with an exemption for "solidified water-based paint in quantities of less than one gallon"; for purposes of transportation, paint, paint thinner, and paint remover will not be considered hazardous waste, but will be handled as solid waste. Require the Agency of Natural Resources, in cooperation the paint and coatings manufacturers and wholesalers, and in consultation with the Technical Advisory Committee on Solid Waste to develop and implement a plant that would cover the collection, recycling, reuse, treatment, of disposal of unused paint and coatings products, including thinners and strippers. Signed by the Governor on June 26.

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Notice

NPCA invites all members interested in participating in negotiations on the Vermont household hazardous waste program to call Matt Dustin in the State Affairs Division. NPCA is currently meeting every two weeks with Vermont officials to develop a program by January 1, 1992, as mandated by state law.

The law, passed this summer, requires the state's Secretary of Natural Resources, in consultation with manufacturers and distributors in the state, to develop a comprehensive system for the collection, recovery, recycling, reuse, treatment or disposal of used paints and coatings and their containers.

Federation of Societies for Coatings Technology

1991 Annual Meeting and Paint Industries' Show

Preliminary Program

Metro Toronto Convention Centre
Monday, Tuesday, Wednesday • November 4 - 5 - 6
Toronto, Ontario, Canada

Preliminary Program

"The International Coatings Environment: Today's Opportunity, Tomorrow's Challenge"

MONDAY, NOVEMBER 4

OPENING SESSION
(8:30)

Sixty-Ninth Annual Meeting of the Federation of Societies for Coatings Technology opened by President Kurt F. Weitz

Invocation and In Memoriam

Welcome: Gerry Parsons, President of Toronto Society for Coatings Technology and Chairman of the Program Committee

Larry Ham, Chairman of the Host Committee

Kenneth R. Hyde, Chairman of the Paint Industries' Show Committee

Introduction of Distinguished Guests

E.W. FASIG KEYNOTE ADDRESS

Europe '92—World Economy—Peter C. Newman, Canadian Journalist and Political Correspondent

WORLD CLASS QUALITY— A FRAMEWORK FOR ACTION
(2:00-4:30)

Moderator—John A. Lanning, Product Quality Manager, Porter Paints Div., Courtaulds Coatings, Inc., Louisville, KY

Overview of a Meaningful Total Quality Management Program with Emphasis on Total Improvement—Dr. Peter J. Hunt, President, Productivity Management Consultants, Clearwater, FL

How to Start a Quality Program—Focus on Top Management and Total Employee Involvement—R. Edward Bish, Manager, Training and Regulatory Affairs, Jamestown Paint & Varnish Co., Jamestown, PA

The Cadillac Quality Story—Stephen J. Seaton, Director, Dealer Service Development, Cadillac Motor Car Div., General Motors Corp., Detroit, MI

Standardization in Manufacturing Procedures—Heinz Newman, Operations Manager, Polymers and Resins North America, Rohm and Haas Co., Philadelphia, PA

Safety and Total Quality Management—A.H. Schultz, Safety, Health & Environmental Manager, E.I. du Pont de Nemours & Co., Inc., Wilmington, DE

PROFESSIONAL DEVELOPMENT COMMITTEE SYMPOSIUM ON ADVANCED TOPICS IN COATINGS RESEARCH
(2:00-4:00)

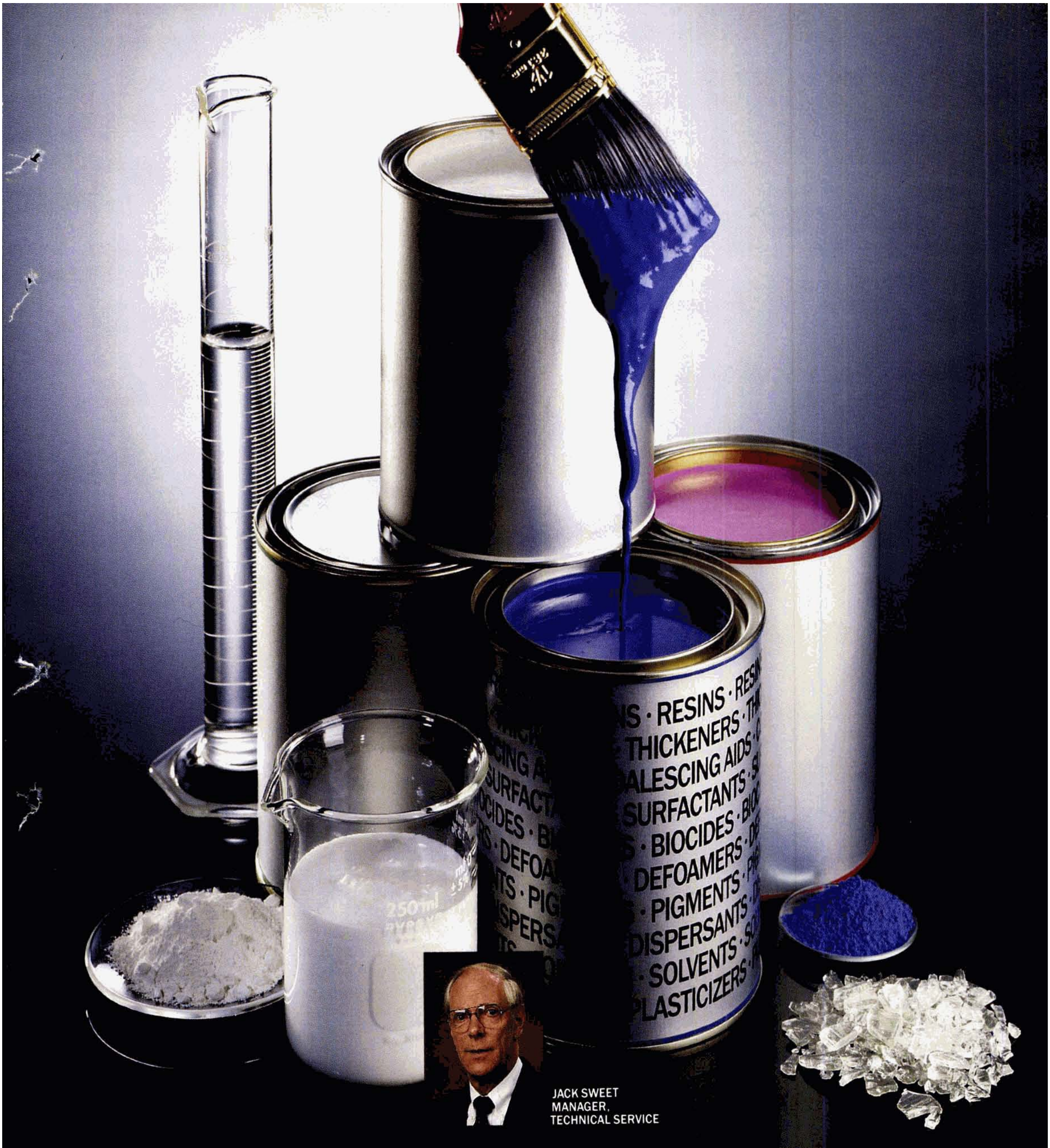
Moderators: Dr. Rose A. Ryntz, Technical Director, Plastics and Industrial Finishes, Coatings Div., Akzo Coatings, Inc., Troy, MI and Dr. Clifford K. Schoff, Scientist, Head of Physical Chemistry Group, PPG Industries, Inc., Allison Park, PA

Outlook for Self-Assembling Polymers as Coatings Binders—Dr. Frank N. Jones, Director, National Science Foundation Industry/University Cooperative Research Center, Eastern Michigan University, Ypsilanti, MI

Starburst Dendrimers: Molecular Level Control of Size, Shape, Surface Chemistry, Topology, and Flexibility from Atoms to Macroscopic Matter—Donald A. Tomalia, Michigan Molecular Institute, Midland, MI

New Developments in Coating with Waterbase and Powder Paints—Prof. Ion I. Inculet, Applied Electrostatics Research Centre, Faculty of Engineering Science, The University of Western Ontario, London, Ontario, Canada

Advances in Zinc Phosphate Pretreatments—Dr. Thomas Cape, CM Surface Treatment, Inc., Southfield, MI



JACK SWEET
MANAGER,
TECHNICAL SERVICE

SOCIETY PAPERS—I
(2:00-4:30)

Moderator: Patricia A. Shaw, Technical Director, Davlin Coatings, Inc., Berkeley, CA

Changes in Hiding During Latex Film Formation. Part IV. Effect of Film Thickness and Toning—Cleveland Society for Coatings Technology. Presented by Freidun Anwari, Coatings Research Group, Inc., Cleveland, OH

Clear Liquid Separation in Latex Paints Containing Cellulosic/Associative Thickener Systems—Cleveland Society for Coatings Technology. Presented by Ben J. Carlozzo, Tremco, Inc., Cleveland, OH

Effect of Siloxane Modification on the Physical Attributes of an Automotive Coating—Detroit Society for Coatings Technology

Coatings for Automotive Plastics—Toronto and Montreal Societies for Coatings Technology and the Vancouver Section of the Pacific Northwest Society for Coatings Technology. Presented by Gordon E. Major, Bethco Consultants, Bramlea, Ontario, Canada

Sparkle Paint—Using Recycled Ground Glass as Pigment—Golden Gate Society for Coatings Technology. Presented by Gregg Lindblom, Chemistry Dept., California Polytechnic State University, San Luis Obispo, CA

POLYMERS: ADVANCED TECHNOLOGY
(2:00-4:30)

Moderator: Mary G. Brodie, Strongsville, OH

Polyester Oligomers of Narrowed Molecular Weight Distribution—David Rogemoser, Roy C. Williams, and Richard M. Benton, Coatings, Polymers, and Resins Div., Reichhold Chemicals, Inc., Buffalo, NY

Ultrasonically Initiated Free Radical Catalyzed Polymerizations—Dr. James O. Stoffer, O.C. Sitton, and Hwei-Ling Kao, Chemistry Dept., University of Missouri-Rolla, Rolla, MO

Novel Flexible Epoxy Resins for Waterborne Coating Applications—David S. Sheih and Duane S. Treybig, Coatings, Adhesives, and Sealants Application Laboratory, The Dow Chemical Co., Freeport, TX

A Comparison of the Formability of Coatings from Epoxy Resins, Epoxy Phosphate Ester Resins, and *In-Situ* Advancement Epoxy Resins—J.L. Massingill, Jr. and R.C. Whiteside, Jr., Coatings, Adhesives, and Sealants Application Laboratory, The Dow Chemical Co., Freeport, TX

Structure/Property Relationships Among Epoxy Resins Used in Industrial Protective Coatings—D.L. Steele, Coatings, Adhesives, and Sealants Application Laboratory, The Dow Chemical Co., Freeport, TX

TUESDAY, NOVEMBER 5

ROON AWARDS COMPETITION PAPERS—I
(9:00-11:00)

Moderator: Peter A. Hiscocks, Senior Group Chemist, Ashland Chemicals, Mississauga, Ontario, Canada

Latex Film Formation at the Molecular Level: The Effect of Coalescing Aids on Polymer Diffusion—Dr. Mitchell A. Winnik and Yongcai Wang, Department of Chemistry, University of Toronto, Toronto, Ontario, Canada, and Frank Haley, ICI Canada, Toronto, Ontario, Canada

Possible Reaction Pathways for Self-Condensation of Melamine Resins: Reversibility of Methylene Bridge Formation—Dr. Frank N. Jones and Upasiri Samaraweera, Eastern Michigan University, Ypsilanti, MI

A Novel Design Strategy for Blocked Isocyanates to Enhance Their Reactivity with Alcohols. Oxime Blocking Agents which Undergo Intramolecular Cyclization—J. Wells Carter, Union Carbide Corp., Bound Brook, NJ, and Dr. S. Peter Pappas, Polymers and Coatings Department, North Dakota State University, Fargo, ND

T_g-Temperature Property (T_gTP) Diagram for Thermosetting Systems: Anomalous Behavior of Physical Properties vs Extent of Cure—Xiaorong Wang and John K. Gillham, Polymer Materials Program, Department of Chemical Engineering, Princeton University, Princeton, NJ

Registration Hours

Sunday, November 3 .... 8:00 a.m.-7:30 p.m.
Monday, November 4 .... 7:00 a.m.-5:30 p.m.
Tuesday, November 5 .... 7:00 a.m.-5:30 p.m.
Wednesday, November 6 .... 7:00 a.m.-12:00 noon

Paint Show Hours

Monday, November 4	10:00 a.m.-5:30 p.m.
Tuesday, November 5	8:00 a.m.-5:30 p.m.
Wednesday, November 6	8:00 a.m.-12:00 noon

MANUFACTURING COMMITTEE SEMINAR ON WASTE MINIMIZATION/PRODUCTION OPTIMIZATION
(9:00-12:00)

Moderator: Anne M. Probizanski, Ampro Technologies, Riverside, CA

Introduction: Dr. Charles Rooney, President, Orr & Boss, New York, NY

The Rationale for Change—Samuel J. Bright, Plant Manager, E.I. du Pont de Nemours & Co., Inc., Toledo, OH

Quality Productivity Improvement—Alvin A. Crego, Plant Manager, The Glidden Co., Oakwood, GA

Summary/Closing Comments: Dr. Rooney

Moderator and speakers will assemble as a panel for an open discussion period to conclude the seminar.

Presentation of the 1991 Morehouse Golden Impeller Award for outstanding achievement in dispersion technology will be made at this session.

GENERAL PAPERS ON COATINGS TECHNOLOGY
(9:00-11:30)

Moderator: Robert S. Deruiter, Laboratory Manager, Reichhold Ltd., Weston, Ontario, Canada

Propylene Glycol Ethers as Coalescing Aids in Waterborne Acrylic Emulsions—James R. Bodwell, David C. Dehm, Joseph Junker, and Michael P. Law, ARCO Chemical Co., Newtown Square, PA

The Adhesion of Ice to Coatings and the Performance of Ice Release Coatings—V.K. Crouch and R.A. Hartley, ORTECH International, Mississauga, Ontario, Canada

Spheroidal Iron Oxide Yellows: A New Generation of Pigments for Paints and Colorants—Axel Wilms, Manager, Technical Service, Applications Department, Mobay Corp., Pittsburgh, PA

Powder Coating Chemistry and Properties—Vipul Joshi, Senior Chemist, CIBA-GEIGY Corp., Ardsley, NY

Improvement of Corrosion Properties of Coatings Using Wetting and Dispersing Additives—Janos Hajas, Byk-Chemie GmbH, Wesel, Germany

SOCIETY PAPERS—II
(9:00-11:00)

Moderator: Robert D. Athey, Jr., Athey Technologies, El Cerrito, CA

Suitability of ASTM Test Method for High Solids VOC Determination—Philadelphia Society for Coatings Technology

Selection of Corrosion Test Methods Based on Mechanism Principles—Northwestern Society for Coatings Technology

Flash Rust Testing and Inhibitor Evaluation Through a New Spectrophotometric Integration Technique—St. Louis Society for Coatings Technology. Presented by Michael R. Van De Mark, Chemistry Department, University of Missouri-Rolla, Rolla, MO

Variable Characteristics of Titanium Dioxide Pigments Using SEM and Particle Size Analyses—Houston Society for Coatings Technology. Presented by David Siller, Kenrich Petrochem Inc., Sugarland, TX

ROON AWARDS COMPETITION PAPERS—II
(2:00-4:00)

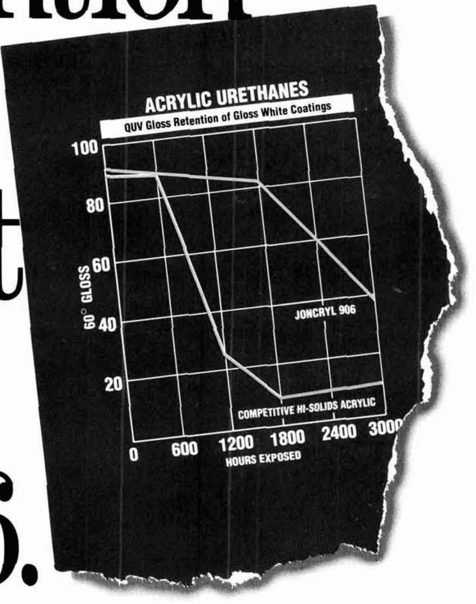
Moderator: Dr. Richard J. Himics, President, Daniel Products Co., Jersey City, NJ

Pigment Stabilization Through Mixed Associative Thickener Interactions—Dr. David J. Lundberg, Senior Coating Chemist, 3M Co., St. Paul, MN, and Dr. J. Edward Glass, Polymers & Coatings Dept., North Dakota State University, Fargo, ND

Use of a Mathematical Model to Predict the Effects of Extenders on Pigment Dispersion in Paint Films—J. Temperley, M.J. Westwood, M.R. Hornby, and L.A. Simpson, Tioxide Group PLC, Central Laboratories, Stockton-on-Tees, Cleveland, England

Electrostatic Painting of Plastics I: Electrical Properties of Plastics and Primers—Dr. David P. Garner, Staff Research Scientist, Polymers Department, and Dr. Alaa A. Elmoursi, Staff Research Engineer, Electrical and Electronics Engineering Department, General Motors Research Laboratories, Warren, MI

If You Think You Need To Sacrifice Gloss Retention To Reduce VOCs, Start Thinking Joncryl® 906.



To comply with lower VOC requirements, more and more formulators are turning to Joncryl acrylic polymers for high solids, 2-Pak urethane coatings. Like our innovative Joncryl 906 acrylic polyol for high performance maintenance, transportation and factory OEM coatings, offering lower VOCs and performance that's similar to conventional solids urethane finishes.

Compared to other low VOC acrylics, Joncryl 906 provides superior gloss retention and exterior durability at a VOC level of 3.2 lbs./gal. Not to mention excellent chemical and solvent resistance, fast dry times and a practical pot life. And with an equivalent weight of 600, Joncryl 906 reduces isocyanate demand and lowers formulated coating costs.

Don't let tightening VOC regulations hurt your performance. Switch to Joncryl high solids acrylic polyols—the only ones produced with our patented SGO technology. For more information on Joncryl 906 or our entire line, write to SC Johnson Wax, Specialty Chemicals, Racine, WI 53403. Or call **1-414-631-3920.**

SC Johnson wax
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Electrostatic Painting of Plastics II: Electric Field Effects—Dr. Alaa A. Elmoursi, Staff Research Engineer, Electrical and Electronics Engineering Department, and Dr. David P. Garner, Staff Research Scientist, Polymers Department, General Motors Research Laboratories, Warren, MI

RESEARCH PAPERS: INTERNATIONAL SOURCES
(2:00-4:00)

Moderator: George R. Pilcher, Technical Director, Akzo Coatings, Inc., Columbus, OH

Electrochemical Impedance Spectroscopy in the Study of Metal Pretreatment and Protecting Coating—Dr. Prof. P.L. Bonora, Head, Laboratory of Electrochemistry, Department of Materials Engineering, University of Trento, Trento, Italy. (Presented on behalf of FATIPEC: Federation of Associations of Technicians in the Paint, Varnish, Lacquer, and Printing Ink Industries of Continental Europe)

Introduction of a Newly Developed Coating Technology to Protect Submerged Structures Against Fouling—Iwao Momiyama, Kiyoshi Nanishi, and Masato Kishihara, Kansai Paint Co., Ltd., Kanagawa, Japan. (Presented on behalf of JSCM: Japan Society of Colour Material)

Simultaneous Assessment of Influence on Hiding Power by Several Compositional Factors: Taguchi Approach—V.S. Vaidya and V.M. Natu, Asian Paints (India) Ltd., Bombay, India

Micro Titanium Dioxide—Properties and Applications—Dr. Brian J. Meldrum, Tioxide Chemicals, Central Laboratories, Stockton-on-Tees, Cleveland, England

CORROSION COMMITTEE SYMPOSIUM ON COATINGS FOR CORROSION CONTROL OF NONFERROUS SUBSTRATES
(2:00-4:30)

Moderator: Horace Philipp, Supply & Services Canada, Hull, Ontario, Canada

Filiform Corrosion on Aluminium Auto Body Sheet—Gregory Courval, H. Lagace, and J. Allin, Kingston Research and Development Centre, Alcan International Ltd., Kingston, Ontario, Canada

State-of-the-Art Finishes for Copper and Its Alloys—Saul Spindel, President, D/L Laboratories, New York, NY

Manufacturing Processes for Metallic Coated Sheet Steels—R. James Shaffer, Director of Marketing, Advanced Coatings Technologies, Inc., Southfield, MI

Organic Coatings for the Protection of Imide-Based Composites—Dr. Charles R. Hegedus, Materials Engineer, Aerospace Materials Div., Naval Air Development Center, Warminster, PA

Presentation of the 1991 Corrosion Committee Publication Award for best corrosion-related paper published in the JOURNAL OF COATINGS TECHNOLOGY will be made at this session.

WEDNESDAY, NOVEMBER 6

COATINGS: GLOBAL PERSPECTIVES
(9:00-10:30)

Moderator: John E. Hall, Technical Service Manager, Tioxide, Inc., St. Laurent, Quebec, Canada

The New Zealand Coatings Market: Opportunities and Drawbacks—Don MacDonald, Chief Executive, Protec Creative Coatings Ltd., Aukland, New Zealand (Presented on behalf of OCCA-NZ: Oil and Colour Chemists' Association-New Zealand)

Powder Coatings: Global Perspective—Gregory J. Bocchi, Executive Director, The Powder Coating Institute, Alexandria, VA

UV and Electron Beam Curing: A Global Perspective—Tony Berejka, President, RadTech International, Huntingdon, NY

ANNUAL BUSINESS MEETING
(9:00-10:00)

Annual Business Meeting of the Federation.

Presentation of these awards: A.F. Voss/*American Paint & Coatings Journal* . . . Southern Society A.L. Hendry . . . Outstanding Service . . . Society Speaker . . . Society Secretaries.

Installation of Officers, 1991-92.

MATTIELLO MEMORIAL LECTURE
(10:30-11:30)

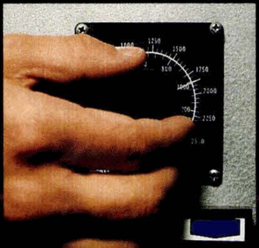
Introductory comments by John Vandeberg, DSM Desotech, Inc., Des Plaines, IL, Chairman of the Joseph J. Mattiello Memorial Lecture Committee.

Structure/Property Relationships of Thermoset Coatings—Dr. Loren W. Hill, Senior Fellow, Surface Coatings Group, Monsanto Chemical Co., Indian Orchard, MA

AWARDS LUNCHEON
(11:45)

Presentation of these awards: George Baugh Heckel . . . Paint Show . . . Roon Foundation . . . Union Carbide.

Featured Speaker: Michael Broome, Humorous Motivator.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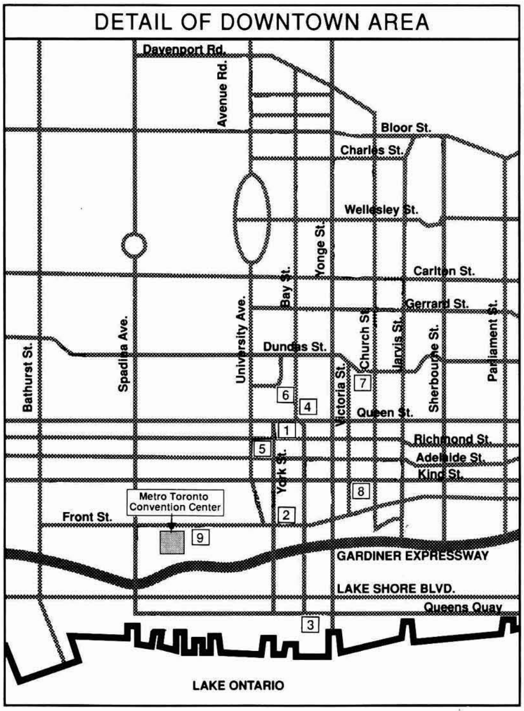
2000
2250

HOTEL ROOM AND SUITE RATES*

Map Key	Hotel	Singles	Doubles/Twins	Suites	
				1 BR	2 BR
1	Sheraton Centre	$140	$155	$300-412	$360-700
	Towers	152	183		
2	Royal York	140	155	425-875	565-1,425
3	Westin Harbour Castle	140	160	250	375
4	Marriott Eaton Centre	139	149		
5	Hilton International	140	155	324	446-900
6	Holiday Inn Downtown City Hall	99	109	175	400
7	Bond Place	89	89		
8	King Edward	165	165	360-485	525-650
9	L'Hotel	145	160	295-400	375-490

*The rates are quoted in Canadian funds. At the present time the U.S. dollar is worth $1.13 Canadian. (To determine the rates in U.S. dollars multiply by .87). The rates are subject to Provincial and Goods and Services Tax and other applicable taxes.


DETAIL OF DOWNTOWN AREA

SHUTTLE BUS SERVICE

Shuttle bus service will be provided between the cooperating hotels and the Metro Toronto Convention Centre beginning Sunday, November 3

1991 FSCT Annual Meeting and Paint Industries' Show
Metro Toronto Convention Centre
Monday, Tuesday, and Wednesday, November 4, 5, 6

69th Annual Meeting & 56th Paint Industries Show
FSCT
1991

APPLICATION FOR HOTEL ACCOMMODATIONS

Mail to:

By 10/4/91

FSCT Housing Bureau
P.O. Box 126
207 Queen's Quay West
Toronto, Ont., M5J 1A7
Canada
Fax: 416-367-9088

Please indicate below the type of accommodations desired and choice of hotels. (Refer to hotel map and rates on opposite page). All reservations will be processed by the FSCT Housing Bureau. Hotel assignments will be made in accordance with prevailing availability. You will receive an acknowledgment from the Housing Bureau. This is not the hotel confirmation. That will come directly to you from the hotel to which you have been assigned. Prior to October 4, all changes must be made, in writing, through the Housing Bureau. After October 4, all modifications should be made directly with the hotel.

A one-nights' deposit MUST accompany each housing request. Checks or credit cards may be used. Checks **must** be made out to FSCT Housing Bureau.

TYPE OF ACCOMMODATION	**NUMBER**	**RATE**	**CHOICE OF HOTEL**
Single (1 person, 1 bed)	________	________	(1) ________
Twin (2 people, 2 beds)	________	________	(2) ________
Double (2 people, 1 bed)	________	________	(3) ________
Suite (parlor and 1 bedroom)	________	________	(4) ________
Suite (parlor and 2 bedrooms)	________	________	

NAMES OF ROOM OCCUPANTS AND DATES OF ARRIVAL/DEPARTURE

Type of Room	**Name**	**Dates** **Arrive**	**Depart**

Please Type Additional Reservations on a Separate Sheet and Attach to This Form

SEND CONFIRMATION FOR ALL RESERVATIONS TO:

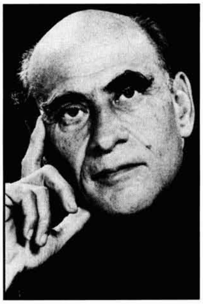
Name ______________________ Telephone ______________
Company ______________________ FAX ______________
Address ______________________________________
City, State, Zip ______________________________________
Country ______________________________________
Name of Credit Card ______________ Signature ______________
Credit Card Number ______________ Exp. Date ______________

Note: Requests for accommodations at either the Sheraton Centre or the Royal York will be limited to 10 rooms per company. A parlor counts as one room.

1991 Annual Meeting
Paint Industries' Show
Featured Presentations

Keynote Address

Monday, November 4



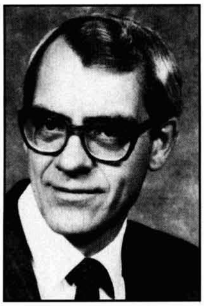
"Europe '92—World Economy"

Peter Newman

As a journalist and political correspondent, Peter Newman, is known for his behind-the-scenes political reporting, featured in the Canadian weekly, *Maclean's*. Mr. Newman is currently working on *Merchant Princes*, the final volume of his history of the Hudson's Bay Company. His extensive writing credits include a two-volume examination of the Canadian establishment; a book on the Bronfman dynasty, the story of the Montreal family behind the Seagram empire; and a profile of Conrad Black, an obscure Toronto businessman, who is now rapidly building an international press empire.

Mattiello Lecture

Wednesday, November 6



"Structure Property Relationships of Thermoset Coatings"

Dr. Loren W. Hill

Dr. Loren Hill is Senior Fellow, Surface Coatings Group, at Monsanto Chemical Co., Indian Orchard, MA. Although his career began at North Dakota State University, Dr. Hill is recognized for achievements in both academia and industry. His research has focused on rheology of high solids coatings, and has expanded to include structure property relationships of crosslinked coatings. Dr. Hill has examined the use of dynamic mechanical anaysis to determine crosslink density and to support the design of resin structures to obtain optimized combinations of physical properties. An invited lecturer at many seminars and conferences, he is recognized for his extensive publishing and teaching credits. Dr. Hill has sought to support the pioneering work of Joseph J. Mattiello in expanding the application of basic sciences to solving problems in the decorative and protective coatings field.

FSCT Luncheon

Wednesday, November 6

Michael Broome

During the past ten years, Mr. Broome has addressed over 2,000 audiences throughout the nation. He is able to adapt his humorous and motivational presentation to virtually any type of audience. While addressing topics of goal setting, people management, stress avoidance, America and the family, Mr. Broome emphasizes that achieving a balance in living is the ultimate barrier of success. If Mr. Broome's talks begin with that rare commodity—laughter—they end even more unconventionally in grateful applause and real inspiration.

1991 PAINT INDUSTRIES' SHOW

EXHIBITORS

A

Alt-Chem International	1045
Aceto Corp.	2422
Advanced Coating Technologies	1833
Advanced Software Designs	1741
Air Products & Chemicals, Inc.	1427
Ajinomoto U.S.A., Inc.	134
Akzo Chemicals	1233
Alcan-Toyo America, Inc.	1821
Alcoa Industrial Chems., Div. of Aluminum Co. of America	1401
Allied Signal, Inc.	1613
Ambrose Company	1203
American Chemical Society/C&E News	1501
American Cyanamid Co.	633
American Iron and Steel Institute	133
Amoco Chemical Co.	945
Ampac, Inc.	1645
Anachemia Solvents Ltd.	118
ANGUS Chemical Co.	1829
Anker Labelers USA, Inc.	1302
Aqualon Co.	1533
Arco Chemical Co.	1543
Aries Software Corp.	2440
Ashland Chemical Co., Coatings & Resins Div. Canada	811
Atlas Electric Devices Co.	919
Atochem North America	2245
Automated Filling Specialists	1340
Aztec Catalyst Co.	2433

B

B&P Environmental Resources	2033
B.A.G. Corp.	2441
BASF Corp., Chemicals Div.	833
Blackmer Pump, Dover Resources Co.	2128
Bohlin Reologi, Inc.	2507
Brookfield Eng. Labs., Inc.	2305
Brookhaven Instruments Corp.	1447
Buckman Laboratories, Inc.	827
Buhler, Inc.	127
Bulk Lift International, Inc.	1237
Burgess Pigment Co.	1925
Byk-Chemie USA	925
Byk-Gardner, Inc.	933

C

C B Mills, Inc.	1143
CR Minerals Corp.	845
Cabot Corp., Cab-O-Sil & Special Blacks Div.	325
Calgon Corp., Div. of Merck & Co., Inc.	1922
Canada Colors & Chemicals Ltd.	2520
The Carborundum Co., Fibers Div.	2246
Cardolite Corp.	1946
Cargill, Inc.	1713
Carroll Scientific, Inc.	1445
Celite Corp.	424
Cellier Corp.	2010
Chemical Marketing Reporter	1845
Chemical Week	1146
Coatings Magazine	1041
Color Corp. of America	619
Colorgen, Inc.	844
Columbian Chemicals Co.	2317
Consolidated Research, Inc.	1321
Cookson Pigments, Inc.	2327
Coulter Electronics, Inc.	345
Cray Valley Products International	1929
Crosfield Chemicals, Inc.	705
Cuno Process Filtration Products	1921
Cyprus Industrial Minerals Co.	1844

D

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DSA Consulting, Inc.	1443
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Defelsko Corp.	116
Degussa Corp.	1629
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Disti, Inc./Distill-Kleen, Inc.	1245
Dominion Colour Corp.	444
Dow Chemical USA	525
Dow Corning Corp.	533
Draiswerke, Inc.	1529
Drew Industrial Division	225
Dry Branch Kaolin Co.	428
Du Pont Co.	1333

E

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Eagle Picher Minerals, Inc.	2346
Eagle Zinc Co.	212
Eastern Michigan University	2623
Eastman Chemical Products, Inc.	1933
Ebonex Corp.	2031
Eiger Machinery, Inc.	1740
Elcometer, Inc.	138
Elektro-Physik USA, Inc.	1235
Elmar Industries, Inc.	2509
Engelhard Corp., Spec. Min. & Colors Group	1621
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Epworth Manufacturing Co., Inc.	1824
Etna Products Inc., Specialty Chemical Div.	746
Exxon Chemical Co.	1125

F

FCF-Bowers, Inc.	2239
FMC Corp., Food & Phamaceutical Prod. Div.	647
FMJ International Publications, Paint & Chemical Div.	2525
Fawcett Co., Inc.	2516

Federation of Societies for Coatings Technology	Lobby
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Fischer Technology, Inc.	744
Freeman Polymers Div. of Cook Composites & Polymers	1040

G

GAF Filtration Products	2323
Paul N. Gardner Co., Inc.	644
Geneq, Inc.	122
B.F. Goodrich Co., Spec. Polym. & Chem. Div.	1907
W.R. Grace & Co., Davison Chemical Div.	2019
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H

H.E.R.O. Industries Ltd.	2014
Halox Pigments, Div. of Hammond Lead Products	1633
Harcros Pigments, Inc.	1011
Henkel Corp., Process Chemicals	1417
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Hockmeyer Equipment Corp.	913
Hoechst Celanese Corp.	1343
Hoechst Celanese Corp., Waxes & Lubricants Group	2628
Horiba Instruments, Inc.	1746
J.M. Huber Corp.	1129
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Hungalu Trading Co.	1336
Hunterlab	2119

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International Specialty Products, Inc.	1323

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King Industries, Inc.	2427
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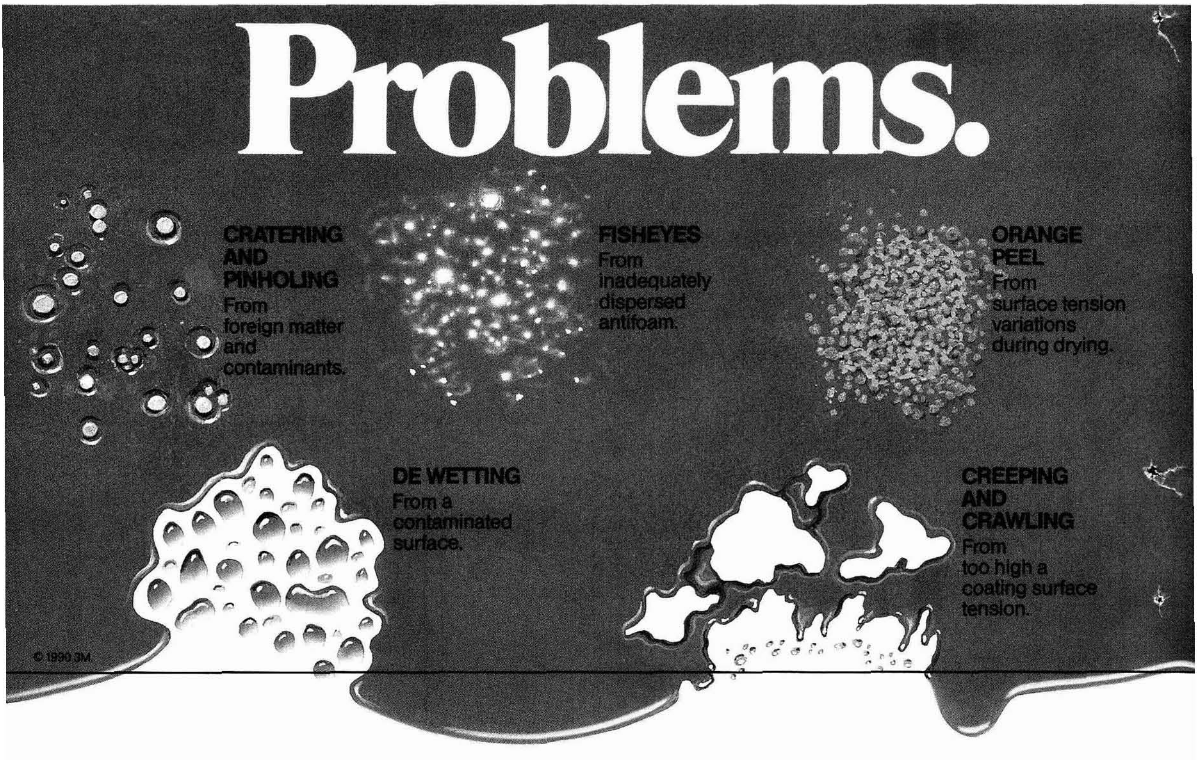
Krones Machinery Co., Ltd.	328
Kronos, Inc.	1317



L

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Charles Ross and Son Co.	403
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Shell Chemical Co.	1725
Sherwin-Williams Chemicals Co.	331
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Silberline Manufacturing Co., Inc.	719
Sino-American Metals & Minerals	124
Siva International, Inc.	2146
Smart Turner Limited	111
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Southern Clay Products	2421
University of Southern Mississippi	2617
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Sub-Tropical Testing Service	1239
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Thiele Engineering Co.	1521
Tioxide, Inc.	2125
Troy Chemical Corp.	1033

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Union Carbide Corp.	411
Union Process, Inc.	1920
United Catalysts, Inc., Rheo. & Perf. Minerals Group.	425
United States Testing Co., Inc.	346
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Van Waters & Rogers	2529
R.T. Vanderbilt Co., Inc.	2124
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Versa-Matic Tool, Inc.	546
Vorti-Siv, Div. of M&M Industries, Inc.	1420

W

Wacker Silicones Corp.	2039
Warren-Rupp, Inc., A Unit of Idex Corp.	324
Whallon Machinery, Inc.	112
Wilden Pump & Engineering Co.	214
Witco Corp	819

X

X-Rite, Inc.	211

Y

York Fluid Controls Ltd.	645

Z

Zeelan Industries, Inc.	1915

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FEDERATION MEETINGS AND OTHER EVENTS

Sunday, November 3

Board of Directors Meeting (9:00 a.m.)	Sheraton, Dominion
Women in Coatings Reception (5:30 p.m.)	Sheraton, Dominion
Paint Show Exhibitors Reception (6:30 p.m.)	Convention Centre, Reception Hall

Monday, November 4

Speakers Breakfast (7:30 a.m.)	Convention Centre, Room 202D
Opening Session (8:30 a.m.)	Convention Centre, Theatre
Paint Show Opens (10:00 a.m.)	Convention Centre, Upper Hall
Spouses Welcome Reception (2:00 p.m.)	Convention Centre, Reception Hall
Gallows Bird Reception (5:00-7:00 p.m.)	Sheraton, Kent

Tuesday, November 5

Speakers Breakfast (7:30 a.m.)	Convention Centre, Room 202D
Spouses Continental Breakfast (7:30 a.m.)	Sheraton, Dominion
Spouses Tour (8:45 a.m.)	Sheraton, Richmond Street Entrance
Canadian Luncheon (12:00 noon)	Convention Centre, Constitution Ballroom
International Visitors Reception (6:30 p.m.)	Royal York, Tudor 7-9

Wednesday, November 6

Speakers Breakfast (7:30 a.m.)	Convention Centre, Room 202D
Annual Business Meeting (9:00 a.m.)	Convention Centre, 206F
Annual Luncheon (12:00 noon)	Convention Centre, Constitution Ballroom
President's Reception (6:30 p.m.)	Sheraton, Dominion
Past-Presidents' Dinner (7:30 p.m.)	Sheraton, Elgin
Past-Presidents' Wives' Dinner (7:30 p.m.)	Sheraton, Kenora

SPOUSES ACTIVITIES

Monday, November 4

The Spouses Program of Activities will begin with the traditional get-acquainted Wine and Cheese Social in the Metro Toronto Convention Centre Reception Hall. There will be a raffling of door prizes contributed by suppliers to the Paint Industry.

Tuesday, November 5

Continental Breakfast will be served in the Dominion Ballroom of the Sheraton Centre Hotel.

Luxury coaches will depart from the Sheraton for a spectacular guided tour of the city. The tour highlights such famous landmarks as the award-winning City Hall, Osgoode Hall, the spectacular Eaton Centre, quaint old St. Lawrence Market,the Harbourfront and Queen's Quay, the SkyDome, Casa Loma—Canada's only castle—and the magnificent Royal Ontario Museum. The Museum offers visitors a unique combination of earth and life sciences, fine art and archaeology. The internationally acclaimed collections include Egyptian mummies, Chinese artifacts, a Ming Tomb, and even twelve complete dinosaur skeletons. Following the tour of the museum the spouses may either shop in the chic boutiques of Hazelton Lanes or return by motorcoach to the hotel.

An elegant three-course luncheon will be served at Ed's Warehouse. Located in the theatre district, the decor features a large collection of antiques blended with a theatrical motif.

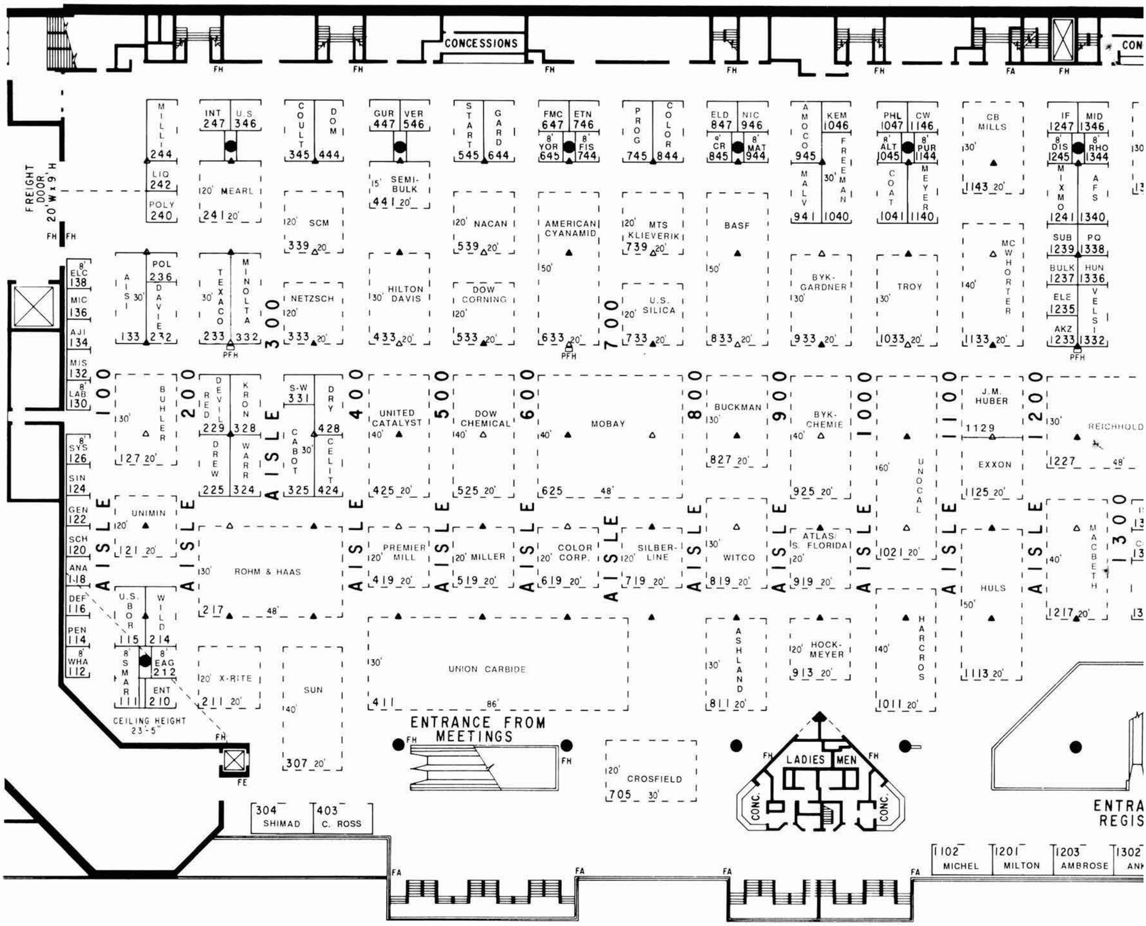
Wednesday, November 6

The Annual Luncheon will be held in the Constitution Ballroom of the Convention Centre.

Several Federation awards will be presented. The featured speaker will be Michael Broome, motivational humorist.

* * *

The spouses registration fee ($50.00 in advance, $60.00 in Toronto) includes the Wine and Cheese Social, the Continental Breakfast, and the tour and luncheon. Tickets for the Wednesday Annual Luncheon are available for $25.00 in the registration area of the Convention Centre.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UNION CARBIDE 411
START 545
GARD 644
NACAN 539
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COLOR CORP. 619
PROG 745
COLOR 844
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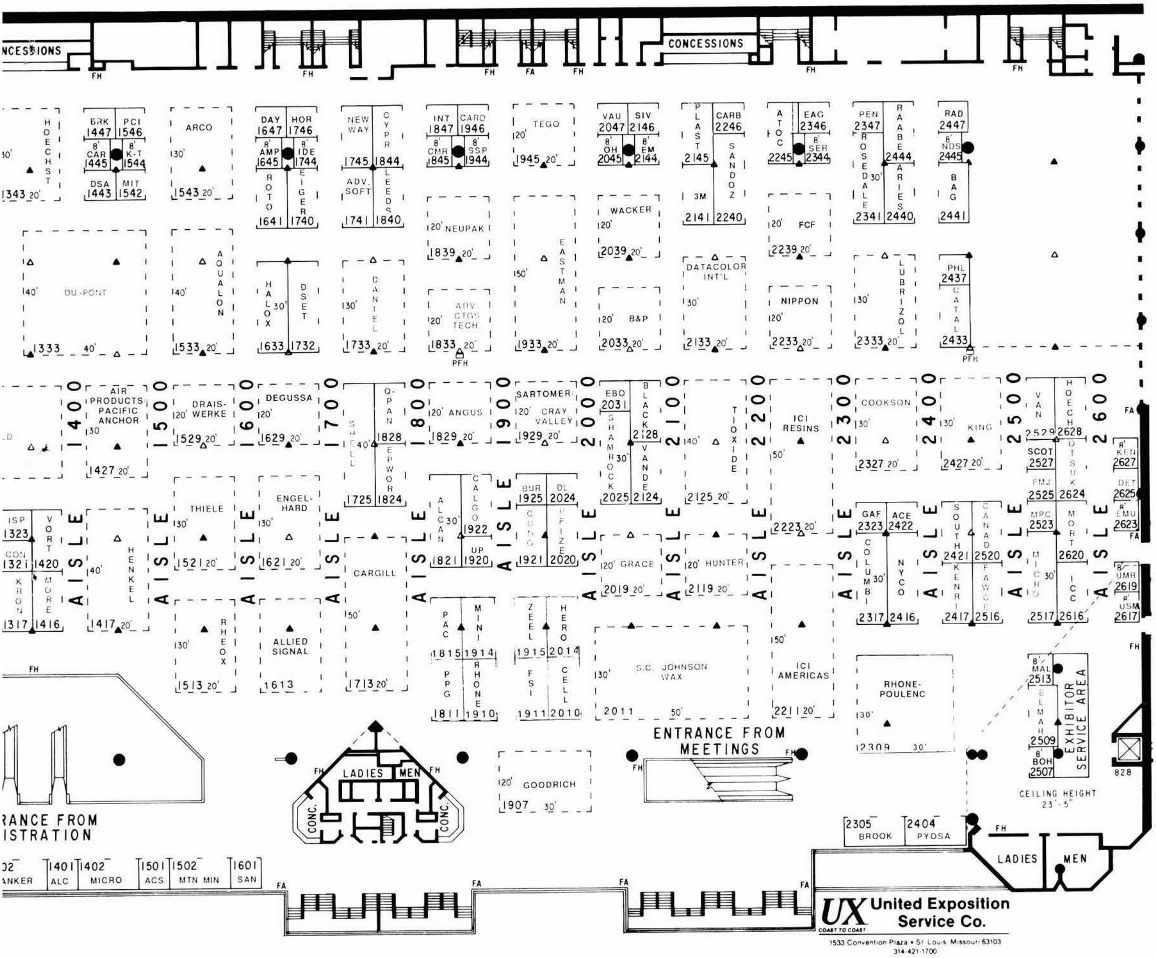


FEDERATION OF SOCIETIES FOR COATINGS TECHNOLOGY

56th ANNUAL PAINT INDUSTRIES SHOW

NOVEMBER 4-6, 1991

METRO TORONTO CONVENTION CENTRE

TORONTO, ONTARIO, CANADA

ADDITIONAL HIGHLIGHTS

"INTERNATIONAL COATINGS ENVIRONMENT: TODAY'S OPPORTUNITY, TOMORROW'S CHALLENGE"

The theme of the 1991 Annual Meeting underscores that today's coatings environment requires pro-active marketing and technology strategies. An opportunity today will be a challenge tomorrow if not addressed in a timely and effective manner. To address this theme, programming will emphasize the international perspective and will focus on such topics as quality improvement, cutting edge technology, and environmentally and performance engineered products. Also on the program will be the Mattiello Memorial Lecture, Roon Awards Papers, Society Papers, and Seminars. Speakers will come from throughout the world of coatings science and manufacture.

NINE HOTELS TO FURNISH HOUSING

Nine hotels have reserved blocks of rooms for the Federation event, with the Sheraton Centre Hotel and Royal York Hotel serving as co-headquarters. Other hotels include the Westin Harbour Castle, Marriott Eaton Centre, Hilton International Toronto, Holiday Inn-Downtown City Hall, Bond Place, King Edward and L'Hotel. Prior to October 4, all housing will be processed through the Toronto Convention and Visitors Association's Housing Bureau. After October 4, all reservations must be made directly with hotels. For housing information, contact Federation headquarters.

REGISTRATION FEES

Advance registration forms and information were sent to all members in April. Advance fees are $65 for members and $80 for non-members. The fee for spouses' activities is $50 in advance. Retired members and their spouses may register for the special advance fee of $25 each. The cut-off date for advance registration is October 4.

On-site registration will be $75 for full-time and $55 for one-day for members. Non-member fees will be $95 for full-time and $70 for one-day. Spouses' activities fees will be $60 on-site.

PROGRAM COMMITTEE

Chairman of the 1991 Program is Gerry Parsons, of DeSoto Coatings Ltd., Mississauga, Ont., Canada. Serving with Mr. Parsons are: John Lanning (Vice-Chairman), Courtaulds Coatings, Inc., Porter Paint Div., Louisville, KY; Mary G. Brodie, Strongsville, OH; Rob Deruiter, Reichhold Ltd., Toronto, Ont.; John Hall, Tioxide, Inc., St. Laurent, Que.; Peter Hiscocks, Ashland Chemicals, Mississauga, Ont.; George R. Pilcher, Akzo Coatings, Inc., Columbus, OH; and Roger Woodhull, California Products Corp., Cambridge, MA

FEDERATION ANNUAL LUNCHEON WILL BE HELD ON WEDNESDAY

The Annual Federation Luncheon will be held on Wednesday, November 6, at the Metro Toronto Convention Centre. Tickets may be purchased for $25.00 in advance or on-site at the registration area of the Convention Centre. Highlighting the event will be an address by Michael Broome, a motivational humorist.

AMERICAN AIRLINES AND AIR CANADA OFFER SPECIAL FARES TO TORONTO

American Airlines and Air Canada, in cooperation with the FSCT, are offering special discounted fares which afford passengers a 25-40% minimum savings off their round trip, undiscounted day coach fares for travel to the FSCT Annual Meeting and Paint Industries' Show on the airlines' domestic systems.

To take advantage of these discounts, you must travel between October 28-November 12, 1991; purchase tickets at least seven days in advance; phone 1-800-433-1790 (for American Airlines) or 1-800-361-7585 (for Air Canada) for reservations. Immediately reference the FSCT file number: **Star File #S-02O1CN** (for American Airlines) or **File #917086** (for Air Canada). The special fares are available only through these numbers.

Discounts are good for both direct and connecting flights to Toronto. If you use a travel agent, have your reservations placed through the toll-free number to obtain the same fare advantages. Both American Airlines and Air Canada have a variety of other promotional fares, some of which may represent even greater savings. When you phone for reservations, ask for the best discount applicable to your itinerary.

FEDERATION BOARD OF DIRECTORS TO MEET ON SUNDAY IN SHERATON

The Board of Directors of the Federation will meet on Sunday, November 3, at 9:00 a.m. in the Sheraton Centre Hotel.

TRAVEL FROM THE U.S. TO CANADA

When you arrive at Lester B. Pearson International Airport, you are required to go through Customs & Immigration before collecting your baggage. (You will receive a Customs Declaration form onboard your inbound flight.)

Citizens and legal residents of the United States do not need visas to enter Canada. However, all American citizens must show proof of citizenship. Documents such as a birth certificate, passport, or "green card" are acceptable. You should also carry photo I.D. due to tightened security on all airlines. Naturalized citizens need naturalization certificates or other proof of citizenship. NOTE: A VALID DRIVER'S LICENSE IS NOT SUFFICIENT IDENTIFICATION.

Following immigration, proceed to the baggage claim area to collect your bags. Baggage carts (complimentary) and skycaps are on hand for luggage transfer. Due to tightened security no one other than inbound passengers and ground crew are allowed in the baggage claim area. You are then required to go through customs control.

Citizens of countries other than the United States should check with the Canadian Embassy or nearest Consulate before departure.

RETURN TO U.S. FROM CANADA

We suggest you allow a minimum of 2 to 2 1/2 hours before flight departures to check into the airport. Upon arrival at Pearson International Airport, you are required to go through U.S. Customs and security with your bags.

DUTY FREE ALLOWANCES— U.S. VISITORS

For every 30 days, returning U.S. citizens are allowed to bring back duty free, $400 worth of personal or household merchandise, provided they have been out of the U.S. for 48 hours. This amount can include one carton of cigarettes, 100 cigars (no Cuban), one pound of smoking tobacco and 32 ounces of liquor. Goods bought in Canada but manufactured in the U.S. are duty free and not included in the basic exemption; however, a receipt of purchase may be required.

TAX REBATES

Provincial Sales Tax of 8% and Federal Goods and Services Tax of 7% are levied on goods and services purchased for use of consumption within Ontario. In general, visitors may apply for a refund of these taxes once they have accumulated $100 worth of receipts for non-disposable merchandise to be used outside Canada. Sales Tax refund forms can be obtained on arrival in Toronto at the Transport Canada Information Desk or Canada Customs Office.

Workshop on VOC Compounds To Follow FSCT Convention in Toronto

A two-day workshop on Paint Volatile Organic Compounds (VOC) will be conducted by the American Society for Testing and Materials, in Toronto, on November 7-8, immediately following the FSCT Annual Meeting.

The course which includes laboratory demonstrations at TSL Environmental Labs, Inc., is designed for chemists and others who use U.S. EPA tests to determine if paints or coatings meet VOC requirements. Individuals from industry, government regulatory bodies, commercial laboratories, and paint users can benefit.

Course instructors, Hiroshi Fujimoto, of BASF Inmont Division's Analytical Services Laboratory, William C. Golton, of Du Pont's Marshall Laboratory, and Richard W. Scott, formerly of Sherwin-Williams Co.'s analytical department, will feature ASTM Test Methods used in EPA Reference Method 24.

Registration fee is $535 (U.S.). The course will be held at The Stage West Hotel, Mississauga, Ont. For more information, please contact Kathy Dickinson, ASTM Standards Technology Training, 1916 Race St., Philadelphia, PA 19103; telephone: 215-299-5480; fax: 215-299-5470.

A Five Kilometer Fitness Run

Especially for Attendees at the 1991 Paint Show in Toronto, Ont., Canada

Tuesday, November 5, 1991, at 7:00 a.m.

Start: East end of Coronation Park—Out and back along a paved foot path

Bus transportation will be available to runners beginning at 6:15 and 6:30 a.m. from two convenient locations, Sheraton Centre and Royal York co-headquarters hotels.

Sponsored by Troy Corporation

In conjunction with the Federation of Societies for Coatings Technology

All runners are invited to join us this year for the annual event on the Paint Show schedule—the Paint Show 5000, a five kilometer fun and fitness run in Toronto, Ontario, Canada.

The run is scheduled to start 7:00 a.m. on Tuesday. Participants will run on a measured, police-protected five kilometer (3.1 mile) course on the beautiful Toronto Shoreline. A time clock will be located at the finish.

The Paint Show 5000 is designed to be a fun, fitness, or training event open to all who want to take a five kilometer running tour of Toronto. Everyone will be a winner!

T-shirts and a sports mini-flashlight will be given to all participants, but you must be pre-registered to run. *No entries will be accepted on race day.*

Entry fee: $5.00 U.S. Funds. **Entries must be received before October 30, 1991.** A portion of every runners' registration fee will be donated to the Coatings Industry Education Fund.

● ●

Mail entry form with a check for $5.00 entry fee in U.S. Funds (no cash, please) payable to:

Troy Corporation/Paint Show 5000
One Avenue L, Newark, NJ 07105

NAME

TITLE

COMPANY

CITY/STATE/ZIP

TELEPHONE

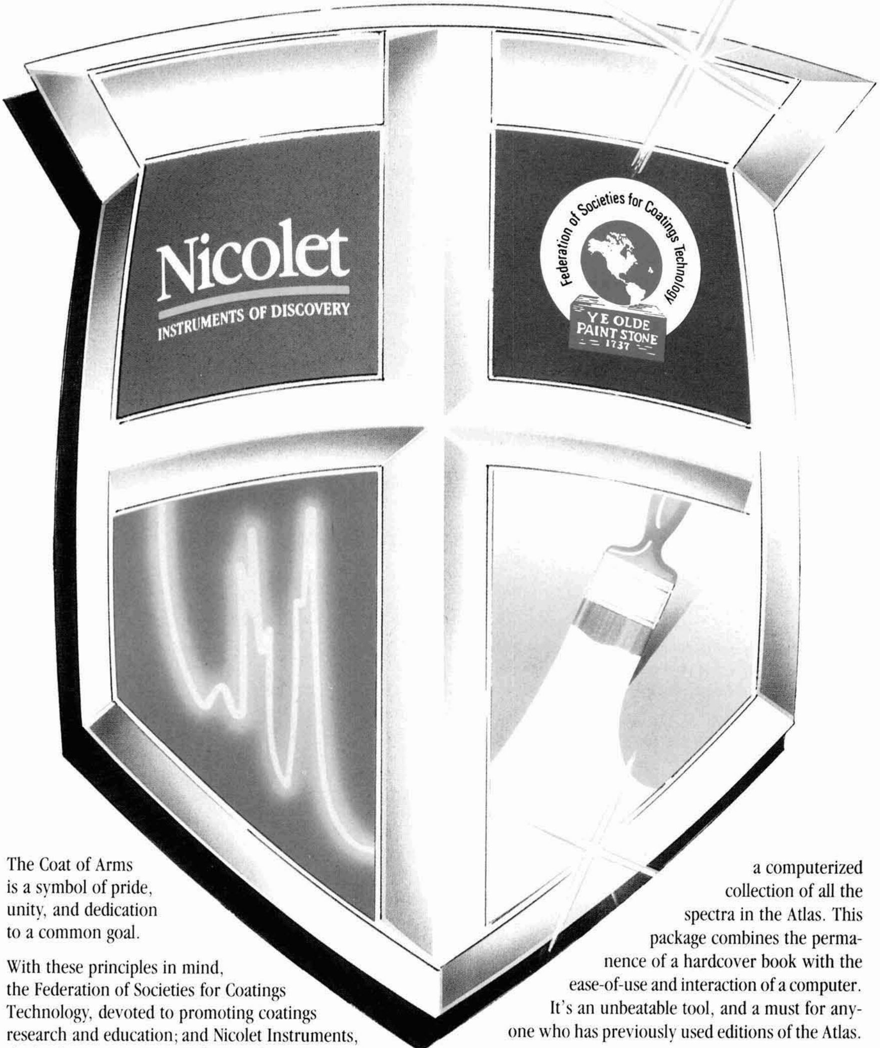
SHIRT SIZE (Circle One).
Large — Extra-Large

In consideration of this entry being accepted, I the undersigned intending to be legally bound, hereby for myself, my heirs, executors and administrators, waive and release any and all rights and claims I may have against the Troy Chemical Corporation, the Federation of Societies for Coatings Technology, the city sponsors, their staff, officials, volunteers and any representatives, successors or assignees for any injuries that may be suffered by me in this event. I further hereby certify that I am physically fit and have sufficiently trained for the completion of this event

NAME (PLEASE PRINT)

DATE

SIGNATURE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Please fill out this form and mail with a check in the correct amount (made payable to the FSCT) **to the Federation address shown above.** All checks must be payable in U.S. Funds. Any that are not will be returned. DEADLINE DATE FOR ADVANCE REGISTRATION IS OCTOBER 4. NONE WILL BE ACCEPTED AFTER THAT DATE.

A $10.00 charge will be made for cancellations received prior to October 4. No refunds will be made after that date.
NO CREDIT CARDS WILL BE ACCEPTED. NO FAXES WILL BE ACCEPTED.

INDUSTRY REGISTRATION FEES:

A ☐ **MEMBER** **$65.00**

Please name the Federation Society in which you are a paid-up member:

____
Federation Constituent Society

B ☐ **NON-MEMBER** **$80.00**

G ☐ **SPECIAL FEE FOR RETIRED MEMBERS** **$25.00**

____
Federation Constituent Society

INFORMATION FOR REGISTRATION BADGE:

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FIRST NAME LAST NAME

COMPANY

STREET

CITY STATE *(U.S. only)* POSTAL CODE

COUNTRY *(OTHER THAN U.S.)* TELEPHONE NO.

BUSINESS CLASSIFICATION DATA FOR THE ABOVE REGISTRANT:

YOUR COMPANY (CHECK ONE BLOCK)

- AA ☐ Manufacturers of Paints, Varnishes, Lacquers, Printing Inks, Sealants
- BB ☐ Manufacturers of Raw Materials
- CC ☐ Manufacturers of Equipment and Containers
- DD ☐ Sales Agent for Raw Materials + Equipment
- EE ☐ Government Agency
- FF ☐ Research/Testing/Consulting
- GG ☐ Educational Institution Library
- HH ☐ Paint Consumer
- JJ ☐ Other

YOUR POSITION (CHECK ONE BLOCK)

- KK ☐ Management/Administration
- LL ☐ Manufacturing and Engineering
- MM ☐ Quality Control
- NN ☐ Research and Development
- PP ☐ Technical Sales Service
- QQ ☐ Sales and Marketing
- RR ☐ Consultant
- SS ☐ Educator/Student/Librarian
- TT ☐ Other

SPOUSES REGISTRATION AND INFORMATION FOR REGISTRATION BADGE:

D ☐ **SPOUSE** **$50.00**

NICKNAME

FIRST NAME LAST NAME

CITY STATE *(U.S. only)* POSTAL CODE

SPECIAL FEE FOR THE SPOUSES OF RETIRED MEMBERS ONLY:

H ☐ **$25.00**

TICKETS FOR FEDERATION LUNCHEON, WEDNESDAY, NOVEMBER 6 (@$ 25.00)

Z ☐ **NUMBER REQUIRED:** ____________
$25.00 EACH.

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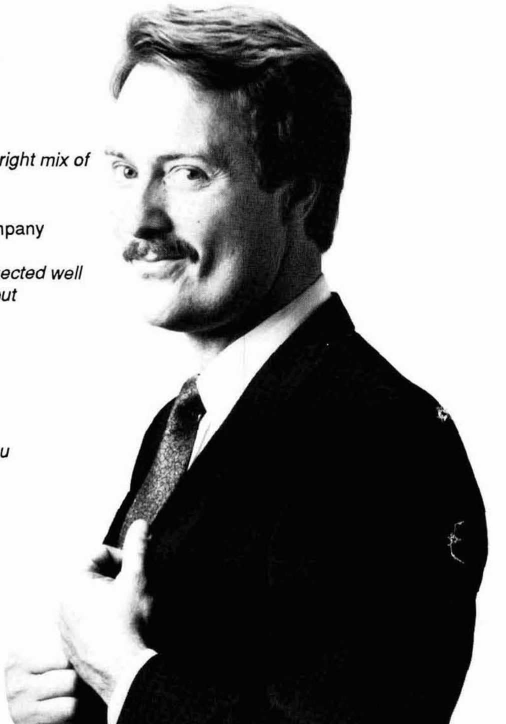


AMERICA RATES MICHAEL BROOME AS ONE OF ITS MOST ENJOYABLE SPEAKERS I I I

"You really hit a home run with the group, . . . Your speech had just the right mix of humor and inspiration."—IBM Corporation

"Michael was an unqualified success"—Monumental Life Insurance Company

"Michael was everything we had hoped he would be and more. He connected well . . . and in a humorous, but thoughtful manner, made strong points about positive mental attitude"—Apple Computer, Inc.

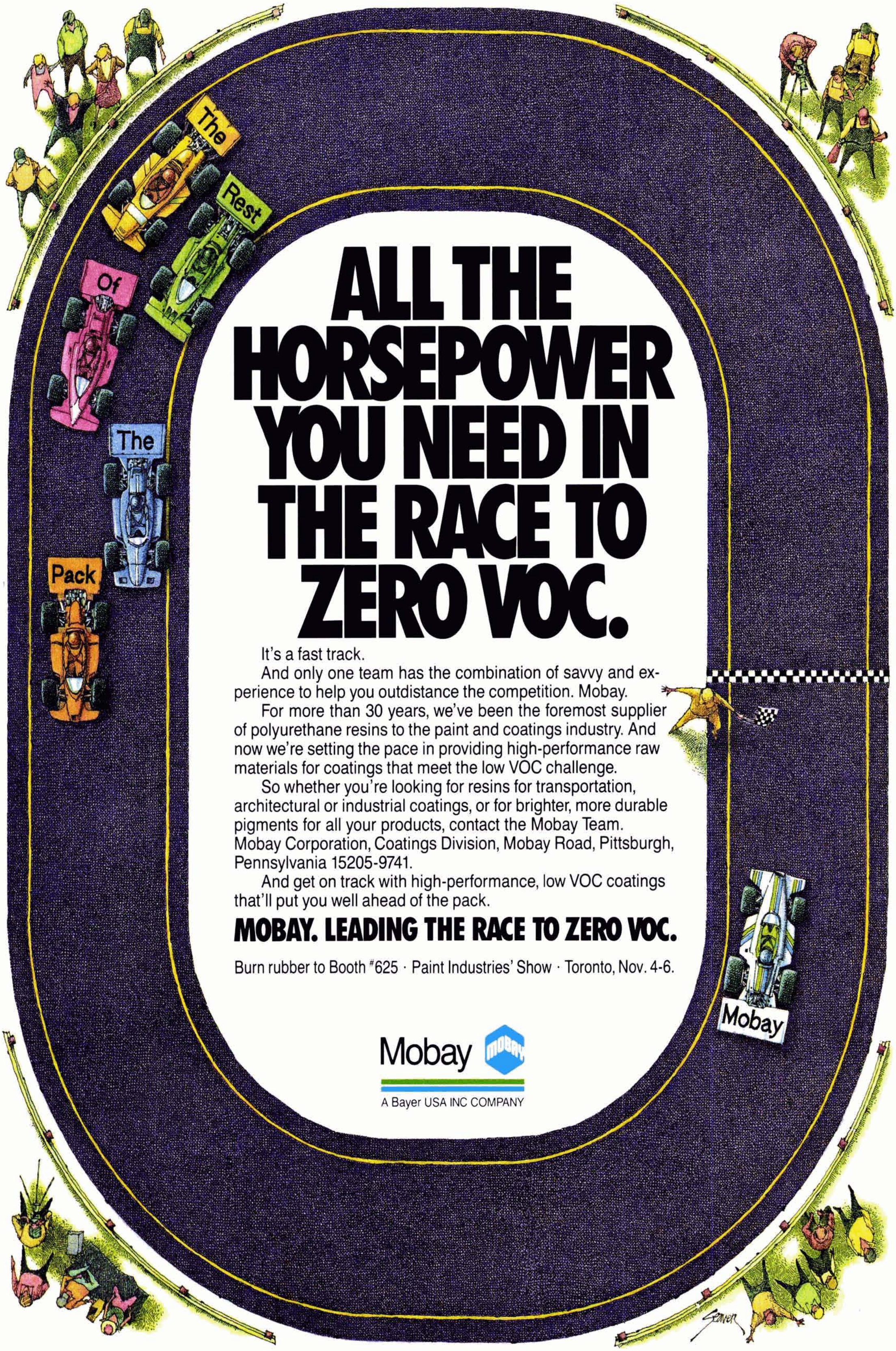
"Your advanced billing certainly was not overstated! Your inspiring and motivating speeches wee the highlight of our convention."—Chevron, U.S.AA.

"Thanks so much for makng me look like a genius for recommending you to my bosses."—The Prudential Insurance Company

The Federation of Societies for Coatings Technology is pleased to announce that MICHAEL BROOME, popular humorous motivational speaker, will appear at its Annual Luncheon, on Wedensday, November 6, at the Toronto Convention Centre. Comments on Mr. Broome's previous presentations include such superlatives as "fantastic," "tremendous," "exciting," and "the best speaker we've ever had."

Also to be featured at the Luncheon will be the Federation's most prestigious awards Tickets may be purchased in advance by fililng out the form enclosed in this manual or on-site at the Registration Area in the Toronto Convention Centre.

Plan to attend to see if you agree with the hundreds of responses Michael Broome has received claiming "It doesn't get any better than this! ! !"



ALL THE HORSEPOWER YOU NEED IN THE RACE TO ZERO VOC.

It's a fast track.

And only one team has the combination of savvy and experience to help you outdistance the competition. Mobay.

For more than 30 years, we've been the foremost supplier of polyurethane resins to the paint and coatings industry. And now we're setting the pace in providing high-performance raw materials for coatings that meet the low VOC challenge.

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And get on track with high-performance, low VOC coatings that'll put you well ahead of the pack.

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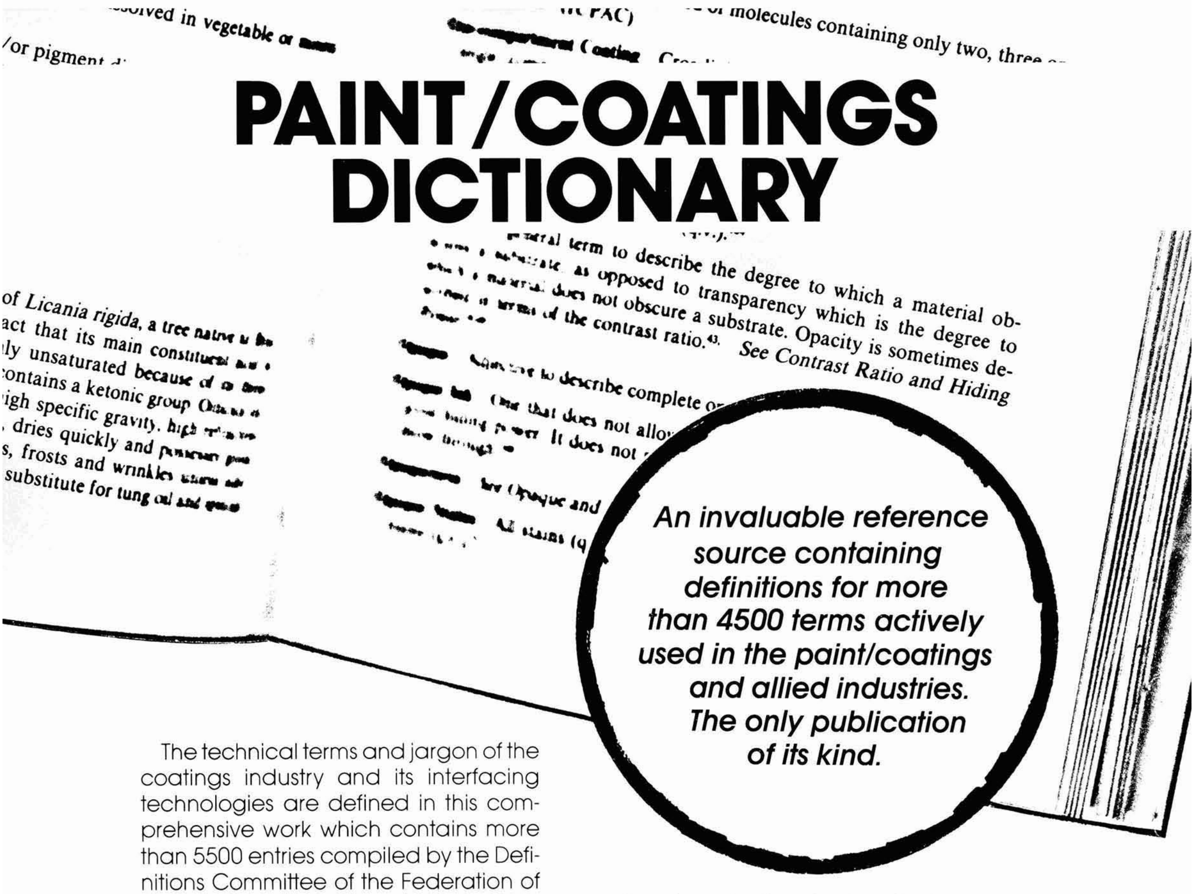

PAINT/COATINGS DICTIONARY

An invaluable reference source containing definitions for more than 4500 terms actively used in the paint/coatings and allied industries. The only publication of its kind.

The technical terms and jargon of the coatings industry and its interfacing technologies are defined in this comprehensive work which contains more than 5500 entries compiled by the Definitions Committee of the Federation of Societies for Coatings Technology. Over 4500 terms are defined, and more than 1000 additional entries are synonyms cross-referenced to the defined terms.

The broad scope of terms included reflects the obvious usefulness of the dictionary to a wide audience, ranging from the layman, to artists and artisans, to technicians in all the coatings-related fields.

A unique feature is classification of terms into one or more of 73 categories, which have been number coded and appear as superscripts following each definition. The terms are listed in their appropriate categories, making up a thesaurus which comprises the second section of the dictionary.

An extensive bibliography of more than 600 references forms the third section.

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REVIEW PAPER

Effects of Acidic Deposition On Painted Wood: A Review

R. Sam Williams
Forest Products Laboratory*

Acidic deposition has captured the attention of many researchers during the last decade and considerable knowledge has been gained in many disciplines including forestry, limnology, atmospheric sciences, and materials science. The study of the degradation of materials by acidic deposition has included the effects on wood, paint, and painted wood. The literature pertinent to the effects of acidic deposition and its precursors on these materials is critically reviewed. The subjects include transport properties of paints and polymers, the reactions of acids with paint components, and the degradation of wood. The research on acidic effects on paint degradation leaves many questions unanswered and the review forms the basis for future research recommendations.

INTRODUCTION

Painted wood is a marriage of two remarkable materials. Paint coatings are thin adherent films of complex mixtures of polymers, pigments, and extenders, with small amounts of uncured monomer, drying agents, surfactants, and other additives. The paint film forms as the solvent evaporates from a polymer solution or suspension and/or as the small molecules react to form a polymer. Wood is an equally complex mixture of polymers and other compounds arranged in an anisotropic, moisture-sensitive, dimensionally unstable material having large variability within a single species and even within a single piece. Given the complexities of these materials and their differences in properties—particularly the moisture induced dimensional changes—one would probably consider such a materials system doomed to failure. But it is not so!

Although wood can decay and both wood and paint coatings are susceptible to photochemical degradation, a properly applied paint system on wood can last a decade, and history offers many examples of properly maintained painted wood lasting for centuries. Even under extreme conditions, such as on wooden boats in water, paints last well. This does not mean that paint problems do not exist, but, almost without exception, they begin with poor design of the structure and are made worse by incorrect application of the paint. Although this review focuses on paint degradation—particularly those systems that degrade too quickly and/or fail catastrophically within a short time—one should not forget the vast amount of properly maintained paint on wood weathering slowly while protecting the substrate for centuries.

Wood finishes vary from highly crosslinked barrier coatings such as catalyzed epoxides to porous low-solids-content stains and wood sealers. This wide variety of finishes is complicated by the range of wood and wood-based composites used as substrates and wide range of uses. Given the broad array of types of paints and finishes, it is interesting that research on painted wood has included only a narrow range of finishes and wood-based substrates that are used outdoors (*Table* 1)[1]. Virtually all acidic deposition-related research on wood finishes has dealt with high-solids-content paint coatings.

The ultimate goal of research on finishes is a cost effective increase in service life. Service life, whether under normal or acidic conditions, represents a significant economic concern. The in-place value of paints that could be at risk to degradation by acidic deposition reaches billions of dollars a year in the United States (*Table* 2).[2] The $24.1 billion calculated for architectural coatings includes coatings on wood, masonry, vinyl, and other materials; finishes on wood substrates comprise by far the major portion of these uses (*Figure* 1). Paints were included in the research sponsored by the National Acid Precipitation Accessment Program (NAPAP) because of the high value of in-place coatings on wood. Much of the recent research reviewed in this report was completed within this program.

This review includes a critical analysis of the published research on acidic deposition and provides recommendations for future research. The research addressed discolora-

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*United States Department of Agriculture, Forest Service, One Gifford Pinchot Dr., Madison, WI 53705-2398.

Table 1—Finishing Methods for Exterior Wood Surfaces[1,a]

	Water-repellent Preservative		Semi-transparent Stains		Paints	
Type of Exterior Wood Surface	**Suitability**	**Expected life[b] (yr)**	**Suitability**	**Expected life[c] (yr)**	**Suitability**	**Expected life[d] (yr)**
Siding						
Cedar and redwood	High	1-2	Moderate	2-4	High	4-6
Smooth (vertical-grained)	High	2-3	Excellent	5-8	Moderate	3-5
Roughsawn or weathered						
Pine, fir, spruce, etc.						
Smooth (flat-grained)	High	1-2	Low	2-3	Moderate	3-5
Rough (flat-grained)	High	2-3	High	4-7	Moderate	3-5
Shingles						
Sawn	High	2-3	Excellent	4-8	Moderate	3-5
Split	High	1-2	Excellent	4-8	—	—
Plywood (Douglas-fir and southern pine)						
Sanded	Low	1-2	Moderate	2-4	Moderate	3-5
Textured (smooth)	Low	1-2	Moderate	2-4	Moderate	3-5
Textured (roughsawn)	Low	2-3	High	4-8	Moderate	4-6
Medium-density overlay[e]	—	—	—	—	Excellent	6-8
Plywood (cedar and redwood)						
Sanded	Low	1-2	Moderate	2-4	Moderate	3-5
Textured (smooth)	Low	1-2	Moderate	2-4	Moderate	3-5
Textured (roughsawn)	Low	2-3	Excellent	5-8	Moderate	4-6
Hardboard, medium density[f]						
Smooth						
Unfinished	—	—	—	—	High	4-6
Preprimed	—	—	—	—	High	4-6
Textured						
Unfinished	—	—	—	—	High	4-6
Preprimed	—	—	—	—	High	4-6
Millwork (usually pine)						
Windows, shutters, doors, exterior trim	High[g]	—	Moderate	2-3	High	3-6
Decking						
New (smooth)	High	1-2	Moderate	2-3	Low	2-3
Weathered (rough)	High	2-3	High	3-6	Low	2-3
Waferboard	—	—	Low	1-3	Moderate	2-4

(a) Data compiled from the observations of many researchers. Expected life predictions are for an average location in the continental U.S.; expected life will vary in extreme climates or exposure (desert, seashore, deep woods, etc.).

(b) Development of mildew on the surface indicates a need for refinishing.

(c) Smooth, unweathered surfaces are generally finished with only one coat of stain, but roughsawn or weathered surfaces, being more adsorptive, can be finished with two coats, with the second coat applied while the first coat is still wet.

(d) Expected life of two coats, one primer and one topcoat. Applying a second topcoat (three-coat job) will approximately double the life. Top-quality acrylic latex paints will have the best durability.

(e) Medium-density overlay is generally painted.

(f) Semi-transparent stains are not suitable for hardboard. Solid-color stains (acrylic latex) will perform like paints. Paint are preferred.

(g) Exterior millwork, such as windows, should be factory treated according to Industry Standard IS4-81. Other trim should be liberally treated by brushing before painting.

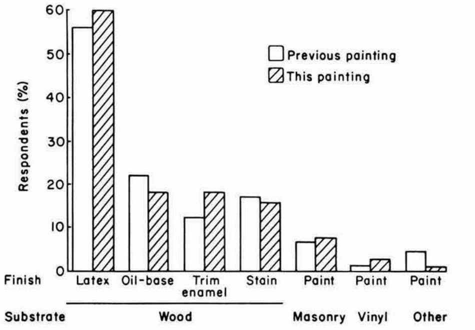

Figure 1— Types of architectural coatings and substrates determined from a 1986 survey[2]

tion of paint by H_2S, formation of bloom, retardation of curing, instability of pigments, effects of SO_2 on the binder, and effects of SO_2 at the paint/wood interface. The research has covered only a small fraction of the wide array of finishes, wood species, and wood-based composites used on wood outdoors (*Table* 1).

SUBSTRATE AND FINISH CHARACTERISTICS

Substrates vary considerably from area to area around the nation and over time. Fifty years ago, solid wood of a few species such as western redcedar (*Thuja plicata*), redwood (*Sequoia sempervirens*), and bald cypress (*Taxodium distichum*) dominated the residential siding market. These have been partially replaced by other species and by wood-composite materials such as plywood, particleboard,

Table 2—1987 Paint Shipments and Associated Coats for the United States[2]

Classification	Shipments (gal. x 10^6)	Factory Cost ($ x 10^6)	In-Place Value ($ x 10^9)
Architectural coatings (ext.)			
Oil-based	80	807	9.5
Water-based	123	944	14.6
Automotive finishes			
New vehicles	73	1323	12.0
Refinishing	44	904	22.0
Coil coating	20	303	2.0
Industrial maintenance paints	28	313	2.8
Traffic marking paints	19	95	0.7

flakeboard, medium-density fiberboard, and melamine-formaldehyde-impregnated paper overlays of these materials (*Table* 1). Each species has its own characteristics and wood-composite materials have specific properties that make them distinctly different from their base materials. Finish requirements for different species and different composite materials vary and these properties must be taken into account when formulating finishes.

Wood

Wood properties that are important in finishing are species, moisture content, density and texture, resin and oil content, growth pattern and grain orientation, and defects such as knots, reaction wood, and diseased wood.[3] These properties are characterized by the chemical composition, microstructure, and macrostructure of wood[4,5] [see reference (6), p. 2-1].

Wood is degraded naturally by fungal and bacterial decay and by weathering. Wood-finishing problems caused by decay can be serious but are not included in this review because the growth of wood-decay fungi is insensitive to pH in the range of 4 to 7 [see reference (7), p. 162].

Weathering is the photochemical degradation of the surface of wood and is not to be confused with decay. UV radiation is necessary for weathering to occur, and radiation of these wavelengths can penetrate about 75 μm into the surface of unfinished wood.[8] UV degradation is manifested in an initial color change, followed by the gradual erosion of the wood surface. The radiation causes cleavage of the lignin, particularly in the lignin-rich middle lamella. With a decrease in its molecular weight, segments of the lignin are removed from the surface through the action of moisture, thus causing the wood cells to become less tightly bound. Changes in moisture content cause dimensional changes that accelerate this loosening process. As exposure to radiation continues, the wood cells erode from the surface. In softwoods, the erosion is more rapid in the less dense earlywood than in the latewood, which leads to an uneven surface (*Figure* 2). Surface erosion, however, proceeds very slowly. The erosion rate for solid wood in temperate zones is on the order of 0.3 - 1.2 cm per century and depends mainly on the amount of UV exposure, wood species, and density.[9-11] Other factors affecting the erosion rate include moisture, mechanical abrasion, temperature, and air pollution.

Because weathering of wood is a surface deterioration, it directly affects paint adhesion. The eroded and roughened surface of weathered wood impairs the adhesion of subsequently applied film-forming finish to the substrate.[12-17] Surface degradation occurs if peeled areas are exposed to the weather before refinishing. In the study by Williams,[17] western redcedar boards were weathered outdoors and painted following exposure. Outdoor exposure for as little as four weeks caused significant decrease in paint adhesion; boards exposed for 16 weeks lost about 50% of their paint adhesive strength. This degradation can be slowed or even stopped by wood finishes. The amount of protection the wood surface gets from the finish depends on the finish properties—most notably, the amount and type of pigment in the finish.

Finishes

The modes of paint failure depend, to a large degree, on exposure conditions, the type of finish and substrate, and the interactions among these factors. As a finish system ages, various agents interact with the components of the system to effect change. Effects may vary from one system to another and with the agent causing the change. For example, sunlight and oxygen can effect chemical reactions, and changes in ambient temperature and water can effect physical changes in both the finish and substrate. These are the main factors that cause degradation of painted wood. Other minor factors may include the effects of acidic deposition.

These factors act in concert to effect various degradation mechanisms but it is often difficult to identify the mechanism responsible for the paint failure. Acidic deposition could affect any of these mechanisms.

LITERATURE REVIEW

Concern about air pollution effects on coatings is not new. Meller and Sisson[18] reported the high economic cost of materials damage caused by industrial pollution. They included paint and other protective coatings as materials at risk and discussed the use of aluminum pigmented primers to protect wood substrates from "acid smoke" and moisture. Since that time, a number of researchers have attempted to determine what part of the cost of coatings maintenance is

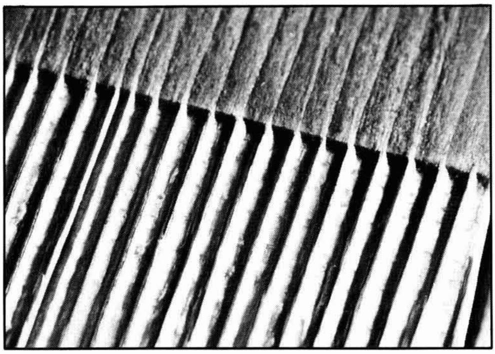

Figure 2—Photograph of a piece of western redcedar (*Thuja plicata*) exposed to the weather for eight years. The unweathered section at the top was protected with a metal strip

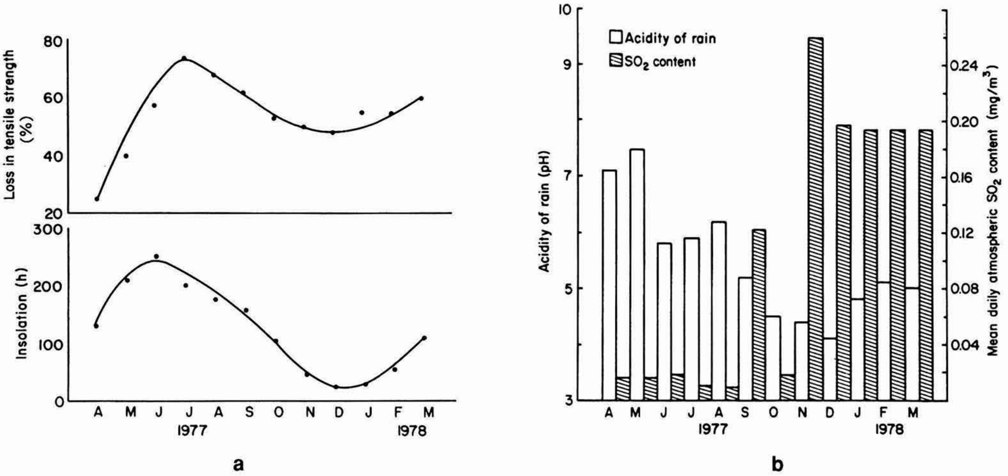

Figure 3—a: Loss of tensile strength of spruce microsections and the mean monthly insolation[21]; b: Mean monthly pH of rain water and sulphur dioxide concentration in the air[21]

attributable to acidic deposition. Studies have included laboratory chamber exposures, outdoor exposures, and consumer and industry surveys. Larson[19] considered SO_2 to be the most serious pollutant threat to paint systems and he mentioned H_2SO_4, HCl, H_2S, and HNO_3 as minor pollutants. He also listed soot and finely divided carbon as contributors to acidic degradation because these particles retain moisture and absorb pollutants.

Gross[20] reviewed the effects of gaseous components such as SO_2, H_2S, NH_3, and O_3, solids such as NaCl, $(NH_4)_2SO_4$, and NH_4Cl, smoke, and volatile organic compounds (VOCs) on paint and paint components. He included methods of investigation, evaluation, and chemical analysis. Information on mechanisms was limited to SO_2, the effect of H_2S on color changes in pigments, and O_3 to binder degradation. Little information was given on the effect of H_2SO_4, NO_2, and VOCs. Gross[20] stated that the field was at an elementary stage, that relationships between concentration of pollutants and mode of action could not be made at that time, and that the cost estimate for degradation was unreliable. He outlined several areas for future research. His list of research needs is still pertinent. No single researcher or team has attempted to evaluate all aspects of the problem, but many have investigated the effects on various components. Given the range of paint and varnish coatings used by various researchers, the interaction among weathering factors and finish components, and the different modes of paint failure, it is useful to organize this discussion by finish component (i.e., binder, pigment, and alkaline components), substrate, and their interface. Agents include sulfuric (H_2SO_4), sulfurous (H_2SO_3), and nitric (HNO_3) acids, hydrogen sulfide (H_2S), sulfur dioxide (SO_2), and ozone (O_3). H_2SO_3/SO_2 are discussed in considerable detail because of their high solubility and permeation in paint coatings and their possible effect on substrates.

Substrate

The wood substrate is an anisotropic material that can change dimension quickly with changes in moisture content. The wood substrate, therefore, subjects the paint coating to these changes. Typical manifestations of substrate change are loss of adhesion (peeling and/or cracking), degradation of the wood surface where the coating has been breached, and penetration of the substrate by chemicals where they have diffused through or circumvented the coating.

Under normal conditions with a two- or three-coat paint system, paint on wood slowly erodes from the surface through the combined action of primarily sunlight and moisture; when the primer coat begins to show, the surface or topcoat can be easily repainted with an additional topcoat. If the paint system fails at the paint/wood interface, the substrate is exposed to weathering. It may not be possible to refinish this unprotected wood for some time. Similarly, wood may be left unfinished while a project is under construction. If wood is more rapidly degraded by acidic deposition during these exposures, it directly affects the paint adhesion when the wood is eventually finished or refinished. The effects on wood and other cellulosic materials of acid rain and the oxides of nitrogen (NO_x) and sulfur (SO_x) have been evaluated.

Raczkowski[21] found that exposing strips of microtomed spruce (*Picea abies*) to outdoor weathering resulted in decreased tensile strength as compared with unexposed controls. The loss in tensile strength along the grain was generally directly related to the amount of sunlight during the summer and fall, but the loss in strength for winter and spring seemed greater than could be accounted for on the basis of sunlight alone (*Figures* 3a and 3b). This greater strength loss was attributed to higher acidity levels. Qualitative inspection of the data indicated that loss of strength was caused by sunlight and was exacerbated by acid, particularly during the winter months. It was not possible to quantify the effect of acid.

Evans and Banks[22] exposed microtomed sections of lime (*Tilia vulgaris*) and Corsican pine (*Pinus nigra*) to dilute sulfuric, sulfurous, nitric, acetic, and formic acids (pH 2.0-6.0) for up to 12 months at 40°C. Specimens showed loss of strength that was pH dependent. The strength loss caused by sulfurous acid was greater than all other acids at similar pHs. They noted that the strength losses may have been caused by a combination of both hydrolytic degradation of the hemicelluloses and a sulfonation reaction of the lignin. Scanning electron microscopy (SEM) data showing failure at the lignin-rich middle lamella further supported the speculation that lignin degradation is partially responsible for the decreases in strength and toughness.

Feist[23] and Williams[24] measured surface degradation of wood surfaces following xenon arc accelerated weathering to determine the efficacy of surface treatments of wood. The degradation of the surface was manifested as erosion and was measured microscopically.[9] These techniques were used to determine the effect of acid treatment on the erosion rate of western redcedar (*Thuja plicata*). Six acid soaks were used: nitric and sulfuric acids at pHs of 3.0, 3.5, and 4.0. Results were similar with both acids and increased the erosion rate 10% over that of the controls.[25]

In subsequent studies, western redcedar specimens were treated with sulfuric, nitric, and sulfurous acids at pHs from 2.0 to 4.0.[26] The erosion rate was dependent on pH and acid type. At a pH of 2.0, sulfurous acid doubled the weathering rate. The effect was slightly less for sulfuric and nitric acids. Statistical analysis of the data showed no significance for any of the acids at pH 3.5 or above.

Deppe and Schmidt[27] evaluated the effect of pH on accelerated weathering of coated and uncoated particleboard. Specimens were soaked in pH 2 sulfuric acid for 72 hours every four weeks during accelerated weathering. With some adhesive systems, particularly melamine/isocyanate-urea/formaldehyde mixed systems, a drop in adhesive strength was observed. Degradation of melamine/formaldehyde (MF)-impregnated paper overlay and a clear MF polymer film were also observed.

Fengel[28] investigated the degradation of spruce (*Picea sp.*) exposed to high concentrations of HCHO, Cl_2, NH_3, and SO_2. Dick and Murphey[29] studied the degradation of wood surfaces by high concentrations of O_3. In a series of three papers, Arndt and Gross[30-32] reported on color and weight changes caused by outdoor exposure and accelerated weathering of wood. No degradation was quantified by any of these investigators using concentrations typical of those found under outdoor exposure conditions.

Interface: Transport Properties Of Wood Finishes

Wood does not allow large amounts of moisture to collect at the paint/substrate interface because of its porous hydrophilic nature, and free water does not exist in wood below its fiber saturation point (approximately 30% by weight). Although it is possible to exceed the fiber saturation point locally at the paint/wood interface under certain conditions—such as a cold paint surface on wood having a high moisture content—moisture is generally wicked away from the interface so that a uniform moisture content is maintained throughout the wood. Liquid water is not likely to form at the paint/wood interface from rain and dew as long as the paint coating is intact. Most liquid water will be shed by the paint coating. Moisture problems occur when the fiber saturation point is exceeded at the paint/wood interface because of improper selection of finish, poor design, and/or marginal application techniques. In situations where the fiber saturation point is not exceeded, the wood substrate undergoes large dimensional change with changes in moisture content. Stresses on the coating system caused by dimensional changes in the paint film and the wood probably increase the risk of failure. These stresses can cause cracking parallel to the wood grain.

In situations where painted wood is fully exposed to the weather, moisture problems result from the rapid sorption of water through cracks in the paint, joints, nail holes, etc. This type of exposure can quickly give extremely high moisture content at the paint/wood interface. Whether water gets to paint/wood interface by diffusion or through stress-induced cracks in the paint film, it inevitably leads to loss of paint adhesion, subsequent peeling, and often wood decay as well. The exact mechanism for peeling is not very well understood, but it appears that the moisture content at the interface must be above the wood's fiber saturation point before peeling occurs. The stress without water does not seem to result in peeling. Paint peeling is one of the more serious paint degradation mechanisms and may be related to transport properties. Transport properties of paint coatings play a role in determining the risk of degradation to the paint system.

Moisture Transport

In a review of the diffusion and permeation of gases, liquids, and vapors in polymer films, Park[33] found that much of the research on transport properties of paint dealt with moisture, oxygen, and salt (primarily chlorides) transport.

Research on moisture transport properties of paint coatings on wood showed that paints are fairly porous and that it is possible for moisture to diffuse readily into and out of painted wood. It should be emphasized that paint coatings inhibit the loss of moisture more than they do the absorption of moisture and that, under cyclic exposure to high and low

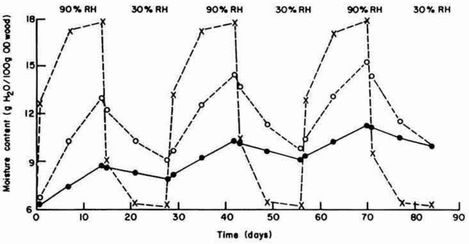

Figure 4—Change in moisture content of ponderosa pine (*Pinus ponderosa*) sapwood finished with one and three coats of aluminum paint when exposed to alternating cycles of 30% and 90% RH at 27°C.[34] x--x—unfinished wood; o---o—aluminum paint, one coat, 25% MEE; and •—•—aluminum paint, three coats, 65% MEE

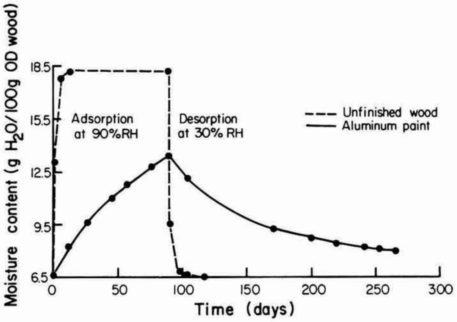

Figure 5—Change in moisture content of ponderosa pine (*Pinus ponderosa*) sapwood finished with three coats of aluminum paint when exposed to 90% and 30% RH at 27°C compared to unfinished wood[34]

relative humidity, paint traps moisture (*Figure* 4). This type of cyclic exposure is seldom a problem under most circumstances because sufficient drying time usually passes between periods of high humidity. If wood is subjected to continuous high humidity from either the inside or the outside, loss of adhesion is likely. Kitchens and bathrooms that lack proper moisture barriers and farm buildings that contain livestock subject painted wood to high moisture from the interior.

Feist et al.[34] reported on the moisture transport properties of 91 wood-finish systems. The study evaluated the movement of water vapor through finishes by comparing moisture pick-up in the painted specimens against that of unpainted controls. The ratio gave a moisture-excluding efficiency (MEE) as a percentage of the weight gain of the controls. An MEE of 100% meant the finish was 100% effective in blocking moisture penetration into the finish.

The MEE values for a wide range of finishes are listed (*Table* 3), and typical values for oil-based paints are about 40%. A paint system having one coat of primer and one or two latex-based topcoats provides a lower MEE than would three coats of oil-based primer. For unfinished wood, the moisture absorption-desorption cycles repeat uniformly (*Figure* 4), but for painted specimens, the effectiveness in trapping moisture increases as the MEE increases, as shown by steadily increasing moisture contents. For a single cycle (*Figure* 5), desorption back to an equilibrium moisture content (EMC) of 6.5% requires more than 250 days for a three-coat paint system.

The MEE for water repellents and water-repellent preservatives is about zero for a one-coat system. Absorption-desorption cycles are similar to those of unfinished wood (*Figure* 4). The strength of the water repellents is in their high water-vapor transmission but low liquid-water transmission.

Lindberg[35] reported similar results with finishes including two-component polyurethane, oil, alkyd, and acrylic latex-based paints.

Ahola[36] showed that moisture transport properties of paint coatings changed with weathering. Some paints became more permeable while others became less permeable. The study included both vapor-phase and liquid-water exposure of latex, oil, alkyd, and polyurethane paints and oil and acrylic latex stains. Perera and Vanden Eynde[37] studied six paints formulated for use on porous materials and showed that water-vapor and liquid-water transport properties and mechanical properties changed as paint film was soaked in water. Water leached out soluble components in the film, leaving it less permeable to additional water exposure. The film had increased tensile strength and tensile yield stress and decreased elongation after water leaching.

Analysis of leachates showed loss of extenders. The authors[37] concluded that values from transport studies with relatively new paint coatings may not be representative of the properties during its service life. Oesterle et al.[38] also reported that changes occur in the structure of paint films with repeated sorption and desorption of moisture.

The permeabilities of free films of polymers and paints have been reported by several researchers.[39-42] The permeabilities depended on the type of polymer. For some polymers, the crosslink density controlled the diffusion rate and this was the primary consideration. For other polymers, the permeability was controlled by the solubility of water in the polymers. It appears that the limiting factor (crosslinking or solubility) in moisture transport in paint films depends on the type of film.

Like water, acid may be absorbed by painted wood either by diffusion through paint or by the flow of acid solutions, vapors, or aerosols through voids in the paint coating.

Sulfur Dioxide Transport

The transport of SO_2 through pigmented and unpigmented polymer films provides an indication of how vulnerable the substrate is to degradation. A wide variety of polymers and paint films has been investigated. Lindner[43] measured the diffusion of SO_2 through free films of chlorinated rubber, linseed oil, nitrocellulose, and epoxide. Davis and Rooney[44] studied the permeation, solubility, and diffusion of SO_2 in polyethylene, poly(w-amino-undecanoic acid) (Nylon 11), and polycarbonate; they reported that no changes occurred in the IR spectra of any of the polymers exposed to SO_2. Jellinek et al.[45] reported no degradation for poly(hexamethylene adipamide) (Nylon 66). In a later study, Davis et al.[46] measured SO_2 permeabilities of several polymers. Polymers included those with good barrier properties such as polyester, polycarbonate, poly(vinyl chloride), and blends of poly(vinylidene chloride) with polypropylene or regenerated cellulose and polymers with poor barrier properties such as high- and low-density polyethylene, and polystyrene. Ranade et al.[47] reported sigmoid-shaped sorption curves for the uptake of SO_2 in diglycidyl ether of bisphenol A (DGEBA) crosslinked with diethylene triamine. They stated that this non-Fickian behavior was typical for polymers in their glassy state. In a later work using polymers in their rubbery state, Ranade et al.[48] reported the diffusion of SO_2 in amine-crosslinked aliphatic epoxide polymer as Fickian over the temperature range 1°-45°C. The diffusion coefficient varied from 7.5×10^{-9} to 28.8×10^{-9} cm^2/s over this range. The polymer had a low glass-transition temperature and was in its rubbery state for all measurements. Diffusion coefficients from the literature were tabulated; values varied from $10{,}000 \times 10^{-10}$ cm^2/s for vulcanized natural rubber to 1.25×10^{-10} cm^2/s for poly[(5,7-dihydro-1,3,5,7-tetraoxobenzo [1,2-c:4,5-c′]dipyrrole-2,6(1H,3H)-diyl)-1,4-phenyleneoxy-1,4-phenylene]

(Kapton™) polyimide. The kinetics and equilibria of SO_2 in Kapton polyimide were described by Koros et al.[49] and the chemical interactions by Iler et al.[50] Hsieh[51] reported the volumetric diffusion coefficient of SO_2 in ethylcellulose as 530×10^{-10} cm^2/s and nitrocellulose as 7.9×10^{-10} cm^2/s.

Kuehne and Friedlander[52] investigated the permeation of several polyacrylates and cellulose triacetate membranes to SO_2. Desor and Pauly[53] evaluated a number of solvent- or waterborne paints for barrier properties against CO_2 and SO_2. The permeability of the waterborne dispersion paints was higher than for the solventborne.

Funke and Haagen[54] reviewed the literature on SO_2 permeability of polymer films and paint films and tabulated the results (*Table* 4). They stressed the high solubility of SO_2 in organic coatings and pointed out the need for the development of nontoxic alternatives to lead to scavenge SO_2 in paints.

Funke et al.[55] investigated the absorption of anhydrous SO_2 by unpigmented films of alkyd/melamine and epoxide resins. The weight gains following 24-hour exposure were 14 and 11%, respectively, and, upon evacuation, the polymers retained 20-30% of the weight gain. They attributed this retention to the chemical reaction of SO_2 with the resins. These resins were also cast on steel substrates and soaked in 1% aqueous solutions of sulfuric and sulfurous acids. Corrosion of the steel substrate was detected within hours of immersion in the sulfurous acid, whereas the panels in sulfuric acid were corrosion-free for days and even weeks if the coating resisted degradation.

For unpigmented polymer films, it is apparent that the diffusion, solubility, and permeation of SO_2 depend on the polymer type. Diffusion is Fickian for polymers at temperatures above their glass transition (T_g). Although it is slight

Table 3—Moisture-Excluding Effectiveness (MEE)[a] of Three Coats of Various Finishes on Ponderosa Pine[34]

Effective		Somewhat Effective		Ineffective	
MEE%	**Finish Type**	**MEE%**	**Finish Type**	**MEE%**	**Finish Type**
95	Paraffin wax-dipped	74	Polyurethane paint—gloss (2-component)	19	Nitrocellulose lacquer
91	Epoxy finish—clear (2-component)	73	Pigmented shellac house paint	16	Acrylic latex flat
87	Epoxy paint—gloss (2-component)	69	Paraffin wax—brushed	11	Water repellent (1% wax)
84	Aluminum flake-pigmented urethane varnish (oil-modified)	66	Polyurethane finish—clear (2-component) semi-transparent stain)	11	FPL natural finish (linseed oil-based)
82	Aluminum paint (linseed/phenolic/menhaden)	60	Alkyd house primer paint (tall maleic alkyd resin)	10	Latex enamel wall paint (epoxy)
80	Enamel paint—satin (soya/tung)	59	Epoxy paint—gloss (1-component)	4	Acrylic latex house primer paint
		59	Enamel paint—gloss (soya alkyd; interior)	2	Tung oil
		57	Marine enamel—gloss (soya alkyd)	1	Latex pigmented shellac
		50	Epoxy varnish—gloss (1-component)	0	Semi-transparent oil-based stain
		48	Polysilicone enamel (silicone alkyd)	0	Solid-color latex stain (acrylic resin)
		46	Floor and deck enamel (phenolic alkyd)	0	Alkyd flat wall paint (soya alkyd)
		44	Urethane varnish (oil modified)	0	Latex flat wall paint (vinyl acrylic resin)
		44	Gym seal (linseed oil/phenolic resin/tung oil)	0	Paste furniture wax
		42	Shellac	0	Linseed oil
		42	Solid-color oil-based satin (linseed oil)	0	Linseed oil sealer (50%)
		41	Oil-based house paint (tall/soya alkyds)	0	Unfinished wood (control)
		35	Floor seal (phenolic resin/tung oil)		
		32	Flat latex primer wall paint (butadiene-styrene resin)		
		30	Spar varnish (soya alkyd)		

(a) MEE: 100% = perfect protection or no absorption of water vapor; 0% = no protection, as with unfinished wood.

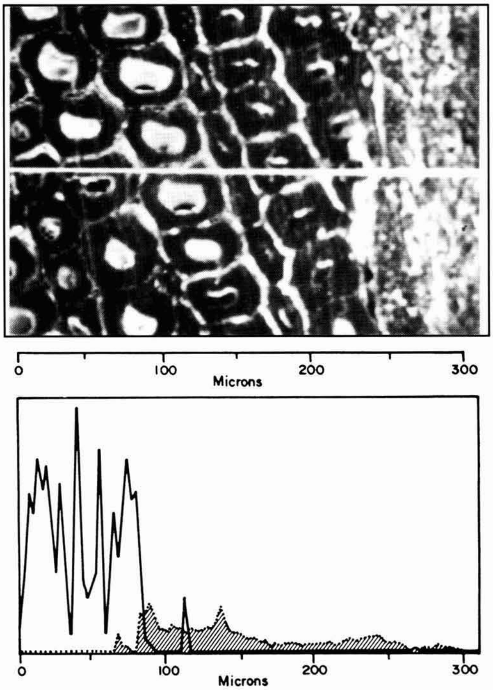

Figure 6—SEM/EDS line scan of sulfurous-acid-treated Southern pine (*Pinus sp*) having one coat of acrylic latex primer and two top coats (Ti = ——, S = ------). Vertical full scale (VFS) = 10,643[63]

for some polymers, they tend to show non-Fickian behavior below their T_g. In addition, the permeability of polymers to SO_2 is rather high compared with other gases; this is caused mainly by the high solubility of SO_2 in many polymers.

From the research reviewed in this section, it is clear that unpigmented polymer films have a large range of permeabilities but that the polymers used in paint formulation generally do not form barriers to SO_2 either in the gaseous state or in solution as sulfurous acid. Although 20% of the absorbed SO_2 was retained in the alkyd/melamine and epoxide films and probably reacted with the polymer, there appears to be little degradation to the polymer itself from SO_2 at low concentrations. The absorption is inhibited by pigments; furthermore, those pigments that can catalyze the oxidation of SO_2 and scavenge the resultant sulfate ions can limit the penetration even more than can typical pigments.

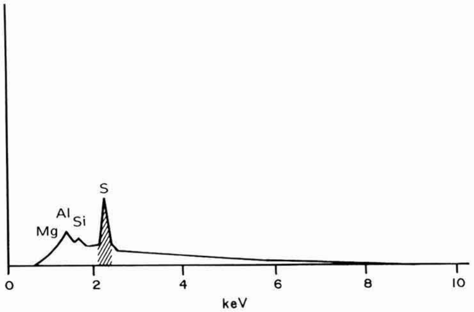

Figure 7—EDS showing the elemental constituents just below paint/wood interface. Vertical full scale (VFS) = 4,096 counts[63]

Svoboda and coworkers[56-59] reported that SO_2 permeated 65% linseed oil-modified pentaerythritol alkyd (naphthenate dryers) free films. The absorption into the film was linear with the square root of time and increased with temperature. At 30°C, the SO_2 penetrated approximately 30 μm into the film after four days. Svoboda et al.[56] also exposed isolated films to dilute sulfuric acid for 27 days. Penetration of sulfuric acid was not detected. The authors attributed the difference in penetration of sulfurous and sulfuric acids to differences in ionic concentrations. The permeation of acids into polymer films depends, to a large extent, on the solubility of the acid in the polymer. Volatile low molecular weight acids such as HF, HCl, HNO_3, and H_2SO_3 dissolve into the polymer in the molecular form.[59] They reported that polymers having low dielectric constants permit the rapid dissolution of undissociated molecular acid into the polymer and that the division between those that dissolve and those that do not, such as sulfuric and phosphoric acids, depends on the energy required to discharge an undissociated molecule from solution at the polymer/solute interface. They reported that SO_2 exists primarily in the molecular form and diffuses into paint in this form whereas sulfuric acid exists in aqueous solutions as hydrated ions. They also reported that the addition of neutral salts such as Na_2SO_4 in H_2SO_4 or NaCl in HCl shifts the equilibrium of the acid dissociation and thus affects the activity of the ions and the ability of the acid to permeate the film. The lack of penetration of sulfuric acid has also been attributed to the repulsion of the negatively charged ions by the polymers.[55]

The impermeability of the film to sulfuric acid led to the study of films containing a small amount of catalyst, such as Cu, to oxidize sulfite to sulfate, and an additional pigment to scavenge the sulfate, such as $BaCO_3$ or Pb_3O_4.[57,58] Pigments such as these decreased the SO_2 penetration into the films to as little as 20% of that into the unpigmented films. A 10% pigment volume concentration (PVC) of ZnO or TiO_2 decreased the SO_2 penetration by 50%. Higher PVC had little further effect on decreasing the penetration. The penetration rate for the pentaerythritol alkyd with 10% PVC TiO_2 was 0.11 $\mu m/min^{1/2}$ and decreased to only 0.10 $\mu m/min^{1/2}$ at 30% PVC.

Sulfur dioxide diffuses readily through paint. A number of studies have documented the high solubility and the ease with which the anhydrous gas permeates paint coatings. Paint can absorb SO_2 and/or HSO_3^- from sulfurous acid but it is not clear whether the dissolved SO_2 or the bisulfite ion is the diffusing species. It has been shown that SO_2 reacts with galvanized steel substrates and that the reaction products diffuse back through the paint film and are contained in the run-off from the painted specimens.[60] In a study by Spence et al.[61] that used acrylic latex paint on aluminum substrates, the paint failed because of corrosion of the aluminum substrate and subsequent loss of paint adhesion. Williams et al.[62,63] have also shown that SO_2/HSO_3^- in dilute sulfurous acid permeates acrylic latex paint on wood. In the case of porous films such as latex paints on reactive substrates, the diffusion of SO_2 through the film was sufficient to bring about catastrophic paint failure.

The high permeability of paint coatings to SO_2/HSO_3^- could possibly degrade the wood substrate. It has previously been shown that loss of adhesion can occur if wood weathers before initial painting. It was also shown that acid treatment of specimens during exposure to accelerated weathering increased the rate of surface deterioration; the rate at which wood weathered increased by as much as 50% when wood was exposed to sulfurous, sulfuric, or nitric acids.[25,26] On the basis of the more rapid degradation of wood under acidic conditions, the loss in adhesive strength would probably be higher for boards exposed in areas having acidic deposition than those boards exposed in areas having little acidic deposition.

The SEM/energy dispersive spectroscopy (EDS) analysis was used to detect sulfur in western redcedar (*Thuja plicata*) and southern pine (*Pinus sp.*) wafers painted with alkyd-oil or acrylic latex primer paint following exposure to sulfurous acid, sulfuric acid, and sodium sulfate.[62,63] Sulfur was detected in those specimens exposed to sulfurous acid (*Figures* 6 and 7) but not in those exposed to sulfuric acid (*Figure* 8) or sodium sulfate solutions. If, therefore, sulfuric acid or the sulfate ion is to affect paint performance, it must reach the wood surface through voids in the paint (*Figure* 8).

The results clearly show that for both alkyd and acrylic latex paints, sulfur dioxide and/or sulfurous acid readily diffuse to the wood surface. The sulfur compounds accumulate or react with wood at the paint/wood interface of an intact paint system; sulfuric acid does not. It is likely that SO_2/HSO_3^- reacts with the wood at the paint/wood interface. Given the three major constituents of wood—cellulose, hemicellulose, and lignin—it is most likely that the reaction of SO_2 with wood takes place via a substitution at the a-carbon of the phenylpropane unit typical of that found with sulfite pulping (*Figure* 9).[64,65]

The major effect of the SO_2 reaction at the wood/paint interface is probably degradation of lignin; however, small amounts of both cellulose and hemicellulose degradation products also have been recovered from western redcedar soaked in dilute H_2SO_3 or H_2SO_4.[25] Similar amounts were formed with both acids, but the degradation of the wood was about 40% faster for H_2SO_3 than for H_2SO_4 at pH 2.0. This more rapid degradation by H_2SO_3 was probably caused by the reaction with lignin. The celluloses are more resistant to reaction with H_2SO_4.

Although Raczkowski,[21] Evans and Banks,[22] and Williams[25,26] have shown that H_2SO_3 degrades wood at normal temperatures and low concentrations and evidence exists for this chemical reaction at the paint/wood interface, there is no evidence for a loss of paint adhesion associated with this chemical reaction. With SO_2/HSO_3^-, there may be some effect at the paint/wood interface, but it cannot be quantified. All that can be said with certainty is that, in those areas with high SO_2 emissions, painted wood is susceptible to some added degradation at the paint/wood interface.

The reactions of other acids at the paint/substrate interface are not well established. Several studies on the diffusion of H_2SO_4 through paint have shown that an intact paint coating is impervious to H_2SO_4. Effects of sulfuric acid on painted wood are limited to the paint, and any interface effect is unlikely unless the paint develops cracks or the film integrity is breached. If the coating develops cracks or has voids, some degradation of wood may be possible if the pH is below 3.5. Acidic deposition offers a potential for decreased adhesion, but no effect has been proven.

Table 4—Sulfur Dioxide Permeability of Polymer Film[54]

Polymer Film	Temperature (°C)	Thickness (mm)	Permeability x 10^9 ml (STP) mm cm^2 sec cm hg
Polyethylene low density	25	230	20.9
high density	25	—	5.68
Polyamide (Nylon 11)	25	61.4	6.58
	25	41	2.16
Polycarbonate (Lexon)	25	131	22.4
	25	25	21.0
Vinylidene chloride-vinyl chloride copolymer	25	—	0.201
Poly(ethylene terephthalate)	22	—	5.27
	25	13	0.201
Poly(methyl methacrylate)	22	—	0.132
Poly(vinyl chloride) (rigid)	25	145	0.116
Teflon	25	—	4.2
Polystryene	25	38	22.0
Cellulose (cellophane)	22	—	52.7
Cellulose nitrate	25	—	176.0
Vulcanized rubber	22	—	1450.0
Silicone rubber	22	—	11800.0

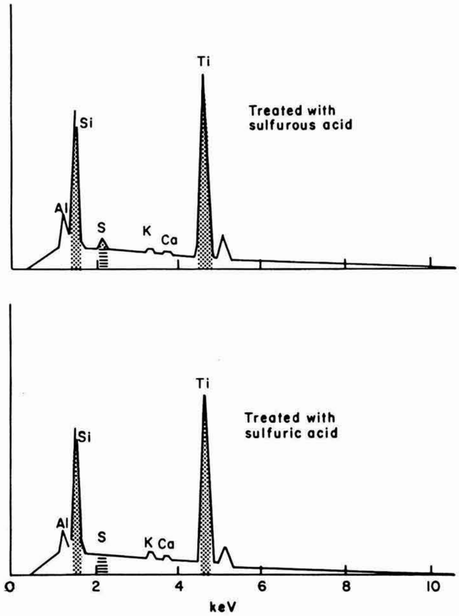

Figure 8—EDS of the paint/wood interface of western redcedar painted with an alkyd primer and topcoat: Top—treated with sulfurous acid. Bottom—treated with sulfuric acid[62]

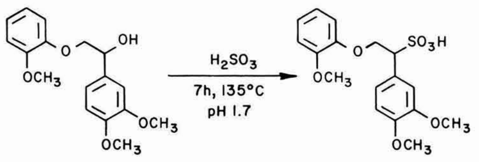

Figure 9—Reaction of SO_2 with lignin[64,65] (courtesy of S. Ralph)

Limiting the acid concentration to that typically found in acidic deposition may not take into account other factors. For example, if acid is absorbed by wood, it is unknown whether the pH of this acid decreases during periods of drying. If the acid is concentrated by the drying of the wood, it is possible that these stronger acids could contribute to hydrolysis of the celluloses; however, this has not been reported. It appears that even if low pH contributed to more rapid degradation in these water-induced failures, the problem would not exist where there weren't already a serious water problem.

Paint Coating

BINDER: The binder in paint is a general term for the polymeric material that forms the paint film either by evaporation of a solvent from a polymer solution or of a carrier from a dispersion or by polymerization of monomers. For film formation by polymerization, drying occurs as the solvent evaporates and polymerization begins. As the polymerization continues, crosslinking of the chains occurs to yield a cured film. The binder acts to bind pigment particles together and to the substrate.

Holbrow's[66] evaluation of oil and oil-alkyd paints and varnishes focused primarily upon the drying of binders and was based on laboratory studies using SO_2. The SO_2 concentrations ranged from 1 to 2 ppm, typical of those measured in Manchester, England, to concentrations in excess of 10,000 ppm. At concentrations of 1-2 ppm, the drying time of linseed, tung, and bodied dehydrated castor oil increased 50-100%. At 7-10 ppm, drying was further retarded. Chemical analysis of the dried paint films revealed that the SO_2 interfered with the autooxidation of the film by reducing the hydroperoxide. At high SO_2 concentrations, drying was completely inhibited. When oil-based paints and varnishes were placed over a solution of 0.2% SO_2 (approximately 16,000 ppm in the atmosphere), the paints and varnishes did not dry; however, when the paints were cured for a few days prior to exposure, these high concentrations of SO_2 seemed to have had no effect.

Exposure of dry but not fully cured films to SO_2 affected the gloss retention of the films, particularly if moisture condensed on the films. Several paints—long-oil pentaerythritol alkyd, linseed stand oil phenolic varnish, long-oil glycerol alkyd, linseed stand oil copal ester varnish, and linseed stand oil—were dried for 24 hours, cooled, placed above a 1.2% sulfurous acid solution for 15 minutes, and exposed to accelerated weathering for seven days. The pentaerythritol alkyd was hardly affected, but the gloss of the linseed stand oil copal ester varnish dropped more than 20% compared to controls. The gloss of the phenolic varnish and the glycerol alkyd dropped about 50%. The greatest effect occurred within the first day or two of cure and the effect was more pronounced under moisture-condensing conditions. The SO_2 exposure during the early stages of oil cure rendered the films moisture-sensitive and they wrinkled under further exposure to moist conditions. All films retained more than 80% gloss if allowed to cure for seven days before exposure. Both warmth and moisture in the weathering chamber were necessary to cause the SO_2-induced loss in gloss.

Many of the paints studied by Holbrow have been replaced by newer formulations and there is no documentation of drying problems with these finishes. In addition, latex paints have replaced alkyds for many architectural uses on wood in the United States. In Europe, alkyds are still popular. There have been no further reports on the curing of oil-based paints following Holbrow's[66] report. It is not known if new oil-based formulations show problems similar to those Holbrow reported in curing of the binder. It does not seem to be a problem at this time. Because latex paints form films by loss of water and concurrent coalescence of the latex particles, ambient SO_2 should not chemically affect their film formation.

Hendricks and Balik[67] studied the effects of SO_2 on free films of paint and the base latex polymer for one of the paints. The base latex polymer used in their research was a terpolymer comprised of approximately equimolecular amounts of vinyl chloride, vinyl acetate, and butyl acrylate and a small amount of methyl methacrylate. Two latex paints were formulated from this polymer; one contained $CaCO_3$ and the other did not. An alkyd gloss paint was also included in their studies. The paint formulations were typical for a mid-priced house paint.

Hendricks and Balik[67] reported the solubility of SO_2 in these paint films and films of the base polymer as being linear with pressure (Henry's Law behavior) over the range of 50-700 torr with the maximum pick-up for the base polymer of 14% (by weight) (*Figure* 10). The pick-up for the paint film was the same if normalized for the amount of pigment.

Table 5—Solubilty, Diffusion Coefficients, and Permeability of Paint with and without $CaCO_3$ and the Base Polymer[67]

Sample	Solubility (mg SO_2/g sample-torr)	Diffusion Coef. x 10^9 (cm^2/sec)	Permeability x 10^9 $\left[\frac{cm3SO_2\ (STP)\ cm^2}{cm^3\ sample\text{-}cm\ Hg\text{-}sec}\right]$
Base Polymer	0.189	14.2	12.1
Latex with $CaCO_3$	0.0622	10.6	4.88
Latex without $CaCO_3$	0.0681	10.9	5.52

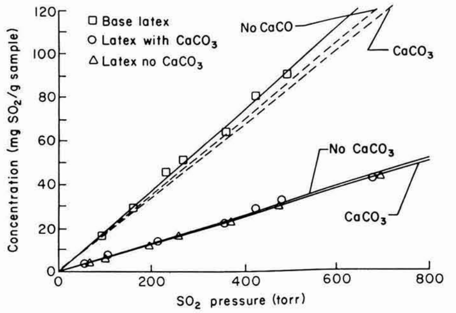

Figure 10—Sorption isotherms of SO_2 in paint specimens at 28°C[67]

They concluded that the pigment did not affect solubility. They also determined diffusion as a function of pressure and extrapolated to zero to obtain the diffusion coefficient (*Figure* 11). The solubilities, diffusion coefficients, and permeabilities calculated from these measurements were reported (*Table* 5). The effect of pigment decreases the diffusion coefficient; fillers such as $CaCO_3$ caused the same changes as pigments. As expected, the crosslinked alkyd had a lower value.

Both the base latex polymer and paint made from this polymer desorbed all the SO_2 when a vacuum was applied to the film; the alkyd paint retained approximately 15-20% of the SO_2 absorbed, even after several days at <1 mtorr. Xu and Balik[68-69] concluded that the SO_2 had reacted with the polymer in the paint. They also determined quantitatively the rate of $CaCO_3$ removal from the paints exposed to pH 2, 3, or 4 sulfurous acid or to distilled water (weak carbonic acid, pH 5.6) (*Figure* 12). They reported the complete dissolution of all $CaCO_3$ with all acids and with distilled water. The rates of dissolution were dependent on acid strength. The nominal mass loss was 27%; the reaction was diffusion-controlled at pH 2 and dependent on the acid concentration at pH 3 and above. IR analysis confirmed the loss of $CaCO_3$. The paint without $CaCO_3$ had less than 7% mass loss and showed no change in the IR spectra even after one month's immersion in pH 2 sulfurous acid. They reported similar results with 10 other acids at pH 3.

On the basis of a series of experiments, in which the IR peak intensities were monitored during the exposure of paint to sulfurous acid, Xu and Balik[69] reported that the latex film collapsed as the $CaCO_3$ was removed and the film thickness decreased by 16%. The sorption-desorption experiments were expanded to include thin strips of uncoated wood. Whereas the free films of latex paint lost all SO_2 in the desorption mode, the wood retained 18% (by weight) of the absorbed SO_2.

Fornes, Gilbert, and co-workers determined the effects of SO_2 (both dry and mixed with water vapor) and UV light exposure on free films of paint and base latex.[70,71] The polymer in these films was the same as that used by Hendricks and Balik.[67] They determined the change in gel fraction and the molecular weight distribution of the soluble fraction as the films degraded during exposure. Contact angles were measured and changes in surface morphology were investigated. Dynamic mechanical analysis (DMA) was used to determine the dynamic elastic modulus and T_g. Chemical changes in the gel and solution fractions and surface changes were monitored using ^{13}C nuclear magnetic resonance (NMR), Fourier transform infrared (FTIR) spectroscopy, x-ray photoelectron spectroscopy (XPS), and elemental analysis.

Patil et al.[70] reported that certain combinations of SO_2/H_2O/UV light had detrimental effects on the polymer in paint films (*Table* 6). In these exposures, high levels of SO_2 were used to evaluate various techniques for measuring film degradation. The base polymer had a multi-modal molecular weight distribution and an initial gel content of approximately 22%. After a 24-hour exposure to SO_2 and UV light (under both wet and dry conditions), the gel content increased to about 60-65% and the viscosity of the soluble fraction decreased. They interpreted this as an indication of chain scission (decrease in viscosity) and crosslinking (increase in gel percent) but that the mechanical properties were dominated by a crosslinking. DMA showed a dramatic increase in T_g. Sulfur dioxide alone caused essentially no change under dry conditions. After 96 hours, the contact angle was 0° and the T_g increased from 23°C to 87°C. The viscosity also decreased. Under wet conditions, chain scission was even greater; the viscosity dropped from 1.0 to 0.08 dl/g and the crosslinking was less. They reported that DMA clearly showed increased T_g, with the modulus remaining high, and they interpreted this as significant crosslinking.

On the basis of the ^{13}C NMR results, Sankar et al.[71] reported that the polymer exposed to SO_2/UV light had a decrease in carbonyl signal associated with the acrylate group, whereas UV light alone did not. It was also reported that HCl and acetic acid were formed during exposure by the decomposition of polyvinyl chloride and polyvinyl acetate and the formation of unsaturated carbon-carbon bonds. The formation of sulfur-carbon bonds was reported. They also suggested that slow attack of the butyl acrylate group occurs. They reported a synergistic effect on polymer degradation between UV light and SO_2 under both wet and dry conditions.

The degradation reactions of the binder, however, have been proven for high concentrations of SO_2/HSO_3^-. They are more rapid when moisture is present and are synergistic with UV light. Degradation includes both crosslinking and chain

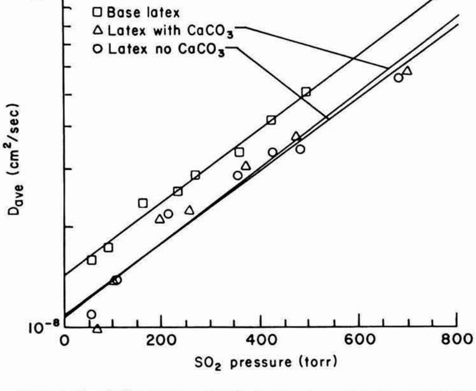

Figure 11—Diffusivities of SO_2 in paint specimens at 28°C[67]

Table 6—Properties of the Base Polymer of a Latex Paint upon Exposure to SO_2/H_2O/UV Light Combinations[70]

Exposure Conditions					Properties			
Time (hrs)	UV Light (350 nm)	Air	SO_2	H_2O	[n] (dl/g)	Gel (%)	Contact angle (deg)	T_g (° C)
0				-	1.00	22	77	23
24	+	+	-	-	0.98	28	77	15
48	+	+	-	-	0.83	29	78	16
96	+	+	-	-	0.55	36	78	16
48	-	-	+	-	1.00	22	74	25
96	-	-	+	-	1.00	21	76	23
24	+	-	+	-	0.15	65	45	—
48	+	-	+	-	0.13	64	50	78
96	+	-	+	-	0.12	65	—[a]	87
24	+	+	-	+	1.00	19	78	—
48	+	+	-	+	1.00	21	72	—
96	+	+	-	+	0.90	23	83	—
24	+	-	+	+	0.19	61	45	—
48	+	-	+	+	0.05	60	40	49
96	+	-	+	+	.08	58	—[a]	60

(a) Drop spread immediately.

scission. However, no concentration-degradation relationship has been established at high concentrations, nor has degradation at low concentrations been established. It is unclear whether the degradation of paint coatings by SO_2 also occurs at levels typical of those found in the environment.

There are only a few published reports on the effect of acids other than SO_2/H_2SO_3 on the binder in paint coatings. The only documented case of finish degradation with dilute H_2SO_4 (pH 2) was the report by Deppe and Schmidt[27] on the degradation of melamine-formaldehyde coatings on particleboard; there was no quantification of the degradation. In other studies of acid effects, the acid strengths were considerably stronger than found in the environment. Other than as reported by Deppe and Schmidt,[27] no deterioration of clear coatings was noted at pHs typical of those found in the environment.

Strong acids and high concentrations of O_3 have been used to accelerate the degradation of paint coatings. Tsingarelli and Orzhakhovskii[72] reported the effects of formic and acetic acid vapors, NO_2, and nitric, formic, and acetic acid solutions on the durability of unpigmented coatings as measured by anticorrosive protection or loss of electrical insulating capacity. Gutfreund[73] used O_3 to deteriorate paint in accelerated testing and correlated the results with outdoor testing.

Pigments, Extenders, and Driers: Pigments, extenders, and driers comprise the solids in the paint film held in place by the binder. The pigments give paint its opacity and may be colored or uncolored. As with pigments, extenders are generally inorganic in nature and are used to help control rheology and increase the solids content of the paint. Driers catalyze the curing of polymers and are often organometallic compounds such as cobalt naphthenate.

Ward[74] investigated soiling of exterior house paint for a variety of paint formulations with and without lead pigments and driers. The lead pigments and driers caused blackening of paints in industrial areas. Hoffmann[75] developed a method for maintaining extremely low concentrations of H_2S for laboratory studies and later reported the effects of these low concentrations on paint.[76] In investigating the sulfide staining of flat and gloss alkyd paints, he found that staining resulted from the reaction of H_2S with small amounts of lead naphthenate driers in the paint. Staining did not occur in paints containing cobalt naphthenate driers. Watson,[77] however, reported that H_2S could cause sulfide staining of paints containing cobalt driers.

Sulfide staining can also occur if paint containing phenylmercury mildewcides is exposed to H_2S.[78] Wohlers and Feldstein[79] reported that H_2S concentrations above 0.05 ppm for several hours under optimum conditions could darken

Table 7—Paint Formulations Used by Spence et al.[61]

	Alykd		Latex	
Ingredients	Subtotal (%)	Components (%)	Subtotal (%)	Components (%)
Pigments	35.3		36	
Titanium dioxide		22.6		23.8
Magnesium silicate		7.4		—
Silica		3.1		11.0
Tetrachloromethyl sulfonyl pyridine		—		0.8
Mildew-resistant agent NTC		1.2		—
Silicate		1.0		0.4
Vehicle	64.7		64	
Polyester resin		—		4.4
Acrylic		—		14.5
Water		—		45.1
Raw linseed oil		7.6		—
Soya alkyd resin		24.4		—
Mineral spirits and driers		32.7		—

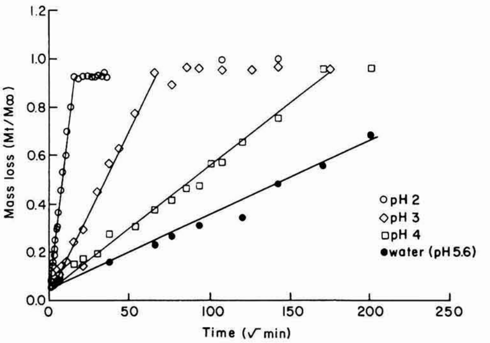

Figure 12—Mass loss of $CaCO_3$ from latex paint specimens exposed to sulfurous acid[68]

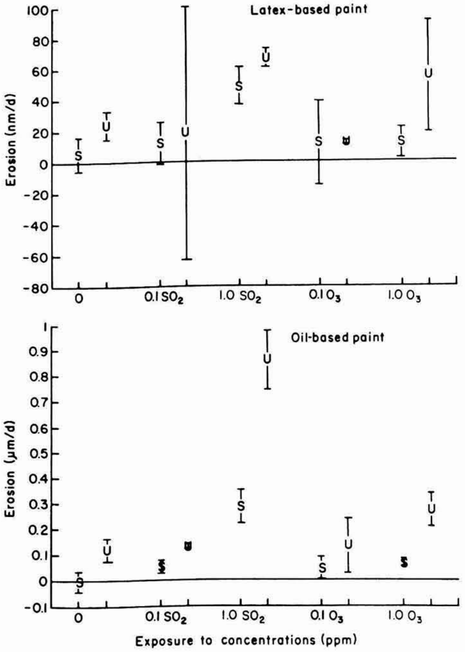

Figure 13—Erosion of shaded, s, and unshaded, u, panels painted with latex or oil-based paints exposed to SO_2 or O_3 in a laboratory chamber.[86] The bars represent the 95% confidence limits for these slopes

paint. When the darkening was not severe, the original color returned within several days after the H_2S had abated as a result of air oxidation. In cases of severe darkening, as much as six months was required for paint to revert to its original color.

The staining intensity of lead and mercury sulfides depends on the distribution of the metal salts in the paint film and the H_2S concentration in the atmosphere.[80] Macdonald[81] reported similar results. Merz[82] reviewed building materials at risk to environmental pollution and cautioned against using red lead, white lead, chrome yellow, chrome orange, or chrome green in exterior paints used in environments having high H_2S pollution. The degradation of paint by H_2S is a local effect, and it affects only a few pigments. In areas where H_2S is common, care in selecting paint should eliminate potential problems.

Holbrow[66] reported that some pigments could be discolored by SO_2. Paints containing Brunswick green were sensitive to 0.2 ppm concentrations of SO_2 for the first few hours after painting and to higher concentrations (200 ppm) for several days. The color change was caused by the bleaching of the lead chromate ($PbCrO_4$). Several other pigments were sensitive to sulfur compounds. Boxall and von Fraunhofer[83] found that red lead (PbO_2 $2PbO$) darkened on exposure to sulfur compounds; basic lead sulfate ($2PbSO_4$ PbO) discolored; and ultramarine blue ($3Na_2O_3$ Al_2O_3 $6SiO_2$ $2Na_2S$) rapidly decomposed when exposed to dilute acid.

Torlaschi et al.[84] studied the effect of SO_2 on anatase and rutile titanium dioxide (TiO_2), zinc oxide (ZnO), iron oxide-yellow (FeO OH), iron oxide-red (Fe_2O_3), chrome oxide (Cr_2O_3), cadmium yellow (CdS), cadmium red ($CdS(Se)$), lithopone ($ZnS + BaSO_4$), ultramarine ($(Na,Ca)_8(Al_6Si_6O_{24})S$), Prussian blue ($KFe$ $Fe(CN)_6$ xH_2O), chrome yellow ($Pb(Cr,S)O_4$), molybdate red ($Pb(Cr,S,Mo)O_4$), and zinc chromate ($K_2Zn_3(CrO_4)_4$ $Zn(OH)_2$ $2H_2O$) pigments. At 0.67% SO_2 in air, zinc oxide and zinc chromate reacted to form water-soluble salts, which leached from the film. Chrome yellow and molybdate red were reduced to chromium sulfate. The degradation was less if the formulation also included TiO_2 pigment. The other pigments were stable at this concentration, but the authors reported that, at higher concentrations, some of the pigments exhibited incipient degradation, particularly if drops of condensed acid were allowed to evaporate. Merz[82] identified several pigments sensitive to sulfuric acid (white lead, red lead, zinc oxide, zinc white, zinc yellow, zinc green, lithopone, ultramarine blue, and Schweinfurt green). He also cautioned against using $CaCO_3$ extenders.

The discoloration of pigments occurs in limited areas and is of a temporary nature and, even if data were available, it would not be appropriate to use it as a measure of paint degradation. The phenomenon merits mention, however, because of the relative aesthetic value of pigments in paint coatings exposed to the environment. Painted wood is often refinished because of discoloration, particularly surface deposits such as mildew, but it is not possible to assess the magnitude of this problem. In addition, discoloration is often accompanied by other forms of degradation and the interactions among these degradation modes is also difficult to assess.

Many paint components sensitive to color change are no longer extensively used in house paint because of environmental concerns. This is particularly true for lead-containing pigments and driers.

Alkaline components of paints, which serve as extenders and colorants and affect flow characteristics of paint, can neutralize acid. $CaCO_3$ and ZnO are alkaline components of many paints. Acids and their precursors such as SO_2, at concentrations typical of those found in the environment,

Table 8—Accumulated Run-off Concentrations for Laboratory Chamber Experiments[60]

			Concentration (nmoles/cm^2) of							
Sample	Condition	Vol. (ml)[a]	H^+	Ca^{++}	Zn^{++}	$HCOO^-$	NO_3^-	HSO_3^-	SO_4^{--}	HCHO
Latex	Dew	1.89	4.6	2.4	74.9	47.5	108.3	12.7	32.5	53.7
	Dry	0.00	18.2	2.6	31.6	2.3	129.8	0.0	4.8	—
Latex-c[b]	Dew	2.06	13.8	357.0	59.6	23.6	161.1	368.6	86.8	533.6
	Dry	0.00	3.0	255.5	30.8	7.0	497.8	0.0	7.3	—
Oil	Dew	1.57	144.4	3.2	37.2	55.2	120.1	0.0	96.8	164.9
	Dry	0.00	4.9	0.8	9.4	2.7	22.6	0.0	4.4	—
Oil-c,z[c]	Dew	4.26	38.6	109.6	171.2	105.7	306.6	13.4	100.7	259.7
	Dry	0.00	4.3	40.6	50.0	4.0	147.2	0.0	5.2	—
G-steel[d]	Dew	5.99	21.2	1.7	2277.6	704.1	517.2	2235.6	692.0	3668.1
	Dry	0.00	2.1	0.9	425.3	7.7	764.1	0.0	46.1	—

(a) Total volume of dew collected.
(b) c= Contains $CaCO_3$
(c) z= contains ZnO.
(d) Galvanized steel.

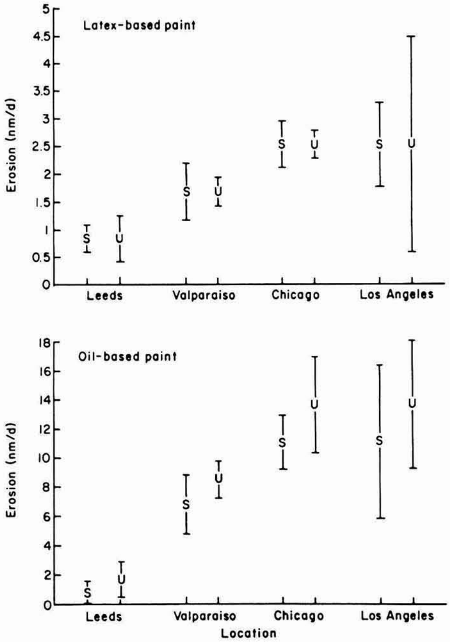

Figure 14—Erosion of shaded, s, and unshaded, u, panels painted with latex or oil-based paints exposed to outdoor weathering at four sites.[86] The bars represent the 95% confidence limits for these slopes

can react with these components. The rate of dissolution is a function of acid strength, and laboratory studies have shown that dissolution occurs with dilute mineral acids, such as sulfuric, as well as with weak acids, such as carbonic and sulfurous acid.[69] At pHs typical of those found in the environment, the loss of $CaCO_3$ can be measured gravimetrically. In studies using gaseous SO_2, degradations occurred more rapidly during periods when the surface was wet. They showed that binder morphology changed as $CaCO_3$ dissolved, and it seems that paint binder has some effect on the dissolution rate of alkaline components exposed to sulfurous acid. It is certain that paints having these components will lose weight when exposed to acid but the phenomenon is complicated by other factors.

Spence and collaborators[85,86] exposed both oil-based and latex house paints to laboratory and field tests (*Table* 7). The oil-based paint contained calcium carbonate and magnesium silicate extender pigments whereas the acrylic latex-based paint contained only aluminum/sodium/potassium silicate extenders. Although these finishes were formulated for use on wood, they were applied to stainless steel substrates because the objective of the study was to evaluate film-surface deterioration, not the film-substrate interface. All specimens were exposed to SO_2 and O_3, and some to UV light (unshaded) while others were shaded. Exposure to 0.1 ppm SO_2 had no effect (*Figure* 13). The rates for the latex coatings increased to about 60 nm/day when exposed to 1.0 ppm SO_2. The difference between the shaded and unshaded remained about the same. The greatest increase in erosion rate (about 0.3 µm/day and 0.9 µm/day for shaded and unshaded, respectively) occurred with oil-based house paint having $CaCO_3$ extender pigments exposed to 1.0 ppm SO_2.

In most cases the effect of light and SO_2 appeared consistent except for the oil-based house paint. In that case, the erosion of the unshaded specimens was more than twice as fast as the erosion of the shaded specimens. The data indicate a synergism between these two effects with the oil-based house paint, but not with the latex house paint. It should be noted, however, that the oil-based paint contained $CaCO_3$ whereas the latex paint did not and oil-based paints are more susceptible to UV degradation than acrylic latex paints. The synergism may be an isolated effect caused by combining a highly UV-sensitive binder with $CaCO_3$ extender pigments. The surface erosion was confirmed using attenuated total reflectance-infrared (ATR-IR) spectroscopy and scanning electron microscopy.

The results with O_3 were less clear although the oil-based paint was more severely affected than the latex paint. The degradation with O_3 appeared to have been primarily a photochemical degradation. The relative difference between the control and the specimens exposed to O_3 was the same at both concentrations under shaded conditions but increased when unshaded (*Figure* 13).

The data from field exposures[86] showed significant differences in erosion of paint coatings for specimens from a clean site and three dirty sites (*Figure* 14). It was not possible to establish a cause and effect relationship because no pollutant concentration data were obtained for these sites. The ATR-IR and SEM analyses were similar to the results from the chamber study and showed greater binder degradation for the alkyd. The highest erosion rate occurred for coatings with acid-sensitive extender pigments (mainly $CaCO_3$) in areas of high pollution.

In a later study,[61] a controlled environment chamber was used to identify direct and possible synergistic effects of SO_2, NO_2, and O_3 on an oil-based house paint and an acrylic latex house paint (*Figure* 15). The paints were applied to aluminum panels and exposed to all combinations of low- and high-concentration conditions: 0.03 or 0.5 ppm SO_2, 0.05 or 0.5 ppm NO_2, 0.08 or 0.5 ppm O_3, and 50 or 90% relative humidity. The surface erosion as determined by mass loss was measured at 250, 500, and 1000 hours of accelerated weathering (*Figure* 15). Variables in chamber conditions included temperature, relative humidity, pollutants (SO_2, NO_2, and O_3), dew, and light. The chamber was constructed such that the paint surfaces were subjected to moisture-condensing conditions. The results of the study, based only on mass loss, indicated that oil-based house paints having magnesium silicate extenders were affected by SO_2 and relative humidity. This can easily be seen by plotting the data in decreasing order of erosion and arbitrarily separating the data into three groups (*Figure* 15). The highest erosion generally occurred on specimens exposed to high SO_2 (S) and high relative humidity (H). The lowest erosion rate occurred on specimens exposed to low SO_2 (s) and low relative humidity (h). The high and low levels of nitrogen dioxide (N,n) and ozone (O,o) appeared to have no effect.

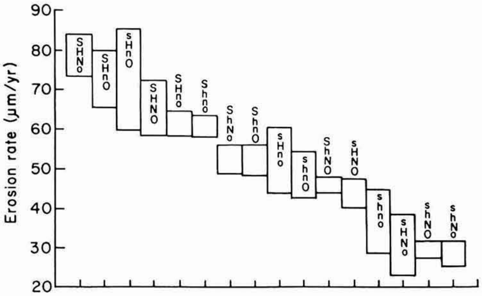

Figure 15—Effect of RH, SO_2, NO_2, and O_3 on the erosion rate of oil-based paint coating. R and r, S and s, N and n, and O and o designate high and low concentrations of moisture (RH), SO_2, NO_2, and O_3, respectively. From data by Spence et al[61]

Table 9—Average Ion Concentrations of Run-Off from Panels Exposed at Raleigh, NC or Steubenville, OH [60]

Sample	Condition	H^+	Na^+	K^+	Ca^{++}	Zn^{++}	$HCOO^-$	Cl^-	NO_3^-	SO_4^{--}
						Concentration (nmoles/cm²) of				
					RALEIGH, NC					
Latex	DI	0.28	2.09	1.14	0.59	—	0.24	0.35	1.22	1.22
	Ambient	4.18	3.02	1.78	2.12	—	0.98	7.29	5.73	5.17
Latex-c[a]	DI	0.13	1.67	0.74	4.25	—	0.29	4.36	1.80	1.46
	Ambient	1.29	3.36	2.11	11.75	—	0.94	10.17	6.91	6.45
Oil	DI	0.49	0.44	0.27	0.63	—	0.06	1.0	10.79	0.59
	Ambient	4.16	0.85	0.93	0.83	—	0.46	1.6	82.22	2.70
Oil-c,z[b]	DI	0.88	0.35	0.87	1.19	0.64	1.42	1.2	31.04	0.52
	Ambient	1.32	0.69	0.34	3.63	1.98	0.44	2.7	04.19	3.37
					STEUBENVILLE, OH					
Latex	DI	0.10	3.43	0.73	5.18	—	1.41	6.38	1.06	4.22
	Ambient	5.40	0.78	0.90	15.15	—	0.07	6.67	11.02	19.15
Latex-c[a]	DI	0.08	4.23	0.85	6.94	—	1.47	6.36	1.22	4.73
	Ambient	1.91	0.85	1.03	24.14	—	0.07	8.50	13.01	24.31
Oil	DI	0.25	5.11	0.68	3.36	—	1.78	7.42	0.80	3.34
	Ambient	3.50	0.60	0.69	13.69	—	0.07	4.55	9.60	15.38
Oil-c,z[b]	DI	0.14	2.42	0.33	3.24	0.99	1.17	4.36	0.76	2.90
	Ambient	1.59	0.87	0.76	19.96	3.47	0.09	5.47	11.46	20.50

(a) c=contains $CaCO_3$.
(b) z=contains ZnO.

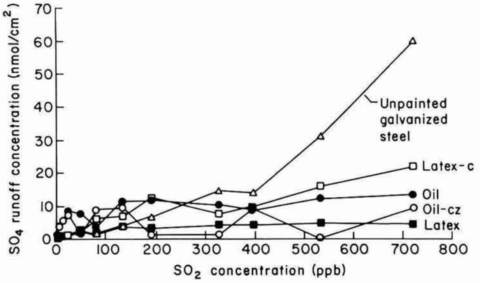

Figure 16—Sulfate ion runoff concentration as a function of SO_2[60]

In a more recent report, Haynie and Spence[87] evaluated two house paints that were exposed for up to 30 months at nine locations in the area of St. Louis, Missouri. At each of these locations, the ambient pollution levels and weather conditions were monitored. Measurements included SO_2, NO_2, and O_3 concentrations, sunlight, and time of wetness. The paints were formulated without $CaCO_3$, applied to stainless steel substrates, and placed both in northern and southern exposures at each site. After the 30-month exposure, the mass loss of the specimens was evaluated with respect to the various combinations of the environmental conditions. The only statistically significant result obtained was for exposure to NO_2 and time of wetness; NO_2, in combination with moisture, caused a gain in mass. Results for SO_2 were not significant.

The results from these experiments should be viewed with some caution because of possible complications in using mass-loss measurements to calculate film erosion. Addition- or condensation-type reactions of pollutants with paint components, diffusion of pollutants into the film, outgassing of the paint, and accumulation of dirt (particularly in the field exposures) can all adversely affect the mass-loss measurements.

With these concerns in mind, the evaluation of erosion by mass loss in paints that are resistant to erosion is likely to be lost in experimental error, whereas paints containing $CaCO_3$ or silicates show measurable losses. These losses completely overshadow the other degradative processes that may be occurring in the paint during the exposure. It is not surprising, therefore, that significant effects were found, in the preceding experiments, only for paint containing $CaCO_3$ or silicates. Evaluating the other effects requires an understanding of the process involved in the degradation and can only be achieved by other techniques including laboratory and field exposure experiments.

The laboratory studies did not take into account the different permeabilities of polymers and acids, the effects of UV light, or the dry deposition of other alkaline materials. Since the permeation of SO_2 in paint is high, alkaline components can readily react. In exposure to other acids that do not penetrate polymer films as well as SO_2, it is not clear how UV degradation of the polymer affects the results. It may be necessary for the polymer to undergo UV degradation to expose the pigment to the acid. UV degradation is further complicated by the unknown effects of low concentrations of acid. Either $CaCO_3$ reaction or photochemical degradation of the binder may be the rate-determining factor in the erosion of paint coatings. If the dissolution of $CaCO_3$ is slower than the photodegradation of the binder, then the loss of $CaCO_3$ commensurate with erosion should not be considered a function of the acid. Only those factors that affect the rate-determining step for a particular failure mode should be considered for determining the accelerating effect. For example, if acidic deposition increased the rate of erosion of the surface but the paint failed by peeling, there is not a clear link between the acidic deposition and the damage function for this mode of failure.

Edney[60] and coworkers[88,89] reported the chemical composition of run-off from painted western redcedar panels coated with latex and alkyd paints formulated with and without $CaCO_3$. The panels were exposed outdoors at Raleigh, North Carolina (suburban), and Steubenville, Ohio (industrial) and were compared with painted galvanized steel panels exposed in a chamber. In the chamber study, painted galvanized steel panels were exposed to a complex gas mixture containing steady-state concentrations of 230 ppb O_3, 180 ppb NO_x, 380 ppb HCHO, 7 ppb HNO_3, and SO_2. The SO_2 concentration was varied from 0 to 722 ppb for each of the exposures and the SO_4^{-2} concentration of the runoff was measured for the various SO_2 concentrations (*Figure* 16).

The run-off data from the chamber study (*Table* 8) showed that acidic gases such as SO_2 and HNO_3 dissolved the alkaline ($CaCO_3$ and ZnO) components in the paint. Those finishes high in $CaCO_3$ had ZnO and high Ca^{+2} and Zn^{+2} run-off. A substantial amount of zinc was leached from all painted galvanized steel, whereas the specimens painted on western redcedar exposed outdoors had no detectable zinc, unless the paint contained ZnO pigment. This substantiates the transparency of paint to SO_2 and shows that the substrate can be degraded, particularly under wet (dew) conditions.

Edney reported that leaching of ZnO (the mildewstat) might harm the paint, but he could not link the loss of $CaCO_3$ to a decrease in service life. He indicated that degradation of polymers would likely cause harm to film integrity but found no evidence for polymer degradation.

Higher bisulfite salt (HSO_3^-) concentrations were found in runoff samples collected from specimens containing alkaline components exposed under moist conditions. The SO_2 was absorbed into the water on the surface and reacted with the alkaline components, is forming bisulfite salts. In specimens with less accessible alkaline components, such as $CaCO_3$ in oil-based paint, the reaction was slower than with more accessible $CaCO_3$ in latex paint (*Table* 8). The acid concentrations confirm this reaction and were lower in the runoff from the specimens having high HSO_3^- concentration.

Edney[60] compared the calcium run-off from specimens exposed at Steubenville and Raleigh (*Table* 9). The difference for latex paint with and without $CaCO_3$ at Raleigh was about 9 nmole/cm² day (11.75 minus 2.12) and at Steubenville, about 9 nmole/cm² day (24.14 minus 15.150). For oil paint at Raleigh, the difference was about 3 nmole/cm² day (3.63 minus 0.83) and at Steubenville, about 6 nmole/cm² day (19.96 minus 13.69). From this data, it appears that the ambient conditions in Steubenville as compared with Raleigh have no effect on the amount of $CaCO_3$ leached from latex paint and only a little effect on oil paint. Soluble calcium salts were, for the most part, caused by calcium salt precipitation and not from dissolution of $CaCO_3$. The almost identical values for the dry deposition (DI) support this conclusion, although the lower values are somewhat puzzling.

Surface Deposits

Surface deposits such as soiling and salt formation are most often problems in protected areas such as under eaves and soffits. The formation of water-soluble crystals of ammonium sulfate "blooming" on the surface of paint is an example of salt formation.

Ames and Gourley[90] investigated the formation of bloom on varnish prepared from pentaerythritol alkyd resins. They identified $(NH_4)_2SO_4$ as the compound responsible for the deposit but did not determine whether it was deposited as $(NH_4)_2SO_4$ or formed in place by the reaction of SO_2 with NH_3 under moist conditions. Others who have also investigated bloom formation[66,91,92] have reported that it requires moisture and is dependent on the type of paint. The formation was more severe on the pentaerythritol alkyd than on glycerol alkyd. Hill[93] reported that crystalline bloom could form on paint through a thermal precipitation mechanism. He found that moisture was unnecessary for bloom formation and reported $(NH_4)_2SO_4$ particle sizes of less than 2 μm diameter deposited under dry conditions. Giese[94] reported that bloom on latex house paint occurred mainly on protected areas of structures and was caused mainly by SO_2. The problem was worse for paint containing $CaCO_3$.

Strauch et al.[95] reviewed bloom formation on paint coatings and summarized the data to show six causes for this effect. Deposits of atmospheric pollutants and acid-catalyzed degradation of the paint components were two of the causes; others were extraction of soluble components of the film such as wetting and dispersing agents, diffusion of pretreatments through the paint, diffusion of soluble salts from the substrate, and combinations of these five causes. In their investigations to verify these causes, they exposed emulsion paints to acid in the 4-4.5 pH range for two years. Paints with and without $CaCO_3$ showed no bloom formation. They did not rule out possible degradation at higher pHs over longer time but described the degradation as chalking. They did verify the formation of sulfates from atmospheric pollution under moist conditions. On wood substrates, pretreatments with alkaline stripper caused bloom formation if the stripper was not neutralized and thoroughly washed from the surface. The residue consisted of sodium and calcium carbonates.

Schurr and Van Loo[96] and Campbell et al.[86] investigated the cause of intercoat peeling of house paints on under-eaves and found that, under certain weather conditions common to the Great Lakes area of the United States, paints containing zinc salts or barium metaborate caused the formation of a residue on the surface of paint. When the eaves subsequently were repainted, this residue caused catastrophic intercoat failure. The residue was shown to contain sulfates, but no mechanism was proposed for the formation of these sulfates. They could have formed by direct dry deposition of sulfate particles or by the reaction of SO_2 or sulfuric acid aerosols with the paint. They reported that the problem could have been eliminated by washing the under-eave area prior to repainting.

Holbrow[66,97] reported that soiling of paint by particulates—including sulfates and chlorides of iron, calcium, and zinc—in highly industrial areas led to longer service life. He indicated that the longer life was probably caused by decreased UV radiation of the paint film and the neutralizing of acid by alkaline deposits.

Karyakina and Viktorova[98] developed a method for evaluating the susceptibility of paint to dirt pick-up: The difference in luminosity before and after exposure yielded a value for dirt retention. Raaschou-Nielsen et al.[99] reported that dirt retention by painted surfaces can be a serious problem in industrial areas and they investigated the factors affecting dirt retention. They found that dirt retention increased with increased tack and decreased T_g. They also developed an accelerated test method.

Combined Effects

The only quantitative cause and effect information is based on the research by Spence and coworkers and is contained in a review by Haynie.[100] The incremental effects include only increased erosion of the paint caused by the dissolution of $CaCO_3$ or silicate-containing extender pigments. Haynie attempted to establish the decrease in durability of paint exposed to SO_2 as related to the increase in painting frequency necessitated by increased erosion. He developed an equation on the basis of the erosion data obtained from painted specimens exposed to SO_2 and moisture. The model predicts the increase in erosion over the estimated typical erosion at a pH of 5.2 and an SO_2 concentration of 0 (representative of a clean environment).

Haynie's model takes into consideration SO_2 concentration and rain acidity, but it applies only to erosion of the paint coating and does not consider some of the more serious modes of paint degradation such as cracking and loss of adhesion. "Just based on the variability of the available data, the magnitude of the error in any economic cost estimate will be the same as the estimate. This means the cost could be zero or twice as much as the estimate. Assumptions in economic analysis increase this error."[100] With the present state of knowledge, many research gaps exist.

CONCLUSIONS

The study of acidic deposition effects on the service life of painted wood is complicated by several factors. These include:

- a wide range of types of substrates and finishes;
- variability of these materials;
- variability in weathering conditions from year to year and place to place; and
- inconsistencies in the results between outdoor weathering and "accelerated" weathering.

Synergism and other interactions among these factors further complicate these studies. A comprehensive model that encompasses all the modes of degradation of painted wood and includes the incremental effects of acidic deposition on these modes cannot be determined at this time. In general, it has not yet been possible to quantify the effects of acidic deposition for isolated modes of degradation because these effects are often obscured by the variability of painted wood. Some effects have been identified.

Effects of Acidic Deposition

The reaction of acid with the alkaline components of paint is the only well documented degradation mechanism that could affect a large amount of paint in service. It would be prudent to avoid using these components in formulating paints for use in areas of high pollution and/or acidic deposition. On the basis of the run-off data from Steubenville, Ohio, the dissolution of $CaCO_3$ is less than expected because of the neutralizing effect of alkaline dry deposition. The values from clean sites might better represent the actual risk over wide geographic areas.

Sulfur dioxide has the potential to affect the durability of coatings on wood, although causes and effects have not been determined for any of the paint components at risk. In addition, SO_2 can have little effect over large geographic areas because it is converted to sulfuric acid. Only the alkaline components have been proven to be at risk to low acid concentrations typical of those found in acidic deposition, and even those effects are complicated by a combination of factors.

In the absence of obvious catastrophic failure, the service life or durability of finished wood is usually determined by compiling several performance criteria such as gloss, cracking, peeling, etc., to obtain an overall evaluation. In addressing the question of the effect of acidic deposition on painted wood, even more factors come into play. Compilation of the various results reviewed here into an overall performance criteria should also include the other major factors that contribute to paint system degradation.

Despite all the research into the degradation of finishes, cause and effect relationships are still not possible. To expect a single model to explain all wood finishes or even all paints is unrealistic. A more reasonable approach is to consider a type of finish—and substrate, if applicable—and attempt to quantify the most common degradation mechanism for this finish. For example, in the research on erosion of $CaCO_3$-containing paints, researchers were well on their way to quantitatively defining a cause and effect relationship for this pigment in two types of finish.

It is possible to evaluate several degradation mechanisms and to discuss the influences of acids and other pollutants on these mechanisms. It is even possible to obtain reasonable cause and effect relationships for some of these degradation mechanisms. It is not possible to combine these into a model that quantifies the effect. The investigations of effects at the paint/wood interface are not conclusive. It has been shown that SO_2 diffuses through paint and reacts with the wood under the paint, but loss of paint adhesion has not been measured. It should be noted, however, that the standard deviation of the adhesive strength of both exposed and unexposed paint coatings on wood is quite high and any loss of adhesion caused by the acidic environment would not be obvious.

Research Potentials

The isolated effects of acidic deposition on painted wood cannot be evaluated until the mechanisms of paint degradation under non-acidic conditions are known. Rigorous scientific and technical bases have not been established for evaluating paint degradation under normal exposure. Paint evaluation has focused primarily on quick assessment of formulations using accelerated test methods or empirical evaluation of specimens during and after field exposure. There has been no long-term research commitment to the study of materials properties of paint and its components, particularly when combined with a substrate.

A number of publications have dealt with new instrumental techniques for determining paint characteristics, and, although these characteristics have been used in a few cases to monitor changes in paint coatings as they weather, this information has not established clear mechanisms of failure or correlated laboratory data with service life of paint coatings in the field. In general, research on the modes of paint failure has not addressed fundamental material considerations or assessed chemical changes and interactions among the weathering factors and paint components. No equation is available for combining the various degradation factors into an overall model that quantifies degradation for panels exposed to normal weathering conditions. In addressing acidic deposition research, scientists have had to address both problems: the basic research on weathering of paints and the incremental effects of acid deposition.

To close this research gap, this researcher recommends two research tracks: (1) one that investigates changes in the paint film (both surface and bulk) independent of substrate, and (2) one that investigates the paint/substrate interface (including both substrate and film properties). The first approach focuses on the effects at the paint surface that are primarily driven by the photo-oxidation of the paint film components and includes the study of bulk properties of the film. The second takes into consideration the bulk properties of the substrate, the original surface of the substrate, and the nature of the interface formed by the coating and substrate. This binary approach would measure the effects of chemicals that diffuse through the film, and describe the materials properties of both the coating and substrate.

This approach demands a determination of fundamental materials properties, both chemical and physical, of painted wood as it weathers under various conditions, both in the laboratory and in the field. Research of this nature requires a long-term commitment. A study of the effects of acidic deposition on painted wood should begin with basic studies of the polymers most commonly used in paint including new ones now being developed. The research should include laboratory and field exposures with controlled exposures to various environmental factors including, but not limited to, acid. Cause and effect determinations demand experimental designs that include ranges of concentrations of various acids and their precursors and combinations of these pollutants. Long-term exposure to concentrations typical of those found in the environment is essential. The minimum concentrations should be typical of those found in suburban areas in northeastern United States and the maximum should be typical of those found in major industrial areas. The exposure periods should be several years. The critical factor in these experiments will be determining the changes in materials properties, particularly the subtle chemical changes in films of the pure polymers, coatings of these polymers on wood, and the wood/polymer interface. These determinations can be made using currently available techniques that include analysis of run-off from specimens and nondestructive and destructive chemical analysis and mechanical testing.

As the research with the polymer progresses, finishes should be formulated using these polymers and a similar range of experiments conducted using these finishes. The finishes should include several common pigments including acid-sensitive extenders such as $CaCO_3$, but this should be a minor part of the program. It might be necessary to evaluate chemical changes in pigments and other minor components as well as in the polymer. Exposure regimes (both laboratory and field) for the paints should parallel those developed using the polymers. The research must include measurement of subtle changes in materials properties of all components of the paint system.

In a particular failure mode, it is necessary to identify the rate-determining step and to define any synergism in the degradation processes. In addition, the chemical changes associated with embrittlement, chain scission, loss of adhesion, and surface degradation should be defined. By understanding the chemical changes under various experimental conditions, both in the laboratory and in the field, that effect the various modes of failure, it may be possible to delineate the factors that catalyze acidic deposition. Such an understanding gives the background information necessary for determining the mechanisms of acidic attack of painted wood and the effect of acid on the rate-determining step in that failure mode.

Understanding of materials properties obtained through rigorous laboratory experiments will provide insight into the subtle changes that occur in field exposure. The evaluation of field exposure data must include the materials property link between specimens exposed in the field and those exposed under laboratory conditions. In outdoor testing, it should be the chemical changes and changes in mechanical properties of all components that define the finish performance. Visual evaluation is not likely to differentiate acid-induced degradation from normal degradation on painted wood. The isolation of degradation products unique to a particular degradation mechanism could well lead to new methods for accelerated evaluation procedures.

A research effort of this magnitude would require the formation of a research team comprising experts from many disciplines and would require substantial financial commitment. Are the benefits worth the price? On the basis of acidic deposition effects to painted wood, probably not. On the basis of understanding the mechanisms of paint degradation, the elucidation of links between accelerated weathering data and field data, the design of better paints, and determining the effects of pollution on paint performance, the answer is clearly "Yes."

The commitment to such a research program may be forced by events at hand. The most serious concern throughout the paint industry in the United States is compliance with volatile organic compound (VOC) legislation. Many of the traditional finishes used on wood will no longer be acceptable because of this legislation (including oil-based semi-transparent stains, oil- and alkyd-based primers and topcoats, solventborne water repellents and solventborne water-repellent preservatives). Environmental concerns will probably not require that latex formulations be changed, but these finishes may not give the properties that many consumers prefer. As traditional finishes are removed from the marketplace, their replacements might require a new generation of finishes. The durability of these should be determined and acidic environments should be a part of the experimental protocol. Previous studies on assessing acid degradation of finishes (particularly those on oil- and alkyd-based formulations) will probably not apply to these new finishes.

The introduction of these new low VOC finishes might also be complicated by changes within the wood industry. The change away from traditional species such as redwood and western redcedar will probably continue. More hardwoods will probably be used—not only domestic but also tropical species. The trend toward faster-grown, smaller-diameter trees will probably continue. Wood from these different species and smaller trees will not have the same properties as wood from traditional slower-grown species. New composite materials will be developed and will include new adhesives. These composites will be all wood-bases or combinations of wood and nonwood materials. Compatibility of these new substrates with new finishes will be a major challenge regardless of the effects of acidic deposition.

More research is needed to formulate comprehensive and fundamental understanding of the performance of painted wood under normal exposure conditions. When these data have been generated, cause and effect patterns and failure mechanisms can be defined. Then, the relative effects of acidic exposure to finished wood can be assessed and evaluated as part of the greater picture of materials degradation in the United States.

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A Study of Thixotropic Flow Behavior Of Alkyd Solutions

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The thixotropic flow behavior of alkyl solutions was investigated with a Model RV 100 Haake Rotovisco viscometer equipped with a coaxial cylinder sensor system. The variation of shear stress and viscosity with changes in shear rate was studied. The thixotropic structure of 60% solids alkyd solutions was markedly affected over a broad range of shear rates including low shear rates. Thixotropic structure recovery was usually realized after about five hours at rest.

INTRODUCTION

Coatings are used for protection of substrates against hostile environments and for aesthetic purposes. When a coating is formulated, various flow-related or rheological characteristics that affect application must be taken into consideration.

Rotational viscometers have been widely used to determine viscosity and other rheological behavior at particular shear rates. The correlation of coating viscosity with application behavior has been the subject of many investigations.[1-14] Much of this work has been concerned with pseudoplastic and thixotropic coatings which are receiving significant attention in the field of industrial coating products.

Since application and post application flow phenomena caused by brushing, rolling, spraying, and leveling occur at different shear rates, it is important that viscosity and other flow behavior of coatings are studied over a wide range of shear rates. The flow-related criteria that determine leveling properties in paints are viscosity, yield value, flow behavior, and regeneration of thixotropic structure. Thixotropic coatings require control of such properties so application requirements can be met.

Thixotropic flow behavior is typical for formulations that contain molecular elements whose attractive forces can exert their effect mainly when the system is at rest. These attractive forces between particles have the ability to form physical linkages between the particles and thus create a gel structure when the formulation is at rest. However, even at low shear rates, the physical linkages within or between moving structures or agglomerates that collide with each other can be ruptured, and the linkages between separated particles cannot be quickly reformed. If the shear rate is sufficiently low so that collisions of agglomerates are not very frequent, the particle agglomerates are continually disrupted to smaller and smaller formations. This means that at low shear rates the thixotropic material is characterized by a decrease in viscosity with increasing time of measurement. The higher the shear rate, the more rapid is the decrease in viscosity. If too high a shear rate is applied, the entire change in viscosity is essentially instantaneous and the time dependence of viscosity cannot be measured. However, it is important to understand whether or not the degree of thixotropic-structure reduction attained at low shear rates, after very long times, is incomplete and limited by the shear rate applied, or complete as it is when very high shear rates are imposed on the system.

Particularly interesting alkyd coatings are those that exhibit thixotropic flow behavior. Polymers prepared from alkyds and polyamides are frequently used as the main binder component in thixotropic alkyd coatings. The first thixotropic alkyd was prepared by Winkler[15] in 1952. Thixotropic alkyd resins are commercially manufactured by British Cray Valley Products Ltd. and Austria Vianova Kunstharz AG under the name "Gelkyds." A number of publications that deal with the preparation, properties, and advantages of thixotropic alkyds and al-

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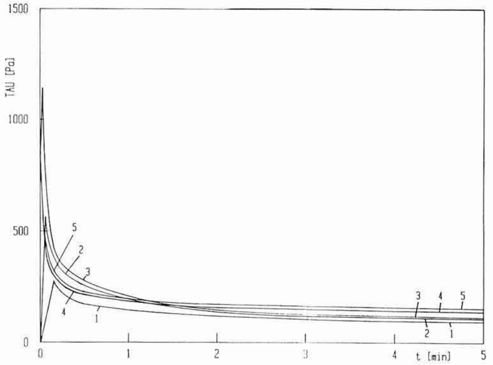

Figure 1—Dependence of the shear stress on the time of measurement. Curves 1-5 drawn by recorder for D 0.117 s^{-1}, 0.585 s^{-1}, 1.17 s^{-1}, 5.85 s^{-1}, and 11.7 s^{-1}

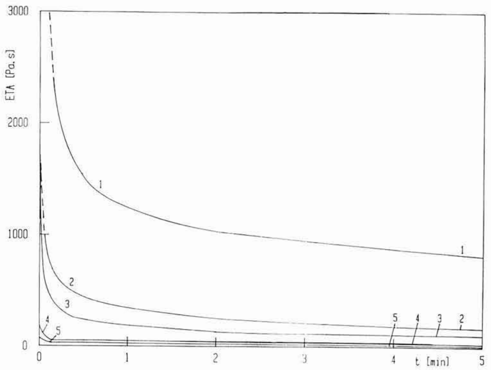

Figure 2—Dependence of viscosity on the time of measurement. Full curves 1-5 were calculated from curves presented in *Figure* 1. Notation of curves as in *Figure* 1

kyd coatings are available.[16-30] Also, various methods and instruments that are used for measuring and evaluating the flow behavior and structure recovery of thixotropic materials have been described.[31-60] The main goal of the present paper is to develop a method of measuring the flow, viscosity, and recovery behavior of a thixotropic alkyd, THIX S 60, that was prepared in this Institute.

EXPERIMENTAL

Thixotropic alkyd THIX S 60 was prepared from a soybean oil alkyd, that had an oil length of 60 and an acid number of 12 mg KOH/g, and a polyamide resin Eurelon™ 935 supplied by SCHERING AG. Five weight percent of the polyamide was added to the soybean alkyd and the mixture was heated and stirred at 220°C until the resin product became clear. A thixotropic alkyd solution of 60% by weight concentration, THIX S 60, was prepared by dissolution of the resin in white spirit which contained 14% by weight of aromatics. THIX S 60 is used in combination with medium and long alkyds for thixotropic lacquers, enamels, and primers.

Rheological measurements were carried out with a Model RV 100 Haake Rotovisco viscometer. The MV I and SV I rotor and cup assemblies were used. These assemblies allow shear rates of between 0.0445 s^{-1} and 1,117 s^{-1} to be attained. The cone and plate sensor system could not be used because of solvent evaporation from the solutions. Sample temperature was measured by a Pt-100 temperature sensor that was incorporated in the cup and was maintained at 20°C ± 0.1°C by means of a circulating liquid heat transfer medium.

The following test protocol was used. The required amount of sample was loaded into the cup, the rotor was immersed into the sample by slowly pushing the cup upward, the cup was attached to the viscometer, and the sample was allowed to remain at rest for a definite time (as explained in the next section) before measurements were started. Measurements of the dependence of shear stress, TAU, on time of measurement at a particular shear rate (TAU-time), and of the dependence of shear stress on the shear rate, D, when a definite range of shear rates was used for a particular time of measurement (TAU-D), were made.

RESULTS AND DISCUSSION

TAU—Time Measurements

The purpose of making measurements that describe a decrease of the shear stress, TAU, with time of measurement, was to estimate the rate of destruction of the thixotropic structure and to determine the final values of TAU which are independent of further shearing at the particular shear rate employed.

RATE OF THIXOTROPIC STRUCTURE DISRUPTION DETERMINATION: The loaded sample was allowed to rest in the measuring system of the viscometer for four hours at 20°C before measurements were started. The TAU-time measurements were carried out at shear rates of 0.117, 0.585, 1.17, 5.85, and 11.7 s^{-1} for curves 1, 2, 3, 4, and 5, respectively (see *Figure* 1). From the data in *Figure* 1, it is apparent that the TAU-time curves exhibit maxima with coordinates TAU_p and t_p. As the shear rate increases, the TAU_p value is higher and the t_p value is lower. (At the two highest rates of shear employed, the maxima could not be recorded.) The ascending portions of the curves cannot be taken as real since the measured shear stresses are lower than the true ones corresponding to the shear rate set on the RV 100. The actual shear stress at the peak of the curve corresponds with that measured by the RV 100 at set shear rate and so do the TAU values at the descending portion of the curves. It is important to understand that destruction of the thixotropic structure, which becomes apparent in decreasing viscosity, is already taking place during the initial stages of measurement, that is, before the maximum of the curve is attained, and continues after the maximum is reached.

The influence of shear rate on the rate of disruption of thixotropic structure can be more clearly seen from the time dependence of viscosity, ETA, data given in *Figure* 2. These curves were calculated from the data of *Figure* 1 by means of the relationship:

$$\text{ETA} = \text{TAU/D}$$

Within 0.1 min, the initial viscosity decreased to about 3,000 Pa·s at the very low shear rate of 0.117 s^{-1} and to about 20 Pa·s at a shear rate of 11.7 s^{-1}. In the time interval from 0.1 min to 5 min, the decrease in viscosity continued to about 1,000 Pa·s in the former case, and is negligible in the latter case. The data in *Figure* 2 also indicate that at a shear rate of 11.7 s^{-1} the decrease of the original, very high viscosity, to about 60 Pa·s is almost immediate.

FINAL TAU VALUE DETERMINATION: The dependence of TAU on time, and of percent TAU maximum, %TAU_m, on time, at the various shear rates is given in *Figure* 3. The shear rate D_r = 0.1% (D_r is shear rate expressed in percentages of the maximum value, D_m = 445 s^{-1}) was used first and measurements were carried out until the change in TAU was negligible. Then higher shear rates, D_r equals 2, 5, 7.5, 10, 15, 20, 40, 70 and 100%, were successively used. Shearing of the sample was stopped only for the short time required to set a new value of shear rate by the switch on the RV 100.

All curves that were drawn by the recorder start at the beginning of the coordinate system. At shear rates of 44.5, 66.7, 89.0, 178.0, 311.5, and 445.0 s^{-1} (*Figure* 3), the TAU values immediately increase to the maxima, whereupon they decrease to constant values. In general, the decreases are very small and almost negligible at a shear rate of 44.5 s^{-1}. Thus, it can be concluded that when shear rates higher than about 44.5 s^{-1} are successively used, almost no further disruption of the structure occurs at $t>0$. The very small decrease of viscosity may be assigned to a slight rise of temperature caused by the imperfect transfer of dissipated heat, a quantity that increases as the shear rate increases. This explanation seems more probable than a hypothesis that an additional, though small, disruption of structure, at $t>0$, is caused by the increased shear rate.

In another set of measurements, the experiment was begun at D_m = 445 s^{-1} and TAU was determined until it became constant. Subsequent measurements of the dependence of TAU on time were carried out at lower values of shear rate. At the end of each experiment, the shear rate was set again to 445 s^{-1} and the shear stress was monitored to its constant value. The scheme of experiments is described in *Figure* 4. Shearing of the sample was interrupted only for the very short time required to set a new value of shear rate of the viscometer.

When the curves in *Figures* 3 and 4 are compared, it is apparent that the final values of TAU obtained from both sets of measurements are equal for shear rates between 89 and 445 s^{-1} (see *Table* 1). At the lower shear rates ($D_r \leq 20\%$), the final TAU values obtained in the second set of measurements are slightly lower than those found in the first set. These small differences (see *Table* 1) are obviously caused by a slower disruption of the thixotropic structure in the first set (see *Figures* 1 and 2). If even longer times of measurement had been used in this first

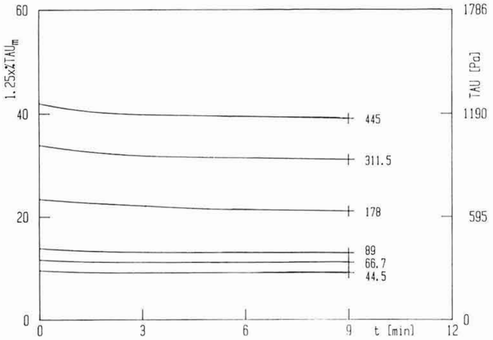

Figure 3—Dependences of TAU (or %TAU_m) vs time (100% of TAU_m = 3720 Pa). The shear rate was gradually increased when the sample was successively measured. Numbers attached to curves designate the shear rate D (s^{-1})

Table 1—Final Values of TAU Obtained from TAU-Time Measurements

	TAU (Pa)	
D (s^{-1})	For Subsequent Measurements the Shear Rate was Gradually Increased	Before Each Measurement at a Definite Shear Rate the Sample was Sheared at D = 445 s^{-1}
0.45	100	38
8.9	125	82
22.5	172	144
33.4	215	182
44.5	247	223
66.7	312	298
89.0	379	372
178.0	625	625
311.5	911	911
445.0	1157	1157

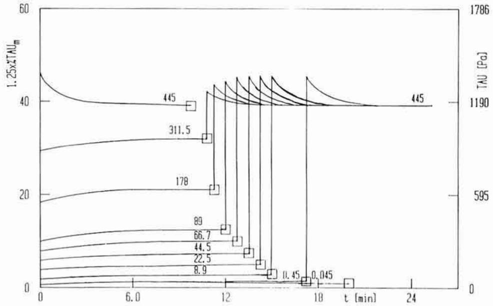

Figure 4—Dependences of TAU (or %TAU_m) vs time (100% of TAU_m = 3720 Pa). Before each measurement the shear rate was again set to D = 445 s^{-1}. Numbers attached to curves designate D (s^{-1})

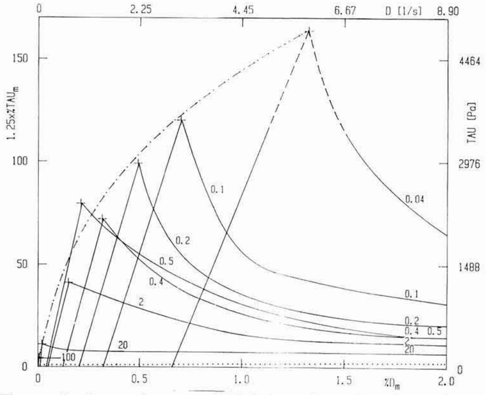

Figure 5—Dependences of TAU (or %TAU$_m$) vs D (or %D$_m$) (100% of TAU$_m$ = 3720 Pa, 100% of D$_m$ = 445 s^{-1}). Numbers attached to full curves drawn by recorder for the first set of measurements (peaks of the curves denoted by cross marks) designate time (min) at which D = 8.9 s^{-1} is reached. Dot-and-dashed line represents the curve corresponding to a fully disrupted thixotropic structure

set, the shear stresses would probably decrease to the final values obtained in the second set. Regardless of this, the differences are so small that it is evident that a recovery of the original structure cannot be practically observed even when the lowest shear rate, 0.0445 s^{-1}, is applied immediately after shearing a sample at 445 s^{-1}. (Final values of TAU are also plotted in *Figure* 7, where the dependence of TAU on D is described.)

The curves drawn by the recorder for various shear rates start at the beginning of the coordinate system (*Figure* 4) and coincide with the %TAU$_m$ axis. This means that at the start of an experiment, the shear stress very rapidly increases to a certain value, which depends on the shear rate, and then levels off to a constant value. The curves for a shear rate of 445 s^{-1} have a different shape; that is, they display a maximum and a slight decrease to a constant value. The probable reason for these small changes of TAU is a slight increase or decrease of temperature which is caused by an increase or decrease of the dissipated heat when the shear rate is increased or decreased. This is a more reasonable explanation than invocation of a slight recovery or destruction of the thixotropic structure.

TAU-D Measurements

When thixotropic behavior is investigated through experiments wherein rate of shear, D, is increased from zero to the maximum, ''upward'' measurement, and then D is decreased from the maximum to zero, ''downward'' measurement, the choice of times used for both measurements is of primary importance. It is obvious that if an upward measurement is carried out for a longer time and that if another upward measurement is carried out for a shorter time, then the flow curve corresponding to the longer time lies under that corresponding to the shorter time. If the thixotropic recovery occurred during the downward measurements, under similar circumstances the position of the flow curves would be just the opposite.

From the TAU-D measurements using different long times for upward and downward measurements at D = 0 to 445 s^{-1}, it was found that only the flow curves in upward experiments are affected by the time of measurement, whereas those in downward experiments do not differ in a practical sense. This means that if the shear rate is continually decreased from D$_m$ = 445 s^{-1} to zero, practically no recovery of thixotropic structure occurs. This is also in agreement with the results obtained from the TAU-time measurements. Flow curves corresponding to the fully disrupted thixotropic structure are represented by dotted lines in *Figures* 5 and 6 and by dotted and dashed lines in *Figure* 7.

To obtain these data, two sets of TAU-D measurements were performed. In the first set, all measurements were carried out at different times, t_2, with the same sample. After each measurement, the sample was allowed to rest in the measuring system for five hours. In the second set, measurements were carried out for each time, t_2, with a new sample. Each new sample was allowed to rest in the measuring system for five hours before measurement. Conditions for the measurements are given in *Tables* 2 and 3. The dependences of TAU vs D and %TAU$_m$ vs %D$_m$ of the first set are shown in *Figure* 5, with D$_r$ = 0 to 2% and D = 0 to 8.9 s^{-1}. The dependence of TAU vs D for both sets of data are given in *Figure* 6, with D$_r$ = 0 to 10% and D = 0 to 44.5 s^{-1}. The corresponding dependencies for the second set of measurements are described in *Figure* 7, with D$_r$ = 0 to 100% and D = 0 to 445 s^{-1}. The numbers associated with each of the curves designate times, t in minutes, taken for measurements in the given ranges of shear rate.

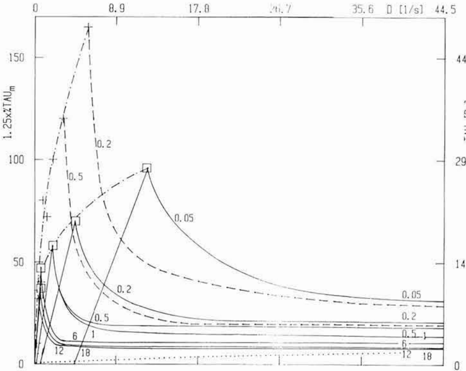

Figure 6—Dependences of TAU (or %TAU$_m$) vs D (or %D$_m$) (100% of TAU$_m$ = 3720 Pa, 100% of D$_m$ = 445 s^{-1}). Numbers attached to curves drawn by recorder for the second set of measurements (full lines; peaks of the curves denoted by squares) and the first set of measurements (dashed lines; peaks denoted by crosses) designate the time (min) at which D = 44.5 s^{-1} is reached. Dot-and-dashed lines represent the envelope curves; dotted line represents the curve corresponding to fully disrupted thixotropic structure

Table 2—Influence of the Time of Measurement upon the Flow Curves in the First Set of Measurements (*Figures* 5 and 6)

Measurement TAU-D		D = 0 − max. D	D = 0 − 8.9 s^{-1}	D = 0 − 44.5 s^{-1}	Peak of Curve	
Max. % of D_m	Max. D (s^{-1})	t_2[a] (min)	t[b] (min)	t (min)	D (s^{-1})	time (s)
0.1	0.445	5	100	500	0.05	30
0.1	0.445	1	20	100	0.1	12
5	22.25	5	2	10	0.67	9
5	22.25	1	0.4	2	1.3	3.6
20	89	5	0.5	2.5	0.9	3.1
20	89	1	0.1	0.5	3.1	2.1
50	222.5	5	0.2	1	2.2	3
50	222.5	1	0.04	0.2	5.9	1.5
2.4	10.68	24	20	100	0.1	12

(a) t_2 is the time necessary to attain max. % of D_m ($D_m = 445$ s^{-1}).
(b) t is the time necessary to attain 8.9 s^{-1} or 44.5 s^{-1}, respectively.

Certain differences between the results of both sets of data, *Figure* 6, are obviously caused by the fact that in the first set, the sample was left in the measuring system for a long time and a small amount of solvent evaporation with accompanying slight concentration increase of alkyd resin took place. This factor caused more difference between the viscosities in both sets of measurements at the lower shear rates. Differences between viscosities at the higher shear rates are less significant the higher the shear rate, as evidenced by the descending portions of the curves in *Figure* 6.

It is apparent from the data in *Figures* 5 and 6 that the curves exhibit maxima whose coordinates, TAU and D, are higher the shorter the time of measurement. For previously mentioned reasons, the upward portions of the curves cannot be taken as real data. Disruption of the thixotropic structure, decrease of viscosity, occurs already in the initial stage of measurement, that is, before the maximum of the curve, and continues after the maximum is attained. The times corresponding to the maxima are listed in *Tables* 2 and 3. They decrease with a decrease in the time of measurement, t. However, since the maxima of curves corresponding to shorter times lie at higher values of shear rate than maxima of curves corresponding to longer times, the disruption of thixotropic structure at the maximum is larger, lower viscosity, in the former case than in the latter.

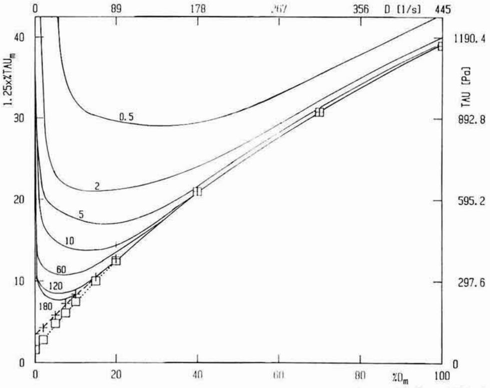

Figure 7—Dependences of TAU (or %TAU_m) vs D (or %D_m) (100% of TAU_m = 3720 Pa, 100% of D_m = 445 s^{-1}). Numbers attached to full curves drawn by recorder for the second set of measurements designate the time (min) at which D = 445 s^{-1} is reached. Dashed line connects the crosses corresponding to final values of TAU obtained from measurements of TAU vs time presented in *Figures* 1 and 3 (gradual increase of D). Dotted line corresponding to fully disrupted thixotropic structure connects the squares corresponding to final values of TAU obtained from the TAU-time measurements presented in *Figure* 4 (decrease of the shear rate from 445 s^{-1} to a definite value)

Table 3—Influence of the Time of Measurement upon the Flow Curves for the Second Set of Measurements (*Figures* 6 and 7)

Measurement TAU-D		D = 0 − max. D	D = 0 − 44.5 s^{-1}	D = 0 − 445 s^{-1}	Peak of Curve	
Max. % of D_m	Max. D (s^{-1})	t_2[a] (min)	t[b] (min)	t (min)	D (s^{-1})	time (s)
100	445	180	18	180	—	—
50	222.5	60	12	120	—	—
100	445	60	6	60	0.4	4.0
50	222.5	5	1	10	2.2	3.0
100	445	5	0.5	5	2.2	1.5
100	445	2	0.2	2	4.4	1.2
100	445	0.5	0.05	0.5	12.0	0.8

(a) t_2 is the time necessary to attain max. % of D_m ($D_m = 445$ s^{-1}).
(b) t is the time necessary to attain 44.5 s^{-1} or 445 s^{-1}, respectively.

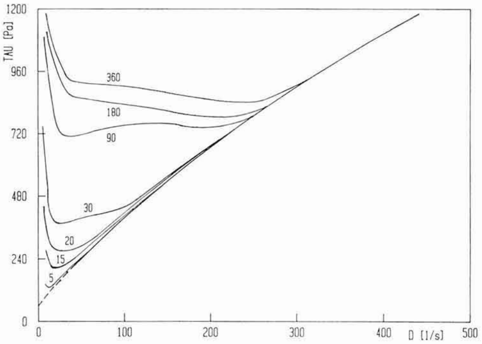

Figure 8—Histeresis (recovery) curves: flow curves upward (____) and flow curves downward (---). Time of the TAU-D measurement $t_2 = 3$ min for D = 0 – 445 s^{-1}. Prior to measurements, the samples have been left standing. Numbers attached to curves designate times (min) of standing

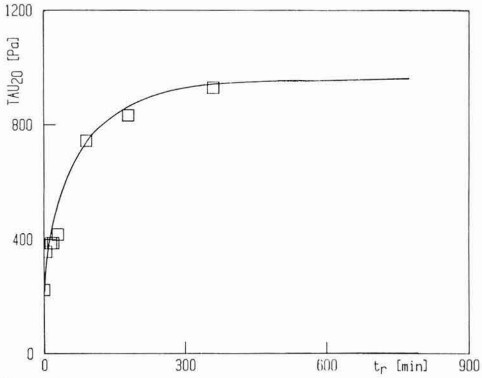

Figure 9—Dependence of TAU_{20} on the time of standing at rest of the sample after shearing at D = 445 s^{-1}. TAU_{20} designates the value of TAU at $D_r = 20\%$ (D = 89 s^{-1}) obtained from measurement of TAU vs D (maximum D = 445 s^{-1}, t_2 = 3 min)

The dependence of shear stress on rate of shear for nondisrupted or essentially nondisrupted structures would be useful. However, since the structure is significantly destroyed by even very low shear rates operating over relatively very short times, and since the upward portions of the experimental curves are not real, it is not possible to obtain exact initial portions of the TAU vs D curves. To obtain a rough dependence, the maxima of the experimental curves given in *Figures* 5 and 6 were connected by envelope curves passing through the origin of the coordinate system. True dependencies would be above the envelope curves and would have a non-zero intercept corresponding to the yield value.

The maximum viscosity corresponding to the smallest extent of thixotropic structure disruption can be assessed from the slope of a straight line connecting the points of the envelope curve, *Figure* 5, at D = 0.0445 s^{-1} and D = 0.445 s^{-1}. This results in a value of 2,300 Pa·s, which can be compared with the viscosity of 2,400 Pa·s corresponding to the maximum of the dependence of TAU-time for D = 0.117 s^{-1} shown in *Figure* 2. The minimum viscosity corresponding to a fully disrupted structure, ETA = 4 Pa·s, can be assessed as the slope of a straight line connecting the points of the dotted curves, *Figure* 5, at D = 0.0445 s^{-1} and D = 0.445 s^{-1}. As the curve corresponding to fully disrupted structure (*Figure* 7) has an intercept TAU = 37 Pa at D = zero, it seems that even the sample with a fully disrupted thixotropic structure exhibits a definite, though small, yield value.

The influence of the times of measurement, t, on the shape of flow curves for the entire range of shear rates, D_r, from 0 to 100%, is given in *Figure* 7. It is apparent that differences between the curves are considerable at the low shear rates. As the shear rate increases, these differences decrease and become slight at $D_r > 40\%$.

As in measurements of the time dependence of TAU, the rise of sample temperature and accompanying decrease of viscosity due to imperfect heat transfer plays a part in the measurements of TAU vs D at the higher shear rates. The shorter the time of measurement, t, (i.e., the faster the change of D) the smaller is the rise of temperature of the sample above the control point of 20°C, and the higher is the value of TAU at 445 s^{-1}. This factor is probably responsible for differences between the flow curves at $D_r > 40\%$ (see *Figure* 7), and perhaps also for greater curvatures of flow cures than would actually occur in a perfect situation.

Recovery of the Thixotropic Structure

As no recovery of the thixotropic structure disrupted by the previous action of a high shear rate (for instance 445 s^{-1}) is practically observed, even at very low shear rates, the rate of recovery of the thixotropic structure must be measured in such a manner that a sample with fully disrupted structure is left to rest for a definite time before flow measurement. When flow measurements are completed, the sample is again allowed to rest, but for a longer time than previously, and then flow measurements are again repeated. Cycles of "standing at rest" then "measuring flow property" were repeated several times with the time of standing at rest systematically varying from several minutes to several hours. The hysteresis or recovery curves are presented in *Figure* 8.

The dependence of TAU_{20} on time of standing at rest is shown in *Figure* 9. TAU_{20} designates the value of TAU at D_r = 20%, with D_m = 445 s^{-1} obtained from the TAU-D measurements (maximum % of D_m = 100%, t_2 = three minutes). From *Figure* 9, it is apparent that the thixotropic structure is essentially fully recovered after about five hours at rest.

CONCLUSIONS

Use of the Haake Rotovisco viscometer with MV I and SV I rotor and cup assemblies proved to be suitable for an investigation of the thixotropic behavior of alkyd solutions.

The measurements indicate that the thixotropic structure of alkyd resin solutions is markedly disrupted by even very low shear rates. The lower the shear rate, the longer is the time required for a complete disruption of the network. Shearing for one minute at 5.85 or 11.7 s^{-1} causes a decrease in viscosity from a very high original value to low values of 40 Pa·s and 20 Pa·s, respectively. When the shear rate increases during measurement, the decrease in viscosity depends on both the time of measurement and the rate of change of the shear rate. The faster the change of shear rate, the lesser is the extent of structural disruption at a particular shear rate and, on the contrary, the larger is the extent of the structural disruption at a definite time of measurement. The rates of change of the shear rate, such as 3.7 s^{-1}/min or 44.5 s^{-1}/min, result in a decrease of the original very high viscosity to about 4.85 Pa·s during 18-min measurements at $D = 0$ to 66.7 s^{-1}, or during two-minute measurements at $D = 0$ to 89 s^{-1}. If in the latter case, the shear rates 66.7 $s^{-1} < D \leq 89$ s^{-1} are attained within less than two minutes, the viscosity is greater than 4.85 Pa·s. It is apparent that an increase in the shear rate above 66.7 s^{-1} is not equivalent to a shorter time of shearing with regard to efficiency in disruption of thixotropic structure.

It has been demonstrated that the thixotropic structure cannot be practically recovered, even when very low shear rates are successively employed after previously shearing the sample at a high shear rate. Thus, the thixotropic structure recovers only if the sample is left at rest. With the system investigated, the recovery was almost complete after five hours.

Since the proper dependence of TAU on D in the range of the lowest shear rates cannot be measured, an approximate dependence of TAU on D for the lowest shear rates can be obtained by constructing an envelope curve.

The magnitude of thixotropy is proportional to the quantity and strength of the physical associations between particles that are continually ruptured during flow that can rebuild only when the material stands at rest. It can be evaluated from the difference between flow or viscosity curves in upward and downward experiments, that is, by estimating the size of area bounded by the respective flow curves. If the influence of various solvents, the type of alkyl, and alkyd concentration is to be investigated, the conditions during all shear stress/rate of shear measurements should be kept constant. That is, the same time of measurement should be used for a definite range of shear rate.

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Use of Methylolated Abietic Acid And Toluene Diisocyanate In the Modification of Triglyceride Oils

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In this study, methylolated abietic acid and toluene diisocyanate were used together in the modification of some triglyceride oils, such as poppy seed oil, tobacco seed oil, sunflower oil, and linseed oil. For this purpose, preformed partial glyceride mixtures of each oil were, initially, partly esterified with methylolated abietic acid. Subsequently, the remaining hydroxyl groups were combined with toluene diisocyanate. In addition, toluene diisocyanate and abietic acid were reacted separately with the partial glyceride mixtures of each oil and the resulting products were used as control samples for the comparison of film properties. Another comparative sample was also prepared by reacting ester gum with linseed oil. An investigation of the film properties indicated that methylolated abietic acid could be utilized together with toluene diisocyanate as a modifier for binders based on drying and semi-drying oils.

INTRODUCTION

Gum rosin, which contains approximately 90% of abietic acid and its isomers, is obtained from the exudation of pine trees. This natural product is used largely in the manufacture of paints and varnishes due to its low cost. However, when rosin is used directly, it does not have all the properties which are expected from a surface coating material, such as water, alkali, and acid resistances. Therefore, rosin is treated in a number of ways according to the application. The most important types of chemically upgraded rosin are limed rosin, ester gum, maleic-modified rosin, rosin-modified phenolic resins, and a variety of treated rosins obtained by hydrogenation, polymerization, and disproportionation.[1,2]

Differing from the previously mentioned ways rosin is treated, the functionality of rosin and, hence, its usefulness, can be increased by the addition of a hydroxymethyl group through the reaction of formaldehyde with rosin acids.[3–6] In connection with this, Lewis and Hedrick used hydroxymethylated derivatives of rosin acids in polyurethane films which may be useful for coatings and elastomers.[7] Hedrick investigated the alkoxylated hydroxymethylated rosin derivatives as reactants for rigid urethane foams.[8] On the other hand, Minor and Lawrence explained that rosin-based varnishes could be prepared from the methylolated rosin by esterifying it with fatty acids or transesterifying it with triglycerides, followed by reacting the free carboxyl groups with glycerol.[9]

In the present study, methylolated abietic acid was used together with toluene diisocyanate (TDI) in the modification of triglyceride oils, such as poppy seed oil, tobacco seed oil, sunflower oil, and linseed oil. To do this, first, an excess amount of preformed partial glycerides mixture of each oil was esterified with methylolated abietic acid and, subsequently, the resulting intermediate was reacted with TDI through the remaining hydroxyl groups. The chemical reaction involved in this process is shown in *Figures* 1 and 2. Additionally, in order to obtain comparative samples, abietic acid and TDI were reacted separately with the partial glycerides. The product resulting from the latter case is the well known urethane oil. Apart from these samples, the reaction product of ester gum with linseed oil was included as an additional comparative sample. Finally, film properties of all samples were determined. The specimens modified with methyl-

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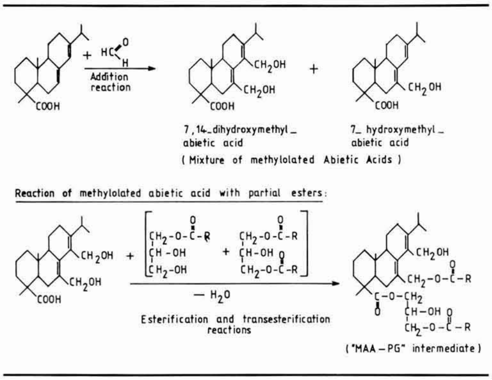

Figure 1—Preparation of methylolated abietic acid and MAA-PG intermediate

Table 1—Some Characteristics of the Triglyceride Oils Used in the Study[a]

Oil Specimen Used in the Study	Refractive Index, n_D^{20}	Acid Value	Saponification Value	Ester Value	Iodine Value[b]
Sunflower seed oil...	1.4750	0.6	188.3	187.0	121.5
Tobacco seed oil....	1.4761	5.3	192.4	187.1	132.5
Poppy seed oil......	1.4760	10.9	193.4	182.5	132.0
Linseed oil.........	1.4811	1.0	196.4	195.4	166.6

(a) Working procedure for the analytical methods were taken from reference (11) unless otherwise stated.
(b) Reference (22).

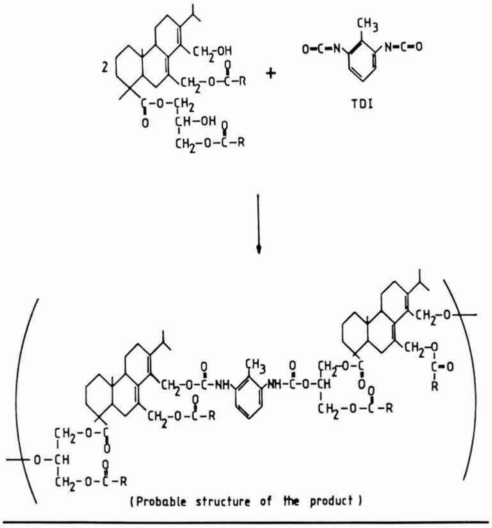

Figure 2—Reaction of MAA-PG intermediate with TDI

olated abietic acid and TDI possessed good film properties.

EXPERIMENTAL

Materials

Pure abietic acid was prepared from commercial gum rosin of Turkish origin according to the procedure of Steele.[10] Acid value and melting point were found at 185 and 164°C, respectively. Four types of triglyceride oils were used. Poppy seed and tobacco seed oils were extracted in the laboratory from the corresponding seeds of Turkish origin. Sunflower and linseed oils were commercially purchased. *Table* 1 presents the main characteristics of these oils. TDI consisting of 80% 2,4- and 20% 2,6-isomers was used. Other chemicals were reagent grade Merck products.

Experimental Apparatus

Preparation of methylolated abietic acid was performed in a flask fitted with a condenser. Monoglycerate and other reactions involved in the modification process were all carried out in a four-necked flask equipped with a stirrer, a thermometer, an inert gas inlet tube, and an air condenser.

PROCEDURES

Preparation of Methylolated Abietic Acid

Pure abietic acid and paraformaldehyde in an acetic anhydride-acetic acid mixture were reacted in accordance with Black and Hedrick.[3] The resulting mixture of acetoxy derivatives was saponified, acidified, and extracted with diethyl ether. The ether extract was washed with water and dried over Na_2SO_4. After removing the solvent, the mixture of methylolated abietic acids was obtained and its acid value was determined.[11] The average number of $-CH_2OH$ groups attached per abietic acid molecule was calculated from the difference between the molecular weights of abietic acid and methylolated abietic acid.

Modification of Oils With Methylolated Abietic Acid and TDI

Each oil was subjected to the glycerolysis reaction to prepare the partial esters to be used in the modification process. Thus, 100 g of oil and 10 g of glycerol were heated to 218°C, and $Ca(OH)_2$, 0.1% of the oil, was added. Temperature was raised to 232°C and the reaction was continued at this temperature for one hour under nitrogen atmosphere. The content of the reaction flask was taken into diethyl ether, washed with water, dried over Na_2SO_4, and the solvent was removed. Acid and hydroxyl values of the glycerolysate were determined.[11]

For the modification of oils, two parts of partial glycerides mixture and one part of methylolated abietic acid, by weight, were heated under the inert gas flow. By mixing the reactants in this manner, no doubt that the ratio of

Table 2—Samples Subjected to Heat Treatment and the Obtained Results for Evaluating the Side Reactions Taking Place in the Modification Process

Sample	Acid Value	Saponification Value	Anhydride Value	Ester Value	Ester Value Plus Anhydride Value	Decarboxylation	Decrease in Acid Value, %
Abietic acid:							
Unheated	185	—	—	—	—	—	—
Heated	149	166	17	—	—	19	19.5
Methylolated abietic acid:							
Unheated	152	—	—	—	—	—	—
Heated	97.2	118.9	—	—	21.7	—	36
Methylolated abietic acid-sunflower oil mixture[a]:							
Unheated	50.7	—	—	125.1	—	—	—
Heated	10.9	160	—	149.1	—	—	78.5
Abietic acid-sunflower oil mixture[a]:							
Unheated	61.7	—	—	125.1	—	—	—
Heated	52.4	172.2	—	119.6	—	—	15.2

(a) One part of methylolated abietic acid (or abietic acid) and two parts of oil, by weight, were mixed.

[hydroxyl groups of partial glycerides]/[carboxyl groups of methylolated abietic acid], mol/mol, was changed according to the hydroxyl value of glycerides mixture. However, at least 45% excess of hydroxyl groups was present in the reaction medium. When the mixture was completely melted, 0.1% of $Ca(OH)_2$, based on partial glycerides, was added as a catalyst. The temperature was then raised to 275°C and kept constant for 30 min. After cooling, the contents of the flask were mixed with diethyl ether, washed with water, and dried over Na_2SO_4. Acid and hydroxyl values of the solvent-free and dry product were determined. These intermediates containing free hydroxyl groups will be referred to as MAA-PG hereafter. In the next step, the remaining hydroxyls of MAA-PG were allowed to react with the equivalent amount of TDI under moisture free conditions. For this purpose, MAA-PG was dissolved in dry xylene and heated to 40-50°C. At this temperature, TDI was added in a dropwise manner during a 30 min period after the 0.02% of lead naphthenate (24%), based on MAA-PG, was added. When the TDI addition was completed, the temperature was raised to 90-95°C. The reaction was continued at this temperature for six hours. Free isocyanate content of the product was determined by a wet method using n-butylamine.[12]

Preparation of the Comparative Samples

Three kinds of comparative samples were prepared. In order to obtain the first two control samples, abietic acid and TDI were separately reacted with the partial glycerides of each oil. In the former case, partial glycerides and abietic acid, in equivalent amounts, were heated for 45 min under the same conditions as those applied to the reaction between methylolated abietic acid and partial glycerides. These products will be assigned as AA-PG. In the latter case, the obtained products are the well known urethane oils and were prepared by applying the ingredients' ratios given by Stanton.[13] Thus, 75 g of oil, 6.5 g of glycerol, and 0.2 g of calcium naphthenate (4%) were added to the reaction flask and heated to 250°C under a nitrogen atmosphere. Heating was continued at 250°C for two hours to complete the transesterification. After cooling, dry xylene was added, the contents were reheated to 40-50°C, and 18.5 g of TDI were added slowly over a 30 min period. Lead naphthenate (24%) was added in the amount of 0.02% of the oil portion. The temperature was set at 90-95°C, and the reaction was continued for another four hours in order to obtain the final product. The free isocyanate content of the product was determined.[12]

The third comparative sample was prepared by cooking the ester gum with linseed oil. Ester gum was obtained according to a previous procedure.[14] For this purpose, 100 g of rosin was heated under the inert gas flow. After it was melted, 10.2 g of glycerol was added slowly with agitation. The temperature was raised to 275°C and held constant for five hours. Then, by applying vacuum, traces of water and glycerol were removed. At the second step, 100 g of ester gum thus obtained was heated with 160 g of bodied linseed oil (21.7 cP, 25°C) at 290°C for 5½ hr.[15] The acid value and viscosity of the resulting product were determined. This sample is denoted as LO-EG.

Investigation of Side Reactions Taking Place During the Manufacture of MAA-PG and AA-PG

In parallel experiments, abietic acid and methylolated abietic acid were heated separately at 275°C for 30 min under the inert gas flow. In addition, the abietic acid-sunflower oil mixture and the methylolated abietic acid-sunflower oil mixture were subjected to the same heating process. Acid and saponification values were determined for each sample before and after the heat treatment.[11] Anhydride value, decarboxylation (in unit of saponification value), and ester value were calculated by means of acid and saponification values.

Determination of Film Properties

Film properties such as drying time,[16] flexibility,[17] adhesion,[18] water resistance,[19] alkali resistance,[19] and acid resistance[19] were determined. For this purpose, each

Table 3—Some Properties of Partial Glycerides Mixture Used in the Preparation of MAA-PG Intermediates and AA-PGs

Origin of the Partial Glycerides Mixture	Acid Value	Hydroxyl Value
Sunflower seed oil	2.6	110
Tobacco seed oil	2.1	120
Poppy seed oil	1.2	135
Linseed oil	2.0	125

Table 4—Properties of the MAA-PG Intermediates and Their Corresponding TDI-Modified Products

Origin of Partial Glycerides Mixture Used in the Modification	MAA-PG Intermediate		Reaction Product of MAA-PG with TDI		
	Acid Value	Hydroxyl Value	Acid Value	Free TDI,[a] %	Viscosity,[b] cP (25°C)
Sunflower seed oil	3.7	58	3.1	0.75	104
Tobacco seed oil	6.2	63	4.8	0.97	107
Poppy seed oil	3.7	88	2.8	0.87	1425
Linseed oil	5.8	89.8	4.4	0.93	1556

(a) Reference (12).
(b) Samples were thinned with xylene to 50% solid content.

Table 5—Some Properties of the Control Samples Prepared in the Study

Oil Specimen	AA-PG Sample		Urethane Oil		LO-EG Sample	
	Acid Value	Viscosity,[a] cP (25°C)	Free TDI,[b] %	Viscosity,[a] cP (25°C)	Acid Value	Viscosity,[a] cP (25°C)
Sunflower seed oil	17.7	5.3	0.62	17.9	—	—
Tobacco seed oil	14.1	5.5	0.56	14.5	—	—
Poppy seed oil	20.0	5.6	0.57	13.4	—	—
Linseed oil	18.0	6.4	0.53	19.47	3.2	24.2

(a) Samples were diluted with xylene to 50% solid content.
(b) Reference (12).

sample was thinned with xylene to 60% solid content. 0.5% lead naphthenate and 0.05% cobalt naphthenate, as metal based on solid content, were added to the linseed oil-based samples. Double the amount of drier was added to other samples. Driers were added 24 hr before the film application. In drying time determinations, a Bird film applicator with 40 μ aperture was used for film application on glass plate; dry film thickness being 17 μ. For the other tests, a dipping method was used. In this case, the average dry film thickness was 20 μ. For the flexibility, adhesion, and water resistance tests, tin-plate panels were used as the substrate, while glass tubes were used for the alkali and acid resistance tests, as explained in the related standard methods. A water resistance test was performed 48 hr after the film application. However, this period was 72 hr for other tests.

RESULTS AND DISCUSSION

Acid values of methylolated abietic acid and abietic acid prepared in this study were found to be 152 and 185, respectively. The molecular weights calculated by using these values are 369.08 and 303.24 for methylolated abietic acid and abietic acid, respectively. The difference between the molecular weights indicates that the average number of $-CH_2OH$ group attached per abietic acid molecule is 2.12.

As mentioned, the main reactions taking place during the modification of oils with methylolated abietic acid and TDI are given in *Figures* 1 and 2. However, it is reported in the literature that abietic acid is remarkably labile at temperature above its melting point and the effect of temperature on the abietic acid is of obvious importance in technical operation, where acid function of abietic acid is of primary interest.[20] By taking this fact into account, the extent to which the other reactions take place was investigated and the obtained results are shown in *Table* 2.

Since the saponification value measures the total acidity, including potential acid derivatives (e.g., anhydride), the change in this value is a reliable index of degree of

Table 6—Film Properties of the Comparative Samples Prepared in the Study

Applied Test	Urethane Oil Based on:				AA-PG Sample Based on:				LO-EG Sample Based on Linseed Oil
	Sunflower Oil	Tobacco Seed Oil	Poppy Seed Oil	Linseed Oil	Sunflower Oil	Tobacco Seed Oil	Poppy Seed Oil	Linseed Oil	
Drying time[a] (set-to-touch)	30 m	30 m	30 m	30 m	223 m	337 m	486 m	190 m	30 m
Adhesion	3B	4B-3B	2B	3B	4B	5B	2B	3B	5B
Flexibility (cylinder with 2 mm diameter)	p	p	p	p	p	p	p	p	p[b]
Water resistance	nc	nc	nc	nc	120 m	130 m	135 m	130 m	31 m
Alkali resistance[c]	pr: 380 m	pr: 330 m	pr: 285 m	pr: 390 m	pr: 46 m	pr: 65 m	pr: 66 m	pr: 116 m	pr: 25 m
Acid resistance[d]	nc	nc	nc	nc	nc	nc	nc	nc	nc

(a) Test was carried out at 25°C and 60% relative humidity.
(b) Test was positive when the cylinder with 10 mm diameter was used.
(c) Test was carried out at 25°C and 5% NaOH solution.
(d) Test was carried out at 25°C and 9% H_2SO_4 solution.
Legends: m—minute; p—positive; nc—no change; and pr—partial removal.

Table 7—Film Properties of the Samples Modified with Methylolated Abietic Acid and TDI

	Methylolated Abietic Acid-TDI Modified Product Based on:			
Applied Test	**Sunflower Oil**	**Tobacco Seed Oil**	**Poppy Seed Oil**	**Linseed Oil**
Drying time[a] (set-to-touch)	21 m	11 m	6 m	3 m
Adhesion	5B	5B	5B	5B
Flexibility (cylinder with 2 mm diameter)	p	p	p	p
Water resistance	110 m	95 m	80 m	80 m
Alkali resistance[b]	pr:400 m	pr:1000 m	pr:2500 m	pr: 3500 m
Acid resistance[c]	nc	nc	nc	nc

(a) Test was carried out at 25°C and 60% relative humidity.
(b) Test was carried out at 25°C and 5% NaOH solution.
(c) Test was carried out at 25°C and 9% H_2SO_4 solution.
Legends: m—minute; p—positive; nc—no change; and pr—partial removal.

destruction of the acid function. Additionally, for a monocarboxylic acid such as abietic acid, the most probable explanation of a thermally induced difference between acid and saponification values is the anhydride formation.[20,21] Therefore, the anhydride value given in *Table* 2 was calculated by subtracting the acid value from the saponification value.

It can be seen from *Table* 2 that abietic acid underwent anhydride formation and decarboxylation during the heating process as was observed by LaLanda.[20] Methylolated abietic acid also lost its acidic function. This behavior may be due to the anhydride formation, decarboxylation, and the esterification reaction between methylolated abietic acid molecules. In this case, the degree of decarboxylation occurred to a greater extent as compared to the case of abietic acid. The sum of ester and anhydride values for the heated methylolated abietic acid sample was found to be 21.7. This illustrates that esterification between methylolated abietic acid molecules, if any, is minor. Consequently, most of the carboxyl groups of methylolated abietic acid are esterified with the hydroxyls of the partial glycerides.

The greatest decrease in acid value was observed in the heat treatment of the methylolated abietic acid-sunflower oil mixture. This reveals that carboxyl groups are readily esterified with the hydroxyl groups formed on the triglyceride molecules, due to transesterification between triglyceride and methylolated abietic acid molecules. The smaller decrease in acid value in the heat treatment of abietic acid-sunflower oil mixture confirms this observation. Consequently, it is clear that transesterification occurs during the esterification of methylolated abietic acid with partial glycerides as well.

Acid and hydroxyl values of the glycerolysates used in the preparation of MAA-PGs and AA-PGs are given in *Table* 3. As can be seen, exactly the same hydroxyl value could not be obtained for all glycerolysates even under the same reaction conditions. Some properties of the MAA-PG intermediates, as well as of their reaction products with TDI, which are the main products of this study, are given in *Table* 4. As shown in this table, the reaction of TDI with the free hydroxyl groups of MAA-PG essentially reached completion.

Table 5 presents some properties of the comparative samples. Free isocyanate contents of the urethane oils are as low as 0.5%. The acid values of the AA-PG samples are in acceptable magnitude.

The applied tests for determining the film properties and the obtained results are given in *Tables* 6 and 7, respectively, for the comparative samples and the methylolated abietic acid-TDI modified products. As can be seen, the samples modified with methylolated abietic acid and TDI show even better drying properties, alkali resistance, and adhesion than do the samples of classic urethane oils. The structurally hindered nature of the rosin acid carboxyl group is reported to be responsible for the unusual resistance of the ester linkage to cleavage by water, alkali, and acids.[1] It is quite likely that the previously mentioned hindrance becomes more effective after increasing the functionality of abietic acid via inserting methylol groups in the molecule.

SUMMARY

Gum rosin is a natural product obtained from the exudation of pine trees. This natural product is largely used in the manufacture of paints and varnishes due to its low cost. However, when rosin is used directly, it lacks the properties which are expected from a surface coating material, such as resistance to water, acid, and alkali. Therefore, rosin needs to be upgraded in a number of ways. In this study, methylolated abietic acid was used together with toluene diisocyanate in the modification of some triglyceride oils such as poppy seed oil, tobacco seed oil, sunflower oil, and linseed oil. Methylolated abietic acid was prepared through the reaction of abietic acid with paraformaldehyde. In the modification process, the preformed partial glycerides mixture of each oil was initially reacted partly with methylolated abietic acid, and the remaining hydroxyl groups were combined with toluene diisocyanate. Additionally, the partial glycerides mixture of each oil was subjected to the reaction with only toluene diisocyanate and only abietic acid, respectively. The obtained products were used as control samples in comparison of the film properties. The film properties showed that methylolated abietic acid could be used together with toluene diisocyanate as a modifier for the binders based on drying and semi-drying oils.

ACKNOWLEDGMENT

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REVIEW PAPER

New Horizons in Coatings Technology: 1990

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The worldwide coatings sales in 1990 exceeded $55 billion. U.S. coatings firms accounted for almost 40% of this market which was divided almost equally between architectural and product finishes. The U.S. tonnage of powder coatings increased to over 65,000 tons with a dollar volume of $13.5 million. Sherwin-Williams continues to be the dominant paint producer in the U.S. The worldwide trend towards the increased use of waterborne coatings continues and trends toward reduced volume of solvents is being enhanced by the use of blends of carbon dioxide and organic solvents.

INTRODUCTION

This is an update of annual reviews on coatings technology previously published in the JOURNAL OF COATINGS TECHNOLOGY.[1] In spite of the introduction of many materials of construction that do not require a protective or decorative coating, the sales of paint and related products continue to increase.[2] The worldwide dollar volume of coatings produced in 1990 was approximately $35 billion and was distributed (in billions of dollars) in the various regions as follows:

North America	$13.5
Western Europe	11.5
Japan	4.5
Other Areas	5.5

Coating sales in the U.S. (in millions of dollars) in 1990 were distributed as follows:

Architectural	$ 4,990
Product Finishes	4,666
Special Purpose Coatings	2,680
Miscellaneous Products	1,100
Total	$13,436

According to Reich,[3] the total sales of coatings in the U.S. in 1989 was $12.6 billion, for a total volume of 1.04 billion gallons (3.9 billion liters) and a percentage distribution as follows:

Architectural	51%
Product Finishes	33%
Special Purpose Coatings	16%

The total sales of adhesives and sealants in the U.S. in 1987 was $4.7 billion. According to Frost and Sullivan, the 1990 sales volume of structural adhesives was $714 million; and this volume should increase to $824 million in 1994. Guidice reports the 1990 adhesive and sealant sales as $42.5 billion.[4] Chemark, of Cincinnati, predicts the 1991 and 1994 sales of sealants to be $1.17 billion and $1.6 billion, respectively. IAL Consultants, of London, predicts an annual production of 200,000 tons of sealants in France, Germany, and the UK.[5]

Frost and Sullivan report the annual U.S. sales volume of powder coatings as 50,000 tons and 70,000 tons, respectively, in 1987 and 1992.[6] According to Bodner,[7] 8,500 tons of powder coatings were consumed in Western Europe in 1988 with the following distribution:

Germany	2,900 tons
UK	2,500 tons
Italy	2,400 tons
France	900 tons

Morris[8] reports sales (in millions of dollars) of powder coatings throughout the world as follows:

North America	$13.5
Western Europe	11.5
Japan	4.5
Other	5.5

The annual production of coatings in Eastern European countries in 1988 in thousands of tons was, as follows:

East Germany	416
Poland	404
Czechoslovakia	208

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Romania	178
Bulgaria	151
Hungary	139

In East Asia in 1988, 4,550 tons of UV curable coatings were used as follows:

Japan	3,000 tons
Taiwan	1,000 tons
Korea	500 tons
China	50 tons

The consumption of paints and coatings (in kg) per capita in 1989 in Asian countries was as follows:[9]

Singapore	19.4 kg
Japan	18.0
Taiwan	13.0
United Arab Emerite	12.8
Bahrain	11.2
Israel	10.0

As shown by the data in the following table, Sherwin-Williams, with annual sales of $2 billion, continues to be the major producer of coatings in the U.S.:

Producer	**Sales ($ millions, 1989)**
Sherwin-Williams	$2,123
Valspar	527
Grow Group	411
RPM-Ohio	396
Standard Brands	315
Lilly Industrial Coatings	212
Guardsman	150

In the chloride process for the production of white pigment, liquid titanium-tetrachloride is produced in a fluidized bed chlorinator in the presence of coke at 800-900°C and oxidized at 1000°C.[10] The annual production, in millions of tons, and their percentage share of the market by the major producers of titanium dioxide, is shown in the following table:

Du Pont	500	20.0%
Tioxide	450	8.0%
SCM	391	15.6%
NL	317	12.7%
Total	1,658	

The percent of titanium dioxide consumed in the principal end product use of titanium dioxide in paints in the U.S. and the UK is as follows:

	U.S.	UK
Paints	52%	60%
Paper	24%	13%
Plastics	14%	15%
Rubber/Ceramics	7%	9.5%

The history of artist pigments has been published.[11]

The resin consumption, in thousands of tons, in 1990 is shown in the following table.[12]

Acrylics	96
Epoxies	75
EVA	116
HDPE	99
LDPE	677
LLDPE	83
Polypropylene	16
Aliphatic Polyesters	9
Aromatic Polyesters	5
PVC	11
UF/MF	41

As a result of licensing oxidation technology from Flecher-Challenge (Auckland, New Zealand), Sherwin-Williams restarted its titanium dioxide production program.

As shown by the following table, many mergers of coatings firms have occurred during the last few years.[13–17]

Acquired Firm	**Purchaser**	**Annual Sales ($ millions)**	**Purchase Price ($ millions)**
Bostik	Orkem	285	185
Krylon	Sherwin-Williams	105	150
Olympic (Lucite)	PPG	110	130
Spencer-Kellogg	Dainippon	—	86
Koppers	RPM	—	56
Crown-Metro Aerospace	Dexter	—	23
Aurolin	BASF	—	22
DeSoto (architectural)	Sherwin-Williams	175	80
PKC	Courtaulds	—	—
Usiloy	Loctite	—	456
Anchor Continental	Lincoln Group	—	70
Mead Release	Rexlon	—	38
DeSoto (coatings operation)	Courtaulds	122	135
Krylon (aerosol)	Borden	—	150
Krylon (car colors)	Blue coral	—	—
Reliance Universal	AKZO	—	—
Whittaker (coatings)	Morton	180	225
DeSoto (latex/resin plant)	Rohm and Haas	—	—

Unocal plans to invest $50 million in a plant which will produce 82,000 tons of PVAC emulsions annually. Lakokraska, an association which controls 60% of the coatings business in the USSR, is producing 2.2 million tons of varnish and 400,000 tons of pigments annually.[18]

Over 400 delegates attended the 18th Annual Waterborne, Higher-Solids and Powder Coatings Symposium, sponsored by the University of Southern Mississippi and the Southern Society for Coatings Technology, in New Orleans, LA, on February 6-8, 1991.[19] Several new books on coatings technology were published in 1990-1991.[20–23] The 1990 Mattiello Memorial Lecture was presented by Dr. Henry J. Leidheiser, former Director of the Center for Surface and Coatings Research, Lehigh University.

Tilak has reviewed progress in higher-solids coatings formulations.[24] Waterborne coatings with a clear urethane topcoat are being used for automobile exteriors.[25] New information has been provided on water-based coatings and atomization application processes,[26] waterborne paper coatings,[27] and conductive coatings.[28] Simple tests for emulsion coatings are available[29] and a new dispersion mill has been described.[30] Ketone and ester solvents accounted for 25%, aromatics (benzene, toluene, and xylene) accounted for 31%, aliphatic hydrocarbons accounted for 21%, and alcohols accounted for 12% of the 1.97 million tons of solvents used for coatings in the U.S. in 1989.[31]

The $300 million U.S. powder coatings market is expected to increase by about 10% annually through 1995.[32] North American powder coating sales, which in 1989 were 48,000 tons, are expected to reach 90,000 tons in 1995. In 1989, Western European powder sales were

130,000 tons. New multicrosslinking systems are being used for curing acrylic and polyester powder coatings.[33] UCB Chemicals is producing UV curable resins for powder coatings.[34]

Bitumen-polymer blends[35] and heavy duty powder coatings[36] are being used in construction. Copolymers of tert-butylstyrene are being used in powder coatings and carboxy polyethylene/triglyceryl diisocyanate blends are being used for outdoor architectural coatings.[37]

Specialty resins are being applied to surfaces via powder coatings techniques,[38] and these and photo resins are used in printing inks.[39,40] Thermosetting acrylic resins are being used as powder coatings.[41] New information is available on quality control and powder coatings.[42,43] The flow of powder resins has been improved.[44]

New antifouling paints have been evaluated[45] and thus, more environmentally friendly marine paints have been developed.[46,47] The use of pigments in wax crayons has been discussed.[48] New pigments are available,[49] the use of carbon black as a pigment has been discussed,[50] and new heterocyclic compounds such as, 1,4-diketopyrrollo 3,4-pyrrole (DPP)[51] are available. New information is available on printing ink formulations,[52] zirconium salts as driers,[52] electrodeposition of phenolic resins,[53] and phenolic emulsions.[54] The surface tension reduction and compatibility of silicones and other flow agents has been correlated with their efficiency.[55] Data on the glass transition temperature (T_g), obtained by DSC, have been used to monitor the cure of epoxy resin coatings systems.[56]

New information is available on UV stabilizers,[57,58] radiation curable coatings,[59] IR spectrographic analysis of coatings,[60] and coalescent agents.[61,62] HALS, in the presence of UV absorbers, does not react with acid catalysts.[63]

Adhesion of coatings on polypropylene has been improved by using chlorinated polyethylene as a primer and by treating the surface with flame or plasma.[64] Mono- and multi-layered extrusion coatings and improved extruders have been described.[65,66] Battelle Institute is producing thin films with uniform pores by evaporation of acetone solvent from polymethyl acrylate film in outer space.[67] The rheology and coatings program established by Dr. R. Myers at Kent State University in 1965 has been expanded and improved.[68] The data on accelerated aging of coatings has been correlated.[69]

In an attempt to protect the environment from graffiti, the Chicago, IL, City Council has banned the sale of spray paint. The use of aqueous dispersions of laminating films on paper[70] and the use of latex with low volatile organic content (VOC) has also reduced environmental damage from coatings applications.[71] The American Society for Testing Materials (ASTM) has published a manual with VOC specifications. The ultimate aim of California's Air Products Management plan, that is, zero emissions by the year 2007, includes the elimination of reactive organic gas (ROG).[72]

CPVC determined via scratch hardness, adhesion, and gloss of electrodeposited films is comparable to CPVC values determined by chemical methods.[73] Tests for assessing the encapsulation of asbestos insulation products have been developed.[74] Ethylene glycol dialkylether aprotic solvents, which are alleged to have teratogenic potential, are being replaced by diethers based on propylene glycol (Proglyde DMM).[75] New ISO standards on coatings have been published.[76]

A uniform thin coating (Diamonex), with a controlled refractive index of 1.8-2.4, has been formed by bombarding surfaces with carbon ions from an accelerated ion gun. Monsanto has joined with Diamonex in an attempt to commercialize these coatings which are based on a "spin off" from Air Products. Oxygen transmission of PET bottles has been reduced by coating with a thin layer of glass.[77]

Dow has licensed "know how" on acrylic latex from ICAP (Milan) in order to play a part in the 700,000 ton world market. The annual U.S. market is 395,000 tons, based on solids in the emulsions. Rohm and Haas, BASF, and Hoechst are the leading producers of acrylic latex. Freedonia estimates that 4.7 million tons of this product, valued at $5.7 million, will be produced in 1993. Bisphenol A epoxy acrylate oligomer is used in radiation cured coatings.[78] Poly 2-ethylhexyl acrylate is being used as a plasticizer and toughening agent for coatings.

Modified alkyds are being produced from Hawaiian seed oil.[80] Since many commercial styrenated alkyds are actually blends of polystyrene and alkyds, procedures have been developed for the development of graft copolymers of alkyds and styrene or p-methyl styrene.[81,82] New information on alkyds and polyesters has been published.[83–85] Information on the use of tall oil in printing inks,[86] on the copolymerization of drying oils with vinyl monomers,[87] and ethyl acid maleate copolymers[88] has been supplied. Polyamide films produced by the condensation of C-21 dicarboxylic acid and ethylene diamine,[89] solder resistant coatings,[90] and heat resistant polymethylpentene coatings have been investigated.

New information is available on adhesion of epoxy resins,[91] flexiblization of epoxy resins by the addition of phosphate esters,[92] and on elastified epoxy resin systems.[93] New information has been supplied on water-cured polyurethane films,[94] films from blocked isocyanates,[95] and two-packaged polyurethane coatings.[96] Silicone coatings[97] and polytetrafluorethylene cable liners[98] have been evaluated.

The number of articles from the coatings industry, which employs 4% of all chemists, abstracted in *Chemical Abstracts*, has decreased from 8% in 1979 to 5.6% in 1989.[99] The Unicarb system, in which 80% of organic solvents are replaced by carbon dioxide has been licensed to several coating firms. The annual sales in millions of dollars for the leading U.S. paint and coating producers in 1990 were as follows:[100]

Sherwin-Williams	$2,267
Valspar	531
RPM-Ohio	439
Grow Group	412
Standard Brands	298
Lilly-Industrial Coatings	232
Guardsman	193
Total	$4,462

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Society Meetings

LOS ANGELES .... JUNE

Outstanding Service Awards

Philip C. Bremenstuhl, of Ashland Chemical Company, has been elected to the position of Society Secretary for the 1991-92 year.

Outstanding Service Awards were presented by Awards Chairman Melinda Rutledge, of Rheox, Inc.

Ms. Rutledge presented one of the Awards to William J. Haar, of Surface Protection Industries, Inc. Mr. Haar, who has served as the Spring Folic Chairman for many years, recently retired.

Also, an Outstanding Service Award was presented to Golden Gate Society member Patricia Shaw, of Davlin Coatings, Inc. Ms. Shaw was honored for having served as Chairman of the Technical Committee while a member of the Los Angeles Society. She is credited with presenting papers during the FSCT Annual Meeting, and setting a format which has enabled the Society Technical Committee to continue to operate on a productive level. Ms. Shaw received her Outstanding Service Award during the May meeting of the Golden Gate Society.

Environmental Affairs Committee Chairman Dave Muggee, of E.T. Horn Company, presented a report on the latest rules and regulations which affect the paint and coatings industry.

Item one was a newly published list (Title 26, Section 22-12000) of chemicals which cause cancer or reproductive toxicity. Mr. Muggee stated that toluene has been listed as a reproductive toxin as of January 1. If toluene is contained in a paint formula, the cans must be labeled appropriately by January 1, 1992.

Also, a new Air Resources Board Appendix A on substances to be inventoried has been made public (AB 2588).

Sara Title III, Section 313 Form R had to be filed by July 1.

The final environmental news item focused on the Accident Prevention Program which has been mandated by Senate Bill 198 (California). According to this new piece of legislation, the Accident Prevention Program had to be in place at all workplaces by July 1.

V.C. Bud Jenkins, *Secretary*

PHILADELPHIA .... MAY

"VOC Regulations And Criminal Exposure"

The slate of Society Officers for the year 1991-92 was introduced to the membership. Following a vote, the newly elected officers for the coming year are: President—Peter C. Kuzma, of VIP Products Corporation; Vice President—William J. Fabiny, of Sermagard Coatings; Secretary—Brian O'Connor, of McWhorter Resins, Inc.; Treasurer—Robert D. Thomas, of M.A. Bruder & Sons, Inc.; Assistant Treasurer—Barrett C. Fisher, of Van Horn, Metz & Company, Inc.; Senior Member-at-Large—Howard J. Salmon, of Clement "Coverall" Company; and Junior Member-at-Large—Thomas Brown, of Consultants Consortium.

Also, Wayne A. Kraus, of Aqualon Company, will continue to serve as the Society Representative to the Federation's Board of Directors.

The meeting's speaker was Alexia Morrison, of Swidler & Berlin, a Washington, D.C.-based law firm. Ms. Morrison's topic was "Environmental Compliance—VOC Regulations and Criminal Exposure for Corporations and Their Executives."

The speaker began her presentation by stating that the government is increasing its activities in criminal pursuit of violations in the environmental arena.

The Clean Air Act passed in 1990 has made VOCs the focal point of today's governmental actions. According to Ms. Morrison, the Justice Department is targeting potential groups of defendants—corporations and individuals—in certain geographic areas that have been identified previously as having environmental problems. The Department is focusing in on specific pollutants, especially in the geographic areas which encompass more than one state.

It was noted that the Justice Department, OSHA, EPA, and the FBI may be working together in the future in pursuit of environmental crimes. Ms. Morrison said that according to Attorney General Dick Thornburgh, 78% of the targeted violators include not only the corporations, but the top executives of these companies. In 1990, 703 defendants were indicted for environmental violations.Of the 703 defendants, 202 were corporations and 481 were individuals. According to the speaker, the advent of the Federal Uniform Sentencing Guidelines adds another dimension to criminal prosecution of environmental violators. She said two-year minimum jail sentences for convictions are now the norm for violators.

The speaker explained the difficulty in keeping up with the ever changing statutes and the volume of regulations. She noted that under the 1990 Clean Air Act, states have been asked to implement a program for issuing permits for the emission of controlled pollutants, and where the states fail to implement the program, the EPA will intervene and take control. According to Ms. Morrison, the permit process requires the signature of a person who will be ultimately responsible, thus certifying that the company will not exceed the levels of emissions of the controlled pollutants. She stated that this person, in effect, is responsible,

LOS ANGELES SOCIETY OFFICERS—Elected to serve on the Board of Directors for 1991-92 are (l-r): Society Representative—Jan P. Van Zelm; Treasurer—V.C. Bud Jenkins; President—James D. Hall; Vice President—Sandra Dickinson; Secretary—Philip C. Bremenstuhl; and Past-President—James F. Calkin

and will be the designated felon should criminal prosecution for violations become necessary.

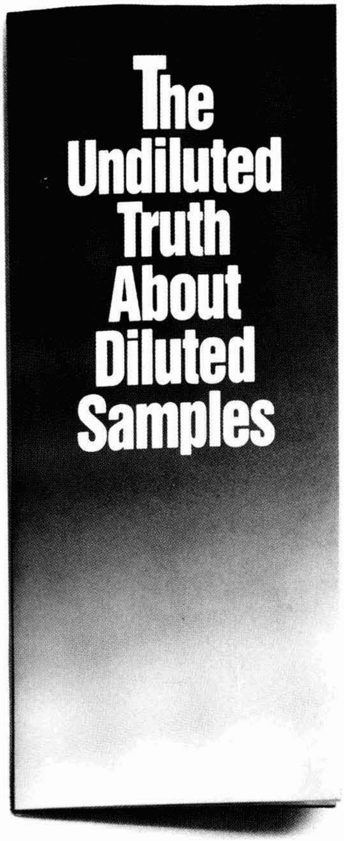
Ms. Morrison said that a person of record on a permit request does not have to know that a violation has been committed to be prosecuted to the fullest extent the law allows.

In conclusion, a thorough environmental audit was recommended as the primary method to assure that a company is in compliance. In addition, Ms. Morrison advised against covering up a violation should one occur.

Q. What is involved in an environmental audit?

A. A consultant in environmental issues or a law firm dealing in environmental litigation or a combination of both can assess your situation. They take into account what your activities are and the nature of your business. Also, they pinpoint the responsible people within an organization, while formulating an audit to best fit your needs. They can then define your liabilities and responsibilities.

WILLIAM J. FABINY, *Secretary*



PIEDMONT .... JUNE

Past-Presidents' Night

The meeting was attended by 18 Society Past-Presidents, including: Donald E. Wiesman (1959-60); William B. Shepard (1962-63), Society Honorary Member; James A. Bohlen (1966-67), Society Honorary Member; Gerard M. Currier (1969-70), of Reliance Universal, Inc.; Gary Marshall (1971-72), of Sadolin Paint Products, Inc.; Earnest L. Broome ((1972-73), of Chemical Coatings, Inc.; William O. Younger (1973-74), of DeSoto, Inc.; Norman O'Bryant (1974-75), of Valspar Corporation; Clifton E. Barton (1975-76), of Megachem, Inc.; James A. Martz (1977-78), of Lilly Company; Charles B. Wilson (1978-79), of Reliance Universal, Inc.; James N. Albright (1981-82), of Lilly Company; Sara M. Robinson (1982-83), of Heucotech Ltd.; James E. Husted (1983-84), of Husted & Associates; Michael S. Davis (1985-86), of Premium Coatings, Inc.; Charles T. Howard (1987-88), of DeSoto, Inc.; Barry F. York (1988-89), of Reliance Universal, Inc.; and Forest G. Fleming (1989-90), of Reliance Universal, Inc.

The former Presidents were honored and recognized for their contributions to the Federation and the Society.

A. Dale Baker, of Kohl Marketing, Inc., was elected to serve as Society Treasurer for the 1991-92 year.

The following individuals were presented with 25-Year Pins and framed certificates celebrating a quarter century membership in the Society: James M. Bohannon, of Valspar Corporation; John Davis, retired; Charles T. Howard; and Terry J. Keel, retired.

Technical Committee Chairman Frank C. Schaffer, of Rohm and Haas Company, announced that the following members have agreed to serve on the Committee: James N. Albright, Michael S. Davis, Forest G. Fleming, Michael Hadnagy, and Sara M. Robinson.

The meeting's technical speaker was Ronald K. Litton, of Eastman Chemical Products, Inc. Mr. Litton gave a presentation on "SOLVENT SELECTION FOR WATER-BASED INDUSTRIAL COATINGS."

The speaker stated the four factors to be taken into consideration when selecting coalescing aids for waterborne coatings include evaporation rate, solubility parameter, how the coalescent partitions in an emulsion system, and stability.

Mr. Litton reviewed the pressure the coatings industry is under from legislative officials at the local, state, and federal levels regarding the reduction of VOC emissions. He stated that the 1990 Clean Air Act gave the EPA the directive to establish 12 new controlled technique guidelines. He said because of new and evolving regulations to meet these guidelines, increasing research and development work is being done in the area of waterborne industrial emulsion coatings.

The speaker emphasized that the polymers used in waterborne industrial emulsions differ from those used for architectural emulsions in that they are harder, have higher technique guidelines, and have a higher pH of 7.5 to 9.5.

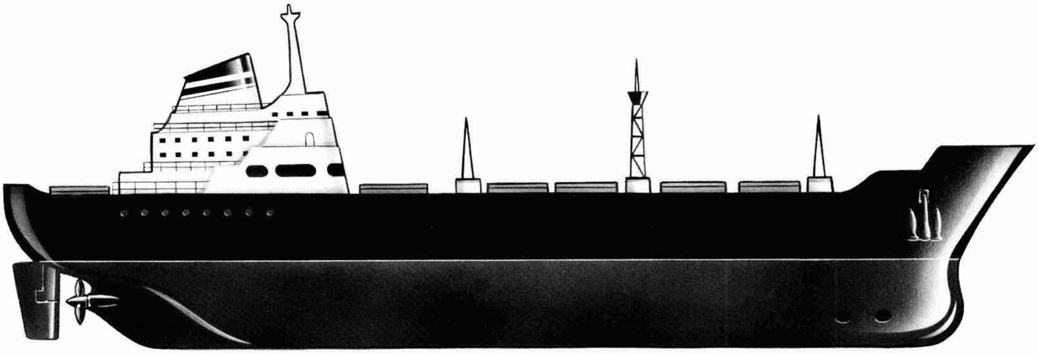
Mr. Litton said the primary function of a coalescing aid is to help emulsions achieve film formation. With waterborne industrial emulsions, the coalescing aid is designed to balance coalescence with property development, including drying speed, hardness development, and chemical resistance. He stated that the most commonly used coalescing aids are glycol ethers.

PAST-PRESIDENTS' NIGHT—Former Society Presidents attending the New York Society May Meeting are (l-r): Seated—Alfred Sarnotosky (1975-76); William Singer (1976-77); Herman Singer (1968-69); Sidney Levinson (1967-68); and Arthur Tracton (1989-90). Standing—Moe Bauman (1958-59); Saul Spindel (1978-79); Herbert Ellis, Jr. (1983-84); Raymond Gangi (1985-86); Theodore Young (1982-83); Michael Iskowitz (1984-85); Marvin Schnall (1980-81); John Burlage (1987-88); Donald Brody (1981-82); George Dippold (1977-78); Irwin Young (1988-89); and Sidney Rubin (1979-80)

The speaker explained the importance of evaporation rate in determining the effectiveness of a coalescing aid, taking into consideration how the evaporation rate varies with humidity. He said the efficiency of a coalescing aid can also be measured through its activity, both by its solubility parameter and how it partitions in the emulsion system. The final factor in determining the effectiveness of a coalescing aid is the stability of the solvent in the system.

In conclusion, Mr. Litton said that with increasing demands for lower VOCs emitted by coatings users and even lower solvent levels in emulsion polymers, the efficiency of these coalescing aids becomes even more important. According to the speaker, the higher the efficiency of the coalescing aid, the lower the amount that has to be used; thus, lower VOCs are obtained.

ANNETTE SAUNDERS, *Secretary*



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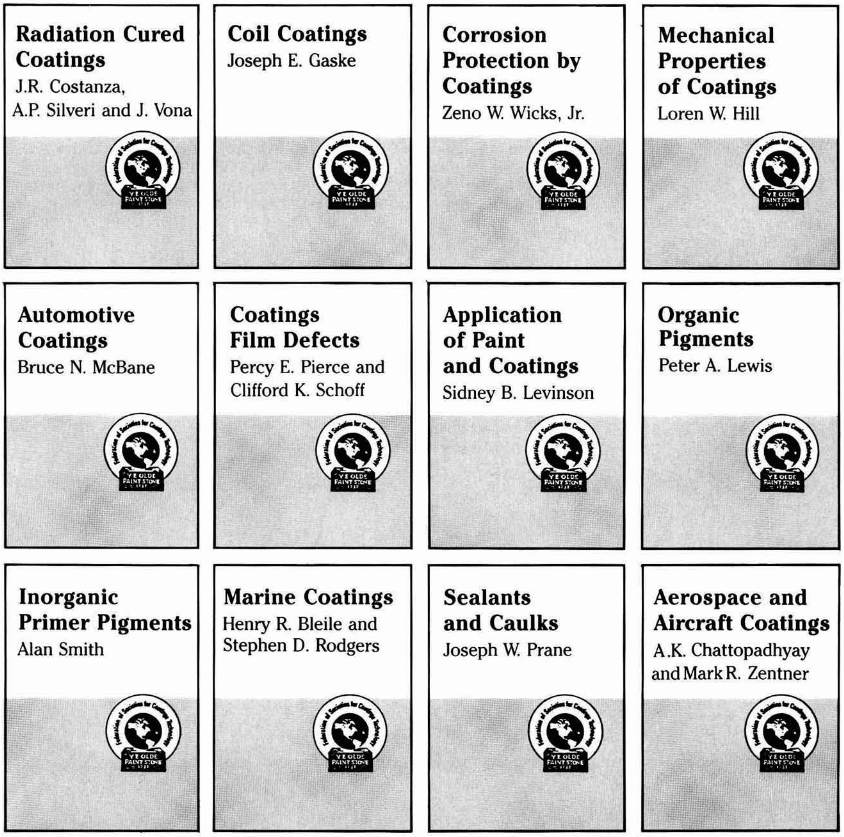

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People

Lilly Industrial Coatings, Inc. has announced that **Dennis Centofante** has joined its corporate staff as Director/Research and Development. In this capacity, Mr. Centofante will be responsible for the corporate research, development, and resin laboratories headquartered in Indianapolis, IN. He comes to Lilly with over 17 years of experience, including technical and managerial achievements in the coatings industry. Mr. Centofante is a member of the Chicago Society.

Pat Wagle has been appointed Technical Director for The Flood Company, Hudson, OH. Mrs. Wagle joined the company in 1982 as a Chemist and Quality Control Technician responsible for formulated products. She later became Assistant to the Technical Director, **Don Davis**, who recently retired from Flood.

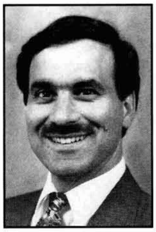
David Woodhead has accepted the promotion of President of the Magnetic Materials Division of The Dexter Corporation, Windsor Locks, CT. He succeeds **David E. Warburton** who recently retired.

Mr. Woodhead joined Dexter through the original Hysol Division in 1966. He most recently served as Group Vice President for the Specialty Plastics & Composites Group. Mr. Woodhead will relocate to the Magnetic Materials Division headquarters in Sunnyvale, CA.

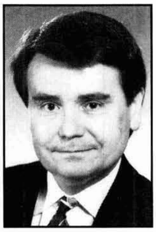
The position of Vice President of Manufacturing of Preservative Paint Company, Seattle, WA, has been filled by **James A. Todd**. He brings over 20 years of experience in the paint and coatings industry to this position. For the past eight years, Mr. Todd had served as Plant Manager at Olympic Stain Company's Seattle facility.

Alan J. Goodman has been appointed to the position of Product Manager/Coatings Business Unit for ANGUS Chemical Company, Northbrook, IL. In this newly created position, Mr. Goodman will be responsible for management of the commercial products of the unit. Prior to joining the company, he held sales and management positions for both American Cyanamid and SCM.

In addition, **Pattabhi Raman** has joined the staff of ANGUS as Manager/Process Chemistry. Before joining the firm, Dr. Raman was a Marketing Coordinator for UOP.


D. Centofante


P. Wagle


T. Downes


P. Foster

Terry Downes has been named President of ACS-Datacolor, Inc., Lawrenceville, NJ. Formerly Executive Vice President of the company, he succeeds **Donald E. Hall** who retired recently. Mr. Downes has served in various management and senior executive positions with the company during the past 18 years.

Unocal Chemicals and Minerals Division, Chemicals Distribution, Schaumburg, IL, has announced the following promotions: **Pamela Swanson**—Branch Sales Manager, Los Angeles, CA; **Dean Bell**—Senior Branch Manager, Charlotte, NC; **Rich Gredler**—Industry Manager, Houston, TX; **Jerry Dunn**—Branch Manager, Nashville, TN; and **David Christian**—Branch Sales Manager, Miami, FL.

Mr. Gredler is a member of the Houston Society and Mr. Dunn is a member of the Southern Society.

Eastman Chemical Company, Kingsport, TN, has announced several appointments within the organization. The changes include: **James J. Barbarito**—Business Manager/Resin Intermediates; **William T. Sade**—Market Manager/Resin Intermediates; **Eric DeLoach**—Business Manager/Coatings Business; **Stephen N. Belote**—Market Manager/Coatings Business; **Matt J. Russ**—Manager/Inks and Pigments; and **David S. Oaks**—Market Manager/Inks and Pigments.

In addition, the following personnel moves were effected: **Francois Vleugels**—Market Manager/Europe, Middle East, and Africa; **Larry A. Munsey**—Manager/Business Development, Coatings, Inks, and Resins; **Stanley W. Polichnowski**—Manager of Technology; and **James T. Wallin**—Manager of Administration.

The naming of **Paula Foster** as Manager/Atlanta Division has been announced by Ribelin Sales, Inc., Dallas, TX. Ms. Foster was employed by Wattyl Paint Corporation (formerly Precision Paint Corporation) as Purchasing Manager for 15 years before joining Ribelin.

The American Filtration Society, Kingwood, TX, has appointed **Bob Baumann** as Technical Editor for the society's papers, proceedings, and *Fluid-Particle Separation Journal*. Mr. Baumann will be responsible for technical contributions to the society journal including correspondence with authors, coordination of activities of members of the editorial board, and development of an appropriate review process.

Philadelphia Society member **Carl Fuller**, and his wife Margaret, have returned from Buenos Aires, Argentina where Mr. Fuller served as a volunteer with the International Executive Service Corps (IESC).

Mr. Fuller, a Chemist, was recruited by IESC to assist a chemical products manufacturer with improving quality and production of synthetic red iron oxide pigments. This was his fifth project for the IESC.

IESC is a not-for-profit organization of American business men and women devoted to providing managerial and technical assistance to private enterprises in developing countries. Since 1965, IESC has completed more than 13,000 projects in 95 countries.

FATIPEC Names Max Raaff Its President

The Federation of Associations of Technicians in the Paint, Varnish, Lazquer, and Printing Ink Industries of Continental Europe (FATIPEC) has elected **Max H.L. Raaff** President.

Born in 1934 in Bandung, Indonesia, Mr. Raaff studied mechanical and chemical engineering at the HTS, Dordrecht in Holland. He obtained a Degree in Chemical Engineering in 1958. Mr. Raaff joined the Shell Nederland Company in 1960 where he was responsible for the technical service industrial application of asphaltic bitumen. From 1962 to 1966, he was employed by Neville Cindu Chemie Uithoorn as a Technical Service Engineer for Western Europe in application fields for coumarone-indene and petroleum resins.

Mr. Raaff joined the Board of NVVT in 1974, and in 1975 he became Treasurer to assist the organization of the 15th FATIPEC Congress in Amsterdam in 1980. In May 1987, Mr. Raaff was elected to succeed **Herman de Vries** as the Chairman of NVVT.

In other FATIPEC news, **Francis Borel** has become the General Secretary of FATIPEC succeeding Christian Bougery, who held the post for 40 years.

Mr. Borel was born in 1939 in Paris, France. After studies and obtaining a Degree at the Chemistry School of Paris, he served in the nuclear division of the army.

After a short period in the paint field at Pechiney and Kuhlmann Companies, Mr. Borel joined the Borelac Company where he served as Technical Director and Manager. In 1972, he joined Ravaud & Mouscadet, responsible for raw materials of paints and varnishes. Mr. Borel then joined Byk-Chemie Company where he was Manager for a French subsidiary, specializing in paint additives.

Mr. Borel has been the General Secretary of the AFTPV from 1972 to 1988, and he served as President of AFTPV from 1988 to 1990.

His father, **Jean Borel**, was the President of the First International Paint Congress, which lead to the creation of FATIPEC in 1947.

Xavier l'Angevin has been named Corporate Chief Engineer of OMYA, Inc., Paris, France. Mr. l'Angevin will spearhead the technical research and development for all new and existing CACo$_3$ operations in North America and the Pacific Rim.

In addition, **Vincent E. Sadowski** has assumed the role of Plant Manager for the company's ground calcium carbonate manufacturing facility in Florence, VT, the position vacated by Mr. l'Angevin. Mr. Sadowski's responsibilities include all aspects of the production, packaging, and shipping of slurry and dry products for the paper, paint, and plastics industries.

Rohm Tech, Inc., Fitchburg, MA, has appointed **John T. Kolackovsky** to the position of Business Manager/Polymers Division. Mr. Kolackovsky most recently served as Manufacturing Manager and brings over 20 years of experience as an engineer in the chemical industry to this position.

The promotion of **Michael A. Curtis** to Product Manager/Quaternary and Related Biocides for the Performance Chemicals Group at Lonza Inc., Fair Lawn, NJ, has been announced. Since joining the company in 1989, Mr. Curtis has held the position of Account Manager for Lonza's Western Region.

ARCO Chemical Company, Newtown Square, PA, has announced the election of **Jack E. Oppasser** and **Marie L. Knowles** to its Board of Directors.

Mr. Oppasser currently serves as a Senior Vice President and President, ARCO Chemical Europe, Inc. He has been with ARCO Chemical and other ARCO companies for more than 27 years and has held a number of positions in human resources, business management, and marketing.

Mrs. Knowles, Vice President and Controller for ARCO, joined the company in 1972. Since that time, she has held various positions which include: Manager of Corporate Planning; Assistant Treasurer; and Vice President of Finance, Control, and Planning for ARCO International Oil and Gas Company.

Phil Pulley has accepted the position of General Manager for Croda Inks Corporation's Memphis, TN, plant. Prior to this assignment, Mr. Pulley was the Technical Manager/Fluid Inks with the company's Atlanta, GA, facility.

In addition, Croda has named **Thomas J. Socha** Assistant General Manager for the company's Lockland, OH, plant. Mr. Socha brings to this position extensive experience in quality control in addition to assisting in a variety of management functions.

Croda Inks Corporation is headquartered in Niles, IL.

Robert L. Pettibone has accepted the position of National Sales Manager for the industrial products segment of Goodyear's newly-created Engineered Products Division, Akron, OH. Mr. Pettibone joined Goodyear in 1967 as a Sales Trainee in the company's Industrial Products Division.

In addition, **Joseph Lappan**, previously Field Sales Engineer for Roofing Products, has been named Field Sales Manager for the Product Group, which is part of the Engineered Products Division. He has been with the company since 1985.

David B. Church, General Manager/Silicas for PPG Industries, Pittsburgh, PA, has been assigned additional duties in the company's Chemicals Group. He will be adding the management of the company's Teslin microporous polyolefin film to his responsibilities. Mr. Church joined PPG at its Barberton, OH, chemical plant in 1965 as an Operations Engineer.

William H. Joyce, of Union Carbide, has been elected to a one-year term as Chairman of The Society of the Plastics Industry, Inc. (SPI), Washington, D.C. Mr. Joyce succeeds outgoing Chairman **Lee Shobe**, of Dow Brands, Inc.

Ripley W. Gage, of Gage Industries, Inc., was elected to a second one-year term as Vice Chairman of the Board. **Richard T. Studer**, of HPM Corporation, also was elected to a second one-year term as the Board's Secretary. **R. Bruce Ray**, of Ray Products, Inc., was elected to a one-year term as Treasurer.

In addition, 23 new Directors will serve on the SPI Board. They include: **Edward J. Abrams**, of Hardman, Inc.; **Nigel D.T. Andrews**, of GE Plastics Americas, General Electric Company; **Robert A. Buzzard**, of All American Enterprises, Inc.; **Anthony J. Carbone**, of Dow Plastics, Dow U.S.A.; **Alan B. Coxhead**, of Novacor Chemicals, Inc.; **Charles W. Eha**, of The Charles W. Eha Company; **James D. Frankland**, of New Castle Industries, Inc.; **Deborah Hauser**, of Novacor Chemicals, Inc.; **Fred E. Heine**, of Acromark, Inc.; **Richard Hess**, of Borden, Inc.; **John Kretzschmar**, of Blako Industries, Inc.; **Roger Lewis**, of Witco Corporation; **Richard Luciano**, of Ashland Chemical Company; **John Manning**, of Crane/VIPCO; **Ray McGowan**, of Mobil Chemical Company; **William G. Pryor**, of Van Dorn Company; **John L. Russ**, of Borden Chemicals and Plastics; **Rand N. Shulman**, of Shell Chemical Company; **Robert Styer**, of Creative Forming; **Henry W. Sullivan**, of Huntsman Chemical Corporation; **Harley H. Thomas**, of Vinyl Plastics, Inc.; **Ron Underwood**, of Poly Pipe Industries, Inc.; and **Robert Valle**, of American National Can Company.

Thomas Kelly Bitar has been appointed Manager of Publication Services for the Instrument Society of America (ISA), Research Triangle Park, NC. Mr. Bitar was promoted from Administrator to fill the post vacated by **Sally Walter** when she was made Director of the newly created Customer Services Department.

Quentin S. Clark, Jr. has been named Director of Standard and Technical Services for ISA. Mr. Clark will oversee ISA's staff support for standards development and other technical activities, and will provide technical counsel to the society staff and general membership.

The positions of Midwestern Sales Representative and Northeastern Sales Representative for ISA have been filled by **Jill A. Borrow** and **Robert C. Johnson**, respectively. Ms. Borrow will be based in Chicago, IL, and Mr. Johnson will work out of Wilton, CT.

Dumond Chemicals, Inc., New York, NY, has appointed **John Steinhauser** Sales Manager/Steel Structures Division. Mr. Steinhauser's responsibilities will focus on marketing and technical support for large steel-structure applications, including water tanks, petroleum tanks, and bridges. He brings many years of experience in the surface preparation field to his new position.

William C. Merz has been named Vice President and General Manager of Ashland Chemical Inc.'s FRP Supply Division, Columbus, OH. Mr. Merz joined Ashland in 1989 as Western Regional Manager of FRP Supply. He is a veteran of the fiber reinforced plastics industry and has served in various managerial positions with Koppers Corporation, Omni Fiberglass, and Owens Corning Fiberglas.

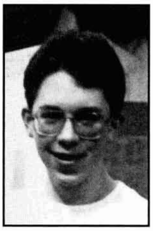
Also, the position of Vice President/Research and Development at Ashland Chemical has been filled by **Donald S. Mueller**. In this capacity, Mr. Mueller will be responsible for directing the company's research and development activities, which support product development efforts for Ashland's specialty chemical divisions. He will be based at company offices in Dublin, OH.

The naming of **Stephen M. Crum** as Vice President has been announced by the Polymer Products Division of the Chemicals Group of American Cyanamid Company, Wayne, NJ. In this position, Mr. Crum will be responsible for the division's coating resins, polymer additives, urethane chemicals and elastomers, molding compounds, and automotive products businesses.

The Board of Directors of The Mearl Corporation, New York, NY, has announced that **Fred J. LoFaso** has accepted the position of Senior Vice President/Global Sales and Marketing. In this capacity, Mr. LoFaso will continue to direct and coordinate the sales and marketing efforts of Mearl's worldwide network of offices and representatives in addition to assuming further responsibilities at corporate headquarters.

The Pigments Division of CIBA-GEIGY Corporation, Hawthorne, NY, has named **Jean Schaeflé** President. Dr. Schaeflé succeeds Division President **John Boehle, Jr.**, who has been appointed Corporate Vice President of Internal Audit. A native of Mulhouse, France, Dr. Schaeflé joined CIBA-GEIGY Limited, in Basel, Switzerland, the world headquarters for the Swiss firm, in 1979.

The annual Hanna Award in Chemical Coatings for the Best Project in the science and technology of chemical coatings was presented at Ohio Science Day held recently. The winner was **Paul R. Golownia**, a 10th grade student at Hudson High School in Hudson, OH, for his project entitled "Electroplating with Shellac." The judges found his work to be both comprehensive and well thought-out, exhibiting a balanced regard for both scientific content and practical application. They were particularly impressed that Paul chose to investigate an area where little published work is currently available, and where potential environmental impact may be significant.



The Hanna award consists of $500 and an engraved plaque. It is presented by the Columbus, OH, facility of Akzo Coating Inc., to help create a greater interest in the chemical coatings industry at the high school level, and to help foster a greater interest in chemical coatings as a potential career field in science and technology.

Roger S. Porter, a Professor of polymer science and engineering at the University of Massachusetts, has been named to the Dr. Harold A. Morton Distinguished Visiting Professorship at The University of Akron (UA), Akron, OH.

The distinguished visiting professorship was established in 1987 with a portion of a $1 million endowment created by Mildred Morton in memory of her late husband. This professorship brings distinguished scholars from all fields of polymer science and polymer engineering to UA for three to 12 months to work with faculty and students.

Prof. Porter, known for his development of polyethylene fiber, will consult with faculty and lecture during the fall semester.

Maurice P. (Skip) Knapp has been named President of Mettler Instrument Corporation, Hightstown, NJ, the U.S. affiliate of the Swiss firm Mettler-Toledo AG. Mr. Knapp also serves as President of Ingold Electrodes, Inc., Wilmington, MA, a position he has held since 1986 when Ingold became a Mettler-Toledo company. Prior to that, Mr. Knapp served as General Manager of the Ingold joint venture with Instrumentation Laboratory, Inc.

Richard Haywood Bass has been named a Technical Sales Representative/Georgia and Alabama, by Dexter Chemical Corporation, Bronx, NY. Prior to joining Dexter, Mr. Bass held positions with Lenmar Chemical, American Emulsions, and Henkel Chemical.

Obituary

James F. Compton, Investor Relations Director for PPG Industries, Inc., Pittsburgh, PA, died recently. He was 59 years old.

Mr. Compton joined PPG in 1967 as Coordinator of Chemicals Group product planning, and from 1968 until 1977 served as Manager of the group's Pigments Business Unit.

Prior to joining PPG, he was Vice President of Sales for National Mine Service Company and held marketing and product management posts with Monsanto Company.

Los Angeles Society for Coatings Technology Honorary Member, **Trevellyan Whittington**, a Consultant, died recently.

Mr. Whittington served as Society President in 1969-70.

Cleveland Society Hosts 34th Technical Conference At the B.F. Goodrich R&D Center, June 6, 1991

The Educational Committee of the Cleveland Society for Coatings Technology held its 34th Annual Technical Conference at the B.F. Goodrich Research and Development Center, on June 6. The topic of this year's conference was "Advances in Additive Technology, Water-Based, High-Solids, and Powder."

Approximately 90 registrants attended the one-day seminar.

Papers presented included:

"Additives—What are They? An Introduction"—Robert Vash, of Byk-Chemie

"Humidity and Temperature Effects upon the Formation of Latex Films Compensated by Coalescing Agents"—Douglas K. Pollock, of Dow Chemical

"Naturally Occurring Associative Thickeners"—Alex Jamieson, of Case Western Reserve University

"Calcium Sulfonate Gel Additives for Efficient Rheology Control"—Demetrios "Jim" Stephanadis, of The Lubrizol Corp.

"Acrylic Copolymer Additives to Improve Film Defects"—Gary L. Julian, of B.F. Goodrich Co.

"New Associative Cellulosic Thickeners for Water-Based Coatings"—Emmett M. Partain, of Union Carbide

"Rheology Modifiers: Modeling Their Performance in High-Gloss Paints"—Tammy L. Maver, of Rohm and Haas Co.

"Surface Treated Pigment—A 90s Solution to Some of Coatings' Problems"—Romesh Kumar, of Hoechst Celanese Corp.

Members of the Society's Educational Committee consisted of: Co-Chairman—DeVilla Moncrief, of The Sherwin-Williams Co.; Co-Chairman—Jacqueline Welker, of Inter-Colour Dimensions; Ex-Officio Member Ben J. Carlozzo, of Tremco Inc.; Ex-Officio Member Richard Ruch, of Kent State University; John Weaver, of Case Western Reserve University; Robert Mullen, of Case Western Reserve University; Victor Sandorf, of Coatings Development Co.; James A. Miller, of Adhesive Consultants; Sharon Kaffin, of The Glidden Co.; Dick Eley, of The Glidden Co.; Kevin Hershfield, of Lancer Dispersions; Robert Green, Jr., of Cook Paint & Varnish Co.; Ann Marie Canton, of The Sherwin-Williams Co.; Leonard Uitenham, of The Sherwin-Williams Co.; and Richard A. Mikol, of Tremco Inc.

CLEVELAND SOCIETY TECHNICAL CONFERENCE SPEAKERS—Presenting papers at the 34th Annual Technical Conference are (l-r): Front row—Alex Jamieson, Robert Vash, Romesh Kumar, and Tammy Maver. Back row—Douglas Pollock, Emmett Partain, Gary Julian, and Demetrios "Jim" Stephanadis

The Powder Coating Institute Announces Technical Seminars

Three technical seminars devoted to powder coating have been scheduled for this fall by The Powder Coating Institute (PCI), Alexandria, VA. The all-day sessions are designed to provide a basic introduction to powder coating materials, systems and applications, as well as explore the economics of powder finishing.

Topics to be covered will include: powder coating materials; manufacturing and quality control; pretreatment; application equipment and powder delivery; curing; and the economic benefits of powder coating versus conventional liquid finishing.

Seminar dates and locations are: September 12—Holiday Inn Downtown, Salt Lake City, UT; October 9—Holiday Inn Airport, Newark, NJ; and December 5—Wilson World Hotel at DFW Airport, Dallas, TX.

For more information and seminar registration materials, contact PCI, 1800 Diagonal Rd., Ste. 370, Alexandria, VA 22314.

Golden Gate Society Conducts Conference on "Paint Technology and Quality in the 90s"

The Manufacturing Committee of the Golden Gate Society for Coatings Technology presented Conference '91 on "Paint Technology and Quality in the 90s," June 17, at the Holiday Inn, South San Francisco, CA.

The program consisted of the following presentations:

"Performance Oriented Packaging"—Mike McQuiston, of B.W. Norton Co.

"Criteria for Dispersion Equipment Control"—Christ Zoga, of Premier Mill Corp.

"Household Hazardous Paint Recycling"—Rick Miller, of the San Mateo County Department of Health Services

"Computer Controlled Production"—Puis Eigenmann, of Buhler, Inc.

"Formula Base Software"—Christy Hudson, of Pacific Microsoftware Engineering

"Further Developments in Micro Fine Wet Grinding"—Edward Cossama, of Draisewerke, Inc.

"Statistical Quality and Process Control"—Bill Abercrombie, of J.M. Huber Corp.

"Automated Color Dispensing"—Reid Hogue, of Dunn-Edwards

"Hazardous Waste Generators: Cradle to Grave Responsibilities—An Issue for the 1990s"—Judy Bay, of Van Waters and Rogers.

Tapes of the program are available for a fee of $20 for attendees and $50 for non-attendees. For information, contact Ron Hughes, Ashland Chemical Co., 8600 Enterprise Dr., Newark, CA 94560.

Coatings Science Mini-Course to Focus on Fundamentals November 2-3, 1991, at Sheraton Centre, Toronto, Ont., Canada

Dr. Shelby Thames, of the Department of Polymers Science at The University of Southern Mississippi (USM), Hattiesburg, MS, and Dr. James Stoffer, of the Department of Chemistry at The University of Missouri-Rolla (UMR), Rolla, MO, will be offering a Coatings Science Mini-Course on November 2-3, 1991 at the Sheraton Centre Hotel, Toronto, Ontario, Canada. The course will take place the weekend prior to the Annual Meeting & Paint Industries' Show of the Federation of Societies for Coatings Technology.

The course is designed to cover the fundamentals of coatings science as well as recent developments in the field. Course topics include: resins, solvents, primer and extender pigments, additives, some formulation techniques, and the mechanism of film formation. The topics will be discussed via a format that the beginner will comprehend and the experienced person will find challenging. Methods to formulate high-solids, waterborne, and powder coatings that meet the new VOC regulations will be presented. Design parameters for optimizing coating properties will also be discussed.

Shelby F. Thames, Distinguished University Research Professor and Professor of Polymer Science at USM, has maintained a strong coatings research and development effort for many years. He has served as a private consultant, lecturer, and expert witness for a wide variety of industrial, academic, and other organizations.

In 1970, Dr. Thames founded the USM Department of Polymer Science. He is a cofounder of the Waterborne and Higher Solids Coatings Symposium which has run successfully for 19 years. He was honored as the Joseph J. Mattiello Memorial Lecturer by the Federation in 1982 and has published widely.

James O. Stoffer, Professor of Chemistry and Senior Research Investigator, Graduate Center for Materials Research, UMR, has received five Outstanding Teacher Awards, as well as a Faculty Excellence Award from UMR. He is presently Chairman of the Polymer and Coatings Science Program in the Department of Chemistry.

Dr. Stoffer is the author of the first papers on microemulsion polymerizations, the use of ultrasonics for dispersion of pigments, ultrasonic initiated free radical catalyzed polymerizations, and the preparation of transparent composites.

For more information, contact Dr. Shelby Thames or Deborah Theisen, Dept. of Polymer Science, USM, Southern Station Box 10076, Hattiesburg, MS 39406-0076.

Fundamentals of Color Seminar Slated for the Fall

The Macbeth Division of Kollmorgen Instruments Corp., Newburgh, NY, has released the 1991 fall schedule of the seminar "The Fundamentals of Color."

The two-day seminar, an introduction to the basic principles of color science, is oriented toward people involved in the design, production, quality control, or inspection of materials for which color is important. The program is devoted to lectures and demonstrations explaining color naming and specification, visual inspection, the basis of color measurement, and the general principles of managing color in business and industry.

Dates and locations include: September 12-13—Sheraton Tara, Newton (Boston), MA; October 10-11—Radison Hotel San Diego, San Diego, CA; October 24-25—Sheraton Valley Forge Hotel, King of Prussia, PA; November 7-8—Holiday Inn Fairlane, Detroit, MI; November 13-14—The Wynfrey Hotel, Birmingham, AL; and December 5-6—Raleigh Marriott Crabtree Valley, Raleigh, NC.

Contact Wanda Smith, Macbeth, P.O. Box 230, Newburgh, NY 12551-0230 for housing and registration information.

Materials Research Society Schedules Courses On Materials Science and Technology

The Materials Research Society (MRS), Pittsburgh, PA, will be offering three new short courses on materials science and technology entitled "Cementitious Materials," "Shape-Memory Materials," and "Biomaterials." The courses, to be held in conjunction with technical symposia, will be among 23 offered during the 1991 Fall Meeting of the MRS on December 2-6, in Boston, MA.

Other courses and symposia will focus on optoelectronic materials, high-temperature superconductors, electron microscopy, thin-film analysis, various aspects of semiconductor technology, microelectronic packaging, plasma etching, and high resolution x-ray diffraction.

The courses are designed to meet the needs of professional scientists, engineers, technical staff, and managers who wish to know the latest techniques in characterization and fabrication of materials.

Complete course information is obtainable by writing MRS, 9800 McKnight Rd., Pittsburgh, PA 15237.

International Colour Association to Celebrate 25th Anniversary on June 23-24, 1992

The International Colour Association (AIC) will celebrate its 25th Anniversary by conducting a two-day international symposium on "Computer Color Formulation," on June 23-24, 1992, on the campus of Princeton University, Princeton, NJ. The symposium will be preceded by the Inter-Society Color Council (ISCC) Annual Meeting on June 21-22.

The meetings will include discussions on a wide range of topics related to color and appearance, working sessions of ISCC project committees, the symposium, and a banquet celebrating the AIC Silver Jubilee.

The AIC symposium will be divided into four sections covering colorant formulation: where the substrate plays a significant role (e.g., printing); from simulated color (e.g., from CRTs, liquid crystal, Maxwell disk, etc.); allowing for appearance effects (e.g., due to gloss or polychromatic pigments); and general theory and practice.

In addition, a meeting of ASTM Comittee E-12 on Appearance is scheduled on June 24.

For housing and registration details, write Danny Rich, ISCC Secretary, ACS Datacolor, 5 Princess Rd., Lawrenceville, NJ 08648.

University of Akron to Offer Polymer Specialization Program

Chemical and mechanical engineering undergraduate students at the University of Akron, Akron, OH, are being offered a polymer specialization program to prepare them for work in the rubber plastics industry.

The program identifies several polymer courses from which students must select three as electives in their senior year. The course "packages" vary slightly for chemical and mechanical engineers, but the basic components include an introduction to polymers, a choice of polymer lecture classes, and a design project or a polymer engineering class.

For further details, contact, Dave Nypaver, The University of Akron, Akron, OH 44325-0604.

Rheology and Coatings Laboratory at Kent State University To Present Course on "Weathering Techniques," October 16-18

The program "Accelerated and Natural Weathering Techniques for Coatings and Polymers," will be offered October 16-18, by the Rheology and Coatings Laboratory of Kent State University (KSU), Kent, OH.

The program is as follows:

Wednesday, October 16

"Service Life Prediction for Coatings Systems"—Johnathan W. Martin, of National Institute of Standards & Technology

"Infrared Evaluation of Coatings Durability"—Jack Hartshorn, of Du Pont Co.

"Accelerated Testing of Coatings for Corrosion Control"—Brian Skerry, of The Sherwin-Williams Co.

"Improved Durability of Organic Coatings with Light Stabilizers"—Mark S. Holt, of CIBA-GEIGY Corp.

Thursday, October 17

"Spectroscopic Approaches for Predicting Coating Weatherability"—David R. Bauer, of Ford Motor Co.

"Overview of Laboratory Accelerated Weathering Methods"—Douglas M. Grossman, of The Q-Panel Co.

"Electrochemical Impedance Spectroscopy for Predicting Corrosion Protection by Coatings"—Edward A. Cuellar, of BP America

"Development in Comparing Accelerated Weathering Methods by Characterization of Weathered Films"—Goutam Gupta, of The Sherwin-Williams Co.

Friday, October 18

"Laboratory Accelerated Tests Can Work for You!"—John L. Scott, of South Florida Testing Service

"Appearance Performance Modeling for Accelerated Data"—Rick Mathew, of Americhem, Inc.

The object of this course is to predict the service life of coatings and polymers by accelerated and natural weathering techniques. Lectures will include variations in accelerated and exterior testing methods. A correlation between natural weathering with various spectroscopic results will be included. Accelerated testing of coatings for corrosion control, appearance performance modeling, and an overview of laboratory weathering techniques will also be described.

The course is designed for practitioners in polymer coatings on metallic and nonmetallic surfaces and those interested in the aging of coatings and plastics. This includes personnel in the research, products development, engineering, marketing, and producers of surface-coated hardware. The techniques should also appeal to managers, supervisors, and technicians who are interested in the service life of coatings.

Information can be obtained by contacting Carl J. Knauss, Program Manager, Chemistry Dept., KSU, P.O. Box 5190, Kent, OH 44242-0001.

Preliminary Program and Additional Highlights of 1991 Annual Meeting & Paint Industries' Show of the Federation Begins on Page 25

COATINGS SCIENCE MINI-COURSE

November 2-3, 1991
Sheraton Centre, Toronto, Canada

SHORT COURSE TOPICS

Introduction

Formulations
High solids which meet new VOC specifications
Latex, water-borne and water-dispersible formulations
Calculations

Resins
Step-growth and chain-growth polymers including molecular design mechanisms: Condensation, free radical, anionic, and cationic polymerizations

Degradation of Polymer Coatings
Mechanisms of degradation
Methods for stabilizing coatings

Pigments and Extender Pigments
Where and when to use them
Characteristic properties

Additives
Use, types, and levels: rheology modifiers, surfactants, dispersants, coalescing agents, plasticizers, antifoam agents, driers, antiskinning agents

Powder Coatings

Formulating Trade Sales and Industrial Coatings

The course is for professionals in the field of coatings research, paint manufacturing, sales and technical services. It is designed to cover the fundamentals of coatings science as well as the latest developments in the field.

Lectures will be held November 2-3, 1991, from 8:30 a.m. to 5:00 p.m. in the Sheraton Centre, Toronto, the weekend before the Paint Show. Tuition is $800 per person and includes lecture notes and hard copies of slides. For additional information or registration, contact Deborah Theisen, USM Department of Polymer Science, (601) 266-5754, FAX (601) 266-5880. Registration deadline is October 20, 1991.

Shelby F. Thames
Professor of Polymer Science
The University of Southern Mississippi

James O. Stoffer
Professor of Chemistry
The University of Missouri—Rolla

Book Review

RADIATION CURING OF POLYMERIC MATERIALS

Edited by
Charles E. Hoyle and
James F. Kinstle

Published by
American Chemical Society
1155-16th St., N.W.
Washington, D.C. 20030 (1990)
567 Pages, $99.95

Reviewed by
Thomas J. Miranda
Whirlpool Corp.
Benton Harbor, MI

This book is part of ACS Series #417, and is devoted to radiation curing. The volume is divided into the following sections: introduction; photoinitiators; novel radiation photocurable systems; properties of radiation-cured systems; photodegradation; radiation curing of cationic polymerization; laser initiated curing; and high energy radiation curing.

The first two chapters provide an overview of UV and electron beam curing to provide those less familiar with these processes a starting point to the more specific papers such as photoinitiation, cationic cure systems, novel curable systems including the norbornenes, acrylated melamines, and nonacrylated curing mechanisms. Laser induced polymerization is also described, which is an important part of photofabrication. The volume concludes with a section on high energy radiation in which the authors discuss the use of gamma radiation to degrade photoinitiators to form cationic initiating species.

This book would be useful to those interested in the growing area of radiation polymerization.

PHTHALOCYANINE RESEARCH AND APPLICATIONS

By
Arthur L. Thomas

Published by
CRC Press, Inc.
2000 Corporate Blvd.
Boca Raton, FL 33431 (1990)
336 Pages, $179.95

Reviewed by
Darlene R. Brezinski
Consolidated Research Inc.
Mt. Prospect, IL

Admittedly not of broad general interest, this text is an extensive review that covers the field of phthalocyanine science and technology thoroughly and provides access to the world literature in the field due to its extensive and complete referencing. Quite obviously, this text would be of interest to the pigment industry as the phthalocyanine blues and greens have outstanding stability to light, heat, acids, and alkalis. Their use is extensive in printing inks, coatings, paints, and plastics.

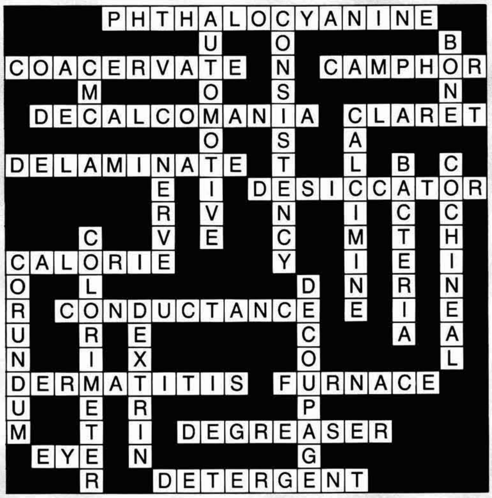
The first several chapters are devoted to the basic chemistry of phthalocyanines: synthesis, reactions, solution chemistry, physical chemistry, analysis, and spectroscopy. These are review chapters and have extensive and complete referencing.

Of interest to the coatings industry would be the chapter reviewing coatings with attention on dispersion and formulations. A chapter on ink focuses on ink jet inks, marking inks, writing inks, printing inks, and thermal transfer inks.

Other areas of interest which are reviewed are phthalocyanine polymers, conductive polymers and metal phthalocyanine polymers, photopolymer compositions, laser and optical recording applications, and toners.

In summary, this text is a single source review with current references provided for all aspects of phthalocyanine research and applications. It is interesting to note that over 5,000 phthalocyanines are now known and new ones are being created each year with a broadening base of applications.

CLASSIFIED ADVERTISING



Solution to August's *"CrossLinks"*

Literature

NMR Software

The availability of a software package that runs on industry standard computers for processing one- and two-dimensional NMR data is featured in a product release. The package is currently implemented on the SUN SPARC, SGI IRIS, and is soon to be offered for the IBM RISC/6000 computers. More information on the UXNMR/P software system can be obtained by contacting Connie Johnson, Bruker Instruments, Inc., Manning Park, Billerica, MA 01821.

Xenon Exposure System

Details are obtainable on a large component xenon exposure system designed to provide manufacturers of large parts or component assemblies with a means of determining the resistance of their product to sunlight and various other weather conditions. The spectral output of the xenon lamps closely simulates natural sunlight. More information on the Model XR260 Large Component Xenon Exposure System is available from Atlas Electric Devices Co., 4114 N. Ravenswood Ave., Chicago, IL 60613.

Industrial Maintenance Coating Systems

A new 16-page brochure providing extensive information on coating systems for plant engineers, maintenance supervisors, and industrial maintenance painting contractors has been issued. This four-color brochure consists of case history and feature articles, new products, and literature pertaining to industrial maintenance coating systems. All inquiries for additional information should be identified as "Application Advantage, Corrosion Control Volume III (SWS-3615)," and sent to The Sherwin-Williams Co., c/o HKM Direct, 5501 Cass Ave., Cleveland, OH 44102.

Air Emissions

Gas standards for precise measurement of a variety of air emissions is the topic of a 12-page brochure. The literature discusses EPA Protocol gases, as well as products and services for stationary source emissions monitoring, ambient air monitoring, motor vehicle emissions certification, and city/state vehicle emissions testing. For more details, request Form #6931 from Liquid Carbonic, Advertising Dept., 135 S. LaSalle St., Chicago, IL 60603.

Phenolic Crosslinker

A six-page booklet detailing a phenolic resin developed for use in fast-curing formulations for coil coatings applications has been printed. The resin is described as a low molecular weight phenolic resin based on substituted phenols. Suggested formulations are given for coil coatings, including epoxy/phenolic and phenolic-crosslinked organosol food can coatings. FDA status is also covered in the literature. Copies of the booklet, "UCAR® Phenolic Resin Solution BKS-7590," designated F-60783, are available from Union Carbide Chemicals and Plastics Co. Inc., Solvents, Resins, and Intermediates, Dept. L4489, 39 Old Ridgebury Rd., Danbury, CT 06817-0001.

Microwave Methodologies

A four-page, full-color brochure offering high-speed microwave methodologies on polymers, plastics, chemicals, pulp, paper, petroleum, coal, rubber, environmental, and waste water materials has been issued. Also included are microwave applications for solids analysis, ashing, and sample preparation for AA/ICP analysis. For further information, write CEM Corp., P.O. Box 200, Matthews, NC 28106.

Saturated Latex

A patented process that reportedly creates an ozone resistant, saturated nitrile rubber in latex form has been introduced through literature. Potential applications include: adhesives to textiles, metals, and ceramics; as a binder for high temperature nonwoven materials; coatings, inks, and paints; surface coatings for conventional rubber products; and as a saturant. Contact Goodyear, Akron, OH 44316-0001.

Storage Tank

Information has been released on a steel and fiberglass reinforced polyester resin double-wall underground storage tank. Fuels including gasoline, diesel fuel, jet fuel, ethanol, neat methanol, and M-85 can reportedly be stored in the tank. Further information on the Permatank® double-wall underground storage tank is obtainable from Clawson Tank Co., P.O. Box 350, 4545 Clawson Tank Dr., Clarkston, MI 48346-0350.

Graft Copolymer

A graft copolymer which has been reportedly proven to be a soil remover and a "soil shield" on fabrics containing polyester fibers, is the subject of a data sheet. The polymer is designed to guard against the deposit of oily stains on clean polyester and polyester-blend fabrics. Copies of the report on Sokalan® HP 22 polymer can be obtained by writing to BASF Corp., Performance Chemicals, 119-2 Cherry Hill Rd., Parsippany, NJ 07054.

Detackification Program

A detackification program, which can reportedly be customized to work with all paint spray booth systems and is designed to reduce sludge formation by up to 50% over traditional clay treatments has been introduced in a product bulletin. The program uses an all-liquid technology that can detackify most paint systems, including high-solids, multi-component, and waterborne formulations. For more details on Betz ACDP™ (Activator Catalized Detackification Program) and ACDP Polycate™, contact James P. McIntyre, Betz MetChem, 200A Precision Dr., Horsham, PA 19044.

Emulsion

A six-page brochure highlights a new emulsion for building product applications. The literature includes a chart listing the emulsion's typical properties, which include high-bond strength, nontoxicity, and freeze-thaw stability. To obtain a copy of the brochure, "Vinac® 524BP Emulsion for Building Products," write Air Products and Chemicals, Inc., Polymer Chemicals Div., 7201 Hamilton Blvd., Allentown, PA 18195-1501.

Horizontal Bead Mill

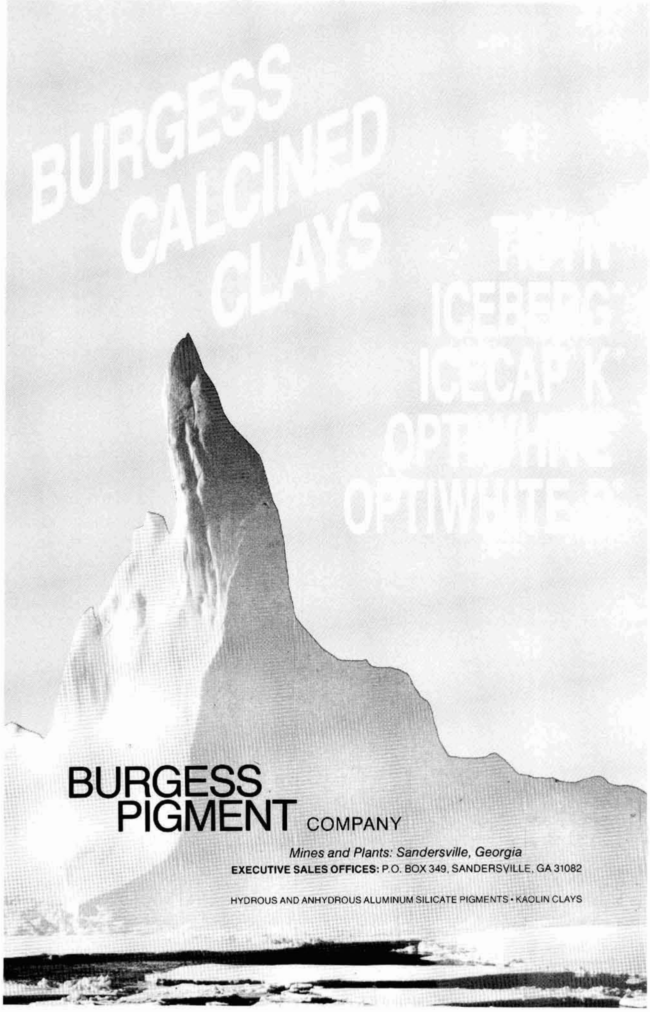
The introduction of a horizontal bead mill ranging in sizes from 0.25 liter laboratory model through the full size, 40 liter production mill has been made through a data sheet. Features such as a removable product discharge screen, cartridge-type mechanical shaft seal, and complete grinding media discharge without chamber removal allow full user serviceability with reportedly minimum downtime. For further details, write Epworth Manufacturing Co. Inc., 1400 Kalamazoo St., South Haven, MI 49090.

Asbestos Substitute

A high performance plastic that displays metallurgical properties and can reportedly be used as a substitute for asbestos in high temperature applications, is the subject of recently released literature. The plastic is a fully polymerized polybenzimidazole produced by a melt condensation reaction. For further technical details on Celazole®, write PBI Performance Parts, Hoechst Celanese Corp., 18207 Chisholm Trail, Ste. 216, Houston, TX 77060.

Waterproofer

A 12-page, full-color booklet which describes some of the most common causes of masonry water problems and explains how a waterproofer can be used to help solve them has been released. The product can be used on basements, retaining walls, cisterns, swimming pools, and water tanks. To obtain a copy of the "Waterproofing Made Easy," brochure and details on Drylock Masonry Waterproofer, write UGL, P.O. Box 70, Scranton, PA 18501.



Viscosity Sensor

Literature has been issued on an in-line viscosity sensor which features FM approval for hazardous fluids, stainless steel construction, internal RTD temperature probe, temperature capability to 190°C, and overall range of 0.1-20,000 cp. For more information on the SPC301 Piston Viscosity Sensor, write Cambridge Applied Systems, Inc., 57 Smith Place, Cambridge, MA 02138.

HPLC Columns

The introduction of new reversed phase HPLC columns has been made through a technical data sheet. Available in 4.6 mm I.D. x 25 cm and 4.6 mm I.D. x 12.5 cm, these columns are packed with 300 Å pore size spherical media with a choice of C18, C8, and C4 chemistries. For more information, contact Sharman V. Pate, Whatman Inc., 9 Bridewell Pl., Clifton, NJ 07014.

GC Columns

A four-page brochure describing recently developed porous layer open tube gas chromatography columns has been released. The columns are designed for extended hydrocarbon analysis and provide resolution of typical mixes in refinery and natural gas from C_1 to C_{10}. For a free copy of the GS-Alumina™ brochure, write J&W Scientific, 91 Blue Ravine Rd., Folsom, CA 95630.

Cleaning Gun

A brochure providing technical data and application ideas on a compressed-air-operated industrial cleaning gun has been released. The product can be used as a wet or dry vacuum or as a blow gun for numerous industrial applications. Contact Vortec Corp., 10125 Carver Rd., Cincinnati, OH 45242, for in-depth details on the Hand-E-Vac cleaning gun.

FT-IR Software

Optical spectroscopy software for data collection and processing is detailed through literature. The software is icon based and mouse controlled. A keyboard may be used for text input. Write Mary Ann Finch, Bruker Instruments, Inc., Manning Park, Billerica, MA 01821 for further details on the OPUS FT-IR software.

Metering Pump

A two-page brochure highlighting a corrosion-resistant metering pump has been released. Design features of the pump include a cast iron housing, a high-performance oil-operating worm and wheel drive, and a built-in pressure-relief valve. For a free copy of the literature on the Model 1710 pump, contact Olivia Mady, Proportioneer Pumps, 150 Elmgrove Park, Rochester, NY 14624.

Quartz Fiber Crucible

A technical data sheet describing a high temperature quartz fiber crucible (950°C or 1742°F) has been printed. This product is designed to allow air to circulate through the crucible and around the sample increasing the rate of sample oxidation. Increased oxidation accelerates combustion and decreases analysis time. For more information, write CEM Corp., P.O. Box 200, Matthews, NC 28106.

Programmable Injector for GC

A capillary on-column injector for gas chromatographs is the topic of a data sheet. The new temperature programmable injection port is designed to be used for quantitative injection and analysis of thermally labile samples. Further information on the OCI-14 Capillary On-Column Injector can be obtained by contacting Shimadzu Scientific Instruments, Inc., 7102 Riverwood Dr., Columbia, MD 21046.

Polyurethanes

A line of waterborne polyurethane and polyurethane blends for automotive components requiring a pliable coating that does not crack when flexed is the subject of a product sheet. Suggested applications include interior leather, and possibly interior and exterior trim, rubber sheel protectors, bumpers, and other components that require a flexible coating. For additional details on Roda® pur polyurethane, contact Andy Honeycheck, Rohm Tech Inc., 195 Canal St., Malden, MA 02148.

Laser Interferometer

A new laser interferometer which employs direct measuring interferometry technology is the focus of literature. Applications range from the testing of tiny microscope lenses, ball bearings, photo lenses, metal mirrors for lasers, to large mirrors for telescopes. For more technical information on the DIRECT 100 laser interferometer, write Carl Zeiss, Inc., One Zeiss Dr., Thornwood, NY 10594.

Semi-Synthetic Coolant

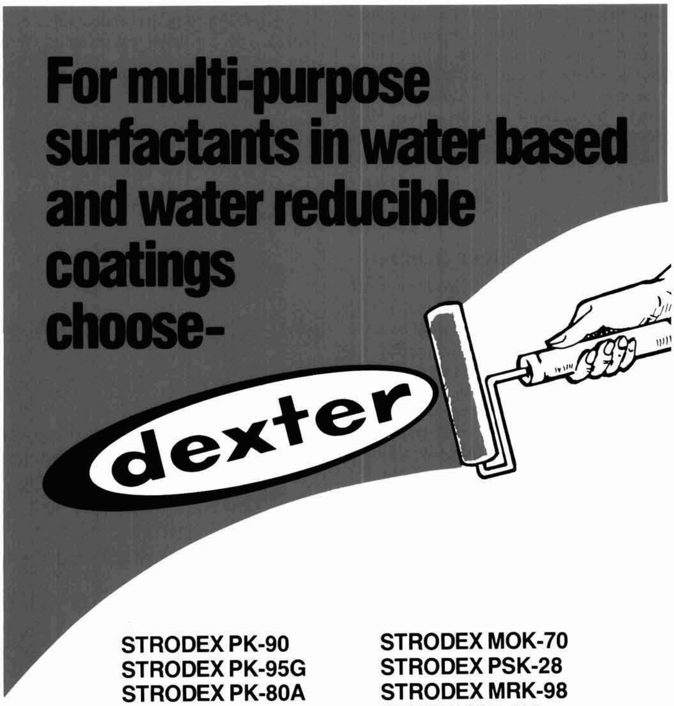
Technical literature has been released on a semi-synthetic coolant which combines synthetic materials and a micro-emulsion of unique petroleum compounds. The coolant contains no phenols, halogens, PCMC, phosphates, nitrates, and nitrites which minimize toxicity and disposal problems. Detailed performance and application data on RECOOL 1050S semi-synthetic coolant is available from Man-Gill Chemical Co., 23000 St. Clair Ave., Cleveland, OH 44117.

FT-Raman Accessory

A line of FT-Raman accessories for multi-range FT-IR spectrometers is detailed in a press release. The accessory reportedly utilizes the interferometer in the FT-IR optics bench and incorporates a proprietary Raman detector and Raleigh rejection filter system resulting in low noise spectral data over a wide range. Contact Mary Ann Finch, Bruker Instruments, Inc., Manning Park, Billerica, MA 01821, for further details on the FRA 106 FT-Raman accessory.

Acrylic-Based Additives

A new additive kit featuring a sampling of acrylic-based additives for flow control, air release, and pigment depression is being offered. The kit is designed to provide formulators with the convenience of having a select group of additives at their fingertips along with an easy-to-read application chart. Write Cook Composites and Polymers Co., P.O. Box 419389, Kansas City, MO 64141-6389 for further information on the Coroc® additives kit.



Waterborne Epoxy Coating

The introduction of a two component, chemically-cured waterborne clear epoxy finish has been made through a data sheet. The finish is designed for interior use on concrete floors, wood floors, trim, doors or paneling, brick, or decorative masonry walls. More details on Tru-Glaze-WB™ epoxy coating are obtainable by writing Devoe & Raynolds Co., 4000 Dupont Circle, Louisville, KY 40207.

Lampblack Dispersion

Literature has been released on the availability of a new water-based lampblack compound. The product is designed to provide tint strength, blue tone, compatibility, and less tendency toward flooding and floating in most aqueous vehicle systems used in the industry. Samples of dispersion BS 14985 are obtainable by writing CDI Dispersion, 27 Haynes Ave., Newark, NJ 07114.

Regenerated Thermal Oxidizer

A regenerated thermal oxidizer which uses high temperatures and turbulence to convert airborne pollutants to simple carbon dioxide and water vapor is the subject of a data sheet. The oxidizer is designed for use in printing, coating, chemical processing, converting, automotive spray painting, and other industries. For further information on the RE-THERM VF®, contact Reeco, Box 600, 520 Speedwell Ave., Morris Plains, NJ 07950-2127.

Duel-Beam Spectrometer

A new duel-beam spectrometer for applications requiring sample and reference spectra has been introduced in a product bulletin. Features include two spectra on a single diode array, dual beam (monitors sample and reference simultaneously), and one grating. For product specifications on Model MD10 Dual-Beam Spectrometer, write American Holographic, Inc., 521 Great Rd., P.O. Box 1310, Littleton, MA 01460.

Acrylic Resin

An aqueous acrylic binder that reportedly exhibits adhesion to glass and to natural and synthetic fibers has been introduced through literature. The resin is formaldehyde and acrylonitrile free, and is 50% solids dispersed in water and can be processed by conventional techniques. For more information on Rohatol DV 440 aqueous acrylic binder, write Rohm Tech, Inc., 83 Authority Dr., Fitchburg, MA 01420.

Transvector Vacuum Pump

A brochure has been issued which describes a new compressed-air-operated transvector vacuum pump. Applications include removing used coolant, metal chips, sludge, hydraulic oil, solvents, or tramp oil from lathes, milling machines, EDM, surface grinders, sumps, and open pits. For more details, write Vortec Corp., 10125 Carver Rd., Cincinnati, OH 45242.

Weathering Tester

An accelerated weathering tester which is designed to recreate damage caused by sunlight, rain, and dew has been introduced. Also highlighted in the product release is a new cyclic corrosion test chamber. Write Russell Raymond, Technical Services Representative, Q-Panel Co., Cleveland, OH 44145, for more details on the Q-U-V Accelerated Weathering Tester and the Mebon Prohesion® chamber.

Styrene Pigment

A technical brief describing a polymer pigment designed to enhance the gloss and opacity of coated papers has been printed. The solid sphere, polystyrene pigment is formulated for easy glossing and finishing. Write Unocal Polymers, 1700 E. Golf Rd., Schaumburg, IL 60173-5862 for more information on 76 RES 7116 pigment.

Surface Analysis System

A new auger nanoprobe surface analysis system is described in a 14-page, full color brochure. The literature provides a complete overview of the features and application of the nanoprobe, with numerous supporting spectra. For additional information on the PHI 670 Auger Nanoprobe, contact Steve Deppa, Perkin-Elmer, Physical Electronics Div., 6509 Flying Cloud Dr., Eden Prairie, MN 55344.

Coming Events

FEDERATION MEETINGS

For information on FSCT meetings, contact Federation of Societies for Coatings Technology, 492 Norristown Rd., Blue Bell, PA 19422 (215) 940-0777, FAX: (215) 940-0292.

1991

(Sept. 24-26)—Statistical Process Control for the Coatings Industry (Level II) Seminar. Airport Hilton Hotel, Toronto, Ontario, Canada.

(Nov. 4-6)—69th Annual Meeting and 56th Paint Industries' Show. Convention Center, Toronto, Ontario, Canada.

1992

(May 17-20)—Federation "Spring Week." Board of Directors Meeting on the 17th; Incoming Society Officers Meeting on the 18th; Spring Seminar on the 19th and 20th. Sheraton Boston Hotel and Towers, Boston, MA.

(Oct. 21-23)—70th Annual Meeting and 57th Paint Industries' Show. McCormick Place, Chicago, IL.

1993

(Oct. 27-29)—71st Annual Meeting and 58th Paint Industries' Show. World Congress Center, Atlanta, GA.

SPECIAL SOCIETY MEETINGS

1992

(Feb. 26-28)—Southern Society. 19th Annual Waterborne, Higher-Solids, and Powder Coatings Symposium. Co-sponsored by the Department of Polymer Science at the University of Southern Mississippi (USM). New Orleans, LA. (Robson F. Storey and Shelby F. Thames, Co-Organizers, WBHS&PC Symposium, Dept. of Polymers Science, USM, Southern Station Box 10076, Hattiesburg, MS 39406-0076).

(Mar. 11-13)—Southern Society Annual Meeting. Grosvenor Resort Hotel, Orlando, FL. (Billy Lee, Kemira, Inc., P.O. Box 368, Savannah, GA 31402).

(Mar. 29-31)—Houston and Dallas Societies. Southwestern Paint Convention. South Shore Harbour Resort & Conference Center, League City (Houston), TX. (Dennis Crozier, Crozier-Nelson Sales, Inc., 2505 Collingsworth, Houston, TX 77026).

OTHER ORGANIZATIONS

1991

(Sept. 15-18)—79th Annual Canadian Paint and Coatings Association (CPCA) Convention. Le Chateau Montebello, Montebello, Quebec, Canada. (CPCA Convention, 9900 Cavendish Blvd., Ste. 103, Montreal, Quebec, Canada, H4M 2V2).

(Sept. 17-20)—Eurocoat 91. XIX International Congress/Exhibition. Nice, France. (A. Chauvel, AFTPV, 5, rue Etex, 75018 Paris, France).

(Sept. 23-25)—Finishing '91 Conference and Exposition. Sponsored by the Society of Manufacturing Engineers (SME) and the Association for Finishing Processes. Dr. Albert B. Sabin Convention Center, Cincinnati, OH. (SME Event Public Relations Dept., One SME Dr., P.O. Box 930, Dearborn, MI 48121).

(Sept. 23-25)—"Polymer Blends and Alloys." Seminar sponsored by The Division of Polymeric Materials Science and Engineering of the American Chemical Society. Hilton Head Island Beach and Tennis Resort, Hilton Head, SC. (Angelos V. Patsis, Institute of Materials Science, State University of New York, New Paltz, NY 12561).

(Sept. 24)—"The Implications of Information Technology (IMPoIT)." Symposium sponsored by the West Riding Section of the Oil & Colour Chemists' Association (OCCA). Bodington Hall, University of Leeds, Leeds, England. (Yvonne Waterman, OCCA, 967 Harrow Rd., Wembley, Middlesex, HA0 2SF, United Kingdom).

(Sept. 24-26)—The Polyurethanes World Congress 1991. Co-sponsored by the European Isocyanate Producers Association and the Polyurethane Division of The Society of Plastics Industry (SPI), Inc. of the USA. Acropolis Arts & Convention Center, Nice, France. (Fran Lichtenberg, Polyurethane Div., SPI, 355 Lexington Ave., New York, NY 10017).

(Sept. 24-26)—Finishing '91. Exhibition sponsored by Turret Group plc. Telford Exhibition Centre, Telford, Shropshire, England. (Nigel Bean, Exhibition Sales Manager, Turret Group plc, Turret House, 171 High St., Rickmansworth, Herts, WD3 1SN, England).

(Sept. 29-Oct. 2)—RADTECH Europe '91 Conference and Exhibition. Edinburgh Exhibition and Trade Centre, Edinburgh, Scotland. (Exhibit Manager, RADTECH 91, c/o FMJ International Publications Ltd., Queensway House, 2 Queensway, Redhill, Surrey, RH1 1QS, United Kingdom or Conference Secretary, RADTECH '91, c/o PRA, Waldegrave Rd., Teddington, Middlesex, TW11 8LD, England).

(Oct.)—ASTM Committee B-8 on Metallic and Inorganic Coatings meeting. Philadelphia, PA. (George A. DiBari, International Nickel Co., Park 80 West—Plaza Two, Saddle Brook, NJ 07662).

(Oct. 2-4)—Hazardous Materials Management Conference and Exhibition/South (HazMat/South). Sponsored by *HazMat World* magazine. Georgia World Congress Center, Atlanta, GA. (Tower Conference Management Co., 800 Roosevelt Rd., Bldg. E, Ste. 408, Glen Ellyn, IL 60137-5835).

(Oct. 6-11)—"High Performance Polymeric Adhesives and Composites." Short course sponsored by The American Chemical Society (ACS). Virginia Tech, Blacksburg, VA. (Pamela McInally, Continuing Education Short Course Office, ACS, 1155-16th St., N.W., Washington, D.C. 20036).

(Oct. 7-10)—"Introduction to Coatings Technology." Short course sponsored by Kent State University (KSU), Kent, OH. (Carl J. Knauss, Director, Cooperative and Continuing Education, Chemistry, KSU, Kent, OH 44242).

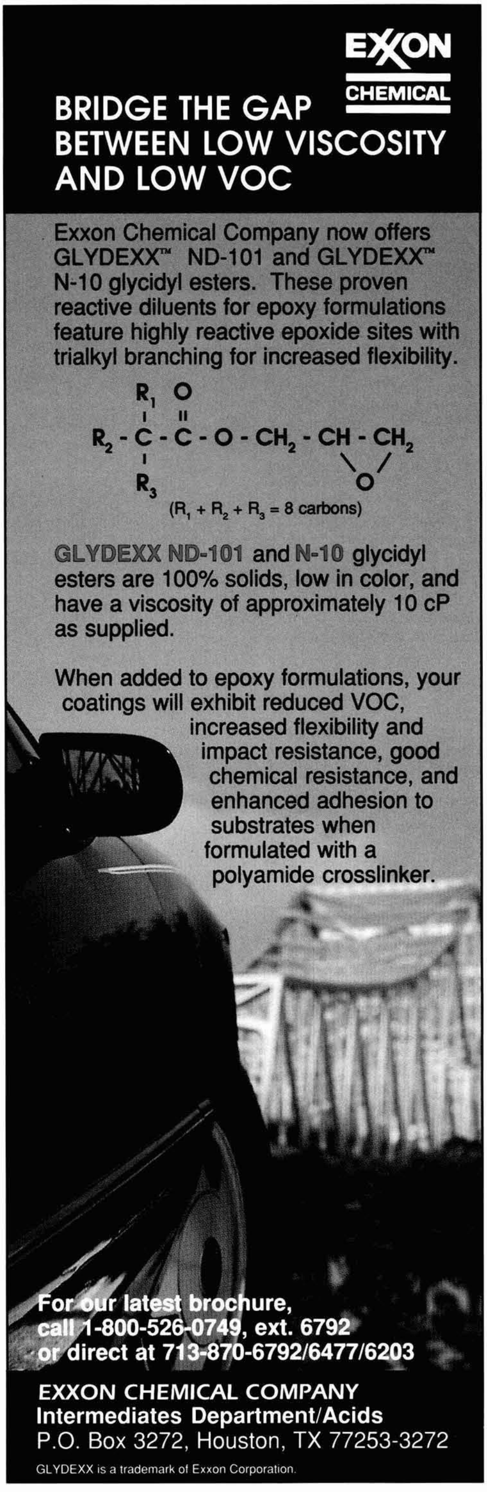
(Oct. 9)—Technical seminar on "Powder Coating." Sponsored by The Powder Coating Institute (PCI). Holiday Inn Airport, Newark, NJ. (PCI, 1800 Diagonal Rd., Ste. 370, Alexandria, VA 22314).

(Oct. 9-11)—"Verbundwerk '91." 3rd International Trade Fair on Composite Technology, Reinforced Plastics, Metals, and Ceramics. Rhein-Main-Halls, Wiesbaden, Germany. (Diana Schnabel, DEMAT, Postbox 110 611, 6000 Frankfurt 11, Germany).

(Oct. 14-18)—"Scanning Electron Microscopy and Microanalysis for Polymeric Science." Conference sponsored by the State University of New York (SUNY). Nevelle Resort Hotel, Ellenville, NY. (Institute of Materials Science, SUNY, New Paltz, NY 12561).

(Oct. 16-18)—"Accelerated and Natural Weathering Techniques for Coatings and Polymers." Short course sponsored by Kent State University (KSU), Kent, OH. (Carl J. Knauss, Director, Cooperative and Continuing Education, Chemistry Dept., KSU, Kent, OH 44242).

(Oct. 20-24)—ASTM Committee D-13 on Textiles Meeting. Wyndham Franklin Plaza, Philadelphia, PA. (Bode Buckley, ASTM, 1916 Race St., Philadelphia, PA 19103-1187).



(Oct. 21-23)—104th Annual Meeting of the National Paint & Coatings Association (NPCA). San Francisco Hilton Hotel, San Francisco, CA. (NPCA, 1500 Rhode Island Ave., N.W., Washington, D.C. 20005).

(Oct. 21-24)—Euro–Asian Interfinish '91 Conference. (Aviezer Israeli, Chairman, The Metal Finishing Society of Israel, Ortra Ltd., P.O. Box 50432, Tel–Aviv 61500, Israel).

(Oct. 21-25)—23rd Introductory Short Course on "Paint Formulation." Sponsored by University of Missouri-Rolla (UMR), Rolla, MO. (Norma Fleming, Sr. Continuing Education Coordinator, UMR, 119 M.E. Annex, Rolla, MO 65401-0249).

(Oct. 27-31)—ASTM Committee D-33 on Protective Coating & Lining Work for Power Generation Facilities Meeting. Cocoa Beach Holiday Inn, Cocoa Beach, FL. (Susan Canning, ASTM, 1916 Race St., Philadelphia, PA 19103-1187).

(Oct. 28-30)—"Advances in Polymer Colloids/Emulsion Polymers: Polymerization, Characterization, and Applications." Course sponsored by the State University of New York (SUNY). Orlando, FL. (Institute of Materials Science, SUNY, New Paltz, NY 12561).

(Oct. 28-30)—"Science and Technology of Coatings." Course sponsored by the State University of New York (SUNY). Orlando, FL. (Institute of Materials Science, SUNY, New Paltz, NY 12561).

(Oct. 28-Nov. 1)—"Fundamentals of Chromatographic Analysis." Short course sponsored by Kent State University (KSU), Kent, OH. (Carl J. Knauss, Director, Cooperative and Continuing Education, Chemistry Dept., KSU, Kent, OH 44242).

(Oct. 28-Nov. 1)—Ninth International Conference on "Photopolymers," on Oct. 28-30, and Fourth International Conference on "Polyimides," on Oct. 30–Nov. 1. Sponsored by the Society of Plastics Engineers, Inc. (SPE). The Nevele Country Club, Ellenville, NY. (Prabodh Shah, c/o SPE, Mid Hudson Section, P.O. Box 546, Hopewell Junction, NY 12533).

(Nov. 2-3)—"Coatings Science," mini-course. Sheraton Centre, Toronto, Ont., Canada. (Shelby Thames or Deborah Theisen, University of Southern Mississippi, Dept. of Polymer Science, Southern Station Box 10076, Hattiesburg, MS 39406-0076).

(Nov. 4-5)—"Electrochemical Impedance: Analysis and Interpretation." Symposium sponsored by ASTM Committee G-1 on Corrosion of Metals. San Diego, CA. (John R. Scully, Sandia National Labs., Org. 1834, P.O. Box 5800, Albuquerque, NM 87185).

(Nov. 4-6)—Specialty Plastics Conference '91. Sponsored by Maack Business Services. Hotel International, Zurich-Oerlikon, Switzerland. (Dawn Singer, Maack Business Services, Moosacherstrasse 14, CH-8804 Au/Zurich, Switzerland).

(Nov. 6-8)—POWDEX. Organized by Cahners Exhibition Group. Georgia World Congress Center, Atlanta, GA. (Angela Piermarini, Show Manager, Cahners Exposition Group, 1350 E. Touhy Ave., P.O. Box 5060, Des Plaines, IL 60017-5060).

(Nov. 7-8)—"Paint Volatile Organic Compounds." Course presented by ASTM, Toronto, Ont., Canada. (Kathy Dickinson, ASTM, 1916 Race St., Philadelphia, PA 19103).

(Nov. 8-12)—1991 International Surface Finishing & Coatings Exhibition (SF China '91) and the 1991 International PC Board Making & Electro-Chemicals Exhibition (PCB China '91). Shanghai Exhibition Center, Shanghai, P.R. China. (Sinostar International Ltd., 10A Harvest Moon House, 337-339 Nathan Rd., Kowloon, Hong Kong).

(Nov. 10-15)—1991 National Conference and Exhibition of Steel Structures Painting Council (SSPC). Long Beach Convention Center, Long Beach, CA. (SSPC, 4400 Fifth Ave., Pittsburgh, PA 15213-2683).

(Nov. 11-13)—"Fundamentals of Adhesion: Theory, Practice, and Applications." Course sponsored by the State University of New York (SUNY). New Orleans, LA. (Institute of Materials Science, SUNY, New Paltz, NY 12561).

(Nov. 18-22)—North American Research Conference on Crosslinked Polymers. Sponsored by the Division of Polymeric Materials: Science and Technology of the American Chemical Society. Marriott's Hilton Hotel Resort, Hilton Head, SC. (Angelos V. Patsis, Institute of Materials Science, State University of New York, New Paltz, NY 12561).

(Nov. 19-21)—14th Resins & Pigments Exhibition. Sponsored by the Oil & Colour Chemists' Association. The Paint Research Association's 11th International Conference on November 18-20. Brussels Exhibition Center, Belgium. (Jane Malcolm-Coe, PR & Publicity Manager, FMJ International Publications Ltd., Queensway House, 2 Queensway, Redhill, Surrey, RH1 1QS, United Kingdom).

(Nov. 20-21)—"Lithographic Printing—From Raw Materials to Waste Recycling—The Integrated Approach." International symposium sponsored by the Oil & Colour Chemists' Association (OCCA). Brussels, The Netherlands. (Yvonne Waterman, OCCA, Priory House, 967 Harrow Rd., Wembley, Middlesex, England HA0 2SF).

(Dec. 2-4)—"Electrochemical Techniques for Corrosion Measurement." Sixth annual symposium and refresher course sponsored by EG&G Princeton Applied Research. New Orleans, LA. (EG&G Princeton Applied Research, P.O. Box 2565, Princeton, NJ 08543).

(Dec. 2-6)—Fall Meeting of the Materials Research Society. Also, three short courses to be presented include: "Cementitious Materials," "Shape-Memory Materials," and "Biomaterials." Boston, MA. (Materials Research Society, Meetings Dept., 9800 McKnight Rd., Pittsburgh, PA 15237).

(Dec. 5)—Technical seminar on "Powder Coating." Sponsored by The Powder Coating Institute (PCI).Wilson World Hotel at DFW Airport, Dallas, TX. (PCI, 1800 Diagonal Rd., Ste. 370, Alexandria, VA 22314).

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(Feb. 18-20)—Hazardous Materials Management Conference and Exhibition/Northern California. San Jose Convention Center, San Jose, CA. (Tower Conference Management Co., 800 Roosevelt Rd., Bldg. E—Suite 408, Glen Ellyn, IL 60137–5835).

(Feb. 23-26)—Williamsburg Conference, "Comparison of Color Images Presented in Different Media." Co-sponsored by the Inter-Society Color Council and the Technical Association of Graphic Arts, Colonial Williamsburg, VA. (Milton Pearson, RIT Research Corp., 75 Highpower Rd., Rochester, NY 14623).

(Mar. 9-13)—PITTCON '92 Conference. New Orleans Convention Center, New Orleans, LA. (Pittsburgh Conference, Dept. CFP, 300 Penn Center Blvd., Ste. 332, Pittsburgh, PA 15235-5503).

(Mar. 17-18)—Electrocoat/92. Sponsored by *Products Finishing* magazine. Drawbridge Inn, Ft. Mitchell, KY. (Greater Cincinnati Airport Area). (Cindy Goodridge, Gardner Management Services, 6600 Clough Pike, Cincinnati, OH 45244).

(Mar. 24-26)—Surface Coating '92. Conference and Trade Show sponsored by Chemical Coaters Association International (CCAI). Indianapolis Convention Center, Indianapolis, IN. (CCAI, P.O. Box 54316, Cincinnati, OH 45254).

(Apr. 1-8)—Surface Treatment '92 Exhibition. Hannover Fairgrounds, Hannover, Germany. (Hannover Fairs USA Inc., 103 Carnegie Ctr., Princeton, NJ 08540).

(Apr. 5-10)—"Water-Based Coatings" Symposium. Sponsored by American Chemical Society, Division of Polymeric Materials: Science and Engineering. San Francisco, CA. (F. Louis Floyd, The Glidden Co., 16651 Sprague Rd., Strongsville, OH 44136, or John L. Massingill Jr., The Dow Chemical Co., Bldg. B-1603, Freeport, TX 77541).

(May 11-14)—Powder & Bulk Solids '92 Conference/Exhibition. O'Hare Exposition Center, Rosemont (Chicago), IL. (Cahners Exposition Group, Dept. Powder & Bulk Solids '92, 1350 E. Touhy Ave., P.O. Box 5060, Des Plaines, IL 60017-5060).

(June 1-4)—Fifth International Symposium on Polymer Analysis and Characterization. Inuyama Hotel, Inuyama City, Japan. (Howard Barth, Du Pont Co., Experimental Station, P.O. Box 80228, Wilmington, DE 19880-0228).

(June 14-18)—XXIth FATIPEC Congress. Amsterdam, The Netherlands. (General Secretary Francis Borel, 34 Chemin du Halage, La Bonneville, Mery sur Oise, France).

(June 15-17)—Euroformula '92. International Trade Fair. RAI International Exhibition and Congress Centre. Amsterdam, the Netherlands. (RAI, Europaplein, 1078 GZ, Amsterdam,the Netherlands).

(June 21-24)—ISCC 61st Annual Meeting and AIC 25th Anniversary. International symposium on "Computer Color Formulation." Princeton University, Princeton, NJ. (Danny Rich, ISCC Secretary, ACS Datacolor, 5 Princess Rd., Lawrenceville, NJ 08648).

(Oct. 25-30)—Fourth Corrosion and Protection Iberoamerican Congress and First Panamerican Congress on Corrosion and Protection. Mar del Plata, Argentina. (CIDEPINT, 52 entre 121 y 122, 1900 La Plata, Argentina, South America).

(Nov. 4–6)—'92 International Conference on Colour Materials. Sponsored by the Japan Society of Colour Material. Osaka Sun Palace, Expo Park Senri, Osaka, Japan. (S. Tochihara, Chairman of Executive Committee of the '92 ICCM, c/o Japan Society of Colour Material, Kitamura Bldg. 5F, 9-12, 2-chome, Iwamoto-cho, Chiyoda-ku, Tokyo 101, Japan).

Advertisers Index

'Humbug' from Hillman

The topic for this lesson, dear students, is "Stress and Why Learn to Love It." Since my move to the glorious countryside of Vermont, stress descends on me when I discover worms on the cauliflower plants and aphids on the tomatoes . . . or is it vice versa? They say it is impossible to remember pain and as time goes on it is becoming more and more difficult for me to remember what stress in the working place was really like. Libby says she remembers because she had to live it with me. It all came back to me, however, when I received a clip from that fine magazine, *Science,* sent to me by my old friend, the talented and, I hope, stress free Ruth Johnston-Feller.

In the article, "Stress For Success" written by Daniel E. Koshland, Jr., the anatomy of stress is examined in fine detail via an interview by *Science* with the esteemed and learned Dr. Noitall. *Science* extols Dr. Noitall as "the man who treats Atlas for lower back pain and the man who can see a bleeding ulcer without even a scanning electron microscope." I quote, in most part:

Science—Why should the modern office be more stressful than the jungle?

Noitall—What a stupid question. Take information transfer as a simple case. Can anyone operate a computer using the instruction booklet given by the company? Or assemble a scientific instrument after reading the operating instructions? In the good old days, there was the Ten Commandments—clear, simple, direct—they don't have writers like that anymore.

Science—But, surely, threats to life and limb were much greater in those days.

Noitall—That is exactly the problem. In the good old days, the boss had a cat-o'-nine-tails and job expectations were clear cut. After 12 hours a day at hard labor, no one had trouble sleeping. Today between psychiatric counseling, management techniques, sexual, political and disability harassment and truth in advertising, the terra ain't firma anymore.

Science—But at least modern jobs don't require much physical strength.

Noitall—What a silly thing to say. Have you ever tried to open one of those modern courier packages in tearproof plastic? I have seen grown men burst into tears after trying to open a little bag of peanuts.

Science—Do you believe there is a conspiracy to add stress to the American worker?

Noitall—Absolutely. There are certain unexplained phenomena that are clearly designed to create doubt in the rational mind. For example, bill forms that are too big to fit into the envelopes provided must be a CIA plan to create vulnerability. Then dressing for work is a major pressure point. Wearing a tie classifies you as being too old and a mini skirt as being too young. Jeans are too devil-may-care and a gray flannel suit is too conservative . . . A worker in Michigan was arrested for bringing blasting caps to the office to open an aspirin bottle, but was aquitted when the jury found there was no other method.

Science —How does the stress in other countries compare to that here?

Noitall —All our stress indicators, such as the low number of psychiatrists per capita, indicate that people in other countries are more relaxed. We have found one country without ozone, asbestos, health insurance problems, power lunches, or complaints to OSHA, and we have sent stress experts to learn why they don't have U.S. anxieties.

Science —Could I ask the identity of this country?

Noitall —Of course. Bangladesh.

Dr. Noitall has mentioned some of the key elements of the causes of stress. Recognizing them and learning to laugh at them while going down in flames is essential to the enjoyment of stress. Take management techniques, for example. I can remember when "Management by Objectives" replaced the cat-o'-nine-tails for whipping the ranks in line. Management was by the managed rather than by the managers. The boss, one up in the line, pontificates, "You promised to exceed last January by 10% and you only increased by 7.654%. For shame, here we allow you to set your own goals and look what happens!! No appreciation!"

Or—take the "What Have You Done For Us Lately" technique—and you can have it. "In 1988 you increased sales by 15%. In 1989, you increased sales by 22%, but look at 1990, your increase was only 8%. You're slipping, friend. We fear that you will have to be replaced if you don't get your act together again. Don't you understand what I'm saying? You're not trembling enough."

If you don't learn the excitement of loving stress, it is important to learn how to deal with it. Psychiatrists say that one way is to find some poor soul who'll listen and talk your heart out. But then:

I lend a sympathetic ear
To other people's woes
However dull it is to hear
Their real or fancied throes
I pay attention to every gloomy line
Attention undiminished.
Because I plan to start on mine
The moment theirs are finished.
—The Lion

Found in Ron Alexander's "Metropolitan Diary" in an old and yellowing issue of the *New York Times*:

Overheard in the downtown Seventh Avenue subway one recent Monday evening, one woman to another.

Woman One:	Want to go to a movie tonight?
Woman Two:	Nah. I'm going to watch TV.
Woman One:	So what's on that's so good.
Woman Two:	Mother Theresa at 9. Cher at 10.

—Herb Hillman
Humbug's Nest
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Color Origins