jct JOURNAL OF COATINGS TECHNOLOGY

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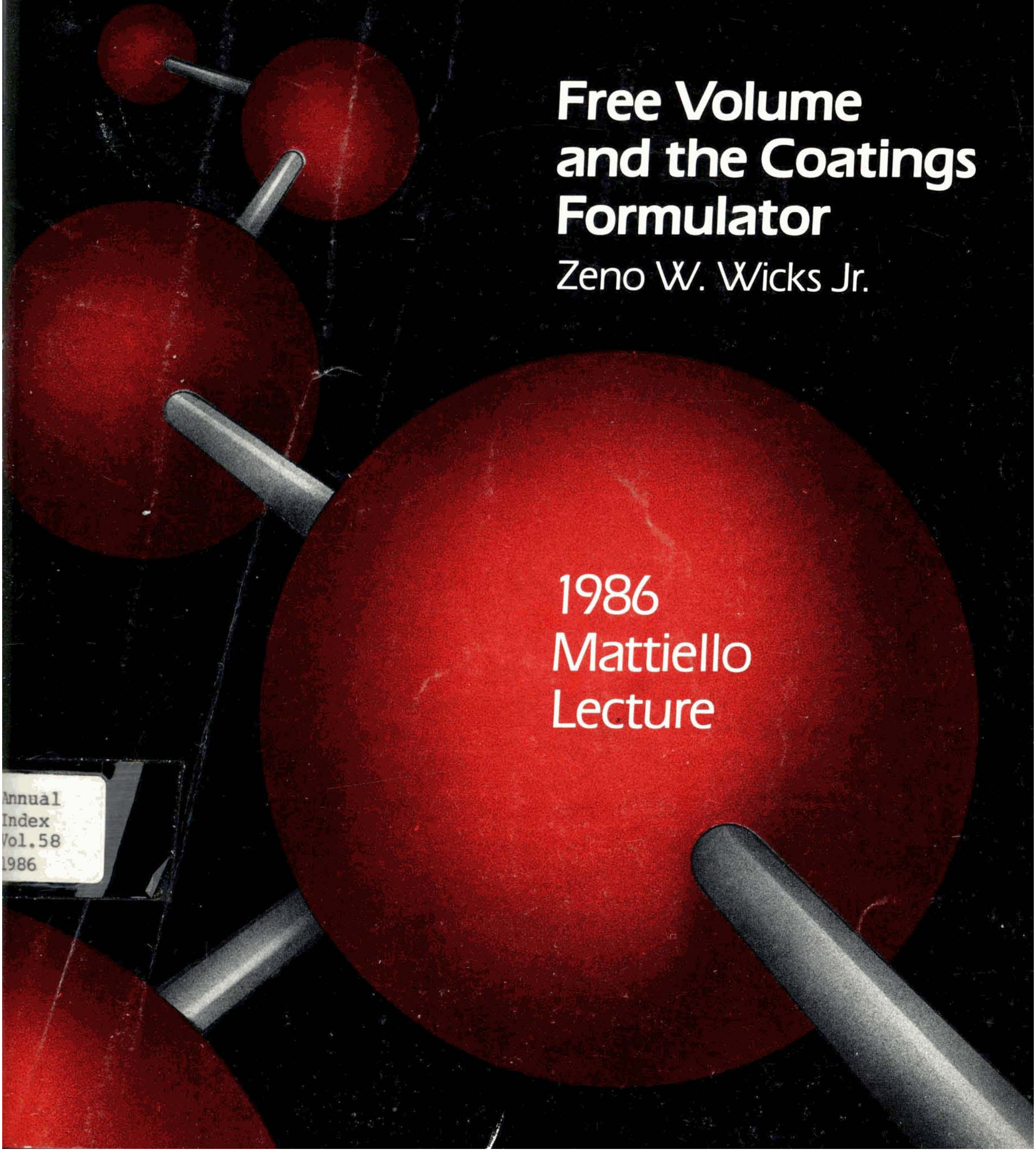
December 1986

Free Volume and the Coatings Formulator

Zeno W. Wicks Jr.



1986 Mattiello Lecture

Annual
Index
Vol.58
1986

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DECEMBER 1986

jct JOURNAL OF COATINGS TECHNOLOGY

VOLUME 58 NUMBER 743

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SOCIETY OF
NATIONAL
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PUBLICATIONS

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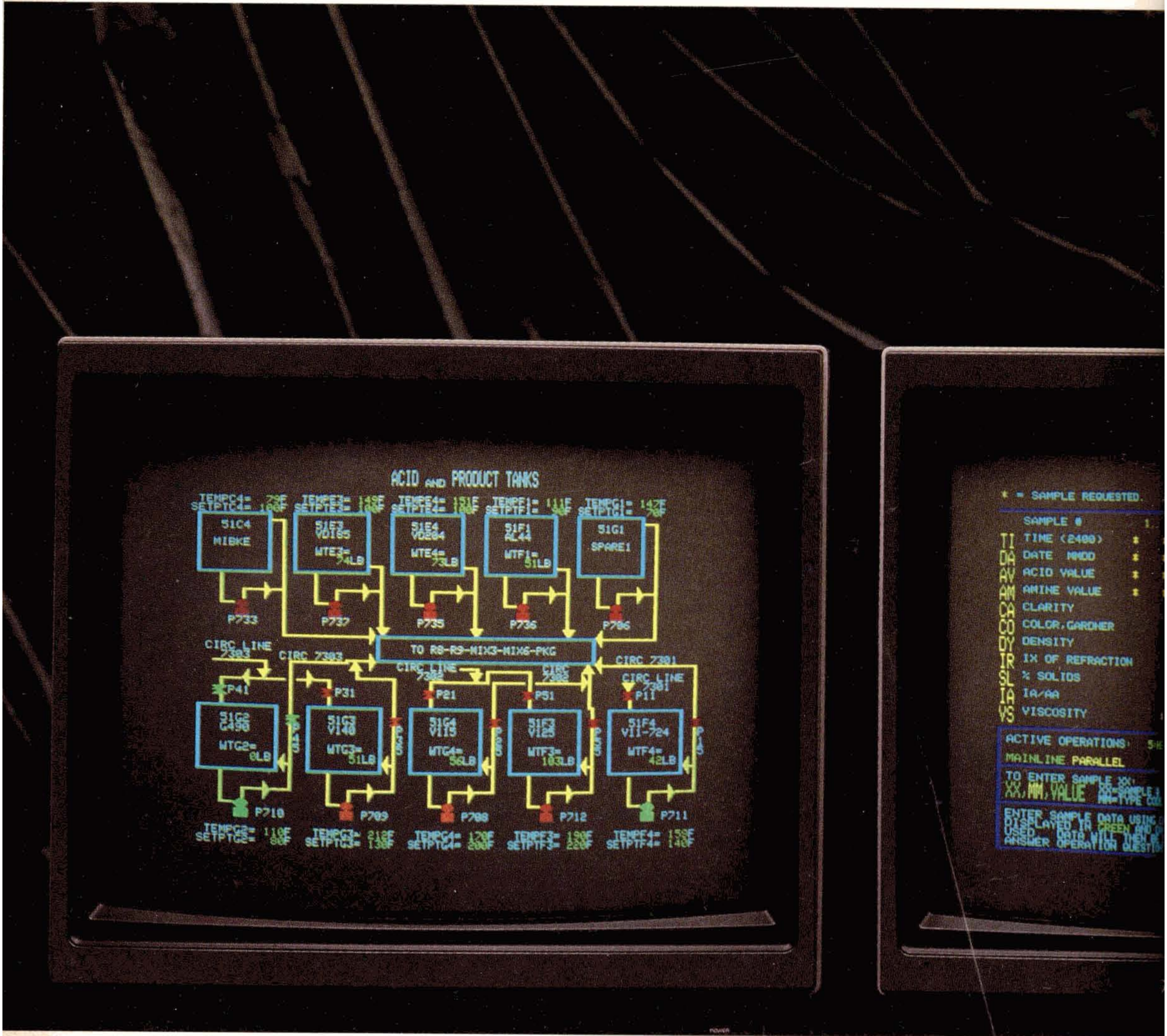

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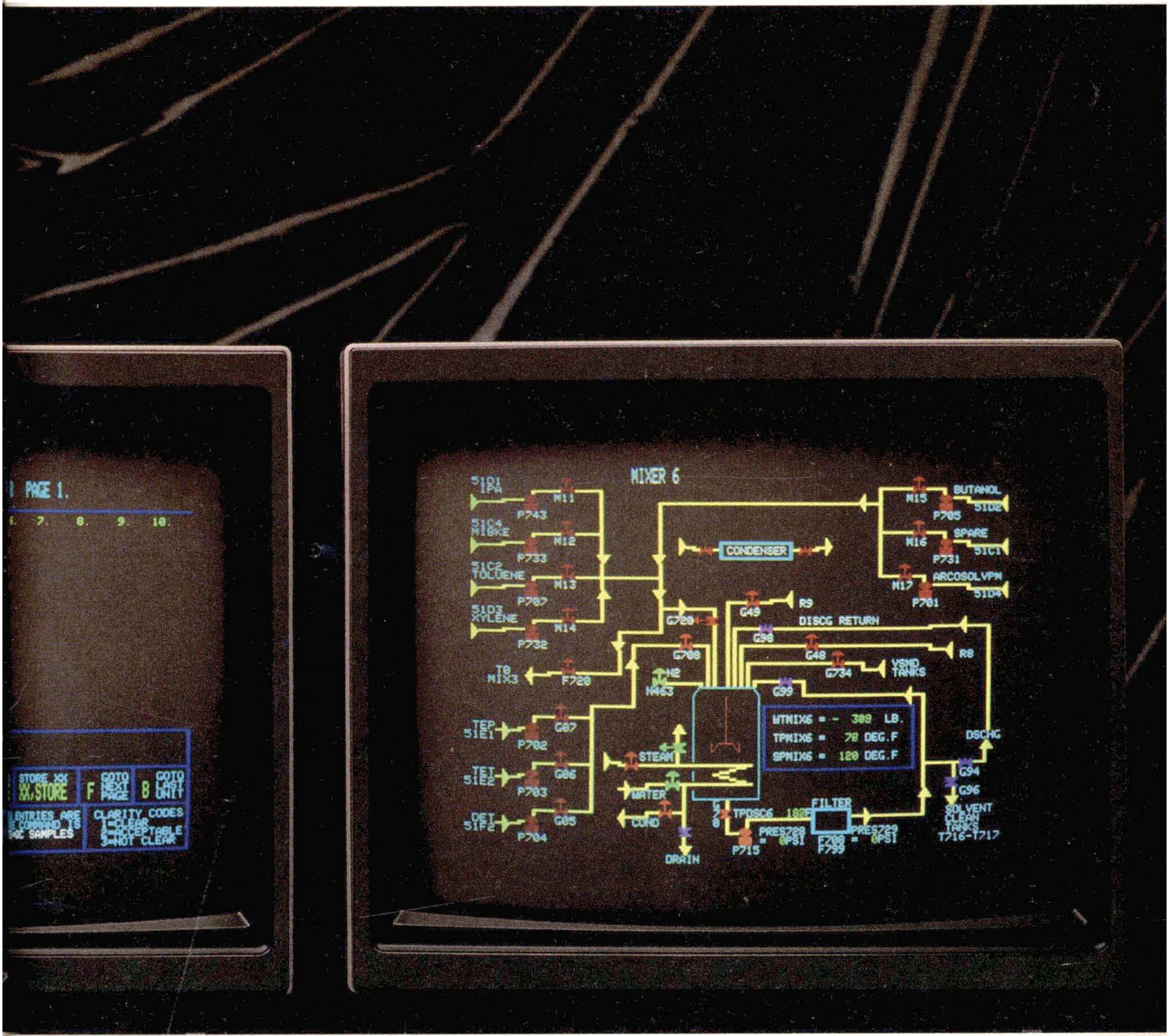

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Comment

64 Down and the Future to Go

The 64th year in the grand history of the Federation of Societies for Coatings Technology is about to close. As it does, we would like to recall the most significant developments and achievements during a successful 1986.

New Series on Coatings Technology—Under the editorial direction and guidance of the Editors (Drs. Thomas J. Miranda and Darlene Brezinski, of the Chicago Society), the first four booklets (Radiation Cured Coatings, Film Formation, Introduction to Polymers and Resins, and Solvents) were released during the latter half of the year. Several others are being readied for publication in 1987.

Membership—The Federation rolls, which grow a little each year, topped a record 7,000. This may seem strange, what with all of the industry mergers and consolidations. Nevertheless, it is true and in support of a coatings industry employment analysis in a recent edition of *C&E News*.

Seminar on Automotive Color Control—This new venture was arranged in cooperation with the Detroit Colour Council and the Manufacturers Council on Color and Appearance, who were co-sponsors. More than 450 attended the week-long sessions (in June) devoted to the SAE Recommended Practice J1545 for determining measured color difference for automotive parts and materials.

Professional Development Committee—This newest committee of the Federation (chaired by F. Louis Floyd, of Cleveland) completed its first year. Its summer survey of the membership produced a return far beyond their expectations, and those of any direct-mail questionnaire. And responding quickly to another of its objectives, it will sponsor a four-city seminar on Statistical Process Control in March 1987: Chicago, 2-3; Atlanta, 9-10; Philadelphia, 16-17; and Los Angeles, 30-31.

Coatings Industry Education Fund—The successor organization to the former Paint Research Institute had its first year of operation, too, with Neil S. Estrada, of Golden Gate, as the Chairman of the Trustees. CIEF will continue to fund the annual Roon Foundation Awards and has approved matching funds for scholarship grants in cooperation with the Pittsburgh Society. Other assistance programs are under consideration.

Liaison with National Forest Products Association—Federation representatives Saul Spindel (New York), Emil Iraola (Pacific Northwest), and Technical Advisor Roy Brown met with NFPA members and a joint committee has been formed. The first meeting will be in April at the Forest Products Laboratory in Madison, WI. Quite coincidentally, the subject of the Federation's 1987 Spring Seminar will be "Coatings for Wood Substrates" (May 1-2, in Seattle).

Environmental Control Committee—Following a suggestion by the Golden Gate and Los Angeles Societies, the first meeting ever of the Federation committee with Society Environmental Control Committee Chairmen was sponsored by the Federation, September 17, in Louisville. Bob Minucciani, of Golden Gate, presided in the absence of Chairperson Joyce Specht St. Clair who was disabled with a broken ankle. Even though only 12 Societies were represented, it was a constructive meeting and a start to finding effective ways to inform the membership of significant regulatory matters which impact upon the industry.

Insurance Program for Members—At the request of the New York Society, the Federation looked into an insurance program for its membership. A proposal was submitted by the Federation's insurance agent and approved by the Board of Directors in May. The brochure of the first program—Hospital Cash—has been released. The others (Term Life, Accidental Death/Dismemberment, and Disability) will follow.

Annual Meeting and Paint Show—The 1986 Show was the largest, with 242 exhibitors in 58,000 net sq. ft. of exhibit space. The Show has attracted 84 new exhibitor firms in two years.

Surely, there will be as constructive a report as this a year from now, because the older the Federation gets, the better it gets.

Frank J Borrelle

Frank J. Borrelle

Abstracts of Papers in This Issue

FREE VOLUME AND THE COATINGS FORMULATOR—Z.W. Wicks, Jr.

Journal of Coatings Technology, 58, No. 743, 22 (Dec. 1986)

Free volume is defined and the difficulties of quantification are pointed out. The relationship between free volume and viscosity are discussed especially from the point of view of high solids coatings. The effects of free volume availability on film formation by solvent evaporation and by coalescence are treated. Recent work on the effects of free volume on the rate and extent of crosslinking and its implications for formulating ambient cure coatings is reviewed. Effects of free volume on coatings film properties are illustrated by brief discussions of popping, adhesion, corrosion control, and mechanical properties.

EVALUATION OF PHOTOINITIATOR PERFORMANCE—D.J. Gaber

Journal of Coatings Technology, 58, No. 743, 35 (Dec. 1986)

The purpose of this study was to determine the best photoinitiator performer in a UV cure system. Thin films, prepared by using reduced formulations and the photoinitiators of Irgacure 184, Vicure 10, and DEAP, were subjected to the common testing methods of Sward Hardness, Impact Resistance, and double MEK rubs. Data proved Irgacure 184 to be the best in these tests, providing generally superior results.

JCT JANUARY 1987

Post-Convention Issue

Complete coverage of the Annual Meeting and Paint Industries' Show of the Federation of Societies for Coatings Technology will be published in the January issue of the Journal of Coatings Technology. Follow-up features will include awards, technical proceedings, exhibitor booth descriptions, and Convention and Annual Meeting News.

IONOMER/SEMI-IPN COATINGS FROM POLYURETHANES AND VINYL CHLORIDE COPOLYMERS—A. Patsis, et al.

Journal of Coatings Technology, 58, No. 743, 41 (Dec. 1986)

Ionomer semi-IPN coatings were prepared from a carboxyl-containing vinyl chloride (VMCC) copolymer and polyurethanes (PU) with and without tertiary amine nitrogen in the polymer backbone at various PU/VMCC ratios.

The morphology and physical properties of these ionomer semi-IPN coatings containing opposite charge groups were compared with those without opposite charge groups. The former exhibited higher mechanical properties and adhesive strength and did not reveal any phase separation as determined by SEM and TMA.

SOLUTION PARAMETERS OF LINSEED OIL ALKYD: THEIR DEPENDENCE ON SOLUTE-SOLVENT INTERACTIONS—M.V. Ram Mohan Rao and M. Yaseen

Journal of Coatings Technology, 58, No. 743, 49 (Dec. 1986)

Intrinsic viscosity, which characterizes the polymer in the state of infinite dilution, has been used for determining various solution parameters of alkyd resin in good, intermediate, and θ-solvents. The relationship between intrinsic viscosity and weight average molecular weight has been used for determining the Mark-Houwink constants, a and K, of the resin. These constants are found to depend on the nature of solute-solvent interactions. The solution parameters, K_θ, $f(\bar{r}^2)_0$, B, and χ, obtained from Kurata-Stockmayer and Stockmayer-Fixman plots, are found to depend on solubility parameters of solvents. The solubility parameter of the alkyd has been estimated by taking into account the solute-solvent interaction parameter χ and the solubility parameters of solvents. The results indicate that several solution parameters of the alkyd resin can be obtained from measurement of solution viscosity.

Federation of Societies for Coatings Technology
and
Pacific Northwest Society for Coatings Technology

present

SPRING WEEK '87

April 29–May 2
The Westin Hotel • Seattle, Washington

Featuring
FSCT Seminar on

"Coatings for Wood Substrates"

May 1-2

Seminar program will include the following topics:

Solid Wood Substrates—Their Properties and Potential for Painting Problems

Plywood—Uses, Properties, and Potential Painting Problems

Cedar and Redwood—Uses, Properties, and Potential for Problems when Painting and Staining

Stains for Wood Siding—Types, Uses, and Properties

How the Home Builder Can Help to Avoid Paint Problems

The Responsibility of the Architect

Spring Week Schedule

Wed., April 29 —	FSCT Society Officers Meeting
Thur., April 30 —	PNW Golf FSCT Board of Directors Meeting PNW Evening Social
Fri., May 1 —	FSCT Spring Seminar
Sat., May 2 —	Seminar until 12:30 pm PNW Sports Competition Closing Dinner Dance

Advance Registration/Hotel Forms for Members and Non-Members Are Included In This Issue, Pages 10 and 11.

United Airlines has been selected as official carrier for Spring Week '87. Discounts will range from 40%-70% off normal round-trip coach fares. To make reservations, phone 1-800-521-4041, and refer to the Federation's account number—7013-D. Be sure to request the lowest fare available.

FEDERATION MEMBERS ONLY—ADVANCE REGISTRATION
for
SPRING WEEK ACTIVITIES
and
SEMINAR ON COATINGS FOR WOOD SUBSTRATES

Sponsored by FSCT and PNWSCT

Thursday, Friday, Saturday, April 30–May 2, 1987
Westin Hotel, Seattle, Washington

Please complete all applicable sections of this form. Mail with check in the correct amount to FSCT at address below. All checks must be payable in U.S. Funds.

Fed. Socs. Coatings Tech.
1315 Walnut St.
Philadelphia, PA 19107

No advance registrations will be accepted after **April 10.** After that date, the Seminar registration fee (including Saturday Dinner-Dance) will be $135.00. Other fees remain the same.

Membership status is subject to verification by the FSCT Staff. This form and check will be returned to anyone not currently enrolled as a member of the Federation of Societies for Coatings Technology.

MEMBER REGISTRATION

Name ______________________ Nickname for Badge ______________
Business Affiliation ______________________ Phone ______________
Address ______________________________________
City ______________________ State/Province ______________
Mailing Zone ______________________ Country ______________
Name of Federation Society In Which You Are A Member ______________

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Name ______________________ Nickname for Badge ______________
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The confirmation of your reservation will come to you directly from the Westin, located at 1900 Fifth Ave., Seattle, WA 98111. Phone: 206-624-7400. All reservations will be held until 6:00 p.m. None can be guaranteed after April 6, 1987.

Rates: Single or Double ($82.00) Suites: Deluxe P & 1 BR ($350.00)

Check Accommodation Desired: ________ Single ________ Double ________ Suite

Date/Day of Arrival ______________________ Day/Date of Departure ______________

Note: All room rates are subject to a state sales tax of 7.9% and city room tax of 5.0%.

SCHEDULE OF FEES FOR FEDERATION MEMBERS ONLY

Check Events Desired	Events	Fee Per Person	Write-In Amount Below
	Member		
________	Seminar on "Coatings for Wood Substrates" Friday and Saturday, May 1-2	$110	________
________	Dinner-Dance, Saturday, May 2	Included With Above Fee	
________	Dinner-Social, Thursday, April 30	$ 25	________
________	Golf, Thursday, April 30 (includes lunch)	$ 30	________
	Spouse		
________	Spouses Activities	$ 50	________
________	Dinner-Dance, Saturday, May 2	Included With Above Fee	
________	Dinner-Social, Thursday, April 30	$ 25	________
	(Enclose Check in This Amount)	TOTAL FEES	________

NON-MEMBERS ONLY—ADVANCE REGISTRATION
for
SPRING WEEK ACTIVITIES
and
SEMINAR ON COATINGS FOR WOOD SUBSTRATES

Sponsored by FSCT and PNWSCT

Thursday, Friday, Saturday, April 30–May 2, 1987
Westin Hotel, Seattle, Washington

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Fed. Socs. Coatings Tech.
1315 Walnut St.
Philadelphia, PA 19107

No advance registrations will be accepted after **April 10.** After that date, the Seminar registration fee (including Saturday Dinner-Dance) will be $150.00. Other fees remain the same.

NON-MEMBER REGISTRATION

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Address ____
City ______________________ State/Province ______________
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SPOUSE REGISTRATION

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City ______________________ State/Province ________ Country ______________

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Date/Day of Arrival ______________________ Day/Date of Departure ______________

Note: All room rates are subject to a state sales tax of 7.9% and city room tax of 5.0%.

SCHEDULE OF FEES FOR NON-MEMBERS ONLY

Check Events Desired	Events	Fee Per Person	Write-In Amount Below
	Non-Member		
______	Seminar on "Coatings for Wood Substrates" Friday and Saturday, May 1-2	$125	______
______	Dinner-Dance, Saturday, May 2	$ 40	______
______	Dinner-Social, Thursday, April 30	$ 25	______
______	Golf, Thursday, April 30 (includes lunch)	$ 30	______
	Spouse		
______	Spouses Activities	$ 50	______
______	Dinner-Dance, Saturday, May 2	Included With Above Fee	
______	Dinner-Social, Thursday, April 30	$ 25	______
	(Enclose Check in This Amount)	TOTAL FEES	______

Federation News

Highlights from the Board of Directors Meeting and Other News from the 1986 AM&PS in Atlanta

Attendance (59)

The attendance included all (36) members of the Board; 13 Past-Presidents, three of whom are on the Board; and 10 other guests. Among the latter were officers from four other industry associations: OCCA Australia, FATIPEC, FSPVT, and MPIMA.

Amendments to Standing Rules

To SR VIII B. — Duties of Federation Committees —will be added this statement under the section titled "Annual Meeting Awards": "All proposals for awards shall be submitted to the Federation Executive Committee for approval."

Actions of Executive Committee

Those from May 16 and September 4, 1986, were approved. (In the interest of space, they will not be repeated here).

The Executive Committee met in special session on November 3, and presented the following resolution to the Board, in response to the environmental issues discussed and acted upon at previous Board meetings:

> "WHEREAS the resolution regarding the establishment of staff support for issues relating to the environment is too open ended, and
>
> "WHEREAS in order for the Federation of Societies for Coatings Technology to provide adequate staff support for environmental issues, it would require a major modification in staffing patterns, responsibilities, and budget, and
>
> "WHEREAS the National Paint and Coatings Association presently expends a budget in excess of 2.5 million dollars and employs about 25 persons, both professional staff and support staff dedicated to address environmental and related issues, therefore
>
> "BE IT RESOLVED that the motion passed by the Board of Directors in May 1986 relating to staff support for environmental issues be rescinded and, that the Federation membership, both through its staff office and its Societies, be urged to do the following:
>
> "(1) Stimulate Society Environmental Committees to a significant level of increased activity.
>
> "(2) Establish liaison with NPCA Environmental and related committees on a Society basis.
>
> "(3) Develop increased committee participation on the Federation Environmental Control Committee and also improved communication among Federation members through establishment of an Environmental Update Newsletter to be issued from Federation Headquarters to Societies regarding the state of current affairs as they pertain to legislative and regulatory issues, and that adequate funding be provided."

After considerable discussion, involving several members of the Board and Bob Minucciani (representing the Federation's Environmental Control Committee), the resolution was approved by the Board.

Elections

The slate presented in the Spring by the Nominating Committee was elected:

President-Elect — Deryk R. Pawsey, of Pacific Northwest

Treasurer — James E. Geiger, of Southern

Executive Committee — Kurt Weitz, of Toronto (3 years)

Board (At-Large) — Ronald R. Brown, of Southern (2 years); L. Lloyd Haanstra, of Los Angeles (2 years)

Board (Past-President) — Terryl Johnson, of Kansas City (2 years)

Carlos E. Dorris, of Dallas, moves up to the Presidency.

Coatings Industry Education Fund

The Board (the Stockholders of CIEF) elected the following Trustees for the coming year: Neil S. Estrada, FSCT Past-President and Chairman of the Investment Committee; Joseph A. Vasta, Chairman of the Educational Committee; James E. Geiger, incoming FSCT Treasurer; George R. Pilcher, Chairman of the Professional Development Committee; and Jan A. Grodzinski, Chairman of the Technical Advisory Committee. (Later in the day, the Trustees elected their own officers: Estrada as President, Vasta as Vice-President, and Geiger as Treasurer).

At the Stockholders meeting, new objectives of CIEF (formerly PRI) were proposed. They are basically similar to the old PRI, but with certain words deleted– – – – –:

(1) To advance the knowledge and application of the ~~chemical, physical, and mathematical sciences relating to~~ the technology of coatings ~~by supporting research at colleges and universities through the granting of fellowships~~.

(2) To aid in the dissemination of the results of such ~~research and education~~ activities ~~to the public~~ through scientific publications and lectures.

The new objectives were approved by the Stockholders.

Committee Activities

Corrosion — Jay Austin, incoming Chairman, spoke to the committee's request for $15,674 to fund a "Survey of Accelerated Test Methods for Anticorrosive Coating Performance" to be conducted by the Steel Structures Painting Council. The final report would be presented at the October 1987 Annual Meeting in Dallas. The request was referred to the Executive Committee.

Educational — Chairman Joe Vasta reviewed his committee's request for $21-25,000 to produce a 15-minute video tape on careers in the coatings industry. (Angeli Film and Videotape, Inc. is the contractor). This request, too, went to the Executive Committee.

Professional Development — Chairman F. Louis Floyd presented several revealing graphs of results from the committee's summer survey, from which there was an astounding 55% response. As he stated in his written report, the Federation membership is predominantly in the "Active" class, employed in technical activities, supervises others, is over 40 years old, predominantly holds B.S. Degrees, and predominantly is employed by manufacturers of coatings with more than $10 million in sales. The detailed report will be published in a future JCT.

Publications — Chairman Tom Miranda's report indicated that the first four units in the Series on Coatings Technology have been published. "Coil Coatings" is next.

(Continued on page 14)

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Highlights from the Board of Directors Meeting *(Continued)*

Several others are being processed for release during 1987.

All committee reports will appear in the January 1987 JCT.

Other Business

Lewis P. Larson, of CDIC, was elected to Federation Honorary Membership.

The next Board meeting will be in Seattle during Spring Week — April 30, 1987.

1986 Annual Meeting and Paint Show

The unofficial registration count is near the 6,500 mark, making Atlanta second only to Chicago, 1984.

All Program Sessions were very well received. Several hundred were in the beautiful auditorium of the Georgia World Congress Center in Atlanta to hear Lee Sherman Dreyfus present one of the most outstanding and thought-provoking Keynote Addresses ever presented at the AM. There was SRO at the Powder Coatings Symposium. Zeno Wicks' Mattiello Lecture also attracted a large audience.

The Paint Show was the biggest ever with 242 exhibitors in nearly 58,000 net square feet of exhibit space. The GWCC is a magnificent facility and the Show was one of the most colorful ever presented by both the Federation and the quality-conscious Show exhibitors.

The Luncheon Speaker was Heywood Hale Broun, Sports Broadcaster and Commentator. All but one of the awards listed below were presented at the lunch. Fifteen 50-year members were present.

The Federation owes its thanks—*for a job very well done*—to: Percy Pierce, Chairman of the Program Committee; John Ballard, Chairman of the Paint Show Committee; Jim and Lynne Geiger, Chairmen of the Host Committee; and to all the dedicated members from various Societies who worked with them. The Southern Society folks—those good guys and gals in the red hats—were just great.

The number of registrants from countries other than the U.S. and Canada will probably be the highest ever—a good sign that the Paint Show is coming on as *the* exhibit for the international paint manufacturing industry.

Annual Meeting Awards

HECKEL—Neil S. Estrada, retired, from the Golden Gate Society.

ROON—(1) Pamela Kuschnir, Richard R. Eley, and F. Louis Floyd, of the Glidden Co.

(2) Steven L. Kangas and Frank N. Jones, of North Dakota State Univ.

BRUNING—Rolf G. Kuehni, of Charlotte, NC.

MMA—(B) Golden Gate Society
(C) Piedmont Society

APJ—Detroit Society

PAINT SHOW—Poly-Resyn, Inc.—Raw Materials, Single Booth

Ciba-Geigy Corp.—Raw Materials, Double Booth

Daniel Products Co.—Raw Materials, 3-5 Booth

Johnson Wax—Raw Materials, 6+ Booth

Erichsen Instruments, Inc.—Equipment

Reeco—Service Industries

ALFRED HENDRY—John W. Catino, of Lehigh University

Dennis J. Gaber, of Eastern Michigan University

GOLDEN IMPELLER—Earl E. Baumhart, of Coatings Eng. & Systems Co., Kansas City, MO

TRIGG—(1) Joan Lamberg, of Northwestern Society

(2) Mark Troutman, of Pittsburgh Society

SOCIETY SPEAKERS—(1) Rose Ryntz, of Detroit Society

(2) Richard Braunhausen, of Chicago Society.

A special medallion—from the Secretary General of the China National Coatings Industry Association—was presented to President Bill Mirick by Jack Benham, a member of the Southern Society. Jack and his wife journeyed to the Peoples' Republic of China in September. As part of a scientific exchange program, he lectured on "Coatings Plant Operations." Jack was an emissary for both the FSCT and the NPCA. The presentation was made at the Business Meeting.

Frank J. Borrelle
Executive Vice-President

Committee Activities

ENVIRONMENTAL CONTROL

EPA Handbook for Small Quantity Hazardous Waste Generators Published

The Federal E.P.A. has just published (September, 1986) a very informative document for small quantity hazardous waste generators. The title is: "Understanding the Small Quantity Generator Hazardous Waste Rules: A Handbook for Small Business."

The handbook is written in plain English and is presented in a manner which is highly understandable. If you are not already in the E.P.A.'s hazardous waste generator 'loop' and not sure where you belong (if you do at all) in the hazardous waste regulations, this handbook will be a big help. Key issues addressed include:

- The three most important things you should know about managing your hazardous waste on-site;
- The three most important things you should remember about shipping your hazardous waste off-site;
- The four most important things you should remember about managing your wastes properly.

Most of the new rules for small quantity generators of hazardous waste became effective on September 22, 1986. Also, on March 27, 1987, small quantity generators that decide to store hazardous waste for longer than six (6) months, perform certain kinds of waste treatment, or dispose of hazardous waste on their property must apply for a R.C.R.A. permit and comply with additional rules.

To obtain your copy of this E.P.A. handbook, ask for EPA document #530-SW-86-019 when you call 1-800/368-5888 (EPA's Small Business Ombudsman Hotline) or write U.S. E.P.A., Office of Solid Waste and Emergency Response, Washington, D.C. 20460.

Joyce S. St. Clair
Chairperson

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Government and Industry

Industry Statesmen Honored at NPCA Annual Meeting

During the National Paint and Coatings Association's 99th annual meeting held in Atlanta, GA, on November 3-5, six men received the association's Industry Statesman Awards. The awards, given in recognition of a career of distinguished service to the paint and coatings industry, were given by Maurice C. Workman, 1985-86 NPCA President, to the following recipients:

Benjamin M. Belcher, Sr., had served as Chairman of the Executive Committee of Benjamin Moore & Co., Montvale, NJ, until his retirement in 1984. He joined the firm in 1934 and became its first President in 1952. Mr. Belcher assumed the role of Chairman in 1955. During World War II, he headed the protective coatings branch of the War Production Board, a group responsible for allocating critical raw materials to industry. Mr. Belcher has served on the Board of Directors and Executive Committee of the National Paint, Varnish, and Lacquer Association, NPCA's predecessor organization, and served for two years as its Chairman of the Board during 1958 and 1959. In 1962, he received the Association's highest honor, the George Baugh Heckel Award.

Rodwin E. Gulick, after 35 years in the coatings industry, retired in 1986 from Union Carbide Corp., S. Charleston, WV, where he held various management positions in product research and development, and marketing for resins, solvents, and specialty chemicals for the coatings industry. Mr. Gulick now heads Gulick Associates, through which he plans to stay involved with the industry. As a member of the Industry Suppliers Committee, he was instrumental in developing the NPCA Data Bank Program (now The U.S. Paint Industry: Technology Trends, Markets, and Raw Materials). His work on MCI's government data subcommittee also helped to insure the more accurate reporting of statistical information about the industry.

Richard C. Kerr, after receiving a Bachelor of Science degree from UCLA and Ph.D. from the California Institute of Technology, joined Union Carbide Corp. as a Technical Representative in 1956. He remained with the company in a number of posts until his retirement last year as a Vice-President. Currently, he is President of Kerr Enterprises. During the early 1970s, Dr. Kerr served on NPCA's Board of Directors, a post he also held in 1983 to 1985. In addition, he was a member of the Industrial Coatings Committee for several years, and served on the Ad Hoc Risk Management Committee in 1984.

William D. Kinsell, Jr., had joined Glidden Co. in 1955 as a Sales Promotion Manager, and held a number of positions with the company before becoming its President in 1976. Upon his retirement, Mr. Kinsell has continued his active involvement in civic affairs participating in the United Way, Junior Achievement, and Kentucky Council for Economic Education. He continues his involvement in the coatings industry as a consultant to raw material supplier companies. In NPCA he served on the Board of Directors, held the post of Treasurer, and Vice-President, and became the Association's President in 1983. He received the NPCA George Baugh Heckel Award in 1984.

Lawrence N. Streff, is employed as the Manager of Environmental Engineering for PPG Industries, Inc., Allison Park, PA. He began his career with the firm in 1947 as a Development Engineer. A veteran member of NPCA's Water Quality/Waste Management Task Force, Mr. Streff served as mission manager during a critical period, and was instrumental in obtaining the withdrawal of EPA proposals that would have set a zero-discharge standard for paint washwater, and would have listed all paint manufacturing waste as hazardous *per se* subject to RCRA requirements. The withdrawals resulted in enormous savings to the industry. In addition, as a member of the Task Force he contributed proposed effluent regulations for resin production, and Superfund enforcement.

George C. Voss, currently Chairman of Isis Chemicals, Inc., Stamford, CT, has previously served as the firm's Vice-President and President. He participated on NPCA's Chemical Coatings Committee from 1969 to 1981, serving as the committee's Chairman for two of those years. Mr. Voss also served as an NPCA board member 1977 and 1978, and has been a member of the Association's Small Paint Manufacturers Committee since 1981. He was also on the Board of Directors of Verlan, Inc., formerly NPCA's captive insurance company, and participated on an ad hoc committee formed to negotiate the 1985 sale of Verlan to a group of its policyholders.

Calgon Corp. Acquires Hercules' Water Management Technology

Calgon Corp., Pittsburgh, PA, has purchased the Water Management Technology business of Hercules' Specialty Chemicals Co., Wilmington, DE. A subsidiary of Merck & Co., Inc., Rahway, NJ, Calgon has integrated the business into its Water Management Div., which offers specialty chemical products, equipment, and services for water-related systems at industrial and municipal plants in the U.S. and abroad.

Approximately 60 sales and technical employees from Hercules have joined the Calgon Water Management Div.'s Domestic Group.

Through the acquisition, the Water Management Technology's Triad Information Network has been added to the existing CalGUARD program. Triad is an interactive computer-based information system that provides answers to customer queries about the status of their water systems.

Arco to Expand Bayport Plant

Arco Chemical Co., a division of Atlantic Richfield Co., Philadelphia, PA, has announced the construction of new facilities at its Bayport, TX plant for production of the company's propylene glycol ethers.

The project, which incorporates proprietary processing, advanced instrumentation, and quality improvements developed at Arco Chemical's Technology and Development facilities in Newtown Square, PA, is scheduled for completion by the summer of 1987.

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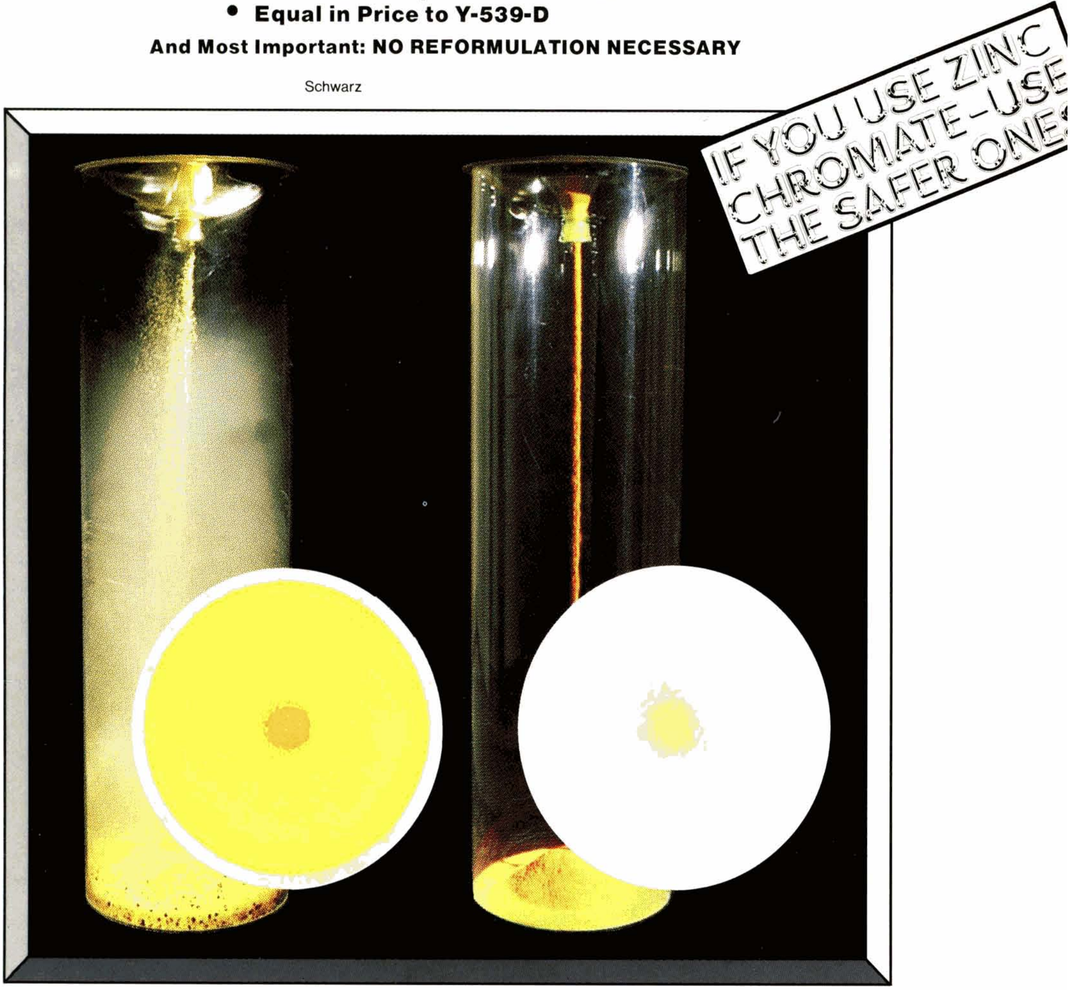

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Dr. David King receives the Queen's Award from Sir John Gilmour. Standing behind are (left to right): Mr. and Mrs. Joseph Scheller, Mrs. David King, Mr. and Mrs. Ernest Scheller, Jr., Councillor Robert King, Lady Ursula Gilmour, and Mr. Ian Stewart

Silberline Ltd., Scotland, Honored for Export Achievement

Silberline Ltd., of Leven, Scotland, was presented the Queen's Award for Export Achievement at special ceremonies at the plant in September 1986. Silberline received the same honor in 1981.

The award was presented to the firm's Managing Director, Dr. David King, by the Lord Lieutenant of Fife, Sir John Gilmour, of Montrave.

On hand from the parent company in the U.S. (Silberline Mfg. Co., Lansford, PA) were President and Mrs. Ernest Scheller and Mr. and Mrs. Joseph Scheller.

Silberline established manufacturing facilities in Scotland in 1974. It now employs 46 people.

Multiclient Coatings Survey Sponsored by WEH Corp.

A new multiclient survey from the WEH Corp., San Francisco, CA, covers markets, trends, raw materials, distribution, geography, contractors, application methods, and similar aspects for the high performance coatings industry. The survey is part of a continuing series on the deep recession in oil and marine activities.

The demand in the United States for coatings used in 14 heavy duty markets is forecast to approach $1200 million in 1996, according to the WEH Corp. This is up from the near $720 million in 1986, and is equivalent to a growth rate of near five percent per year.

The growth rate would be considerably higher except for the damper imposed by the continued marine downturn and the unattractive crude oil exploration prospects in anti-corrosive end-uses in both maintenance and new construction.

The Hazardous Material, Sewage Treatment, and Water Storage and Bridge and Highway market will provide the strong upward pressures.

The study is available from the WEH Corp., P.O. Box 40066, San Francisco, CA 94140.

DeSoto to Restructure Business Segments

DeSoto, Inc., Des Plaines, IL, will restructure operations within its two business segments, chemical coatings and specialty products, through the sale of businesses whose annual sales approximate $30 million and the consolidation of certain West Coast facilities.

The segments include the firm's automotive coatings business and plant in Westland, MI; the Royal Fireplace Furnishings Div., in Chattanooga, TN; and the fatty acid product lines produced at DeSoto's Fort Worth plants. The company also plans to sell its Orange, CA, coatings/detergent facility and to consolidate its West Coast consumer paint and detergent operations at other plants, including those in Berkeley and Union City, CA.

DL to Develop Coatings for Air Launched Rockets

D/L Laboratories New York, NY, has been contracted by the U.S. Air Force to develop coatings and/or coatings systems for air-launched rockets. The coatings will be used to prevent the corrosion of steel or aluminum and/or the migration of moisture and liquid organics.

The program will include the formulation of new coatings as well as the evaluation of proprietary coatings and coatings systems presently available in the marketplace.

Companies that offer raw materials, technology, or formulated coatings for possible use in this program are requested to send complete information and any supporting data (no samples at this time) to Saul Spindel, D/L Laboratories, 116 E. 16 St., New York, NY 10003.

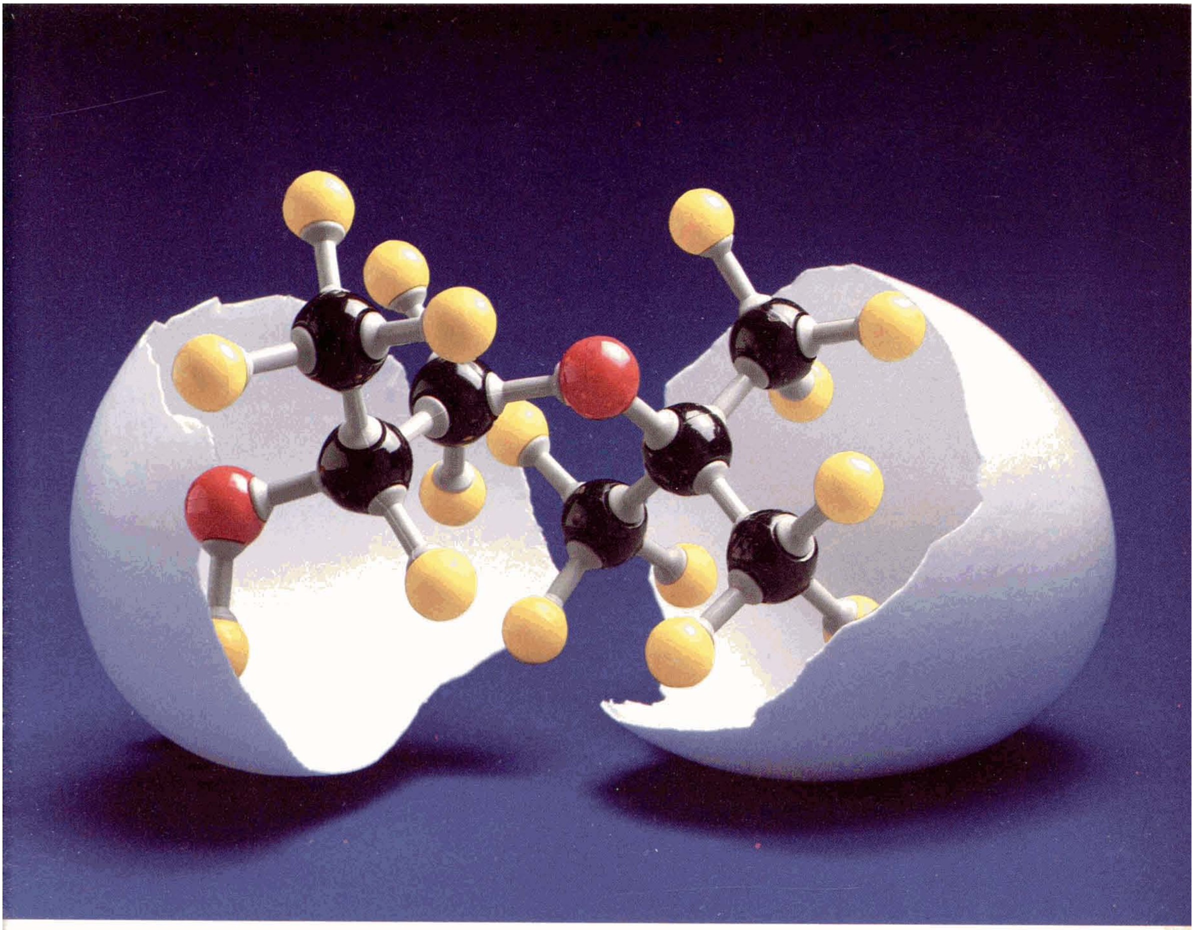
Cyanamid Begins Construction of West Virginia Plant

American Cyanamid Co., Wayne, NJ, is constructing a new facility for the manufacture of a new family of aliphatic isocyanate products. The $20 million plant will be located at the company's complex in Willow Island, WV, and is expected to be in use by mid-1987.

Raabe Corp. Facility Opens

The Raabe Paint Co., Milwaukee, WI, recently opened the doors of its new production and office facility in Menomonee Falls, WI, and officially became Raabe Corp.

The Raabe Corp. has three main warehouse areas adjoining one another, and is equipped with the latest state-of-the-art technology. The facility was designed to comply with the strict insurance codes placed upon the aerosol paint industry.



Introducing ARCOSOLV® PTB ether, the high-performance/lower-toxicity butyl ether.

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ARCOSOLV PTB (propylene glycol monotertiary butyl ether) offers formulators a unique structural blend of hydrophobicity and hydrophilicity, moderate evaporation rate, low surface tension, excellent coupling ability, and solvency power for a wide range of resins, oils and waxes. It can improve product performance versus formulations using conventional glycol ethers, such as ethylene glycol butyl ether (EB) and propylene glycol propyl ether (PP).

Enhanced resin stability improves film performance.
ARCOSOLV PTB ether is essentially (99%) secondary in structure. It does not react with water-reducible alkyd or polyester resins as conventional EO-based glycol ethers like EB and EP do. Stable molecular weight means retention of production quality, and can provide higher customer satisfaction.

Improved toxicology profile.
Like all ARCOSOLV P series ethers and acetates, ARCOSOLV PTB ether has been tested and found to be of low toxicity. In testing specifically designed to address the EPA's questions on EB, no evidence of blood or reproductive organ toxicity was found with PTB.

The CASE for formulation with ARCOSOLV P series ethers keeps getting stronger.
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Paint Adherence to Zinc Coated Steel Is Subject of Study by Battelle

Battelle Memorial Institute, Columbus, OH, is offering participation in a multi-client program to determine material properties, treating, painting, and assembly methods needed to obtain the best adherence of paint to zinc-coated steel.

A follow-up to a recently completed laboratory study, the new program will consist of both accelerated service-life testing and outdoor exposure evaluations of a variety of steel compositions and primers. The results will provide information on corrosion resistance and paint adherence.

During the 16-month program, technical experts at Battelle's Geneva Div. will:

- Correlate results of accelerated laboratory tests with those of outdoor exposure evaluations conducted under varying environmental conditions on stationary steel panels and on operating vehicles;
- Assess paint adherence and corrosion resistance on assemblies involving two or three different materials; and,
- Define conditions for best results for steel treating and painting.

Fifteen types of steel will be tested. These panels will undergo outdoor exposure tests for weathering and corrosion resistance in Florida, Arizona, and Sweden.

An important aspect of the program consists of evaluations for perforation corrosion. The accelerated tests will be conducted by carrying out corrosion tests on both unpainted and primed panels.

Additional information can be obtained from Ernest A. Bortis, Battelle, 505 King Ave., Columbus, OH.

Kyanize Paints Purchased by SICO Inc., Montreal

SICO, Inc., of Montreal, has reached an agreement to acquire Kyanize Paints, Inc., and to develop further the market share of Kyanize and Nu-Brite paint products in the United States.

Kyanize is a paint product manufacturer with plants in Everett, MA, and Springfield, IL. President and Treasurer, Harry A. Hall III, will remain with Kyanize and become a director at SICO.

SICO, Inc., has plants in Montreal, Toronto, Quebec City, and now Nu-Brite Chemical Co., Inc., in Taunton, MA.

Avecor Improves Plant Capacity

A new extrusion line has been installed at the North Kansas City, MO, plant of Avecor Inc., San Fernando, CA, increasing the plant's capacity by 25%. This marks the firm's third expansion for 1986. Earlier this year a high-intensity processing line was added to the San Fernando, CA, facility and a new warehouse was erected in Denver, CO.

Avecor is a national supplier of color concentrates, liquid dispersions, and blended dry colors to the plastics industry. In addition to their facilities in California and Colorado, the firm operates a plant in Vonore, TN.

Midland Awards Vendor Efforts

At their first vendor recognition program the Midland Division of Dexter Corp., Waukegan, IL, selected both the Chemicals and Resin divisions of Shell as the joint recipients of its 1985 Vendor of the Year Award. Other vendors receiving awards of excellence included: Ashland Chemical Co., Dow Chemical U.S.A., Eastman Chemical, Exxon Chemical, and Union Carbide Corp.

Diamond Shamrock Chemicals Acquired by Occidental

Occidental Petroleum Corp., Darien, CT, has completed its acquisition of Diamond Shamrock Chemicals Co., a subsidiary of Diamond Shamrock Corp.

Diamond Shamrock Chemicals, which is comprised of an industrial chemicals division, a soda products division, a process chemicals division, and cogeneration facilities, was purchased at approximately $850 million, including about $110 million in assumed debt.

Through the purchase, Occidental plans to expand its production of potassium hydroxide and chlorine and caustic soda. Earlier this year, Occidental acquired the PVC resins business of Tenneco Polymers, Inc., a subsidiary of Tenneco Inc.

65th Annual Meeting & 52nd Paint Industries' Show
Dallas Convention Center • Dallas, Texas
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Applied Color Systems Forms Subsidiary

Applied Color Systems, Inc., Lawrenceville, NJ, announced the formation of a wholly owned subsidiary in the common market, Applied Color Systems GmbH, headquartered in Marl, West Germany. Newly named Managing Director Wilhelm Cornelius has served as Director of Operations for ACS Europe for the past 10 years.

ACS, Inc., a subsidiary of Armstrong World Industries, develops computer color control systems and software for textile, paint and coatings, plastics and ink, and printing industries.

The ACS Marl, W. Germany, subsidiary is responsible for sales and technical support in Europe, the Middle East, parts of the Far East, Africa, and India.

Grow Group Sells Devoe Marine Coatings

A licensing agreement between Grow Group, Inc. and the Kansai Paint Co., Ltd. of Osaka, Japan, has been executed. Involved is the sale and manufacture of Grow Group's Marine and Corrosion Control Group consisting of Devoe Marine Coatings Co. and Devoe Napko Protective Coatings Division heavy-duty marine offshore and industrial product lines.

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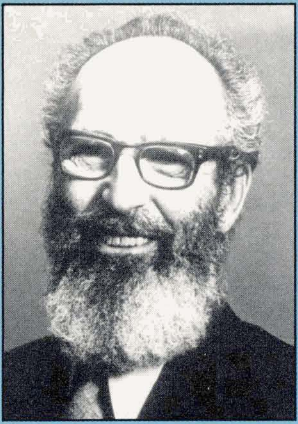

Zeno W. Wicks, Jr.

Zeno W. Wicks, Jr., former Department Chairman of Polymers and Coatings at North Dakota State University, was graduated from Oberlin College in 1941 and obtained his Ph.D. in Organic Chemistry at the University of Illinois in 1944. He then joined the Central Research Laboratories of Interchemical Corp. (now BASF Inmont) in New York City. Initially, he was assigned to work on drying oil and alkyd resin research.

In his 28-year career at Inmont, Dr. Wicks served as Director of Central Research Laboratories, Vice-President of Planning and Commercial Development, Group Vice-President, and a member of the Board of Directors. His last assignment was the responsibility for the coatings, adhesives, sealants, and coated fabrics laboratories for the automotive, building, and general industrial markets division of the corporation.

Dr. Wicks has conducted or directed industrial research projects in the areas of coatings, polymers, coated fabrics, printing inks, textile colorants, plastics, and sealants. In addition, he has served as a consultant to a number of governmental agencies with regard to environmental regulations in the coatings industry.

In 1972, Dr. Wicks transferred from industry to academia when he joined the faculty of North Dakota State University as Professor and Chairman of the Polymers and Coatings Dept. With Loren Hill and Peter Pappas, he participated in the reinvigoration of the first academic coatings center in the world. In 1981, he was designated a Distinguished Professor of the university.

In research at NDSU, Dr. Wicks became involved in a broad range of work related to different aspects of the coatings field, partly due to a wide range of interests but also because of a conviction that one can teach about a topic more effectively if one has done research related to that topic. His principal areas of research included "water-soluble" acrylic resins and baking enamel systems, UV curing, chemistry of crosslinking reactions, and viscosity of oligomer solutions. With his graduate students and colleagues, Dr. Wicks published 20 research papers and 14 review and general interest papers from 1975-1985. Four of the research papers were awarded Roon prizes as the best technical papers offered for presentation at the Annual Meetings of the Federation of Societies for Coatings Technology.

However, while active in research, his first interest was in teaching. He instituted a modernization and expansion of the course work at NDSU. The primary emphasis in the courses was to achieve an understanding of the basic principles and to illustrate their application to real life problems of coatings formulation. Dr. Wicks realized that in many cases there had not yet been sufficient basic research, and hypotheses based on work in other fields of chemistry, especially polymer chemistry, were developed to provide a tentative basis to relate science to the art of coatings formulation. After some years experience with university students, courses were designed to be given as short courses for technical personnel from industry companies.

The connection between teaching and the polymers and coatings industry is seen by Dr. Wicks as being a totally interrelated system. And he is particularly interested in promoting understanding and cooperation between the two. NDSU's Polymers and Coatings Department's Industry Advisory Committee has proven to be of great value both to the Department and to the industry members. It has served as a model for other departments at NDSU and in some other universities' programs for industry-university interactions.

Although he retired from the faculty at NDSU in 1983, Dr. Wicks has remained active as a consultant to the industry, teaching workshops and short courses on subjects ranging from polymers and coatings to management practices and productivity.

By combining his fondness for travel with the love of teaching, Dr. Wicks, with his wife, Susan, has brought these courses not only to companies in the U.S., but also to China, England, and France.

Dr. Wicks is an Honorary Member of the Federation's Northwestern Society and is an Emeritus member of the American Chemical Society.

1986 JOSEPH J. MATTIELLO MEMORIAL LECTURE

Free Volume and the Coatings Formulator

Zeno W. Wicks, Jr.
North Dakota State University*

FOREWORD

I very much appreciate the honor of being designated the 1986 Mattiello Lecturer. I suppose that I may be the last recipient of this honor who actually met Joe Mattiello. I can remember being introduced to him when I started to work for Interchemical Corporation (now BASF Inmont) in 1944. He was a consultant for the company. He said something to the effect that I was fortunate to be entering the field at just the time it was changing from an art to a science. Now, forty odd years later, I tell young people starting in the coatings field that they are fortunate to be entering at a time when the transition from art to science is beginning. Actually, of course, the transition has been proceeding for a century or more. I welcome the change and recognize the need for our field to become more firmly scientifically based. On the other hand, the complexities and variations mean there will be a substantial role for the formulator's art into the indefinite future. Scientists too often fail to recognize the skill of formulators in making useful coatings in spite of the immense complexities of the problems; and the formulators are too often so busy practicing their art that they fail to take advantage of the understanding that science can provide, which could increase the efficiency of formulating.

Many, many people contributed to my education over the last 42 years. Those who made the largest contribution were those who stand with one foot in the art and the other foot in the science of coatings. From my Interchemical days, I would particularly like to recognize my debt to Harry Burrell and Charles Kumins, both earlier Mattiello Lecturers. More recently, there have been three academic people with this Mattiello quality who have made major contributions to my education: Loren Hill, formerly at North Dakota State University and now at Monsanto; Peter Pappas at NDSU; and Werner Funke at the University of Stuttgart. I also must acknowledge the approximately 2,000 students from NDSU and industry who have sat through my classes. Their searching questions forced me to clarify my understanding of the basic concepts of coatings science. One of the important things that I learned from them is how much I don't know. This to me is the fascination of coatings—there is so much that we don't know. We can approach problems, recognizing our ignorance, by establishing hypotheses and designing our work to test these hypotheses. If we were wrong, we have filled in a little of the void in our knowledge. If the hypothesis was right, then we can go on to test the limits of applicability of the idea. To me, this is a more satisfying approach to formulating than reaching bottles off the shelf and hoping something will work.

While I enjoyed all of the many aspects of the industry in which I participated, clearly I enjoyed teaching the most. Therefore, I have decided to give what might be called a teaching lecture. As a topic, I selected: Free Volume and the Coatings Formulator. The objective is to discuss some of the important aspects of the relationship between free volume and the application and performance properties of coatings. Even though many of these relationships cannot yet be quantified, an understanding of the concepts can permit the formulator to work more efficiently and thereby increase his productivity.

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Free volume is defined and the difficulties of quantification are pointed out. The relationship between free volume and viscosity are discussed especially from the point of view of high solids coatings. The effects of free volume availability on film formation by solvent evaporation and by coalescence are treated. Recent work on the effects of free volume on the rate and extent of crosslinking and its implications for formulating ambient cure coatings is reviewed. Effects of free volume on coatings film properties are illustrated by brief discussions of popping, adhesion, corrosion control, and mechanical properties.

FREE VOLUME

The free volume of an amorphous material is the volume not occupied by the molecules making up the material. While this is easy to state, it is not easy to determine, or even define, as an absolute number. For applications of interest in coatings, the schematic drawing shown in *Figure* 1 provides a basis for visualizing the variables that affect free volume. Specific volume, i.e., volume per unit mass, is plotted as a function of temperature, T (°K). As temperature increases, the specific volume increases. There is no additional matter; the same matter is just occupying more space, i.e., there is unoccupied or free volume between the molecules. Starting at very low temperatures, increasing the temperature results in the atoms and molecules vibrating more rapidly and with greater force. Neighboring molecules are knocked farther apart, thereby increasing specific volume. As the temperature is increased above the glass transition temperature, T_g, the slope of the specific volume plot as a function of temperature increases. The energy in the molecules is sufficient that a molecule, or molecular segment, can knock its neighbor out of the way sufficiently to create a hole large enough, and with sufficient lifetime, to permit conformational changes and movement of a molecule or molecular segment into the hole. The free volume spaces (holes) which are generated are transient, opening and closing.

Determination of an absolute T_g is experimentally difficult and perhaps not possible; in fact, some workers doubt the existence of an absolute T_g. Experimental T_g depends upon the rate of heating. If the amorphous material is heated rapidly, there may not be time for molecules or molecular segments to move into some hole before it closes. As a result, a still higher temperature will have to be reached before such motion occurs; i.e., experimentally determined T_g's increase as the rate of heating increases. It should also be remembered that experimental T_g will depend upon the rate at which the sample of amorphous material has been cooled for the determination. If, as is common, the material is cooled rapidly from above T_g to below T_g, some "holes" may be frozen in the amorphous matrix. The T_g of a rapidly cooled glass will thus be lower than the T_g of a slowly cooled glass. When a sample which has been cooled rapidly is allowed to stand at a temperature below T_g, it will slowly "anneal" or "densify." It will contract to a smaller volume and the T_g will slowly increase to the same or similar level of T_g determined with a slow rate of cooling. Since, as will be discussed later, mechanical properties of coatings vary with free volume, the rate of cooling and time of aging at a temperature below T_g can lead to changes in mechanical properties. A review of changes in the glassy state below T_g over time is given in reference (1). An excellent overall discussion of glass transition temperatures is presented in reference (2).

T_g is the temperature below which the time required to establish equilibrium specific volume is longer than the time scale of the experiments. From a thermodynamic point of view, it has been proposed that there is a more fundamental transition temperature, T_2, at a lower temperature than T_g at which configurational entropy is zero.[3] Other workers have arrived at essentially the same concept, calling this temperature the thermodynamic glass transition temperature using the symbol, T_∞.[4] Perhaps this temperature may be thought of as being equivalent to a T_g determined when heating at an infinitely slow rate a sample which had been cooled at an infinitely slow rate.

The dashed line in *Figure* 1 parallel to the solid line plot below T_g represents the specific volume without the 2.5% free volume calculated to be present below T_g in an amorphous solid.[2] Free volume is shown schematically in the figure by the hatched area. As can be seen, the free volume at any given temperature, T, above T_g will be dependent on $(T-T_g)$ and on the relationship of the slopes of the dependence of specific volume on temperature above and below T_g, (i.e., the difference in expansion coefficients above and below T_g). As is evident from looking at the figure, one could also relate free volume to the ratio of T/T_g (or T/T_2).[3,4] While it is possible that in some cases T/T_g is a mathematically superior way of expressing the relationship of free volume with temperature, in this paper we will stay with the more widely used $(T-T_g)$.

At this point, it may be well to emphasize that all amorphous materials, which can be cooled to a sufficiently low temperature without crystallizing, show glass transition temperatures. Many people seem to feel that T_g is a property unique to polymers. The term comes from studies of the temperature dependence of properties of glasses. Small molecule liquids, including many solvents, which can be supercooled well below their freezing temperatures without crystallization, exhibit glass transition temperatures, as do solutions of resins and polymers. It is unfortunate that very commonly T_g is defined as the temperature below which polymers are brittle and above which they are flexible.[5] Examples will be given later to show that this is not the case. T_g is best defined as the temperature above which there is an increase in the temperature coefficient of expansion.

FREE VOLUME AND VISCOSITY

The processes involved in the flow of amorphous materials have not been fully elucidated. All workers would agree that free volume is involved but would not necessarily agree on the mechanism of flow. For our purposes, we will use the relatively simplistic concept of jumping from free volume hole to free volume hole. When no stress is applied to an amorphous material above T_g, molecules (or molecular segments) jump into holes between molecules in a random Brownian motion. However, when a stress is applied, the jump directions which relieve the stress are preferred. Flow occurs through the coordination of many such jumps. Resistance to flow, i.e., viscosity, depends on both the free volume available for jumps and on the extent of coordination of jumps under stress. Much research remains to be done to elucidate the factors controlling the viscosity of coatings resin solutions but it is clear that an important factor is the availability of free volume. In turn, an important factor controlling the free volume is the difference between the T_g of the resin solution and the temperature.[6-8]

Mathematically, the relationship between temperature and viscosity can be expressed by several types of equations. The one that has been used most widely is the relationship suggested by Williams, Landel, and Ferry—the WLF equation (1).*[9]

$$\ln\eta = \ln\eta_{T_r} - \frac{c_1\,(T-T_r)}{c_2 + (T-T_r)} \qquad (1)$$

Equation (1) has been shown to fit data for the temperature dependence of viscosity for a wide variety of amorphous materials including acrylic resin solutions,[8,10] polyester resin solutions,[7] melamine-formaldehyde resin solutions,[7] polystyrene,[9,11] silicone fluids,[8] a BPA epoxy resin,[8] polybutenes,[8] an alkyd resin solution,[12] poly(vinyl chloride),[11] slightly crosslinked natural and polyurethane rubbers,[11] several solvents such as *m*-xylene,[8] ethyl benzene,[13] *n*-propanol,[13] propylene glycol,[13] etc. Equation (1) is a useful empirical relationship but it requires many experimental data points for reasonably accurate determination of constants c_1 and c_2 and provides little basis for predicting the effect of changes in composition on viscosity.

Conceptually, it is more useful to use T_g as the reference temperature resulting in WLF equation (2), where viscosity at T_g is assumed to be 10^{12} Pa·s:

$$\ln\eta = 27.6 - \frac{A\,(T-T_g)}{B + (T-T_g)} \qquad (2)$$

This equation has been shown to give an excellent fit with experimental data for at least most of the systems listed above except for solvents and dilute resin solutions.[8] It has the advantage over equation (1) that we have a reasonably clear understanding of the effect of some changes in composition on T_g[2] and can, therefore, predict the effect of some changes of composition on viscosity. In their early work, Williams, Landel, and Ferry[9] found that constants A and B had similar values for several polymers and proposed 40.2 and 51.6, respectively, as "universal constants," as shown in equation (3):

$$\ln\eta = 27.6 - \frac{40.2\,(T-T_g)}{51.6 + (T-T_g)} \qquad (3)$$

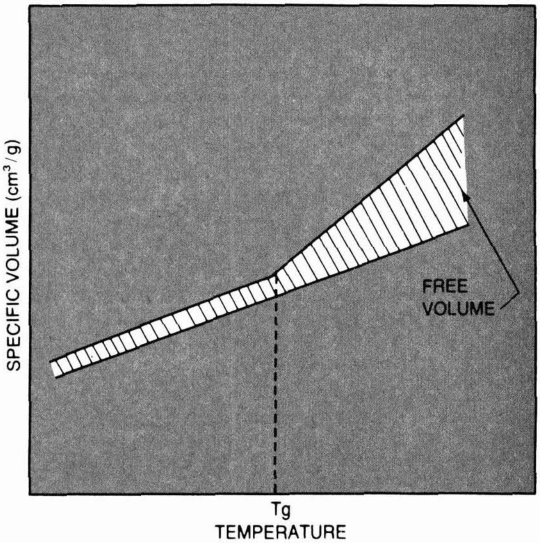

Figure 1—Schematic representation of the dependence of specific volume of an amorphous material on temperature. The hatched area represents free volume (From reference 44 with permission)

The value of 51.6 for constant B indicates that viscosity should be infinite when the temperature is 51.6° below T_g; that is, the value for T_2 should be 51.6° lower than T_g.[3] It has been shown by many workers that the values for A and B are not universal.[8,11,14] This means that ($T-T_g$) is an important but not exclusive variable controlling free volume. Equation (3) can, nevertheless, be useful in cases where it is desirable to make an approximate calculation with a minimum of data. Equation (3) can be useful in making predictions of viscosities at other temperatures when at least three (preferably more) data points are available. It may be more convenient to use the linear form of equation (2), that is, equation (4):

$$\frac{1}{27.6 - \ln\eta} = \frac{1}{A} + \frac{B}{A(T-T_g)} \qquad (4)$$

When one has adequate data and accurate predictions are needed, equation (1) is preferred.

Recognition that viscosity of resin solutions is controlled by free volume availability which is in turn to a major degree controlled by ($T-T_g$), provides a conceptual tool of value to the coatings formulator. Many of the factors controlling the T_g of a material are known.[2] In resin solutions, one major factor is the T_g of the resin. In order of increasing T_g and, therefore, in general, increasing viscosity, one can list: linear siloxanes, linear polyethers, linear aliphatic chains, acrylic ester polymers, and methacrylic ester polymers. We also know that in the case of acrylic and methacrylic esters, methyl esters give higher T_g's and viscosities than ethyl esters which in turn are higher than butyl esters. We know that, in general, aromatic ring content increases T_g while aliphatic chain content decreases T_g, e.g., short oil alkyds give higher T_g and viscosity than long oil alkyds of the same molecu-

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*For consistency, all equations are stated with natural logs rather than base 10 logs, signs are set so that constants will normally have positive signs and, where appropriate, viscosities are in Pa·s. Equations from the literature have been restated to follow these conventions.

Table 1—Solvent T_g's[8,13,15]

Solvent	T_g (°K)
2-methyl butane	68,69
2-methyl-2-butene	73
2-methyl pentane	80
methyl cyclohexane	85,87
3-methyl hexane	88
acetone	93,100
4-methyl cyclohexene	94
methanol	96,103,110
ethanol	97,100
ethyl cyclohexane	98
l-propanol	98,109
methylene chloride	99,103
isopropyl cyclohexane	108
ethyl benzene	111,116,120
l-butanol	111,118
toluene	113,115,117
n-butyl cyclohexane	119
n-propyl benzene	122,126,128
m-xylene	125
n-butyl benzene	125,130
n-pentyl benzene	128,136
benzene	131
water	136,139
n-hexyl benzene	137,140
t-butyl benzene	140
cyclohexanol	150,161
ethylene glycol	154,155

lar weight. Styrenated alkyds have higher T_g's than the corresponding non-styrenated alkyd. It is also well known that in most cases the lower the molecular weight, the lower the T_g and the lower the viscosity. It is known but perhaps less widely recognized that the T_g of resin solutions depends upon their concentration[7,8,10] and the structure of the solvent.[8] The solvent acts as a plasticizer and it has been recognized for many years that plasticizers reduce the T_g and viscosity of polymers.[2] Little work has been reported on the determination and calculation of the T_g of coatings resin solutions. Recently, equation (5) has been shown to fit experimental data for the dependence of T_g on concentration for solutions of acrylic oligomers[8]:

$$\frac{1}{T_g} = \frac{w_s}{T_{gs}} + \frac{w_o}{T_{go}} + Kw_ow_s \qquad (5)$$

While the equation needs testing with other resin systems to see if it has general applicability, it could be a useful empirical relationship. In any case, the lower the concentration, the lower the T_g of the solution and the lower the viscosity. For a particular resin, the T_g of its solutions will also be affected by the solvent structure in two ways. First, solvent T_g depends upon its structure and, second, interactions between the solvent and the resin will affect constant K in equation (5) and hence the T_g of the solution. Solvent T_g can only be determined experimentally for solvents which can be supercooled sufficiently below their freezing point without crystallization to exhibit the transition. It has been shown that it is easiest to determine solvent T_g's of solvents with a ratio of boiling point to freezing point (in °K) of two or higher.[15] In some cases where the T_g of a pure solvent cannot be determined, it can be estimated by extrapolation of data obtained for the T_g of solutions of the solvent in another solvent of known T_g. *Table* 1 provides a list of T_g's of solvents of potential interest in coatings. While solvent T_g is a factor affecting the T_g of resin solutions, it is possible that solvent resin interactions have larger effects on resin solution viscosities.

It has been shown by various workers that the viscosity of high solids coatings drops more rapidly with temperature than is the case with conventional coatings.[6,16] As a result, oven sagging is more likely to be encountered with high solids coatings than with conventional coatings. On the other hand, the advantages of using hot spray are even greater with high solids coatings than with conventional coatings. This difference in behavior presumably results from a more rapid change in free volume with temperature for high solids coatings than with conventional coatings. No data on the constants in the WLF equation (2) for high solids coatings as compared to conventional coatings have been reported in the literature, presumably because the values of constant A are higher for high solids coatings. This could result from a greater dependence of thermal expansion coefficient in the range of 25-100°C. Since high solids coatings in general have higher polar group contents both from the resins and from the solvents and hence have higher numbers of hydrogen bonds that separate in the temperature range of 25-100°C, it seems reasonable to speculate that there would be a greater degree of dependence of free volume on temperature for such high solids coatings. Research is needed to test the validity of the hypothesis. Perhaps, if we had real data, another concept would be available to help the coatings formulator.

FREE VOLUME AND "DRY" FILM FORMATION

In most cases, coatings materials are liquids which must be converted to a "dry," "solid" film after application. Since the resins used in coatings are amorphous, there is not a simple definition of what is meant by a dry or solid film. A useful definition of a solid film is that it will not flow significantly under the forces to which it is subjected during the time of observation.[17] Thus, one can define whether a film is dry under a set of conditions by stating the minimum viscosity required so that flow will not be observable in that time. For example, it has been reported that a film will be "dry to touch" if its viscosity is greater than 10^3 Pa·s.[18] On the other hand, it is said that a viscosity greater than 10^7 Pa·s is required if the definition of "dry" is that the film should resist blocking when two of the coated surfaces are put against each other for two seconds under a pressure of 14 kPa (20 psi).[18]

If we consider the relatively simple case of an unpigmented lacquer, we can estimate the T_g the lacquer film must have to be "dry" by using WLF equation (3) with the "universal" constants. We find that the $(T-T_g)$ corresponding to a viscosity of 10^3 Pa·s is 54°. The estimated T_g to be "dry to touch" at 25°C would, therefore, be −29°C. Similarly, the estimated minimum T_g corresponding to the 10^7 Pa·s required to resist blocking at

25°C at 20 psi for two seconds calculates to be 4°C. If the pressure would be higher, the time longer, or the temperature higher, the T_g of the film would have to be higher to resist flow.

A simple example of such a lacquer could be just a solution of a copolymer of vinyl chloride and vinyl acetate with a hydroxy functional vinyl monomer having a number average molecular weight of 23,000 which is reported to give coatings with good mechanical properties without need for crosslinking.[19] The T_g of the polymer is reported to be 79°C. Even if only highly volatile solvents are used in making the lacquer, if the lacquer is applied at room temperature, the "dry" film will contain several percent of retained solvent. As the initial solvent evaporates, free volume decreases, and when free volume becomes sufficiently limited, further loss of solvent will be controlled by the rate of diffusion of the solvent molecules through the film rather than the rate of evaporation at the surface. As the solvent evaporates, T_g of the remaining film increases. If the film is being formed at 25°C from a solution of a resin with a T_g greater than 25°C (79°C in our example), loss of solvent will become very slow when the T_g of the solution has increased to 25°C. If one needed for some reason to have a solvent free film, one would have to heat the film to a temperature significantly above the T_g of the solvent free polymer. Reference (20) is an excellent review article on solvent retention.

Solvent is retained not only in lacquer films but also in thermosetting films, even when the films are baked at temperatures well above the boiling points of the solvents. It has been shown that solvents are retained in baked films of epoxy-amine coatings resulting in lower glass transition temperatures of the cured films and changes in a variety of properties.[21] Free volume factors involved in crosslinking will be discussed in a later section.

The rate of solvent diffusion through the film depends not only on the temperature and the T_g in the film but also on solvent structure and solvent-polymer interactions. Since the solvent molecules move through free volume holes in the film, it follows that the rate of movement will be more rapid for small molecules than for large ones. Also, the cross-sectional area of the solvent molecules has been related to the rate of loss during the diffusion stage. Thus, isobutyl acetate (IBAc) has a higher relative evaporation rate than *n*-butyl acetate (BAc), but IBAc diffuses more slowly during the second stage of drying.[20] More recently, it has been shown that *n*-octane diffuses more rapidly out of a film than isooctane although isooctane has a higher relative evaporation rate.[22] Linear molecules are thought to diffuse more rapidly through free volume holes because their cross-sectional area is smaller than that of the branched chain isomers. (Since linear solvents would probably have lower T_g's than their branched chain isomers, the T_g of resin solutions in them might be lower than the T_g of resin solutions in the branched chain isomer at the same concentration. Thus, $(T\text{-}T_g)$ would be larger and solvent diffusion would be more rapid for the straight chain isomer.)

It is well known that, in many cases, it is more difficult to control sagging of spray applied high solids coatings than is the case with analogous conventional coatings, in spite of the fact that thinner wet films of high solids coatings can be applied than with a conventional coating to reach the same dry film thickness and that the volume of coating which sags per unit time increases with the third power of wet film thickness. It has been shown, in some cases, that an important factor involved in the sagging problem is that less solvent is lost between the spray gun and the work when applying high solids coatings than when applying conventional coatings.[16,23] One hypothesis to explain this lower loss of solvent, and hence lower viscosity of the coating after it arrives at the work, is that loss of solvent from the high solids coating may become controlled by free volume availability for diffusion of the solvent molecules even at low viscosity.[6,22] While this explanation has been criticized,[24] to date no real alternative explanation has been established. Clearly, further research is needed. Meanwhile, the paint formulator, in many cases, must approach the problem of sag control of spray applied high solids coatings by modifying the formula so that it exhibits thixotropic flow properties.[16]

COALESCENCE OF POLYMER PARTICLES

Film formation in the case of latex paints requires coalescence of high molecular weight polymer particles into a continuous film. This coalescence requires that the polymer molecules in the particles be free to move into other particles after the water evaporates from the applied film. This movement can occur only if there are a sufficient number and size of free volume holes in the latex particles into which the molecules can move. In other words, the T_g of the latex particles must be lower than the temperature at which film formation is being attempted. Latex paint films "dry" relatively rapidly and it has been stated that coalescence is very rapid. However, the time required for complete coalescence can be long. It is not generally recognized by the consuming public (and, unfortunately, not even by some paint formulators) that the properties of latex paint films continue to change over a period of weeks or even months until the coalescence is complete. The rate of coalescence depends upon free volume availability and, as discussed earlier, a major factor affecting free volume availability is $(T\text{-}T_g)$.

Not only is the rate of coalescence controlled by free volume availability, so is the viscosity of the coalesced film. It was shown earlier that for a film to withstand even a relatively mild blocking test, the $(T\text{-}T_g)$ would have to be of the order of 21°C. If the film should resist blocking at 40°C, the T_g of the film should be at least 19°C. However, in many cases the paint must be formulated so that it can be applied at a temperature as low as 5°C, so that the T_g of the latex particles would have to be lower than 5°C. (In this oversimplified example, the possible effects of pigments on film formation are ignored.) There have been two major approaches to this difficult problem. First, one can add a coalescing agent to the formula of the latex paint. The coalescing agent dissolves in the latex particles, acts as a plasticizer, increases free volume availability, reduces T_g, and, hence, permits film formation at a lower temperature. After the film has formed, the coalescing agent can slowly diffuse to the surface of the film and then evaporate. Since the free volume in the film is relatively low, because even with the coalescing agent present the $(T-T_g)$ will be fairly small, the rate of loss of the coalescing agent will be slow. Furthermore, as the coalescing agent evaporates, the T_g will increase so that the rate of loss will become slower and slower. Even though the films feel dry, they will still block and pick up dirt for relatively long periods of time after application. In view of the importance of formulating latex paints using the most appropriate T_g polymer and coalescing agent structure and concentration, it is surprising that I have seen no published reports of studies of the T_g of such systems or of the change of T_g with time after application when stored at different temperatures.

The second broad approach to the problem of permitting application at low temperatures while achieving resistance to blocking and dirt pick up is by designing the latex particles so that they have differential T_g's between the interior of the particles and the outer surface of the particles. Most research of this type has been done in industrial laboratories and is proprietary. One paper describing this approach to latex preparation was presented as a Mattiello Lecture by Ken Hoy.[25] He describes a technique for synthesizing a latex with a gradient of composition and hence of T_g from the center to the surface of the particles while maintaining compatibility of the range of polymer structures. The lower T_g polymer molecules are kept at the surface of the particles by incorporating a small amount of acrylic acid as a comonomer and converting the carboxylic acid groups to salt groups with ammonia. The polar salt groups tend to stay at the water interface. After application the water evaporates, the ammonia evaporates, then the particles coalesce at a relatively low temperature due to the low T_g at the surface of the coalescing particles. As the film stands, the polymer molecules intermingle to reach an equilibrium blend with a higher T_g. This can permit a better balance of film formation temperature and blocking resistance. Obviously, achievement of such an equilibrium still takes time and can be accelerated by use of coalescing agents. However, one can reach some level of resistance to blocking and dirt pick up in less time than with a conventional latex.

Another type of coating where film formation occurs by coalescence is powder coatings. Since the powder must not fuse or sinter during storage, the free volume at storage temperature must be sufficiently low to avoid coalescence during the time interval required by stability requirements. In general, the T_g of the powder formula would be set so that it is higher than the storage temperature. However, rapid fusion after application requires that the $(T-T_g)$ be as large as possible. Availability of free volume not only permits coalescence but also leads to low enough viscosity for leveling of the film to minimize orange peel. As is common in coatings formulation, compromises must be made between storage stability and the baking temperature required for film formation and leveling. Again basic studies of the factors controlling free volume availability should provide useful tools to the formulator. The problems of powder coatings formulation are further complicated by the effect of free volume availability on crosslinking reactions in thermosetting powder coatings.[26] The relationships between crosslinking and free volume are discussed in the next section.

FREE VOLUME AND CROSSLINKING

The rates of crosslinking reactions during storage and the initial stages of curing of films are controlled by kinetic parameters. Pappas and Hill have discussed these kinetic considerations.[27] However, before two functional groups can react with each other, they must be in close proximity. If there is no free volume, the functional groups can not get adjacent to each other and no reaction can occur. If the free volume is sufficiently large, the functional groups have easy access to each other and the rate of reaction will be governed by concentrations of reactants and the kinetic parameters of the reaction. At intermediate levels of free volume, the reaction rate will be controlled by the rate of diffusion through the reaction matrix.

If one is working with relatively low molecular weight resins and crosslinkers, the amount of free volume will decrease as the reaction proceeds and, correspondingly, the T_g will increase. If the temperature of curing is higher than the T_g of the fully reacted system, the reaction will go to completion. If, however, the temperature of curing is below the thermodynamic T_g, i.e., T_2, the reaction will stop before completion. An increasing number of studies of such effects are being published in literature.[28-31] One will see the statement made that reactions cease when the T_g of the system has increased to equal the temperature of reaction.[28] Another paper, however, reports that a crosslinking reaction continues after T_g has risen above T but that the reaction slows to a rate two to three orders of magnitude slower than when the temperature is above T_g.[30] In this case, the author reports that reaction will continue at a slow rate at temperatures as much as 50°C below T_g. It is of interest to note that earlier we said that with the "universal" constants in the WLF equation, T_2 was 51.6°C below T_g.

The variety of reports in the literature may reflect the experimental difficulties involved in studies of reaction rates and the extent of reaction in polymer systems and in determining T_g. If reaction rates are very slow, it is common to say that no reaction occurred rather than to say that no reaction could be detected during the time span of observation. Analysis for residual unreacted functional groups in polymer systems can be relatively inaccurate when the amounts are small. Commonly, it is even difficult to know the temperature of the reaction. This particular problem can be especially difficult in the case of very fast reactions such as in the case of UV curing.[32] UV sources also emit infrared and the reactions involved are exothermic; the temperature within the film may, for these two reasons, be significantly higher than the air temperature. This could lead to a reaction proceeding until the T_g is higher than the reported temperature of the reaction. Also, if a film is exposed for durability tests, especially outdoors, the temperature for a degradation

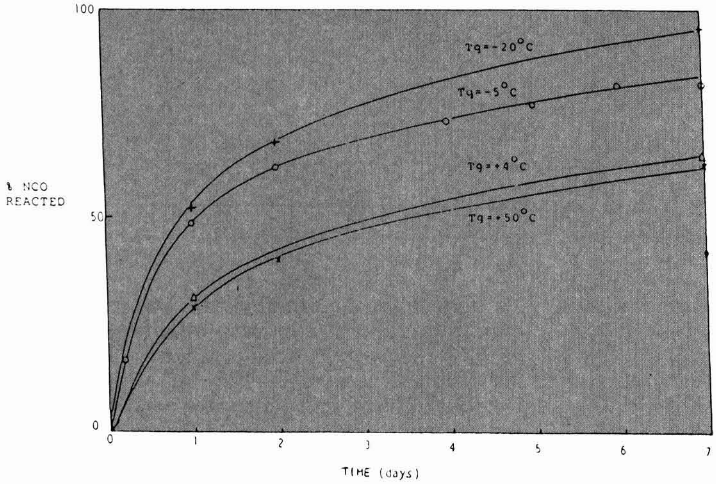

Figure 2—Extent of reaction of the trimethylolpropane adduct of *m*-tetramethylxylene diisocyanate with a series of acrylic polyols of varying T_g. Using 0.02 equivalents of OH and NCO with 0.0005 equivalents of dimethyl tin dilaurate catalyst at 21°C and 50% RH (From reference 34 with permission)

reaction could vary over a wide range. Another problem is the measurement of T_g. The T_g of a system is very dependent on the method of determination. The rate of cooling of the sample for the determination, the rate of heating during the determination and, in cases where mechanical property changes are being used for the determination, the rate of application of stress (and perhaps the amplitude of the stress) can all make large changes in the value obtained experimentally. In any case, the experimental T_g will be higher than T_2.

It also may be that there will be different effects depending on the type of reaction involved. It may be "easier" for small crosslinking molecules to react than for groups on polymer chains to react. It may be easier for free radicals to react than for functional groups because they can react with many sites on the other molecule whereas the functional group must find the other functional group with which to react. A recent paper has suggested that the crosslinking reactions may depend not just on the T_g of the polymer system but also on the structure of the backbone.[33] For example, two thermosetting acrylic resins reported to have the same T_g but made with different amounts of methacrylate monomers compared to acrylate monomers behaved differently. The reactions proceeded to the same degree of completion under similar conditions, but with the high methacrylate content systems, the films obtained were much harder. The author suggests that intramolecular reactions of the crosslinking groups may be less likely when the backbone of the resin is relatively rigid due to the high methacrylate content, whereas when the backbone is higher in acrylate content, the backbone will be more flexible and it is easier for it to bend back on itself to undergo intramolecular reactions which do not lead to crosslinking different polymer molecules. When there is more intermolecular crosslinking, the film may be harder than when the crosslinking reactions have been intramolecular.

Another recent paper provides an example of the importance of free volume availability in crosslinking.[34] The authors were evaluating a trimer derived from a new aliphatic diisocyanate which contains an aromatic ring, *m*-tetramethylxylene diisocyanate, as a crosslinker for hydroxy functional resins. Although essentially complete reactions were obtained when films were cured at elevated temperatures, when the coatings were cured at 21°C, the reaction not only was slow, it also essentially stopped at about 50% completion. The acrylic resin being crosslinked had been designed for use with a more flexible isocyanate crosslinker, the triisocyanate biuret derivative of hexamethylene diisocyanate. A series of lower T_g acrylic resins was synthesized. It was found that as the T_g of the acrylic resin was decreased, the crosslinking reaction at 21°C was faster and went more nearly to completion. The results are illustrated in *Figure* 2. With a properly designed acrylic resin, the experimental isocyanate gave room temperature cured films at comparable rates, extent reaction and film hardness to the results obtained with the linear, more flexible, isocyanate and an acrylic resin which had been designed for use with it. Similar results were obtained with polyester resins by properly designing the T_g of the polyester to go with the new diisocyanate. Resins and crosslinkers must be selected or designed to be used with each other. This is especially important for ambient temperature curing films.

Another example of the effects of free volume on film formation is encountered in the use of styrenated alkyds as primer vehicles. Due to the high styrene content, styrenated alkyds have higher T_g's than non-styrenated alkyds. After application, the solvent evaporates and the films of styrenated alkyd primers "dry" very rapidly due to the high T_g. However, while the films feel dry, the crosslinking reaction is not complete and one must be careful of the timing of applying a top coat. If the primers are top coated at a stage when they are only partly crosslinked, lifting of the primer by the solvents in the top coat is likely. While there have been no studies of changes in T_g and extent of crosslinking reported, it is probable that crosslinking of styrenated alkyds at room temperature

Table 2—Residual Solvent and T_g of Epoxy-Amine Coatings

Solvent	Retained Solvent (Wt. %)	T_g (°C)
None	0	130
Methyl ethyl ketone	3.5	112
Toluene	4.3	105
2-Methoxyethanol	5.3	104

Data selected from reference (21).

Table 3—Critical Film Thickness for Popping

Copolymer T_g(°C)	Critical Dry Film Thickness (μm)	
	Water	Solvent
−28	50	>120
−13	30	>70<95
− 8	20	>70<95
14	10	55
32	5	25

occurs more slowly than does the crosslinking of the corresponding non-styrenated alkyd. Again, basic studies may provide useful tools for the formulator.

It is common to hear that one cannot apply epoxy-amine primers at low temperatures. No studies of the changes of T_g during the room temperature cure of epoxy-amine primers have been reported. However, from studies of the changes of T_g of other kinds of epoxy-amine systems that have been published, one can visualize the possible problem of curing epoxy-amine coatings at low temperature. In one case, an epoxy resin with a T_g of −23°C yielded a crosslinked plastic with a T_g of 132°C after complete reaction with a polyamine.[30] When the reaction was carried out at 26°C for 70 hours, the T_g was reported to be about 50°C and the reaction was only 70% complete.

As noted earlier, solvent applied epoxy coatings can retain solvent in the film which can affect the T_g and properties of the film.[21] *Table* 2 shows percent solvent retention and T_g of epoxy-amine coatings films which had been applied solvent-free and with three different solvents. All films were baked four hours at 80°C followed by four more hours at 130°C. The extent reaction of the epoxy groups was in the range of 93-97%.

Many variables affect the extent of reaction in epoxy-amine systems. It has been shown that amine structure, stoichiometric ratio, presence of catalyst, catalyst concentration, temperature, and rate of heating all have significant effects.[35] In designing an epoxy-amine system for use at low temperatures, the T_g's of the epoxy resin, the amine crosslinker, and the fully reacted system must be such as to permit complete (or at least adequate) cure at the desired temperature. Much further research is needed before quantitative predictions can be made but the basic concept can still be useful to the person formulating epoxy-amine coatings for low temperature application.

From this brief summary, it is evident that much further research is needed to understand the relationship between free volume and the crosslinking of coatings. However, even with the present incomplete understanding, the general concepts can be useful in formulating coatings and understanding some kinds of problems that are encountered with coatings.

FREE VOLUME AND PROPERTIES OF FILMS

Free volume availability can affect the application of coatings. The somewhat controversial question of the effect of free volume availability on the sagging of spray applied high solids coatings has already been mentioned.

Popping of baking enamels when they are put into the oven can also be related to free volume availability. It has been shown that the probability of popping increases as film thickness increases. Baking panels with differing film thicknesses of the coating under standardized conditions permits the determination of the critical minimum film thickness for popping for a formulation. *Table* 3 shows the critical film thicknesses for popping for a series of white baking enamels made with "water-soluble" acrylic resins with different T_g's. One series of the coatings was reduced for application with solvent and the other series was reduced with water. Films were baked at 150°C. The critical film thickness for popping increases as the T_g of the copolymer decreases. When solvent is lost first from the top of the film, a high viscosity (low free volume) layer can form at the top of the film while substantial amounts of solvent still are present in the lower levels of the film. As the temperature increases, this solvent is vaporized leading to blistering (popping). Popping is more likely to occur with high T_g resins since the viscosity of the top layer of the film will be higher after the same amount of solvent has been lost.

Intercoat adhesion and adhesion of coatings to plastics can be affected by the availability of free volume in the substrate. If the temperature of the substrate is above the T_g of the substrate, migration of solvent molecules or, more importantly, resin molecules into the free volume holes of the substrate can occur relatively easily. As a result, there will be an interpenetration of the top coat molecules into the matrix of the primer or plastic substrate. While adhesion is most easily achieved at temperatures above the T_g of the substrate, it is also possible to obtain the necessary free volume by having the solvent of the top coat dissolve into the surface of the substrate hence acting as a plasticizer to increase the available free volume in the substrate and permit development of intercoat adhesion.

The effect of the availability of free volume on the diffusion of resin molecules, solvent molecules, and reactive functional groups has been discussed so far. Analogously, diffusion of other molecules such as water and oxygen is affected by the availability of free volume. Werner Funke has shown that the major factor affecting corrosion control by coatings is the adhesion of the coating to the steel in the presence of water but the corrosion protection is also influenced by the permeability of the coating film to water and oxygen.[37] Since an important factor affecting permeability of oxygen and water is diffusion rate, the permeabilities of coatings will be affected by free volume availability. Thus, an important factor is the (T-T_g) of the coating. Since, as discussed earlier, some free volume is still available below T_g, minimum diffusion of oxygen and water through the film should presumably be found when the temperature is below T_2. However, crosslinking of the film requires that the temperature be above T_2. This may be one reason that baked coatings almost always give superior corrosion protection to that afforded by similar composition air dry coatings. Studies of the free volume of these systems is more complicated than is the case with simple unpigmented coatings films. The presence of pigment can affect the T_g and the permeability of the coating to water and oxygen. Charles Kumins has addressed some of the factors involved in this interaction in his Mattiello Lecture.[38] Also, the presence of the water can affect the T_g of the film. Water can act as a plasticizer for many films, particularly those, such as urethane coatings, which have strong intermolecular hydrogen bonding. A recent study of moisture diffusion in epoxy-amine thermoset plastics illustrates the phenomenon. After oven curing, the plastic had a T_g of 124°C; however, when a sample was allowed to equilibrate with water, the T_g came down to 97°C.[39] Thus, the presence of the water reduces the T_g of the system and, therefore, increases the rate of diffusion of not only water but also of oxygen. These considerations are vital in formulating corrosion protection coatings, particularly coatings that are to be cured at ambient temperature. It is also critical to remember that free volume availability must be taken into consideration when testing corrosion protection of coatings. If the tests are run at high temperatures in order to accelerate corrosion, the results may bear no relation to results which may be obtained in actual use.

The mechanical properties of coatings can be profoundly affected by the availability of free volume. Coatings films are viscoelastic solids. The viscous response of such films is related to the availability of free volume. If the free volume is zero, the material will show a purely elastic response, that is, deformation will be proportional to the stress applied and when the stress is released the material will return to its original shape. If the stress is sufficiently high, the material will break. Such a material is brittle. If, however, some free volume is available at the temperature at which the stress is applied, that is, if T is greater than T_2, viscous flow as well as elastic deformation can occur. Such a material may be flexible. Its ability to withstand a stress without breaking will be dependent on the rate of application of stress. If the stress is applied rapidly so that there is little time for viscous flow, the response will be primarily elastic and there may be brittle failure. If, however, the stress is applied slowly, there will be the opportunity for viscous flow to occur, relieving part of the stress so that more strain can be applied before rupture occurs. The mechanical properties of such a thermoplastic system will thus be controlled by the free volume available and the rate of application of stress. It is common to see as a definition of T_g, that it is the temperature below which a material is brittle and above which it is flexible.[5] That is an erroneous definition. Thermoplastic polymers exhibit a brittle-ductile transition temperature, T_b.[40] Below this temperature, they are elastic and will break if their tensile strength is exceeded; above this temperature, they are viscoelastic. Different thermoplastic polymers show large differences. In the difference between T_g and T_b, for example, the polycarbonate of bisphenol A is still ductile 350 degrees below its T_g while other polymers, such as polystyrene, are ductile until only about 10 degrees below T_g. Reasons for such differences have not yet been fully elucidated. It may be that, in some cases, T_b is related to T_2. Perhaps the greater susceptibility of polystyrene to crazing at temperatures below T_g as compared to polycarbonate plastics[41] is related to this difference in temperature behavior.

When relatively low molecular weight polymers are crosslinked, initially, T_g increases but after this, T_g does not increase further. As the degree of crosslinking is increased further, the modulus above T_g increases, the films are harder, have higher tensile strength, are less extensible and, therefore, more likely to break if sufficient stress is applied. The films will generally behave as viscoelastic materials until the degree of crosslinking gets to be very high and hence the mechanical properties will depend upon the rate of application of stress as well as the temperature. Few studies of brittle-ductile transition of crosslinked polymers have been reported. Examples of crosslinked materials that have been described as ductile to differing degrees depending upon degree of crosslinking are amine cured epoxy resins[42] and polyurethane coatings.[43] Further research on brittle-ductile behavior of coatings could be of considerable practical value.

Physical properties of coatings such as flexibility, impact resistance, abrasion resistance, and formability depend upon the availability of free volume and hence on the temperature and rate of application of stress. For further discussion of the relationship of temperature (free volume) and mechanical properties see references (2), (44), and (45).

Physical properties of coatings will commonly change with aging of coatings. Unless the solvent is removed at a temperature substantially higher than T_g, residual solvent will diffuse slowly out of the film, T_g will increase, and, at any particular temperature, the film will become more likely to show brittle failure. Since latex particle coalescence is slow in the late stages and since loss of coalescing agent is slow due to limited free volume, properties of latex paints, such as dirt retention and blocking change relatively slowly with aging. Since, in many cases, thermosetting coatings, especially those applied and cured at ambient temperature, reach the stage of diffusion rate control of the crosslinking reaction before the reaction is complete, film properties can be expected to change with age. As has been shown earlier, plastics, [1-46] and therefore presumably coatings, which have been heated above their T_g and then cooled will undergo annealing, densification, and increasing T_g with aging. Such films would become more brittle with age. Hill suggests that property changes that have been attributed to slow solvent loss, long term additional crosslinking, and crosslinking due to outdoor exposure may actually be caused by densification in some cases.[47]

SUMMARY

The availability of free volume affects the properties of coating materials at all stages. An understanding of the relationships between the availability of free volume and the properties of coatings and coatings films can assist the coatings formulator in making more intelligent decisions in formulating coatings. In most cases, these concepts can, at this time, only be used qualitatively and much further research will be needed to achieve significant quantitative relationships. I hope that you will agree that the topic of free volume illustrates the Mattiello character of a bridge point between the art and the developing science of coatings.

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1986 A.L. HENDRY AWARD PAPER

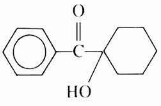
Evaluation of Photoinitiator Performance

Dennis J. Gaber
Eastern Michigan University*

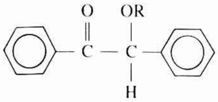
The purpose of this study was to determine the best photoinitiator performer in a UV cure system. Thin films, prepared by using reduced formulations and the photoinitiators of Irgacure 184, Vicure 10, and DEAP, were subjected to the common testing methods of Sward Hardness, Impact Resistance, and double MEK rubs. Data proved Irgacure 184 to be the best in these tests, providing generally superior results.

INTRODUCTION

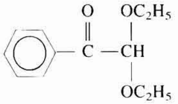
The research conducted was to evaluate the performance of three photoinitiators: Irgacure 184® (I), Vicure 10® (II), and DEAP® (III) in UV-cured coating formulation systems. Their structures are as follows:



I

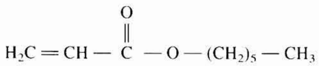


II



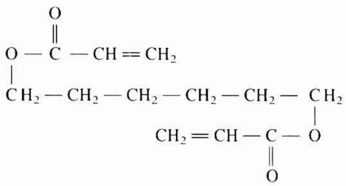
III

The photoinitiators were used in reduced formulations prepared from the commercially available materials of Celrad 3600®, an acrylated epoxy resin and the three reactive diluents of hexyl acrylate (IV), hexanediol diacrylate (V), and trimethylolpropane triacrylate (VI), shown below:



$$H_2C=CH-\overset{\overset{\displaystyle O}{\|}}{C}-O-(CH_2)_5-CH_3$$

IV



$$\begin{array}{l} O-\overset{\overset{\displaystyle O}{\|}}{C}-CH=CH_2 \\ | \\ CH_2-CH_2-CH_2-CH_2-CH_2-CH_2 \\ \qquad\qquad\qquad\qquad\qquad\qquad\quad | \\ \qquad\qquad\qquad CH_2=CH-\underset{\underset{\displaystyle O}{\|}}{C}-O \end{array}$$

V

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*Department of Interdisciplinary Technology, Ypsilanti, MI 48197.
Irgacure 184 is a registered tradename of CIBA-GEIGY Corp.
Vicure 10 is a registered tradename of Stauffer Chemical Co.
DEAP is a registered tradename of the Upjohn Co.

Celrad is a product of Celanese Specialty Resins.

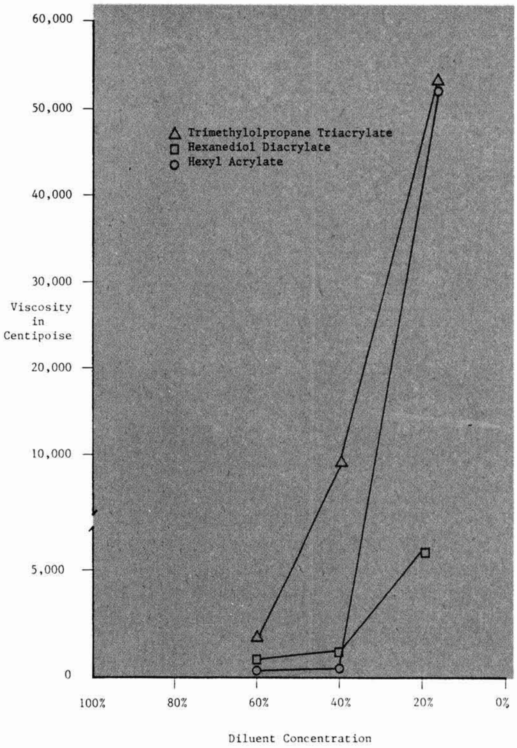


Figure 1—Brookfield Viscosity values

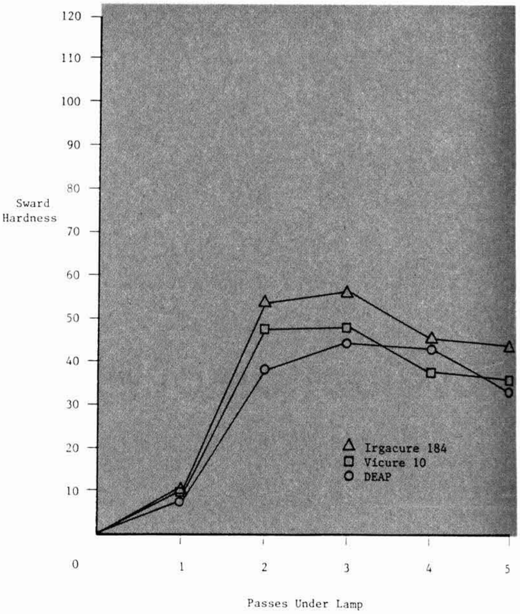


Figure 3—Sward Hardness values for HA at 40% reduced concentration

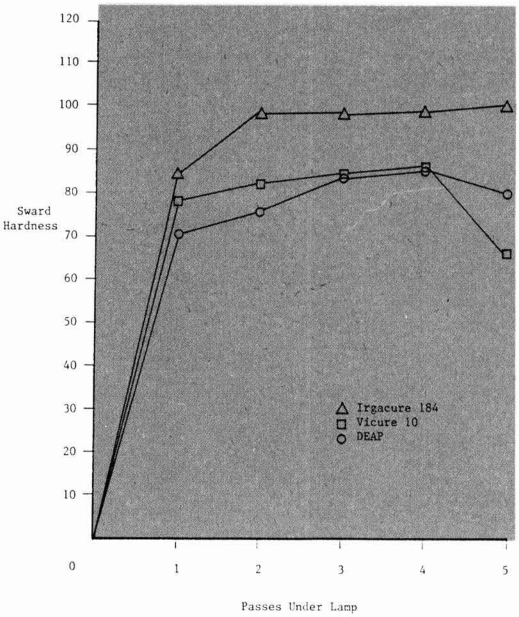


Figure 2—Sward Hardness values for HA at 20% reduced concentration

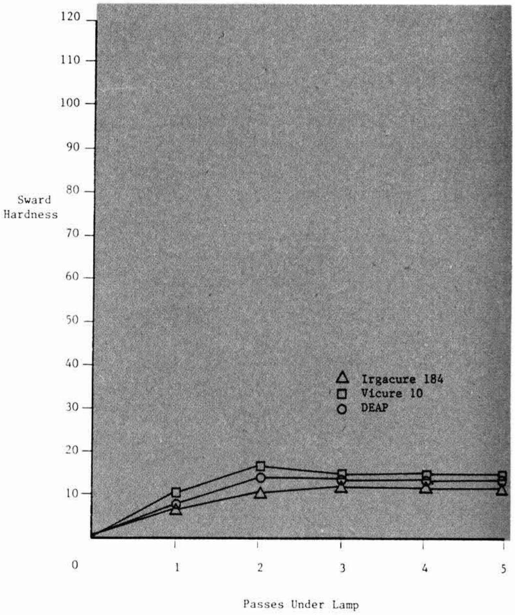


Figure 4—Sward Hardness values for HA at 60% reduced concentration

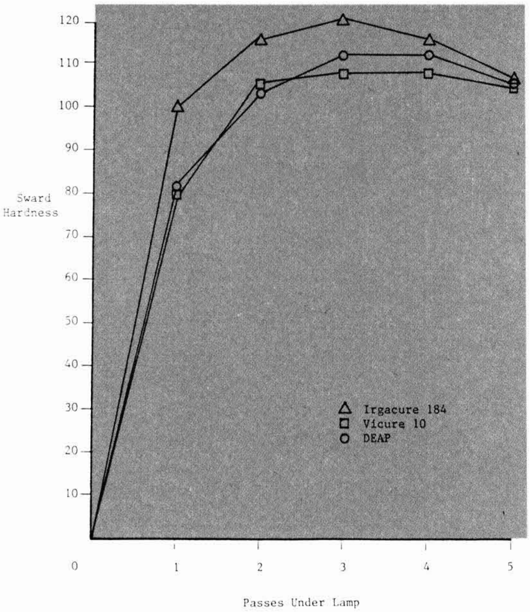


Figure 5—Sward Hardness values for HDODA at 20% reduced concentration

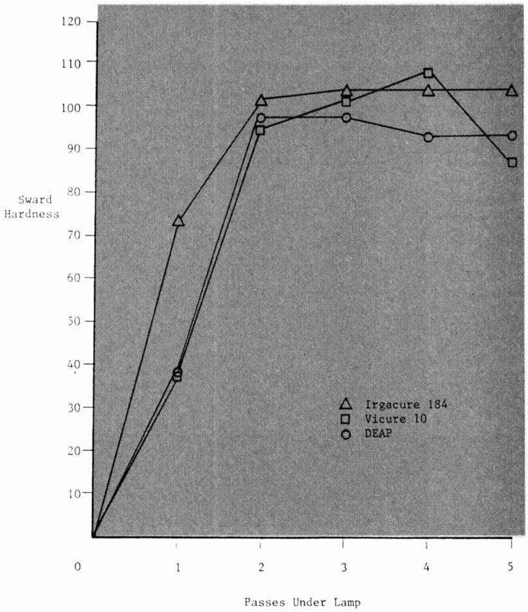
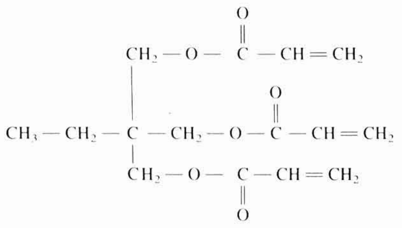


Figure 6—Sward Hardness values for HDODA at 40% reduced concentration



VI

Test data were obtained by measuring the viscosity and cure behavior of the formulations and the hardness and impact resistance of the coatings. Compatibility observations were made on all reduced formulations on a clear/cloudy basis; all formulations were clear.

METHODS AND MATERIALS

The approach used to screen the three photoinitiators was to dilute Celrad 3600 with hexyl acrylate (HA), hexanediol diacrylate (HDODA), and trimethylolpropane triacrylate (TMPTA) at 20%, 40%, and 60% concentrations by weight. The initial tests performed were compatibility observations and viscosity measurements made on the reduced formulations using a Brookfield Viscometer, model RVF (ASTM D 2196). Photoinitiators then were added slowly with constant mechanical mixing to each formula at 2% by weight concentrations, on an equimolar basis at 22 ± 2°C. Drawdowns were made using a #32 wire wound rod on 4″ × 8″ × .0200″ (10.2 × 20.3 × .05 cm) steel panels. The panels were passed immediately under one 200 watt/in., medium pressure mercury Hanovia lamp, at a height of 5.4 in. (13.7 cm) and at a line speed of 50 ft/min (15.2 m/min) in an air curing environment. Consistency of a 3 mil (±0.1) dry film was obtained by monitoring the film with a General

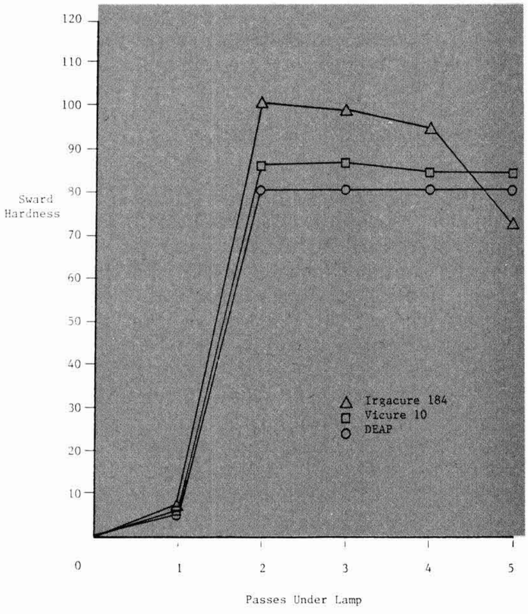


Figure 7—Sward Hardness values for HDODA at 60% reduced concentration

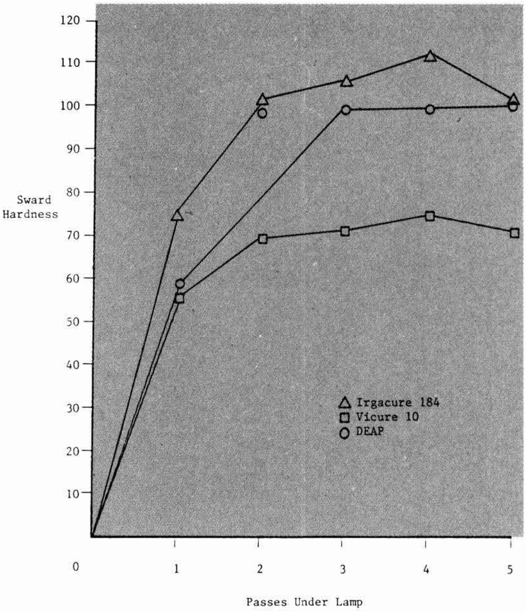


Figure 8—Sward Hardness values for TMPTA at 20% reduced concentration

Electric magnetic mils-thickness meter (ASTM D 1186). Degree of cure was determined by Sward Hardness (ASTM D 2134), and the number of double MEK (ASTM D 3732) rubs needed to penetrate the film. These tests were performed ½-1 hr after exposure. Impact resistance data was obtained from the steel panels using an extrusion force of a 2 lb punch falling at various heights with a spherical head diameter of 0.50 in. (1.27 cm) at 22 ± 2°C (ASTM D 2794). The values were obtained on panels at maximum hardness.

RESULTS AND DISCUSSION

Brookfield Viscosity values are given in *Figure* 1. HA and TMPTA were very viscous formulations at 20% concentration. Viscosities of all three standards decreased rapidly at 40% and 60% concentrations. At 20% concentrations, photoinitiators were added and mechanically mixed, resulting in a high concentration of small air bubbles. The bubbles were removed from the solution over a standing period of three days.

Upon completion of each pass, the panel was evaluated for Sward Hardness and double MEK (methyl ethyl ketone) values. *Figures* 2, 3, and 4 show Sward Hardness values for HA at reduced concentrations of 20%, 40%, and 60% with all three photoinitiators. There is a rapid decline in the hardness values as diluent concentration increases. At 20% and 40% concentrations, however, Irgacure 184 gave higher values more rapidly with less degradation than did Vicure 10 or DEAP. At 60% concentration, very low hardness values were obtained and the differences in performance of the photoinitiators are probably insignificant.

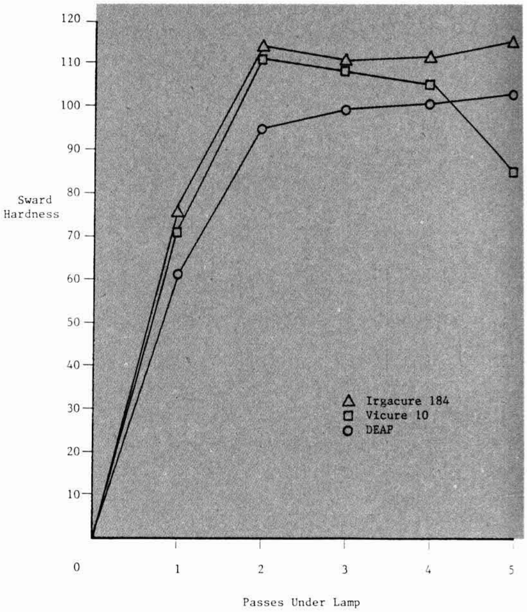


Figure 9—Sward Hardness values for TMPTA at 40% reduced concentration

Results of values obtained with Sward Hardness for HDODA reduced formulas are contained in *Figures* 5, 6, and 7 for all three photoinitiators. The crosslinking ability of HDODA allows a degree of hardness higher than HA formulas to be obtained even at low resin concentra-

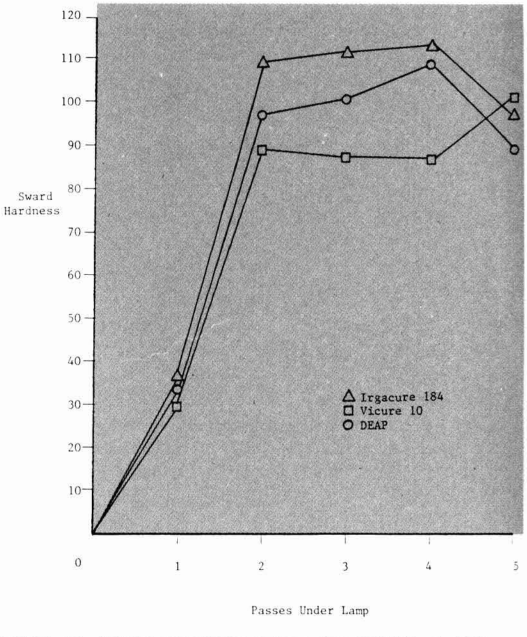


Figure 10—Sward Hardness values for TMPTA at 60% reduced concentration

Table 1—Degree of Cure by Number of Double MEK Rubs

Hexyl Acrylate

No. of Passes	20% Irg	20% Vic	20% DEAP	No. of Passes	40% Irg	40% Vic	40% DEAP	No. of Passes	60% Irg	60% Vic	60% DEAP
1	100	100	100	1	100	82	100	1	14	10	13
				2	—	100	—	2	100	20	25
								3	—	100	82
								4	—	—	100

Hexanediol Diacrylate

No. of Passes	20% Irg	20% Vic	20% DEAP	No. of Passes	40% Irg	40% Vic	40% DEAP	No. of Passes	60% Irg	60% Vic	60% DEAP
1	100	100	100	1	100	100	100	1	100	100	100

Trimethylolpropane Triacrylate

No. of Passes	20% Irg	20% Vic	20% DEAP	No. of Passes	40% Irg	40% Vic	40% DEAP	No. of Passes	60% Irg	60% Vic	60% DEAP
1	100	100	100	1	100	100	100	1	100	100	100

tion.[1] Again, the Irgacure 184 proved to be the better photoinitiator, giving a faster, harder cure. In the 20% and 60% concentrations, there was degradation of the film which was not observed with the 40% formula, and the DEAP initiated systems were the most consistent, with hardness values remaining fairly constant.

The formulations using TMPTA gave film cures that were high for all concentrations which is attributable to TMPTA's crosslinking ability. *Figures* 8, 9, and 10 show that Vicure 10 performed poorly in the 20% formula and significantly degraded in the 60% formula. DEAP, again, was consistent except for the 60% formula where it showed degradation at the fifth pass.

It was observed that slight "degradation" or softening of the cured film took place in some instances after the fourth or fifth pass. This was an unexpected observation and is reminiscent of "cure reversion." However, this could be an artifact caused by the effects of coating thickness, heat, or relaxation processes. Further investigation would be warranted for a clear understanding of this phenomenon.

Table 2—Reverse Impact Resistance—in./lbs at Failure

Hexyl Acrylate

20%		40%		60%	
Irg 184	3	Irg 184	12	Irg 184	74
Vic 10	5	Vic 10	12	Vic 10	84
DEAP	4	DEAP	8	DEAP	66

Hexanediol Diacrylate

20%		40%		60%	
Irg 184	2	Irg 184	1	Irg 184	1
Vic 10	2	Vic 10	1	Vic 10	1
DEAP	2	DEAP	1	DEAP	1

Trimethylolpropane Triacrylate

20%		40%		60%	
Irg 184	1	Irg 184	1	Irg 184	1
Vic 10	1	Vic 10	1	Vic 10	1
DEAP	1	DEAP	1	DEAP	1

Cure of the coating was also evaluated by double MEK rubs (*Table* 1). All of the reduced formulations of HDODA and TMPTA were considered cured after one pass, withstanding 100 MEK rubs. The 40% and 60% HA formulations are the only two that exhibited less than full cure at less than two passes of 50 ft/min, as evidenced by double MEK rubs. Irgacure 184 performed the best in the 60% HA formula taking only two passes to cure. In the 40% formula, Vicure 10 needed only two passes to cure, whereas DEAP and Irgacure 184 cured after only one pass.

Impact resistance was measured by using the extrusion method and is summarized in *Table* 2. All TMPTA formulations with each photoinitiator used proved to be very brittle, as each coating failed a force greater than 1 in./lb, reflecting the hardness of the coatings. The HDODA formulations are brittle, with one exception being the 20% concentration, where the coating could withstand an impact of 2 in./lb. Formulations with HA withstood the greatest impact, with the 60% concentrations able to take a force of up to 84 in./lb without cracking, attributable to its softness, adhesion, and compliance. Vicure 10 performed the best in all three HA concentrations, giving the highest impact resistant coatings, with DEAP and Irgacure 184 performing nearly as well.

DENNIS J. GABER is a graduate student in the Polymers and Coatings/Business Management curriculum at Eastern Michigan University. This paper was a recipient of the 1986 Alfred L. Hendry Award sponsored by the Federation of Societies for Coatings Technology, with slight modifications for publication. Mr. Gaber received his B.S. Degree in Soil Science from the University of Wisconsin–Stevens Point in 1981.

CONCLUSION

Of the three photoinitiators used in three reduced formulations of reactive diluents and resin, Irgacure 184 produced the best results in Sward Hardness and double MEK rubs, while it gave impact resistance values that are comparable to the best performer, Vicure 10. Results obtained using DEAP were slightly less desirable than those with Vicure 10, and considerably less desirable than those with Irgacure 184. In a few instances however, DEAP did outperform Vicure 10. Based on all tests performed and data obtained, the overall best performer was Irgacure 184, followed by Vicure 10, then DEAP.

ACKNOWLEDGMENT

I would like to express appreciation for support to my wife Julie, Dr. John C. Graham at Eastern Michigan University, and Alcolac, Baltimore, MD.

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(1) Roffey, C.G., "Photopolymerization of Surface Coatings," John Wiley & Sons, Ltd., New York, 1982.

1987 A.L. HENDRY AWARDS

Established in 1986, the Alfred L. Hendry Memorial Awards are sponsored by the Southern Society of the Federation of Societies for Coatings Technology. The Awards commemorate the industry contribution of the late Alfred L. Hendry, President of A.L. Hendry & Co., Tampa, FL, and a Past-President and long-time member of the Southern Society.

The Awards are presented to the best student-authored papers on some aspect of coatings technology. Papers may be authored by either graduate or undergraduate students currently enrolled in a college program.

Administered by the Federation's Educational Committee, which also judges the entries, the awards will be presented at the FSCT Annual Meeting, to be held in 1987 at the Dallas Convention Center, October 5-7.

Prospective student authors are invited to submit manuscripts to the Federation headquarters office (1315 Walnut St., Philadelphia, PA 19107). Deadline for receipt of entries in the 1987 competition is June 19, 1987.

Ionomer/Semi-IPN Coatings from Polyurethanes and Vinyl Chloride Copolymers

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Ionomer semi-IPN coatings were prepared from a carboxyl-containing vinyl chloride copolymer (VMCC) and polyurethanes (PU) with and without tertiary amine nitrogen in the polymer backbone at various PU/VMCC ratios.

The morphology and physical properties of these ionomer semi-IPN coatings containing opposite charge groups were compared with those without opposite charge groups. The former exhibited higher mechanical properties and adhesive strength and did not reveal any phase separation as determined by SEM and TMA.

INTRODUCTION

Interpenetrating polymer networks (IPNs) are a unique blend of crosslinked polymers in which the chains of the two polymers are held together by permanent entanglements formed by homocrosslinking of the component polymers.[1] The degree of interpenetration depends upon the miscibility between the constituent polymers. Most polymer pairs are not compatible because, in contrast to low-molecular weight materials, the entropy of mixing two macromolecules containing a large number of segments is relatively small while the enthalpy of mixing is usually positive or near zero, unless specific interactions are present.[2-10] To achieve miscibility, the presence of specific interactions is usually required and these include: hydrogen bonding;[11-17] charge-transfer complexes;[18-20] anion-cation interaction;[2-9,21,22] and ion-dipole interactions.[23-27] These specific interactions generally give rise to the remarkable properties of the resulting polymer blends, alloys, and IPNs.

Semi- or pseudo-IPNs are combinations of linear with crosslinked polymers resulting in various degrees of interpenetration.[28-34]

Interest in polyurethane ionomers has increased in the last decade because of their growing uses in water-based coatings, adhesives, medical, and semi-conductor applications. However, relatively little information has been published regarding the synthesis and properties of ionomer semi-IPNs. The purpose of the present study was to study the effects of opposite charge groups in ionomer semi-IPNs based on polyurethanes and a vinyl chloride copolymer.

EXPERIMENTAL

Raw Materials

The raw materials used in this study are presented in *Table* 1. The polyether polyol and short chain diols were degassed at 80-90°C under vacuum overnight to remove any moisture. MEK was treated with molecular sieves 4A overnight to remove any moisture prior to use. The other materials were used as received.

Procedures

PREPARATION OF POLYURETHANES (PU): A resin kettle under dry nitrogen was charged with H_{12}MDI. A mixture of 1,4-butanediol, or N-methyldiethanolamine, and poly-

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Table 1—Raw Materials

Designation	Description	Supplier
Terathane® 1000 (PTMO)	Poly(1,4-oxytetramethylene) glycol MW≃1000	E.I. du Pont de Nemours & Co.
$H_{12}MDI$	Dicyclohexylmethane-4,4'diisocyanate	Mobay Chemical Co.
1,4 BD	1,4-Butanediol	BASF-Wyandotte Co.
TMP	Trimethylolpropane	Celanese Chemical Co.
T-12	Dibutyltin dilaurate	M & T Chemical Co.
N-MDEA	N-methyldiethanolamine	Pennwalt Co.
VMCC	Poly(vinylchloride-vinyl acetate-maleic acid), MW = 15000, maleic acid≅1%	Union Carbide Corp.
Thermolite® 25	Thermostabilizer of PVC	M & T Chemical Co.
MEK	Methylethyl ketone	Eastman Chemical Co.
—	Molecular sieves 4A	Union Carbide Corp.

(oxytetramethylene) glycol (PTMO) was added at an NCO/OH ratio of 2:1.

The reaction was carried out at 100°C for about two hours until the theoretical isocyanate content, as determined by the di-n-butylamine titration method[27] was reached. The PU prepolymer with or without tertiary amine nitrogen groups was dissolved in dry MEK to obtain a prepolymer solution of 30-40% solids. It was then mixed with a mixture of 1,4-BD/TMP (4:1 by equiv. ratio) at an NCO/OH = 1.05/1.0 ratio in the presence of T-12 catalyst (0.05% based on total weight). The reaction mixture was cast in a metal mold treated with a release agent at ambient temperature. After standing 3-5 hr at room temperature, the mold was placed in an oven and post-cured at 100°C for 16 hours. The samples were then conditioned in a desiccator for one week before testing.

Vinyl Chloride Copolymer: A vinyl chloride-vinyl acetate-maleic acid copolymer (VMCC) (1% of maleic acid) was dissolved in MEK to obtain a homogeneous solution of about 30% solids. A stabilizer for VMCC, Thermolite 25, was added into the above solution at 0.5% (by wt.) based on the solids content of VMCC.

Preparation of Semi-IPNs: The prepolymer and VMCC solutions were mixed at different PU/VMCC ratios. The catalyst and the crosslinking agent of PU were added at an NCO/OH ratio of 1.05. The mixtures with different compositions were then cast in metal molds (treated with a release agent) at ambient temperature to obtain film samples of ca. 40-60 mils thickness for determination of the stress-strain properties. The PU crosslinking reaction was carried out at 80°C for 2-3 hr and post-cured at 100°C for 16 hr. The film samples were then conditioned in a desiccator for one week before testing. The above solutions with different compositions were also coated on aluminum panels for testing of the Gardner impact and lap shear strength.

INSTRUMENTAL TECHNIQUES AND MEASUREMENTS

The tensile strength, modulus, and elongation at break were measured by means of an Instron Tensile Tester at a crosshead speed of 20 in./min (ASTM D-412) and the hardness by means of a Shore A Durometer (ASTM D-2240).

Table 2—Mechanical Properties of Semi-IPN Coatings from PU and VMCC with and without Opposite Charge Groups

Composition of PU/VMCC	Opposite Charge Groups	Tensile Strength psi	Modulus at 100%, psi	Elongation %	Hardness	
					A	D
100:0	—	2236	1098	347	77	—
95:5	$-\underset{\vert}{\overset{\vert}{N}}\overset{\oplus}{\diagup}-COO^{\ominus}$	2464	1717	320	90	42
80:20	$-\underset{\vert}{\overset{\vert}{N}}\overset{\oplus}{\diagup}-COO^{\ominus}$	4182	2708	230	94	49
75:25	$-\underset{\vert}{\overset{\vert}{N}}\overset{\oplus}{\diagup}-COO^{\ominus}$	3961	2852	200	95	51
70:30	$-\underset{\vert}{\overset{\vert}{N}}\overset{\oplus}{\diagup}-COO^{\ominus}$	3460	3138	120	92	50
60:40	$-\underset{\vert}{\overset{\vert}{N}}\overset{\oplus}{\diagup}-COO^{\ominus}$	3227	2591	60	91	48
50:50	$-\underset{\vert}{\overset{\vert}{N}}\overset{\oplus}{\diagup}-COO^{\ominus}$	2852	2218	30	90	46
100:0	—	939	—	142	90	—
95:5	—	988	—	96	90	38
80:20	—	1435	—	25	91	40
75:25	—	1466	—	22	91	40
70:30	—	1333	—	21	92	43
60:40	—	782	—	17	90	46
50:50	—	488	—	15	90	45

Table 3—Lap Shear Strength of Semi-IPN Coatings from PU and VMCC with and without Charge Groups

Composition of PU/VMCC	Opposite Charge Groups	Lap Shear Strength psi (Al/Al)
100:0	—	147
95:5	$-\underset{\vert}{\overset{\vert}{N}}\overset{\oplus}{\diagup}-COO^{\ominus}$	156
80:20	$-\underset{\vert}{\overset{\vert}{N}}\overset{\oplus}{\diagup}-COO^{\ominus}$	278
75:25	$-\underset{\vert}{\overset{\vert}{N}}\overset{\oplus}{\diagup}-COO^{\ominus}$	405
70:30	$-\underset{\vert}{\overset{\vert}{N}}\overset{\oplus}{\diagup}-COO^{\ominus}$	416
60:40	$-\underset{\vert}{\overset{\vert}{N}}\overset{\oplus}{\diagup}-COO^{\ominus}$	310
50:50	$-\underset{\vert}{\overset{\vert}{N}}\overset{\oplus}{\diagup}-COO^{\ominus}$	177
100:0	—	95
95:5	—	137
80:20	—	160
75:25	—	213
70:30	—	198
60:40	—	187
50:50	—	183

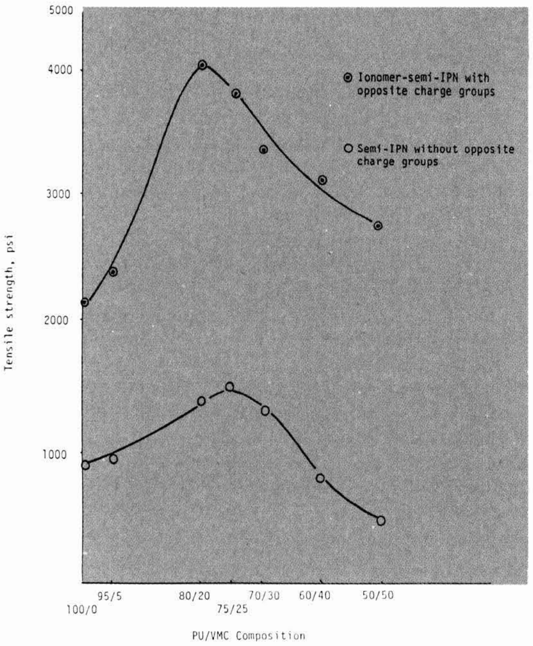


Figure 1—Effect of different compositions of PU/VMCC on the tensile strength of semi-IPN coatings with or without opposite charge groups

The impact resistance of the semi-IPN coatings was measured on a Gardner-SPI modified Variable Height Impact Tester using both the direct and the indirect techniques.

A TMS-2 Thermomechanical Analyzer (Perkin-Elmer) was used to determine the glass transition temperature of the ionomer semi-IPNs at temperatures ranging from −100°C to +100°C and 0.01 mm of penetrating range, 80 g of penetrating weight, and a heating rate of 10°C/min.

The chemical resistance was measured by placing the coated panels into a 10% NaOH of HCl solution at room temperature for one week.

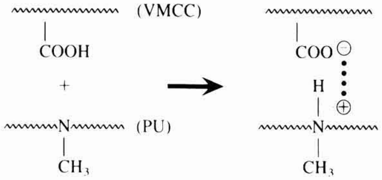
The reverse side and the edges of the panels were coated with wax to protect the metal surfaces from chemical attack.

To observe the morphology of the semi-IPNs with or without opposite charge groups, samples were prepared by freeze-fracturing in liquid nitrogen and applying a gold coating of approximately 200 Å thickness. Micrographs were obtained by using a Phillips Scanning Electron Microscope Model SEM 505.

RESULTS AND DISCUSSION

Effect of Different Compositions of PU/VMCC on the Mechanical Properties of Semi-IPN Coatings with and without Opposite Charge Groups

As shown in *Tables* 2 and 3 and *Figures* 1 and 2, the semi-IPN coatings with opposite charge groups exhibited improved properties due to quaternization of the carboxyl group in VMCC by the tertiary amine nitrogen in the PU, as shown in the following schemes:



As a result, the miscibility between the PU network and the VMCC linear chains was greatly improved and both tensile and lap shear strength were enhanced compared to the materials without opposite charge groups in which only hydrogen bonding between carboxyl and urethane could be formed instead of ionic bonds.

It has been known that the miscibility between poly(vinyl chloride) and polyesters depends upon the $CH_2/C=O$ ratio,[28] and that the chain length of the glycol in the esters plays an important role in the miscibility.[28] Pandyopadhyay and Shaw[29] indicated that the polyurethane based on PTMO exhibited poor miscibility with PVC compared to one based on polycaprolactone glycol due to the fact that the PTMO-based PU physically bonded with PVC could not be produced as readily as with polycaprolactone glycol-based PU with PVC.[28]

The hydrogen bonding between the carboxyl groups in VMCC and the urethane groups in the PU without tertiary amine nitrogen was not strong enough to improve the miscibility of the two polymer systems presumably due to the very low concentration of carboxyl groups in the VMCC. The semi-IPNs without opposite charge groups exhibited low stress-strain properties and low lap shear strength. On the other hand, the semi-IPNs with opposite charge groups, even at low concentration of ionic bonds, exhibited relatively high stress-strain properties and lap shear strength.

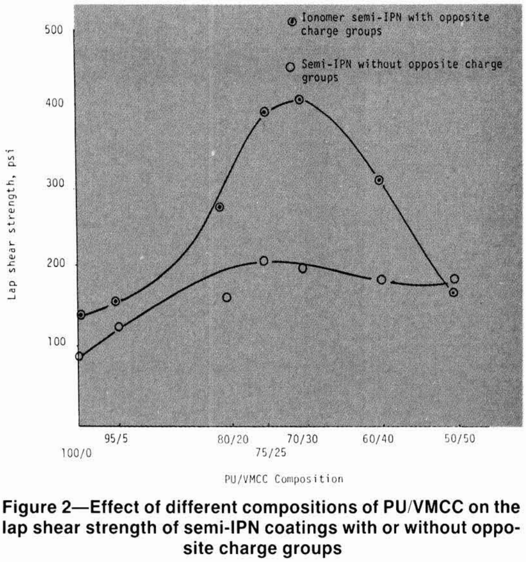


Figure 2—Effect of different compositions of PU/VMCC on the lap shear strength of semi-IPN coatings with or without opposite charge groups

Table 4—Impact Strength of Semi-IPN Coatings from PU and VMCC with and without Charge Groups

Composition of PU/VMCC	Opposite Charge Groups	Impact Strength, in. lb.	
		Direct	Indirect
100:0	—	160	160
95:5	$-\underset{\mid}{\overset{\mid}{N}}{}^{\oplus}/-COO^{\ominus}$	150	160
80:20	$-\underset{\mid}{\overset{\mid}{N}}{}^{\oplus}/-COO^{\ominus}$	150	160
75:25	$-\underset{\mid}{\overset{\mid}{N}}{}^{\oplus}/-COO^{\ominus}$	150	150
70:30	$-\underset{\mid}{\overset{\mid}{N}}{}^{\oplus}/-COO^{\ominus}$	140	150
60:40	$-\underset{\mid}{\overset{\mid}{N}}{}^{\oplus}/-COO^{\ominus}$	140	140
50:50	$-\underset{\mid}{\overset{\mid}{N}}{}^{\oplus}/-COO^{\ominus}$	140	120
100:0	—	160	160
95:5	—	140	160
80:20	—	140	130
75:25	—	130	130
70:30	—	130	130
60:40	—	130	120
50:50	—	120	110

Table 5—Solvent and Chemical Resistance of Semi-IPN Coatings

Composition of PU/VMCC	Opposite Charge Groups	Solvent Resistance[a]		Chemical Resistance[b]	
		MEK	Xylene	10% HCl	10% NaOH
100:0	—	>50	>50	Failure	Failure
95:5	$-\underset{\mid}{\overset{\mid}{N}}{}^{\oplus}/-COO^{\ominus}$	48	45	Failure	Pass
80:20	$-\underset{\mid}{\overset{\mid}{N}}{}^{\oplus}/-COO^{\ominus}$	48	45	Pass	Pass
70:30	$-\underset{\mid}{\overset{\mid}{N}}{}^{\oplus}/-COO^{\ominus}$	41	40	Pass	Pass
75:25	$-\underset{\mid}{\overset{\mid}{N}}{}^{\oplus}/-COO^{\ominus}$	39	38	Pass	Pass
60:40	$-\underset{\mid}{\overset{\mid}{N}}{}^{\oplus}/-COO^{\ominus}$	36	35	Pass	Pass
50:50	$-\underset{\mid}{\overset{\mid}{N}}{}^{\oplus}/-COO^{\ominus}$	34	33	Pass	Pass
100:0	—	>50	>50	Failure	Failure
95:5	—	48	48	Failure	Failure
80:20	—	45	48	Failure	Failure
70:30	—	40	46	Pass	Pass
75:25	—	37	46	Pass	Pass
60:40	—	37	45	Pass	Pass
50:50	—	34	40	Pass	Pass

(a) Double rub with cotton saturated with solvent the highest rub time without change of the surface was recorded.

(b) At room temperature for one week.

Increasing the concentration of VMCC resulted in more brittle materials with lower tensile and lap shear strength.

The maximum tensile strength of the semi-IPNs appeared at about the 80:20 ratio of PU/VMCC for both semi-IPNs with and without opposite charge groups. Presumably the maximum entanglement between the VMCC chains and the PU network also occurred at this composition (*Table* 2 and *Figure* 1).

The maximum lap shear of the semi-IPNs, however, appeared at about the 75:25 composition for ionomer semi-IPNs with opposite charge groups and 70:30 composition for the semi-IPNs without opposite charge groups (*Table* 3 and *Figure* 2).

All the semi-IPNs without opposite charge groups exhibited very poor elongation due to their poor miscibility. The relatively high tensile strengths of the 75:25 and the 80:20 ratios of PU/VMCC could be due to the higher degree of interpenetration between the chains of VMCC and the PU networks resulting from improved miscibility because of hydrogen bonding between the carboxyl and urethane groups (*Table* 2 and *Figure* 1).

Gardner Impact Strength of Semi-IPNs with and without Opposite Charge Groups

The ionomer semi-IPN coatings with opposite charge groups gave better results than the semi-IPNs without opposite charge groups due to their greater flexibility. The impact strength decreased with increasing concentration of VMCC due to its inherent brittleness (*Table* 4).

Solvent and Chemical Resistance of Semi-IPN Coatings

As shown in *Table* 5, both semi-IPNs with and without opposite charge groups exhibited poor solvent resistance with increasing concentrations of VMCC due to the fact that VMCC is a thermoplastic, linear polymer. In contrast to the solvent resistance, the chemical resistance of semi-IPN coatings increased with increasing concentration of VMCC. It is interesting to note that the ionomer semi-IPN coatings with opposite charge groups exhibited better solvent and chemical resistance than those without opposite charge groups, presumably due to the fact that a high degree of interpenetration occurred between the chains of VMCC and the PU networks, which was brought about by formation of ionic bonds between opposite charge groups.

Glass Transition Temperatures of Semi-IPN Coatings

The Tg's for both semi-IPNs with and without ionic bonds (or opposite charge groups) between the two polymers are shown in *Table* 6. Ionomer semi-IPNs with ionic bonds only gave single Tg's for each composition. The Tg's increased with an increase of VMCC in PU/VMCC composition due to the introduction of rigid VMCC with a high Tg. In contrast, semi-IPNs without ionic bonds gave two Tg's for each composition except at 100% and 95:5 ratios of PU/VMCC. These results imply that some phase separation had occurred in these semi-IPN systems due to the fact that the free energy of mixing in the systems may be either positive or zero because of the lack of physical interaction between the two polymers (ionic bonds).

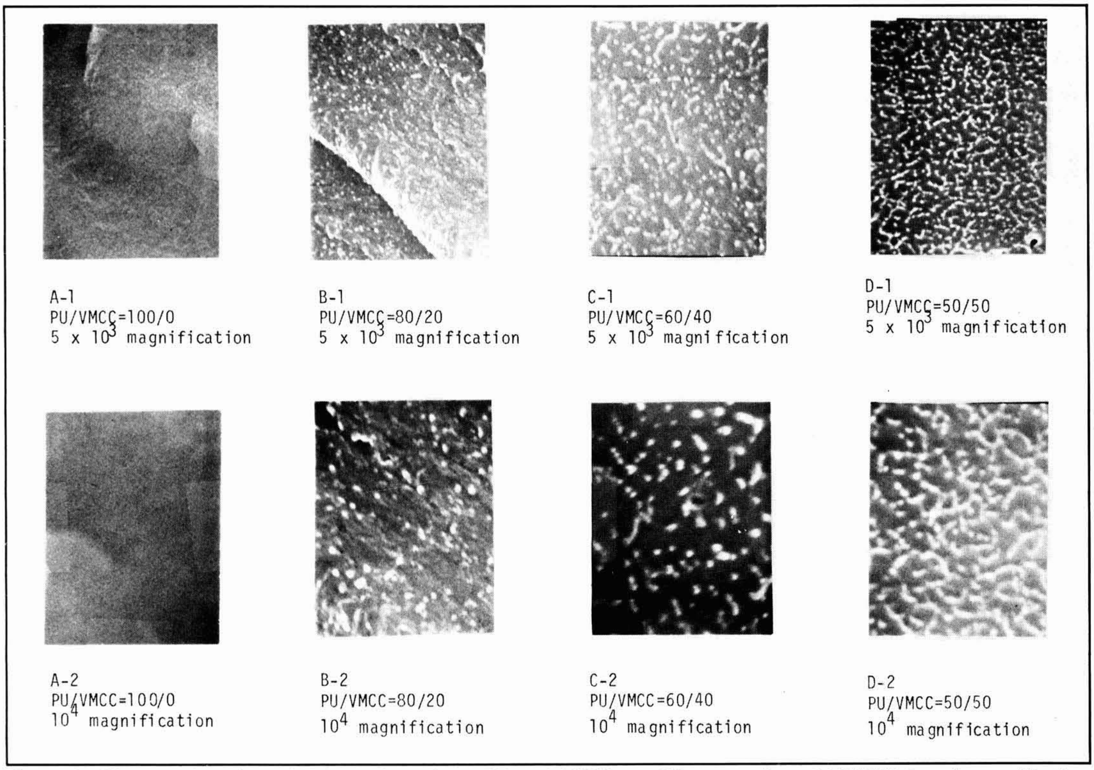
As shown in *Table* 6, the glass transition temperatures of both PU and VMCC for semi-IPNs without ionic bonds were shifted inwards with the Tg of PU shifting to higher temperatures and the Tg of VMCC shifting to lower temperatures in the semi-IPN systems without ionic bonds. This implies that some interpenetration between the PU networks and the VMCC polymer chains had taken place. Only the 95:5 composition of PU/VMCC exhibited a single Tg, presumably due to the fact that semi-IPNs with low concentration of VMCC could be compatible through the hydrogen bonding between the urethane groups and the carboxyl groups of VMCC.

Morphology of Semi-IPN Coatings by Scanning Electron Microscopy (SEM)

Micrographs of semi-IPN coatings without opposite charge groups are shown in *Figure* 3 (from A-1 to D-1) at different compositions of PU/VMCC and magnifications. *Figure* 3 (A-1 and A-2) are micrographs of polyurethanes only at 5 × 10^3 and 10^4 magnification, respectively. In *Figure* 3 (B-1 to D-1), the composition of PU/VMCC was changed from 80:20 to 50:50. All of the

Table 6—Glass Transition Temperatures of Semi-IPN Coatings from PU and VMCC with and without Opposite Charge Groups

Composition of PU/VMCC	Charge Groups	Glass Transition Temperature by TMA, (K°)	
100:0	—	229	
95:5	$-\overset{\mid}{\underset{\mid}{N}}\overset{\oplus}{—}/-COO^{\ominus}$	266	
80:20	$-\overset{\mid}{\underset{\mid}{N}}\overset{\oplus}{—}/-COO^{\ominus}$	279	
75:25	$-\overset{\mid}{\underset{\mid}{N}}\overset{\oplus}{—}/-COO^{\ominus}$	289	
70:30	$-\overset{\mid}{\underset{\mid}{N}}\overset{\oplus}{—}/-COO^{\ominus}$	291	
60:40	$-\overset{\mid}{\underset{\mid}{N}}\overset{\oplus}{—}/-COO^{\ominus}$	296	
50:50	$-\overset{\mid}{\underset{\mid}{N}}\overset{\oplus}{—}/-COO^{\ominus}$	304	
100:0	—	218	—
95:5	—	247	—
80:20	—	254	324
75:25	—	257	330
70:30	—	259	336
60:40	—	265	340
50:50	—	269	341
0:100	—	345	—



A-1
PU/VMCC=100/0
5 x 10^3 magnification

B-1
PU/VMCC=80/20
5 x 10^3 magnification

C-1
PU/VMCC=60/40
5 x 10^3 magnification

D-1
PU/VMCC=50/50
5 x 10^3 magnification

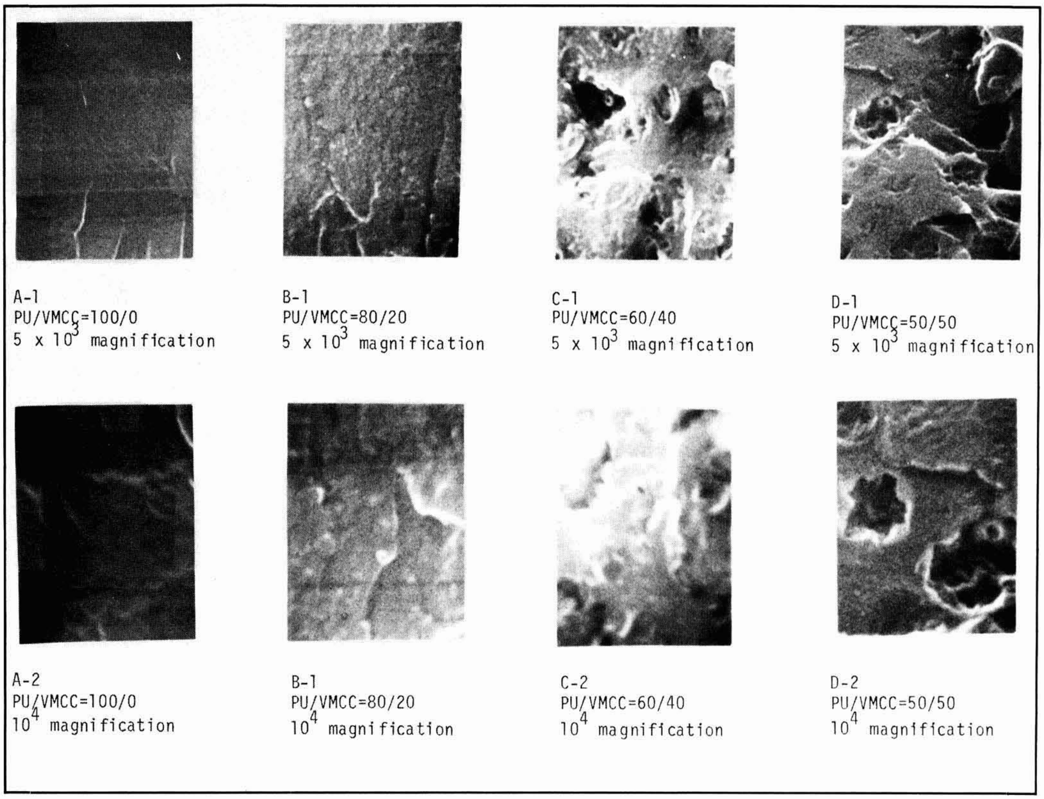
A-2
PU/VMCC=100/0
10^4 magnification

B-2
PU/VMCC=80/20
10^4 magnification

C-2
PU/VMCC=60/40
10^4 magnification

D-2
PU/VMCC=50/50
10^4 magnification

Figure 3—Micrographs of semi-IPN coatings from PU and VMCC at different ratios of PU/VMCC and magnification (by SEM)



A-1
PU/VMCC=100/0
5 x 10^3 magnification

B-1
PU/VMCC=80/20
5 x 10^3 magnification

C-1
PU/VMCC=60/40
5 x 10^3 magnification

D-1
PU/VMCC=50/50
5 x 10^3 magnification

A-2
PU/VMCC=100/0
10^4 magnification

B-1
PU/VMCC=80/20
10^4 magnification

C-2
PU/VMCC=60/40
10^4 magnification

D-2
PU/VMCC=50/50
10^4 magnification

Figure 4—Micrographs of ionomer semi-IPN coatings from PU and VMCC at different ratios of PU/VMCC and magnification (by SEM)

micrographs exhibited obvious phase separation, in which the white particles of VMCC dispersed into the dark matrix of the PU. Increasing the concentration of VMCC, the area of the dispersed phase of VMCC was increased with the VMCC particles in close proximity to each other.

In contrast, the micrographs of the ionomer semi-IPN coatings with opposite charge groups, *Figure* 4 (A-1 to D-1), did not reveal any phase separation. No white particles of the VMCC phase were visible in the dark matrix of the PU phase. Presumably the ionic bonds between the carboxyl and tertiary amine groups provided the best opportunity for interpenetration between the linear chains of VMCC and the networks of PU to prevent any possible phase separation from the ionomer semi-IPN microphase. The physical properties of ionomer semi-IPNs with opposite charge groups were obviously improved compared to the semi-IPNs without opposite charge groups as previously mentioned (see *Tables* 2 and 3 and *Figures* 1 and 2).

CONCLUSIONS

The miscibility between poly(vinyl chloride) and polyurethanes based on poly(oxytetramethylene) glycol can be improved by introducing opposite charge groups to form ionic bonds. The improvement in miscibility from ionic bonds between the two polymer systems provided the best chance for interpenetration between the linear chains of VMCC and the PU networks in order to obtain good physical properties of the ionomer semi-IPN coatings from PU and VMCC.

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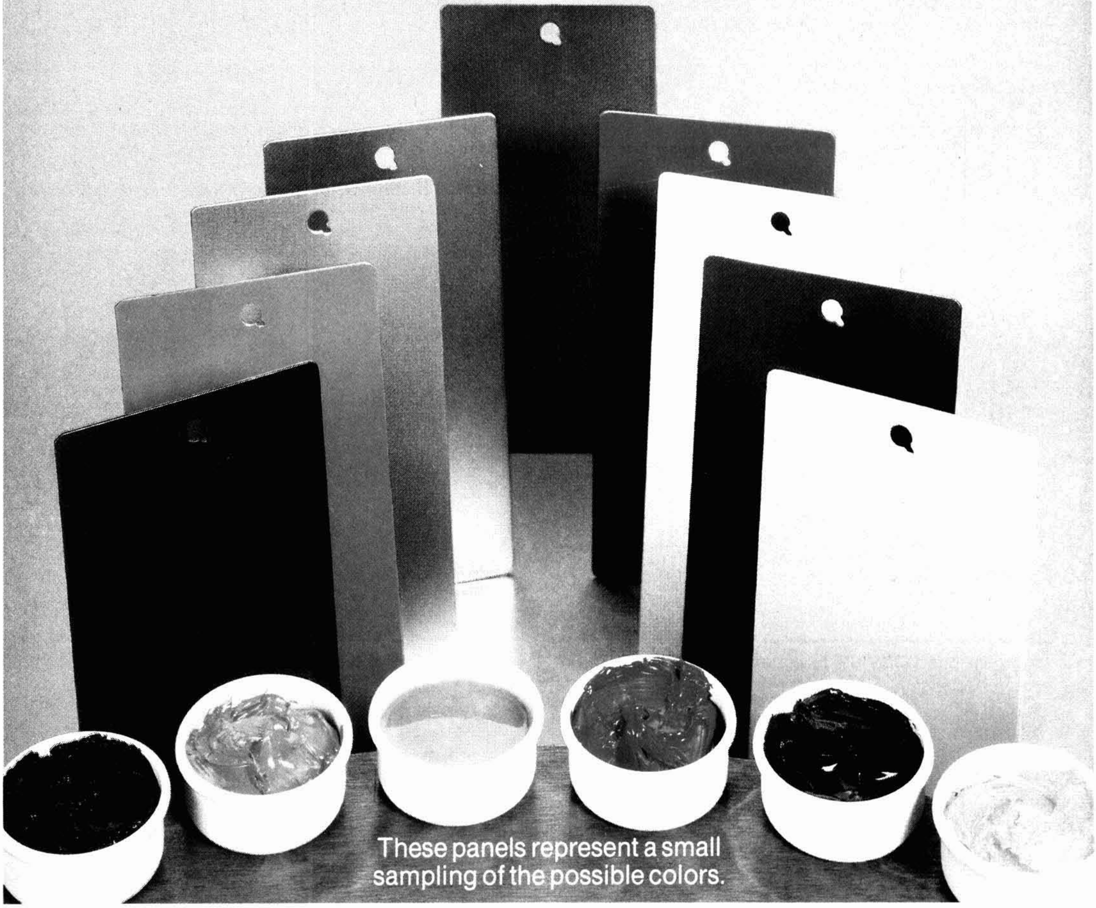

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Solution Parameters of Linseed Oil Alkyd: Their Dependence on Solute-Solvent Interactions

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Regional Research Laboratory*

Intrinsic viscosity, which characterizes the polymer in the state of infinite dilution, has been used for determining various solution parameters of alkyd resin in good, intermediate, and θ-solvents. The relationship between intrinsic viscosity and weight average molecular weight has been used for determining the Mark-Houwink constants, a and K, of the resin. These constants are found to depend on the nature of solute-solvent interactions. The solution parameters, K_θ, $f(\bar{r}^2)_0$, B, and χ, obtained from Kurata-Stockmayer and Stockmayer-Fixman plots, are found to depend on solubility parameters of solvents. The solubility parameter of the alkyd has been estimated by taking into account the solute-solvent interaction parameter χ and the solubility parameters of solvents. The results indicate that several solution parameters of the alkyd resin can be obtained from measurement of solution viscosity.

INTRODUCTION

Solvents have distinct influence on resin-solvent miscibility, resin-pigment interaction, dispersibility, rheology, and ease of application in the wet state. Similarly, other factors like compatibility, swelling, adsorption, viscosity, tolerance for non-solvents, and evaporation also affect the appearance and performance of the coating. The interaction between resin and solvent determines their miscibility and can be estimated by the properties of the dilute solution of the resin. Intrinsic viscosity, the most frequently measured property of dilute solution, has been used for determining the interaction of alkyd resin with various solvents. To obtain information about the solution properties, the practical data are treated as hydrodynamic and thermodynamic properties.

The properties of dilute solution of a polymer which depend on solute-solvent interactions have been explained in terms of hydrodynamic models.[1-5] Flory and Fox[6] suggested that viscosity of polymer solution depended on the volume occupied by the polymer molecule and treated it as hydrodynamic sphere. The solution parameters of polymers specifically known as hydrodynamic parameters are usually derived from the data on the thermodynamics of solute-solvent interactions.[7-10] They can be determined precisely by the measurement of the flow properties of polymer solution. The interpretation of results in terms of the size and structure enables the characterization of the polymer.

Molecular Weight Dependency of Intrinsic Viscosity

The flow properties of polymeric materials in dilute solutions are widely used for determining the thermodynamic and hydrodynamic parameters.[4,6,7,10] Intrinsic viscosity, one of the properties which characterizes the polymer in the state of infinite dilution, has been used extensively for the determination of solution parameters.[11-15] The molecular weight dependency of intrinsic viscosity is given by the well-known Mark-Houwink equation:[16]

$$[\eta] = k\bar{M}_w^{a} \qquad (1)$$

Here, K and a, the Mark-Houwink constants which are characteristics of a particular polymer solvent combination, depend on the nature of solute-solvent interactions.[12,14,17] K depends on solute-solvent interaction; the

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state of polymer solution is defined by a. Usually,[18] the value of a is in the range of 0.5 to 1. In the extreme case of a maximally extended chain, $a < 1$.

Intrinsic Viscosity in θ State of Solution

The polymer solution where the decrease in coil density and the corresponding increase in viscosity occurs because of little solvation by the solvent is known as the θ state and the solvent is the θ solvent.

In the case of θ solutions,[19] the partial molar free energy due to polymer-polymer, polymer-solvent interaction is zero and $a = 0.5$. This represents the condition of limiting solubility of the polymer in a solvent and it is also called the θ state in which the molecules are unperturbed. In this state, the polymer molecule contracts and the intrinsic viscosity-molecular weight relationship is expressed:[20,21]

$$[\eta]_\theta = K_\theta \bar{M}_w^{0.5} \tag{2}$$

where K_θ is the value of K in unperturbed state and $[\eta]_\theta$ is the $[\eta]$ in θ solvent.

Unperturbed Dimensions

The hydrodynamic properties of a polymer coil in solution depend on short range and long range interactions between chain segment of the polymer. In the state of good solute-solvent compatibility, long range interactions are favored and they give rise to an excluded volume effect.[13] In θ-state of the polymer solution, the short range interactions are related to unperturbed dimensions. The root mean square end to end distance $(\bar{r}^2)_0$ of the polymer segment can be calculated by the following equation:

$$K_\theta = \phi \left[\frac{(\bar{r}^2)_0}{\bar{M}_w} \right]^{3/2} \tag{3}$$

where the hydrodynamic constant, ϕ, $= 2.68 \times 10^{21}$.

Ideally, unperturbed dimensions are determined using viscosity data of dilute polymer solutions in θ solvents. However, measurements made on solutions in non-θ-solvents can also be used with suitable extrapolation of data.[6,7,22-25]

Solution Parameters: Kurata-Stockmayer Equation

Kurata and Stockmayer[24] suggested the following equation for estimating the unperturbed dimensions of a polymer in non-θ-solvents:

$$\frac{[\eta]^{2/3}}{\bar{M}_w^{1/3}} = K_\theta^{2/3} + 0.363\,\phi\,B \left[\frac{g(\alpha_\eta)\,\bar{M}_w^{2/3}}{[\eta]^{1/3}} \right] \tag{4}$$

The term B in equation (4) is the long range interaction parameter and is dependent on the thermodynamics of solute-solvent interactions. The relation of B to χ, the solute-solvent interaction parameter, is given below:

$$B = 2\,\bar{\nu}^2\,\frac{(0.5-\chi)}{NV_1} \tag{5}$$

The symbols, $\bar{\nu}$, N, and V_1 represent partial molar specific volume, Avogadro number, and molar volume, respectively. The function of $g(\alpha_\eta)$ in equation (4) is defined below:[22]

$$g(\alpha_\eta) = \frac{8\,\alpha_\eta^3}{(3\alpha_\eta^2 + 1)^{3/2}} \tag{6}$$

Here, α_η is the linear expansion factor.[7]

$$\alpha_\eta = \left[\frac{[\eta]}{[\eta]_\theta} \right]^{1/3} \tag{7}$$

Stockmayer-Fixman Equation

Stockmayer and Fixman[25] suggested the following simplified form of Kurata-Stockmayer's equation, which is applicable only when $\alpha_\eta < 1.5$:

$$\frac{[\eta]}{\bar{M}_w^{1/2}} = K_\theta + 0.51\,\phi\,B\,\bar{M}_w^{1/2} \tag{8}$$

The Mark-Houwink constants a and K as well as the parameters K_θ, f $(\bar{r}^2)_0$, B, and χ have been used for characterizing the nature of solute-solvent interactions.[26,27]

Interaction Parameter-Solubility Parameter

Lipson and Guillet[28] used the data on χ obtained from GLC studies for determining the solubility parameter of the polymer using the following equation:

$$\left(\frac{\delta_1^2}{RT} - \frac{\chi}{V_1} \right) = \left(\frac{2\delta'_2}{RT} \right) \delta_1 - \left(\frac{\delta_2'}{RT} + \frac{\chi s}{V_1} \right) \tag{9}$$

Here, δ_1 and δ_2 are the solubility parameters of solvent and solute, respectively, and χ_s is entropic contribution to χ.

Present Study

The solution viscosity of five fractions of semi-polymerized linseed oil-pentaerythritol phthalate alkyd was measured in good, intermediate, and poor solvents. The solubility parameter of alkyd was estimated using equation (9) with the value of χ derived from equation (5). This value was compared with those obtained from the plots of other solution parameters for alkyds, i.e., a, K, and K_θ as function of δ of solvents.

EXPERIMENTAL

Resin Fractions

In organic coating formations, alkyds form the major part of the total consumption among the resins. With this consideration, and with prior knowledge about some of its physico-chemical properties, a 66% linseed oil-pentaerythritol phthalate alkyd was selected.[29] This alkyd, which had an acid value less than 10 in solid content ≃ 100%, was fractionated by using toluene-methanol as solvent-non-solvent system.[22] The repeated operation of this process produced sufficiently purified narrowly dis-

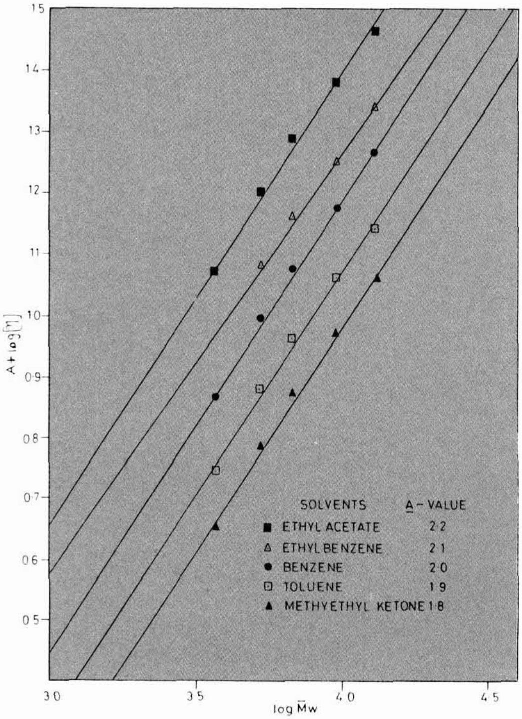

Figure 1—Double logarithmic plots of intrinsic viscosity [η] of alkyd fractions vs molecular weight. $\bar{M}_w$ in different solvents. "A" is an arbitrary constant used to displace lines vertically for clarity

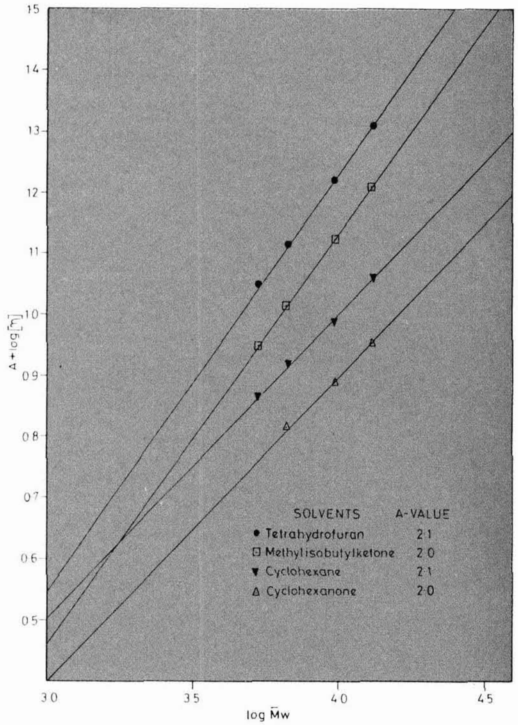

Figure 2—Double logarithmic plots of intrinsic viscosity [η] of alkyd fractions vs molecular weight. $\bar{M}_w$ in different solvents. "A" is an arbitrary constant used to displace lines vertically for clarity

tributed fractions of the alkyd. Five fractions with weight average molecular weights $\bar{M}_w$, in the range of 3,800 to 12,000, were selected.

Molecular Weight of Resin Fractions

The number of average molecular weight, $\bar{M}_n$, of alkyd fractions was determined by the freezing point depression method using benzene solvent.[30] Kohan[31] referred to Flory's[32] views that in linear condensation polymerization $\bar{M}_w$ and $\bar{M}_n$ might be related to the extent of reaction. P. Young,[33] while describing the molar mass distribution, has reported the following equations for the linear condensation product.

$$\bar{M}_n = \frac{M}{(1 - P)} \qquad (10)$$

and

$$\bar{M}_w = \frac{(1 + P)}{(1 - P)} M \qquad (11)$$

where M is the molecular weight of the polymer repeating unit. It was presumed that the polymerization of alkyd

Table 1—Intrinsic Viscosity, [η] and Mark-Houwink Constants, a and K: Their Dependence on Solubility Parameter δ of Solvents

		[η] dL/g of Alkyd Fraction F, in Different Solvents					Mark-Houwink Constants from Plots of Log [η] vs Log $\bar{M}_w$	
Solvents	δ (cal/cc)$^{1/2}$	F_1 $\bar{M}_w$=12,765	F_2 $\bar{M}_w$=9,659	F_3 $\bar{M}_w$=6,771	F_4 $\bar{M}_w$=5,213	F_5 $\bar{M}_w$=3,801	a	K×10^4
1. Cyclohexane	8.18	0.091	0.078	0.065	0.058	—	0.500	7.94
2. Methyl isobutyl ketone	8.57	0.162	0.133	0.104	0.089	—	0.675	2.72
3. Ethyl benzene	8.80	0.174	0.142	0.114	0.095	—	0.688	2.57
4. Toluene	8.91	0.176	0.144	0.115	0.096	0.072	0.733	1.74
5. Ethyl acetate	9.10	0.184	0.151	0.121	0.101	0.074	0.746	1.65
6. Benzene	9.15	0.183	0.149	0.119	0.099	0.073	0.743	1.64
7. Methyl ethyl ketone	9.27	0.182	0.148	0.118	0.097	0.072	0.736	1.73
8. Tetrahydrofuran	9.52	0.161	0.132	0.104	0.089	—	0.683	2.52
9. Cyclohexanone	9.88	0.090	0.077	0.065	0.059	—	0.500	7.94

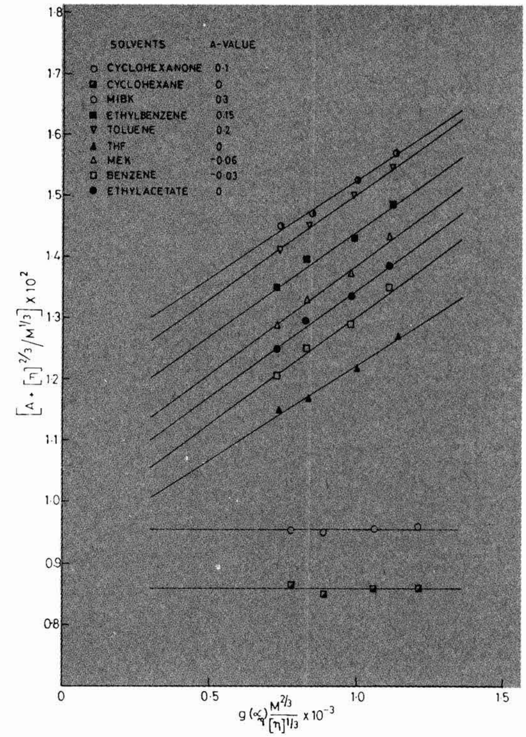

Figure 3—Kurata-Stockmayer plots for alkyd fractions in different solvents. "A" is an arbitrary constant

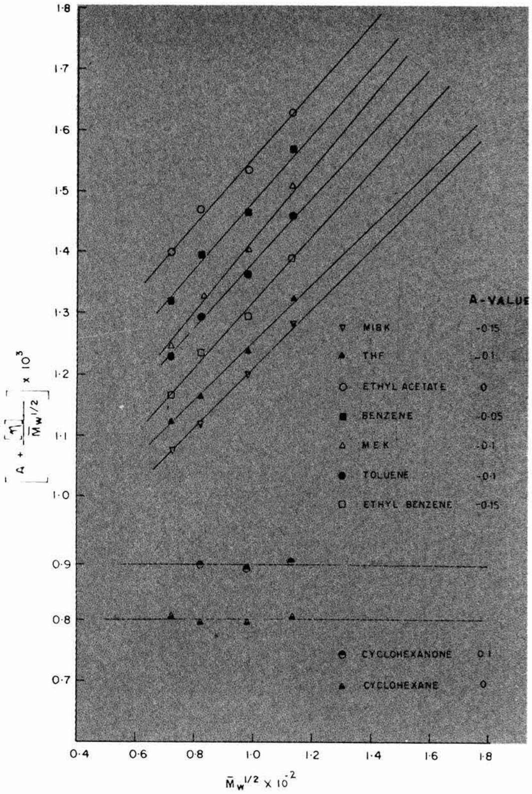

Figure 4—Stockmayer-Fixman plots for alkyd fractions in different solvents. "A" is an arbitrary constant

was linear during the initial stages of condensation. On the basis of this assumption, the above equations were used for determining $\bar{M}_w$ of alkyd from its $\bar{M}_n$. The calculation of molecular weight of polymer repeating unit of alkyd is described elsewhere.[34]

The weight average molecular weight of the alkyd fraction was also determined by gel permeation chromatography and it was found not to differ much from that obtained by the above procedure. The spectroscopic analysis of the fractions showed no variation in the composition of fractions with molecular weight. As the increase in the molecular weight of the individual fractions is due to the growth of molecular chain, the dilute solution of higher molecular weight fractions was used for the viscosity measurements.

Solvents

Analytical reagent grade solvents with solubility parameters in the range of 8-10 $(cal/cc)^{1/2}$ were selected on the basis of physico-chemical parameters of solute and solvents for viscosity measurement. The expected solu-

Table 2—Solution Parameters of Alkyd Obtained from Plots of Kurata-Stockmayer Equation

		Solution Parameters of Alkyd in Different Solvents			
		Long Range Interaction Parameters		Short Range Interaction Parameters	
Solvents	δ $(cal/cc)^{1/2}$	$B \times 10^{26}$	χ	$K_{\theta} \times 10^3$	$[\frac{(\bar{r}^2)_0}{\bar{M}_w}] \times 10^{17}$
1. Cyclohexane	8.18	0.0	0.5	0.797	2.97
2. Methyl isobutyl ketone	8.57	0.334	0.445	0.854	3.19
3. Ethyl benzene	8.80	0.351	0.424	0.926	3.45
4. Toluene	8.91	0.372	0.418	0.940	3.50
5. Ethyl acetate	9.10	0.370	0.410	1.000	3.73
6. Benzene	9.15	0.384	0.418	0.977	3.64
7. Methyl ethyl ketone	9.27	0.383	0.417	0.955	3.56
8. Tetrahydrofuran	9.52	0.317	0.448	0.875	3.26
9. Cyclohexanone	9.88	0.0	0.5	0.797	2.97

Table 3—Solution Parameters of Alkyd Obtained from Plots of Stockmayer-Fixman Equations

		Solution Parameters of Alkyd in Different Solvents			
		Long Range Interaction Parameters		Short Range Interaction Parameters	
Solvents	δ (cal/cc)$^{1/2}$	B × 10^{26}	χ	K_θ × 10^3	$[\frac{(\bar{r}^2)_0}{\bar{M}_w}]$ × 10^{17}
1. Cyclohexane	8.18	0.0	0.5	0.799	2.98
2. Methyl isobutyl ketone	8.57	0.354	0.442	0.875	3.26
3. Ethyl benzene	8.80	0.396	0.415	0.925	3.45
4. Toluene	8.91	0.400	0.411	0.950	3.54
5. Ethyl acetate	9.10	0.408	0.401	1.000	3.73
6. Benzene	9.15	0.430	0.407	0.980	3.66
7. Methyl ethyl ketone	9.27	0.446	0.404	0.970	3.62
8. Tetrahydrofuran	9.52	0.350	0.443	0.875	3.26
9. Cyclohexanone	9.88	0.0	0.5	0.799	2.98

bility parameter of the alkyd is around 9.1 (cal/cc)$^{1/2}$ and solvents which have their δ-values close to that of the resin are likely to be good solvents for it and vice-versa.[29] The likely order of preference of solvents for alkyd is ethyl acetate, benzene, toluene, and MEK (with their δ = 9.1, 9.15, 8.91, and 9.27, respectively) good solvents; ethyl benzene, THF, and MIBK (δ = 8.8, 9.52, and 8.59) intermediate solvents; and cyclohexane (δ = 8.18) and cyclohexanone (δ = 9.88) poor solvents.

Viscosity Measurements

Alkyd solutions of different concentrations ranging from 0.3 to 1.5 g/dL were prepared by the successive dilutions of stock solution (concentration 2 g/dL). The solvent was weighed to improve the accuracy and converted to volume. The viscosity was measured at 25 ± 0.004°C (Schott Gerätte thermostatic control) using calibrated Ubbelohde capillary viscometers and AVS/N System which automatically records the flow time of the liquid to 0.01 of a second.

Intrinsic Viscosity

Intrinsic viscosity [η] was determined using conventional procedure of plotting η_{sp}/C versus C, the concentration.

$$\left(\frac{\eta_{sp}}{C}\right)_{C \to 0} = [\eta] + K_H [\eta]^2 C \quad \text{Huggins}^{35} \qquad (12)$$

The Huggins constant, K_H, depends on solute-solvent interactions.

RESULTS

The values of Mark-Houwink constants a and K derived from the extrapolated plots of log [η] and log $\bar{M}_w$ (*Figures* 1 and 2) along with the weight average molecular weight of each fraction and their intrinsic viscosity in different solvents are reported in *Table* 1. The short range interaction parameters K_θ and f $(\bar{r}^2)_0$ and the long range interaction parameters B and χ obtained from plots of Kurata-Stockmayer and Stockmayer-Fixman equations (*Figures* 3 and 4) are given in *Tables* 2 and 3 along with the solubility parameters of each solvent.

DISCUSSION

Mark-Houwink Constants a and K

The values of constants a and K derived from plots in *Figures* 1 and 2 are found to depend on the type and solubility parameters of solvents. When alkyd solutions are prepared in solvents which have characteristics similar to those of the solute, the values of a do not differ much from each other. For example, they are in the range of 0.733 to 0.746 with respect to solvents, toluene, ethyl acetate, benzene, and MEK (*Table* 1). Hergenrother and Nelson[36] also observed similar results while studying the viscosity molecular weight relationship for fractionated polyethylene terephthalate.

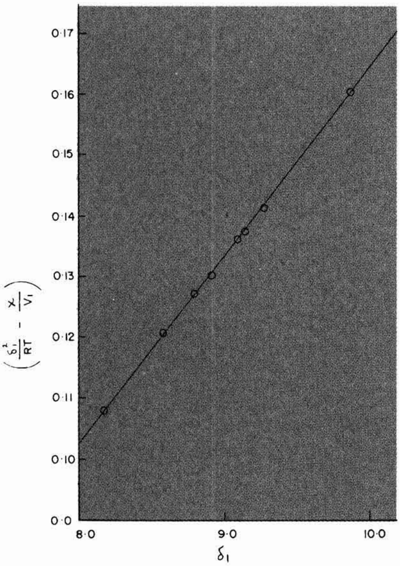

Figure 5—Interaction parameter, χ, vs solubility parameter, δ, of solvents

Solvents, cyclohexane ($\delta = 8.18$) and cyclohexanone ($\delta = 9.88$) which are not as compatible with the alkyd and which also have wide differences in their solubility parameters were selected to study the nature of their interactions with the resin. It is interesting to note that the value of a for alkyd solutions in these solvents is 0.5. Hence, cyclohexane and cyclohexanone may be considered as θ solvents for 66% linseed oil pentaerythritol phthalate alkyd.

The constant K is also dependent on the type of solvents. For example, the values of K are 1.64 and 1.65×10^{-4} with respect to benzene and ethyl acetate and 7.94×10^{-4} for cyclohexane and cyclohexanone.

Solution Parameters of Alkyd Resin

Solution parameters of polymeric materials depend largely on their conformational and thermodynamic properties which, in turn, are influenced by the short range and long range interactions between the chain segments of the polymer. The interaction parameters, K_θ and B, obtained from plots in *Figures* 3 and 4 and the parameters, $f(\bar{r}^2)_0$ and χ, derived from equations (3) and (5) are found to depend on the solute-solvent interactions (*Table* 3). The solute-solvent compatibility can be characterized by taking into account the dependence of these short range and long range interaction parameters on the type of solvents.

The behavior of a polymeric material in solution can be explained in θ and non-θ conditions. In θ condition, the short range interactions between atoms and groups which are near neighbors determine the unperturbed dimensions which are independent of the nature of solvent.[37] The solution parameters K_θ and $f(\bar{r}^2)_0$ of alkyd resin with respect to solvents cyclohexane and cyclohexanone are independent of the nature of these solvents.

The variation in the values of K_θ and $f(\bar{r}^2)_0$ in non-θ condition is attributed to the fact that the specific solvent effect on the thermodynamic interactions between polymer segment and solvent causes an alteration in the geometric parameters such as bond angles and bond lengths, etc.[38] With a further increase in the thermodynamic efficiency of a particular solvent to dissolve the polymer, K_θ and $f(\bar{r}^2)_0$ increase and attain optimum values. Because of this, in solvents, such as ethyl acetate and benzene, which have good interaction with alkyd, values of solution parameters K_θ and $f(\bar{r}^2)_0$ are the maximum (*Table* 2).

The thermodynamic behavior of a polymer in solution can also be explained in terms of long range parameters B and χ. In the unperturbed state, the values of parameters B and χ are 0 and 0.5, which represent the state of limiting solubility. The value of $B = 0$ and that of $\chi = 0.5$ for alkyd solutions in cyclohexane and cyclohexanone indicate the state of limiting solubility of alkyd in these solvents (*Table* 3).

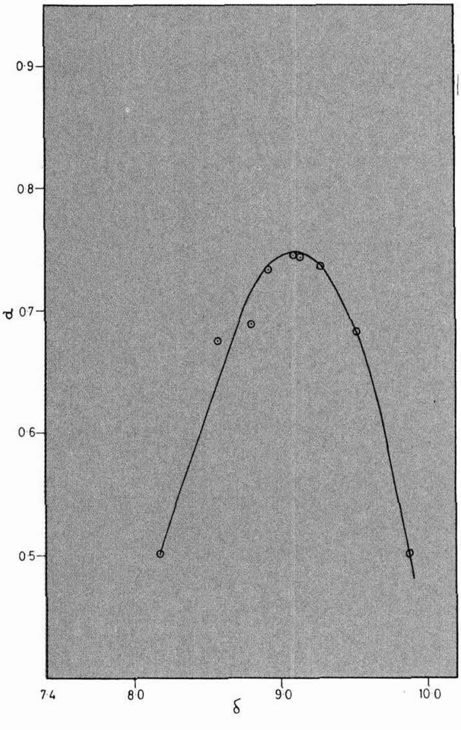

Figure 6—Mark-Houwink constant, a, vs solubility parameter, δ, of solvents

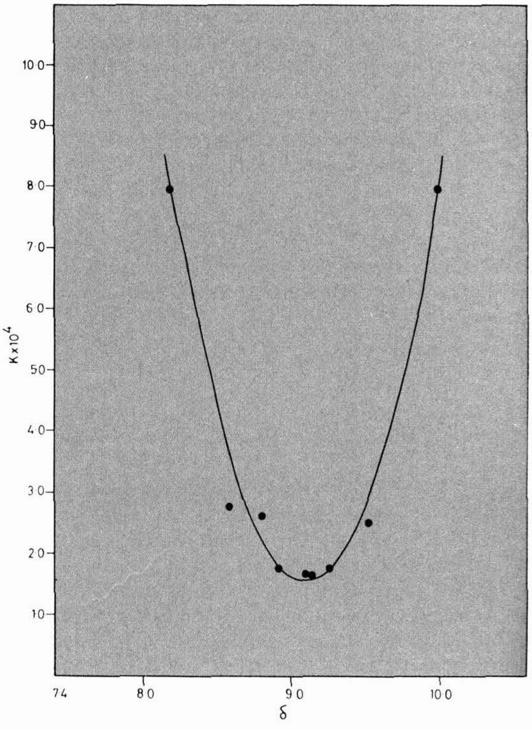

Figure 7—Mark-Houwink constant, K, vs solubility parameter, δ, of solvents

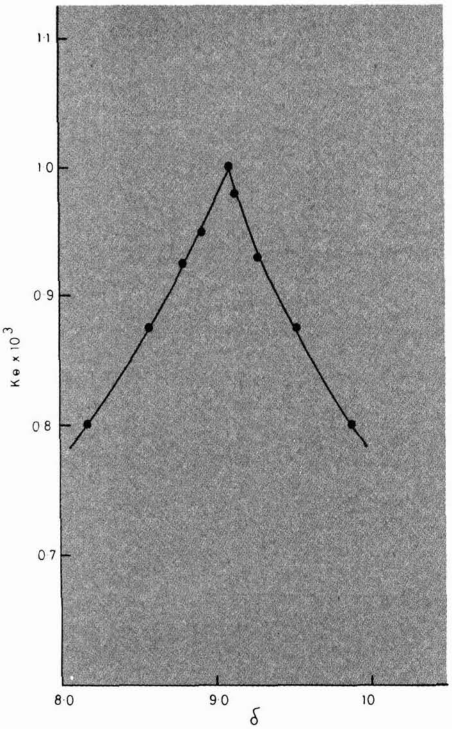

Figure 8—Unperturbed dimension, K_θ, vs solubility parameter, δ, of solvents

Limitations of Kurata-Stockmayer Equation

The calculated values of the function $g(\alpha_\eta)$ is not more than 1.265 for the alkyd-solvent system described here. The Stockmayer-Fixman equation is recommended to have good applicability when the value of function $g(\alpha_\eta)$ is less than 1.5. As the value of function $g(\alpha_\eta)$ is much lower than 1.5, the solution parameters of alkyd calculated by using Kurata-Stockmayer and Stockmayer-Fixman equations do not differ much from each other. In the case of the Kurata-Stockmayer equation, more variables are involved in plotting the data than with the Stockmayer-Fixman equation, a modified form of Kurata-Stockmayer equation. It may be preferable to use Stockmayer-Fixman equation for estimating solution parameters of polymers if the limiting conditions are satisfied.

Solubility Parameters of Alkyd

In the past, because of the polymeric form of alkyds, indirect methods were used for determining the solubility parameter of alkyds.[29,34] In the present study, the dependence of χ on solubility parameters of solvents has been used for directly estimating the solubility parameter of the alkyd from the slope of the plot of Lipson and Guillet's equation (9) (*Figure* 5). The value of δ_2^∞ obtained from the plot of data is given below:

$\delta_2^\infty = 9.05$ (cal/cc)$^{1/2}$ for linseed oil-pentaerythritol-phthalate alkyd

To support the above findings, the values of solubility parameter of alkyd were derived from the plots of a vs δ, K vs δ, and K_θ vs δ. The plots of constants a and K_θ in *Figures* 6 and 8 have distinct maxima and that of constant K versus δ has a clear minimum in *Figure* 7. Such types of definite inflections in the plots can be equated to the state of optimum interaction between resin and solvent. Hence the value on the δ-axis which corresponds to the inflection point of the plot was equated to the solubility parameter of the resin. The values of solubility parameter of linseed oil alkyd obtained from plots in *Figures* 6, 7, and 8 are 9.06, 9.06 and 9.08 (cal/cc)$^{1/2}$.

SUMMARY

The advantage of determining interaction parameter χ from solution viscosity is that it does not involve complicated steps. Further, solubility parameter of the polymer calculated by using data on χ may be compared with that obtained from other solution parameters.

The values of Mark-Houwink constants a and K for linseed oil alkyd obtained from the double logarithmic plots of $[\eta]$ and $\bar{M}_w$ are found to be affected by the type of solvents used in viscosity determination.

Cyclohexane and cyclohexanone are θ solvents for 66% linseed oil pentaerythritol phthalate alkyd.

The solubility parameter of an alkyd can be determined from solution parameters obtained using various solvents.

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OPEN FORUM

Coatings Technology—Why We Don't Get Enough Respect

Marco Wismer
PPG Industries, Inc.*

Introduction

For many years—long before it became fashionable—I was an outspoken advocate for research and technology in our industry. It was lonely work. Sometimes I felt like the ancient prophets must have felt—condemned to preaching the gospel of science to largely unreceptive audiences. Occasionally people listened; but more often, they didn't.

So I know how lonesome it can be to do technical missionary work in an industry as steeped in tradition as ours is. But I also know how rewarding the success of that mission can be—both in a professional and in a material sense.

Even though the value of advanced technology to our industry has been clearly established by now—and even though the value of our products to society has been incalculably great—and even though the quality of science which takes place in our industry is frequently outstanding—we have still not won the respect of our peers in other industries. The consequences of non-recognition have been taking their toll: recruitment, research support, product innovation, and self-respect are all among its victims. Therefore, I'd like, first, to take a closer look at why our achievements are routinely overlooked and, second, to propose some remedies which can help to turn that situation around.

An Industry Problem: Unappreciated Successes

As I see it, the tendency of people outside our industry to overlook coatings technology stems from two very different sources—our successes and our failures. The problem with our successes is that the contribution which a coating makes to a product is usually interpreted as a characteristic of the product itself. A beautifully finished car, for example, is seen as a beautiful car rather than a beautiful car *coating*. The same applies to other manufactured goods as well. Our successes are hidden in the goods to which our products have been applied.

Even worse are coatings whose function is to prevent you from noticing things which would otherwise offend you. Take, for example, the coatings used in beer cans to keep any metallic taste from affecting the product. Do people drink from the can and then comment on its wonderful coating? Of course not; they talk about the beer. And, in the unlikely event that they give it any thought at all, they probably conclude that aluminum simply doesn't affect its taste.

The sad fact is that it is almost always the least sophisticated component of a coating — its color — that people think of when they think about our industry's products. Unfortunately, that applies to technically educated people as much as it does to laymen. So, one of the first jobs we've got to do is to educate our professional peers to recognize our successes when they see them. After that, we can turn our attention to the general public.

The central message has to be that the value-to-performance ratios of coatings are higher than essentially any other products on the market. For example, a coating with a film thickness of only three mils represents less than one percent of the total cost of an average automobile. Yet it protects the car's value by resisting corrosion and greatly enhancing its appearance. The same is true of food packaging. A coating with a film thickness equivalent to just one-tenth of a human hair extends the shelf life of a food or beverage can by an order of magnitude. It also protects its taste and preserves the appearance of the finished product. Yet it represents less than four-tenths of one percent of the total product cost. Likewise, a housepaint generally accounts for only one-fifth the total cost

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Presented at the 63rd Annual Meeting of the Federation of Societies for Coatings Technology, October 7, 1985, in St. Louis, MO.

*One PPG Place, Pittsburgh, PA 15272.

Table 1—R&D Expenditures as Percentage of Sales

Industry	Percentage
Semiconductors	8.2
Information Systems	7.4
Aerospace	4.5
Electronics	4.3
Chemicals	3.1
Industrial Coatings	2.6
Coatings	1.9

Sources: 1983 Operating Cost Survey (NPCA). *Business Week*—July 8, 1985

of a paint job, yet it protects the entire house from deterioration and greatly enhances its value. The list of examples could go on and on.

Failures and Shortcomings: Need for Stronger Commitment

But not all of our industry's problems stem from its unappreciated successes. We must also face up to the fact that we have some legitimate failures and shortcomings as well. At one level, these include simple product failures—coatings which don't perform as well as people expect. Of course, sometimes their expectations are unrealistic, and at other times a consumer-applied product may be misapplied. In those cases, a customer's failure becomes construed as an industry failure. But apart from those instances, the actual performance of coating products *really does* vary quite a bit. Our commitment to quality has been uneven.

A lot of that, I'm sure, has to do with the nature of our industry. Paints have been produced for all of recorded history. Until very recently, paintmaking was definitely an art, not a science. The transformation of paint manufacture into a modern industry happened just within the span of a few decades. I can clearly recall seeing varnish makers hovering over the resin kettles where their secret recipes of gums and oils were being prepared. There were no standards of composition, performance, or even appearance back then. And paint manufacturers were everywhere; it was essentially a cottage industry.

> *"A product or process has to be developed before it is needed; when it is needed, it is too late."*

To a certain extent, that's still true. There are well over a thousand paint manufacturers in the United States today—some of them are little more than mixing sheds. The products they make are generally unsophisticated and the marketing practices they use are even less refined. It's not a situation that encourages respect for our industry, even though its overall size—$22 billion in sales last year—should certainly command attention.

But apart from those circumstances and from the resulting fact that most people think of commodity-type consumer paints as what we're all about, the reality is that our industry has much less commitment to R&D than many others do. Compare what we spend on R&D to this representative group of high-tech industries (*Table* 1). We're way, way down there.

So one of the first things I would advocate to enhance the vitality of our industry and earn the respect of our peers is to increase our research efforts. There's plenty of opportunity for that. At the level of basic science, there is growing excitement over discoveries concerning phenomena which occur exclusively on surfaces. And in the applied sciences, the past few years have seen tremendous breakthroughs in polymer chemistry and material synthesis.

Leapfrog Products and Incremental Improvements

If you look at the pioneering scientific work involved in coating technology today, you see an impressive array of disciplines. They include: polymer chemistry, organic chemistry, inorganic chemistry, analytical chemistry, electrochemistry, surface and colloid chemistry, rheology, color physics, chemical engineering, corrosion, adhesion, material science, microbiology, photochemistry, and physics. We have the *potential* for becoming one of the most exciting and attractive industries to this country's top graduate students. But for the most part, that potential remains unfulfilled. There's something still missing; it's the excitement and challenge that comes from applying those skills to breakthrough projects. Let me explain.

Table 2—Leapfrog Product Developments

Nitrocellulose
Alkyds
Titanium Dioxide White Pigments
Latex Paints
Epoxy Based Paints
Urethane
Cathodic Electrodeposited Coatings
Universal Top Coats
Clear Over Color Top Coats

In every industry, you can divide the research projects into two broad categories: (1) leapfrog products and processes, and (2) incremental improvements. I define leapfrog product or process as a technical advance of such magnitude that it forces the entire industry to change. It's the homerun of developmental technology. Some examples from our own industry are included in *Table* 2.

Unfortunately, not that many leapfrog projects have really changed the coatings business over the years. Much of our industry remains rooted in the artisan tradition. But if this industry is to grow and meet its true potential, we will need to redouble our technical efforts. We will need to concentrate more on leapfrog projects. And to make sure we direct those efforts to where they're really needed, we must anticipate the future requirements of our customers better than we have in the past.

A product or process has to be developed *before* it is needed; once it's needed, it's too late to start. But in order to anticipate what will be needed far enough in advance to be prepared, we need to get much, much closer to our customers. And I don't limit that to just our sales and marketing people. I mean our technical and scientific people as well.

At PPG, we have a series of teams consisting of one marketing person and one technical person who have a shared responsibility for customer contact. We have these teams operating in every business segment. That pattern has given us a tremendous advantage in anticipating our future markets. And as we address those needs, we concentrate on developing leapfrog solutions—products or processes which are so much superior to anything else available, that we frequently end up with a market all to ourselves. That's the commercial significance of leapfrogs.

The list of important incremental developments in our industry is much larger than our list of leapfrogs. Certainly, many more will be added over time, and others may have been overlooked which ought to be on this list right now. (*Table* 3). Even so, we have quite a few. Incremental improvements are important to our staying in business. Without them, our customers would not be well served. But incremental improvements won't protect our industry against the inroads of competing technologies which are oriented to protecting and enhancing surfaces. To do that, we need to look toward some technical challenges which are currently on the horizon (*Table* 4).

Three Managerial Challenges: Planning, Policy and People

But even our success in meeting these technical challenges won't propel us into the vanguard of high technology. We also face some important managerial challenges. In my capacity as a coatings research director, I broke these challenges into three categories—the three P's, as I called them—Planning, Policy and People.

Planning: We must plan our research in such a way that our long-range plans dovetail with the long-range needs of our customers. They must also correspond with current trends in technology and emerging social needs. I realize that's easier said than done. For example, our customers don't always recognize their own future needs; we frequently have to anticipate those needs for them. As I noted earlier, a product has to be developed *before* it's needed; by the time it's needed, it's too late.

A related part of the planning process requires us to think of ourselves as a service industry rather than as a manufacturing industry. We must develop ways to surround our customers with service so that we can solve their problems as they arise. I call this customer obsession.

Table 3—Outstanding Incremental Product Developments

High Gloss Latex Paints
Semigloss Latex Paints
Waterbased High Gloss Alkyds
High Solids Coatings
Flow and Dip Primers
Photoresists
Optical Fiber Coatings
Elastomer Coatings
Latices with Good Wet Adhesion
Organic Coatings to Replace Porcelain
Elastomeric Coatings for Concrete
Refinish Coatings for Metal Siding
Fire Proofing Coating for Structural Steel
Two Pack Durable Urethane Coatings
Water-borne Automotive Basecoat
Water-borne Can Coatings
Polyvinylidene Fluoride Coil Coatings
Nontoxic Anticorrosive Pigments
Vapor Cure Coatings

Policy: It must be our policy to invest a significant share of the available research dollars into leapfrog products and processes. Otherwise, we neglect our industry's future and the future of our customers as well. Of course, I realize how tempting it is to put all of your technical manpower into incremental projects; that pacifies our market managers and satisfies the immediate needs of our customers at the same time. But it won't advance our customers' long-range interests, nor will it protect our own.

People: However, the most significant of the three P's is people. Without good people, no technical program can survive. I have often asked myself: what characteristics make for a successful R&D person? And I've concluded that a successful R&D professional has to have three important capabilities: imagination, know-how, and hard work.

Without imagination, there can be no creative process. And without that creative process, inventions won't be made. It takes imagination to anticipate the needs of your customers and imagination to translate them into quality research projects.

Without know-how, inventions can't be developed and solutions can't be implemented. A solid technical education with a firm grounding in the sciences is a must for the successful R&D professional.

Finally, without hard work, inventions just don't get done. Inspiration must be accompanied by perspiration. Inventions often result from the unexpected. And the only way you can observe the unexpected is when you work, when you experiment, when you generate results, when you act.

Another key ingredient of invention is risk-taking. I remember when we conducted the first experiments with cationic resins for cathodic electrodeposition. The first panel we made was terrible. The coating had craters; it had bubbles; it looked like the face of the moon. Then we showed it to a consultant and told him that it was a cationic-electrocoat film. He immediately ran to the blackboard, drew a few equations, and explained how the cathode generates twice as much gas as the anode. You could never get a smooth, pinhole-free film from the cathode, he explained. Those comments prompted us to redouble our R&D efforts. We felt if *he* were thinking anodic, then our competitors were probably thinking that way, too. So we concluded that it was worth the risk of trying to develop a cationic process that really worked. If we succeeded, we knew we'd have the field to ourselves.

Table 4—Future Technical Challenges

Low Cost Replacement for Titanium Dioxide White Pigment
Auto Refinish System Free from Toxic Effects
Consumer Paint which Eliminates Messiness of Painting
Solventless Paint which Can Be Applied by Conventional Methods
Non-toxic Coating which Cures at 250°F or Less
Non-toxic Corrosion Inhibiting Pigment which Is as Effective as Chromates
Superior Adhesion Promoters, Better Adhesion, Better Corrosion Resistance
Coating for Mixed Metal/Plastic Substrates on Line
Improved Coatings for Galvanized Steel
Temporary Coatings for both Painted and Unpainted Substrates

> *". . . a successful R&D professional has to have three important capabilities: imagination, know-how, and hard work."*

The rest, as they say, is history. The moral of the story is that we have to encourage risk-taking. We must create an atmosphere in our industry which supports innovation. And an important part of creating that environment is to resist the impulse to punish risk-takers for their occasional failures. We learn from our failures even more than we learn from our successes. If someone isn't free to fail, they're not really free to succeed, either.

Conclusion

Let me emphasize that the work we're doing today is something in which we can all take pride. But with additional effort, we could also become the envy of every researcher in the industrial world. If we commit ourselves to leapfrog research, to uncompromising quality, to outstanding customer service, and to attracting the best available scientific talent, our future will be in good hands. Our customers will be well served, our careers will be more fulfilled, and the respect which has eluded us for so long will have finally been secured.

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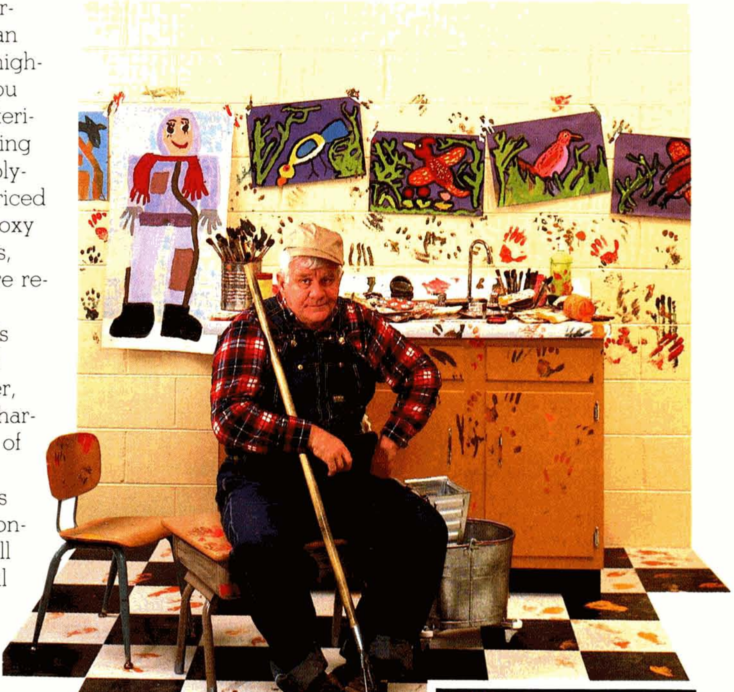

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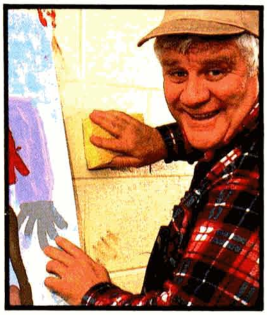

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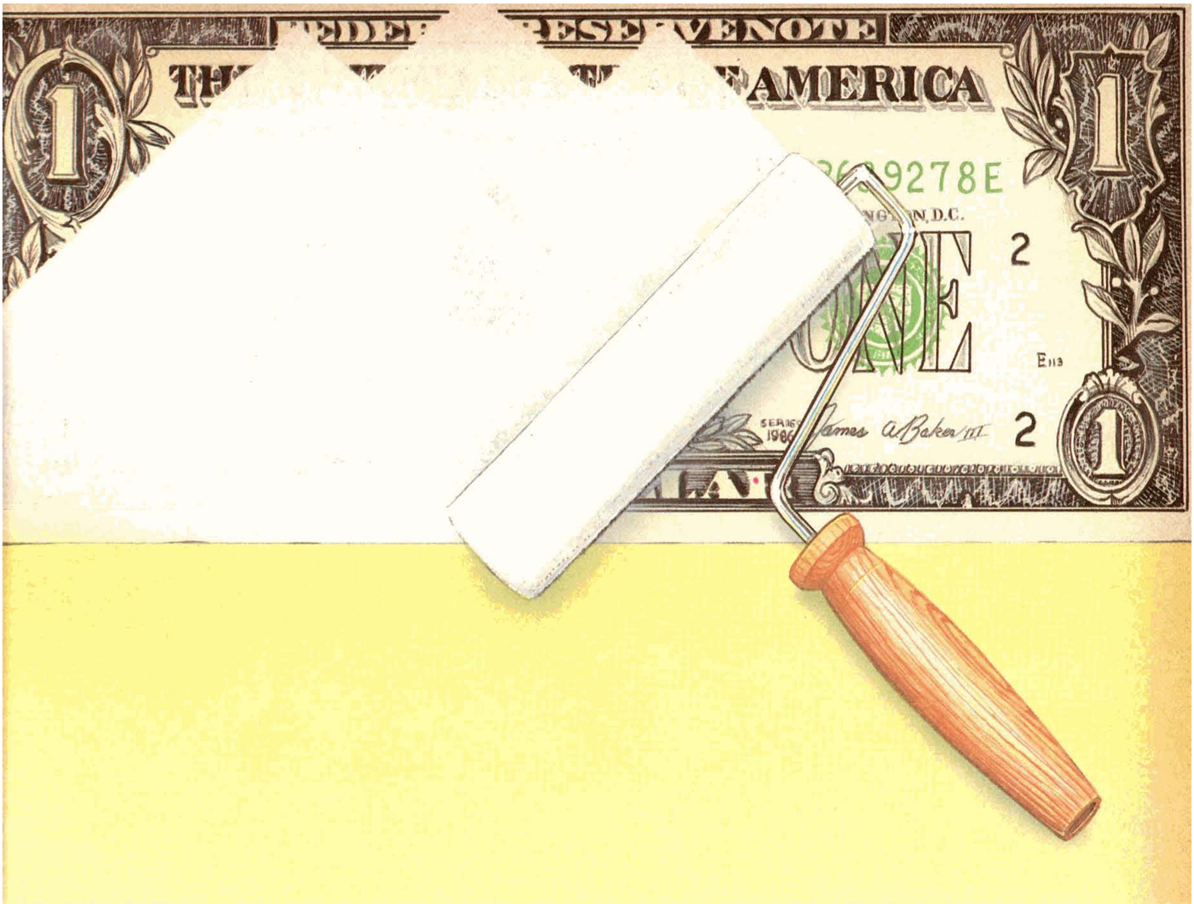

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Federation of Societies for Coatings Technology

CDIC .... SEPT.

"Polyethylenes and Waxes"

Incoming Society President Joseph W. Stout, of Hanna Chemical Coatings, was presented the Nuodex Gavel by Don Roettker, of B.H. Roettker Co., Inc. The full slate of 1986-87 CDIC Officers were then recognized. They include: Vice-President—Andy Nogueira, Fischer Industrial Coatings; Secretary—Carolyn Tully, Sun Chemical Corp.; Treasurer—N. Jay Huber, Jr., Paint America Co.; and Society Representative—Lloyd R. Reindl, Flanagan Associates, Inc.

Next, Mr. Stout made an appeal to the membership for Technical and Environmental Chairpersons.

Educational Chairman Jim Flanagan, of Flanagan Associates, Inc., introduced the Educational Speaker of the evening. Robert Hellebush, of Omni Management, Inc., spoke on "TAX REFORM 1987 — BEFORE AND AFTER."

George Goodwin, of Daniel Products, provided the technical talk, "ADVANTAGES OF PREDISPERSED POLYETHYLENES AND WAXES IN HIGH PERFORMANCE COATINGS."

Mr. Goodwin discussed the applications and properties of slip additives noting that additives are used in finishes for furniture, appliances, flat stock, cans, paper, and leather. He then told of the two major properties which slip additives impart: they lower the coefficient of friction, which improves metal marking resistance and reduces damage in forming coated metals; and they increase the apparent film hardness, improving block, abrasion, and rub resistance.

Next, the speaker summarized the advancement of the additives. Historically, he explained, two methods were used to give slip to industrial finishes. One method involved spraying a light oil over the coated surface, and the other incorporated a lubricant such as motor oil, beeswax, or paraffin to the wet coating. Both methods were effective but required that the greasy residue be removed before the finished product could be sold. In the 1950's, low molecular weight polyethylenes came into use. They were effective in improving the surface properties, but their use was limited as they lowered gloss and proved difficult to incorporate. In the 1960's silicone polymers developed that were easy to incorporate and effective in lowering the coefficient of friction. However, they caused problems in intercoat adhesion, crawling, and cratering. Mr. Goodwin explained that the deficiencies of silicones steered the search for slip additives back to synthetic waxes.

The development of synthetic waxes was then described by Mr. Goodwin. He noted that the problem of incorporation of synthetic wax was alleviated by the development of two techniques for particle size reduction: dry grinding and wet grinding. In dry grinding, the wax particle is micronized to a certain size. In wet grinding, the process takes place in a pebble or media mill, where all particles remain in the mill until reduced to optimum, uniform particle size. He added that further developments in wet grinding have generated different grades in a variety of solvents. Mr. Goodwin also noted that for a polyethylene or wax to perform effectively in a coating, it must float to the surface during the bake cycle and ideally it should lie on the surface of the film where, he explained, it acts as ball bearings forming a discontinuous layer that imparts slip. Conversely, a particle trapped in the film is ineffective, and those situated just at the surface may cause loss of gloss or cratering.

Lastly, Mr. Goodwin listed the benefits of predispersed polyethylenes and waxes. He mentioned that both materials eliminate the problem of incorporation since they are ready to use and can be mixed with low energy, and that the wet grinding process employed in developing ultrafine dispersions has virtually no effect on gloss and clarity in high gloss clear coatings. In addition, he explained that the availability of waxes and polyethylenes dispersed in a variety of solvents has greatly expanded the range of applications in coatings systems.

Q. Can you totally eliminate metal marking on low gloss systems?

A. Generally not. With a hard polyethylene, you can significantly reduce it. If the extender pigment is very hard or abrasive, it is almost impossible to eliminate metal marking.

Q. Can you effectively predisperse a high molecular weight polyethylene; can it be readily incorporated?

A. Yes, they can be predispersed so that they can be added as a liquid in the last step of the let-down.

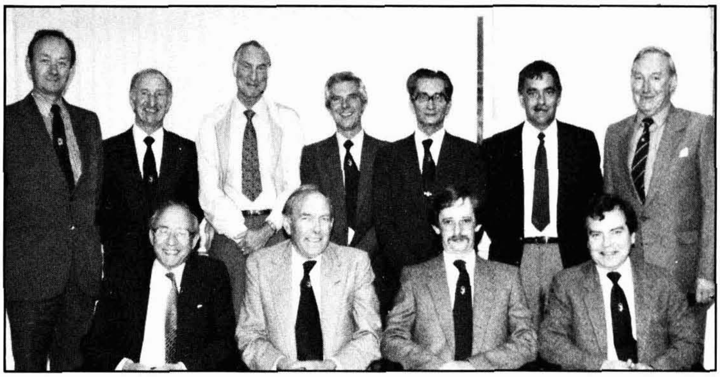
CAROLYN TULLY, *Secretary*

CHICAGO .... SEPT.

"Acid Catalyst Trouble Shooting" and "Polycarbodiimides"

Incoming President, Ronald Kleinlein, of Sherwin-Williams Co., announced that the Society is in need of a Photographer-Reporter. Those interested should contact him. Mr. Kleinlein also reported that the Chicago Safety Council on Laboratory Safety would be conducting a seminar.

CDIC OFFICERS for 1986-87 (left to right): Vice-President—Andrew Nogueria; President—Joseph W. Stout; Secretary—Carolyn L. Tully; and Treasurer—Jay Huber



1986-87 OFFICERS OF THE BIRMINGHAM CLUB: Standing, left to right: Social Officer—John R. Green; Society Representative—Ray B. Tennant; President-Elect Designate—Stanley J. Mitchell; Robert E. Arnold; John N. Hitchin; Roy Ingleston; and Technical Committee Chairman—Roland L. Staples. Seated (left to right): Treasurer—Stan V. Brettell; President—Graham W. Fowkes; President-Elect—Gerry J. Gough; and Secretary—David M. Heath

Education Committee Chairman, Ted Fuhs, of Southern Coatings and Chemical, informed members of the Coating Short Course. The 16-week class will begin in January of 1987.

Program Chairman, Ray Cziczo, of Reliance Universal, introduced the technical speakers for the evening. Leonard J. Calbo, of King Industries, provided the first talk. Dr. Calbo spoke on "Acid Catalyst Trouble Shooting in High-Solids and Water-Borne Coatings." Charles B. Mallon, of Union Carbide Corp., addressed the topic of "Polycarbodiimides as Crosslinks for Water Borne-Coatings."

Evans Angelos, *Secretary*

DALLAS . . . . SEPT.

"Synthetic Amorphous Silica"

The slate of nominees for 1986-87 Society Officers officers was read. All were approved by a unanimous vote. The newly elected Officers are: President—Ashwin Parikh, Coulter Electronics; Vice-President—Noel L. Harrison, Western Specialty Coatings Co.; Secretary—Bruce Alvin, DeSoto, Inc.; Treasurer—Steve Stephens, Ribelin Sales, Inc.; and Society Representative—William E. Wentworth, Jones-Blair Co.

John Rothermel, of Sherwin-Williams Co., proposed that the Society honor the late Fred Couch, of Sherwin-Williams, with an Honorary Membership for his more than 40 years of service in the coatings industry. The motion was approved unanimously.

Van G. Falcone, of Koppers Co., was presented with a plaque for his work as Membership Chairman for 1985-86.

Robert Thomas, of PPG Industries, Inc., provided the technical presentation, "Synthetic Amorphous Silicas in Coatings."

The talk included a discussion of the various types of amorphous silicas available commercially to coatings manufacturers. In addition, Mr. Thomas detailed their applications and advantages in various types of coatings. The relative costs involved when choosing a silica for a particular application were also explored by the speaker.

Bruce Alvin, *Secretary*

GOLDEN GATE . . . . SEPT.

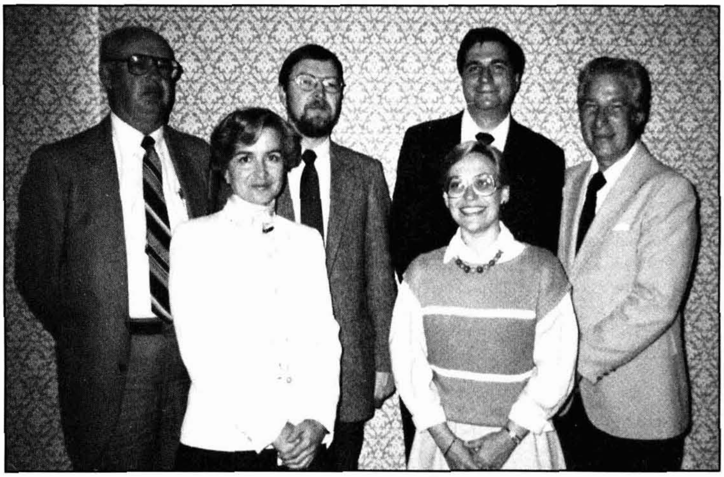
Past-Presidents' Night

The meeting opened with a presentation of a Twenty-Five Year Pin to Bert Cole, retired from Abbott Cole & DeGraf, by outgoing Society President Bob Miller, of Dunne Quality Paints.

Incoming President Patricia Shaw, of Davlin Coatings, Inc., introduced the 12 Past-Presidents in attendance.

The 1986 Alfred Apfel Memorial Scholarship Awards were then presented by Mr. Miller. Two $1,000 scholarships were bestowed to children of Society members. The recipients were: Christopher Ehmke, son of Ronald Ehmke, Pacific Dispersions, who will be entering San Francisco State to major in Chemistry; and Pauline Chang, daughter of Steven Chang, O'Brien Corp., who will be attending U.C. Berkeley to major in Biochemistry.

Mr. Miller then presented Certificates of Appreciation to all of the Committee Chairpersons serving the 1985-86 term. Recipients included: Educational—Dan Gilbert, VIP Enterprises; Environmental Control—Robert Minucciani, Glidden Coatings and Resins; Manufacturing—



OFFICERS OF THE CLEVELAND SOCIETY, 1986-87, (left to right): Robert Bromfield; Treasurer—Ilona Nemes-Nemeth; Vice-President—Richard Eley; Past-President—Scott Rickert; President—Madelyn K. Harding; and Secretary—R. Edward Bish

Louis F. Sanguinetti, Jasco Chemical Co.; Membership—Karl Sauer, Pfizer, Inc.; Program—Pat Shaw, Davlin Coatings, Inc.; Publicity—David Filson, Clorox; and Technical—Timothy G. Specht, The Flecto Co.

Society Vice-President Jim Donlin, of Pacific Coast Chemical, announced that he will be the instructor of the Society course "Introduction to Coatings Technology." The course will run from September 17, 1986 until February 19, 1987, and is being held at the O'Brien Corp.

Manufacturing Committee Chairman Louis Sanguinetti announced that the topic of the 1987 Manufacturing Conference will be Toxic Waste and HMIS. He invited new members to join the committee.

Technical Committee Chairman Bob Athey, of Athey Technologies, reported that committee member Tim Specht will be presenting a paper at the Atlanta Show on "Cycle Variation in the Fluorescent Condensation Test Apparatus and Gloss Retention in Consumer Alkyd Enamels."

Ted Deldonno, of Rohm and Haas Co., spoke on "WATER-BORNE INDUSTRIAL COATINGS."

Using a slide presentation, Mr. Deldonno discussed thin film coatings of the following aqueous resins: aqueous dispersion (latex), water reducible (alkyd and acrylic), and colloidal dispersions. In addition, he addressed the topic of formulation design. This, he explained, centers on utilizing a combination of the latex and water reducible types to arrive at good thin film coatings for the protection of steel. Proper combination of the two types enables the formulator to overcome shortcomings of each when used alone and to obtain the beneficial attributes of each polymer resin type. These characteristics include: gloss, hardness, chemical resistance, flexibility, durability, pigment wetting, and water resistance.

Lastly, the speaker reviewed how the drying environment affects thin film formation. The environmental constraints mentioned were forced air flow, temperature variation, and relative humidity.

ERNEST J. SOLDAVINI, *Secretary*

1986-87 OFFICERS and Committee Chairpersons of the Western New York Society (left to right): Membership Chairman—Richard A. Foss; Secretary—Marko K. Markoff; Publicity Chairman—Charles C. Tabbi; President—Michael L. DePietro; Treasurer—Gerald F. Ivancie; and Vice-President—Jean L. Luck

LOS ANGELES........... SEPT.

"Water-Borne Industrial Coatings"

A moment of silence was observed in honor of four members who recently died: Larry Goodmanson, retired from Fredericks-Hansen Co.; wife of Robert Hunter, formerly associated with the Samson Chemical Co.; Ronald J. Schubert, of Ameritone Paint Corp.; and Ron Dae, of W.W. Henry Co.

The new slate of officers was introduced by outgoing President Michael Gildon, of Guardsman Chemicals. They are: President—Henry J. Kirsch, Trans Western Chemicals, Inc.; Vice-President—Ray DiMaio, Koppers Co.; Secretary—Parker Pace, Behr Process Corp.; Treasurer—Melinda Rutledge, Allo Chemical Co.; and Society Representative—Jan P. Van Zelm, Byk Chemie USA.

Wayne Cochran, of Nuodex, then presented the Nuodex Gavel to incoming President Henry Kirsch.

Mr. Kirsch announced the 1986-87 Committee Chairperson appointments. He noted the special qualities needed for these positions and requested that anyone desiring to assist or discuss the committees contact the committee heads as needed.

Frank Peters, of Dunn-Edwards Corp., presented diplomas to the 32 recent Paint Technology Course graduates. Due to a tie, the "Outstanding Student" honor was awarded to two individuals. The recipients, both employed with Products Research and Chemical Corp., were Nairi Kazorian and Anie Kazorian. Mr. Peters noted that the new Paint Course would begin on September 25 and urged that those interested should pre-register as soon as possible.

Ken O'Morrow addressed the meeting with an update from the Environmental Committee. He warned that there is going to be a landfill ban effective on November 8, 1986. The situation is very confused, he explained, but politically there is little likelihood that there would be any withdrawal from the outright ban of the disposal of almost all paint related wastes. Mr. O'Morrow also reported that the landfill owners stated that they would not accept paint wastes after the October 1 deadline.

The evening technical presentation was delivered by Theodore Deldonno, of Rohm and Haas Co. He discussed "WATER-BORNE INDUSTRIAL COATINGS."

Mr. Deldonno focused on water-borne coatings based on latex emulsions noting that they have enjoyed growing use in the general industrial finishing areas as VOC regulations have toughened. To successfully employ these resin systems, the user must pay careful attention to formulation and film formation, he explained. Newer latex polymers are designed specifically for the industrial area and offer the user an easier route to achieve much of the same performance and latitude enjoyed by solvent-based systems, concluded Mr. Deldonno.

PARKER PACE, *Secretary*

NEW ENGLAND.......... SEPT.

"Reflections on the Phenomenon of Fading"

The guest speaker was Ruth Johnson-Feller, of Mellon Institute. She provided a slide presentation and talk entitled "REFLECTIONS ON THE PHENOMENON OF FADING." This presentation, the 1985 Mattiello Lecture, was published in the May 1986 issue of the JCT.

ROGER WOODHULL, *Secretary*

PHILADELPHIA.......... SEPT.

"Metallic/Organic Coatings"

The meeting opened with a moment of silence for Emory Fleming, Past-President of the Society, who passed away during the summer.

Constituent Society Meetings and Secretaries

BALTIMORE (Third Thursday—Martin's Market Square, Towson, MD). Helen Keegan, Valspar Corp., 1401 Severn St., Baltimore, MD 21230. Virginia Section—Fourth Wednesday, Ramada Inn-East, Williamsburg, VA.

BIRMINGHAM (First Thursday—Strathallan Hotel, Birmingham, England). D.M. Heath, Holden Surface Ctgs. Ltd., Bordesley Green Rd., Birmingham B9 4TQ England.

CHICAGO (First Monday—meetings alternate between Como Inn in Chicago and Sharko's West in Villa Park). Evans Angelos, Kraft Chemical Co., 1975 N. Hawthorne Ave., Melrose Park, IL 60160.

CDIC (Second Monday—Sept., Jan., Apr., June in Columbus; Oct., Dec., Mar., May in Cincinnati; and Nov., Feb. in Dayton). Carolyn Tully, Sun Chemical Corp., 4526 Chickering Ave., Cincinnati, OH 45232.

CLEVELAND (Third Tuesday—meeting sites vary). R. Edward Bish, Jamestown Paint & Varnish Co., 108 Main St., Jamestown, PA 16134.

DALLAS (Thursday following second Wednesday—Executive Inn. Near Lovefield Airport). Bruce Alvin, DeSoto, Inc., P.O. Box 461268, Garland, TX 75046.

DETROIT (Fourth Tuesday—meeting sites vary). Joanne Cederna, BASF Inmont Corp., 26701 Telegraph Rd., Southfield, MI 48086.

GOLDEN GATE (Monday before third Wednesday—Alternate between Francesco's in Oakland, CA and Leaning Tower Restaurant in S. San Francisco). Ernest Soldavini, Nuodex Huls, 5555 Sunol Blvd., Pleasanton, CA 94566.

HOUSTON (Second Wednesday—Look's Sir-Loin Inn, Houston, TX). James Tusing, PPG Industries, Inc., P.O. Box 1329, Houston, TX 77251.

KANSAS CITY (Second Thursday—Cascone's Restaurant, Kansas City, MO). Roger Haines, Tnemec Co., Inc., P.O. 1749, Kansas City, MO 64141.

LOS ANGELES (Second Wednesday—Steven's Steak House, Commerce, CA). Parker Pace, Behr Process Corp., P.O. Box 1287, Santa Ana, CA 92702.

LOUISVILLE (Third Wednesday—Executive West Motor Hotel, Louisville, KY). Louis Holzknecht, Devoe Marine Coatings, 1437 Portland Ave., Louisville, KY 40203.

MEXICO (Fourth Thursday—meeting sites vary).

MONTREAL (First Wednesday—Bill Wong's Restaurant). R. Ferris, Canbro Ltd., 29 E. Park St., Valleyfield, Que., Canada J6S 1P8.

NEW ENGLAND (Third Thursday—LeChateau Restaurant, Waltham, MA). Roger Woodhull, California Products Corp., P.O. Box 569, Cambridge, MA 02139.

NEW YORK (Second Tuesday—Landmark II, East Rutherford, NJ). David Penichter, D.H. Litter Co., Inc., 116 E. 16th St., New York, NY 10003.

NORTHWESTERN (Tuesday after first Monday—Jax Cafe, Minneapolis, MN). Richard Karlstad, Ceramic Industrial Coatings, 325 Hwy. #52-South, Osseo, MN 55396. Winnipeg Section (Third Tuesday, Marigold Restaurant)—Neil Webb, Phillips Paint Products Ltd., 95 Paquin Rd., Winnipeg, MB, Canada R2J 3V9.

PACIFIC NORTHWEST (Portland Section—Tuesday following second Wednesday; Seattle Section—the day after Portland; British Columbia Section—the day after Seattle). John Daller, McCloskey Corp., 4155 N.W. Yeon, Portland, OR 97210.

PHILADELPHIA (Second Thursday—Williamson's, GSB Bldg., Philadelphia, PA). Lawrence J. Kelly, Peltz-Rowley Chemicals, 5700 Tacony St., Philadelphia, PA 19135.

PIEDMONT (Third Wednesday—Howard Johnson's, Brentwood Exit of I-85, High Point, NC). Barry York, Reliance Universal, Inc., P.O. Box 2124, High Point, NC 27261.

PITTSBURGH (First Monday—Montemurro's, Sharpsburg, PA). Richard G. Marci, Royston Laboratories, 128 First St., Pittsburgh, PA 15238.

ROCKY MOUNTAIN (Monday following first Wednesday—Bernard's Arvada, CO). Jeffrey B. Johnson, Sashco, Inc., 1395 S. Acoma, Denver, CO 80223.

ST. LOUIS (Third Tuesday—Salad Bowl). Robert L. Wagnon, Mozel Chemical Products Co., 4003 Park Ave., St. Louis, MO 63110.

SOUTHERN (Gulf Coast Section—Third Thursday; Central Florida Section—Third Thursday after first Monday; Atlanta Section—Third Thursday; Memphis Section bi-monthly on Second Tuesday; Miami Section—Tuesday prior to Central Florida Section—R. Scott McKenzie, Southern Coatings & Chemicals, P.O. Box 2688, Sumter, SC 29150.

TORONTO (Second Monday—Cambridge Motor Hotel). Larry Ham, Stochem Inc., 5200 Dixie Rd., Suite 201, Mississauga, Ont., Canada L4W 1E4.

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

John Catino, of Lehigh University, one of the winners of the Southern Society's "Alfred L. Hendry Award" for the best paper by a graduate student, was introduced.

Regulatory Chairman, Dick Kiefer, McCloskey Corp., asked members to write to their Pennsylvania State Representative in support of Bills HB-2425 and HB-2426 covering Tort Reform.

Mr. Kiefer then installed the officers for the 1986-87 year: President—Donald F. Denny, E.W. Kaufmann Co.; Vice-President—Thomas L. Peta, C.J. Osborn Chemicals; Secretary—Lawrence J. Kelly, Peltz Rowley Chemical Co.; Treasurer—Orville Brown, M.A. Bruder & Sons, Inc.; Assistant Treasurer—Fred Lipson, LPC Ltd; Senior Member at Large—Christopher H. Huhn, Loos and Dilworth, Inc.; and Junior Member at Large—Peter Kuzma, V.I.P. Chemical Corp.

The Nuodex Gavel was presented to incoming President Donald F. Denny by Frank Gaffney, of Harry W. Gaffney Co., Inc.

Mr. Denny presented the Past-President's Pin to outgoing President Phil Reitano, of Charles A. Wagner Co., Inc.

Dr. Richard Granata, Assistant Director, Corrosion Laboratory of the Sinclair Laboratory at Lehigh University, provided the meeting's technical presentation: "Corrosion Mechanisms of Metallic/Organic Coatings."

Covering some of the factors involved in metal corrosion, Dr. Granata focused on the effect of divalent metal ions on the metal interface between a polymer coating and a steel substrate. He said that by introducing metal ions to a steel substrate, the interface adhesion and delamination caused by water and oxygen permeating polymer coatings can be controlled and blistering minimized.

Implanting steel substrates with metal ions such as titanium or aluminum can dramatically improve blistering resistance by neutralizing the OH ions that may reach the metal/coating interface in acid environments such as sulfuric acid. Dr. Granata then described and interpreted the test methods used in measuring interface corrosion.

Q. When titanium was implanted on the steel surface, did it act as 100% titanium?

A. The iron potential was changed due to the titanium alloy and the fact that the steel was now more amorphous.

Q. Does titanium alloy change substrate or does it just change surface?

A. Hard to say. Probably both.

Lawrence J. Kelly, *Secretary*

Future Society Meetings

Baltimore

(Jan. 15)—Federation Night. "Tools and Rules of Adhesion Science"—Douglas B. Rahrig, S.C. Johnson & Son, Inc.

Birmingham

(Jan. 8)—"Particle-Size Reduction in Wet Systems"—D. Palmer, Marchant Bros. Ltd.

(Feb. 5)—"Epoxy-Curing Agents"—W. Burrell, Anchor Chemicals Ltd.

(Mar. 5)—"Determination of Short and Long Term Protection Offered by Chromate-Free Anti-Corrosion Paints"—Mr. Nitsche, BASF Stuttgart.

(Apr. 2)—Memorial Lecture for E.A. Bevan "Amino Resin Development"—R. Barrett, B.I.P. Chemicals Ltd.

Chicago

(Jan. 5)—"The PVC of Latex Paints and Formula Optimization"—William Meadows, Cyprus Industrial Minerals.

(Feb. 2)—"When the OSHA Inspector Calls, Be Prepared by Establishing Procedures"—Hobart G. Miller, Label. "On Site Recovery and EPA Compliance"—Fred Slock, Progressive Recovery, Inc.

(Mar. 2)—"How Close Is Close Enough"—Terry Downes, Applied Color Systems, Inc. "Effective Filtration of Industrial Coatings"—Carney Likens, Commercial Filters.

(Apr. 6)—"New Insights into the Chemistry of Silicones for the Coatings Industry"—speaker from Byk Chemie USA. "High Solids Urethane Coatings"—Bernard Taub, Spencer Kellogg Products, NL Chemicals/NL Industries, Inc.

Golden Gate

(Jan. 19)—"Effective Filtration of Industrial Coatings"—Carney Likens, Commercial Filters.

(Mar. 16)—"New Developments in High Solids Coatings"—Richard Johnson, Cargill, Inc.

(Apr. 13)—"Vinyl Rheology Modified Systems"—Rick Caudwell, Reichhold Chemicals, Inc.

(May 18)—"Advantages of Predispersed Polyethylenes and Waxes in High Performance Coatings"—Elio Cohen, Daniel Products Co.

Los Angeles

(Jan. 14)—"Effective Filtration of Industrial Coatings"—Carney Likens, Commercial Filters.

(Mar. 11)—"New Developments in High Solids Coatings"—Richard Johnson, Cargill, Inc.

(Apr. 8)—"Vinyl Rheology Modified Systems"—Rick Caudwell, Reichhold Chemicals, Inc.

(May 13)—"Advantages of Predispersed Polyethylenes and Waxes in High Performance Coatings"—Elio Cohen, Daniel Products Co.

New York

(Jan. 13)—"The Case for In-House Solvent Recovery"—Michael Schmutzer, Disti, Inc.

(Feb. 26)—Joint Meeting with NYPCA. "Legislative Update."

(Mar. 10)—"Hardeners for Epoxy Coatings"—John Sinclair, Pacific Anchor Chemical.

(Apr. 7)—"Update on Powder Coatings"—Sid Harris, Consultant.

(May 12)—Past-Presidents' Night. PaVac Awards Presentation.

Pacific Northwest Portland, Seattle, and Vancouver Sections

(Jan. 20-22)—"Effective Filtration of Industrial Coatings"—Carney Likens, Commercial Filters.

(Mar. 17-19)—"New Developments in High Solids Coatings"—Richard Johnson, Cargill, Inc.

(Apr. 14-16)—"Vinyl Rheology Modified Systems"—Rick Caudwell, Reichhold Chemicals, Inc.

(May 19-21)—"Advantages of Predispersed Polyethylenes and Waxes in High Performance Coatings"—Elio Cohen, Daniel Products Co.

Philadelphia

(Jan. 21)—Joint Meeting with PPCA. "New Tax Reform Laws"—Speaker from Internal Revenue Service.

(Feb. 12)—Federation Night. "New Insight into Chemistry of Silicone for the Coatings Industry"—Speaker from Byk-Chemie U.S.A.

(Mar. 12)—Educators' Night. "Employment Opportunities in the Coatings Industry"—Speakers to be announced.

Piedmont

(Jan. 21)—"Application of Jeffamine® Coatings in the Industry"—W.C. Crawford, Texaco Chemical Co.

(Mar. 18)—Federation Night.

(Apr. 15)—"Career Enhancement"—Richard Fayssoux, Jr., Eastman Chemical Products, Inc.

(May 20)—"Current Dispersion Milling Method"—Armin Szatmary, Premier Mill Corp.

(June 17)—"An Introduction to Appearance Analysis"—Richard W. Harold, Hunter Associates Laboratory, Inc.

Pittsburgh

(Jan. 5)— "Flow and Leveling of Coatings"—Robert Vash, Byk-Chemie USA.

(Feb. 2)—"Effects of Government Regulations on Lab Factory Scale-Up"—Hillary Holste, PPG Industries, Inc.

(Mar. 2)—"Epoxy Curing Agents"—Wheeler Crawford, Texaco.

(Apr. 6)—"New Epoxy Resins Technology"—Marcel Gaschke, CIBA-GEIGY Corp.

(May 4)—"In-Store Computer Matching"—Dennis Dempsey, Color Corp. of America.

Rocky Mountain

(Jan. 12)—"Effective Filtration of Industrial Coatings"—Carney Likens, Commercial Filters.

(Mar. 9)—"New Developments in High Solids Coatings"—Richard Johnson, Cargill, Inc.

(Apr. 6)—"Vinyl Rheology Modified Systems"—Rick Caudwell, Reichhold Chemicals, Inc.

(May 11)—"Advantages of Predispersed Polyethylenes and Waxes in High Performance Coatings"—Elio Cohen, Daniel Products Co.

TWELVE IMPECCABLE EXCUSES FOR NOT GIVING BLOOD.

"1. I think I have lumbago.
2. I'm type Z negative.
3. I'm on the grapefruit diet.
4. I gave six months ago.
5. I just got back from Monaco.
6. The lines are thirteen blocks long.
7. My mother won't let me.
8. I didn't sign up.
9. I'm going out of town.
10. Asthma runs in my family.
11. I forgot to eat this morning.
12. I'm allergic to flowering magnolia."

Each one's a doozy, but we're hoping you won't use any of them. Give blood through the American Red Cross. Please, don't chicken out.

EXCUSES DON'T SAVE LIVES. BLOOD DOES.

American Red Cross

Elections

C-D-I-C

Active

Niemiec, Matthew L.—Wabash Products Co., Terre Haute, IN.

Associate

Haltrecht, Monica M.—NL Chemicals/NL Industries, Inc., Louisville, KY.

Irvine, W. Bryn—Tri-Mar Corp., Hamilton, OH.

DALLAS

Active

Adams, Jim—Adams Paint Mfg. Co., Lubbock, TX.

Godwin, David R.—NDRC Laboratories, Garland, TX.

Miles, Ronda—Union Carbide Corp., Garland.

Mod, Judy A.—Hilton-Davis Chemical, Carrollton, TX.

Parsons, Gary D.—Sherwin-Williams Co., Garland.

Richerson, John A.—Roach Paint Co., Dallas, TX.

Simmons, Harry C.—Sherwin-Williams Co., Garland.

Smith, Robert E.—Welco Mfg. Co. of Texas, Dallas.

Wren, Henry K.—Del Paint Mfg. Co., Oklahoma City, OK.

Associate

Nickell, Grover L.—Raw Materials Corp., Dallas, TX.

Reed, Lance D.—Ottawa Silica Co., Arlington, TX.

Smith, Susan S.—Dow Chemical USA, Dallas.

LOUISVILLE

Active

Godbey, E. Floyd, Jr.—Reliance Universal, Inc., Louisville, KY.

Leightner, William G.—Porter Paint Co., Louisville.

Associate

Bless, George—DA Champbell Co., Inc., Cincinnati, OH.

Corbett, Chris J.—Chemcentral, Inc., Louisville, KY.

NEW ENGLAND

Active

Coogan, Richard G.—Polyvinyl Chemical Ind., Wilmington, MA.

Dixon, Brian G.—Cape Cod Research, Buzzards Bay, MA.

Gaw, Debra A.—Permuthane—Div. of ICI, Peabody, MA.

Golden, Kathy H.—Polyvinyl Chemical Ind., Wilmington.

Moore, Donald A.—Raffi and Swanson, Inc., Wilmington.

Paquette, Michael T.—Permuthane—Div. of ICI, Peabody.

Weinberg, Joseph H.—Permuthane—Div. of ICI, Peabody.

Winstead, Maynard R.—Glyptel Inc., Chelsea, MA.

Associate

Calhoun, Edward H.—CDF Corp., Marshfield, MA.

McHenry, Michael A.—John R. Hess and Sons., Providence, RI.

Slade, William F.—CL Hauthaway Inc., Lynn, MA.

Stiff, Wendy L.—Hercules Incorporated, Mont Clare, PA.

Warehime, Gary C.—Polyvinyl Chemical Ind., Wilmington, MA.

NEW YORK

Active

Asif, Mohammad—Nuodex Inc., Piscataway, NJ.

Dallago, Raymond P.—Diamond Shamrock Chem. Co., Morristown, NJ.

Freiman, Aaron—Mercury Paint Corp., Brooklyn, NY.

Guacci, Anthony J.—Minwax Co., Inc., Montvale, NJ.

Hermele, Jules J.—Polymer Plastics, Hauppauge, NY.

Marcus, Robert T.—Macbeth Div. Kollmorgen, Newburgh, NY.

Jablon, Michael—Benjamin Moore & Co., Newark, NJ.

Velis, Pedro J.—NL Chemicals, Hightstown, NJ.

Associate

Baron, Glenn S.—Hercules Incorporated, Lake Hiawatha, NJ.

Brincat, Louis A.—Mobay Chemical Corp., Haledon, NJ.

Genco, Paul V.—Nuodex Inc., Piscataway, NJ.

Holland, Thomas J.—EM Industries, Inc., Hawthorne, NY.

Sanz, Georgina M.—Stauffer-Wacker Sili, Edison, NJ.

Smith, Rex S.—Pilot Chemical Co., Woodbridge Center, NJ.

Verhagen, Len—Hockmeyer Equip. Corp., Harrison, NJ.

NORTHWESTERN

Active

Juntti, E. William—USG Corp., Cloquet, MN.

People

Joseph D. Giusto has been promoted to Vice-President of Operations for Lenmar, Inc., in Baltimore, MD. Mr. Giusto joined Lenmar, Inc., in 1975 and was elevated to Operations Manager in 1985. He is now responsible for all production, purchasing, and engineering at Lenmar. Mr. Giusto is a Past-President of the Baltimore Society and is currently Society Representative to the Federation Board.

Kevin Joesel has been appointed Sales Representative for Boehle Chemicals, Inc., Southfield, MI. He will be responsible for Michigan and northwestern Ohio. Mr. Joesel is a member of the Chicago Society.

Everett W. Campbell has been named Director of Production for Goodyear's Chemical Div. in Akron, OH. He succeeds **William B. Hirsch,** Vice-President of the newly formed Polyester Division.

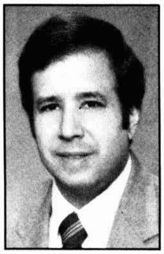
Mr. Campbell, most recently Manager of Goodyear's Beaumont, TX chemical plant, will be replaced by **John D. Fisher,** former Manager of chemical plants engineering.

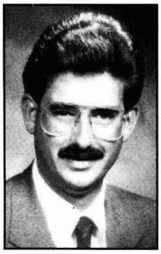
Ferro Corporation has named **James H. Gavlenski,** Product Coordinator, PERC Porcelain Enamel Powder Coatings, for the Coatings Div., Cleveland, OH. Mr. Gavlenski will be responsible for coordinating the field technical activities for PERC.

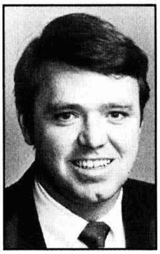
John Boehle, Jr., has been appointed Vice-President in charge of the Additives Department of the Plastics & Additives Div. at CIBA-GEIGY, Hawthorne, NY. He succeeds **William Considine,** a member of the New York Society, who has retired after 18 years with the corporation. Assuming Dr. Boehle's former position as Vice-President in charge of the division's Pigments Department will be **H.E. "Tad" Kinne.**

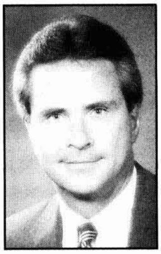
Dr. Boehle will be responsible for the marketing, sales, production, and research activities for the Additives Department. He has been with GEIGY Chemical Corp. since 1968.

Mr. Kinne, a member of the GEIGY Chemical Corp. since 1965, will direct all Pigments Department activities.


J. D. Giusto


K. Joesel


M. J. Kenny


W.W. McPhillips

Michael J. Kenny has been appointed Vice-President, Marketing-U.S. for NL Chemicals, Hightstown, NJ. He will be responsible for directing NL Chemicals' sales and marketing, product management, advertising, customer service, technical service, and distribution efforts. He has been with NL Chemicals since 1969.

John R. Chapman, President of NL Chemicals North American Operations, has retired.

Two senior level marketing executives at Avecor, Inc., San Fernando, CA, have new assignments. **Richard Woolsey** has been named National Accounts Manager and **Reginald Hill** is Mid-Western Sales Manager.

Mr. Woolsey, who joined Avecor in 1983, will be responsible for coordinating sales for large firms with multiple plants located throughout the country.

Mr. Hill, with Avecor since 1977, is based at the firm's North Kansas City, MO plant, and will supervise a sales organization that covers eight mid-western states.

The CAB-O-SIL Div., Cabot Corp., Tuscola, IL, has named **Brad Thorburn** Western Sales Manager with sales responsibility for the Southwest and West Coast. Mr. Thorburn has been with Cabot for 25 years and most recently served as Southwest Regional Sales Manager. He is a member of the Houston Society.

In addition, former CAB-O-SIL Market Analyst **Craig Nelson** has been named Southwest Regional Manager, Dallas, TX. Mr. Nelson and West Coast Regional Manager **John Collins** both report to Mr. Thornburn.

E.C.C. America, Inc., Atlanta, GA, a subsidiary of EEC International, has promoted **W. Warren McPhillips** to Vice-President of Sales. Mr. McPhillips has been with ECCA for nine years and most recently served as Director of Domestic Sales. In his new position, Mr. McPhillips will be responsible for directing sales efforts worldwide.

Insilco Corp. has announced that **Donald Gels,** President of its Red Devil Paint Company Div., has also assumed responsibility as President and Chief Executive Officer of its Enterprise Cos. division.

Each company will continue to operate autonomously with **Harry True** continuing his responsibility as Executive Vice-President of the Enterprise Cos., Wheeling, IL, and **Barry Douglas** continuing on as Executive Vice-President of Red Devil Paint Co., Mt. Vernon, NY.

Mr. True is a member of the Chicago Society.

The Kelco Div., Merck & Co., Inc., San Diego, CA, announced that **Beverly J. Holman** has joined the staff as Associate Technical Representative for the Industrial Div. Ms. Holman previously worked for Dow Corning Corp., Midland, MI.

Arthur D. Little, Inc., Cambridge, MA, has named **Stephen Rudolph** the new Manager of its Product Technology Practice. He succeeds **Derek Till,** who is retiring after 35 years with the company. Mr. Rudolph joined Arthur D. Little in 1976 and previously served as Manager of the Organic and Polymer Chemistry Unit in the Product Technology Section.

As a result of an expanding customer base in the Southeast, DeSoto, Inc., Des Plaines, IL, has named **Mike Berger** Account Manager for the Appliance and Product Finishes Group. He will service new and existing business in the Southeast region. Mr. Berger joined DeSoto in 1982 and was named the Industrial Coatings Div.'s Salesman of the Year in 1983.

Alvin H. May has been appointed Division Vice-President, Corporate Sales, for the Nalco Chemical Co., Naperville, IL. Mr. May joined Nalco in 1974 as a District Representative. In 1984 he was named Executive Account Manager in Corporate Sales.

The Bee Chemical Co., Lansing, IL, announced that **Kim Stephens** has been promoted to Manager, Business Machine Coatings. She will be responsible for the functional and decorative coatings in the electronic industry and for conductive coatings, including the Isolex® line of EMI/RFI shielding paints. Ms. Stephens joined the Bee Chemical Co. as a Product Manager in 1984.

Universal Color Dispersions, Lansing, IL, has promoted **Charles B. Fritze** to General Manager. He will be responsible for coordinating the marketing and sales operations through 19 agency sales distributors in the United States and Canada. Mr. Fritze joined UCD in 1984 and previously served as National Sales Manager. He is a member of the Chicago Society.

Brian W. Burrows has joined USG Corp., Chicago, IL, as Director, Research and Development. He will be responsible for operations of the Graham J. Morgan Research Center, Libertyville, IL. Mr. Burrows is author or co-author of 26 publications in physical chemistry, electrochemical science and technology, and energy conversion.

Heinz Rzehak has been appointed Manager, applied research and technical service for Degussa Chemical Div., at the firm's new Allendale, NJ, laboratory. In this position, Dr. Rzehak will be responsible for implementing and enhancing technical service for the company's hydrogen peroxide, feed additives, polymer, and new products.

Obituary

Francis Scofield, retired Vice-President of technical affairs for the National Paint and Coatings Association, died on September 6. He was 80.

An honorary member of the Federation of Societies for Coatings Technology and the Baltimore Society, Mr. Scofield served the NPCA more than 35 years.

A native of Lanham, MD, Mr. Scofield earned a B.S. degree from Lehigh University. Mr. Scofield was President of the Division of Paint, Varnish and Plastics Chemistry of the American Chemical Society, was active in ASTM, the American Oil Chemists' Society, the Optical Society of America, the American Society of Agricultural Engineers, and the American Institute of Chemists. He was a recipient of the 1957 Herman H. Shuger Memorial Award of the Baltimore Paint Association.

Mr. Scofield is survived by two daughters: Mrs. Ronald Rowland, of Florence, VT and Mrs. Lindsay Dawson of Bella Vista, AR; a brother; and a sister.

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XVIIIth FATIPEC Congress Attracts 900 to Venice, Italy; Lothar Dulog, of Germany, Elected President for 1987-88

More than 900 persons attended the XVIIIth Congress of FATIPEC in Venice, Italy, September 21-26. The Presiding Chairman was Dr. Amleto Poluzzi, of the Italian Association, and Vice-President of FATIPEC in 1985 and 1986.

FATIPEC is the Federation of Associations of Technicians in the Paint, Varnish, Lacquer, and Printing Ink Industries of Continental Europe. It is composed of seven member associations: France, Belgium, Holland, Germany, Italy, Switzerland, and Hungary. The official languages of FATIPEC are French, German, and English. The site of the biennial Congress rotates among the members.

Christian Bourgery, a founding member, has served as Secretary General of FATIPEC since its establishment in 1950. His office is in Paris.

Americans in Attendance

Among the registrants were 30 Americans: FSCT President Bill Mirick and Mary; FSCT Executive Vice-President Frank J. Borrelle and Rose; Abel Banov (*American Paint Journal*); Ross Dowbenko (PPG); Terry Downes (Applied Color); the William Goltons (DuPont); Donald Hall (Applied Color); Isidor Hazan (DuPont); the Richard Himics (Daniel Products); Shimomi Kazuki (BASF Inmont); Tinh Nguyen (National Bureau of Standards); the Harold Peters (El Paco Chemicals); the Leonard Schaeffers (Leneta); the Ernie Schellers (Silberline); the Jerry Seiners (PPG); Ralph Stanziola (Industrial Color Technology); the James Strauss' (Micro Powders); William Wellman (Exxon); the Marco Wismers (PPG); and D.W. Wu (DuPont).


A. Poluzzi


G. Varasi

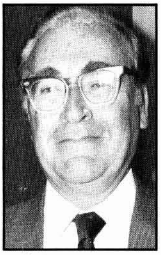
Other Registrants

According to the published roster, the balance of the registrants came from 22 other countries. Included were the following Past-Presidents of FATIPEC: C. Bourgery, E.V. Schmid, D. Pagani, H. Rechmann, J. Roire, L. Kovacs, A. Toussaint, and R. Capanni. The President in 1985-86 was G. Varasi.

110 Papers Presented

One hundred and ten papers (from authors world-wide) were presented during the four full days of program sessions. They were presented by the authors in one of the three official languages with simultaneous translation of plenary papers only through special radio headphones.

Two papers were presented on behalf of the Federation of Societies for Coatings Technology (FSCT): "Fire Protective Coatings for Structural Steel"—A.J. Seiner and A.T. Ward, of PPG Industries, Inc., and "Color Simulation and the Coatings Industry"—R. Stanziola, Consultant. Other papers of U.S. origin were: "The Dominant Role of Solvents in High Solids Coatings and Electrostatic Spraying of High Solids Coatings"—W.E. Wellman, C.J. Bouboulis, A.I. Yezrielev, and J. Troxell (Exxon); "Application of Computers in Coatings Formulation Work" and "Prediction of Viscosities of Liquid Measures by a Group Contribution Method"—D.T. Wu (DuPont); "Detection of Micron-Size Corrosion on Steel Under Coatings" and "Degradation Mechanisms of Epoxy Coatings on Steel Under Corrosion Environment"—T. Nguyen (NBS).


J. Seiner


R. Stanziola


Members of the International Coordinating Committee who attended the FATIPEC Congress in Venice. Left to right: Kenjiro Meguro, Christian Bourgery, Dante Pagani, Amleto Poluzzi, William Mirick, and Jacques Roire

All papers have been published in the official FATIPEC Congress Books. For information about price and availability, write to: AITIVA, Piazza Morandi 2, I 20121 Milano, Italy.

FATIPEXPO

Running concurrently with the program sessions in the Excelsior Hotel and Palazzo del Cinema were the exhibits under the name, FATIPEXPO. There were 43 exhibitors and among them these familiar names in the FSCT's Paint Show: Applied Color Systems, Arco Chemical, Alcan Toyo, Ashland Chemical, Ciba-Geigy,

(Continued on page 78)

FATIPEC Congress Held In Venice (Continued from page 77)

Dow Chemical, Merck, Hoechst, Huels, NL Chemicals, Pacific Scientific, Polyvinyl Chemicals, Sandoz, Silberline, and Tego Chemie.

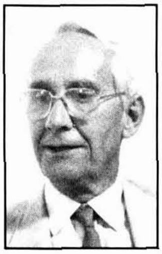
International Coordinating Committee

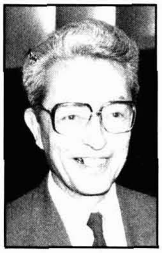
The International Coordinating Committee (ICCATCI) held its annual meeting during the Congress. Present were: *FATIPEC*—A. Poluzzi, D. Pagani, J. Roire, C. Bourgery, and Mrs. Bourgery, who served as interpreter; *Oil and Colour Chemists Assn.*—Frank Redman, President; *Scandinavian Federation of Paint and Varnish Technologists*—Arja Saloranta, President, and Charles Hansen; *Japan Society of Colour Material*—Kenjiro Meguro, President, and S. Yoshida; *FSCT*—W. Mirick and F. Borrelle.

Committees in Charge

Committees responsible for the Congress were:

Organizing: President—Gianfranco Brenni; A. Maschiadri, H. Junghanns, A. Poluzzi, and G. Guainazzi.


G. Brenni


L. Dulog

Scientific: President—Dante Pagani, A. Poluzzi, G. Guiainazzi, P. Bonora, G. Torriano, M. Pegoraro, A. Priola, G. Savini, and M. Poggi.

Secretariat: President—Ambrogia Villa, C. Barazzone, A. Carlini, A. Zambrini, and L. Gabualdi.

Next President of FATIPEC

The 1987-1988 President of FATIPEC will be Lothar Dulog, of Forschungsintitut Pigmente, Stuttgart, Germany.

XIXth FATIPEC Congress

The next Congress of FATIPEC will be held in Aachen, Germany, September 18-25. The theme will be "Science and Technology of Paints and Their Components—Today and in the Future."

SSPC Annual Meeting To Be Held, Jan. 19-22

The 37th annual meeting and symposium of the Steel Structures Painting Council is scheduled for January 19-22, 1987, at the Fairmont Hotel, in New Orleans, LA. The focus of this year's symposium is the "Impact of Regulations and Litigation on the Protective Coatings Industry." Program Chairman is Dr. Robert F. Brady, Jr., of the U.S. Naval Research Laboratory.

The symposium will feature 20 scheduled speakers who will discuss methods of avoiding litigation, complying with environmental regulations, and meeting health and safety requirements. Committee members will deliberate during 25 technical sessions about specifications, guides, and procedures to improve conditions in the protective coatings industry.

For additional information, contact Aimee Beggs, Steel Structures Painting Council, 4400 Fifth Ave., Pittsburgh, PA 15213.

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______	"Radiation Cured Coatings"—J.R. Costanza, A.P. Silveri, and J.A. Vona (7M86002)		______
______	"Introduction to Polymers and Resins"—J. Prane (7M86003)		______
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______	The Setaflash Tester	($100)	______
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______	Introduction to Resin Operation	($65)	______
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______	Operation of a Vertical Sand Mill	($75)	______
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______	Federation Training Series on Test Methods	($70)	______
______	**Paint/Coatings Dictionary**	(Mbr.–$30; Non-Mbr.–$50)	______
______	**Infrared Spectroscopy Atlas**	(Mbr.–$75; Non-Mbr.–$100)	______
______	**Color-matching Aptitude Test Set**	($400)	______
Pictorial Standards of Coatings Defects			
______	Complete Manual	($80)	______
	Individual Standards ($2 ea., plus $2 per photo as noted)		______

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- G ☐ Educational Institution/Library
- H ☐ Paint Consumer
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- D ☐ Research and Development
- E ☐ Technical Sales Service
- F ☐ Sales and Marketing
- G ☐ Consultant
- H ☐ Educator/Student
- J ☐ Other ______________ *(please specify)*

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Literature

Vapor Cure Technology

A recently released brochure describes the vapor cure process for curing coatings on various substrates at room temperature. The process is designed to cure coatings on heat-sensitive materials such as plastic, wood, electronic components, and fully assembled parts without damage. For more information, write to Vapocure Technology, Inc., 45 McBride Ave. Extension, Paterson, NJ 07501.

Liquid UV Absorber

A liquid UV absorber specifically for coatings is described in a technical data sheet. The product reportedly is soluble in common coating solvents and compatible with coatings resins. For additional information which details key physical properties, write the Additives Dept., CIBA-GEIGY Corp., Three Skyline Dr., Hawthorne, NY 10532.

Rheological Additive

A rheological additive for high performance coatings applications is described in literature. The product is designed to simplify the formulation and manufacture of high performance coatings. For more information and a sample, write to NL Chemicals, Inc., P.O. Box 700, Hightstown, NJ 08520.

Solvent Recovery Literature

A four-color brochure covering system features, technical characteristics, utility requirements, and standard systems production data of a solvent recovery system has been published. For a copy of the eight-page brochure, write to Morehouse Industries, Inc., 1600 W. Commonwealth Ave., P.O. Box 3620, Fullerton, CA 92632.

Coatings Information Kit

A coatings information kit for the design engineer and technical information on polyurethane coatings was recently made available. For a free information kit on Chemglaze® and Photoglaze® coatings, contact Lord Corporation, Industrial Coatings Division, 2000 West Grandview Blvd., P.O. Box 10038, Erie, PA 16514-0038.

High Speed Paint Mixer

A recently released product bulletin introduces a new high speed paint mixer able to handle pints to five gallon containers. For further details on the 5050 High Speed Mixer, write to Red Devil, Inc., 2400 Vauxhall Rd., Union, NJ 07083-1933.

Structured Pigments and a Super Extender

Information on the development of two new grades of structured pigments and the development of a super extender has been made available in literature. The structured pigments are used in the production of rubber products and bonding systems. The super extender replaces titanium dioxide in flat and eggshell paint formulations. For technical literature and samples of Samflex-475™, Samflex-585™, and Samhide-583™, contact T.G. Florea or Dr. S.K. Wason, Huber Clay Division, Rt. 4, Macon, GA 31298.

Heat Stabilizer for PVC

Information is available on a new heat stabilizer recommended for light stable PVC formulations used in window profiles and siding. For more information, write the Additives Dept., CIBA-GEIGY Corp., Three Skyline Dr., Hawthorne, NY 10532.

Spectroscopy

An application note furnishes an introduction to high resolution NMR spectroscopy of solids. Two major causes of line broadening in solids are examined. Copies of G565-9546-1 are available from IBM Instruments; Inc., Orchard Park, P.O. 3332, Danbury, CT 06813.

Synthetic Silicates Brochure

A brochure describing how synthetic silicates are used for dry liquid concentrates, conditioning and carrier applications, and as anti-caking and grinding agents in the paint, agricultural, chemical, food processing, waste disposal, and rubber industries is available. For a free copy of the four page Micro-Cel® and Celkate® synthetic silicates brochure, FF-22, write to Manville Service Center, 1601 23rd St., Denver, CO 80216.

Wet Abrasion Scrub Tester

An abrasion scrub tester designed to measure abrasion resistance of heavy duty coatings is described in literature. The instrument is designed with standard hogbristle brushes and a resettable five digit counting mechanism allowing a predetermined number of strokes to be set and the instrument left to operate unattended. For more details, write to Paul N. Gardner Co., Inc., 316 NE First St., Pompano Beach, FL 33060.

Temperature Meter

A product bulletin introduces a temperature meter designed to meet a wide variety of temperature measurement applications. For more information, write Sheen Instruments, Ltd., 8 Waldengrove Rd., Teddington, Middlesex TW11 8LD.

Fifth Generation Microprobe

A fifth generation instrument, used for high spatial resolution surface chemical analysis, has been introduced in a new product bulletin. For more information on the PHI 660 SAM, contact Bob Adamzak or Lori Broecker, Perkin-Elmer, Physical Electronics, 6509 Flying Cloud Dr., Eden Prairie, MN 55344.

Organometallic Coupling Agents

Eleven new organometallic coupling agents having applications in different thermosets, coatings, thermoplastics, elastomers, and ceramics have been introduced in literature. They are included in a revised and expanded edition of a distributed reference manual. For further information about the Kenrich coupling agents, or a copy of the revised "Kenrich Reference Manual," write Kenrich Petrochemicals, Inc., P.O. Box 32, Bayonne, NJ 07002-0032.

Surface Analyzing Instruments

A recently released product bulletin introduces a series line of surface analysis instrumentation. The instruments accommodate fully intact samples up to eight inches in diameter. For more information on the 5000 LS ESCA Series line, contact Bob Adamzak or Lori Broecker at Perkin-Elmer, Physical Electronics, 6509 Flying Cloud Dr., Eden Prairie, MN 55344.

Solvent Selection System

A computer aided solvent selection system aimed at helping paint manufacturers and formulators modify or develop solvent systems is the topic of technical literature. For more information on CASS, contact Joy Hutchinson, The Dow Chemical Company, Midland, MI 48640.

Piping Containment System

A new piping containment and access system for steel underground storage tanks, designed to contain pipe leaks and filling spills, is described in recently released literature. All external components including the pump, piping, gauge, and fittings are located in one place. Additional information is available from the Clawson Tank Co., 4701 White Lake Rd., Clarkston, MI 48016-0350.

Stabilizer Blends for Plastics

Literature describing two new stabilizer blends for plastics is available. For data and samples of these two products, write the Additives Dept., CIBA-GEIGY Corp., Three Skyline Dr., Hawthorne, NY 10532.

Chromate Pigments

The latest toxicological and epidemiological findings on chromate pigments are summarized in a recently published report. A copy of the 24-page publication is available from Heubach, Inc., Heubach Ave., Newark, NJ 07114.

Butadiene-Acrylonitrile Copolymer

Information on a butadiene-acrylonitrile copolymer in dry, free-flowing form is available. The product is designed to limit the migration and volatility of the plasticizers in a compound. Additional information on the product may be obtained by writing Goodyear Chemical Data Center, P.O. Box 9115, Akron, OH 44305.

Combating High Temperature Corrosion

A comprehensive digest of newer methods to combat high temperature corrosion with arc sprayed coatings of aluminum and nickel-chromium alloys has been compiled. The digest provides data on types of coatings, specified thicknesses, and methods of application for a range of service conditions. For a free copy, contact Frank M. Velapoldi, TAFA Incorporated, Dow Road, P.O. Box 1157, Bow (Concord), NH 03301-1157.

Phthalocyanine Green Pigments

Three new plastics grade phthalocyanine green pigments are introduced in recently released literature. The pigments reportedly have heat stability, migration resistance, lightfastness, and dispersibility for plastics applications. For more information, write the Plastics & Additives Div., CIBA-GEIGY Corp., Three Skyline Dr., Hawthorne, NY 10532.

Mini Glossmeter

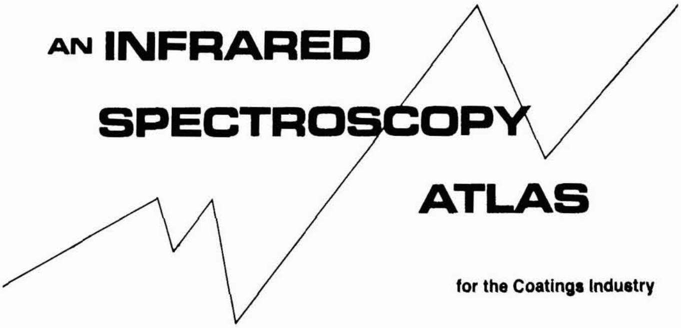
A mini glossmeter is described in a recently released product bulletin. The glossmeter reportedly is suitable for gloss measurements on a wide variety of materials including paint films, plastics, and packaging. For more details, write to Sheen Instruments, Ltd., 8 Waldengrove Rd., Teddington, Middlesex TW11 8LD.

Dibutoxyethyl Phthalate

Information is now available on a product that is designed to meet the needs of cellulosic and urethane polymer formulators. For additional information and free samples of Plasthall® DBEP, contact Cleland Rector, Marketing Manager, The C.P. Hall Company, 7300 S. Central Ave., Chicago, IL 60638.

Copper Conductive Coating

A recently released product bulletin introduces a new, non-oxidizing, modified copper conductive coating for EMI/RFI shielding. The product is designed for application involving shielded rooms, monitors, printers, keyboards, and facsimile machines. For additional information write the Bee Chemical Co., 2700 E. 170th St., Lansing, IL 60438.



AN INFRARED SPECTROSCOPY ATLAS

for the Coatings Industry

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This revised and expanded 896-page book (by the Chicago Society for Coatings Technology, 1980) contains a compilation of 1433 spectra, fully indexed, of materials commonly used in the coatings industry. Spectra of many recently marketed materials are included, as well as examples of Fourier transform infrared spectra.

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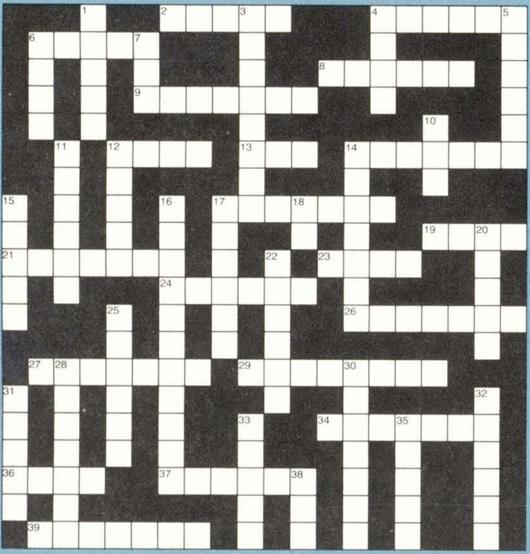

Solution
to be
published in
January issue

No. 15

ACROSS

2. Red iron oxide
4. Decorative band
6. Horizontal timber
8. Lake pigment base
9. Packing material (mineral)
12. Looped yarn bundle
13. Holds our products
14. Artistic water color
17. Alkyd (Syn.)
19. Permanent, e.g., color_______
21. Natural calcium carbonate
23. Processed press cake
24. Off-white
26. ______green
27. Ionic crosslinked resin
29. Type of wood (angiosperm)
34. Sulfuric acid
36. Mass subunit
37. Concrete component
39. High-boiling alcohol, C6

DOWN

1. Small particles
3. Anti-skin chemical
4. Rheological term
5. Protein catalyst, E____
6. Pioneer color scientist
7. Phosphate plasticizer (Abr.)
10. Yellowish brown
11. Elastomer (Syn.)
12. Organic yellow pigment
14. Intaglio printing method
15. Siccative (Syn.)
16. To absorb heat
17. Metallic sulfate
18. Acidity or alkalinity, e.g.
20. Adherent oxide coating
22. Fineness measurement
25. Wallcovering pattern
28. Synthetic drier salt
30. Calcium carbonate
31. Goes with 22 down
32. Dihydric alcohol
33. To mix together
35. Paint vehicle component, R___N
38. Bituminous material

Coming Events

FEDERATION MEETINGS

For information on FSCT meetings, contact FSCT, 1315 Walnut St., Philadelphia, PA 19107 (215-545-1506).

1987

(March)—Seminar on Statistical Process Control. Sponsored by FSCT Professional Development Committee. Scheduled by region: March 2-3—Marriott Hotel, Chicago O'Hare Airport, Chicago, IL; March 9-10—Atlanta Marriott (downtown), Atlanta, GA; March 16-17—Marriott, Philadelphia Airport, Philadelphia, PA; and March 30-31—Marriott, Torrance, CA.

(Apr. 29-May 2)—Combined Federation Spring Week and Pacific Northwest Society Symposium. The Westin Hotel, Seattle, WA. FSCT Society Officers Meeting on April 29; FSCT Board of Directors Meeting on April 30; Seminar on May 1-2. Concludes with a dinner dance on May 2.

(Oct. 5-7)—65th Annual Meeting and 52nd Paint Industries' Show. Convention Center, Dallas, TX.

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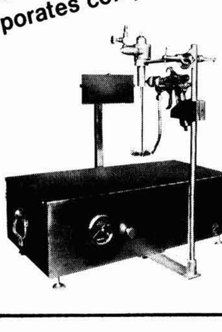

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(Oct. 19-21)—66th Annual Meeting and 53rd Paint Industries' Show. McCormick Place, Chicago, IL.

SPECIAL SOCIETY MEETINGS

1987

(Feb. 23-25)—Southern Society 14th Annual Water-Borne and Higher-Solids Coatings Symposium. New Orleans, LA. (Dr. Gordon L. Nelson, Chairman, Department of Polymer Science, University of Southern Mississippi, Southern Station Box 10076, Hattiesburg, MS 39406-0076).

(Feb. 23-25)—Western Coatings Societies' Symposium and Show, Monterey Convention Center, Monterey, CA. (Barry Adler, Royell, Inc., 1150 Hamilton Ct., Menlo Park, CA 94025).

(Apr. 1-3)—Southern Society. Annual Meeting. Dutch Inn, Lake Buena Vista, FL. (C. Lewis Davis, 802 Black Duck Dr., Port Orange, FL 32019).

(Apr. 7-8)—Chicago Society's Symco '87 "Risky Business: Technology of Our Times." Knickers, Des Plaines, IL. (William Fotis, The Enterprise Cos., 1191 S. Wheeling Rd., Wheeling, IL 60090).

(Apr. 29-May 2)—Combined Federation Spring Week and Pacific Northwest Society Symposium. The Westin Hotel, Seattle, WA. April 29—FSCT Society Officers Meeting; April 30—FSCT Board of Directors Meeting; PNW Golf; PNW Evening Activities; May 1—Seminar; May 2—Seminar continued; PNW Sports Competition; Dinner Dance.

(June 12-13)—Joint meeting of St. Louis and Kansas City Societies. Holiday Inn, Lake of Ozarks. (A.E. Zanardi, Thermal Science, Inc., 2200 Cassens Dr., Fenton, MO 63026).

1988

(Apr. 13-15)—Southern Society. Annual Meeting. Charleston, SC. (Scott McKenzie, Southern Coatings Co., P.O. Box 160, Sumter, SC 29150).

(Apr. 28-30)—Pacific Northwest Society. Annual Symposium. Vancouver, B.C., Canada. (Yvon Poitras, General Paint Corp., 950 Raymur Ave., Vancouver, B.C., Canada V6A 3L5).

1989

(Mar. 13-15)—Western Coatings Societies Symposium and Show. Disneyland Hotel, Anaheim, CA. (Andy Ellis, NL Industries, Inc., 200 N. Berry St., Brea, CA 92621).

OTHER ORGANIZATIONS

1987

(Jan. 19-22)—Annual Meeting, Technical Symposium and Coatings Technology Exposition of Steel Structures Painting Council.

Fairmont Hotel, New Orleans, LA. (James G. Busse, SSPC, 4400 Fifth Ave., Pittsburgh, PA 15213).

(Feb. 4-6)—"Formula" Forum on Chemical Specialties sponsored by the Societe Francaise de Chimie, Nice. (Societe Francaise de Chimie, Departement Congres, 250 rue Saint Jacques 75005 Paris, France).

(Feb. 8-11)—Inter-Society Color Council. Williamsburg Conference on "Geometric Aspects of Appearance." The Lodge, Colonial Williamsburg, VA. (Dr. D.H. Alman, Du Pont Co., P.O. Box 2802, Troy, MI 48007).

(Feb. 17-19)—"Coatings Failure Analysis" course sponsored by KTA-Tator, Inc., Pittsburgh, PA. (William Corbett, KTA-Tator, Inc., 115 Technology Dr., Pittsburgh, PA 15275).

(Mar. 3-5)—"Coating Inspection of Industrial Facilities" course sponsored by KTA-Tator, Inc., Pittsburgh, PA. (William Corbett, KTA-Tator, Inc., 115 Technology Dr., Pittsburgh, PA 15275).

(Mar. 9-13)—CORROSION/87. National Association of Corrosion Engineers. Moscone Center, San Francisco, CA. (NACE, P.O. Box 218340, Houston, TX 77218).

(Mar. 17-19)—Powder Coatings '87. G-MEX Exhibition Center, Manchester, England. (Mervyn W.K. Little, Specialist Exhibitions Ltd., Grantleigh House, 14-32 High St., Croydon, Surrey CRO 1YA, England).

(Mar. 20-25)—The International Paint Industry & Anti-Corrosion Technology Exhibition, Beijing, People's Republic of China. (Sino Trade Promotions, 15A Wing Cheong Commercial Bldg., 19-25 Jervois St., Central, Hong Kong).

(Mar. 26-29)—Colour 87—the International Exhibition for Painting Techniques and Colour Application. Cologne, Germany. (Koln Messe, Postbox 210760, D-5000 Cologne 21, Germany).

(Apr. 5-7)—Inter-Society Colour Council. Annual Meeting. "Industrial Problems in Color Science." Barclay Hotel, Philadelphia, PA. (Dr. A. Rodrigues, Du Pont Co., 945 Stephenson Hwy., Troy, MI 48084).

(Apr. 5-10)—ACS, Div. of Polymeric Materials: Science & Engineering, Anaheim, CA. (T. Davidson, Ethican, Inc., Route 22, Somersville, NJ 08876).

(Apr. 6-7)—27th Annual Symposium of the Washington Paint Technical Group. Sponsored by the National Paint & Coatings Association. Marriott Twin Bridges Hotel, Washington, DC. (Ken Zacharias, NPCA, 1500 Rhode Island Ave., N.W., Washington, DC 20005).

(Apr. 7-9)—"Bridge and Highway Structures Coatings Inspection" course sponsored by KTA-Tator, Inc., Pittsburgh, PA. (William Corbett, KTA-Tator, Inc., 115 Technology Dr., Pittsburgh, PA 15275).

(Apr. 21-23)—"Coatings Specifiers" course sponsored by KTA-Tator, Inc., Pittsburgh, PA. (William Corbett, KTA-Tator, Inc., 115 Technology Dr., Pittsburgh, PA 15275).

(Apr. 29-May 1)—26th Annual Marine and Offshore Coatings Conference. Sponsored by the National Paint & Coatings Association. New Orleans Hilton Hotel, New Orleans, LA. (Ken Zacharias, NPCA, 1500 Rhode Island Ave., N.W., Washington, DC 20005).

(May 12-14)—HAZTECH Canada Exhibition and Conference. Toronto International Centre, Mississauga, Ontario. (Beverly Gibson, Exhibition Management Company, 6143 S. Willow Dr., Suite 100, Englewood, CO 80111).

(May 18-21)—Surface Coating '87. Chemical Coaters Association. Milwaukee, WI. (CCA, Box 241, Wheaton, IL 60189).

(May 31-June 5)—Sixth International Meeting on Radiation Processing. Skyline and Holiday Inn Hotels, Ottawa, Ont., Canada. (Mrs. E. Golding, International Meeting on Radiation Processing, P.O. Box 13533, Kanata, Ont., Canada K2K 1X6).

(June 17-19)—"Chemically Modified Surfaces" Conference co-sponsored by Colorado State University and Dow Corning Corp. Holiday Inn, Fort Collins, CO. (Ward T. Collins, Mail Stop C41C00, Dow Corning Corp., Midland, MI 48686-0994).

(June 17-20)—Oil and Colour Chemists' Association Biennial Conference. Eastbourne, England. (Mr. R.H. Hamblin, Director & Secretary, OCCA, Priory House, 967 Harrow Rd., Wembley, Middlesex HA0 2SF, England).

(August 6-9)—Oil and Colour Chemists' Association Australia. 29th Annual Convention. Wrest Point Convention Center, Hobart, Tasmania, Australia. (OCCAA, 6 Wilson Ave., Felixstow, South Australia, 5090 Australia).

(July 13-16)—SUR/FIN '87 Chicago—International Conference & Exhibit of Electroplating and Surface Finishing. McCormick Place, Chicago, IL. (AESF, 12644 Research Parkway, Orlando, FL 32826).

(Aug. 23-28)—"Copolymerization" Symposium. Sponsored by the Polymer Div. of the Royal Australian Chemical Institute and the Div. of Polymer Chemistry of the ACS. Sydney, Australia. (Prof. D. Tyrell, Polymer Science & Engineering, Univ. of Massachusetts, Amherst, MA 01003).

(Sept. 13-18)—"Mechanisms and Measurement of Water Vapor and Liquid Water through Materials" Symposium co-sponsored by ASTM Committees C-16, D-1, D-8, D-10, D-20, and F-2. Philadelphia, PA. (ASTM, 1916 Race St., Philadelphia, PA 19103).

(Sept. 15-18)—XVIIth Congress of AFTPV (French Association of Paint and Varnish Technicians) and Eurocoat. Nice, France. (J. Roire, 5, Rue Etex, 75018 Paris, France).

(Sept. 20-23)—Canadian Paint and Coatings Association. 75th Annual Convention. Four Seasons Hotel, Vancouver, B.C. (CPCA, 515 St. Catherine St. W., Montreal, Que., H3B 1B4 Canada).

(Oct. 14-16)—SURTEC '87 Berlin. International Congress Center, Berlin. (Gabriela Thal, 1625 K St., N.W., Suite 500, Washington DC 20006).

(Nov. 7-11)—10th International Congress on Metallic Corrosion sponsored by Central Electrochemical Research Institute on behalf of International Corrosion Council. Madras, India. (Dr. V.I. Vasu, Chairman, ICMC Organizing Committee, Director CERI, Karaikudi 623006, Tamil Nadu, India).

Advertisers Index

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'Humbug' from Hillman

My, how time does fly. Here it is October and tradition—nay, my Editor—insists that this is the time for happy holiday greetings and warm wishes for the New Year. At this time in my life, I can't afford to rush the seasons like that. On the one hand, I say in shocked surprise, "What? Again? Already? I haven't really cleared the fog from last New Year's Eve." But, then a small happy voice pipes up from within, "It's not really here. It's still October. There's still time."

So, readers as you open up this Journal time capsule, you have the cheery words of a younger "Humbug"—"Much joy of the season and a blessed New Year to you all!"

—Wife, trying to cheer up husband, "Look at it this way—you may be low man on the totem pole at work, but here you're second in command."

—While weeding out his wardrobe, a man came across a sports jacket he hadn't worn for years. He found a claim check in a pocket for a pair of shoes he had left for repair and forgotten. Out of curiosity, he went to the repair shop and presented the stub. The cobbler when to the back room, returned moments later and said, "They'll be ready Tuesday."

—The Lion

Scrawled on a New York building wall was the following—"I love grils"; the next day this was crossed out and in its place was written, "I love girls"; on the third day was asked, "What about us grils?"

A large group of ailing people were lined up in front of a new free clinic early one morning. One little man walked past everyone and headed for the front of the line. The crowd howled in protest and pushed him back to the end of the line.

The little guy muttered to himself and again started to the front. Again he was pushed back. A third time he tried and this time he was hoisted bodily and thrown back—fists flying from all sides. He got up, dusted himself off and thundered, "Just push me back once more—and I won't open the clinic."

—from *Parts Plus* via Roy Tasse

What better gift to our readers than to share with them some further brilliant advice as collected by that distinguished purveyor of wisdom, Howard Jerome.

- If you can't get your work done in 24 hours, work nights.
- A pat on the back is only a few centimeters from a kick in the butt.
- It doesn't matter what you say you do. It only matters what you say you've done and what you're going to do.
- You can go anywhere you want if you look serious and carry a clipboard.
- Eat one live toad the first thing in the morning, and nothing worse will happen to you the rest of the day.
- If at first you don't succeed—try, try again. Then quit. No use being a damn fool about it.
- There will always be beer cans rolling on the floor of your car when the boss asks for a ride home from the office.
- The last person who quits or was fired will always be held responsible for everything that goes wrong—until the next person quits or is fired.
- If you are good, you will be assigned all the work. If you are really good, you'll get out of it.

If Howard doesn't meet your philosophical needs, we can fall back on Bob Ahlf, and I mean—"fall back." Tom Miranda, who bravely delivers these dire messages from Bob should try to remember what happened to messengers like him in the good old days of the absolute monarchs.

- Once you get up there, it's all downhill.
- Time flies like an arrow. Fruit flies like a banana.
- The problem with being a genius is that it takes another genius to know he is.
- Old age ain't for sissies.
- Japan has four times as many engineers as we do, but we have fifteen times as many lawyers.
- In this world there is a lot more dirty laundry than clean.
- Tall, bald people are the first to know when the rain starts.
- Some people can talk so you can hardly see the boss's lips move.

—Herb Hillman
Humbug's Nest
P.O. Box 135
Whitingham, VT 05361

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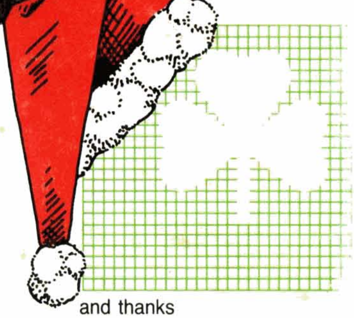
Season's Greetings from the innovator of powder technolog



and thanks
for a very good year.