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JOURNAL OF COATINGS TECHNOLOGY

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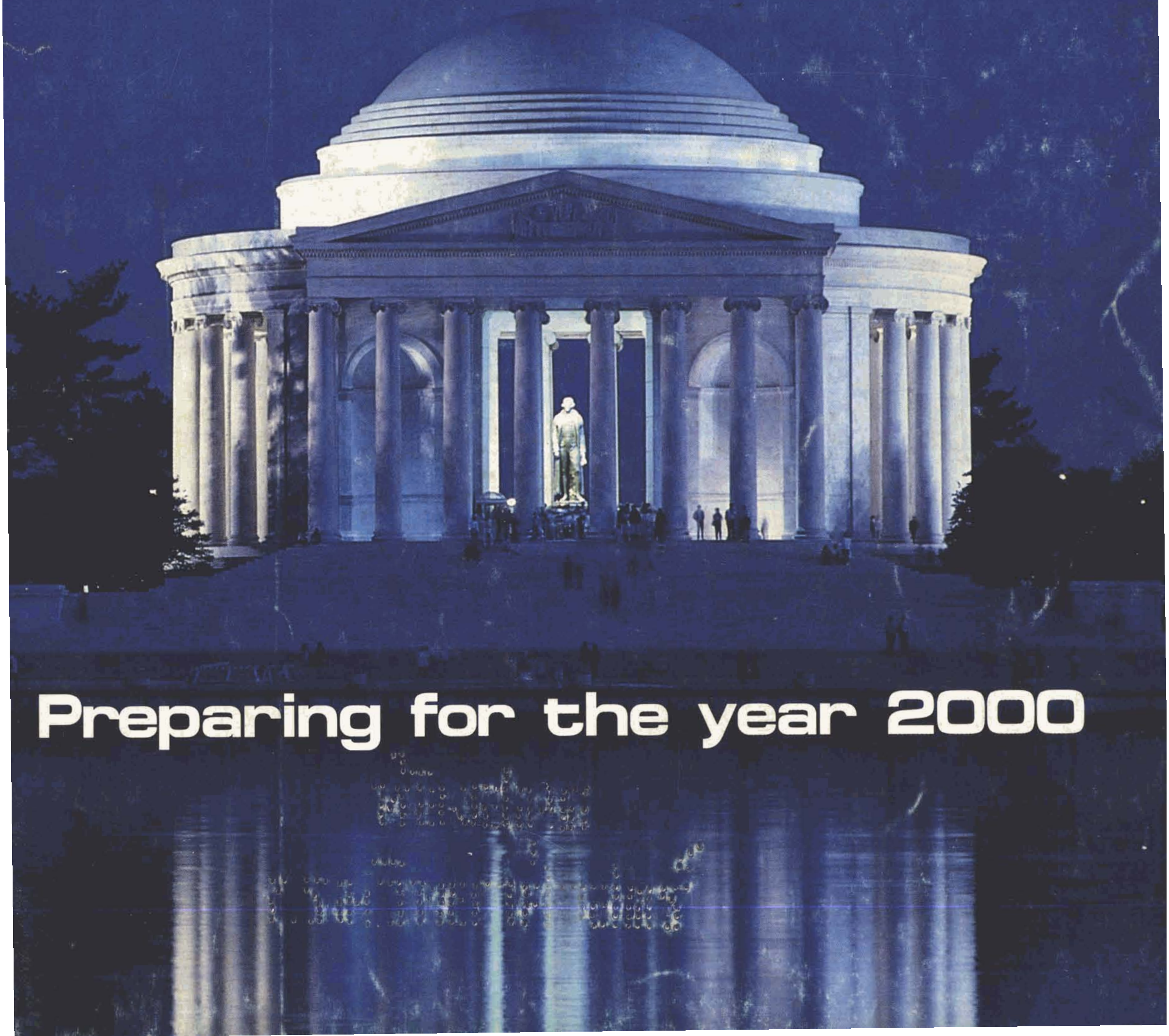
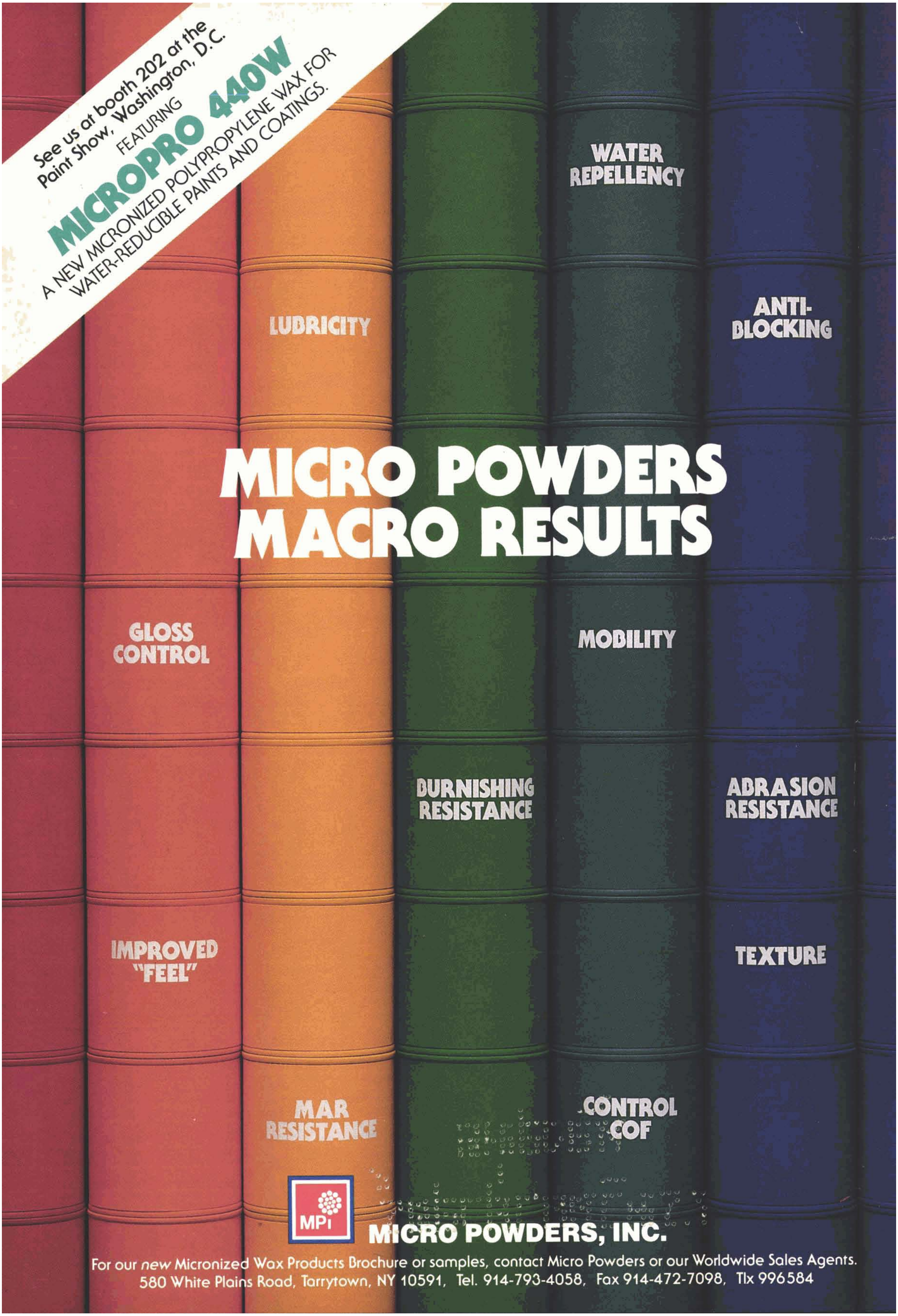
October 1990

Annual Meeting & Paint Show Issue

A Decade of Decision:



Preparing for the year 2000



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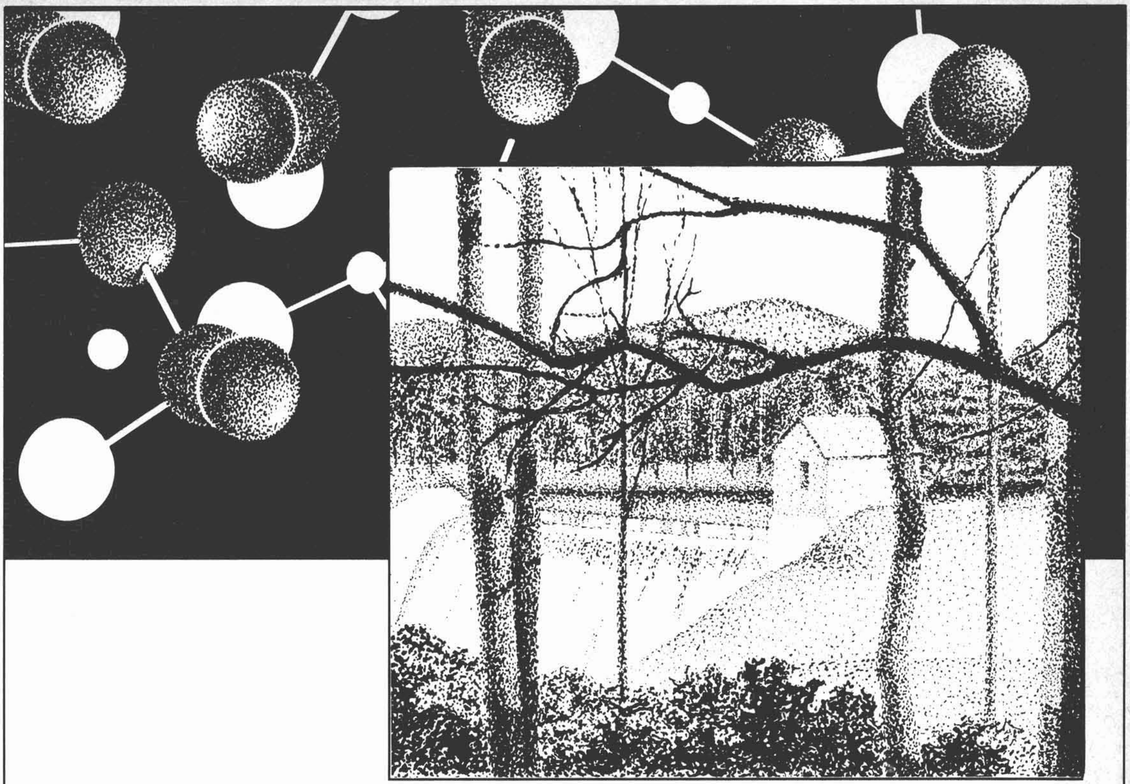

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OCTOBER 1990

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VOLUME 62 NUMBER 789

Technical Articles

87 Water Sensitivity of Cast Calcium Carbonate Filled Acrylic Acid Terpolymer Films — R.J. Ruch et al.
95 Optimum Particle Size of Titanium Dioxide and Zinc Oxide for Attenuation of Ultraviolet Radiation — P. Stamatakis et al.
101 Comparison of Methods for the Preparation of Acetoacetylated Coating Resins — J.S. Witzeman, W.D. Nottingham, and F.D. Rector
115 Electropaint-Substrate Interactions — C.K. Schoff
125 A European Approach to UV Protection with a Novel Pigment — R.F. Sharrock
133 Performance Comparison of Exterior Finishes on Hardboard Siding — Kansas City Society for Coatings Technology

Federation News

19 1990 FSCT Annual Meeting Program
30 Annual Meeting Program Abstracts
56 Current 1990 Paint Show Exhibitors
62 Paint Industries' Show Floor Plan
64 Exhibitors Listed by Product/Service Classification
78 Federation Meetings and Other Events/Spouses Information
80 Annual Meeting and Paint Industries' Show Additional Highlights

Departments

Comment 7 So Long, Philadelphia; Hello, Blue Bell!
Abstracts 10
Government and Industry 13
Regulatory UPDATE 17
JCT Guide for Authors 84
Society Meetings 143
Future Society Meetings 144
People 145
Obituary 147 Albert J. Kirsch, John M. Thomas, and George A. Keim
CrossLinks 148 Solve the October Puzzle
Meetings/Education 149 Latest Advances in Coatings Science and Technology Focus of Conference Scheduled December 3-7
150 Louisville Society Co-Sponsors Surface Coatings II Course
Literature 153
Letters to the Editor 155 "Fineness of Grind Conversion Scale"
Book Review 157 "Painting of Steel Bridges and Other Structures"
Coming Events 159
Humbug from Hillman 162 "And Now Let Us Pray"

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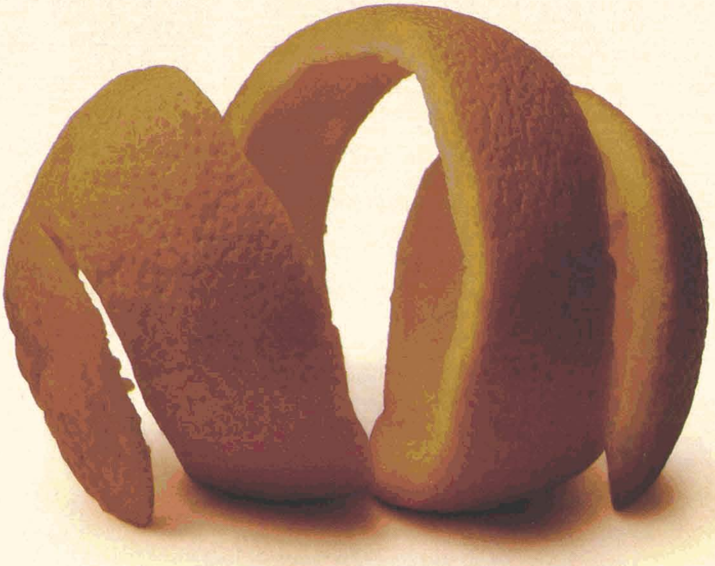

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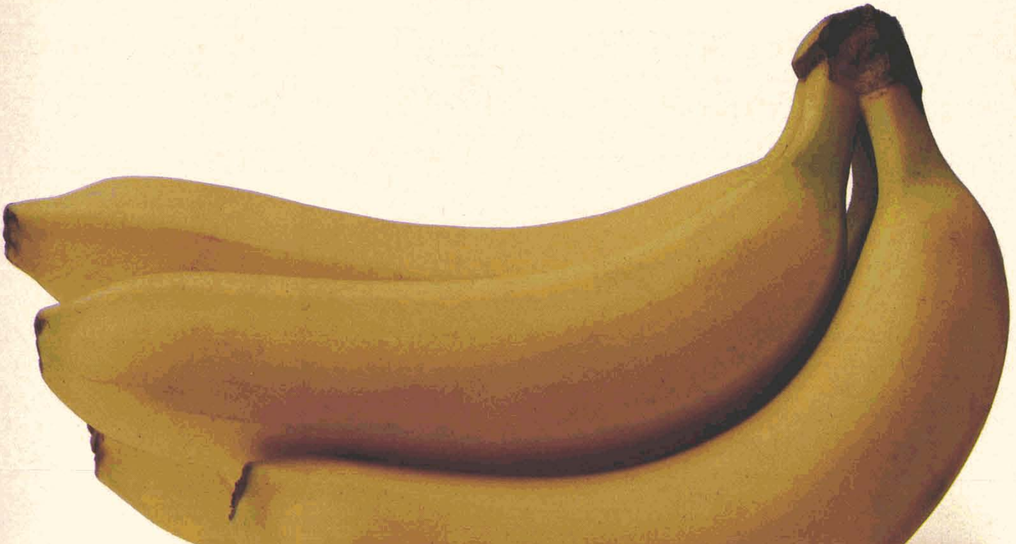

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Comment

So Long, Philadelphia; Hello, Blue Bell!

It is with great pleasure that I announce the relocation of the Federation Headquarters to its new offices in the Philadelphia suburb of Blue Bell, PA, on Monday, September 10.

Although the particulars about the building have been mentioned in this space several times before, they are worth repeating one more time: located at 492 Norristown Rd., about 15 miles NW of Center City Philadelphia, adjacent to major highways and Pennsylvania Turnpike, the office is a two-story building of 9,500 sq. ft., with 5,000 sq ft. of basement storage, FSCT will use three-quarters of the space and lease the remainder.

Those, quite simply, are the details. However, the actual move into the new offices this past week was anything but simple. Packing and then unpacking the several hundreds of cartons needed in the move, fine-tuning the telephone and computer systems, and generally getting used to the new location has filled the days (and sometimes evenings) with new challenges.

But, without exception, the Staff has come to view the new headquarters as "home." The offices are everything we had hoped they would be—and more.

We extend our sincere thanks to the Board for their foresight in approving the relocation. Although Philadelphia has served well for the FSCT in years past, it has become increasingly apparent that the city is experiencing social as well as financial problems. The timing of the move was excellent.

We especially thank the Ad Hoc Building Committee for its dedication and perseverance in, first, locating just the right spot and then following through on the many details needed to ensure that the Federation's new headquarters was first-class. Chairman Jim Geiger and his committee members, Jim McCormick, John Oates, Deryk Pawsey, and Colin Penny, spent long hours over the past $1^{1}/_{2}$ years in visiting the sites and meeting with realtors and developers.

Of course, the new headquarters building would mean little without the 15 exceptional persons who work there. The Federation Staff was asked to make the move while in the middle of final preparations for the Annual Meeting and Paint Show. As usual, they took everything in stride and with as little disruption as possible. They are a fine group of professionals.

An invitation is extended to any and all to visit our new headquarters and see for themselves how the challenge is being met by the Federation.

Robt F. Ziegler

Robert F. Ziegler,
Executive Vice President

When a bear cub is born to a she-bear during the mother's winter sleep, it may only weigh ½ to 1 pound. Cubs emerge from the den in the spring and can weigh 40 pounds by autumn. They stay with their mother for 1 to 2 years. They're strong, intelligent and learn and grow quickly.

Then they go off on their own.

AFTER TWO YEARS OF HEALTHY GROWTH, WE'RE READY TO STRIKE OUT ON OUR OWN. In today's harsh competitive environment, most new businesses have a hard time just surviving. But since the Sherex Polymers Group was created in 1988 by Sherex Chemical Company, we've thrived—with 25% sales growth last year alone. ☐ Now we're ready to go our own way as a brand-new company: Schering Berlin Polymers. ☐ As Schering Berlin Polymers, we'll have the global

backing of Schering AG, Berlin · West Germany, to continue providing high-performance resins and polymer chemicals for customers throughout North America. ☐ Meantime, Sherex will now concentrate more fully on its core business: using natural oleochemicals to solve challenging problems. ☐ It's a big step for both of us. But a natural one. ☐ After all, it's easier to succeed when you have your own territory.

SCHERING BERLIN
Polymers

Abstracts of Papers in This Issue (continued)

region or the ultraviolet component of ordinary fluorescent lighting. With the diminished ozone layer, even more UV radiation from the sun is projected to reach the earth in the years ahead.

Through the action of light, the lignin in wood is decomposed on the surface, which leads to the destruction of the cell structure; thus, greatly increasing the uptake of water, which in turn leads to cracking and other damage.

Traditional UV absorbers have served the industry well over the years, but resin technologies, more demanding coatings requirements, and the ever-increasing use of water-borne and high-solids coatings have pushed them to the limit.

This paper discusses a European solution to UV protection in water-borne, as well as, traditional solvent based coatings, and suggests the use of a novel pigment that provides UV protection. Because of its inorganic nature, this pigment is judged to be superior in many respects to traditional organic compounds. The evaluation of several UV absorbers, their properties, and performance characteristics in thin films will be described in some detail. Typical European formulas and raw materials are provided.

PERFORMANCE COMPARISON OF EXTERIOR FINISHES ON HARDBOARD SIDING—Kansas City Society Technical Committee

Journal of Coatings Technology, 62, No. 789, 133 (Oct. 1990)

A 40-month exposure study on the performance of exterior flat and satin coatings on various medium density hardboard siding substrates has demonstrated a significant improvement in both substrate protection and coating performance with two- and three-coat systems versus a single topcoat application.

Individual coating and substrate tests were also run to predict potential exposure failure. Coatings tested utilized poor to good wet adhesion emulsion and oil/alkyd resin topcoats in combination with oil/alkyd and latex primers. Coating systems were evaluated over 18 unprimed and factory preprimed hardboard substrates of varying density, swell, and moisture absorption tendencies.

Best overall performance was obtained over oil/alkyd primed substrates with all acrylic or acrylic terpolymer topcoats. The poorest performance was obtained where a single coat of topcoat was utilized without a field applied primer.

SPECIAL ISSUE NOTICE

January '91 Issue

The January 1991 issue of the *Journal of Coatings Technology* will feature highlights of the 1990 Annual Meeting and Paint Industries' Show in Washington, D.C., October 29-31. This Wrap-up Issue will feature information on all exhibitors, with emphasis on products and special booth features; photo displays of award-winning booths; as well as a complete review of important Annual Meeting and Paint Show happenings.

68th Annual Meeting & 55th Paint Industries Show
FSCT
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Washington, D.C.
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Abstracts of Papers in This Issue

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NPCA Announces Forum Sessions and Speakers For 103rd Annual Meeting, in Washington, D.C.

The National Paint and Coatings Association (NPCA), Washington, D.C., has announced the speakers for the forum sessions to be held during its 103rd annual meeting, in Washington, D.C., on October 31-November 2.

The sessions will deal with several aspects of doing business in the 1990s and beyond, in keeping with the meeting theme, "Destination 2000."

Scheduled forums and featured speakers include:

"Environmental Pressures on Business in the 1990s"—Kevin Phillips, political writer and commentator;

"Competing in the International Arena"—panel discussion with experts representing the Export-Import Bank, United Nations International Development Organization, World Bank, and U.S. Department of Commerce;

Regulatory Update Breakfast—NPCA staff representatives will discuss vital industry issues;

"Decade of the 90s: Global 2000"—Robert Evans, futurist;

"Economic Outlook and Overview of the Paint and Coatings Industry"—Richard Marcotulli, of American Cyanamid Corporation;

"Waste Source Reduction: Harvesting the Profits of Environmental Responsibility"—Charles Rooney, of Orr & Boss; and

"Strategy 2000: Reaching for Technological, Market, and Economic Success"—Walter McDonald, of The McDonald Group.

Also, NPCA has announced that Tom Noon, of Industry Insights, Inc., will address a Small Paint Manufacturers Breakfast session, during its annual meeting. Mr. Noon's topic is "Managing for Higher Profits: Putting the NPCA Operating Cost Survey to Work for You."

The presentation will give paint manufacturers information on how to better utilize data from NPCA's Operating Cost Survey as a profit management tool.

Industry Insights works closely with NPCA's Management Information Committee in compiling the Survey, as well as the association's monthly sales index.

Akzo Acquires 51% Interest In Turkish Coatings Company

Akzo, The Netherlands, has acquired a 51% interest in Kemipol, a Turkish coatings producer. The agreement took effect on August 1.

The joint venture is to be known as Akzo Kemipol AS. Akzo will contribute capital and technology in the field of automotive and other industrial coatings to the venture.

Akzo Kemipol will concentrate its efforts on the industrial coatings market in Turkey.

Kemipol AS is headquartered and has modern production facilities in Izmir. Sales offices are located in Istanbul, Ankara, and Adana.

Kemipol employs approximately 175 people and supplies industrial coatings, including automotive finishes.

Du Pont and Kansai Paint Form Coatings Company To Serve Japanese and Korean Automakers

Du Pont, Troy, MI, and Kansai Paint Company, Japan, have formed a joint venture to supply coatings to Japanese and Korean automakers and their parts suppliers with operations in North America. The deal was effective August 1.

The new venture is called Du Pont-Kansai Automotive Coatings Company. It is the first North American venture between American and Japanese automotive finishes suppliers.

The new company will develop and market original equipment (OEM) finishes, as well as provide customer technical service. Products and technology licensed or sold through the venture will include primers, surfacers, topcoats and clearcoats, and finishes for the automakers' component suppliers.

Du Pont will own 60% of the company, and will provide research, technical service, and manufacturing for Canada, Mexico, and the United States Kansai will own the remainder and provide marketing and technical support in Japan.

Initially, the new company will have approximately 120 employees.

H. Nelson Furman has been named President of Du Pont-Kansai. Formerly, he was Business Manager—International Accounts for Du Pont's OEM finishes business. Executive Vice President of the new company is J. Ishiwatari, who served previously as President of Kansai Paint (America) Inc.

Battelle Completes Packaging Materials Study

Battelle, Columbus, OH, has released a report which predicts that more plastics are to be used in packaging in the future. The "Packaging Materials and Processes for the Future" study is the result of a multiclient program completed by Battelle.

The study identifies materials and processing methods with the greatest potential impact on materials suppliers, package converters, and package users during the 1990s.

The report focuses on identifying and describing more than 40 materials and processes of the future. According to officials at Battelle, 75% of those materials are plastics using various polymer combinations.

Selected developments in glass, metals, and quartz-like coatings also are described in the report.

The study analyzes the concerns of the industry, including: solid-waste issues; demand shifts based on changing demographics; changes in production methods related to automation; labor problems and trends; and corporate consolidations and restructuring.

The report also discusses basic functions of packaging which includes product containment, protection, storage and distribution, merchandising, and consumption. Development trends such as aseptic, microwave, modified-atmosphere, and tamper-evident packaging are analyzed in the study.

Thirty-five companies—21 American, seven Japanese, and 7 European—have subscribed to the program. The 300-page report is available to interested companies at a cost of $9,800.

More information about "Packaging Materials and Processes for the Future" is available from Joseph Wray, Battelle, 505 King Ave., Columbus, OH 43201-2693.

Dexter Corporation Purchases Storalene AB; New Delivery Fleet Services Packaging Division

The Dexter Corporation, Windsor Locks, CT, has finalized the purchase of Storalene AB, Sweden, formerly the nonwovens subsidiary of Stora Kopparbergs Bergslags AB, Sweden.

The acquisition was subject to approval by the Swedish government.

Storalene AB will be operated by its present management as part of the Dexter Nonwovens Division, headquartered in Windsor Locks. The company will be known as Dexter Nonwovens AB.

The division serves food packaging, medical, and industrial customers.

In other news, Dexter's Packaging Products Division now operates its own bulk delivery fleet of custom-designed tanker trucks. The fleet is based at the division's principal U.S. manufacturing center in Birmingham, AL.

The delivery trucks are dedicated solely to Dexter Packaging Products interior food and beverage can coatings.

The Packaging Products Division produces protective interior and exterior coatings and end sealants for beer, soft drink, and food cans; coatings for glass container closures and flexible packaging; adhesives for microwavable packaging; and adhesive primers for construction materials.

New Weathering Laboratory Opened by Q-Panel Company

The Q-Panel Company, Cleveland, OH, has expanded their testing services facility to include a new 1,500 sq ft laboratory.

The new lab is dedicated to accelerated weatherability testing. Twenty-five Q-U-V Accelerated Weathering Testers are available for weathering research and contract testing.

Q-Panel develops data on the correlation between natural and accelerated weathering.

Arco and Sumitomo Chemical Plan Capacity Expansions

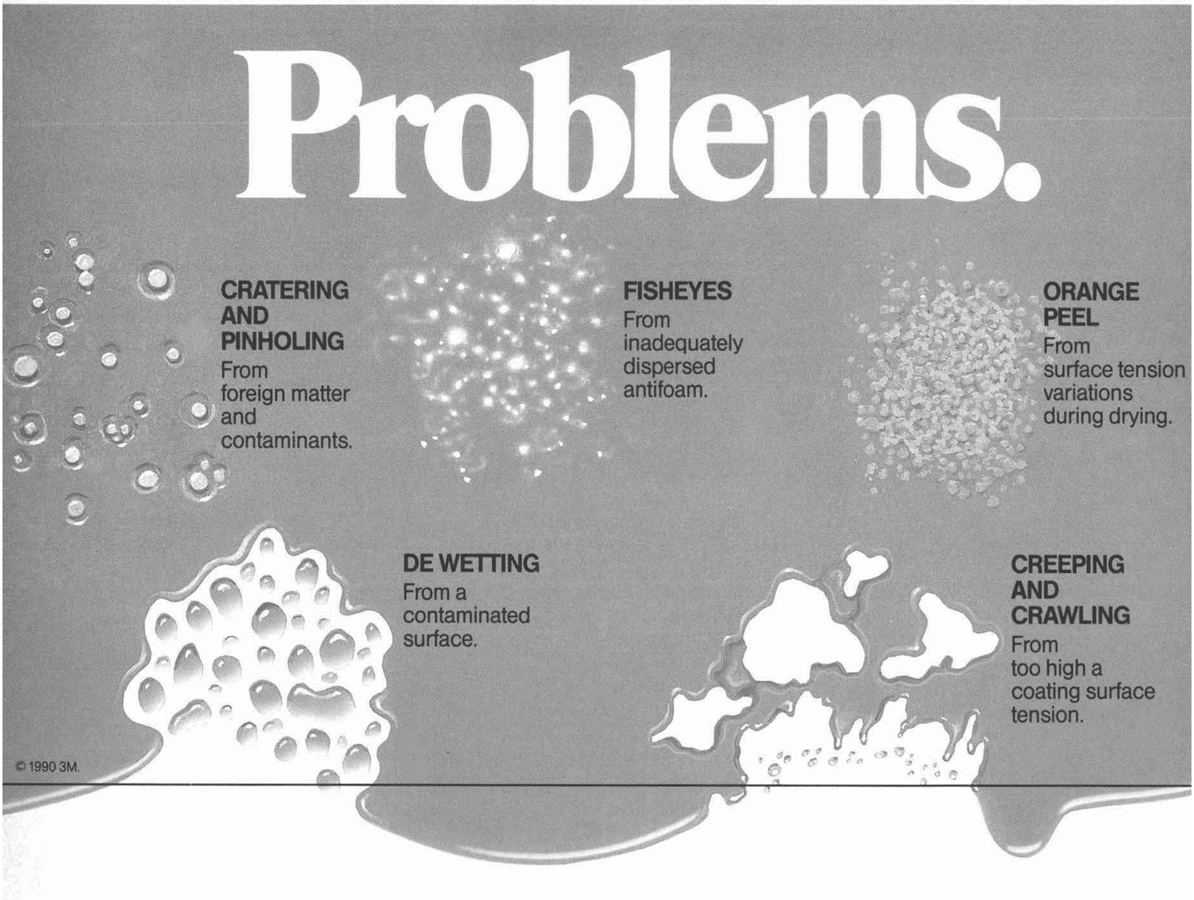
Two capacity expansions of propylene oxide and styrene monomer have been jointly announced by Arco Chemical Company, Newtown Square, PA, and Sumitomo Chemical, Japan. The expansions will take place through their joint venture, Nihon Oxirane.

Both expansions are at the joint venture's Chiba facility.

The first expansion of 10,000 metric tons of propylene oxide and 25,000 metric tons of styrene is scheduled to be on stream by this quarter. The expansion will bring Nihon Oxirane's annual rated capacity to 140,000 metric tons of propylene oxide and 335,000 metric tons of styrene.

Another expansion, currently under study and subject to final board approvals, is planned to be on stream in 1993. This capacity expansion would increase Nihon Oxirane's annual rated capacity to an estimated 200,000 metric tons of propylene oxide and 450,000 metric tons of styrene.

Nihon Oxirane uses Arco Chemical's proprietary propylene oxide/styrene monomer co-product technology.



Akzo Coatings Inc. Opens New Automated Paint Facility in Pontiac, MI

Akzo Coatings Inc., Louisville, KY, has announced the completion of a new, state-of-the-art paint plant in Pontiac, MI.

The facility utilizes technologically-advanced computer and processing equipment to produce Akzo's Sikkens brand car refinish products, including basecoats and clearcoats, isocyanate-free topcoats, and hardeners.

The plant's 24,000 sq ft manufacturing area features sophisticated plant-wide control and information systems.The system provides state-of-the-art multi-product, multi-batch real time control of the plant.

The most critical phase of the information control process provides computerized batch information to a special additive dosing system that measures the bulk raw materials by exact weight.

The information system enables operators to control simultaneously multiple batches as well as generate statistical process control information in real time.

The facility also contains an automated filling line, a plant-wide spill containment system, process tanks that operate under an inert atmosphere, and a statistical process control system in place.

Akzo Coatings Inc. is part of the Coatings Division of Akzo.

Clawson Tank Constructing New Headquarters Building

Clawson Tank Company, Clarkston, MI, has announced that construction is underway for a new headquarters building in Springfield Township, near Clarkston.

The headquarters will be a 16,000-sq ft, two-story, brick structure on five acres in which Clawson will consolidate engineering, sales, accounting, and administration functions.

Clawson manufactures storage and shipping containers ranging from 50,000-gal underground storage tanks to portable/stackable shipping containers in the 150- to 570-gal capacities.

Rohm and Haas Agrees to Purchase DeSoto Plant

Rohm and Haas Company, Philadelphia, PA, has announced that it has agreed in principle to purchase the Chicago Heights, IL, plant of DeSoto, Inc. from the Sherwin-Williams Company.

The transaction will take place upon completion of the sale of DeSoto's consumer paint business to Sherwin-Williams.

The Chicago Heights operation currently manufactures both paint and latex emulsion polymers.

Following the sale, Rohm and Haas will manufacture latex emulsions at the site, while The Sherwin-Williams Company will continue to operate the paint production facility.

Terms of the agreement, which are subject to regulatory approval and certain other conditions, were not disclosed.

Solutions.

Ironically, the worst time to try to solve a problem is when you have a problem. At 3M, we've developed a program which helps you eliminate coatings problems before they occur by incorporating our fluorochemical additives.

We'd like to send you a free 6-pack of our coatings additives. These free samples will give you a chance to use the right solutions the first time, so you'll see your problems for the last time.

For information on 3M surfactants and details on how to get your free 6-pack sampler, please write: Fluorad™ Coatings Additives, 3M Industrial Chemical Products Division, 3M Center Bldg. 223-6S-04, St. Paul, MN 55144-1000.

Innovation working for you™

3M

DeSoto Sells Coatings Businesses to British Group; Domestic Consumer Paint Business to Sherwin-Williams

DeSoto, Inc., Des Plaines, IL, battling to fend off a hostile takeover bid from a New York investment group, announced the tentative sale of its industrial coatings, surfactants, and emulsifier businesses to a consortium led by a British company.

In a separate deal, DeSoto announced it has entered into a definitive agreement for the sale of its domestic consumer paint business to the Sherwin-Williams Company, Cleveland, OH, for an estimated $80 million. Sears is the biggest single customer for DeSoto's domestic architectural paint operation.

DeSoto also was negotiating the sale of certain thickener technology.

DeSoto signed a definitive agreement for the sale of its industrial coatings businesses to Courtaulds plc of the United Kingdom for $135 million. Courtaulds, in turn, plans to sell certain segments of the industrial coatings operations to DSM Resins B.V., The Netherlands, and The Valspar Corporation, Minneapolis, MN.

Witco Corporation, New York, NY, signed an agreement to purchase DeSoto's surfactant and emulsifier lines and facilities.

In a statement, DeSoto said it will retain, for the present, its household detergent businesses and plants.

The sales, which are subject to stockholder and regulatory approval, were approved at a special Board of Directors meeting on July 10. The sales are expected to net the company $280 million in proceeds, subject to adjustments, before taxes and debt repayment.

The announcements follow a lengthy DeSoto struggle to fend off a hostile takeover bid from Sutton Holding Corporation, a New York investor group.

DeSoto plans to distribute "substantially all" of the net proceeds of the sales, after adjustments for taxes and repayment of outstanding debt, to stockholders shortly after the transactions are final. That distribution is expected to total about $145 million, following liquidation of certain working capital, taxes, and costs related to the transaction.

DeSoto announced that the sales are part of a plan of partial liquidation. Stockholders will be able to treat distributions from the sales as returns of capital to the extent of most of their tax basis in their stock.

The company said net proceeds from any sales of associated thickeners and domestic paint businesses also will be distributed to stockholders.

In addition, DeSoto plans to distribute to stockholders approximately $28 million, the after-tax funding in the company's retirement plans.

Under the sales agreements:

Courtaulds plc will acquire DeSoto's aerospace and paper coatings businesses and a Berkeley, CA, plant; DeSoto Coatings Ltd. of Canada; and two foreign subsidiaries, DeSoto Titanine plc of Britain and DeSoto Far East in Singapore.

Courtaulds plans to sell DeSoto's radiation cure business, including its optical fiber coatings operation and Elgin, IL, plant to DSM Resins, which has had joint venture agreements with DeSoto for 25 years. DSM Resins also will get DeSoto's 50% stake in Japan Fine Coatings.

Valspar will acquire DeSoto's coil coating business, its appliance coating, and package coating businesses, along with a Garland, TX coatings and resins plant, and test fence sites in Marengo, IL, and Fort Myers, FL, for $46 million in cash.

Witco will acquire DeSoto's surfactant and emulsifier businesses and plants in Harahan, LA, and Ft. Worth, TX.

Sherwin-Williams will acquire DeSoto's consumer paint business, including plants in Chicago Heights, IL, Columbus, OH, Greensboro, NC, and Orlando, FL, and leased warehouses in Bakersfield, CA, and Lancaster, PA.

DeSoto will continue to operate its detergent business and plants located in Joliet, IL, Union City, CA, and Stone Mountain and Columbus, GA. The detergent business had revenues of $72.6 million in 1989.

Unicarb™ System Licensed to Graco and Nordson

Union Carbide Chemicals and Plastics Company Inc., Danbury, CT, has licensed its new Unicarb™ System coating technology to Graco, Inc., Minneapolis, MN, and Nordson Corporation, Westlake, OH.

The Unicarb System is designed to reduce emissions of volatile organic compounds.

According to officials at Union Carbide, Graco and Nordson, as licensed suppliers, will be tasked with developing, manufacturing, and marketing specially designed Unicarb system equipment.

Graco supplies technology and expertise for the management of fluids for both industrial and commercial applications.

Nordson supplies equipment and systems for applying protective and decorative coatings to wood, metal, and plastic products. The Unicarb System developed by Nordson includes delivery systems and specially designed electrostatic and non-electrostatic spray guns.

Both Graco and Nordson join Unicarb System licensees who will supply equipment and coatings to the automotive, wood and metal furniture, heavy equipment, appliances, aerospace, and truck and bus markets.

Engelhard to Retain Gold and Silver Businesses

The worldwide gold and silver businesses of Engelhard Corporation, Edison, NJ, will not be sold to Degussa AG as previously announced on March 15.

Engelhard will sell certain North American operations and retain its European operations, both of which produce products based on gold and silver.

According to sources at Engelhard, the company will continue to operate those gold and silver product and refining businesses that complement their existing worldwide platinum group metal fabrication operations.

Also, sources have reported that Engelhard will attempt to sell its North American electrical contacts, metal joining, and jewelry operations in Plainville and Mansfield, MA, Warwick, RI, and Aurora, Ont., Canada. The company will continue to serve the North American market with its electronic and decorative chemicals, platinum group metal products, and precious metal refining.

Engelhard is provider of specialty chemical products, engineered materials, and precious metal management services.

Unocal Chemicals Division Recognized for Safety Record

The Lammot du Pont Safety Award for 1990 was awarded to the Petrochemical Group, Unocal Chemicals Division, Schaumburg, IL. The award was presented recently at the annual meeting of the Chemical Manufacturers Association (CMA), in White Sulphur Springs, WV.

The Lammot du Pont Award is given to the member company which most improves its safety record over a five-year period, and which maintains a safety record better than the chemical industry average.

The award is bestowed to recognize safety achievement, and to inspire CMA member companies to greater efforts in promoting industrial safety.

Regulatory UPDATE

OCTOBER 1990

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.

Transportation—Hazardous Materials Transportation Reauthorization—The House Public Works Subcommittee on Surface Transportation has approved a substitute for H.R. 3520, the Hazardous Materials Transportation Act Reauthorization (HMTA). H.R. 3520 has been cleared by the House Energy and Commerce Committee.

As passed by the Energy Committee, H.R. 3520 contains strict language pre-empting state laws and regulations that conflict with Federal HMTA laws. The bill also contains federal guidelines for routing and new placarding requirements. Controversial language actively pushed by Rep. Douglas Applegate (D-OH) requiring a computerized product identification system for all hazardous materials shippers has so far been kept out of both versions of H.R. 3520. (The Applegate amendment would require all shippers and carriers of hazardous materials to provide data on every shipment to a central computer at an estimated cost to industry of over $10 per shipment). As an alternative to Applegate's amendment, the Mineta substitute instead calls for a "needs assessment" study to by conducted by the National Academy of Sciences. Simultaneously, the Department of Transportation is to issue a proposed rule on product identification. Congress will review both the study and the proposed rule before making any significant changes.

The Senate Commerce Committee also approved legislation to reauthorize the HMTA (S. 2963). This bill requires DOT to conduct a one-year study on product identification and placarding. Unlike H.R. 3520, the Senate bill's federal pre-emptive language over state and local laws is non-specific.

Because the HMTA bills are still too controversial, chances of passage in the end-of-the-year crunch package is very unlikely.

Backhauling—Backhauling legislation is a more volatile issue than the reauthorization of the HMTA, primarily because it is a "panic" issue generated by an onslaught of concentrated, negative publicity. Although not considered a big ticket item on the remaining agenda, the probability of this issue becoming law before Congress adjourns is quite good.

The Sanitary Transportation of Food Act, H.R. 3386 (Clinger R-PA) passed the full House by a vote of 410-15 in March. The bill requires the Department of Transportation, in consultation with several other agencies, to set standards for what materials can be shipped in trucks and rail cars that are used to haul food. Cargo tanks that haul ultrahazadous materials such as asbestos would be barred from carrying food, and refrigerated trucks would be barred from shipping garbage and hazardous materials.

The bill was immediately received in the Senate and referred to the Commerce, Science and Transportation Committee. The Senate introduced its own version of backhauling legislation on June 13, S. 2393 (Exon, D-NE), which incorporated much of the language from H.R. 3386. The Senate bill, now a combination of both Senate and House bills, by-passed committee mark-up and was placed directly on the calendar for a floor vote, indicating the intention to act expeditiously.

Waste Reduction—Legislation that encourages industry to prevent environmental pollution by reducing hazardous waste at the source has been passed by the full House.

The legislation requires that the Environmental Protection Agency (EPA) establish an office independent of other EPA program offices to develop and implement a strategy to reduce the production of hazardous wastes. Among the responsibilities would be coordination of information collected about activities of companies regulated under Section 313 of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). In addition to the information those companies already submit to EPA, they would be requested to add data on efforts to reduce chemical waste.

The bill also establishes a matching grant program to fund state waste reduction programs that provide to businesses specific technical assistance, and provide training in waste reduction techniques through local engineering schools or other appropriate means.

The Senate companion bill (S. 585) is still waiting for action by the Environment and Public Works Committee.

Clean Air—The Clean Air Conference Committee is expected to ratify a tentative agreement on new requirements for nonattainment, effectively completing their third clean air title. House and Senate staff members have worked out an accord that basically adopts the more comprehensive House provisions.

Under the agreement, even small businesses such as dry cleaners and automotive paint plants would be required to install new control equipment in areas where pollution is severe. The new requirements are more stringent than those

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

spelled out in the Senate bill in that more businesses in a greater number of communities will be required to comply.

The Bush Administration opposes the stronger language stating that if small companies are forced to install the new smog-control equipment, the legislation would become to costly. Environmentalists, on the other hand, have little sympathy for small companies arguing that in many urban areas, they account for close to half of the pollution problems. While the Senate bill had no requirement for federal oversight, the new agreement maintains the House provision for federal intervention should cities fail to meet their own air pollution control plans.

The Conference Committee moved very quickly on the nonattainment portion of the bill, leading speculators to believe they will indeed pass the legislation before the October 5 adjournment target. However, there are still a few remaining controversial issues such as employment compensation for those who loose their jobs because of the new restrictions on factories and utilities. Those problems, coupled with the struggle for a balanced budget and the crisis in the Persian Gulf, may force Congress to put off passing the Clean Air Act until either a lame duck session, or even next year.

Indoor Air Quality—The Indoor Air Quality Act, H.R. 1530 (Kennedy D-MA), and S. 657 (Mitchell D-ME), introduced earlier this year, would provide $48.5 million a year for five years for researching and monitoring indoor air quality. Action on the Senate bill is still possible this year as S. 657 has been reported by the Environment and Public Works Committee and currently pending on the Senate floor.

It is difficult to predict whether or not the House bill will move because it has been sequentially referred to three different committees. The Science, Space and Technology Committee has marked up and reported the bill, but no action has been taken by the Energy and Commerce Committee, or the Education and Labor Committee.

Superfund—The Superfund Program is due for reauthorization in 1991. Oversight hearings were to begin this fall, but have yet to be scheduled, and a complete restructuring of the program could begin as early as next spring.

Meanwhile, on the Hill, bills have been introduced in both Houses of Congress (Garn S. 2827) and (LaFalce H.R. 4494) that would relieve lenders from any liability when they foreclose on contaminated property. The U.S. EPA is aware of a problem regarding the interpretation of the "innocent landowners" exemption in the statute, but would prefer to address the problem through rulemaking, rather than trying to change the law. It is very unlikely that these measures will see any action primarily because key members of both the Energy and Commerce Committee and the Environment and Public Works Committee oppose the legislation.

States Proposed Legislation and Regulations

Arkansas

Hazardous Waste—The Department of Pollution Control and Ecology has issued two proposed regulations.

The first makes revisions to the Hazardous Waste Management Code, to incorporate federal rules by reference; adopt the paint filter test; clarify manifesting instructions for rail transporters; clarify TSDF requirements to inspect and accept or reject incoming hazardous waste shipments; clarify the requirement for generators of PCBs and PCB-contaminated wastes to submit an annual hazardous waste report; clarify the requirement to report PCB hazardous waste classification and DOT hazard class in annual hazardous waste reports; and provide additional information for implementation of the toxicity characteristics leaching procedure. Further, it adopts the specific treatment standards and effective dates for the Third Wastes and alternative treatment standards for lab packs.

The other proposal adopts by reference all applicable hazardous waste regulations promulgated by the EPA from July 1, 1990 to July 31, 1990, dealing with revocation of certain portions of the effluent guidelines and pretreatment standards for the organic chemicals, plastics, and synthetic fibers point source category; and rules developed under the authority of RCRA Section 3018(b) to assure that hazardous wastes discharged to POTWs are adequately controlled to protect human health and the environment.

Comment deadline for both proposals is October 11, 1990. For more information on either or both, contact Becky Allison, Information Officer, Department of Pollution Control and Ecology, 8001 National Drive, P.O. Box 9583, Little Rock, AR 72219.

California

Air Quality—A. 2759 (Eaves) authorizes air pollution control districts and air quality management districts with respect to mobile and stationary sources, to establish and implement a system to use emission reductions to offset future increases.

A. 3152 (Tanner) requires the State Air Resources Board and the State Department of Health Services to report to the Governor and the Legislature by January 1, 1992 with recommendations for a plan to reduce or prevent public exposure to indoor air pollutants.

A. 3189 (Tanner) requires the South Coast Air Quality Management District to carry out powers and duties relating to air pollution control in the South Coast Air Basin; requires that emission offsets and reductions acquired from stationary sources operating within the air basin will result in ambient air quality improvement.

A. 3783 (Campbell) applies a penalty to violation of a rule or regulation of an air pollution control district or air quality management district limiting emissions of toxic air contaminants identified by the state board.

A. 4059 (Wyman) authorizes pollution control districts and air quality management districts to require any owner or operator of any air pollution emission source to describe the source and disclose data necessary to estimate emissions.

A. 4092 (Roybal-Allard) requires air pollution control officers to request specified information from a supplier of volatile organic compounds or chemical substances. It makes it a misdemeanor for failure to comply.

S. 1770 (McCorquodale) creates the San Joaquin Valley Air Quality Management District; assumes the functions of the county air pollution control districts in those areas; specifies the duties and functions of the district with respect to the adoption of rules and regulations; permits the district to adopt a schedule of fees levied on sources of air pollution subject to district regulation.

S. 1817 (Roberti) enacts the Toxic Air Pollution Prevention Act of 1990. Requires specified facilities to prepare a pollution prevention audit and plan to be submitted to the appropriate air pollution control district or air quality management district, initially, as specified and to conduct an audit and establish a plan every four years thereafter. Imposes various duties on the State Air Resources Board relating to toxic air emissions reduction, including regulations adoptions.

S. 2652 (Russell) requires every district including specifically the Bay Area Air Quality Management District, the South Coast Air Quality Management District, and the Sacramento Metropolitan Air Quality Management District to consider and make findings as to the cost-effectiveness in adopting regulations for attainment and maintenance of ambient air quality standards.

S. 2672 (Presley) allows increases at a stationary source in one air pollution control district or air quality management district to be offset by reductions in another district, whereby reductions in the emission of air contaminants may be banked and used to offset future increases in emissions.

Hazardous Waste—A. 2595 (Tanner) requires each city within a county with a hazardous waste management plan to take a specified action, within 180 days after receiving written notification from that county that the county hazardous waste management plan has been approved and to implement the approved plan. Requires the Department, if the Department disapproves the county or regional hazardous waste management plan, to provide the county with its reasons for disapproval.

Household Hazardous Waste—A. 2597 (Tanner) exempts hazardous wastes generated or disposed of by any public agency operating such a program or any person operating a household hazardous waste collection program under an agreement with a public agency.

A. 2641 (Wright) requires the State Department of Health Services to allow the city, county, or special district which operates a household hazardous waste program, or any person operating a household hazardous waste collection program under an agreement with a public agency, to allow small quantity commercial sources which comply with specified criteria to participate in that program.

A. 2707 (LaFollette) would impose a state-mandated local program by requiring each city to prepare, adopt, and submit by July 1, 1991, to the county in which it is located, a household hazardous waste element of specified content.

Toxic Substances—A. 1469 (Margolin) requires the Occupational Safety and Health Standards Board to revise the California Code of Regulations to include certain carcinogens and industrial processes listed by the International Agency for Research on Cancer, and substances for which the State Department of Health services has issued a hazard alert regarding carcinogenicity, unless a substance or industrial process is covered by a separate comparable standard.

A. 1728 (Katz) enacts the Toxics Reporting and Use Reduction Act of 1990. Makes a statement of legislative intent, defines terms, and requires the Environmental Affairs Agency, in cooperation with each state and local agency which collects hazardous materials data, to establish systems and procedures for collecting, storing, and distributing hazardous materials data to make the data available to the public and among state and local agencies as specified.

A. 4160 (Katz) enacts the Children's Poison Protection Act of 1990; requires a toxic household product manufactured on and after January 1, 1992, that contains any of certain specified substances and sold in this state to include a bittering agent within the product, unless the product is packaged with child-resistant safety closures, as specified.

Liability Insurance—A. 2730 (LaFollette) requires the Insurance Commissioner to investigate the need for an environmental impairment liability insurance program and to hold a hearing relating to the investigation.

Taxes—A. 3580 (Katz) authorizes a city, county, or city and county to levy a tax by ordinance on the sale at retail within its jurisdiction of aerosol paint containers, containers of any other marking substances, felt tip markers with a specified writing surface, and any other marking instrument, as defined.

Packaging—A. 3994 (Sher) makes it unlawful for any person to represent that any consumer good, as defined, which it manufactures or distributes is "ozone friendly," "biodegradable," "photodegradable,""recyclable," or "recycled," unless that article meets specified definitions or meets definitions established in trade rules adopted by the Federal Trade Commission.

Aerosol/Graffiti—S. 1097 (Torres) provides that it is a misdemeanor for a person or business to sell in this state any container which utilizes aerosol propellant for paint or other paint-like products for consumer application. Deletes the provision making it a misdemeanor for any person under the age of 18 years to purchase an aerosol container of paint capable of defacing property.

S. 1977 (Kopp) requires a court to suspend, restrict, or delay for one year the driving privilege of persons 13 years of age or older who commit vandalism by defacing property with paint or any other liquid.

S. 2448 (Watson) enacts procedures for the establishment of graffiti abatement districts with specified powers for the purpose of abating graffiti. Authorizes these districts to impose a tax on the sale of marking substances or instruments.

Georgia

Hazardous Waste—This proposed regulation makes revisions to the hazardous waste management rules, to incorporate federal amendments and 1990 state legislation. Changes pertain to the toxicity characteristics leaching procedure (TCLP); the addition of 25 organic chemicals to the list of toxic constituents of concern; specification of treatment standards and effective dates for prohibitions on land disposal (Third Third Schedule); limitation on organic air emissions as a class at hazardous waste TSD facilities; addition of 47 testing methods; allowance under limited circumstances of a landfill, surface impoundment, or land treatment unit to remain open after the final receipt of hazardous wastes; and others. For more information, contact Harold Reheis, Assistant Director, EPD or Jennifer Kaduck, Hazardous Waste Management Program, (404) 656-6802 or Lucy Justus, Public Information Coordinator, (404) 656-0772, Department of Natural Resources, EPD, 205 Butler Street, Floyd Towers E., Suite 1154, Atlanta, GA 30334.

Idaho

Hazardous Waste—This proposal updates existing hazardous waste regulations by incorporating the federal changes adopted between July 1, 1987 and July 1, 1990, and correcting typographical errors. Also repeals the section on public and confidential records. Rules affected concern the hazardous waste management system; identification and listing of hazardous waste; standards applicable to generators, to transporters, and to operators of hazardous waste TSD facilities; interim status standards for TSDs; standards for the management of specific hazardous wastes and specific types of facilities; land disposal restrictions; permits; state procedures for RCRA and HWMA permit applications; and inspection plans. For more information, contact Donna Pettibone, Department of Health and Welfare, Division of Environmental Quality, 450 W. State Street, Boise, ID 83720-9990, (208) 334-5879.

Indiana

Occupational Safety and Health—This proposal incorporates OSHA provisions that amend the general industry standards for air contaminants, occupational exposure to formaldehyde, and standards for Nationally Recognized Testing Laboratories. For more information, contact the Occupational Safety Standards Commission, Indianapolis, IN.

Kentucky

Hazardous Waste—Regulations were proposed in the state of Kentucky which:

1) Establish standards applicable to generators of hazardous waste; establish the pre-transport requirements for labeling, marking, placarding, and accumulation time.
2) Establish liability requirements for persons engaging in the storage, treatment and disposal of hazardous waste.
3) Establish minimum standards for hazardous waste sites or facilities qualifying for interim status; establish the general standards for these facilities.
4) Establish minimum standards for hazardous waste sites or facilities qualifying for interim status; establish the liability requirements.
5) Establish minimum standards for underground storage tanks.
6) Establish land disposal restrictions and treatment standards for hazardous wastes; establish waste specific prohibitions on land disposal.
7) Establish land disposal restrictions and treatment standards for hazardous wastes; establish waste specific prohibitions on land disposal.
8) Establish land disposal restrictions and treatment standards for hazardous wastes; establish prohibitions on storage of restricted wastes.
9) Establish a list of groundwater analyses for which to screen when contamination is suspected at RCRA land based hazardous waste treatment, storage, and disposal facilities.
10) Establish land disposal restrictions and treatment standards for hazardous wastes; contains the appendix to the chapter concerning the California list of halogenated organic compounds regulated under land ban.
11) Establish the permitting process for hazardous waste sites or facilities; establishes the specific Part B information requirements for miscellaneous units for disposal.

For more information on any of these regulations, contact Susan Bush, Director, Division of Waste Management, Frankfort Office Park, 18 Reilly Road, Frankfort, KY 40601.

Air Quality—This proposal prescribes the regulations for the prevention, abatement, and control of air pollution; provides for the defining of terms to be used.

This proposal designates the status of all areas of the Commonwealth of Kentucky with regard to attainment of the ambient air quality standards.

For more information on these regulations, contact Hisham M. Saaid, Acting Director, Division of Air Quality, 316 St. Clair Mall, Frankfort, KY 40601.

Massachusetts

Toxic Substances—S. 1618 (Committee on Commerce/Labor) provides for the establishment of an occupational lead poisoning registry.

Missouri

The Division of Environmental Quality has proposed regulations to:

1) Add definitions necessary for the better understanding of Missouri rules pertaining to air quality standards.
2) Rescind and replace rules pertaining to emission standards for hazardous air pollutants.

For more 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 Hampshire

USTs—This proposal amends the existing rules for underground storage tanks and establishes rules which are consistent with current Environmental Protection Agency requirements and New Hampshire State law. For more information, contact Timothy R. Denison, Chief, ODDCF, Department of Environmental Services, Water Supply and Pollution Control Division, 6 Hazen Drive, P.O. Box 95, Concord, NH 03301, (603) 271-3644.

South Carolina

Hazardous Waste—This regulation includes groundwater monitoring requirements and corrective action requirements for solid waste management units; replaces the current Extraction Procedure Test with the Toxicity Characteristic Leaching Procedure to be used to determine whether a waste is hazardous by the characteristic of toxicity. For more information, contact Hartsill W. Truesdale, Chief, Bureau of Solid and Hazardous Waste Management, Columbia, SC 29201.

Virginia

Air Quality—This proposed regulation requires a permit to operate for all stationary sources of air pollution with exemptions for some smaller facilities. Enhances the Air Pollution Control Board's ability to ensure compliance with emission standards, reduces the levels of allowable emissions for stationary sources to provide for growth of new emissions, provides a mechanism to substitute for consent orders when necessary to enforce source specific requirements. Comment deadline is October 26, 1990. For more information, contact Nancy S. Saylor, Department of Air Pollution Control, Division of Program Development, P.O. Box 10089, Richmond, VA 23240, (804) 786-1249.

Washington

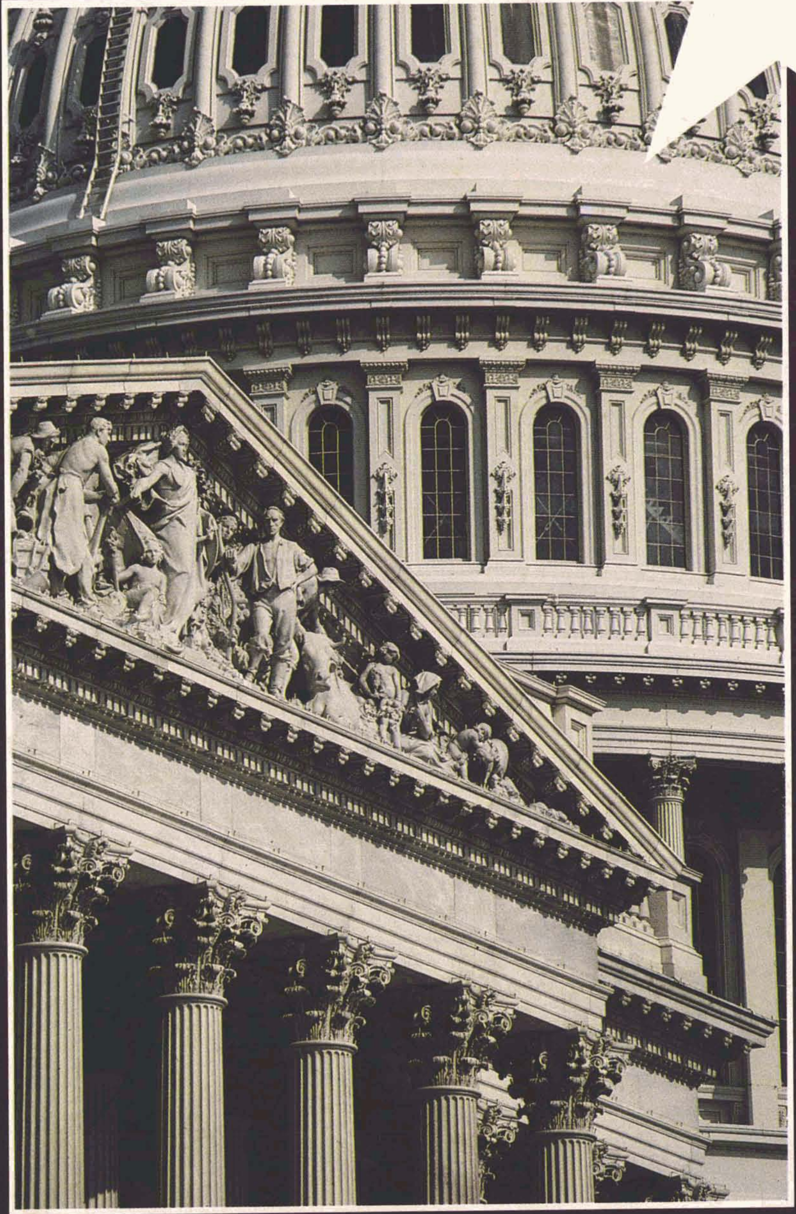
Underground Storage Tanks—This proposed regulation pertains to the control of leaking underground storage tank systems containing petroleum and other regulated substances. Contains new requirements for new tanks and tank upgrading; establishes sources for a financial responsibility fund; prohibits delivery of products to tanks out of compliance with tank regulations; requires examination and licensing of tank service personnel. For more information, contact Thom Lufkin, Department of Ecology, Mail Stop PV-11, UST Section, Olympia, WA 98504.

Pollution Liability Insurance—This proposal establishes rules for petitions, appeals, and other formal actions by or before the Pollution Liability Insurance Agency. For more information, contact William Bafus, Pollution Liability Insurance Agency, 1015—10th Avenue, S.E., Mail Stop EN-12, Olympia, WA 98504.

Federation of Societies for Coatings Technology

68th Annual Meeting
55th Annual Paint Industries' Show

Program



Washington Convention Center

Monday, Tuesday, Wednesday
October 29, 30, 31, 1990

Washington, D.C.

Program

"A Decade of Decision: Preparing for the Year 2000"

MONDAY, OCTOBER 29

OPENING SESSION
(9:00)

Sixty-Eighth Annual Meeting of the Federation of Societies for Coatings Technology opened by President John C. Ballard

Invocation and In Memoriam

Welcome: Gary Morgereth, President of Baltimore Society for Coatings Technology

Richard C. Chodnicki, Chairman of the Host Committee

Gary W. Gardner, Chairman of the Program Committee

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

Introduction of Distinguished Guests

E.W. FASIG KEYNOTE ADDRESS

A Generation of Eagles—Lee Sherman Dreyfus, President, Lee Sherman Dreyfus, Inc., and former Governor of the State of Wisconsin

PROFESSIONAL DEVELOPMENT COMMITTEE SYMPOSIUM

PART I — TESTING : THE KEY TO THE QUALITY REVOLUTION
(2:00-3:30)

Moderator: Dan Gilbert, Technical Director, Surface Protection Industries, Inc., Los Angeles, CA

Testing Quality in the Coatings Industry—Dr. David P. Schussler, Senior Research Associate, Chemicals and Pigments Department, DeLisle Plant, E.I. du Pont de Nemours & Co., Inc., Pass Christian, MS

Naval Sea Systems Command and the General Services Administration Naval Shipyard Paint Testing Program—William B. Roberts, Head, Laboratory Div., Coating Productivity Evaluation Center, Norfolk Naval Shipyard, Norfolk, VA, Jacqueline H. Sample, Program Manager, Naval Shipyard Laboratories, Norfolk, VA, and Eugene A. Moore, Jr., Director of Quality Assurance, General Services Administration, Washington, D.C.

Results of Good and Bad Testing—Saul Spindel, President, D/L Laboratories, New York, NY

PART II—ADVANCED TOPICS IN COATINGS RESEARCH
(3:30-5:00)

Moderator—Dr. Richard J. Himics, President, Daniel Products Co., Jersey City, NJ, and Chairman of the Professional Development Committee

New Developments in Transportation Coatings—Dr. John L. Gardon, Vice-President, Research and Development, Akzo Coatings Inc., Troy, MI

A New View on the Formulation of Latex Coatings—Dr. Gordon P. Bierwagen, Professor of Polymers and Coatings, North Dakota State University, Fargo, ND

Recent Developments in Organic Corrosion Inhibitors for Coatings—Dr. Adalbert Braig, Technical Manager, Organic Corrosion Inhibitors for Coatings, CIBA-GEIGY, Corp., Ardsley, NY

INTERACTIVE EFFECTS OF COATINGS COMPONENTS
(2:00-5:00)

Moderator—Richard M. Hille, Products Manager, General Paint and Chemical Co., Cary, IL

Structural Effects of Hydroxyalkyl(meth)acrylate Monomer on Cure Rats of Acrylic Polyol Resins—W.C. Cun-

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Water-Reducible Unsaturated Polyester Prepolymers as Binders for UV-Curable Coatings—Michael J. Dvorchak, Mobay Chemical Corp., Pittsburgh, PA

The Role of Emulsifiers in Autodeposition Latexes—Dr. Taki J. Anagnostou, Coatings Research Institute, Eastern Michigan University, Ypsilanti, MI, and Dr. Pravin K. Kukkala, National Starch & Chemical Co., Bridgewater, NJ

Formulating Stable Acrylic Latex Paints Containing Zinc Oxide—I. Victor Mattei, Richard Martorano, and Eric A. Johnson, Research Laboratories, Rohm and Haas Co., Spring House, PA

Development of a New Adhesion Promoter for Coating Thermoplastic Polyolefin—Dr. Slayton E. Fry, D.W. Magouyrik, E.J. Sacksteder, and P.J. Green, Arkansas Eastman Co., Batesville, AR

The Effect of Diol Selection on Polyesters for Urethane Coatings—Dr. Carl J. Sullivan, R & D Dept., ARCO Chemical Co., Newtown Square, PA

SOCIETY PAPERS
(2:00-4:30)

Moderator—Patricia A. Shaw, Technical Director, Davlin Paint Co., Berkeley, CA

Changes in Hiding During Latex Film Formation. Part II. Pigment Packing Effects—Cleveland Society for Coatings Technology. Presented by Ben J. Carlozzo, Tremco, Inc., Cleveland, OH

Changes in Hiding During Latex Film Formation. Part III. Effect of Dispersant Level and Emulsion Properties—Cleveland Society for Coatings Technology. Presented by Freidun Anwari, Coatings Research Group, Inc., Cleveland, OH

The Effect of Dispersion on the Physical and Performance Properties of Trades Sales (Architectural) Coatings—Baltimore Society for Coatings Technology. Presented by Mary Somerville, Technical Service Representative, Bruning Paint Co., Baltimore, MD

Correlation of Hardness in Coating Films Using Koenig and Sward Pendulum Hardness Testers—Toronto Society for Coatings Technology. Presented by Steven P. Nuyten, R&D Chemist, Reichhold Limited, Weston, Ontario, Canada

Statistical Modeling Drying of Coatings—Golden Gate Society for Coatings Technology. Presented by Margaret Hartmann, Quality Control Manager, The Dexter Corp., Hayward, CA

COATING A SOUND FOUNDATION
(2:00-4:30)

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

Wood/Coating Interactions: Pretreatments, Primers, and Topcoats—Dr. William C. Feist, Project Leader, Wood Surface Chemistry and Protection, Forest Products Laboratory, U. S. Dept. of Agriculture, Madison, WI

Aluminum Sheet Substrate/Coating Interfacial Adhesion as Related to Surface Properties and Processing Conditions—Dr. Jean Ann Skiles, Technical Supervisor, and John K. McBride, Technical Specialist, Alcoa Laboratories, Aluminum Co. of America, Alcoa Center, PA

Substrate Factors Affecting the Performance of Organic Coatings on Steel Sheet Surfaces—Bruno Perfetti, Senior Research Consultant on Organic Coatings, Technical Center, U.S. Steel Div. of USX Corp., Monroeville, PA

Coating Thermoplastic Olefins—Dr. Rose A. Ryntz, Technical Director, ICS Laboratory, Akzo Coatings, Inc., Troy, MI

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

TUESDAY, OCTOBER 30

COATINGS HISTORY IN THE MAKING: A TECHNOLOGY PROFILE—I
(9:00-11:00)

Moderator—Gerry Parsons, Technical Director, DeSoto Coatings Limited, Mississauga, Ontario, Canada

Electron Beam Processing—Now and for the Future—Dr. Alan F. Klein, President and Chairman of the Board, RPC Industries, Hayward, CA

UV Curing—A Compliance Technology for the 90s—Donald L. Eshenbaugh, Jr., Vice-President, R & D Coatings Inc., Wexford, PA

Electrodeposition—The Adventure Continues—Dr. Edward L. Jozwiak, Director for Electrodeposition Research, R&D Center, PPG Industries, Inc., Allison Park, PA

Photoinitiated Laser Curing: State of the Art and Opportunities—Dr. Douglas C. Neckers, Executive Director, Center for Photochemical Sciences, Bowling Green State University, Bowling Green, OH

MANUFACTURING COMMITTEE SEMINAR ON CHALLENGING TRADITION
(9:00-11:00)

A stimulating investigation into flexible manufacturing and various alternatives to our industry's "batch" approach for making coatings.

Moderator—John W. Covington, Principal, Covington Consultants, Millersville, MD

We Must Challenge Tradition to Improve—John W. Covington

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Flexible Manufacturing for the Paint Plant—Phillip C. Howlett, Senior Vice President, Fluid Management, Inc., Wheeling, IL

The Other Side of the Story—How Other Industries Produce Color—Kenneth Boyle, Product Manager, Applied Color Systems, Inc., Princeton, NJ

A Way to Address the Small Batch Problem—Larry K. Kytasaari, Vice President, Operations, Tnemec Co., Inc., N. Kansas City, MO

Quick-Tint®—An Automated Factory Approach to Custom Color Problems—Kenneth N. Edwards, Corporate Secretary, Dunn-Edwards Corp., Los Angeles, CA

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

Presentation of the 1990 Morehouse Golden Impeller Award for outstanding achievement in dispersion technology will be made at this session.

POLYMERS: THE KEY BUILDING BLOCK
(9:00-11:00)

Moderator—John Hall, Manager of Coatings Technical Service, Tioxide, Inc., St. Laurent, Quebec, Canada

Fundamental Studies of Epoxy Resins for Can and Coil Coatings. III. Effect of Bisphenol Structure on Flexibility and Adhesion—Robert A. Dubois and P.S. Sheih, The Dow Chemical Co., Freeport, TX

Use of Oxazolidines as a Route to High Build, One-Component, Moisture-Curing Polyurethane Coatings for the Construction Industry—M. B. Bassi, Mobay Corp., Pittsburgh, PA

Novel Fluoropolymer Resins for Premium Durability Coatings—Robert E. Gilliam, Technical Manager, Coatings, Polymers, and Resins Div., Reichhold Chemicals, Inc., Pensacola, FL, and M. Ooka and H. Tanaka, Dainippon Ink and Chemicals, Inc., Tokyo, Japan

Intrinsically Conducting Polymer Colloids—Dr. Mahmoud Aldissi, Champlain Cable Corp., Winooski, VT and Dr. S.P. Armes, University of Sussex, Brighton, United Kingdom

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

Moderator—Dr. Richard Eley, Scientist, Coatings Research Dept., The Glidden Co., Dwight P. Joyce Research Center, Strongsville, OH

Gloss of Paint Films and the Mechanism of Pigment Involvement—Dr. Juergen H. Braun, Research Associate, Chemicals and Pigments Dept., E. I. du Pont de Nemours & Co., Inc., Wilmington, DE

Prediction of Coating Failure Over Sheet Molding Compound (SMC): Solvent Permeation Studies—Dr. Rose A. Ryntz, W.R. Jones, and Andrew Czarnecki, Akzo Coatings, Inc., Troy, MI

The Interactions of Associative Thickeners with Paint Components as Studied by the Use of a Fluorescently Labeled Model Thickener—Brough Richey, Andrea B. Kirk, Eric K. Eisenbartt, Susan Fitzwater, and Dr. John W. Hook III, Research Laboratories, Rohm and Haas Co., Spring House, PA

Surface Studies of Hydrous Oxide-Coated Rutile in Non-Aqueous Media—T.B. Lloyd, J. Li, F.M. Fowkes, J.R. Brand, and Dr. Louis J. Dizikes, Kerr-McGee Chemical Corp., Oklahoma City, OK

COATINGS HISTORY IN THE MAKING:
A TECHNOLOGY PROFILE—II
(2:00-4:30)

Moderator—Mary G. Brodie, Cleveland, OH

Retrospect and Prospect of Water-borne Industrial Coatings—Dr. Robert Fitch, Consultant, Fitch and Associates, Racine, WI

Status and Future Prospects for High Solids Coatings—Dr. Frank N. Jones, Chairman, Dept. of Polymers and Coatings, North Dakota State University, Fargo, ND

Registration Hours

Sunday, October 28	8:00 a.m.-5:00 p.m.
Monday, October 29	8:00 a.m.-5:30 p.m.
Tuesday, October 30	8:00 a.m.-5:30 p.m.
Wednesday, October 31	8:00 a.m.-3:00 p.m.

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Paint Show Hours

Monday, October 29	11:00 a.m.-5:30 p.m.
Tuesday, October 30	9:00 a.m.-5:30 p.m.
Wednesday, October 31	9:00 a.m.-3:00 p.m.

Powder Coatings from a Finishing Curiosity to Finishing Ahead in the 90s—Steven Kiefer, Market Manager, Morton International, Reading, PA

Architectural Water-borne Coatings; Technological Advances in the Past Decade—Freidun Anwari, Coatings Research Group, Inc., Cleveland, OH

CORROSION COMMITTEE SYMPOSIUM ON ANTI-CORROSIVE COATINGS: THE NEXT GENERATION

(2:00-4:45)

Moderator—Donald W. Collier, Technical Director, Trade Sales, Porter Paints Div., Courtaulds Coatings, Inc., Louisville, KY

How to Develop an Improved Laboratory Corrosion Test—Dr. Herbert E. Townsend, Senior Research Fellow, Bethlehem Steel Corp., Bethlehem, PA

A Combined Corrosion/Weathering Accelerated Test for Coatings for Corrosion Control: Correlating Field and Laboratory Exposures—Dr. Brian S. Skerry and C.H. Simpson, Consumer Div., Technical Center, The Sherwin-Williams Co., Cleveland, OH, and C.J. Ray, Industrial Maintenance Laboratory, The Sherwin-Williams Co., Morrow, GA

Surface Chemistry Aspects of Polymer Metal Adhesion—Dr. James P. Wightman, Chemistry Dept., Center for Adhesion and Sealant Science, Virginia Polytechnic Institute, Blacksburg, VA

Compliance when Using Heavy Metals—William Stewart, The Valspar Corp., Minneapolis, MN

Development of Chromate-Free Primers for Aluminum and Steel to Meet CGSB Specifications—Terry Foster, G.N. Blenkinsop, P. Blattler, and M. Szandorowski, Canadian Department of National Defence, Ottawa, Ontario, Canada

Presentation of 1990 Corrosion Committee Publication Award for best corrosion-related paper published in the JOURNAL OF COATINGS TECHNOLOGY will be made at this session.

SAFETY AND PERFORMANCE INTO THE 21st CENTURY

(2:00-4:30)

Moderator—Steve Bussjaeger, Technical Director, Davis Paint Co., N. Kansas City, MO

Solvent-Based Paint Strippers; Alternatives to Methylene Chloride—Dr. Carl J. Sullivan, R & D Dept., ARCO Chemical Co., Newtown Square, PA

Polyurethane Coatings: Safe Application in Outdoor Maintenance Painting—H. E. Myer, Product Safety Supervisor, Corporate Occupational and Product Safety Dept., Mobay Corp., Pittsburgh, PA

Characterization of the Components of an Oven Condensate by Gas Chromatography/Mass Spectrometry—Ronald J. Wingender, Packaging Products Div., The Dexter Corp., Waukegan, IL

Flexible Coatings for Exterior Wood—Steven W. Rees, Coatings Evaluation Laboratory Manager, Cray Valley Products Ltd., Farnborough, Kent, England (Presented on behalf of OCCA: Oil and Colour Chemists' Association — UK)

Statistical Analysis of the Evolution of the Yellowness Index During an Accelerated Weathering of a Coating—Dr. Patrick Schutyser, Coatings Research Institute, Limelette, Belgium (Presented on behalf of FATIPEC: Federation of Associations of Technicians in the Paint, Varnish, Lacquer, and Printing Ink Industries of Continental Europe)

ROON AWARDS COMPETITION PAPERS—II

(2:00-4:30)

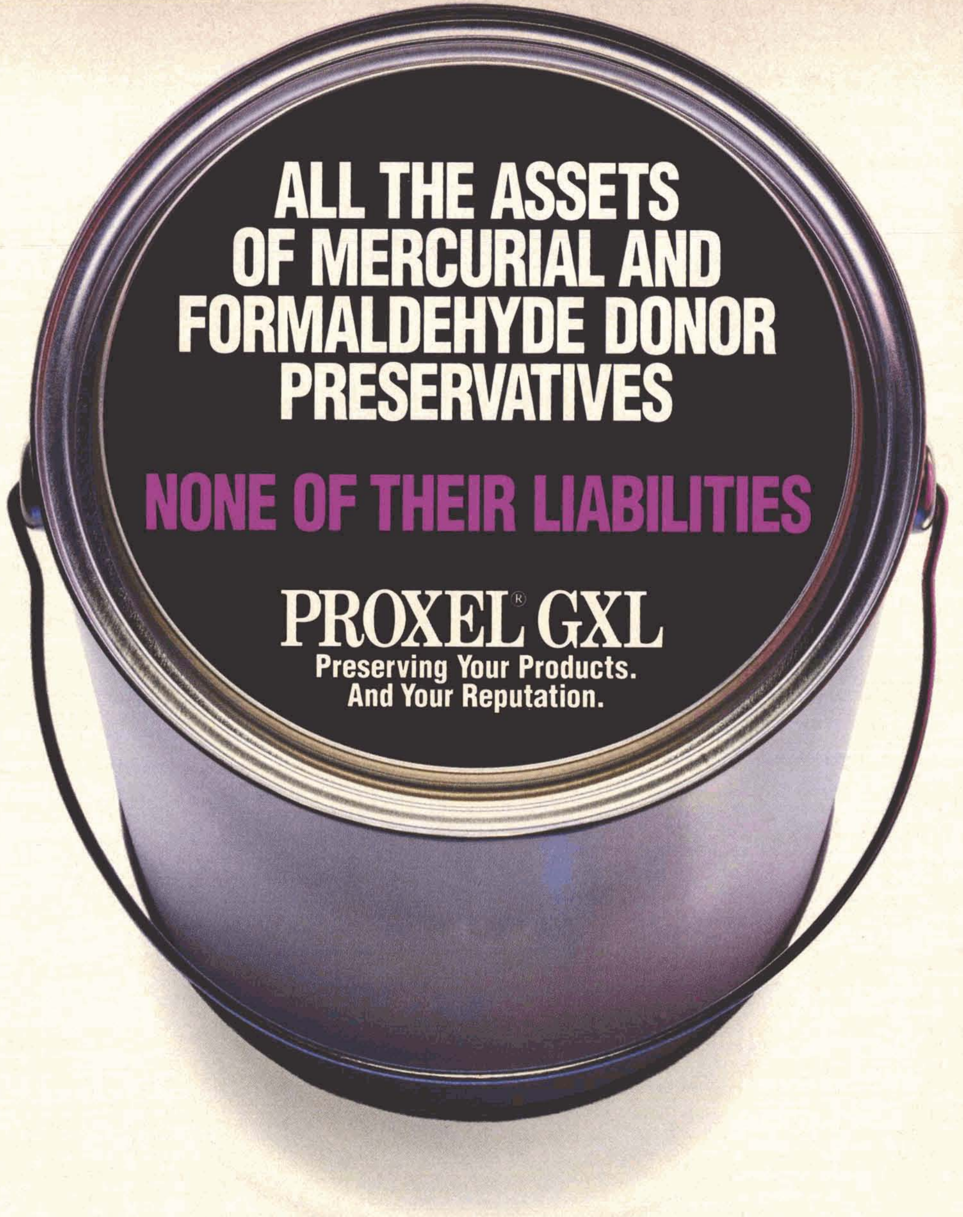
Moderator—Dr. Gordon P. Bierwagen, Dept. of Polymers and Coatings, North Dakota State University, Fargo, ND

Specific Interactions and Adsorption of Film-Forming Polymers—Dr. Henry P. Schreiber and Javier Lara A., Dept. of Chemical Engineering, Ecole Polytechnique l'Universite de Montreal, Montreal, Quebec, Canada

Adhesion and Flexibility Contributions to the Performance of Epoxy Phosphate Ester Coatings—Dr. John L. Massingill, Development Associate, Coatings, Adhesives, and Sealants Laboratory, The Dow Chemical Co., Freeport, TX

Latent Amine Catalysts for Epoxy-Carboxy Hybrid Powder Coatings. Investigations and Phase Change Control of Reactivity—Dr. S. Peter Pappas, Loctite Corp., Newington, CT, and Victor D. Kuntz and Betty C. Pappas, Polymers and Coatings Dept., North Dakota State University, Fargo, ND

Performance and Stability of Ketoxime Blocked Isocyanate/Epoxy Based Simple Component Coatings—Dr. John



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M. McIntyre, Research Leader, Coatings Application Development Laboratory, The Dow Chemical Co., Freeport, TX

Rheological Considerations of Abrasion Resistant Self-Healing Polyurethane Resins—Y. Abe and N. Okoshi, Dainippon Ink and Chemicals, Inc., and Dr. Andrew Woo, Coatings, Polymers, and Resins Div., Reichhold Chemicals, Inc., Pensacola, FL

WEDNESDAY, OCTOBER 31

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, 1990-1991.

REGULATORY AFFAIRS
(9:00-10:30)

Moderator—Sidney J. Rubin, Vice-President, Empire State Varnish Co., Inc., Brooklyn, NY, and Chairman of the Environmental Affairs Committee

Crystalline Silica: A Material Showing "Limited Evidence of Carcinogenicity" to Humans—Sidney Lauren, CR Minerals Corp., Golden, CO

A Coatings Manufacturer's Guide to Regulatory Requirements and Pollution Prevention Options—Kevin F. Gashlin, Director, New Jersey Technical Assistance Program, Hazardous Substance Management Research Center, New Jersey Institute of Technology, Newark, NJ

Formaldehyde Regulatory Update—Jeffrey D. Felder, Manager, Product Safety, Monsanto Chemical Co., St. Louis, MO

BASICS FOR THE YEAR 2000
(9:00-10:00)

Moderator—Dr. Mary E. McKnight, Research Chemist, United States Dept. of Commerce, National Institute of Standards and Technology, Gaithersburg, MD

Sorption of Moisture on Epoxy and Alkyd Free Films and Coated Steel Panels—Howard N. Rosen and Dr. Jonathan W. Martin, United States Dept. of Commerce, National Institute of Standards & Technology, Gaithersburg, MD

Cyclic and Continuous Immersion Results for Scribed and Unscribed Alkyd Coated Steel Panels—Dr. Jonathan W. Martin, Edward Embree, and Wynee Tsao, United States Dept. of Commerce, National Institute of Standards & Technology, Gaithersburg, MD

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

Introductory comments by John C. Ballard, Vice-President/Manager, Technical Service, Kurfees Coatings, Inc., Louisville, KY, and President of the Federation of Societies for Coatings Technology and Chairman of the Joseph J. Mattiello Memorial Lecture Committee.

Electrochemical Techniques for Studying Protective Polymeric Coatings—Dr. Henry J. Leidheiser, Jr., former Director of the Center for Surface and Coatings Research, Lehigh University, Bethlehem, PA.

AWARDS LUNCHEON
(12:00)

Presentation of these awards: George Baugh Heckel . . . Paint Show . . . Roon Foundation . . . Armin J. Bruning.

Featured Speaker: Douglas Kiker, TV News Correspondent.

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ABSTRACTS OF PAPERS

TESTING QUALITY IN THE COATINGS INDUSTRY

David P. Schussler, E.I. du Pont de Nemours & Co., Inc.

The coatings industry is becoming increasingly interested in quality management. Statistical process control (SPC) is one of the primary tools to be used in managing quality. The realization is increasing that SPC cannot function unless the source of the data, the test, is under control.

The very same techniques used to manage quality in production processes can be applied to measurement processes. Over the past several years experience has been developed in applying a number of standard techniques to assuring the quality of the test. These are discussed along with details and examples of their applications.

NAVAL SEA SYSTEMS COMMAND AND THE GENERAL SERVICES ADMINISTRATION NAVAL SHIPYARD PAINT TESTING PROGRAM

William B. Roberts, Norfolk Naval Shipyard; Jacqueline H. Sample, Naval Shipyard Laboratories; and Eugene A. Moore, Jr., General Services Administration

The Naval Shipyard Paint Test Program was established in June 1989 as a cooperative program between the General Services Administration (GSA/FSS) and the Naval Sea Systems Command (NAVSEA 07) to test paint procured for the Navy by GSA contract. Under this program, GSA recognizes the validity of naval shipyard receipt testing of paints for conformance to specification requirements, and GSA will enforce quality provisions of contracts based on shipyard test results without further testing by GSA laboratories. The program also provides a means for GSA to share test data with designated NAVSEA testing facilities.

The NAVSEA objectives for this agreement are: (1) to improve the productivity of the naval shipyards; (2) to have quality paints meeting project needs at the production site; and (3) to eliminate the generation and storage of hazardous waste through expedient return to the vendor of rejected paints. The GSA objectives are: (1) to improve the procurement of quality coatings in a timely manner; (2) to reduce the time to resolve complaints; and (3) to reduce the time and cost for disposal of defective paints.

NEW DEVELOPMENTS IN TRANSPORTATION COATINGS

John L. Gardon, Akzo Coatings, Inc.

In automotive OEM topcoats the recent new requirements are acid-rain etch resistance, stone-chip resistance, lowered VOC, and low-bake coatings for plastics. Aqueous basecoats under high solids clearcoats, two component urethane systems, block copolymers, and special etch resistant systems satisfy the new needs.

Ambient-temperature-cure/low VOC systems of high performance are needed for car refinish and aviation markets. Aqueous latex or epoxy primers, high solids urethanes, and epoxy systems are technologies being adapted to the difficult new requirements.

These new needs require innovation in resins and pigmentation. Current trends are discussed.

A NEW VIEW ON THE FORMULATION OF LATEX COATINGS

Gordon P. Bierwagen, North Dakota State University

Formulation practice in latex coatings can be best described as a mixture of science, empiricism, art, and history. Many new materials are available to the designer (formulator) of latex coatings such as associative thickeners and microvoid materials, but the way in which "expert" formulators design coatings remains relatively unchanged.

This presentation discusses the possible applications of EXPERT SYSTEMS (ES) methods in latex coating formulation. ES techniques are methods by which the practices of an "expert" in an area of technology are codified in computer usable form for use by other practitioners. Initial work on a project to develop an "Expert Latex Coating Formulator" and its implications for education as well as product development are presented.

RECENT DEVELOPMENTS IN ORGANIC CORROSION INHIBITORS FOR COATINGS

Adalbert Braig, CIBA-GEIGY Corp.

Organic corrosion inhibitors which provide permanent corrosion protection in coatings should be considered as an alternative to existing concepts. Various results from exposure tests demonstrate the efficiency of organic inhibitors (based on 2-benzothiazolylthio-succinic acid chemistry), both as a replacement for anticorrosive pigments as well as in combination with zinc phosphate.

A product profile and some mechanistic aspects (accoustic microscopy, contact angles, galvanostatic corrosion testing, adsorption experiments) are discussed.

STRUCTURAL EFFECTS OF HYDROXYALKYL-(METH)ACRYLATE MONOMER ON CURE RATES OF ACRYLIC POLYOL RESINS

W.C. Cunningham, W.R. Hunt, Phillip W. Barnett, C.J. Boriack, and D.A. Grilli, Dow Chemical U.S.A.

The effects of hydroxyalkyl(meth)acrylate (HA(M)A) monomer structure on the cure rates of model automotive clearcoat enamels formulated with acrylic polyol resins and

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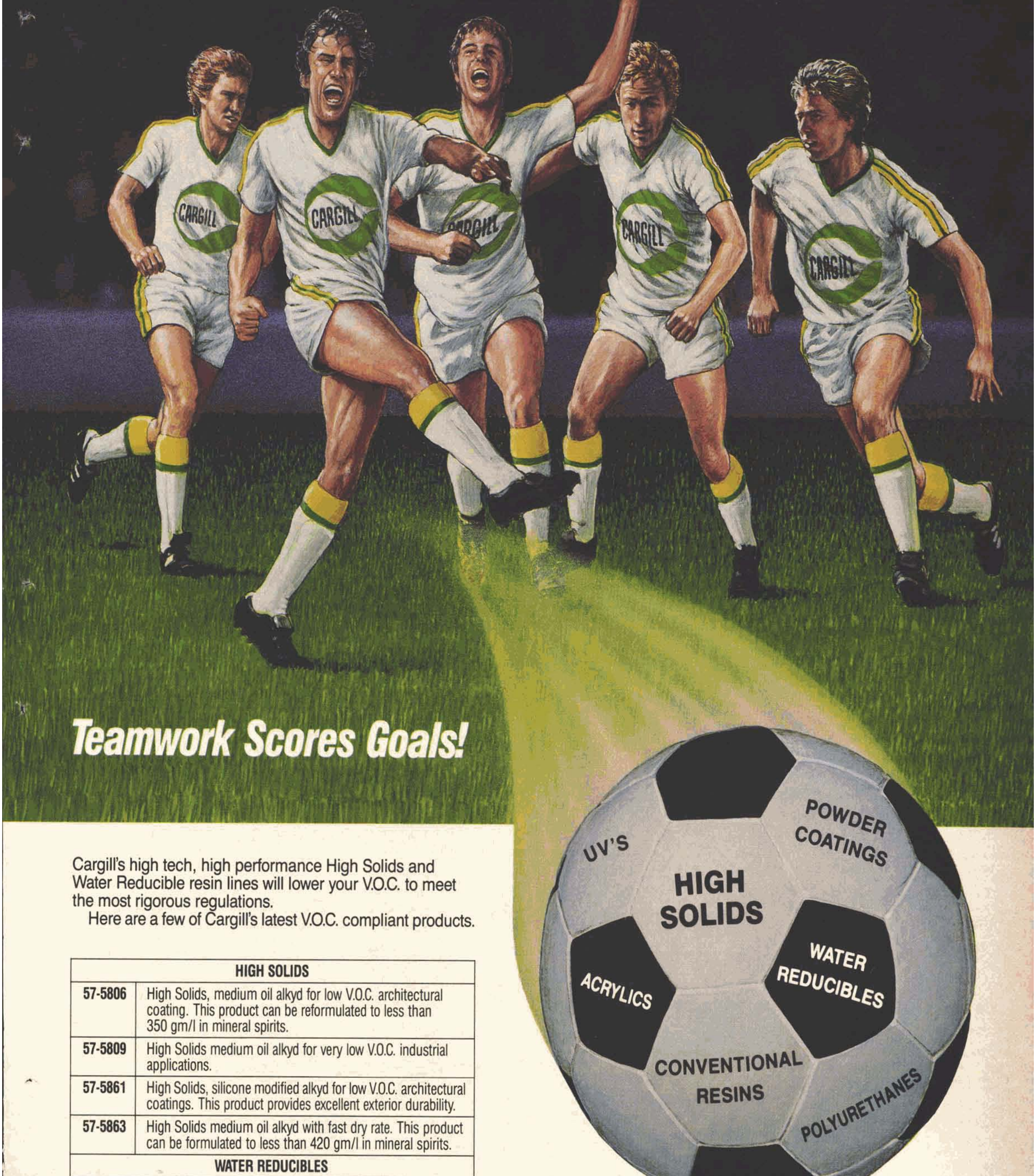

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57-5809	High Solids medium oil alkyd for very low V.O.C. industrial applications.
57-5861	High Solids, silicone modified alkyd for low V.O.C. architectural coatings. This product provides excellent exterior durability.
57-5863	High Solids medium oil alkyd with fast dry rate. This product can be formulated to less than 420 gm/l in mineral spirits.
	WATER REDUCIBLES
132-1297	This self crosslinking resin provides superior corrosion resistance and hardness coupled with flexibility in baking enamels.
155-1380	Water reducible modified polyolefin designed for outstanding package stability in exterior wood stains.
74-7495	A water reducible chain stopped alkyd that is the high performer for DIP, flow, and spray applications.

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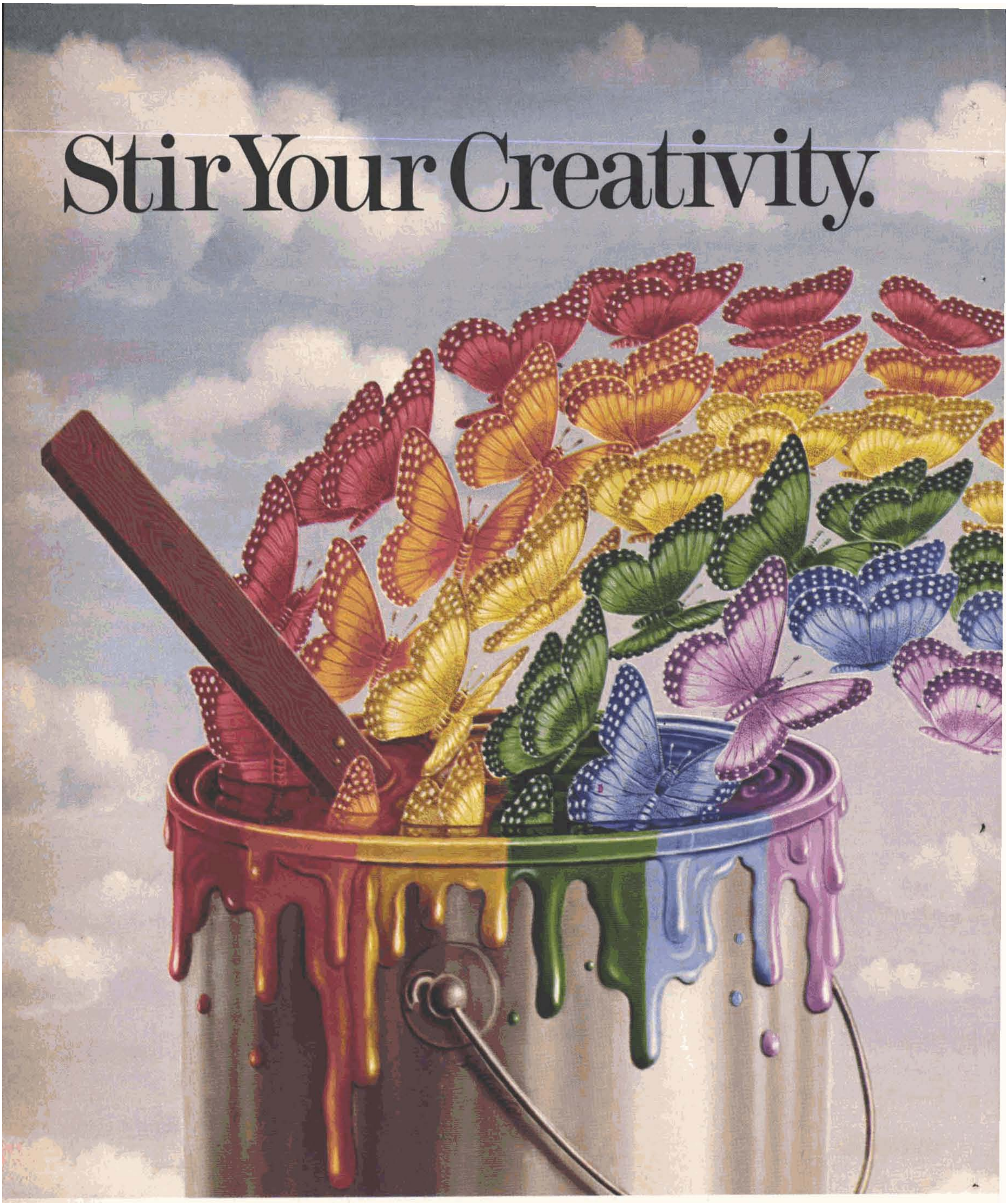

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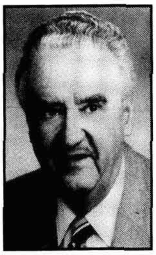
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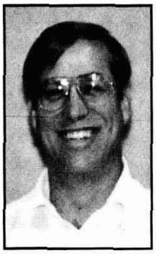
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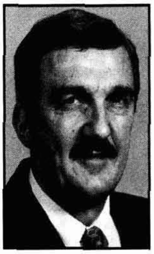
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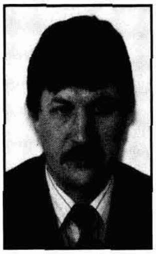
A. Braig

either a melamine-formaldehyde (M-F) or polyisocyanate crosslinker were studied. Using a mass spectroscopy technique to measure the evolution of methanol, the relative cure rates of the HA(M)A copolymer resins with fully methylated M-F crosslinker were:

CO-4HBA > CO-HEMA "= CO-HEA" = CO-HBMA > CO-HPA

The model acrylic-isocyanate enamel cure rates were determined with thin film FTIR by measuring NCO group disappearance and the order of reactivity of the HA(M)A acrylic

CO-4HBA > CO-HEA > CO-HEMA "=CO-HPMA" = COO-HPA > CO-HBA

Physical properties and results of accelerated weathering of the experimented coatings are given.

WATER-REDUCIBLE UNSATURATED POLYESTER PREPOLYMERS AS BINDERS FOR UV-CURABLE COATINGS

Michael J. Dvorchak, Mobay Chemical Corp.

The development of water-reducible unsaturated polyester resins had to overcome two problems. First, the copolymerizable monomer, usually styrene, cannot be used. Therefore, a resin system needed to be developed that produced coatings with adequate properties even in the absence of monomers, and that produced stable coatings systems with good chemical and water resistant properties even though it was water-reducible.

The incorporation of polyols which had allyl ether groups allowed the formulation of unsaturated polyester resins that do not require styrene in order to cure to a film with good properties. The further incorporation of special nonionic emulsifiers into the polymer backbone made the unsaturated polyester resin water-reducible.

Coatings formulations based on this water-reducible unsaturated polyester has attained VOC's as low as 0.2 lbs/gal without using monomer diluents or amine solubilizing agents. These formulations have been cured by a cobalt/hydrogen peroxide mechanism. UV-curing allows the faster curing. The proper selection of UV photoinitiator makes it possible to UV cure even pigmented systems. The curing conditions and properties of the resulting coatings are discussed.

FORMULATING STABLE ACRYLIC LATEX PAINTS CONTAINING ZINC OXIDE

I. Victor Mattei, Richard Martorano, and Eric A. Johnson, Rohm and Haas Co.

Zinc oxide has been used in paint manufacturing since the 1860s and is still used today in many high quality exterior paints because it enhances mildew and UV protection, and hiding. However, these benefits often come at the cost of in-can stability.

The problems and interactions of components of an acrylic latex paint are reviewed, giving the formulator a better understanding and a higher degree of confidence. Key interactions of dispersants, pigments, binders, and additives are discussed and some novel recommendations offered.

DEVELOPMENT OF A NEW ADHESION PROMOTER FOR COATING THERMOPLASTIC POLYOLEFIN

Slayton E. Fry, D.W. Magouyrik, E.J. Sacksteder, and P.J. Green, Arkansas Eastman Co.

Current standards in the automotive industry require that coatings on thermoplastic polyolefin (TPO) parts maintain good adhesion when subjected to high humidity and solvent contact. A program was intiated several years ago that was designed to develop new adhesion-promoting CPOs with improved resistance to attack by various external media. A major facet of this program has dealt exclusively with the modification of several existing CPOs via the reactions of certain difunctional molecules with pendant maleic anhydride groups present on the backbone of the CPO. The presence of certain functional groups can significantly alter the humidity resistance of the coating system when the CPO is used as a primer for TPO as compared to currently available commercial products.

A comparison of the structure of the modifers vs the effect of the modification on the resultant performance properties has led to the commercialization of a new modified CPO (CP164-1) which has excellent adhesion-promoting properties and humidity resistance when applied to polyolefinic substrates as a primer.

THE EFFECT OF DIOL SELECTION ON POLYESTERS FOR URETHANE COATINGS

Carl J. Sullivan, ARCO Chemical Co.

With the introduction of MPDiol as a commercially available diol in 1990, more choices have become available to the polyester resin manufacturer and consequently more choices are available to the urethane coating producers.

In this report, MPDiol is compared to some of the more commonly used diols as a component in polyesters de-

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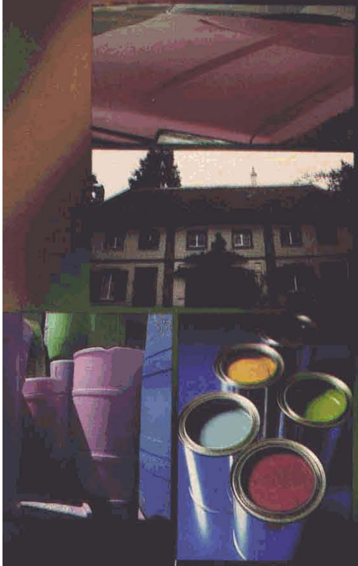

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signed for urethane applications. The effect of diols on polyester properties is summarized, and the effect that the diol constituent has upon the performance of the final urethane coating is detailed. Compared to conventional diols, MPDiol has the reactivity characteristics of diprimary diols but it has the favorable handling characteristics of many of the branched diols.

CHANGES IN HIDING DURING LATEX FILM FORMATION. PART II. PIGMENT PACKING EFFECTS

Cleveland Society for Coatings Technology

Changes in hiding during latex film formation were monitored by measuring the reflectance (Y) as a function of dry time for a coating applied over a black substrate. This was accomplished by placing a wet drawdown against the viewpoint of a computer interfaced spectrophotometer and measuring the reflectance approximately every six seconds.

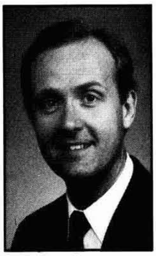
Packing effects were studied by varying the ratio of coarse to fine calcium carbonate in a coating system containing 15% PVC titanium dioxide. The contrast ratio, film porosity, abrasive scrub resistance, and sheen of the dry coating were compared to results obtained by the developed method.

CHANGES IN HIDING DURING LATEX FILM FORMATION. PART III. EFFECT OF DISPERSANT LEVEL AND EMULSION PROPERTIES

Cleveland Society for Coatings Technology

Changes in hiding during latex film formation were monitored by a method developed in Parts I and II of this series. Part I discussed the effect of pigment volume concentration (PVC), extender oil absorption, and glycol cosolvent level; Part II investigated pigment packing effects.

In this study, dispersant level, coalescent level, latex particle size, and binder glass transition temperature (T^g) were examined. Results obtained by the developed method were compared to coatings viscosity, contrast ratio, film porosity, and abrasive scrub resistance.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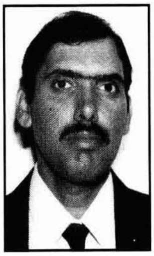
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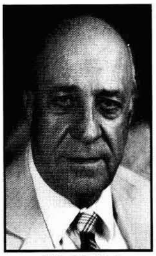
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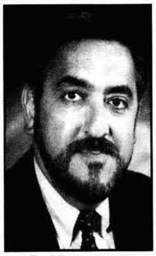
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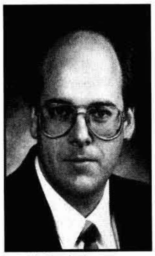
E.A. Johnson


C.J. Sullivan

CORRELATION OF HARDNESS IN COATING FILMS USING KOENIG AND SWARD PENDULUM HARDNESS TESTERS

Toronto Society for Coatings Technology

Hardness of coating films is routinely evaluated in the paint industry as a simple method of determining a paints usefulness for specific applications. Hardness in this case is defined as resistance to scratching, indentation, or penetration by a hard object. Globally, most paint producers do not use the same method of evaluating hardness; therefore, it would be beneficial to establish correlation between different methods.

This presentation gives an overview of the use of Sward and Koenig Pendulum hardness testers by evaluation of five types of paint films applied to glass and cold rolled steel substrates. These coatings were tested at different film thicknesses and under two drying conditions: bake and air-dry. A comparison of these hardness results is discussed.

STATISTICAL MODELING DRYING OF COATINGS

Golden Gate Society for Coatings Technology

The drying rate study reported in 1989 was continued. That study recorded weight loss of drying coatings as a function of time, temperature, film thickness, formulation, and substrate. The data plots appeared to have two sections, an initial linear drying curve section where solvent evaporation was hypothesized as the model, and a final slower linear drying curve section wherein the controlling process is probably solvent migration through the polymer film.

Examination of the data gathered in 1989 was done with statistical techniques to determine the importance of the seven variables designed into the study. The best models showed: (1) The data best fit a hyperbolic function of time; (2) The most important variables were time, temperature, and film thickness; (3) The inclusion of pigment at lower than PVC slowed drying in most models, though possible not statistically significant; (4) The porosity and heat conductivity of the substrate were occasionally important minor variables in some models showing drying retardation, if statistically significant at all; and (5) The minor variable contrasting latex vs solvent was important in only one model, showing retardation of drying of water, if significant.

The statistical models do not exactly reproduce the actual drying curves, and require more sophisticated approaches. The models used are excellent guides to the sense of what is happening; however, for reasons of imperfect fit to the actual drying rate curves, the statistical models have been discarded.

The observed drying curve, having two linear sections, has a more compelling rationale for being the preferred

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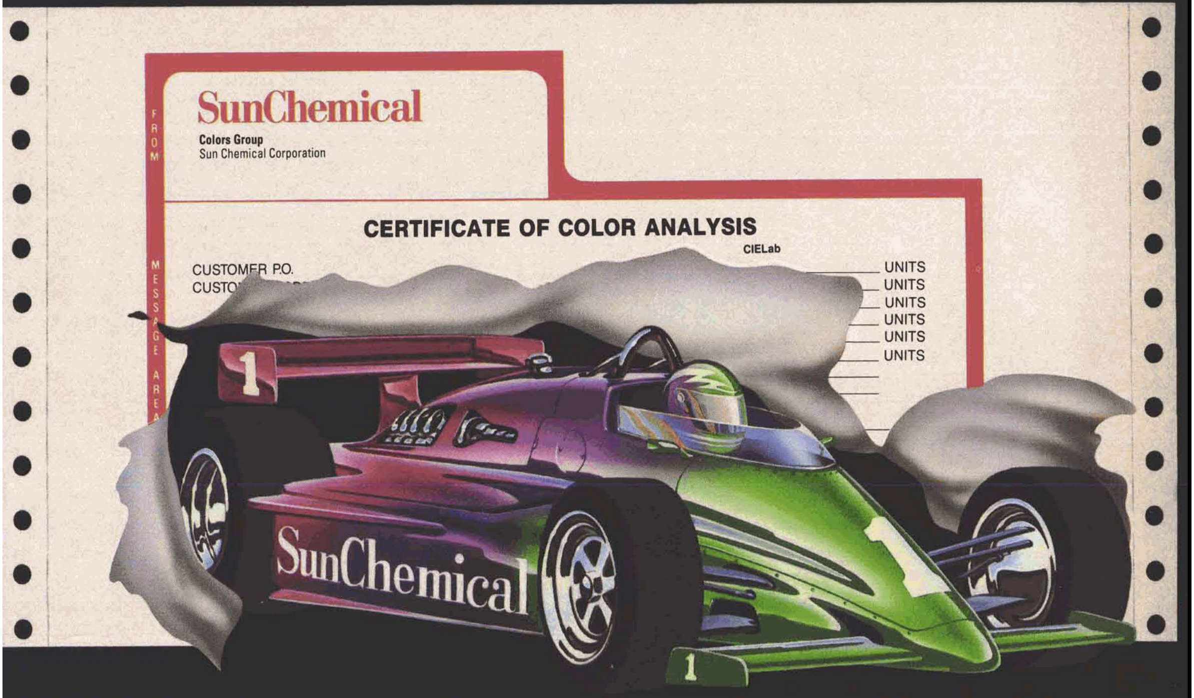

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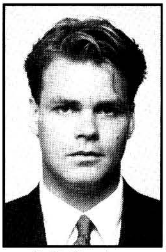

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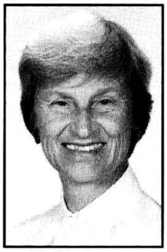

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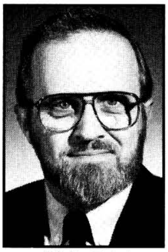

W.C. Feist

characterization. The two linear sections of the observed drying curve are due to the solution evaporation rate control in the earlier stage, and the solvent permeation to the surface controlling the latter stage. The statistical models have no such compelling rationale for adoption, and should therefore be used only as guides.

WOOD/COATING INTERACTIONS: PRETREATMENTS, PRIMERS, AND TOPCOATS

William C. Feist, Forest Products Laboratory

Many new wood products and new, relatively untried wood coatings are being introduced into construction markets. Fundamental information on exterior wood protection, wood weathering, and the interactions of pretreatments and coatings on wood surfaces is important in developing suitably durable exterior coating products.

This presentation discusses the surface chemistry of various wood component and coating interactions, and factors important in determining the exterior weathering performance of wood and wood-based products. Included in the discussion is a description of the fundamental chemical and physical factors that affect exterior coating performance on different wood species, on composites, and on new, wood-based products.

ALUMINUM SHEET SUBSTRATE/COATING INTERFACIAL ADHESION AS RELATED TO SURFACE PROPERTIES AND PROCESSING CONDITIONS

Jean Ann Skiles and John K. McBride, Aluminum Co. of America

Surface chemistry and physical surface characteristics for both the aluminum alloy sheet and organic coating influence sheet/coating interfacial adhesion. Described are aluminum alloy sheet substrate characteristics which influence the initial quality of sheet/coating interfacial adhesion, i.e., physical surface characteristics of the mill finished aluminum alloy sheet surface, and the surface chemistry of a cleaned, etched, and conversion coated aluminum alloy sheet surface.

Also discussed are factors which influence the interfacial adhesion durability, i.e., environmental conditions and thermomechanical stresses induced by forming operations for an organic-coated aluminum substrate.

SUBSTRATE FACTORS AFFECTING THE PERFORMANCE OF ORGANIC COATINGS ON STEEL SHEET SURFACES

Bruno Perfetti, U.S. Steel Div. of USX Corp.

The typical responses of carbon steel and coated steel sheets to coating processes are discussed in terms of the characteristic surface variables which apply to each of these materials. Steel sheet products are normally coated or painted for purposes of protection or decoration.

The coatings used for a particular application are selected on the premise that the sheet surfaces will be receptive to the coating and otherwise compatible with it to assure the suitable performance of the resulting coated system. When the coated or painted surfaces fail to meet the durability and protective qualities expected of them, it is usually because the surfaces were not in a suitable condition for coating.

This report reviews the various substrate factors which affect the adherence and corrosion properties of the painted sheet system, and includes comments on the effects of surface composition, preparation and pretreatments, and the responses of the organic-coated sheets to various conditions of exposure and service.

COATING THERMOPLASTIC OLEFINS

Rose A. Ryntz, Akzo Coatings, Inc.

Consumption of automotive plastics in the United States continues to climb and is expected to double by 1999. It is estimated that the average weight of plastic use per automobile will be 300 pounds. This increased use of plastics, both in interior and exterior applications, also increases the importance of developing coatings for plastics.

This presentation discusses the types of coatings used in plastics, particularly the surface treatments utilized and type of coatings applied to obtain weatherable, adhesive coating to thermoplastic olefins.

ELECTRON BEAM PROCESSING—NEW AND FOR THE FUTURE

Alan F. Klein, RPC Industries

The converting industries are increasingly turning to electron beam processing for the production of unique or vastly improved products and/or to facilitate compliance with new or stricter environmental regulations. During the past few years, several market segments have emerged as those which will likely be the growth areas of the 1990s for electron beam processing. Although they have not all achieved the same degree of commercialization to date, there are combinations of product, production (including environmental) and market factors in each of these growth areas that favor increased utilization of e-beam processing.

These market segments are described to indicate the current state-of-the-art; near future trends are also discussed. A glimpse into the longer term future is presented, with special emphasis on the advances in coatings technology that are required to support these growth areas in e-beam processing.

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UV CURING—A COMPLIANCE TECHNOLOGY FOR THE 90s

Donald L. Eshenbaugh, Jr., R & D Coatings Inc.

Over the past ten years, UV curing technology has shown very rapid growth in certain applications but has grown slower than projected in other areas. The dominant technology has been free radical acrylate chemistry but other materials such as vinyl ethers and unsaturated polyesters provide opportunities for growth.

This paper examines the state of the art of UV curing technology and discusses how and why UV curing has met the needs of certain markets. It also discusses areas where UV curing has not grown as expected and how coatings companies are addressing these opportunities.

ELECTRODEPOSITION—THE ADVENTURE CONTINUES

Edward L. Jozwiak, PPG Industries, Inc.

From the introduction of the electrodeposition process for coating automotive wheels in the 1960s, "electrocoats" have been widely used throughout the industrialized world to apply primers, and, in many cases, one-coat finishes for the automotive, agricultural, industrial, and appliance markets. The widespread availability and utility of both anionic and cationic products has presented exciting technical challenges for coatings suppliers, and encouraged extensive work by engineers and designers to utilize the subtle, as well as obvious quality and production advantages of this coatings application process.

This presentation offers a view of the rapidly improving products that encourage the expanding use of E-coat in its traditional markets, as well as offering examples of new areas where this process innovation will enhance competitive strengths as we prepare for the year 2000.

PHOTOINITIATED LASER CURING: STATE OF THE ART AND OPPORTUNITIES

Douglas C. Neckers, Bowling Green State University

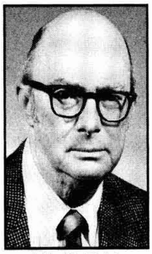
Photoinitiated polymerization using lasers as the radiation source has been a long time in coming. There are several reasons. Photoinitiated polymerization processes were developed largely around the mercury resonance lamp, and its wavelengths in the UV. Therefore, compounds were developed which absorbed ultraviolet radiation and converted the absorbed energy to free radicals which, in turn, initiated the polymerization of acrylates. In the main the applications were for solventless printing and for solvent free varnishes. Large markets in the latter developed in Europe. Reliable UV lasers of sufficient power to trigger these initiators were not a priority item.

UV lasers of sufficient power to trigger UV photoinitiators are rather new. Direct writing with these in speciality applications, such as photoresists, has been in the planning stages for a number of years but has only grown with the development of techniques like stereolithography, i.e., three dimensional imaging.

Continuous, in contrast to pulsed, visible lasers require light absorbing systems which initiate at one of the principal wavelengths of common laser systems. The argon ion laser has principal lines at 488 nm and 514 nm, for example; and the helium/neon laser emits at 632 nm. Since there is much greater power available, and more reliability, with visible systems, visible lasers are clearly more convenient for most opportunities.

The opportunities are in direct writing applications. The goals are the development of visible and infrared photoinitiators which trigger chemical processes as fast as possible, and with the lowest powered laser the application will allow. The rule of thumb is that the lower the power, the easier the laser is to use and the simpler its design. Other opportunities exist in the development of new monomer systems, and different kinds of photoinitiators. In practice, there really are no other monomers which can be easily photopolymerized at the speeds required for most applications, save acrylates. Since acrylates have a number of shortcomings in areas other than the coatings industry, the development of new monomer systems which can be photoinitiated in anxiously awaited in the field.


J.A. Skiles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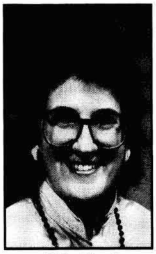
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WE MUST CHALLENGE TRADITION TO IMPROVE

John W. Covington, Covington Consultants

Does your company have policies, procedures and techniques that are obstacles to improved performance? If so, your organization may be a victim of inertia. Inertia keeps us from challenging the assumptions that bind us to the traditional solutions and approaches to our business.

This presentation addresses the issue of challenging tradition and sets the stage for some practitioners who have.

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Phillip C. Howlett, Fluid Management, Inc.

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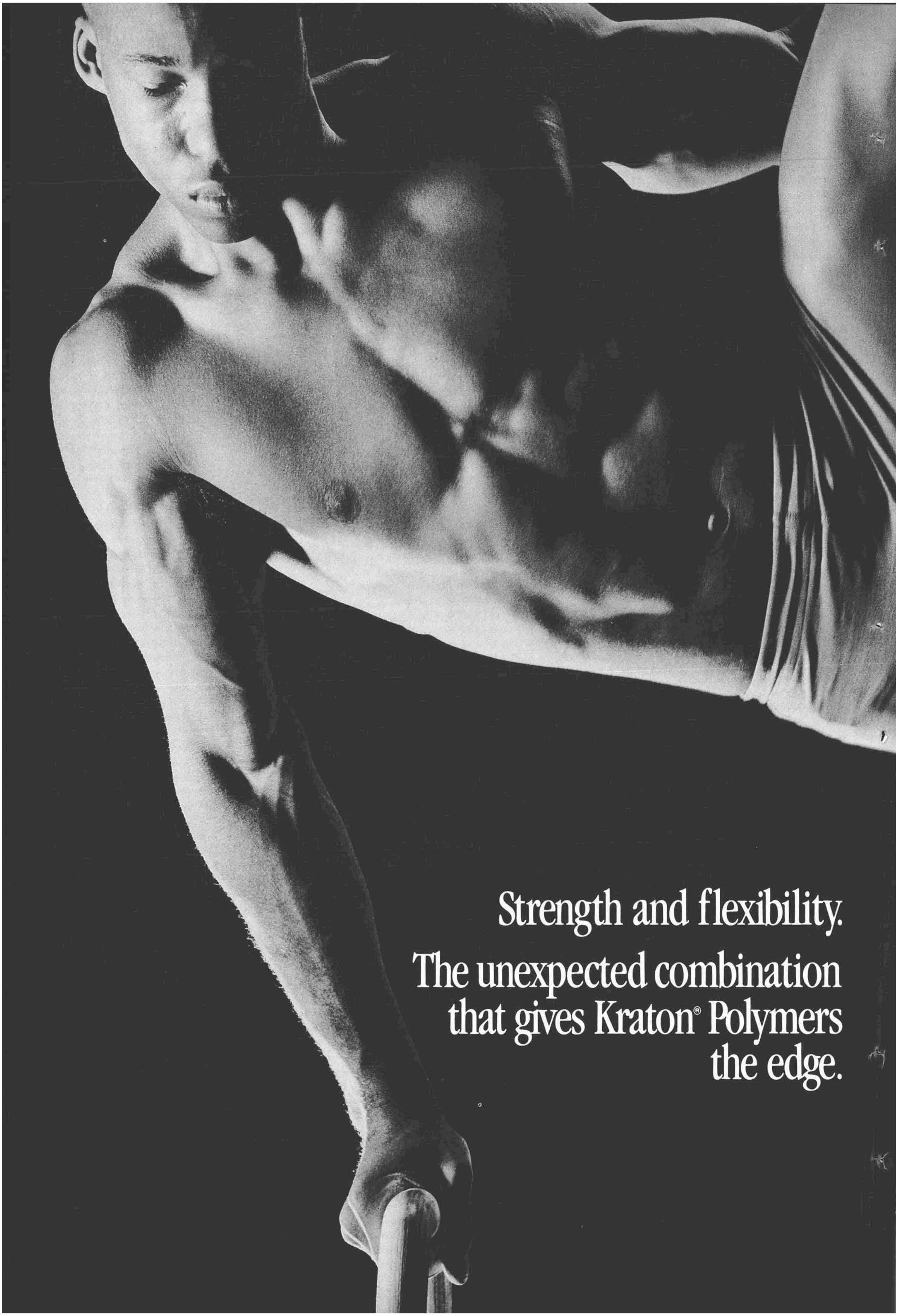
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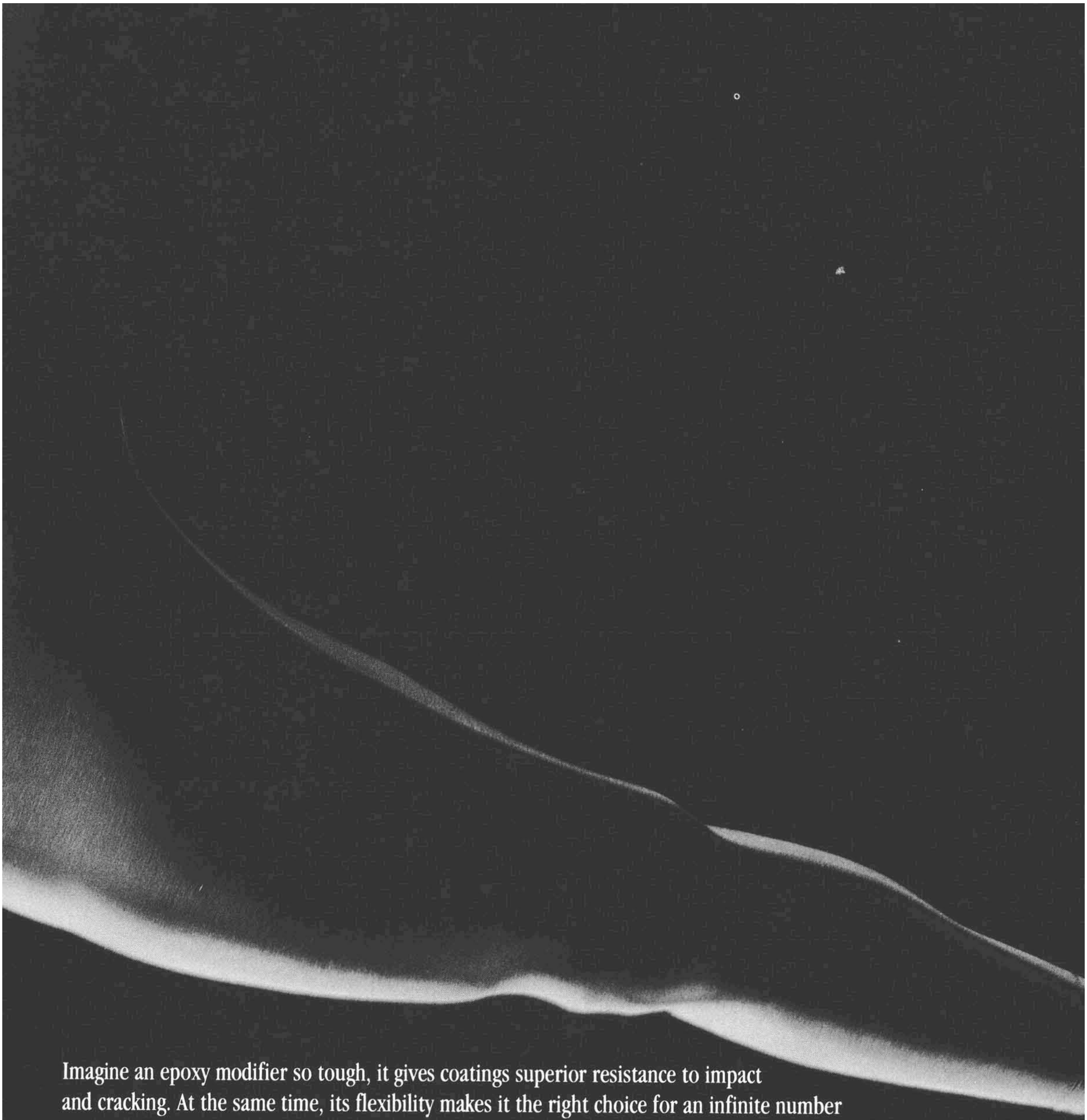

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Larry K. Kytasaari, Tnemec Co., Inc.

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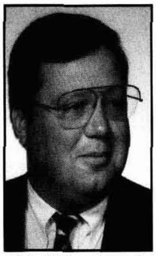
QUCK TINT®—AN AUTOMATED FACTORY APPROACH TO CUSTOM COLOR PROBLEMS

Kenneth N. Edwards, Dunn-Edwards Corp.

Dunn-Edwards Corp., being faced with a growing number of in-store tints, has developed an automated line to deal, at the factory level, with special color orders not needed for delivery for 24 hours. The system is designed to be totally automated from the input of the order at the store, until the palletized unit shipping of the completed cans from the factory. Thus, order input, queuing, formulating, labeling, shipping and billing are all an integrated part of the software programs.

The problems which led up to the development of the Quik-Tint® line, as well as the design of the line, are illustrated and discussed. A brief discussion of the integration of the in-store custom tinting to those colors generated by Quik-Tint® and the full scope of that program is included.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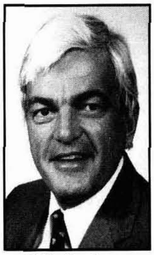
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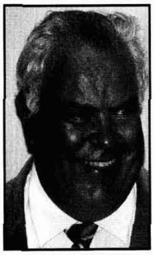
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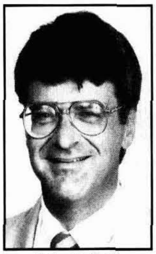
R.A. Dubois

FUNDAMENTAL STUDIES OF EPOXY RESINS FOR CAN AND COIL COATINGS. III. EFFECT OF BISPHENOL STRUCTURE ON FLEXIBILITY AND ADHESION

Robert A. Dubois and P.S. Sheih, The Dow Chemical Co.

In response to a clear and growing need for more flexible can and coil coatings, many reports have demonstrated improvements to bisphenol-based epoxy coatings through a wide variety of innovative blending and grafting techniques. However, the success of these techniques appears to be limited by the rigidity of the bisphenol unit. Other reports show significant improvement by using the inherently more flexible aliphatic epoxies. Unfortunately, they often suffer from loss of other properties such as adhesion, or chemical or water resistance, or reactivity.

This presentation discusses incorporating greater flexibility into the structure of the bisphenol unit. Systematic variation in the structure of the bridging group between the phenol units of bisphenols was correlated with coating performance, not only for solvent systems, but for waterborne systems as well. This technique yields coating flexibilities approaching those of aliphatic epoxies while retaining the adhesion, reactivity and chemical and water resistance characteristic of bisphenol-based epoxies.

NOVEL FLUOROPOLYMER RESINS FOR PREMIUM DURABILITY COATINGS

Robert E. Gilliam, Reichhold Chemicals, Inc.; and M. Ooka and H. Tanaka, Dainippoin Ink and Chemicals, Inc.

Traditional fluoropolymers for coatings applications, such as the homopolymer of polyvinylidene fluoride, are limited in application due to their poor solubility in general coating solvents, low gloss, and the requirement of high temperatures for film cure.

A new fluoropolymer has been developed that exhibits the durability of the traditional fluoropolymers, but has the ease and versatility of application comparable to conventional coatings crosslinked with polyisocyanates or aminoplasts and exhibits good gloss and pigment wetting.

INTRINSICALLY CONDUCTING POLYMER COLLOIDS

Mahmoud Aldissi, Champlain Cable Corp.

One of the main characteristics required for electrical and/or optical activities to occur in a polymer is a conjugated backbone which can be subject to oxidation or reduction by electron acceptors or donors. Due to delocalization of the π electrons in conjugated polymers, chain rigidity is very often a predominant property, and, as a result, an aggregated character of the chains is typical in such materials. This results in intractability, which has been one of the drawbacks in the field.

Therefore, several techniques have been developed to introduce processability. One process developed recently, takes advantage of the aggregated character and consists of forming colloidal dispersions or latex forms of conducting polymers.

Two methods have been employed to produce stable dispersions. The first utilizes a dispersion polymerization

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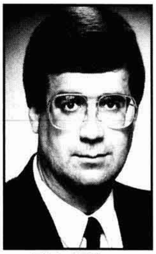
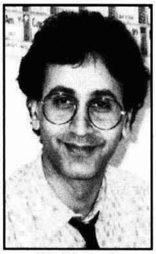

R.E. Gilliam


M. Ooka


M. Aldissi

route in which macroscopic precipitation is prevented by a thin, physically-adsorbed outer-layer of a suitable polymeric surfactant which acts as a steric stabilizer. The second method consists of the synthesis of a graft copolymer in which one of the components is the steric stabilizer. These processes, the resulting products and their properties and potential application areas are the subject of this presentation.

GLOSS OF PAINT FILMS AND THE MECHANISM OF PIGMENT INVOLVEMENT

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

An hypothesis is proposed for the mechanism by which pigment degrades the gloss of paint films: Surface tension contrasts the surface of wet paint to optical smoothness and perfect gloss. During drying, structure develops within the film. Smoothness turns into roughness and gloss begins to degrade when the strength of this structure, its yield stress, exceeds the surface tension. The structure is controlled largely but not exclusively, by flocculation and packing of pigment particles.

The proposed mechanism is supported by correlations between gloss and bulking characteristics of pigments and by ample and diverse experimental results. The hypothesis did predict patterns of rheology and gloss during drying that were confirmed experimentally.

PREDICTION OF COATING FAILURE OVER SHEET MOLDING COMPOUND (SMC): SOLVENT PERMEATION STUDIES

Rose A. Ryntz, W.J. Jones, and Andrew Czarnecki, Akzo Coatings, Inc.

The major failure attributed to coating appearance as applied over sheet molding compound (SMC) are those due to solvent popping or solvent blow through from the substrate through the coating. Evidence has been reported which indicts solvent penetration of coating solvents into the porous substrate which later erupts through the cured coating upon heating thereby affording a cratered-like appearance.

Studies relate the tendency of solvents to diffuse through a variety of coating types to the solvent blow through resistance of the cured coating/SMC composite. Relationships are derived which correlate the ability of a coating to inhibit the solvent blow through failure on SMC to solvent permeation resistance of a coating formulation into the SMC/coating composite. With this predictive relationship, acceptable finishes can be qualified on SMC by the coating formulation utilized.

THE INTERACTIONS OF ASSOCIATIVE THICKENERS WITH PAINT COMPONENTS AS STUDIED BY THE USE OF A FLUORESCENTLY LABELED MODEL THICKENER

Brough Richey, Andrea B. Kirk, Eric K. Eisenbartt, Susan Fitzwater, and John W. Hook, III, Rohm and Haas Co.

A model associative thickener has been synthesized which is a hydrophobically modified polyethylene oxide urethane (HEUR) molecule in which pyrene groups serve as the terminal hydrophobes. This model thickener has rheological properties which are very similar to those of an important commercial thickener, with the advantage that the fluorescence of the pyrene hydrophobes is sensitive to their local environment and to their state of aggregation. From fluorescence studies of this model thickener the following is concluded: (1) The extent of AT-AT interactions increases monotonically over a wide range of thickener concentration in the water or continuous phase. At the concentrations normally employed in latex paints, nearly all of the terminal hydrophobes of thickeners in the continuous phase are aggregated in small clusters containing about six ends. (2) AT's interact predominantly through their terminal hydrophobes with the latex surface. The binding can be described by a simple Langmuir model and the free energy at the AT-latex binding interaction is about -6 Kcal per mole of bound thickener. (3) The presence of shear slow at rates as high as 1500 /s does not significantly alter the fluorescence of labeled thickeners present in At-water or AT-latex -water mixtures. This suggests that these types of AT interactions may not be significantly altered by shear flows of this magnitude.

These results provide new experimental constraints on the possible mechanisms by which AT's thicken aqueous polymer dispersions.

SURFACE STUDIES OF HYDROUS OXIDE-COATED RUTILE IN NON-AQEUOUS MEDIA

T.B. Lloyd, J. Li, F.M. Fowkes, J.R. Brand, and Louis J. Dizikes, Kerr-McGee Chemical Corp.

The dispersibility of TiO_2 in non-aqeuous media continues to be of great interest to coatings scientists. In this regard the acid-base surface chemistry of coated rutile is crucial. Flow microcalorimetry with a downstream refractive index detector was used to measure the amount of adsorption and its exothermic heat from xylene solutions of pyridine, phenol, water and alkyd resin on modified rutile surfaces. Subsequent desorption allowed measurements of the degree of irreversible adsorption. Pigments were coated with precipitated layers of hydrous silica, alumina or both. Silica coating increased surface acidity and alumina coating provided surface basicity.

Acid-base interactions dominated the adsorption. For example, acidic phenol was more strongly adsorbed by basic alumina coatings than by acidic silica ones. The alkyd resin, a polyester with both acidic and basic func-

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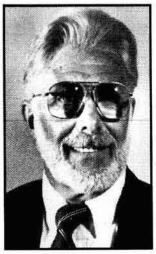
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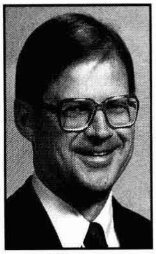
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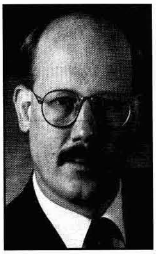
S. Kiefer

tionality, was found to adsorb primarily through its acidic alcohol and/or carboxyl groups. The amount of water adsorbed and its molar heat of adsorption was generally greater than that of the other probes.

The influence of the alkyd resin and purified lecithin upon flocculation of the pigments in xylene was studied by photon correlation spectroscopy. Zeta potentials, a contributing factor to dispersion stability, were measured on the same systems and correlations are drawn between the nature of the treated surface and the stability of the dispersion in xylene with alkyd resin, with lecithin or with both materials present.

SURFACE CHEMISTRY ASPECTS OF POLYMER/ METAL ADHESION

James P. Wightman, Virginia Polytechnic Institute

Adhesion is a multidisciplinary area encompassing polymers, mechanics and surfaces, at least, and is a subject which transcends the bounds of traditional academic departments similar to corrosion, heterogeneous catalysis and lubrication. The interphase is an important concept in adhesion science in that the region between the bulk properties to the adherend and the bulk properties of the adhesive often control the durability of an adhesive bond.

Recent laboratory results of studies of aluminum, copper, steel and titanium bonded with both thermoset and thermoplastic adhesives are presented with an emphasis on surface chemistry. Specific topics addressed the adherend surface analysis, adhesive penetration, mechanical testing, failure surface analysis, moisture intrusion, and interphase properties.

DEVELOPMENT OF CHROMATE-FREE PRIMERS FOR ALUMINUM AND STEEL TO MEET CGSB SPECIFICATIONS

Terry Foster, G.N. Blenkisop, P. Blattler, and M. Szandorowski, Canadian Department of National Defence

Due to concerns over the toxicity of chromates and chromate pigments (known carcinogens), two chromate-free primers have been developed. These primers are candidates to replace the current Canadian General Standards Board (CGSB) specification 1-GP-121, Wash Primer and 1-GP-132, Primer for Aluminum Substrates.

The chromate-free wash primer is a two component system based on a polyvinyl butyral resin containing a combination of phosphate and borate anti-corrosive pigments, colouring pigments, alcohol solvents, and an organofunctional silane.

The mechanical properties of the chromate-free wash primer, such as coating flexibility and compatibility, and adhesion to steel surfaces, are similar to those of chromate containing wash primer. The absence of chromate reduces the cross-linking reaction of vinyl resin in the traditional wash primer and as a result the chromate-free wash primer is not as resistant to aggressive environments. However, the chromate-free wash primer was found to be equivalent to the traditional wash primer when compared under immersion, atmospheric exposure, and salt fog conditions.

One of the chromate-free primers is based on a vehicle composed of an oil-modified alkyd with an oil-modified highly heat-polymerized phenol-aldehyde resin dispersion similar to the current 1-GP-132 specification, and a second formulation based on the short oil and a medium oil alkyd mixture. Procedures similar to those used to develop the chromate-free wash primer were used to develop the anti-corrosive pigment mix of phosphate and borate. These chromate-free primers can be used on both aluminum and steel alloys, are compatible with alkyd topcoats used on Canadian Forces ships, and have the further advantages of fast drying time, flexibility, salt fog resistance and gasoline resistance that are required of the current 1-GP-132 specification.

SOLVENT-BASED PAINT STRIPPERS: ALTERNATIVES TO METHYLENE CHLORIDE

Carl J. Sullivan, ARCO Chemical Co.

Increased awareness of the health and environmental impact of chlorinated solvents is forcing companies to identify effective alternatives to methylene chloride based paint strippers. N-methyl pyrrolidone is a well known alternative; however, its high cost often discourages more widespread usage. A very broad solvent blending study has identified some synergistic n-methyl pyrrolidone combinations which are not only effective, but cost-effective.

This report summarizes the experimental results and provides examples for industrial and consumer applications. Particular emphasis is given to the methods to adjust simple recommendations in order to meet job specific performance criteria.

POLYURETHANE COATINGS: SAFE APPLICATION IN OUTDOOR MAINTENANCE PAINTING

H.E. Myer, Mobay Corp.

Polyisocyanate-activated coatings, like other high performance coatings, contain ingredients which must be controlled during the application process. Solvents, monomeric isocyanates, and polymeric isocyanates are examples of such ingredients.

Extensive air monitoring was performed during the brush/ roller and spray application of polyurethane maintenance coatings. Based on these measured concentrations, recommendations were made as to what respiratory protection was needed during bridge and chemical tank painting operations. In addition, area sample results were used to identify the area around the painting operation where there was potential for overexposure. Data and resulting recommendations are presented.

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FLEXIBLE COATINGS FOR EXTERIOR WOOD

Steven W. Rees, Cray Valley Products Ltd.

Coatings for exterior wood need a high level of flexibility and good adhesion to give good protection to the substrate.

In this presentation, some of the methods of achieving and maintaining adequate flexibility are described. The results of natural and accelerated weathering tests on experimental coatings are discussed.

STATISTICAL ANALYSIS OF THE EVOLUTION OF THE YELLOWNESS INDEX DURING AN ACCELERATED WEATHERING OF A COATING

Patrick Schutyser, Coatings Research Institute

The presentation describes the accelerated weathering of a coating. The evolution of its Yellowness Index under constant UV irradiation is measured at different temperatures as a function of weathering time. The life times of the coating samples are determined and the corresponding life time distributions established through application of the principles of Reliability Theory. This leads to the calculation of service life estimates of the coating for the different temperature levels considered here.

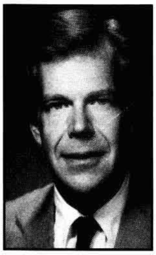
The use of this approach to accelerated weathering data has the advantage of yielding results with their respective confidence limits. Consequently, statistically significant conclusions can be drawn on the influence of the temperature on the Yellowness Index of the coating studied.

SPECIFIC INTERACTIONS AND ADSORPTION OF FILM-FORMING POLYMERS

Henry P. Schreiber and Javier Lara A., Ecole Polytechnique l'Universite de Montreal

A study has been carried out of the adsorption onto rutile and organic pigments of polyester dispersion and binder resins. Acid/base interaction potentials of pigments and of resins, and polymer/solvent interactions were determined by inverse gas chromatography (IGC). The quantity of polymer adsorbed was found to vary greatly among the pigments. A knowledge of acid/base interaction potentials was sufficient to rationalize the adsorption of any given polymer on a wide range of pigments. A general correlation, involving all of the polymers and pigments of this study, also required use of the Flory-Huggins polymer/solvent interaction parameter.

A new interaction parameter has been introduced to permit a convenient and powerful rationalization of adsorption in film-forming systems. It was shown also that molecular fractionation occurs during adsorption. In pigmented films, based on polydisperse polymers, the polymer at the pigment surface has a higher molecular weight than polymer chains some distance from the adsorbing surface. The extent of fractionation depended on acid/base interactions. These interactions therefore may affect a wide range of properties in the final coating.



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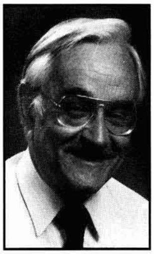

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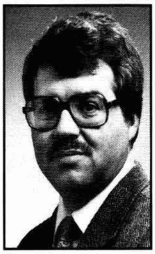

H.E. Myer

ADHESION AND FLEXIBILITY CONTRIBUTIONS TO THE PERFORMANCE OF EPOXY PHOSPHATE ESTER COATINGS

John L. Massingill, Dow Chemical U.S.A.

Improvements are needed in the performance of epoxy bake coatings to allow coating suppliers to optimize their products for new applications. Epoxy/resole coatings made with phosphate esters of advanced epoxy resins have been shown to give significant improvements in wedgebend and T-bend tests compared to the formulations made from the base resins. The reason for the improvements was postulated to be a combination of (1) improved adhesion through the phosphate ester group and (2) improved flexibility from chain extension through reaction of terminal resin hydroxyl groups with the resole curing agent. This presentation uses T-peel adhesion, free film elongation, microscopy, and spectroscopy to evaluate the importance of these two potential mechanisms to the improved performance observed.

The acid-base interaction of the acidic resin phosphate ester hydroxyl with the basis metal oxide substrate was evaluated by spectroscopy and by comparing wet and dry T-peel adhesion of test coatings on tin free steel. The possibility of improved flexibility by linear chain extension was evaluated using free film elongation and microscopy.

LATENT AMINE CATALYSTS FOR EPOXY-CARBOXY HYBRID POWDER COATINGS. INVESTIGATIONS AND PHASE CHANGE CONTROL OF REACTIVITY

S. Peter Pappas, Loctite Corp., and Victor D. Kuntz and Betty C. Pappas, North Dakota State University

Ten crystalline amic acids, derived from four carboxylic acid anhydrides and four diamines, possessing both primary and tertiary amine groups, were synthesized and investigated as latent amine catalysts for bisphenol A epoxy-polyester carboxy (hybrid) powder coatings. On heating, the zwitterionic amic acids underwent thermally induced intramolecular cyclization to imides, which catalyzed the carboxylic acid-epoxide reaction leading to cure of the powder coatings.

It was reasoned that cyclic imidization might be facilitated by melting of the amic acids, in which case latency could be controlled by the melting point phase change. This premise was investigated by DSC, TGA, and thermal FTIR studies on the amic acids, together with DSC and storage stability studies on melt-mixed powder coatings.

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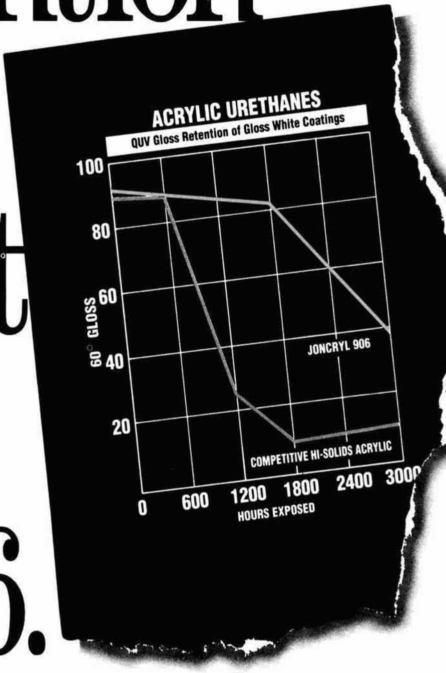

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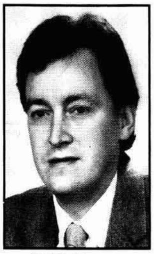

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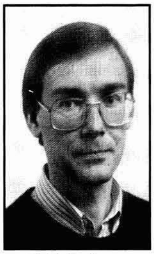

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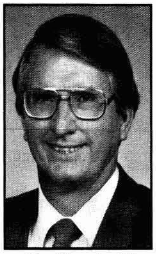

J.L. Massingill

PERFORMANCE AND STABILITY OF KETOXIME BLOCKED ISOCYANATE/EPOXY BASED SIMPLE COMPONENT COATINGS

John M. McIntyre, The Dow Chemical Co.

Current industrial and environmental trends are towards lower temperature cured (125°C-150°C) water borne coatings. Evaluations in the laboratory have shown variations in appearance and corrosion performance of water-borne coating formulations comprising acidified epoxyamine adducts and ketoxime blocked isocyanates.

Dispersion stability often decreased with age, while the conductivity and pH increased with age. Viscoelastic-thermal analyses and thermal photomicroscopic studies of the coatings indicated that the coatings cured at much lower temperatures than the deblocking temperatures of the ketoxime blocked isocyanates themselves. Kinetic and mechanistic studies showed that the ketoximes blocked isocyanates tend to react with primary hydroxyl and/or primary amine groups on the epoxy amine adduct resin or solvents, but not with the secondary hydroxyl groups.

RHEOLOGICAL CONSIDERATIONS OF ABRASION RESISTANT SELF-HEALING POLYURETHANE RESINS

Y. Abe and N. Okoshi, Dainippon Ink and Chemicals, Inc., and Andrew Woo, Reichhold Chemicals, Inc.

Urethane resins have been used in coatings for plastic substrates because they provide durable and tough films. Two of the major applications for these resins are interior automotive parts and electrical appliances.

A new optically clear and abrasion resistant polyurethane has been developed to provide flexible, soft, leather-like coatings. These coatings are highly abrasion resistant and have the unique feature of "self-healing" when exposed to moderate abrasion.

The abrasion resistance and rheological characteristics of these films were studied by correlating these properties with polymer structure, particularly the polyol component of these two-package resins. We have correlated the stress-relaxation curves of these polymers with the haze values of the test films, and the current results indicate that those films with the shortest relaxation times have the highest abrasion resistance and "self-healing" properties against steel wool.

These results, in combination with new urethane colored beads, have been found to yield unique coatings which provide excellent "suede-like" finishes.

CRYSTALLINE SILICA: A MATERIAL SHOWING "LIMITED EVIDENCE OF CARCINOGENICITY" TO HUMANS

Sidney Lauren, CR Minerals Corp.

Regulatory constraints on the use of raw materials for coatings have fallen thus far principally on solvents; some film-formers, such as those containing free isocyanate groups, or those generating free formaldehyde during cure; some pigments, such as those containing heavy metals, and some additives, such as lead driers and phenyl mercury preservatives. To this partial list, a massive report in 1987 by the International Agency for Research on Cancer (IARC) added crystalline silica, a nominally inert material, as showing "limited evidence of carcinogenicity" by humans.

Commercial grades of diatomaceous silica (diatomite), used universally as flatting agents, were commonly considered amorphous; actually, they contain 60% or more of crystalline silica, and have therefore come under control as hazardous substances of OSHA.

How crystalline silica is generated in this natural product by a processing step, and the availability of an alternate, high-brightness diatomite, equally effective as a flatting agent, but containing less than 1% crystalline silica, are discussed from the viewpoint of formulators who value continued access to this efficient functional filler.

A COATINGS MANUFACTURER'S GUIDE TO REGULATORY REQUIREMENTS AND POLLUTION PREVENTION OPTIONS

Kevin F. Gashlin, New Jersey Institute of Technology

This presentation provides regulatory awareness guidance to owners and operators of businesses that manufacture and/or use paint and other architectural coatings which are subject to the existing Clean Air Act.

Described are pollution prevention options successfully used by those industries. These are illustrated with case studies documenting the technology, evaluating its transferability, and its availability to the industry.

FORMALDEHYDE REGULATORY UPDATE

Jeffrey D. Felder, Monsanto Chemical Co.

Formaldehyde is a basic industrial chemical as well as a naturally-occurring metabolite. It has been safely used for many years. However, it is not without its hazards. Its properties as an irritant are well established. There is far less agreement as to sensitization and carcinogenicity. Because of both its irritant properties and concern as to the more disputed effects, it remains the subject of regulatory scrutiny. This includes activities for control in the workplace (e.g., OSHA and ACGIH), the environment (e.g., EPA and various States), and interiors (e.g., EPA, CPSC, HUD, ASHRAE).

This presentation discusses in some detail OSHA and ACGIH regulatory efforts, as they are of most immediate concern to the coatings industry, and deals briefly with general outside and interior environmental issues. Both are largely in earlier stages of development than the workplace issues.

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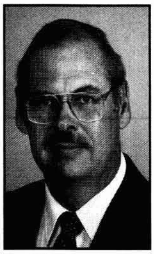
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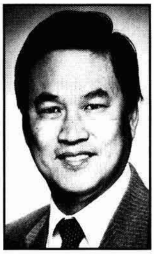
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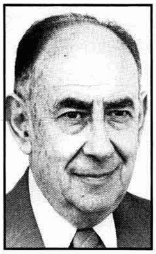
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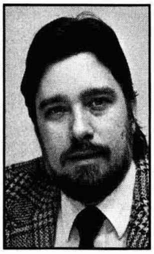
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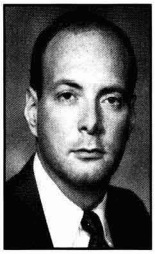
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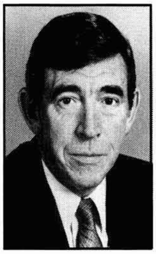
D. Kiker

SORPTION OF MOISTURE ON EPOXY AND ALKYD FREE FILMS AND COATED STEEL PANELS

Howard N. Rosen and Jonathan W. Martin, National Institute of Standards & Technology

Adsorption isotherm curves at 23°C were determined for alkyd and epoxy free films and coated steel panels, as well as for alkyd "pocket" panels, consisting of an unadhered film surrounding steel panels. The isotherms consisted of a linear portion of about 75% relative humidity (RH) followed by a rapidly rising portion to 100% RH. A model assuming weak bonding forces between paint film and water with microvoid condensation at high RH gave an excellent fit to the data.

Transient adsorption and desorption data on the approach to equilibrium conditions showed differences between alkyd and epoxy coatings. Surface resistance was significant for alkyd films and sorption followed Fickian models. For the epoxy coating, surface resistance was not significant and moisture movement was non-Fickian.

CYCLIC AND CONTINUOUS IMMERSION RESULTS FOR SCRIBED AND UNSCRIBED ALKYD COATED STEEL PANELS

Jonathan W. Martin, Edward Embree, and Wynee Tsao, National Institute of Standards and Technology

The coatings industry recently has shown increasing interest in developing and adopting cyclic accelerated aging tests as the preferred method for determining the service life of a coating system. Seemingly little attention has been paid, however, to systematically studying the effects that cyclic wetting and drying have on panel degradation. One way of doing this is by comparing the degradation rates of nominally identical sets of panels exposed to a continuous or cyclic wet-dry exposure environment.

Four sets of medium-oil alkyd coated steel panels were immersed in a 5% NaCl solution in the absence of an applied electrical potential. Two sets were continuously immersed in the electrolyte, while the other two were cyclically immersed. Of the two sets of panels assigned to each immersion condition, one contained a prominent scribe mark, while the other did not. Panel degradation was tracked by periodically monitoring the size, location, and number of cathodic blisters appearing on a panel and by analyzing the chemical properties of the blister fluid.

For both scribed and unscribed panels, the cyclic immersed panels took between two and three times longer to achieve an equivalent level of degradation as that of the continuously immersed panels. Within an exposure treatment, the degradation response of scribed and unscribed panels mainly differed in the length and variability of their incubation periods, the time during which blisters do not form on a panel. The incubation period for the scribed panels was much shorter and less variable than that of the scribed panels. Finally, the chemical analysis of the blister fluid and the physical characterization of the blisters do not support osmotically driven blister growth.

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*Offer restricted to staff at a paint manufacturer currently making two-part solvent-borne epoxy enamels, and to one comparison per company.

1990 PAINT INDUSTRIES' SHOW

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Aceto Corp.	1054
ACS-Datacolor	431
Advanced Coating Technologies	1631
Advanced Software Designs	1805
Air Products & Chemicals, Inc.	1031
Alcan-Toyo America, Inc.	237
Allied Signal Corp.	1831
C.M. Ambrose Co./Pioneer Packaging	521
American Cyanamid Co.	1531
American Institute of Chemists	1803
American Iron & Steel Institute	1333
Amoco Chemical Co.	1404
ANGUS Chemical Co.	747
Anker USA, Inc.	154
Aqualon Co.	721
Arco Chemical Co.	1037
Aries Software Corp.	1923
Ashland Chemical Co. IC&S Div.	137
Atlas Electric Dev. Co./South Florida Test Serv.	1311
Atochem North America, Lucidol	130
Atochem North America	1943

B&P Environmental Resources	1821
B.A.G. Corp.	1142
BASF Corp. Chemicals Div.	1005
Bilt-Rite Corp.	1746
Blackmer Pump Div./Dover Resources Co.	344
Bohlin Reologi, Inc.	1711
Brookfield Engineering Labs., Inc.	1827
Brookhaven Instruments Corp.	1546
Buckman Laboratories, Inc.	445
Buhler, Inc.	821
Bulk Connection, Inc.	2007
Bulk Lift International, Inc.	1810
Burgress Pigment Co.	940
Byk-Chemie USA	705
Byk-Gardner, Inc.	715
CB Mills, Inc.	831
CR Minerals Corp.	1550
CSC Publishing Inc.	1649
Cabot Corp.,CAB-O-SIL & Specials Blacks Div.	336
Calgon Corp., Div. of Merck & Co., Inc.	625
The Carborundum Co.	1510
Cardolite Corp.	1705
Cargill, Inc.	653
Caschem, Inc.	513
Catalyst Resources, Inc.	303
Cellier Corp.	150
Charles Ross and Son Co.	1846
Chem-Tel Inc.	456
Chemical & Engineering News	301
Chemical Marketing Reporter	1806
Chemical Week	1503
CIBA-GEIGY Corp.	1213
Clawson Tank Co.	951
Coatings Magazine	1815
Colloids, Inc.	321
Color Corp. of America	647
Colores Hispania, S.A.	1708
Colorgen, Inc.	703
Columbian Chemicals Co.	551
Consolidated Research Inc.	1753
Cookson Pigments, Inc.	1415
Coulter Electronics, Inc.	1926
CPI Purchasing	1948
Cray Valley Products International	1527
Crosfield Chemicals, Inc.	1843
Cuno Process Filtration Prod.	205
Cyprus Industrial Minerals Co.	1820

D/L Laboratories	931
Daniel Products Co.	331
Dantco Mixers Corp.	1709
Davies Can Co.	1927
Day-Glo Color Corp.	457
Degussa Corp.	1053
University of Detroit	1801
Diano Color Products	1306
Dominion Colour Co.	1842
Dow Chemical USA	121
Dow Corning Corp.	1433
Draiswerke, Inc.	1521
Drew Chemical Corp.	1637
DSA Consulting, Inc.	1915
DSET Laboratories, Inc.	837
Du Pont Co.	637

E.C.C. America	1721
Eagle Picher Minerals, Inc.	1609
Eagle Zinc Co.	138
Eastern Michigan University	1703
Eastman Chemical Products, Inc.	905
Ebonex Corp.	1224
Eiger Machinery, Inc.	1931
Elcometer, Inc.	1620
Elders Resources Chemicals Inc.	1909
Elektro-Physik USA, Inc.	358
Elmar Industries, Inc.	2023
EM Industries, Inc. Pigments Div.	115
Engelhard Corp., Spec. Min. & Colors Group	805
Ensco, Inc..	1001
Epworth Manufacturing Co., Inc.	245
Etna Products Inc., Specialty Chemical Div.	1808
European Coatings Journal	1508
Exxon Corp.	1221

Fawcett Co., Inc.	1212
Federation of Societies for Coatings Tech.	Lobby
Filter Specialists, Inc.	2016
FMC Corp., Food & Phamaceutical Div.	1707
FMJ International Pub., Paint & Chem.l Div.	1147
Freeman Poly. Div. of Cook Composites & Poly.	120
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H.B. Fuller Co.	1914

GAF Chemicals Corp.	1910
Paul N. Gardner Co., Inc.	1143
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Hitox Corp. of America	2015
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Hoechst Celanese Corp.	231
Hoechst Celanese Corp., Waxes & Lubricants	1747
Horiba Instruments, Inc.	126
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Hüls America, Inc.	605
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Ideal Manufacturing & Sales	1220
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Industrial Finishing Magazine	2013
Interfibe Corp.	1906
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Kent State University	1603
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Kronos, Inc. (formerly NL Industries)	403
KTA-Tator, Inc.	1536
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Leeds & Northrup, Unit of General Signal	134
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Macbeth Div., Kollmorgen	213
Magnesium Elektron, Inc.	2024
Malvern Instruments	158
Malvern Minerals Co.	1515
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Manville Sales Corp.	1113
Matec Applied Sciences	1908
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Michelman, Inc.	2031
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Mid-States Engineering & Manufacturing	1427
Miller Manfacturing Co., Inc.	1727
Millipore Corp.	1807
Milton Roy Co.	1306
MiniFIBERS, Inc.	2003
Minolta Corp.	901
Mississippi Lime Co.	1902
University of Missouri-Rolla	1702
Mitech Corp.	802
Mixing Equipment Co., Inc.	1647
Mixmor, Inc.	2012
Mobay Corp.	921
Modern Paint & Coatings	1149
Monsanto Co.	1507
Morehouse Industries, Inc.	430
Mountain Minerals Co., Ltd.	102
Myers Engineering	936
Nametre Co.	1751
Netzsch Inc.	1327
Neupak, Inc.	537
Neutronics, Inc.	1748
New Way Packaging Machinery, Inc.	356
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North Dakota State University	1602
NYCO	1205
Oak Printing Co.	1506
Obron Atlantic Corp.	1611
ORB Industries, Inc.	1904
Ortech International	1704
PQ Corp.	1121
Pacific Micro Software Engineering	146
Paint & Coatings Industry Magazine	2035
Paint Research Associates	1601
Pen Kem, Inc.	1548
Penn Color, Inc.	556
Pfizer Specialty Minerals	129
Philipps 66 Co., Specialty Chemicals	402
Pioneer Packaging Machinery/Ambrose Corp.	521
Poly-Resyn, Inc.	2004
PPG Silica Products, Unit of PPG Industries	1736
Premier Mill Corp.	304
Progressive Recovery, Inc.	1614
Pyosa, S.A. De C.V.	1752
Q-Cim Development Laboratories	1949
The Q-Panel Co.	1047
Quantachrome Corp.	1605
Raabe Corp.	110
Red Devil, Inc.	1743
Reichhold Chemicals, Inc.	337
Rheometrics, Inc.	1936
Rheox, Inc. (formerly NL Industries)	505
Rhone-Poulenc Inc.	321
Rhone-Poulenc Specialty Chemical (formerly Hi-Tek Polymers)	321
Rohm and Haas Co.	305
Ronnigen-Petter	1141
Rosedale Products, Inc.	1056
Russell Finex, Inc.	1304
Sandoz Chemicals Corp.	857
Sanncor Industries, Inc.	1148
Schering Berlin Polymers Inc.	1651
Semi-Bulk Systems, Inc.	1137
Serac, Inc.	531
Shamrock Technologies, Inc.	650
Sheen Instruments Ltd.	1847
Shell Chemical Co.	720
Sherwin-Williams Chemicals Co.	955
Shimadzu Scientific Instrument	103
Silberline Manufacturing Co.	1017
Sino-American Metals & Minerals (S.F.) Inc.	1950
Siva International, Inc.	106
South Florida Test Service/Atlas Electric Devices	1311
University of Southern Mississippi	1701
Spartan Color Corp.	1935
Startex Chemical Co.	1917
Steel Structures Painting Council	1901
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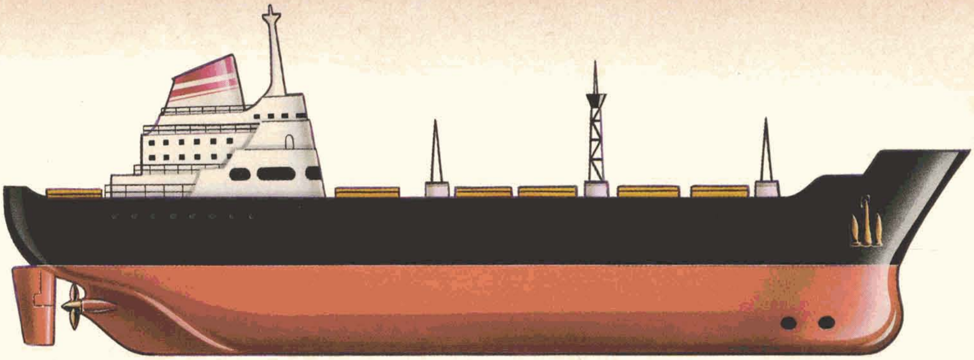

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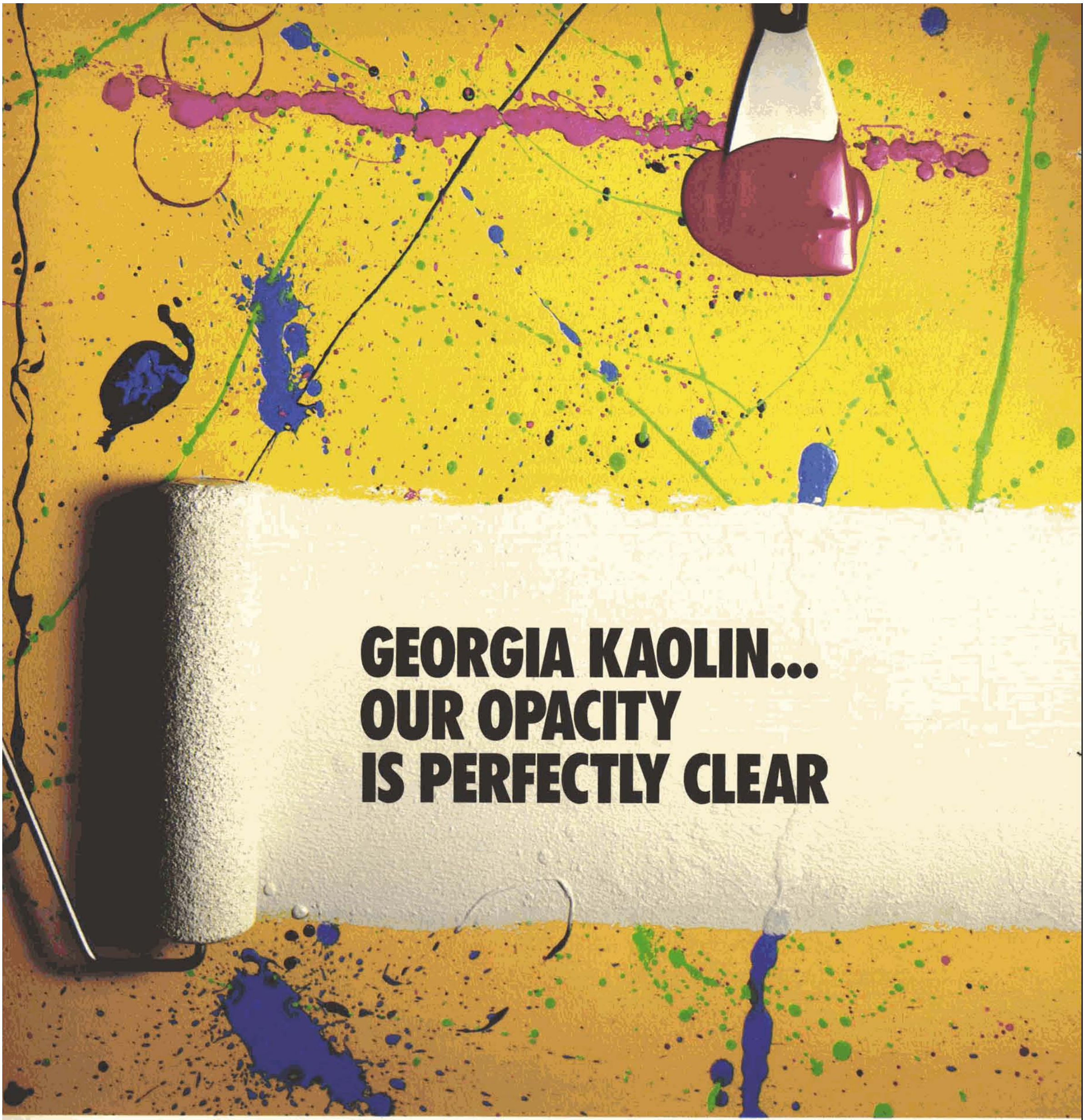

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Systech Environmental Corp.	1501
Tego Chemie Service USA	1737
Texaco Chemical Co.	140
The Triplex Group, Inc.	1043
Thiele Engineering Co.	853
Tintometer Co.	1802
Tioxide America, Inc.	1623
Troy Chemical Corp.	631
Turbomixer Corp.	1853
U.S. Silica Co.	1421
U.S. Stoneware Corp./Jaygo, Inc.	2006
Ultra Filter Systems	1952
Unimin Specialty Minerals Inc.	1643
Union Carbide Chemical & Plastics	251
Union Process, Inc.	621
United Catalysts, Inc.	813
United Mineral & Chemical Corp.	1946
United States Testing Co., Inc.	1849
Universal Color Dispersions	1216
Unocal Chemicals Div.	937
Van Waters & Rogers	1003
R.T. Vanderbilt Co., Inc.	1543
Velsicol Chemical Corp., Specialty Chemicals Div.	116
Versa-Matic Tool, Inc.	209
Viking Pump, Inc., Unit of Idex Corp.	1117
Vorti-Siv, Div., M&M Industries, Inc.	933
Wacker Silicones Corp.	1715
Warren-Rupp, Inc.	623
Wilden Pump & Engineering Co.	1123
Witco Chemical Corp., Organics Div.	1317
WSI Engineering Co.	1156
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Zeelan Industries, Inc.	302
Zircon Corp.	1851

A Five Kilometer Fitness Run

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Tuesday, October 30, 1990, at 7:00 a.m.

Start: On the Mall near the Ice Rink,
Madison Drive Walk
Finish: Inner Walkway of the Mall

Sponsored by Troy Chemical 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 Washington, D.C.

The run is scheduled for 7:00 a.m. on Tuesday. Participants will run on a measured, police-protected five kilometer (3.1 mile) course twice around the Mall. 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 Washington, D.C.. Everyone will be a winner!

T-shirts and a memento 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. **Entries must be received before October 15, 1990.** 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 (no cash, please) payable to:

Troy Chemical Corporation/Paint Show 5000
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SHIRT SIZE (Circle One)
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OCTOBER 29-31, 1990
WASHINGTON, D.C. CONVENTION CENTER

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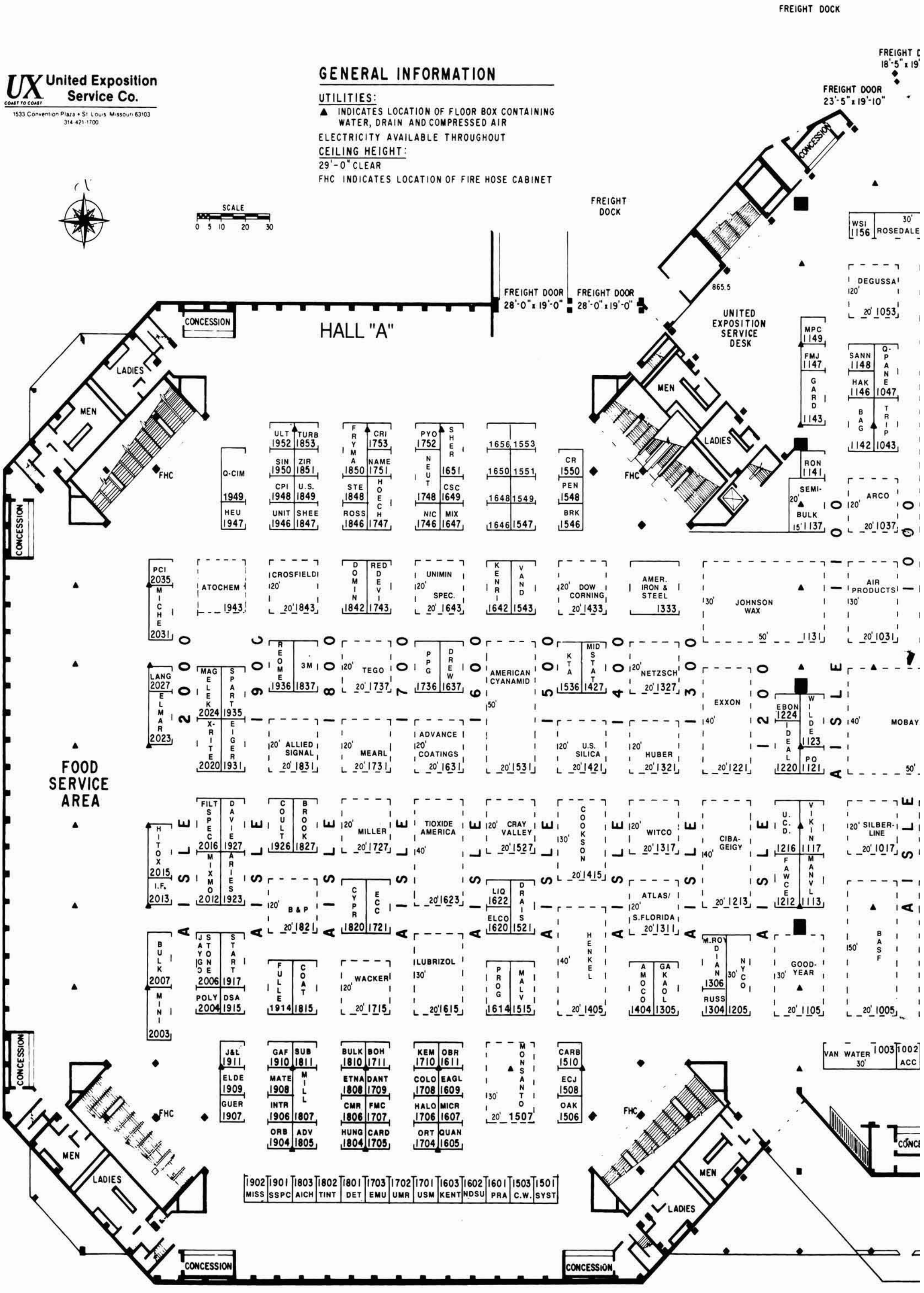

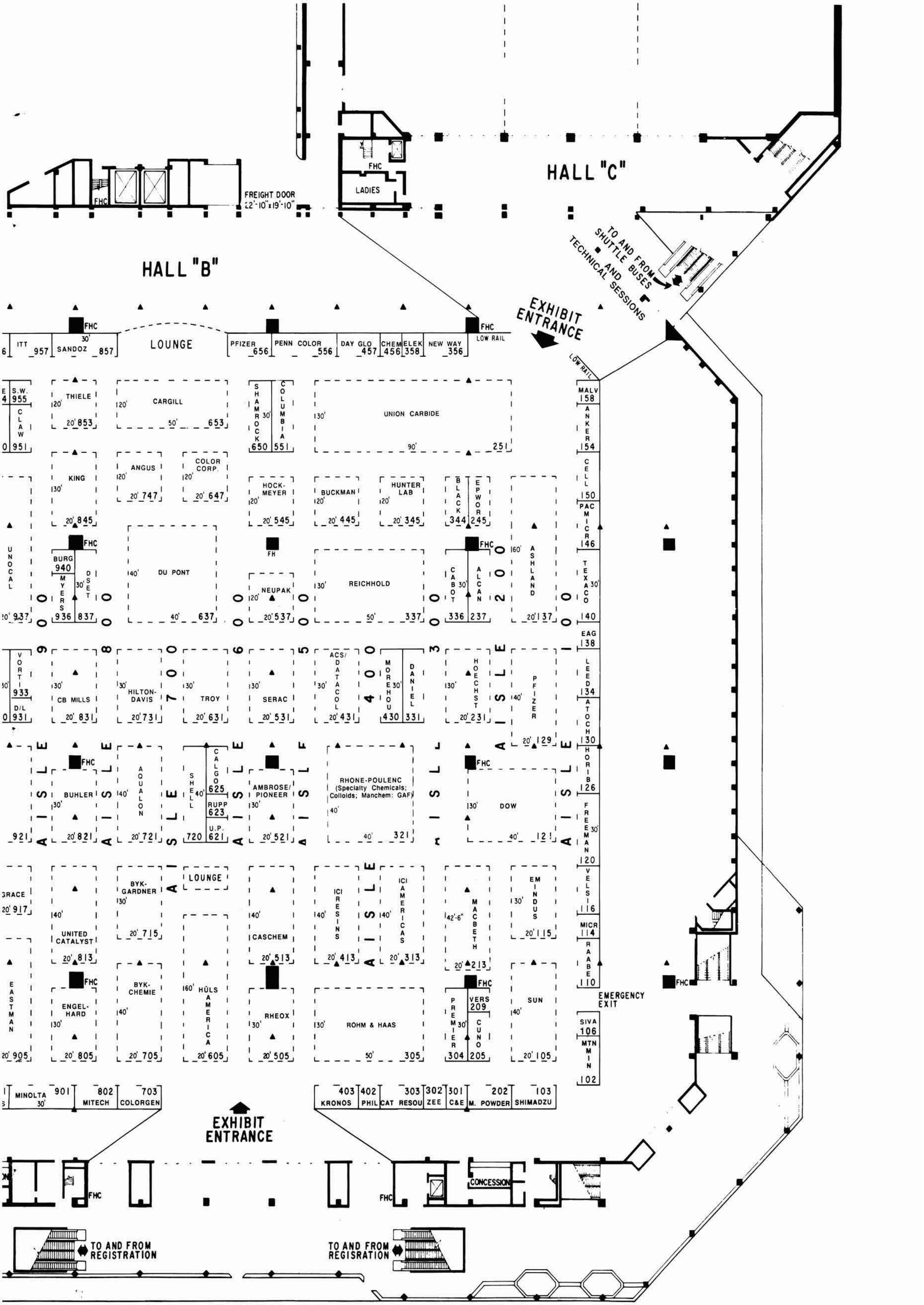HALL "C"
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CHEM 456
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NEW WAY 356
S.W. 955
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UNION CARBIDE 251
MALV 158
ANKER 154
CELL 150
PAC MICR 146
KING 845
ANGUS 747
COLOR CORP. 647
HOCKMEYER 545
BUCKMAN 445
HUNTER LAB 345
BLACK 344
EPWOR 245
TEXACO 140
UNOCAL 937
BURG 940
MYERS 936
DSET 837
DU PONT 637
FH
NEUPAK 537
REICHHOLD 337
CABOT 336
ALCAN 237
ASHLAND 137
EAG 138
VORTI 933
D/L 931
CB MILLS 831
HILTON-DAVIS 731
TROY 631
SERAC 531
ACS/DATACOL 431
MOREHOU 430
DANIEL 331
HOECHST 231
PFIZER 129
LEED 134
ATOCH 130
HORIB 126
BUHLER 821
AQUALON 721
SHELL 720
CALGO 625
RUPP 623
U.P. 621
AMBROSE/PIONEER 521
RHONE-POULENC (Specialty Chemicals; Colloids; Manchem: GAF) 321
DOW 121
FREEMAN 120
921
AISLE 900
AISLE 800
AISLE 700
AISLE 600
AISLE 500
AISLE 400
AISLE 300
AISLE 200
AISLE 100
GRACE 917
BYK-GARDNER 715
LOUNGE
UNITED CATALYST 813
CASCHEM 513
ICI RESINS 413
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MACBETH 213
EM INDUS 115
VELSI 116
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HÜLS AMERICA 605
RHEOX 505
ROHM & HAAS 305
PREMIER 304
VERS 209
CUNO 205
SUN 105
SIVA 106
MTN MIN 102
MINOLTA 901
MITECH 802
COLORGEN 703
KRONOS 403
PHIL 402
CAT RESOU 303
ZEE 302
C&E 301
M. POWDER 202
SHIMADZU 103
EXHIBIT ENTRANCE
CONCESSION
TO AND FROM REGISTRATION
TO AND FROM REGISRATION

EXHIBITORS

Listed by Product/Services Classification

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RAW MATERIALS

ADDIVITES

Aceto Corp.	1054
Air Products & Chemicals, Inc.	1031
Allied Signal Corp.	1831
American Cyanamid Co.	1531
ANGUS Chemical Co.	747
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Elders Resources Chemicals, Inc.	1909
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GAF Chemicals Corp.	1910
W.R. Grace & Co., Davison Chemical Div.	917
Henkel Corp., Process Chemicals	1405
Hoechst Celanese Corp., Waxes & Lubricants Group	1747
Hüls America, Inc.	605
ICI Americas, Inc.	313
King Industries, Inc.	845
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3M, Industrial Chemicals Div.	1837
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Van Waters & Rogers	1003
R.T. Vanderbilt Co., Inc.	1543
Velsicol Chemical Corp., Specialty Chemicals Div.	116
Wacker Silicones Corp.	1715
Witco Chemical Corp., Organics Div.	1317
Zircon Corp.	1851

CHEMICAL INTERMEDIATES

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Ashland Chemical Co. IC&S Div.	137
BASF Corp., Chemicals Div.	1005
Cray Valley Products International	1527
Eastman Chemical Products, Inc.	905
Exxon Corp.	1221
GAF Chemicals Corp.	1910
Hüls America, Inc.	605
King Industries, Inc.	845
Mobay Corp.	921
Phillips 66 Co., Specialty Chemicals	402
Rhone-Poulenc Spec. Chem.(formerly Hi-Tek Polymers)	321
Texaco Chemical Co.	140
Union Carbide Chemicals & Plastics	251
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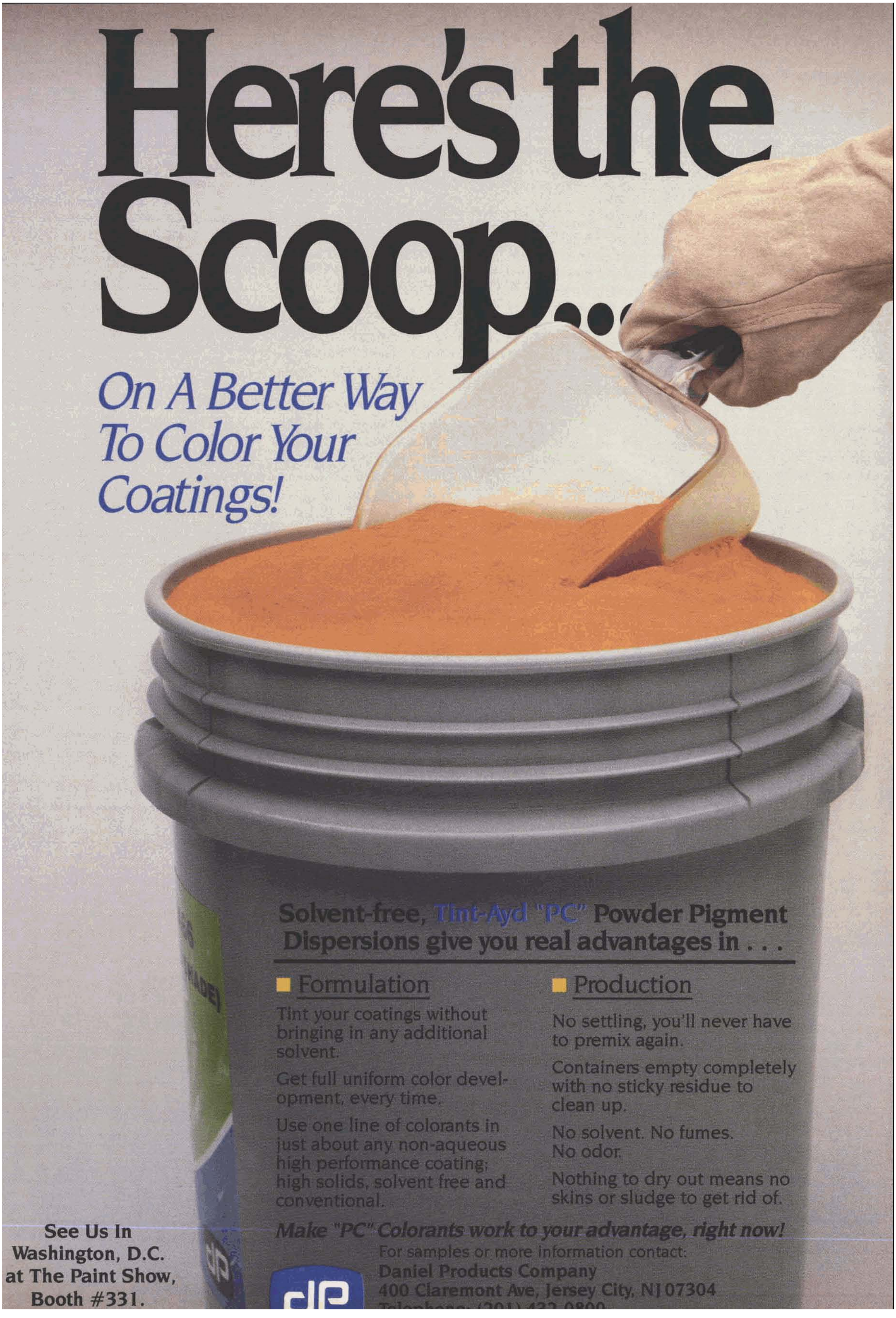
Color Corp. of America	647
Daniel Products Co.	331
Day-Glo Color Corp.	457
Degussa Corp.	1053
EM Industries, Inc., Pigments Div.	115
Harcross Pigments, Inc.	129
Heucotech	1947
Hilton-Davis Co.	731
Hüls America, Inc.	605
ICI Americas, Inc.	313
The Mearl Corp.	1731
Sandoz Chemicals Corp.	857
Spartan Color Corp.	1935
Sun Chemical Corp.	105
United Mineral & Chemical Corp.	1946
Universal Color Dispersions	1216
Zircon Corp.	1851

EXTENDERS

Burgess Pigment Co.	940
Cardolite Corp.	1705



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Cyprus Industrial Minerals Co.	1820
E.C.C. America	1721
Elders Resources Chemicals, Inc.	1909
Georgia Kaolin Co., Inc.	1305
Harcross Pigments, Inc.	129
Hitox Corp. of America	2015
Indusmin Inc.	1050
Magnesium Elektron, Inc.	2024
Malvern Minerals Co.	1515
Manville Sales Corp.	1113
Mississippi Lime Co.	1902
Mountain Minerals Co., Ltd.	102
PQ Corp.	1121
PPG Silica Products, Unit of PPG Industries	1950
U.S. Silica Co.	1421
Unimin Specialty Minerals Inc.	1643
Van Waters & Rogers, Inc.	1003
R.T. Vanderbilt Co., Inc.	1543
Zeelan Industries, Inc.	302

FIBERS

The Carborundum Co.	1510
Interfibe Corp.	1906
MiniFIBERS, Inc.	2003

LATICES AND EMULSIONS

Air Products & Chemicals, Inc.	1031
Dow Chemical USA	121
H.B. Fuller Co.	1914
S.C. Johnson & Son., Inc. (Johnson Wax)	1131
Michelman, Inc.	2031
Rohm and Haas Co.	305
Sanncor Industries, Inc.	1148
Union Carbide Chemicals & Plastics	251
Unocal Chemicals Div.	937

OILS (DRYING/NON-DRYING)

Caschem, Inc.	513
Cookson Pigments, Inc.	1415
United Catalysts, Inc.	813

PIGMENTS, INORGANIC

Aceto Corp.	1054
BASF Corp., Chemicals Div.	1005
Buckman Laboratories, Inc.	445
Caschem, Inc.	513
CIBA-GEIGY Corp.	1213
Colores Hispania, S.A.	1708
Columbian Chemicals Co.	551
Cookson Pigments, Inc.	1415
Degussa Corp.	1053
Dominion Colour Co.	1842
E.C.C. America	1721
Elders Resources Chemicals, Inc.	1909
EM Industries, Inc., Pigments Div.	115
W.R. Grace & Co., Davison Chemical Div.	917
Halox PIgments, Div. of Hammond Lead Products	1030
Harcross Pigments, Inc.	129
Heucotech	1947
Hilton-Davis Co.	731
Hitox Corp. of America	2015
J.M. Huber Corp.	1321
Hungarian Aluminium Corp.	1804
Kemira Oy	1710
Kronos, Inc. (formerly NL Industries)	403
Magesium Elektron, Inc.	2024
The Mearl Corp.	1731
Mobay Corp.	921
Mountain Minerals Co., Ltd.	102
PQ Corp.	1121
Pfizer Specialty Minerals	656
Pyosa, S.A. De C.V.	1752
Rheox, Inc. (formerly NL Industries)	505
Sherwin-Williams Chemicals Co.	955
Sino-American Metals & Minerals (S.F.) Inc.	1950
Tioxide America, Inc.	1623
United Mineral & Chemical Corp.	1946
Van Waters & Rogers, Inc.	1003

PIGMENTS, ORGANIC

BASF Corp., Chemicals Div.	1005
CIBA-GEIGY Corp.	1213
Day-Glo Color Corp.	457
Dominion Colour Co.	1842
Ebonex Corp.	1224
Hilton-Davis Co.	731
Hoechst Celanese Corp.	231
ICI Americas, Inc.	313
Mississippi Lime Co.	1902
Mobay Corp.	921
Pyosa, S.A. De C.V.	1752
Rohm and Haas Co.	305
Sandoz Chemicals Corp.	857
United Mineral & Chemical Corp.	1946

PIGMENTS, METALLIC

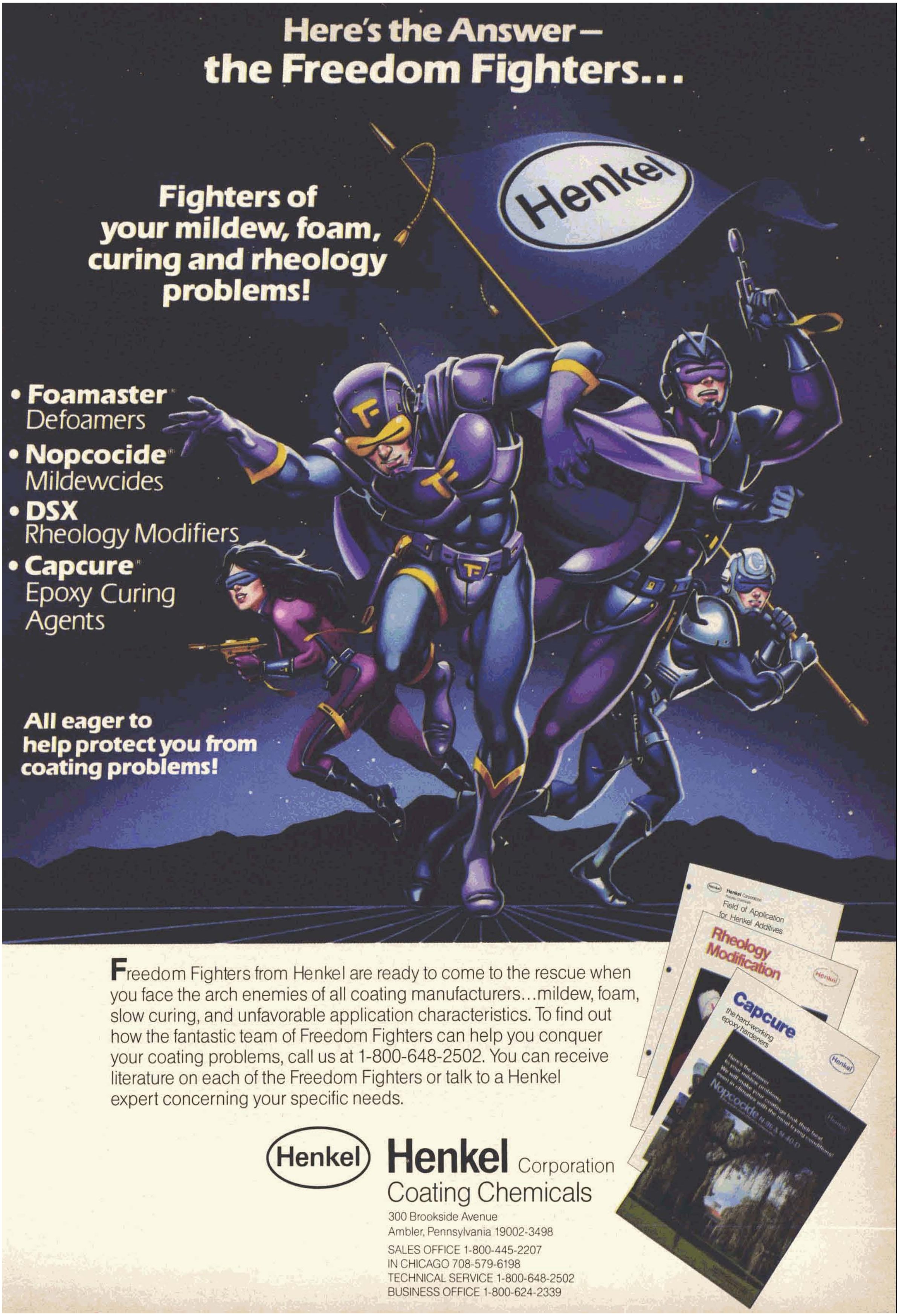
Alcan-Toyo America, Inc.	237
Eagle Zinc Co.	138
Hungarian Aluminum Corp.	1804
Obron Atlantic Corp.	1611
Silberline Manufacturing Co.	1017

PLASTICIZERS

BASF Corp., Chemicals Div.	1005
Cardolite Corp.	1705
Eastman Chemical Products, Inc.	905
Hüls America, Inc.	605
Reichhold Chemicals, Inc.	337
Van Waters & Rogers, Inc.	1003
Velsicol Chemical Corp., Specialty Chemicals Div.	116

RESINS

Air Products & Chemicals, Inc.	1031
Aqualon Co.	721
Ashland Chemical Co. IC&S Div.	137
Atochem North America	1943
BASF Corp., Chemicals Div.	1005
Cardolite Corp.	1705
Cargill, Inc.	653
Caschem, Inc.	513
CIBA-GEIGY Corp.	1213
Cray Valley Products International	1527
Dow Chemical USA	121
Dow Corning Corp.	1433
Eastman Chemical Products, Inc.	905
Elders Resources Chemicals, Inc.	1909
Etna Products Inc., Specialty Chemical Div.	1808
Freeman Polymers Div. of Cook Composites & Polymers	120
GAF Chemicals Corp.	1910
Goodyear Chemical Div.	1105



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Guer-Tin Brothers Polymers	1907
Hüls America, Inc.	605
ICI Americas, Inc.	313
ICI Resins U.S.	413
S.C. Johnson & Son, Inc. (Johnson Wax)	1131
Mobay Corp.	921
Monsanto Co.	1507
Reichhold Chemicals, Inc.	337
Rhone-Poulenc Inc.	321
Rhone-Poulenc Spec. Chem. (formerly Hi-Tek Polymers)	321
Rohm and Haas Co.	305
Sanncor Industries, Inc.	1148
Schering Berlin Polymers, Inc.	1651
Shell Chemical Co.	720
Tego Chemie Service USA	1737
Union Carbide Chemicals & Plastics	251
Universal Color Dispersions	1216
Wacker Silicones Corp.	1715
Zircon Corp.	1851

SOLVENTS

Aceto Corp.	1054
ANGUS Chemical Co.	747
Arco Chemical Co.	1037
Ashland Chemical Co. IC&S Div.	137
BASF Corp., Chemicals Div.	1005
Eastman Chemical Products, Inc.	905
GAF Chemicals Corp.	1910
Halogenated Solvents Industry Alliance	1706
Phillips 66 Co., Specialty Chemicals	402
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Cardolite Corp.	1705
Catalyst Resources, Inc.	303
Elders Resources Chemicals, Inc.	1909

PROPELLENTS

Phillips 66 Co., Specialty Chemicals	402

PRODUCTION EQUIPMENT

CLEANING

Hockmeyer Equipment Corp.	545
Progressive Recovery, Inc.	1614
The Triplex Group, Inc.	1043

CONTAINERS/DRUMS

Accurate Industries	1002
B.A.G. Corp.	1142
Clawson Tank Co.	951
Davies Can Co.	1927
Langston Companies, Inc.	2027
Mid-States Engineering & Manufacturing	1427
Semi-Bulk Systems, Inc.	1137
Stelfab Niagara Ltd.	1848

FILLING/PACKAGING/LABELING

C.M. Ambrose Co.	521
Anker USA, Inc.	154
B.A.G. Corp.	1142
Cellier Corp.	150
Elmar Industries, Inc.	2023
Ideal Manufacturing & Sales Corp.	1220
Langston Companies, Inc.	2027
Neupak, Inc.	537
New Way Packaging Machinery, Inc.	356
Pioneer Packaging Machinery/Ambrose Corp.	521
Semi-Bulk Systems, Inc.	1137
Serac, Inc.	531
Startex Chemical Co.	1917
Thiele Engineering Co.	853

FILTERING/STRAINING

Cellier Corp.	150
Cuno Process Filtration Products	205
Filter Specialists, Inc.	2016
Millipore, Inc.	1807
Ronnigen-Petter	1141
Rosedale Products, Inc.	1056
Russell Finex, Inc.	1304
Ultra Filter Systems	1952
Vorti-Siv, Div., M&M Industries, Inc.	933

GRINDING/MILLING

Buhler, Inc.	821
CB Mills, Inc.	831
Charles Ross and Son Co.	1846
Draiswerke, Inc.	1521
Eiger Machinery, Inc.	1931
Epworth Manufacturing Co., Inc.	245
Fryma, Inc.	1850
Jaygo Inc./U.S. Stoneware Corp.	2006
Morehouse Industries, Inc.	430
Netzsch Inc.	1327
Premier Mill Corp.	304
U.S. Stoneware Corp./Jaygo Inc.	2006
Union Process, Inc.	621

INSTRUMENTATION AND CONTROL

Brookhaven Instruments Corp.	1546
Elcometer, Inc.	1620
Haake/Fisons Instruments	1146
Macbeth Div. of Kollmorgen Corp.	213
Nametre Co.	1751
Neutronics, Inc.	1748

MATERIALS HANDLING

B.A.G. Corp.	1142
Cellier Corp.	150
Clawson Tank Co.	951
Hockmeyer Equipment Corp.	545
Langston Companies, Inc.	2027
Mid-States Engineering & Machinery	1427
Semi-Bulk Systems, Inc.	1137
Versa-Matic Tool, Inc.	209
Viking Pump Div., Unit of Idex Corp.	1117
Wilden Pump & Engineering Co.	1123

MIXING/DISPERSING

Bohler, Inc.	821
Cellier Corp.	150
Charles Ross and Son Co.	1846
Dantco Mixers, Inc.	1709
Draiswerke, Inc.	1521
Eiger Machinery, Inc.	1931
Epworth Manufacturing Co., Inc.	245
Fawcett Co., Inc.	1212
Fryma, Inc.	1850
Hockmeyer Equipment Corp.	545
Jaygo, Inc./U.S. Stoneware Corp.	2006
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Morehouse Industries, Inc.	430
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Red Devil, Inc.	1743
Semi-Bulk Systems, Inc.	1137
Turbomixer Corp.	1853
U.S. Stoneware Corp./Jaygo, Inc.	2006

Pumping/Metering

Blackmer Pump Div./Dover Resources Co.	344
Harcross Pigments, Inc.	129
ITT Marlow Pumps	957
Liquid Controls Corp.	1622
Versa-Matic Tool, Inc.	209
Warren-Rupp, Inc.	623
Wilden Pump & Engineering Co.	1123

Safety/Fire Protection

Neutronics, Inc.	1748

Tinting/Mixing

Dantco Mixers Corp.	1709
Draiswerke, Inc.	1521
Epworth Manufacturing Co., Inc.	245
Fawcett Co., Inc.	1212
Hockmeyer Equipment Corp.	545
Miller Manufacturing Co., Inc.	1727
Mixmor, Inc.	2012
Morehouse Industries, Inc.	430
Red Devil, Inc.	1743

SERVICES/EQUIPMENT

Consulting/Testing

Advanced Coating Technologies	1631
Atlas Electric Devices Co./South Florida Test Service	1311
B&P Environmental Resources	1821
Brookhaven Instruments Corp.	1546
Cellier Corp.	150
Consolidated Research, Inc.	1753
D/L Laboratories	931
DSET Laboratories, Inc.	837
Elcometer, Inc.	1620
Horiba Instruments, Inc.	126
J&L Instruments Corp.	1911
KTA-Tator, Inc.	1536
Micromeritics Instrument Corp.	114
Micron, Inc.	1607
Nicolet Instrument Corp.	1746
Paint Research Associates	1601
Raabe Corp.	110
South Florida Test Service/Atlas Electric Devices	1311
University of Southern Mississippi	1701
Sub-Tropical Testing Service	1811
United States Testing Co., Inc.	1849
WSI Engineering Co.	1156

Educational

American Institute of Chemists	1803
American Iron & Steel Institute	1333
University of Detroit	1801
Eastern Michigan University	1703
Elcometer, Inc.	1620
Hockmeyer Equipment Corp.	545
Kent State University	1603
KTA-Tator, Inc.	1536
University of Missouri-Rolla	1702
North Dakota State University	1602
University of Southern Mississippi	1701
Steel Structures Painting Council	1901

Exposure Testing

Advanced Coating Technologies	1631
Atlas Electric Devices Co/South Florida Test Service	1311
D/L Laboratories	931
DSET Laboratories, Inc.	837
KTA-Tator, Inc.	1536
South Florida Test Service/Altas Electric Devices	1311
University of Southern Mississippi	1701
Sub-Tropical Testing Service	1811
United States Testing Co., Inc.	1849

Publishing

American Iron & Steel Institute	1333
Chemical & Engineering News	301
Chemical Marketing Reporter	1806
Chemical Week	1503
Coatings Magazine	1815
CPI Purchasing	1948
CSC Publishing, Inc.	1649
European Coatings Journal	1508
FMJ International Publications, Paint & Chemical Div.	1147
Industrial Finishing Magazine	2013
Modern Paint & Coatings	1149
Paint & Coatings Industry Magazine	2035

Solvent Reclamation

Ashland Chemical Co., IC&S Div.	137
B&P Environmental Resources, Inc.	1821
CB Mills, Inc.	831
Progressive Recovery, Inc.	1614
Rosedale Products, Inc.	1056
Siva International, Inc.	106
Van Waters & Rogers, Inc.	1003

Waste Disposal

Accurate Industries	1002
Ashland Chemical Co., IC&S Div.	137
B&P Environmental Resources, Inc.	137
B.A.G. Corp.	1142
Ensco, Inc.	1001
Hockmeyer Equipment Corp.	545
Systech Environmental Corp.	1501
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Color Cards

Oak Printing Co.	1506

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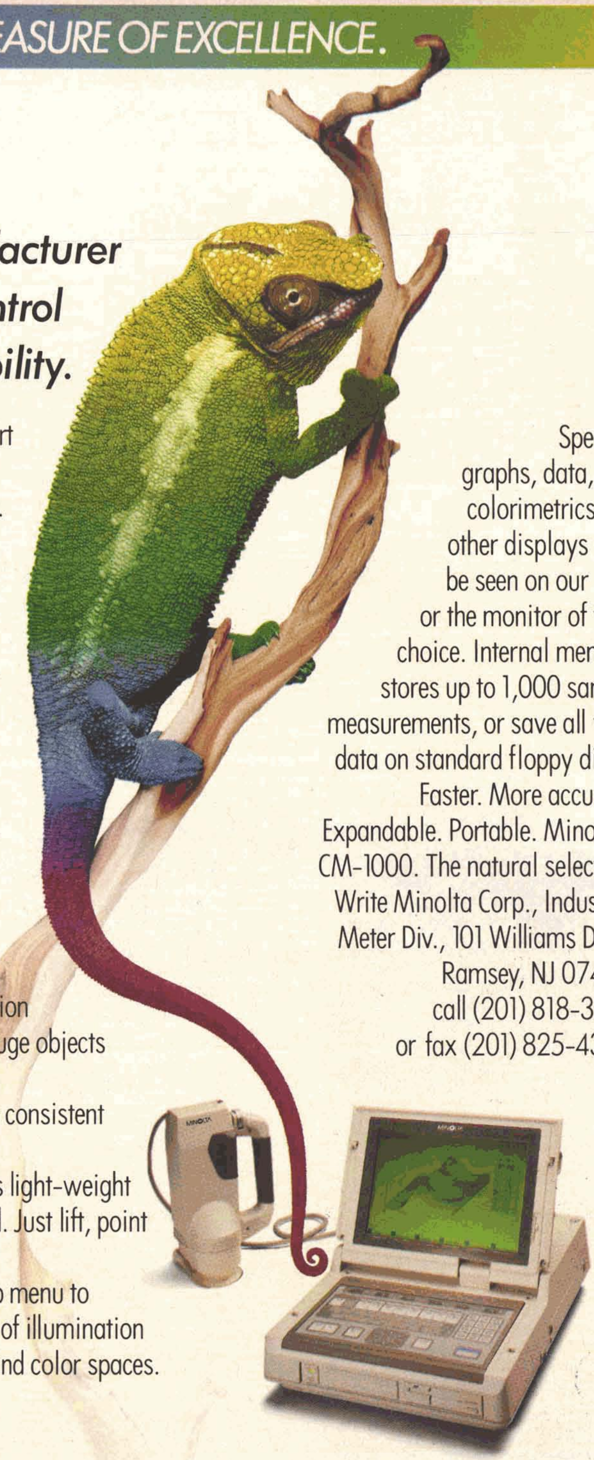

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Paint Research Associates	1601
University of Southern Mississippi	1701

LABORATORY APPARTUS AND TESTING EQUIPMENT

Accelerated Weathering

Advanced Coating Technologies	1631
Atlas Electric Devices Co/South Florida Test Service	1311
DSET Laboratories, Inc.	837
KTA-Tator, Inc.	1536
Q-Panel Co.	1047
South Florida Test Service/Atlas Electric Devices Co.	1311
Sub-Tropical Testing Service	1811

Coatings Application

Advanced Coating Technologies	1631
Elcometer, Inc.	1620
Paul N. Gardner Co., Inc.	1143
Pen Kem, Inc.	1548
Sheen Instruments Ltd.	1847

Color/Optical/Appearance Measurements

ACS-Datacolor	431
Byk-Gardner, Inc.	715
Colorgen, Inc.	703
Coulter Electronics, Inc.	1926
Diano Color Products	1306
Elcometer, Inc.	1620
Paul N. Gardner Co., Inc.	1143
Hunterlab	345
Macbeth Div., Kollmorgen	213
Milton Roy Co.	1306
Minolta Corp.	901
Nicolet Instrument Corp.	1746
Pen Kem, Inc.	1548
Sheen Instruments Ltd.	1847
Sub-Tropical Testing Service	1811
Tintometer Co.	1802
X-Rite, Inc.	2020

Computer/Software/Microprocessors

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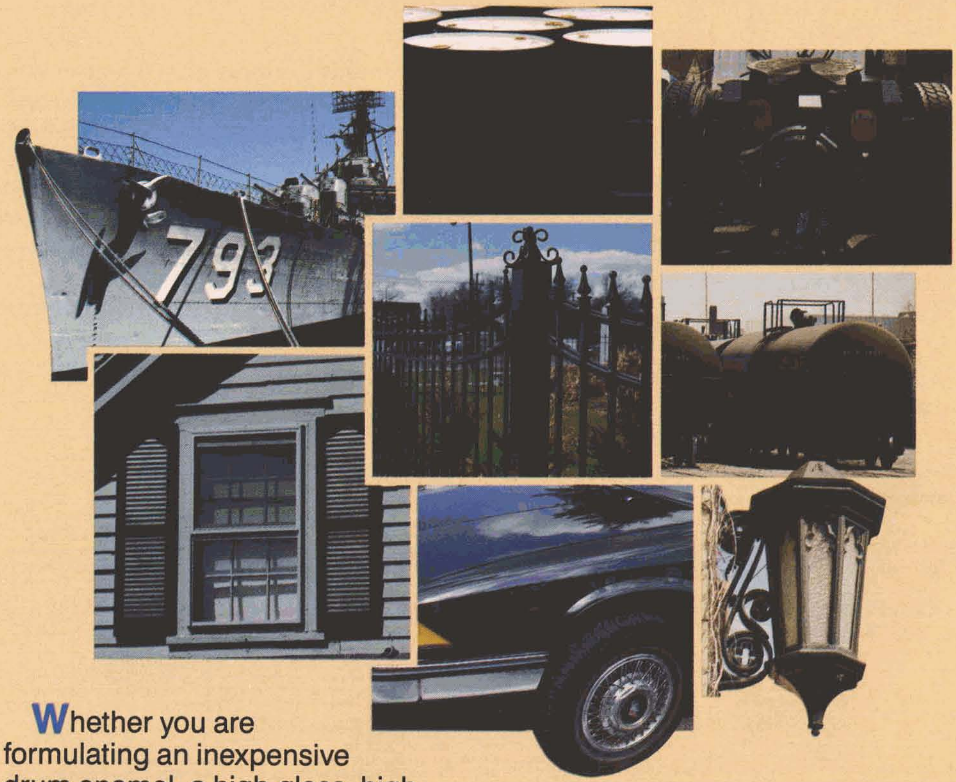

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Milton Roy Co.	1306
Nicolet Instrument Corp.	1746
Pacific Micro Software Engineering	146
Pen Kem, Inc.	1548
Q-Cim Development Laboratories	1949

LAB MILLS

Byk-Gardner, Inc.	715
CB Mills, Inc.	831
Epworth Manufacturing Co., Inc.	245
Jaygo, Inc/U.S. Stoneware Corp.	2006
Morehouse Industries, Inc.	430
Myers Engineering	936
Netzsch Inc.	1327
U.S. Stoneware Corp./Jaygo, Inc.	2006
Union Process, Inc.	621

PHYSICAL/MECHANICAL

Atlas Electric Devices Co/South Florida Test Service	1311
Brookhaven Instruments Corp.	1546
Byk-Gardner, Inc.	715
Elcometer, Inc.	1620
Horiba Instruments, Inc.	126
J&L Instruments Corp.	1911
Leeds & Northrup, Unit of General Signal	134
Matec Applied Sciences	1908
Micromeritics Instrument Corp.	114
Quantachrome Corp.	1605
Sheen Instruments Ltd.	1847
Sub-Tropical Testing Service	1811

RHEOLOGICAL

Bohlin Reologi, Inc.	1711
Brookfield Engineering Labs., Inc.	1827
Byk-Gardner, Inc.	715
Haake/Fisons Instruments	1146
J&L Instruments Corp.	1911
Mitech Corp.	802
Nametre Co.	1751
Pen Kem, Inc.	1548
Rheometrics, Inc.	1936

TEST CHARTS/PANELS

Advanced Coating Technologies	1631
Elcometer, Inc.	1620
KTA-Tator, Inc.	1536
Q-Panel Co.	1047

GAGES

Byk-Gardner, Inc.	715
Elcometer, Inc.	1620
Elektro-Physik USA, Inc.	358
KTA-Tator, Inc.	1536
Sheen Instruments Ltd.	1847

BALANCES/SCALES

Shimadzu Scientific Instruments, Inc.	103

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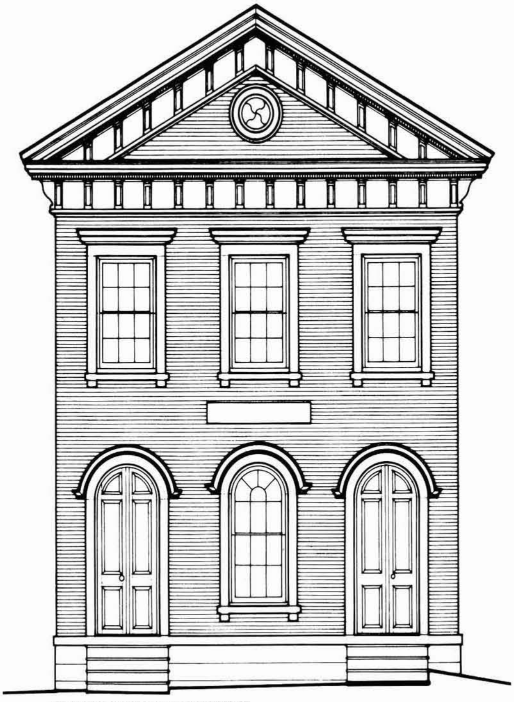

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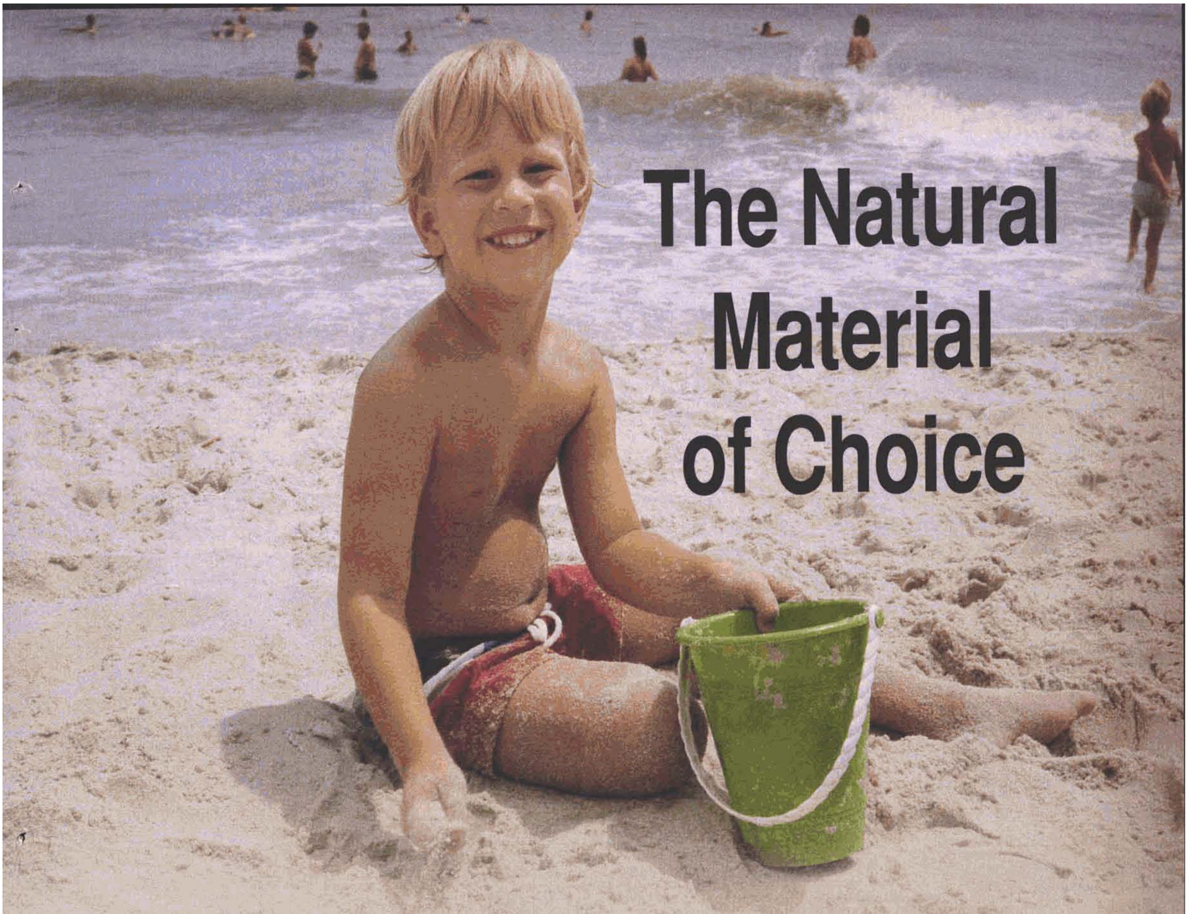

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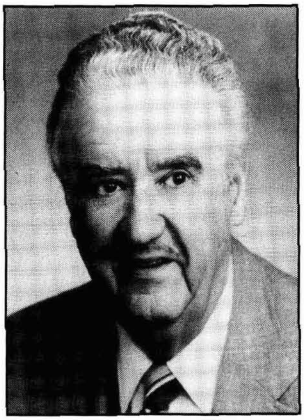
1990 Annual Meeting
Paint Industries' Show
October 29, 30, 31, 1990
Washington Convention Center
Washington, D.C.

Washington
Convention Center
Washington, D.C.
October 29-30-31, 1990

Opening Session

Monday, October 29



Keynote Address

"A Generation of Eagles"

Lee Sherman Dreyfus

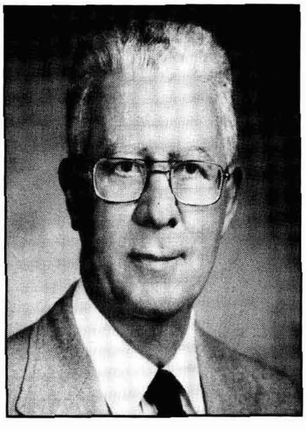
The former Governor of the State of Wisconsin (1979-83), Lee Sherman Dreyfus is a noted orator. Currently President of Lee Sherman Dreyfus, Inc., Dr. Dreyfus serves on the Board of Directors for many organizations, including the Wisconsin-based Marcus Corporation, the President's Council of Experimental Aircraft Association, and the Milwaukee Orchestra. In addition, he serves on the Board of Directors for American Energy Week, Inc. in Washington, D.C. The achievements of Dr. Dreyfus have been noted in *Who's Who in the World* and *Who's Who in America.*

Mattiello Lecture

Wednesday, October 31

"Electrochemical Techniques for Studying Protective Polymeric Coatings"

Dr. Henry Leidheiser, Jr.



Most recently the Director of the Center for Surface and Coatings Research at Lehigh University, in Bethlehem, PA, Dr. Henry J. Leidheiser is recognized for his work on the surface properties of single crystals of metals. He is renowned for his electrochemical studies of protective metallic and organic coatings. Dr. Leidheiser is also recognized for his extensive publishing credits and for his work in organizing many technical conferences. His most recent research activities have focused on such areas as corrosion under organic coatings, the nature of ions within a coating, the chemistry of the metal/organic coating interface, and the application of electrochemical techniques to appraising organic coatings.

In response to new regulations concerning the level of volatile organic compounds (VOC) in paints and coatings, paint formulators can breathe a sigh of relief. By turning to low VOC paints based on Amoco® trimellitic anhydride (TMA) and isophthalic acid (IPA), they're able to maintain paint quality while reducing hydrocarbon emissions.

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FEDERATION MEETINGS AND OTHER EVENTS

Sunday, October 28

Board of Directors Meeting (9:00 a.m.)	Sheraton, Maryland
Women in Coatings Reception (5:30 p.m.)	Sheraton, Richmond and Arlington
Paint Show Exhibitors Reception (6:30 p.m.)	Convention Center, Second Floor Lobby

Monday, October 29

Speakers Breakfast (7:30 a.m.)	Convention Center, Rooms 25-26
International Visitors Lounge (8:00 a.m.-5:00 p.m.)	Convention Center, Room 6
Opening Session (9:00 a.m.)	Convention Center, Rooms 39-40
Paint Show Opens (11:00 a.m.)	Convention Center, Halls A & B
Spouses Welcome Reception (2:00 p.m.)	Convention Center, Rooms 38-39
Gallows Bird Reception (5:00-7:00 p.m.)	Sheraton, Colorado

Tuesday, October 30

Speakers Breakfast (7:30 a.m.)	Convention Center, Room 25
Spouses Continental Breakfast (7:30 a.m.)	Sheraton, Washington Ballroom and Grand Hyatt, Independence Ballroom
International Visitors Lounge (8:00 a.m.-5:00 p.m.)	Convention Center, Room 6
Spouses Tour (9:30 a.m.)	Sheraton, 24th Street Entrance and Grand Hyatt, 10th Street Entrance
NDSU Alumni Reception (11:30 a.m.)	Convention Center, Room 21
Canadian Luncheon (12:00 noon)	Grand Hyatt, Independence A
International Visitors Reception (6:30 p.m.)	Sheraton, Ballroom N

Wednesday, October 31

Speakers Breakfast (7:30 a.m.)	Convention Center, Room 24
Spouses Continental Breakfast (7:30 a.m.)	Sheraton, Washington Ballroom and Grand Hyatt, Constitution Ballroom
International Visitors Lounge (8:00 a.m.-5:00 p.m.)	Convention Center, Room 6
Annual Business Meeting (9:00 a.m.)	Convention Center, Room 15
Annual Luncheon (12:00 noon)	Convention Center, Rooms 38-39
President's Reception (6:30 p.m.)	Sheraton, Virginia
Past-Presidents' Dinner (7:30 p.m.)	Sheraton, Colorado
Past-Presidents' Wives' Dinner (7:30 p.m.)	Sheraton, Idaho

SPOUSES ACTIVITIES

Monday, October 29

The Spouses Program of Activities will begin with the traditional get-acquainted wine and cheese social in the Convention Center Rooms 38-39. There will be favors and door prizes contributed by suppliers to the Paint Industry.
Wine courtesy of Pfizer, Inc.

Tuesday, October 30

Continental Breakfast will be served in the Washington Ballroom of the Sheraton Washington Hotel and the Independence Ballroom of the Grand Hyatt Hotel.

Luxury coaches will depart from the Sheraton and Grand Hyatt for a spectacular tour of the our nation's capital. The tour includes Washington's famous sights and museums. A visit to the Capitol, National Gallery of Art, the Smithsonian's Museum of American History, the Lincoln Memorial, and Vietnam Memorial will be included in the tour. Buses will journey past the White House, through Georgetown, and along "Embassy Row." As an added delight, the tour guides will present tales of Washington's past and present—and, especially for Halloween—the city's best documented ghost stories.

Luncheon will be served at the famous Sequoia Restaurant in Georgetown's Washington Harbor complex. The restaurant features American cuisine, and offers a lovely view of the Potomac River and the Kennedy Center.

Wednesday, October 31

Continental Breakfast at the Sheraton Washington and Grand Hyatt.

The Annual Luncheon will be held in Rooms 38-39 of the Convention Center. The featured speaker will be Douglas Kiker, noted TV news correspondent. Several Federation awards will be presented.

The spouses registration fee ($50.00 in advance, $60.00 in Washington, D.C.) includes the wine and cheese social, two continental breakfasts, and the Tuesday tour and luncheon. Tickets for the Wednesday luncheon are available for $25.00 in the registration area at Convention Center

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ADDITIONAL HIGHLIGHTS

"A DECADE OF DECISION: PREPARING FOR THE YEAR 2000"

The theme of the 1990 Annual Meeting emphasizes that, more so than in decades past, the 1990s will demand decisions on coatings technology, substrates, and application methods which will influence the products, markets, and profitability of the industry as it enters the 21st Century. Programming will focus on discussions of these areas as they relate to current state-of-the-art and future demands, as well as environmental considerations. 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, with the Sheraton Washington serving as headquarters hotel. Other hotels include the Omni Shoreham, Washington Hilton, Capital Hilton, Ramada Renaissance Techworld, Grand Hyatt Washington, Holiday Inn Crowne Plaza, J.W. Marriott, and Days Inn/Downtown Convention Center. All housing will be processed through the Washington D.C. Convention Bureau.

HOST COMMITTEE

The Baltimore Society will serve as the Host for the Annual Meeting. General Chairman of the 1990 Annual Meeting is Richard C. Chodnicki, of Van Horn, Metz & Co., Inc. Assisting him are the following sub-committee chairpersons: *Information Services*—Mitch Dudnikov, of Genstar Stone Products Co.; *Program Operations*—Tom Mitchell, of Hüls America, Inc.; *Registration Area*—Mel Hammel, of Fein Container Corp.; *Federation Exhibit*—Bob Hopkins, of SCM Chemicals Inc.; *Hospitality Suite*—Richard DiMarcantonio, of Steeltin Can Corp.; and *Spouses' Activities*—Carolyn (Richard) Chodnicki and Carolyn (Tom) Mitchell.

PROGRAM COMMITTEE

Chairman of the 1990 Program is Gary M. Gardner, of Tnemec Co., Inc. Serving with Mr. Gardner are: Gerry Parsons (Vice-Chairman), DeSoto Coatings Ltd., Mississauga, Ont., Canada; Robert F. Brady, Jr., U.S. Naval Research Laboratory, Washington, D.C.; Mary G. Brodie, The Sherwin-Williams Co., Cleveland, OH; Richard M. Hille, General Paint & Chemical Co., Cary, IL; Richard J. Himics, Daniel Products Co., Jersey City, NJ; Terryl F. Johnson, Cook Paint & Varnish Co., Kansas City, MO; and George R. Pilcher, Akzo Corp., Columbus, OH.

REGISTRATION FEES

Advance registration forms and information was 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.

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 $65 for one-day. Spouses' activities will be $60 on-site.

DELTA AND US AIR OFFER SPECIAL FARES TO D.C.

Delta Airlines and US Air, in cooperation with the Federation, are offering special discounted airline fares which afford a 40% minimum savings off round trip, undiscounted day coach fares for travel to the FSCT Annual Meeting and Paint Industries' Show on the airlines' domestic systems. The discount from Canada is 35%.

To take advantage of these discounts, you must travel to Washington, D.C. between October 24 and November 4, 1990; purchase tickets at least seven (7) days in advance; and telephone the following numbers for reservations, giving the applicable FSCT File Number: for Delta—1-800-241-6760 **(File #U0235)**; for US Air—1-800-334-8644 in the U.S., or 1-800-428-4322 in Canada **(File #719568).** These special fares are available only through these numbers.

Discounts are good for both direct and connecting flights to Washington, D.C. If you use a travel agent, have reservations placed through the toll-free numbers to obtain the same fare advantages. Both Delta and US Air have a variety of other promotional fares, some of which may represent even greater savings. When making reservations, request the best discount applicable to your itinerary.

FEDERATION ANNUAL LUNCHEON WILL BE HELD ON WEDNESDAY

The annual Federation Luncheon will be held on Wednesday, October 31, at the Convention Center. Tickets may be purchased in advance or on-site at the registration area of the Convention Center. Highlighting the event will be an address by Douglas Kiker, one of the nation's most respected television news correspondents.

FEDERATION BOARD OF DIRECTORS TO MEET ON SUNDAY IN SHERATON

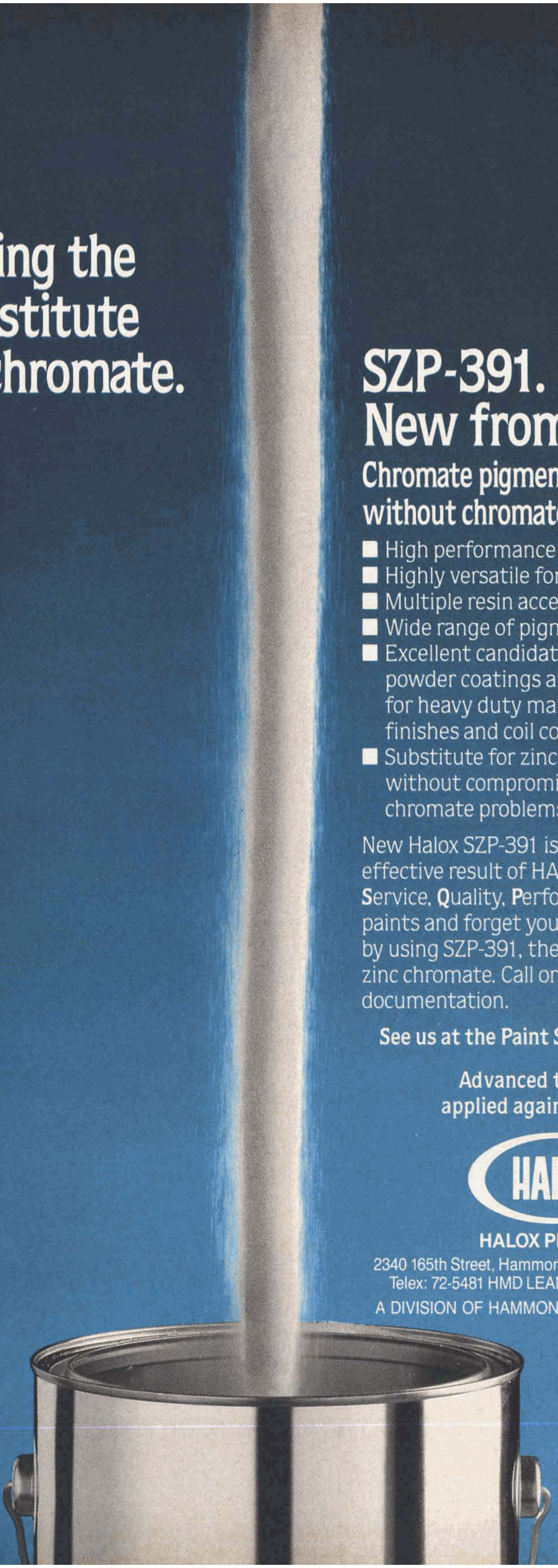
The Board of Directors of the Federation will meet on Sunday, October 28, at 9:00 a.m. in the Sheraton Washington Hotel.

NPCA TO MEET SAME WEEK AT WASHINGTON HILTON

The National Paint and Coatings Association will meet beginning Wednesday, October 31, at the Washington Hilton. Persons who have registered for NPCA and who pick up their badges on Tuesday, October 30 will be admitted to the Paint Show on *Tuesday only* with the compliments of the Federation.

ASTM STANDARDS TRAINING COURSE TO FOLLOW FSCT ANNUAL MEETING

The American Society for Testing and Materials (ASTM) will sponsor a Standards Technology Training Course, "Measuring Paint Volatile Organic Compounds (VOC)" on November 1-2, 1990 in Washington, D.C., following the Annual Meeting and Paint Show. The course will be held at the Holiday Inn-Washington, D.C.-Central, 1501 Rhode Island Ave. For more information, contact Kathy Dickinson, ASTM, 1916 Race St., Philadelphia, PA 19103.



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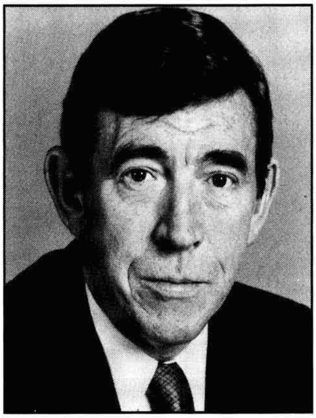
Plan to Attend the

FSCT Annual Luncheon

Wednesday, October 31
at the
Washington Convention Center, Hall C



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and Awards Presentations

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- Roon Foundation Awards
- Paint Industries' Show Awards

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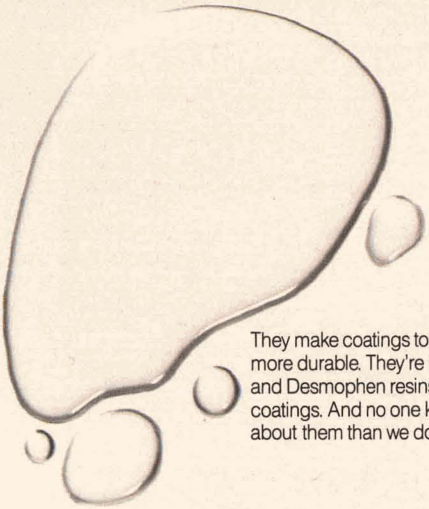

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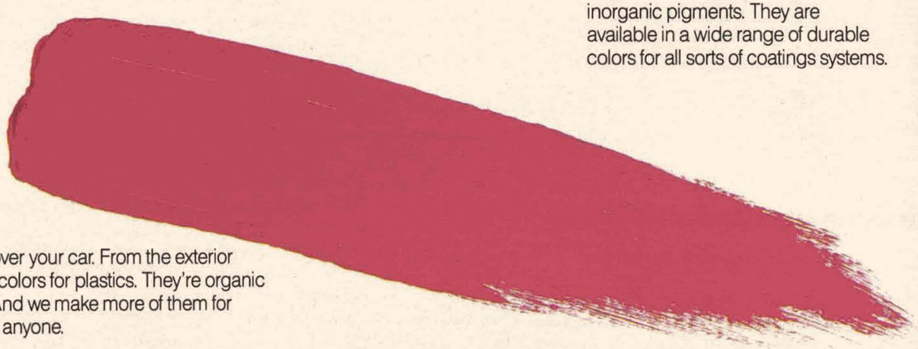

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jct JOURNAL OF COATINGS TECHNOLOGY

GUIDE FOR AUTHORS

GENERAL

The Journal of Coatings Technology is published monthly by the Federation of Societies for Coatings Technology for its membership of approximately 7,300 in 26 Constituent Societies in the United States, Canada, Great Britain, and Mexico. The Journal is devoted to the advancement of knowledge in the science and technology of surface coatings, the materials comprising such coatings, and their use and performance.

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

The Journal of Coatings Technology has first right to the publication of papers presented at the Annual Meeting of the Federation and at local regional meetings or symposia of the Constituent Societies.

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

SUBMISSION OF MANUSCRIPTS...

...for the Journal

Four complete copies should be sent to the Editor, Journal of Coatings Technology, 1315 Walnut St., Philadelphia, PA 19107. The cover letter should address copyright clearance, and release issues discussed above and should specify paper category: *Original Research, Review, Open Forum*, or *Back to Basics*.

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

...by Constituent Societies For Annual Meeting Presentation

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

...for Roon Foundation Award Competition

Ten complete copies of the manuscript are required, and should be submitted to the Chairman of the 1990 Roon Awards Committee, Richard Eley, The Glidden Co., 16651 Sprague Rd., Strongsville, OH 44136. (For complete details, see "Roon Awards" section of the Journal in January 1990 issue.)

MANUSCRIPT PREPARATION

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

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

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

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

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

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

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

Manuscripts should be typed with double spacing on one side of $8^1/_2$ x 11 inch (22 x 28 cm) paper, with at least one-inch (2.5 cm) margins on all four sides. All paragraphs should be indented five spaces, and all pages should be numbered at the top center, or upper right corner.

Title

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

Authors' Biographies and Photographs

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

Abstracts

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

Text

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

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

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

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

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

Metric System

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

Tables, Graphs, and Drawings

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

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

Graphs should be on good quality white or nonphotographic blue-lined 8$^1/_2$ x 11 inch paper. Each graph should be drawn on a separate sheet, numbered, and the captions listed on a *copy* of the original graph. Graph captions and legends should also be typed on a separate sheet from original for typesetting.

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

Photographs

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

Color prints and slides are unacceptable.

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

Nomenclature

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

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

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

Equations

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

Summary

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

Acknowledgment

If used, it should follow the summary.

References

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

(1) Pascal, R.H. and Reig, F.L., "Pigment Colors and Surfactant Selection," *Official* DIGEST, *36*, No. 475 (Part 1), 839 (1964).

(2) Davidson, H.R., "Use and Misuse of Computers in Color Control," JOURNAL OF COATINGS TECHNOLOGY, *54*, No. 691, 55 (1982).

(3) Stephen, H.G., "Hydrogen Bonding—Key to Dispersion?," *J. Oil & Colour Chemists' Assoc.*, *65*, No. 5, 191 (1982).

(4) Patton, T. (Ed.), "Pigment Handbook," Vol. 1, John Wiley & Sons, Inc., New York, 1973.

(5) Henderson, W.A. Jr. and Singh, B. (to American Cyanamid Co.), U.S. Patent 4,361,518 (Nov. 30, 1982).

OTHER INFORMATION

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

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

* * * *

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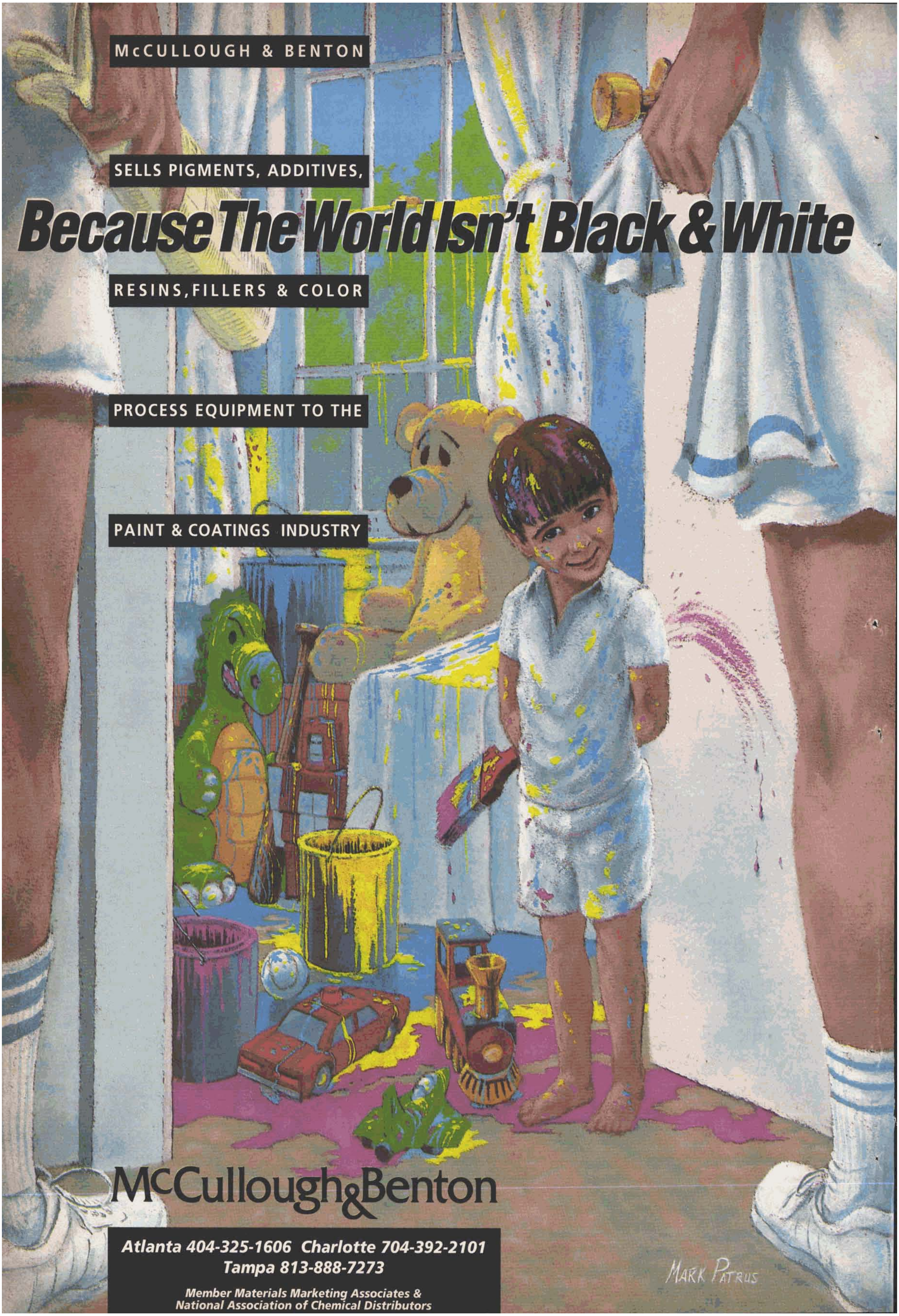

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Water Sensitivity of Cast Calcium Carbonate Filled Acrylic Acid Terpolymer Films

Richard J. Ruch, Shunquiong Yue, Carl J. Knauss, and Charles A. Kumins
Kent State University*

Random terpolymers of α-methyl-styrene-styrene-acrylic acid in ammonia solutions were mixed with calcium carbonate filler and cast on quartz and glass for wetting and for permeability studies. A minimum $CaCO_3$/terpolymer mass ratio of 5 to 1 was required for good film adhesion as determined by ultrasonic impedometry. The work of adhesion of water to the films was two-stage and Fickian in nature. The water permeability of the films also was two-stage in nature, but was non-Fickian, and was sensitive to the solids loading of the casting mixture.

INTRODUCTION

The polymeric components in a coatings formulation may initially serve as an aid in the dispersion process, and subsequently in the stabilization of the colloidal dispersion.[1] During the film-forming process, the conformations assumed by the free and by the adsorbed polymer will have an important bearing on the adhesion of the coating and such resultant film properties as permeability and cohesive strength. The conformations of water-borne polymers are affected by such factors as acid number, pH, and polymer loading.

The water permeability of polymers that are in the glassy state may have a brief induction period when the process is Fickian (Case I) in nature.[2] Within a short period of time, however, the permeability becomes non-Fickian in nature and the power, n, of the time dependence changes from n = 1/2 (Case I) to n = 1 (Case II) or n > 1 (Super Case II). This change may be due to the presence of microvoids in the film, plasticization by water, swelling of the film, and other features such as the development of stress regions.

Polymers having a glass transition temperature (T_g) much above the film-forming temperature produce films that are brittle, crack, and lose adhesion. A filler pigment, such as $CaCO_3$, can relieve stresses in a film and improve film formation. The addition of too much filler, however, will cause the critical pigment volume concentration (CPVC) to be exceeded. The latter may lead to chalky films which have poor adhesion to the substrate due to most of the adsorbable groups of the polymer interacting with the pigment filler. Hence, only a fairly narrow range of pigment volume concentrations (PVC) in such systems may lead to films having desirable properties.

Acid/base interactions are important in filled polymers and have been shown to induce heterogeneities in films.[3] The present study investigated the effect of varying the PVC, the solids loading of the film-forming solutions, and molecular weight dependency on water permeability for an acid/base compatible system; namely, an acrylic acid terpolymer near the oligomeric range with calcium carbonate as a filler pigment.

EXPERIMENTAL

Materials

Random terpolymers of α-methyl-styrene-acrylic acid were provided by S.C. Johnson & Son, Inc., and have the properties shown in *Table* 1. The proprietary terpolymers are coded as A, B, and D for discussion purposes.

A natural ground calcium carbonate powder supplied by the J.M. Huber Corporation was used as the filler pigment. The density was 2.7 g/cm^3 with a median particle size of 3 microns. The surface area of the calcium carbonate was found to be 1.8 M^2/g by gas adsorption techniques with nitrogen and to be 1.6 M^2/g by a nonaqueous solution titration with octanoic acid.

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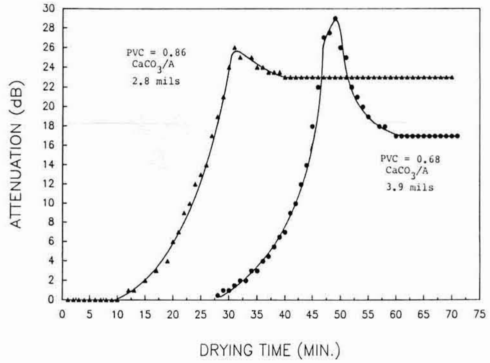

Figure 1—Drying curves of several terpolymer A films with $CaCO_3$ filler as measured by ultrasonic impedometry

The film-forming solutions were made by dissolving the appropriate amount of the terpolymer in a 1.0 M ammonia solution. A calculated amount of $CaCO_3$ to achieve a given PVC was added to the resultant polymer solution and allowed to equilibrate for a day or so with intermittent stirring.

Film Preparation

The films were cast on glass or quartz using the film-forming solution. The glass slides were first cleaned with laboratory detergent and a potassium dichromate/sulphuric acid cleaning solution to remove contaminants. After rinsing with acetone, the slides were heated to 100°C in an oven. The quartz was cleaned with organic solvents only. An appropriate volume of solution was added to achieve desired film thicknesses. Film formation and experimental measurements were all made under ambient conditions.

Adhesion

An ultrasonic impedometer previously described in the literature[5,6] was used to assess the degree of adhesion of the films to the quartz substrate. Pulses of shear waves with a frequency of 15 MHz and a duration of four microseconds were propagated through the quartz bar. The rigidity of the resultant films was high, and the attenuation in decibels (db) necessary to lower the first echo to a reference point was used as a measure of the modulus of the film during and after film formation.

Table 1—Polymer Properties
(α-Methyl-Styrene-Styrene-Acrylic Acid Terpolymer)

Sample	M_w	Acid #	T_g(°C)
A	10,000	190±10	70
B	8,000	200±10	85
D	4,900	215±10	67

Wetting

A Rame'-Hart A-100 NRL contact angle goniometer with attached camera was used to record the profile of drops of water on the cast films.[6] Kodak technical panachromic film (black and white) with an ISO/ASA of 25/15° was used. A drop volume of about 0.004 mL was placed on the film surface with a microsyringe and photographs were taken as a function of time.

The following equations were used to calculate the contact angle, θ, of the water droplets:

$$\theta = 2 \times \tan^{-1} (H/R') \text{ (acute or obtuse angles)} \qquad (1)$$

$$\theta = 90° + \sin^{-1} (H/R - 1) \text{ (obtuse angles only)} \qquad (2)$$

where, R is the radius of the droplet, R′ is the radius of the base of the drop, and H is the maximum height of the drop. Visual measurements with the goniometer were within ± 2° on the average from those values calculated with the aid of equations (1) and (2).

Permeability

The volume of the water droplets can be determined from the photographs taken for wetting measurements by the following equation:[7]

$$V = \pi/6 \times H \times (3R'^2 + H^2) \qquad (3)$$

where, R, R′, and H are as previously defined. The relative mass permeability is proportional to the volume

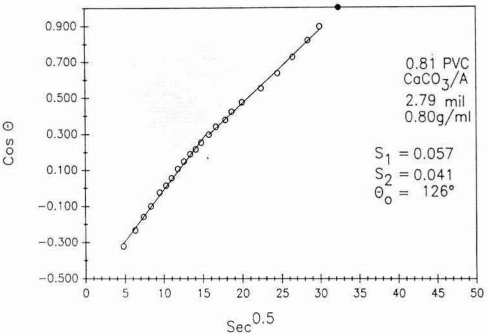

Figure 2—Time-dependent wetting study of terpolymer A film. Total solids in casting solution: 0.80 g/mL

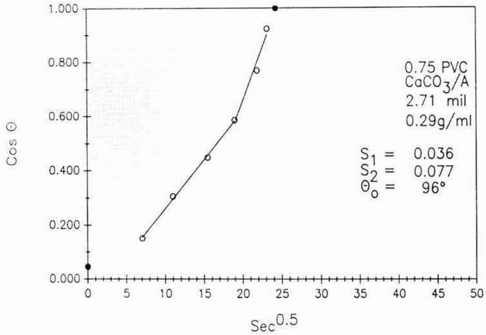

Figure 3—Time-dependent wetting study of terpolymer A film. Total solids in casting solution: 0.29 g/mL

Table 2—Wetting Data for $CaCO_3$/Terpolymer: PVC = 0.75 – 0.81

Terpolymer	100 S_1 ($sec^{-0.5}$)	100 S_2 ($sec^{-0.5}$)	θ_o
A	4.2 ± 1.0	7.4 ± 1.7	103 ± 14°
B	4.0 ± 0.6	4.1 ± 0.6	128 ± 1°
D	3.6 ± 0.3	6.2 ± 0.2	143 ± 10°

permeability which can then be expressed as a function of time by the equation:

$$(V_o - V)/V_o = Kt^n \qquad (4)$$

where, V_o is the initial volume of the water droplet, V is the volume at time t, K is a rate constant for the penetration process, and n is the exponential power of time.

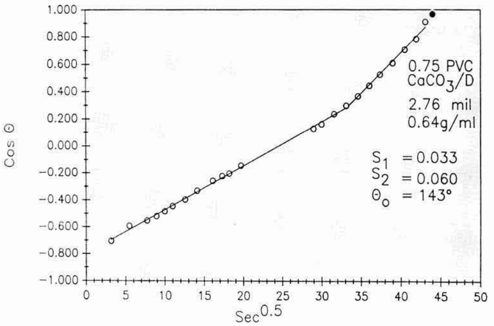

Figure 5—Time-dependent wetting study of terpolymer D film. Total solids in casting solution: 0.64 g/mL

RESULTS

Adhesion

Films formed from polymer only were too brittle for study due to their T_g lying above the film-forming temperatures. Various PVC loadings of polymer with $CaCO_3$ and varying film thicknesses were prepared for the study. Representative PVC loadings ranged from 0.68 to over 0.90. Film thicknesses ranged from less than one mil to over five mils. A range of two to four mils gave the best film formation as judged by results from attenuation studies. The attenuation in decibels rises as the degree of adhesion of the film increases and as the modulus of the film increases.

As shown in *Figure* 1, a maximum in attenuation was generally attained during film formation, which was followed by a variable drop due to adhesive loss as the film dried. The magnitude of this attenuation drop decreased as the PVC increased. At a PVC of 0.86 and above for terpolymer A, stresses were relieved to such an extent that the plateau of the curves was near the maximum attenuation value. Although the very high PVC loadings gave large attenuations with very little attenuation drop on film drying, the films were noticeably powdery in nature as might be expected. Calcium carbonate films, without terpolymer, gave an attenuation of only several decibels. Hence, some carboxyl groups of the polymers must have been adsorbing even at high PVC values.

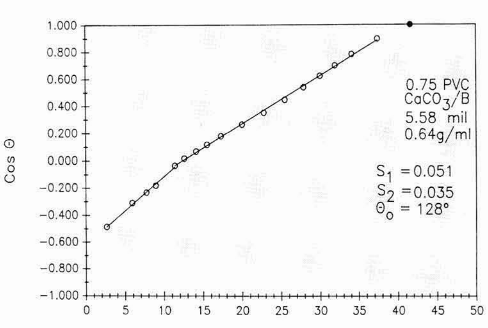

Figure 4—Time-dependent wetting study of terpolymer B film. Total solids in casting solution: 0.64 g/mL

Wetting

As the water droplets penetrate the films, the base of the droplets become slightly wider, indicating that the angles being measured are indicative of advancing angles. The cosine of the contact angles were found to be a linear function of time to the one-half power. *Figures* 2-5 show the wetting of terpolymer films of A, B, and D filled with $CaCO_3$ at various PVCs, film thicknesses, and solids loadings of the film-forming solutions.

Table 2 shows the results for a variety of films of A, B, and D terpolymer formed at various PVCs, film thicknesses, and solids loadings of the film-forming solutions. Most of the plots had two straight-line regions. S_1 and S_2 represent the slopes of these respective regions. θ_o is the average initial contact angle of water on the films. When the PVC is comparable, θ_o is smaller for films formed from the more dilute film-forming solutions.

Permeability

Figures 6-9 show a log/log plot of equation (4) for the water permeability of terpolymers A, B, and D filled with $CaCO_3$ and cast at various PVCs, film thicknesses, and solids loadings of the film-forming solutions. The power dependence of time, n, can be obtained from the slope of such plots, as well as the rate constant K from the intercept when t = 1 sec. Most plots had two segments, and hence two n and two K values which are shown in *Table* 3. The first three entries in the table are for film-forming solutions which had a total (filler + terpolymer) solids loading above 0.5 g/mL, whereas the last entry had a total solids loading of 0.3 g/mL. The latter solutions were made by diluting the higher solids solutions with water. It may be noted from *Table* 3 that the n_2 values for the more concentrated film-forming solutions hover around a value of one, whereas it is the n_1 values for the more dilute film-forming solutions that are near a value of one. The rate constants K show a parallel behavior.

Figure 10 shows that there is a functional relationship between K and n for the terpolymer A films studied. There is a similar correlation for terpolymers B and D.

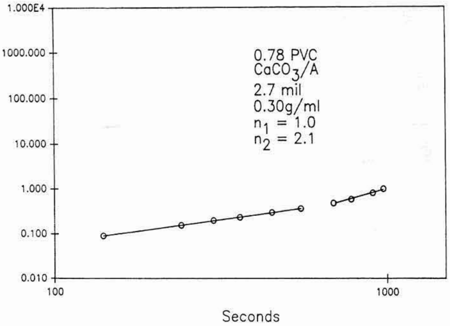

Figure 6—Water permeability of terpolymer A film. Total solids in casting solution: 0.30 g/mL

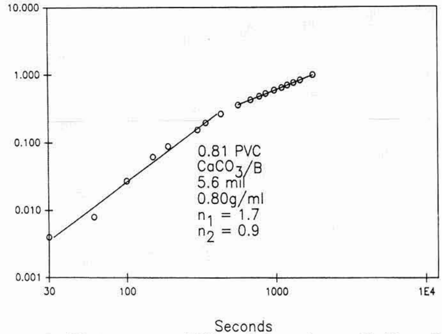

Figure 8—Water permeability of terpolymer B film. Total solids in casting solution: 0.80 g/mL

Table 4 lists the slopes and intercepts obtained from *Figure* 10 for terpolymer A and the corresponding results for terpolymers B and D.

DISCUSSION

Adhesion

The carboxylic groups of the terpolymers effectively interact with both the glass or quartz substrate and with the $CaCO_3$ filler pigment. This leads both to adhesion to the substrate and to the relief of stresses in the otherwise brittle films. Increasing the PVC effectively lowers the T_g of the terpolymer, as has been shown by Kumins[8] with TiO_2 in poly(vinyl acetate vinyl chloride). Patton[9] gives a value for the CPVC of $CaCO_3$ as 0.68. Although most of the films in this study exceed this value, there are apparently enough carboxyl groups accessible to the substrate to provide adequate adhesion up to rather high PVC values.

Figure 11 shows one effect on attenuation of adding small amounts of water to a terpolymer A film filled with calcium carbonate. The water is added at point *a* and the attenuation immediately rises. This rise most likely occurs from water reaching the substrate with a resultant increase in the modulus of the film. This may occur because the water penetrates microcracks or develops a hydrogen bond pathway. For some films in the present study and those in another study,[5] the attenuation drops after the water reaches the substrate due to delamination of the film and then slowly rises back to the original value. In *Figure* 11, this behavior is not observed, perhaps due to stronger adhesive bonding to the substrate.

In *Figure* 11, the water completely penetrates the film near point *b* and there is another rise in attenuation. This may be due to swelling of the terpolymer film, as water hydrogen bonds to the carboxyl groups leading to a concomitant rise in the modulus of the film. Whether or not there is delamination of the film, the attenuation always recovers to near the value before attack by solvent as the film once more drys.

Wetting

The work of adhesion of water to the films is defined by the following equation:

$$W_{Ad} = \gamma_{LV} (1 + \cos \theta) \tag{5}$$

where, γ_{LV} is the surface tension of the wetting liquid. The work of adhesion is thus proportional to the cos θ, and plots such as those in *Figures* 2-5 can be envisioned as a measure of the time dependence of the work of adhesion of water to the films. It is reasonable to expect the work of adhesion, at least initially, to reflect a Fickian process (n = 1/2). The liquid/film interface is at the

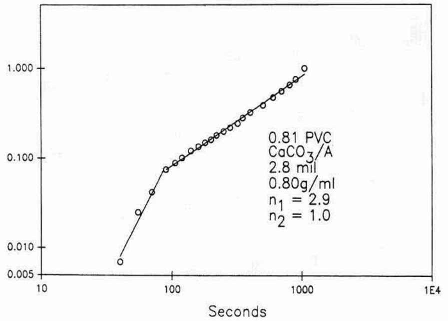

Figure 7—Water permeability of terpolymer A film. Total solids in casting solution: 0.80 g/mL

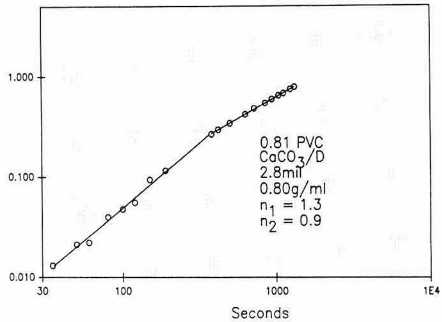

Figure 9—Water permeability of terpolymer D film. Total solids in casting solution: 0.80 g/mL

Table 3—Penetration Data for $CaCO_3$/Terpolymer: PVC = 0.68 − 0.91

Solids Loading[a] Grams/mL	Polymer	n_1	n_2	$-\log K_1$	$-\log K_2$
>0.5	A	1.9±0.5	1.1±0.2	4.8±1.6	3.2±0.4
	B	2.7±1.7	1.0±0.2	8.5±3.2	3.4±0.7
	D	1.8±0.4	1.0±0.1	5.2±1.0	3.4±0.4
0.3	A	1.1±0.1	2.3±0.5	3.3±0.1	6.5±1.4

(a) Total of filler and terpolymer.

boundary of the diffusion system and should, if in any segment of the film, follow Fickian kinetics.

The wetting angle is affected by interactions at the liquid/film interface, and previous studies[7-10] have shown that reorientations of polar groups occur at this interface. As more and more hydrophilic carboxyl groups are exposed at the surface, the wetting increases as evidenced by the contact angle decreasing in magnitude with time. The increase in θ_0 going from terpolymer A to D shown in *Table* 2 indicates that the polar carboxyl groups are more effectively hidden at the interface as the molecular weight of the terpolymer decreases. The lower molecular weight terpolymer should reach equilibrium more readily and produce a lower energy surface with a larger initial contact angle.

Permeability

Table 5 shows that dilution of a film-forming solution increased the total film drying time two-fold. However, the edge drying time increased tenfold. The dilution of the film-forming solution increased the time available for conformational equilibration of the polymer before adsorption on the substrate occurred. This results in less strained conformations developing in the drying films. A small change in pH occurred on diluting the film-forming solution, but previous studies[11] have suggested that the terpolymer would remain essentially in a rigid rod conformation until broken down by salt formation between the carboxyl groups and the calcium ions.

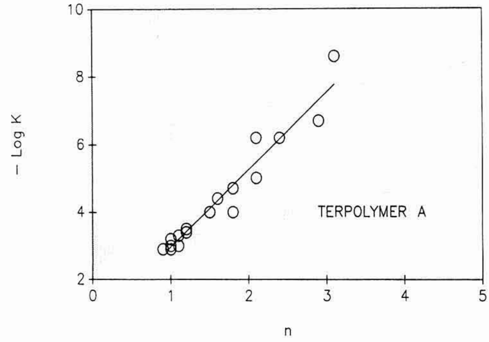

Figure 10—Functional relationship between rate constant K and time dependence n for terpolymer A

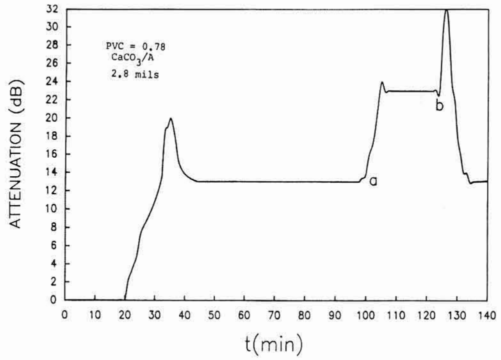

Figure 11—Attenuation profile for terpolymer A film attacked at point a with 0.02 mL water. Bulk water penetrated at point b

For films processed from a film-forming solution of 0.3 g/mL as shown in *Table* 3, water penetration occurs by a simple swelling process (Case II). The swelling process produces stress in the unswelled regions of the film and raises the activity of the polymer in that region. This leads to a driving force, similar to an osmotic pressure gradient, which leads to a value of $n_2 > 1.5$ (Super Case II) during the latter part of the penetration process.

For films processed from a film-forming solution > 0.5 g/mL as shown in *Table* 3, n_1 is significantly larger than one. The more concentrated film-forming solutions dry more rapidly, adsorb onto the substrate early as evidenced by short edge-drying times, and hence lead to large stresses in the resultant films. As a result, Case II kinetics does not occur initially in the drying process. Only after stresses have been relieved does the penetration process drop back to $n = 1$, or Case II diffusion. Just as rapid cooling of polymers below their T_g produces more free volume than slower cooling,[12] a more rapid rate of film formation may produce more free volume accounting for the faster initial rates of diffusion. Only subsequently does relaxation-controlled diffusion take over.

Table 4—Functional Dependence for − Log K vs n

Terpolymer	Slope	Intercept
A	2.3	0.7
B	2.5	0.8
D	2.6	0.6

Table 5—Drying Times for CaCo$_3$/A: PVC = 0.78, 2.7 mils

Solids	Dry Time	Edge Drying
0.95g/mL	110 min	9 min
0.39g/mL	203 min	100 min

SUMMARY

A model system consisting of a water soluble polymer containing acid groups interacting with a basic $CaCO_3$ pigment has been used for casting films. The wetting and water permeability of the films have been studied employing rather simple experimental techniques. Two regimes were found in both the wetting and the permeability studies.

The surface area of the $CaCO_3$ is such that there is sufficient terpolymer at all PVCs studied to completely coat the pigment with a uniform layer by train adsorption. Extensive loop and tail adsorption could reduce pigment coverage, but the acid/base interactions are so favorable that this possibility seems remote. The CPVC of $CaCO_3$ is about 0.7, which is near the minimum PVC value at which film adhesion and the film modulus became acceptable. When the PVC rises significantly above the CPVC, interstitial voids suffer and there are fewer free carboxyl groups available for adhesion to the substrate.

The rapid drying rates with concentrated film-forming solutions lead to greater stresses and more free volume than were present for more dilute film-forming solutions with the same solids loading. As a consequence, the driving force for diffusion was higher for the former films than for the latter, and Case II diffusion occurred during a second stage when the film-forming solutions were concentrated.

The increase in base size with time for water droplets arises because the water spontaneously advances over high energy hydrophilic carboxyl groups as they become exposed. The droplet comes to rest on the lower energy hydrophobic groups in the terpolymer. The increasing θ_o values with increasing molecular weight for the terpolymers indicated that the lower molecular weight polymer molecules had more flexibility and were able to achieve a lower energy surface than the higher molecular weight terpolymer. At identical PVCs for terpolymer A, θ_o was lower for films formed from the more dilute film-forming solutions, indicating more flexibility of the molecules in reorienting when exposed to the water droplets.

Water can penetrate the films rapidly through microcracks and either delaminate the film or increase the film modulus if no delamination occurs. Swelling of the terpolymer also increases the modulus. In all types of penetration, however, the film drys and reachieves a modulus nearly identical to the value before the attack.

ACKNOWLEDGMENT

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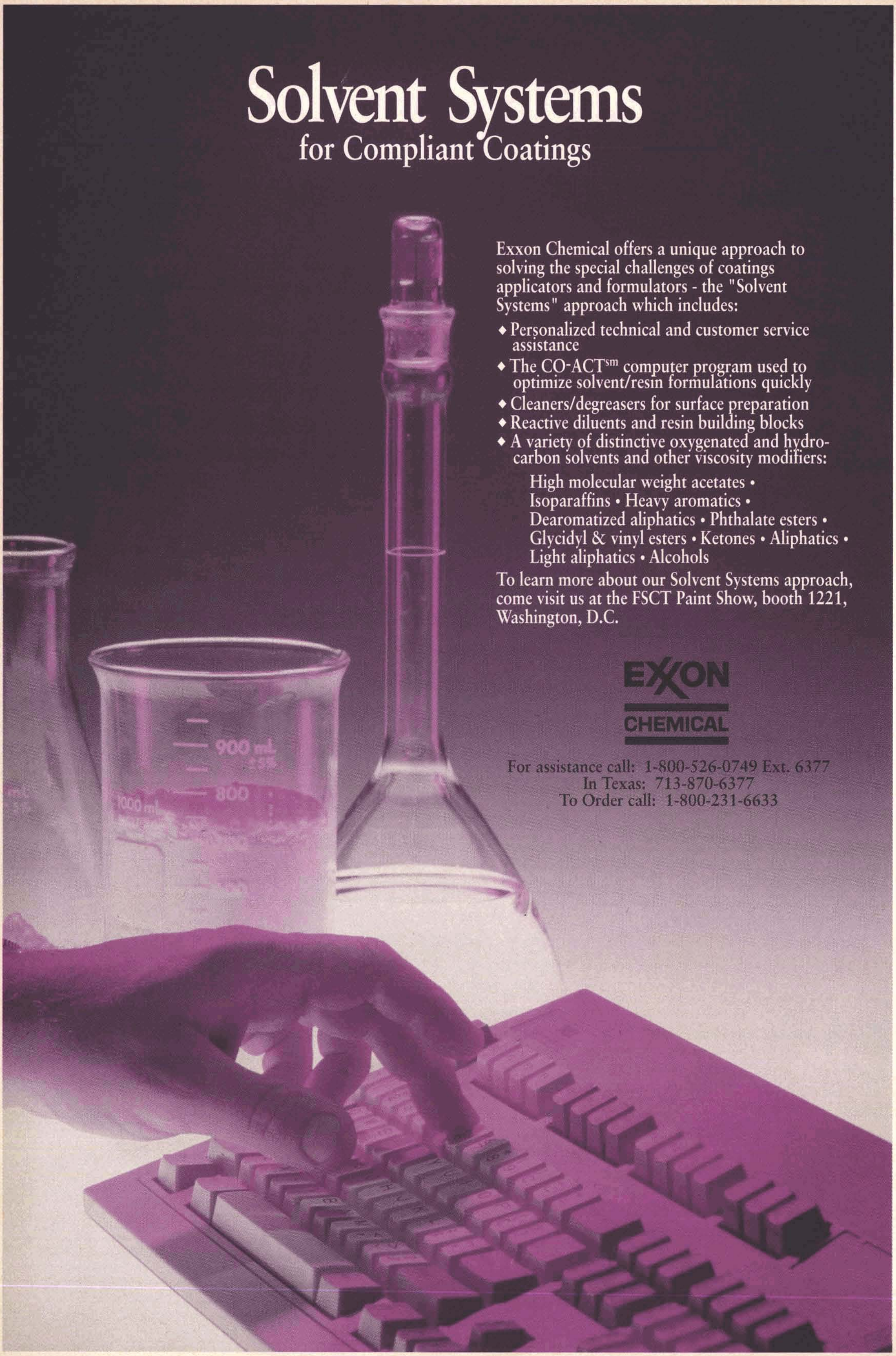

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Optimum Particle Size Of Titanium Dioxide and Zinc Oxide For Attenuation of Ultraviolet Radiation

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Kerr-McGee Corporation*

G.C. Salzman
Los Alamos National Laboratory

and

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Oklahoma State University

The optimum size of particles used to protect polymers from ultraviolet radiation is calculated using a theoretical model for light scattering and absorption. Titanium dioxide and zinc oxide, two common ultraviolet-attenuating materials, are examined in this work.

The optimum size for spherical titanium dioxide particles is well-defined, and varies uniformly from 0.05 micrometer for 0.3-micrometer ultraviolet radiation to 0.12 micrometer for 0.4-micrometer radiation, respectively. For zinc oxide the optimum is less distinct. In general, particles with a diameter less than about 0.06 micrometer attenuate (i.e., scatter and absorb) ultraviolet radiation most effectively over the same ultraviolet range.

INTRODUCTION

Optimization of particles for opacification of polymer films has been examined in several studies to establish the best particle for use in paints and plastics.[1-7] However, light scattering and absorption models have not been used to determine the optimum particle size of ultraviolet attenuating particles, in spite of the economic importance of these materials.

The objective of this study was to define the optimum particle size for particulate materials used to attenuate ultraviolet radiation. This study involved two inorganic materials used frequently in this application, titanium dioxide and zinc oxide.

PROCEDURE

Attenuation of radiation by particles in a film was calculated for a nonabsorbing polymer supporting either titanium dioxide or zinc oxide ultraviolet-absorbing particles. This particle-bearing layer protects an underlying polymer from an ultraviolet radiation source such as sunlight.

The interaction of radiation with the absorbing particles involved in this work is modeled using an expression for the two-stream theory presented by Bohren.[8] The interaction of ultraviolet radiation with the film assumed in these calculations is illustrated in *Figure* 1.

In this study, the reflectance and transmittance of the polymer film are calculated from the complex refractive index of the particles, their size, and the wavelength of the ultraviolet radiation. Four quantities are required for these calculations: the single-scattering albedo, ω_o; the reflectance of an infinitely thick film of particles, R_∞; the optical thickness, $\bar{\tau}$; and the dimensionless attenuation coefficient, k. These terms are defined in the text to follow.

The reflectance, R, and transmittance, T, are calculated from the scattering efficiency, Q_{sca}, extinction efficiency, Q_{ext}, and asymmetry parameter, g, for particles in the film using Mie theory. The reflectance of an infinitely thick film is also required to determine R and T, and this quantity is,

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*Kerr-McGee Center, Oklahoma City, OK 73125.

$$R_\infty = \frac{\sqrt{1-\omega_o g} - \sqrt{1-\omega_o}}{\sqrt{1-\omega_o g} + \sqrt{1-\omega_o}} \quad (1)$$

where the single-scattering albedo is defined as,

$$\omega_o = \frac{Q_{sca}}{Q_{ext}} \quad (2)$$

The film reflectance and transmittance are,

$$R = \frac{R_\infty \left(1 - e^{-2k\bar{\tau}}\right)}{1 - R_\infty^2 \, e^{-2k\bar{\tau}}} \quad (3)$$

$$T = \frac{\left(1 - R_\infty^2\right) e^{-2k\bar{\tau}}}{1 - R_\infty^2 \, e^{-2k\bar{\tau}}} \quad (4)$$

where the optical thickness is,

$$\bar{\tau} = \frac{3fhQ_{ext}}{4r} \quad (5)$$

The particle radius is denoted by r, f is the particle volume fraction, and h is the film thickness.

The dimensionless attenuation coefficient in equations (3) and (4) is,

$$k = \sqrt{(1-\omega_o g)(1-\omega_o)} \quad (6)$$

Finally, absorptance is determined from an energy balance as shown by,

$$A = 1 - (R + T) \quad (7)$$

The quantity, fh, has important physical significance. This term is the particle loading expressed as volume of solid per unit area of film. The mass loading of either titanium dioxide or zinc oxide can be found by dividing fh by the corresponding density of the solid.

The complex refractive indices of titanium dioxide and zinc oxide used in this work were obtained from references (9) and (10), respectively. All calculations were performed for monosize particles, and light scattering was calculated as a function of particle diameter and wavelength of the incident ultraviolet radiation. The refractive index of the polymer used in these calculations was 1.55.

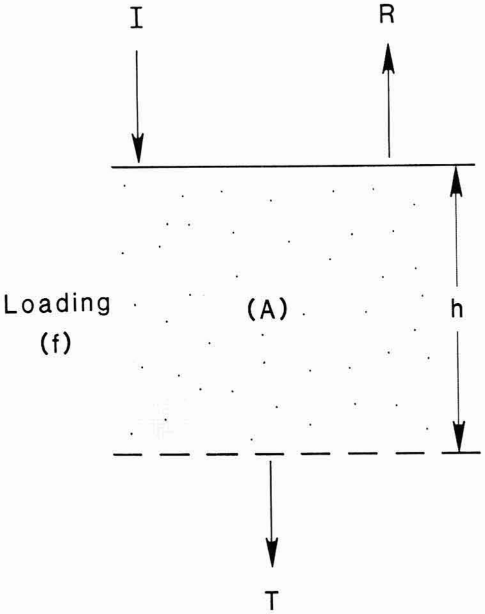

Figure 1—Thin film containing absorbing material used to model the attenuation of ultraviolet radiation

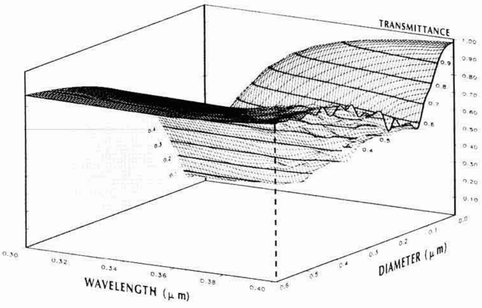

Figure 2—Transmittance of a film containing spherical titanium dioxide particles as a function of particle size and wavelength of ultraviolet radiation. The product of the particle volume concentration and film thickness (fh) used in these calculations was 0.05 μm

COMPUTATIONAL RESULTS

The most favorable conditions for moderation of damage to the polymer by ultraviolet radiation are those which minimize transmittance (maximize attenuation) of ultraviolet radiation. This principle is used to identify the optimum conditions for attenuation of ultraviolet radiation throughout this study.

The results obtained for titanium dioxide are shown in *Figure* 2, which shows the fraction of the incident ultraviolet radiation transmitted by the protective layer on the surface of the polymer film. Transmittance is shown as a function of particle diameter and wavelength. The wavelength of radiation used in these calculations ranges from

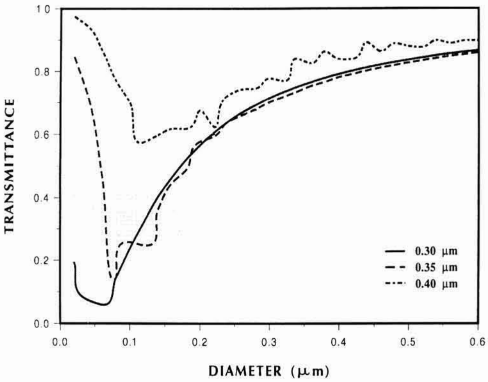

Figure 3—Transmittance of a film containing spherical titanium dioxide particles as a function of particle size at 0.3-, 0.35-, and 0.4-μm ultraviolet radiation. The product of the particle volume concentration and fh used in this work was 0.05 μm

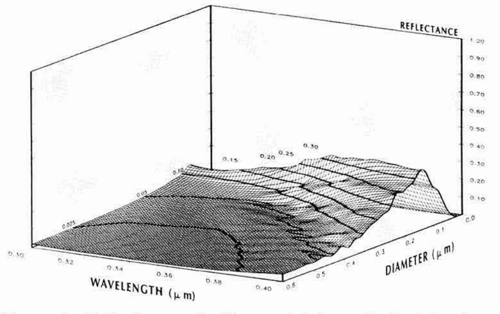

Figure 4—Reflectance of a film containing spherical titanium dioxide particles as a function of particle size and wavelength of ultraviolet radiation. The product of the particle volume concentration and fh used in this work was 0.05 μm

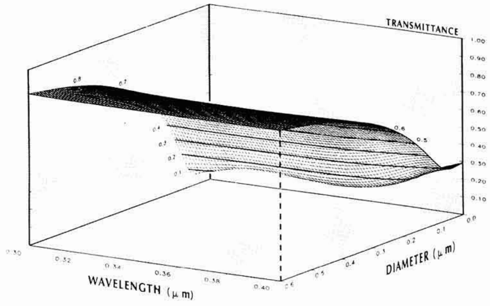

Figure 6—Transmittance of a film containing spherical zinc oxide particles as a function of particle size and wavelength of ultraviolet radiation. The product of the particle volume concentration and fh used in this study was 0.05 μm

0.3 to 0.4 micrometer (μm), corresponding to solar ultraviolet radiation.

Figure 2 illustrates several interesting features of this system. The particle diameter that provides the greatest attenuation depends on the wavelength of the incident radiation. This diameter varies from 0.05 μm for 0.3-μm radiation to 0.12 μm for 0.4-μm radiation. At the optimum particle size, the incident ultraviolet radiation is attenuated effectively. That is, the transmittance of 0.3-μm radiation is only five percent for a 0.05-μm particle. These results are also demonstrated in *Figure* 3 which exhibits three cross sections of *Figure* 2. These cross sections show the transmittance as a function of particle size for ultraviolet radiation with wavelengths of 0.3, 0.35, and 0.4 μm.

The importance of scattering can be assessed by considering the reflectance of the particle-loaded polymer film. *Figure* 4 shows the reflectance of the film as a function of particle diameter and wavelength. Reflectance is greatest for optimum-size particles at the long wavelength end of the UV spectrum, indicating that scattering is an important mechanism for attenuation of ultraviolet radiation at such wavelengths.

Absorption is more important at short wavelengths as illustrated in *Figure* 5, which shows the absorptance of a polymer film containing titanium dioxide spheres as a function of incident radiation wavelength and particle diameter. For titanium dioxide, both scattering and absorption are important in attenuating ultraviolet radiation in polymer films, each mechanism predominating at different ends of the UV spectrum.

The product of film thickness and titanium dioxide loading, fh, was chosen to be 0.05 μm. This value provides sufficient transmittance of ultraviolet radiation so that the performance of the titanium dioxide particles could be compared readily across a large range of size and wavelength. The value of fh corresponds to a titanium dioxide loading of 12 mg/M^2. In terms of film thickness, this fh value would correspond to a one μm-thick film containing five volume percent titanium dioxide.

Figure 6 shows the transmittance for a zinc oxide film with an fh of 0.05 μm, which corresponds to a loading of 10 mg/M^2. Transmittance is presented as a function of particle diameter and wavelength. The transmittance of ultraviolet radiation by zinc oxide-bearing polymer films is significantly different from that obtained for titanium dioxide. For zinc oxide, small particles provide the highest attenuation, and the effectiveness of the particles declines rapidly as size increases.

Since the real portion of the refractive index of zinc oxide is smaller than that for titanium dioxide, absorption plays a more important role for zinc oxide in attenuation of ultraviolet radiation than does scattering. This is consistent with the data shown in *Figures* 7 and 8, which

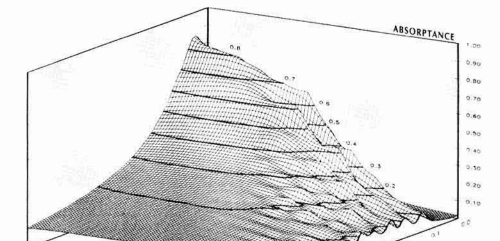

Figure 5—Absorptance of ultraviolet radiation in a film containing spherical titanium dioxide particles as a function of particle size and wavelength. The product of the particle volume concentration and fh used in these calculations was 0.05 μm

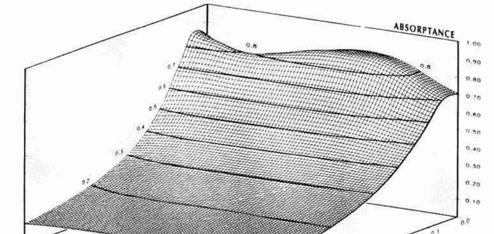

Figure 7—Absorptance of ultraviolet radiation in a film containing spherical zinc oxide particles as a function of particle size and wavelength. The product of the particle volume concentration and fh used in these calculations was 0.05 μm

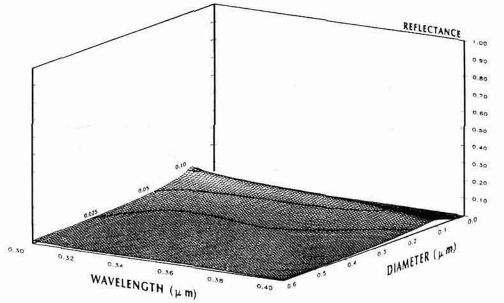

Figure 8—Reflectance of ultraviolet radiation in a film containing spherical zinc oxide particles as a function of particle size and wavelength. The product of the particle volume concentration and fh used in these calculations was *0.05* μm. Note that the scale on the vertical axis is different from that used in the previous figures

illustrate the absorptance and reflectance, respectively, of zinc oxide as a function of particle size and wavelength. Comparison of the data in these figures indicates that absorption predominates over the range of particle sizes and wavelengths considered.

Figures 2 and 6 show that large titanium dioxide and zinc oxide particles do not attenuate ultraviolet radiation effectively. This behavior can be understood in terms of the e-folding distance. This term is the distance over which the intensity of absorbed radiation falls to 1/e times (37%) of the incident intensity for bulk titanium dioxide or zinc oxide. The e-folding distance is the inverse of the absorption coefficient for these materials.

For particles with radii greater than the e-folding distance, radiation is absorbed primarily in the outer layers of the particle, and the material in the interior is underutilized. Hence, titanium dioxide and zinc oxide particles larger than the e-folding distance do not screen ultraviolet radiation effectively, whereas small particles do.

CONCLUSIONS

(1) The optimum size of titanium dioxide spheres for attenuation of ultraviolet radiation ranges from 0.05 to 0.12 μm over the wavelength range of 0.3 to 0.4 μm.

(2) Scattering plays an important role in attenuation of ultraviolet radiation by titanium dioxide at long ultraviolet wavelengths, and absorption plays an important role at short ultraviolet wavelengths.

(3) The optimum size zinc oxide particle for attenuation of ultraviolet radiation is less than 0.06 μm for the wavelength range of 0.3 to 0.4 μm.

(4) Absorption is the dominant mechanism for attenuation of ultraviolet radiation by zinc oxide in polymer films in the wavelength range of 0.3 to 0.4 μm.

ACKNOWLEDGMENTS

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Comparison of Methods for the Preparation Of Acetoacetylated Coating Resins

J. Stewart Witzeman, W. Dell Nottingham, and F. Del Rector
Eastman Kodak Company*

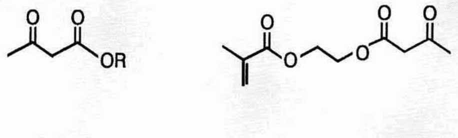
Acetoacetylated polymers and resins have been shown to be capable of undergoing a variety of crosslinking reactions and have lower viscosity properties than the corresponding hydroxylated polymers. Kinetic, synthetic, and spectroscopic data are presented which show that the best industrial method for acetoacetylation of monomeric and polymeric materials is by transesterification (transacetoacetylation) with t-butyl acetoacetate. This reagent can be used to efficiently prepare acetoacetylated resins from a wide variety of starting materials with little color development. The use and properties of several acetoacetylated polyester resins in high-solids enamels is also discussed.

INTRODUCTION AND OVERVIEW

Incorporation of the acetoacetyl functional group [(**1**) in *Figure* 1] onto polymers has been used in coatings to impart functionality capable of undergoing a variety of crosslinking reactions, while simultaneously lowering the viscosity of the resulting formulation. Among the processes which have been used to effect crosslinking of acetoacetylated polymeric materials are reactions with diamines, melamine, aldehydes, isocyanates, chelation with metals, and Michael reaction with activated olefins.[1] Coatings prepared from acetoacetylated polymers utilizing these crosslinking strategies often exhibit improved flexibility, salt-spray resistance, and/or better adhesion to the metal surface. These improvements have been attributed to the ability of the acetoacetyl functional group to chelate with the metal substrate. The interest in the use of acetoacetylated materials in coatings along with the need for more general, industrially relevant, procedures to prepare these compounds led us to investigate methods of preparation of acetoacetylated coating resins, as well as the properties of these acetoacetylated materials and the resultant coatings derived from these compounds.

Previous work from these and other laboratories[1b,2] has shown that acetoacetylated acrylic resins can be prepared by copolymerization of acetoacetoxyethyl methacrylate (AAEM) [(**2**) in *Figure* 1] with acrylic or methacrylic monomers. In other cases, however, acetoacetylated polymers or resins are desired which must be prepared by acetoacetylation of the polymeric substrate, rather than by polymerization of acetoacetylated monomers. One area where this type of an approach is necessary is in the preparation of acetoacetylated polyester resins.

Acetoacetylated materials can be prepared (*Figure* 2) by treating a nucleophile with diketene [(**3**) in *Figure* 2],[3] from the thermal reaction of 2,2,6-trimethyl-4*H*-1, 3-dioxin-4-one[4] [(**4**) in *Figure* 2], TKD, the diketene-acetone adduct, or by transesterification with another acetoacetate[5,6] (transacetoacetylation). The lachrymatory



1
Acetoacetate

2
AAEM

Figure 1—General structure of acetoacetates and acetoacetoxyethyl methacrylate (AAEM)

Presented at the 16th Annual Water-Borne and Higher-Solids Coatings Symposium, in New Orleans, LA, on February 1-3, 1989.

*Eastman Chemical Co. Research Labs., Kingsport, TN 37662.

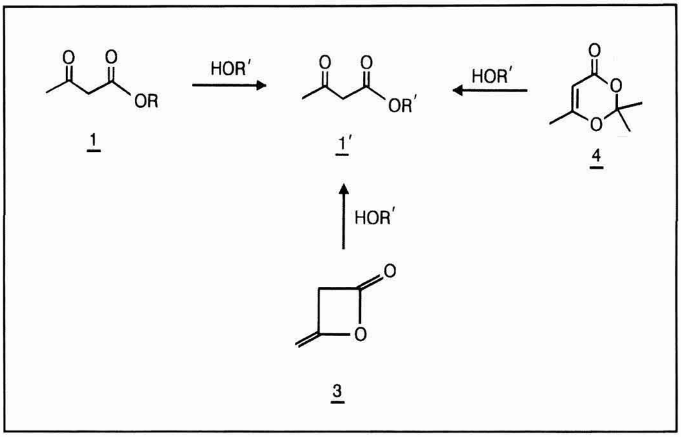


Figure 2—Methods of preparation of acetoacetylated materials

properties of diketene along with concerns regarding its safe shipping and the need for dedicated facilities for its use make this material impractical in many industrial applications. The synthetic utility of dioxinone [(**4**) in *Figure* 2] has been well documented, but it has not yet been widely used in industrial applications. The transacetoacetylation reaction, in principle, should be readily amenable to an industrial process. This reaction seems particularly attractive in coating applications, since the use of transesterification reactions is well known in the preparation of polyester coating resins. This type of transesterification reaction has received surprisingly little attention in the chemical literature. Known examples of this reaction are of little industrial utility due to the long reaction times,[5,6] dilute solutions,[6] excess reagents,[5,6] large amounts of catalysts,[6] and/or drying agents[6b] involved.

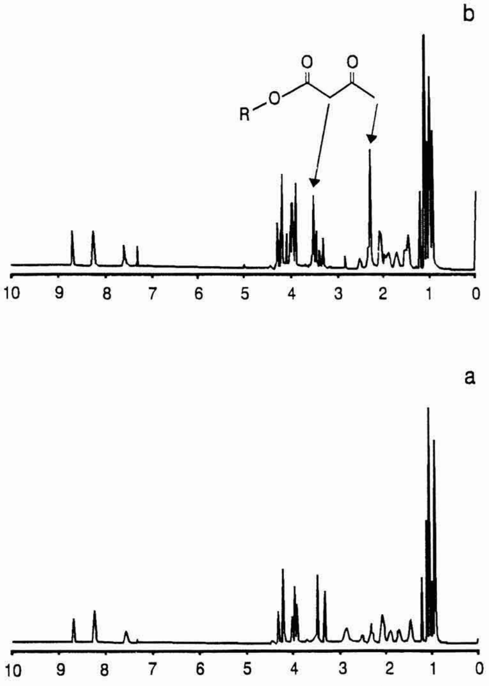


Figure 3—300 MHz ^{1}H NMR spectrum of HS-3-4ND resin before (a) and after (b) acetoacetylation

COMPARISON OF STANDARD ACETOACETYLATION TECHNIQUES IN THE ACETOACETYLATION OF A POLYESTER RESIN

To determine how standard acetoacetylation conditions affect the chemical and physical properties of a coating resin, a typical high-solids polyester resin was subjected to several different reaction conditions. The resin studied (HS-3-4ND) is comprised of (weight %) 44.19% neopenty glycol (NPG), 3.0% trimethylolpropane, 28.85% dimethyl-1,4-cyclohexanedicarboxylate, and 23.94% isophthalic acid.[*] This resin was treated with diketene [(**3**) in *Figure* 2], dioxinone [(**4**) in *Figure* 2], and under transacetoacetylation conditions with methyl acetoacetate (MAA) or ethyl acetoacetate (EAA) using 0.1% dibutyltin oxide catalyst. The stoichiometry of the resin and acetoacetylating reagents were adjusted so as to acetoacetylate 50% of the available hydroxyl groups. The former two acetoacetylation reactions proceeded efficiently, with the diketene process being complete after 0.5-1.5 hr at 65-80°C while the TKD process was complete after 1.5 hr at 120-155°C.[†] The transacetoacetylation reactions, on the other hand, were much slower, requiring 6-8 hr to complete. Analysis of the various products from these reactions by ^{1}H Nuclear Magnetic Resonance spectroscopy (NMR) showed the appearance of acetoacetyl methyl and methylene resonances at ca. 2.29 and 3.50 ppm respectively, demonstrating that the resin had been acetoacetylated as expected (*Figure* 3). Further evidence that this functionalization of the polymer had been realized was obtained by using ^{13}C NMR spectroscopy which showed the appearance of an acetoacetyl methyl carbon at ca. 31.5 ppm and the corresponding methylene at 50.3 ppm. (See section on the analysis of these resins.)

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[*] Typical properties of the HS-3-4ND resin are: OH# 210, Acid # 7-13, Mn 900-1100. For more information see Eastman Publication N-308.

[†] This is the total time necessary to conduct the reaction, including removal of the volatile acetone by-product by distillation, the time necessary to effect reaction is much shorter. [See reference (8b)].

More careful analysis of the ^1H NMR spectral data suggested that the course of these transacetoacetylation reactions is subtly different from the dioxinone or diketene processes. In particular, the molecular weight of the resins subjected to transacetoacetylation appeared to have been reduced relative to the materials prepared using diketene or TKD. This is apparent from comparison of the ratios of NPG gem-dimethyl resonances at 1.09, 1.04, 0.99, and 0.91 ppm; which are due to the NPG-bis-(isophthalic ester), NPG-isophthalic ester end-group, NPG-bis(1,4-cyclohexanedicarboxylic ester), and NPG-(1,4-cyclohexanedicarboxylic ester) end-group, respectively.* A much higher proportion of hydroxy end-groups in the transacetoacetylated resins is apparent from this spectral data (*Figure* 4).

Since all four products had a similar amount of acetoacetyl moiety incorporated in the resin, the higher ratio of end-group glycols suggests a concomitant reduction in the molecular weight of the resin. Such a reduction might be expected to be accompanied by capping of the polyester with the ethyl or methyl alcohol co-product from the acetoacetates. Evidence that such a capping process is actually occurring can be obtained from the NMR spectra of the transacetoacetylated resins which suggest the presence of small amounts of ethyl or methyl ester end-groups.† Further evidence that these transacetoacetylation processes were accompanied by a subtle reduction in the molecular weight of the resin was obtained using high performance liquid chromatography (HPLC). Analysis of the reaction products by this technique demonstrated that the proportion of higher oligomers (n = 6-8) in the resins subjected to transacetoacetylation was smaller than either the other acetoacetylated resins or the unacetoacetylated material (*Figure* 5). While these differences were small, the fact that such a breakdown was occurring suggested that it could be difficult to produce a product with consistent properties using this procedure.

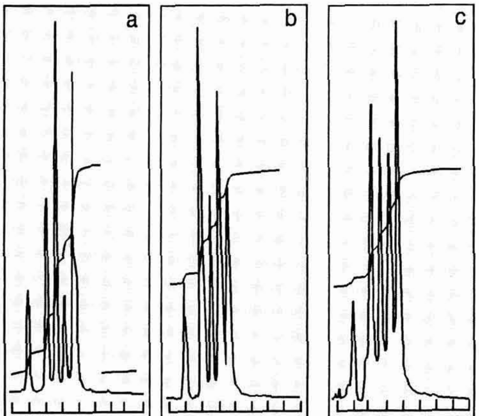

Figure 4—Expansion of NPG methyl region of 300 MHz ^1H NMR spectrum of (a) HS-3-4ND resin, (b) HS-3-4ND resin acetoacetylated with diketene, TKD, or t-BAA, and (c) HS-3-4ND acetoacetylated with MAA or EAA

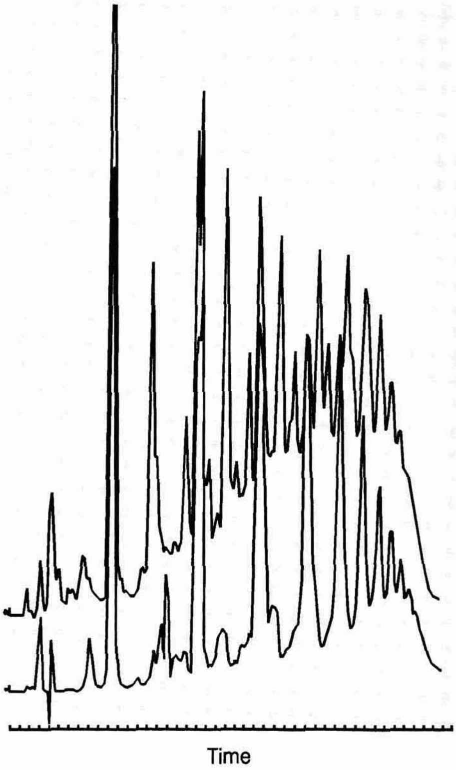

Figure 5—HPLC trace of HS-3-4ND resin before (lower trace) and after (upper trace) acetoacetylation

The sluggishness of the aforementioned transacetoacetylation reactions along with the evidence that these processes can be accompanied by breakdown and/or scrambling of the polyester backbone suggested that MAA or EAA are not especially attractive reagents for transacetoacetylation under conditions of relevance to chemists in the coatings industry.

KINETIC STUDIES ON THE TRANSACETOACETYLATION REACTION

The preceding studies suggested that a better understanding of the mechanism of the transacetoacetylation process was needed. In particular, information was desired on how variation in the structure of the ester component R of the acetoacetate [(**1**) in *Figure* 6] affects the rate of transacetoacetylation. The rate of reaction of a series of acetoacetates with n-butanol in xylene solvent was chosen as a model[7a] (*Figure* 6).

The results of these kinetic experiments are summarized in *Table* 1. Examination of the concentration dependence of this reaction clearly demonstrates that these transacetoacetylation processes proceed by a mechanism distinctly different from that of typical transesterification reactions. In particular, the effect of nucleophile

---

*Comparison of these spectra with the spectra of the mono and dibenzoate of NPG helped in the assignment of 1.09 and 1.04 ppm signals. A resonance due to the mixed diester is presumably indistinguishable from these four peaks.

†A weak resonance due to the methyl ester end-group is noted at 3.67 ppm in the MAA reaction; while the ethyl ester end-group is suggested by signals at 4.42 ppm (CH_2) and 1.43 ppm (CH_3).

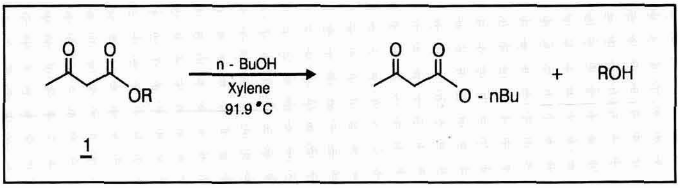

Figure 6—General reaction scheme for kinetic studies

concentration on the observed first-order rate constants indicates that the process is first-order overall; first-order in acetoacetate and zero-order in nucleophile. The relative reactivity of variously substituted acetoacetates is also different from what would be expected if the transacetoacetylation reaction were to parallel the transesterification of simple esters; with the more sterically encumbered t-butyl and t-amyl acetoacetates being 10-20 fold more reactive than other analogues. The similarity in the rate of reaction of ethyl, methyl, isobutyl, and isopropyl acetoacetates suggests that the enhanced reactivity of the tertiary acetoacetates is unique. The somewhat slower rate of reaction (relative to EAA or MAA) of diisopropylcarbinol acetoacetate, which is sterically hindered by the two gem-dimethyl groups, demonstrates that the enhanced reactivity of the t-butyl and t-amyl acetoacetates is due to more than just the steric bulk associated with the ester substituent.

This kinetic data indicates that t-butyl acetoacetate (t-BAA) [(**5**) in *Figure* 7] is the reagent of choice for transacetoacetylation, being 10-20 times more reactive than other acetoacetates and 1.2-1.7 fold more reactive than TKD at 91.9°C. It should be noted that other tertiary acetoacetates, while in principle useful, are presumably less advantageous than t-BAA because of the lower volatility of the alcohol co-product and higher cost of the resulting material.

Once t-BAA had been identified as the reagent of choice for transacetoacetylation reactions, the question of how various additives affect the rate of reaction of this material could be addressed. The work of Taber[6a] and Gilbert[6b] suggests that the rate of these processes could be enhanced by addition of a dimethylaminopyridine (DMAP) catalyst. The kinetic data summarized in *Table* 2 indicate that moderate amounts (ca. 5 mol%) of either DMAP or tetramethylguanidine (TMG) have no dramatic effect on the rate of the process. These reactions also were accompanied with a significant (and undesirable) increase in the color of the reaction product.* Use of a titanium catalyst at the levels suggested (36 mol%) for a variety of transesterifications,[8] showed, if anything, an inhibition in the rate of the process. Furthermore, the insoluble titanate complexes formed in this reaction make work-up of the crude reaction mixture much more complicated than the uncatalyzed process.† Similarly, variation in the reaction solvent does not dramatically affect the rate of the process, with the more polar n-butyl acetate being somewhat slower than xylene.

The equilibrium constants for these processes could not be determined under the reaction conditions used to determine the rates of reaction. The fact that MAA and EAA were in equilibrium with n-butyl acetoacetate was apparent from following the conversion of these materials after 24-48 hr. The apparent first-order rate constants for these interconversions, while similar at low conversion, are

---

*It should be noted that while our data suggests that these catalysts do not affect the rate of the reaction of n-butanol with t-BAA, it is possible that these catalysts affect the rate at longer conversions for the processes involving the less reactive EAA or MAA.

†Analysis of this reaction was complicated by the presence of titanate complexes and the formation of small (ca. 10%) amounts of isopropyl acetoacetate, presumably from displacement of isopropanol by n-butanol from the Ti(OiPr)$_4$ catalyst. The analytical problems associated with this latter reaction led to a larger experimental uncertainty associated with this rate constant, but the lack of any advantage from use of the titanium catalyst is clear.

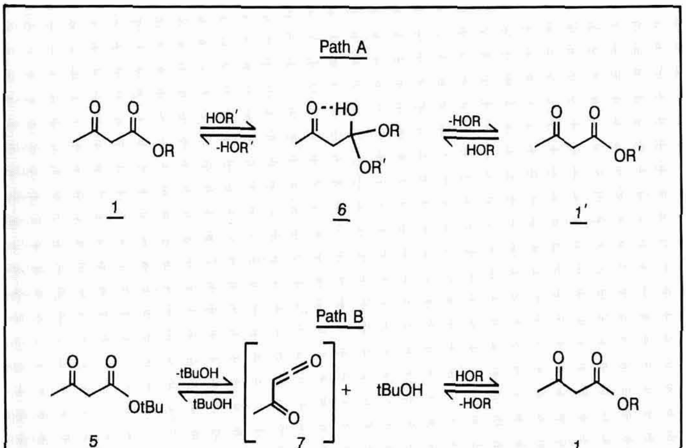

Figure 7—Effect of butanol concentration on reaction rate of EAA

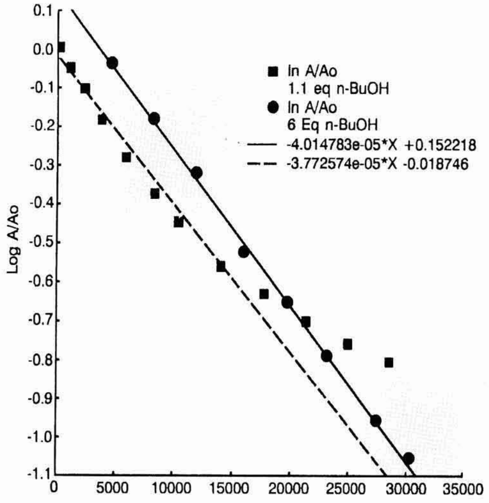

Figure 8—Mechanistic possibilities for the transacetoacetylation reaction

dependent on the amount of n-butanol present at much higher conversions; with the lower amount of n-butanol leading to lower conversion to n-butyl acetoacetate.* This effect is shown graphically in *Figure* 8, which compares the reaction profile of EAA with 1.1 and 6.0 equivalents of n-butanol at 106°C. This phenomena is not observed with t-BAA [(**5**) in *Figure* 7], thus demonstrating that the equilibrium constants for this material are much more favorable. Preliminary experiments conducted at 106°C in a pressure bottle indicated that the EAA/t-BAA equilibrium favors EAA by 15.0-22.0:1; reflecting a free energy difference (ΔG°) of ca. 1.9-2.3 kcal/mol. These results, although preliminary, indicate that the difference in reactivity between MAA or EAA and t-BAA will be even more pronounced at extended conversions.

MECHANISM OF THE TRANSACETOACETYLATION REACTION

The generally accepted mechanism of transacetoacetylation is that proposed by Bader,[5a,b] which involves an equilibrium between the starting acetoacetate and the resulting transesterified material via the hydrogen-bonded intermediate [(**6**) in *Figure* 7] (Path A). The lack of any dependence of the observed rate constants on the nucleophile concentration along with the surprisingly rapid rate of the more sterically encumbered tertiary esters demonstrates that this mechanism cannot be operative. A mechanism which is more consistent with the experimental results (Path B, *Figure* 7) is one in which the acetoacetate decomposes unimolecularly in the rate-determining step to a reactive intermediate such as acetylketene [(**7**) in *Figure* 7].

This intermediate has been demonstrated to be involved in the formation of acetoacetates from dioxinone [(**4**) in *Figure* 2].[9b] The rate of a reaction following this mechanism would be dependent on the structure of the acetoacetate and independent of the nucleophile,* which is in accord with the experimental results.† The activation parameters (*Table* 3) for transacetoacetylation of t-BAA and EAA suggest that while the rates of the two processes differ, the mechanisms of the two reactions are very similar. Thus, this proposed mechanism appears to be quite general.

USE OF t-BAA IN PREPARATIVE ORGANIC CHEMISTRY

The synthetic utility of t-BAA was evaluated by preparing a variety of simple acetoacetylated products according to *Figure* 9.[7b] *Table* 4 lists the yields obtained from acetoacetylation reactions with a few representative nucleophiles, including glycols, amines, and alcohols. The reaction appears quite general, can be carried out with equimolar amounts of alcohol and acetoacetate in concentrated solutions, does not require catalysts, and is much more rapid than other transacetoacetylation processes. The major co-product from this reaction is t-butanol and not isobutylene. The fact that both the pri-

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*For example, reaction of EAA with 1.11 eq nBuOH showed percent conversions of 48.7, 53.4, and 55.4 after times of 1418.2, 1913.2 and 2911.7 min. These values correspond to "instantaneous" rate constants of 7.8×10^{-6} sec^{-1}, 6.7×10^{-6} sec^{-1}, and 4.62×10^{-6} sec^{-1}, respectively (versus a value of 1.02×10^{-5} sec^{-1} obtained from 0-815.5 min). In an experiment where 5.99 eq nBuOH were used, percent conversions of 71.4, 78.9, and 87.2 were obtained at 1421.3, 1686.6, and 1942.5 min, respectively. These latter values correspond to "instantaneous" rate constants of 1.45×10^{-5} sec^{-1}, 1.54×10^{-5} sec^{-1}, and 1.76×10^{-5} sec^{-1} (versus 1.36×10^{-5} sec^{-1} for the 0-600 min time period).

*This assumes the rate of decomposition of acetoacetate is much slower than the corresponding rate of reaction of acetylketene [(7) in *Figure* 7] with alcohol. [See reference (8b) and references cited therein.]

†Tertiary alcohols exchange with MAA and EAA very slowly, if at all [references (5) and (6)], supposedly due to the steric inhibition associated with formation of intermediate [(6) in *Figure* 7] from the primary acetoacetate. The rate of formation of an intermediate of this sort from [(5) in *Figure* 7] would also be expected to be slow, which is well precedented in the non-acid catalyzed transesterification of the esters of simple carboxylic acids. (See for example "The Chemistry of Carboxylic Acids and Esters," Patai (Ed.), Wiley, 1969, NY, Chapter 3, p 117, and references cited therein.) This proposed mechanism would also explain the observation that 2,2-disubstituted acetoacetates do not undergo transacetoacetylation reactions, since these materials can not form the acyl ketene intermediate.

Table 1—Rate Constants for Reaction of ROAcAc With n-BuOH at 91.85°C

Entry	R	$k \times 10^4$[a]	(S)[b]	[nBuOH][c]	[ROAcAc][c]
1.	tBu	1.716	(0.07)	0.492	0.474
2.	tBu	1.662	(0.03)	2.623	0.475
3.	tBu	1.859	(0.03)	1.027	0.472
4.	tBu	1.559	(0.05)	0.174	0.068
5.	Et	0.102	(0.002)	0.526	0.473
6.	Et	0.136	(0.001)	4.987	0.477
7.	Me	0.097	(0.001)	0.611	0.551
8.	iBu	0.138	(0.004)	1.068	0.474
9.	iPr	0.140	(0.007)	1.070	0.537
10	$HC(iPr)_2$	0.083	(0.003)	1.046	0.477
11.	tAm	1.460	(0.07)	1.072	0.495
12.	TKD [(**4**) in *Figure* 2][d]	1.07	(0.03)		

(a) First-order rate constant in sec^{-1}.
(b) Standard deviation from ANOVA analysis.
(c) Molar concentrations of n-BuOH and acetoacetate, respectively.
(d) See reference (9b) for a complete listing of kinetic parameters for this compound.

Table 2—Effect of Various Additives on Experimental Rate Constant for Reaction of t-Butyl Acetoacetate With n-Butanol at 91.85°C

Additive[a]	k × 10^4[b]	(S)[c]	[nBuOH][d]	[tBuOAcAc][d]
DMAP, 0.0237M	2.08	(0.03)	1.038	0.475
TMG, 0.0243M	2.11	(0.05)	1.061	0.489
Ti $(OiPr)_4$, 0.165M	0.98	(0.07)	1.108	0.496
nBuOAc (solvent)	0.99	(0.06)	0.68	0.599

(a) Additive and concentration, respectively. DMAP = dimethyl aminopyridine; TMG = tetramethylguanidine.
(b) First-order rate constant in sec^{-1}.
(c) Standard deviation from ANOVA analysis.
(d) Molar concentrations of n-BuOH and t-BAA, respectively.

mary and secondary hydroxyls on 2,2,4-trimethyl-pentan-1,3-diol (TMPD® glycol) are effectively acetoacetylated indicates that the acetoacetylating reagent is not particularly sensitive to the substitution of the glycol.

The acetoacetylation of 1-methylcyclohexan-1-ol and 2-methyl-3-butene-ol with [(**5**) in *Figure* 9] illustrates that higher boiling tertiary alcohols can be acetoacetylated with this material. This is in sharp contrast to the transacetoacetylation reactions of EAA and MAA.[5a,6] The yield for preparation of phenyl acetoacetate under standard reaction conditions was poor, but could be improved significantly when cyclohexane was used to help azeotropically remove t-butanol from the reaction.

ACETOACETYLATION OF POLYMERIC MATERIALS WITH t-BAA [(5) IN *FIGURE* 9]

With the preparative utility of t-BAA in the acetoacetylation of a variety of simple nucleophiles demonstrated, it became incumbent upon us to evaluate the use of this reagent in acetoacetylation reactions involving hydroxylated polyesters and other polymers. The first example considered was that of the HS-3-4ND resin previously mentioned. Use of t-BAA in the acetoacetylation of this material proceeded smoothly without a catalyst to produce a functionalized resin which was identical by ^{1}H and ^{13}C NMR spectroscopy, as well as HPLC analysis to those materials produced from diketene or TKD. This acetoacetylation was complete within 1-2 hr, vs 6-8 hr for MAA or EAA. The end-group distribution in the resin acetoacetylated with t-BAA was similar to the materials produced from reaction with dioxinone [(**4**) in *Figure* 2] or diketene, suggesting no reduction in the molecular weight of the resulting acetoacetylated resin.

Table 3—Effect of Temperature on Rate of Reaction of EAA and t-BAA

Temperature (°C)	k (sec^{-1}) × 10^4[a]	k (sec^{-1}) × 10^4[a]
91.85	0.10	1.65
98.70	0.19	2.50
106.00	0.37	5.16

Activation Parameters

Acetoacetate	Log A (sec^{-1})[b]	Ea (kcal/mol)[b]
EAA	9.83	24.76
t-BAA	9.45	22.14

(a) Average first-order rate constants.
(b) Correlation coefficient (R2) from ANOVA analysis = 0.999 for EAA and 0.978 for t-BAA.

The next polyester resin studied (HS-3-4T)[*] was one which was prepared from a 2:1 mixture of TMPD and isophthalic acid. Earlier studies had shown that this resin was difficult to acetoacetylate with MAA or EAA, presumably due to the large number of secondary hydroxyls on the resin. By reaction of the resin at 100% solids with t-BAA at 140°C, it was possible to effect 89% acetoacetylation (99% conversion). The resulting acetoacetylated resin is dramatically lower in viscosity than the starting resin. (The properties of these acetoacetylated materials will be discussed in a subsequent section.)

The generality of this procedure was studied by treating a high-solids polyester resin with varying amounts of acetoacetylating reagent [(**5**) in *Figure* 9]. The resin used (HS-3-6T)[†] is comprised of TMPD (54 wt%), TMP (4.7 wt%), isophthalic acid (22.0 wt%), and adipic acid (19.3 wt%). The ratio of resin to acetoacetylating reagent was adjusted so as to effect 11, 18, 25, 50, and 85% acetoacetylation. The reactions were carried out by adding the t-BAA to the hot (125°C) resin in xylene (70% solids). The extent of acetoacetylation was verified by NMR spectroscopy. All of the materials were produced with little color buildup. These experiments demonstrated that this method is very versatile, and can be used to acetoacetylate a resin to a desired functionality or viscosity.

The preceding reactions were typically carried out either neat or in toluene or xylene solvent. Other solvents which can be used include n-butyl acetate, ethyl-3-ethoxy propionate (Ektapro® EEP), SC-150, and ketone solvents such as MAK, MIBK, or DIBK. A solvent is often necessary for reactions where acetoacetylation with complete t-butanol removal is required. In cases where process conditions necessitate the use of solvent, it is usually possible to carry out the reaction at the percent solids level ultimately desired for the coating formulation.

This method appears quite general and has been used to acetoacetylate higher molecular weight, amorphous polyesters, as well as acrylic and phenoxy resins. For example, an amorphous hydroxylated polyester prepared from terephthalic acid and NPG was treated with [(**5**) in *Figure* 9] in n-butyl acetate to produce a material in which 58% of the free hydroxyls had been acetoacetylated.

Similarly, an acrylic comprised of 70 mol% methyl methacrylate (MMA) and 30 mol% hydroxy ethyl methyacrylate (HEMA) in Ektapro® EEP solvent (60% solids) was effectively acetoacetylated at the 50 and 85% acetoacetyl levels using [(**5**) in *Figure* 9]; as was an acrylic terpolymer prepared from a 48/32/20 mol% mixture of butyl methacrylate(BMA)/MMA/HEMA. A phenoxy resin (UCAR®PKHH) was similarly acetoacetylated to ca. 25% acetoacetyl in EEP solvent. While acetoacetylated acrylics are usually prepared from AAEM [(**2**) in *Figure* 1], these results demonstrate the generality of this meth-

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[*] Typical properties of the HS-3-4T resin are: OH# 265-285, Acid # 2-4, Mn 600-800. For more information see Eastman Publication N-271.

[†] Typical properties of the HS-3-6T resin are: OH# 170, Acid # 4-8, Mn 900-1100. For more information see Eastman Publication N-306.

Ektapro is a registered tradename of Eastman Kodak.
UCAR is a registered tradename of Union Carbide.

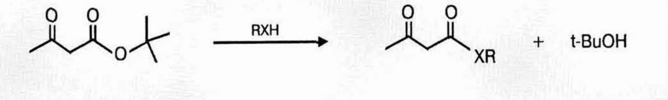

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Figure 9—General reaction scheme for synthetic studies

od, as well as the potential of this reaction as an alternative route to these resins. This approach may be particularly attractive for preparation of laboratory quantities of acrylic resins for evaluation purposes.

ANALYSIS OF ACETOACETYLATED MATERIALS

The interest in this new class of polymers has led to a need for methods of analysis and identification of the resulting acetoacetylated resins. While a detailed discussion is beyond the scope of this paper, a few general comments can be made.

Estimation of the molecular weight of low molecular weight acetoacetylated resins by GPC is often unreliable, presumably due to the change in retention volume of the species upon acetoacetylation. Analysis of the resin by HPLC can provide valuable information about the extent of acetoacetylation, but these analyses can be complicated by the large number of oligomeric species often present. Ebulometric determination of molecular weight is sometimes complicated by the depolymerization of the resin in the HFIP solvent commonly used for these analyses. The presence of acetoacetyl functionality can be determined by FTIR, but determination of the extent of acetoacetylation by this method is difficult. The acid number of acetoacetylated resins cannot be determined by standard base titration methods due to the competitive deprotonation of the active methylene on the acetoacetyl group. Potentiometric titrations have been used to differentiate between acid and acetoacetyl groups with some success, but it is not possible to differentiate between polymer-bound acetoacetyl from unreacted t-BAA using this method.

Two of the most informative and useful methods of analysis of acetoacetylated resins are ^{1}H and ^{13}C NMR spectroscopy. The ^{1}H NMR spectrum provides useful information regarding the structure and extent of acetoacetylation while the ^{13}C data provides further structural information which is often complimentary to the ^{1}H data. The products derived from acetoacetylation of the HS-3-4ND resin are illustrative of the utility of these methods. *Figure* 3 shows the 300 MHz ^{1}H spectra of the starting (a) and acetoacetylated (b) HS-3-4ND resins in $CDCl_3$ solvent. The previously mentioned appearance of the resonances at 2.29 and 3.50 ppm demonstrates the presence of the acetoacetyl methyl and methylene groups, while the downfield shift of the NPG methyl and methylene resonances is consistent with conversion of the hydroxyl end-groups to an acetoacetylated species. Analysis of the integrated peak intensities of the various peaks due to the acetoacetyl group enables one to determine the extent of acetoacetylation. For example, comparison of the total area of the NPG gem-dimethyls to the acetoacetyl methyl, after correction for the different number of methyls per functional group, can be used to determine the extent of acetoacetylation. In principle, a similar analysis can be conducted by comparing the integrated peak intensities of the various NPG and acetoacetyl methylene groups. The complexity of these spectral regions, however, is such that unambiguous assignment of these resonances is often difficult. The presence of unreacted t-BAA can be determined by the presence of the characteristic nine proton t-butyl singlet at 1.47 ppm.

To accurately assess the extent of acetoacetylation in a resin it is necessary to consider both the keto and enol forms of the acetoacetate. In simple acetoacetates, the methyl resonance due to the enol is observed at ca. 2.04 ppm (vs ca. 2.3 ppm for the keto), while the methine proton on C-2 is typically observed between 5.0 and 5.3 ppm. The hydroxyl proton due to the enol shows a pronounced downfield shift, being typically noted in the 12.0-13.5 ppm region. The concentration of the enol form is typically 5-10% that of the keto species. The enol content is readily determined in simple acetoacetates by noting the enol methyl and/or methine protons. In acetoacetylated resins, however, the methyl and methine enol resonances may be obscured by other species and the downfield hydroxyl protons must be used.

The ^{13}C NMR spectrum of an acetoacetylated material can be used to gain further insight into the structure of an acetoacetylated resin. While the use of this technique in

Table 4—Yield of Various Acetoacetylated Materials Using t-Butyl Acetoacetate

Nucleophile (Solvent)[a]	g (Nu)	g (t-BAA)	mL Solvent	Yield (%)	Experimental Method[b]
TMP[c] (X)	47.5	171.00	100	90[d]	B
TMPD[c] (X)	10.1	22.4	30	87[d]	A
NPG[e] (X)	10.0	32.1	32	87[d]	A
NPG (T)	159.2	491.3	450	81[d]	B
CHDM[e] (X)	9.8	22.1	28	69[f]	A
$HNBu_2$ (X)	7.7	9.2	25	96	A
PhOH (X/CH)	30.1	33.5	110/100[g]	74	B
$PhNH_2$ (X)	10.0	17.2	25	83	A
n-BuOH (X)	10.0	21.4	40	87	A
n-OctOH (T)	13.0	16.6	50	83	B
$PhCH_2OH$ (T)	10.8	16.6	50	89	B
$p(NO_2)$ $PhNH_2$ (T)	13.8	16.2	50	86	B
1-Me-cyclohexanol (T)	11.4	16.2	50	83	B

(a) X = xylene, T = toluene, and X/CH = xylene-cyclohexane mixture.
(b) See Experimental section for a description of the method.
(c) TMPD = 2,2,4,-trimethyl-1,3-pentanediol. TMP = trimethylolpropane.
(d) Yield of bis-acetoacetate for TMPD, NPG, and CHDM, and tris-acetoacetate for TMP.
(e) NPG = neopentyl glycol or 2,2-dimethyl-1, 3-propanediol, and CHDM = cyclohexane 1,4-dimethanol.
(f) Yield of crystalline material, some cis isomer lost in recrystallization.
(g) 110 mL xylene, 100 mL cyclohexane.

Table 5—Acetoacetylated Polyester Resin HS-3-6T (Resin Properties)

% Acetoacetylation	0	11.2	18.2	25	50	85
% Solids, determined, 30 min at 325°F	68.4	63.7	64.3	66.4	67.1	65.9
APHA Color	120	120	140	140	160	160
Gardner Color	1	1	1	1	1	1
Gardner Viscosity	H−	B−	B−	C+	A+	A−
Brookfield Viscosity, 23.2°C, centipoise	264	173	165	144	128	96

Table 6—Acetoacetylated Polyester Resin HS-3-4T (Resin Properties)

% Acetoacetylation	0	90
% Solids, determined, 30 min at 325°F	75.0	74.0
APHA Color	80	220
Gardner Color	2	4
Gardner Viscosity	Z4+	L+
Brookfield Viscosity, 22.4°C, centipoise	11,000	416

the analysis of coating resins has been discussed in detail elsewhere,[10a] a few observations regarding its use can be made. The ^{13}C NMR spectra of most high-solids coating resins are complicated, due to the many different types of carbons present. While, in principle, the new peaks due to acetoacetylation of a resin could be determined by analysis of the carbon spectra of the resin prior to and after acetoacetylation, an easier way exists to make this assignment. This involves use of a technique known as Distortionless Enhancement by Polarization Transfer (DEPT).[10b] This technique breaks the ^{13}C spectrum into four subspectra: one due to all carbons which have attached protons; one due to methine carbons; one due to methylene carbons; and one due to methyl carbons. Use of this technique can help simplify otherwise complicated spectra, thus enabling the acetoacetyl methyl and methylene resonances to be readily assigned. This simplification is demonstrated in *Figure* 9. Note the appearance of the new acetoacetyl methyl (31.5 ppm) and methylene (50.3 ppm) carbons in the acetoacetylated resin.

PROPERTIES OF ACETOACETYLATED RESINS

Once an industrially viable method for the acetoacetylation of resin systems had been established, it was necessary to evaluate the effects of acetoacetylation on the properties of the resins in question. For this study, four base resins were selected—two polyesters and two acrylics. These resins had been acetoacetylated to various percent conversions using t-BAA. Percent solids, color, and viscosity data were evaluated for each series of resins.

The first polyester resin evaluated was Eastman formulation HS-3-6T, a TMPD glycol-based high-solids resin. The control properties were determined, as well as properties at 11, 18, 25, 50, and 85% acetoacetylation. *Table* 5 details the results of these evaluations. As the data shows, a dramatic decrease in viscosity was observed between 0 and 25% acetoacetylation. Beyond 25% conversion, however, the decrease in viscosity became less pronounced. *Figure* 10 graphically shows the effect of acetoacetylation on viscosity. Very little color development was observed after conversion of the resin.

The other polyester resin evaluated was Eastman formulation HS-3-4T, another TMPD glycol-based high-solids resin. This resin was tested at 0 and 90% acetoacetylation. As observed with the HS-3-6T, the HS-3-4T also exhibited a dramatic decrease in viscosity after acetoacetylation, with only slight color development (*Table* 6). The results observed for both polyester resins indicate that acetoacetylation offers many possibilities in the production of higher-solids resins for lower VOC coatings.

The effect of acetoacetylation on the 70/30 MMA/HEMA acrylic copolymer and the 32/48/20 MMA/BMA/HEMA terpolymer was determined by examining the properties of these base resins, as well as the acetoacetylated polymers (50 and 85% acetoacetylation). The data from these determinations are given in *Table* 7. The data demonstrate that acetoacetylation of the acrylic resins results in a viscosity decrease, similar to the polyester resins, with very little color development. This data also indicates that acetoacetyl chemistry can be an effective tool in producing higher-solids resins to meet the increasingly stringent demands of the coatings market.

PROPERTIES OF COATINGS PREPARED FROM ACETOACETYLATED RESINS

To further define the utility of acetoacetylated resins to the coatings industry, it was necessary to evaluate the crosslinking capability of these materials. For this study, the previously mentioned resins were formulated into clear, melamine-crosslinked coatings, using hexamethoxymethyl melamine as the crosslinking reagent. The formulations of these enamels are given in *Tables* 8-10. Viscosity and percent solids values were determined for the enamels. The coatings were spray applied to 20 gauge cold-rolled steel with Bonderite® 37

Table 7—Acetoacetylated Acrylic Resins (Resin Properties)

Resin Composition Mole Ratio	MMA/BMA/HEMA 32/48/20			MMA/HEMA 70/30		
% Acetoacetylation	0	50	85	0	50	85
% Solids, determined, 30 min at 325°F	60.2	59.9	60.8	60.9	59.8	60.4
APHA Color	20	40	60	40	40	80
Gardner Color	1	1	1	1	1	1
Gardner Viscosity	Z8−	Z7+	Z7	Z9	Z7	Z7
Brookfield Viscosity, 22.8°C, centipoise	128,000	43,200	37,400	156,000	79,000	59,800

Bonderite is a registered tradename of the Parker Rust Proof Company.

Table 8—Acetoacetylated Polyester Resin HS-3-6T (Enamel Formulas and Constants)

% Acetoacetylation	0	25	50	85
Wt resin solution	50 g	51.6g	51.0g	51.9g
Hexamethoxymethyl melamine[a]	14.7g	14.7g	14.7g	14.7g
pTSA at 40% NVW	0.4g	0.4g	0.4	0.4g
Solvent blend[b] added for viscosity adjustment	11.0g	4.0g	3.0g	2.0g
Initial Brookfield viscosity, centipoise	504	280	248	200
Final Brookfield viscosity, centipoise	160	160	168	154
Final No. 4 Ford Cup viscosity, sec	30	—	—	—
Calculated % solids	65.5	72.1	73.2	74.2

(a) Resin/crosslinker ratio = 70/30.
(b) Solvent Blend = 65.5/17.3/17.2, MAK/EEP/n-BuOH.

Table 10—Acetoacetylated Acrylic Resins (Enamel Formulas and Constants)

Resin Composition Mole Ratio	MMA/HEMA[a] 70/30			MMA/BMA/HEMA[b] 32/48/20		
% Acetoacetylation	0	50	85	0	50	85
Wt resin solution	91.5g	91.5g	91.5g	83.5g	83.5g	83.5g
Hexamethoxymethyl melamine	10.0g	10.0g	10.0g	13.5g	13.5g	13.5g
pTSA at 40% solids	0.8g	0.8g	0.8g	0.8g	0.8g	0.8g
MAK	13.5	13.5	13.5	13.5	13.5	13.5
DIBK	13.5	13.5	13.5	13.5	13.5	13.5
Ektasolve EB Solvent	13.5	13.5	13.5	13.5	13.5	13.5
Ektapro EEP Solvent	121.0	117.0	109.0	46.0	49.0	46.0
Brookfield viscosity, centipoise	100	102	104	104	100	98
No. 4 Ford Cup viscosity, sec	25	25	25	25	25	25
Determined % solids, 30 min at 325°F	31.2	28.1	31.0	27.3	27.3	28.6

(a) Resin/crosslinker ratio 85/15.
(b) Resin/crosslinker ratio 80/20.

pretreatment and cured for 30 min at 325°F. Samples were also drawn on glass for Knoop hardness determinations, and cured on the same schedule. The results of the wet enamel and cured film testing are shown in *Tables* 11-13.

The viscosity and percent solids data of acetoacetylated polyester resin HS-3-6T were heavily affected by the relatively low initial solids content of the resins. The initial Brookfield viscosities of the enamels, however, do exhibit the advantages to be obtained by the use of acetoacetylation. The enamels exhibit consistently lower initial viscosity as percent acetoacetylation increases. The MEK double rub resistance of the cured coatings, greater than 200 rubs, indicates complete cure of the enamel. On examining the properties of the cured coatings, however, the acetoacetylated resins appear to exhibit better flexibility (impact resistance) than the control resin, at equivalent hardness. Based on the data presented in *Table* 11, it

Table 9—Acetoacetylated Polyester Resin HS-3-4T (Enamel Formulas and Constants)

% Acetoacetylation	0	90
Wt resin solution	194.1	196.7
Hexamethoxymethyl melamine[a]	48.6	48.6
pTSA at 40% NVW	2.4	2.4
Solvent blend added[b] to adjust viscosity	80.0g	30.0g
Initial Brookfield viscosity, centipoise	7120	544
Final Brookfield viscosity, centipoise	124	144
Final No. 4 Ford Cup viscosity, sec	30	30
Determined % Solids 30 min at 325°F	62.5	68.3
Determined VOC. 30 min at 325°F, lb/gal	3.25	2.86
Calculated % solids	75.2	89.1

(a) Resin/crosslinker ratio = 75/25.
(b) Solvent Blend = 74/24, Xylene/MAK.

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Table 11—Acetoacetylated Polyester Resin HS-3-6T Coating Properties

% Acetoacetylation	0	25	50	85
Avg. film thickness, mil	1.7	1.5	1.5	1.5
MEK double rubs passed	200+	200+	200+	200+
Tukon hardness, Knoops	13.9	13.9	13.9	13.9
Pencil hardness to scratch	3H	3H	3H	3H
Impact resistance, in.-lb				
Direct	56	56	84	76
Reverse	12	12	52	40

Substrate—20-gauge, cold-rolled steel with Bonderite 37.
Cure Schedule—30 min at 325°F.

appears that the optimum level of acetoacetylation for a melamine crosslinked system is approximately 50%. This observation that a mixture of both hydroxy and acetoacetyl melamine crosslinks provides the best combination of properties has also been noted with other polyester-based systems.[11]

Polyester resin HS-3-4T yielded an excellent evaluation of the effects of acetoacetylation on the properties of the wet enamel. The coating containing the acetoacetylated resin had a lower initial viscosity than the control, which translates to a higher solids content at equivalent viscosity. The volatile organic content (VOC) of the enamel also was determined. The values obtained exhibit a decrease in VOC after acetoacetylation of the resin, which is consistent with the observed decrease in viscosity. As this enamel utilizes a lightly crosslinked resin, the 150 MEK double rubs resistance obtained from the coating is indicative of complete cure. The cured coating based on the acetoacetylated resin also exhibits improved flexibility without loss of hardness.

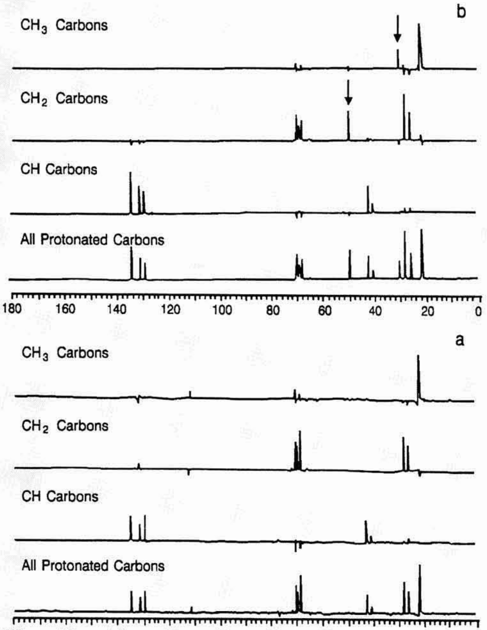

Figure 10—DEPT spectra of (a) HS-3-4ND resin and (b) HS-3-4ND acetoacetylated with t-BAA [(5) in *Figure* 7]

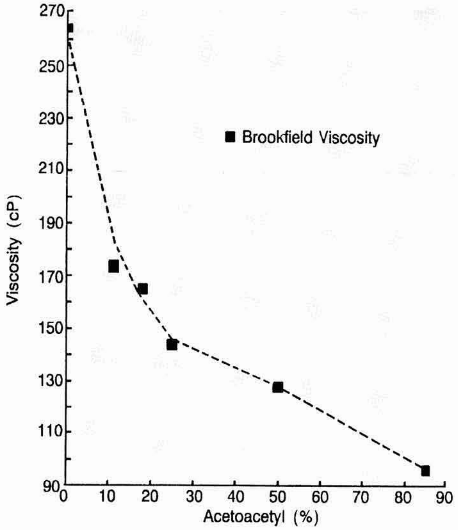

Figure 11—Effect of percent acetoacetylation on Brookfield viscosity of HS-3-6T resin

The data on these melamine acetoacetylated polyester systems, while preliminary, suggest that these systems not only provide a means to higher-solids, lower VOC formulations, but may also offer a means to coatings with improved performance properties.

The acrylic resins used for this evaluation also exhibited good crosslinking with melamine resins. As formulated, the enamels were lower in viscosity than was expected, and show little difference in viscosity as a result. The properties of the cured coatings, however, show that the acetoacetate group can be used to crosslink with melamines and give properties at least equal to the conventional hydroxyl-melamine reaction.

EXPERIMENTAL

General

The p-xylene solvent used in the kinetic studies (Kodak) was distilled prior to use to remove trace levels of tolualdehyde. All other reagents were used as purchased. The constant temperature bath used in the kinetic experiments has been described elsewhere.[9b] Isopropyl acetoacetate and t-amyl acetoacetate were prepared from the corresponding alcohols and TKD [(**4**) in *Figure* 2] in xylene solvent in 74% and 81% yields, respectively.[4] Gas chromatographic analyses were carried out on a Hewlett-Packard HP 5890 gas chromatograph with flame ionization detector on a 30m × 0.25mm DB-5 microbore capillary column. Samples were injected in duplicate using an HP 7673A autoinjector and integrated using an HP 3393A integrator. The resultant data from the gas chromatograph was transferred to a DEC VAX computer and the rate constants determined using the linear least squares routine available on the RS1 statistical package using the protocols described elsewhere.[9b] ^{1}H NMR spectra were obtained on either a JEOL model GX-270 or a Varian model Gemini 300 NMR spectrometer, while ^{13}C NMR spectra were obtained at 75 MHz on the Varian instrument.

Kinetic Experiments

A solution of acetoacetate (4.7-5.4 mmol), n-butanol (4.9-5.0 mmol), and p-dichlorobenzene internal standard (ca. 450-550 mg) were diluted to 10 mL with p-xylene in a volumetric flask. The solution was placed in a 25 mL two-neck flask equipped with condenser, N_2 inlet, and stoppered side-arm, and immersed in a constant temperature bath which was maintained within ±0.1°C of the specified temperature. Samples from the reaction were periodically withdrawn and the time noted. These samples were diluted with p-xylene and analyzed by gas chromatography. For the rates of reaction of isopropyl, isobutyl, ethyl and methyl acetoacetates, the T = infinity values were estimated using the experimentally determined response factor of n-butyl acetoacetate. The acetoacetates of t-amyl alcohol and n-butanol could not be separated by gas chromatography, so the rate of this reaction was determined by the rate of appearance of t-amyl alcohol and of disappearance of n-butanol.

Preparative Experiments

METHOD A: The preparation of the bis-acetoacetate of NPG is illustrative of the procedure. In a 125 mL Erlenmeyer flask equipped with magnetic stirrer and thermometer was placed 10.03 g NPG (0.096 mol), 32.1 g t-BAA (0.203 mol), and 32 mL xylene. The solution was heated with stirring on a hot plate to the boiling point of xylene. Once the solution reached 138°C (ca. 10-20 min), it was removed from the hot plate, cooled to room temperature, concentrated *in vacuo,* and short-path distilled to yield 22.83 g (87.1%) bis-acetoacetate b.p. 145-148°C (0.05 mm Hg). Care must be taken in the distillation of this material to prevent thermal decomposition of the bis-acetoacetate.

METHOD B: The procedure involved heating the alcohol and t-BAA in a 100 mL round-bottom flask with magnetic stir bar, and 5-plate Oldershaw column with still head for removal of the t-butanol by-product. A solution of n-octanol (13 g, 0.1 mol), t-BAA (16.6 g, 0.105 mol), and 50 mL toluene were heated at reflux until the theoretical amount of t-BuOH was obtained (ca. 15-30 min after the system reached reflux). The reaction mixture was subsequently concentrated *in vacuo* and distilled to give 17.8 g (83.2%) octyl-acetoacetate b.p. 95-100°C (1.0 mm Hg).

Table 12—Acetoacetylated Polyester Resin HS-3-4T Coating Properties

% Acetoacetylation	0	90
Avg. film thickness, mil	1.4	1.5
MEK double rubs passed	150	150
Tukon hardness, Knoops	21.5	21.7
Pencil hardness to scratch	3H	3H
Impact resistance, in.-lb		
Direct	24	68
Reverse	4	12

Substrate—20-gauge, cold-rolled steel with Bonderite 37.
Cure Schedule—30 min at 325°F.

Table 13—Acetoacetylated Acrylic Resins Coating Properties

Resin Composition Mole Ratio	MMA/HEMA 70/30			MMA/BMA/HEMA 32/48/20		
% Acetoacetylation	0	50	85	0	50	85
Avg. film thickness, mil	1.4	1.7	1.6	1.5	1.8	1.5
MEK double rubs passed	200+	200+	200+	200+	200+	200+
Tukon hardness, Knoops	27.1	25.7	25.1	39.8	33.0	33.0
Pencil hardness	6H	6H	6H	7H	7H	7H
Impact resistance, in.-lb						
Direct	24	20	20	16	16	16
Reverse	4	4	4	4	4	4

Substrate—20-gauge, cold-rolled steel with Bonderite 37.
Cure Schedule—30 min at 325°F.

METHOD C: This preparation involved a modified procedure of Method B. In a 300 mL three-neck flask equipped with a thermometer in the pot, a stoppered side-arm, and a 5-plate Oldershaw column with still head (with thermometer) was placed 33.52 g (0.2119 mol) t-BAA, 30.1 g (0.3199 mol) phenol, 110 mL p-xylene, and 100 mL cyclohexane. The solution was heated to reflux for 1.5 hr (pot T = 100°C) after which time the azeotrope was taken off at a 15:1 reflux ratio. After 3 hr a total of 75 mL distillate had been obtained and the temperature of the pot had risen to 115°C. An additional 65 mL cyclohexane was added and the solution heated for four additional hours, during which time an additional 55 mL distillate was obtained. An additional 50 mL cyclohexane were added and the solution heated for three additional hours. The crude reaction product was concentrated *in vacuo* and vacuum distilled to give 21.87 g (74.1%, corrected for recovered t-BAA) phenyl acetoacetate.

Acetoacetylation of Polymers

These reactions were typically carried out by placing the resin as a 60-100% solids solution in a three-neck flask equipped with addition funnel, thermometer, and a distillation column with still head. The resin was heated to 120-140°C and the t-BAA was added via the addition funnel. When the head temperature of the distillation column reached 68-85°C (b.p. t-butanol = 82°C) the distillate was collected. The distillate was usually 85-100% t-butanol as determined by gas chromatography. In acetoacetylations of higher molecular weight viscous resins, it is necessary to use a solvent and heat the solution to boiling to remove all of the volatile t-butanol. Among the types of distillation columns employed in these reactions were: Vigereaux, Oldershaw and steam-heated, Penn-State packed. While the recovery of t-butanol is indicative of the progress of this reaction, it is thought that the rate of removal of the t-butanol by distillation is much slower than the actual rate of acetoacetylation.

Experimental Method for Determination of VOC Levels

A 1.5 mL sample of the formulation was drawn into a tared, 2 mL syringe and the weight of the formulation determined. The formulation was injected into a tared aluminum pan, and the weight of the formulation determined, and 5 mL of acetone were added to dilute and thin the film. The pan was placed in an oven and cured under the same conditions used for the coated metal panels (325°F for 30 min) and the weight of the cured formulation determined. The VOC level was calculated according to:

$$\text{VOC (g/L)} = \frac{\text{Total weight volatiles in grams}}{\text{Total volume of formulation in L}}$$

$$\text{VOC (lb/gal)} = \frac{\text{VOC in g/L}}{119.83}$$

SUMMARY AND CONCLUSIONS

The previously stated results demonstrate that the acetoacetylating reagent t-BAA [(**5**) in *Figure* 7] can be used to effect acetoacetylation of a wide variety of resins, glycols, and polymers. It is possible to control the extent of acetoacetylation by the stoichiometry of the acetoacetylating reagent used. Unlike many other acetoacetylating reagents, this material does not require a catalyst to effect the acetoacetylation and can be used to produce materials with little color development. This material also has advantages over methyl or ethyl acetoacetate in that it is more reactive, can be used to effect a higher extent of acetoacetylation of a hydroxylated material, and does not require the use of catalysts.

The acetoacetylated resins produced using this material have significantly lower viscosities than the unacetoacetylated base resins and, therefore, can be used to produce coating formulations with lower VOCs. The properties of the resultant coatings are as good or better than formulations prepared from the unacetoacetylated base resins. Coatings based on acetoacetylated polyesters crosslinked with melamine have improved flexibility with equivalent hardness. While the coatings in this study employed melamine crosslinkers, it is expected that the acetoacetylated resins discussed in this work can be readily employed in formulations which use other types of crosslinkers.

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Electropaint-Substrate Interactions

Clifford K. Schoff
PPG Industries, Inc.*

The key to improving the corrosion resistance of painted metal objects is to optimize the properties of and control the interactions between the components of the complex metal/pretreatment/coating composite that forms the total finish. For appliances and automobiles, the introduction of electrodeposition primers and zinc coated steels has led to better corrosion resistance. However, interactions between the electrodeposition coating and the pretreatment and/or zinc coated steel are not well understood. This paper is concerned with such interactions and reports findings from recent research on them.

INTRODUCTION

There have been significant improvements in the corrosion resistance of many automobiles, appliances, and other steel products in the last few years. For example, it is generally agreed that there has been a steady decrease in both cosmetic and perforation (inside-out) corrosion of automobiles in North America and recent evidence[1] confirms this. These improvements are due to developments in the components of the complex composite that makes up the total coating system or "finish," particularly the introduction of zinc coated steels, new zinc phosphate pretreatments, and cationic electrodeposition (E.D.) primers. Corrosion resistance should become even better as we develop a more complete understanding of and control over the components of the finish and their interactions.

With so many components, there are a number of interfaces and a like number of interactions or possible problems. The key interface for corrosion resistance probably is the one between the primer and the zinc phosphate pretreatment. However, because the pretreatment is porous rather than being a solid layer, there is the possibility of fingers of paint reaching down to or near the substrate giving a primer-substrate interface. Interactions at both of these interfaces will be important to adhesion, corrosion resistance, and other properties. In addition, the electrodeposition coating conceivably could affect the pretreatment-substrate interface. None of these interactions between electrodeposition coatings and pretreatments/substrates during and immediately after deposition are well understood. This paper is concerned with such interactions and reports findings from recent research on them as well as reviewing earlier work.

The electrodeposition of organic coatings is a complex process. The deposition is not a matter of plating as with metals, but depends on the electrolysis of water at the interface between the coating and the metal/pretreatment to produce H^+ ions (anodic electrodeposition) or OH^- ions (cathodic electrodeposition) in order to destabilize and precipitate the paint. The process is one of high voltage (200-400 V) and high current densities (1-10 ma/cm^2), both of which would be expected to affect the pretreatment and the metal substrate.

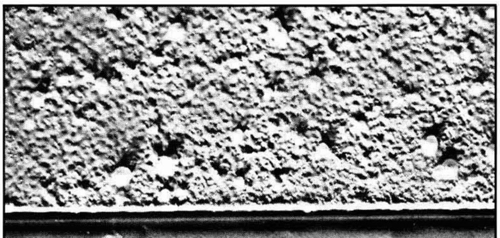

Figure 1—Unbaked (top half) and baked (bottom half) high build primer films over galvanneal zinc-iron alloy coated steel. Photograph taken at 10×

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*P.O. Box 9, Allison Park, PA 15101.

Table 1—Cratering Tendencies of Conventional and High Build Cationic E.D. Primers [Two Minute Depositions at 24°C, (75°F)]

Substrate	200V Conventional	200V High Build	300V Conventional	300V High Build
Cold-rolled steel	None	None	None	None
Zinc sheet	None	None	Moderate	None
Hot-dipped galvanized	None-Low	None	Moderate	None-Low
Electrogalvanized	None	None	Moderate	None-Low
Galvanneal Zn-Fe alloy	Moderate	None-Low	High	High
Zinc-iron electro alloy	Moderate	None-Low	High	High
ZINCROMETAL®	Low	None	High	Moderate
Zincrox	—	None	—	None

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Anodic electrocoats have long been known for their high metal dissolution and phosphate disruption,[2] but cathodic electrocoats also give interactions, particularly over zinc coated steels. One such interaction is the electrical discharge (rupture) over certain zinc alloy coated steels which results in craters, pinholes, and gassing. Another interaction is due to the high pH at the interface, which can cause partial dissolution of the phosphate pretreatment and, occasionally, the zinc layer on zinc coated steel. Both of these interactions can be controlled and some phosphate dissolution appears to be beneficial, so they should not be problems as such. However, it is important to understand them.

PINHOLING/CRATERING

Description of the Phenomenon

Pinholes and craters have been noted in cathodic electrodeposition primers deposited over zinc coated steels at high voltages for many years.[3-16] The lower half of *Figure* 1 illustrates the defects which are composed of small pits or pinholes and larger volcano-like craters. They result in holes or thin spots in the coating and are undesirable because of their possible deleterious effect on both appearance and corrosion resistance. Electrical discharge and gassing during deposition have been suggested as causes,[4,6-8,11-16] but only recently has it been shown definitely that electrical discharge is the cause of the defects and that for cationic electrodeposition (E.D.) coatings, electrical discharge and the phenomenon known as rupture are one and the same.[12]

Within the voltage range normally used for electrodeposition, only zinc-iron and zinc-nickel alloy coated steels have shown pinholing and cratering when electrocoated, although at very high voltages or with excessive ac ripple (a wavy dc signal with high voltage peaks), virtually any substrate could suffer the defect. Most observers believe that the presence or absence of a zinc phosphate pretreatment has no effect,[4,6,8] but there have been results to the contrary.[17]

In the field, most pinholing/cratering defects have been associated with high levels of ac ripple, but improved rectifiers and capacitor/choke combinations have made this cause virtually disappear. Electrochemical pinholing/cratering now is more apt to occur because of inadvertent use of zinc alloy steel instead of straight galvanized or because of steel (iron) contamination of the zinc layer. Electrodeposition systems designed for zinc alloy steels (three minutes or longer immersion, relatively low voltage) are in commercial operation in many parts of the world and almost never have problems.

Experimental

Depositions were carried out on 2.5 × 7.5 cm coupons with a minicoater based on a modified one liter corrosion test cell and a high voltage, regulated (low ripple) power supply. The experimental details have been described elsewhere,[8] but the usual characterization technique is to determine the voltage at which the pinholing/cratering begins for a given substrate with a given electrodeposition paint. This is called the threshold voltage and can be used as an index of pinholing/cratering resistance or tendency. It can be determined at different temperatures, with different E.D. primers, etc. It should be noted that the geometry of our lab bath differs considerably from that of E.D. baths in automobile or appliance factories in terms of anode-cathode distances and ratios. Experience has taught us that our threshold voltages for pinholing/cratering are roughly 100 V lower than would be seen in a commercial bath.

Conventional electrodeposition coatings have a higher tendency to pinhole/crater than do high build coatings. This is shown in *Table* 1 which compares cratering tendencies at two voltages for conventional and high build coatings over several substrates.

Most of our work was done with high build coatings because of their superior pinhole/crater resistance and the fact that they are superseding conventional electrodeposition primers in most applications. Pinholing/cratering threshold voltages for high build coatings at two different temperatures over a variety of substrates are shown in *Table* 2. The wide threshold ranges for many of the substrates reflect the large number of specimens tested (often as part of solving other E.D. problems), batch differences and changes in the E.D. baths used, and batch and manufacturer variations in zinc coated steels. Results with a given E.D. bath are much more precise. Regard-

Table 2—Cratering Threshold Voltages for High Build Primer

Substrate	Two Minute Depositions 24°C (75°F)	Two Minute Depositions 30°C (86°F)
Cold-rolled steel	>340V	>340V
Zinc sheet	>340	>340
Hot-dipped galvanized	280-340	300->340
Electrogalvanized	290-340	310->340
Galvanneal Zn-Fe alloy (~ 85 Zn 15 Fe)	200-260	240-280
Zinc-iron electro alloy (~ 85 Zn 15 Fe)	220-260	240-280
Low iron electro alloy (~ 95 Zn 5 Fe)	200-230	—
Zinc-nickel alloy(s) (9-15% Ni)	210-340	250->340
Bilayer (Fe-Zn/Zn-Fe) alloy coating	340->340	>340
ZINCROMETAL (Zn-rich organic coating/chromate treatment)	240-260	310-320
Zincrox (multilayered Zn-Cr-CrO_x)	340->340	>340

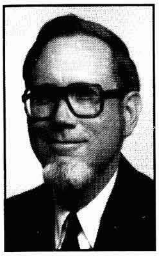
less of the data scatter in *Table* 2, it is clear that zinc-iron alloys have a greater tendency to give pinholing/cratering than do galvanized (zinc only) steels. Zinc-nickel alloys provide quite variable results (even for a given bath), but tend to be intermediate between zinc-iron and galvanized in pinholing/cratering tendency. Raising the bath temperature reduces the tendency to give the craters, although this may adversely affect other properties such as bath stability.

Later work in our laboratories[12] confirmed that electrical discharges do occur during cationic electrodeposition and are the cause of pinholing/cratering. This was shown in three different ways. The first, and the most dramatic, was direct visual observation (and video recording) of the sparks through a special transparent resin solution. The second involved the use of a computer as a recorder to detect discharge-produced electric current spikes over short (millisecond) time intervals. The third used acoustic emission to measure the growling, crackling, and sizzling noises produced by the discharges. [See reference (12) for details.]

All of the techniques showed that discharges were more intense and occurred at lower voltages over galvanneal zinc-iron alloy than over galvanized or cold-rolled steel. Interestingly enough, cold-rolled steel did give electrical discharges at high voltages (above ~330 V) or high current densities, but these rarely resulted in visible defects. They were accompanied by acoustic emission, but not current spikes. It appeared that a large number of less intense sparks occurred simultaneously. The differences between the electric current responses of substrates are shown in *Figure* 2 which clearly illustrates the spikes caused by the electrical discharges during deposition over galvanneal.

Discussion

It has been clearly shown that electrical discharges can occur during electrodeposition and that they are the cause of pinholing and cratering in cationic electrodeposition primers over galvanneal and other zinc-iron alloys. The sparks and defects can be reduced or prevented through the use of high build primers, lower voltages, higher bath temperatures, and suppression of ac ripple.[8,11] Although we know how to avoid electrical discharges or mitigate their effects, we still do not know their exact mechanism or cause or why they occur more readily over zinc-rion alloys than over zinc or steel.



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POSSIBLE SPARKING MECHANISMS: In our early work[8,11] we believed that sparking probably was due to dielectric breakdown in the irregular, semi-solid deposited paint, although we were aware that discharge occurs more readily in gases. Dielectric failure is possible. Assuming that it takes a field strength of 10^6 V/cm to cause dielectric breakdown[12,13,18] and that the voltage drop across the film is 350 V, then breakdown could occur if the film was 3.5 μm or less in thickness. Considering the very irregular and highly fissured nature of the deposition and that sparking begins early in the film growth process, such a film thickness is entirely possible. This thickness dependence also would fit with the observation that higher build coatings give higher pinhole/cratering threshold voltages.[8,11] However, other than the fact that the defects

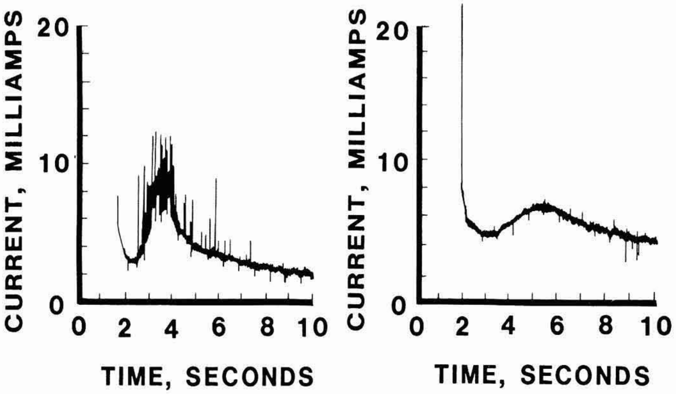

Figure 2—Current-time plots for depositions over galvanneal (left) and cold-rolled steel (right) at 290 V[12]

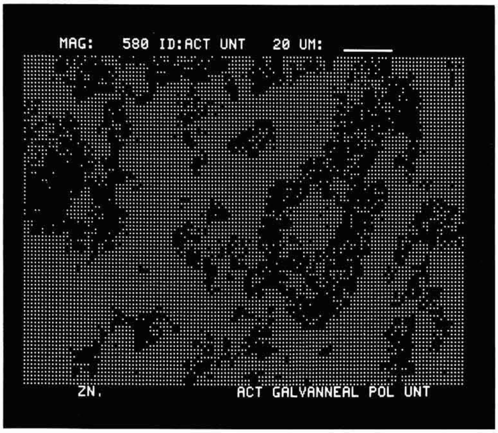

Figure 3—Energy-dispersive x-ray zinc map (580 × magnification) of the surface of a specimen of galvanneal zinc-iron alloy. The white spots indicate the preponderance of zinc, the dark areas show iron-rich regions

resemble those produced in unbaked films with a high voltage spark generator (Tesla coil), we have no proof for such a mechanism.

Several investigators[13,15,16,19] have postulated that the sparks occur in hydrogen gas bubbles trapped in the deposited film and Doroszkowski[13] gives calculations to show that the minimum voltage for onset of sparking in hydrogen is in the region of voltages used for cationic electrodeposition. These calculations assume bubbles roughly as large as the coating is thick. We have rarely observed such large bubbles in films, although we have seen and reported large balloon-like bubbles on the surfaces of films over zinc-iron alloys[8,11] (see upper part of *Figure* 1). In observing depositions with a video camera,[12] we have seen a number of coatings that contain few bubbles, yet give many sparks. Most bubbles appear during and after the sparking, not before. Electrical discharge in bubbles may be a reasonable mechanism in situations where large numbers of bubbles are produced, such as in depositions over zinc-iron alloys, but seem less likely over zinc or cold-rolled steel where there are very few bubbles, but sparking still can occur.

One thing that is attractive about the discharge in hydrogen theory is that it fits in with the fact that rupture voltage is dependent on the cathode material. It turns out that the critical voltage for discharge in gases also is related to the electrode material via the electron work function,[13] a parameter usually associated with photoelectron emission. Rupture voltage has been shown to be dependent on the electron work function of the cathode.[13,15]

Electrical discharge may well be occurring in hydrogen gas, but the gas does not have to be in the form of bubbles trapped in the film. When we have observed the deposition process with a video camera and 40 × lens, we have noted that, after the initial deposition and before sparking begins, there is a change in appearance as if the film has been lifted slightly, perhaps by the formation of a layer of hydrogen gas beneath it. Such a layer undoubtedly would be thinner than the coating or any bubbles in it, thereby giving a higher tendency to spark at a given voltage. A gaseous layer would act as an insulator causing a large electrical charge to build up, whereas the relatively conductive film surrounding any gas bubbles would keep such a charge build-up to a minimum. Finally, a continuous layer of hydrogen would allow discharge at any and every point of high field strength or high conductivity on the substrate, rather than being restricted to bubble sites in the coating.

Some investigators[6,9] believe that there is a relationship between substrate surface nonuniformity and the tendency for the electrodeposited coating to pinhole and crater. For example, zinc-iron alloy coatings consist of a number of different alloy phases and these phases have different conductivities. The idea is that high conductivity regions are the hot spots, the lightning rods, that give electrical discharge. Using energy-dispersive x-ray, we have seen considerable evidence for elemental nonuniformity on galvanneal surfaces with most areas rich in zinc, but others rich in iron (see *Figure* 3). However, one of the worst zinc-iron alloys we have seen for pinholing and cratering was a 95:5 ZnFe electroalloy that was very uniform, both in appearance (even at high magnification) and elementally. In addition, Hart and Townsend[4] pointed out that pinholing/cratering threshold voltages vary for pure metals (e.g., Zn and Mg are low compared to Fe and Al) and that the threshold should be considered as an inherent material property. Nonuniformity may be a contributing factor in electrical discharge, but it is not the main cause.

If nonuniformity is not the reason why zinc-iron alloys are worse for pinholing/cratering than either zinc or steel, then what is? Morita and co-workers[16] postulated that iron acts as a catalyst for more rapid dissolution of zinc and formation of hydrogen during electrodeposition:

$$\text{Anode Reaction} \quad Zn + 4OH^- \rightarrow Zn(OH)_4^{2-} + 2e^-$$

$$\text{Cathode Reaction} \quad 2H_2O + 2e^- \rightarrow 2OH^- + H_2 \uparrow$$

The hydrogen causes bubbles and voids and provides a medium in which electrical discharge can occur. They showed that the amount of zinc dissolution (actually, zinc pickup by the electrodeposition paint film) correlated very well with pinhole/crater density. Beyond ~50% iron, zinc dissolution and crater density dropped sharply, however.

ELECTRICAL DISCHARGE AND RUPTURE: It is well known that sparks can be produced over zinc-iron alloys, but they also can be made to occur over cold-rolled steel, zinc, and various pinhole/crater resisant zinc alloys such as GALVALUME® (55 Al 43.5 Zn 1.5 Si) and GALFAN® (95 Zn 5Al) by depositing at quite high voltages. Work done on cold-rolled steel[12] showed that sparks were of a shorter duration and of lesser intensity than with galvanneal, but the basic mechanism still was the same, even though the phenomenon over steel is more apt to be called rupture. This and other observations offer evidence for saying that rupture (gassing at high voltage) and the defect called pinholing/cratering really are the same

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GALVALUME is a registered tradename of BIEC International.
GALFAN is a registered tradename of International Lead Zinc Research Organization, Inc.

thing. Both give the same distinctive crackling and sizzling noises. Both give off hydrogen gas and, probably, water vapor bubbles. Both involve electrical discharge. For cationic electrodeposition coatings, rupture *is* electrical discharge.

SUBSTRATE DISSOLUTION

Introduction

The high pH of the coating-substrate interface was noted previously. This may seem strange as the pH of most cationic electrodeposition baths is 5-7, slightly acid to neutral. However, the process involves electrolysis of water at the cathode which produces a diffusion layer of OH^- ions. There is a substantial pH gradient between the bulk of the bath and the substrate. It is the high pH that destabilizes and precipitates the colloidal dispersion of micelles of resin, pigment, and additives that constitutes the paint. The critical pH for deposition is dependent on the coating formulation and the resin chemistry, but usually is around 12.

The pH at the interface is high enough to raise concerns about the possible dissolution of the phosphate pretreatment and the zinc substrate. Zinc and zinc compounds begin to show significant solubility around pH 12 and become quite soluble by pH 13.[20] Cold-rolled steel (CRS) is essentially inert in this pH range and the zinc-iron phosphate (Phosphophyllite) formed over it is more resistant to OH^- than the zinc phosphate (Hopeite) normally formed on galvanized steel. After cationic coating, the phosphate layer on CRS normally remains completely intact.[21]

The effect of 0.01N NaOH (pH 12) on pretreatments has been determined.[22] The rate of zinc dissolution was extremely low and rates for the zinc phosphates were not much higher. Only about one percent of the pretreatment dissolved in one hour. Since the substrate and pretreatment are only exposed for a short time during deposition, this would appear to mean that there would be almost no attack during that process. However, although the pH may be realistic for deposition, 0.01N NaOH is far from being representative of the materials at the E.D. bath-substrate interface. Therefore, it is difficult to make any conclusions from these results regarding dissolution rates during deposition.

Since cationic electrodeposition resins are solubilized amine salts, the effect of an amine on the pretreatment would seem to be a more realistic test. Work has been done in this area.[23] It turned out that triethanolamine adjusted to pH 12 was so aggressive that a lower pH test solution had to be used. Results from pH 11 triethanolamine dissolution experiments on zinc phosphates over electrogalvanized steel are summarized in *Figure* 4. The Zn-Mn-Ni phosphate was more resistant than either of the Zn-Ni phosphates, but all were quite soluble and lost considerably more weight than they would have in pH 11 (or 12) NaOH. However, if we consider that the exposure to maximum pH during deposition probably is not longer than the total immersion time (two to three minutes), then we can look at the data in a different light. The dissolution in two minutes is quite small ($\sim$ 1% for the Zn-Mn-Ni phosphate and $\sim$ 5% for the Zn-Ni phosphates).

The importance of these experiments is in establishing the alkali resistance of pretreatments. This property is important during deposition, but even more important if corrosion begins and alkaline corrosion products come in contact with the pretreatment. The results pointed to the probability of some dissolution of pretreatment by electrodeposition amino resins, but did not give any idea of how much. The literature indicated that some pretreatment dissolution was beneficial to overall coatings performance,[24] but that too much dissolution was damaging.[22] However, no one seemed to know how much pretreatment normally dissolved during deposition and how much dissolution was too much. Therefore, we began a series of experiments to determine the effect of the electrodeposition process on pretreatments and substrates.

Experimental

Outline of Methods: Depositions were carried out on 2.5 × 7.5 cm mini-panels in a one liter electrodeposition bath over a range of voltages and times. The coater and related equipment have been described elsewhere,[8] although our power supply now is an EC452 0-500 V device from E-C Apparatus Corporation (St. Petersburg, FL). The coupons (which weighed about 12 g) were weighed to five places, cleaned carefully with reagent grade tetrahydrofuran (THF) solvent, then weighed again. This second value was considered the starting weight of the specimen. The coupon was then placed in the coater, the power turned on (usually for two minutes) then off, and the coupon removed. The coating was rinsed with distilled water, then washed with THF while gently rubbing with a cotton swab. After drying, the

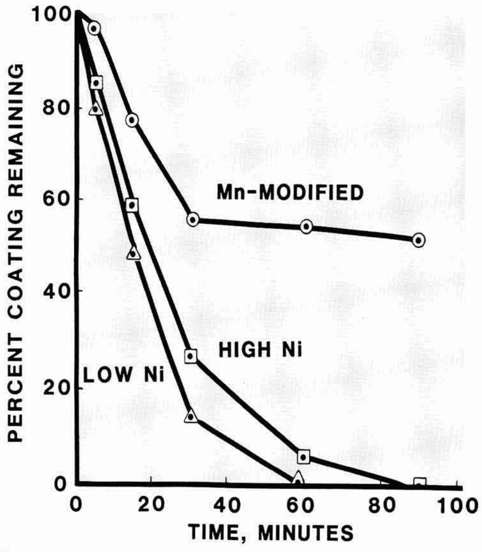

Figure 4—Alkali (10% triethanolamine solution, pH 11) solubility of zinc phosphate pretreatments over electrogalvanized steel[26]

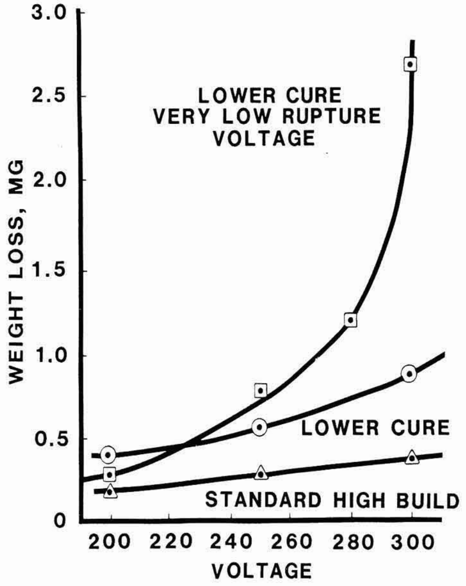

Figure 5—Weight loss during deposition versus deposition voltage for three different E.D. primers over European hot dipped galvanized coated with Zn-Mn-Ni phosphate. Two minute depositions at 30°C

coupon was weighed again to determine how much weight had been lost during deposition. Because the weight losses were small compared to the relatively heavy specimens, the experimental error was fairly large and the precision not as good as we would have liked. Therefore, weight losses were rounded off to the nearest 0.1 mg.

Because of the tedium and poor precision of this method, we recently changed to an x-ray fluorescence method to determine loss of phosphate. The intensity of a single x-ray line is used to determine the amount of phosphate present. Preliminary data indicate that the weighing and x-ray methods give similar results. All of the data reported in this paper come from weighing experiments, however.

MATERIALS: The paints used were high build amino-modified epoxy primers, both standard cure (180°C bake) and lower cure (~ 160°C bake). The substrates included electro- and hot dipped galvanized steels from the U.S. and Europe and cold-rolled steel. They were coated with a variety of zinc phosphate pretreatments, mainly multication types (Zn-Ni, Zn-Mn-Ni) and all received a chromium containing final rinse. The main body of work was done with a standard commercial U.S. automotive electrogalvanized steel pretreated with a series of PPG-Chemfil CHEMFOS® zinc phosphates under carefully controlled conditions and rinsed with a Cr (III) final rinse. These pretreatments were:

Pretreatment 1: Conventional Zn phosphate (high Zn, some Ni modification). This version contains fluoride.

Pretreatment 2: Zn-Ni phosphate (lower Zn, higher Ni than number one).

Pretreatment 3: Zn-Ni phosphate (low Zn, high Ni).

Pretreatment 4: Zn-Mn-Ni phosphate.

Results

Initial examination of the zinc phosphate pretreatments by scanning electron microscopy at 500-2000× before and after deposition (and dissolution) indicated that the crystals did not change in terms of appearance (except for a certain amount of cracking) or x-ray diffraction, but we have not yet determined whether there is any ion exchange as sometimes happens when corrosion products attack zinc phosphate.[25]

Table 3 shows some early weight loss results with standard cure and low cure high build primers over a variety of U.S. and European pretreated substrates. The total zinc phosphate on the areas of the mini-panels affected by the deposition was about 6 mg (~ 2 g/m^2) in each case, except for the 1½ side galvanized which averaged one-third that pretreatment weight. The zinc coated substrates showed little or no dissolution, but the pretreatments lost a fair amount of weight (3-20% for the standard cure; 7->50% for the low cure).

The first thing that was noted was that higher voltages gave greater dissolution. Also, whenever the threshold voltage for pinholing/cratering/rupture was approached or exceeded, the weight loss increased. This is not clear from the standard cure results but can be seen by comparing the two sets of data, since the lower cure E.D. primer gives pinholing/rupture thresholds 30-40 V lower than does the standard cure primer. The chemistries of the two coatings are somewhat different, so one could argue that there may be other things causing weight loss besides the pinholing/rupture process. However, a third primer bath, which differed from the second mainly in terms of a lower level of ultrafiltration and a greater amount of free amine,

Table 3—Pretreatment/Substrate Dissolution, Standard and Low Cure Primers [Two Minute Deposition at 30°C (86°F)]

	Wt. Loss in mg/Standard			Wt. Loss in mg/Low Cure		
Substrate	200V	250V	300V	200V	250V	300V
Nonphos. cold-rolled steel	0	0	0	—	—	—
Nonphos. hot-dipped galv.	0	0	0	0.2	0.4	0.4
Nonphos. electrogalvanized	0-0.1	0-0.1	0-0.2	0.1	0.1-0.2	0.2
Nonphos. 1 1/2 side galv.	0	0	0.1	0.2	0.2	0.2
European HDG with Zn-Ni phosphate	0.3	0.5	0.6	1.4	1.7	2.5
U.S. HDG with Zn-Ni phosphate	0.3	0.5	0.6	0.4	1.3	3.0
European HDG with Zn-Mn-Ni phosphate	0.3	0.3	0.4	0.4	0.6	0.9
U.S. EG with Zn-Ni phosphate ...	0.5	0.8	0.8	0.9	1.6	5.0
U.S. 1 1/2 side galv. with Zn-Ni phos. (only 2 mg of pretreatment) .	0.2	0.3	0.4	0.3	1.1	2.8

Table 4—Pretreatment/Substrate Dissolution High Build E.D. Primer, [Two Minute Depositions at 30°C (86°F)]

All Pretreatments With Cr (III) Rinses

Substrate		Weight Loss, Percent				Coating Wt.
		200V	250V	280V	300V	g/m²
Pretreatment 1	Immersion ..	13	13	20	30	1.2
Conventional	Spray	10	15	15	25	1.2
Pretreatment 2	Immersion ..	8	9	10	19	2.9
Zn-Ni	Spray	6	9	9	14	1.5
Pretreatment 3	Immersion ..	3	6	7	8	3.2
Zn-Ni	Spray	6	9	11	13	2.8
(low Zn, high Ni)						
Pretreatment 4	Immersion ..	1	0.5	1	3	3.2
Zn-Mn-Ni	Spray	0.5	0.5	1	3	2.8

pinholed/ruptured at even lower voltages and gave even higher weight losses. These differences can be seen very readily in *Figure* 5 which illustrates weight loss-voltage plots for a European hot dipped galvanized steel coated with a Zn-Mn-Ni phosphate on testing with the three E.D. primers.

Table 3 lists surprisingly high weight losses with the low cure primer—50% or more at 300 V in some cases. Examination of the coupons after deposition at this voltage showed that some of the zinc coating had been removed as well as much of the zinc phosphate pretreatment. At this voltage with this E.D. bath, the zinc coated substrates are well above their threshold voltages for pinholing/cratering (~ 260 V for EG and HDG, ~ 200 V for 1½ side galvanized). There is a definite connection between such rupture behavior and pretreatment/substrate dissolution. The exact mechanism is not known, but the electrical discharge itself, dissolution of the zinc coating underlying the pretreatment, and the increase in bath temperature with sparking undoubtedly contribute to dissolution and/or spalling.

Table 3 shows that the Zn-Mn-Ni phosphate resists dissolution better than conventional Zn-Ni phosphates. The trication phosphate is one strategy to build alkali resistance into a pretreatment. Another is a low zinc, high nickel phosphate which has been shown to be quite effective.[26] *Table* 4 lists percent weight losses of a series of phosphates over electrogalvanized steel at several voltages with a standard cure high build E.D. primer, but a different batch from that used in the earlier experiments.

Weight losses range from almost zero to about 30%, depending on the pretreatment and the voltage. Differences are not large, but the trends are clear, particularly when the data are plotted as in *Figure* 6 which shows percent weight loss versus voltage for the immersion pretreatments. Weight loss increases with voltage and Pretreatment 4, a Zn-Mn-Ni phosphate, is the most resistant to dissolution during deposition. It did not seem to matter whether the phosphate was immersion or spray. It must be pointed out that the difference in dissolution resistance between Pretreatment 3 (high Ni, low Zn) and Pretreatment 4 (Zn-Mn-Ni) is not reflected in scab corrosion cycle testing results where there is no significant difference.[26]

When weight loss is determined as a function of time, a curve such as that shown in *Figure* 7 normally results. In all cases, most or all of the weight loss occurs in the first 30 sec of deposition. This is not surprising as most of the paint has deposited by this time. Some of the hydroxyl ions are neutralized during deposition and others diffuse into the wet film. Presumably, the hydroxyl ion concentration at the paint-substrate/pretreatment interface drops, which causes the dissolution rate to decrease.

Considering the amount of zinc phosphate (and, sometimes, zinc) that dissolves during the electrodeposition process, what happens to the dissolved material? Some would be expected to be incorporated into the paint and, perhaps, some would be released into the bath. *Table* 5 gives results of atomic absorption measurements of the zinc concentrations in paint that was washed from the coupons. Similar measurements of E.D. baths before and after deposition showed no zinc pickup by the bath.

The total amount of zinc in each film was roughly proportional to the weight loss during deposition. More work needs to be done, but it appears that the dissolved pretreatment and any dissolved zinc substrate are incorporated into the paint film.

Discussion

Pretreatment dissolution does occur during deposition, but the exact effects on performance are not yet known. Another interaction, pinholing/rupture, does hurt appearance[3–16] and corrosion resistance,[5] but this is understandable because the defects are holes or thin spots in the primer. Pretreatment dissolution effects would be expected to be more subtle. We are working on a project to

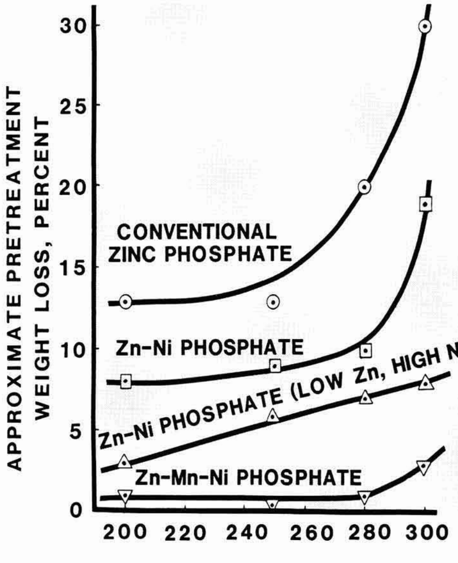

Figure 6—Percent weight loss during deposition versus deposition voltage for a series of immersion pretreatments. High build E.D. primer deposited for two minutes at 30°C over electrogalvanized steel

Table 5—Zinc Levels in Paint Recovered After Two Minute/30°C Depositions Over Pretreatment 2 (Zn-Ni Phosphate) Applied by Immersion

	Over Electrogalvanized			Over Hot-Dipped Galvanized		
Deposition Voltage	Wt. Loss mg	ppm Zn in Paint	Total Zn in Paint, μg	Wt. Loss mg	ppm Zn in Paint	Total Zn in Paint, μg
200	0.6	432	65	0.3	295	44
250	0.7	440	92	0.6	402	84
280	0.8	455	109	0.8	431	103
300	1.5	484	131	0.9	440	119

determine whether dissolution affects ac impedance behavior and resistance to salt spray or cyclic scab corrosion, but it is too early to make any conclusions. Certainly, field and automobile proving ground results do not show obvious corrosion differences between coatings with low and moderate dissolution tendencies. It appears that the total system is working well even though there is some dissolution of one of its components (pretreatment) and, possibly, a smaller amount of dissolution of another (zinc coated steel).

Cooke[24] has indicated that some dissolution is necessary in order for the E.D. primer to anchor through the pretreatment to the substrate beneath. On the other hand, Maeda and co-workers[22] tell us that for good wet adhesion (and subsequent corrosion resistance), the less dissolution the better. It appears that a small amount of dissolution is good and a lot is bad. More work needs to be done to determine the boundary between good and bad, however.

The dissolution of zinc phosphate over zinc coated steel by cathodic treatment is very similar to the effect of anodic electrodeposition on phosphate films over cold-rolled steel as described by Machu.[2] Percentage weight losses during anodic deposition were comparable (from 3-4% to 50% or more), all the anodically removed zinc was found in the paint film and removal of zinc phosphate occurred early in the deposition. Much of the loss of phosphate with anodic deposition was due to spalling. We have yet to see evidence of spalling with cathodic deposition, but suspect that it occurs under rupture conditions. Certainly, if electrical discharge is accompanied by zinc dissolution,[16] some of the weight loss could be explained by loss of adhesion of zinc phosphate due to dissolution of the zinc layer under it. Another effect of the anodic treatment was a substantial increase in the porosity of the zinc phosphate. Presumably, porosity increases with cathodic deposition, but it is not obvious, and we have not yet quantified any changes.

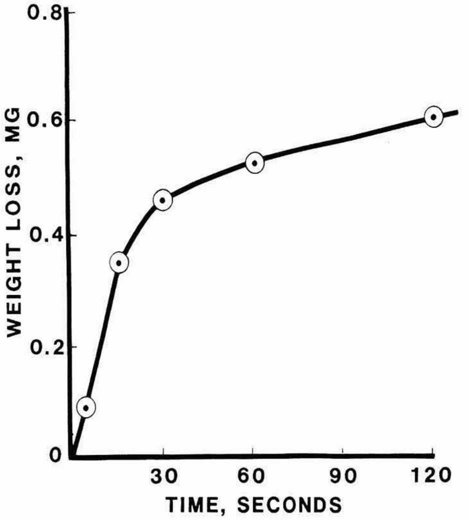

Figure 7—Typical weight loss pattern for a zinc phosphate pretreatment. This plot is for a high build E.D. primer deposited at 30°C over a conventional zinc phosphate on electrogalvanized steel

One very positive interaction between the E.D. bath and pretreatment is the modification of the zinc phosphate by the soluble lead in the E.D. coating. During the deposition process, Pb ions are incorporated into the phosphate crystals.[21,27] There are indications that $Pb(PO_4)_x$ and $ZnFePb(PO_4)_x$ are formed. The phosphate layer becomes more alkali resistant which limits the spread of corrosion and reduces the damage caused by it. Another positive effect would be the removal of the outermost layer of zinc phosphate if this has not already been done by a chromate rinse. There is evidence that over electrogalvanized steel the outer layer contains Fe_2O_3 and $FePO_4$ as well as zinc phosphate and is not conducive to good paint adhesion.[28] Removal of this layer by chromate rinsing improves wet adhesion and alkali resistance,[28] and the electrodeposition process would be expected to do much the same thing.

Although the Zn-Mn-Ni phosphates showed more dissolution resistance during deposition than did Zn-Ni phosphates, this research did not measure their alkali resistance or other properties under corrosion conditions. In scab corrosion cycle testing, high Ni, low Zn phosphates and Zn-Mn-Ni phosphates give equivalent results. Both are superior to conventional zinc phosphates.

The pretreatment layer is more at risk from alkali attack during corrosion than from attack during the deposition process. This is because the pH produced by corrosion products is higher (pH 12-14) and contact with hydroxide ions is much longer. Also, corrosion related attack occurs after the coating is in place and cured and all interfaces are set. The system is quite rigid. Damage to any of the interfaces can lead to delamination. Pretreatment and substrate dissolution during deposition occur while the system is in a state of flux. The coating is forming but is liquid to semi-solid and can bond through pores and interstices to the pretreatment and to the substrate itself even if these are changing and partially dissolving. Subsequent baking allows further relaxation and flow into holes, seams, and other gaps in the pretreatment.

The need for pretreatments with good alkali resistance is behind the movement toward zinc-nickel and zinc-manganese phosphates for galvanized and other zinc coated steels. It is virtually impossible to form alkali-resistant Phosphophyllite $[Zn_2Fe(PO_4)_2]$ on zinc surfaces, but it is possible to design pretreatment solutions that will give Phosphophyllite-like crystal structures using nickel[26] and/or manganese[29,30] along with the zinc. These "Phosphonicollite" and "Phosphomangallate" coatings definitely are more alkali resistant than is Hopeite [$Zn_3(PO_4)_2$] and appear to have considerable promise for improving adhesion and corrosion resistance of coatings over zinc coated steel.

CONCLUSIONS

During electrodeposition, a number of interactions can occur between a cationic coating and the pretreatment and substrate over which it is depositing. At high voltages and/or over zinc-iron and zinc-nickel alloy coated steels, electrical discharge can occur resulting in unsightly and durability-threatening defects. However, this normally is prevented by use of high build electrodeposition primers and careful control of applied voltage, ac ripple, and bath temperature.

Another interaction between the depositing coating and the pretreatment/substrate is dissolution of a portion of the pretreatment and, sometimes, the substrate itself. Depending on the specific zinc coated steel, electrodeposition paint, and pretreatment, dissolution in the laboratory can exceed 50% of the weight of the pretreatment. More normal losses are in the range of 1-20%. It is not yet known how these small scale laboratory results translate to weight losses on automobiles and appliances.

Pretreatment dissolution during cationic electrodeposition over zinc coated steels is greater than expected, but appears to be normal. It does not seem to cause coating failures or corrosion. It appears that a small amount of dissolution allows better anchoring of the coating to the pretreatment and zinc coated steel. Dissolution is greater at higher voltages and under rupture conditions. There is a definite connection between rupture behavior (electrical discharge) and pretreatment/substrate dissolution.

Zn-Mn-Ni phosphate pretreatments are more resistant to attack during electrodeposition than conventional phosphates (which usually have some nickel modification). This greater resistance is due to the lower alkali solubility of Zn-Mn-Ni phosphate.

The final conclusion, based both on the results and discussions previously stated and on ideas that can be drawn from them, is that it is not possible to treat the electrodeposition coating, phosphate, or zinc coated steel separately; each one affects the performance of the others and of the total composite. Only a total system approach will be successful in further improving the corrosion resistance of automobile, appliance, and industrial finishes.

ACKNOWLEDGMENTS

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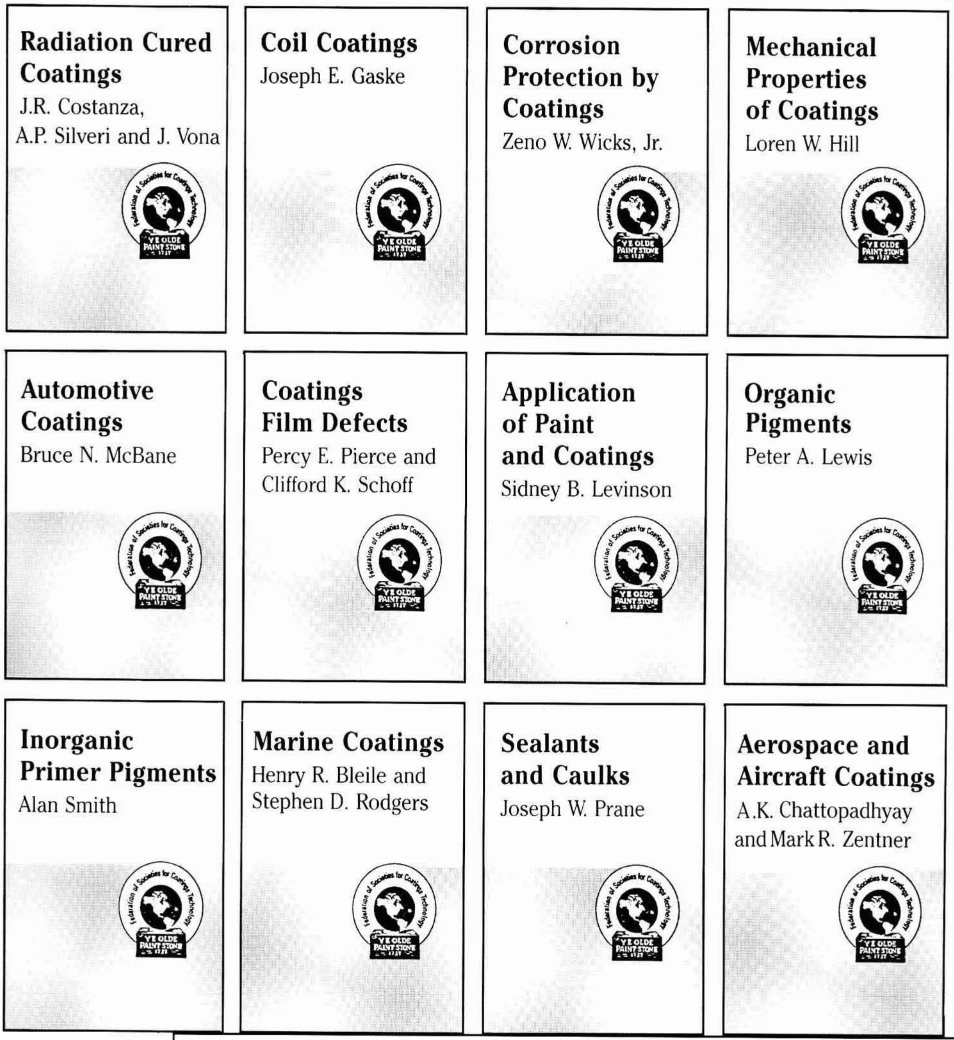

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A European Approach to UV Protection With a Novel Pigment

Robert F. Sharrock[*]
Hilton Davis Co.[†]

The numerous regulatory problems facing the coatings industry and the ever-changing needs of customers to meet the needs of end users have heightened the responsibilities of the coatings chemist, on whom the burden of finding innovative solutions has been placed.

Wood, particularly unprotected wood, is greatly affected by the environment. Protection from moisture and fungi alone is insufficient. Wood is also susceptible to degradation as a result of prolonged exposure to UV radiation; either from the sun's electromagnetic radiation in the UV region or the ultraviolet component of ordinary fluorescent lighting. With the diminished ozone layer, even more UV radiation from the sun is projected to reach the earth in the years ahead.

Through the action of light, the lignin in wood is decomposed on the surface, which leads to the destruction of the cell structure; thus, greatly increasing the uptake of water, which in turn leads to cracking and other damage.

Traditional UV absorbers have served the industry well over the years, but resin technologies, more demanding coatings requirements, and the ever-increasing use of water-borne and high-solids coatings have pushed them to the limit.

This paper discusses a European solution to UV protection in water-borne, as well as, traditional solvent based coatings, and suggests the use of a novel pigment that provides UV protection. Because of its inorganic nature, this pigment is judged to be superior in many respects to traditional organic compounds. The evaluation of several UV absorbers, their properties, and performance characteristics in thin films will be described in some detail. Typical European formulas and raw materials are provided.

INTRODUCTION

The world market for translucent decorative wood (decorative water repellant stains) protection is growing at a faster rate than paint and decorative products in general. There is hardly a country in Western Europe where these products are not used. In many, demand has risen to the point where local production is evident. Even the Japanese, who have used wood in their houses for centuries, are discarding their own traditional products for license. Because the Scadinavian countries use so much wood for external cladding, windows, doors, and structures, it is not surprising that they have invested heavily in the research and development necessary to gain world leadership in wood protection.[1]

What is so special about the Scandinavian approach to the problem? They employ special iron oxide pigment particles which reflect destructive ultraviolet radiation away from the wood to prevent discoloration and other damage.

WOOD PROTECTION: THE BARE FACTS

The unique beauty of natural wood provides a special value in construction use, and its one-of-a-kind grains and textures make it a favorite for home and commercial building designs. But, once the bark is off, it urgently needs a new form of protection.

Wood, particularly unprotected wood, is greatly affected by the environment. Protection from moisture and

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fungi alone is insufficient. Wood is also susceptible to degradation as a result of prolonged exposure to UV radiation,[2] either from the sun's electromagnetic radiation in the UV region or the ultraviolet component of ordinary fluorescent lighting. Unprotected wood will begin to turn yellow or gray.

UV light can penetrate the wood surface up to about 75 µm,[3] and through the action of light, the lignin in wood is decomposed on the surface, which leads to the destruction of the cell structure; thus, greatly increasing the uptake of water which in turn leads to cracking and other damage. With the diminished ozone layer, even more UV from the sun is projected to reach the earth in the years ahead.

In addition, many of the microbiocides used in the formulation of wood-protective coatings are adversely affected by UV light.[4,5] Short wavelength UV light (radiation below 400 nm) has long been recognized as being responsible for most of this damage.[6]

The International Commission on Illumination (CIE) further subdivides the UV portion of the spectrum into UV-A, UV-B, and UV-C, as shown in *Figure* 1.[7] The effects of the various UV wavelength regions can be summarized as shown in *Table* 1.[8]

Table 1—Wavelength Regions of the UV

UV-A 400 to 315 nm	Causes polymer damage.
UV-B 315 to 280 nm	Includes the shortest wavelengths found at the earth's surface; responsible for severe polymer damage; absorbed by window glass.
UV-C 280 to 100 nm	Found only in outer space; filtered out by earth's atmosphere; germicidal.

EXPERIMENTAL TECHNIQUES

Water reducible and solvent based stains were prepared with varying amounts of commercial grade opaque and transparent iron oxide pigment dispersions, as well as a wide variety of UV absorbing agents (at 2.0%)* (Appendixes I-III).

UV absorption tests were carried out on clear, transparent mylar film (5.1 mils) coated with various stains at 15 µm, 25 µm, 50 µm, 75 µm, and 100 µm (1 µm = 0.039 mils) dry film thicknesses. Dry film thickness was measured by micrometer caliper. For exposure tests, sprucewood, cedar, and pine specimens were coated (No. 28 wire rod) at varying dry film thicknesses. Several coats were applied to achieve 75-80 µm (≃ 3.0 mils) dry film coatings.

The measurements were made independently of one another using a Perkin Elmer Model 323, UV/VIS-NIR Recording-Spectrophotometer in the 210-700 nm wavelength range. The transmission was taken relative to air at 100%. The scale used was the 0-100%, with a photometric transmittance accuracy ± 0.5% of full scale.

Similar techniques employ a Zeiss PMQ2 and a Lambda 3 UV/VIS Spectrophotometer.

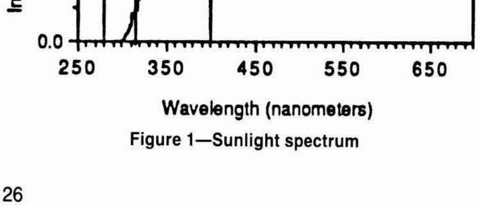

Figure 1—Sunlight spectrum

EFFECTIVE PROTECTION

Wood surfaces can be stabilized against degradation using a variety of techniques.[9] With opaque (covering) paint systems this is not a major problem, and providing UV stabilization via pigmentation is common practice.[10] Certain pigments, such as carbon black and zinc oxide, which are widely used for the coloring of plastics and coatings, also can act as UV stabilizers. Recommended use levels, however, result in opaque systems. With stains or even transparent paints, the position is different. In this case, the UV light can usually pass through the paint without restriction, or in the case of light stains, is only slightly restricted, unless the paint contains enough UV absorbing additives.

With the trend towards transparent wood-protective paints and a clear understanding of the problem, European laboratory technicians set about producing wood protection products which contained sufficient pigment to reduce the damaging effects of UV light while still enabling the wood grain to be seen.

In stain paints, they mainly use transparent iron oxide pigments which when properly formulated ensure adequate UV protection, while maintaining transparency.[11,12]

TRANSPARENT SYNTHETIC IRON OXIDES

Transparent synthetic iron oxide pigments[10] are hydrated ferric oxides of the general formula:

$$Fe_2O_3 \times H_2O$$

They are available as red, orange, and yellow from which a myriad of stain shades are achievable. (Appendix I).

Transparent synthetic iron oxides are employed in stains, offering: transparency of a dye; permanency to

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*Aqueous wood stain: pure acrylate emulsion (approximately 35% solids) Mowilith® DM772 (Farbwerke Hoechst AG, Frankfurt, Germany).

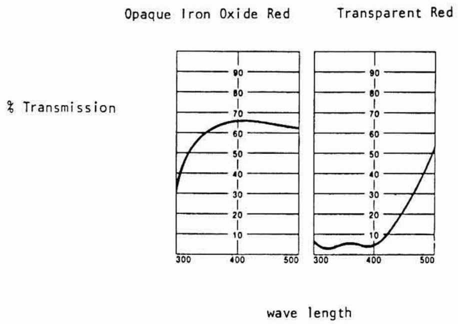

Figure 2—Percent transmission (reference air)

light; durability; chemical resistance; UV screening properties; and economy. Transparent iron oxides are unique iron oxide pigments offering complete transparency plus the outstanding permanency to light attributed to regular iron oxides. Although they are inorganic pigments from a synthesis point of view, they differ from traditional opaque iron oxides. They have extremely small particle size 0.01μ vs 0.15μ, have an acicular particle shape, differ in UV transmission (*Figure* 2), and allow the natural grain of the wood to show even after recoating, unlike opaque oxides.[13]

CONCENTRATION LEVELS/FILM THICKNESS

The UV screening efficiency of transparent iron oxide pigments is a function of concentration and film thickness. *Figures* 3-6 represent a series of transmission curves for varying concentrations of the three colors red, yellow, and orange.*

For applications where lightness is important, the curves show that the transparent yellow oxide can be used to an advantage, although a higher concentration is required.[14]

---

*Transmission curves were prepared using a Perkin-Elmer Model 323, UV-VIS-NIR Recording Spectrophotometer in the 210-360 nm wavelength range. The sample transmission was taken relative to air as 100%. Scale was 0-100%, with a photometric transmittance accuracy ±0.5% of full scale.

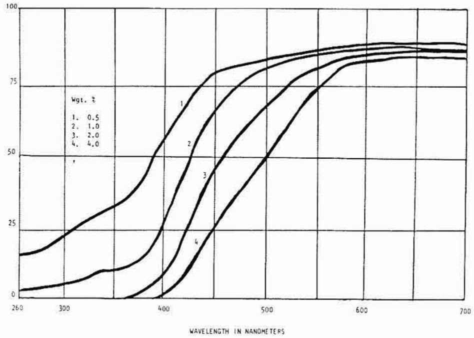

Figure 3—Percent transmission of transparent yellow iron oxide at various concentration levels (1.6 mils film thickness)

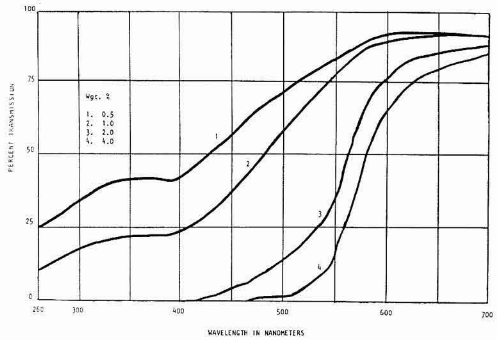

Figure 4—Percent transmission of transparent red iron oxide at various concentration levels (1.6 mils film thickness)

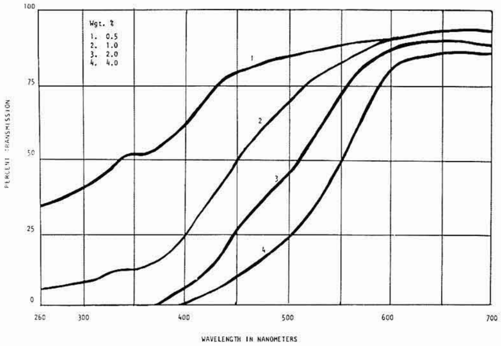

Figure 5—Percent transmission of transparent orange iron oxide at various concentration levels (1.6 mils film thickness)

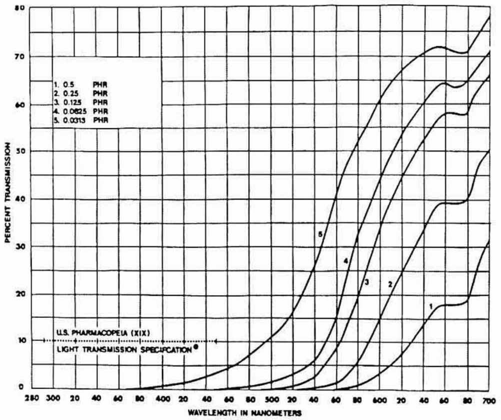

Figure 6—Percent transmission with varying levels of transparent red iron oxide. PRH: part per hundred (100% solids resin) (thick film over 20 mils)

Table 2—UV Transmission of a Wood Stain Based on 2.0% Transparent Iron Oxide

Film Thickness	UV Region UV-C	 UV-B	 UV-A
15 µm	4%	30%	41%
25 µm	2%	12%	30%
50 µm	0%	0%	0%
75 µm	0%	0%	0%

Transparent iron oxides effectively screen out harmful UV light in coatings with a pigmentation of $2g/m^2$. For $100g/m^2$ of applied coating, this means 2.0% (weight basis) solid pigment.[11] This need not be obtained with one coat, but can also be produced by applying several coats (50µm-75M), as shown in *Table* 2.

EFFECT OF PARTICLE SIZE

As with most pigments, the efficiency of UV screening and transparency, as related to film clarity, is most dependent on the dispersion of the pigment within the coating system. In using traditional transparent iron oxides, such as those incorporated in auto metallic finishes which agglomerate during their preparation, loss of efficiency and transparency may occur because it is not possible to grind the pigment to its ultimate degree of fineness. In fact, an auto finishes manufacturer will ball mill for 72 hr to obtain a satisfactory dispersion.

To facilitate the use of difficult-to-grind transparent synthetic iron oxides in coatings and stains, special preparations are available based on discrete pigment particle technology. This technology is based on the fact that the particle size of the pigment is determined in the striking tub when the color is first made, and represents a process to make the original fine (discrete) pigment particle available to the user.

In Europe, to achieve adequate UV absorption when special transparent iron oxide preparations (flushing pastes and liquids) are used, up to about two grams of pure pigment are applied with the stain per square meter of the whole painted surface. With three coats, as is often required for outside work, this requirement can be met with some 6.0% pigment paste in the finished paint, but often can be higher depending on the depth of color desired. These concentrations should be considered approximations since pigment preparations (dispersions) and wood stains will vary in percent solids, pigment volume concentrations, type of resin, binder concentration, type of resin in the system, and other factors. The special iron oxide paste or liquid preparations are easy to handle and do not settle out in the finished wood stain anywhere as much as powdered transparent pigments. Even in thin-film wood stains (penetrating type) they are easier to stir.[11]

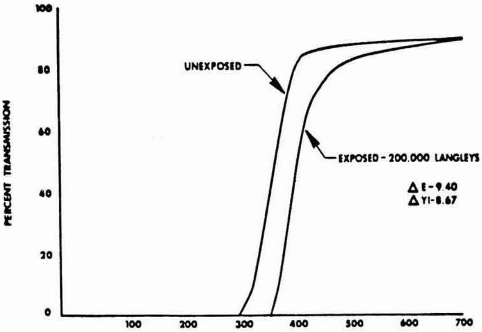

Figure 7—Percent transmission of transparent control blank after prolonged exposure

ROBERT F. SHARROCK currently is Technical Manager, Coatings and Plastics Industries, for the Hilton Davis Co. He has held both R&D and marketing functions in the coatings industry for 25 years.

He was graduated from Saint Peter's College in New Jersey with the B.S. Degree in Chemistry and received his M.B.A. in Marketing from Xavier University in Cincinnati, OH. Mr. Sharrock is an active member of the Federation of Societies for Coatings Technology (CDIC Society), the Society of Plastics Engineers, and serves on the Suppliers Committee of the National Paint and Coatings Association. He has co-authored patents and technical publications, mainly in the field of color and dispersions.

COMPARISON TO UV ABSORBING SUBSTANCES

Traditional UV absorbers have served the industry well over the years, but resin technologies, more demanding coating requirements, and the ever-increasing use of high-solids and water-borne coatings have pushed them to the limit.

On a worldwide basis, we are seeing an increase in environmental awareness which has increased the demand for water-thinnable wood stains, especially emulsion-based ones (Appendixes I-III).[11] *

In Europe, the UV absorbers which were used were those whose effectiveness in aqueous systems was in dispute for various reasons, for example, poor dispersability. Products in emulsion form have now been developed and it is easier to incorporate these into aqueous systems.

Table 3 shows comparative test results in each of the UV regions of a range of UV absorbing agents, including benzophenone derivatives, benzo triazole derivatives (solvent soluble and emulsion types), and transparent iron oxide. UV absorbers added in solvent-dissolved form to the aqueous stains generally were inferior. This is attributed to the fact that the substances could not be finely precipitated sufficiently in the stain. The wood stain pigmented with the transparent iron oxide shows better UV

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*Ibid.

Table 3—Percent Transmission of Various UV Absorbing Substances at 2.0% (Dry Film Thickness 75 μm) Water-Borne Coating

Substance	UV Region		
	UV-C	UV-B	UV-A
Benzotriazole derivative (solvent soluble)	18%	45%	45%
Benzotriazole derivative	8%	35%	35%
Benzophenone derivative	4%	20%	20%
Transparent iron oxide	0%	0%	0%

absorption (less transmission) than the UV absorbing substances. Wagner has reported[15] that UV absorbing substances did not achieve more than 95% absorption—even for dry film thicknesses of 100 μm, while transparent iron oxides attained 100% absorption—even at thicknesses of only 50 μm.

PROLONGED UV STABILITY

Prolonged UV stabilization is afforded by the transparent iron oxide pigments. *Figure* 7 shows the effect of prolonged exposure (200,000 Langleys)* to direct accelerated sunlight and water on the equitorial mount with mirrors for acceleration plus a water spray test (EMMAQUA)† machine to an unprotected transparent control sample. A progressive loss in percent transmission is evident as degradation proceeds. The degradation is manifested by a significant color change while the transparent iron oxide pigments provide prolonged protection (*Figure* 8).

Colored wood stains** pigmented with transparent iron oxide have been found[15] completely perfect after two years, while benzophenone derivatives and stains combined with phenolic resins had perfect films up to 18 months. After this period, the first damage from exposure became evident. Benzotriazole derivatives resulted in damage to the wood at an earlier stage and the resistance to weathering was not generally as good.

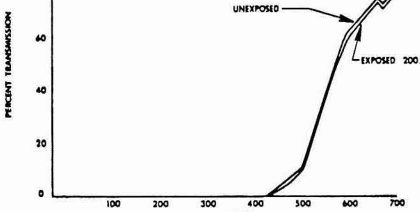

Figure 8—Percent transmission of transparent control pigmented with transparent red iron oxide after prolonged exposure

CONCLUSION

It has been demonstrated that the synthetic transparent iron oxides, which offer the transparency of a dye and the permanency to light attributed to regular iron oxides, effectively screen out harmful UV light at concentrations low enough (2.0% at 50 μm dry film thickness) to maintain transparency in wood coatings. They differ from opaque iron oxides in UV transmission and allow the natural grain of the wood to show even after recoating, unlike opaque oxides.

When compared to typical UV absorbers (at equal concentration), the transparent iron oxides provide superior UV absorption, especially in thin films.

For applications where lightfastness (color in the visible range) is important, transparent yellow iron oxide can be used to an advantage, although a higher concentration is required.

Coating chemists can now draw on the experience of our international colleagues and benefit from the use of transparent iron oxides as economical alternatives or adjuncts to traditional UV absorbers in transparent and semi-transparent stains, adding both protection, glamor, and warmth to the natural beauty of wood.

ACKNOWLEDGMENTS

The author would like to thank Charles R. Lubbers and Kenneth L. Becker for their assistance in sample preparation, obtaining data, and developing test procedures.

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*100,000 Langleys equals eight months outdoor sun hours.

†EMMAQUA test stands which intensify the solar radiation eight times at Desert Sunshine Exposure Tests, Inc., Phoenix, AZ.

**Ibid.

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* * *

APPENDIX I

Solvent Based Alkyd Stain

Item	Parts by Wt.
Transparent yellow oxide flush	3.34
Transparent red oxide flush	2.78
Flushed lampblack	0.83
Synoloc 34	6.90
Synoloc 77W	35.60
Super gelkyd 391W	11.90
Aerosil TS 100	2.60
LANCO wax PP1362D	1.80
Paraffin wax (110-115 Grad F)	0.20
Preventol CMK	1.00
Pineol	1.00
Ca-Octoate	0.40
Pb-Octoate	1.14
Co-Octoate	0.23
Ethyl Glycol	2.00
Methyl-ethyl-ketoxim	0.13
White spirit	28.15
	100.00

APPENDIX II

Aqueous Wood Stain (≃ 30% Solids)

Item	Parts by Wt.
6C-11-B123 Super Seatone® Trans-Oxide® Red	106
Syloid® 244 (amorphous silica matting agent)	12
Water	240
Ammonia 25% solution	3
Densil® P (bactericide & fungicide)	16
Troykyd® LLBA (thickening agent)	18
Plex® 4889 D (acrylic)	566
Lusolvan® FBH (film coalescing agent)	11
Propylene glycol	28
	1000

International Suppliers

Syloid	W. R. Grace Ltd.
Densil	ICI
Troykyd	Laport Industries
Lusolvan	BASF United Kingdom Ltd.
Trans-Oxide	Hilton Davis Co. (USA); PMC Specialties Group, International Division, London, England
Plex	Rohm GmbH

APPENDIX III

Water Reducible Linseed Oil Polymer Stain

Item	Parts by Wt.
Kelsol 3937-WG4-45®	420.00
Butoxy Ethanol	12.50
Aerosol OT-75®	2.25
Intercide T-O®	4.90
Polyphase AF-1®	7.30
Ethylene Glycol Propyl Ether (EP)	18.00
Manganese Hydrocure II®	6.90
Byk 020®	1.40
Michemlube 743®	33.00
Syloid 234®	20.00
Byk 301	1.40
Ammonia	1.75
Water	316.00
	845.40

Stain Base Physical Data

pH:	8.2-8%
Viscosity:	75-80 Ku
Solids:	26.0% (wt)

Kelsol is a registered tradename of Spencer Kellogg (Reichhold).
Aerosol is a registered tradename of American Cyanamid Company.
Intercide is a registered tradename of Interstab Chemicals.
Polyphase is a registered tradename of Troy Chemical Corporation.
Manganese Hydrocure is a registered tradename of Mooney Chemicals.
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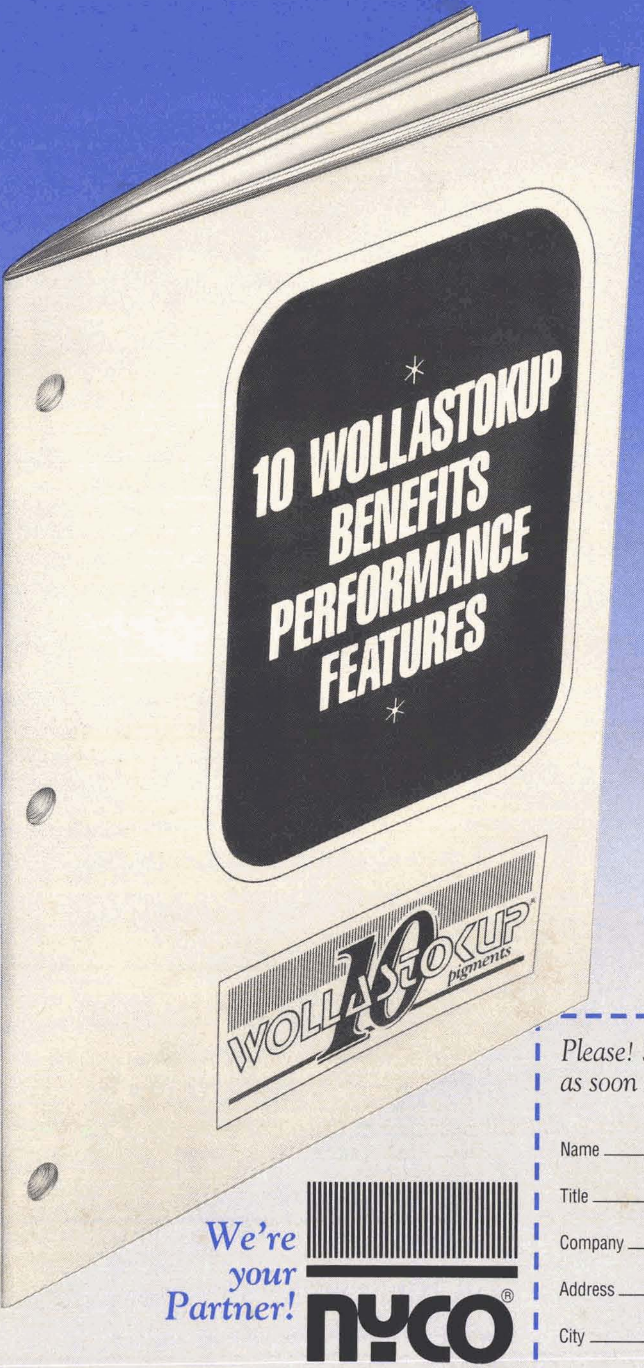

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1989 CONSTITUENT SOCIETY PAPER

Performance Comparison of Exterior Finishes On Hardboard Siding

William Bailey, Steve Bussjaeger, Nick F. Dispensa, Gregg Early, Mark Froese,
Roger Haines, Al Moser, Lawrence J. Murphy, and Marlon A. Trigg*
Kansas City Society for Coatings Technology
Technical Committee

A 40-month exposure study on the performance of exterior flat and satin coatings on various medium density hardboard siding substrates has demonstrated a significant improvement in both substrate protection and coating performance with two- and three-coat systems versus a single topcoat application.

Individual coating and substrate tests were also run to predict potential exposure failure. Coatings tested utilized poor to good wet adhesion emulsion and oil/alkyd resin topcoats in combination with oil/alkyd and latex primers. Coating systems were evaluated over 18 unprimed and factory preprimed hardboard substrates of varying density, swell, and moisture absorption tendencies.

Best overall performance was obtained over oil/alkyd primed substrates with all acrylic or acrylic terpolymer topcoats. The poorest performance was obtained where a single coat of topcoat was utilized without a field applied primer.

INTRODUCTION

Hardboard is a generic term for a panel manufactured primarily from interfelted ligno-cellulose fibers consolidated under heat and pressure in a hot press to a density of at least 31 lbs per cubic ft (0.50 g per cubic cm). Other materials may be added during manufacture to improve certain properties, such as stiffness, hardness, finishing properties, and resistance to abrasion and moisture, as well as to increase strength, durability, and utility.[1] Hardboard is used in a variety of exterior and interior applications and has become a major factor in markets that were predominantly held by plywood or lumber.

There are two basic manufacturing processes for hardboard siding, and a third process combines certain aspects of the other two. These are wet, dry, and wet-dry processes. In all of these, the manufacturing process is similar in nature and produces a product with some advantages and limitations when compared to solid wood. Hardboard is less prone to grain raising, splitting, cracking, and warping. However, its dimensional stability in some directions is not as good as in solid wood.[2]

Exterior hardboard is primarily available in 4 ft (1.2 m) width panel or 16 ft (4.9 m) length lap siding. Panel or lap siding that is to be finished by the consumer can generally be found in one of the three following categories: (1) smooth/preprimed—no texture with a factory applied primer (*Figure* 1); (2) textured/unprimed—an embossed surface with no factory applied primer. Texture comes in a variety of styles. Only a small percentage of hardboard is used in this form in the commercial market; and (3) textured/preprimed—an embossed surface with a factory applied primer.

This study is a continuation of the previous work done in 1984 by the Kansas City Society for Coatings Technology.[3] It expands upon the types of coatings and coating systems used. A more in-depth look was taken at the physical properties of the individual coating and substrate and how they relate to actual coating performance on exterior exposure.

MATERIALS AND METHODS

Substrates

The hardboard panels in this study were obtained through the American Hardboard Association, the national trade organization representing manufacturers of hardboard siding. Manufacturers were asked to supply medi-

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Presented by Mr. Bussjaeger at the 67th Annual Meeting of the Federation of Societies for Coatings Technology, in New Orleans, LA, on November 9, 1989.

*Mr. Trigg is a member of the Pacific Northwest Society.

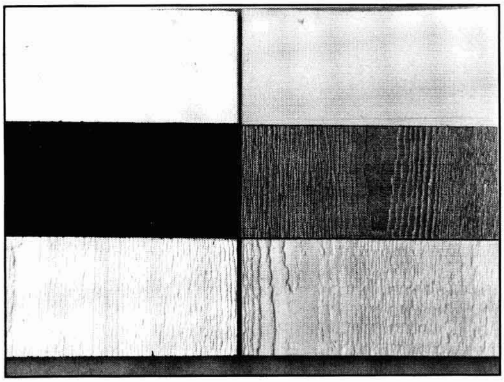

Figure 1—Typical hardboard panels. Top two panels—smooth preprimed; middle two panels—textured unprimed; and bottom two panels—textured preprimed

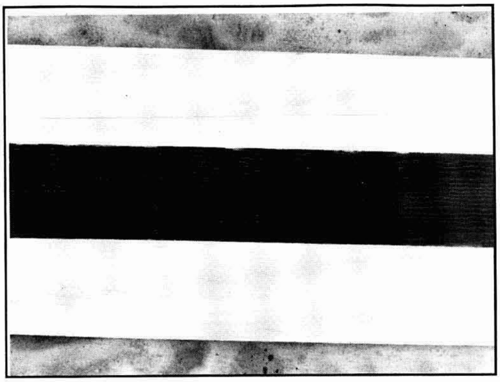

Figure 2—Unprimed textured hardboard D-2 with "field applied" primer. Top one-third—oil/alkyd primer; middle one-third—no primer; and bottom one-third—latex primer

um-density hardboard, 1 ft × 2 ft (30.5 cm × 61 cm) sections, in each of the following categories: smooth/preprimed, textured/unprimed, and textured/preprimed. Six hardboard manufacturers supplied products in each category.

Each of the manufacturers was arbitrarily assigned an alphabetic code. A-F, and each board type was designated numerically as follows: 1 = smooth/preprimed; 2 = textured/unprimed; and 3 = textured/preprimed. The boards were identified only by this alphabetic/numeric designation throughout the evaluation (i.e., A-1, D-3, F-2, etc.). A total of 108 boards were used in the exposure study.

Primers

Two primers were utilized in the exposure testing. Physical properties of these primers are listed in *Table* 1. One was an oil/alkyd (20% TT-L-215/80% TT-R-266 Type I, Class A) solvent based primer[4] and the other a latex (acrylic emulsion[5] with alkyd modification) primer.

Each hardboard panel was primed in the same manner as exhibited in *Figure* 2. The top 4 in. (10 cm) of the panel were coated lengthwise with the oil/alkyd primer. The bottom 4 in. (10 cm) were coated with the latex primer. The middle 4-in. (10 cm) section received no "field applied" primer. Each primer was spray applied at a rate of 400 sq ft per gal (10 sq m per L). No panels were used that exhibited any obvious surface damage such as scars, gouges, etc.

Dry film thicknesses ranged from 1.9 to 2.1 mils (47 to 53 microns) for the oil/alkyd primer and 1.5 to 1.7 mils (37 to 43 microns) for latex primer. Since all field applied coatings were applied at a given spread rate, the oil/alkyd primers and topcoats resulted in a thicker dry film due to their higher volume solids.

Table 1—Physical Properties of Primers

Oil/Alkyd Primer		Latex Primer (Alkyd Modified)	
Titanium dioxide	12.8%	Titanium dioxide	13.8%
Talc	29.9%	Silica	11.5%
Barium metaborate	4.3%	Mica	2.3%
Soya alkyd resin/ linseed oil	28.0%	Zinc oxide	1.0%
		Acrylic resin	19.1%
Mineral spirits and additives	25.0%	Long oil soya alkyd	4.6%
		Water and additives	47.7%
	100.0%		100.0%
Weight per gallon	11.38		10.83
PVC	36.0		28.0
% Volume solids	59.2		40.7
% Weight solids	76.6		54.2
VOC	319 g/L		107 g/L
Viscosity (Krebs-Stormer)	89 K.U.		86 K.U.

Topcoats

Table 2 provides a formulation overview of the finish coats included in this series. Five resins were incorporated into this evaluation: Four different latex polymers and one oil/alkyd resin system were utilized. Each resin was incorporated into a 43 PVC flat formulation and a 25 PVC satin formulation. Each topcoat was shaded with 2 oz per gal of universal phthalo green colorant to obtain a pastel green color.

The following numeric designations were used to identify the five resins used: 01 = vinyl acrylic copolymer; 02 = acrylic terpolymer I; 03 = acrylic terpolymer II; 04 = all acrylic polymer; and 05 = oil/alkyd.

All topcoats were spray applied at a spread rate of 400 sq ft per gal (10 sq m per L) on the smooth hardboard and approximately 300 sq ft per gal (28 sq m per L) on the textured hardboard. No special surface preparation was used. Dry film thicknesses of the topcoats ranged from 1.7 to 1.9 dry mils (43 to 47 microns) per coat on latex topcoats and 2.1 to 2.4 dry mils (52 to 60 microns) per coat on the oil/alkyd topcoats.

Panels were topcoated in the following manner. After application of primers, each panel was divided into two sections. The left half received the 43 PVC formulation and the right half the 25 PVC formulation. *Figure* 3 shows a field primed hardboard panel after receiving the initial coat of the two topcoats. The initial coat was

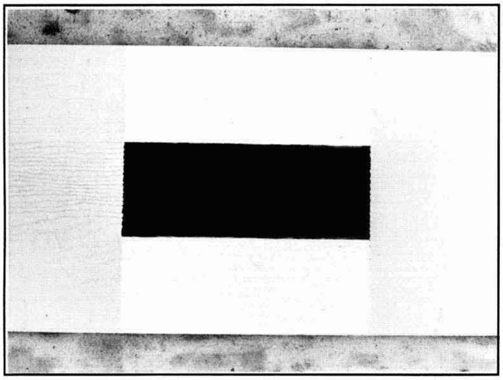

Figure 3—D-2 hardboard with primers and initial coat of topcoat. Left section—43 PVC; and right section—25 PVC

applied to the outer one-half of each section. A second coat of each topcoat was then applied over the entire section of its respective PVC which resulted in a variety of coating systems for each hardboard panel exposed. A total of 12 coating systems per board consisted of the following: two PVC levels, 25 and 43; three primed substrate sections (oil/alkyd primer, latex primer, no primer); and one and two coats of each PVC topcoat. *Figure* 4 shows completed panels that have been on exposure for 40 months.

Table 2—Topcoat Properties
Latex Topcoats—01, 02, 03, and 04

Latex 43 PVC		Latex 25 PVC	
Titanium dioxide	17.5%	Titanium dioxide	19.3%
Talc	13.2%	Calcium carbonate	2.5%
Amorphous silica	2.2%	Latex resin solids[a]	20.7%
325 Mesh mica	2.2%	Water and additives	57.5%
Latex resin solids[a]	16.1%		100.0%
Water and additives	48.8%		
	100.0%		
Volume solids	34.3%		29.6%
VOC	135 g/L		181 g/L
Viscosity (K.U.)			
Vinyl acrylic (01)	96		90
Acrylic terpolymer I (02)	92		87
Acrylic terpolymer II (03)	99		96
All acrylic (04)	93		80

Oil/Alkyd Topcoats—05

Oil/Alkyd 43 PVC		Oil/Alkyd 25 PVC	
Titanium dioxide	18.2%	Titanium dioxide	18.6%
Talc	18.2%	Calcium carbonate	18.6%
Amorphous silica	4.6%	Soya alkyd/linseed oil	36.6%
325 Mesh mica	4.6%	Mineral spirits and additives	26.2%
Soya alkyd/linseed oil	21.0%		100.0%
Mineral spirits and additives	33.4%		
	100.0%		
Volume solids	48.7%		63.2%
VOC	400 g/L		288 g/L
Viscosity (K.U.) (05)	81		97

(a) Resin solids replaced on dry volume basis.

An accompanying set of panels with the same finishes was applied onto natural wood siding, southern yellow pine, and western red cedar. Two brush coats of each topcoat were applied at a spread rate of 400 sq ft per gal (10 sq m per L) over latex primed, oil/alkyd primed, and unprimed substrate. The purpose of this series was to monitor coating performance, especially in the areas that are related to stress failures caused by woodgrain.

A "blank" hardboard panel (see *Figure* 4) of the 18 different substrates with no finish coats was also exposed. These panels, as well as all finished panels, were edge primed with the oil/alkyd primer. In January of 1986, all panels were allowed to cure seven days prior to installation on the test fence. A total of over 1,100 systems were placed on exposure.

Testing was run to quantify differences in abrasion resistance, and wet and chalk adhesion[6] on the four 43 PVC latex coatings.

Exposure

The hardboard panels were fastened to cedar supports and then onto galvanized metal A-frames at a 45° south exposure in Kansas City, MO. Panels were grouped according to the six manufacturers and their three hardboard products.

All boards were inspected monthly. ASTM performance ratings were taken only after 40 months of exposure.

Substrate Analysis

Of the many tests outlined in ASTM D1037 ("Evaluating the Properties of Wood Base Fiber and Particle Panel Materials"), four were performed as outlined in *Table* 3. Physical property requirements for hardboard siding are set forth in ANSI/AHA A135.6-1984.[7] The objective of

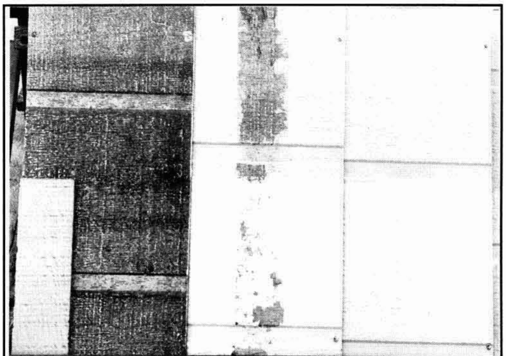

Figure 4—Completed A-3 preprimed hardboard panels on exposure. Left panel—preprimer only; middle panel—vinyl acrylic systems (01); and right panel—acrylic terpolymer I systems (02). The small panel in the lower left corner is a preprimed panel before exposure

Table 3—Substrate Tests

Board Characteristic	ASTM D 1037
Size and appearance	Sections 7 through 10
Water absorption and percent swell	Sections 100 through 106
Moisture content	Sections 124 through 125
Density	Sections 124 through 125

these tests was to determine whether hardboard, like natural wood siding, varies in many respects, and how some of these differences (swell, water absorption, density, etc.) may affect the paint holding characteristics of the board.

All tests were run according to ASTM standards and represent an average of multiple testing. Weights were accurate to within 0.01 g and measurements to 0.001 in. (25 microns).

Preprimer Analysis

The factory applied primer on the smooth hardboards was also subjected to infrared analysis along with a number of other tests to correlate paint holding characteristics.

Crosscut adhesion[8] tests were run on the factory applied primer of the smooth preprimed hardboard. Crosscut adhesion was also run utilizing the acrylic terpolymer II (03-25 PVC and 43 PVC) formulations over the same six hardboard panels. The latex topcoats were spray applied at a spread rate of 400 sq ft per gal (10 sq m per L) and aged 48 hr prior to testing.

Enamel holdout was run[9] using a 3 PVC gloss black alkyd enamel.[10] The product was spray applied at a spread rate of 400 sq ft per gal (10 sq m per L). A 60° gloss was run after 48 hr of cure. After the gloss readings were obtained, a section of the gloss black was recoated with a spray application of the acrylic terpolymer II (03-43) and checked for any visual defects.

Exposure Performance Ratings

Each finishing system was evaluated for six different criteria and assigned a numerical rating as specified in ASTM methods listed in *Table* 4. An overall performance rating [General Performance Rating (G.P.R.)] was given to each system, based on the average performance scores on all substances.

RESULTS AND DISCUSSION

Substrate Analysis

Densities of the hardboards tested ranged from a low of 43.62 lb/ft^3 up to 62.17 lb/ft^3 (0.70 g/cm^3 to 1.00 g/cm^3). In four of the six manufacturers' hardboard, the smooth preprimed board exhibited a lower density than that of its textured unprimed and preprimed counterparts. *Table* 5 gives an overview of the various hardboard test results. One manufacturer's board had densities that were equal for all three types and the other had a higher density for the smooth preprimed than its textured counterparts. The average densities of hardboards were approximately six percent higher than those used in the 1984 study. Densities for typical softwoods are 20 to 35 lb/ft^3 (0.32 to 0.56 g/cm^3) while hardwoods are in the 30 to 45 lb/ft^3 (0.48 to 0.72 g/cm^3) range.[11]

Moisture content ranged from a low of 4.4% to a high of 7.4% with an average of 5.6%. This average is very close to the 1984 study where the hardboards averaged 5.7% in moisture content. Natural woods used in exterior siding commonly are in the 7 to 14% range.[11]

The test for water absorption, a test for resistance to moisture, is the amount of water absorbed by an immersed sample over a 24 hr period and is expressed as a percent increase in weight. Ranges for the smooth preprimed hardboard were from 4.9% to 16.2%; textured unprimed were 6.9% to 25.8%; and textured preprimed 5.5% to 16.4%. ANSI/AHA A135.6-1984 specifies a 15% maximum water absorption of which only F-1, F-2, and F-3 did not conform. There was no definite trend to suggest that the smooth preprimed hardboard showed a greater or lesser tendency to absorb water compared to unprimed or preprimed hardboard panels.

Swelling is the thickness increase after a sample has been submerged in water for a 24 hr period. This is important in areas where hardboard may be subjected to areas of high humidity, frequent rainfall, or substantial variations in humidity. In all cases, the unprimed hardboard showed the greatest tendency toward swelling. All hardboards subjected to this test were below the 10% maximum allowable thickness swell as specified per ANSI/AHA A135.6-1984.

Table 4—Criteria for Evaluating Test Coatings

Performance Criteria	ASTM Designation
Erosion	D-662 "Evaluating Degree of Erosion of Exterior Paints"
Checking	D-660 "Evaluating Degree of Checking of Exterior Paints"
Cracking	D-661 "Evaluating Degree of Cracking of Exterior Paints"
Flaking (adhesion loss)	D-772 "Evaluating Degree of Flaking (scaling) of Exterior Paints"
Chalking	D-659 "Evaluating Degree of Resistance to Chalking of Exterior Paints"
Discoloration	All surface contamination was numerically rated based on FSPT standards for dirt and mold contamination.

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Marlon Trigg (Pacific Northwest Society)	Olympic Stain

Table 5—Hardboard Properties

Board	Process	Thickness[a]	Density[b]	S.G.[c]	% Moisture	% Absorption	% Swell
A-1	Wet	0.400	47.7	0.76	5.7	12.0	3.8
A-2	Wet	0.387	48.9	0.78	6.1	10.3	4.1
A-3	Wet	0.392	53.0	0.85	5.8	8.6	3.0
B-1	Dry	0.317	57.2	0.92	4.5	10.6	4.4
B-2	Dry	0.400	46.3	0.74	5.5	14.2	6.3
B-3	Dry	0.383	52.4	0.84	5.8	8.8	3.9
C-1	Wet	0.477	53.3	0.85	5.4	6.8	3.6
C-2	Wet	0.481	57.0	0.91	5.8	6.9	4.1
C-3	Wet	0.495	56.0	0.90	5.8	7.7	3.8
D-1	Wet	0.397	56.8	0.91	6.3	4.9	1.3
D-2	Wet	0.378	58.8	0.94	4.9	9.8	8.1
D-3	Wet	0.389	62.2	1.00	5.1	5.5	3.3
E-1	Wet/dry	0.406	43.1	0.69	4.6	12.8	5.7
E-2	Wet/dry	0.378	49.5	0.79	4.4	10.5	6.0
E-3	Wet/dry	0.386	46.6	0.75	5.8	11.3	5.9
F-1	Dry	0.415	43.6	0.70	7.4	16.2	4.8
F-2	Dry	0.407	46.7	0.75	5.8	25.8	7.4
F-3	Dry	0.405	48.8	0.78	6.0	16.4	4.6

(a) Inches.
(b) Pounds per cubic foot.
(c) S.G. = specific gravity (grams per cubic centimeter).

Physical properties of hardboard versus natural woods in moisture testing and dimensional change will not be exactly the same. This would be expected since wood used to produce hardboard has been reduced to fiber then rearranged into a grainless, homogeneous product.

Preprimer Analysis

Fourier Transform Infrared analyses were run on the primers of each of the smooth preprimed hardboard panels. The analyses were done by scraping 2 mg of each primer, preparing two percent KBr pellets, and doing throughput. The infrared spectra show acrylic resin, titanium dioxide, and various extender pigments. *Table* 6 reflects the testing performed on the smooth preprimed hardboard panels. Gloss on all smooth preprimed hardboard panels was below five on a 60° gloss reading. This would indicate that the preprimers are fairly high in PVC.

Crosscut adhesion yielded a wide range of results (see *Table* 6). The acrylic terpolymer II (03) was used to establish any differences in adhesion characteristics of

Table 6—Factory Preprimer Analysis

	Board					
Property	A-1	B-1	C-1	D-1	E-1	F-1
Gloss @ 85°	10	2	3	3	5	2
Adhesion (w/03-43)	4[a]	5	4	5	0[b,c]	0
Adhesion (w/03-25)	0	4	4	5	0	0
Enamel holdout (Gloss @ 60 of TT-E-489 Enamel)	75[d]	74	76	83	78	43[e]
Recoatability (appearance of 03-43 over TT-E-489)	Slight Crawl	No Crawl	No Crawl	No Crawl	Very Slight Crawl	Moderate Crawl
Resin composition	Acrylic	Acrylic	Acrylic	Acrylic	Acrylic	Acrylic
Pigment composition	TiO_2/Silica	$TiO_2/CaCO_3$	$TiO_2/CaCO_3$	$TiO_2/CaCO_3$	TiO_2/Talc	TiO_2/Silica
Film thickness (mils) (Tooke gauge)	1.0	2.0	2.0	1.5	1.5	3.0
40 month exposure (loss of adhesion)	100%	98%	50%	3%	30%	0%

(a) Six percent of topcoat and factory primer removed upon tape pull.
(b) 85% of topcoat and factory primer removed upon tape pull.
(c) 10% of factory primer removed on crosscut when run without topcoat. A, B, C, D, and F exhibited 100% retention (5 rating).
(d) Slight hazing of gloss alkyd.
(e) Moderate hazing of gloss alkyd.
(f) Although no peeling was recorded, preprimer was severely eroded.

Table 7—Physical Properties of 43 PVC Latex

Property	Vehicle # 01	02	03	04
Wet adhesion to gloss alkyd (force to peel in grams)	150	650	500	1550
Adhesion to oil chalk (force to peel in grams)	100	450	300	1000
Adhesion to latex chalk (force to peel in grams)	50	300	150	850
Abrasive scrub resistance (no. of cycles)	884	180	442	430

the various hardboard panels. Only substrate D obtained 100% adhesion with both the 25 and 43 PVC topcoats. All other hardboards demonstrated with varying degrees of adhesion, with F rating the poorest. Substrates E and A were the only substrates to lose factory preprimer and topcoat on tape pull in the adhesion testing.

Gloss readings on the enamel holdout of the black gloss alkyd over the smooth preprimed hardboard ranged from 43 to 83 at 60° after a 48 hr cure. On substrates A and F, hazing of the enamel was visible. The extreme low gloss reading on substrate F is due primarily to the hazing and not to excessive porosity. Substrates B, C, and F exhibited pinholing during application of the enamel, which is an indicator of porosity due to high PVC.

The preprimed substrates did show a marked improvement in enamel holdout when comparing unprimed versus preprimed textured hardboard. The degree of penetration of an initial coat of primer or topcoat was dramatically less on the preprimed panels. The only exception was the difference between A-2 and A-3. It appeared that this board incorporates a paper overlay which cuts coating penetration into the hardboard.

An application of acrylic terpolymer II (03-43) over the gloss black enamel exhibited good surface wetting over substrates B, C, D, and E. Over substrates A and F, the latex film had poor surface wetting and the dried film exhibited visible surface to substrate craters in the latex topcoat.

Table 8—Exposure Characteristics on Natural Wood

Characteristic	43 PVC Resin Systems 01	02	03	04	05
Chalking	6	6	6	6	5
Fading	6	6	6	5	4
Discoloration	7	8	7	8	8
Grain cracking[a] (SYP)[b]	2	6	4	8	6
Grain cracking (WRC)[c]	10	10	10	10	10
G.P.R.[d]	6.2	7.2	6.6	7.4	6.6
	25 PVC Resin Systems				
Chalking	7	7	9	7	6
Fading	8	8	8	8	5
Discoloration	7	8	6	8	8
Grain cracking (SYP)	9	9	9	9	6
Grain cracking (WRC)	6	8	8	9	10
G.P.R.	7.4	8.0	8.0	8.2	7.0

(a) Grain cracking was rated on two coats of topcoat direct to wood.
(b) SYP = southern yellow pine.
(c) WRC = western red cedar.
(d) G.P.R. = general performance rating.

The exposed panels of uncoated preprimed hardboard yielded a wide range of results. *Table* 6 reflects adhesion loss of the preprimer from the smooth panels only. The textured preprimed counterpart of smooth board had similar results. Hardboards A and B lost virtually all of their preprimer, whereas D retained the majority of its preprimer. Panel D-3 retained 100% of its preprimer, however, at 40 months, the surface had darkened by dirt pickup and become water repellent.

Topcoat Analysis

The data in *Table* 7 was used to quantify the various characteristics of the four emulsion polymers used in the 43 PVC formulation. The all acrylic (04-43) had dramatically higher ratings in the areas of wet and chalk adhesion over the vinyl acrylic (01-43) and acrylic terpolymers (02-43 and 03-43). The vinyl acrylic formula rated the poorest in all adhesion tests.

Abrasive scrub of the vinyl acrylic (01-43) was well above the all acrylic and acrylic terpolymers. The acrylic terpolymer I (02-43) exhibited the poorest abrasive scrub resistance. Even though systems rated the highest in abrasive scrub, they were rated the lowest on dirt pickup on 40 month exposure.

Exposure Ratings

Data on the chalking, topcoat discoloration, and fade exposure characteristics are outlined in *Table* 8. These ratings (10 = best, 0 = worst) reflect readings from the natural wood substrates. Chalking, discoloration (surface), and fade ratings are reflective of those taken on the hardboard panels. On natural wood, the all acrylic (04) outperformed the other resin systems, especially in the area of grain crack resistance on southern yellow pine. The vinyl acrylic was the poorest rated product on natural wood. The oil/alkyd at 25 PVC outperformed all 25 PVC latex systems in the area of grain crack resistance on the western red cedar. All systems were rated a 10 on grain cracking when topcoated over the oil/alkyd or latex primer.

VINYL ACRYLIC TOPCOATS (01 SERIES): The vinyl acrylic formulations were the poorest performing compared to

Table 9—Vinyl Acrylic (01) G.P.R.[a] on Hardboard

	43 PVC			25 PVC		
	O.P.[b]	N.P.[b]	L.P.[b]	O.P.	N.P.	L.P.
Smooth preprimed						
1 Coat topcoat	8.15	7.65	8.15	8.50	7.50	8.50
2 Coats topcoat	8.15	7.80	8.15	8.15	7.65	7.90
Textured unprimed						
1 Coat topcoat	8.05	5.15	7.65	8.25	5.65	7.90
2 Coats topcoat	8.05	6.40	7.65	7.90	6.75	7.15
Textured preprimed						
1 Coat topcoat	8.15	6.80	8.00	8.50	6.30	8.15
2 Coats topcoat	8.15	7.15	7.90	8.40	6.75	7.80

(a) General Performance Rating.
(b) O.P. = oil/alkyd primed; N.P. = no primer; and L.P. = latex primed.

Table 10—Acrylic Terpolymer I (02) G.P.R. on Hardboard

	43 PVC			25 PVC		
	O.P.	N.P.	L.P.	O.P.	N.P.	L.P.
Smooth preprimed						
1 Coat topcoat....	8.35	8.00	8.35	8.85	8.75	8.85
2 Coats topcoat...	8.35	8.20	8.35	8.85	8.85	8.85
Textured unprimed						
1 Coat topcoat....	8.25	7.00	8.25	8.85	6.85	8.75
2 Coats topcoat...	8.25	7.70	8.25	8.85	8.35	8.85
Textured preprimed						
1 Coat topcoat....	8.25	7.70	8.35	8.85	8.20	8.85
2 Coats topcoat...	8.35	8.10	8.35	8.85	8.75	8.85

Table 11—Acrylic Terpolymer II (03) G.P.R. on Hardboard

	43 PVC			25 PVC		
	O.P.	N.P.	L.P.	O.P.	N.P.	L.P.
Smooth preprimed						
1 Coat topcoat....	8.15	7.90	8.15	8.85	8.85	8.85
2 Coats topcoat...	8.15	8.15	8.15	8.85	8.85	8.85
Textured unprimed						
1 Coat topcoat....	7.75	6.50	8.05	8.75	6.60	8.85
2 Coats topcoat...	8.15	8.05	8.15	8.85	8.70	8.85
Textured preprimed						
1 Coat topcoat....	8.05	7.80	8.15	8.85	8.60	8.85
2 Coats topcoat...	8.15	8.15	8.15	8.85	8.85	8.85

the other emulsion and oil/alkyd topcoats. The one- and two-coat systems performed consistently poorer on preprimed hardboard on sections where no field primer was applied (see *Table* 9). The vinyl acrylic displayed a greater tendency toward checking over the latex primer than over the oil/alkyd primer.

Severe loss of adhesion was evident, particularly on A-1 and A-3. After four days of exposure, the topcoat formed large blisters during a light drizzle over the one- and two-coat/no primer sections of the 25 PVC section. The blisters did recover upon drying. The blistering cycle did reoccur during periods of precipitation through the first month of exposure. This poor wet adhesion ultimately led to coating failure in the form of severe peeling over the no primer section only.

In all cases of adhesion failure on preprimed hardboard, the point of failure was the primer/preprimer interface and not the preprimer/fiber interface. This was also the case with the other resin systems when adhesion failure occurred over preprimed hardboard.

With the exception of hardboard A, the vinyl acrylic performed better over preprimed textured hardboard than unprimed textured hardboard. One coat 43 PVC consistently showed loss of adhesion from 10 to 90% over the no primer section of the various unprimed hardboards, A-2 through F-2. Panels A-3 and F-3 showed loss of adhesion of the 43 PVC vinyl acrylic on the no primer section of the textured preprimed hardboard.

Cracking of the vinyl acrylic was quite common on many of the textured hardboards. Cracking was more frequent with the 25 PVC on textured hardboard over no primer and latex primed sections. The only cracking recorded over an oil/alkyd primed surface was on panel B-2 with two coats of the 01-25 vinyl acrylic. Cracking of the 25 PVC vinyl acrylic was more prevalent with two coats of topcoat versus a single coat.

On smooth preprimed hardboard (B-1, C-1, and F-1) fiber swell was evident on the one-coat/no primer sections. Panel A-1 had 75% loss of the 25 PVC topcoat and 5% loss of the 43 PVC topcoat over the no primer section. Panels D-1 and E-1 exhibited equal topcoat performance on the no primer, latex primed, and oil/alkyd primed sections with both one and two coats of topcoat.

Acrylic Terpolymer I Topcoats (02 Series): These acrylic terpolymer finishes performed well on the majority of boards (see *Table* 10), as did the acrylic terpolymer II (03) and the all acrylic (04). These three systems (02, 03, and 04) exhibited similar performance characteristics when compared on an equivalent formulation basis.

There were no severe adhesion failures similar to that of the vinyl acrylic where no field applied primer was utilized. There were a few instances of peeling failure on some hardboards. On B-3, both the 43 and 25 PVC showed stress failure in the form of moderate peeling on the 43 PVC and slight peeling of the 25 PVC one-coat/no primer systems. There was also slight peeling on C-2 over the one-coat/no primer section only.

There were no signs of cracking of either the 43 or 25 PVC over oil/alkyd or latex primed substrates. Discoloration was evident in many of the one coat only areas of the unprimed hardboards, with D-2 hardboards being the worst. This discoloration was held in check with the use of either primer. The 25 PVC finishes held a slight edge in performance over the 43 PVC finishes.

When comparing two-coat systems, a primer/topcoat system slightly outperformed a two-coat topcoat system. A slight edge in performance was noticed when comparing oil/alkyd versus latex primed two-coat systems. In all cases, the three-coat systems were equal to or better than the one- or two-coat systems.

Acrylic Terpolymer II Topcoats (03 Series): Again performance was very good with this resin system (see *Table* 11). Peeling was evident on the one coat/no primer 43 PVC section on B-3. Slight cracking of the 25 PVC one-coat/no primer system on the same board was also recorded. Moderate peeling was noted on the one-coat/no primer system on hardboard C-2.

The most notable feature of resin system 03 was its apparent color retention. Although fade and chalk resis-

KANSAS CITY SOCIETY TECHNICAL COMMITTEE (l-r): Al Moser, Nick Dispensa, Roger Haines, Gregg Early, Lawrence Murphy, William Bailey, and Chairman Steve Bussjaeger

Table 12—All Acrylic (04) G.P.R. on Hardboard

	43 PVC			25 PVC		
	O.P.	N.P.	L.P.	O.P.	N.P.	L.P.
Smooth preprimed						
1 Coat topcoat....	8.15	8.00	8.15	8.85	8.75	8.85
2 Coats topcoat...	8.15	8.15	8.15	8.85	8.85	8.85
Textured unprimed						
1 Coat topcoat....	8.15	6.30	8.15	8.85	7.20	8.85
2 Coats topcoat...	8.15	8.05	8.15	8.85	8.70	8.85
Textured preprimed						
1 Coat topcoat....	8.15	6.90	8.05	8.85	8.60	8.85
2 Coats topcoat...	8.15	8.15	8.15	8.85	8.85	8.85

tance of this resin appeared to be better than the other three emulsions, it was rated the lowest in terms of dirt pickup. The 25 PVC finishes fared slightly better than their 43 PVC counterparts.

ALL ACRYLIC TOPCOATS (04): Similar performance data was obtained when compared to the 02 and 03 resin systems (see *Table* 12). Moderate peeling was recorded with the 43 PVC one-coat/no primer system on B-3 and C-2. Slight fiber swell was noticed on the one coat 43 PVC on hardboard C-1, however, this was also evident on C-1 for the other four resin systems.

Discoloration was slightly more pronounced with the all acrylic on the one-coat/no primer systems of unprimed hardboard when compared to equal systems of the vinyl acrylic and acrylic terpolymers. Chalking and fade characteristics were similar to that of acrylic terpolymer I (02).

OIL/ALKYD TOPCOATS (05): In terms of peeling, these systems performed almost as well as the acrylic systems and better than the vinyl acrylic (see *Table* 13). This is a reversal of the 1984 study where the oil/alkyd was outperformed by the vinyl acrylic. The most pronounced failure was on B-3 where moderate peeling was evident with the 25 PVC one-coat/no primer system. On the same hardboard, the 43 PVC showed only slight cracking. The 25 PVC one-coat/no primer system also exhibited slight cracking on boards C-2 and C-3. Fiber swell was noted on one-coat/no primer systems of B-1 and C-1 in both the 25 and 43 PVC finishes.

In the one-coat systems over unprimed hardboard, the 25 PVC was slightly poorer in terms of crack resistance versus the 43 PVC. All two- and three-coat systems performed well. As was the case with the two-coat acrylic systems, a primer/topcoat system rated slightly better than a two-coat topcoat system. No cracking was recorded on two- or three-coat systems.

Table 13—Oil/Alkyd (05) G.P.R. on Hardboard

	43 PVC			25 PVC		
	O.P.	N.P.	L.P.	O.P.	N.P.	L.P.
Smooth preprimed						
1 Coat topcoat....	7.85	7.70	7.85	8.15	7.80	8.15
2 Coats topcoat...	7.85	7.85	7.85	8.15	8.15	8.15
Textured unprimed						
1 Coat topcoat....	7.85	6.75	7.85	8.15	6.50	8.15
2 Coats topcoat...	7.85	7.70	7.85	8.15	7.80	8.15
Textured preprimed						
1 Coat topcoat....	7.85	7.60	7.85	8.15	7.55	8.15
2 Coats topcoat...	7.85	7.75	7.85	8.15	7.90	8.15

The oil/alkyd rated lower for chalking and fade characteristics versus all latex systems. There was no evidence of mildew growth on any of the systems exposed.

SUMMARY

This exposure study illustrates the enhanced protection and weatherability of multiple coat systems on the hardboards tested. After 40 months of exposure, single-coat systems of 25 and 43 PVC vinyl acrylic latex systems without a field application of primer exhibited the highest rate of adhesion failure. This is contradictory to the earlier findings of the five-year exposure work completed in 1984 by the Kansas City Society,[12] where a single coat of the oil/alkyd topcoat with no field applied primer rated the poorest. Performance of similar one- and two-coat systems, latex and oil, was better with this series than the previous exposure with equal exposure time.

An improved preprimer and hardboard substrate account for these differences. Preprimers in this series were based on acrylic resins, whereas in the 1984 series, alkyd preprimers were predominately utilized. In this exposure series, field applied coatings had better performance ratings on preprimed textured hardboard over its unprimed textured counterpart. In the previous exposure series, several topcoat systems exhibited a higher rate of peeling on preprimed versus unprimed textured hardboard.

There was no statistical correlation between paint holding characteristics and hardboard density, manufacturing process, moisture content, water absorption, or swell. On preprimed hardboard, no correlation could be drawn between preprimer adhesion or exposure characteristics and overall coating system performance.

It can be stated that the 25 PVC formulations performed better than their 43 PVC equivalents in multiple coat systems. Multiple coat systems employing an initial coat of primer, alkyd or latex, performed equal to or better than the multiple coat systems utilizing topcoat only. Coating systems exhibited better performance on smooth preprimed hardboard than on unprimed or preprimed textured hardboard.

Latex systems using the higher wet adhesion polymers showed better resistance to early blistering and peeling failure. At this point, there is no data to support the supposition that the superior wet/chalk adhesion and grain crack resistance of the all acrylic will afford better crack and peeling resistance than the acrylic terpolymer equivalents on hardboard.

From the results of this study, it appears that a minimum of two coats, preferably a field primer/topcoat system, is necessary for satisfactory performance on exterior preprimed or unprimed hardboard. There is not sufficient exposure data to suggest a three-coat system (one coat primer/two coats topcoat) will perform better than a two-coat system (one coat primer/one coat topcoat). Less than satisfactory results can be expected with one-coat systems on preprimed or unprimed hardboard.

All acrylic polymer and acrylic terpolymer topcoats would be preferred over vinyl acrylic polymer and oil/alkyd topcoats. The oil/alkyd primer showed only a slight performance edge over the latex primer.

ACKNOWLEDGMENTS

The Kansas City Society Technical Committee wishes to thank Davis Paint Company for exposure site arrangements and testing facilities along with Tnemec Company, Inc. for the use of their testing facilities.

We are also grateful to the American Hardboard Association and its contributing members for their time, cooperation, and materials.

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GOLDEN GATE ....JUNE

"Coatings Manufacture in a Regulated Age"

A moment of silence was observed in memory of Elder C. Larson, who died recently. Mr. Larson was a Past-President of the Federation (1979-80) and the Golden Gate Society (1970-71).

The Society Executive Board voted to send a memorial donation to the Cal Poly Fund in honor of Mr. Larson.

The slate of officers for the 1990-91 year was introduced as follows: President—Gordon Pioch, of Triangle Coatings, Inc.; Vice President—Jack Duis, of Pacific Coast Chemical Company; Secretary—Larry G. Sayre, of O'Brien Corporation; and Treasurer—Margaret R. Hartmann, of Dexter Corporation.

An all-day conference preceded the meeting. The session entitled "Coatings Manufacture in a Regulated Age" was co-chaired by Manufacturing Committee Chairman Louis F. Sanguinetti, of Jasco Chemical Corporation, and Ronald Hughes, of Ashland Chemical Company.

The co-chairmen introduced the session's speaker, Society member Ned Kisner, of Triangle Coatings, Inc. Mr. Kisner's topic was "PARLE—What It Is and What It Is Doing."

The speaker said that PARLE stands for the Program Advocating Responsible Legislation for the Environment, and it gives the industry a chance to speak out, to work with regulators, and to find solutions for environmental problems. PARLE is an open forum and all opinions are welcome.

Mr. Kisner stated that PARLE also is educational and several specific opportunities were discussed.

He said the "Big Green" initiative needs to be studied carefully and he urged voters to evaluate it carefully on the California ballot.

According to the speaker, regulators need to be educated on the capabilities of the industry. In addition, formulators and manufacturers recognize that they use toxic chemicals. Mr. Kisner said one of the education processes is to assess the relative risk of these materials and to inform the public.

Q. What has PARLE accomplished?

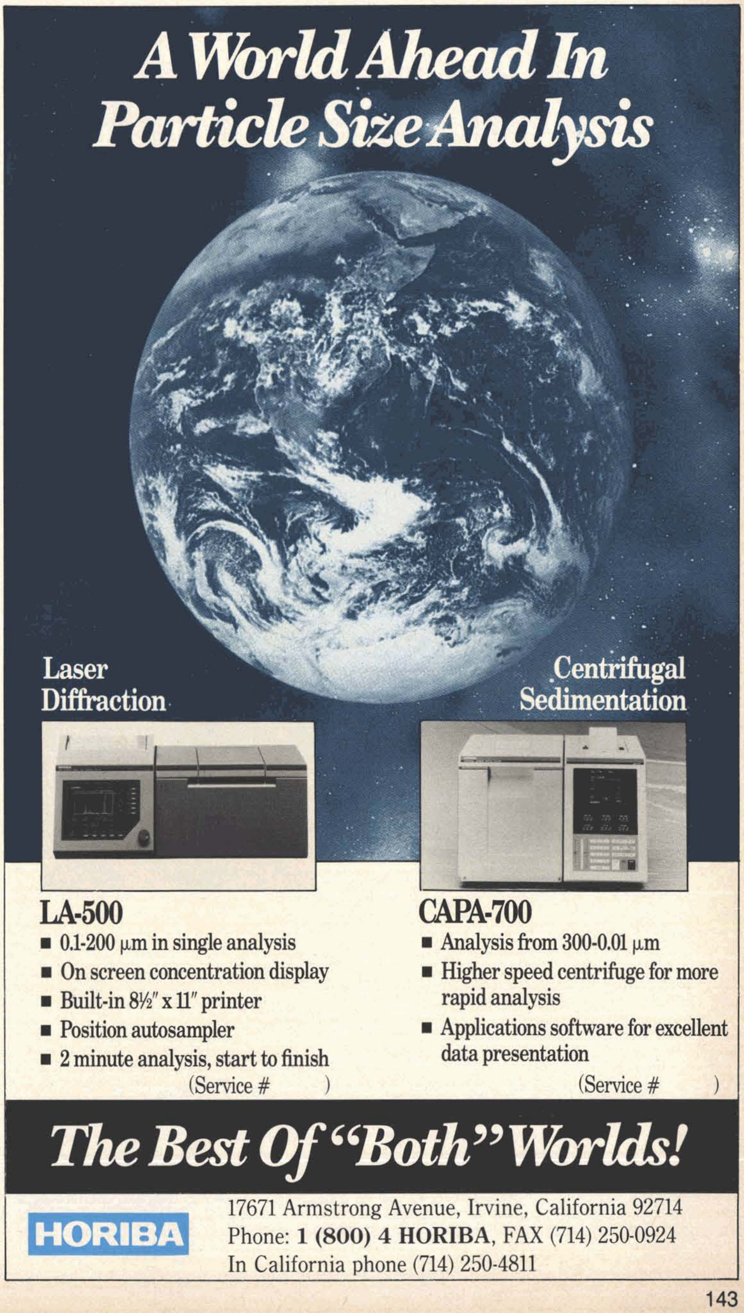
A. We have put together an organization which will continue to pursue the goals to educate and to inform. We have organized a Regulatory Affairs seminar for October 1991. We look forward to increased membership to better represent the industry. We welcome all input and points of view.

Q. How do you join and what does it cost?

A. We are part of the Golden Gate Paint and Coatings Association. Dues are $200 per year per company. Individuals and nonmembers may join. If the dues amount is a problem, some arrangements can be made.

A video tape of this talk and other presentations made at "Conference '90," sponsored by the Manufacturing Committee, are available from Ronald Hughes, Ashland Chemical Company, 8600 Enterprise Dr., Newark, CA 84560.

Margaret R. Hartmann, *Secretary*



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Future Society Meetings

Birmingham

(Nov. 1)—"Recent Developments in Water Based Technologies"—Herr Sickert, Bayer.

(Dec. 6)—"The Role of Multicompatible Stainers in the Industrial Paint Market"—Mike Husbands, Sandoz.

(Jan. 10)—"The Benefits of Color Computer Measurement Equipment in the Coatings Industry"—Colin Wilkinson, Kirkstol Colour Service.

(Feb. 7)—"Can Lines"—R.P. Clarke, Nacanlo Ltd.

(Mar. 7)—"Modern Dispersion Equipment for Surface Coatings"—Colin Bow, Netzsch Ltd.

(Apr. 4)—"1992: A Legislative Update for the Paint Industry"—Tony Newbold, Paintmakers Association of Great Britian.

(May 2)—62nd Annual General Meeting.

Chicago

(Nov. 5)—"Human V.O.C. (Victims of Crime)"—Roger Sether, Criminologist.

Cleveland

(Oct. 16)—"Solvent Emission Control for the Future"—Dr. C.W. Glancy, Union Carbide.

(Nov. 20)—"Trends in Environmental Control for the 90s"—Thomas Graves, Director of Federal Affairs, NPCA.

(Jan. 15)—Joint Meeting with Cleveland PCA.

(Feb. 19)—"The Use of Ropaque Opaque Polymers in Architectural Coatings"—Dr. Elmer Williams, Jr., Rohm and Haas Co.

(Mar. 19)—"Choosing the Most Effective Dispersants for High Solids Coatings"—Marvin Schnall, Troy Chemical Corp.

(Apr. 16)—"Coatings Characterization by Thermal Methods"—Michael Neag, The Glidden Company.

(May 21)—"Formulation of New Varnishes for Old Master Paintings"—Dr. E. Rene´ de la Rie, National Gallery of Art.

New York

(Nov. 13)—"Carbon Black Pigments in Coatings"—Dr. Maria Nargiello, DeGussa Corp.

(Jan.)—"Second Generation Coalescing Agents for Industrial Acrylics Latices"—Don King, Exxon Chemicals.

(Feb.)—Joint update legislative meeting for the NYSCT/MNYPCA.

(Mar.)—"Polyurethanes in the Baking Industry for Powder, Wire, and Coil"—Robert Henderson, Mobay Corp.

Philadelphia

(Nov. 8)—"Type 2 Urethane Associatives + Latex Paint = Value Added Performance"—Robert H. Dey, Rheox, Inc.

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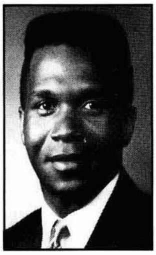
People

M. Anthony Johnson, a 10-year veteran of The Dow Chemical Company, Midland, MI, has been appointed Market Development Manager for the industrial, protective, and marine coatings group. Mr. Johnson joined Dow's Plaquemine, LA facility in chlor-alkali production support in 1980. In 1982, he was promoted to Senior Research Chemist in organic technical service and development. He also has held the positions of Senior Accounts Specialist in Dow's San Francisco sales office and Senior Business Opportunity Analyst at the company's Midland headquarters.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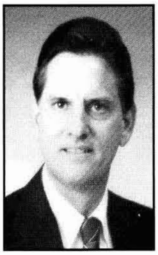
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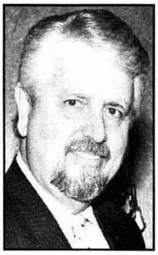

D. Morehouse

The promotion of **William Lee Coble** to Business Manager for the Polymer Processing and Coating Chemicals Groups of Akzo Chemicals Inc., Chicago, IL, has been announced. Mr. Coble's responsibilities will include the development, implementation, and management of Fyrol Flame Retardants Group and benzene phosphorus dichloride (BPD) derivatives for North America.

Rheometrics, Inc., Piscataway, NJ, has named **Neil J. Abitabilo** Vice President of Administration & Finance. In this capacity, he will direct the administrative and financial operations of the company.

Tadao Hayashi, Professor Emeritus of Applied Chemistry, University of Osaka Prefecture, Osaka, Japan, has been chosen as the recipient of the 1990 American Electroplaters and Surface Finishers Society (AESF) Scientific Achievement Award. The award recognizes individuals who have made outstanding contributions which have raised the theory and practice of electroplating and the allied sciences, raised the quality of products or processes, and enhanced the dignity of the profession. As the recipient of this award, Dr. Hayashi will deliver the William Blum Lecture during the Opening Session of AESF SUR/FIN® 91 in Toronto, Ontario, Canada.

Robert L. Klein has joined the staff of ANGUS Chemical Company, Northbrook, IL, as Vice President, Research and Development. Prior to joining ANGUS, Mr. Klein served as the Director of R&D for The APG® Surfactant Group of Henkel Corporation.

In addition, **James P. O'Brien** has been named Distributor Manager for ANGUS. In this position, he will be responsible for the company's distributors of AMP™, solvents, and Nitrofuel®.

Parker+Amchem, Madison Heights, MI, has announced the following appointments: **James I. Maurer**—Vice President of Business Development and Technology; **Francis M. Orfin**—Business Area Director/Automotive; and **David W. Barney**—Group Manager/Ford, Chrysler, and Navistar Accounts.

Gary G. Hawn has joined the staff of ICI Specialty Chemicals, Wilmington, DE, as Manager/Surfactants Applications Development for the Surfactants Businesses in the United States. In this capacity, Dr. Hawn will serve as Manager of the technical group responsible for the applications research, product development, and technical service support for the U.S. surfactants business, including personal care, agricultural chemicals, textiles, metalworking, and industrial markets.

Vahe Karayan, with 17 years' experience in the chemical and plastics industry, has been named Technical Services Manager for Avecor company's San Fernando, CA plant. Prior to joining Avecor, Dr. Karayan was Technical Manager for Lilly-Ram Industries in Gardena, CA.

Gregory P. Zern has been promoted to Manager of Engineering/Quality Improvement of Betz MetChem, Horsham, PA. Mr. Zern joined Betz in 1976 as a District Sales Representative and has since transferred to the Engineering Department where he received promotions to Project Engineer, Project Supervisor, and Group Leader.

In addition, **Tim Bridges** and **Doug Simon** have been named Account Managers. In his new position, Mr. Bridges will be responsible for customer sales and service in Alabama and central Tennessee. Mr. Simon will oversee the sales and services in the Southland District.

Morehouse Industries, Fullteron, CA, has announced the retirement of **Dale Morehouse** as the company's Chief Executive Officer. He will continue to serve as Chairman of the Board. Elected to replace Mr. Morehouse as Chief Executive Officer is the firm's current President and Chief Operating Officer **James R. Swartwout**. Mr. Swartwout is a member of the Los Angeles Society.

Bopinder S. Phull has been named to the position of Principal Corrosion Scientist for the LaQue Center for Corrosion Technology, Wrightsville Beach, NC. Mr. Phull will be responsible for planning and coordinating research, testing, training, and consulting programs. Prior to joining the company in 1984, he was Deputy Group Leader, Corrosion and Protection Centre Industrial Services in Manchester, England.

In addition, **Dennis Melton**, who joined the firm in 1971 as a Laboratory Assistant, has been promoted to Corrosion Engineer. In this capacity, Mr. Melton will direct project management activities and will be active in the area of operating equipment evaluations.

Daniel J. Pisano, Jr. has been appointed President of the Macbeth Division of Kollmorgen Instruments Corporation, Newburgh, NY. Dr. Pisano joines Macbeth after a 10-year association with the Perkin-Elmer Corporation where he held a number of general management position, most recently serving as Vice President/Technology.

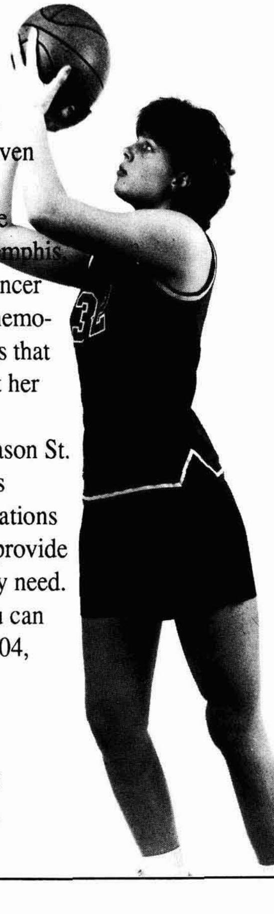
Saran Technical Services, Inc., Indianapolis, IN, has announced the naming of **Charles M. "Chuck" Noonan** as Technical Director and Operation Manager. Mr. Noonan brings 25 years of experience in research and development to this position.

Don Wozniak has been promoted to Branch Manager of the South Bend, IN, branch office of Van Waters & Rogers Inc., a subsidiary of Univar Corporation, Seattle, WA. Bringing more than 13 years' industry experience to this post, Mr. Woznaik has held a variety of sales and managerial positions with Van Waters & Rogers and McKesson Chemical Company, a firm VW&R acquired in 1986.

Also, **Joseph C. Adams** has been named Senior Corporate Counsel for the Legal Department of Univar Corporation.

McWhorter, Inc., Carpentersville, IL, has announced three additions to their Sales and Marketing Departments. **Richard M. Gallas** has been named Marketing Manager; he will direct all marketing related functions at the company. **Brian P. Corrigan** has been appointed Account Manager for Michigan and Ohio. **Ron Bonnell** has joined McWhorter as an Account Manager; his responsibilities will include Missouri, Kansas, Iowa, and Eastern Tennessee. Mr. Bonnell is a member of both the Kansas City and St. Louis Societies.

Michelle lost a leg to cancer. Now, she's back in the game.



Not long ago Michelle faced an ordeal that no child should have to face -- the horror of osteosarcoma. The cancer spread through her right leg and threatened to end her young life before it had even begun.

Fortunately, the doctors at St. Jude Children's Research Hospital in Memphis, Tennessee were able to arrest the cancer using a combination of radiation, chemotherapy and surgery. The procedures that saved Michelle took her leg, but not her active life.

Children like Michelle are the reason St. Jude exists, and why your support is needed. St. Jude depends upon donations from concerned people like you to provide the help that sick kids so desperately need.

For more information on how you can help, write to St. Jude, P.O. Box 3704, Memphis, TN 38103, or call 1-800-USS-JUDE.

ST. JUDE CHILDREN'S RESEARCH HOSPITAL
***Danny Thomas**, Founder*

Martin Strauss has joined the staff of Micro Powders, Inc., Tarrytown, NY as Vice President of Operations. His responsibilities will include facilitating the operation of production and inventory control as well as acting as a liaison with their customers.

Croda Inks Corporation, Niles, IL, has announced the retirement of **George D. Moore**, Manager of the company's Memphis, TN plant. Mr. Moore joined Hill-Hentschel, a company that eventually became part of Croda in 1944 as a Batch Weigher and Mill Operator. He later served in a variety of positions, which included becoming Location Manager in 1983. He is succeeded in this position by his son, **Kevin Moore**. The younger Moore has also held a number of positions in the Croda organization, including Laboratory Technician, Technical Sales Representative, Product and Technical Manager, and Assistant General Manager, Memphis plant.

In addition, **Mark J. Wiedmann**, formerly National Manufacturing Manager at the company's Product Development Laboratory (PDL), in Atlanta GA, has been appointed General Manager of PDL, while **Ronald C. Ziegler**, who was Locational Manager, is now spearheading Croda's research and development activities at the laboratories in Atlanta.

Also, **Johnny R. James** has been appointed Research Chemist. Mr. James is assigned to the firm's PDL in Atlanta where the company's corporate research and development activities are conducted. **Kevin L. Tanner** has been named as Technical Sales Representative. Mr. Tanner will be headquartered at Croda's Memphis, TN location.

Carl Scaccia has been named to the newly created position of Business Director for Ashland Chemical, Inc.'s Specialty Polymers & Adhesives Division. Based at company headquarters in Columbus, OH, Dr. Scaccia will oversee the SP&A Division's product groups and will have reporting to him the seven business managers of those groups.

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Obituary

Albert J. Kirsch, retired, American Cyanamid Company, died on June 30. He was 74 years old.

Mr. Kirsch was retired as a Chemist with the American Cyanamid Company, where he worked for 39 years. He was a consultant to the company following his retirement. Mr. Kirsch was the author of the book, "50 Years of Amino Coating Resins."

Mr. Kirsch was a member of the Federation for more than 40 years.

John M. Thomas, retired Vice President and General Manager of the Celanese Resins Division of Celanese Coatings Company, Louisville, KY, died on June 7. He was 76 years old.

Mr. Thomas' career in the chemical industry began in 1936 when he was employed with the Jones-Dabney Company in Louisville as an Enamel Sample Development Chemist. In 1945 he was promoted to Technical Director of the Resins Division. Mr. Thomas continued his work in the resins group in the sales department from 1948 until 1954, when he was promoted from Sales Manager to Vice President of the Resins & Chemicals Division. He continued in this position after Celanese purchased Jones-Dabney in the mid-1960s.

Mr. Thomas was a member of the American Chemical Society and the Paint Industry Raw Materials Committee. He was also a Past-President of the Louisville Paint and Varnish Association and Past-Vice President of the Chemical Coatings Industry Committee.

George A. Keim, retired, Ashland Company, IC&S Division, died on June 9. He was 72 years old.

Mr. Keim joined Ashland Oil & Refining Company in 1947 in the firm's Accounting Department. He transferred to the Credit Department in 1949 and Purchasing Department in 1950. Mr. Keim became District Manager of the IC&S Division in 1962. He retired from the company in 1982.

A member of the Western New York Society, Mr. Keim served as President in 1969-70. He was also active in the Society's educational programs prior to his retirement.

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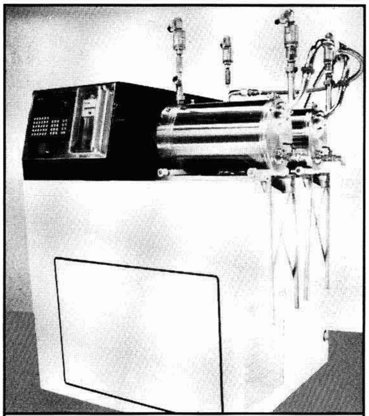

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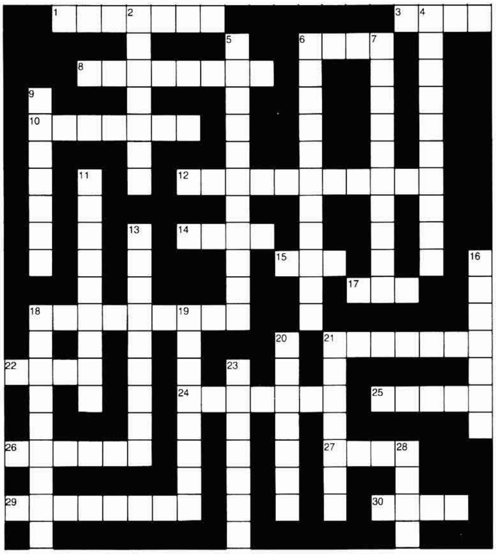

No. 38

Solution
to be
Published in
November issue

ACROSS

1. Type of carbonate pigment
3. To lose color
6. Timber or girder, e.g.
8. Banister (Syn.)
10. The opposite of being basic (Chem.)
12. Color contributing groups in organic molecules
14. To get a grip on
15. Put this fabric on your paint roller
17. Home to the lac bug
18. Chemical reaction vessel (lab use)
21. Benzene derived organic acid used as peptizing agent C_6H_5COOH
22. Corn-derived protein, soluble in alcohol
24. Unit of heat measurement
25. Harmonious color grouping
26. Turpentine solvent
27. Chemical test for unsaturation of organic molecules
29. A red sulfide derivative of mercury used as a pigment
30. Common ketone solvent (Abr.)

DOWN

2. Naturally occurring form of 1 Across
4. Chemical compound which can be either acidic or basic
5. Curing T_____
6. Use this to fill small holes or cracks in metal or wood
7. White crystalline pigment for corrosion resistance
9. To be in between and resistant
11. Glassy component of traffic paints
13. Mixture of 1 Across, glue, and water
16. Material used to kill microbes
18. Shellac has this acid
19. Pointed; sharp
20. Air-drying liquid—forms clear films
21. Not quite the bee's knees
23. What some get at the company picnic, _____ed
28. Film which may form on the surface of a stored can of paint

Latest Advances in Coatings Science and Technology Focus of Conference Scheduled December 3-7

The "First North American Research Conference on Organic Coatings Science and Technology" will be held on December 3-7, at the Marriott's Hilton Head Resort, Hilton Head, SC.

The international conference has been organized by the Institute of Materials Science, State University of New York (SUNY), New Paltz, NY, and sponsored by The Division of Polymeric Materials Science and Engineering of the American Chemical Society.

The Gordon Research Conference on Coatings and Thin Films is now on a two-year cycle. The First North American Conference on Organic Coatings Science and Technology will be presented every other year, and will provide a forum for discussing the latest advances in coatings science and technology from a global perspective. The focus will be on current and future concerns for the environment in the context of low VOC coatings science and technology, and will examine coatings durability.

Themes for the 1990 conference will include: Advances in Characterization and Synthesis; Role of Supercritical Fluids in Coatings Technology; Scientific Advances in High Solids and Powder Coatings; and Recent Advances in Epoxy Chemistry and Technology.

Presentations to be delivered during the conference sessions are as follows:

"NMR Imaging Applied to Coatings and Adhesives"—Jack Koenig, of Case Western Reserve University;

"Characterization of Polymers and Coatings by Thermal Stimulated Current (TSC) and Relaxation Map Analysis Spectroscopy (RMA)"—Jean Pierre Ibar, of Solomat Instrumentation;

"Functionalization of Acrylic Polymers and Polyolefins by Chemical Modification and Copolymerization"—Francesco Ciardelli, of University of Pisa;

"Radiation Induced Cationic Polymerization of Vinyl Ethers"—Sonny Jonsson, of Beckers R&D;

"Thermodynamics of Polymer Super Critical Fluid Mixtures"—Marc Donohue, of Johns Hopkins University;

"Determination of Phase Phenomena of Coatings Materials in Super Critical Carbon Dioxide"—David C. Busby, of Union Carbide Technical Center;

"Atomization Characteristics of Coatings Sprayed with Super Critical Carbon Dioxide"—Kenneth M. Perry, of Union Carbide Technical Center;

"Finishing of Automotive Components by Super Critical Carbon Dioxide Sprayed Paints"—James C. Perry, of General Motors Technical Center;

"Chemical Evaluation of High Solids Coatings Weatherability"—David R. Bauer, of Ford Motor Company;

"Thermoset Powder Coatings: Catalysis and Tribo-Charging of Polyester-Epoxy Systems"—A.F.M.J. van der Ploeg, of DSM-Resins BV;

"Dual-Curable Compositions for High Solids Coatings"—Michael C. Palzotto, of 3M Company;

"New Reactive Diluents for Reactive Coatings"—Stoil Dirlikov, of Eastern Michigan University;

"Photopolymerization Using Pulsed Lasers: Applications for High Solids Coatings"—Charles E. Hoyle, of University of Southern Mississippi;

"Anomalous Glassy-State Properties of Thermosets vs Extent of Cure: Density, Modulus, Water Adsorption, Stresses, and Physical Aging"—John K. Gillham, of Princeton University;

"Mechanics of Thin Coatings and Stress Determination in Coated Parts"—Richard J. Farris, of University of Massachusetts;

"Effects of Physical Aging on Polyol/Melamine Coating Films"—Peter Jan Greidanus, of DSM Research and Patents;

"Models of Glass Transitions of Coatings Polymers"—Robert W. Johnson, of DeSoto, Inc;

"Low Viscosity Epoxy Resin Exhibiting Lacquer Dry Characteristics"—M.B. Cavitt and D.D. Waters, of Dow Chemical U.S.A.;

Performance Enhancement of High Solids Epoxy In-Situ Advancement Coatings by Epoxy Phosphate Esters"—J.L. Massingill and R.C. Whiteside, of Dow Chemical U.S.A.; and

"Structure Property Relations for Epoxy/Anhydride Resin Systems"—P.H. Corcoran and Y.K. Lee, of DuPont Marshall Labs.

For additional information, contact Angelos V. Patsis, Director, Institute of Materials Science, SUNY, New Paltz, NY 12561.

Coatings Research Center Under Development at EMU

The College of Technology of Eastern Michigan University (EMU), Ypsilanti, MI, is using a $50,000 grant by the National Science Foundation (NSF) to develop an NSF Coatings Research Center on the EMU campus.

The center will be an EMU/NSF/industry cooperative and will work as a partnership to conduct contract research.

Ten member companies, paying $30,000 each, will join the center in its first year and will be given regular and early access to research findings, as well as patent rights, as a benefit of their membership.

Among the first 10 member companies are: South Coast Air Quality Management District; RTZ Chemicals Interchem Inc.; PRA Laboratories; Oakite Products Inc.; H.H. Robertson Company Building Products Technical Center; Flint Ink Corporation; Ford Motor Company; The Dexter Corporation; and the State of Michigan.

A projected membership of 20 companies and a $600,000 annual budget is targeted for 1995-96. Until that time, NSF has committed $50,000 a year, or a total of $250,000, to help fund the center. Also, EMU intends to add two member companies annually to the inaugural 10 until the targeted membership of 20 is reached in 1995-96.

The NSF Coatings Research Center will operate out of Sill Hall and will use an industrial advisory board to examine project proposals and make research awards. Faculty from the EMU Department of Chemical Engineering will participate in the center.

The Coatings Research Center, which is expected to begin operations this year, will serve as a research, communications, and problem-solving unit with regard to the coatings field and will aid in the training of coatings scientists.

University of Missouri-Rolla to Offer Two Coatings Short Courses in Spring 1991

The Coatings and Polymer Science Program in the Department of Chemistry at the the University of Missouri-Rolla (UMR), Rolla, MO, is offering two short courses for the spring of 1991.

The "62nd Introductory Short Course: Basic Composition of Coatings" is scheduled for March 11-15, 1991. The course is designed to introduce the newcomer, as well as those involved in raw material manufacture, sales, and technical service, to the technical aspects of paint composition, manufacture, testing, and use.

Topics to be discussed include: history of paint; materials used in manufacture; simple formulating techniques that can be put to immediate use; introduction to the equipment used to make and test modern protective coatings, and modern chemical instrumentation applied to coatings; and simple costing that allows beginners to start on a stable economic basis.

Particular attention will be given to the needs of newcomers to the coatings industry in laboratories, production units, or marketing groups.

Time will be allowed for private, in-depth conversations to explore special problems. Featured guest lecturers from industry will discuss new ideas.

The "22nd Introductory Short Course: Paint Formulation" is slated for March 25-29, 1991. The class will consist of classroom and laboratory work designed to teach the formulation of paints to meet specific requirements.

Included among the subjects to be discussed are: basic raw materials and their influences on the performance of the finished coating; formulation and testing of coatings in the laboratory to meet the special demands of the job; limitations of plant production equipment and formulation variables for moving a coating from the lab to the plant; modern chemical instrumentation as applied to coatings; and statistical experimental design.

Continuing Education Units will be awarded for successful completion of each short course.

For more information about course content, contact Michael Van De Mark, Director, Coatings and Polymer Science, UMR, Rolla, MO 65401-0249.To register, contact Norma R. Fleming, Continuing Education Coordinator, UMR, Rolla, MO 65401-0249.

Radtech Europe '91 Slated for Sept. 29-Oct. 2, in Edinburgh

The Radtech Europe Conference '91 will be held at the Edinburgh Exhibition and Trade Centre, on September 29-October 2, 1991. An exhibition will be run concurrently in the Royal Highland Exhibition Hall, making the event the first fully international conference and exhibition to be held in the United Kingdom devoted entirely to radiation curing.

Featured during Radtech '91 will be scientific lectures and a student workshop aimed at personnel who are inexperienced in radiation technology.

For further information on Radtech '91, write Conference Secretary, Radtech '91, c/o PRA, Waldegrave Rd., Teddington, Middlesex, TW11 8LD, United Kingdom.

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Louisville Society Co-Sponsors Surface Coatings II Course

The Louisville Society for Coatings Technology and the Department of Chemical Engineering, Speed Scientific School, University of Louisville, are co-sponsoring "Surface Coatings Technology II: Pigments, Solvents, and Additives." The course is being conducted currently at University of Louisville's Belknap Campus and will end on December 11.

The class is a 15-week overview of the non-resinous coating raw materials. The properties of these materials and their contribution to the final coating will be discussed.

Topics scheduled to be covered include: introduction to coatings technology; solvents and plasticizers; introduction to pigments; white and extender pigments; introduction to color and appearance; inorganic color pigments; organic color pigments; specialty pigments; anti-corrosive technologies; additives for pigment dispersion; rheology-control additives; surface-control additives; stabilizing additives; catalytic additives; and additives for water-borne coatings.

The class is designed for chemists, chemical engineers, technicians, and other coatings personnel.

Contact Louisville Society Educational Committee Chairman Paul R. Baukema at Akzo Coatings, Inc., R&D Div., P.O. Box 37230, Louisville, KY 40233 for more details on the course.

Chemical Technician—Coatings Courses Being Sponsored by George Brown College

George Brown College is sponsoring evening courses in Coatings and Plastics Technology at the St. James Campus, in Toronto, Ont., Canada. The courses are approved by the Ministry of Colleges and Universities, and certified jointly by the College and the Toronto Society for Coatings Technology.

Courses underway currently include: "Plastic Materials"; "Resins B"; "Non-Polymeric Constituents of Coatings"; "Organic Coatings"; and "Coatings Laboratory."

The "Plastics" class is focusing on types, properties, structure, applications, identification, and degradation and stabilization of plastics. Also being covered are additives and reinforcements, and rheology.

"Resins B" topics are raw materials, manufacturing method types, properties, chemistry, curing, formulating for special properties, characterization, analysis and applications in coatings of polyurethanes, acrylics, and emulsions.

Detailed study of pigments, solvents, flame retardants, plasticizers, surfactants, and additives for solvent-based and water-borne coatings are included during course discussion.

"Organic Coatings" subjects are: raw materials—oil, resins, solvents, driers, additives, primer and extender pigments; formulations and properties of organic coatings; principles of formulation; film formation; dispersion; testing; lacquers and varnishes; trades sales, industrial, corrosion, chemical resistant, powder, high-solids, and water-borne coatings; and preparation and application methods.

The "Coatings Lab" requires the "Organics Coatings" class as a prerequisite. It features quality control of raw materials; preparation and evaluation of lacquers, varnishes, and water-borne coatings; and report writing.

The courses scheduled are designed to be taken separately. Credits may be accumulated towards the Chemical Technician—Coatings Certificate and/or Diploma.

For information on the coatings courses, write George Brown College, St. James Campus, 200 King St. E., Toronto, Ont., M5T 2T9 Canada.

Munsell Lab to Conduct Color Reproduction Course

The Munsell Color Science Laboratory of the Rochester Institute of Technology (RIT), Rochester, NY, will present the intensive short course "Principles of Color Reproduction," on October 17-19. The class will be taught by Dr. R.W.G. Hunt, former member of the Kodak Research Laboratories and international expert in the field.

The course subject matter is designed for scientists, engineers, computer programmers, and managers from the photography, television, graphic arts, and electron imaging industries.

The program will examine the following topics: the visual system; color vision; color atlases and light sources; spectrophotometry; R,G,B, colorimetry; CIE systems; color discrimination; trichromatic color reproduction; additive and substrate methods; sensitometry; television technology; and printing technology.

For additional details, contact Colleen McCabe, Munsell Color Science Laboratory, RIT, P.O. Box 9887, Rochester, NY 14623-0087.

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Eastern Michigan Installs New "Laboratory" Software

Eastern Michigan University (EMU), Ypsilanti, MI, has acquired and installed the software program "Desk Top Laboratory," fro DSA Consultant Inc. The announcement was made by Taki J. Anagnostou, Professor and Program Coordinator of EMU's Polymer and Coating Technology.

The purchase of the instructional aid was made possible by a grant from the Detroit Paint and Coatings Association so that coating students can be computer instructed in the formulation of various coating systems. The software has found major acceptance with European coating companies and also has been installed in several American operations.

Proper utilization of the program enables a formulator to control, understand, and accurately predict formulation properties such as hide, gloss, dispersion, and viscosity. In addition, systems can be adjusted to be crosslinked with various functional groups such as alkoxyl melamines, epoxies, and isocyanates and is easily adaptable to any other crosslinking chemistry. The program is unique in its approach to a formula cost, solvent, and pigment analysis.

Through the use of the "Desktop Formulator," students can become acquainted with the normal practices and methods of the coatings industry as they apply to raw material coding, bulking, and proper dispersion techniques.

Color Seminar Schedule Announced by HunterLab

The schedule for the "Color and Appearance" seminars sponsored by HunterLab, Reston, VA, has been announced.

Dates and locations for the color seminar are as follows: October 17-18—Washington, D.C.; November 14-15—Cincinnati, OH; and December 5-6—Dallas, TX.

The one-day program emphasizes practical solutions and techniques of color and appearance control. Topics to be covered include understanding appearance, color scales, tolerance setting, instrument geometries, and practical applications. An optional second day offers a hands-on laboratory session.

Contact Janet Whaley, HunterLab, 11491 Sunset Hills Rd., Reston, VA 22090 for additional details.

Ninth Annual ICASC Seminar Scheduled for October 16

The Ninth Annual Symposium "Wetting, Spreading, and Leveling," sponsored by the InterUniversity Center for Adhesives, Sealants, and Coatings (ICASC), is slated for October 16, at the Buckingham Center for Continuing Education at the University of Akron, Akron, OH.

Papers to be presented include:

"Fundamentals of Wetting, Spreading, and Leveling"—J.A. Mann, Case Western Reserve University;

"Wetting and Wettability of Substrates for Coating"—C.K. Schoff, of PPG Industries, Inc.;

"The Kinetics of Displacement Wetting in Liquid/Liquid Solid Systems"—R.T. Foister, of General Motors Research Lab;

"Wetting Pertaining to Practical Adhesion Bonding"—H. Schonhorn, of Kendall Company;

"Surface Engineering by Self-Assembling Mixed Monolayers"—A. Ulman, of Eastman Kodak; and

"The Rheology of Adhesive Emulsion"—R.L. Hoffman, of Monsanto Company.

For additional details on the seminar, write ICASC, Millis Science Center, Case Western Reserve University, Cleveland, OH 44106.

CALL FOR PAPERS

"Comparison of Color Images Presented in Different Media"

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February 23-26, 1992 Colonial Williamsburg, VA

All prospective authors are invited to submit papers for the "Comparison of Color Images Presented in Different Media" conference cosponsored by the Inter-Society Color Council and the Technical Association of Graphic Arts, on February 23-26, 1992, at Colonial Williamsburg, VA.

The conference will focus on the difficulties encountered when comparing images presented in different media that are intended to simulate each other or another image. The objectives of the conference will be to identify the problems involved in comparing images displayed in different media. It will address such topics as color space transformation, ambient conditions, viewing geometry, surface properties, and adaptation. The present status of inter media image comparison, identification of the significant factors involved, and exploration of the technology used in such comparisons will be discussed.

The conference will be technical in nature and will consist of invited and contributed papers emphasizing the exchange of information and discussion. Papers of a commercial nature will not be accepted. Contributed papers will consist of a 30-minute presentation. Extended abstracts will be available prior to the conference and a conference proceedings will be published.

Anyone wishing to present a paper should submit a title and abstract by March 1, 1991. The title and abstract should not exceed 750 words. Names of authors, affiliations, and principal author's address, and day time telephone number should be sent to: Milton Pearson, RIT Research Corp., 75 Highpower Rd., Rochester, NY 14623.

Authors will be notified of acceptance by June 1, 1991.

Aliphatic Isocyanates

The applications and characteristics of a new aliphatic isocyanate are described in a new technical brochure. The 12-page publication details the chemical and performance characteristics of the product, as well as toxicological properties. Suggested applications for the aliphatic isocyanate include such areas as specialty coatings, aqueous dispersions, roof and deck coatings, floor coatings, concrete and wood coatings, castable elastomers, potting compounds, sealants, adhesives, urethanes, thermoplastics, and lacquers. For more information, contact American Cyanamid Co., One Cyanamid Plaza, Wayne, NJ 07470.

Modified Polyolefin Resin

An air dry modified polyolefin resin for penetrating stains on vertical wood surfaces is the focus of a newly released technical data sheet. Shipped at 100% solids, the polyolefin is designed to provide increased package and shelf stability. To learn more about Resin 155-1380 or other water reducible stain vehicles, write: Cargill, P.O. Box 5630, Minneapolis, MN 55440.

Solvent Recovery System

Literature has been published which introduces an on-site solvent recovery system featuring closed-loop operation to recirculate cooling water, solid-state controls with fiberoptic interfacing and a patented liner for residue disposal. More details on Recyclene® R-2AX systems are available from: Elizabeth Miller, Product Manager, Siva International Inc., 405 Eccles Ave., S. San Francisco, CA 94080.

Potentiostat

A completely computer-controlled potentiostat is the subject of recently released literature. For complete details on VersaStat™, write to: EG&G Princeton Applied Research, P.O. Box 2565, Princeton, NJ 08543-2565.

Process Viscometer

A recently published four-color brochure describes the viscosity measurement and application of a process viscometer. The instrument is a rotational concentric cylinder which measures viscosity by sensing the viscous drag on a patented torque tube system. For more details, contact: Louis DiCorpo, Brookfield Engineering Labs., Dept. NR-79, 240 Cushing St., Stoughton, MA 02072.

Surfactants

Information has been released which details a company's line of surfactants and low-VOC resins. The products include several recent acquisitions, as well as aliphatic polyisocyanates, which feature a new HDT-LV low-viscosity trimer for low-VOC applications. For complete details, contact Rhone-Poulenc Inc., Specialty Chemicals Group, CN 7500, Cranbury, NJ 08512-7500.

X-Ray Fluorescence System

A new four-page brochure describes a new table top x-ray fluorescence coating thickness measurement system. According to the literature, the system measures the thickness of most coatings, including multilayer coatings on any base and also inspects small diameter parts, or dual coatings such as gold and nickel over copper. For a copy of the brochure, contact CMI International, 2301 Arthur Ave., Elk Grove Village, IL 60007.

Controlled Lighting Cabinet

Recently released literature details the features of a new controlled lighting cabinet which reportedly complements a computer color control system by providing the means for accurate visual assessment of color samples and materials. More information on the TRU-VUE can be obtained by contacting Applied Color Systems, P.O. Box 5800, Princeton, NJ 08543.

Acrylic Emulsion

An acrylic copolymer, designed for use in premium roof coatings and elastomeric wall coatings and mastics, is highlighted in a new data sheet. The publication describes the typical properties of the emulsion, which has a high pigment binding capacity and is compatible with commonly used extenders and paint additives. For a copy of "FLEXBOND® 471 Acrylic Emulsion," contact Air Products and Chemicals, Inc., Polymer Chemicals Div., 7201 Hamilton Blvd., Allentown, PA 18195-1501.

Mass Spectrometer

Technical information has been released which describes a fully mobile mass spectrometer designed for on-site environmental analyses. For more information, contact Dr. J. Wronka, Bruker Instruments, Inc., Manning Park, Billerica, MA 01821.

Raw Materials Inventory

An updated inventory of raw materials for organic pigments listed under the Toxic Substances Control Act (TSCA) has been published. The new brochure provides an alphabetical listing by standard commercial name of the key organic pigment raw materials. Tables include chemical names, formulae, Colour Index names, and CAS registry numbers. The brochure is available from Sun Chemical Corp., Sales Office, 411 Sun Ave., Cincinnati, OH 45232.

Two-Component Epoxies

A two-component, new generation, interior water-borne epoxy has been introduced in literature. This polyamide epoxy coating hardens to a nonporous finish is designed for use on most interior architectural or industrial surfaces. Additional details on Mira-Plate II may be obtained by writing: The O'Brien Corporation, 450 E. Grand Ave., S. San Francisco, CA 94080.

Check Valves for Tubing

A new line of high performance thermoplastic tubing check valves has been introduced in technical literature. The tubing checks are designed to perform with many different applications, including liquids, gases, pressure and vacuum. To obtain a copy of the literature, write Plast-O-Matic Valves, Inc., 430 Route 46, Totowa, NJ 07512.

Corrosion Resistant Mixers

A new 12-page, full-color brochure describes a company's line of mixers and features a new corrosion resistant model. Bulletin B-564 provides technical information, performance capabilities and photographs which compare the product's mixing results with those of traditional mixers. For a free copy of the brochure, contact Maude Hall, Lightnin, 221 Rochester St., P.O,. Box 190, Avon, NY 14414.

Low Toxicity Solvents

Recently published technical information describes a line of high performance, low toxicity solvents, including propylene glycol-based solvents, n-methyl pyrrolidone propylene carbonate and other specialty chemicals for the paint and coatings industry. Information on formulations and characteristics can be obtained from ARCO Chemical Company, 3801 West Chester Pike, Newtown Square, PA 19073.

Styrene-Acrylic Emulsions

Data sheets on eight Vancryl™ products used in formulating inks and/or coatings have been issued. The data sheets provide information on the products' physical and performance properties, along with suggested starting formulations. Covered products include five styrene-acrylic emulsions intended for various applications, as well as a solid acrylic emulsion, a solid acrylic resin, a resin solution, and an acrylic colloidal dispersion. For copies of the data sheets, contact Air Products and Chemicals, Inc., Polymer Chemicals Div., 7201 Hamilton Blvd., Allentown, PA 18195-1501.

Environmental Risk Management

The Air & Waste Management Association has published a 258-page book which contains proceedings of an international specialty conference on environmental risk management in North America. The book, which includes 21 papers by leading decision-makers from government and industry, costs $35 for association members and $50 for nonmembers. To order "Managing Environmental Risks," send a prepaid order (Order Code SP-73) in U.S. funds to the Air & Waste Management Association, P.O. Box 2861, Pittsburgh, PA 15230.

Ultramicrobalances

A new four-color brochure describes a company line of microprocessor controlled ultramicrobalances. These fully automated balances are designed to weigh samples from 0.1 g up to 1000 mg. For a free copy of the brochure, "The Perkin-Elmer AD Series Autobalances," write: The Perkin-Elmer Corp., 761 Main Ave., Norwalk, CT 06859-0012.

Powder Coatings

To help managers make smooth transitions from liquid to powder coatings, the Society of Manufacturing Engineers (SME), in cooperation with the Association for Finishing Processes of SME, have published a book entitled "Powder Coating Applications." Topics covered in the 265-page, hardcover book range from powder material and their applications, pre-treatment equipment, application and recovery systems, curing and conveyor equipment, safety, and quality control to powder coating processes. The book is available for $42 (SME members—$34). contact the Customer Service Department of SME, One SME Dr., P.O. Box 930, Dearborn, MI 48121-0930 for more information on the publication.

Rheometer

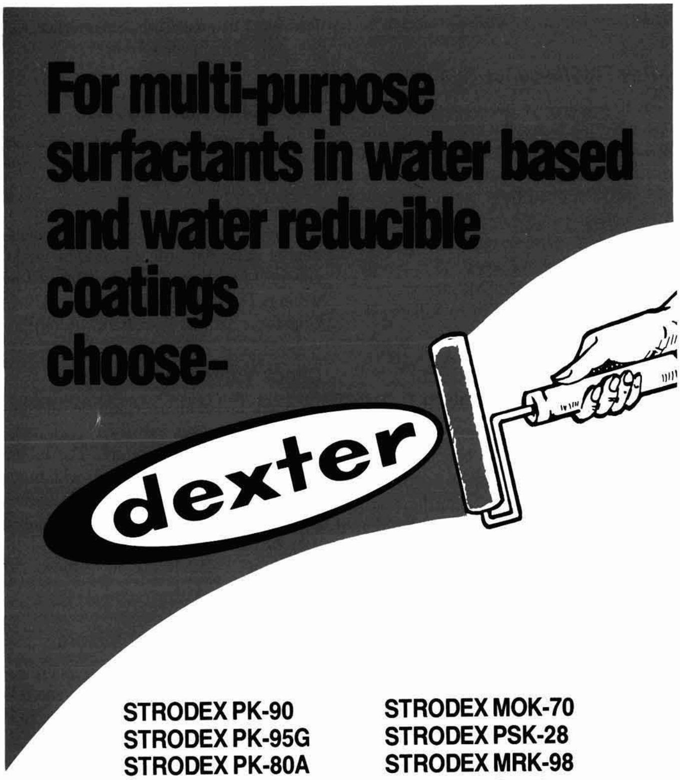
Information has been released on a controlled stress melts rheometer which utilizes an electrically heated couette geometry. The system provides sensitivity for measurements up to 400°C on low viscosity samples and a static thermal environment for long sample stability while minimizing contributions due to edge effects. Contact Laura Migliore, Bohlin Reologi Inc., 2540 Rt. 130, #105, Cranbury, NJ 08512 for more details.

Water-Borne Silanes

A new series of water-borne organofunctional silanes has been introduced in literature. The silanes contain no volatile carriers or byproducts and are water-reducible. Currently, 12 water-borne silane products have been developed and are available for a variety of industrial uses. For more information, contact Elizabeth C. Crann, Huls America Inc., Turner Place, P.O. Box 365, Piscataway, NJ 08855-0365.

Water-Borne Urethane Polymers

A series of aliphatic water-borne urethane polymers is the focus of technical information. The polymers, fully reacted, high molecular weight colloidal dispersions, provide continuous films when dried at room temperature and can be applied using conventional techniques. Contact Sanncor Industries, Inc., 300 Whitney St., Leominster, MA 01453-3209 for more details on the Sancure 2100 Series.



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Nonmercurial In-Can Preservative

A nonmercurial, broad-spectrum antimicrobial that provides in-can preservative for the protection of latex based coatings is the focus of a newly published technical data sheet. For more information on Canguard™ 327, contact ANGUS Chemical Co., 2211 Sanders Rd., Northbrook, IL 60062.

Crosslinking Resin

The introduction of a new amino powder coating resin has been made in literature. The resin, which will be available by the fourth quarter of the year, reportedly offers impact resistance, gloss, hardness, powder stability, light stability, and resistance properties. Additional information can be obtained by contacting American Cyanamid Co., One Cyanamid Plaza, Wayne, NJ 07470.

Vapor Injection Cure System

A new brochure describing a vapor injection cure and vapor permeation cure systems for polyurethane coatings has been released. Suggested applications include vinyl film laminate for furniture, simulated leather goods, wall coverings, and flat stock wood. To obtain a copy of the brochure on VIC® and VPC® technology, write: Ashland Chemical, Inc., P.O. Box 2219, Columbus, OH 43216.

Phenolic Resins

A six-page booklet on a thermosetting phenolic resin developed for high-quality baking coatings for food can interiors and other metal finishing applications has been published. According to the booklet, features of coatings based on the phenolic resin include resistance to heat, corrosion, chemicals, stains and blush, as well as adhesion to tin-plated steel and other metals. Additional applications include coil coating primers, and coatings for process equipment and general metal protection. Copies of the booklet, "UCAR® Phenolic Resin CKS-3892," designated F-60761, are available from Union Carbide Chemicals and Plastics Co., Inc., UCAR Coatings Resins, Dept. L4489, 39 Old Ridgebury Rd., Danbury, CT 06817-0001.

Preparation Detergents

Recently released technical information describes a new series of preparation detergents which contain no alkylphenols. The products are suitable for all stages of preparation and all types of batch and continuous equipment for both woven and knit goods. For details, contact Dexter Chemical Corp., 845 Edgewater Rd., Bronx, NY 10474.

Waste Container Coatings

A newly published brochure provides information on a complete line of air-drying enamel products and undercoat primers specially developed for the waste container industry. The four-color, four-page brochure, "Waste Container Coatings," presents performance characteristics, product data, and quality charts on VOC compliant solvent-reducible enamels For copies, contact Sherwin-Williams Stores Group, c/o Robert Silverman Co., 1375 Euclid Ave., Cleveland, OH 44115.

Concrete Floor Coating

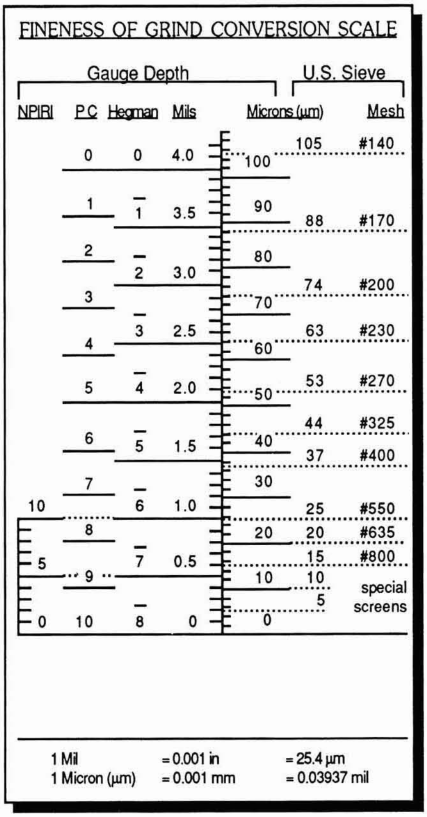
A free information kit on a new coating for concrete floors is available. These coatings meet EPA standards for low VOC emissions and protect concrete floors from impact, abrasion, and chemicals. The kit includes technical data, diagrams, and selections and application information. Request the "Free Information Kit on Chemglaze® CRU Coatings for Concrete Floors," from: Lord Corp., Industrial Coatings, 2000 W. Grandview Blvd., P.O. Box 10038, Erie, PA 16514-0038.

Letters to the Editor

To the Editor:

I am enclosing a quite useful "fineness of grind conversion scale" which was sent to me. It is quite useful to incoming chemists and laboratory technicians when checking various viscosities.

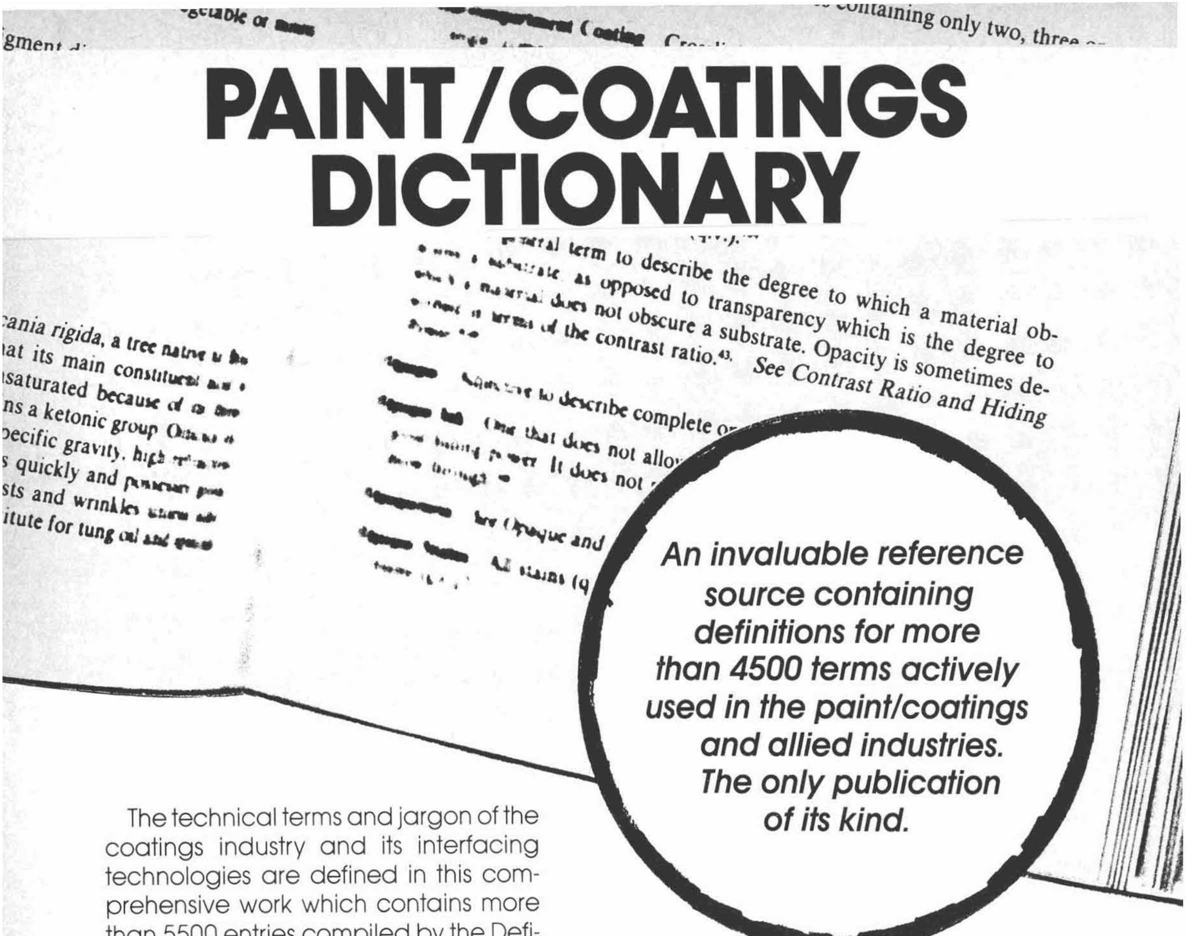
John C. Ballard
Kurfees Coatings, Inc.
Louisville, KY 40202



The measurement and reporting of particle size is often confusing and contradictory. For example, as Hegman value decreases, the actual size of particles in inks and coatings increases. This upside down relationship, and rightside up relationship of mils vs microns is succinctly exhibited in the Fineness of Grind Conversion Scale.

For a free copy of the Fineness of Grind Conversion Scale, send a stamped self-addressed envelope to Flanagan Associates Inc., 10999 Reed Hartman Highway, Suite 139, Cincinnati, Ohio 45242.—Ed.

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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Book Review

PAINTING OF STEEL BRIDGES AND OTHER STRUCTURES

By
Clive H. Hare

Published by
Van Nostrand Reinhold
115 Fifth Avenue
New York, NY 10003 (1990)
xii + 303 Pages

Reviewed by
Charles R. Hegedus
Naval Air Development Center
Warminster, PA

This text provides a thorough presentation and discussion of the design and use of protective coatings for steel structures, especially bridges. Through the 11 chapters and numerous figures and tables, the author goes far beyond discussion of typical binders and pigments. In addition to detailed descriptions of surface preparation and coating systems, the book provides a discussion of issues such as job execution, in-service monitoring, and costs. Therefore, it is a good reference for both the coatings chemist and design engineer, as well as others involved with the design, painting, and maintenance of exterior steel structures.

The introductory chapter provides an abstracted history of coatings used on bridges dating back to the early 1800s. Chapters 3-5 specifically address information on surface preparation, coating system description and performance, and coating system selection/specifications, respectively. Much of this information is provided in enough detail to be useful without being burdensome or boring. Along with the obvious practical applications of the material, this presentation provides the reader with an interesting feel for the evolution of coating systems and their performance. As most authors of this type of text are compelled to do, Mr. Hare includes a chapter on corrosion control. The beneficial aspects of this chapter are its discussion, specifically on inhibitive, sacrificial, and barrier coatings, along with its 125 references.

Chapters 6-9 discuss job execution, quality assurance and control, in-service monitoring, and painting costs, respectively. These chapters are particularly useful to contractors, procurement officers, and maintenance engineers. The discussion on job execution centers mainly on contracting aspects such as contracting methodologies, contractor qualifications, and the bidding and reward process. Other information pro-

(Continued on page 158.)

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Book Review
Continued from page 157.

vided in this chapter concerns job preparation, rigging and equipment, and paint application procedures. The latter seems somewhat out of place relative to other information in the chapter; however, it is necessary for a complete presentation of the subject.

It was reassuring to read such a thorough presentation on inspection since this is one of the most important functions for quality assurance during the painting process and for maintenance considerations throughout the lifetime of the structure. Sections on inspector training, qualifications, duties, and requirements spell out what a good inspector should know and do. A separate section is provided on material assurance and control.

Three tables with Chapter 8 compare the service performance of sacrificial, inhibitive, and barrier coatings on bridges. Discussions on failure analysis and causes are provided also. Due to the thorough presentation on inspection for quality assurance, it is surprising that there is not a section which fully addresses in-service inspection. The techniques and instrumentation utilized are not necessarily the same. This would be a beneficial addition to the text in a second edition.

Chapter 9 provides an interesting presentation of the costs of painting (labor, rigging, freight, materials, etc.). Methods for determining these costs and bid calculations are provided. Although this section may be old hat for those in the paint calculating business, it is certainly interesting to others in the paint industry who are not usually involved with this end of the business. There are tables which provide a detailed comparison of the costs of various coating systems. Finally, there is a discussion of a model for determining bridge corrosion costs which is at least interesting and may be useful to those directly concerned with such issues.

In the last two chapters, the author discusses trends and conclusions/recommendations, respectively. The value of discussing ongoing and future concerns may be considered suspect, but the author's experience has allowed him to form some valuable opinions on what issues need to be addressed. It should be noted that, as with the aircraft industry, concerns over the safety of aging bridges is growing. Therefore, emphasizing this subject is valid. The conclusions and recommendations chapter tie the previous 10 chapters together in a well summarized synopsis.

This book is practical and presents a part of the painting industry not many of us see. It is a must for those directly involved with painting steel structure for day-to-day use. It also can serve as a general information document for those in other areas of the paint industry.

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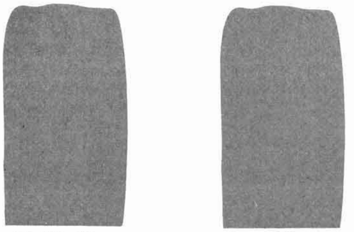
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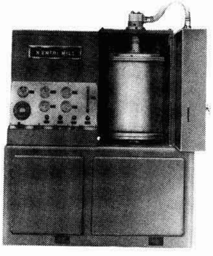
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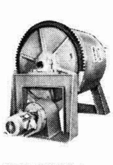
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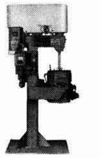
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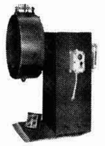
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Coming Events

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.

1990

(Oct. 29-31)—68th Annual Meeting and 55th Paint Industries' Show. Convention Center, Washington, D.C.

1991

(Nov. 4-6)—69th Annual Meeting and 56th Paint Industries' Show. Convention Center, Toronto, Ontario, Canada.

1992

(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

1991

(Feb. 6-8)—Southern Society. 18th Annual Water-Borne, 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 Polymer Science, USM, Southern Station, P.O. Box 10076, Hattiesburg, MS 39406-0076).

(Feb. 18-20)—Western Coatings Societies' 20th Biennial Symposium and Show. Hilton Hotel, San Francisco, CA. (Patricia Stull, Pacific Coast Chemicals, 2424—4th St., Berkeley, CA 94710).

(Mar. 13-15)—Dallas and Houston Societies. Southwestern Paint Convention. Dallas, TX.

(Apr. 3-6)—Southern Society Annual Meeting. The Peabody Hotel, Memphis, TN. (Vernon Sauls, McCullough & Benton, P.O. Box 272360, Tampa, FL 33688).

(May 2-4)—Pacific Northwest Society. Annual Symposium. Meridien Hotel, Vancouver, British Columbia, Canada. (John P. Berghuis, Kronos Canada, Inc., 3450 Wellington Ave., Vancouver, B.C., Canada V5R 4Y4).

(June 7-8)—Joint Meeting of the St. Louis and Kansas City Societies. Holiday Inn, Lake of the Ozarks, MO.

OTHER ORGANIZATIONS

1990

(Oct. 14-18)—"Corrosion Engineering of the Future." Seminar sponsored by the National Association of Corrosion Engineers (NACE) and the U.S. Armed Forces. Richmond, VA. (Gary Wiatrek, Membership Services Coordinator, NACE, P.O. Box 218340, Houston, TX 77218).

(Oct. 14-19)—ISA/90. Conference and exhibition sponsored by The Instrument Society of America (ISA). New Orleans, LA. (Brian Duckett, ISA, 67 Alexander Dr., P.O. Box 12277, Research Triangle Park, NC 27709).

(Oct. 15-19)—"Introductions to Coatings Technology." 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. 16)—"Wetting, Spreading, and Leveling." Ninth Annual Symposium sponsored by the Interuniversity Center for Adhesives, Sealants, and Coatings (ICASC). Buckingham Center for Continuing Education, The University of Akron, Akron, OH. (ICASC, Millis Science Center, Case Western Reserve University, Cleveland, OH 44106).

(Oct. 17-19)—Airpol '90. Seminar sponsored by National Association of Corrosion Engineers (NACE). Galt House, Louisville, KY. (NACE, Education and Training, P.O. Box 218340, Houston, TX 77218).

(Oct. 17-19)—"Principles of Color Reproduction." Short course sponsored by The Munsell Color Science Laboratory. Chester F. Carlson Center for Imaging Science, Rochester Institute of Technology (RIT), Rochester, NY. (Colleen McCabe, Munsell Color Science Laboratory, RIT, P.O. Box 9887, Rochester, NY 14623-0887).

(Oct. 23-24)—"Management of Industrial Wastewater: Minimization & Treatment." Symposium sponsored by Society of Manufacturing Engineers (SME). Ramada Inn, Somerset, NJ. (Lisa Machnacki, SME, Conference Dept., One SME Dr., P.O. Box 930, Dearborn, MI 48121-0930).

(Oct. 25-26)—"Water in Exterior Building Walls: Problems and Solutions." Symposium sponsored by ASTM. Dearborn, MI. (Thomas A. Schwartz, Symposium Chairman, Simpson Gumpertz & Heger, Inc., 297 Broadway, Arlington, MA 02174).

(Oct. 29-31)—"Fail-Safe Plastics." Seminar sponsored by Plastics Consultant 1990. Sheraton Fisherman's Wharf, San Francisco, CA. (Maro Communications Inc., P.O. Box 44092, Tucson, AZ 85733).

(Oct. 30-31)—"Prepainted Metal: A Manufacturing Solution for the '90s." Seminar cosponsored by The National Coil Coaters Association (NCCA) and The Society of Manufacturing Engineers (SME). Hyatt Regency, Oak Brook, IL. (NCCA, 1900 Arch St., Philadelphia, PA 19103 or SME, One SME Dr., P.O. Box 930, Dearborn, MI 48121-0930).

(Oct. 31-Nov. 1)—"How Environmental Regulations in the United States Control the Paint and Coatings Industry." Course co-sponsored by the University of Oxford, Department of External Studies, and the University of California, Berkeley, Continuing Education in Engineering, University Extension. Oxford, England. (CPD Unit, University of Oxford, Department for External Studies, 1 Wellington Square, Oxford OX1 2JA, England).

(Oct. 31-Nov. 2)—103rd Annual Meeting of the National Paint and Coatings Association (NPCA). Washington, D.C. (NPCA, 1500 Rhode Island Ave., N.W., Washington, D.C. 20005).

(Oct. 31-Nov. 2)—"Advances in Polymer Colloids (Emulsion Polymers): Polymerization, Characterization, and Applications." Short course sponsored by State University of New York (SUNY). Orlando, FL. (A.V. Patsis, Institute of Materials Science, CSB 209, SUNY, New Paltz, NY 12561).

(Nov. 1-2)—"Measuring Paint Volatile Organic Compounds (VOC)." Training course sponsored by ASTM. Holiday Inn-Washington, Washington, D.C. (Kathy Dickinson, ASTM, 1916 Race St., Philadelphia, PA 19103).

(Nov. 4-9)—Euro/Surfas '90. 11th Surface Treatment Exhibition. Barcelona, Spain. (Euro/Surface '90 Surface Treatment, Avda. Reina M.ª Cristina, s/n., 08004 Barcelona, Spain).

(Nov. 5-7)—"Copolymer Blends & Alloys—How to Hit the Jackpot." Seminar sponsored by Plastics Consultant 1990. Sheraton World Resort, Orlando, FL. (Maro Communications Inc., P.O. Box 44092, Tucson, AZ 85733).

(Nov. 5-7)—"Failure Prevention of Polyethylene Flexible Membrane Liners for Landfills." Seminar sponsored by Plastics Consultant 1990. Sheraton World Resort, Orlando, FL. (Maro Communications Inc., P.O. Box 44092, Tucson, AZ 85733).

(Nov. 6-8)—HazMat/West '90. Technical Conference and Exhibition sponsored by *Hazmat World Magazine*. Long Beach Convention Center, Long Beach, CA. (Tower Conference Management Co., 800 Roosevelt Rd., Bldg. E, Ste. 408, Glen Ellyn, IL 601-37-5835).

(Nov. 7-9)—"Accelerated and Natural Weathering Techniques for Coatings and Polymers." Short course sponsored by Kent State University (KSU). (Carl J. Knauss, Director, Cooperative and Continuing Education, Chemistry Dept., KSU, Kent, OH 44242).

(Nov. 9-11)—43rd Annual National Decorating Products Show. Sponsored by the National Decorating Products Association (NDPA). Indiana Convention Center, Indianapolis, IN. (Lillian Smysor, NDPA, 1050 N. Lindbergh Blvd., St. Louis, MO 63132-2994).

(Nov. 11-17)—"Basic Coating Inspection." Session I of the International Coating Inspector Training and Certification Program. Sponsored by the National Association of Corrosion Engineers (NACE), Sheffield, England. (NACE Europe, P.O. Box 251, Guildford, Surrey, GU1 3DJ, United Kingdom).

(Nov. 12-14)—"Fundamentals of Adhesion: Theory, Practice, and Applications." Short course sponsored by State University of New York (SUNY). Orlando, FL. (A.V. Patsis, Institute of Materials Science, CSB 209, SUNY, New Paltz, NY 12561).

(Nov. 12-14)—10th International Resins & Pigments Conference. Sponsored by the Paint Research Association (PRA). Sheraton Copenhagen Hotel, Copenhagen, Denmark. (D. Dasgupta, PRA, Waldegrave Rd., Teddington, Middlesex, TW11 8DL, England).

(Nov. 13-16)—ASTM Committee B-8 on Metallic and Inorganic Coatings meeting. San Antonio, TX. (Peggy Loughran, ASTM, 1916 Race St., Philadelphia, PA 19103).

(Nov. 24)—"Surface Finishing in the 1990s—The Way Ahead." Conference and exhibition sponsored by The Metal Finishing Association. Holiday Inn, Near Windsor, England. (The Metal Finishing Association, 27 Frederick St., Birmingham B1 3HJ, England).

(Nov. 25-30)—"Basic Corrosion." Course sponsored by the National Association of Corrosion Engineers (NACE), London, England. (NACE Europe, P.O. Box 251, Guildford, Surrey, GU1 3DJ, United Kingdom).

(Nov. 25-30)—"Corrosion Control in Oil and Gas Production." Course sponsored by the National Association of Corrosion Engineers (NACE), London, England. (NACE Europe, P.O. Box 251, Guildford, Surrey, GU1 3DJ, United Kingdom).

(Nov. 26-28)—ASE '90. The Fourth International Conference and Exhibition on Adhesives, Sealants, and Encapsulants. Amsterdam, The Netherlands. (ASE '90 Administration Office, Network Exhibitions & Conferences Ltd., Printers Mews, Market Hill, Buckingham MK18 1JX, United Kingdom).

(Dec. 2-7)—SSPC '90. Conference and Exhibition sponsored by the Steel Structures Painting Council (SSPC). Opryland Hotel, Nashville, TN. (SSPC, 4400 Fifth Ave., Pittsburgh, PA 15213-2683).

(Dec. 3-5)—"Electrochemical Techniques for Corrosion Measurement." Fifth Annual Symposium sponsored by EG&G Princeton Applied Research. St. Louis, MO. (Ruth Rearick, EG&G Princeton Applied Research, P.O. Box 2565, Princeton, NJ 08543).

(Dec. 3-7)—"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).

(Dec. 3-7)—First North American Research Conference on Organic Coatings Science and Technology. Co-sponsored by The Division of Polymeric Materials Science and Engineering, American Chemical Society. Marriott Hilton Head Resort, Hilton Head, SC. (Angelos V. Patsis, Director, Institute of Materials Science, State University of New York, New Paltz, NY 12561).

(Dec. 9-14)—"Polymer Chemistry: Principles and Practice." Course sponsored by The American Chemical Society (ACS). Virginia Tech,

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Blacksburg, VA. (ACS, Dept. of Continuing Education, Meeting Code VPI9003, 1155 Sixteenth St., N.W., Washington, D.C. 20036).

1991

(Jan. 28-30)—"Concrete: Surface Preparation, Coatings and Linings, and Inspection Techniques." Symposium sponsored by National Association of Corrosion Engineers (NACE). J.W. Marriott Hotel, Houston, TX. (NACE Education and Training Dept., P.O. Box 218340, Houston, TX 77218).

(Feb.)—Inter-Society Color Council Williamsburg Conference. Williamsburg, VA. (Louis A. Graham, Lou Graham & Associates, Inc., 1207 Colonial Ave., Greensboro, NC 27408).

(Feb. 3-8)—"Protective Coatings and Linings." Course sponsored by the National Association of Corrosion Engineers (NACE), London, England. (NACE Europe, P.O. Box 251, Guildford, Surrey, GU1 3DJ, United Kingdom).

(Feb. 3-8)—"Cathodic Protection: Theory and Data Interpretation." Course sponsored by the National Association of Corrosion Engineers (NACE), London, England. (NACE Europe, P.O. Box 251, Guildford, Surrey, GU1 3DJ, United Kingdom).

(Feb. 17-20)—14th Annual Meeting of The Adhesion Society, Bellview Biltmore Hotel, Clearwater, FL. (Howard M. Clearfield, IBM T.J. Watson Research Center, P.O. Box 218, M/S 38-145, Yorktown Heights, NY 10598).

(Feb. 17-22)—"Basic Coating Inspection." Session I of the International Coating Inspector Training and Certification Program. Sponsored by the National Association of Corrosion Engineers (NACE), Sheffield, England. (NACE Europe, P.O. Box 251, Guildford, Surrey, GU1 3DJ, United Kingdom).

(Feb. 17-22)—"Intermediate Coating Inspection." Session II of the International Coating Inspector Training and Certification Program. Sponsored by the National Association of Corrosion Engineers (NACE), Sheffield, England. (NACE Europe, P.O. Box 251, Guildford, Surrey, GU1 3DJ, United Kingdom).

(Mar. 4-8)—Corrosion/91 sponsored by the National Association of Corrosion Engineers (NACE). Cincinnati, OH. (NACE, Conference Manager, P.O. Box 218340, Houston, TX 77218).

(Mar. 11-15)—62nd Introductory Short Course on the Basic Composition of Coatings. Sponsored by University of Missouri-Rolla (UMR), Rolla, MO. (Norma R. Fleming, Sr. Continuing Education Coordinator, UMR, 119 M.E. Annex, Rolla, MO 65401-0249).

(Mar. 19-21)—"farbe + lack 91." The First Congress Exhibition for the Coating, Printing Inks, Adhesives, and Sealants Industry. Sponsored by *farbe + lack.* Nuremberg Exhibition Grounds, West Germany. (Klaus Geissler, Manager, Events Division, Curt R. Vincentz Verlag, Postfach 62 47, 3000 Hannover 1, West Germany).

(Mar. 25-29)—22nd Introductory Short Course on Paint Formulation. Sponsored by University of Missouri-Rolla (UMR), Rolla, MO. (Norma R. Fleming, Sr. Continuing Education Coordinator, UMR, 119 M.E. Annex, Rolla, MO 65401-0249).

(Apr. 3-5)—Hazardous Materials Management Conference and Exhibition/Central (HazMat/Central '91). O'Hare Exposition Center, Rosemont, IL. (Tower Conference Management Co., 800 Roosevelt Rd., Bldg. E—Ste. 408, Glen Ellyn, IL 60137-5835).

(Apr. 22-25)—The Euro-Asian Interfinish Isreal 1991. Conference sponsored by the Metal Finishing Society of Isreal. Herzlia, Isreal. (Secretariat, Ortra, Ltd., 2 Kaufman St., Tel-Aviv 61500, Isreal).

(May)—ASTM Committee B-8 on Metallic and Inorganic Coatings meeting. Atlantic City, NJ. (George A. DiBari, International Nickel Co., Park 80 West—Plaza Two, Saddle Brook, NJ 07662).

(May 29-31)—Fourth International Symposium on Polymer Analysis and Characterization; June 1-2—Short course "Major Polymer Characterization Techniques and Methods." Baltimore Inner Harbor, MD. (Judith A. Watson, Professional Association Management, 750 Audubon, East Lansing, MI 48823).

(June 12-14)—SURCON '91, "Developments in the Science of Surface Coatings." Moat House International Hotel, Stratford-upon-Avon, England. (Simon Lawrence, CIBA-GEIGY Pigments, Hawkhead Rd., Paisley, Renfrewshire PA2 7BG, Scotland).

(June 19-21)—First International Symposium on Environmental Effects on Advanced Materials. Sponsored by National Association of Corrosion Engineers (NACE). Catamaran Resort Hotel, San Diego, CA. (NACE Customer Service Dept., P.O. Box 218340, Houston, TX 77218).

Advertisers Index

ADVANCED COATING TECHNOLOGIES, INC.	150
AMOCO CHEMICAL CO.	77
ANGUS CHEMICAL CO.	69
AQUALON CO.	39
BOHLIN RHEOLOGI	93
CB MILLS	147
CABOT CORP.	73
CARGILL, INC.	31
CHEM-TEL INC.	68
CIBA-GEIGY CORP.	29
COULTER ELECTRONICS	21
CROSFIELD CHEMICAL	41
DAICOLOR-POPE, INC.	47
DANIEL PRODUCTS CO., INC.	65
DEXTER CHEMICAL CORP.	154
DOW CORNING	Cover 3, 57
EPWORTH MANUFACTURING CO., INC.	158
EXXON CHEMICAL	94
GENSTAR STONE PRODUCTS CO., INC.	157
GEORGIA KAOLIN CO., INC.	60
GOODYEAR CHEMICAL	49
HALOX	81
HENKEL CORP.	67
HITOX CORP. OF AMERICA	158
HORIBA INSTRUMENTS, INC.	143
ICI AMERICAS INC.	27
S.C. JOHNSON & SON	51
KERR-McGEE CHEMICAL CORP.	45
KING INDUSTRIES, INC.	99
LEEDS & NORTHRUP	144
3M/FLUOROCHEMICAL SPEC.	14-15
McCULLOUGH & BENTON	86
McWHORTER, INC.	79
MICRO POWDERS, INC.	Cover 2
MINOLTA CORP.	71
MOBAY CORP.	83
NYCO	131
OLIN CORP.	23
REICHHOLD CHEMICAL, INC.	25
RHEOMETRICS INC.	72
RHEOX, INC.	53
ROHM AND HAAS CO.	11, 55
SANDOZ CHEMICALS CORP.	35
SANNCOR INDUSTRIES, INC.	1
SCHERING BERLIN	8-9, 59
SEEGOTT INC.	100
SHAMROCK TECHNOLOGIES, INC.	Cover 4
SHELL CHEMICAL CO.	42-43
SUN CHEMICAL CORP.	37
UNION CARBIDE	4-5
U.S. SILICA COP.	75
VANCE LABORATORIES, INC.	151
R.T. VANDERBILT CO., INC.	2
WITCO CORP.	32-33

****

CLASSIFIED ADVERTISING	146, 160

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'Humbug' from Hillman

John R. Warner, from the quiet refuge of his retirement sent us samples from a thirty year old "Pun Book," some of which will be published later in this column. Fair warning!!! If there are no serious repercussions, we will dare to treat (?) you to more in future issues. John also sent us an appropriate article written by Patrick O'Neil that was found by John's sister in Oregon. Here are excerpts:

And Now Let Us Spray

It usually starts innocently enough. Maybe a stranger driving through your neighborhood will slam on the breaks and get out of his car, pointing at your house and laughing. Maybe your kids start getting off the school bus at another stop. Maybe it's as simple as a note from a neighbor tied to a brick and thrown through your front window: "Paint your house or we'll burn the thing down."

If you're a self-respecting macho suburban guy you'll do the job yourself.... Anybody with a friend or two can easily paint a large house on a Saturday morning between 10:30 and noon. "Yep," you say to a friend during a backyard barbecue. "This old barn's looking a little shabby. Looks like it's gonna need a coat of paint here pretty quick, Phil . . . Phil? . . . Phil? . . . You won't see Phil again until he gets a notarized copy of the spray gun rental receipt plus a Polaroid snapshot of the newly painted house.

But anybody can paint a house if he has the basic equipment and follows a few simple tips:

•*Friends*—You'll need a smart one and two dumb ones. The smart one will mix the paint, set up the sprayer,s and generally keep both feet firmly in contact with earth in the vicinity of the ice chest. The dumb ones will go up the ladders.

•*Ladders*—Ladders have two parts: Part A: The "upper" or "business end." The upper end of the ladder is the one most commonly used for breaking out the bedroom windows during the hazardous masking process. A ladder tends to attract large quantities of gravity around the upper end which contributes to a certain amount of attrition in house painting's volunteer labor force. Part B: The "lower" or "business end" of the ladder. This end should at all times rest on some perfectly stable surface such as a Nerf ball or skateboard. Unless the upper end is occupied by a flying squirrel, the lower end should be held in place by a strong and trusted assistant who will simultaneously scamper for another half case of beer.

•*Beer*—Sometimes referred to as "painter's bait." It is widely believed to negate the effects of gravity. It will also eliminate many of the streaks, drips, spatters and other imperfections associated with the painting process.

•*Spray Gun*—This extremely effective labor saving device is used for converting paint into a cloud of paint molecules that drifts onto neighbors' cars and cats and occasionally onto the side of your house.

•*Paint*—This substance exists in five basic physical states: "Too thick," "Too thin," "Too much," "Too little," and "Wrong shade."

•*Masking*—Proper masking form involves standing on the top of the ladder, holding on tightly with one hand, the other hand holding firmly the masking tape. With the other hand, tear off a strip of paper. With the other hand, apply the paper and tape, the other hand smoothing the tape to make a tight seal.

•*Your wife*—She's the one with her hands on her hips squinting in disbelief as the Malibu Suntan in the paint can dries to International Orange on the sides of the house. Your smart friend, the paint mixer, will calmly explain how International Orange will eventually weather out to Malibu Suntan.

•*Trim*—How your neighbor's new third wife looks from the vantage point on top of the ladder as she sunbathes nude in a corner of their yard. "That's O.K., Honey. I'll just eat lunch up here on the roof. Toss up some sandwiches and a six pack."

•*Yellow pages*—Try looking under "P" for "Painting Contractors."

Good friend, Alvin Guttman, who is not a lawyer or a doctor or a broker makes the following poetic observations:

Professional Odds

The lawyer makes his dollar.
The lawyer turn a buck.
Win, lose or draw, you grease his paw;
Win, lose or draw, you're struck.

The doctor's charge is certain;
Of this be well assured;
The bill he'll send does not depend
Upon you're being cured.

The broker in his wisdom,
May offer you advice;
You buy, then sell; the stock does well
Or badly—he's paid twice.

What lofty satisfaction
To these men must belong
What clear delight, for they are right
Though they be right or wrong!

To be blamed on John Warner (as promised):

—The explorer came down from the North Pole; when he reached the last Lapp, he knew he was at the Finnish line.

—Old accountants never die, they just lose their balance.

—When the principal asked the teacher how long she planned to teach school, she replied, "From here to maternity!"

—Herb Hillman
Humbug's Nest
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