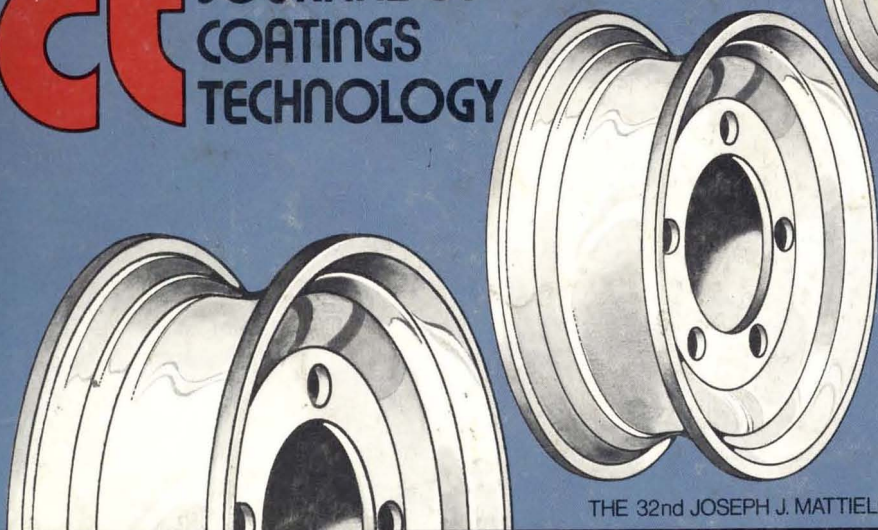


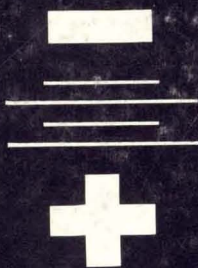
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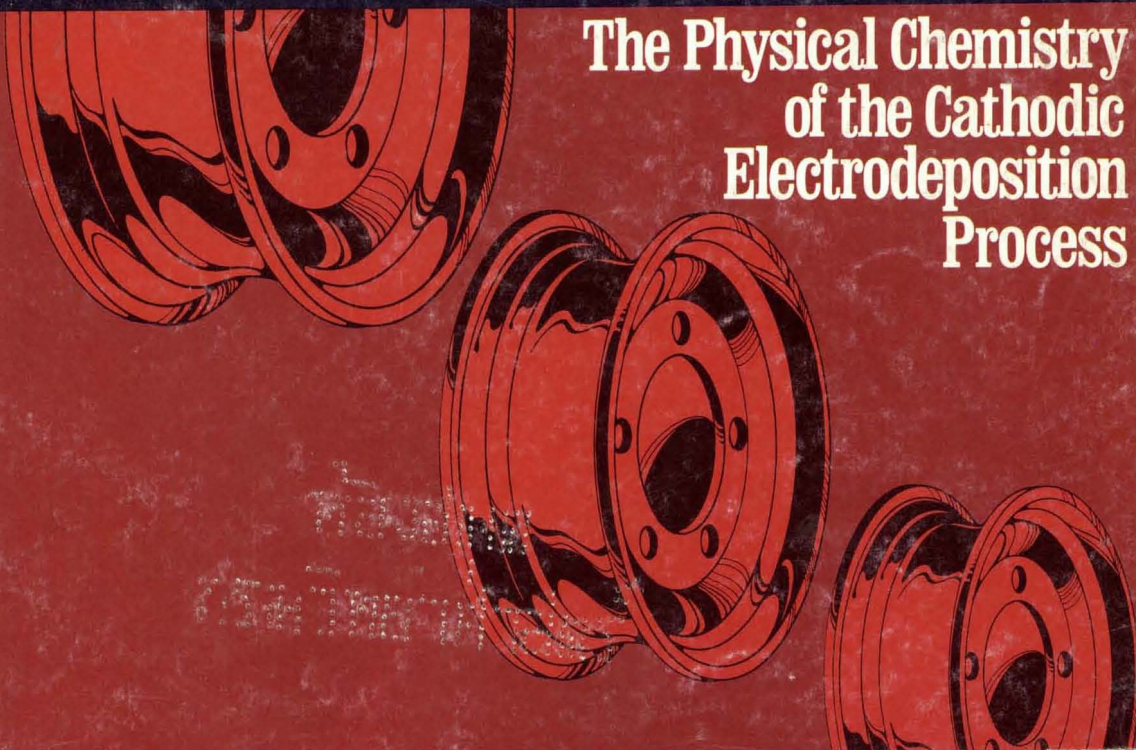
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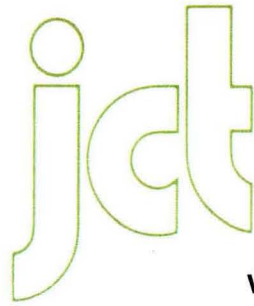
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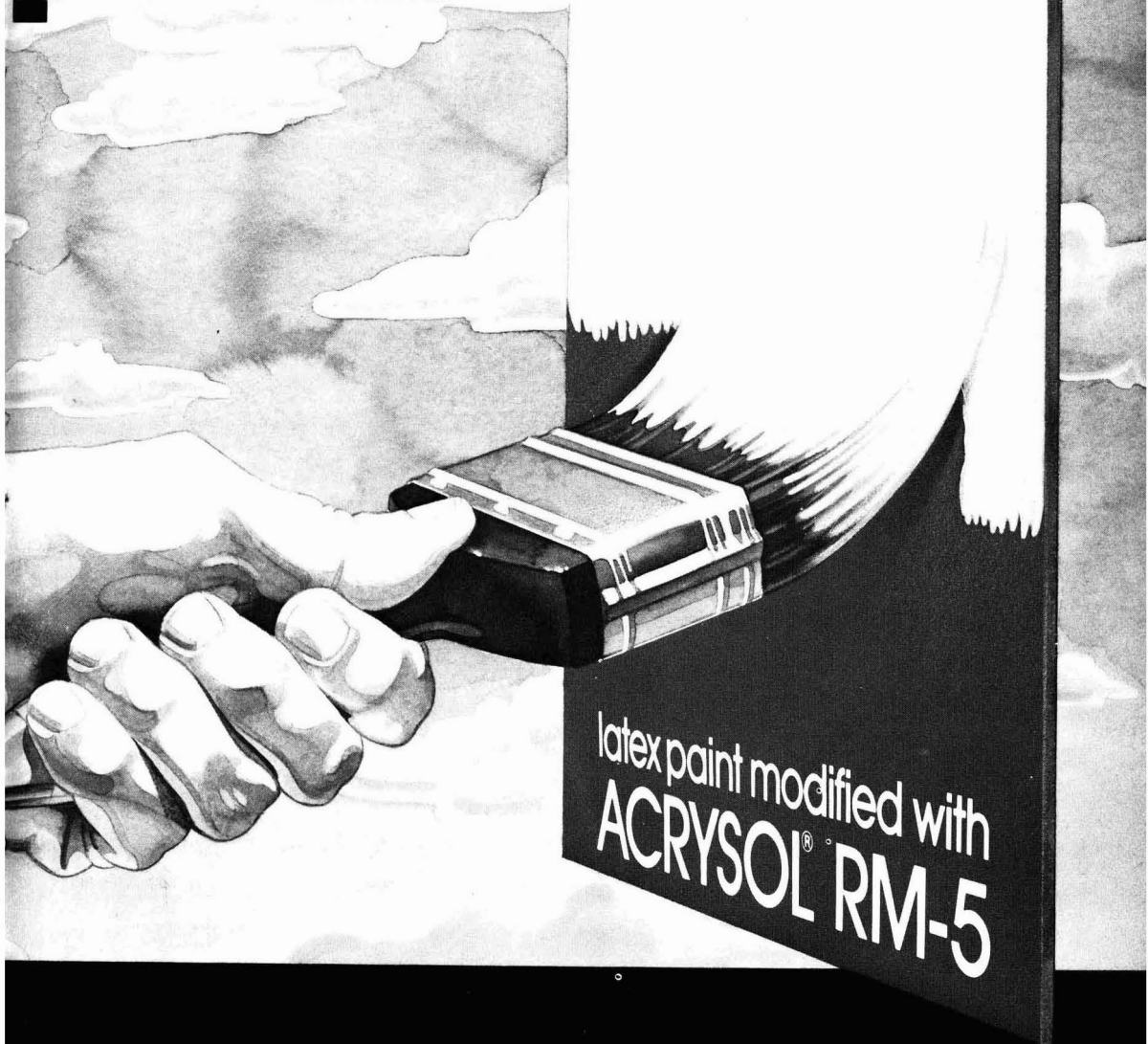


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Happy New Year(?), PRI

The beginning of a new year, and especially a new decade, offers one a fresh start and compels a rededication of effort in most personal matters. But, for many, the resolve of New Year's Eve is immediately lost in a maze of football and family gatherings and finally forgotten in the activities of day-to-day life. The spectre of a promise never fulfilled seldom rises to haunt one's complacency.

Like individuals, the Federation also sets goals for the coming year, but it can ill-afford the luxury of complacency. One of its goals is a revitalized, reoriented Paint Research Institute.

The incoming President of PRI, Peter Robinson, addressed this issue at the recent Annual Meeting, and his remarks regarding the "New Directions" of PRI are published in this month's JCT. His prognostication of future research programs is worth your close attention, as is Dr. Raymond R. Myers' "Research Director's Report" of current programs, which will be published in February's JCT.

Currently, an ad hoc committee composed of five Federation Past-Presidents is exploring the purpose, goals, and activities of PRI. In an attempt to identify its role, they will be visiting with the Executive Committees of nearly every local Society to elicit constructive ideas, and it is hoped that the total membership will also offer its input.

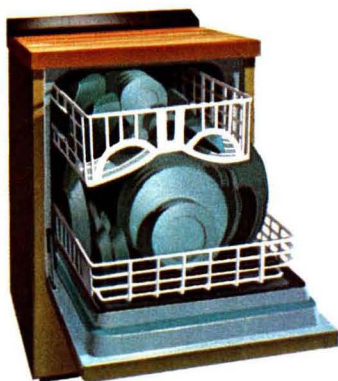
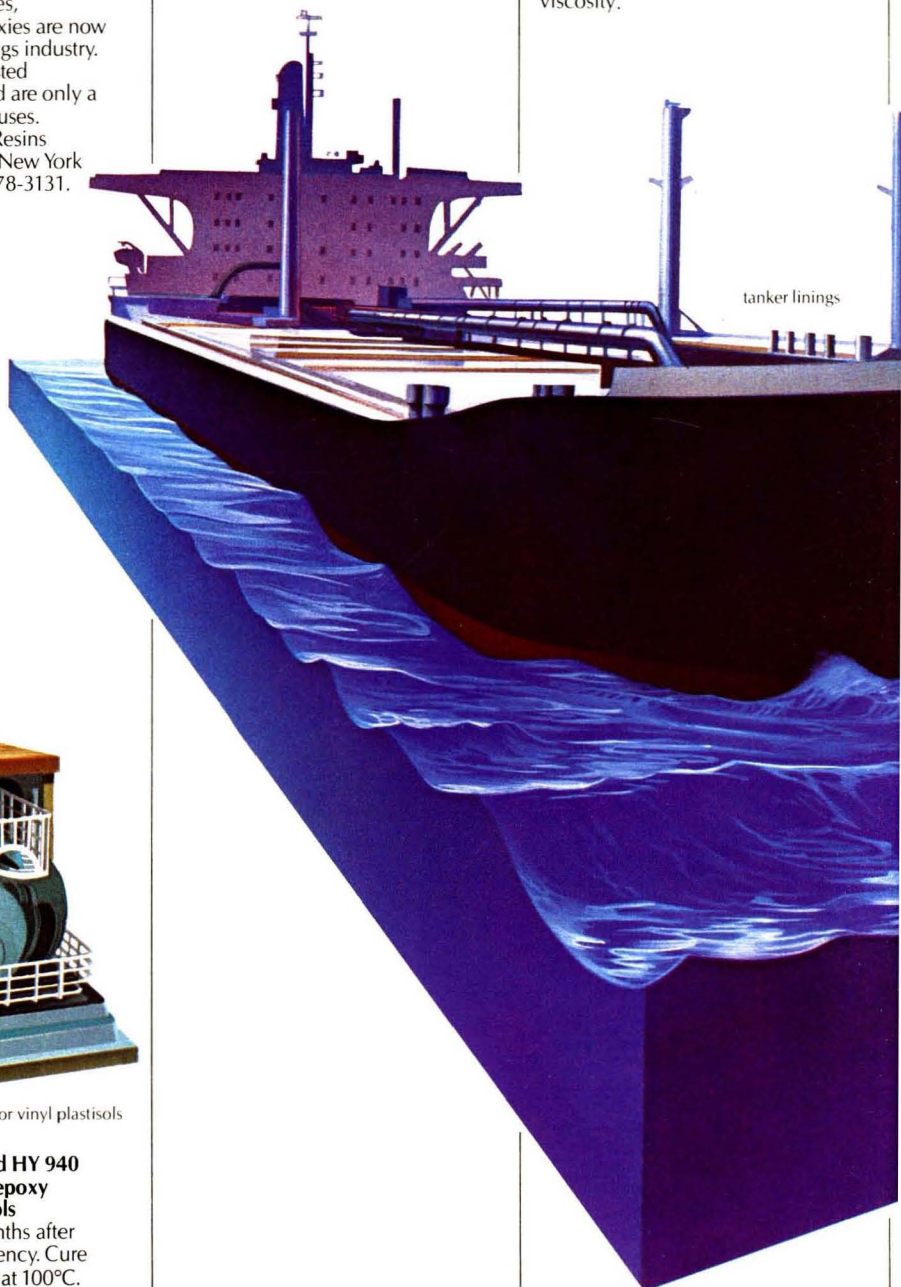
If met with indifference, the committee's task would be a hopeless exercise in futility. These visits should initiate a purposeful dialogue if the Paint Research Institute is to be "born again" and its path redirected.—RFZ

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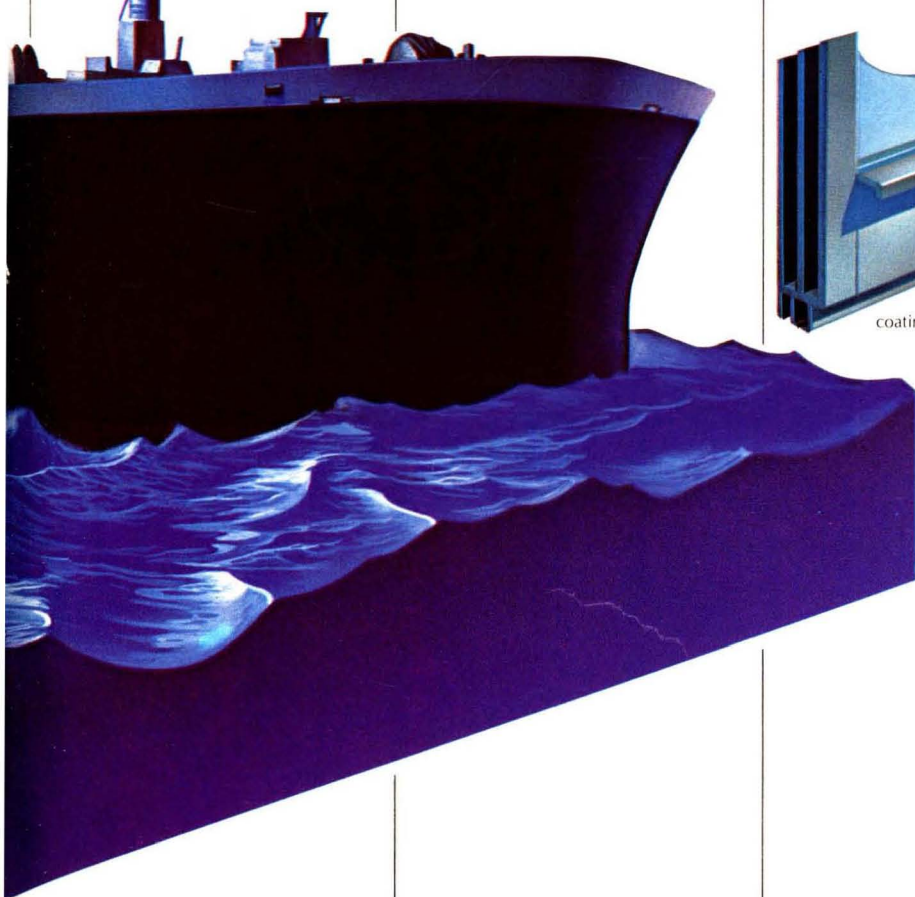
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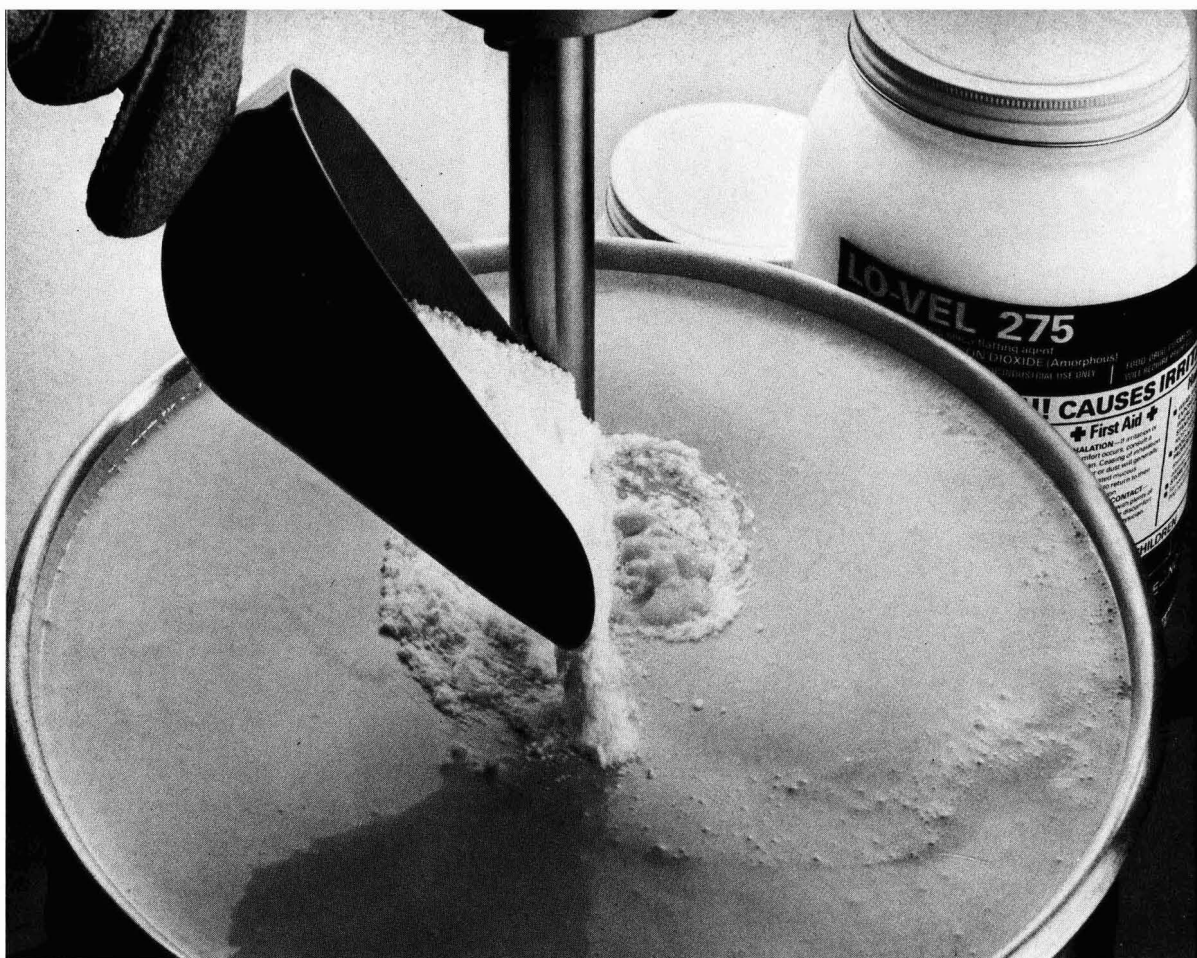
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Abstracts of Papers in This Issue

THE PHYSICAL CHEMISTRY OF THE CATHODIC ELECTRODEPOSITION PROCESS—P.E. Pierce

Journal of Coatings Technology, 53, No. 672, 52 (Jan. 1981)

Electrodeposition has gained worldwide acceptance as a coating process for automotive, appliance, and general industrial coatings. The advantages of the process are high levels of coating utilization, automation, low levels of pollution, and high throwpower, i.e., the ability to coat the recessed portion of complex shaped metal parts.

In the original electrodeposition process the parts to be coated were made the anode. Recently, a new process in which the parts to be coated are made the cathode has gained increasing acceptance because higher levels of corrosion protection can be obtained with cathodically deposited coatings.

The cathodic process is an electrochemical process. The physical chemistry of the process and the understanding of the process depends on a knowledge of electrochemistry.

In order for film deposition to begin, a suitable boundary layer around the part must be formed. Once the boundary layer is established, the rate of film growth depends on the number of electrochemical equivalents required to neutralize the solubilizing salt groups, voltage, and the conduction characteristics of the deposited layer. If the film redissolves in the bath, the process of film growth will stop at some point giving rise to a limiting film thickness.

The throwpower is also related to the electrochemistry of the deposition process as well as the geometry of the throwpower cell. Thus, throwpower can be calculated and the results of various throwpower tests, such as the GM and Ford tests, compared.

Among the factors which contribute to improved corrosion protection in the cathodic process is the development of improved polymers which are more resistant to cathodic disbonding. It is expected that the cathodic electrodeposition process will continue to gain acceptance, especially in those areas in which superior levels of corrosion resistance are required.

HIGH PERFORMANCE GEL PERMEATION CHROMATOGRAPHY CHARACTERIZATION OF OLIGOMERS USED IN COATINGS SYSTEMS—C. Kuo and T. Provder

Journal of Coatings Technology, 53, No. 672, 69 (Jan. 1981)

In conventional GPC, the analysis time has been lengthy and the resolution in the low molecular weight region has been limited. With the advent of high efficiency columns, the speed of analysis and resolution in the low molecular

weight region has been greatly improved. The latter feature makes high performance GPC (HPGPC) an indispensable characterization tool for the analysis of oligomers/polymers in environmentally acceptable coatings systems. In this paper, the qualitative and quantitative HPGPC methodologies developed for the analysis of oligomers and polymers are described. Specific applications include (a) quality control of supplier raw materials, (b) guiding resin synthesis and processing, (c) modifying resin synthesis to improve end-use properties, and (d) correlating oligomer and polymer MWD with end-use properties.

SOME SUBSTRATE AND ENVIRONMENTAL INFLUENCES ON THE CATHODIC DELAMINATION OF ORGANIC COATINGS—H. Leidheiser, Jr. and W. Wang

Journal of Coatings Technology, 53, No. 672, 77 (Jan. 1981)

Polybutadiene coatings, 10–20 μm in thickness, were applied to steel, galvanized steel, aluminum, tin, lead, cobalt, nickel, and silver substrates and the degree of delamination that occurred on cathodic treatment in an electrolyte was determined as a function of the following experimental variables: oxygen in electrolyte, cathode potential, film thickness, pretreatment of substrate, type of electrolyte, electrolyte concentration and temperature. The extent of delamination was determined as a function of the number of coulombs passing through the interface. The delamination was related to the relative magnitude of the cathode reaction, $\text{H}_2\text{O} + 1/2\text{O}_2 + 2\text{e}^- = 2\text{OH}^-$, that occurred under the coating to the magnitude of the cathodic reaction that occurred on the exposed substrate at a defect. The significance of the findings to the development of an accelerated test for appraising the corrosion protective properties of organic coatings was discussed.

RESIDUAL STRAIN DUE TO SOLVENT LOSS FROM A CROSSLINKED COATING—S.G. Croll

Journal of Coatings Technology, 53, No. 672, 85 (Jan. 1981)

Data show that epoxy coatings cast from a very slow-evaporating solvent have residual internal strain that increases with coating thickness. A theory is presented, which agrees well with experimental results, based on the idea that solvent volume loss from the crosslinked coating is responsible for the strain. The strain depends on solvent evaporation and diffusion rates, as well as the curing reaction kinetics and coating solution concentration. A calculation, using this theory, models the excellent adhesion of epoxy coatings and shows that adhesion may be improved by using a faster evaporating solvent.



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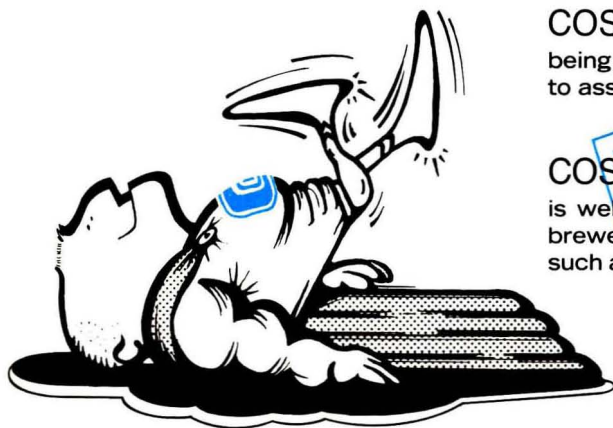
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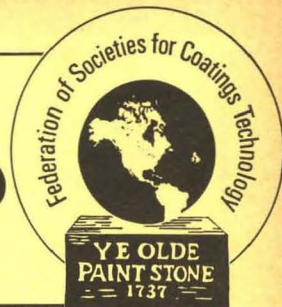


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FEDERATION

newsletter



COLOR SYMPOSIUM IN LOUISVILLE, MARCH 24-26, TO FEATURE PAPERS, WORKSHOPS, AND EQUIPMENT

A symposium on "Color Appearance and Instrumentation" (SCAI) will be held March 24-26, at the Executive West, Louisville, KY, under the joint sponsorship of the Federation, the Manufacturers Council on Color and Appearance, and the Inter-Society Color Council.

The program will be divided between general paper presentations and "hands on" workshop sessions. Among the featured speakers will be Dr. David Wright, of England, who will talk about the experimental origins of the 1931 CIE system of colorimetry.

Other paper presentations will focus on such topics as: color communication; industrial metamerism; colorant formulation; measurement of appearance; goniospectrophotometry; on-line color control; tinting strength assessment; color difference assessment; sample preparation; and education in the instrumental measurement of color and appearance.

There will be four workshops: three will feature equipment displays for color formulation, color measurement, gloss, and other appearance measurement; the fourth, a sample-preparation-and-presentation tutorial. The workshop format is designed to offer a "working meeting" environment, and registrants are invited to bring samples with them.

General program sessions are under the direction of Dr. Robert Marcus, of Mobay Chemical Corp. Arrangements for the workshops and instrument displays are being handled by Charles Leete, Executive Director of the MCCA.

The registration fee of \$125 includes three continental breakfasts, coffee breaks, and two lunches. (The exhibitor registration fee will be \$50).

To register, or to obtain complete program information, write to: Thomas A. Kocis, Director of Field Services, Fed. Socs. for Coatings Tech., 1315 Walnut St., Philadelphia, PA 19107. (215-545-1506).

PAINT RESEARCH INSTITUTE WILL PRESENT SYMPOSIUM ON "STABILITY AND STABILIZATION OF COATINGS SYSTEMS"

The Federation's Paint Research Institute will sponsor a Symposium on "Stability and Stabilization of Coatings Systems," on May 4-5, at the Battelle Laboratories in Columbus, OH.

The Trustees of PRI chose "Stability" as the topic of the 1981 Symposium because it is the most timely subject facing the average coatings manufacturer. Some of the stability problems occur before the product reaches the market; others take place during application; still others, in the dried film. The Symposium emphasizes the role played by the formulator and, therefore, concentrates mainly on the behavior

of the paint while it is in the liquid form. Sessions will be devoted to: Controllable Factors in Making Stable Coatings Systems; Specific Chemistry of Stabilization; On-line Stabilization Problems; and Research Ideas for Stabilization.

The registration fee of \$150 covers registration, lunches both days, a mixer and banquet on Monday, and handouts. The check for Symposium registration should be made payable to "William Mirick, PRI Symposium" and mailed to Mr. Mirick at Battelle Laboratories, 505 King Ave., Columbus, OH 43201. (Phone: 614-424-5543). Housing is also available through Mr. Mirick, but payable directly to the hotel.

CALL FOR PAPERS TO BE PRESENTED AT 1981 FEDERATION ANNUAL MEETING

Authors wishing to present papers at the 1981 Annual Meeting of the Federation, October 28-30 in Detroit, MI, are invited to submit manuscripts for review.

Theme of the convention is "Challenge, Change, and Opportunity." and Program Chairman Thomas J. Miranda invites speakers to present original papers which address the many and varied aspects of the theme, such as, innovations in research, meeting the challenges of regulatory compliance and hazardous waste disposal, and analyzing and responding to causes of industrial and trade sales coatings failures.

Prospective speakers are requested to submit abstracts for review to: Dr. Thomas J. Miranda, FSCT Program Chairman, c/o Elisha Gray II R&E Center, Whirlpool Corp., Monte Rd., Benton Harbor, MI 49022. The deadline for abstracts is March 1.

FEDERATION TO HOST MEETING WITH SOCIETY OFFICERS IN DENVER

Each Society will send an officer to the annual meeting of Society Officers with Federation Officers and Staff on May 14, in Denver. This annual orientation meeting has been a success since its initiation in 1977. The open session, with plenty of across-the-table discussion, provides the officers a closer look at Federation/Society matters and sheds light on their future responsibilities as Society Presidents. The Federation will reimburse the transportation expense to the meeting.

NEWS BRIEFS FROM THE SOCIETIES

BALTIMORE--The December plant tour was to the frit manufacturing facility of Mobay Chemical.

CHICAGO--SYMCO '81 will be held at the Fountain Blue Restaurant in Des Plaines.

CLEVELAND--192 paint, ink, adhesive and coatings chemists (from as far away as Argentina, Australia, and Brazil) attended the Pigment Dispersion Symposium on October 7. Speakers were: James White, of Hockmeyer; Leo Dombrowski, of

Chicago Boiler; Bill Callahan, of Paul Abbe; Cal Tatman, of Glidden; Fred Scheidegger, of Ciba-Geigy; and Vic Lewis, of Cabot. Treasurer Girish Dubey was in charge of the program.

GOLDEN GATE--The first session of the Basic Coatings Course was completed by 34 students....."Safety and Government Regulations" will be the theme of the annual Manufacturing Committee Seminar, June 15.....Barry Adler was voted Committee Chairman of the month (October) for his direction of the Scholarship Committee.

HOUSTON--The speaker at the December meeting was Sandra Collins, of Hilton-Davis, who related "The Difficult and Rewarding Aspects of Selling from a Salesperson's Point of View".....Sponsoring January Symposium on "Environmental Regulations and the Coatings Industry." Speakers are: Art McDermott, of Nalco; Ray Pierrehumbert, of Union Carbide; Jim Larson, of Cargill; and Carl Hoffman, of Abcor.

LOS ANGELES--More than 2,000 are expected to attend the 15th Biennial Western Coatings Societies Symposium and Show at the Disneyland Hotel in Anaheim, March 4-6. The exhibit is billed as "the second largest paint exhibit in the world," second only to the Federation's annual Paint Show. Tony Rumfola, of TCR Industries, is General Chairman. Don Jordan, Society President, is Co-Chairman. Working with them are: Exhibits--W.A. Addington, of Universal Paint, and Earl Smith, of Spencer Kellogg; Publicity--Andy Ellis, of Pacific Air Chemicals; Advisor--Romer Johnson, of Dorsett & Jackson; Entertainment--Ron Johnson, of McCloskey Varnish; Technical--Bob McNeill, of PPG Industries; International--Mario Montferrand, of Given Paint; Secretary-Treasurer--Geneva Schminke, of H.M. Royal; and Registration & Housing--Dick Sutherland, of E.T. Horn.

LOUISVILLE--Now offering a course on "Quality Control of Raw Materials and Finished Paint Products" under the direction of Educational Chairman, Jim Hoeck, of Reliance Universal.....Plans to present paper on "Corrosion Inhibitive Pigments at 1981 Annual Meeting in Detroit.

MONTREAL--Walt Kolanitch, of Sherwin-Williams, and Educational Chairman, is working on an Introductory Coatings Course in French; also a Symposium on Quality Control for the Fall.....Making big preparations for 50th Anniversary Soiree on May 9 at Ritz Carlton Hotel.

NEW ENGLAND--Board of Directors decided that the next "Coatings and Ink Expo" (which made its debut in 1980) will be repeated during 1981-82 year.....Night courses at the University of Lowell are: Polymer Chemistry I, Coatings Formulation & Application, Plastics Processing Theory I.....Planning joint meeting with NPCA, NDPA, and PDCA on March 19.....Also a joint meeting with SPE on March 24.

NEW YORK--Several \$500 scholarships are available to students of science, studying as undergraduates or graduates at an accredited institution of higher learning. Preference is given to people, or children of people, currently employed in the coatings industry within the boundaries of the Society.

NORTHWESTERN--Planning a symposium for March 10.

PHILADELPHIA--"Conversion Enamels--Energy Savers" will be subject at February Technical Committee meeting. In March it will be "New Generation Coatings -- Application Workshop."

PIEDMONT--Educational Committee is preparing brochure to interest students in co-op program at University of North Carolina - Greensboro.....Emil Sagovac was presented 25-year pin.

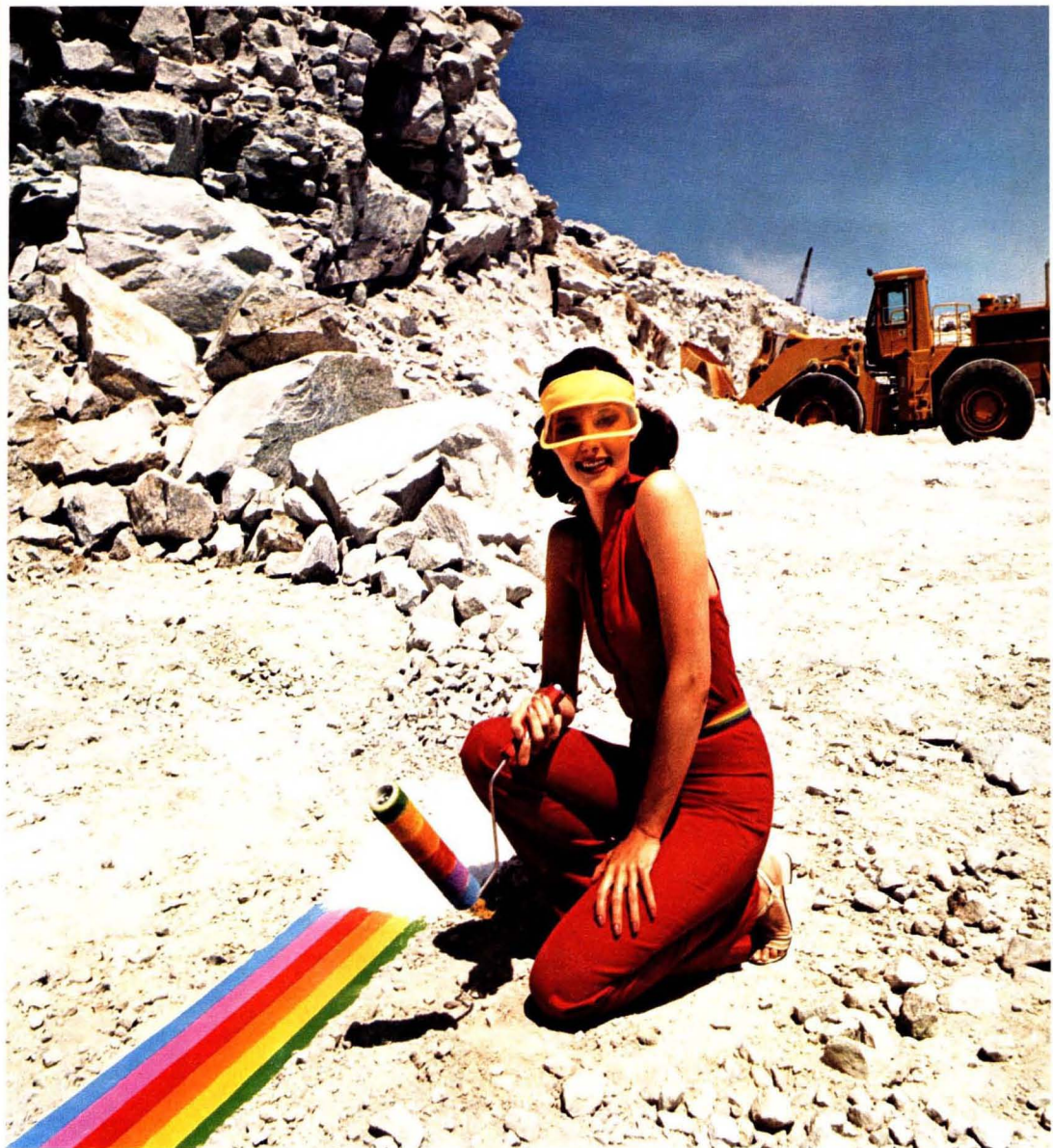
ST. LOUIS--More than 100 from the Society and local PCA attended November joint meeting on "Hazardous Waste." The speakers, all specialists, came from industry and government in the state.

SOUTHERN--"Coatings Technology - The End Users Perspective" is theme of the annual meeting, March 11-13, at Hilton Inn, in Birmingham, AL. Keynote Address--"We Need to Help Our Products Go First Class"--will be presented by Charles W. "Chuck" Finegan, of Havco Paints in Florida, and a Past-President of the Federation. Other presentations will include: Panel Discussion on "Practical Problems of Waterborne Coatings"--Tom McCraney, of Mobile Paint; Craig Larson, of Wyandotte Paint; Dave Barton, of Barton Associates; Tom Graves, of the NPCA legal staff..."Trends in Metal Finishing"--Joseph Ziegweid, consultant..."High Solids Solvent-Based Coatings"--Vic Ginsler, of Freeman Chemical..."Role of Organic Co-Solvents in Waterborne Coatings"--Robert Eaton, of Union Carbide..."Paint Quality - the Producer"--Thad Broome, of Precision Paint (and the President of the Southern Society)...Panel Discussion on "Paint Quality - the User"--Len Fulghum, of Furgeson-Fulghum; Bob Kane, of International Harvester; Paul Oliver, of U.S. Steel..."Paint Quality - the Consumer"--Joe Csernica, of Consumers Union. General Chairman of the meeting is Peter Decker, of Union Carbide.

TORONTO--Plans to present paper on "Mill and Media Wear" at Federation's 1981 Annual Meeting in Detroit.

COMING EVENTS

- Mar. 4-6...Western Coatings Symposium & Show. Disneyland Hotel, Anaheim, CA.
- Mar. 11-13..Southern Society. Annual meeting. Hilton Inn, Birmingham, AL.
- Mar. 24-25..Cleveland Society. Conference on Advances in Coatings Technology, Baldwin-Wallace College, Berea.
- Mar. 24-26..Symposium on Color Appearance and Instrumentation. Sponsored by FSCT, ISCC, and MCCA. Executive West, Louisville.
- May 1-2.....Pacific Northwest Society. Annual Symposium. Washington Plaza Hotel, Seattle.
- May 4-5.....Paint Research Institute. Symposium on "Stability and Stabilization of Coatings Systems." Battelle Institute, Columbus, OH.
- May 9.....Montreal Society. Fiftieth Anniversary Dinner Dance.
- May 14-15...Federation Spring Meetings. Society Officers on 14th; Board of Directors on 15th. Hilton Hotel, Denver.
- Oct. 28-30..Federation Annual Meeting and Paint Industries' Show. Cobo Hall, Detroit.



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Symposium on Stability and Stabilization of Coatings Systems

May 4-5, 1981

Battelle Memorial Institute Columbus, Ohio

PURPOSE

Coatings formulation changes mandated by regulations have introduced problems in stability. Some of these problems are simply exaggerated forms of difficulties that have been surmounted in the past; others are unique to the system.

Research opportunities abound in situations such as these. One hears that coatings markets have reached a stage of maturity, and that there is reduced demand for basic research in a mature industry. However the opposite is true when the technology is undergoing fundamental changes; then the situation is viewed as an opportunity by the individual company riding the crest of a change. Research is necessary in order to stay on the crest.

The Trustees of the Paint Research Institute have chosen stability as the topic of PRI's 1981 Symposium as the most timely subject facing the average coatings manufacturer. Some of the stability problems occur before the product reaches the market; others take place during application; still others, in the dried film. This Symposium emphasizes the role played by the formulator and, therefore, concentrates mainly on the behavior of the paint while it is in the liquid form.

Who Should Attend?

Although the paint formulator has been singled out as the one most likely to profit from attendance at this symposium, anyone engaged in finishing manufactured articles using organic coatings should register.

Accommodations

Battelle, Columbus Laboratories has served as the host for our past four symposia. Excellent accommodations for 125 persons are available, and the attention paid by the host has contributed to the success of past programs. Lodging is nearby and a block of rooms has been reserved for symposium participants.

REGISTRATION AND HOUSING

The basic fee of \$150 covers registration, lunches both days, a mixer and banquet Monday night, and handouts. The check for Symposium registration should be payable to: "William Mirick, PRI Symposium," and mailed to him at Battelle, Columbus Laboratories, 505 King Avenue, Columbus, Ohio 43201. (Phone: (614) 424-5543). Housing is also available through Mr. Mirick, but payable directly to the hotel.

PROGRAM COMMITTEE

Raymond R. Myers, Program Chairman
Paint Research Institute
Kent State University
Kent, Ohio 44242
(216) 672-2034

Herbert L. Fenburr, Consultant
Carl J. Knauss, Kent State University
Charles A. Kumins, Sherwin-Williams Co.
Otto C.C. Lin, E.I. duPont deNemours & Co.
William Mirick, Battelle,
Columbus Laboratories

FEDERATION OF SOCIETIES FOR COATINGS TECHNOLOGY

Fall 1980 Board of Directors Meeting

Fifty-two members attended the Fall Meeting of the Board of Directors of the Federation of Societies for Coatings Technology on October 28, 1980, at the Hyatt Regency Hotel in Atlanta, GA.

The following were present :

Officers

President Elder C. Larson
President-Elect William H. Ellis
Treasurer Howard Jerome

Society Representatives

Baltimore Alex Chasan
Birmingham John Hitchin
Chicago John T. Vandenberg
C-D-I-C William Mirick
Cleveland Fred G. Schwab
Dallas Carlos Dorris
Detroit Harry B. Majcher
Golden Gate A. Gordon Rook
Houston Willy C.P. Busch
Kansas City Terry Johnson
Los Angeles Gerald L. West
Louisville Joseph A. Bauer
Mexico Antonio Pina
Montreal Horace Philipp
New England Charles Aronson
New York S. Leonard Davidson
Northwestern Lowell Wood
Pacific Northwest John A.J. Filchak
Philadelphia John A. Stigle
Piedmont Gary Marshall
Pittsburgh Edward Vandevort
Rocky Mountain James E. Peterson
St. Louis Herman Lanson
Southern J.T. Robertson
Toronto A. Clarke Boyce
Western New York Eugene LeVe

Other Members

John C. Ballard Louisville
Neil S. Estrada Golden Gate
Milton A. Glaser Chicago
Ruth Johnston-Feller Pittsburgh
James A. McCormick Baltimore
Thomas J. Miranda Chicago
Colin Penny Baltimore

Guests

Dr. Orin Keplinger and Dr. Raymond R. Myers, President and Research Director of the Paint Research Institute.

The following Past-Presidents of the Federation: Newell P. Beckwith (Detroit); William Dunn (Toronto); Michael Malaga (Cleveland); John Oates (New York); Martin E. Schleicher (Western N.Y.); Carroll M. Scholle (Chicago); and Willard Vasterling (Kansas City). (Board members S.L. Davidson, N.S. Estrada, M.A. Glaser, J.A. McCormick, and A.G. Rook are also Past-Presidents.)

Curtis P. Bailey (Pacific N.W.); John Fitzwater (New England); Thomas Keene (Cleveland); Bobby D. Moore (Southern); Deryk R. Pawsey (Pacific N.W.); and Lee Sveum (Northwestern).

Staff

Frank J. Borrelle, Executive Vice-President; and Thomas A. Kocis, Director of Field Services.

Mr. Borrelle called the roll of members and reported all present. The report of the Spring 1980 Board of Directors meeting was approved as published in the July 1980 JOURNAL OF COATINGS TECHNOLOGY.

Reports of Officers and Staff

PRESIDENT LARSON

The Eighties opened with many challenges to the Coatings Industry. A downturn in the economy at the beginning of the year is leveling out and now shows some significant signs of a swing upward. Technological developments are playing a vital part in the recovery of the economy and in the quality, diversification, and application of coatings.

It is refreshing to see so many announcements in the trade journals and brochures of technical information seminars and courses featuring advancements in polymers and coatings technology. The Federation and the NPCA are justifiably proud of these thrusts in learning experiences within our industry. We look forward to additional technological achievements in the near future through the efforts of the Paint Research Institute and the FSCT Technical and Education Committees. Several chapters have been written for the forthcoming Correspondence Course "Science and Technology of Coatings" that is under development by FSCT and professors at the University of Southern Mississippi. Completion of Volume I of the 2-part course is scheduled for the Fall term of 1981. We appreciate the diligent work that the FSCT Review Board members are doing in reviewing the chapters written by USM.

It was a pleasure for Margaret and me to serve as official representatives of the FSCT at the XVth FATIPEC Congress in Amsterdam in June. Liaison between our European, Australian and Japanese counterparts and members of the FSCT is at an all-time high. The bibliography on "Technical Uses of Computers" mentioned in the Newsletter section of the September 1980 issue of JCT [see November 1980 JCT—Ed] is an outstanding example of bridging the mileage and language barriers through technology. I was delighted to present the FSCT contribution for the bibliography to the International Coordinating Committee while in Amsterdam.

Our participation in the 50-year anniversary celebration of the Birmingham Club was a delightful experience in technology and sociability. I had the high honor of accepting Birmingham's gift of a new "Presidential Jewel" for FSCT. The jewel is to be worn by the Federation President at official functions.

The Program Committee has planned an excellent technical program for our 58th Annual Meeting. The 45th Paint Industries Show will set another record with its larger-than-ever exhibit space. We look forward to another fine convention.

I thank the Board of Directors, Headquarters Staff, Committee Chairmen and members, and special delegates for their excellent help in making this another successful year for the FSCT.

ELDER C. LARSON,
President

PRESIDENT-ELECT ELLIS

Federation demands on the President-Elect have been minimal during the summer months, giving me time to plan and organize for the coming year. Planning and organizing consist mostly of reviewing programs and appointing Committee Chairmen to guide them effectively.

Highly qualified people have accepted chairmanships of all committees. Some are new to the positions and some are con-

tinuing, but all were selected on the basis of ability, interest, and dedication. There is also a pending vacancy on the Paint Research Institute Board of Trustees that is being filled.

Visits to local Societies and other organizations have been relatively few since the Spring Board of Directors Meeting. My wife, Bea, and I represented the Federation at the Kansas City-St. Louis joint meeting in Kansas City and at the Canadian Paint Manufacturers' Association annual meeting in Quebec City. I also attended the Golden Gate Society's Manufacturing Committee Seminar in June and that evening presented the Federation slide show at the regular monthly meeting. All of the meetings yielded much valuable information and food for thought.

As this Federation year comes to a close, it is time to look forward with enthusiasm and dedication to the new year. With everyone's help, we can build on the achievements of the past to make even greater progress in 1980-81.

W. H. ELLIS,
President-Elect

TREASURER JEROME

The Federation budget is on target and the figures reported are the result of careful and prudent study. Board members can rest assured that our Federation staff is made up of a group of people dedicated to a very high level of performance. The Paint Show and advertising income accounts are in line with budget projections. When the final tally is in, the year 1979-1980 will show it to have been a satisfactory one. Your Treasurer takes no credit for this pleasant state of affairs. Our success is due to the labors of a large number of people, not the least of whom are those on our Philadelphia staff.

Following the May Board of Directors meeting, I had the privilege of attending the 50th Anniversary meeting of the Kansas City Society. As part of my normal duties, I attended Host and Executive Committee meetings and meetings of the Paint Research Institute Trustees.

The sum of all these various meetings has been an excellent personal learning experience which I know will serve me well in the future. The interchange that takes place provides valuable training for the Treasurer.

HOWARD JEROME,
Treasurer

EXECUTIVE VICE-PRESIDENT BORRELLE

This report covers Federation and staff operations in 1980. All activities have progressed satisfactorily and the year should be another successful one.

PUBLICATIONS

JCT: Advertising income is in line with the budget. Production expenses may exceed the budget because of the soaring costs of paper stock. Overall volume is being held in check to help offset this.

Thanks are extended the Publications Committee (Tom Miranda, Chairman) and the Editorial Review Board for their good services during the year, including the productive meeting on March 18, in Philadelphia.

Bob Ziegler, who joined staff in 1976, became Editor of the JCT on September 1; a promotion I was pleased to recommend to the Executive Committee.

The current circulation of the JCT is 9,179; U.S.—6,692;

Canada—785; Other Countries—1,702. There are 6,624 member subscribers and 2,555 non-member subscribers.

Year Book: Advertising income was close to budget. The 1980 edition was released on March 3. In an effort to publish future editions even earlier, the Board of Directors has set a deadline date of November 15, for receipt of Society rosters.

Paint/Coatings Dictionary: Total sales, by year's end, will be about 3,000 copies.

Pictorial Standards of Coatings Defects: About 200 copies of this revised manual, published in mid-1979, will be sold by the end of the year.

Infrared Book: There will be sales of about 750 copies this year. It was published in January 1980.

Newsletter: Four have been published. They are direct-mailed to key Federation and Society personnel, and also published in the JCT.

Activities Booklet: A new Federation Activities Booklet was written. Copies were mailed to the Board of Directors and Society Officers in June. Quantities will be made available to the Societies.

Handbook: This annual compilation of Federation/Society officers, committee chairmen, etc., is now an established publication. The 1981 edition is underway.

Federation Series: The manuscript of "Statistics for the Coatings Industry" has been received and is being reviewed. It will be published next year. The author of the proposed unit on "Color and Appearances" has advised that, because of a change in employment, he will not be able to write this unit. Five of the original units are currently being revised and updated.

OTHER SERVICES

Color-matching Aptitude Test Set: The inventory of the 300 sets of the 1978 edition produced in May 1978 is running out (240 sold). Munsell Color Co. has been asked for a quotation to produce another 300 sets, using the chips already in stock.

Audio-visual Programs and Correspondence Course at USM: These are covered in the report of the Director of Field Services.

File of Monthly Meeting Talks: We continue to release, on a quarterly basis, the titles/authors of talks presented at Society monthly meetings. Detailed reports on the talks are available upon request. This service is not attracting the interest that was anticipated.

SOCIETIES

Welcome to two new Sections: the Richmond (Va.) Section of Baltimore and the Memphis (Tenn.) Section of Southern. The latter may cause a change in the boundaries of the Dallas and Southern Societies.

The names of 6,566 members (4,666 Active, 1,586 Associate, 314 other) were published in the 1980 *Year Book*.

ANNUAL MEETING AND PAINT SHOW

The 1980 Paint Show will be the largest (in area) in Federation history:

	1980	1979
Net Square Feet, Paid	34,350	32,900
Paid Exhibitors	141	145
Paid Exhibit Booths	319	329

In spite of several cancellations, the Show is still a sell-out. Hugh W. Lowrey and his Program Committee deserve commendation for the interesting and informative presentations aimed at the theme, "Three R's for the 80's."

The Host Committee (Berger Justen, Chairman) is well-prepared and eager to perform their services. We thank them for their willing and able help.

Because of sharing hotel headquarters with the NPCA, that hotel "runneth over." All hotels in the original block, and some new ones, have been sold out, indicating a good registration.

PAINT RESEARCH INSTITUTE

Letters soliciting 1980 contributions were sent to last year's donors. Tom Kocis or I attended the Trustees' meetings and submitted reports to the Executive Committee.

FSCT EXHIBITS

Rosemary Falvey and Dick Gross handled the Federation's booth at the Baltimore Society's "Coatings Show" in March. Tom Kocis and I will tend to the Federation's exhibit at the March 1981 Western Coatings Societies' Show. We may also exhibit at the NACE Show in April.

OFFICER/STAFF VISITS

In the company of a Federation officer, Tom Kocis or I met with the Executive Committees and attended monthly meetings of: the four Southern Sections, Houston, St. Louis, Baltimore, Chicago, Northwestern, New England, Detroit, New York, Western New York, Pittsburgh, Louisville, Kansas City, and Birmingham. The latter two were 50th anniversary meetings.

I attended, with Society Representative Lowell Wood, the May meeting of the Winnipeg Section of the Northwestern Society. That was a "first" for me. Another "first" will be the visit to the new Richmond Section of the Baltimore Society on October 15.

President-Elect Bill Ellis was the sole Federation representative at the June meeting of the Golden Gate Society. (Tom Kocis was ill).

Also attended were the Southern Annual Meeting, the Southwestern Paint Convention, the Pacific Northwest Symposium, and the joint meeting of St. Louis and Kansas City.

We find the Societies to be generally sound and well-organized. Their leadership is of high caliber and best of all, they are striving to present monthly meetings and educational programs of widest appeal to their membership. Some have conducted surveys in order to ascertain membership needs.

SOCIETY OFFICERS MEETING

The fourth Society Officers meeting in Minneapolis was as successful as the previous ones. A report of the meeting, by Rosemary Falvey, was sent to all attendees.

INVESTMENT TRUST FUND

I cooperated with Dr. Herbert L. Fenburr, Investment Chairman, and James A. McCormick, Finance Chairman, in the transfer of the Federation's Investment Trust Fund to the Girard Bank in Philadelphia, on July 30.

On August 11, an additional \$100,000 (from short-term investment program) was added to the permanent Investment Trust. These funds represented an accumulation of surplus from Federation operations during the past few years.

Previously, \$10,000 and \$16,500 was added to the Investment Trust (in 1975 and 1977). \$50,000 of the total (\$126,500) is full repayment of the same amount borrowed from the Trust in 1973 to purchase materials for the Color-matching Aptitude Test Set, 1978 edition.

COMMITTEE LIAISON

As directed by the Executive Committee and Board of Directors on May 16, I contacted the National Paint and Coatings Association. The five-page letter to Allan Gates, Vice-President of Administration of NPCA, spelled out the many problems the Federation faces with the present back-to-back schedule and the accompanying reasons for the Federation's announced intent to split.

I also visited with Larry Thomas, Executive Director of NPCA, on August 11, and reviewed the matter further. I followed that meeting with a letter to Mr. Thomas which summarized the key points in the discussion.

Although there has been no written response from NPCA, it is apparent that Messrs. Gates and Thomas want to keep the conventions together. They claim that such an arrangement is good for the industry in that it saves the time and expense of suppliers and others who attend both meetings. Mr. Thomas did indicate that if circumstances are such that there must be a split, so be it, but he prefers status quo.

I feel that there will be a mixed reaction to a split and not as many opposed as NPCA may claim. It all depends upon a company's involvement in the conventions of one or the other, or both. Many exhibitor companies feel that five or six days of "conventioning" are exhausting. Also, the strain on the joint headquarters hotel deprives them of preferred hotel sleeping rooms, suites, and function space; equally a major disadvantage to the Federation. The simultaneous NPCA departure/FSCT arrival in the headquarters hotel on Wednesday is another factor leading to problems which we are certain to experience this year in Atlanta . . . and next year in Detroit.

At the August 11 meeting, Mr. Thomas requested more time to review this matter with the NPCA Board of Directors and the Industry Suppliers Committee.

Time is running out though because the Federation's large hotel and exhibit hall package must be booked at least six years in advance. A decision for 1985 will have to be made very soon.

The Federation and NPCA already have confirmed and approved joint dates and locations in 1981 (Detroit); 1982 (D.C.); 1984 (Chicago); and 1988 (Chicago). In 1983, the Federation will be in Montreal; the NPCA in Los Angeles.

I hope to present to you, just as soon as possible, my recommendations for 1985, 1986, 1987, 1989, and 1990 . . . on a solo basis.

STAFF

Members of staff are: Rosemary Falvey (Director of Meetings and Conventions/Director of Membership Services/Office Manager); Kathryn Ferko (Assistant to the Treasurer); Dick Gross (Manager of Advertising Services/Art Director); Linda Hanratty (Secretary); Tom Kocis (Director of Field Services/Director of Annual Meeting Programming); Lorraine Ledford (Associate Editor of JCT and other publications); Dorothy Robinson (Subscription Fulfillment Manager); Mary Sorbello (Secretary/Annual Meeting Registration Manager); Patricia Viola (Assistant Editor of JCT); and Bob Ziegler (Editor of JCT).

Ronna Righter left in August to raise a family. Pat Viola will leave in November to be with her husband who has accepted a teaching scholarship at Cornell University.

I thank staff for their good work, dedication, and accomplishments during the year.

On behalf of staff, sincere thanks to President Elder Larson, the other officers, Board members, and committee chairmen for their cooperation and service throughout the year. It was a pleasure to have worked with them.

FRANK J. BORRELLE,
Executive Vice-President

Educational—Work on Correspondence Course on Science and Technology of Surface Coatings being developed in conjunction with University of Southern Mississippi is well underway. Members of Editorial Review Board met with USM staff personnel in August to critique initial chapters written for Volume I of the two-volume text for the Course. Course development is currently behind original timetable, but USM authors have expressed confidence that their output will improve and that targeted Course availability by late 1981 will be accommodated. (Educational Committee session at 1980 Annual Meeting will be devoted to presentation on the Correspondence Course.)

Reports on Society educational activities were compiled and published in September JCT.

Number of booklets from Federation Series on Coatings Technology currently being revised and updated. These include: #4—"Modern Varnish Technology;" #5—"Alkyd Resins;" #6—"Solvents;" #7—"White Hiding and Extender Pigments;" and #17—"Acrylic Resins."

Promotion of career opportunities in coatings industry is project currently being pursued. Development of literature and slides is underway to assist presentations by Society personnel at local high schools.

Annual update of "Guide to Coatings Courses" now underway, to be published by year's end.

Technical Advisory—Committee has selected a list of proposed topics for Society technical project work to complement current efforts. Basic idea is to generate interest and enthusiasm among members to enlist their participation, and where possible incorporate learning techniques which will enable them to grasp new idea or approach. These include:

Mildew Growth and Fungicidal Studies—Involves the use of mildew-inhibitive polymers currently in the laboratory development stage, as part of PRI's mildew research program. They would be formulated into conventional paint systems and simple lab scanning techniques conducted to determine effectiveness. Panels would be prepared and exposed in various geographical areas for comparative results with lab studies. Implementation awaits approval of PRI on suitable polymer for the undertaking.

Computer Program for Paint Formulation—Development of low-cost micro-computers offers potential for widespread application in the paint industry. Suggested project is to develop programs on formulation, color analysis, inventory control, etc., which could be stored on tapes or discs. (Baltimore Society has already begun work on such a project.)

Corrosion Control—One approach would be study of stability aspects of corrosion-inhibitive pigments recommended for use in water-borne systems—technical review of state-of-the-art (i.e., zinc chromate, zinc calcium molybdate, zinc phosphate, barium metaborate) vehicle types could be epoxy ester, acrylic latex, and medium oil alkyd, all in all-aqueous systems, either dispersion or emulsion type. Work would be simple package stability testing.

Washability Testing—NPCA is undertaking, in conjunction with ASTM Subcommittee D01.41, development of a satisfactory procurement method for commercial, off-the-shelf paint products in response to a query from the Office of Management and Budget. Immediate project is for latex flat wall paints and how to test them for opacity, gloss, washability, and scrubability. Round-robin test program will be undertaken. NPCA is looking for simple test for washability.

Reports on Society technical project work were published in August JCT.

Environmental Control—Committee will sponsor panel discussion on Waste Management by EPA Regulations at 1980 Annual Meeting.

Planning early publication of next Newsletter, and hope to have subsequent editions appear on regular basis—input needed from Society Environmental Control Committee Chairmen to furnish info on regulatory developments in their local areas.

Corrosion—Committee met May 8, in Washington, D.C., to redefine its aims and goals to best address the many aspects of corrosion and its ramifications for the coatings industry.

Session at 1980 Annual Meeting will focus on Protection of Resources through Corrosion Control, and Committee hopes to sponsor such presentations on regular basis at Federation conventions.

Recommended following topics for Society technical work in corrosion area: Non-Corrosive Pigments in Aqueous and Non-Aqueous Systems; Repainting of Exterior Steel; Water-Based Vehicles in Corrosion-Inhibitive Coatings; Effect of Surface Preparation on Coatings Performance; and Painting Over Zinc.

Members will gather informational items on corrosion control and submit to Federation headquarters for publication in JCT.

Program—Three full days of programming have been scheduled for the 1980 Annual Meeting, with presentations keyed to the theme, "Three R's for the Eighties: Research, Resources, and Regulations." Again this year, to help assure high level, quality papers, prospective authors were asked to submit manuscript drafts for review before granting acceptance for presentation.

Meanwhile, Program Committee for 1981 Annual Meeting met in Chicago on September 11, to develop a theme ("Challenge, Change, and Opportunity") and select general topics for presentation. Follow-up discussions are scheduled to be held during the 1980 Annual Meeting in Atlanta.

AUDIO/VISUAL PROGRAMS

Toronto Society's Manufacturing Committee presentation on "Introduction to Resin Operations" has been added to Federation A/V library. The program will be on display at the Federation Booth in Atlanta.

Production nears completion on Birmingham Club's four-part presentation on "The Setaflash Tester," which will be shortly available as part of the Educational Committee's Training Series on Test Methods. Two other Training Series programs are in various stages of production: script has been reviewed for Western New York's "Impact Resistance"—awaiting receipt of slides; review currently underway on Kansas City's production, "Measurement of Hiding."

PUBLICATIONS

Color terms being compiled from *Paint/Coatings Dictionary*, to be published in booklet form and offered for sale to members of Inter-Society Color Council and other groups and individuals interested in color.

SYMPOSIUM ON COLOR AND APPEARANCE INSTRUMENTATION

Federation is again co-sponsoring (along with Manufacturers Council on Color and Appearance and Inter-Society Color Council) Symposium on Color and Appearance Instrumentation, to be held March 24–26, 1981, in Louisville. Previously held in 1978, the 2½ day event will feature paper presentations, workshops, and "hands-on" displays of color instrumentation equipment for the coatings industry.

Site arrangements have been completed, and all programming presentations and authors lined up for the Symposium. FSCT staff will again be responsible for planning, promotion, and registration needs.

THOMAS A. KOCIS,
Director of Field Services

Paint Research Institute

PRESIDENT KEPLINGER

Our active grants, proposed projects and donations were reviewed again, July 17 and 18. Contributions from industries and foundations are higher this year. Associations are somewhat lower and donations by Federation Societies are quite low. The Mildew program is reasonably well outlined and should require minimal additional expense. It also promises to be adequately funded with seven supporting companies. The High Solids program is currently funded for polymer studies at North Dakota State University. An encounter session is planned so there should be some additional funding to cover those expenses.

We hope to be able to secure a "State of the Art" review as a by-product of some of the governmental studies going on in corrosion. It should be relatively inexpensive.

Our symposium for 1981 has already been announced. It will consider "Stability and Stabilization of Coatings Systems" and will be presented at the Battelle Memorial Institute of Columbus on May 4–5.

During the preceding six months, a Federation Ad Hoc Committee consisting of Past-Presidents McCormick, Beckwith, Estrada, Glaser and Oates, has been formed to evaluate the activities of the Paint Research Institute. We look forward to their comments and suggestions.

There have been some changes on the Board of Trustees. Early in the year Dr. C. Malcolm Hendry took the place of Len Afremow. John Weinman has resigned. He will be replaced by Dr. Darlene Brezinski, Manager, Research Services, DeSoto, Inc.

The Board of Trustees will meet to elect officers and conduct essential business. As an example, we have found it extremely difficult to identify research needs for medium-sized companies. Sources for consultants, technology awareness, and assistance toward the use of computers have been suggested, along with handling the details of governmental regulations. These are certainly problems but it would appear that they should be considered research problems.

Our present programs still would seem to be valid.

ORIN KEPLINGER,
President

RESEARCH DIRECTOR MYERS

Six grants were active in 1980. Three concerned mildew defacement; two were part of the aqueous program; and one was launched in the area of high solids. Progress on these grants is covered.

Plans are laid for the 1981 symposium on Stability and Stabilization of Coatings Systems. Four half-day sessions will be held on May 4–5.

An encounter session has been scheduled for December 18, on the subject of High Solids Coatings. Personnel have been selected. Invitations are extended to the Trustees as observers; others may be invited upon expressing interest or upon nomination by Trustees or participants.

A new service to Federation members has been started by PRI. Tutorials on the use of computers are planned after a canvass is made of the need perceived by a sampling of small companies. Software packages will be generated.

A compilation has started of consultants available to coatings manufacturers. This compilation may not be consistent with PRI's charter, and therefore it has been held in abeyance. A critical survey on corrosion control has been commissioned.

Grant Progress

A. MILDEW DEFAACEMENT

- (1) Charles U. Pittman, University of Alabama
"Polymer-Anchored Mildewcides."

Abstract—Grafts of fungicides to acrylic polymers are made and paint systems are made from the resulting copolymer. Laboratory tests show that fungicide is active but does not leach from the coating.

Relevance—A fixed fungicide should be long-lasting and not toxic, even if it is soluble or volatile as an additive. Toxicity would be minimized if the fungicide were attached by a bond that resists salivary enzymes.

- (2) Robert A. Zabel, SUNY at Syracuse
"The Role of *Aureobasidium pullulans* in the Disfigurement and Deterioration of Latex Paint Films."

Abstract—Mildew growth on wood is revealed in early stages by controlled (axenic) culture. Nutrient and moisture requirements are determined.

Relevance—Growth requirements are a prelude to stunting mold growth. The assay procedure developed in this study is rapid and reliable—and needed by the industry.

- (3) Donald J. Siehr, University of Missouri, Rolla
"Control of Cell-Wall Biosynthesis in *Aureobasidium pullulans*"

Abstract—*A. pullulans* protoplasts are made (free of cell walls) and the biochemistry involved in their manufacture of new walls is studied.

Relevance—Fungicides may be discovered by knowing how they interfere with synthesis of cell walls.

B. AQUEOUS PROGRAM

- (1) Raymond R. Myers, Kent State University
"Film Formation and Polymer Transitions"

Abstract—Water-borne acrylic acid copolymers dry at rates and to degrees that are determined by the neutralizer and degree of neutralization. Water retention is ascertained and related to clustering tendencies.

Relevance—Energy requirements and time lapses on drying are severe drawbacks, as is water sensitivity of the dried films. Formulation variables to maximize economy should be indicated by systematic study.

- (2) Henry P. Schreiber, Ecole Polytechnique
"Surface and Physical Properties of Water-Borne Coatings"

Abstract—Copolymers do not always produce films of uniform cross section. Surface tension indicates

whether a particular group is oriented outward and reveals if formulation variables change this orientation and consequent wettability.

Relevance—Polar polymers used in water-borne coatings will most likely orient. If exploited, orientation could enhance adhesion and reduce water resistance of cured film.

C. HIGH SOLIDS

- (1) Zeno W. Wicks, Jr., North Dakota State University
"Rheology of Concentrated Oligomer Solutions"

Abstract—Selection of a model system containing terminal carboxy groups will be made after preparation difficulties are resolved. Thereafter, characterization of the oligomers will be performed, with emphasis on application and curing of highly concentrated solutions.

Relevance—Insufficient information on the physical chemistry of low molecular weight polymers (oligomers) requires a standard preparation upon which various measurements will be made, starting with rheology.

RAYMOND R. MYERS,
Research Director

Society Business

NEW YORK

Mr. Davidson said that the Society had sent a letter to all Societies in May, requesting cooperation and assistance in setting up a "special monthly meeting speakers' circuit." The booking of one speaker for several meetings would reduce the workload of the Program Committee and also help attract better speakers. Since there were few replies to the letter, Mr. Davidson asked the Society Representatives to review this matter with their own groups.

LOUISVILLE

Mr. Bauer noted that the Society participated as a member of the Louisville Coatings Waste Disposal Association and conducted a survey on the amounts, types, and disposal methods of waste produced by local coatings manufacturers. A paper will be prepared for the JCT on this project.

GOLDEN GATE

Mr. Rook stated that their membership is concerned about the relationship of PRI projects to the work of the average Federation member. He also said that members on the West Coast receive the JCT during the month *after* the publication month. He asked if the JCT could not be published sooner.

[*Mr. Borrelle replied that the JCT is mailed from the Harrisburg, PA, Post Office between the 15th and 20th of each month. Because the JCT is handled as second-class mail, delivery across the country takes a lot of time, much of it depending upon local post offices. His own copy usually takes three weeks to go from Harrisburg to his home, a distance of about 90 miles. Nevertheless, the JCT staff will check again to see what can be done about earlier delivery.*]

TORONTO

Mr. Boyce requested that, for the third consecutive year, the Board recommend to the Executive Committee that the Toronto and Montreal Societies be granted permission to delay payment of dues (1981) until September 30 (1981). *Motion made by Mr. Boyce, seconded by Mr. Philipp, and approved.*

BIRMINGHAM

Mr. Hitchin stated that the JCT should feature more papers on practical matters (production and management).

[*Dr. Miranda, Chairman of the Publications Committee, responded that the committee would like very much to publish practical papers. Their availability, however, is very limited.*]

CHICAGO

Mr. Vandenberg commented that the Society cannot justify the continuation of financial support to PRI because results of research from PRI do not meet the needs of their members.

PACIFIC NORTHWEST

Mr. Filchak said that the Society is restudying the proposed "In-Plant Materials Handling Data Sheet" in view of concern expressed over the legal implications and potential liabilities involved.

PITTSBURGH

Mr. Vandevort reported that the Pittsburgh Society had revised its proposed amendment to the Federation's By-Laws which would permit Associate members to vote and hold office. The revision was submitted to the By-Laws Committee on August 28.

[*Mr. Schwab, Chairman of the By-Laws Committee, stated that the committee would meet during the Annual Meeting and review the Pittsburgh proposal. He invited Mr. Vandevort to the meeting.*]

CONTRIBUTIONS TO PRI

During the meeting, contributions to the Paint Research Institute were presented by four Societies as follows: Cleveland—\$750.; Houston—\$500.; Kansas City—\$500.; and Louisville—\$500.

The contributions were gratefully acknowledged by FSCT President Larson and PRI President Keplinger.

Amendments To By-Laws

[*The following amendment to the By-Laws was passed for first reading at the Board of Directors meeting, May 16, 1980, and was presented for adoption and approved at the October 28, 1980 meeting.*]

ARTICLE III—ORGANIZATION

WHEREAS the Federation's Executive Committee passed the following action on October 6, 1979:

"That the President, or duly appointed representative, and the Research Director of PRI submit progress reports to and attend the two meetings of the Board of Directors and further that this statement be made a provision of the Standing Rules and be referred to the By-Laws Committee for preparation of the proper resolutions," be it

RESOLVED that By-Laws Article III, Section B, Sub-Paragraph n, be revised as follows [additions in *italic*, deletions in parenthesis ()]:

- (n) Receive written reports on their activities from the Federation officers, (and) Committee Chairmen, *and both the President, or duly appointed representative, of the Paint Research Institute and its Research Director* semiannually; and from Constituent Societies annually.

* * * * *

[*The following amendment to the Standing Rules was presented for adoption and approved at the October 28 meeting.*]

ARTICLE SRVII—OPEN MEETING

WHEREAS the Federation's Executive Committee passed the following action on October 6, 1979:

"That the President, or duly appointed representative, and the Research Director of PRI submit progress reports to and attend the two meetings of the Board of Directors and further that this statement be made a provision of the Standing Rules and be referred to the By-Laws Committee for preparation of the proper resolutions," be it

RESOLVED that Standing Rules Article SR VII, Section A, Sub-Paragraph (2) be revised as follows [additions in *italic*, deletions in parenthesis ()]:

- (2) The President of the Federation shall extend an invitation to appropriate officers of the Canadian Paint & Coatings Association, the Mexican Association of Paint & Ink Manufacturers, the National Paint & Coatings Association, (and the Paint Research Institute) *and both the President of the Paint Research Institute and its Research Director* to attend meetings of the Board. The President may also invite officers of other organizations which he deems to be appropriate.

* * * * *

[*The following amendment to the By-Laws was accepted for first reading at the October 28 meeting. It will be presented for adoption at the May 15, 1981 meeting of the Board of Directors.*]

ARTICLE III—ORGANIZATION

WHEREAS an important annual duty of the President is to nominate the Trustees of the Paint Research Institute for election by its Members, who are the Federation Board of Directors, and

WHEREAS this duty is not currently included in the Federation By-Laws, be it

RESOLVED that By-Laws Article III, Section C, Paragraph(1) be amended by adding new sub-section e., as follows:

- "e. Nominate annually the Trustees of the Paint Research Institute for election by its Members (Federation Board of Directors)."

Nominations And Elections

The following slate of candidates for Federation Office (1980-81) was presented by Nominating Committee Chairman James A. McCormick at the May 15, 1980 meeting of the Board of Directors.

President-Elect—Howard Jerome, of the St. Louis Society (Spatz Paint Industries). He is currently Treasurer.

Treasurer (one to be elected)—A. Clarke Boyce, of the Toronto Society (Nacan Products Ltd.) and Terry Johnson, of the Kansas City Society (Cook Paint & Varnish Co.). Both are Society Representatives.

Society Representative to the Executive Committee (three-year term, one to be elected)—Joseph Bauer, of the Louisville

Society (Porter Paint Co.) and Fred Schwab, of the Cleveland Society (Coatings Research Group, Inc.).

Member-at-Large on the Board of Directors (two-year term, *two to be elected*)—John Emmerling, of the Baltimore Society (Lenmar Lacquers, Inc.); John A. Gordon, Jr., of the St. Louis Society (University of Missouri-Rolla); William Holmes, of the Dallas Society (DeSoto, Inc.); and Hugh W. Lowrey, of the CDIC Society (Perry & Derrick Co.)

Past-President on the Board of Directors (two-year term, *one to be elected*)—Herbert L. Fenburr, of the CDIC Society (retired); and John J. Oates, of the New York Society (Troy Chemical Corp.).

Since a call for further nominations from the floor produced no additional candidates, the nominations were closed, and a secret ballot was taken.

The results of the voting were as follows:

Treasurer—Mr. Boyce.

Society Representative—Mr. Schwab.

Board of Directors—Messrs. Holmes and Lowrey.

Past-President—Mr. Oates.

Since Mr. Boyce, the Treasurer-Elect, has two years of service remaining on the Executive Committee, Mr. McCormick called for nominations from the floor for the unexpired term of Mr. Boyce. Mr. Davidson nominated Mr. Bauer, seconded by Mr. Filchak. There were no other nominations and Mr. Bauer was duly elected to the Executive Committee through 1982.

Review of Actions Of Executive Committee

[*One of the duties of the Board of Directors is to approve or disapprove all actions of the Executive Committee.*

The actions of the Executive Committee, at its meeting of August 22, 1980, are listed below.

All were approved by the Board of Directors.]

That the Federation's First Half Statement of Income and Expense be accepted as presented.

That the Paint Research Institute's First Half Statement of Receipts and Disbursements be accepted as presented.

That Dr. Thomas Miranda be re-appointed Technical Editor of the JCT, 1980-81.

That Federation Pension Plan Trustees in 1980-81 be the then President-Elect, Treasurer, and Executive Vice-President.

That the First Quarter operating budget for 1981 be set at one-quarter of the 1980 budget, for operational purposes only.

That the Federation continue to pay (in 1980-81) certain transportation expenses (round trip air coach fare from home city to meeting city) as follows: (1) To all members of the Board of Directors and Executive Committee who attend their meetings, except any held in conjunction with the Annual Meeting; (2) To specified members of Federation committees to attend their meetings (those held during the Annual Meeting excluded) but only when funds to cover these meetings have been appropriated by the Executive Committee; (3) To Past-Presidents of the Federation who attend the Board of Directors meeting held during the Annual Meeting.

That the Federation continue to pay (in 1980-81) the complete travel expenses (within the budget) of Federation officers and the Immediate Past-President on matters of official Federation business. Also, that the Executive Committee deem it appropriate and in the best interests of the Federation that spouses accompany the officers on certain Executive Committee-approved travel during the year at the expense of the Federation.

That the Investment Committee be commended for the efficient and expeditious handling of the transfer of the Federation's Investment Trust Fund.

That the authors of the Correspondence Course at the University of Southern Mississippi be urged to keep pace with the timetable for preparation of the course, as outlined in the contract.

That any Executive Committee action to purchase Directors/Officers indemnification insurance be tabled.

That Helen Skowronka be commended for her fine work in compiling and preparing the bibliography on "Technical Uses of Computers in the Paint Industry."

That the Chairman of the Investment Committee be an automatic member of the Finance Committee and that the descriptions of each committee be revised accordingly.

That the Federation advise its Mexico Society that it will visit them on a biennial basis, provided that arrangements can be made to meet with the Society's Executive Committee and general membership.

That Robert Ziegler be promoted to Editor of the JCT.

That annual salary adjustments for staff become effective with the next regularly-scheduled two-week pay period following the fall Executive Committee meeting at which they are approved.

Old Business

INVESTMENT TRUST

The Federation's investment trust had been moved from Pittsburgh to the Girard Bank in Philadelphia, in July 1980.

The bank's recommendations for the investment of the Federation's funds were discussed and upon motion by Mr. Davidson, seconded by Mr. Filchak and approved, the Board recommended to the Executive Committee that the Federation's investments follow Girard Bank's recommendations dated August 27, 1980.

Mr. Malaga commended the Investment Committee for the expeditious handling of the transfer of the trust.

AD HOC COMMITTEE ON PRI

As announced at the previous Board meeting, President Larson appointed an ad hoc committee to study the Paint Research Institute. The committee will look at the programming, funding, and administration of PRI for the purpose of finding ways to make PRI a more effective research arm of the Federation.

The Board of Directors recommended that the Federation President write a letter to all Societies and request their constructive criticisms of PRI. New ideas and suggestions for research projects are welcome. President Larson urged each Society to devote some discussion time to PRI and to respond to the President's letter.

Members of the ad hoc committee (Past-Presidents James A. McCormick, Newell P. Beckwith, Neil S. Estrada, Milton A.

Glaser, and John J. Oates) plan visits to the Societies for the purpose of discussing PRI at both the executive and general meetings.

FUTURE AM&PS SCHEDULE

Mr. Borrelle reiterated, from his report to the Board, that the Federation's needs for the Annual Meeting and Paint Show are such that it must book cities several years in advance and that now is the time to set the schedule for the complete 1980's.

Since the National Paint and Coatings Association had not officially responded to the Federation's May 16th letter regarding a split in the annual conventions, it can be assumed that the NPCA (however reluctant) had accepted the Federation's position in this matter.

This was confirmed, Mr. Borrelle continued, at the NPCA Board of Directors meeting held two days prior in Atlanta. President Larson and Mr. Borrelle attended the meeting at which the NPCA Board approved their own dates and locations for 1985, 1986, 1987, 1988, and 1989.

Since the May meeting of the Federation Board, Mr. Borrelle said he had been seeking cities for the future with the timing of the AM&PS (when separate from NPCA) to be as early in October as possible.

He then requested the Board to approve the following dates and cities:

1985—First week in October, St. Louis. (NPCA will be in New Orleans, Nov. 3-6).

1986—Second week of October, Chicago. (NPCA will be in Washington, Oct. 27-29).

1987—First week of October, Dallas. (NPCA will be in San Francisco, Oct. 19-21).

1988—First week in October, Kansas City. (NPCA will also be in Kansas City, Oct. 29-Nov. 1).

1989—First week in October, New Orleans. (NPCA will be in Washington, Oct. 28-31).

The Board of Directors approved the above cities and dates with the specific days of the week to be confirmed later by Mr. Borrelle.

(The Federation and NPCA will be together in: 1981—Detroit; 1982—Washington; 1984—Chicago; 1988—Chicago. In 1983, the Federation will be Montreal; NPCA in Los Angeles. NPCA will be in San Francisco, 1987.)

New Business

FEDERATION HONORARY MEMBERSHIP FOR PAST-PRESIDENT HOWARD G. SHOLL

Howard G. Sholl, a Past-President of the Federation (1958-59) and the Baltimore Society, had been proposed by the Society for Federation Honorary Membership. As specified in Standing Rules II, the Secretaries of each Society and the Board of Directors were advised of the nomination.

By unanimous vote, the Board of Directors elected Mr. Sholl a Federation Honorary Member.

ROLL OF HONOR FOR PAST-PRESIDENT JEAN P. TEAS

Jean P. Teas, a Past-President of the Federation (1971-72) was proposed by the Cleveland Society for Federation Honorary Membership. The Societies and Board were advised accordingly.

Unfortunately, Mr. Teas died on September 26, 1980.

Therefore, the Board of Directors unanimously elected Mr. Teas to the Federation's Roll of Honor.

Committee Reports

A.F. VOSS/AMERICAN PAINT JOURNAL AWARDS

Although six Societies advised their intent to present papers at the 1980 Annual Meeting, only five were finally submitted. Of these, the three selected as award winners were:

FIRST PRIZE (\$200)—"Renewable Resources for the Coatings Industry: Part I—What and Where"—Chicago Society.

SECOND PRIZE (\$175)—"Flash Rust Inhibitors: An Evaluation of Some Amines and Organic Salts in an Aqueous Acrylic Coating"—New England Society.

THIRD PRIZE (\$125)—"Corrosion Inhibitive Performance of Some Commercial Water-Reducible Nontoxic Primers"—Golden Gate Society.

It is hoped that the rejuvenation of the Technical Advisory Committee results in an increase in the number of papers to be presented by Societies in future years. Looking back a decade, there were 11 papers in 1969, 14 in 1970, and 11 in 1971.

A cutback in R&D funding is part of the reason for this decline; however, more encouragement is needed to increase the dedication of all Society Technical Committees.

HORACE PHILIPP,
Chairman

CORROSION

A one-day meeting of the Corrosion Committee was held May 8, 1980, in Washington, D.C. Those in attendance were as follows: Saul Spindel (Chairman), Dean Berger, Arnold Eickhoff, William Johnson, Richard Max, Raymond Myers, Deryk Pawsey, Horace Philipp, Lothar Sander, Armand Stolte, and Thomas Kocis (Federation).

At the outset it was noted that Corrosion Committee meetings have usually been held in conjunction with the Federation Annual Meeting, but have not provided ample opportunity for a full dialogue because of the constraints of time and other commitments. Therefore, this meeting was scheduled to afford sufficient opportunity to delineate aims and goals to best address the many aspects of corrosion and its ramifications for the coatings industry, in keeping with the Committee duties as detailed in the Federation Year Book.

In the discussions at the meeting, major emphasis focused on: sponsoring corrosion-related presentations for Federation Annual Meeting programming; project suggestions for Society Technical Committee undertaking; liaison with other organizations; and promotion of interest in corrosion control among Federation members.

ANNUAL MEETING PROGRAM PRESENTATIONS

The committee recommended that the subject of corrosion be addressed on a regular basis at Federation Annual Meetings, and that the Corrosion Committee should be consulted for suggestions. For the 1981 Federation Annual Meeting, recommended topics were: "The Fundamentals of Corrosion"; and "The History of Corrosion Problems in Auto, Sheet and Structural Steel."

It was felt that these topics would be of widest interest to the Federation membership.

SOCIETY TECHNICAL COMMITTEE PROJECTS

A number of Society Technical Committee Chairmen have expressed interest in pursuing projects on corrosion and its control; however, they have experienced difficulty in pinpointing specific areas in which to work. Accordingly, the Federation's Technical Advisory Committee asked the Corrosion Committee for recommendations.

After considering a number of potential project suggestions, the Committee recommended the following: Non-corrosive pigments in aqueous and non-aqueous systems; Repainting of exterior steel; Water-based vehicles in corrosion inhibitive coatings; Effect of surface preparation on coatings performance; and Painting over zinc.

These suggestions were forwarded to the Technical Advisory Committee.

LIAISON

The Federation has, for some years, maintained close liaison with the National Association of Corrosion Engineers and the Steel Structures Painting Council. This liaison has been fruitful, and the committee endorses its continuance.

Further, the committee believes delegate representation should be established with other industry groups who are also involved in corrosion control activity, e.g., National Coil Coaters Association, Organic Chemistry Division of American Chemical Society, etc.

Liaison with these groups will be pursued and discussed further at the next committee meeting.

PROMOTING INTEREST IN CORROSION CONTROL

In order to generate greater interest in corrosion and its control, it was recommended that initial effort should focus on publication of informational items on such topics in the *JOURNAL OF COATINGS TECHNOLOGY*. Committee members will forward this information to Federation headquarters.

In addition, committee members agreed to watch for significant papers on corrosion that appear in such publications as the American Chemical Society's preprint booklet, which they feel should be recommended for reprinting in the *JCT*.

SAUL SPINDEL,
Chairman

EDUCATION

The Editorial Review Board (ERB) for the FSCT/USM Correspondence Course in Coatings Technology held an organization meeting at the University of Southern Mississippi on January 17, 1980. At this meeting, preliminary goals were established and responsibilities assigned. It was decided that all members of the ERB would receive copies of all chapters as they are completed, but only the designated reviewing specialists would be obligated to return their comments. These special reviewers are to try to get their suggestions to the chapter author within two weeks of receipt and *must* get them back to USM within a month of receipt. All chapters of the first course were scheduled for completion by September 1981. All members of the ERB are encouraged to make comments on all chapters as they receive them. A second meeting was scheduled for June 20 at Atlanta. Progress on chapter writing lagged behind schedule to such an extent that the June meeting was rescheduled to August 7. This meeting was mostly concerned with the fact that the actual production of finished chapters for review was seriously behind the schedule that had been suggested. Chapter authors were requested to make up the deficits as rapidly as possible, the completion goal was changed to, "late 1981" and another meeting scheduled for December 2, 1980, in St. Louis.

A general meeting of the Education Committee was held on April 17 at Louisville. Progress, ideas, problems and suggestions were shared by all members. Special interest was shown in the educational efforts of the Golden Gate, Los Angeles, New York, Chicago, Louisville, and Detroit Societies, which are doing a great deal, in different ways, to help their members advance in knowledge and ability. The Kansas City, St. Louis, and Pittsburgh Societies continue to work at the high school level to interest teachers and students in coatings as a career.

A rough draft of a paper concerning coatings as a career was circulated for comment. It was suggested that some slides or other visual aids would make it more effective and more adaptable for use by the various Societies in their contacts with local high schools and community colleges. These visual aids will be prepared as the paper is completed.

The 1980 compilation of educational courses, conferences and seminars was displayed. All members were urged to keep the Federation informed of their local offerings so the list can be kept complete and up-to-date.

Several of the "Federation Series on Coatings Technology" are in process of revision and two more are being written. No tentative dates have been proposed for these.

It was decided that general meetings of all members of the Education Committee, with some time allowed for short regional meetings, were more productive than the system of having a general meeting one year and regional meetings on alternate years. In accordance with this, a general meeting will be planned for 1981.

JOHN A. GORDON,
Chairman

ENVIRONMENTAL CONTROL

The Environmental Control Committee was responsible for a newsletter that was issued in June 1980 covering the regulations issued by the Environmental Protection Agency on May 19, 1980 for Hazardous Waste and Management Consolidated Permit Application Forms required by the Resource Conservation and Recovery Act of 1976. Because the proposed regulations are complicated, a discussion of them will be part of the Annual Meeting Program.

EPA has indicated that there will be more questions on these regulations as some of them were designated as interim-final and not final-final on May 19, 1980. The Coatings Industry must be prepared to meet these regulations no later than November 19, 1980.

While everyone is concerned with disposal of waste or "where do we get rid of this stuff", the other facet which the Federation should be considering is "recycling". Not only is this consideration required by the Federation, but each of our local Societies should consider the problem. EPA hopes that RCRA will be administered by the states, and it is doubtful that all 50 states will have 50 sets of regulations that are exactly the same.

Looming in the near future are regulations that will be issued by the Occupational Safety and Health Administration and the Environmental Protection Agency covering the labeling of materials supplied by you to the workplace and the materials used by you in the workplace that can be considered acute and/or chronic hazards. We have received some information about what may be proposed but no guarantee that this will be the actual proposal. It was expected that these would be issued before election day as a concession to the unions. Be prepared for something in the near future.

The Environmental Committee will continue to serve the Federation. What we need is more requests for our services.

S. LEONARD DAVIDSON,
Chairman

INTER-SOCIETY COLOR COUNCIL

Planning continues for the upcoming (March 24-25, 1981) Symposium on Color and Appearance Instrumentation (SCAI-2) to be held in Louisville. In these turbulent economic times, we are fortunate that only one speaker has had to withdraw from the program. Thus, we have 15 commitments out of 16 possible slots. If necessary, the symposium can easily adjust to containing only 15 papers.

This year, the Dry Color Manufacturers Association (DCMA) Award Subcommittee chose not to make an award.

With next year's SCAI-2, I am sure that there will be an award in 1981, and I expect that the subcommittee will have a difficult time choosing among so many fine papers.

My own situation has changed during 1980, as I changed my place of employment during June. Since my new position removes me directly from the field of color, I felt that it was proper to resign the chairmanship of this committee. During the Annual Meeting in Atlanta, I will transfer the chair to Dennis Osmer, of the CIBA-GEIGY Corp. Dennis has served on the ISCC Committee for a number of years, and is totally familiar with its workings. I am sure that under his leadership, SCAI-2 will be a rousing success and the ISCC Committee will continue to be a credit to the Federation.

R. T. MARCUS,
Chairman

MANUFACTURING

As mentioned in the Spring Report the Steering Committee met January 23. One of the major items of discussion was the seminar on "Safety" to be presented at the Annual Meeting in Atlanta.

A second meeting was held April 29, to complete the details for the Safety Seminar. Gil Cain, of Hercules, who will be moderator for the session, attended the meeting and assisted in the planning. Carroll Scholle and Richard Max, of the Steering Committee, obtained Gabe Malkin and Francis Gaughan as speakers. The other speakers will be Gil Cain and Nelson Lamb, of Hercules.

The slide tape titled "Introduction To Resin Operations," prepared by the Manufacturing Committee of the Toronto Society, has been reviewed and edited. The finished product will be displayed at the Federation booth at this convention.

There are three other slide/tapes that are worthwhile and we have encouraged the respective Societies to update the programs. The programs are: (1) Sand Mill Operation (Kansas City); (2) Cartridge Straining (Houston); and (3) MSM Filling Machine (New York).

Dick Stewart, of the Pacific Northwest Society, attended our April 29 meeting. The PNW Society project on the "In-Plant Materials Handling Data Sheet" was discussed. The committee agreed that: (1) the project was worthwhile; (2) the data would have to be continually updated to comply with regulatory requirements. The committee offered its continued assistance.

Richard Max has developed a talk on computer applications in the paint plant, which he will present at Society meetings if requested.

The work of the Steering Committee has been proceeding nicely. It is now time that the committee could be strengthened by the addition of a few new members from other Societies. If there are any interested members, have them contact the Chairman.

DONALD J. FRITZ,
Chairman

PUBLICATIONS

The Publications Committee and Editorial Review Board were reviewed, and changes and new additions were made where required. We have been more effective in reducing some backlogs and times for reviews. The Roon Papers and Annual Meeting papers have been reviewed in an orderly fashion.

Recommendations of the Publications Committee Meeting have been followed up. A new column has been added to reflect the lighter side of technology. Plans are underway to hold a meeting of the Publications Committee early in 1981.

Educational booklets are being revised and new ones solicited as required.

We have reviewed key meetings and symposia and requested submission of appropriate manuscripts.

THOMAS J. MIRANDA,
Chairman

ROON AWARDS

Winners in the 1980 competition were:

FIRST PRIZE (\$800)—"Kinetic Parameter Considerations for Maximizing Stability and Minimizing Cure Temperature of Thermosetting Coatings. Sulfonium Salts as Latent Thermal Initiators for Cationic Polymerization"—S. Peter Pappas and Loren W. Hill, North Dakota State University, Fargo, ND.

SECOND PRIZE (\$450)—"A Computer Method for Predicting Evaporation of Multicomponent Aqueous Solvent Blends at Any Humidity"—Albert L. Rocklin and David C. Bonner, Shell Development Co., Houston, TX.

THIRD PRIZE (\$300)—"Primary Amine Zwitterion Copolymers"—Zeno W. Wicks, Jr. and Chiew-Wah Koay, of North Dakota State University, Fargo, ND.

FOURTH PRIZE (\$200)—"Synthesis of Blocked MDI Adducts, Their DSC Evaluation and Effect on Pigmentation"—Taki J. Anagnostou, Wyandotte Paint Products Co., Troy, MI, and Ernest Jaul, Union Carbide Corp., S. Charleston, WV.

UMBERTO ANCONA,
Chairman

TECHNICAL INFORMATION SYSTEMS

The Technical Information Systems Committee has engaged in the following projects:

(1) Compilation of bibliography on "Technical Computer Applications in the Coatings Industry"—This bibliography was compiled for distribution by the Federation at the June 1980 meeting of the International Committee for Coordinating Activities of Technical Groups in the Coatings Industry (ICC), and will be published in the JOURNAL OF COATINGS TECHNOLOGY. [See November 1980 JCT—Ed.]

(2) Planning a half-day program at the FSCT Annual Meeting—The bibliography on technical computer applications served as the theme for the TISCO-sponsored session, at which five speakers will discuss computer applications in formulation, manufacture, and color formulation and matching in the coatings industry as well as on-line computer searching of external data bases and the bibliography itself.

(3) "Technical Articles in Other Publications"—The committee continues to submit contents of coatings periodicals for publication in the JCT under the heading of "Technical Articles in Other Publications."

(4) Preparation of the Annual Subject/Keyword Index to JCT—For the fourth year, the Committee is preparing the Annual Keyword Index to JCT.

HELEN SKOWRONSKA,
Chairman

DELEGATE TO NPCA AND GOVERNMENTAL AGENCIES (Environmental Control)

As most of the activities that concern the coatings industry in the field of regulations have been directed to regulations based on the Clean Water Act of 1977 and the Resource Conservation Act of 1977, your delegate has been a part of the NPCA Task Force on Water Quality/Waste Management.

Several meetings have been held by this task force to present the industry's positions on regulations covering the discharge of waste water and to provide information for the Environmental Protection Agency to have latex paint wastes deleted from the list of toxic wastes.

Your delegate also serves on the Labeling Committee of the NPCA which prepared a second edition of the Labeling Guide. At the present time the Labeling Committee is considering the regulations proposed by the Environmental Protection Agency under its authority of the Toxic Substances Control Act.

Your delegate will continue to attend those meetings and participate in their activities so that liaison between the NPCA and the FSCT can be maximized.

S. LEONARD DAVIDSON,
Delegate

DELEGATE TO SSPC

The meeting of the Steel Structures Painting Council (SSPC), held June 3-5, was attended by 128 men and women, of whom 41 are members of the Federation. It is interesting to note that Federation members are officers of 20 out of the 30 active Advisory Committees and Subcommittees.

Advisory Committee Meetings

- (1) *PACE*. Chairman—William C. Johnson (Philadelphia). Confidentiality restrictions have been removed from most materials in the tables of the new PACE report on Phase I.

PACE is going into Phase II. It was agreed that, although confidentiality will be respected as much as possible, at least the following information is to be submitted with all test samples:

- (1) Generic classification
- (2) VOC (volatile organic compounds) concentration
- (3) Lead and chromate content

Another coating study will start in 18 months. In the meantime, SSPC will investigate surface preparation by wet blasting, pickling, the 3M method and the use of inhibitors.

The next PACE report will be issued about the end of 1981. This will include new data from Phase I and the initial data from Phase 2.

- (2) *Tank Painting*. Chairman—W. Wallace. Tank painting has become more difficult and expensive due to federal and state (especially EPA and OSHA) resistance to certain types of coatings.

The committee will consider PACE participation, collection of case histories and establishing an informational regulatory subcommittee.

The Tank Painting chapter has been written (Vol. 1) and is being reviewed.

- (3) *Volume 1 Revision*. Chairman—Dean M. Berger (Philadelphia). All but five chapters are either ready or almost ready-for-print.
- (4) *Volume 2 Revision*. Chairman—A. Levy; Secretary—Sidney Lauren (Cleveland). The volume has been divided into six sections: (1) How to use Volume 2; (2) Painting Systems—Discussion and specifications; (3) Paints—Discussion and specifications; (4) Surface Preparation—Discussion and specifications; (5) Pretreatment—Discussion and specifications; and (6) Paint application—Specifications: PA-1 Application, PA-2 Film thickness measurement, PA-3 Safety.

Drafts of the various sections are under review.

A third volume, Volume 3, was considered as a reference source for procurement documents, i.e., a Specification Guide. This will be considered for possible completion by late 1980.

- (5) *Surface Preparation*. Co-Chairmen—K. Trimber and J. Flaherty. The latest specification drafts were reviewed and modified.

The committee will consider new specifications: (1) Water blast cleaning; (2) Hand and power tool cleaning with elimination of all mill scale and rust; (3) Cleaning of contaminated surfaces.

Also visual references and profile measurement.

The Surface Preparation Guide is being revised and should be ready in late 1980.

- (6) *Water-Borne Epoxies*. Chairman—Edward G. Bozzi (New York); Secretary—L. Holley. 30 samples of paint systems are being submitted for PACE evaluation. However, application data has been insufficient and has been requested from cooperators. Suppliers will also submit data on generic type, VOC concentration and pigmentation.

Panels will be exposed at various outdoor locations. The 3,000 hour salt fog exposure test should be completed by the end of 1980.

- (7) *Latex Paints for Steel*. Chairman—Arnold J. Eickhoff (New York). Specifications have been completed for: (1) Latex primer, (2) Latex semi-gloss topcoat, (3) 3 coat paint system.

Paint systems of various qualities will be selected for PACE evaluation: (1) Poor durability, (2) Moderate durability, (3) Excellent durability—to determine the effectiveness of the specifications.

- (8) *Water-Miscible Coatings*. Chairman—Clifford F. Dukes (Louisville); Secretary—W. Kurnick. This committee is tentative depending on the interest of the industry. Work will be limited to commercially available air drying paint systems based on water-miscible: Alkyds, Uralkyds, Epoxy esters, Acrylics.

Literature and samples will be solicited from raw material suppliers and paint manufacturers for evaluation in the PACE program.

- (9) *Zinc-Rich Topcoating*. Chairman—Walter Pregmon (Philadelphia). The scope of the guide has been changed to "Proper Application of a topcoat over Zinc-Rich primers for non-immersion service." The last draft of the guide was reviewed and modified.
- (10) *Zinc-Rich Performance Specifications*. Chairman—G. Everts; Secretary—Arthur L. Cunningham (Chicago). Draft #2 of the proposed specification was reviewed and modified. A round-robin test will be conducted to determine the parameters for the proposed specification.

- (11) *Zinc-Rich Revision of SSPC-PS 12.00*. Chairman—Kenneth B. Tator (Pittsburgh). The title of the guide will be "Zinc-Rich Coating Systems". The guide will also include a definition section. Various paragraphs of the guide were assigned for review and revision. It is hoped that the complete draft will be ready for review at the January meeting.

- (12) *Low-Cost Shop Paint*. Chairman—William C. Spangenburg (Pittsburgh). Review of SSPC-PS 13.00 was continued. It will be rewritten as a performance specification. It is anticipated that a draft will be ready by the January meeting.

- (13) *Urethane Coatings*. Chairman—C. Bye. Draft #16 of the "Guide to Urethane Systems for Structural Steel" was reviewed. It is ready for submission to Executive Committee ballot.

Individuals, not the committee, will cooperate in the PACE project. Variations in polyols and polyesters are too great to enable a combined committee effort in this program.

- (14) *Epoxy Coatings*. Chairman—Dean M. Berger (Philadelphia). The specifications for the paint and paint system were reviewed and minor editorial changes made. Both are now ready for balloting by the SSPC Research Committee.

Committee members will cooperate with the PACE and Water-Borne Epoxy committees.

- (15) *Vinyl Coatings*. Chairman—Thomas Ginsberg (New York); Secretary—Robert J. Martell (New England). Action was completed on Specifications SSPC—Paint 8, SSPC—Paint 9, and SSPC—Paint 106, SSPC—PS 4.00 through PS 4.05 will be reviewed by mail in order to meet the December 1980 deadline for completion of review of Volume 2. The committee will consider developing a specification for a high-build, high-solids vinyl system.
- (16) *Coal Tar Epoxy*. Chairman—Henry R. Stoner (New York); Act. Secy—P. Hergenrother. Draft #3 of Specification SSPC Paint No. 16 was reviewed with specific reference to a Safety section. This must be clarified by legal counsel before the specification can be published. Draft #1 of the SSPC Standard Safety and Waiver Clause was reviewed and discussed. Future specifications for consideration are high solids, solvent free and water reducible coal tar epoxies.

Other Advisory Committee Reports

- (1) *Aluminum Pigmented Coatings*. Chairman—J. Williams; Secretary—Karl P. Karsten (Pittsburgh). The specification for thixotropic aluminum coating, SSPC Paint X A1 1X-79P has been accepted by the SSPC Executive Committee and is ready for printing. The committee, in conjunction with the Aluminum Association Technical Committee on Powders and Pigments, has completed a program to calculate potential energy savings by the use of aluminum coatings. A draft of the report has been submitted to committee members for review. The committee is considering a joint program with SSPC and Carnegie Mellon Institute of Research to investigate the effect of aluminum in zinc-rich paints.
- (2) *Silicone Alkyd Paints*. Chairman—William A. Finzel (Detroit). The specifications for silicone alkyd paints and paint systems have been improved. The committee will cooperate in obtaining water-borne silicone alkyd paints for the PACE projects.
- (3) *Chlorinated Rubber*. Chairman—Henry R. Stoner (New York); Secretary—R. Wint. The last draft of the Guide for Selecting Chlorinated Rubber Systems, SSPC—Paint System No. 15.00, was reviewed and approved. A proposed SSPC Standard Safety and Waiver Document was reviewed. Comments will be submitted to SSPC. Federal Specification TT-P-1046 "Chlorinated Rubber Zinc-Rich Primer" was reviewed. It was agreed to recommend that surface preparation equal to commercial blast cleaning, i.e., SSPC-SP6, be specified to improve performance. Specification SSPC—Paint 17-78T, Chlorinated Rubber Inhibitive Primer, will have to be revised to eliminate lead from the control formula. A round-robin will be conducted to develop the necessary data.
- (4) *Surface Preparation Profile*. Chairman—L. Schwab. The PACE salt fog test will end at 9,000 hours. SSPC has 60 panels exposed at Kure Beach and 60 panels exposed in an industrial environment. In addition, 180 Navy test panels are exposed in a severe marine environment in the Pacific. The next inspection will be in the Fall of 1980.
- (5) *Maintenance Painting*. Chairman—M. O'Connor. Draft No. 4 of "Guide to Maintenance Painting with Conventional Paint Systems" is being reviewed and modified by the committee and the SSPC staff.

- (6) *Performance Specifications*. Chairman—H. Elsasser. A questionnaire will be distributed to SSPC members soliciting ideas and data in an effort to develop a general performance specification.

- (7) *New Surface Preparation Methods*. Chairman—V. Williams. A general scheme for classification has been reviewed and adopted. A literature search for new methods is an on-going program with new literature being sent to the chairman and SSPC. Presentations on new methods are given at SSPC meetings, when available.

- (8) *Education*. Chairman—J. Oechsle; Vice-Chairman—Kenneth B. Tator (Pittsburgh). This is essentially handled by SSPC.

SIDNEY B. LEVINSON,
Delegate

Society Reports

At the Spring 1980 Board of Directors meeting, a policy was established which requested that annual Society Reports summarize current Society activities and problems, and offer constructive suggestions for the improvement of Federation service and activities.

These reports were presented at the current Board meeting and complete copies were distributed to every member of the Board. Following are pertinent highlights for 1979-80.

Baltimore

Society membership expressed concern over the Paint Research Institute's viability, and a vote was made to withhold financial support from the PRI until tangible improvements are made in the administration, finance, and technical management of its programs. . . . Complimented the FSCT Technical Steering Committee for its activities. . . . Education Committee awarded scholarships, and is considering the establishment of a local college level coatings program to augment Correspondence Course of Federation. . . . In cooperation with the Piedmont Society, established a Virginia Section which will operate under the auspices of the Baltimore Society.

Birmingham

Requested that all correspondence with Club be via air mail due to the length of time taken by surface mail. . . . JCT should feature more papers in the areas of practical production and management.

Chicago

Areas of concern during the year include: difficulty in meeting all members' needs because of the size of the Society; indemnification of Society officers; effective communication with committee chairmen outside the Society; and the justification of continued financial support for PRI.

C-D-I-C

An analysis of meeting attendance was conducted and a questionnaire was sent to the membership to determine the drop in membership activity. Co-chairmen of large committees were selected in major cities of Society in an effort to increase involvement.

Cleveland

Held 23rd Cleveland Society Symposium, conducted in four sessions: Recent Developments in Deposition Technology; High-Performance Technologies; Corrosion Concepts and

Analysis; and Low Temperature/ Ambient Cure. Initiated cash award for best paper during Symposium. Attendance was 116 . . . Education Committee participated in local science fair with the awarding of two \$100 prizes; Nine members served as lecturers at Kent State coatings course; Established \$1800 scholarship fund for members use at Kent State coatings courses . . . Continued PRI matching funds program for fourth year . . . Presented Society's Award of Merit to Dr. John C. Weaver.

Dallas

Increased membership: 91 Active, 33 Associate . . . Sponsored seminar on Latex Flat Formulation . . . Hosted Southwestern Paint Convention . . . Cooperated with Dallas PCA in establishing junior college program for paint technology; made scholarship donation to University of Southern Mississippi . . . Manufacturing Committee conducting work in Hazardous Material Handling.

Detroit

Society experiencing loss of support from automotive-related companies because of economic downturn . . . Have expressed concern over perception of PRI programs not relating to Society needs . . . Courses sponsored at University of Detroit drawing fewer attendees due to local economic climate.

Golden Gate

Society will conduct three coatings courses and six plant tours during 1980-81; Established Fred Apfel Scholarship Awards which were presented to three children of Society members . . . Manufacturing Committee conducted seminar, "Manufacturing Aid of the Decade," with 81 in attendance . . . Elected first Associate member to Society Presidency . . . Areas of concern include: late mail delivery of JCT; relativity of PRI projects to average Society member.

Los Angeles

Continued conducting course in paint technology at Los Angeles Trade Technical College; Revised scholarship program, awarded one \$2,000 scholarship for 1981-82 year . . . Manufacturing Committee conducted seminar on "Waste Disposal, Energy Conservation, and Filtration" . . . Two current technical projects are: Color as a Function of Viewing Angle; Corrosion Inhibition of Treated Extender Pigments in Aqueous Systems.

Louisville

Held joint meetings with Louisville PCA . . . Average year's attendance at meetings was 80-85 . . . Participated as a member of Louisville Coatings Waste Disposal Association by conducting a survey on the amounts, types, and disposal methods of waste of local paint manufacturers . . . Held successful symposium on "Compliance with Government Regulations and Hazardous Waste Disposal" . . . Believes that FSCT sponsorship of joint research projects among Societies would be more efficient.

Mexico

Conducted one-day seminar on "Resins" . . . Voted that Associate members may be elected to officer positions.

Montreal

Held 13th annual Joint Symposium with Toronto Society . . . Education Committee continued to conduct the Introductory Coatings Technology course . . . Planning for the 50th Anniversary celebration of the Society in May 1981.

New England

Sponsored regional trade show and conducted seminar . . . Suggestions include: reorganization of PRI; better communication with NPCA; and creation of a committee to study the admission of Associate Members to full status in the Federation.

New York

Allowed Associate Members full voting privileges and Board of Directors offices . . . Reinstated Laboratory Technicians Program . . . Continuing efforts to activate Technical Committee.

Northwestern

Held symposium on "Emission Regulations Update" . . . Urge continuation of FSCT Society Officers Meetings.

Pacific Northwest

Revised by-laws to permit Associate Members to vote on all issues and to hold all offices with the exception of Society Representative . . . Concern was expressed that the Correspondence Course will truly relate to the practical needs of the industry . . . Active involvement in the Environmental Control Committee, jointly with Puget Sound PCA and state and federal agencies.

Philadelphia

Experienced 18% decrease in Active membership in last 5 years . . . Technical Committee is continuing monthly dinner meeting programs.

Piedmont

After five years' effort, Society established co-op educational program at University of North Carolina in Greensboro . . . Working with Piedmont PCA and local trade associations in the evaluation of EPA guidelines and compliance with hazardous waste disposal regulations . . . The nature of the specialized furniture coating industry and the extreme competitiveness of coatings manufacturers in the Piedmont area have prevented the Society from becoming an active participant in many Federation programs. It is hoped that the new education program will encourage more involvement in national projects . . . Amended Society boundaries to allow formation of Virginia Section of Baltimore Society . . . Increased membership to 132.

Pittsburgh

Extended voting and office holding privileges to Associate members . . . Restructured leadership to seven-member Board of Directors . . . Technical Committee working on project, "Flash Point Measurement Errors in Water-Based Paints" . . . Presented two awards at local Science Fair.

St. Louis

Increased membership 19% . . . Held successful "Education Night" for local Chemistry teachers . . . Presented awards at local Science Fair . . . Assisted St. Louis University with coatings related courses.

Toronto

Encouraging more membership participation in Educational and Technical Committee projects . . . Held Joint Symposium with Montreal Society.

The next meeting of the Board of Directors will be held on Friday, May 15, 1981, at the Hilton Hotel in Denver.

In Memoriam

We report with deep regret the passing of the following members during the last year:

Baltimore

ROBERT T. PICKET—Retired (McCormick Paint Co.)

Birmingham

MANFRED HESS—Retired (Consultant)

Chicago

OSCAR B. BISHOP—Retired (Imperial Color)

HANS W. BOOS—Federated Paint Co.

CARL L. RYDSTROM—Retired—Soc. Past-Pres.

Cleveland

DR. GEORGE DOMANSKI—Glidden Coatings & Resins

JEAN P. TEAS—Retired (The Flood Co.) Federation
Past-Pres. 1971-72

Detroit

GLENN BITKOWSKI—Valspar Corp.

Houston

JOSEPH E. RUSSELL—Retired (Texas Sol. & Chem. Co.)

Kansas City

HERBERT H. HAAS—Retired—Soc. Past-Pres. (Pratt & Lambert Inc.)

HAROLD KICKER—Retired—Soc. Past-Pres. (Seidlitz Conchemco)

Los Angeles

BEN AVEY—Southern Lacquer

DANIEL A. COPENHAVER—Calsol, Inc.

JAMES J. GARTLAND—Miramar Publishing Co.

GORDON G. HALVERSON—Pacific Coast Chemicals

ROBERT S. HALEY—Emery Industries

RALPH LEFERER—Cyprus Ind. Minerals Co.

THOMAS B. MCENEANY—PVO International

C. H. McLELLAN—Old Colony Paint

EDWARD J. MURPHY—Old Colony Paint

Louisville

OTTO J. MILETI, SR.—Retired—Soc. Honorary Member

HARRY K. STRASSELL, III—Progress Paint Co.—Soc. Historian

Miss MARY K. WEBER—Retired (Hy-Klas Paint, Inc.)

LEO GREISBAUM—Retired—Soc. Past-Pres. (Louisville Varnish Co.)

Montreal

ART EASTMAN—Soc. Past-Pres. (Sico, Inc.)

HY KRENTSER—Retired—Soc. Honorary Member & Past-Pres. (Sherwin-Williams)

D. LAIRD—Retired—Soc. Past-Pres. (C. I. L. Paints)

SLIM MOLE—Retired (Reliance Univ. Ltd.)

FRANK M. O'DEA—Soc. Past-Pres. (Formerly Swing Paints)

New England

VICTOR J. BABEL—Retired—Soc. Past-Pres.

HARRY KELFER—Retired—Soc. Past-Pres. (Sterling-Clark-Lurton Corp.)

FRANK McNULTY—Eagle Can Co.

ROBERT PERRY—Retired—Soc. Past-Pres. (Kyanize Paint, Inc.)

New York

ALEXANDER C. HABER—Retired

HENRY J. STALZER—Retired (National Lead Co.)

GUSTAVE TAUBE—Consultant

DR. MARCUS THAU—Consultant

Northwestern

F. J. CIHAK—Warner Hardware Co.

Pacific Northwest

JOHN BUCKINGER, SR.—Soc. Past-Pres. (Miller Paint Co.)

GUS EHLERS—McCloskey Varnish Co.

ART RODDA—Retired (Rodda Paint Co.)

RICHARD G. SAWYER—Chem Central

JOSEPH W. SMITH—Columbia Paint Co. (Helena, Mont.)

GEORGE C. STANDISH—Rohm & Haas (Canada) Ltd.

Philadelphia

EARL T. FATZINGER—Retired (Reichard Coulston, Inc.)

J. ROGER GARLAND—Soc. Past-Pres. (Gulf & Western Ind.)

JOHN M. LINETTI—IMC Chem. Group, Inc.

FRANK R. ZARKOWSKI—Anglo American Varnish Co.

St. Louis

CECIL E. CRAFT—Don V. Davis Co.

HUGH K. EDWARDS—Hugh K. Edwards Co.

Southern

D. FRANK CONDON—D. F. Condon Co.

CARL L. RYDSTROM—Retired (Norcote Co.)

CARROLL M. SCHOLLE,
Chairman, Memorial Committee



**Symposium
on
Color and Appearance Instrumentation**

**March 24-26, 1981
Executive West Louisville, KY**

Sponsored by

**Federation of Societies for Coatings Technology
Manufacturers Council on Color and Appearance
Inter-Society Color Council**

The 2½-day program will be divided between general sessions and "hands-on" equipment workshop sessions on instrumentation for measuring color and appearance in the coatings industry.

The format is designed to offer a "working meeting" environment, and registrants are invited to bring samples with them.

Manufacturing, production, quality control, and research and development personnel should all benefit from this definitive update on the various aspects of such topics as color measurement, color formulation, gloss and other appearance, and sample preparation.

For complete program details and information on registering, contact FSCT headquarters.

**Federation of Societies for Coatings Technology,
1315 Walnut St., Suite 832, Philadelphia, PA 19107.
(215) 545-1506**

FSCT Co-Sponsored Color Symposium to Feature General Sessions, Workshops, and Equipment Displays

A 2½-day symposium on instrumentation for measuring color and appearance will be held March 24–26 at the Executive West, Louisville, Ky., under the joint sponsorship of the Federation of Societies for Coatings Technology, Manufacturers Council on Color and Appearance, and Inter-Society Color Council.

The program will be divided between paper presentations and “hands-on” workshop sessions, at which the latest color measurement equipment will be displayed.

The first two days will be devoted to morning and afternoon general sessions. These will be followed by four concurrent workshops. Registrants will rotate from one workshop to the next until all have been attended.

A morning general session will be held on the final day.

There will be four workshops: three will feature equipment displays for color formulation, color measurement, and gloss and other appearance measurement; the fourth will be a sample-preparation-and-presentation tutorial.

The workshop format is designed to offer a “working meeting” environment, and *registrants are invited to bring samples with them.*

Attendance will be limited so that registrants will have maximum opportunity for discussions.

Open time will be available for those registrants wishing to pursue additional inspection of equipment on display and for discussions with representatives from the equipment manufacturers.

General program sessions are under the direction of Dennis Osmer, of CIBA-GEIGY Corp. Arrangements for the workshops and instrument displays are being handled by Charles Leete, Executive Director of the Manufacturers Council on Color and Appearance.

Registration fee for the symposium is \$125. This includes two lunches, three continental breakfasts, and five coffee breaks, as well as a copy of the newly-published “Glossary of Color Terms” booklet.

Registration and housing forms are available from Federation of Societies for Coatings Technology, 1315 Walnut Street, Suite 832, Philadelphia, Pa. 19107.

Symposium Program

TUESDAY, MARCH 24
(Morning)

General Session A

“Color Marketing and Consumerism”—Joyce Davenport, DeSoto, Inc., Des Plaines, IL.

“The Experimental Origins of the 1931 CIE System of Colorimetry”—W.D. Wright, Consultant, Radlet, Herts, England.

Workshops

(Afternoon)

General Session B

“Color Communications”—James Davidson, Macbeth Div. of Kollmorgen Corp., Newburgh, NY.

“Black, White, and Everything in Between”—Robert Hillman, Sears, Roebuck and Co., Chicago, IL.

“Evaluation of Coating Appearance—An Overview”—Harry K. Hammond, III, Gardner Laboratory, Div. of Pacific Scientific Co., Bethesda, MD.

Workshops

Instrumentation Clinic

WEDNESDAY, MARCH 25
(Morning)

General Session C

“Precision, Accuracy, and Standardization Requirements of Color-Measuring Instruments”—Charles J. Sherman, The Sherwin-Williams Co., Chicago, IL.

“Collaborative Reference Program for Color and Appearance Measurements: An Eight-Year Performance Report”—Charles G. Leete, Manufacturers Council on Color and Appearance, McLean, VA.

“Difficult Samples to Measure”—Richard Harris, Applied Color Systems, Inc., Princeton, NJ.

(Afternoon)

General Session D

“Use and Misuse of Computers in Color Control”—Hugh R. Davidson, Davidson Colleagues, Tatamy, PA.

“High-Speed On-Line Color Measurement”—Jerry Alford, Ford Aerospace and Communications Corp., Charlotte, NC.

“Color Measurement of Wet Paint”—Don W. Parker, and George M. Lorditch, Macbeth Div. of Kollmorgen Corp., Glenwood, IL.

Workshops

Instrumentation Clinic

THURSDAY, MARCH 26
(Morning)

General Session E

“Pitfalls of Pigment Strength Assessment”—Reinhold William Bartsch, Jr., CIBA-GEIGY Corp., Ardsley, NY.

“Color Difference Assessment”—Fred W. Billmeyer, Jr., Rensselaer Polytechnic Institute, Troy, NY and Danny C. Rich, The Sherwin-Williams Co., Chicago, IL.

General Session F

“Testing for Color—An Analytical Procedure”—A.M. Keay, Harmon Colors Corp., Hawthorne, NJ.

“Education in the Instrumental Measurement of Color and Appearance”—Richard S. Hunter, Hunter Associates Laboratory, Reston, VA.

Abstracts of Papers to be Presented At Color and Appearance Instrumentation Symposium

Color Marketing and Consumerism

Joyce S. Davenport
DeSoto, Inc.
Des Plaines, IL

In recent years we have seen world markets changing virtually overnight and the emergence of new influences and societies. There are few areas where labor costs, inflation, and energy shortages have not taken their toll. In many instances we have had to reevaluate our attitudes regarding merchandising and marketing of products, and with these changes in mind, many marketing analysts and executives believe that color could be the single most identifiable factor influencing sales. In this austere economic climate, marketers can utilize color to motivate sales for a wide variety of products and services.

This may seem to be a clearly defined statement and it would appear a simple task executing this philosophy—but what colors are we to use? Certainly one can choose color, but will it sell the item? No, not if it's the wrong color! An excellently designed product may not generate the sales it should because the color fails to have eye appeal or does not fit appropriately into the area it was designed for.

It is also important for designers and stylists to be aware of what is currently in the market place. Communication between the artistically creative groups and their technically oriented counterparts is essential in order to avoid disastrous mistakes regarding such areas as raw materials and pigment selection. With this information in mind it will be easier to make a knowledgeable decision regarding color selection. It is important to remember that economic, political and social forces affect everyone and everything, including the color palette.

The Experimental Origins of the 1931 CIE System of Colorimetry

W. D. Wright
Consultant
Radlef, Herts, England

In 1931 the Commission Internationale de l'Eclairage (CIE) defined a set of colour matching functions in terms of which colors could be specified on an internationally agreed system of trichromatic colorimetry. This marked the beginning of a new era in color

technology and led to major developments in the color industries during the 50 years since 1931.

With colorimetry now completely caught up in the world of the micro-processor, it is perhaps timely to remind ourselves of how it all began and of what the electronic data of 1981 really mean in relation to the standard human observer of 1931. The standard had to be based on the color matching characteristics of a group of observers from which an average observer could be derived, and this presentation traces the experimental studies from Maxwell (1860) onwards, leading up to the recommendations finally adopted by the CIE. This was primarily an Anglo-American affair, and it was touch-and-go whether agreement could be achieved by 1931. The leading participants in the discussions were Guild (U.K.) and Priest (U.S.A.), with Judd (U.S.A.) in the background, and there was something of a battle between the National Physical Laboratory, in England, and the National Bureau of Standards, in the United States. The author's involvement was merely to provide half the experimental data used to define the standard which he had obtained as a very junior research student at Imperial College in London.

It is planned to have on display some of the historical material (books, papers, reports, etc.) from which the 1931 CIE observer finally emerged.

Color Communications

James G. Davidson
Macbeth Div., Kollmorgen Corp.
Newburgh, NY

What Is Color? This question is often asked by stylists, technicians, and end users. Many times the answer is given in a variety of professional jargon, resulting in confusion, wasted time and effort. The purpose of this presentation is to offer a simple and concise method of answering the question, "What Is Color?"

The content is concerned with the psycho-physical science of colorimetry not the physiology of the eye or of sight. The discussion begins with the definition of the three basic rules of colorimetry: color is relative; color is an aspect of appearance; color is affected by observational conditions. Application of these ground rules results in a color order system for identification of the over 10 million perceptually different colors.

This color order system is based on

three appearance attributes: lightness, hue, and saturation. This provides a common language for both visual and instrumental specification and communication of color from design to manufacture.

Emphasis is placed on the practical "how to" application of the above defined color terminology and methodology.

Black, White and Everything in Between

Robert A. Hillman
Sears, Roebuck and Co.
Chicago, IL

Not too many years ago, all automobiles were black, bed sheeting was white, table linen was white or beige, bathtubs were white, toilet paper was white, and there was only one color for a barn, and that was red. Those were what some people call the "good old days," the days of white porcelain pots with a red band on the top, sitting on a black stove.

It isn't like that anymore. In today's large department stores, there is a proliferation of color. Coppertone, gold, avocado or almond appliances—some of us even have poppy or red. In bed linen and towels, every color under the rainbow is available. Paint comes in thousands of colors. Product identification by color has also become a common practice. The Eastman Kodak Company's yellow film boxes are recognized worldwide.

All is not "rosy," however. This general availability of colored goods has become a consumer's nightmare. People want their homes furnished with merchandise that will "coordinate" when grouped together. Today's consumers want pots that will not clash with their recently purchased stoves. A new carpet color must not clash with that "new sofa" purchased last year, or with the wallpaper that will be purchased next month.

The proliferation of colors has been a nightmare for the modern manufacturer as well as the merchant. Differences in lighting used by designers, manufacturers, retailers and consumers in their homes has caused severe color coordination problems in many areas. This presentation deals with the problems in manufacturing, selling and purchasing color coordinated merchandise, specifically relating to metamerism, color matching and color measurement.

Evaluation of Coating Appearance—An Overview

Harry K. Hammond, III
Gardner Laboratory Div.
Pacific Scientific Co.
Bethesda, MD

Evaluation of appearance can be carried out by eye or instrument. Of course, instrumental data must agree with what the eye sees. Objective measurement requires numbers rather than word descriptions.

Strictly speaking, appearance cannot be measured, but attributes of appearance such as color and gloss are measurable. The degree of sophistication of the measurement technique depends on the application and the ultimate requirements for data.

For standardization of color formulations, spectral reflectances may be desired. For quality control, color differences from target colors are quite sufficient. Simplicity of operation, as well as economic considerations, cause tristimulus colorimeters to be widely used for quality control.

Whether evaluating color or color difference by means of spectrophotometry or colorimetry, the user needs to know the repeatability and reproducibility of his instrumentation. Instrument users need to be aware also that the geometric characteristics of instruments differ, and for this reason results obtained on one type of instrument can differ from those obtained on another type, especially when specimens have different geometric distributions of reflected light.

Instrument standards are also important. They must be provided with accurate calibrations, based on the perfect diffuser, and they must be properly cleaned for use. A dirty standard can only provide "dirty data."

Gloss is sometimes referred to as the fourth dimension of color because the geometric distribution of surface reflected light affects color, particularly when going from a glossy to a mat surface on a dark color.

Measurement of gloss is useful as an evaluation of an appearance parameter, but it is also useful as an index of abrasion or weather resistance of coatings.

Precision, Accuracy, and Standardization Requirements of Color-Measuring Instruments

Charles J. Sherman
The Sherwin-Williams Co.
Chicago, IL

Color-measuring instruments are expected to perform tasks that even the human observer cannot do. Measure-

ments taken at different times and with different instruments are expected to agree with as high an accuracy as direct visual comparison. These seemingly unrealistic demands of instruments are necessary, however, for an effective and efficient instrumental color control program.

At one time short term repeatability to yield accurate color difference measurements of non-metameric samples was the only requirement and indeed the only one that could be attained by instruments. But now with instruments at remote locations and computer color matching programs accessing a common data base, the measurements must also be reproducible. How these requirements grew and the degree to which they are being met in an industrial environment, and the all important role of standardization procedures of color-measuring instruments are discussed.

Collaborative Reference Program for Color and Appearance Measurements: An Eight Year Performance Report

Charles G. Leete
Manufacturers Council on Color and Appearance
McLean, VA

Performance criteria for color measuring instruments is often of major economical importance, particularly where it is essential that different organizations and companies must communicate confidentially about colors and other aspects of appearance.

The Manufacturers Council on Color and Appearance, a non-profit trade association, has sponsored for the past eight years a collaborative reference program on color and appearance test methods. Currently, over 200 laboratories participate in the program with approximately 10 per cent of the participation being from non-U.S. laboratories.

The major objectives of the program are twofold: (1) to provide a means whereby a participating laboratory may periodically check the level and uniformity of its testing in comparison with that of other laboratories; and (2) to improve the reliability of test results both within and among laboratories.

In the program, each participating laboratory selects one or more color and appearance tests from those offered. At the present time the program includes a color and/or difference test and a 60° ASTM gloss test.

Test samples are distributed four times during the program year for each test method. Each participant tests the samples in accordance with instructions

provided and returns the data for analysis. A report is prepared that protects the identity of each participant but includes each laboratory's results and test averages, best values and standard deviations for the group.

A summary comparison is presented showing performance by instrument type for gloss, color and color difference. Problem areas are highlighted for correlation of instruments.

Difficult Samples to Measure

Richard Harris
Applied Color Systems, Inc.
Princeton, NJ

Companies which need consistency in the production of the same colored product are turning to instrumentation. The measurement of samples in these products is critical, because the presentation of the product to a measuring instrument may be very difficult.

Many factors make a sample difficult to measure: the choice of equipment to measure samples may be very difficult. This is because some geometrics may not reproduce a measurement as consistent as possible with some samples; the shapes and other physical properties of some samples may not be easy to present to some instruments; samples may appear easy to measure but because of the orientation of the sample they may produce inconsistent measurements; preparation of a sample is an important part of sample measurement and can be difficult. The preparation should represent end use of a colored product and consistent preparation between operators should be obtained.

This paper assesses the areas which contribute to making a sample difficult to measure.

Use and Misuse of Computers in Color Control

Hugh R. Davidson
Davidson Colleagues
Tatamy, PA

The use of computers for color formulation and control is most successful when good formulation, production methods, and sample preparation principles are followed. Troubles will arise in trying to control a color made with three yellows and white, for example, regardless of what instruments, including the eye, are used. If the texture on a deep blue varies, as another example, no instrumentation can control the color satisfactorily. Computations,

however, can be very useful in identifying the problems and in testing possible solutions.

Good pigment calibrations are essential for good first formulations, but of equal importance is the operators' understanding of what constitutes good formulation for the particular application. In any case, it is unlikely, regardless of how well the pigments are calibrated, that an initial formulation of a high quality coating will be sufficiently close to the standard. A batch correction will have to be made, and it is here that most of the problems in computer color control arise. Production methods, sample preparation, sample measurement, and computer programs become critical. It is here that a "correct" batch add and a "reasonable" batch add may not be the same and that errors in texture may be mistaken for errors in pigmentation.

Examples of these and other computer color control problems are presented.

Color Measurement of Wet Paint

George M. Lorditch
and Don W. Parker
Macbeth Div., Kollmorgen, Corp.
Glenwood, IL

The ability to make color measurements of wet paint affords the possibility of making significant cost reductions in the manufacture of paint.

This paper covers the elimination of panel preparation variables such as film thickness, substrate, and application, the probable increase in tank turnover, and the new spectrophotometric technology that makes wet measurements possible.

Pitfalls of Pigment Strength Assessment

Reinhold William Bartsch, Jr.
CIBA-GEIGY Corp.
Ardslay, NY

This paper covers the pitfalls that arise during pigment strength assessment for quality control, in-house testing, and final acceptance of a finished product.

Included are the factors of pigment assessment problems involving: visual versus instrumental values; ΔE values; laboratory vs. plant production methods; effect of different test methods; technical testing aspects vs. real cost; effect of systems, vehicles, pigment type, pigment/binder, equipment and masstone/tint values; and Basic Evaluation/Q.C./Replacement.

These factors will have an impact on determining pigment strength.

Color-Difference Assessment

Fred W. Billmeyer, Jr.
Rensselaer Polytechnic Institute
Troy, NY
and
Danny C. Rich
The Sherwin-Williams Co.
Chicago, IL

The difficulty of obtaining color differences from instrumental measurements that agree well with visual observations is well known. As stated in earlier papers, the instruments themselves are quite good, but all too often the samples are less than satisfactory, and so far it has not been possible to derive a color-difference equation providing good agreement between differences in color coordinates and perceived color differences. Part of the problem lies in discrepancies between the instrumental and visual conditions: The real observer is not a CIE standard observer. He does not look at the samples under a CIE standard source, and he does not adhere to the same geometry of illumination and view as in the instrument. Another part of the problem is in obtaining adequate visual data on which to base the derivation of a color-difference equation. This is a difficult task, requiring the statistical treatment of many thousands of observations, by many observers, for as many different colors as the equation is designed to account for. The amount of good data available is very small indeed.

Color-difference equations have proliferated until dozens exist, with results which are not interconvertible; many are in widespread use, with no clear favorite, and none demonstrably correlating well, or best, with visual data. To promote uniformity of practice, the CIE in 1976 recommended use of one of two equations, but gave no clear advice as to which was preferred. Further research to develop better equations was encouraged. The directions for such research seem clear, but the methodology is difficult and the task enormous. Recent work at Rensselaer has provided some new methodology and indicated where important simplifications can be made in the experimental studies, but much remains to be done.

Current advice to the paint industry is: (1) In all intercompany or external communications, follow the CIE recommendation, using the CIELAB equation; (2) internally prepare your own samples and do your own experiments to find the equation that works best for you in a particular region of color space, following methods described in the literature; (3) use your selected equations consistently; always specify what is being used; never attempt to interconvert from results of one equation to another by

means of "average" factors; and use the calculated color differences only as aids to visual observations; and (4) support competent research toward better solutions of the problem, by financial contributions through foundations or universities and by cooperating in the production of new bodies of visual data.

Testing for Color—An Analytical Procedure

A. M. Key
Harmon Colors Corp.
Hawthorne, NJ

The preparation and evaluation of colored samples is an analytical procedure, no different than the thousands of analytical processes carried out every day. When considering the significance of a test result, therefore, two basic questions must be answered: (1) how well does the color test reproduce its measurements; and (2) how well does the colored sample represent the material being examined. Too often these questions are avoided when a test for color is involved. With the objective means for color measurement available today, it is possible to establish the degree of confidence that can be given to colored test samples and results.

Experiments involving different test procedures are described in which repeatability and reproducibility were determined in each case by the statistical method known as analysis of variance. With this information the two basic questions can be answered and other useful inferences made.

Education in the Instrumental Measurement of Color and Appearance

Richard S. Hunter
Hunter Associates Laboratory, Inc.
Reston, VA

Appearance is important. More information comes to the individual through his eyes than through all his other senses together. However, people in the process of seeing relate what they see to their knowledge and previous experiences. Seldom do they relate what they see to the actual optical properties of the objects being viewed. To train people to work with optical appearance instrumentally, three types of education are needed.

The first is education to identify the optical dimensions of appearance, their breakdown into attributes, and the bases

of the numerical scales available for the measurement of appearance. Knowledge of these dimensions enables one to relate measured numbers to what he sees. Complete analyses of product appearance are usually too complex and cumbersome to be attempted. Instead, only the specific characteristics important for the product under study are evaluated.

Second is education to provide users familiarity with appearance instrumentation, its proper functioning, and maintenance. The tremendous variety of techniques for obtaining and presenting specimens for measurement is covered here.

Third is education to give knowledge of the optical properties of materials responsible for their appearance. This knowledge enables one who is involved in creating or controlling product color and appearance to know what must be done to his product to achieve a desired final appearance. One can now determine with the modern digital computer what the color of a mixture of materials will be without ever actually making the mixture.

The training courses devoted to the first item, identification of the dimensions and measurement scales for appearance, are probably the most numerous. Also popular are service seminars to train user technicians in the proper care and use of their instruments. Finally, because instruments and computers are progressively taking over the functions of product color formulation, there is active development of education in formulation by the computer using the relationships of optical properties of ingredients to the overall composite product appearance.



Government and Industry

NPCA Cites Respirators as Essential In Industrial Spray Paint Operations

The National Paint and Coatings Association has strongly urged the Occupational Safety and Health Administration (OSHA) to permanently allow industrial spray paint operations to use respiratory protection to shield workers from lead particles which escape into the air.

In comments formally submitted to the U.S. Department of Labor on October 24, NPCA presented evidence showing that respirators are the most economically and technologically feasible way of achieving lead protection standards now required by law.

Last August, the U.S. Supreme Court of Appeals for the District of Columbia ordered OSHA to begin a six month reconsideration of the economic and technical feasibility of new lead exposure standards as applied to paint spray operations and operations in several other industries. Those standards require industry to reduce worker exposure to airborne lead by implementing "engineering and work practices" rather than by providing workers with respirators which consistently have been shown to keep blood lead levels within allowable limits.

OSHA had contended that respirators impair the vision and movement of employees, however, models are now available which protect workers and which are easy and safe to wear, said NPCA.

The Court eventually will decide whether or not the original standard (which includes the requirement that

respiratory protection must be eliminated) is, in fact, feasible. Meanwhile, NPCA will endeavor to convince OSHA that respirators provide the best means of protection for spray painters, and that the standard should be changed accordingly.

NPCA's comments pointed out that because respirators are the only way to keep worker exposure to lead below allowable limits (short of eliminating lead-based pigments altogether), OSHA's disallowing the use of respirators has the effect of banning the future use of lead-containing paints for spray paint operations. This, NPCA explained, would impact significantly and adversely on the color and performance characteristics of coatings used on automobiles, bridges, heavy machinery, and other industrial products.

Furthermore, the Association pointed out that neither Congress or the U.S. Supreme Court have given OSHA an express or implicit authority to ban particular substances from the workplace.

Department of Defense Seeks Participation Of Small Businesses In Innovative Research

The following is a copy of an announcement we received from the Office of the Undersecretary of Defense, Research and Engineering, Washington, D.C.—Ed.

"The Department of Defense, Office of the Under Secretary for Research and Engineering, is considering a new program to increase the participation of small businesses in defense-related innovative high-technology research and development. A source list of small, high-technology business firms is now being compiled for future mailings of program information. Any firm interested in receiving this information should write to: Mr. Hal C. Felsher, Director, Small Business & Economic Utilization Policy Office, Under Secretary of Defense for Research and Engineering, Room 2A 340, Pentagon, Washington, D.C. 20301."

CMA Reports Industrial Energy Conservation

The Chemical Manufacturers Association has reported that 90 chemical companies have reduced their energy consumption an average of 22.7% per unit of output for the 12-month period ending June 30, 1980.

The firms reporting to CMA indicate that reduced operating rates in 1980 have had an adverse effect on conservation.

The total 12-month energy consumption for the reporting companies is about 3.2 quadrillion Btu. The reported energy saving for that period is about 935 trillion Btu which is equivalent to 160 million barrels of crude oil, or nearly 7.5 billion gallons of gasoline.

Proposed Amendments To Federation By-Laws and Standing Rules

The following proposed amendments to the By-Laws and Standing Rules of the Federation of Societies for Coatings Technology will be presented at the Board of Directors meeting on May 15, 1981, in Denver.

• • •

At the Board of Directors meeting of May 15, 1981, the following amendment will be presented for adoption, having been passed for first reading at the October 28, 1980 meeting:

Article III—Organization

WHEREAS an important annual duty of the President is to nominate the Trustees of the Paint Research Institute for election by its Members, who are the Federation Board of Directors, and

WHEREAS this duty is not currently included in the Federation By-Laws, be it

RESOLVED that By-Laws Article III, Section C, Paragraph (1) be amended by adding new sub-section e., as follows:

“e. Nominate annually the Trustees of the Paint Research Institute for election by its Members (Federation Board of Directors).”

At the Board of Directors meeting of May 15, 1981, the following amendment will be presented for first reading:

Standing Rules

Article SR I—Constituent Societies

WHEREAS the Southern Society has requested that the State of Arkansas be included within its boundaries and WHEREAS the Dallas Society has agreed to transfer the State of Arkansas from within its boundaries to the boundaries of the Southern Society, be it

RESOLVED that Standing Rules Article SR I, Section B, be revised as follows:

“*Dallas Society*—That part of the States of Texas and Louisiana lying north of the 31st parallel, plus the entire State of Oklahoma.”

“*Southern Society*—All of the following States: Arkansas, South Carolina, Georgia, Florida, Tennessee, Alabama, Mississippi, and all of Louisiana east of the Mississippi River and south of the 31st parallel.”

Comment: By-Laws Committee recommends adoption.

At the Board of Directors meeting of May 15, 1981, the following amendment will be presented for first reading:

Article VI—Annual Meeting

WHEREAS By-Laws Article III, Section B, Sub Paragraph (1) k specifies that at least two Board meetings be held each year and

WHEREAS By-Laws Article VI deals with only the Annual Meeting, be it

RESOLVED that By-Laws Article VI be amended as follows:

“Article VI—Meetings”

“A. Time, Place, and Program

(1) The Spring Meeting of the Federation Board of Directors shall be held in the second quarter of the year, the exact time and place to be determined by the Board of Directors. This meeting shall include the presentation of reports by Officers and Committees, and a business session.

(2) The Annual Meeting of the Federation shall be held in the last quarter of the year, the exact time and place to be determined by the Board of Directors. The Annual Meeting shall include: the presentation of technical papers and seminars; the Paint Industries' Show; the Fall Board of Directors meeting, at which shall be presented reports by Officers and Committees; the presentation of annual awards; the induction of new officers; and a business session.”

“B. Resolution From the Floor

Any Active Member may propose a resolution addressed to the Federation Board of Directors from the floor during the business sessions of the Federation Board.”

Comment: The By-Laws Committee recommends adoption.

At the Board of Directors meeting of May 15, 1981, the following amendment will be presented for first reading:

Amendment to By-Laws and Standing Rules Re Equal Voting and Office-Holding Privileges

WHEREAS the Pittsburgh Society has proposed that the existing Federation By-Laws and Standing Rules be amended to extend equal voting and office-holding privileges to all Federation members while still maintaining the existing classes of membership, be it

RESOLVED that the Federation By-Laws and Standing Rules be amended wherever applicable in order to extend voting and office-holding privileges to all members, regardless of class of membership.

GUIDE FOR AUTHORS

INTRODUCTION

THE JOURNAL OF COATINGS TECHNOLOGY is published monthly by the Federation of Societies for Coatings Technology. Some 6,500 technical men of the paint industry—associated with 26 Constituent Societies in the United States, Canada, Great Britain, and Mexico—make up the membership of the Federation.

The purpose of the JOURNAL is the advancement of knowledge of the formulation and manufacture of paints, varnishes, lacquers, resins, and related coatings. Its worldwide circulation is about 9,000.

Papers should present new or original data of either a practical or scientific nature. *Papers written in a manner which tends to promote proprietary products are specifically not acceptable.* Papers must meet the standards of the JCT Editorial Review Committee and are accepted with the understanding that they are contributed exclusively to the JOURNAL OF COATINGS TECHNOLOGY and that the material has not been published elsewhere.

The JOURNAL OF COATINGS TECHNOLOGY has first rights to the publication of papers presented at the Annual Meeting of the Federation and at local and regional meetings or symposia of the Constituent Societies. These papers, and others, submitted for publication, must be approved by the JCT Editorial Review Committee, which has authority in all matters affecting the acceptance or rejection of papers and other technical material. Manuscripts not accepted for publication will be returned to the author.

MANUSCRIPT COPIES

GENERAL PAPERS: Four complete copies are required. Send to the Editor, JOURNAL OF COATINGS TECHNOLOGY, 1315 Walnut St., Philadelphia, Pa. 19107.

CONSTITUENT SOCIETY PAPERS (*for presentation at the Annual Meeting*): Ten copies of manuscript are required. They should be mailed as directed in this year's "Guide for Speakers."

ROON FOUNDATION AWARD PAPERS: Seven copies of the manuscript must be sent to the Chairman of the Roon Awards Committee. For complete details, see the "Roon Awards" section of the December 1980 JCT.

MANUSCRIPT PREPARATION AND STYLE

In general, follow the "Handbook for Authors" published by the American Chemical Society Publications, 1155 Sixteenth St., N.W., Washington, D.C. 20036.

Manuscript should be typed, double spaced, on 8½ × 11 paper, typing on one side only with at least one-inch margins around all four sides. Indent paragraphs five spaces.

Title

Keep the title informative, yet as brief as possible consistent with defining the subject matter covered in the paper.

Authors

Give complete names and correct company affiliations and addresses of all authors. A photo (glossy 5 × 7) and brief biographical sketch of each author should be included with the manuscript. Photos should be identified by printing the subject's name on the reverse side, in the margin so as to avoid defacing the photos. Do not clip or staple.

CONSTITUENT SOCIETY PAPERS: Submit names and company affiliations of each member of Technical Committee which prepared paper. Include, if possible, a group photo of committee.

Abstract

A 75-100 word abstract should accompany the manuscript. Avoid exceeding the length, if possible. The abstract, which is published immediately after the by-line and on the abstract pages, should contain an informative, not descriptive, statement concerning the (a) scope, (b) experimental methods, and (c) results or conclusions.

Presentation Data

If the paper has been presented at a monthly or special meeting of a Society for Coatings Technology, or to some other technical group, list the name of the organization and the date of presentation. If someone other than the author presented the paper, this, too, should be noted. Papers presented to associations other than the Federation must be released before they can be considered for publication in the JOURNAL OF COATINGS TECHNOLOGY.

Oral presentations submitted for publication should be rewritten to conform to publication style and format.

Text

This Guide has been prepared in accordance with general publication style, except the type, which is 9 pt. instead of 10 pt. Note the use of subheads. These serve to divide the paper into sections and also to break up the monotonous appearance created by long, continuous lines of type. Use simplicity in word selection whenever consistent with content. Be neither stiff and trite, nor lax, but direct and concise. Include only as much history as necessary to provide background for the particular material covered in the paper.

Metric System

Metric units are to be used wherever applicable and are to be shown in parentheses after the English or other units.

An excellent reference publication for metric conversions is the ASTM Metric Practice Guide (E 380-72) published by the American Society for Testing and Materials, 1916 Race St., Philadelphia, Pa. 19103. A conversion slide, in accordance with E 380-72, is also available.

Tables

Tables should be used sparingly, especially extremely long or wide ones. It is preferred to have tables typed on a separate sheet of paper rather than included in the text. All tables must be referenced in the text, e.g., "see Table 1."

Illustrations

Submit *original* drawings or sharp prints and good, clear glossy photographs. Graphs should be on good quality white, or blue-lined, graph paper. They should not exceed the $8\frac{1}{2} \times 11$ size. Lines or curves should be relatively bold. The ordinate, abscissa, and title should be drawn outside the borders of the graph. Number all illustrations on the back. Captions are usually set in type, so they should be typed all on one separate sheet of paper. All illustrations must be black and white, as color is not acceptable. Slides, also, are not acceptable.

Nomenclature

Follow nomenclature style of *Chemical Abstracts*. Use chemical or common names when meaningful. Where trademarks are helpful for more complete descriptions, show them in footnotes or in an appendix, rather than in the text. If special nomenclature is used, include a nomenclature section at the end of the paper giving definitions and dimensions for all terms.

Equations

These must be typed, or written, clearly. Number each consecutively. If special symbols or Greek letters are used, write out their names in the margin of the sheet at point of first use. Place superscripts ^a and subscripts _b accurately.

Summary

The paper should be concluded with a summary which is intelligible without reference to the main text.

Acknowledgment

If used, it should follow the summary.

References

These should appear in numerical order within the text and be listed at end of manuscript in same order. Authors' names may or may not be shown in text with reference numbers. If possible, include titles of articles referenced in the literature. The following is a suggested style for periodicals^{1 2 3} and books:⁴

- (1) Wilkinson, R.F., "Uses for Water-Soluble Trimellitate Resins," *Official Digest*, 35, No. 457, 129 (1963).
- (2) Woo, J.T.K. and Heinert, D.H., "Coatings from Vinyl Isocyanate Monomer," *JOURNAL OF COATINGS TECHNOLOGY*, 49, No. 632, 82 (1977).
- (3) Hobden, F.W., *J. Oil & Colour Chemists' Assoc.*, 41, 24 (1958).
- (4) Mattiello, J. J., "Protective and Decorative Coatings," Vol. IV, John Wiley & Sons, Inc., New York, 1955.

OTHER INFORMATION

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

Reprints may be purchased in quantities of 100 or more. Authors will receive quotations.

Each author will receive a complimentary copy of issue in which his paper is published.

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Federation of Societies for Coatings Technology
1315 Walnut St., Philadelphia, Pennsylvania 19107

New Directions— The Paint Research Institute Research Program for the 80's

Peter V. Robinson
President, Paint Research Institute*

INTRODUCTION

It is well recognized that our industry, the paint industry, is experiencing change at a rate that it has never experienced before. These changes are reflections of and analogous to the changes which are taking place in society at large. In order to gain some idea of what kind of an environment they will face in 5, 10 or 20 years time, many companies, via their market research departments, are carrying out "futurist" studies of possible future scenarios. My own company has recently completed such a study and I shall quote from its results.

Government regulation will increase. While we think we are over-regulated now, the most probable scenario is that we will become more regulated in the future. The energy economy will continue to be dominated by petroleum for the next 10-20 years and, since almost all the chemical industry is based on 7% of the crude oil supply, our raw materials in the paint industry will continue to be dominated by OPEC.

Perhaps the largest changes that our industry will experience are related to demographics. The trend to smaller families will continue with a consequent trend to smaller houses, smaller appliances (and, of course, smaller automobiles), all leading to a reduction in the surface area required to be painted. Balancing these trends will be an increase in the number of families, up by 13 million by 1990. In addition, changing life styles will

probably result in a consumer demand for much higher durability in consumer products, and this would include paint.

Industry in the United States is dominated increasingly by the bottom-line, by a focus on short-term ROI. This appears to be in contrast to our major competition from Germany and Japan. While there may be signs that this short-term focus is being questioned and perhaps even changed, such changes will not come about overnight. As a result, international competitive forces will probably increase sharply.

Basic research (depending on the definition) is carried out in the paint industry. It is my experience that if a large paint company feels that it is in its interest to carry out a certain research, then it will do so regardless of whether anyone else does that research or not. This kind of research requires resources of trained people, equipment, and commitment. In my own organization, research that was initiated in 1966 and in 1970, was ongoing and finally began to deliver a commercial return in 1977. I do not believe that this experience is unique to my company. Perhaps more important, we do not readily share the results of our research. So the question must be asked "Who does the essential basic research for those companies who do not have the resources to do the research?" In asking this question, I make the assumption that the medium companies intend being in business five to ten years from now. If they do intend being in business, then they have to plan accordingly in all their business functions. Those companies that continue to function in a reactionary mode will be most likely to fail. And paint companies will fail during the next ten years.

Presented at the 58th Annual Meeting of the Federation of Societies for Coatings Technology, October 30, 1980, in Atlanta, GA.

* Mr. Robinson's address is: Glidden Coatings and Resins Div., SCM Corp., 16651 Sprague Rd., Strongsville, OH 44136.

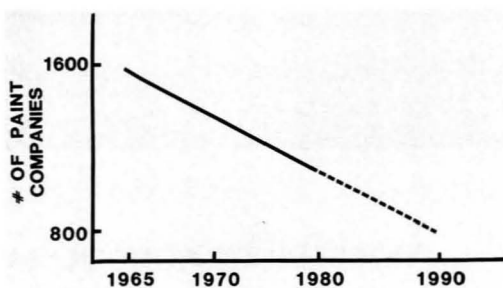


Figure 1—Paint Manufacturers 1965-1990

Overall, the paint industry will continue to grow in dollar volume at the very modest rate of 2% per year. However, it is evident that the consolidation of the paint industry, in respect of a reduction in the overall number of operating entities, will continue. If present trends continue, there will be 800 paint companies in the United States by 1990, down from 1580 companies in 1965. The line is an almost perfect straight line fit, but obviously this has to level out sometime. (Figure 1).

The paint industry is a very mature industry. In mature industries, market pull is vastly more important than technology push in bringing goods to the marketplace. The paint industry is no exception and when regulatory considerations are included in the market pull "demand mix", it is probably true to say that technology push within the paint industry is close to zero.

In summary, during the 80's the paint industry will experience more government regulation, a costlier energy and raw material supply position, sharp changes in product performance, entity consolidation, concentration of research and a mature marketplace. This is the environment in which the PRI also has to function (Table 1).

THE TECHNICAL PROGRAM

When the PRI was formed, its founders determined that the technical program of PRI had to be definable as "basic research". A valuable consequence of this focus was that PRI was accorded a tax exempt status in respect of funding. There are many definitions of basic research, but for our purposes here, we can regard this as referring to research which does not have a specific commercial objective. The whole of our program is devoted to

compliance efforts. In my own company, we have adopted a mnemonic which refers to the reduction in volatile emissions. We focus on the words *reduce, replace, remove* and thereby, arrive at high solids, water-reducibles, and powder coatings. EPA is also interested in the toxicity of coatings materials or their production effluents, and materials such as mercury, lead, chromium, and free phenols also have to be removed.

At PRI our program is totally dominated by these considerations and the need to develop a research program which will benefit the largest number of companies in the paint industry.

The PRI research program, as it is presently formulated, is dedicated to basic research in high solids and water-reducible paints. These are considered to be the coatings of the 80's. In high solids, the Board of PRI considers it essential that some additional understanding is obtained of the oligomeric state. The definition as to what this condition is has caused problems in the past. Oligomers are that condition of matter which exists between monomers and polymers. The low molecular weight characteristic of oligomers leads directly to a lower solution viscosity—or a lower solvent concentration at a given viscosity. The point at which oligomers become polymers is generally at a molecular weight of about 25,000, if one uses glass transition point as the criterion. By this definition, however, oligomers have been used for a long time in the paint industry prior to EPA interest in our industry. Most alkyds, epoxies, urethanes and some acrylics have molecular weights below 25,000, although all latex polymers have much higher molecular weights. For our purposes, it may well be that an oligomer is that state of matter with a molecular weight range of from 500 to 5,000. Very little is known about the behavior of this condition of matter. By comparison, a great deal more is known about the basic behavior of the much higher molecular weight, true polymer. Certainly, one would expect end-group effects to be very much greater in the case of oligomers than is evident in the true polymeric states. Dr. Zeno Wicks, at North Dakota State University, has started on a program to gain greater understanding of the oligomeric condition.

Water-reducibles are also the subject of PRI-sponsored study. Dr. Ray Myers, of Kent State University, is trying to gain a better understanding of the processes leading to the evaporation of water from a water-soluble coating using model polymers. Models suitable for study are always a difficult issue. First of all, the model must be such that it can be readily understood in respect of its physical and chemical composition and, yet, must represent a polymer which could be viable (useful) in the commercial world. However, it is not possible for PRI sponsored research to use a "real world" coatings polymer because of the difficulty of obtaining the fine-detailed information necessary for complete understanding.

Another program dealing with water-reducible paints is our mildew program. In addition to being a water-reducible program, this program is more directly concerned with the removal of toxic substances from the coating as required by EPA. This program is wide

Table 1—Business Environment 1980-1990

The 80s	
Government/Regulation	Up
Energy Cost	Up
Energy Availability	Hold
Raw Material Cost	Up
Raw Material Availability	Hold
Product Performance	Up
No. of Paint Companies	Down
Research Concentration	Up

ranging and requires the contributions of a program manager. Dr. Charles Yeager, of Registration Consulting Associates, is Program Manager, of the overall program which is currently funded by a consortium of six interested sponsor companies and NPCA. (Table 2).

A major goal of this program is to maintain mildew activity as long as the paint film survives. Accordingly, a key component of the Mildew Research Consortium is the effort being directed towards the immobilization of the fungicides that need to be added to a paint film to replace the mercury which many companies feel should be withdrawn in order to comply with stringent effluent regulations. Dr. Charles Pittman, at the University of Alabama, has synthesized ethylenically unsaturated monomers which are derivatives of fungicides and which can be copolymerized with conventional monomers to provide polymer-bound fungicides for use in paint.

It is not my intent to dwell on historical matters. The issues are of now and the future. However, I would like to stress the high value which the companies sponsoring the Mildew Consortium feel they have obtained from it (so far).

There has been no mention of powder coating for our program. The Board of Trustees of PRI felt that the PRI research program should not contain powder coating research. The reasons for this are that powder coating is not considered to be a growth item as is the case with high solids and water-reducibles. Furthermore, only a few companies in the United States are interested in the powder coating business and, generally, a high level of equipment capability is required for a company to carry out the necessary development and customer service work expected by all coatings users. Accordingly, the Board of PRI decided that the interests of the medium-sized paint company would not be served by devoting any of the limited research resources of the PRI effort to an activity which would benefit only a few companies within the paint industry. However, we on the Board of PRI, welcome the guidance of the industry in our market pull environment.

A proposal was made to the Board of PRI on behalf of the medium-sized paint companies that computer technology at the technical or developmental level could well be funded since larger companies will place considerable effort on this technology, thus widening still further the research gap between the larger and medium-sized paint companies. We, on the Board, felt that the medium-sized paint companies would indeed welcome such a project. But is this true? Do the medium-sized paint companies want (or need) this technology? My colleague, Dr. Ted Provder, considered the PRI proposal and identified some distinct impedances to it. In particular, he concerned himself with the issue of software portability. Dr. Provder wrote that "a program written to run on computer x usually will not run on computer y without extensive software modifications." He went on to point out that there is a "need for commonality of hardware and software in the medium paint companies and that before plunging into any major PRI sponsored program, a significant level of analysis of user (medium paint company) need would be obligatory." Dr. Provder's comments are, in my opinion, totally correct and lead to

Table 2—Mildew Consortium Sponsors

Buckman Laboratories
Cosan Chemical Corp.
DuPont Co.
Glidden Coating & Resins Div.
PPG Industries
Troy Chemical Corp.
National Paint and Coatings Association

Program Manager
Dr. Charles C. Yeager,
Registration Consulting Assoc.

the issue of whether the medium paint companies want such work or not.

None of the PRI program is concerned with paint application technology. In the opinion of the industry, should the Paint Research Institute be involved in this work? A quick check reveals that basic studies into electrostatic behavior are being carried out at three institutions outside the United States (England, France, Japan), although none is being carried out in the United States. Work is being sponsored worldwide in the area of the flow and bulk handling of powders at Chicago and at the University of Loughborough in England. This work is of potential benefit in powder coatings. Should the PRI sponsor fundamental studies in the application properties of the new environmentally acceptable coatings and, if so, should we attempt to involve the equipment suppliers? There is always a chance that we can jeopardize our tax exempt status and perhaps this is something that we should seriously consider. Table 3 shows that the Paint Research Assoc. in England welcomes equipment manufacturers as members.

As you can see, I have focused my attention on the wishes of the medium paint companies just as the Board

**Table 3—Paint Research Association, Teddington, England
New Membership**

Samuel Banner & Co. Ltd.
Ordinary—Raw Materials Mfr.
Otsuka Chemical Co. Ltd.
Overseas—Raw Materials Mfr.
Burntwood Engineering Co. Ltd.
Associate—Spray and Allied Equipment Mfr.
Volstatic Coatings Ltd.
Associate—Spray and Allied Equipment Mfr.
Hodge-Clemco Ltd.
Associate—Spray and Allied Equipment Mfr.
Gray-Campling Ltd.
Associate—Spray and Allied Equipment Mfr.
Alenco Hilyn Ltd.
Associate—Spray and Allied Equipment Mfr.
Marley Tile Co. Ltd.
Associate—User
Laconite Ltd.
Associate—User
BP Chemicals (Switzerland)
Overseas—Raw Materials Mfr.

Table 4—Board of Trustees of PRI Functions

- (1) It *interprets* the strategic desires of industry.
- (2) It *plans* a goal oriented Research Program.
- (3) It *communicates* these goals to the Research Director.
- (4) It *evaluates and approves (rejects)* Research proposals for accomplishing these goals.
- (5) It *monitors* the progress of projects.
- (6) It *extends or cancels* projects.
- (7) It *communicates* project results back to Industry.

of PRI has done during the last two years. This medium company focus has been developed at the suggestion of and guided by Dr. Marco Wismer, Vice President of Research & Development for PPG. Now this Board needs the guidance of those medium companies so that it can respond to their wishes. Remember, this is a market pull industry with little technology push contribution. This is a crucial issue because I am aware of at least some large paint companies who do not wish to sponsor medium company focused PRI basic research in perpetuity. They feel that their research dollar can be better spent in addressing their own needs, either internally or at other institutions of their choice. They are, however, prepared to continue "seeding" the basic research efforts of the PRI until the medium paint companies take over the effort for themselves. However, the question is being asked within the larger companies, "if the medium companies show no desire to help themselves, why should the larger companies help them?" Like everyone else, the larger paint companies are feeling the research pinch.

At this time, I would like to delete my name from the Board of PRI for the purposes of my next comments. The Board is an outstanding group of people with extremely wide business, technological, and research experience, competence, and success. Our industry cannot possibly do any better. If there are better people than the Federation should replace the present Board with them. The function of the Board of PRI is to guide the efforts of its Research Director in the scientific areas which will best serve the future business needs of the industry. In order to accomplish this role successfully, the PRI Board must have the *business* direction of the industry so that it can translate business need into scientific goals. The Board of PRI does not see that its role is that of telling the scientists how to do their work, but rather of advising them what kind of work it is we want them to do. In other words, the Board is a management team whose members function in much the same way on the board as they do in their company environment. See *Table 4*.

PRI FUNDING

For the last several years, the PRI budget has hovered around \$120,000 per year. If there is a trend to be

Table 5—"Buying Power" of PRI Funds. 1965–1990

PRI funds—\$125,000 constant
1965—supported 10–12 Researchers
1980—supports 3–4 Researchers
1990—supports 2 researchers?

Table 6—Issues Facing PRI

- Q1. Medium Company Focus?
- Q2. "Correct" Strategic Issues?
- Q3. What are the Strategic Issues?
- Q4. Do the Medium Companies want Research?
- Q5. Are the Medium Companies Prepared to Fund?

discerned, it's downwards. During the same period of time, inflation has struck at us all such that the average cost of acquiring the services of a post-doctoral researcher at a university now stands at about \$25,000 per year. Obviously, the ability of the Paint Research Institute to carry out meaningful research on behalf of its industry is also being eroded by inflationary pressures. (*Table 5*). By contrast, research in the larger paint companies is usually tied to the sales dollar. If sales have made as much progress as salaries, then this means that research in the company is reasonably immune from inflationary pressures. Depending on the "research" definition, the larger companies may well spend upwards of one million dollars per year on research. Again, the technology gap between large and medium company widens. This is a major concern to the Board, who in their Board activities represent the industry and not their companies. The effort that PRI, at its present funding level, can provide for the paint industry is, in my opinion, woefully inadequate for the research tasks which have to be embarked upon and completed during the next several years. There is wide recognition of this situation. Ray Myers has submitted a Kent State University proposal for an industry supported, government supported institute for paint research to the National Science Foundation. One of the contributors to Dr. Myers proposal to NSF, Dr. Alvin Melcher, was quite strong in his recommendation that such an institute should be jointly supported by both NPCA and the Federation (via PRI?). Analogous thoughts are being expressed via the Research Subcommittee of the Scientific Committee of NPCA in relation to a Department of Commerce interest in establishing "centers of technology" for various industries, including paint. It is not my intent to comment upon the validity of these various proposals, still less to make any recommendations. I do believe, however, that the amount of research dollars being allocated to the crucial programs will threaten their completion. We will all be much the worse for that.

I have attempted here to describe the Board of Trustees feeling that there is a need for research in the paint industry and that this should be focused on the specific needs of the medium paint companies. I have attempted not only to draw attention to the costs of doing research, but also to note the cost of not doing research. Finally, I hope that I have left the impression that the Board of Trustees needs specific business direction rather than any open-ended appellatives such as "relevant."

I shall conclude with more questions. Should the PRI continue to focus its efforts on the interests of the medium paint company? If this is considered to be the

correct focus for PRI, are we addressing the correct issues? If not, what kind of issues should we address? (Table 6). And, finally, do the medium paint companies wish to see basic and essential research work carried out on their behalf and how will it be funded?

ACKNOWLEDGMENTS

The author would like to thank the Glidden Coatings and Resins Division of SCM Corp. for permission to include market research information in this paper. He would also like to thank members of the Board of PRI for their many helpful suggestions after reading an early draft of the paper.

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Control of Cell-Wall Biosynthesis in *Aureobasidium pullulans* (Dr. D.J. Siehr, University of Missouri—Rolla)

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The Physical Chemistry Of the Cathodic Electrodeposition Process

Percy E. Pierce
PPG Industries Incorporated*

Electrodeposition has gained worldwide acceptance as a coating process for automotive, appliance, and general industrial coatings. The advantages of the process are high levels of coating utilization, automation, low levels of pollution, and high throwpower, i.e., the ability to coat the recessed portions of complex shaped metal parts.

In the original electrodeposition process the parts to be coated were made the anode. Recently, a new process in which the parts to be coated are made the cathode has gained increasing acceptance because high levels of corrosion protection can be obtained with cathodically deposited coatings.

The cathodic process is an electrochemical process. The physical chemistry of the process and the understanding of the process depends on a knowledge of electrochemistry. The electrochemical investigation of the process has involved researchers in all the major industrial countries, but especially those in Germany, the United States and Japan.

In order for film deposition to begin, a suitable boundary layer around the part must be formed. Once the boundary layer is established, the rate of film growth depends on the number of electrochemical equivalents required to neutralize the solubilizing salt groups, voltage, and the conduction characteristics of the deposited layer. If the film redissolves in the bath, the process of film growth will stop at some point giving rise to a limiting film thickness.

The throwpower is also related to the electrochemistry of the deposition process as well as the geometry of the throwpower cell. Thus, throwpower can be calculated and the results of various throwpower tests, such as the GM and Ford tests, compared.

Among the factors which contribute to improved corrosion protection in the cathode process is the development of improved polymers which are more resistant to cathodic disbonding and the reduction in metal and pretreatment dissolution during cathode film deposition. It is expected that the cathodic electrodeposition process will continue to gain acceptance, especially in those areas in which superior levels of corrosion resistance are required.

INTRODUCTION

Since the introduction of the electrodeposition process for painting metal objects in the early 1960's, this process has been adopted world wide in the automotive, industrial, and appliance areas to provide the first or prime coat to a variety of products. Machu¹ describes these developments in his handbook on electrodeposition technology.

The first electrodeposition process to attain commercial importance was anodic electrodeposition. In the anodic process, the part to be coated is made the anode. The advantages of the electrodeposition process are its automated character, high efficiency of coating utilization, low levels of pollution, and high throwing power, i.e., the ability to coat recessed areas in complex metal shapes such as automobile bodies.

Recently, cathodic electrodeposition has assumed major commercial significance in the industrial and automotive areas. In the cathodic process, the part to be coated is made the cathode. The cathodic process retains the advantages of the anodic process and provides higher levels of corrosion protection.

The successful commercialization of the cathodic electrodeposition process required substantial contributions from many people. Some of these contributors are cited in the acknowledgments to this paper. Of significant

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* Adv. R. & D Center, P.O. Drawer 9, Allison Park, PA 15101

1980 Mattiello Lecturer



Dr. Percy E. Pierce

Dr. Pierce, a native of Bayonne, N.J., received his B. S. degree in Chemistry from Case Institute of Technology (now Case-Western Reserve University) in 1953. He received his Ph.D. degree in physical chemistry from Yale University in 1958.

He began his professional career as an Assistant Professor of Chemistry at Case, where he taught physical chemistry. While teaching at Case, his research interests turned in the direction of latex particle size determination by various light scattering methods.

In 1963, Dr. Pierce joined the Glidden Co. at its Cleveland, Ohio, Coatings and Resins Research Center, where he carried out research on various aspects of the physical chemistry of coatings.

Dr. Pierce joined PPG Industries in 1969 at the Springdale, Pa., Coatings and Resins Research Laboratories, where he continued his research on the physical chemistry of organic coatings.

His current position is Manager of Physical/Analytical Research at the Allison Park Research Center, where he has responsibility for the physical chemistry, analytical, and color research groups. This position reflects Dr. Pierce's concern for quantitative measurement and understanding of coatings systems, processes, and technology.

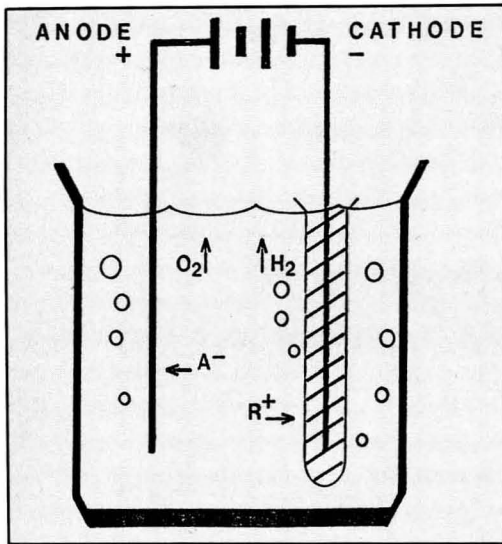


Figure 1—Schematic diagram of the cathodic electrodeposition process

importance in our efforts was our ability to understand the physical bases of the processes involved and to express in numbers, various performance parameters and variables of the process. Some of these efforts will be the subject of this paper.

THE CATHODIC ELECTRODEPOSITION PROCESS

Figure 1 is a schematic diagram showing the cathodic electrodeposition process.

The cathodic electrodeposition bath is a 10–20% solids dispersion of positively charged resin encapsulated

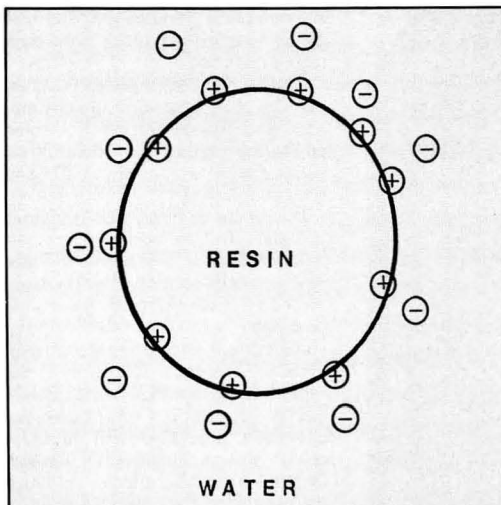
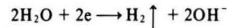
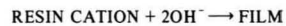


Figure 2—Schematic representation of a cathodic resin micelle and counterions

pigment and resin micelles. The resin contains amino nitrogen or other basic groups which are neutralized with a water soluble carboxylic or mineral acid. The metal object to be coated is made the cathode. The immersed part is coated for 60–120 sec at a constant voltage in the range of 150–350 volts. At the anode, which is made of inert material such as carbon, oxygen gas is produced. The primary process at the cathode is generation of hydrogen gas and hydroxyl ions.



The deposition of the cathodic coating is the result of migration of the positively charged resin and pigment particles to the cathode where they are neutralized and coagulated in the alkaline boundary layer around the cathode.



Although electrochemical dissolution of the substrate does not take place in cathodic electrodeposition, the highly alkaline boundary layer can lead to chemical reaction with the metal substrate especially in the case of amphoteric metals such as zinc and aluminum that are readily attacked by alkali. Despite this possibility, measurements² show that the final metal content of cathodically deposited films is substantially less (2.5–14%) than that in anodically deposited films, depending on substrate and system conditions. Thus, the potential for metal staining is substantially reduced. Improved corrosion resistance is to be expected and is realized. The resulting coating, as in the anodic case, is an adherent film with sufficient mechanical integrity to withstand a stream of rinse water from a spray nozzle. The parts are rinsed after emerging from the bath and baked in an oven.

Cationic Resins and Colloidal Bath Structure

A variety of cationic resins have been proposed for the cathodic electrodeposition process. Some of these efforts have been reviewed by Schenk, Spoor, and Marx.³ Cationic resins require the presence of cationic groups for solubilization to form a stable bath. Several cationic groups have been investigated and have been shown to lead to resins that can be deposited on the cathode. These include resins containing primary, secondary, and tertiary amine groups neutralized by either organic or mineral acid,³ as well as resins containing various onium groups such as quaternary ammonium,⁴ sulfonium,⁵ and phosphonium⁶ groups. The resins solubilized with nitrogen containing groups have attained the widest application and are, commercially, the most significant at this time.

A variety of polymer backbones have also been investigated. These range from various acrylic and vinyl copolymers, modified epoxy resins, acrylics, polyamides, and polyurethanes including various combinations of the above. The epoxy based compositions which yield higher levels of corrosion resistance are currently in largest commercial use.

Early cationic resins gave stable electrodeposition baths in the acidic range 3–5 pH units. These baths were

quite corrosive to the mild steel which was used to fabricate many commercial anodic electrodeposition installations.

This problem has been overcome and stable cationic electrodeposition baths, in the neutral to slightly acidic range 5-7 pH units that are no more corrosive than the anodic baths, are now in use. This permits the adaptation of existing commercial anodic electrodeposition equipment for cationic electrodeposition.

Another problem encountered with cationic resins is that the electrodeposited film is quite basic. Since many curing reactions are acid catalyzed, difficulties arise in finding suitable ways to obtain a cure of cationic systems. This was overcome by utilizing the blocked isocyanate type of cure mechanism.^{7,8}

Colloidal Bath Structure

The cationic resins employed in electrodeposition have a micellar colloidal structure similar to the anodic electrodeposition resins. These resin micelles range in size from 6 nm-140 nm depending on the concentration of solubilizing salt groups. Pierce and Cowan⁹ have previously presented methods for investigating anionic resin micelles and have discussed factors which cause the resins to form micelles.

The organic resin structure is not compatible with water, so in the absence of other forces, the resin and water tend to minimize their interaction with each other. This results in the system attaining its lowest energy by tending to the configuration which allows the greatest resin-resin and water-water interactions and the least water-resin interaction. In the absence of electrostatic forces, this would lead to precipitation of the resin. This of course is just what happens at the cathode during electrodeposition.

Cationic salt groups are electrically charged. Like electric charges repel and unlike electric charges attract each other. Thus, the cationic positive charged groups try to get as far apart as they can. They are, however, constrained by the polymer chains to which they are attached. The tendency for the charged groups to get as far apart as possible and the preference of water to form water-water contacts results in the formation of resin micelles.

The micelles have a compact organic resin core with the cationic salt groups at the surface, tending toward the water phase, where the high dielectric constant of the water causes a further decrease of the electrical free energy of the system. The acid counterions are in the water phase giving rise to an electrical double layer around the resin micelle. A resin micelle is shown schematically in Figure 2.

The greater the concentration of salt groups in the resin, the greater the tendency of the organic phase to disperse. Consequently, the micelle size is smaller, if the concentration of salt groups in the resin is higher.

Sometimes, electrodeposition resins are pictured in aqueous solution, as a loose coiling molecule with charged groups attached to the chain. This model, which is more similar to a polyelectrolyte model, requires a much higher content of charged groups than are present in either the soap micelles or the resin micelles employed in electrodeposition coatings.

Table 1—Comparison of Water-Based Systems

System	Molecular Weight	Salt Groups MEQ/g
Polyelectrolyte	Low to high	5-13
Surfactant	Low	2-4
ED Resins	Low to med.	0.3-2
Latex	Med. to high	0.001-0.3

MEQ = Milliequivalent Weight

As a matter of fact, the resin micelles are not a single molecule but an aggregate of 30-150 individual molecules. This explains why it is possible to ultrafilter electrodeposition baths with membranes that have pore size sufficiently large to pass single resin molecules. Very few single resin molecules exist in the bath. The great majority of resin molecules exist in micellar aggregates consisting of many molecules. This effect is also known for surfactant molecules which have a lower molecular weight and higher charge per unit volume than the electrodeposition resins.

If the concentration of charge groups drops below a certain critical value, then resin micelles are no longer thermodynamically stable. Above a size range 6-140 nm, the resin micelles cannot spontaneously form. Particles larger than this size are possible and colloidal systems can be prepared, but these systems are in the latex size range. Such systems exhibit the properties we usually expect of

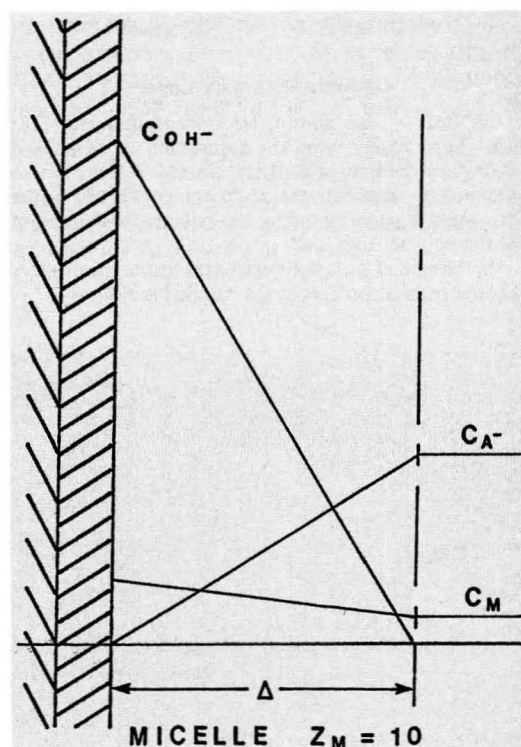


Figure 3—Schematic representation of the cathodic boundary layer for a resin micelle with an average charge of 10

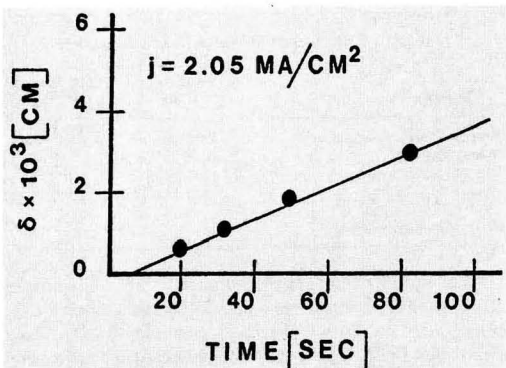


Figure 4—Increase of film thickness with time for the constant current electrodeposition of a cathodic appliance primer

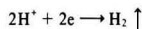
latices and undergo irreversible coagulation when subjected to the long term mechanical shear typical of a commercial electrodeposition installation.

Table 1 is a summary of the comparison of polyelectrolytes, surfactants, electrodeposition resins, and latices. Note that besides the differences in the amount of charged groups per unit weight of resin substantial polymer, molecular weight differences are observed among the four classes of materials discussed. All these materials are technologically useful in the field of coatings but the requirements of electrodeposition have so far been best met with a salt group concentration in range 0.3–2 MEQ's/g and a low to medium (1000–30,000) molecular weight.

Cathode Boundary Layer

As Beck^{10,11} has shown, electrodeposition does not start immediately upon the application of an applied voltage or the flow of electrical current. A finite time is required to establish the necessary conditions in the boundary layer surrounding the cathode for deposition of the polymer film.

In the case of cathodic electrodeposition, the primary electrochemical process at the cathode is either:



or

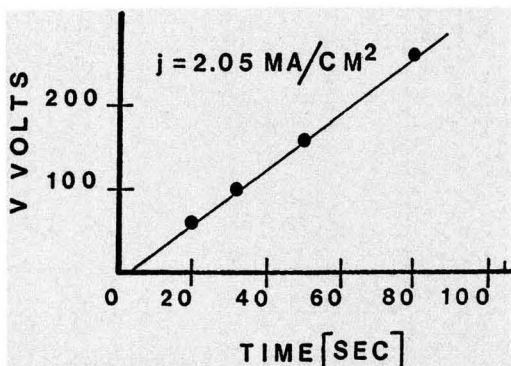
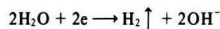


Figure 5—Increase of cathode voltage with time for the constant current electrodeposition of a cathodic appliance primer



The first reaction is favored in acid solution, the second predominates in neutral to alkaline solutions.

The rate of formation of hydroxyl ions at the cathode is given by the equation:

$$V_{OH^-} = j/F \quad (1)$$

where j is the current density and F is Faraday's constant.

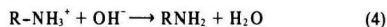
The hydroxyl ions produced at the cathode can diffuse,

$$J_D = -D \frac{\partial C}{\partial X} \quad (2)$$

migrate,

$$J_M = \frac{Ze}{6\pi\alpha\eta} FC = -\frac{Ze}{6\pi\alpha\eta} \frac{\partial V}{\partial X} C \quad (3)$$

and chemically react,



Simultaneously the colloidal resin micelles can diffuse,

$$J_D = -D \frac{\partial C}{\partial X} \quad D = \frac{k\tau}{6\pi\alpha\eta} \quad (5)$$

and migrate,

$$J_M = \frac{\Delta e}{6\pi\alpha\eta} FC = -\frac{D\zeta}{6\pi\eta} FC \quad (6)$$

$$\Delta e = D\zeta\alpha \quad (7)$$

to the cathode. In the case of the resin micelles, the migration term, J_M , is much greater than the diffusion term J_D . In the case of the hydroxyl ions, the migration and diffusion fluxes may be comparable in magnitude. At constant current density, precipitation of the resin micelles does not occur until the hydroxyl ion concentration achieves a critical value related by the solubility product for the system.

$$[RESIN-NH_3^+][OH^-] = K_p \quad (8)$$

In the absence of migration and chemical reaction, it can be shown that in an unstirred electrolyte at constant current density, the concentration of hydroxyl ions at the cathode surface will increase as the square root of time, according to the equation:

$$C_{OH^-} = C_0 + \frac{2j}{F} \left[\frac{\tau}{\pi D_{OH^-}} \right]^{1/2} \quad (9)$$

where τ is the time, C_{OH^-} the hydroxyl concentration at the electrode, C_0 the hydroxyl concentration in the electrolyte, j is the current density, F is Faraday's constant, and D_{OH^-} is the hydroxyl ion diffusion coefficient.

Empirically, it is observed that the product of the square root of the time required for the deposition of a cathodic paint film in an unstirred bath and the current density is constant.

$$j\tau^{1/2} = K \quad (10)$$

According to the previous equation, it is also expected that the product $j\tau^{1/2}$ should be a constant provided that a critical OH^- ion concentration is required to form an adherent film on the cathode.

$$j\tau^{1/2} = 1/2 [\pi D_{OH^-}]^{1/2} F \Delta C_{OH} \quad (11)$$

It is tempting to equate the right hand sides of these two equations and solve for the critical hydroxyl ion concentration.

$$\Delta C_{OH^-} = 2K / [\pi D_{OH^-}]^{1/2} F \quad (12)$$

Thus, the value of K may be used to estimate the hydroxyl concentration required to precipitate the polymer at the cathode.

At the start of electrodeposition, the hydroxyl ion concentration is small compared to the concentration of acid counterions and resin micelles. Thus, neglect of the hydroxyl migration term is probably justified. In the case of quaternary and some onium systems, there is no chemical reaction, merely replacement of the acid counterion by a hydroxyl ion. Thus, the above theory probably represents a good approximation to the physical situation in these cases.

In the case of amine systems, in which chemical reaction of the hydroxyl ion with the amine salt to form amine takes place, the constancy of the product of current density and square root of induction time is also observed. Application of the preceding equation gives reasonable estimates of the hydroxyl ion concentration required to precipitate the cathodic resin at the cathode. However, a better theoretical analysis is needed to account for all the physical processes involved.

After film growth commences, it is assumed that the boundary layer achieves a steady state condition. The steady state boundary layer can be pictured as is shown in Figure 3.

THE KINETICS AND MECHANISM OF CATHODIC ELECTRODEPOSITION

Cathodic electrodeposition can be carried out either under constant voltage or constant current conditions. The voltage and deposition time can be adjusted to control the applied film thickness and the throwpower of the system.

In the laboratory, both types of electrodeposition processes are frequently carried out. Each experiment can yield valuable data on the kinetics of cathodic electrodeposition.

Constant Current Electrodeposition

A critical hydroxyl ion concentration is required before the deposition of a continuous layer of cationic paint can occur. Under constant current electrodeposition conditions, this critical hydroxyl concentration can be obtained from Sand's equation, equation (9).

Figure 4 is a plot of film thicknesses vs time at constant current density for a cationic appliance coating. This data shows that deposition requires a definite time period to take place at constant current density. Once film deposition has started, the film thickness increases rapidly.

The product of current density and the square root of the induction time is a constant for a particular system. From this product, the critical hydroxyl ion concentration can be calculated. From the data shown in Figure 4, the critical pH for electrodeposition of this system at the cathode is calculated to be 11.9.

The slope of the film thickness time curve can be

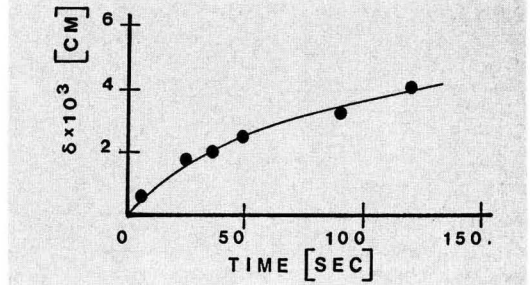


Figure 6—Increase of film thickness with time for constant voltage electrodeposition of a cathodic appliance primer

related to other parameters of the system. In the case of the appliance cationic system, the rate of change of film thickness with time is related to the coulombic efficiency, c, and the current density by the equation:

$$\frac{d\delta}{dt} = cj \quad (13)$$

Thus the film thickness is a linear function of the time

$$\delta = cj [t - \tau] \quad (14)$$

beyond the induction time τ . The slope of the thickness time curve is a measure of the coulombic efficiency of the process, i.e., the cm^3 of film deposited per coulomb of electricity passed.

The voltage time curve at constant current density also shows an induction time followed by a linear rise with time. Voltage-time data for the appliance cationic system is shown in Figure 5. In the case of the appliance system, the current density is related to the film thickness and voltage by the equation:

$$j = \frac{\sigma_F V}{\delta} \quad (15)$$

where j is the current density, σ_F is the film conductivity, V is the voltage and δ is the film thickness. Solving this equation for the voltage V we obtain:

$$V = \frac{j}{\sigma_F} \delta \quad (16)$$

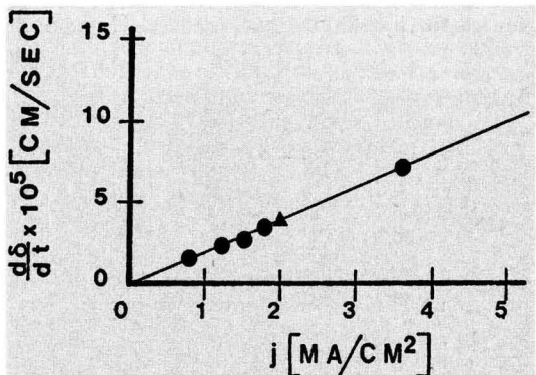


Figure 7—Rate of film growth increase vs current density for the constant voltage electrodeposition of a cathodic appliance primer v = 200 v

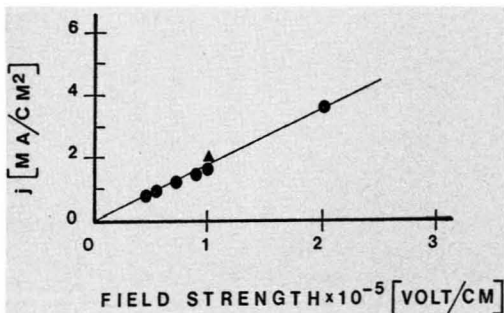


Figure 8—Current density vs field strength plot of a cathodic appliance primer electrodeposited at 200 v showing the ohmic nature of the film conduction

Utilizing the previous result for δ we see that,

$$V = \frac{cj^2}{\sigma_F} [t - \tau] \tag{17}$$

and that at constant current density, the voltage, like the film thickness, is a linear function of time beyond the induction time. This is borne out by the data shown in Figure 5.

Constant Voltage Cathodic Electrodeposition

When the appliance cationic system is coated at constant voltage, the film thickness increases with time as shown in Figure 6. Deposition appears to start instantaneously, however in reality, a very short time, the order of a fraction of a sec, is required for deposition to begin.

The kinetic equation for film growth can be derived from the equations used to analyze the constant current data. We have the film growth equation:

$$\frac{d\delta}{dt} = cj \tag{18}$$

In Figure 7, we have a plot of $\frac{d\delta}{dt}$ derived from the data in Figure 6 plotted vs current density, j . This plot verifies our assumption concerning the form of the film equation. Now, however, j is no longer constant but will vary with film thickness. Figure 8 is a plot of current density vs field strength which verifies the ohmic conduction behavior of

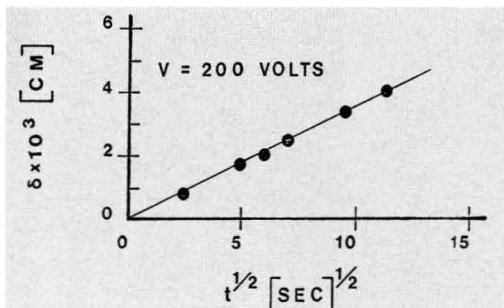


Figure 9—Plot of film thickness vs the square root of time for a cathodic appliance primer electrodeposited at 200 v

the appliance cationic primer film. The current density can thus be eliminated by introducing equation (15) into the film growth equation to give:

$$\delta \frac{d\delta}{dt} = c\sigma_F V \tag{19}$$

Since the applied voltage, V , the coulombic efficiency, c and the film conductivity, σ_F , are constant, this equation can be integrated to give:

$$\delta = [2c\sigma_F]^{1/2} [Vt]^{1/2} \tag{20}$$

Thus a plot of δ vs $t^{1/2}$ should be a straight line with slope equal to $[2c\sigma_F V]^{1/2}$.

Figure 9 is a replot of the film thickness time data. Here the film thickness, δ , is plotted vs the square root of time. This plot is linear as required by the model.

The simple kinetic model just discussed fits the kinetics of film deposition for the cationic appliance coating quite accurately. Other commercial electrodeposition systems also fit this model. Because of its simplicity, it is often applied to electrodeposition data. Unfortunately, there are several complications which enter the kinetic picture that can drastically alter the electrodeposition kinetics. These complications frequently occur together and are not limited to the electrodeposition of organic coatings. They also occur in the growth of oxide films on metals.

THE ELECTRODEPOSITION OF POROUS FILMS

Sometimes the electrodeposition of organic coatings can take place in such a way that porous films are formed. Latex electrodeposition can occur with the formation of porous films, as can the formation of conventional electrodepositable compositions if the polymer is poorly coalesced or if soluble electrolyte leads to excessive gassing at the electrode.

When a porous film is formed, the conductance of the polymer is so much lower than the conductance of the electrolyte, that most of the conduction is through the pores in the film and the polymer conduction can be neglected.¹²

Some constant current electrodeposition data on a porous cathodic appliance primer is shown in Figure 10. As in the nonporous case, a certain time is required in order for the establishment of conditions at the cathode suitable for deposition of the primer. Beyond this time, the amount of material deposited at the cathode increases in a linear fashion, with time as is shown by the linear increase in average film thickness of the deposit. The voltage drop across the film, however, stays very low since most of the conduction is through pores in the film. As electrodeposition continues, the fraction of cathode area covered by pores diminishes and the voltage starts to rise. Eventually, the electrode will seal itself off and when the cathode coverage approaches complete electrode coverage, the voltage rises very rapidly.

If we assume Faraday's law of electrolysis applies, then the rate of change of the surface coverage of the electrode, $\frac{d\theta}{dt}$ is equal to,

$$\frac{d\theta}{dt} = kj \tag{21}$$

where θ is the fraction of surface coverage, k is the cm^2 covered per coulomb required to deposit the film, and j is the current density.

Integrating this equation at constant current density shows that θ increases in a linear way with time:

$$\theta = kjt \tag{22}$$

The time for complete surface coverage ($\theta = 1$) is τ' . Thus, the product of current density and time required beyond the induction time to obtain complete coverage τ' is given by a constant,

$$j\tau' = 1/k \tag{23}$$

which is equal to the coulombs required to cover one cm^2 of electrode surface.

In Table 2 is some data taken from some cathodic electrodeposition experiments with the porous primer electrodeposited at various constant current densities. This data shows the time required before a film begins to deposit at the cathode, τ , and the time measured from this time for the voltage to rise to very high values, τ' , indicating complete electrode coverage. Note that the previously mentioned relationship $j\tau^{1/2} = \text{const}$ is valid for the start of deposition, but that the relationship

$$j\tau' = 1/k \tag{24}$$

is verified by the experimental data for the product of current density and time for complete electrode coverage.

Although the average current density is constant in these constant current density experiments, the current density in the pores increases rapidly as the surface coverage increases. The pore current density j_0 is given by

$$j_0 = j/(1-\theta) \tag{25}$$

where j is the average current density and θ is the surface coverage of the electrode. Note that as θ approaches complete surface coverage, the pore current density increases rapidly. The high pore current density at higher surface coverage is probably a significant factor in sealing off the electrode.

If we assume that the pore current density is a linear function of the voltage, then

$$j_0 = \frac{\sigma_p V}{\delta_o} \tag{26}$$

where σ_p is the conductivity of the pore electrolyte, V is the voltage, and δ_o is the pore depth. Solving for the voltage we have,

$$V = \frac{\delta_o}{\sigma_p} j_0 \tag{27}$$

and introducing the expression $j_0 = j/(1-\theta)$ and $\theta = kjt'$ we obtain,

$$V = \delta_o / k\sigma_p (\tau' - t') \tag{28}$$

Thus, the voltage drop across the deposited porous layer starts at rather low values but increases rapidly as the surface coverage approaches a value of unity (complete surface coverage).

Under constant voltage deposition conditions, the porous layer type of kinetics is more difficult to recognize

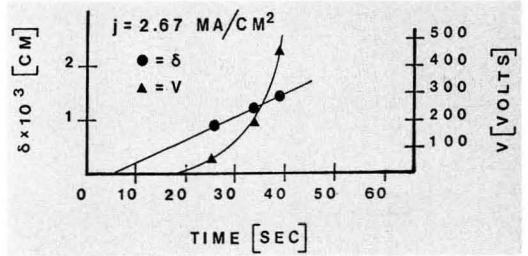


Figure 10—Plot of film thickness and voltage vs time for a cathodic appliance primer electrodeposited at constant current density showing porous film electrodeposition kinetics

and may even go unnoticed unless careful experiments are performed.

In Figure 11 is shown some current density data plotted vs the fraction of cathode area covered, taken under constant voltage conditions at 110–300 v. The same system used for the constant current density experiments was used. Note that the current density is a linear function of $(1-\theta)$ which is the fraction of electrode surface exposed.

Again assuming Faraday's law of electrolysis and using the relationship for the current density, j ,

$$j = j_0 [1-\theta] \tag{29}$$

suggested by the data of Figure 11, we obtain the differential equation for the surface coverage,

$$\frac{d\theta}{dt} = kj = kj_0 [1-\theta] \tag{30}$$

Integrating this equation we obtain:

$$\theta = 1 - e^{-kj_0 t} \tag{31}$$

an exponential increase of the surface coverage from a value of zero at $t = 0$ to one at $t = \infty$.

If we know k from the constant current density experiments and j_0 , the pore current density vs coverage data obtained at constant voltage, we may calculate surface coverage at any time.

Figure 12 is surface coverage data plotted vs time. The experimental surface coverage points at 110–300 v are shown. The curve is calculated from the exponential equation (31) using the experimentally derived values of k and j_0 . Except for one point taken at very low surface which is difficult to measure, the agreement between the calculated exponential curve and the data point are excellent verifying the exponential relationship.

Another interesting consequence of the model is shown in Figure 13. Final film thickness data taken under con-

Table 2—Porous Layer—Cathodic Primer Constant Current Deposition

j ma/cm ²	τ sec	τ' sec	$j\tau^{1/2}$ $\times 10^3$	$j\tau'$ $\times 10^2$
1.33	25	85	6.6	11.3
2.00	11	46	6.6	9.2
2.67	5	36	6.0	9.6

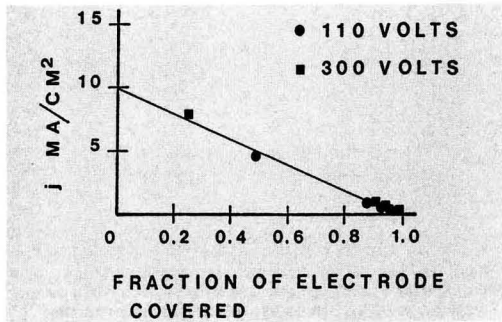


Figure 11—Current density vs electrode surface coverage for a porous cathodic primer electrodeposited at constant voltage

stant voltage conditions for the porous primer is plotted vs applied voltage. The final film thickness increases linearly with applied voltage.

If we assume that j_0 , the current density at zero surface coverage of pore current density, is the same at all applied voltages and assume ohmic conduction in the pores then:

$$j_0 = \frac{\sigma_p V}{\delta_0} \tag{32}$$

where σ_p is the conductivity of the fluid in the pores, δ_0 is the pore depth, and V is the applied voltage. Solving for δ_0 we have

$$\delta_0 = \frac{\sigma_p V}{j_0} \tag{33}$$

Thus, we expect that the final film thickness will be a linear function of the voltage provided that the pore fluid conductance and initial current density of pore current density, j_0 are constants.

The data in the previous figures may be used to calculate the conductance of the pore fluid provided the pore depth is assumed equal to the average cured film thickness.

$$\sigma_p = \frac{j_0 \delta_0}{V} \tag{34}$$

The calculated value 3×10^{-8} is close to that of pure water. The conductivity of the electrodeposition bath is 550×10^{-6} m mhos/cm which indicates that the pore fluid has been largely depleted of ionic material. This is

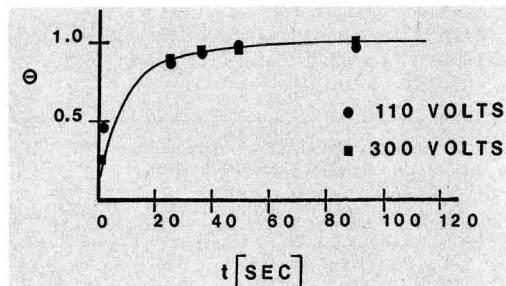


Figure 12—Cathode surface coverage plotted vs time for a porous cathodic primer electrodeposited at constant voltage

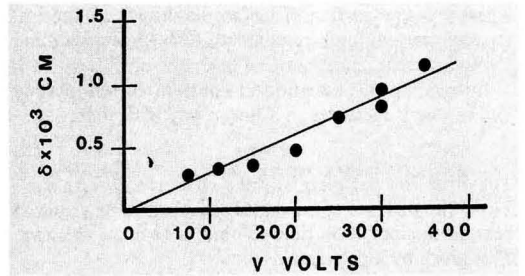


Figure 13—Film thickness at complete surface coverage plotted vs applied voltage for a porous cathodic primer

not surprising in view of the high field strength, resulting concentration polarization, and precipitation of ionic materials in the basic boundary layer to form solid film material.

FILM DISSOLUTION AND LIMITING FILM THICKNESS

Most electrodeposition films left in a stirred electrodeposition bath with the power off will tend to redissolve. If the film redissolves at a rate comparable to the rate of electrodeposition, then the deposited film will tend to a limiting film thickness. This same phenomena has been observed in the kinetics of oxide film growth and in corrosion.^{12,13}

The basic kinetic equation based on Faraday's laws of electrolysis must be modified in the case of film dissolution to include an additional dissolution term. The rate of film growth is, in this case, given by:

$$\frac{d\delta}{dt} = c[j - jd] \tag{35}$$

where δ is the film thickness, t is the time, c is the coulombic yield, j is the current density, and jd is the dissolution current density. This equation shows that film thickness growth stops when,

$$\frac{d\delta}{dt} = 0 \quad \text{and} \quad j = jd \tag{36}$$

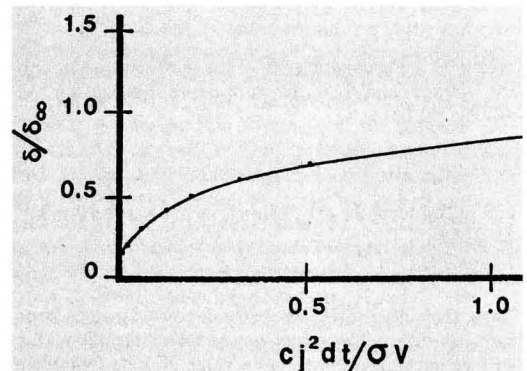


Figure 14—Plot of dimensionless film thickness vs dimensionless time for a film electrodeposited at constant voltage for a system with film dissolution and ohmic conduction characteristics

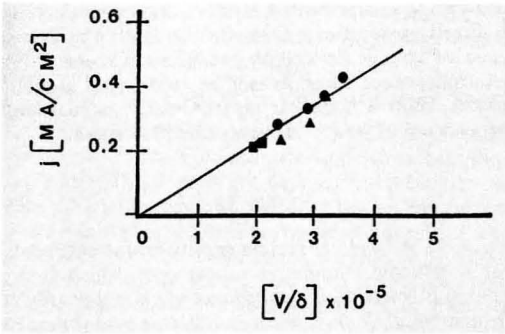


Figure 15—Plot of current density vs field strength for a cathodic primer showing ohmic conduction and film dissolution

In the case of ohmic conduction,

$$j = \frac{\sigma_F V}{\delta} \quad (37)$$

where σ_F is the conductivity of the deposited film, V is the applied voltage, and δ is the film thickness. Combining these relationships, the limiting film thickness is given by:

$$\delta_\infty = \sigma_F V / j d \quad (38)$$

where δ_∞ is the limiting film thickness. Thus, the limiting film thickness is directly proportional to the film conductivity and the applied voltage and inversely proportional to the dissolution current density.

In the case of constant voltage electrodeposition for a system with ohmic film conduction characteristics, the kinetic film growth equation becomes:

$$\frac{d\delta}{dt} = c\sigma_F V \left[\frac{1}{\delta} - \frac{1}{\delta_\infty} \right] \quad (39)$$

If we define the following dimensionless groups

$$X = \delta / \delta_\infty \quad Y = c\sigma_F V t / \delta_\infty^2 = c j^2 d t / \sigma_F V \quad (40)$$

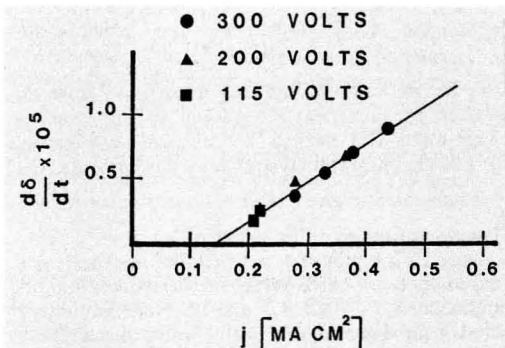


Figure 16—Plot of rate of film growth vs current density for a cathodic primer showing film dissolution behavior and ohmic conduction

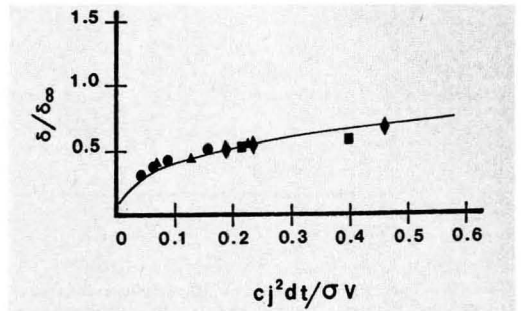


Figure 17—Plot of reduced film thickness vs reduced time for the case of film dissolution and ohmic conduction kinetics showing the agreement between the experimental points for the cathodic primer and the theoretical curve

then the kinetic equation becomes:

$$\frac{dX}{dY} = \left[\frac{1}{X} - 1 \right] \quad (41)$$

X is a reduced or dimensionless film thickness and Y is a reduced or dimensionless time. This equation can be integrated to give:

$$X = 1 - e^{-X-Y} \quad (42)$$

This equation can be solved for a set of X and Y values. These X and Y values are plotted in Figure 14. Note that X , which is the ratio of the film thickness at a given time to the limiting film thickness, rises rapidly at first with the reduced time, Y , and then grows more slowly with increasing reduced time tending to a value of unity at long times.

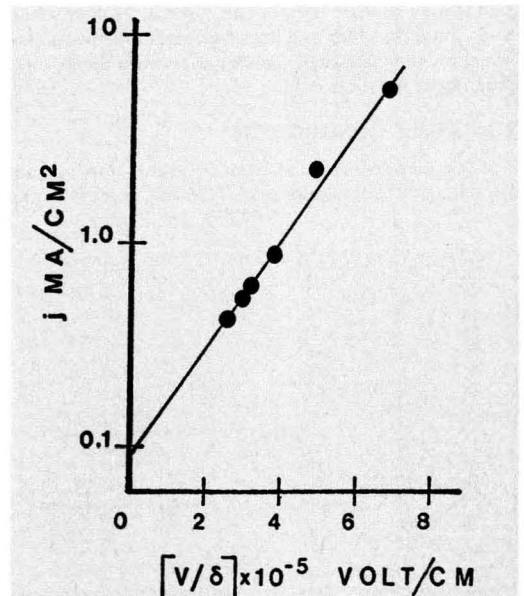


Figure 18—Current density vs field strength for a cathodic primer resin showing nonohmic conduction behavior

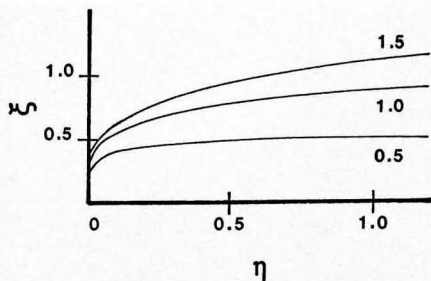


Figure 19—Theoretical curves showing the relationship between reduced film thickness and reduced time at various values of reduced limiting film thickness for electrodeposition of systems with film dissolution and exponential nonohmic conduction

In Figures 15–17, we have some experimental data for a cathodic automotive primer. Figure 15 shows some current density—field strength data showing the ohmic conduction characteristics of the film. The slope of the plot is the film conductance. In Figure 16 is the rate of film thickness change with time, $\frac{d\delta}{dt}$, plotted vs the current density. The slope of the curve is the coulombic efficiency, and the intercept on the current density axis is the dissolution current density. From the value of dissolution current density, coulombic efficiency, applied voltage, and film conductance, the limiting film thickness and dimensionless groups X and Y can be calculated from film growth time data taken at constant voltage. If the theory is valid, then the experimental values of the X and Y dimensionless groups should lie on the theoretical curve obtained by solving the transcendental equation relating X and Y shown in Figure 14.

Figure 17 is a plot of the experimental values of X and Y shown by the data points. The curve is the theoretical X–Y function. The excellent agreement between the two show the close correspondence between theory and experiment for these data.

NONOHMIC CONDUCTION

Many electrodeposition systems, both anodic and cathodic, yield electrodeposition films that exhibit ohmic

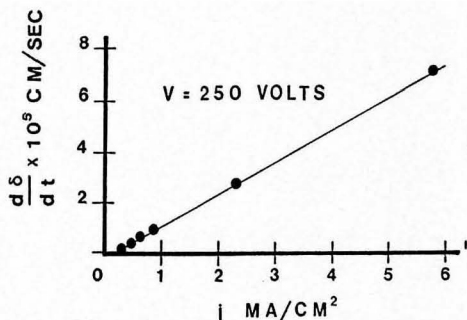


Figure 20—Plot of the rate of change of film thickness vs current density for a cathodic resin with film dissolution and nonohmic conduction characteristics

conduction characteristics. That is, the current density is directly proportional to the field strength which is the ratio of voltage divided by the film thickness. Other electrodeposited films, as well as some types of metal oxides, show a nonlinear (approximately exponential) dependence of current density on field strength.^{12,13}

$$j = A \times \text{EXP} \left[B \frac{V}{\delta} \right] \tag{43}$$

Figure 18 shows some current density field strength data for a cathodic automotive primer resin which shows nonlinear behavior. A semilog plot of current density vs field strength, V/δ , is linear in this case conforming to the above equation. It is not, in general, a priori possibility to predict whether an electrodeposited film will be ohmic or nonohmic in its conduction characteristics, although, certain models give insight into the mechanism of nonohmic conduction and suggest possible structural conditions that will lead to nonohmic behavior.^{12,13}

The important point is to measure current density and field strength to determine the type of conduction behavior. Nonohmic conduction has an important effect on film growth kinetics. Depending on the parameters A and B, nonohmic conduction can produce very rapid initial film growth followed by rapid current cut off. If the complication of film dissolution is added to that of nonohmic conduction, some very useful opportunities offer themselves to alter film growth behavior.

Let's consider the case of film growth with film dissolution and exponential nonohmic conduction. Combining the equations (35 and 44), we obtain that:

$$\frac{d\delta}{dt} = c [A \times \text{EXP} [BV/\delta] - jd] \tag{44}$$

Note that:

$$\delta_{\infty} = BV/\text{Ln}[jd/A] \tag{45}$$

In order to solve this equation, we convert it to dimensionless form by defining the following dimensionless groups: A dimensionless film thickness $\xi = \delta/BV$; a dimensionless time $\eta = cjd t/BV$; and a dimensionless limiting film thickness $\xi_{\infty} = 1/\text{Ln}[jd/A]$. Introducing these variables we obtain the following dimensionless film growth differential equation.

$$\frac{d\xi}{d\eta} = \text{EXP} \left[\frac{1}{\xi} - \frac{1}{\xi_{\infty}} \right] - 1 \tag{46}$$

If we fix the value ξ_{∞} , we may numerically solve this equation by numerical integration. In this case, the Runge-Kutta-Gill method is equivalent to Simpson's rule and the integration is straightforward provided that $\frac{d\eta}{d\xi}$ is integrated to give a table of dimensionless times as a function of reduced film thickness.

Figure 19 is a plot of ξ , reduced film thickness, vs η , reduced time, for three values of the reduced limiting film thickness, $\xi_{\infty} = 0.5, 1.0, \text{ and } 1.5$. Note that initially there is a rapid growth of ξ , with η which then levels out with increasing η values. The lower ξ_{∞} that is the greater the ratio jd/A the more rapidly the limiting film thickness is obtained. For the values of ξ_{∞} shown here, which

are typical values for electrodeposition systems, the rate of film growth is more rapid than the ohmic case as is also the rate of current cut off.

In *Figure 20* is a plot of $\frac{d\delta}{dt}$ plotted vs current density for the same cathodic automotive primer resin whose non-ohmic conduction characteristics were described previously. The slope of the data in *Figure 20* gives the coulombic efficiency and the intercept on the current density axis gives the dissolution current density. From these data, one can evaluate the parameters A, B, j_d , and c which permit the calculation of the reduced variables ξ and η from electrodeposited film thickness vs time data. In this case, the reduced limited film thickness, ξ_∞ is equal to 1.25. The reduced data points obtained from the experimental film kinetic data are plotted as data points in *Figure 21*. The line is the theoretical equation numerically integrated for the value $\xi_\infty = 1.25$. The excellent agreement of the data points and the theoretical line shows the excellent agreement of the data points to the model in this case.

FILM GROWTH MODELS

We have looked at four film growth models and have shown data on four different cathodic electrodeposition systems which are in agreement with these models. These models are not restricted to cathodic electrodeposition systems. A careful examination of anodic electrodeposition systems would reveal that these same film growth laws have their anodic counterparts.^{11,14,15,16}

The data we have presented also do not exhaust all kinetic film growth possibilities. For example, nonohmic film conduction, without film dissolution and porous film conduction, with film dissolution, are some additional obvious cases.

The models presented do show that the film conduction mechanism, the presence or absence of porosity, and the presence or absence of film dissolution have an important influence on cathodic film growth kinetics. These studies also show some of the methods that can be used to determine if these factors are present in a particular system. They also show that, provided the required physical parameters have been evaluated, the course of film growth can be quantitatively predicted.

In addition, these models can be used to explore the consequences of changing various system parameters and the various model parameters such as coulombic efficiency, film conductivity, etc., and can be correlated with changes in the structure of the polymer. For example, the well known relationship between coulombic efficiency and the number of solubilizing salt groups¹⁴

$$c = m/\rho F$$

where c is the coulombic efficiency in $\text{cm}^3/\text{coulomb}$, ρ is the film density in g/cm^3 , F is Faraday's constant in coulombs per equivalent, and m is the number of grams of resin per equivalent of solubilizing salt groups which is known for anodic systems, also applies to cathodic electrodeposition systems.

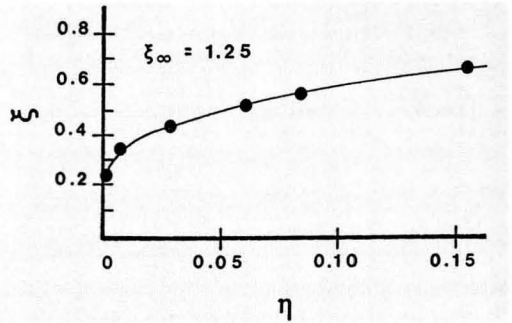


Figure 21—Plot of reduced film thickness vs reduced time for the case of film dissolution and exponential nonohmic conduction showing the agreement between experimental data points and the theoretical curve

THROWPOWER

A major advantage of the electrodeposition process for coating metal parts is its ability to coat recessed areas, cavities, channels . . . in fabricated products. The ability of a coating system to deposit films in recessed areas is called throwpower (see *Figure 22*).

Many methods have been proposed to measure throwpower.¹⁷⁻¹⁹ In the United States, the two most widely used methods are the Ford Cell Test¹⁷ and the GM Cell Test.¹⁸

In this section we examine the theoretical basis of the throwpower test in order to relate the geometric and electrochemical factors which influence the test. The analysis will allow the calculation of the throwpower from electrochemical data obtained on flat panels and

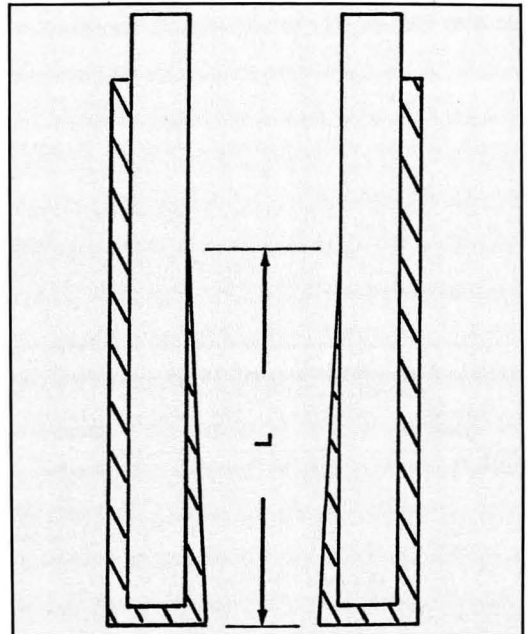


Figure 22—A schematic diagram of a throwpower cell illustrating the concept of throwpower

Table 3—Calculated and Measured Ford Throwpower Cathodic Appliance Primer $\delta_0 = 0.2$ mil

Voltage [Volts]	Time [sec]	Obs. Throw [cm]	Calc. Throw [cm]
50	90	3.5	4.1
100	90	5.4	5.5
150	90	6.4	6.3
200	90	7.6	7.0
250	90	7.9	7.5

also can be used to relate Ford Cell and GM Cell throwpower results.

The Ford and GM Throwpower Tests

The Ford Cell, consists of a piece of 3/4" standard gas conduit which is immersed to a depth of 10–12 in. in a stirred container filled with electrodeposition coating. Inside the tube is a 1/2" metal strip of shim stock running the length of the tube and electrically connected to the tube. A standard 4" × 12" test panel is also electrically attached to the throwpower tube. The inside diameter of the tube is 5/8". In the experiments reported in this paper, a 5/16" metal strip was used instead of the 1/2" strip specified in the Ford procedure.¹²

The GM Cell, consists of an open box constructed from 4" × 12" or 4" × 18" steel panels separated by 3/8" rubber spacers. The left and right edges are covered by the 3/8" slots in the rubber spacers which prevent deposition on the panel edges. The cell is immersed in a stirred tank of electrodeposition coating to within one in. of the bottom of the tank.

A constant voltage is applied for a specific time, typically 60–120 sec. The cell is removed from the tank, rinsed, and taken apart. The strip or metal panels are baked. The thickness of the electrodeposited film inside the recessed area is measured with a Permascope.²¹ A typical profile of the deposited film is wedge-shaped. The length of interior region coated, measured from the immersed open end of the cell, is the throwpower of the coating. Because of difficulties in locating the point at which the wedge ends, the throwpower is frequently specified as the length of the tube, or channel at which the film thickness of the coating is 0.1 mil or some other specified film thickness.

Table 4—Comparison of Ford and GM Cell Throwpower Results

Cathodic Primer	GM Throw [cm]	Ford Throw ^a [cm]	Ratio GM/Ford
1	35.6	27.9	1.27
2	21.6	17.7	1.21
3	30.4	25.4	1.20
4	29.8	22.8	1.30
5	31.7	25.4	1.25

Calculated 1.26 vs Avg < 1.25 >

(a) A 5/16 in. strip was used in the Ford cell employed in this study rather than the 1/2 in. strip usually specified.

Theory of the Throwpower Experiment

Furuno²⁰ has analyzed the throwpower experiment and related the cell geometry and coating properties to throwpower. The following analysis which differs from Furuno's gives essentially the same result.

The current inside the throwpower cell, I , is proportional to the electrodeposition bath conductivity, σ_B ; the cross sectional area of the cell, A , and the voltage gradient in the bath inside the cell, $\frac{dV}{dX}$ by the equation.

$$I = -A\sigma_B \frac{dV}{dX} \quad (47)$$

The current in the interior of the tube diminishes due to the current leakage through the depositing film onto the metal surface of the throwpower cell. The rate of current decay with distance up the tube is given by the equation:

$$\frac{1}{P} \frac{dI}{dX} = j \quad (48)$$

where P is the perimeter of the tube and j is the current density at the coated surface of the tube. Combining these equations we obtain:

$$\frac{d^2V}{dX^2} = - \left[\frac{P}{A} \right] \frac{j}{\sigma_B} \quad (49)$$

Furuno^{19,20} showed that inside the throwpower cell j is almost constant over the whole coated area of the tube. Thus, the preceding equation can be integrated to give:

$$V = V_0 \left[1 - \frac{1}{2} \left[\frac{P}{A} \right] \frac{j}{\sigma_B V_0} X^2 \right] \quad (50)$$

Equation (4) gives the voltage difference between bath and tube wall as a function of distance up the tube.

Now when $V = 0$, $X = L$, where L is the largest distance up the tube which is coated, i.e., the throwpower. Thus, throwpower, L , is given by the equation:

$$L = \left[\frac{2A}{P} \right]^{1/2} \left[\frac{\sigma_B V}{j} \right]^{1/2} \quad (51)$$

Equation (51) is equivalent to Furuno's equation. Furuno verified his equation for several cell geometries and applied it to several coating systems.

Calculation of Throwpower At Some Specified Film Thickness

Frequently, the throwpower is determined at some specified film thickness, typically 0.1 mil. The preceding theory also provides a means for establishing the throwpower at any given specified film thickness.

Because the current density, j , inside the throwpower tube is constant, then the field strength, $\frac{V}{\delta}$ must also be constant. This requires that the film thickness, $\delta[x]$, inside the tube, must have a parabolic profile which matches the voltage difference profile up the tube,

$$\delta[x] = \delta \left[1 - \left[\frac{X}{L} \right]^2 \right] \quad (52)$$

where δ is the external film thickness. Let ℓ be the distance up the tube at which the film thickness is some specified film thickness, δ_0 . Then,

$$\delta_o = \delta \left[1 - \left[\frac{\varrho}{L} \right]^2 \right] \tag{53}$$

solving equation (53) for ϱ we obtain:

$$\varrho = L \left[\frac{\delta - \delta_o}{\delta} \right]^{1/2} \tag{54}$$

Thus ϱ , the throwpower at some specified film thickness δ_o , is equal to the total throwpower L multiplied by the factor $[(\delta - \delta_o)/\delta]^{1/2}$.

Table 3 is a comparison of experimental and calculated throwpower measured at 0.2 mil for a cathodic appliance primer. The deposition time is 90 sec. The voltages vary from 50–250 v. The overall agreement between calculated and measured throwpower is satisfactory, considering the difficulties in measuring film thicknesses of the order of one mil and the uncertainties due to the surface roughness of the panels.

The throwpower at 0.2 mil film thickness is necessarily less than the total throwpower. As the external film thickness becomes larger at higher voltages, the throwpower at 0.2 mil approaches more closely the total throwpower. Since the total throwpower also increases with voltage, operation at the highest voltage possible, short of film rupture, yields the highest throwpower that can be attained with a given system. The data in Table 3 are in agreement with this trend.

Comparison Between GM And Ford Throwpower Test Results

Frequently, it is necessary to relate the results of one throwpower test to another. This can be easily accomplished from the preceding theory, provided that the two cells have a well defined channel geometry. Fortunately, the GM test and the Ford Cell Test, the two most widely used tests in the US, have channel geometrics that can be related.

In relating throwpower results obtained in different equipment, it is important to compare the same system under the same deposition conditions, i.e. the same applied voltage, deposition time, film thickness, etc. If the comparison is made under the same conditions, then equations (51, 54) can be used to calculate GM Cell results from Ford Cell results or vice versa.

First we note that if we hold the system and electro-deposition conditions constant, the throwpower results should only depend on the different system geometries. Thus, the ratio of throwpower in the GM Cell test, L , to the throwpower in the Ford Cell test, L' should be equal to,

$$\frac{L}{L'} = \left[\frac{A}{A'} \frac{P'}{P} \right]^{1/2} \tag{55}$$

where A and P are the area and perimeter of the GM Cell; A' and P' are the area and perimeter of the Ford Cell. Introducing the appropriate dimensions of the two cells we obtain:

$$\frac{L}{L'} = 1.35 \tag{56}$$

Thus, under the same conditions, GM Cell results will be about 35% higher than the corresponding Ford Cell results.

Table 5—Comparison of the Salt Spray Corrosion Resistance of Anodic and Cathodic Automotive Primers

Substrate	Pretreatment	Salt Spray Exposure	Scribe Creep	
			Anodic	Cathodic
Steel	None	336 Hrs.	3/16"	1/16"
Steel	Fe Phosphate	336 Hrs.	1/16"	1/64"
Steel	Zn Phosphate	336 Hrs.	1/32"	1/64"

If we use equation (54) for the throwpower at some specified film thickness, we have,

$$\frac{\varrho}{\varrho'} = \frac{A}{A'} \frac{P'}{P}^{1/2} \tag{57}$$

which is the same form as the equation for the total throwpower, where the unprimed quantities refer to the GM Cell test and the primed quantities refer to the Ford Cell Test.

This equation is also restricted to comparing the same electro-deposition paint under the same conditions which give rise to the same film thickness. Thus, the total throwpower and the throwpower measured at the same specified film thickness in the GM and Ford Cells should have a constant ratio equal to 1.35.

Table 4 lists some Ford and GM throwpower data obtained on several electro-deposition primers. The throwpower was measured at 0.1 mil. The applied voltages and the deposition times were the same, as well as the film thicknesses. In the last column of the table, the ratios of GM to Ford Cell throwpower are listed. These ratios are in good agreement with the theoretical value of 1.26 predicted by the theory for the modified Ford cell used in these experiments. Note that a 5/16" metal strip was used instead of the standard 1/2" one. Thus, it is relatively simple to calculate comparable GM or Ford cell throwpower results provided the other has already been determined.

DISCUSSION OF THROWPOWER

The theoretical basis for the GM and Ford throwpower tests has been examined using concepts first presented by Furuno.²⁰ Experimental throwpower data obtained on primers of various types are shown to be in agreement with this theoretical analysis.

Table 6—Comparison of Substrate Dissolution During Anodic and Cathodic Electrodeposition

Substrate	PPM Fe		PPM Zn	
	Anodic	Cathodic	Anodic	Cathodic
Cold rolled steel	2167	55	—	—
EP-10 Fe Phosphated steel	308	42	—	—
EP-2 Zn Phosphated steel	249	30	13300	83

V = 90 Volts; t = 90 Sec; Anderson, et al., *J. Coatings Tech.*, 50, No. 646, 38-45 (1978).

The theory allows prediction of the throwpower in either the Ford or GM cell tests provided the film growth kinetics of the electrodeposition primers are known from experiments on flat panels.

Specifically, a knowledge of the current density field strength relationship of the deposited film, the electrodeposition bath conductivity, and the film thickness achieved at the end of the electrodeposition are required.

Two equations for estimating throwpower are described. The first is valid for the total throwpower. The second is valid for estimating the throwpower at some specified film thickness, for example 0.1 mil.

These equations show that throwpower can be increased by raising the electrodeposition bath conductivity, raising the voltage, decreasing the final current density, and increasing the film thickness at the end of the throwpower experiment. Since the film thickness also increases with the voltage, this suggests that operation at the highest voltage possible, short of rupture, will give the highest throwpower for a specific system. Increasing the time of deposition will also increase the applied film thickness and the throwpower but, if the film thickness achieves a limiting value, this strategy is not very effective if the system has already attained a film thickness close to its limiting value.

The ratio of the GM to Ford Cell throwpower results is confirmed by experiment to agree well with the theoretically derived value, so that GM Cell results can be estimated from Ford Cell values or vice versa.

CORROSION PROTECTION

Cathodic electrodeposited appliance and automotive primers give outstanding corrosion protection. This advantage is perhaps the prime reason for their rapid acceptance by industry. *Table 5* is a comparison of salt spray performance of an anodic and cathodic automotive primer.²² These data show several important trends. The salt spray exposure of both cathodic and anodic systems improves as the quality of the pretreatment improves as indicated by the reduction in scribe creepage at 336 hr salt spray exposure. The cathodic system gives less scribe creepage than the anodic system and is significantly better over the poorer substrates.

Two factors which contribute significantly to outstanding corrosion protection, are reduced substrate dissolution and a polymer chemical structure which is resistant to attack by hydroxyl ions. In both these respects, cathodic electrodeposition systems perform better than anodic systems.

The electrode reactions at the cathodic do not involve dissolution of the substrate. The primary reaction involves the electrolysis of water to form hydroxyl ions and hydrogen. The highly alkaline boundary layer and film on the metal surface can lead to secondary chemical reactions especially in the case of amphoteric metals such as aluminum, but the extent of this substrate dissolution is small in comparison to anodic electrodeposition.

It is difficult to make comparisons of anodic and cathodic electrodeposition results because of differences in polymer structure, pH, applied voltage etc., but Anderson, et al² have made the most extensive published comparison. Their results are essentially in agreement

with our studies, but have the advantage that care was taken to look at the same acrylic polymer type modified to form an anodic system and a corresponding cathodic system.

Table 6 is a comparison of metal contents of anodic and cathodic films electrodeposited on cold rolled steel, EP-10 iron phosphated steel, and EP-2 zinc phosphated steel taken from the Anderson, et al study.

After a 90 sec electrodeposition time, the metal contents of the anodic films are in all cases significantly higher than the cathodic films.

In the cathodic case, the iron pickup, besides being less than the anodic case, also shows less variation on the various steel substrates. In the case of the EP-2 zinc phosphate pretreatment, substantially less zinc is incorporated into the cathodic electrodeposited film than the anodic one. In both cases, metal pretreatment does lessen the extent of substrate dissolution. For maximum corrosion protection, good metal pretreatment is essential for cathodic systems and for anodic electrodeposition systems.

The second factor in the superior corrosion protection of the cathodic primers are their outstanding resistance to hydroxyl ion attack and cathodic disbonding. This effect has been recently studied by Smith and Dickie²³ for various automotive primer systems, including cathodic systems. Similar results were obtained previously on other systems by Wiggle, Smith and Petrocelli,²⁴ also of Ford.

The methods used by Smith and Dickie are described in the references cited as well as the electrochemical and physical basis of their methods. Their cathodic corrosion test results indicate that the cathodic electrodeposition primer, which they tested, was substantially more resistant to alkali displacement than the others included in their study. This was also reflected in their salt spray testing.

Our salt spray results in *Table 5* also agree with the conclusions of the Ford workers since the superior scribe creepage of the cathodic primer is directly related to its greater resistance to alkali displacement.

CONCLUSION

The successful commercialization of cathodic electrodeposition was based on the experience and the basic knowledge generated from the development and commercialization of the anodic electrodeposition process. The work required a team effort with contributions from many people and disciplines. Despite the great progress made in the leading industrial countries in the basic understanding of the electrodeposition process, much work still remains to be done. Specifically, a better physical chemical understanding of the basic electrode processes, the processes taking place in the boundary layer, the mechanism of film conduction, etc. would be desirable additions to our knowledge.

Future success will depend on knowledge and basic understanding. Joseph J. Mattiello wrote: "The future will have many scientific surprises for the (coatings) industry." The course of the future will be determined by those who have the skill, determination, and the grit to

generate the new developments that are needed to meet the current and future challenges of our industry.

ACKNOWLEDGMENTS

The author wishes to thank Zlata Kovac and Clark Higginbotham for their careful electrochemical measurements and many discussions on the electrochemistry of the electrodeposition process.

Special thanks are due to Marco Wismer, Robert Jerabek, Joseph Bosso, and Roger Christenson for providing the systems discussed in this paper. The patent literature is perhaps the most eloquent testimony to their contribution to cathodic electrodeposition.

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High Performance Gel Permeation Chromatography Characterization of Oligomers Used in Coatings Systems

Cheng-Yih Kuo and Theodore Provder
Glidden Coatings and Resins Division, SCM Corporation*

Gel permeation chromatography (GPC) has been used extensively for the routine molecular weight distribution analysis of polymers at the Glidden Research Center since the early days of GPC developments. However, with conventional GPC, the analysis time has been lengthy and the resolution in the low molecular weight region has been limited. With the advent of high efficiency columns, the speed of analysis and resolution in the low molecular weight region has been greatly improved. The latter feature makes high performance GPC (HPGPC) an indispensable characterization tool for the analysis of oligomers/polymers in environmentally acceptable coatings systems. In this paper, the qualitative and quantitative HPGPC methodologies developed for the analysis of oligomers and polymers are described. Specific applications include (a) quality control of supplier raw materials, (b) guiding resin synthesis and processing, (c) modifying resin synthesis to improve end-use properties, and (d) correlating oligomer and polymer MWD with end-use properties.

INTRODUCTION

Over the last five years, the coatings industry has had to develop new technologies to meet the challenges of governmental regulations in the areas of energy, ecology, and consumerism. The greatest changes have occurred in the industrial or chemical coatings areas with the development of environmentally acceptable coatings systems,

such as high solids, powder, water-borne, and radiation curable coatings. These new coatings technologies require the use of tailor-made low molecular weight polymers, oligomers and reactive additives which, when further reacted, produce higher molecular weight and crosslinked polymers concomitant with the minimization of the evolution of volatile products. In these types of coatings systems, the control of the oligomer/polymer composition and molecular weight distribution (MWD) is critically important.

Conventional GPC does not provide the required resolution in the low molecular weight region for the control of MWD in these oligomer/polymer systems. With the advent of high efficiency columns, the resolution in the lower molecular weight region (molecular weights in the range of 200 to 10,000) has been greatly improved and the speed of analysis increased. These features make high performance GPC (HPGPC) an indispensable characterization tool for the analysis of oligomers/polymers in environmentally acceptable coatings systems.

EXPERIMENTAL

The instrument used in this study was an in-house constructed HPGPC composed of a Waters Associates M-6000 solvent delivery system, Waters Associates U6K injector, Varian Instruments fixed wavelength (254 nm) UV detector, Varian Instruments differential refractometer (DRI), and Waters Associates liquid volume counter.

The instrument was operated at room temperature with Burdick and Jackson distilled in glass THF as the eluting solvent. The sample column bank consisted of six μ -Styragel[®] columns with the following porosity design-

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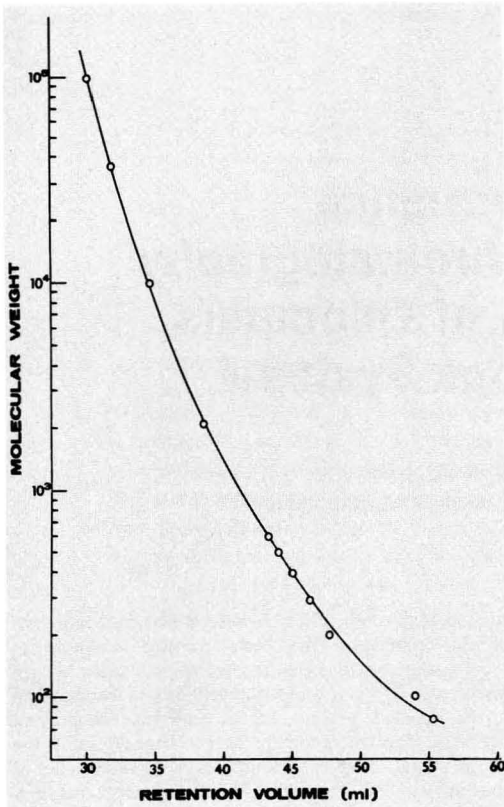


Figure 1—Polystyrene molecular weight calibration curve

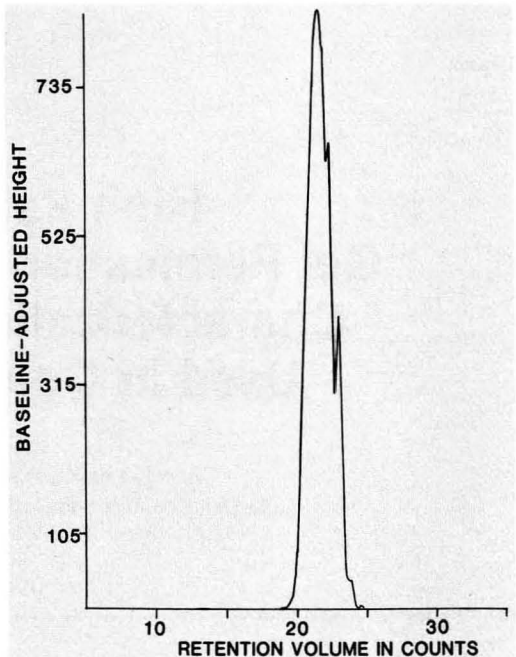


Figure 3—Typical computer generated plot of baseline-adjusted height vs. retention volume

nations: 10^4 , 10^3 , 500, 500, 100, 100Å. The flow rate was adjusted to 0.6 ml/min. A 2.2-milliliter syphon was used to monitor retention volume.

The column plate count was determined from the expression

$$\text{Plate Count} = 16 (V_R/W_b)^2 \quad (1)$$

where V_R is the retention volume and W_b is the baseline width of the plate count standard. Using o-dichlorobenzene as the plate count standard yielded 24,000 plates for 180 cm. of column.

The resolution of the column set was determined from the expression derived by Bly¹

$$R_s = \frac{2(V_{R_2} - V_{R_1})}{W_{b_1} + W_{b_2}} \cdot \frac{1}{\log_{10}(M_1/M_2)} \quad (2)$$

where V_{R_2} and V_{R_1} are retention volumes, W_{b_1} and W_{b_2} are baseline widths and, M_1 and M_2 are peak molecular weights for polymer standards 1 and 2, respectively. For this set of columns, polystyrene standards* of molecular weights 37,000 and 2,000 were used for standards 1 and 2, respectively. The value obtained for R_s was 2.2 at a flow rate of 0.6 ml/min. This value of R_s compares to a value of 1.14 at a 2 ml/min flow rate reported in the literature.² At this flow rate, the column set gave the optimum resolution per unit time. This relatively low flow rate is also required to preserve the column resolution over an extended period of time. This flow rate condition corresponds to the minimum in a Van Deemter plot of height equivalent theoretical plates versus linear velocity and is

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MOLECULAR WEIGHT DISTRIBUTION				
	NUMBER	WEIGHT	Z	Z+2
MEAN	.723E 03	.124E 04	2206E 04	.318E 04
VARIANCE	-.370E 06	-.102E 07	-.232E 07	.465E 04
SKENNESS	-.292E 01	.238E 01	.212E 01	
KURTOSIS	.154E 02	.105E 02	.765E 01	
MEAN WT/MEAN NMBR	1.708			
MEAN Z/MEAN WT	1.667			
MEAN Z+1/MEAN Z	1.546			
MEAN Z+2/MEAN Z+1	1.461			
MEAN Z * MEAN Z+1/MEAN WT	.531E 04			
RANGE	.144E 03 TO .132E 05			
RAW CHROMATOGRAM STATISTICS				
MEAN	.217E 02	MAX PEAK COUNT	21.56	
VARIANCE	.689E 00	MAX PEAK HEIGHT	835.81	
SKENNESS	.143E 00	MOMENT 3 ABOUT MEAN	.938E-01	
KURTOSIS	.239E 01	MOMENT 4 ABOUT MEAN	.263E 01	
AREA	.180E 04			
COLUMN AND BASELINE PARAMETERS				
COLUMN SET	7	STARTING BASELINE COUNT	18.00	
SOLVENT	THF	ENDING BASELINE COUNT	28.00	
VOID VOLUME	8.00	BASELINE SLOPE	-.0160	
TOTAL VOLUME	28.00	FIRST DATA POINT COUNT	19.00	
CALIBRATION CURVE	21	LAST DATA POINT COUNT	24.80	
CALIBRATION POLYMER	POLYSTYRENE 1/80			

#1 count unit = 1 syphon dump of 2.2 milliliters.

Figure 2—Typical computer generated data analysis report

*Obtained from Pressure Chemical Co., Pittsburgh, PA.

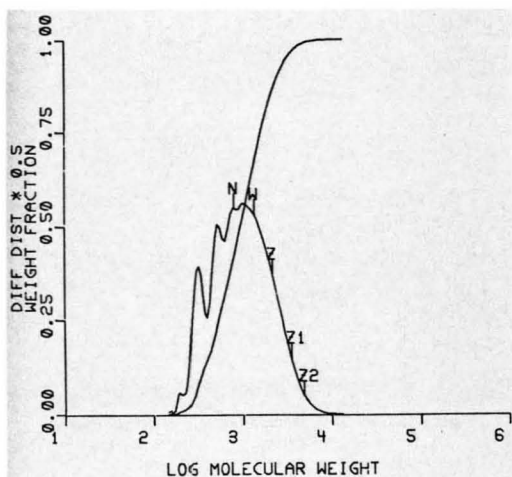


Figure 4—Typical computer generated plot of weight differential and cumulative distributions of molecular weight

in agreement with other published data on μ -Styragel columns.^{3,4}

The column set was calibrated with Pressure Chemical polystyrene standards over the molecular weight range of interest. The molecular weight calibration curve for this column set is shown in Figure 1. The polystyrene molecular weight scale was used to provide quantitative estimates of MWD parameters such as number- and weight-average molecular weight (\bar{M}_n , \bar{M}_w) for relative comparison purposes in conjunction with the analysis of the MWD of oligomers and low molecular weight polymers used in coatings systems.

DATA ACQUISITION AND ANALYSIS

The HPGPC has been interfaced to a Data General NOVA Model 1230 minicomputer for real-time data acquisition and analysis. The minicomputer system has been described previously.⁵ The subsequent data reduction and analysis provides molecular weight averages (\bar{M}_n , \bar{M}_w , \bar{M}_z , \bar{M}_{z+1}) or the equivalent extended chain length averages as well as various polydispersity indices. In addition, statistical shape parameters, such as variance, skewness, and kurtosis for the number-, weight- and z-distributions are provided. A typical computer generated analysis report is shown in Figure 2. The data analysis program provides plots of baseline-adjusted height versus retention volume, as shown in Figure 3, as well as plots of the weight-differential and cumulative distributions of molecular weight with the locations of the respective molecular weight averages (\bar{M}_n , \bar{M}_w , \bar{M}_z , \bar{M}_{z+1} , \bar{M}_{z+2}) marked on the differential curve, as shown in Figure 4. The computation of MWD statistics and plots are based on the method given by Pickett, Cantow, and Johnson.⁶

For oligomeric samples with well-defined peaks (Figure 5), the relative percentage for each component can be obtained by integrating the area under each peak

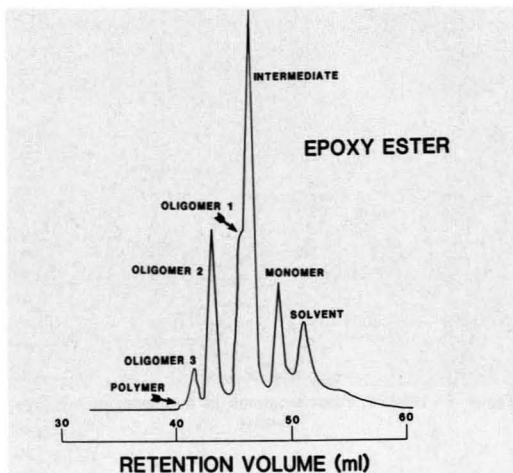


Figure 5—HPGPC chromatogram of a model compound of epoxy-ester

via a gas chromatography data reduction package also resident on the NOVA minicomputer.⁵

RESULTS AND DISCUSSION

The resolution capability of the μ -Styragel column set is shown in Figure 6. A mixture of polystyrenes with molecular weights ranging from 97,000 to 600 were separated according to their molecular weights. The

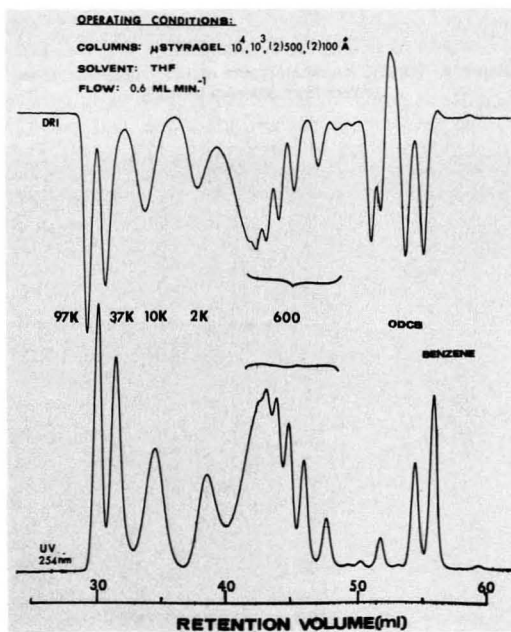


Figure 6—HPGPC traces (UV and DRI) of a polystyrene standard mixture

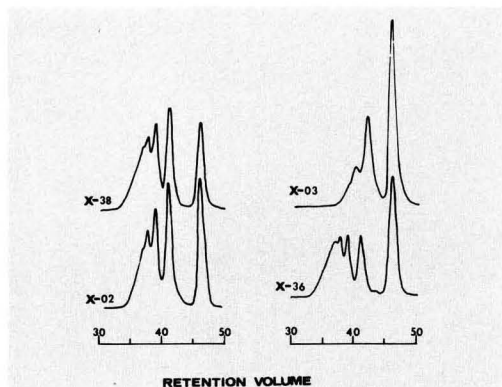


Figure 7—HPGPC chromatograms of four isocyanate cross-linkers

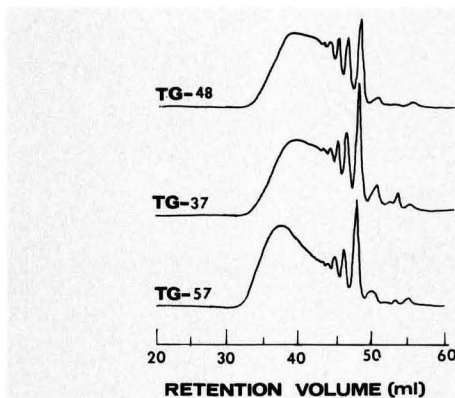


Figure 10—HPGPC chromatograms of acrylic resins

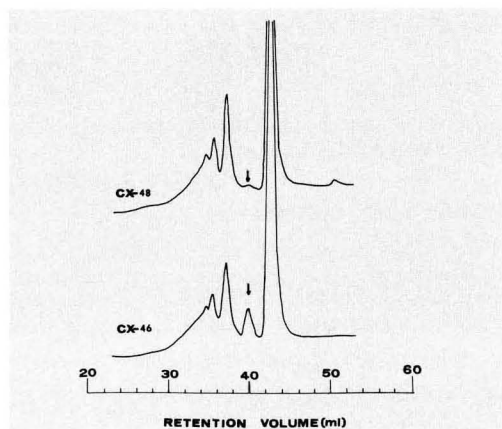


Figure 8—HPGPC chromatograms of two isocyanate cross-linkers from different batches

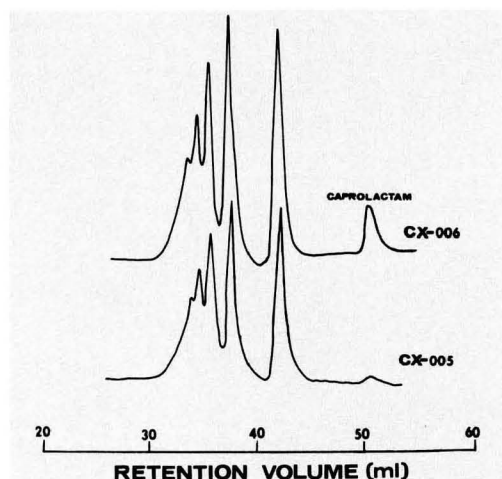


Figure 9—HPGPC chromatograms of two isocyanate cross-linkers from different batches

unique feature of microparticulate high efficiency columns, which include μ -Styragel, is the high resolution in the low molecular weight region.^{3,4,7-10} For the 600 molecular weight polystyrene standard, conventional GPC columns would give only a broad peak. However, the μ -Styragel columns separated this sample into at least six well-defined peaks, as shown in Figure 6 corresponding to monomer, dimer, trimer, and other higher molecular weight oligomers. Even small molecules such as ortho-dichlorobenzene and benzene are readily separated. The high resolution in the low molecular weight regions is particularly suited for fingerprinting the oligomers used in chemical coatings systems. In Figure 6, both UV and DRI traces are shown. For clarity in comparisons, only UV traces will be shown for examples in subsequent discussion, unless where specified otherwise.

Powder Coatings

One of the new coatings technologies which has developed as an innovative response to governmental regulation is powder coatings. These coatings systems are designed to be 100% solids. The development of coatings properties are a result of reacting the low molecular weight polymer with an oligomer crosslinking agent to produce crosslinked polymer. The powder coating usually contains a small amount of an oligomeric flow agent to aid flow and leveling during the baking process. The MWD of the low molecular weight polymer, oligomeric crosslinking agent, and oligomeric flow agent must produce a coatings system such that (a) the powder particles will not "block" (coalesce) upon shipment or storage, (b) the resin system will melt and flow with appropriate leveling characteristics optimum for appearance properties prior to the crosslinking reaction within specific time constraints at a given temperature, and (c) the crosslinking reaction must occur at the appropriate point in time after the resin has melted consistent with the development of both good appearance properties and good mechanical properties. Thus, the MWD of the polymer, crosslinking agent, and flow modifier must be carefully designed and controlled to produce a powder coat-

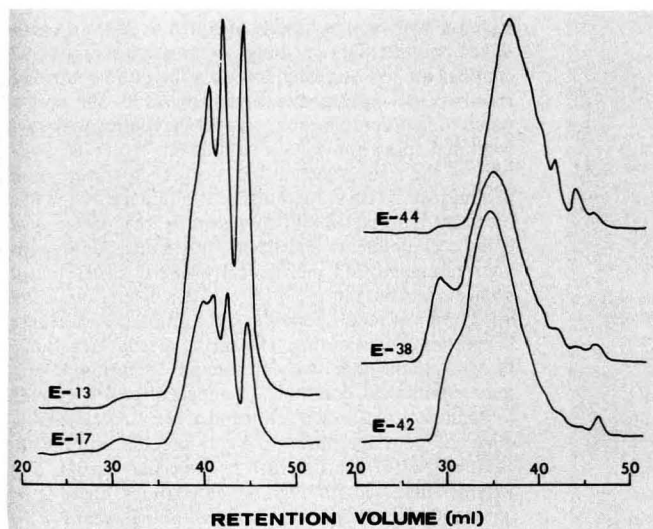


Figure 11—HPGPC chromatograms of high solids polyesters

ings system which meets defined rheological, reactivity, and mechanical property constraints.

Figure 7 illustrates the use of HPGPC to aid a resin chemist in developing an in-house isocyanate crosslinker for a powder coating system. Isocyanate crosslinker X-02 gave desired properties and is considered the standard. At the early stage of the development, resin X-03 was initially made. By changing the types of reactants and reaction conditions, resin X-36 was the next iteration in the resin synthesis process. Finally, X-36 was fine-tuned to produce X-38 which matched X-02 in both its chemical reaction properties and its MWD.

HPGPC also was used for quality control of incoming raw materials. Figure 8 shows the chromatograms of two different batches of blocked isocyanate crosslinkers. One was acceptable and the other was too reactive. As can be seen from the HPGPC traces, the level of the component eluted at retention volume 40 is much higher for CX-46 than for CX-48. This component was associated with free isocyanate functionality which in excess would make CX-46 too reactive. With this information, either the

necessary adjustment for the presence of excessive free isocyanate functionality could be made or this particular batch from the supplier could be rejected.

Another example involved a batch of isocyanate crosslinker which was too tacky. Upon comparing the HPGPC trace of this sample with that of a control, as shown in Figure 9, it is seen that the major difference between these two samples was the level of free caprolactam. The high content of free caprolactam in sample CX-006 depressed the glass transition temperature (T_g) of the sample to such an extent that CX-006 became too tacky. This method of analysis has proved to be a reliable and useful technique for detecting low levels of free caprolactam in this type of oligomeric crosslinker.

Figure 10 shows the HPGPC traces of two different batches of in-house acrylic resins for powder coatings. It is seen that, due to the presence of high levels of low molecular weight components and residual monomer and solvent in sample TG-37, the T_g is 20°C lower than that of sample TG-57. Reducing the amount of low molecular weight components and residual monomer

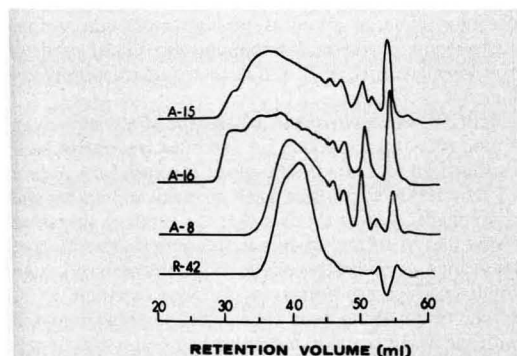


Figure 12—HPGPC chromatograms (DRI traces) of high solids acrylics

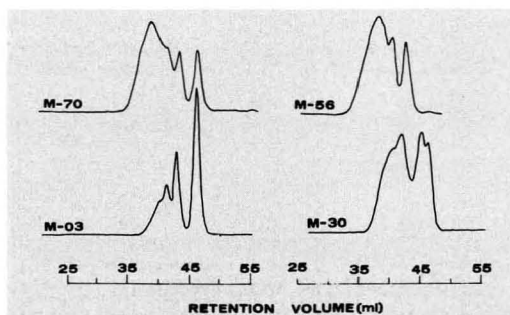


Figure 13—HPGPC chromatograms of melamine resins

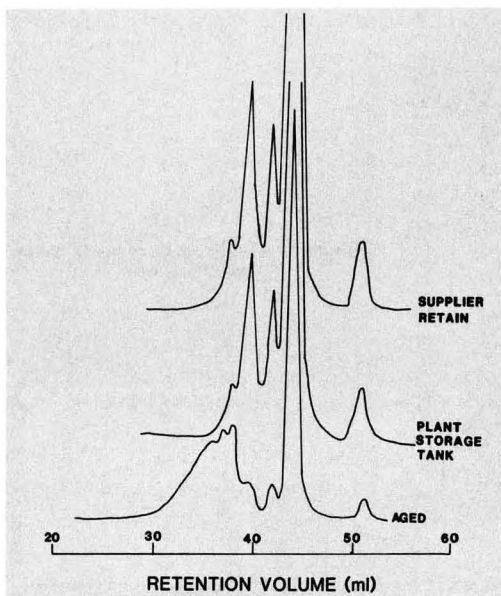


Figure 14—HPGPC chromatograms of epoxy resins

and solvent by vacuum stripping gave an increase in the T_g from 37°C to 48°C for sample TG-37. This brought the sample within the minimum acceptable T_g level consistent with non-“blocking” of the sample.

High Solids

Another technology which has evolved as a response to governmental regulations is high solids coatings. High solids coatings are those which are usually 62.5% nonvolatile or greater on a volume basis. These coatings systems contain oligomers which are generally low in molecular weight, on the order of 500. As in powder coatings, these systems develop mechanical properties upon

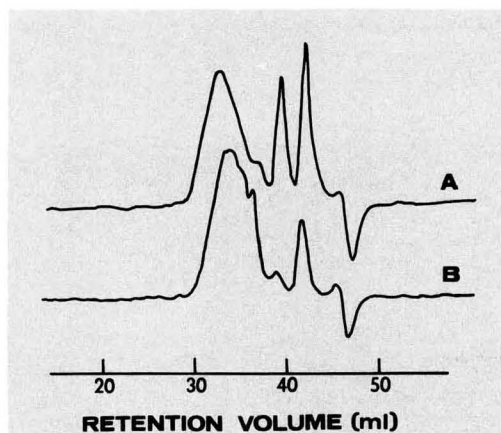


Figure 15—HPGPC chromatograms (DRI traces) of polyester urethane

reaction with a crosslinking agent to produce a cross-linked polymer. The key design parameters in high solids coatings are low viscosity, low volatility, and controlled reactivity.^{11,12} Low coatings viscosity (100–500 cps) is required in order to be able to apply the coating with conventional spray application equipment. However, volatility of the resin system at the curing temperature must be minimal. These constraints necessitate the design of a carefully tailored MWD to minimize the presence of volatile components consistent with molecular weights high enough to aid mechanical property development upon curing, but not too high to have a deleterious effect upon application properties and the ultimate appearance properties of the coating. The curing mechanism should be controllable under varying reaction conditions to produce crosslinked coatings at temperatures low enough to minimize volatile evolution and at the same time minimize energy usage during the cure process. In order to compensate for the decrease in molecular weight of a polymer designed for high solids coatings, there is an increasing dependence on the crosslinking agent for the development of mechanical properties. It becomes important to carefully match the crosslinking agent with the polymer both in terms of reactive functionality and MWD.

For high solids coatings, HPGPC is very useful for screening various resins for the optimization of coatings viscosity and cured film properties. Among the five polyester resins shown in Figure 11, E-17 was finally chosen to be scaled-up due to the unique combination of good film properties (hardness and salt spray resistance) and lowest viscosity. The three resins on the right side of Figure 11 (E-44, E-38, and E-42) were not acceptable because their viscosities were too high as a result of high molecular weight components. While resin E-13 met the requirement of low viscosity for high solids, the film properties were not as good as those of E-17 due to the presence of a high level of unreacted monomer.

Figure 12 shows the HPGPC DRI traces of four high solids acrylic oligomers. The results of paint performance evaluation on these acrylics showed that A-8 possessed similar paint viscosity, pencil hardness, impact, MEK resistance, and adhesion properties to the commercial high solids acrylic R-42 due to the similar molecular weight range. Acrylics A-15 and A-16 possessed two to three units higher in hardness than acrylic A-8 due to the presence of large amounts of high molecular weight components. However, the coatings viscosity of coatings systems made with A-15 and A-16 was unacceptably too high.

HPGPC was also used to analyze the MWD of various amino crosslinkers, which are the most frequently used curing agent for industrial coatings. It is seen from Figure 13 that HPGPC resolved each crosslinker into several components despite the fact that the vendor's literature stated that M-03 and M-56 are monomeric. The effect of these amino crosslinkers on the properties of acrylic high solids coatings has been studied. Using the same set of acrylic resins, it has been shown that coatings prepared with the M-70 crosslinking agent had better 500 hr salt spray resistance but lower impact resistance than coatings prepared with the M-03 crosslinking agent. These

properties are believed to be associated with the higher molecular weight of M-70.

Water-Borne Coatings

Water-borne coatings are replacing solvent-based coatings in such markets as metal decorating (beverage can liners), coil coatings, and wood coatings as a response to meeting government regulations with respect to allowable amounts of volatile solvent emission during the baking process. These coatings are usually in the 5,000–30,000 molecular weight range and are prepared in water-miscible organic solvents up to 70 to 80% solids by volume. Chemically, these resins can be polyesters, alkyds, acrylics, and epoxy esters. Generally, these resins can self-emulsify into water containing some amine.¹³

In the production of epoxy water-borne coatings, it becomes important to monitor changes in the molecular structure of low molecular weight epoxy resins during storage. It is well-known that catalyzed liquid epoxy resins will undergo further reaction upon aging. HPGPC has been used to monitor retains of incoming shipments from the resin supplier and monitor periodic samples from storage tanks of production plants. *Figure 14* shows that, at the time of sampling, the samples that came from the plant storage tank were essentially similar to the retained samples from the supplier. Also shown in the figure is an epoxy sample which has been aged for a year. It is seen that the low molecular weight components had undergone further reaction to form a much higher molecular weight compound. Changes in oligomer distribution, such as this, at any time, will alert the respective production plant to take proper action.

UV Curable Coatings

Typically, UV curable coatings consist of very low molecular weight multi-functional oligomers diluted with reactive monomers and contain a photosensitizer to promote the crosslinking reaction. The almost instantaneous rate of reaction permits very fast line speeds. This type of technology is ideally suited for flat stock, such as floor tile and interior wood paneling. Often such coatings are applied by roll coating application methods. In order to have acceptable appearance properties after cure, the MWD of the oligomer system is one variable along with total coatings viscosity which must be controlled to have the appropriate rheological properties with respect to roll transfer, flow, and leveling. The MWD of the oligomer must be maximized consistent with acceptable rheological properties in order to generate acceptable mechanical properties in the cured film.

HPGPC is very useful for guiding resin synthesis and process development. *Figure 15* shows the HPGPC traces of two polyester-based urethane oligomers produced by varying the order of monomer addition to the reactor. The difference in the oligomer distribution is clearly seen in the 38–45 ml retention volume region. Due to the presence of the high level of very low molecular weight components, the resin produced from process A did not have acceptable mechanical properties compared to the resin produced from process B. The coatings system containing resin A produced a clear protective



DR. CHENG-YIH KUO is an Associate Scientist in the Polymer Physics Section of the Polymer and Coatings Research Dept. of Glidden. He received a B.S. Degree in Chemical Engineering from National Taiwan University and a Ph.D. Degree in Polymer Science from the University of Akron. He has been with Glidden since 1975 and is currently engaged in fundamental research on solution properties of polymers and characterization of organic coatings.

DR. THEODORE PROVDER is Senior Scientist in charge of the Polymer Research and Computer Science Group of the Polymer and Coatings Research Dept. of Glidden. He received the Ph.D. Degree in Physical Chemistry from the University of Wisconsin. Dr. Provder has been with Glidden since 1970 and is engaged in long range research involving polymer chemistry, polymer physics, and the application of computer science to coatings science and technology.



surface coating which when subjected to cure via UV radiation did not meet hardness specifications.

CONCLUSIONS

The emergence of new coatings technologies, such as high solids, powder, water-borne and radiation curable coatings as a response to governmental regulations has led to the development of resin systems where the measurement of the oligomer and low molecular polymer MWD is critically important in order to control the properties of these coatings systems. It has been shown that the HPGPC technique using high efficiency columns provides the necessary resolution in the low molecular weight regions of interest for these coatings systems.

This technique can be extended by use of other detectors. Chromatix¹⁴ have shown that an on-line light scattering detector, under appropriate conditions, can provide absolute molecular weight information in the low molecular weight region. In addition, it should be possible to unravel the subtle and important compositional dependence of the molecular weight distribution for these systems in the low molecular weight region by use of ultraviolet and infrared detectors.¹⁵

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United Kingdom Orders of FSCT Educational Literature

Mr. Ray Tennant, of the Birmingham Society, will act as a source of Federation educational literature (Color-matching Aptitude Test Set; Infrared Spectroscopy; Paint/Coatings Dictionary) for United Kingdom customers. Anyone interested in receiving these items is urged to contact Mr. Tennant. His address is: Carrs Paints Limited, Westminster Works, Alvechurch Road, Birmingham B31 3PG, England.

Some Substrate and Environmental Influences on the Cathodic Delamination of Organic Coatings

Henry Leidheiser, Jr. and Wendy Wang
Lehigh University*

Polybutadiene coatings, 10–20 μm in thickness, were applied to steel, galvanized steel, aluminum, tin, lead, cobalt, nickel, and silver substrates and the degree of delamination that occurred on cathodic treatment in an electrolyte was determined as a function of the following experimental variables: oxygen in electrolyte, cathode potential, film thickness, pretreatment of substrate, type of electrolyte, electrolyte concentration and temperature. The extent of delamination was determined as a function of the number of coulombs passing through the interface. The delamination was related to the relative magnitude of the cathode reaction, $\text{H}_2\text{O} + 1/2\text{O}_2 + 2\text{e}^- = 2\text{OH}^-$, that occurred under the coating to the magnitude of the cathodic reaction that occurred on the exposed substrate at a defect. The significance of the findings to the development of an accelerated test for appraising the corrosion protective properties of organic coatings was discussed.

INTRODUCTION

One of the important mechanisms by which organic protective coatings fail under service conditions is by delamination at the coating/metal interface. The recognition of this fact is exemplified by the number of accelerated corrosion tests designed to determine the rate of delamination under a standard set of experimental conditions. For example, the ASTM has a test¹ to determine the delamination of pipeline coatings under conditions that approximate cathodic protection during underground service. The automobile industry uses a test in which a painted panel is scribed and then exposed to salt spray.² The extent of deadhesion as a consequence of the cathodic reaction which occurs adjoining the scribe

mark³ is one of the important criteria used in evaluating the coating system.

Although cathodic delamination is widely used as an accelerated test method, the number of studies performed that provide information on the mechanism and on the variables which control the rate of delamination is limited. The purpose of this study was twofold: to survey a range of experimental parameters that affect the delamination in the vicinity of a coating defect when the metallic substrate is made the cathode while immersed in an electrolyte; and to utilize the results in understanding better the mechanism of cathodic delamination. The range of experimental parameters that was surveyed included oxygen in electrolyte, cathode potential, film thickness, pretreatment of substrate, type of electrolyte, electrolyte concentration and temperature.

The coating system selected for initial study was polybutadiene. This coating was selected as a model for two reasons: Considerable information on this system was available from previous work in this laboratory,^{4,5} and polybutadiene is moderately permeable to water and oxygen. Under many conditions, the delamination is rapid and much data can be generated within a short period of time.

EXPERIMENTAL

The sample preparation procedure involved cleaning the metal substrate, coating the substrate with polybutadiene, baking the coating, and storing until ready for an experiment. Storage times varied from two days to two weeks and there was no evidence during the research that storage time before use played any significant role in the results. The coated metal was sectioned into pieces, approximately 2×6 cm, and the edges and back side were protected with an epoxy-polyamide coating. Just before the experiment was initiated, the center of the sample was damaged by pressing a pointed instrument into the surface. The exposed substrate was approximately 0.001 cm^2 in area.

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* Center for Surface and Coatings Research, Bethlehem, PA 18015.

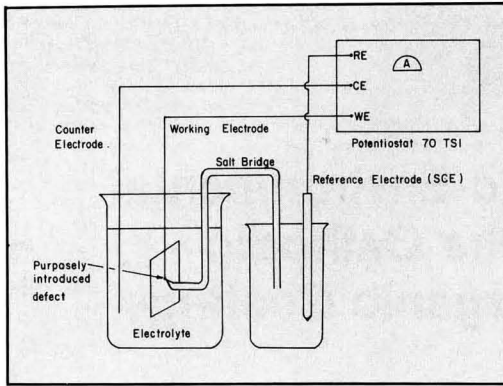


Figure 1—Schematic diagram of experimental arrangement

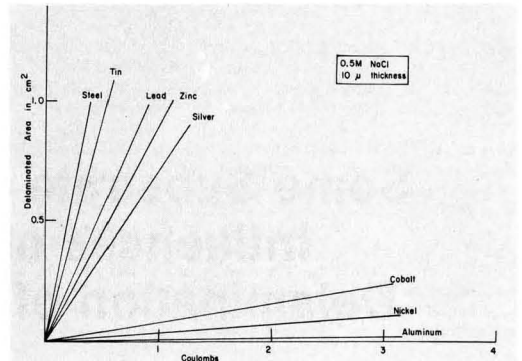


Figure 2—The effect of the nature of the substrate on the cathodic delamination of 10 μm thick coatings in 0.5M NaCl

Metal substrates were obtained from a number of sources. A large supply of cold-rolled steel, 0.09 cm in thickness, was obtained from Bethlehem Steel Co. and the same material was used in all experiments. Galvanized steel samples, identified with a code number in this article, were obtained from several different manufacturers. A description of these samples is given in a separate report.⁶ Tin, nickel, silver, aluminum, lead, and cobalt substrates were obtained as thin sheets from Alfa Chemical Co.

Several surfacing procedures were used. The term “degreased” is used to describe samples that were treated in trichloroethylene and acetone before application of the coating. The term “abrasively polished” refers to panels that were polished with aluminum oxide to a high lustre. Steel panels were also “acid cleaned” and “alkaline cleaned.” Acid cleaned panels were immersed for 5 min at 70–90°C in a 1:1 solution of concentrated HCl and water, rinsed in water, and then immersed in a 1:1 solution of concentrated sulfuric and nitric acids at room temperature for 10 sec. The panels were rinsed in water, immersed for 5–10 min in 5% NaCN at room tempera-

ture, rinsed in water, dried in acetone, and stored in acetone until ready for application of the coating. Alkaline cleaned panels were immersed for 5–10 min at 80°C in a 200 cm³ solution containing 6 g NaOH, 4.8 g Na₂SiO₃, 0.6 g EDTA, and 0.48 g Na₂CO₃. They were thoroughly rinsed in water, dried in acetone, and stored in acetone until ready for application of the coating. Phosphated panels were prepared using a proprietary phosphating solution.

Coatings were prepared from a commercial polybutadiene solution known as Budium® RK-622. The coating thickness was controlled by the use of wirebound laboratory coating rods. The polybutadiene solution was filtered through a 5 μm filter prior to application. The coatings were cured by placing the panels for 25 min in a preheated oven held at 200°C.

The experimental arrangement is shown schematically in Figure 1. The cathode potential was sensed with a capillary tube filled with the electrolyte which was connected by means of a “U” tube to a vessel holding the reference electrode, a saturated calomel electrode (SCE). All potentials are given with respect to SCE. The potential of the cathode was held constant during the experi-

Table 1—Delamination of Polybutadiene From Steel and Zinc (Galvanized Steel) Substrates As a Function of Coating Thickness

Substrate Metal	Environment	Coating Thickness (μm)	Delamination Parameter (cm ² /coulomb)
Steel	0.5M NaCl	10	2.4
		15	1.5
		20	0.73
Steel	0.125M NaCl	10	3.3
		15	1.6
		20	0.88
Zinc	0.5M NaCl	10	0.85
		15	0.47
		20	0.33
Zinc	0.5M NaOH	10	0.87
		15	0.50
		20	0.08

Budium is a registered trademark of E. I. duPont de Nemours & Co., Inc.

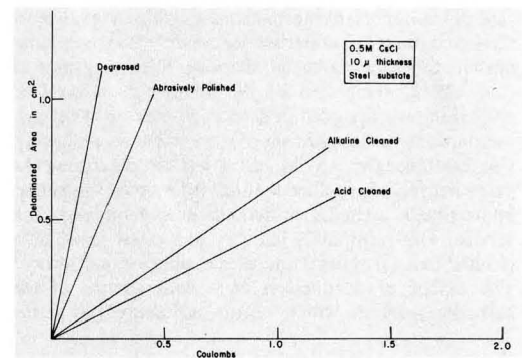


Figure 3—The effect of surface pretreatment on the cathodic delamination of 10 μm thick coatings on steel substrates in 0.5M CsCl

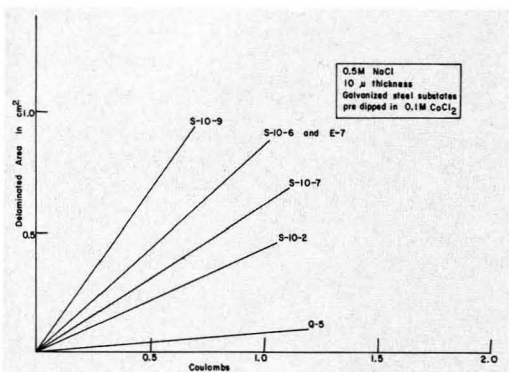


Figure 4—Cathodic delamination in 0.5M NaCl of 10 μ m thick coatings on five different galvanneal steel substrates after dipping in 0.1M $CoCl_2$ solution

ment by means of a potentiostat and the current flowing through the cathode/electrolyte interface was monitored continuously during the experiment.

The cathode potential used with each metal was selected early in the study on the basis that a current of approximately 10 μ amp flowed shortly after the experiment was initiated. Unless otherwise noted in the text, the following cathode potentials were used in all cases for the metals noted:

Aluminum	-1.35 v
Cobalt	-1.48
Lead	-0.95
Nickel	-1.33
Silver	-1.48
Steel	-1.35
Tin	-1.48
Zinc	-1.58

The measured potential was not critically sensitive to the location of the capillary tip as long as the tip was within a mm of the defect and did not cover the defect.

The delaminated area was determined after the completion of the experiment by pressing a piece of adhesive tape against the surface and measuring the area that was removed by microscopic examination. No coating was removed if the adhesive tape was applied to the defect

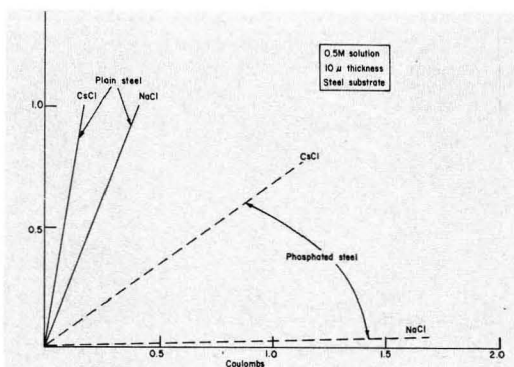


Figure 5—The effect of phosphating on the cathodic delamination in 0.5M $CsCl$ and 0.5M $NaCl$ of 10 μ m thick coatings on steel

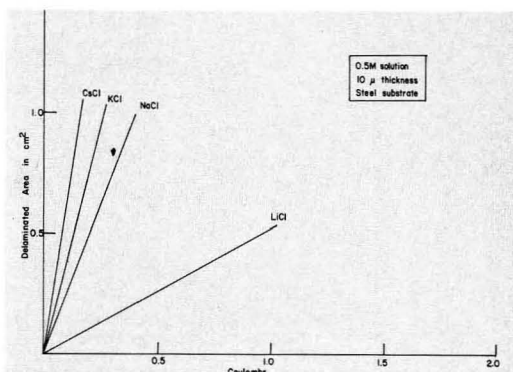


Figure 6—The effect of nature of the electrolyte on the cathodic delamination of 10 μ m thick coatings on steel substrates

before exposure to the electrolyte. Also, no delamination occurred around the defect when the sample was immersed in the electrolyte for several hours in the absence of an applied cathodic potential.

RESULTS

Some of the experimental results will be presented in the form of curves in which the vertical axis is the area of delamination and the horizontal axis is the number of coulombs passed. Data points are not included because the emphasis is on the relative behavior under different conditions.

Effect of Cathode Potential

It was observed in the initial stages of the study that an appropriate cathode potential was in the range of -0.9 to -1.5 v and was dependent on the metal. These potentials resulted in delamination areas that were easily measurable during experimental times of several hours. As stated previously, the sample was potentiostated at a potential that yielded a current of approximately 10 μ amp at the beginning of the experiment. Although no extensive study was made of the effect of cathode potential on the delamination phenomenon, a few experiments were carried out with silver substrates in 0.5M NaCl in which the potential was varied over a range of -1.43 to -1.52 v. The effect of potential on the delamination was relatively small over the potential range studied.

Effect of Oxygen

Insignificant delamination of polybutadiene from steel or zinc samples occurred when the electrolyte was carefully purged of air by bubbling nitrogen through the electrolyte. Thus, dissolved oxygen was essential in the delamination process in the case of these metals.

Effect of Coating Thickness

Results are given in Table 1 for the delamination from steel and zinc (galvanized steel) substrates in NaCl and

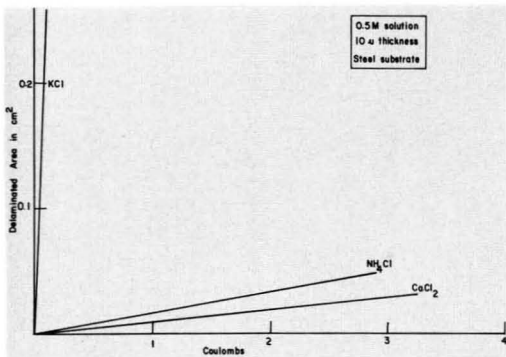


Figure 7—The effect of nature of the electrolyte on the cathodic delamination of 15 μm thick coatings on steel substrates

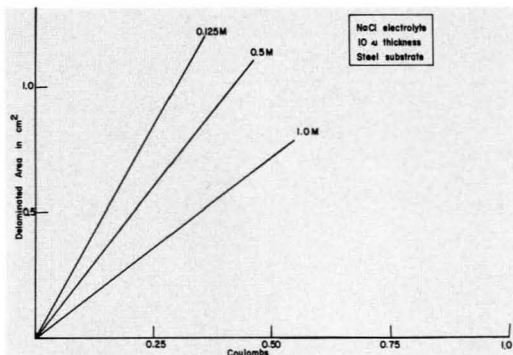


Figure 9—The effect of NaCl concentration on the cathodic delamination of 10 μm thick coatings on steel substrates

NaOH electrolytes as a function of the polybutadiene coating thickness. It will be noted that the delamination parameter decreased with increase in coating thickness.

Effect of Substrate and Substrate Pretreatment

The effect of the nature of the substrate surface was evaluated in several ways. First, different metals were abrasively polished before application of the coating and the rate of delamination was determined. It will be noted from Figure 2 that there was a very large difference in behavior for different metals. Second, the delamination properties of steel samples were determined as a function of the pretreatment. Four different surface treatments were used: (a) simple degreasing in trichloroethylene and acetone, (b) abrasive polishing, (c) alkaline cleaning, and (d) acid cleaning. Data are given in Figure 3 for a polybutadiene coating thickness of 10 μm . Third, galvanized steel samples which had been characterized in a previous study were tested. The range of delamination parameters of these different types of materials was very broad, as is shown in Figure 4. Fourth, the rate of delamination of steels that had been phosphated was determined in 0.5M CsCl and 0.5M NaCl. The beneficial effect of phosphating in reducing the delamination is readily seen in Figure 5.

Effect of Electrolyte

Data are given in Figures 6 and 7 for the delamination from a steel substrate in 0.5M solutions of LiCl, NaCl, KCl, CsCl, CaCl₂, and NH₄Cl and data are given in Figure 8 for the delamination in 0.5M solutions of NaF, NaCl, and NaBr.

Effect of Electrolyte Concentration

It has generally been observed that the cathodic delamination increased with decrease in concentration of the electrolyte. Data illustrative of this conclusion are given in Figure 9.

Effect of Temperature

This variable was not studied extensively and additional work is in progress to allow calculation of activation energies. At the present stage of knowledge, it is preferable to limit the conclusion to the fact that the delamination parameter increases with temperature over a range of 11° to 33°.

Ample evidence was accumulated during the course of this research to indicate that the delamination was not a direct function of the current flowing through the defect. The important criterion was the number of coulombs passed; not the rate of passage of the charge. Data illustrating this lack of correlation with current are obtained

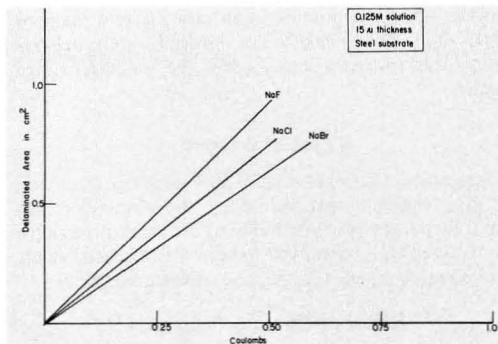


Figure 8—The effect of nature of the electrolyte on the cathodic delamination of 10 μm thick coatings on steel substrates

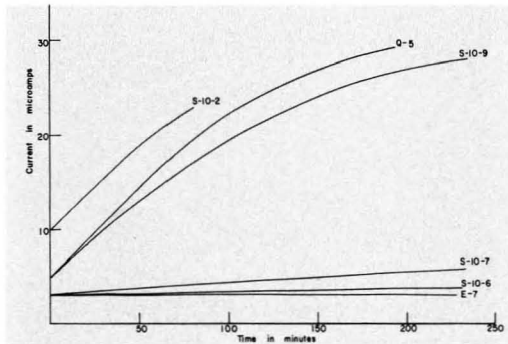


Figure 10—Current flow as a function of time during cathodic delamination

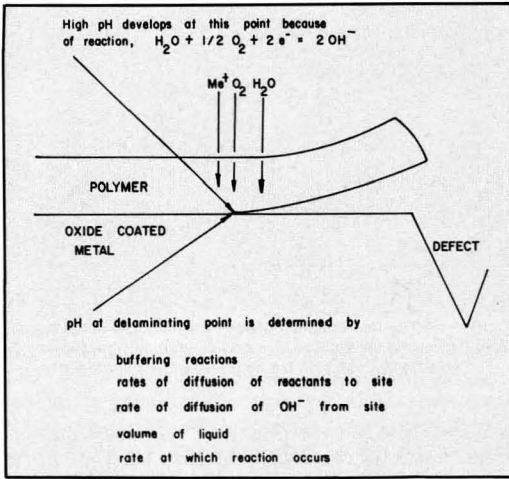


Figure 11—Simplified picture of the mechanism of delamination upon cathodic treatment in an electrolyte

by a comparison of Figures 4 and 10. The relationship between current flowing and time is given for six different samples of galvanized steel in Figure 10 and the delaminated area as a function of number of coulombs passed is given in Figure 4. It will be noted that Samples S-10-9 and Q-5 exhibited very different delamination parameters even though the current passing through the defect was approximately the same. Samples S-10-6 and E-7 delaminated with only slightly different delamination parameters than Sample S-10-9, but the current flowing through the defect was greatly different.

DISCUSSION

It should be stressed that the system which was studied is a model system selected because the delamination occurs in a short time. The coatings are very thin relative to those used for protection of exterior corrodible substrates, but are in the high thickness range for coatings used on the inside of food containers. The conclusions drawn apply specifically to polybutadiene-coated metals

Table 2—Rate of Transmission of Water Through Representative Polymer Films^a

Polymer Type	Transmission Rate In (g)/(ml)/(m ²)(day)	Temperature (°C)
Polyvinyl alcohol	1500	35
Cellulose acetate	1200	39.5
Polybutadiene	680	39.5
Cellulose nitrate	630	35
Polysisoprene	270	39.5
Poly(ethylene terephthalate) (Mylar) [®]	38	39.5
Poly(chlorotrifluoroethylene) (Kel-F) [®]	4.8	39.5

Mylar is registered trademark of du Pont Co.
Kel-F is registered trademark of 3M Co.

Table 3—Permeability of Oxygen Through Representative Polymer Films^a

Polymer Type	Permeability (cm ²) - (cm)/(sec) - (cm ²) - (cm Hg) × 10 ¹⁰	Temperature (°C)
Polyvinyl alcohol	0.0089	25
Cellulose acetate (plasticized)	0.78	30
Polybutadiene	19.2	25
Cellulose nitrate	1.95	25
Polysisoprene	23.8	25
Poly(ethylene terephthalate) (Mylar)	0.045	30
Poly(chlorotrifluoroethylene) (Kel-F)(amorphous)	0.040	25

and may, or may not, be extrapolated to other coatings systems.

It is apparent from the range of data presented that many variables influence the delamination of polybutadiene coatings on metallic substrates. The variables that have been recognized from this study with a single coating system include: coating thickness, nature of substrate, pretreatment of substrate, type of electrolyte, concentration of electrolyte, oxygen in solution, potential at the cathode, and temperature. Presumably there are other variables which were not studied in this program. A hypothesis for the mechanism of cathodic delamination is given here and experimental data are used to show the internal consistency of the data with the hypothesis.

For the purpose of the present discussion, the detailed mechanism by which the polymer/substrate bond is broken and the coating separates from the metal will not be a concern. This question, with specific reference to polybutadiene, is now under study, but a review paper has already been published.⁷ The general picture of the delamination process which is widely accepted in the coatings community is described in Figure 11. Water, oxygen, and metal cations migrate through the coating and the cathodic reaction, $H_2O + 1/2O_2 + 2e^- = 2OH^-$, occurs at the periphery of the delaminating region under the driving force of an applied potential. The major cause of the delamination is the high pH generated at the lead-

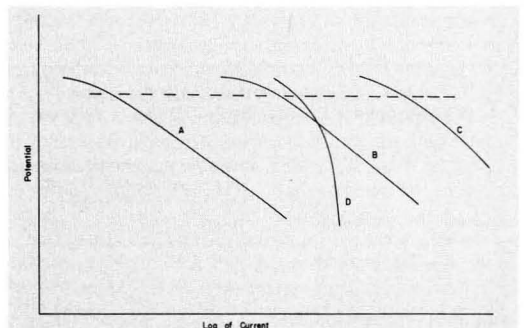


Figure 12—Interpretation of the delamination on the basis of assumed polarization curves at the defect and beneath the coating

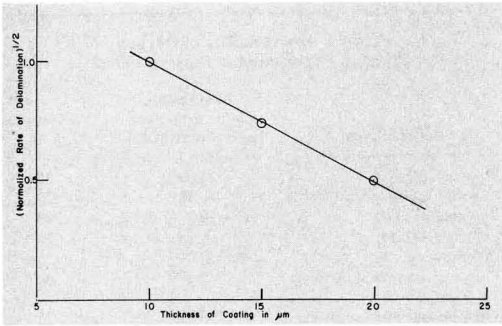


Figure 13—The relation between coating thickness and cathodic delamination under potentiostatic conditions

ing edge of the delaminating zone. The exact boundary or phase which is primarily affected by the high pH generated is not important for the present discussion and it may be within the metal, at the metal/oxide boundary, within the oxide, at the oxide/coating boundary, or within the coating. The magnitude of the pH generated at the leading edge is primarily determined by (a) any buffering reactions which may occur, (b) the volume of liquid in the vicinity of the delaminating edge, (c) the rate of diffusion of OH⁻ away from the site, (d) the rate of diffusion of reactants to the site, and (e) the rate at which the hydroxyl-generating reaction occurs. In this discussion, attention is focused on (e), while still recognizing the importance of (a), (b), (c) and (d).

The following hypothesis is presented to account qualitatively for the experimental results obtained. It is proposed that under the impressed potential, four major cathodic reactions may occur:

- (I) $H_2O + 1/2O_2 + 2e^- = 2OH^-$
- (II) $2H^+ + 2e^- = H_2$
- (III) $2H^+ + 2e^- + 1/2O_2 = H_2O$
- (IV) $M_xO_y + 2yH^+ + xe^- = xM^0 + yH_2O$

At the site of the defect where metal is exposed to the electrolyte, it is likely that reaction II is the dominant reaction. Reactions I and III are probably not dominant at the site of the defect because the small size of the exposed area limits the rate at which oxygen can reach the surface. Oxygen concentration polarization occurs to such an extent that the hydrogen evolution reaction

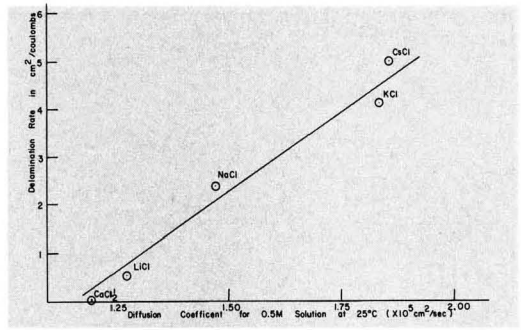


Figure 14—The relationship between the cathodic delamination from degreased steel substrates and the diffusion coefficient for five different electrolytes containing the chloride ion

becomes the dominant method for consuming the electrons. Under the coating, on the other hand, the dominant reaction is I because both oxygen and water readily diffuse through the coating (Tables 2 and 3). The delamination as a function of coulomb flow then is determined by the relative kinetics of reaction II on the exposed metal at the defect and reaction I at the metal/coating interface. Extreme examples are shown in Figure 12. Under the applied potentials used, the reaction under the coating in a specific system and experimental conditions may be represented by Curve D where the rate of the reaction is determined at high cathodic polarizations by the rate at which oxygen and/or water diffuse through the coating to the reaction points at the surface of the metal. Curves A, B, and C represent kinetics for reaction II which occurs on the exposed metal at the defect. If the conditions are such that reaction II is represented by Curve A, very rapid delamination would occur because at the potential marked by the dotted line, reaction I would occur more readily (Curve D). The second case, denoted by Curve B, represents a situation where delamination would also occur, but at a slower rate since the reaction at the defect and the reaction under the coating would occur at approximately the same rates. Curve C represents the case where the reaction at the defect dominates and the reaction under the coating (Curve D) plays a minor role in the consumption of the charge. In the latter case the rate of the delamination would be low.

Unfortunately, kinetic data are not available to deter-

Table 4—Normalized Delamination Parameter Of Polybutadiene Coatings for Four Different Systems

Substrate	Electrolyte	Normalized Delamination Parameter in cm ² per coulomb at -1.35 v		
		10 μm	15 μm	20 μm
Zinc	0.5M NaOH	1.0	0.59	0.09
Zinc	0.5M NaCl	1.0	0.55	0.39
Steel	0.125M NaCl	1.0	0.50	0.27
Steel	0.5M NaCl	1.0	0.58	0.28
Average		1.0	0.55	0.26

Table 5—Relative Amounts of Delamination Of Polybutadiene Coatings from Various Metals On Cathodic Treatment in 0.5M Solutions of CsCl, NaCl, and LiCl

Substrate Metal	Relative Amounts of Delamination	
	CsCl/NaCl	CsCl/LiCl
Cobalt	2.4	—
Lead	1.4	1.5
Nickel	ca. 1.9	2.5
Tin	ca. 1.0	1.2
Silver	1.75	2.5
Steel	2.6	12.5

Table 6—Solubility of Oxygen in Various Electrolytes¹²

	Solubility of Oxygen in cc/L			
	0.125M	0.25M	0.5M	1.0M
Distilled water		-----	5.78	-----
LiCl	5.63		5.17	4.59
NaCl	5.52	5.30	4.92	4.20
KCl	5.52	5.30	4.98	4.26
CsCl	5.67			
NH ₄ Cl	2.31	1.16		0.07

Surface Pretreatment	Relative Delamination in cm ² /coulomb of 10 μm and 20 μm Thick Coatings
Degreased	2.8
Abractively polished	2.2
Alkaline cleaned	2.1
Acid cleaned	2.7

mine the relative rates of reactions I and II in neutral halide solutions on oxide-coated metals typical of those used in the present study. However, it is known that reaction I occurs readily on steel as judged by the rapid rate of rusting in the atmosphere in the presence of chloride; lead oxide is a good catalyst for the oxygen evolution reaction⁹; reaction I occurs readily on oxide-coated zinc¹⁰; and reaction I probably does not occur readily on oxide-coated aluminum since aluminum shows good stability in the atmosphere. It is also known that cobalt and nickel are relatively good catalysts for reaction II. These facts help in interpreting the data presented in Figure 2. It is likely that the relative rates of reaction I/reaction II are high in aerated NaCl solution on surface of steel, tin, lead, zinc, and silver, and are relatively low on surfaces of cobalt, nickel, and aluminum. General statements can only be made at the present time because the delamination is importantly a function of the surface treatment of the metal before the application of the coating as shown in Figure 3.

Reaction IV, the reduction of oxide present at the substrate/polymer interface, probably plays a role in some circumstances. For example, the rapid delamination, as compared to chemically cleaned surfaces, of steel that was simple degreased (Figure 3) may be partially a consequence of the presence of a thicker oxide on the degreased surfaces.

Four series of experiments are available for determining the relationship between the delamination and the thickness of the coating on steel and on zinc. These data are summarized in Table 4, in which the delamination is normalized to the delamination for coatings, 10 μm in thickness. The average values are plotted in Figure 13 and it will be noted that there is an approximate linear relationship between the square root of the delamination parameter and the thickness of the coating. The delamination in these four cases may thus be represented by the equation, $\frac{dA}{dC} = -kt^2 + \text{constant}$, where A is the area delaminated, C is the number of coulombs passed, k is a constant, and t is the thickness of the coating.

The effect of film thickness on the delamination parameter can also be appraised from data obtained on steel samples pretreated in different ways. The relative amount of delamination for two coating thicknesses was approximately the same for steel samples that had been surface treated in various ways as shown in the following tabulation:

Under the conditions used in these experiments with degreased steel and zinc substrates, it appears that the surface of the metal is such an effective catalyst for the reaction, $H_2O + 1/2O_2 + 2e^- = 2OH^-$, that the extent of delamination is determined by the rate of migration of a species through the film to the substrate. It is hypothesized that the rate-controlling step in the experiments summarized in Figures 6 and 7 is the migration of the cation through the coating. It is suggested that the rate at which the hydroxyl ions can be formed is limited by the rate at which counterion cations can reach the vicinity of the surface and provide charge balance near the substrate/polymer interface. The major evidence for this conclusion is the excellent relationship between the diffusion rates of CaCl₂, LiCl, NaCl, KCl, and CsCl¹¹ in 0.5M solution and the delamination from degreased steel substrates as shown Figure 14. The datum point for the delamination parameter in NH₄Cl solution does not fall on the curve plotted in Figure 14. The tentative interpretation of this result is that the NH₄⁺ ion is such an excellent buffer that it does not allow the OH⁻ concentration at the interface to achieve the high value it would achieve in the absence of any buffering action. The solubility of oxygen in NH₄Cl solutions is also low, as will be discussed later.

This simple interpretation in the case of steel does not appear to explain adequately the relative extent of delamination in CsCl, NaCl and LiCl solutions for cobalt, lead, nickel, tin, and silver. The data in Table 5 show that the delamination is not a strong function of electrolyte in the cases of lead, tin, nickel, and silver. An explanation of this lack of agreement of the delamination with diffusion rates of the halide salt is that the oxygen/water reaction is occurring at the interface near to its maximum rate and that the rate of cation migration does not become limiting except in the case of LiCl, which diffuses the most slowly of all the alkali metal chlorides. It should also be expected that the different alkali metal ions may affect the kinetics of the cathodic reactions differently under the coating and at the site of the defect. A complete interpretation of the effect of metal cation on the delamination rate cannot yet be given.

As shown in Figure 9, there was a very significant effect of concentration of electrolyte on the delamination, with the extent of delamination increasing as the electrolyte concentration was decreased. This effect is attributed to the strong influence of osmotic pressure on the concentration of water in the polybutadiene coating. At the highest concentrations of electrolyte, the driving force for water molecules in the coating is to enter the aqueous phase. The net effect is to reduce the concentration of water in the coating and to change the concentration gradient across the coating. There are two consequences of the lower concentration of water in the coating: First, the number of water molecules that migrate across the

coating per unit time is reduced and the cathodic reaction, $\text{H}_2\text{O} + 1/2\text{O}_2 + 2\text{e}^- = 2\text{OH}^-$, is impeded by the reduced concentration of reactant water molecules and is also decreased by the higher OH^- concentration which is achieved because of the lesser number of diluent water molecules. The second consequence is of greater importance, however, in that the lower concentration of water molecules in the film reduces the aqueous transport medium by which the cation migrates through the film. The cathodic reaction is further impeded by the lack of positively-charged counterion (the alkali metal ion) needed to preserve local charge neutrality in the vicinity of the OH^- ions that are generated by the cathodic reaction.

Electrolyte concentration can also play a role in determining the oxygen concentration at the electrolyte/polymer interface since oxygen solubility is a function of electrolyte concentration, as shown by the data given in Table 6. In all cases, the oxygen solubility decreases with increase in electrolyte concentration. The low solubility of oxygen in NH_4Cl solution is particularly noteworthy. This low solubility of oxygen, plus the buffering capability of NH_4^+ ions as alluded to earlier, may be responsible for the low rate of delamination in NH_4Cl electrolyte.

The data are plotted in terms of delaminated area vs the number of coulombs passed through the interface. Although there appeared to be no direct relationship between the delamination and the magnitude of the current flowing through the interface, it was generally true that the current remained essentially constant during the entire experiment in those cases where the delamination rate was rapid. The above comments apply to experiments carried out at room temperature on non-phosphated surfaces. The current tended to increase with time in the case of experiments carried out at 31–33°C at a much greater rate than in experiments carried out at 21–23°C.

It is proposed that the magnitude of the current is a measure of the surface area on which the hydrogen evolution reaction occurs since the cathode potential was constant during the experiment. In those cases where the delamination rate is high, the OH^- concentration adjoining the defect is great and the potential is insufficient to support the hydrogen evolution reaction over a large area because of H^+ concentration polarization effects. In those cases where the extent of delamination is relatively low, the OH^- concentration diffusing into the defect area is lower and the area which is active becomes greater with time as the polybutadiene coating is mechanically injured by the evolving gas bubbles.

One of the major problems facing the coatings industry is the development of an accelerated test that properly appraises the corrosion protective properties of a system that includes substrate, pretreatment, primer and top-coat. The majority of accelerated tests now in use are carried out in a sodium chloride environment and there

is much dissatisfaction with the correlations between performance in the accelerated test and performance under service conditions. One likely explanation for this variation in behavior is that the environments encountered in service are complex and the cathodic corrosion reaction that occurs varies with the environment. For example, the cathodic reaction, $\text{H}_2\text{O} + 1/2\text{O}_2 + 2\text{e}^- = 2\text{OH}^-$, is the dominant one under typical salt spray conditions. However, in the presence of acid rain or under moist conditions where SO_2 or SO_3 is absorbed from the atmosphere by the moisture, the conditions at the surface are acidic and the dominant cathodic reaction may become, $2\text{H}^+ + 2\text{e}^- = \text{H}_2$. As shown by other work in this laboratory^{6,10} on the cathodic behavior of galvanized steel, minor amounts of impurities and the catalytic properties of the oxide film on zinc determine which of the two cathodic reactions dominate.

The above considerations suggest that modifications of the procedure under which cathodic delamination is determined in the laboratory may allow better correlation of accelerated test data with service performance. A rapid test method may allow an appraisal of many variables such as electrolyte, pH, temperature, and cathodic driving force in a single or a few experiments.

ACKNOWLEDGMENT

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Residual Strain Due to Solvent Loss From a Crosslinked Coating

S.G. Croll

National Research Council of Canada*

Data show that epoxy coatings cast from a very slow-evaporating solvent have residual internal strain that increases with coating thickness. A theory is presented, which agrees well with experimental results, based on the idea that solvent volume loss from the crosslinked coating is responsible for the strain. The strain depends on solvent evaporation and diffusion rates, as well as the curing reaction kinetics and coating solution concentration. A calculation, using this theory, models the excellent adhesion of epoxy coatings and shows that adhesion may be improved by using a faster evaporating solvent.

INTRODUCTION

Polymeric surface coatings are frequently applied as a solution by a variety of means, such as brush or spray. The choice of solvent is often based on cost and on the appearance of the dry coating. The fact that a solvent can have a large influence on the durability of a coating may be overlooked.

Internal strain is one factor affecting the performance of a coating. Strains are produced in coatings because of shrinkage, due either to solvent evaporation or to the chemical changes of crosslinking. If the solvent evaporates quickly from the coating mixture, the resin is still in a thermoplastic state when it solidifies, i.e., crosslinking is incomplete. Such coatings dry like lacquers and the resultant residual internal strain is independent of the dried coating thickness.¹

If the solvent is lost from the coating very slowly, solidification occurs because a crosslinked network is formed. In this case, it would be expected that the subsequent loss of solvent would produce a greater strain in thicker films because the solvent had less opportunity

to diffuse out before solidification. Such an increase of internal strain (or stress) has been observed.¹⁻⁴

In this paper, a theory is proposed to explain the latter type of behavior and to account for the effect of solvent concentration, evaporation rate, and coating thickness on the magnitude of the internal strain. The influence of the kinetics of the crosslinking reaction on strain and adhesion is also examined.

THEORY

Definitions of the symbols used are given in *Table 1*.

Internal Strain

It is assumed here that the internal strain is due to the volume of solvent lost after the coating has solidified, with the shrinkage due to chemical change (crosslinking) being ignored at this stage. After a film has solidified, further loss in solvent volume cannot be accommodated by bulk flow. Therefore, internal strain arises in the plane of the coating, because it is constrained to remain at its original liquid dimensions by adhesion to a rigid substrate. The resultant internal strain in a dry, unpigmented, film can readily be calculated in terms of the solvent content. After solidification, the volume of solvent lost, ΔV , is given by

$$\Delta V = \phi' V - \phi'(V - \Delta V) \quad (1)$$

The internal bulk (volumetric) strain is given by $\Delta V/V$ which is equivalent to an isotropic linear strain, ϵ , such that $\frac{\Delta V}{V} = 3\epsilon$.

From equation (1)

$$\frac{\Delta V}{V} = \phi' - \phi'(1 - \frac{\Delta V}{V}) \quad (2)$$

The expression for the internal strain, ϵ , is derived by substitution in equation (2).

$$\epsilon = \frac{\phi' - \phi'}{3(1 - \phi')} \quad (3)$$

* Building Materials Section, Division of Building Research, Ottawa, K1A 0R6, Canada.

Table 1—Definition of Symbols

ΔV	= volume of solvent lost after solidification
V	= volume of coating at solidification
ϕ_s	= volume fraction of solvent present at solidification
ϕ_r	= volume fraction of solvent retained in free, dry, unconstrained film
ϕ_i	= volume fraction of solvent in initial solution
ϵ	= residual internal strain
D	= diffusion coefficient
C	= concentration
C_r	= concentration of solvent retained in dry film
C_i	= concentration of solvent in initial solution
C_s	= concentration of solvent present at solidification
C_t	= concentration of solvent just at the top of the coating
x	= position co-ordinate through film
α	= rate of evaporation, volume lost/area/time
t_c	= coating thickness
T_x	= time at which coating solidified by crosslinking
ρ	= density of solvent
m	= shrinkage of coating
V_p	= volume of resin
t	= time
Φ	= pre-exponential factor
U	= internal strain energy per unit area
γ_A	= interfacial work of adhesion
F	= force per unit width
b	= width of coating
E	= modulus

A prime superscript, ($'$), will indicate a quantity defined in a frame of reference in which coating thickness is invariant with respect to time.

This equation is the same as that used to describe lacquers,⁵ but ϕ'_s has to be calculated differently in this case.

Solidification

A coating can be considered solidified when it no longer behaves as a viscous liquid, i.e., when large scale molecular motion ceases in the polymer.

For a lacquer, solidification is closely allied to the glass transition of the polymer.⁵ The solidification point can be identified as that solvent concentration at which the glass transition temperature of the coating (depressed by the solvent present) coincides with the temperature of the coating. Lacquers solidify at a particular solvent content, constant throughout the film.

This paper is concerned with coatings wherein solvent loss is slow and solidification is due to the formation of a crosslinked network, formed by chemical means. It is this network which prohibits large scale molecular motion. Calculation of internal strain in such a system still requires knowledge of ϕ'_s , as in a lacquer, but for a cross-linked system, the solvent content varies with position within the film according to how much was present when it solidified. Using Fick's law of diffusion, ϕ'_s can be calculated if certain assumptions are made:

(1) It has been found that the degree of conversion of an epoxy resin at the gel point is constant, irrespective of the temperature.⁶ The gel point must be closely related with the solidification of a crosslinked network, so it is assumed here that solidification occurs at a particular degree of conversion throughout the film.

(2) It will be assumed that the reaction between epoxy and hardener follows first order kinetics. Actual order of reaction varies in epoxies,⁷ but first order is a representative type. The consequence of this assumption is that the proportion of the reaction completed at a particular time does not depend on the concentration of the reactants,⁸ which is not true of any other order of reaction.

The result of these two assumptions is that the coating solidifies at a particular degree of conversion, e.g., 90%, which occurs at a particular time, T_x , irrespective of the local concentration of epoxy, hardener, or solvent. Calculation of ϕ'_s is reduced to calculating the amount of solvent present at T_x .

Diffusion and Evaporation of Solvent

Solvent evaporates from the surface of the coating so that solvent lost/area/time = $-D \frac{\partial C}{\partial x} = \alpha(C_r - C_i)$ (4)

where

$\partial C/\partial x$ = concentration gradient at the surface

C_r = concentration of solvent retained in dry film, because when $C_r = C_i$, there is no solvent lost by evaporation.

If the coating at thickness t'_c adheres to an impermeable substrate, then, according to Crank,⁹ the concentration of solvent C'_s at T_x is such that

$$\frac{C'_s - C'_i}{C'_s - C'_i} = 1 - \sum_{n=1}^{\infty} \frac{2L \cos(\beta_n x/t'_c) \exp(-\beta_n^2 DT_x/t'^2)}{(\beta_n^2 + L^2 + L) \cos \beta_n} \quad (5)$$

Where β_n are the roots of

$$\beta \tan \beta = L = \frac{t'_c \alpha}{D} \quad (6)$$

Equation (5) is true as it stands when t'_c is independent of time. Diffusion through the edges of the coating is ignored because the thickness is very much smaller than the other dimensions of the film.

If the very small contribution of the curing agent to the total volume of the coating solution is ignored, then

$$\phi'_s = C'_s/\rho$$

Now equation (5) can be used to substitute for ϕ'_s in equation (3). Before attempting that, however, equation (5) can be simplified in two ways. In practice, the internal strain is measured as a function of the overall dried film thickness, so that the average value of C'_s (ϕ'_s) with respect to depth (x) is needed to compare the theory with experiment. Further, $L (= t'_c \alpha/D)$ is usually much less than unity, which means that β_n are small and the approximation $\beta_n = \tan \beta_n$ can be used. In the simplified expression, only $\beta_1 (= \beta)$ is considered and

$$\beta^2 \approx L \quad (7a)$$

$$L^2 \ll L \quad (7b)$$

(If no assumptions are made of the size of β_n , then a more complicated final expression for the internal strain is produced, which is included later.)

Under these conditions and averaging over the thickness, (x), the result is

$$\frac{C'_r - C'_i}{C'_r - C'_i} = \frac{\phi'_r - \phi'_i}{\phi'_r - \phi'_i} = 1 - \exp\left(\frac{-\alpha T_x}{t'_c}\right) \quad (8)$$

which, when substituted into the expression for internal strain, gives

$$\epsilon = \frac{(\phi'_r - \phi'_i)}{3(1 - \phi_r)} \cdot \exp\left(\frac{-\alpha T_x}{t'_c}\right) \quad (9)$$

Only the first term under the summation sign of equation (5) is significant under these conditions. Equation (9) does not contain any reference to the diffusion coefficient of the solvent through the film. Actually, equation (9) can also be derived by assuming that the diffusion of solvent through the film is fast enough, when compared with the evaporation, to maintain its concentration independent of position.

The thickness of the coating, t'_c , is most conveniently measured for the dry film when it has the most practical significance. ϕ'_i is also measured in the dry film, but ϕ'_r can only be taken from the wet film when the thickness of the film is considerably greater. Formally, equation (5), and thus equation (9), applies only to a frame of reference wherein the t'_c is assumed constant with time. Therefore, to use these equations, all the quantities must be reduced to a frame of reference where the units shrink in the same ratio as the coating (due to solvent evaporation).

$$m(t) = \frac{\text{volume at time, } t}{\text{original wet volume}}, \text{ since the area of the coating is constant.}$$

Concentration in frame units, C' , is the number of units of solvent contained in a unit frame volume. Initially $C_i(\phi_i)$ is the concentration of solvent in unit volume and is calculated from the original coating solution. At some other time, C'_i has to remain constant with respect to the shrinking frame of reference and so

$$\frac{C'_i}{m} = \frac{C_i}{1} \quad (10)$$

or

$$C'_i = mC_i \quad (11)$$

This type of calculation has been presented elsewhere¹⁰ in more detail.

t_c and ϕ_r are measured in the dried film and are the frame units for that time also. However, $C_i(\phi_i)$ is calculated from the initial solution and thus refers to the frame at zero time, so it must be replaced in equation (9) by the corresponding value for the dried coating frame, $C'_i(\phi_i)$.

$$\phi'_i = m \phi_i \quad (12)$$

Now

$$m = \frac{V_p}{1 - \phi_r} \div \frac{V_p}{1 - \phi_i}$$

and V_p = volume of resin (assuming that its density does not change with crosslinking)

$$\therefore \phi'_i = \phi_i \frac{(1 - \phi_i)}{1 - \phi_r} \quad (13)$$

Thus, in terms of parameters as they are conventionally measured,

$$\epsilon = \frac{1}{3(1 - \phi_r)} \left[\frac{\phi_i(1 - \phi_i)}{1 - \phi_r} - \phi_r \right] \exp\left(\frac{-\alpha T_x}{t_c}\right) \quad (14a)$$

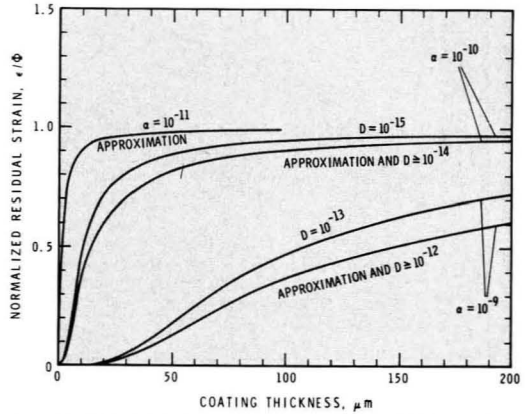


Figure 1—Examples of the predicted variation of residual strain with coating thickness, evaporation rate, α , and diffusion coefficient, D , for a time to solidification of 10^5 s

or fully

$$\epsilon = \frac{1}{3(1 - \phi_r)} \left[\frac{\phi_i(1 - \phi_i)}{1 - \phi_r} - \phi_r \right] \sum_{n=1}^{\infty} \frac{2L \tan(\beta_n)}{\beta_n(\beta_n^2 + L^2 + L)} \exp(-\beta_n^2 DT_x / t_c^2) \quad (14b)$$

where D = diffusion coefficient of the solvent referred to the dried coating frame

In both equations (14a) and (14b), it is clear from the exponential terms that internal strain increases from zero with coating thickness. This is displayed in Figure 1 where equations (14a) and (14b) are compared, plotting the normalized strain, ϵ/Φ , as a function of coating thickness using typical values for the other parameters. Φ is the pre-exponential factor given by

$$\Phi = \frac{1}{3(1 - \phi_r)} \left[\frac{\phi_i(1 - \phi_i)}{1 - \phi_r} - \phi_r \right] \quad (15)$$

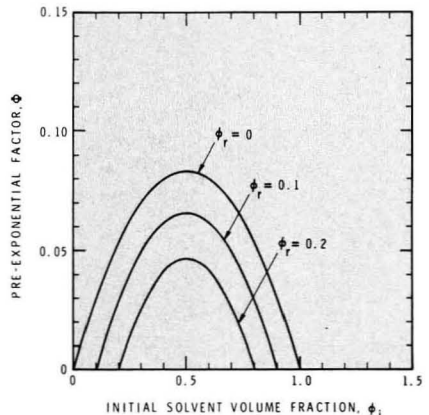


Figure 2—Variation in the pre-exponential factor with initial solvent volume fraction, for different retained solvent concentrations, ϕ_r

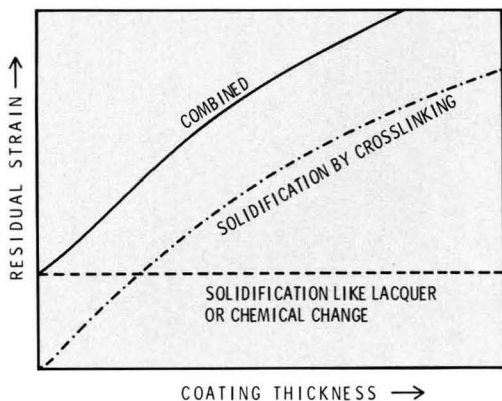


Figure 3—Schematic combination of the possible contributions to residual strain

One can see that allowing for diffusion predicts a slightly larger strain and that the approximation is excellent for faster rates of diffusion. In other words, the approximation holds when the loss of solvent is governed by evaporation rate, where the diffusion coefficient is large enough to maintain the solvent concentration uniform throughout the film. In general, the strain would be quite insensitive to changes in diffusion coefficient, which is a convenient feature of the theory since, in practice, D will vary considerably as the solution concentration changes.

As the time of network formation, T_x , increases, the strain decreases as less solvent is present at solidification. This can be seen in both equations (14a) and (14b), where also fewer terms are needed in the summation as T_x increases. If the crosslinking rate is very high (small T_x) and solvent loss is very slow (small α , D) then the exponential factor (or Σ) becomes constant and equal to unity.

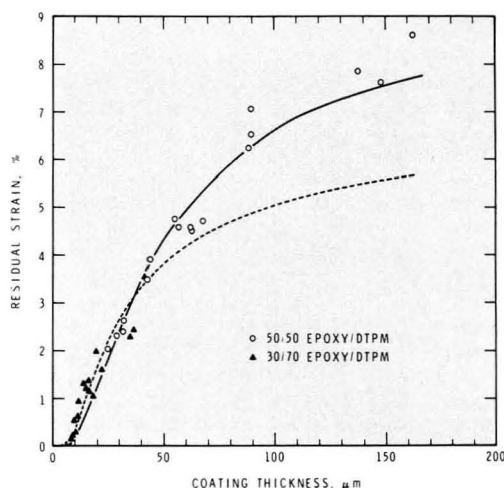


Figure 4—Variation of residual strain with coating thickness for both coating solutions employed

Thus, the strain becomes independent of thickness, but dependent on solvent concentration (via the pre-exponential term). This trend is shown by the curves in Figure 1.

The pre-exponential (pre- Σ) term is plotted in Figure 2 as a function of initial solvent content ϕ_1 , for various ϕ_r . The curves are parabolas with maxima at $\phi_1 = 0.5$. In practice, the region $\phi_1 = 0$ to 0.5 may be inaccessible because of the extremely high viscosity of solutions in this range. As would be expected, this graph shows that the strain decreases as the retained solvent concentration increases. The parabolic nature of the graph originates from the necessity to allow for the change in thickness of the film as it dries.

The theory presented here is for films that solidify by crosslinking throughout their thickness. It is possible, however, to envisage a balance of evaporation rate and diffusion where the top part of a coating dries like a lacquer because the solvent escapes before the cross-linked network is formed. Residual strain would not then decrease to nothing at zero coating thickness, but would be given by the combination of the lacquer and cross-linked contributions (Figure 3). Any contribution to the strain from the shrinkage due to chemical change should also be independent of thickness and combined in the same way as the lacquer behavior.

Effect of Curing Kinetics

The analysis presented here assumes that the curing of the epoxy follows first order reaction kinetics, in that the degree of conversion is independent of reactant concentrations.

In a zero order reaction, the proportion of the reaction completed is proportional to the initial concentration of the reactant. Thus, T_x increases with resin concentration and decreases with increasing solvent content, and will tend to be larger in thicker coatings. So the strain might be expected to increase more slowly with thickness than it does in the theory presented here.

For a second order reaction, the degree of conversion is inversely proportional to the initial concentration of reactants. Following a similar argument, therefore, the strain will increase faster with thickness than for a first order reaction.

Reaction kinetics for epoxies depend on the resin and curing agent, but vary from a value less than one to second order,⁷ so first order has been chosen as typical to represent the system studied here. Any one of these types of behavior can be combined with the lacquer-type behavior for this coating, as in Figure 3.

EXPERIMENTAL

Ambient conditions for all tests were maintained at 23°C (± 1) and 50% RH ($\pm 2\%$).

The epoxy resin used was Epon® 1004 cured with diethylenetriamine (DETA) using 2.4 parts DETA per hundred of the resin (stoichiometric according to resin manufacturer data). Results were obtained from two solution concentrations: one made of equal weights of resin and tripropylene glycol monomethyl ether

(Dowanol TPM®, DTPM); the other of 30 parts resin and 70 of DTPM. It proved impracticable to produce a solution containing more resin than the former.

Tin plate substrates were masked to a convenient length, 60–70 mm, and width 12 mm, and then coated using a variety of draw down blades. Drying was monitored by weighing to 0.1 mg and, when there was no further systematic loss in weight, the coating was considered dry. A typical coating weight was 15 mg or more.

Residual Strain

The procedure was identical to that reported in other work on internal strain.¹ Residual strain was determined by releasing a dried coating from a tinplate substrate by mercury amalgamation of the tin, and measuring its subsequent shrinkage with a travelling microscope. The shrinkage is considered to be identical with the internal strain present in the coating when adhering to the substrate. Shrinkage became constant after 200 days of drying. Coating thickness was measured using a Minictector® FN and found to be quite consistent along the length of any coating.

Residual strain is plotted as a function of coating thickness in Figure 4, which includes data from both coating solutions. The data of the 50/50 solution was presented previously.¹

None of the coatings peeled from the tinplate substrate spontaneously,¹¹ although the thicker coatings were easier to remove than the thin ones.

Retained Solvent Volume Fraction

Residual solvent was measured using a gas chromatograph as before.¹ Crosslinked film cannot be redissolved, but, after standing for 18 hr in cyclohexanone, samples of the films were swollen and extremely soft. One would expect most residual solvent to leach out into the cyclohexanone and be detected by the chromatograph. ϕ_r was found to be 4.1% for the films derived from the 50/50 solution and increased slightly with coating thickness, 4.1% being typical of a 65 μm coating. The coatings derived from the 30/70 solutions retained more solvent: ϕ_r was 10% for a 10 μm coating and 20% for a 35 μm coating.

Evaporation Rate of DTPM

A shallow cylindrical pan (60 mm diameter, 1 mm deep) full of DTPM was weighed periodically to determine the evaporation rate. As in all other tests, conditions were maintained at 50% RH and 23°C. After an initial weight gain, due presumably to water absorption, the weight loss rate was constant for a number of days. The evaporation rate was 1.72×10^{-7} kg/sec/m² (equivalent to 1.78×10^{-10} m³/sec/m² in terms of volume).

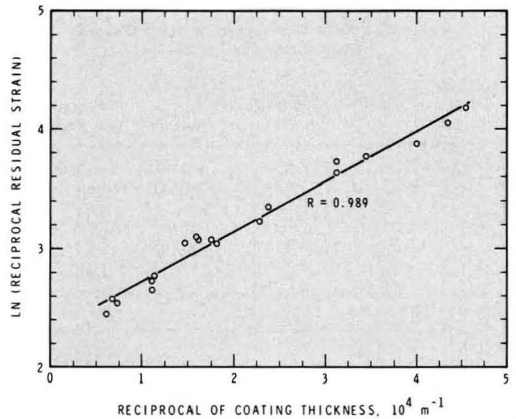


Figure 5(a)—Relationship between LN (reciprocal residual strain) and reciprocal coating thickness, for coatings cast from 50/50 epoxy/DTPM

Time to Solidification

The time taken for an air bubble to move up a tube filled with 30/70 epoxy (+ DETA) solution was measured as the crosslinking reaction progressed. The procedure adopted was similar to that in ASTM D1545. It was found that after 73 hr the bubble halted in its progress up the tube. This value can be used to check the value of T_x derived from the theory, although it is not a strictly analogous experiment.

DISCUSSION

Internal Strain

Figure 4 shows that, over the range of thickness used, the residual strain data seem to lie on the same curve, irrespective of the original coating solution concentration. The range of thickness for the coatings derived from the more dilute solution is smaller. Residual strain tends to zero as the theory would predict, indicating that there is no lacquer-type behavior or chemical shrinkage appar-

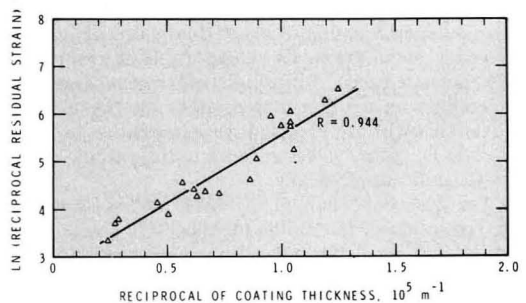


Figure 5(b)—Relationship between LN (reciprocal residual strain) and reciprocal coating thickness, for coatings cast from 30/70 epoxy/DTPM

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Dowanol is a registered trademark of Dow Chemical Co.
Minictector is a registered trademark of Elcometer, Inc.

Table 2—Values of Slopes and Intercepts, with Pre-exponential Factors^a

Original Solution Concentration	Gradient ($= -\alpha T_x$)	Intercept	Pre-exponential Factor
50/50	-4.18×10^{-5} (1.5×10^{-6})	-2.308 (0.038)	0.0995
30/70	-2.86×10^{-5} (2.3×10^{-6})	-2.696 (0.19)	0.0675

(a) Coefficients and data derived from regression lines in Figures 5(a) and 5(b). Numbers in brackets are standard errors.

ent in very thin coatings. DTPM evaporates so slowly that all coatings solidify by crosslinking.

According to equation (14a), \ln (residual strain) plotted as a function of $1/t_c$ should be a straight line. The slope of such a line would be $(-\alpha T_x)$ and the intercept would give the pre-exponential factor. This is shown in Figures 5(a) and 5(b), along with the regression lines obtained and the regression coefficient, R. Values of slopes and intercepts, together with the pre-exponential factors calculated from the intercepts are given in Table 2. The linear dependence formed confirms the validity of the approximation given by equation 14(a).

Values of the pre-exponential factor can be calculated, knowing the composition of the original coating solution and the densities of the constituents. Manufacturers' figures give the densities as 1159 kg/m^3 for the epoxy, 965 kg/m^3 for the DTPM, and 954 kg/m^3 for the DETA. For the 50/50 solution, the pre-exponential factor should be 0.076, and for the 30/70 solution, 0.043 (assuming $\phi_r = 10\%$). The agreement between the calculated and measured values (Table 2) is quite good, especially considering the several assumptions made in the analysis.

The assumption that the reaction kinetics are first order seems to be confirmed by the straight lines of Figures 5(a) and 5(b), indicating a single value of αT_x . It is always possible that α and T_x vary inversely with coating thickness, but the single value of the slope in each graph must be significant.

The continuous curves in Figure 4 were calculated from the parameters derived from Figures 5(a) and (b). Choosing a low value for the diffusion coefficient and manipulating equation 14(b) could provide a better fit to the data, but as the values chosen would be arbitrary, it was not attempted. Diffusion coefficients change considerably with solution concentration and the results of equation 14(b) are comparatively insensitive to variations in D, so any values assigned to them would not be very significant physically.

The dashed portion of the curve in Figure 4 is an extrapolation of the results for the 30/70 solution and shows that results from the two concentrations diverge at a thickness of $34 \mu\text{m}$. This is not evident in the experimental results since thick coatings are difficult to make from dilute solutions.

If the α of DTPM from the 30/70 solution is assumed

to be 70% of the evaporation rate of pure DTPM ($1.78 \times 10^{10} \text{ m}^3/\text{sec/m}^2$), then T_x has a value of $2.2 \times 10^5 \text{ s}$ (61 hr). This is a very approximate calculation since the coating solution must deviate considerably from the ideal behavior; the 30/70 may deviate less than the 50/50, however. The bubble viscosity measurement showed that the solution solidified in 73 hr, under rather different conditions than that of a coating. Nevertheless, the agreement between the two values is good and it indicates that the theory is a good description of the phenomena in a drying coating.

T_x must be independent of solution concentration for the first order reaction kinetics assumed here; therefore, the value of α must change to account for the difference in gradients obtained from Figures 5(a) and (b). α increases by about 50% in the 50/50 solution over the 30/70 solution. This is contrary to what might be expected from ideal solution behavior. One could hypothesize that the higher crosslinked epoxy content in the 50/50 solution becomes incompatible with the DTPM faster than it does in the more dilute solution where there is less resin; hence, a faster evaporation rate.

Theory indicates that more dilute solutions produce less residual strain (assuming that the $\phi_r = 0$ to 0.5 region is inaccessible due to increased viscosity). Rate of diffusion and, consequently, changes in diffusion, do not seem to be important as far as residual strain is concerned. If α increases, as T_x increases, then the strain will be much diminished. However, fast evaporation (large α) or slow crosslinking (large T_x) may result in a large strain because the coating dries like a lacquer. The order of the chemical crosslinking kinetics probably has a considerable effect also, but it is not dealt with explicitly here.

Solvent cannot escape from a bulk solution as fast as from a coating, but crosslinking progresses much the same. The practice of leaving a solution of resin and curing agent in the can for an induction period before application may result in coatings which solidify by crosslinking, thus producing a large internal strain and weakening adhesion. Depending on the relative rates of solvent evaporation and conversion, it may be better to apply films early to obtain coatings that solidify like lacquers. In this way, crosslinking would be completed very slowly, after solidification.

Complete understanding of the phenomena involved in concurrent solvent evaporation and chemical crosslinking in coatings does require more extensive research.

Adhesion

It is well known that epoxies have excellent adhesive properties, but it is also known that residual internal strain (ϵ) can cause a drastic reduction in the adhesion of coatings.¹¹ This part of the discussion deals with the effect on adhesion that these very high levels of internal strain have (which increase with t_c).

An energy balance analysis^{11,12} has shown that adhesion between coating and substrate will fail spontaneously if the internal strain energy per unit area, U, stored in that coating, exceeds the interfacial work of adhesion, γ_A , i.e., $U \leq \gamma_A$ for adhesion.

The simplest illustration of this in an adhesion test is

the 90° peel test where the force per unit width of coating required to peel the coating is given as^{11,12}

$$F/b = \gamma_A - U \quad (16)$$

First, however, U must be calculated as a function of coating thickness, evaporation rate, etc., as in the Appendix.

Since all the coatings remained adhered to the substrate, the thickness at which $U = \gamma_A$ is assumed to be 200 μm . Thus, γ_A can be calculated from equation (A5) to be 136.7 J/m^2 . This is a very large value compared with values reported previously¹¹ of about 15 J/m^2 for an acrylic. It is approximate, but demonstrates the excellent adhesion that epoxy coatings possess.

The variation of peel strength with coating thickness is plotted in Figure 6, using equations (A5) and (16).

One can see that the loss of adhesion as the coating thickness increases becomes very severe. In applying such a coating, a succession of thin coats would be preferable to one thick one. If sufficient time is allowed for the film to solidify between applications, the internal strain and adhesion would be that of a thin film. If, however, another coat is applied while the previous one is still in a thermoplastic state, the solvent will redissolve the existing coating and the higher strain and poorer adhesion of a thick coating will ensue.

A 30/70 solution of epoxy in methyl Cellosolve® produced coatings with a lacquer-like residual strain of 1.81%, independent of coating thickness.¹ In this case

$$U = \frac{1}{2} E \epsilon^2 \cdot t_c$$

and the effect on the 90° peel test is also shown in Figure 6, assuming the same values for E and γ_A .

It can be seen that the adhesion of the coatings using the faster drying methyl Cellosolve is far superior to that of coatings produced from DTPM. If good adhesion is required, then fast solvents that produce a lacquer-like constant value of residual strain should be used. Fast solvents are normally used in the coatings industry but this may be due more to faster drying time than to recognition of the effect of solvent on adhesion. The calculation given here clearly shows the latter.

CONCLUSIONS

The results show that epoxy coatings cast from a very slow-evaporating solvent, DTPM, have residual strain that increases with coating thickness. A theory is presented to account for this, based on the idea that the coating solidifies throughout at a particular degree of conversion and the strain results from the subsequent loss of solvent volume. Overall, the experimental data agree very well with the predictions of the theory.

Residual strain appears to be zero for very thin coatings, indicating that even these solidify by crosslinking and that there is no lacquer-like or chemical shrinkage contribution to the strain.

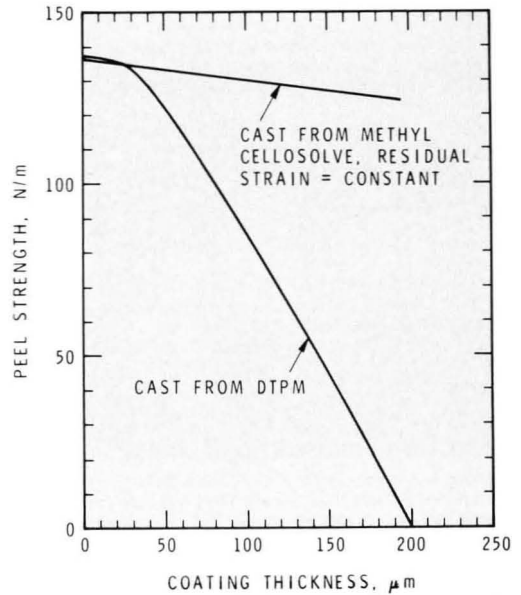


Figure 6—Dependence of peel strength on coating thickness for coatings cast from DTPM and methyl Cellosolve

The linear relationship between ϵ_n (residual strain) and $1/t_c$ shows that the time to solidification is unique, which seems to confirm the choice of first order kinetics to describe the curing reaction. Time of solidification by crosslinking, T_x , derived from the residual strain data, agrees well with values obtained with a bubble viscometer.

If T_x or rate of evaporation, α , is increased, then the theory predicts a reduction in residual strain. The theory also predicts, and the data confirms, that the strain decreases with increasing solvent concentration for concentrations greater than 50% (assuming that resin concentrations greater than 50% are impractical due to their viscosity).

Adhesion of epoxy coatings is very good, as is indicated by the calculation of γ_A . The ever-increasing strain with coating thickness, however, causes a great loss in adhesive strength. The approximate calculations show clearly that the lacquer-like coatings formed from fast solvents show far superior adhesion to those formed from DTPM. If the use of a very slow solvent is unavoidable, then a succession of thin coats with sufficient time to crosslink between applications is preferable, from the point of view of residual strain and adhesion.

ACKNOWLEDGMENTS

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Cellosolve is a registered trademark of Union Carbide Corp.

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APPENDIX A

INTERNAL STRAIN ENERGY

Assuming that the coating is elastic, then U is given by

$$U = \int_0^{t_c} \frac{1}{2} \cdot E \epsilon^2(x, t_c) dx \quad (A1)$$

where E = modulus of the coating which, at long times appropriate to residual strain measurements, is a fraction of the Young's (short time) modulus.

The residual strain as a function of position in a coating is given by

$$\epsilon(x) = \Phi \sum_{n=1}^{\infty} \frac{2L \cos(\beta_n x/t_c)}{\beta_n^2 + L^2 + L} \exp(-\beta_n^2 DT_x/t_c^2) \quad (A2)$$

where

$$\Phi = \frac{1}{3(1-\phi_r)} \left[\frac{\phi_i(1-\phi_i)}{1-\phi_r} - \phi_r \right]$$

If the same approximations are applied now as were in obtaining equation 14(a), then,

$$\epsilon(x) = \Phi \cdot \frac{\cos(\beta_1 x/t_c)}{\cos \beta_1} \exp(-\alpha T_x/t_c) \quad (A3)$$

where $\beta_1 \tan \beta_1 = \alpha t_c/D$

Substituting equation (A4) into the expression for the strain energy stored per unit area gives,

$$U = \frac{t_c E \Phi^2}{4} \left[\frac{\sin \beta_1 \cos \beta_1 + \beta_1}{\beta_1 \cos^2 \beta_1} \right] \exp(-2\alpha T_x/t_c) \quad (A4)$$

From the data for the 30/70 solution coatings

$$\Phi = 0.06745$$

$$\alpha T_x = 2.86 \times 10^{-5} \text{ m}$$

$$\alpha = 1.3 \times 10^{-10} \text{ m}^2/\text{sec}/\text{m}^2$$

$$(T_x = 2.2 \times 10^{-5} \text{ sec})$$

Assuming E = 0.4 GPa.

For these values β_1 is very small, irrespective of D, e.g.,

$$\begin{array}{ll} \text{if } D = 1 \times 10^{-12} & \beta_1 = 0.139 \\ D = 1 \times 10^{-11} & \beta_1 = 0.044 \\ D = 1 \times 10^{-10} & \beta_1 = 0.0014 \text{ for } t_c = 150 \mu\text{m} \end{array}$$

thus $\sin \beta = \beta$ and $\cos \beta = 1$. Hence, equation (A5) can be further simplified to

$$U = \frac{t_c E \Phi^2}{2} \exp(-2\alpha T_x/t_c) \quad (A5)$$

which, like equation 14(a), does not depend on the diffusion coefficient.

Society Meetings

Birmingham

Nov. 6

Mr. D. Lilley, of Donald Macpherson Ltd., discussed "COMPUTERS AND MICROPROCESSORS IN THE PAINT INDUSTRY."

With the aid of slides, Mr. Lilley described some of the systems followed in data processing. He explained how computers evolved and developed. The three types of computers, he said, included the "analogue", which has fast reaction times, the "digital", having good storage capabilities, and the "hybrid", which combines the properties of the other two.

The future of computers would affect the areas of administration, manufacturing, application of paint, and laboratory analysis and formulation, in the paint industry, he said.

Q. Will computer language be standardized?

A. There are many pressures to do this but the variety of languages and their usefulness in different circumstances (eg., Fortran for scientific work) makes it very difficult.

M. GRIFFITHS, *Publ. Officer*

Chicago

Nov. 10

Jim Joudrey, of Columbia Chemicals, discussed "CARBON BLACK." Also, Gus Leap, of Seymour of Sycamore, Inc., spoke about "AEROSOLS."

President Hille announced that at the Annual Meeting the Union Carbide Coatings Technology award and the Materials Marketing Associates award were presented to the Chairman of the Infrared Spectroscopy Atlas committee, John Vandeberg, and that T. Kirk Hay, Chairman of the Renewable Resources committee was presented the A.F. Voss/American Paint Journal Award.

L.F. KINNEY, *Secretary*

Cleveland

Nov. 18

George McTavey, of Cosan Chemical Corp., spoke on "TREATMENT OF LATEX WASTE WATER."

Mr. McTavey indicated the importance to the coatings industry of the EPA's proposed standard issued Jan. 3, 1980, which refers to the effluent limitation guidelines, pre-treatment, and new source performance standards for the industry. The industry, he said, must



Pittsburgh Society Officers for the year 1980-81. (Left to right): President—Raymond C. Uhlig, Technical Coatings Co.; President-Elect—Richard Trudel, Mobil Chemical Co.; Society Representative—Edward Vandevort, PPG Industries, Inc.; Secretary—William Cibulas, Mobay Chemical Co.; and Treasurer—Michael Gillen, Van Horn Metz & Co.

employ the best economically available technology, available towards the goal of eliminating the discharge of all pollutants.

The EPA identified technologies that could be used to achieve this goal. They indicated that complete elimination of discharge of pollutants by recycling and contract hauling of nonrecyclable wastes is the only acceptable solution, he said. Zero discharge was chosen as the best method. Mr. McTavey reported statistics on the enormous impact that this standard would have on industry.

Zero discharge can be achieved by any paint manufacturer. McTavey further urged everyone to examine their present

paint manufacturing procedures with the idea of reducing the amount of water which is presently being used in the manufacture of latex-based coatings. He related that water conservation can be achieved by improving production scheduling to eliminate equipment cleanup, squeegeeing tanks down so less paint is on the sides, using automatic shut-off valves for clean-up water, and using portable high pressure pumps for cleaning. Next, would be to use chemical treatment of waste water. Necessary equipment for flocculation of waste waters is a conical bottom tank, containing a Lightning mixer, with a 3-5 in. valve.

CARL J. KNAUSS, *Secretary*



Birmingham Club Executive Committee for 1980-81. Front row (left to right): Immediate Past-President—J.N. Hitchin; President—R. Ingleston; and President-Elect—J.R. Green. Back row (left to right): Society Representative—D.H.W. Lovegrove; D.M. Heath; Technical Committee Chairman—R.B. Tennant; J.W.D. Chattoe; Treasurer—H.J. Griffiths; and Secretary—B.J. Addenbrooke



Philadelphia Society Board of Directors for 1980-81. Front row (left to right): Treasurer—Willis A. Johnston; President—Barry Oppenheim; President-Elect—Ellis C. Moore; and Immediate Past-President—Carl Fuller. Back row (left to right): Technical Committee Chairman—Robert C. Sonntag; Member-at-large—Frank M. Bartusevic; Member-at-large—Ralph Myers; Honorary Director—J. Richard Kiefer, Jr.; and Society Representative—John A. Stigile

Dallas

Nov. 14

Elio Cohen, of Daniel Products, Co. presented "FACTORS GOVERNING TINTER PERFORMANCE."

Mr. Cohen stated that the five factors governing the performance of tinters, are: (1) Dispersing medium (vehicle & additives); (2) Pigments; (3) Solvents; (4)

Dispersing equipment; and (5) Tinter interactions.

Early problems found when using the same vehicle for all pigments included differences in color with rub up and tinter stability, he said. With "SDV" (specially developed vehicle) one can make a tinter with greater utility. Solvents were said to effect the performance of a tinter due

primarily to the surface tension of the solvent, said Cohen. Of the three methods of dispersing pigments—sand mill, pebble mill, and attritor—the latter gives a coating with cleaner color and more uniformity.

He concluded that the properties needed for ideal performance of tinters included wide range of compatibility and tint performance and no adverse effect on drying time of coating.

WILLIAM A. WENTWORTH, *Secretary*

Los Angeles

Nov. 12

Among the honored guests in attendance was William Ellis, Federation President.

Romer Johnson was awarded the Trigg Award in Atlanta by the Federation. This is the third time in four years that the Los Angeles Society has won this award.

President Jordan reported on the West Coast Symposium. At the Federation Annual Meeting in Atlanta, potential exhibitors were contacted.

Bert Osen challenged the Board of the Technical Committee to do something about "waste water treatment". Bill Meadows, the Chairman of the Technical Committee will be contacted.

Edward M. Antonucci, of Drew Chemical Corp., spoke on "A FORMULATOR'S GUIDE TO SILICONE DEFOAMERS."

Mr. Antonucci gave an overview of the types of defoamers, which include: organic, hydrophobic silica, and silicone. All defoamers can be classified into two groups: emulsifiable and nonemulsifiable, he said.

Q. Why do defoamers have an effect on color acceptance?

A. Because they are hydrophobic and pull surfactants out of the system, and mineral oil affects the surfactants and colorants. There are some defoamers that by design do not affect color acceptance.

Q. Does silicone defoamer effect cure in topcoat?

A. Yes, in some cases. Surface tension may be of influence; this can keep film open. More work is being done on this.

L. LLOYD, *Secretary*

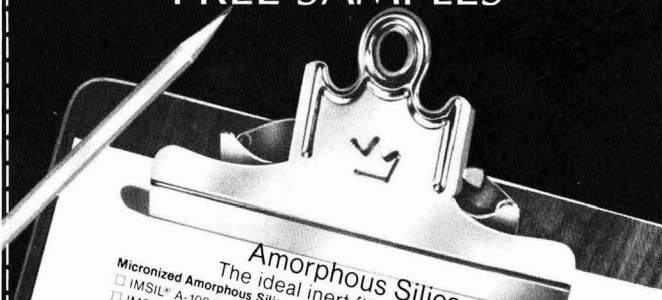
Louisville

Nov. 19

Jim Hoeck, Educational Committee Chairman, announced that a course will be offered in January on "QUALITY CONTROL OF RAW MATERIALS AND FINISHED PAINT PRODUCTS." The course will include laboratory sessions held at various local manufacturing facilities.

It was announced that the Louisville Society had won the MMA Class B

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Award for its Educational Program. The Award Plaque would be engraved with Jim Hoek's name in recognition of his dedication.

Gordon Brown of The Argus Co. presented The Tenneco symbolic gavel to the new Society President, Kirk Menefee.

Stanton O'Connell of Monsanto Plastics and Resins Co. presented "AMINOPLAST AS CROSSLINKERS IN TOMMORROW'S COATINGS." He stressed that amino coatings, both high solids and aqueous, have a significant future in appliance coatings. The chemistry of amino resins and the ways a formulator can use the properties of a particular amino resin to produce systems with high crosslinked densities was discussed. Mr. O'Connell presented charts showing how amino resins, ranging from 80-100% solids, can be best selected for particular uses. He said that functionality and temperature effect the cure of various systems.

JOHN A. LANNING, *Secretary*

Montreal

Nov. 5

The Trigg Award was presented to R. Kuhn, Society Secretary, at the Annual Meeting.

Mr. Jim White gave an explanation about the NACE organization and commented that he would like to see more cooperation between the Montreal Society and NACE.



Baltimore Society Officers for the year 1980-81. Left to right: Secretary—Don Keegan, Valspar Corp.; Treasurer—Joe Guisto, Lenmar, Inc.; Society Representative—Alex Chasan, General Services Administration; President—Gordon Allison, McCormick Paint Works Co.; and President-Elect—Mitch Dudnikov, Harry T. Campbell Sons Co.

The speaker for the meeting was Mr. Robert Kuhn, of Rohm & Haas Co. His topic was "STATISTICAL DESIGN IN FORMULATING HIGH SOLIDS COATINGS."

Mr. Kuhn emphasized the absolute necessity of using statistics when evaluating many variables while formulating. A statistical technique used to study variables while formulating a white high solids coating based on Acryloid AT-400 was presented. Cubical drawings to illustrate this fractional factorial design were shown. Graphs were presented

illustrating data analysis. Mr. Kuhn concluded by saying that a high solids, acrylic/melamine enamel can be formulated for cure at 250° F with 30% butanol, cymel 325 (highly alkylated type) and that no catalyst or amine is required.

R.H. KUHNEN, *Secretary*

New England

Nov. 20

Harold Small, of Marblehead Testing Laboratories, presented "COMPUTERS AND THEIR RELATIONSHIP TO THE LABORATORY, OFFICE, PRODUCTION, SALES AND THE BOSS."

After an introduction of defining various terms commonly used in the computer industry, Mr. Small drew comparisons and capabilities between the micro computers, mini computers, and main frame computers. He then presented examples of how the computers are used in every day situations in the laboratory (color matching, costing, calculating formulations, batch sizes, etc.), in sales analysis (histories, increases, decreases, etc.), and in inventories, plant maintenance, and budgets.

He concluded his presentation by expressing two important ideas. One, "Keep It Simple, Stupid (KISS)" and, two, let the computer generate the information and let people make the decisions. His glimpse into the future showed computer adjusting and maintaining color of in plant continuous operation of paint production, without having to take samples on adjusting individual tanks or batches.

FRAN KOEBERT, *Secretary*



Chicago Society Executive Committee for 1980-81. Seated (left to right): Vice-President—John L. Petty; President—Richard M. Hille; and Secretary—Layton F. Kinney. Standing (left to right): Membership Chairman—Frederick Foote; Treasurer—John R. Ingram; and Associate Members—Evans Angleos and James F. Manier. Not present is Society Representative—John T. Vandenberg.

Piedmont

Nov. 19

Mr. Donald Onnen, of AMF Cuno Div., presented "THE 'WHYS AND

Constituent Society Meetings and Secretaries

BALTIMORE (Third Thursday—Eudowood Gardens, Towson). DONALD KEEGAN, Valspar Corp., 1401 Severn St., Baltimore, MD 21230.

BIRMINGHAM (First Thursday—Warwickshire County Cricket Club). B. J. ADDENBROOKE, Croda Paints Ltd., Bordesley Green Rd., Birmingham B9 4TE, England.

CHICAGO (First Monday—meeting sites in various suburban locations). LAYTON F. KINNEY, Standard T Chemical Co., Inc., 10th & Washington Ave., Chicago Heights, IL 60411.

C-D-I-C (Second Monday—Sept., Nov., Jan., Mar., May in Columbus; Oct., Dec., Feb., Apr., in Cincinnati, Kings Island Inn). NELSON W. BARNHILL, Inland Div., G.M.C., P.O. Box 1224, Dayton, OH 45401.

CLEVELAND (Second Tuesday—meeting sites vary). CARL J. KNAUSS, Kent State University, Kent, OH 44242.

DALLAS (Thursday following second Tuesday—Vic's Gallery Restaurant). WILLIAM A. WENTWORTH, Jones-Blair Co., P.O. Box 35286, Dallas, TX 75235

DETROIT (Fourth Tuesday—meeting sites vary). MIKE KING, U.S. Army TACOM, 765 Dellwood Dr., Ann Arbor, MI 48103.

GOLDEN GATE (Monday before third Wednesday—Sabella's Restaurant, San Francisco). F. ROBB HOLT, Sherwin-Williams Co., P.O. Box 23505, Oakland, CA 94623.

HOUSTON (Second Wednesday—Sonny Look's, South Main). KLEBERT JACOBSON, Cron Chemical Corp., P.O. Box 14042, Houston, TX 77021.

KANSAS CITY (Second Thursday—Cordon Bleu). MIKE BAUER, Tnemec Co., Inc., P.O. Box 1749, Kansas City, MO 64141.

LOS ANGELES (Second Wednesday—Steven's Steak House). LLOYD HAANSTRA, Ameritone Paint Corp., P.O. Box 190, Long Beach, CA 90801.

LOUISVILLE (Third Wednesday—Essex House). JOHN LANNING, Porter Paint Co., 400 S. 13th St., Louisville, KY 40203.

MEXICO (Fourth Thursday—meeting sites vary). JUAN IRAZABAL, Grafex De Mexico, S.A., Calz. Tulychaulco 4615, Mexico, D.F., Mexico.

MONTREAL (First Wednesday—Bill Wong's Restaurant). G.L. SIMPSON, Sico, Inc., 3280 Blvd. St. Anne, Quebec, P.Q., Canada G1E 3K9.

NEW ENGLAND (Third Thursday—Fantasia Restaurant, Cambridge). FRAN KOEBERT, Kyanize Paints, Inc., Second & Boston Sts., Everett, MA 02149.

NEW YORK (Second Tuesday—Landmark II, East Rutherford, NJ). TED YOUNG, Jesse S. Young Co., Inc., P.O. Box 275, Hewlett, NY 11557.

NORTHWESTERN (Tuesday after first Monday—Edgewater Inn). DON EMCH, Valspar Corp., 1101 3rd St. S., Minneapolis, MN 55415.

PACIFIC NORTHWEST (Portland Section—Tuesday following second Wednesday; Seattle Section—the day after Portland; British Columbia Section—the day after Seattle). ROBERT MILLER, Imperial Paint Co., 2526 N.W. Yeon, Portland, OR 97210.

PHILADELPHIA (Second Thursday—Valle's Steak House). WAYNE KRAUS, Lawrence-McFadden Co., 7430 State Rd., Philadelphia, PA 19136.

PIEDMONT (Third Wednesday—Howard Johnson's Coliseum, Greensboro, NC). SARA M. ROBINSON, Union Oil Co. of Calif., P.O. Box 7129, Charlotte, NC 28217.

PITTSBURGH (First Monday—Skibo Hall, Carnegie Mellon Univ.). WILLIAM CIBULAS, Mobay Chemical Co., Penn Lincoln Pkwy. W., Pittsburgh, PA 15205.

ROCKY MOUNTAIN (Monday prior to second Wednesday—Gusthaus Ridgeview, Wheatridge, CO). DONALD R. BAGGE, George C. Brandt, Inc., 6500 Stapleton Dr. S., Denver, CO 80216.

ST. LOUIS (Third Tuesday—Salad Bowl Restaurant). JOSEPH J. WRABEL, JR., CIBA-GEIGY Corp., P.O. Box 26653, St. Louis, MO 63122.

SOUTHERN (Gulf Coast Section—Second Tuesday; Central Florida Section—Thursday after third Monday; Atlanta Section—Third Thursday; Memphis Section—Second Tuesday). WILLIAM G. EARLY, Piedmont Paint Mfg. Co., P.O. Box 6623, Station B, Greenville, SC 29606.

TORONTO (Second Monday—Town and Country Restaurant). A. SUK, K-G Packaging Ltd., P.O. Box 658, Concord, Ontario, Canada L4K 1C7.

WESTERN NEW YORK (Second Tuesday—Holiday Inn, Cheektowaga, NY). CHARLES S. GLINSKI, Pierce & Stevens Chemical Corp., 710 Ohio St., Buffalo, NY 14240.

WHEREFORES' OF CARTRIDGE FILTRATION IN THE COATINGS INDUSTRY."

He began the presentation with a quick review of basic filtration and how it relates to the coatings industry. Slides were shown comparing performances of typical filtration systems with different types of filter cartridges. One point brought out pertained to the use of cartridges. If the number of cartridges in parallel is doubled, then three times the life of the cartridge could be gained. This technique could save time and gain efficiency, he said. Slides illustrated filter choices for unpigmented and pigmented products. Mr. Onnen discussed water-based coatings filtration methods, emphasizing ways to improve filter media life and reduce foaming.

SARA M. ROBINSON, *Secretary*

Rocky Mountain Nov. 10

Mr. Edward Antonucci, of Drew Chemical Corp., presented "A FORMULATOR'S GUIDE TO SILICONE DEFOAMERS."

He explained the types of foam control agents; organic, hydrophobic silica, and silicones, which are available. The use of silicone defoamers was also discussed.

DONALD R. BAGGE, *Secretary*

St. Louis Nov. 22

A panel of four speakers discussed the topic of "HAZARDOUS WASTE."

Bernard A. Rains, Manager of the Industrial Pollution Control, St. Louis Metropolitan Sewer District, stated that Missouri's Clean Water Act and the E.P.A. Resource Conservation and Recovery Act (RCRA) effective Nov. 19, 1980, will require that all water from a plant be pretreated to remove "hazardous waste." The Municipal Sewer District (MSD) identifies potential generators of "hazardous waste" and requires industry to report to MSD on materials sent into the sewer.

Patrick E. Phillips, Chief of Hazardous Waste Management of Missouri's Department of Natural Resources, explained the DNR's responsibility for the enforcement of existing regulations. Mr. Phillips does not expect industry to be able to comply with the law for the immediate future.

The phases of the RCRA, effective November 1980, was discussed by Stephen Bush, of the Hazardous Materials Branch of the Environmental Protection Agency.

James Lee Boyland, consultant for John Steffen Associates, Consulting Engineers, further discussed the phases enacted by the RCRA.

JOSEPH J. WRABEL, JR.,
Secretary

Future Society Meetings

Baltimore

(Feb. 13)—LADIES' NIGHT.
(Mar. 12)—Manufacturing Committee program.
(Mar. 13)—MINITRADE SHOW. Pikesville Hilton.
(Apr. 16)—Education Committee program.
(May 21)—Technical Steering Committee program on PAINT APPLICATION METHODS.

Birmingham

(Feb. 5)—"STATIC ELECTRICITY"—Dr. R.J. Loveland, H.M. Electrical Inspector of Factories.
(Mar. 5)—"MARKETING IN THE EIGHTIES"—P. Harland, Croda Paints Ltd.
(Apr. 2)—"SOME ASPECTS OF AMINO RESINS"—J.E. Sreeves, B.I.P. Ltd, Chemical Div.
(May 7)—"COATING WINDOW FRAMES"—G.W. Rothwell, Building Research Establishment,

Chicago

(Feb. 2)—"LATEX PARTICLE INTERACTIONS"—C.T. Havens, Sherwin-Williams Co.; "NEW WATER-REDUCIBLE POLYMERS"—Henry Kasprzak, Spencer Kellogg Div.
(Mar. 2)—"HARD LATEX POLYMER MODIFICATION OF WATER-SOLUBLE ALKYDS"—Nick Roman, Rohm and Hass Co.; "FSCT CORRESPONDENCE COURSE"—John Gordon, Univ. of Missouri—Rolla.
(Apr. 6)—FSCT SLIDE SHOW—Federation Officers; "MULTI-FUNCTIONAL EPOXIDES"—M. Gaschke, CIBA-Geigy Corp.
(May 9)—AWARDS NIGHT. Installation of 1981-82 Officers.

C-D-I-C

(Feb. 9)—"WASH SOLVENT RECLAMATION"—Larry Durr, DCI Corp.
(Mar. 9)—FSCT SLIDE SHOW, Federation Officers.
(Apr. 13)—PLANT TOUR of Battelle Memorial Institute.
(May 11)—"PIGMENT DISPERSION AND MILLING IN THE PAINT AND RELATED INDUSTRIES"—Edward Carter, Morehouse Industries, Inc.

Detroit

(Feb. 17)—"SAFETY PRACTICES IN THE PAINT INDUSTRY"—Gilbert Cain, Hercules, Inc.

Houston

(Mar. 11)—PAST-PRESIDENTS' NIGHT
(Apr. 8)—"CHLORITE: A NEW FAMILY OF PAINT EXTENDERS"—William Meadows, Cyprus Industrial Minerals.

Los Angeles

(Mar. 11)—"SHORT TIME EVALUATION TECHNIQUE FOR LIQUID AND PARTICLE BEHAVIOR IN COATINGS SYSTEMS"—Frank Zurlo, Byk Mallinckrodt, Chem Prod. GmbH.
(Apr. 8)—"POLYMERIC ORGANIC DISPERSANTS FOR PIGMENTS: PRINCIPLES AND PRACTICES"—Robert D. Athey, Jr., Swedlow, Inc.
(May 12)—"PLANT DESIGN: BUILD NEW—REDESIGN OLD"—Jim White, Hockmeyer Equipment Corp.

Montreal

(Feb. 4)—Manufacturing Committee program.
(Mar. 4)—"SELLING TECHNIQUES"—Graham Oliver, McGill Univ.
(May 7)—PAST-PRESIDENTS' NIGHT
(May 9)—50TH ANNIVERSARY BALL. Ritz Carlton Hotel

New York

(Feb. 5)—"LEGISLATIVE UPDATE"; JOINT MEETING with New York PCA.
(Mar. 10)—MINIWORKSHOPS ON "ZERO EFFLUENCE"; "TYPES AND FUNCTIONS OF ADDITIVES"; "ADHESION OF LATEX PAINTS"; SALES AND MANAGEMENT TOPIC; and "COMPUTER AS A TOOL IN PRODUCTION."
(Apr. 14)—"DISPERSION EQUIPMENT"—Panel Discussion.
(May 12)—PAVAC AWARD NIGHT.

New England

(Feb. 19)—"AMINO CROSSLINKERS: RELATIONSHIP OF STRUCTURE TO COATINGS PROPERTIES AND PERFORMANCE"—Dennis E. Erickson, Monsanto Plastics & Resins; "THE USE OF TITANATE COUPLING AGENTS IN COATINGS"—David Busker, Kenrich Petrochemicals.
(Mar. 19)—JOINT INDUSTRY MEETING.
(Mar. 24)—JOINT MEETING with Society of Plastic Engineers; "MICROBIOLOGICAL DETERIORATION OF PLASTIC AND COATINGS"—Susan Tamborini, Ventron.

Philadelphia

Technical Committee Meetings

(Feb. 5)—"CONVERSION ENAMELS-ENERGY SAVERS"—Paul W. McCurdy, Reichhold Chemicals, Inc.
(Mar. 5)—"NEW GENERATION COATINGS—APPLICATION WORKSHOP: PART I—WATER-BORNE AND HIGH SOLIDS"—speakers from Cargill Chemical Products Div. and Nordson Corp.
(Apr. 2)—"NEW GENERATION COATINGS—APPLICATION WORKSHOP: PART II—TWO COMPONENT AND POWDER"—speakers from Mobay Chemical, Polymeric Corp., and Nordson Corp.
(May)—Society Technical Committee Seminar on "INTERFACES REVISITED."

Pittsburgh

(Feb. 2)—"INDUSTRIAL HYGIENE AND URETHANE COATINGS"—Paul D. Ziegler, Mobay Chemical.
(Mar. 2)—"PIGMENT DISPERSION—WHAT DOES IT MEAN?"—James D. Easton, Harshaw Chemical Co.
(Apr. 6)—"KNOW YOUR ENEMY—THE WEATHER"—George W. Grossman, The Q-Panel Co.
(June 1)—"ART AND ALCHEMY"—John C. Pavlik, Fisher Scientific Co.

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C-D-I-C

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LALLEMENT, JAMES R.—Carter Paint Co., Inc., Liberty, IN
PETERS, JAMES A.—Carter Paint Co., Inc., Liberty, IN
QUORN, PETER J.—Inmont Corp., Cincinnati, OH
RICHARD, MICHAEL J.—Lilly Ind. Ctg.s., Indianapolis
VANCE, JAMES A.—Vance Laboratories, Indianapolis

Associate

HANDLETON, ROBERT T.—Henkel Corp., Cincinnati, OH
JONES, ELMER, JR.—Paul Uhlich & Co., Cincinnati
KENNEDY, RICHARD J.—Hilton Davis Chem. Co., Cincinnati
LAJCAK, DENIS J.—Pfizer, Inc., Loveland, OH
McMASTERS, ROBERT L.—Rohm and Haas Co., Milford, OH
PENDLETON, KENNETH A.—Neville Chemical Co., Cincinnati
RICE, CLAYTON D.—BASF Wyandotte Corp., Cincinnati
SEXTON, TIMOTHY A.—Sexton & Co., Cincinnati

CLEVELAND

Active

COHEN, ALLAN H.—Sherwin-Williams Co., Cleveland, OH
GARD, PAUL N.—Harshaw Chemical Co., Cleveland
GARDNER, JON—Coatings Research Group, Inc., Cleveland
GOLOWNIA, ROBERT F.—Glidden Coatings & Resins Div., Strongsville, OH
OGURCHAK, ANDY—Sherwin-Williams Co., Cleveland, OH

Associate

PARISH, MARK G.—Chem-Materials Co., Inc., Cleveland, OH
RAPACH, JOHN N.—Omya, Inc., Cincinnati, OH

Retired

HOLLENBERG, FRED H.—Maple Hts., OH
MALAGA, MICHAEL W.—Parma, OH

DETROIT

Active

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KERSTEN, RON—Argo Paint & Chemical Co., Westland, MI

SCHWEIGERT, THOMAS F.—Inmont Corp., Detroit, MI

WLODAR, LARRY M.—Wyandotte Paint Prod. Co., Troy, MI

Associate

LANE, PAUL—Jesse W. Eakins Co., Oak Park, MI
MILLER, T.W.—Sherwin-Williams Co., Seline, MI
PATANELLA, JUSTIN P.—Hooker Chemicals, Niagara Falls, NY

HOUSTON

Active

CHAPA, PAUL—Monarch Paint Co., Houston, TX
DECELLES, PATRICK G.—So. Protective Prod., Houston
EILERT, MICHAEL—Champion Paint Mfg. Co., Houston
JORDAN, FRANK W.—Southern Clay Products, Gonzales, TX
KNUDSON, M. I.—Southern Clay Products, Gonzales
MILETI, OTTO J., JR.—Intercoastal Paint Co., Houston
ROWE, RICHARD—Negley and Co., San Antonio, TX
WHITEHAIR, MARK A.—DeVoe and Reynolds Co., Inc., Houston

Associate

RICHEY, R. LANIER—Union Chemical Div., Houston, TX
RUMFORD, ROBERT H.—Ashland Chemical Co., Houston
SAXTON, ROBERT L.—Delta Solvs. & Chemicals, Dallas, TX
SIPTAK, DWAIN E.—Southern Clay Products, Spring, TX

KANSAS CITY

Active

BECKER, ROBERT T.—Farmland Industries, Inc., N. Kansas City, MO
GROSS, RAY—Welco Mfg. Co., Inc., N. Kansas City

Associate

BENNETT, GARY P.—Thompson-Hayward Chem. Co., Kansas City, KS
EATON, RAY N.—Chemtech Terminals, Inc., Kansas City, MO
KOWALSKI, EDWARD B.—SCM Chemical, Troy, MO
MEYER, DALE E.—Cemsac Chemical Co., St. Louis, MO

MEXICO

Active

DIAZ, JOSE OSAWA—Pinturas Dia S.A., Santa Clara Coatitla, Mexico

Associate

GARCIA, JOSE—Gonzalez Cano y Cia S.A., Mexico D.F., Mexico
GARNIC L., Alejandro—Grupo Servicon, Mexico D.F.
GONZALEZ, CESAREO—Gonzalez Cano y Cia S.A., Mexico D.F.
GUEVARA Z., ANTONIO—Solvs y Prods Quims, Mexico Edo, Mexico

NEW YORK

Active

BAIRD, EDWARD—Koppers Co., Inc., Newark, NJ
BHATT, KRISHNAKANT U.—Atlas Paint & Varnish Co., Irvington, NJ
BOBB, RONALD E.—Chemray Coatings Corp., Middlesex, NJ
DESAI, AJIT B.—Troy Chemical Corp., Newark
DOLAN, ROBERT J.—Minwax Co., Inc., Clifton, NJ
GANGLI, RAYMOND P.—Woolsey-Marine, Brooklyn, NY
HARING, WILLIAM J.—Hermitite Div., UMC, Carlstadt, NJ
KORN, LEONARD E., JR.—Crossfield Products, Roselle Park, NJ
LEPSELTER, BERNARD H.—RA Chemical Corp., Brooklyn
MEYER, VICTOR B.—Consultant, Berkeley Heights, NJ
MINEROWICZ, JOHN P.—Atlas Paint & Varnish Co., Irvington, NJ
MISTRY, JITENDRA M.—Reichard-Coulston, Inc., New York, NY
RABINOWITZ, CARL J.—Paragon Paint & Varn. Corp., Long Island City, NY
RO, MARIO-LAZA, JR.—Woolsey-Marine, Brooklyn
SAMIT, S.—Koppers Co., Inc., Newark
SANHUEZA, MANUEL F.—Mobil Chemical Coatings, Edison, NJ
SHU, CHI CHEN—Woolsey-Marine, Brooklyn
STARK, BOB—Empire State Varnish Co., Inc., Brooklyn
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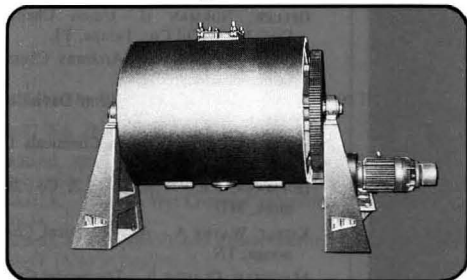
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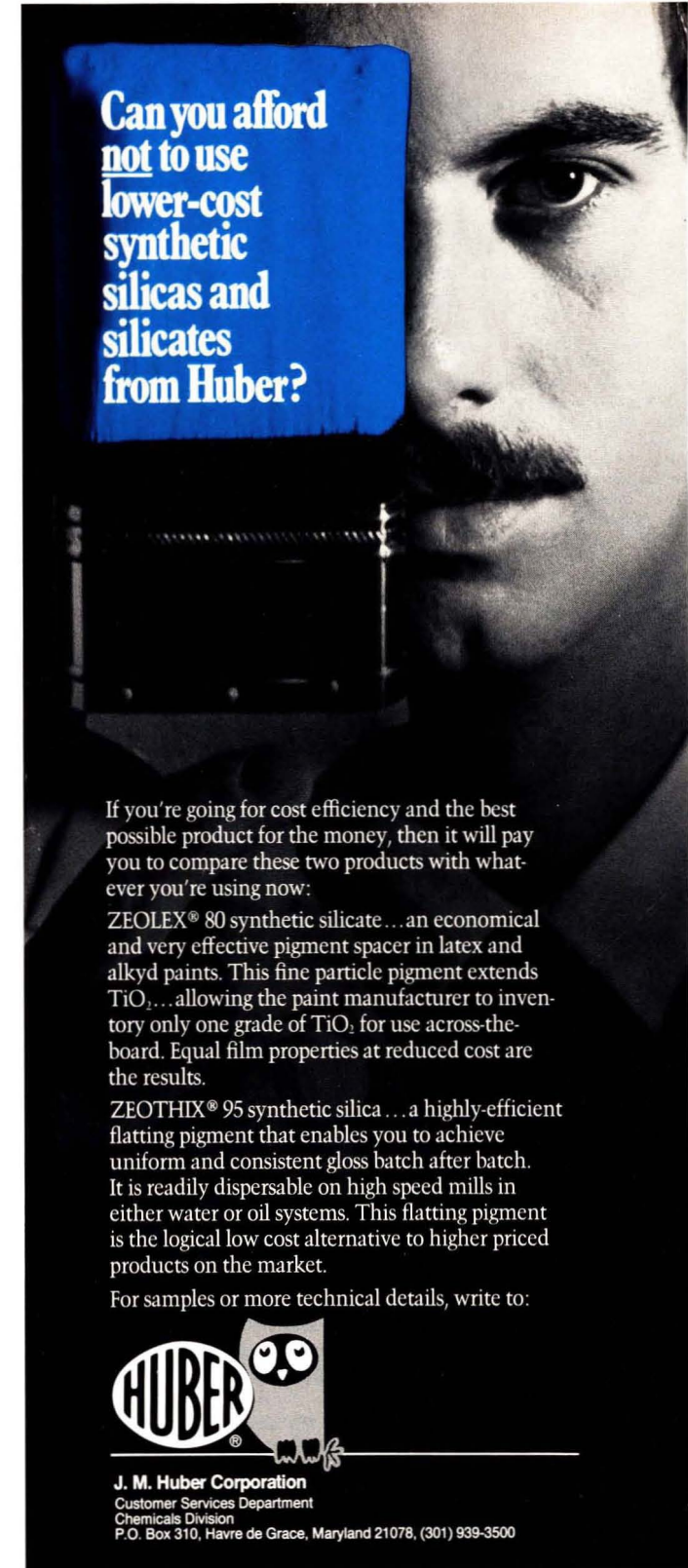
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WISHENGRAD, MARTIN A.—Martin Trading Corp., Ft. Lauderdale, FL.
WUNSTELL, FLOYD M.—Union Carbide Corp., Atlanta.

Technical Articles in Other Publications

Compiled by the Technical Information Systems Committee—H. Skowronka, Chairman

Farbe und Lack (in German)

Published by Curt R. Vincentz Verlag, Schiffgraben 41-43,
3000 Hannover, Postfach 6247.

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- Svoboda, M., Kubatova, H., Knapek, B., and Prazak, M.—“Protective Properties of Pigments and Coatings”; 780-783.
Biermann, M.—“Theory of the Tear-off Test (2). Axi- and Planisymmetric, Linearly Elastic Eigenstates and Simple Examples of Perturbational States in the Middle of the Joint”; 784-796.
Ahmad, H.—“Solubility Parameters of Poly (ethylene sulphonamides) By the Use of Group Contribution Technique.”; 797-798.
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Brushwell, W.—“Further Developments of Coating Materials Based on Vinyl and Epoxy Resins”; 805.

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- Monitor—“Technical Legislation Faces the Paint Industry with Increasing Problems”; 867-869.
Funke, W. and Zatloukal, H.—“Anti-Corrosion Coatings on Steel Structures. Suitability of Constant Potential Polarisation Experiments for Determining Resistance against Undercutting”; 870-875.
Gelbke, H.P. and Zeller H.—“Skin Irritation of Hexanedioldiacrylate; Problems for Evaluation of Animal Experiments”; 876-879.
Oesterle, K.M.—“Early Recognition of Chalking Tendency of Coatings Pigmented with Titanium Dioxide”; 879-888.
Brushwell, W.—“Lacquers and Equipment for Radiation Curing”; 888-893.
Engels, K.—“Can Variable Rotary Stirrer Speeds in the Dissolver Process be Replaced by a Constant High Speed?”; 894-898.

Double Liaison (in French)

Published by EREC, 68 Rue Jean-Jaures, 92800 Puteaux, France

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- Guainazzi, G.C.—“Current Knowledge About Fatty Acid Based Polyamide Resins”; 21-28.
Walker, K.—“Wet on Wet Coatings” (aluminum pigmented coatings); 30-34.
Loucheux, C.—“Application of Photochemistry to Coating Problems”; 39-49. (Also in English).

Journal of the Oil and Colour Chemists' Association

Published by Oil and Colour Chemists' Association, Priory House,
967 Harrow Rd., Wembley, Middlesex, HAO 2SF, England

Vol. 63 No. 6 June 1980

- Chandra, S. and Pasari, S.—“Esters of Polystyrene Glycol and Rosin in Surface Coatings”; 225-229.
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- Chandra, S. and Pasari, S.—“Copolymers of Polystyrene Glycol and Glycerol Phthalate Resins in Surface Coatings”; 321-325.
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- Badran, B.M., El-Anwar, I.M., Ibrahim, M.S., and Ghanem, N.A.—“Surface Coatings Based on Dehydrated Castor Oil. Part I: Physical and Mechanical Properties”; 399-403.
Fowles-Smith, J.E.—“The Corrosion Consultant at Large”; 404-406.
Hingorani, B.H., Uddin, A., Panda, H., and Rakhshinda—“Epoxy Esters of Rosin”; 407-411.
Strivens, T.A.—“Application of Acoustic Emission to Study of Paint Failure”; 412-418.

Paint Manufacture

Published by Wheatland Journals Ltd., 177 Hagden Lane,
Watford WD1 8LW, U.K.

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Smith, C.A.—“Flame Resistant and Intumescent Paints, Part I”; 24-25, 27.

Vol. 50 No. 6 July/August 1980

- Anon.—“Aqueous Powder Suspension Coatings”; 14-15, 17-18.
Knightley, J.—“Vinylidene Chloride Copolymer Latexes for Fire Retardant Systems”; 19-20.
Ellinger, M.L.—“Ecology, Energy, Economy” (Report of Proceedings of FATIPEC XV Congress, June 1980); 22-23.

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- Bierwagen, G.P.—“Pigmented Polymer Beads Increase Durability of Aircraft Coatings” (Summary of paper presented at FATIPEC XV Congress); 10.
Cowley, A.C.D.—“Colours for Automotive Paints”; 11.
Borthwick, P.—“Using Resins Safely”; 17-18.
Ellinger, M.L.—“R & D Report: Anticorrosion and Marine Paints” (literature review); 22-23.
Thust, U.—“Use and Production of Organotins in the D.D.R.” (Based on paper published by Tin Research Association in *Tin and Its Uses*); 24-25.

XVth FATIPEC Congress Will Be Held In Liege, Belgium, May 9-14, 1982

The XVth Congress of FATIPEC (Federation of Associations of Technicians in the Paint, Varnish, Lacquer and Printing Ink Industries of Continental Europe) will be held in Liege, Belgium, May 9-14, 1982, at the Palais des Congres. The host organization will be the ATIPIEC, the Belgian Association member of FATIPEC.

Theme

The theme of the Congress will be "Evaluation and Foresight of Film Properties of Organic Coatings by the Use of Modern Analytical Methods," it was announced by Andre Toussaint, President of FATIPEC.

Present-day economical, ecological, and energy requirements place the paint industry in an accelerated evolution period regarding its technology. This situation creates for the manufacturer and formulator the difficult task to formulate new products having the equivalent, if not better, properties than conventional coatings.

Solutions to the problem might be solved or facilitated and many tests spared by a masterly and precise knowledge of: (1) the materials to be used and how to use them; (2) the interaction between pigments/binders (solvents)/substrates; and (3) the relationship between the physico-chemical properties of the formed film, both at short and long term, and the nature of the materials in the coating.

Call for Papers

Anyone interested in presenting a paper at the Congress, directed to the theme, should contact: Secretary of the XVth FATIPEC Congress, 49 Square Marie-Louise, 1040 Bruxelles, Belgium.

Exhibition

An exhibition of coatings raw materials and manufacturing equipment, under the name FATIPEXCO, will run concurrently with the Congress in the Palais des Congres.

Dr. Andre Toussaint, President of the Association of Technicians of the Paint Industry and Associated Industries of Belgium, has been elected President of the Federation of Associations of Technicians in the Paint, Varnish, Lacquer and Printing Ink Industries of Continental Europe (more popularly known as FATIPEC).

Dr. Toussaint joined the Laboratory of the Paint Industry (IVP) in Brussels, in 1963, as Deputy Director of Research.

Well-known in European paint industry circles, he is: the author of 40 scientific publications; a member of the Scientific Committee of *Progress in Organic Coatings* and *Double Liaison/Chimie des Peintures*; and a member of the IUPAC Macromolecular Division—Working Party on Supported Polymer Films, of which he was Secretary for four years. From 1974-78, Dr. Toussaint was a member of GT-2, European Corrosion Committee.

The Secretary-General of FATIPEC is Christian Bourgerly, whose office is located at Maison de la Chimie, 28 Rue Saint Dominique, 75, Paris, France.



A. Toussaint

Spring Seminar to Focus On Paint Plant Improvement

An extensive two-day seminar on "Paint Plant Design and Operations" will be sponsored by the National Paint and Coatings Association on April 8-9 at Stouffers Riverfront Towers, St. Louis, MO.

The program, similar to that held in Chicago in 1974 and Atlanta in 1977, will focus on both the design and construction of new paint plants and the rehabilitation of older facilities.

Knowledgeable speakers will discuss site selection, plant design, project engineering, equipment selection, scheduling, filling and packaging, warehousing and shipping, and project financing. Specialists will also discuss waste disposal engineering and protection of worker health and safety.

Registration fee is \$60 prior to April 1; \$75 after April 1.

Programs and seminar and hotel registration information is available from the Director of Meetings and Conventions, Karen Bradley. Program and speaker information may be obtained from Royal A. Brown, Technical Div. Vice-President. Both are located at NPCA, 1500 Rhode Island Ave., N.W., Washington, D.C. 20005.

'New Concepts' Is Topic of Rolla Coatings Seminar

"New Concepts of Innovation in Coatings," will be the topic of the seminar presented by the Coatings Continuing Education Dept. of the University of Missouri-Rolla. The seminar, designed to help improve products and systems that meet today's challenges, will be held February 5-6, in Fort Lauderdale, FL.

The presentation format is designed for laboratory and research managers, coatings personnel, chief chemists, and managers. It will deal with the new technology required to meet rapid changes and innovations. Finding ways to handle hazardous wastes, reduce dependence on petrochemicals, meet new formulation problems, cope with rapidly increasing prices calls for innovation now.

Milton A. Glaser and Jack McDade will be the featured lecturers. Both are

experts in their fields and in communicating their knowledge to others.

Mr. Glaser is a consultant to industry and government on matters concerning innovation. He is a well-known lecturer and has written various articles and papers on methods of improving the innovative output of research and development laboratories, including the use of his "Innovative Index", presented in his 1974 Mattiello Lecture.

Mr. McDade, group training manager for 3M Education, Training, and Development, provides complete management and sales programs for the training and development of dealer and customer personnel and managers in eight major 3M divisions.

For additional information, contact Norma Fleming, Seminar Coordinator, Arts & Sciences Continuing Education, University of Missouri-Rolla, Rolla, MO 65401.

Rolla Announces 1981 Coatings Short Course Schedule

The Continuing Education Department of the University of Missouri-Rolla will sponsor its 1981 series of Coatings Short Courses, scheduled from January 13 to November 19.

These intensive course programs will be directed by John A. Gordon, Jr., Professor of Chemistry at Rolla. He will be assisted by lecturers who are representatives of industry, specially experienced and qualified in the specific subject areas.

(Jan. 13 - Nov. 12)—“Refresher for Painting Contractors, Maintenance Engineers and Inspectors”—Designed to introduce the newest techniques, equipment, and products for preparing surfaces for coating. Discussed will be improved methods and equipment for applying coatings and the new kinds of coatings being manufactured to meet the requirements of regulatory agencies.

The locations and dates of the short course are: Scottsdale, AZ, Jan 13-15; St. Petersburg, FL, Feb 10-12; Anaheim, CA, March 3-5; Philadelphia, PA, May 10-12; Kansas City, MO, Nov. 10-12. Cost of the course is \$350.

(Mar. 23 27, Aug. 10-14)—“Introductory Short Course on Composition of Coatings”—Through lectures, audio-visual presentations, and classroom demonstrations, participants will be introduced to the history of paint, the materials used in coatings manufacture, and some simple formulating techniques. Designed for newcomers, this course will offer explanations of the equipment used to make and test modern protective coatings. Fee for the class is \$275 and will be held on the UMR campus.

(Apr. 6-10, Aug. 31—Sept. 4)—“Introduction to Paint Formulation”—This lecture and laboratory course will feature sections on calculating coating formulas for performance, economics, method of manufacture, and compliance with government regulations. Cost of the class is \$350, and will be held on the UMR campus.

(Apr. 13-17, Sept. 7-11)—“Advanced Paint Formulation”—Designed for laboratory staff who have a basic understanding of formulation methods, and wish to broaden their skills. Emphasis of this course will be on proper formulation to achieve specific goals of cost, profit, performance, and ease of manufacture. The course will be held on the UMR campus, with a fee of \$350.

(May 19-20)—“Practical Waste Management for the Coatings Industry”—

This course, designed for plant managers and supervisors, will discuss the nature and hazards of waste, solutions to reduce wastes by planned recycling of materials, and profitable disposal of wastes. It will present solutions to growing restrictions placed on all industry to control wastes and to reduce costs of such operations. The course fee is \$325 and will be held in Kansas City, MO.

(Sept. 21-22)—“Techniques & Mechanics of Marketing Specialty Chemicals”—Designed for marketing and sales managers, sales staff and trainees, the course will present market and customer information, technical knowledge needed to determine the value of a specialty chemical to a customer, and account and business skills. The course will be offered in Kansas City, MO at a fee of \$325.

(Sept. 23-24)—“Managing for Innovation in Coatings”—The course will introduce innovations for these difficult times and increased innovative productivity by using the Glaser Innovative Index Model. Through group participation and workshops, designing a motivation/innovation improvement plan will be presented. The class will be held in Kansas City, MO with a fee of \$325.

(Oct. 25-27)—“Women in Coatings—Meeting the Challenges”—Designed for both men and women in sales, management and technology. This seminar is scheduled to coincide with the 1981 Annual Meeting and Paint Show of the Federation of Societies of Coatings Technology. Speakers from the coatings

industry will discuss the opportunities and challenges that industry offers women. Sessions will deal with skills necessary for assuming leadership situations and success.

(Nov. 17-19)—“Job Estimating Workshop for Painting Contractors”—Study will include blueprint reading, specifications, quantity take-offs, and pricing structures. The class will work with actual plans in as near a real-life situation as possible. Class cost is \$350 and will be held in Kansas City, MO.

For additional information, or to register, contact Norma Fleming, University of Missouri-Rolla, Rolla, MO 65401.

Spray Finishing Workshop To be Held at Bowling Green

The annual Spray Finishing Technology Workshop, sponsored by Bowling Green State University and the DeVilbiss Co., will be held March 23-27 at the university campus and in the technical center of DeVilbiss, in Toledo, OH.

The workshop will feature sessions on equipment and material selection, spray finishing techniques associated with automotive spraying, and furniture and industrial spraying. The latest technology in powder coatings, automatic spraying and plural components will also be discussed.

For additional information, contact the Workshop Director, Dr. Richard A. Kruppa, School of Technology Bowling Green State University, Bowling Green, OH 43403.

ISCC to Celebrate 50th Year at Annual Meeting

The Inter-Society Color Council will hold its Golden Jubilee Annual Meeting at the Roosevelt Hotel in New York City, April 26-28.

Opening the meeting will be a reception on Sunday evening, April 26, at the Fashion Institute of Technology. Attendees will see the Mariano Fortuny Exhibition and a tour of the institute's laboratories will be arranged.

The following day will feature meetings of the Council's 13 active project committees, which will be open to the public. The 50th Anniversary banquet will be held Monday evening.

Three symposia will be held on Tuesday, April 28: “Fifty Years of Progress in the Use of Color,” will be the topic discussed by representatives of

several member bodies of ISCC; “Color in the Future,” will feature predictions of progress over the next five years in a number of fields of application of color; and “Color Education,” will describe some of the small or lesser known educational programs in various areas of color.

The Tuesday luncheon will feature the presentation of the ISCC Godlove Award, and will be followed by a short business meeting.

For further information contact either Dr. Allan B. Rodrigues, E.I. du Pont de Nemours & Co., Inc., 945 Stephenson Hwy, Troy, MI 48084; or, Dr. Fred W. Billmeyer, Jr., Dept. of Chemistry, Rensselaer Polytechnic Institute, Troy, NY 12181.

Southern Society to Hold Annual Meeting on March 11-13

"Coatings Technology—The End Users Perspective," will be the theme during the annual meeting of the Southern Society for Coatings Technology at the Birmingham Hilton Inn & Conference Center, Birmingham, AL, March 11-13.

Program sessions will begin March 12 with the Keynote Address, "We Need to Help Our Product Go First Class," by Charles W. Finegan, President of Havco Paints, Clearwater, FL, and a Past-President of the Federation.

Also scheduled are the following presentations.

MARCH 12

Water-Borne Coatings Practical Problems—Panel Discussion:

"Formulating Commercial Products"—Tom McCraney, Mobile Paint.

"Production"—Craig Larson, Wyandotte Paint.

"Application"—Dave Barton, Barton Associates.

"Waste Disposal—Status of Laws and Regulations"—Tom Graves and/or Bob Nelson, National Paint & Coatings Association.

"Trends in Metal Finishing"—Joseph Ziegwied, Consultant.

Also speaking will be William Ellis, Federation President, and Frank Borrelle, Federation Executive Vice-President.

Reports will be given by students of the University of Southern Mississippi.

MARCH 13

"High Solids Solvent-Based Coatings"—Vic Ginsler, Freeman Chemical.

"Role of Organic Cosolvents in Water-Borne Coatings"—Dr. Robert Eaton, Union Carbide Corp.

"Paint Quality - The Producer"—Thad Broome, Precision Paint.

"Paint Quality - The User"—Panel Discussion:

"Customer Reaction to Cost of Repainting Vs. Price"—Leonard Fulghum, Furgeson-Fulghum, Inc.

"Coatings Performance Requirements in the Industry"—speaker TBA.

"What the Farmers Want"—Bob Kane, International Harvester.

"Problems Related to Warranties

On High Performance Materials"—Paul Oliver, U.S. Steel.

"Paint Quality - The Consumer"—Joseph Csernica, Consumers Union of the United States.

For additional information contact Peter F. Decker, Union Carbide Corp., 17 Executive Park Dr., N.E., Atlanta, GA 30359

George Brown College Offers Coatings Courses

To acquaint industry employees with specialized developments and applications in water-borne, high-solids, and powder coatings, George Brown College, Toronto, Ontario, has scheduled part-time courses for the 1980-1981 academic year.

As part of a two-year package, the courses will be held in the evening on a rotational basis and on Saturdays. Since a previous study of organic and inorganic chemistry and physics at the university level is desirable, the Saturday courses have been designed to review these subjects.

Courses already in progress include "Resins 'C'" (October 7, 1980-January 27, 1981); "Organic Coatings" (October 2, 1980 - May 14, 1981); and "Coatings Technician" (September 27, 1980-May 9, 1981).

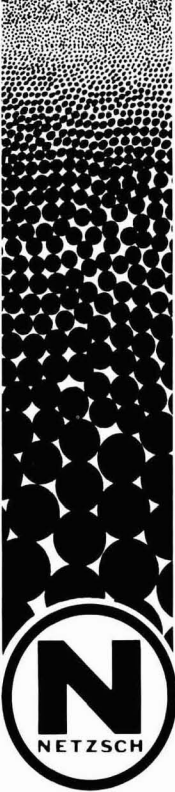
In addition, the following courses are scheduled:

(February 4-May 14)—"Coatings Laboratory"—Emphasis will be placed on topics such as quality control of raw materials, preparation and evaluation of lacquers, varnishes, solvent and water-borne coatings, and report writing. Enrollment is limited and a course in Organic Coatings offered by the college is a prerequisite. Registration fee for the course is \$85.

(February 3-May 12)—"Polymer Chemistry"—As part of the second year program, this course will examine emulsion, condensation, addition, free radical and cationic anionic polymerizations, copolymerization, molecular interactions, identification, and rheology. Registration fee is \$60.

To provide industry recognition to students with accumulated credits in several modules, the college, in association with the Toronto Society for Coatings Technology, will award certificates in Basic Coatings Technology and Advanced Coatings Technology.

For additional information, contact Mr. P. Rodak, Mathematics and Science Div., The George Brown College of Applied Arts and Technology, P.O. Box 1015, Station B, Toronto, Ont. M5T 2T9.



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W. Thomas Cochran, Technical Director of Bruning Paint Co., Baltimore Md., received the 1980 Herman Shuger Award of the Baltimore Coatings Industry Awards Council, at a special awards meeting on November 20.

Mr. Cochran, the 25th recipient of the award, is a Past-President of the Baltimore Society and co-founder of the Baltimore Mini Coatings Show. In the Federation, he was a Host Subcommittee Chairman for the 1976 Annual Meeting and chaired the MMA Awards Committee in 1979 and 1980.

Also at the meeting, Merit Awards were presented to: **Frank Regensburg**, of Cummings Chemical and Container Co; **Mel Sandler**, of Lenmar, Inc.; **Irwin Young**, of Jesse S. Young Co., Inc.; and **Rick Ryder**.

Merrill D. Garret has been promoted to Vice-President of Marketing and Technical of CDI Dispersions, Newark, N.J. Prior to this promotion, Mr. Garret was Marketing Manager for the firm. He is a member of the Philadelphia Society.

Rohm and Haas Co. of Philadelphia, PA has appointed **James J. Gambino** as Market Planning Manager-Maintenance Coatings. He will be responsible for marketing the company's coating products which protect structures and equipment for industry, commerce, and government.

Arthur A. Mees, has been appointed as Senior Marketing Consultant for Union Carbide Corp. Mr. Mees will serve as Marketing Consultant for the Coatings Materials Division and direct the division's acrylics and trade paint marketing programs.

Robert J. Boni has joined Armstrong Products Co., as Senior Chemist. He will be responsible for overall product development in the decorative coatings area.

Tenneco Chemicals has announced the promotion of **Lawrence Okun** to Vice-President and General Manager of Coatings & Colorants. Prior to this appointment, Mr. Okun was Business Director of Coatings & Colorants.



Glidden Coatings and Resins has appointed **Howard J. Horton** as General Plant Manager of the firm's two new facilities in Georgia. He will be responsible for the Columbus resin facility and the paint plant under construction in Gainesville. **June C. Thomason** will replace Mr. Horton as Director of Manufacturing at Glidden Headquarters in Cleveland.

Glidden Coatings and Resins has also announced the following appointments: **William S. Freeh**, Plant Controller at Gainesville; **Richard Helland**, Regional Credit Manager of the southwest region; and **John P. Baldwin**, Zone Manager-Dealer Operations in the southwest.

Scott Paint Corporation, Sarasota, FL has appointed **Scott K. Wagman** as President and Chief Operating Officer.

William X. Hearn, Jr., of Ameron's Protective Coatings Division, has been promoted to Regional Manager of the Northeast Region. He formerly served as Manager of Industrial Sales for the company.

Sun Chemical Corp. has named **Peter Ludwig** General Manager of its Pigments Div., Cincinnati, OH. Ludwig will assume responsibility for worldwide management of the organic pigments operations.

Dr. Robert Rozett has been appointed Manager of the Corporate Plastics Laboratory for the J.M. Huber Corp., Macon, GA. He will be responsible for the development of applications for new and existing fillers for the plastics industry and for the research and plastics testing procedures for the firm's pigments divisions.

Chemcentral Corp. appointed **Richard C. Bartchy** as General Manager of its Cincinnati operation. He will replace **J.M. Williams** who will assume the position of Expanded Regional Manager. Bartchy, former President and General Manager of the company's Buffalo operation, will be succeeded by **Calvin B. Ruzicka**. Bartchy is a member of the Western New York Society.

The Process Chemicals Division of Diamond Shamrock Corp. appointed **Frederick W. Fischer III** as Western Regional Sales Manager. He will be responsible for sales of all division products in 12 western states.

The Spencer Kellogg Division of Tetrax Inc. has appointed **Frederick G. Grant** to the position of San Francisco District Sales Manager, and **Wallace E. Brede** to the position of Los Angeles District Sales Manager.

Spencer Kellogg Div. of Tetrax Inc., Buffalo, NY, has named **Gordon H. Bader** Minneapolis District Sales Manager. In addition, the firm has appointed **Edward J. Baldwin** to the position of Sales Representative for the Chicago area. Mr. Baldwin is a member of the Chicago Society.

Diamonite Products Manufacturing Inc., Shreve, OH, has appointed **Maynard Leedy** Sales Engineer for its lines of grinding mill and wear-resistant coating products. Mr. Leedy will provide engineering assistance to the firm's manufacturer's representatives in both the domestic market and overseas.

Ashland Chemical Company's Research and Development Department has promoted **Richard V. Norton** and **Robert A. Grimm** to Research Managers. Norton's responsibilities include management of process development and pilot plant operations for the ventures research and development groups. Mr. Grimm is responsible for organic chemistry research including homogeneous catalysis which is aimed at the discovery and exploration of new chemistry with potential commercial applications.

Also, **Thomas J. Weeks** has been named to Section Manager. He is responsible for heterogeneous catalysis research and surface chemistry technology.

Paul Petraitis, Vice-President of Premier Paint & Varnish Co., Inc., has been named President of Trendition House Associates. He was also accepted to membership in the Color Marketing Group. Mr. Petraitis is a member of the Chicago Society.

John L. Dawson has been named Manager of the South Sales Region for Kerr-McGee Chemical Corp. Mr. Dawson had been senior sales representative prior to his promotion.

Paul B. Higgins has been named President of Lehman Brothers, Corp. Prior to his promotion, Mr. Higgins was General Manager of the firm.

Elmer Stewart has been appointed Senior Vice-President, Advanced Technology for The Harshaw Chemical Co., Cleveland, OH. In this position, he will be responsible for the development and expansion of new technologies for growth markets related to the firm's manufacturing divisions.

Cellomer Corp. has appointed **David S. Davis**, Vice-President of Marketing. His responsibilities include all marketing activities connected with the company's coatings and resins. Mr. Davis is a member of the Baltimore Society.

Dr. Hector Cochrane has been appointed Technical Director of Cabot Corp.'s Cab-O-Sil division. His responsibilities include Division product and process development, technical service and applications research, supervision of pilot plant, quality assurance, and compliance functions for the Division.

Borden Chemical's Pigments Division has appointed **Ronald F. Payne** as Sales Representative for its line of pigments and related products in the Cincinnati, OH region.

W.B. "Bud" Bartelt has been named by Rust-Oleum Corp. to the post of Senior Vice-President. He will be responsible for the overall direction and coordination of the firm's finance, manufacturing, research and development, international, human resources, general services and management information divisions. Mr. Bartelt is Past-President and current Executive Committee member of the Chicago Society for Coatings Technology.

Brian S. Brandt, has been named to the post of Director of Advertising for Rust-Oleum. He will be responsible for overall coordination and management of consumer and industrial advertising, sales promotion and product publicity activity.

Henkel Corp. has elected **William H. Skelly** to the position of Vice-President, Resins Division. Mr. Skelly has been general manager for the Resins Division and is responsible for the firm's total resins activity.

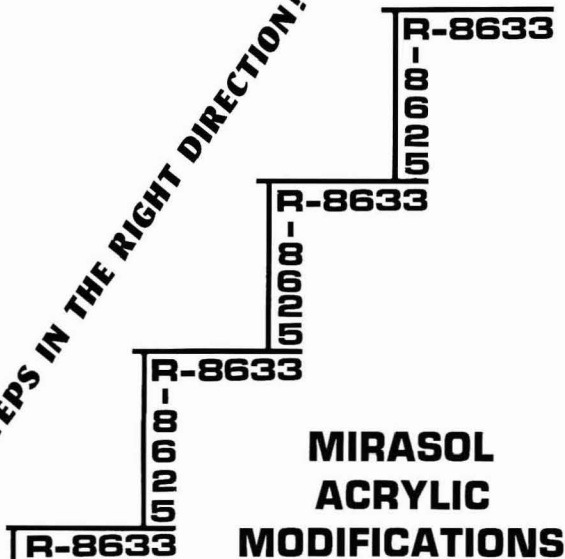
Walter K. Boyd, a senior research leader at Battelle's Houston Operations, has been elected Vice-President of the National Association of Corrosion Engineers. Election to this office carries the automatic term of President beginning in April 1982.

Dennis L. Dalton has been appointed to the position of Technical Service Manager at Buckman Laboratories, Inc. He will be responsible for supplying technical information and assistance in the areas of microbiology and chemistry concerning the paint industry.

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Letters to the Editor

Additional Comments on Plastic Pigment Article

TO THE EDITOR:

I am happy that Drs. Ramig and Floyd apparently recognize that my questioning the validity of referring to polystyrene beads as "pigment" [see August and September 'Letters to the Editor'] was not prompted by any objection on my part to the use of new technology. As a matter of fact, similar terminology has been employed by both Dow and N L Industries in the past to refer to products which differed only in particle size, although they used the more descriptive term of "plastic extender."

My reference to a possible binding power index of zero for the non-film-forming polystyrene beads was a perhaps unfortunate attempt to make a point by reduction of a variable to the point of absurdity. There can of course be no such value. The statement in Drs. Ramig and Floyd's letter to the effect that a binding power index of zero would imply a binder with no binding ability displays, however, a common misconception of the true meaning of this index, which may be traced back to its originator, Berardi.

The binding power index does not necessarily bear any relationship to the "binding ability" that we may assess in terms of adhesion and cohesion. The linseed oil to which Berardi attributed a binding power index of 100 percent is scarcely the perfect binder. It may, however, be used to determine the percentage of voids in a dry pigment packing.

When a latex binder is used, the original dry pigment packing is altered by the introduction of solids polymer particles, forming an entirely new particle-size distribution. The relative solid volumes of pigment and polymer required to produce a packing tight enough to eliminate dry hiding effects was shown by Schaller to be a function of both latex particle size and the ability of the particle to deform. It is now being shown to also be a function of pigment particle size, and particle-size distribution.

Below the CPVC for a given pigment latex paint system, it has been shown that film density departs from the theoretical density that might be calculated from its composition. Pierce has stated that this departure may be accounted for by an apparent increase in the volume occupied by the film's pigmentation. I have more recently found that the ratio of true pigment volume to Pierce's apparent pigment volume is numerically equivalent to the binding power index—which again suggests that it is really a packing factor.

My primary reason for rejecting the use of the term "pigment" in relation to these plastic beads is that their flammability and solubility in common paint solvents would interfere with their identification as such by several com-

monly used methods of test. Admittedly, however, this would not pose a problem where labeling laws do not exist.

FRED B. STIEG
Jekyll Island, GA

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Coming Events

FEDERATION MEETINGS

(Mar. 24-26)—"Symposium on Color and Appearance Instrumentation." Executive West, Louisville, KY. Jointly sponsored by Federation of Societies for Coatings Technology, Manufacturers Council on Color and Appearance, and Inter-Society Color Council. (FSCT, 1315 Walnut St., Suite 832, Philadelphia, Pa. 19107).

(May 14-15)—Spring Meetings. Society Officers on 14th; Board of Directors on 15th. Hilton Hotel, Denver, CO. (FSCT, 1315 Walnut St., Suite 832, Philadelphia, PA 19107).

(Oct. 28-30)—59th Annual Meeting and 46th Paint Industries' Show. Cobo Hall, Detroit, MI. (FSCT, 1315 Walnut St., Suite 832, Philadelphia, PA 19107).

1982

(Apr. 29-30)—Spring Meetings. Society Officers on 29th; Board of Directors on 30th. Boston, MA. (FSCT, 1315 Walnut St., Suite 832, Philadelphia, PA 19107).

(Nov. 3-5)—60th Annual Meeting and 47th Paint Industries' Show. Sheraton Washington Hotel, Washington, D.C. (FSCT, 1315 Walnut St., Suite 832, Philadelphia, PA 19107).

PAINT RESEARCH INSTITUTE MEETING

(May 4-5)—Paint Research Institute Symposium on "Stability and Stabilization of Coatings Systems," Battelle Memorial Institute, Columbus, Ohio. (Dr. Raymond R. Myers, Chemistry Dept., Kent State University, Kent, Ohio 44242).

SPECIAL SOCIETY MEETINGS

(Feb. 25-27)—Eighth Annual Water-Borne and Higher-Solids Coatings Symposium Hyatt Regency Hotel, New Orleans, LA. Sponsored by Southern Society and University of Southern Mississippi. (Dept. of Polymer Science, Univ. of Southern Mississippi, Southern Station, Box 10076, Hattiesburg, MS 39401).

(Mar. 4-6)—Western Coatings Societies Symposium and Show. Disneyland Hotel, Anaheim, CA. (Richard C. Sutherland, E.T. Horn, Co., 16141 Heron Ave., La Mirada, CA 90638.)

(Mar. 11-13)—Southern Society. 45th Annual Meeting. Birmingham Hilton Inn and Conference Center, Birmingham, AL (Peter F. Decker, Union Carbide Corp., 17 Executive Park Drive, N.E. Atlanta, GA 30359).

(Mar. 24-25)—Cleveland Society 24th Annual Conference, "Advances in Coatings Technology." Baldwin-Wallace College, Berea, OH. (George R. Pilcher, Sherwin-Williams Co., 601 Canal Rd., Cleveland, OH 44113.)

(May 1-2)—Pacific Northwest Society. Annual Symposium. Washington Plaza Hotel, Seattle, WA.

(May 9)—Montreal Society. Fiftieth Anniversary dinner-dance, Montreal Que.

(June 15)—Golden Gate Society Seminar, "Safety and Government Regulations." (Louie Sanguinetti, Jasco Chemical Corp., P.O. Drawer J, Mountain View, CA 94042).

1982

(Mar. 10-12)—Southern Society Annual Meeting. Savannah, Ga.

(Apr. 22-24)—Southwestern Paint Convention. Shamrock Hilton Hotel, Houston, TX.

(May 6-8)—Pacific Northwest Society. Annual Symposium. Vancouver, B.C.

1983

(Feb. 23-25)—16th Biennial Western Coatings Societies' Symposium and Show. Hyatt Regency, San Francisco, CA.

OTHER ORGANIZATIONS

(Feb. 3-May 12)—"Polymer Chemistry" Course. St. James Campus, George Brown College, Toronto, Ont. (Mr. P. Rodak, Mathematics and Science Div., George Brown College, P.O. Box 1015, Station B, Toronto, Ont. M5T 2T9).

(Feb. 4-May 13)—"Coatings Laboratory" Course. St. James Campus, George Brown College, Toronto, Ont. (Mr. P. Rodak, Mathematics and Science Div., George Brown College, P.O. Box 1015, Station B, Toronto, Ont. M5T 2T9).

(Feb. 5-6)—"New Concepts of Innovation in Coatings" Seminar. Hilton Hotel, Fort Lauderdale, FL. (Norma Fleming, Seminar Coordinator, Arts & Sciences Continuing Education, University of Missouri-Rolla, Rolla, MO 65401).

(Feb. 8-11)—Inter-Society Color Council. Williamsburg Conference, Williamsburg, VA. (Dr. Fred W. Billmeyer, Secretary, ISCC, Rensselaer Polytechnic Institute, Troy, NY 12181.)

(Feb. 10-12)—"Refresher for Painting Contractors, Maintenance Engineers and Inspectors" Short Course. Sheraton St. Pete Marina, St. Petersburg, FL. (Norma Fleming, Coordinator, Arts & Sciences Continuing Education, University of Missouri-Rolla, Rolla, MO 65401).

(Mar. 3-5)—"Refresher for Painting Contractors, Maintenance Engineers and Inspectors" Short Course. Sheraton-Anaheim Hotel, Anaheim, CA. (Norma Fleming, Coordinator, Arts & Sciences Continuing Education, University of Missouri-Rolla, Rolla, MO 65401).

(Mar. 23-27)—"Introductory Short Course on Composition of Coatings." University of Missouri-Rolla, Rolla, MO. (Norma Fleming, Coordinator, Arts & Sciences Continuing Education, University of Missouri-Rolla, Rolla, MO 65401).

(Mar. 23-27)—"Spray Finishing Technology" Workshop. Bowling Green State University & DeVilbiss Co., Toledo, OH. (Dr. R.A. Kruppa, School of Technology, Bowling Green State University, Bowling Green, OH 43403).

(Apr. 6-10)—"Introduction to Paint Formulation" Short Course. University of Missouri-Rolla, Rolla, MO. (Norma Fleming, Coordinator, Arts & Sciences Continuing Education, University of Missouri-Rolla, Rolla, MO 65401).

(Apr. 6-10)—National Association of Corrosion Engineers "Corrosion/81." Sheraton-Centre and Hotel Toronto, Toronto, Ontario, Canada. (Conference Coordinator, NACE, P.O. Box 218340, Houston, TX 77218).

(Apr. 7-8)—NACE T6 Symposium on Underfilm Corrosion. Sheraton Centre Hotel, Toronto, Canada. (National Association of Corrosion Engineers, 1440 South Creek, Houston, TX 77084.)

(Apr. 13-17)—"Advanced Paint Formulation" Short Course. University of Missouri-Rolla, Rolla, MO (Norma Fleming, Coordinator, Arts & Sciences Continuing Education, University of Missouri-Rolla, Rolla, MO 65401).

(Apr. 26-28)—Inter-Society Color Council Annual Meeting. Roosevelt Hotel, NY. (Dr. Fred W. Billmeyer, Secretary, ISCC, Rensselaer Polytechnic Institute, Troy, NY 12181.)

(Apr. 28-30)—OCCA-32. Oil and Colour Chemists' Association 32nd Annual Technical Exhibition. Cunard International Hotel, London, England. (The Director and Secretary, OCCA, Priory House, 967 Harrow Rd., Wembley, Middlesex HA0 2SF, England.)

(May 10-12)—"Refresher for Contractors, Maintenance Engineers and Inspectors" Short Course. Sheraton-Valley Forge Hotel, Philadelphia, PA (Norma Fleming, Coordinator, Arts & Sciences Continuing Education, University of Missouri-Rolla, Rolla, MO 65401).

(May 17-21)—American Oil Chemists' Society 72nd Annual Meeting. Fairmont Hotel, New Orleans, LA. (American Oil Chemists' Society, 508 S. Sixth St., Champaign, IL 61820).

(May 19-20)—"Practical Waste Management for the Coatings Industry" Short Course. Granada Royale, Kansas City, MO (Norma Fleming, Coordinator, Arts & Sciences Continuing Education, University of Missouri-Rolla, Rolla, MO 65401).

(May 31–June 5)—“Polymer Blends and IPN’s” Short Course. Lehigh University, Bethlehem, PA (Jone Svirzofsky, Lehigh University, Bethlehem, PA 18015).

(June 14–17)—Dry Color Manufacturers’ Association Annual Meeting. The Greenbriar, White Sulphur Springs, WV. (P.L. Lehr, DCMA, Suite 100, 1117 North 19th St., Arlington, (Rosslyn) VA 22209.)

(June 17–20)—Oil and Colour Chemists’ Association Conference, “Alternative Technologies in Coatings.” Beaufort Hotel, Bath, England. (The Director and Secretary, OCCA, Priory House, 967 Harrow Rd., Wembley, Middlesex HA02SF, England.)

(Aug. 10–14)—“Introductory Short Course on Composition of Coatings.” University of Missouri-Rolla, Rolla, MO (Norma Fleming, Coordinator, Arts & Sciences Continuing Education, University of Missouri-Rolla, Rolla, MO 65401).

(Aug. 31–Sept. 4)—“Introduction to Paint Formulation” Short Course. University of Missouri-Rolla, Rolla, MO (Norma Fleming, Coordinator, Arts & Sciences Continuing Education, University of Missouri-Rolla, Rolla, MO 65401).

(Sept. 7–11)—“Advanced Paint Formulation” Short Course. University of Missouri-Rolla, MO 65401.

(Sept. 13–16)—Canadian Paint Manufacturers Association. Four Seasons Hotel, Vancouver, B.C. (Lydia Palazzi, Canadian Paint Manufacturers Assn., 2050 Mansfield, Montreal, Que., Canada H3A 1Y9.)

(Sept. 20–25)—4th Congress of the Association Internationale de la Couleur, “COLOR 81.” International Congress Centre (ICC), Berlin (West), Germany. (Prof. Dr. Heinz Terstiege, (AIC COLOR 81), Bundesanstalt für Materialprüfung (BAM), Unter den Eichen 87, D-1000 Berlin 45, Federal Republic of Germany).

(Sept. 21–22)—“Techniques and Mechanics of Marketing Specialty Chemicals” Short Course. Hilton Plaza Inn, Kansas City, MO (Norma Fleming, Coordinator, Arts & Sciences Continuing Education, University of Missouri-Rolla, Rolla, MO 65401).

(Sept. 23–24)—“Managing for Innovation in Coatings” Short Course. Hilton Plaza Inn, Kansas City, MO (Norma Fleming, Coordinator, Arts & Sciences Continuing Education, University of Missouri-Rolla, Rolla, MO 65401).

(Sept. 28–29)—Golden Jubilee of Colour in the CIE. The Colour Group (Great Britain). Imperial College, London, England. (Ms. M.B. Halstead, Thorn Lighting Ltd., Great Cambridge Rd., Enfield, Middlesex EN1 1UL, England).

(Oct. 13–15)—Association for Finishing Processes of the Society of Manufacturing Engineers. “Finishing ’81” Conference and Exposition, “Economics, Compliance, and Energy.” Cobo Hall, Detroit, MI. (William J. Yeates, Executive Director AFP/SME, One SME Dr., P.O. Box 930, Dearborn, MI 48128).

(Oct. 13–16)—Formula 81. RAI Exhibition Centre, Amsterdam, Holland.

(Oct. 25–27)—“Women in Coatings—Meeting the Challenges” Short Course. Detroit, MI (Norma Fleming, Coordinator, Arts & Sciences Continuing Education, University of Missouri-Rolla, Rolla, MO 65401).

(Nov. 10–12)—“Refresher for Painting Contractors, Maintenance Engineers and Inspectors” Short Course. Hilton Plaza Inn, Kansas City, MO (Norma Fleming, Coordinator, Arts & Sciences Continuing Education, University of Missouri-Rolla, Rolla, MO 65401).

(Dec. 9)—American Society for Testing and Materials Symposium on Selection and Use of Wear Tests for Coatings. Phoenix, AZ. (ASTM, 1916 Race St., Philadelphia, PA 19103.)

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'Kumbug' from Hillman

On Four-Letter Words

Now that the so-called "moral majority" is assuming some responsibility for the election of a new President, could it be possible that we will return to the social norms of yesteryear? There was a time in the early part of this century when pristine and untarnished social relationships were supposed to have existed and the "gentlemen" retired to the drawing room after dinner with their cigars and bawdy jokes. Meanwhile the "ladies" settled, wherever ladies settled, with their embroidery and talk about the children. Never, but never, were naughty four-letter words exchanged in the presence of the fairer sex. In those halcyon, nostalgic days, prudery ran rampant and hypocrisy was not far behind.

If those standards should return to our social intercourse (*careful, Hillman—Ed.*) I am prepared to meet the matter head on—and without "epithets deleted." I intend to express myself as the occasion demands with some of the dirtiest four letter words I know; for example, in mild rebuke—"Go to OSHA"—or, more violently—"You're full of CARB." In mixed company, while chatting about government, I might be tempted to observe—"Well, they really RCRA'd it up this time." I foresee this, mind you, even in mixed company. The women will not return to their cloistered embroidery for I believe that "Women's Lib" will not die easily even though the new Administration promises to abort the pregnant idea of equal rights. I fully expect to use my new glossary with both sexes—without discrimination.

You can depend on bureaucracy to continue to offer a supply of these ugly words even if they have to stretch the glossary of vulgarisms to three or five letter words. Just recently, some EPA of a TSCA (pronounced *tosca*, mother!) came into my office to demand that I keep my waste out of the POTW. That's going too far!

• • •

I am much flattered that this column has produced some very interesting comments and correspondence. I've also had anonymous contributions from some folks, as well, who fear to be identified with this venture into the slightly less than scientific

world. At the recent Atlanta convention I had closet humorists furtively slip me a compilation of unsigned bon mots and then rush off without a backward glance.

One signed religious observation came from John Bax: "When God made man, She was only practicing." A few sent me the following contribution, but Fred Stieg gets credit for being first.

—Herb Hillman

How to win at 'Wordsmanship'

After years of hacking through etymological thickets at the U.S. Public Health Service, a 63-year-old official named Philip Broughton hit upon a sure-fire method for converting frustration into fulfillment (jargonwise). Euphemistically called the *Systematic Buzz Phrase Projector*, Broughton's system employs a lexicon of 30 carefully chosen "buzzwords":

Column 1	Column 2	Column 3
0. integrated	0. management	0. options
1. total	1. organizational	1. flexibility
2. systematized	2. monitored	2. capability
3. parallel	3. reciprocal	3. mobility
4. functional	4. digital	4. programming
5. responsive	5. logistical	5. concept
6. optional	6. transitional	6. time-phase
7. synchronized	7. incremental	7. projection
8. compatible	8. third-generation	8. hardware
9. balanced	9. policy	9. contingency

The procedure is simple. Think of any three-digit number, then select the corresponding buzzword from each column. For instance, number 257 produces "systematized logistical projection," a phrase that can be dropped into virtually any report with that ring of decisive, knowledgeable authority. "No one will have the remotest idea of what you're talking about," says Broughton, "But the important thing is that they're not about to admit it."

It seems to me that your column is a "5-0-5", and I'll be looking forward to seeing it as a regular feature in the Journal.

—FRED STIEG

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1256 N. McLean/Memphis, Tenn. 38108 U.S.A./901-278-0330/Telex 5-3868/Cable Bulab
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