jct JOURNAL OF COATINGS TECHNOLOGY

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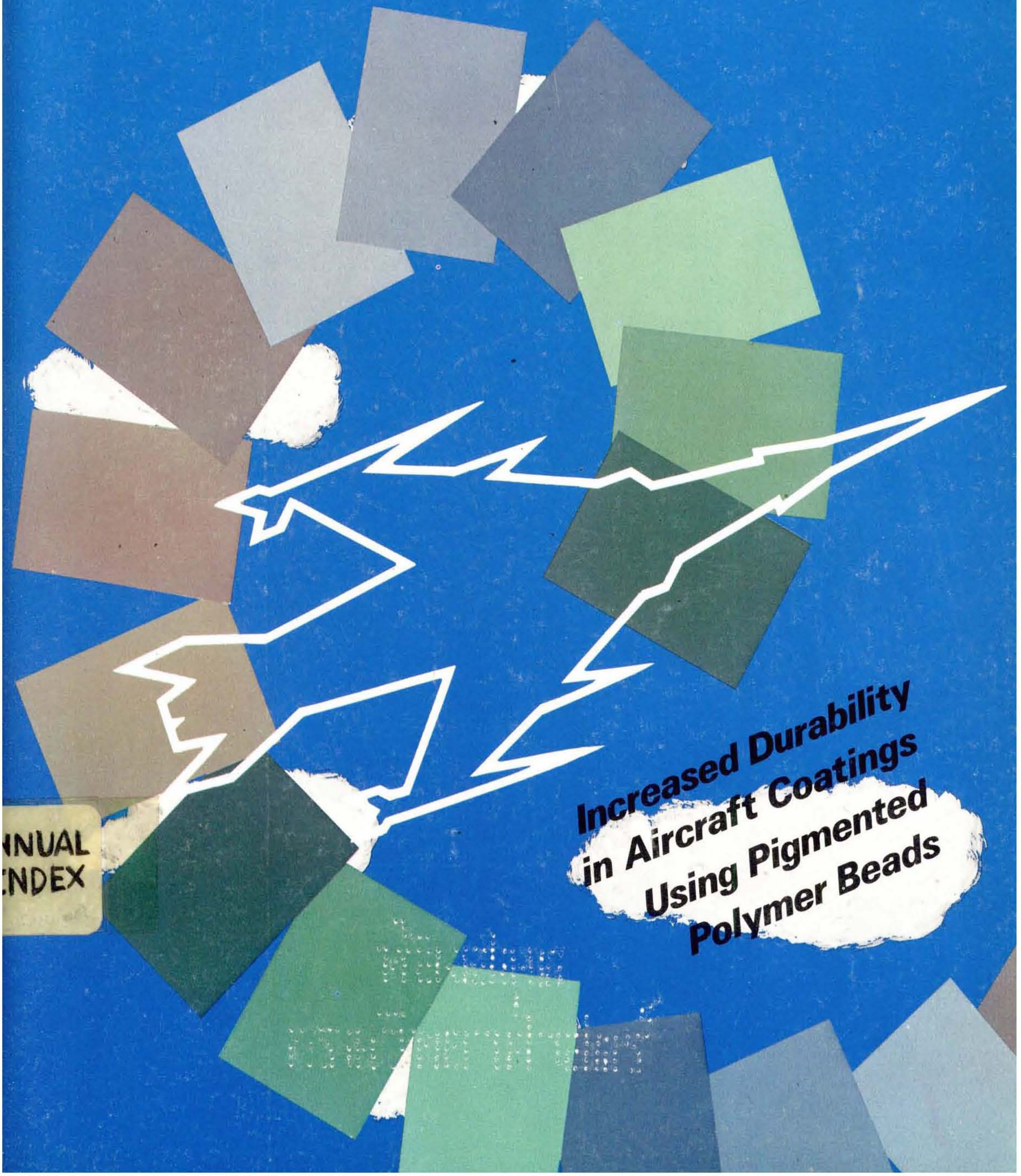
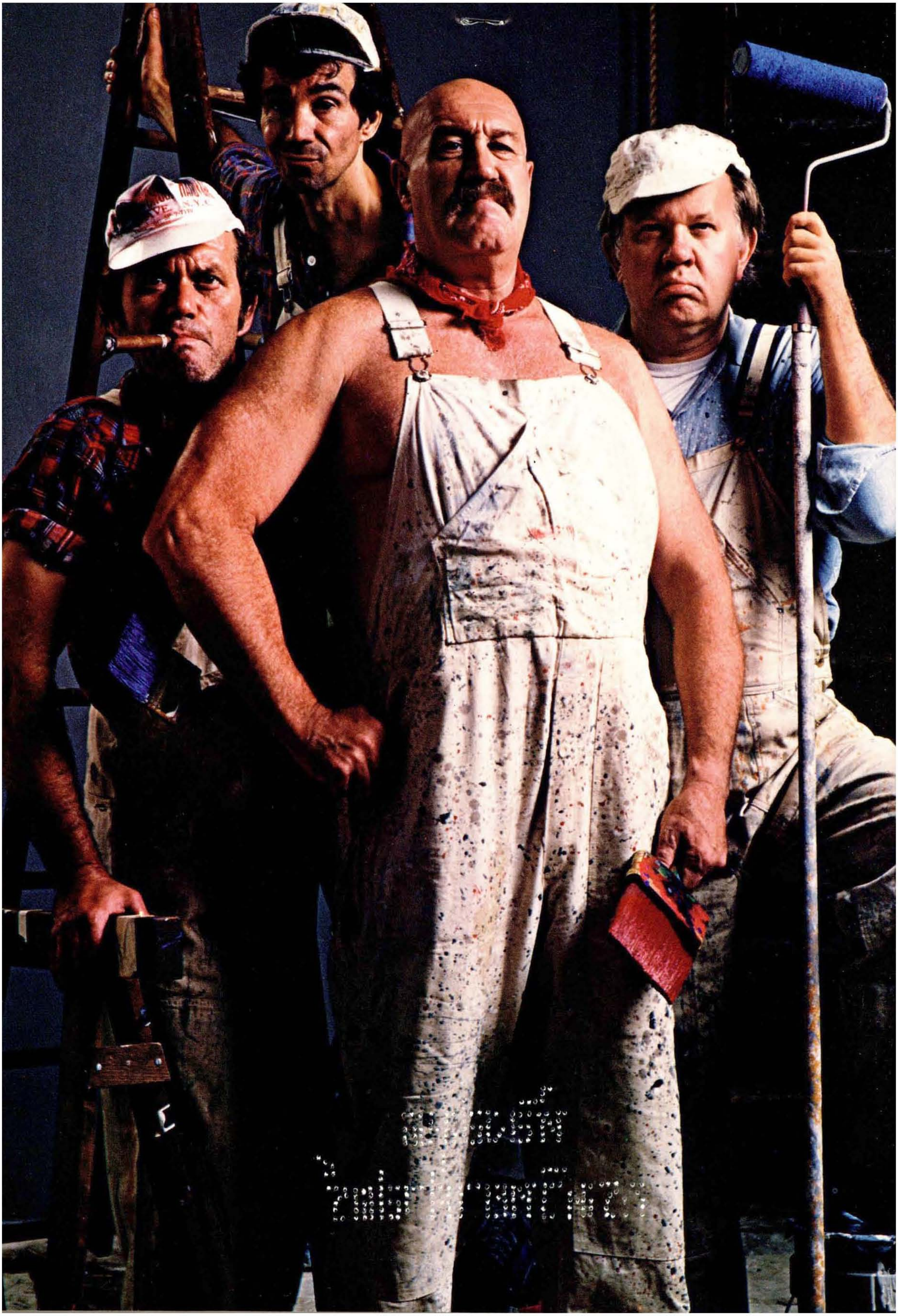
DECEMBER 1982



Increased Durability in Aircraft Coatings Using Pigmented Polymer Beads



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UCAR Acrylics give you the performance of conventional acrylics, but without that high price tag. So you don't have to cut down on your binder to cut raw materials costs.

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Coatings Materials

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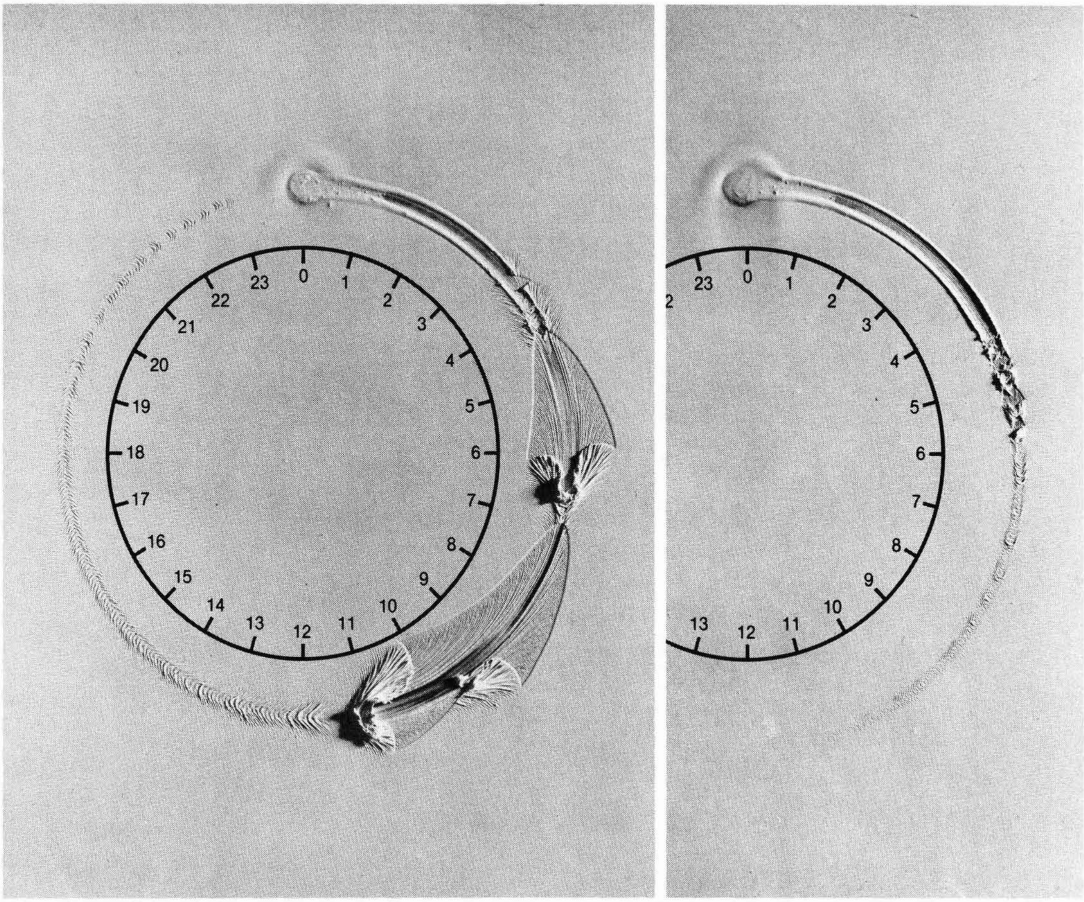

On the left, a high-solids alkyd coating without ACTIV-8 surface-dried in less than 5 hours and through-dried in 23 hours. On the right, the identical formulation with ACTIV-8 took less than 9 hours to through-dry.

How to keep your coatings from becoming a wet blanket.

The Gardener Circular Recorder Test shows ACTIV-8® can help your coatings dry quickly and completely to prevent the problems caused by premature surface drying. By accelerating the drying process and adding stability to your formulations, ACTIV-8 reduces the chances of sags and drips.

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INDUSTRIAL MINERALS AND CHEMICALS

DECEMBER 1982

jct JOURNAL OF COATINGS TECHNOLOGY

VOLUME 54 NUMBER 695

Technical Articles

Federation News

Departments

BPA Membership Applied For May 1982

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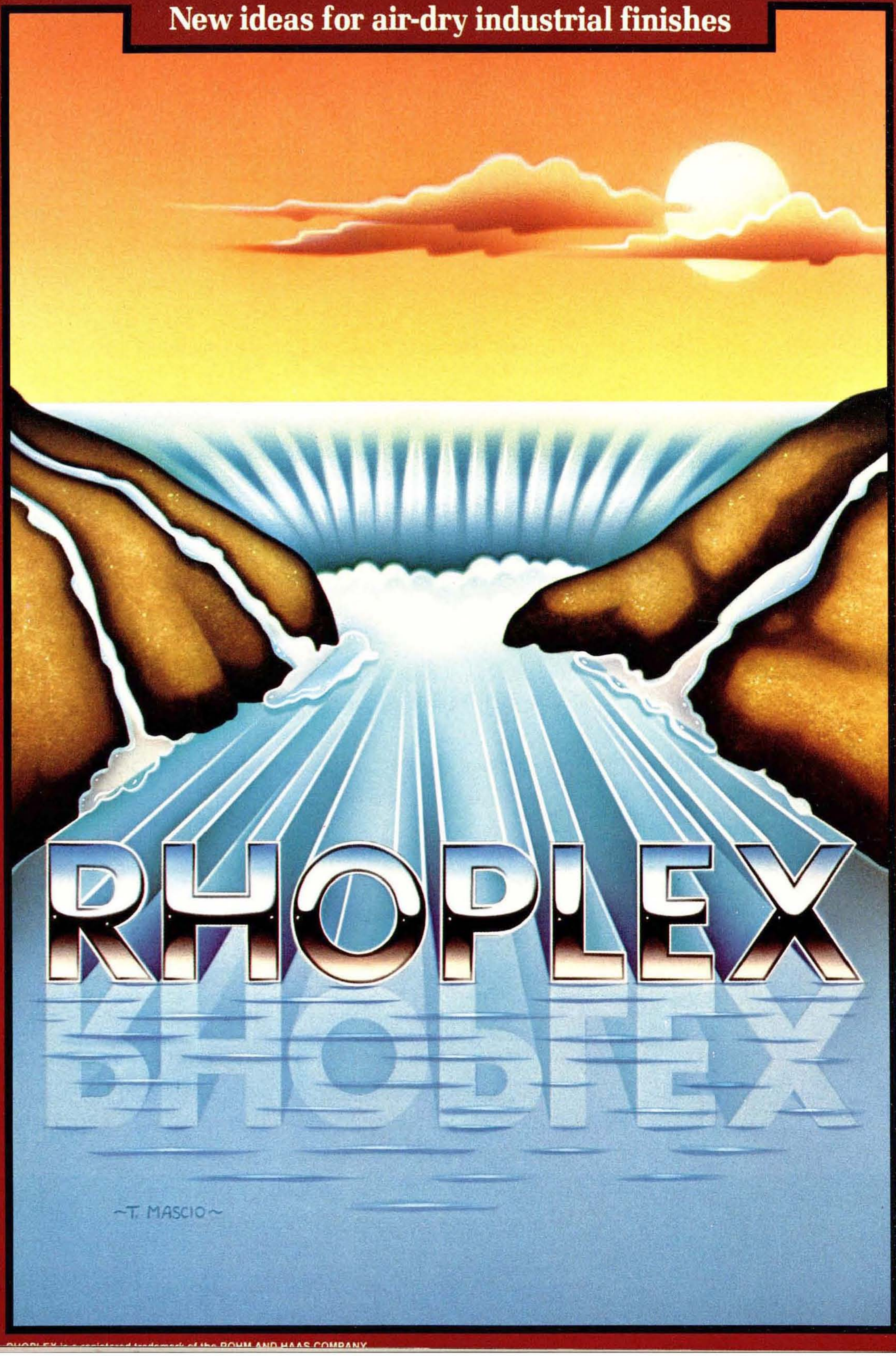

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Comment

Volunteers: The Key to Success

It is indeed an honor to be your fifth Canadian President during the Federation's 61st year, and especially during the year when the Annual Meeting and Paint Show will be held for the first time in Canada. (Montreal, October 12–14).

Committee chairmen are all in place and these people will soon be undertaking their duties to help guide us through another year. My thanks go to these Federation volunteers and to all at the local level also.

Volunteers are like yachts. No matter where they are, they arouse curiosity. Also, their real cost is probably more than anyone can afford.

Who are these volunteers? Where do they come from? Why are they here? They could stay moored where it is safe, and still justify their being. But no, they choose to cut through rough water, ride out the storms, and take chances.

Even though volunteers seem to be slowly disappearing from the North American scene, the Federation continues to be blessed with a dedicated cadre of members who, over the 60 years of our history, have taken the organization to a position of greatness today.

Nevertheless, problems remain and we have some serious challenges ahead in 1983. Among these are:

(1) A balanced Federation budget. But, in keeping with the annual directive, the Finance Committee will present one.
(2) Ways and means of uncovering increased outside contributions to the Paint Research Institute so that it can continue to carry on its research programs.
(3) Improving the Series on Coatings Technology. And, finding authors to write either new booklets or revisions to existing ones.
(4) Continuing with the effort to write a history of the paint industry.
(5) Continuing also with the program to promote career opportunities in the industry.

Are there any volunteers out there to help us meet these challenges?

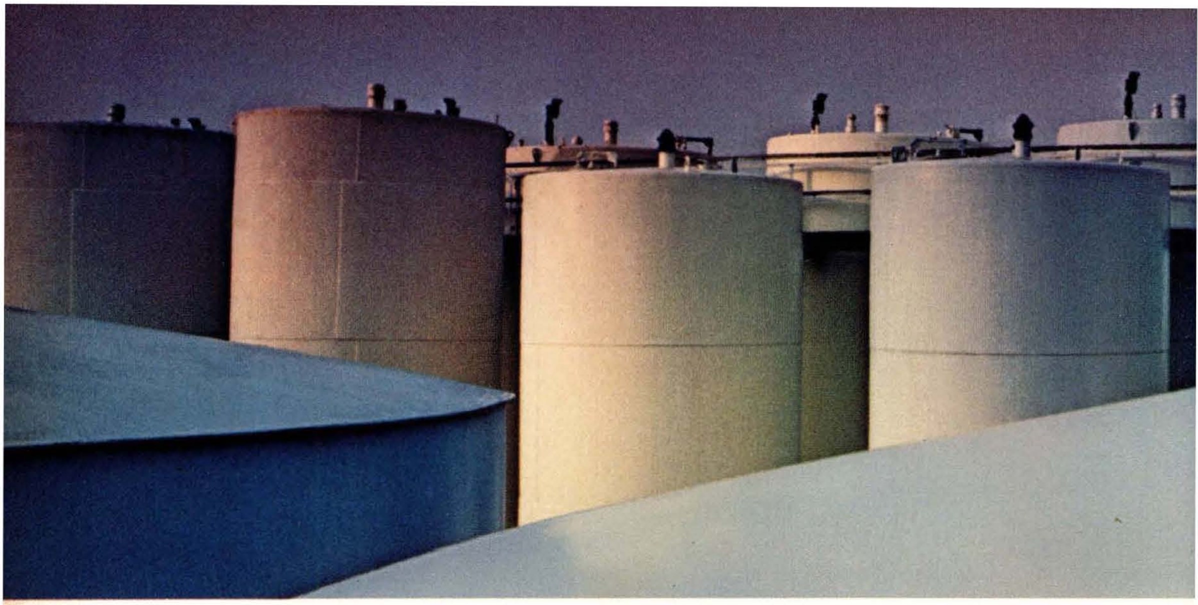
During the coming year, your elected officers along with the professional staff will visit many of the Societies. We look forward to these visits and the privilege of what we might call a "one on one meeting" where we can update the Societies on Federation matters and get a closer understanding of their activities and problems.

Your local Society is your first source of information and inspiration, and I urge you to participate by attending meetings and serving on committees as well.

I also ask that you support your Federation activities. Between the local and national organization, I am sure you will find real, profitable programs that can assist you in your daily careers.

AC Boyce

A. Clarke Boyce,
Federation President, 1982–83



CIBA-GEIGY epoxy resins vs. the toughest applications around

XU-252 based coating.

Aggressive chemicals and organic solvents are tough on storage tank linings. Formulating a coating that resists them is not an easy job if you don't have the right components. Now, three new products from CIBA-GEIGY can help you change that.

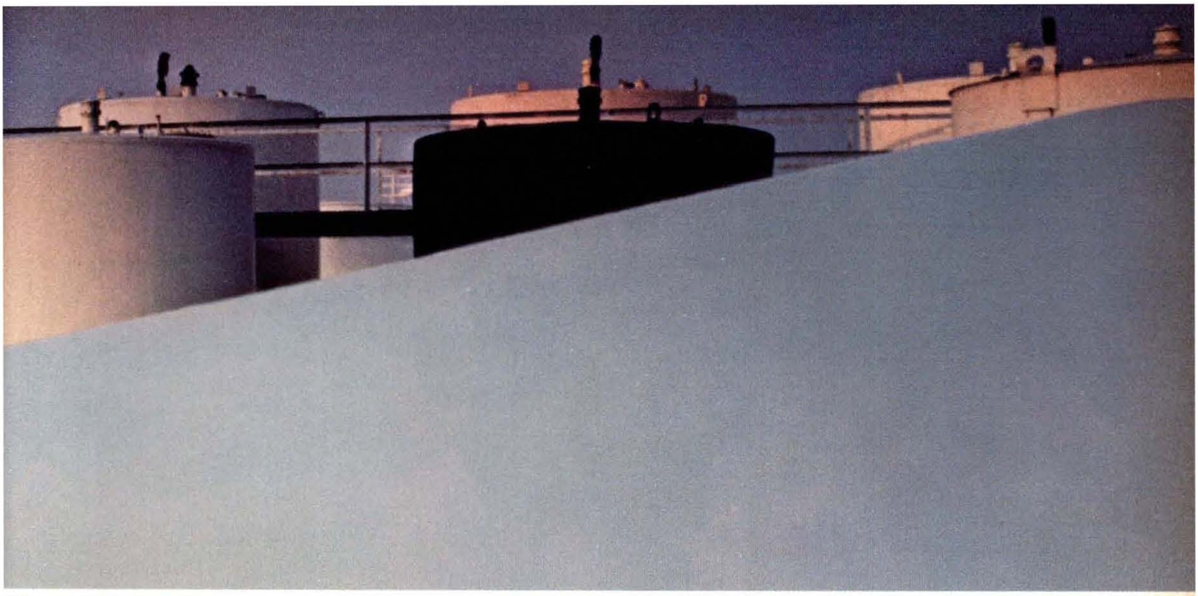
Coatings based on XU-252.

Our new high performance novolac epoxy resin can take on many aggressive chemicals—including chlorinated solvents, ethanol, methanol, aromatic amines, acids, caustic and ammonia—under a variety of service temperatures.

Chemical exposure cell proves outstanding performance.

One of the most realistic tests for chemical resistance, the chemical exposure cell, is designed to simulate service conditions as closely as possible. A coated panel is attached to the end of a cylinder so that the chemical being tested makes direct contact with only the coate surface.

As you can see in the panels, a XU-252 based coating showed n sign of failure even against a solvent like methylene chloride, while one formulated with a standard bisphenol-A based epoxy resin softened and blistered.



Bisphenol-A based coating.

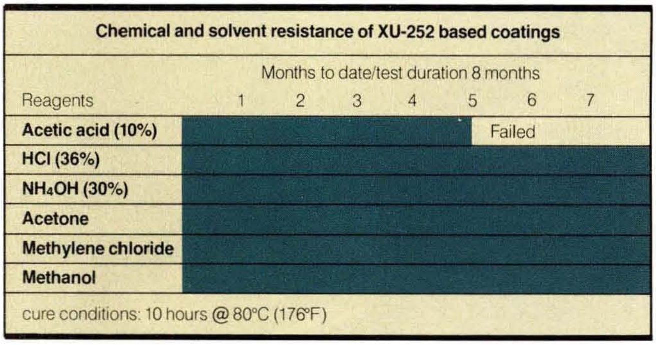
We also tested XU-252 based coatings for resistance against a range of other chemicals. The chart shows some of the toughest ones. In all cases these coatings exhibited excellent resistance to continuous exposure for a minimum of eight months.

Two new hardeners increase chemical resistance.

HY-943 and HY-2969 when formulated with XU-252 provide a variety of new properties.

HY-943 produces solvent-free and high solid coatings with excellent alcohol and chlorinated solvent resistance.

HY-2969 produces solvent-free systems resistant to acids and aromatic solvents even as tough as benzene.



Chemical and solvent resistance of XU-252 based coatings

	Months to date/test duration 8 months						
Reagents	1	2	3	4	5	6	7
Acetic acid (10%)	🟩	🟩	🟩	🟩	🟩	Failed	
HCl (36%)	🟩	🟩	🟩	🟩	🟩	🟩	🟩
NH₄OH (30%)	🟩	🟩	🟩	🟩	🟩	🟩	🟩
Acetone	🟩	🟩	🟩	🟩	🟩	🟩	🟩
Methylene chloride	🟩	🟩	🟩	🟩	🟩	🟩	🟩
Methanol	🟩	🟩	🟩	🟩	🟩	🟩	🟩

cure conditions: 10 hours @ 80°C (176°F)

Tell us about your toughest applications.

Storage tank linings are only one of the tough applications CIBA-GEIGY epoxy resins and hardeners can handle. They're also ideal for such applications as pickling lines, hot waste disposal and nuclear containment areas, pollution control equipment, and flooring in pulp and paper mills.

If you have a tough application that demands a durable, long lasting coating, tell us about it and we'll tell you how our epoxy resins and hardeners can help you formulate one. Write CIBA-GEIGY Corporation, Resins Department, 3 Skyline Drive, Hawthorne, New York 10532, or call 800-431-1900. In New York 914-347-4700.

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YOU DON'T BECOME THE MOST VERSATILE RESINS SUPPLIER BY JUST SELLING VANILLA.

If there were one coatings resin that could fulfill everyone's needs, we'd be more than happy to sell it.

Unfortunately, we've yet to discover it.

However, we do offer a unique range of coatings resins that can meet any need, demand, specification or requirement you may have.

Our phenolics, for instance, are known for their ability to resist acids, solvents and corrosion. So they can be used alone or to upgrade these properties in other resin systems.

Our vinyls have proven for over 40 years that they provide maximum performance in corrosive environments. And, unlike epoxies or urethanes, they are recoatable for easier maintenance.

Coatings based on our phenoxy resins are excellent oxygen barriers, with outstanding stain and corrosion resistance. Phenoxies also have very low levels of taste and odor, properties which are of particular importance in rigid and flexible packaging.

For heat and chemical resistant coatings, we offer several grades of ethyl silicate. And our waterborne resins can be used in a wide variety of maintenance and industrial applications.

To learn more about our unique range of resins, contact your local Union Carbide Sales Representative. Or write to Union Carbide, Dept. K3442, Danbury, CT 06817.

We think you'll find we have the know-how to lick any problems you might have.

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Coatings Materials

Abstracts of Papers in This Issue

INCREASED DURABILITY IN AIRCRAFT COATINGS BY THE USE OF PIGMENTED POLYMER BEADS—G.P. Bierwagen

Journal of Coatings Technology, 54, No. 695, 19 (Dec. 1982)

There are considerable savings which can be achieved if aircraft coatings of increased operational lifetimes can be developed. Matte camouflage coatings present severe performance maintenance problems. The use of pigmented polymer beads, made by suspension polymerization, as matting agents give better durability due to lower porosity films. Further increased durability due to metal oxide pigment encapsulation in the beads and subsequent reduction of photodegradation of the binder also occurs. Economic consequences of this increased durability are described.

INFLUENCE OF LIGHT STABILIZERS ON MAINTAINING SURFACE INTEGRITY AND PREVENTING BIOLOGICAL DEFACEMENT OF POLYMERS—P.D. Gabriele, et al.

Journal of Coatings Technology, 54, No. 695, 27 (Dec. 1982)

When a polymer is exposed outdoors in a fairly humid environment, the surface is subject to degradation with subsequent accumulation of mildew. The degraded surface (i.e., fissures, cracks, erosion) creates a microbial growth environment by virtue of allowing organic contaminants to accumulate. The carbon scavenging mildew organism *(A. pullulans)* then establishes growth. We have now established that by the addition of certain light stabilizers, polymer surfaces remain intact for many years when exposed outdoors. This surface integrity dramatically reduces the potential for dirt pick-up and the organism's ability to establish a habitat.

ELECTROULTRAFILTRATION OF CATIONIC ELECTRODEPOSITION PAINT—J.M. Radovich and I-M. Chao

Journal of Coatings Technology, 54, No. 695, 33 (Dec. 1982)

Additional studies of the effects of the electric field on the membrane flux when ultrafiltering a cationic electrodeposition paint, ED-3002 (PPG Industries, Inc.) have been completed. The magnitude of the gel layer, boundary layer, and membrane resistance and the electroosmosis contribution to the flux through the membrane were determined for three commercial ultrafiltration membranes as a function of paint concentration, transmembrane pressure drop, and electric field strength. The results confirmed the assumptions made in previous work that each resistance (with the exception of electroosmosis) predominates at different values of the applied electric field strength.

EFFECT OF WATER IMMERSION ON THE ACOUSTIC EMISSION AND FAILURE OF AUTOMOTIVE FINISHES—J.A. Rooum and R.D. Rawlings

Journal of Coatings Technology, 54, No. 695, 43 (Dec. 1982)

Acoustic emission monitoring of tensile tests, complemented by other techniques, has been used to study the failure of automotive finishes containing either an anodic or cathodic electrocoat, both dry and after soaking in water for 96 hours. Systems with a cathodic electrocoat were found to be more susceptible to water; they absorbed more water and retained the water for longer times than the anodic systems. Cathodic systems failed at considerably lower strains during a tensile test after immersion than when dry.

ELLIPSOMETRIC STUDIES ON THE CATHODIC DELAMINATION OF ORGANIC COATINGS ON IRON AND STEEL—J.J. Ritter

Journal of Coatings Technology, 54, No. 695, 51 (Dec. 1982)

A number of mechanisms have been proposed to explain the cathodic delamination of organic coatings from iron or steel undergoing corrosion. Ellipsometric studies carried out on these substrates protected by either collodion, acrylic lacquers, or polybutadiene indicate that dissolution of the interfacial oxide in the highly cathodic environment constitutes the predominant mode of delamination. Moreover, the spatial development of cathodic areas has been probed both ellipsometrically and through subcoating electrochemical pH measurements.

The oxide dissolution proposition is supported by independent experiments with uncoated iron in a highly alkaline medium.


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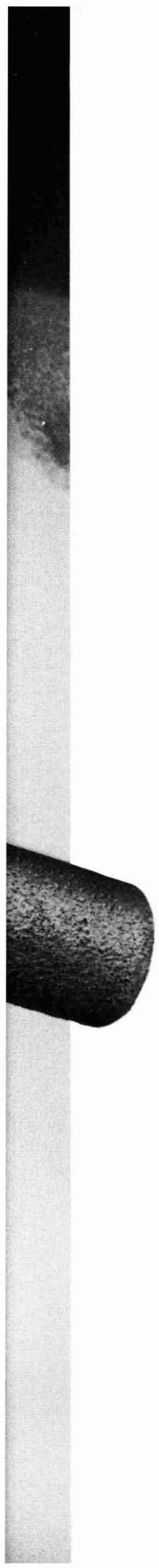

Committee Activities

LIAISON

Progress Report on IUPAC's Supported Polymer Films Group

The International Union of Pure and Applied Chemistry (IUPAC) is the only international organization that is involved with *all* branches of chemistry. Its purpose is the advancement of chemistry and the world-wide dissemination of such knowledge. Created after World War I, the IUPAC, in the United States, is an arm of the National Academy of Sciences—National Research Council. A total of about fifty national organizations are represented in IUPAC.

We in the organic coatings industry are fortunate to be represented by a Supported Polymer Films Group (SPF) which is part of the large Macromolecular Division of IUPAC. The official representatives to this group are Percy Pierce, of the Pittsburgh Society; Milton A. Glaser, of the Chicago Society; and Raymond R. Myers (for the American Chemical Society), of the Cleveland Society.

The Macromolecular Division will meet at its Symposium at the University of Massachusetts, in Amherst on July 12–16.

The following is a progress report of the Group by its Secretary, Dr. J. Sickfeld, of Germany. Included are the minutes of the Group's meeting in Liege, Belgium, held on May 13, 1982. It is felt that information on these activities will be of interest to all JCT readers.

MILTON A. GLASER,
Federation Liaison Committee

NEW PROJECTS

The only item on the agenda was the discussion of new projects. According to the resolutions of the last meeting at Sassenheim, Dr. Kooistra outlined his ideas with respect to his project proposal already presented at Sassenheim, "Characterization of cure of coatings in relation to performance properties." In the subsequent discussion, Dr. Funke at first pointed to the importance not only of the chemical structure but also of the morphology for the performance properties. We also underlined the necessity of well defining the curing conditions (time, heating rate, etc.), because the curing procedure itself influences the final properties of the cured coatings. With respect to the resin types to be selected for the project (Polyester/HMMM), Dr. Biethan mentioned an earlier publication by J. Dörffel and W. Auf der Heyde on "Alterungserscheinungen in wöfrigen Polyester-Melaminharz-Einbrennlacken" in "Farbe und Lack" *86,* 109-116 (1980). It was resolved to make Kooistra's proposal a new project with the participation of Biethan (possibly), Christensen (Dulog possibly at a later stage), Hansen, Kooistra, himself, and Sickfeld. At the Sassenheim meeting Vorster had also expressed his interest in the project. Dr. Toussaint asked for a copy of the new project proposal to be translated into French and published in "Double Liaison."

An announcement of the new project should also be published in "Farbe und Lack" and other journals in order to attract the interest of further participants. Dr. Kooistra will work out a more detailed proposal within the next two months and distribute it to the participants. He was asked to take the leadership of the new project and agreed to do so.

Dr. Oesterle commented upon another project proposal entitled "Paint structure-formation and epistructure-transmission-effect (ETE)" referring to his earlier statements made during the Sassenheim meeting. Although the subsequent discussion revealed that there was no immediate possibility of combining Oesterle's project with that of Kooistra's, the latter one being confined to the initial stages of cure and the first one to the finally cured film, Hansen nevertheless proposed as a compromise to generate Oesterle's project into that of Kooistra with respect to the resin types and samples to be investigated. These should be the same for both projects, and Oesterle and other people who are willing to do so and have the experimental possibilities should measure them according to Oesterle's project. This proposal was accepted as an acceptable procedure.

As another possible project, Schmid proposed the "Formation of cracks and checking in the late age of pigmented coatings during weathering" to be tested by hardness measurements using the Epprecht instrument. The idea behind this proposal was the evaluation of the elasticity modulus as a function of weathering time, the probable increase of the modulus in combination with differences in E-modulus of the surface area and areas below the surface possibly being the reason for the ultimate crack formation. Earlier measurements carried out according to the Epprecht technique have shown that the E-modulus of alkyd resins pigmented in different ways and weathered as long as eight years was very high and did not differ between surfaces exposed to UV-light (direct weathering) and surfaces not exposed to UV. In the subsequent discussion Oesterle pointed out disturbing factors influencing the reliability of hardness measurements with respect to the determination of the elasticity modulus but supported its value for comparison purposes. Some other participants mentioned that such a study should not be confined to hardness measurements; hints were made as for the use of the fatigue testing machine as presented by Simpson in the plenary lecture of the United Kingdom during the FATIPEC Congress, and to other analytical methods. It was agreed that further preliminary tests will be carried out in Switzerland and that the further treatment of the proposal shall be postponed until more detailed results and ideas exist.

The meeting was concluded with some remarks by Gerster on his ideas about measuring differences in surface quality as a consequence of weathering by means of measuring the dielectric constant in the upmost surface area after short exposures.

MISCELLANEOUS

The next meeting of the working party will take place at Zurich in the second half of April 1983. Dr. Schmid will fix the meeting place in due time and contact Dr. Sickfeld also with respect to the exact date (probably Thursday and Friday).

Dr. Dulog closed the meeting with thanks to all participants for their contributions to the discussion.

J. SICKFELD, *Secretary*

Increased Durability in Aircraft Coatings By the Use of Pigmented Polymer Beads

Gordon P. Bierwagen
The Sherwin-Williams Company*

There are considerable savings which can be achieved if aircraft coatings of increased operational lifetimes can be developed. Matte camouflage coatings present severe performance maintenance problems. The use of pigmented polymer beads, made by suspension polymerization, as matting agents give better durability due to lower porosity films. Further increased durability due to metal oxide pigment encapsulation in the beads and subsequent reduction of photodegradation of the binder also occurs. Economic consequences of this increased durability are described.

INTRODUCTION

Tactical aircraft require coatings which must survive extreme conditions and yet meet very closely specified camouflage color and physical property specifications. When the coating no longer meets these performance specifications, it must be removed by expensive and labor-intensive paint stripping operations, and then primed and recoated by hand. Any increase in coating lifetime thus has great positive economic impact because of both a reduction in labor cost (less recoating) and a reduction in true coating annual cost (initial cost/effective lifetime). The matte camouflage coatings used today present a most extreme case for maintenance of coating operational lifetime. The coating must have low gloss, and yet have color tailorability and stability. This low gloss requirement has traditionally implied a high volume loading of matting pigment, which has also implied a lack of durability in the coating.[1] Many of the coating deficiencies caused by the use of normal matting pigments can be overcome by utilizing pigmented polymer beads. These are beads produced by the suspension polymerization of pigment (or pigment and water for vesiculated beads) dispersed in a monomer/oligomer syrup which is then dispersed into water containing a protective colloid. This gives monomer/oligomer beads in the size range 5–40μm which are polymerized to form pigmented polymer beads.[2-8] To extend the bead technology developed by Dulux Australia, Ltd., and further developed within the author's laboratories, work was performed for the U.S. Air Force Materials Laboratory to demonstrate the feasibility of pigmented polymer bead coatings for aircraft use.[8-9] Part of this work is described below.

BEAD SYNTHESIS PROCEDURES

It has long been known that polymer beads can be made in a fairly broad size range by the suspension polymerization method.[10] In addition, pure polymer beads made of polypropylene (Hercoflat®) and polyethylene (Microthene®) have been known to be effective matting agents in coatings where low oil absorption is required. Including the pigment within the polymer matrix of the bead greatly enhances the usefulness of polymer beads in coatings, especially those with low gloss requirements. The bead then performs three functions: it acts as a matting agent, it gives coloration or hiding to the coating, and it eliminates "windows" in the coating which would occur with normal extenders which detract from opacity.

To incorporate the pigment into the monomer/oligomer solution of the bead, and subsequently form the pigmented polymer bead in a suspension polymerization process, is a straight forward process. The process for the preparation of the solid beads is shown in *Figure* 1. The process for vesiculated pigmented beads is shown in *Figure* 2. Both unsaturated polyester in styrene and acrylic oligomer dissolved in acrylic polymer can be used as the polymer matrix of the bead. *Figures* 3 and 4 show SEM photographs of washed bead samples. It was

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This paper was presented in slightly different form at the XVth FATIPEC Congress, Amsterdam, June 8–13, 1980, and was published in the FATIPEC *Proceedings*, Vol. III, pp 110–125.

*10909 S. Cottage Grove Ave., Chicago, Il. 60628.

Hercoflat is a registered tradename of Hercules, Inc.
Microthene is a registered tradename of USI Chemicals.

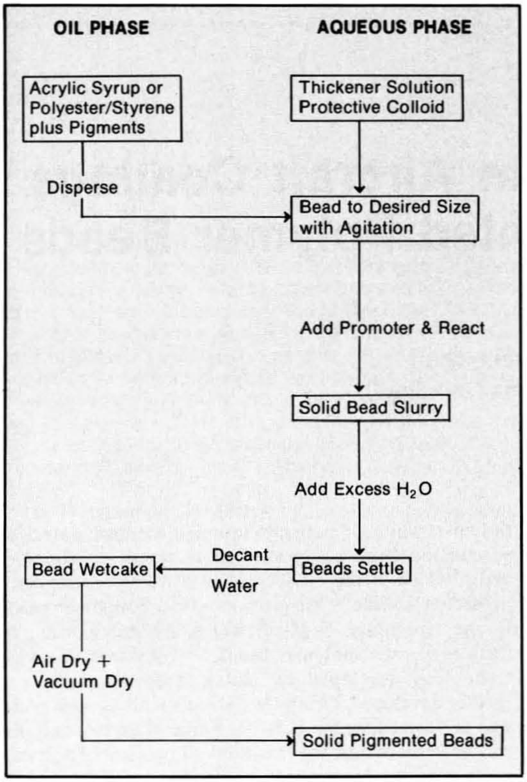

Figure 1—Preparation of pigmented solid beads

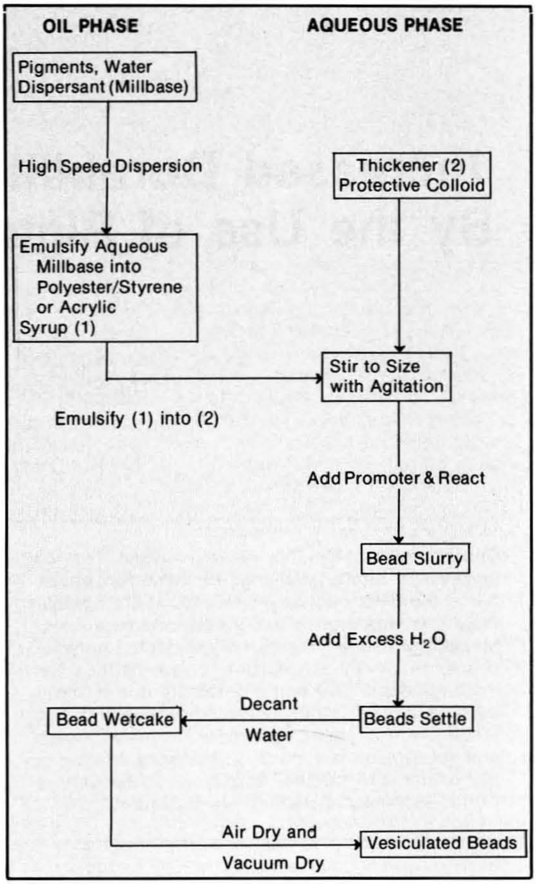

Figure 2—Preparation of pigmented vesiculated beads

concluded that the pigment is encapsulated within a crosslinked polymer matrix, since no pigment can be identified outside of the bead. These pigmented beads, that have been washed and dried, can be used as pigmentary materials, as colorants, and as matting agents.

After synthesis, the beads are characterized by measuring their particle size distribution and density. These two sets of physical parameters enable one to use them on a volumetric basis in formulation based on the ratio of the pigment volume concentration (PVC) to the critical PVC (CPVC),[11] since knowing the particle size data enables the calculation of the coating critical bead and/or pigment volume concentration (CBVC or CPVC).[12] A typical particle size distribution for a pigmented bead sample as measured on a Particle Data Celloscope® is presented in *Figure* 5 which shows that the bead sample is in a size range which makes it a very efficient matting agent (5–50μm). At low bead volume concentration (BVC), a pigmented bead coating will have a low 85° gloss.[8,9] For camouflage coating purposes, a low 85° gloss is essential and thus, a pigmented bead based polyurethane aircraft coating at low gloss and low BVC is possible.

A wide range of colors can be achieved by various bead pigmentation. U.S.A. Federal Standard 595 colors; 34079 (dark green), 30219 (tan), 34102 (light green), and several shades of gray have been successfully prepared with pigmented polymer beads. Reflectance *vs* wavelength for these coatings is presented in *Figure* 6. The bead based coatings studied here all had low (<2%) gloss readings at 85°. Using an elastomeric polyurethane resin† as the matrix, these coatings passed the specifications of U.S.A.F. MIL-C-83286. These coatings, thus, pass some fairly severe physical tests.

STANDARD MATTE AIRCRAFT COATING PERFORMANCE

Several studies of matte aircraft coating performance have shown that there are difficulties in formulating and maintaining the color and mechanical performance required by this class of coatings.[13] A major deficiency

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Celloscope is a registered tradename of Particle Data, Inc.

The Electrozone® Celloscope is a device which characterizes particle size by what is termed "resistazone stream" counting [B. H. Kaye, *Direct Characterization of Fine Particles*, p. 271–297, and references therein, Wiley, NY (1981)]. Kaye describes this class of devices (which includes the Celloscope®, Coulter® counters and other similar instruments) in some detail and has equipment manufacturers and pertinent publications referenced quite thoroughly. [See also Z. Jelinek, *Particle Size Analysis*, pp. 147–150, Ellis Harwood Ltd., Chichester, Great Britain (1970).]

†DeSoto Inc.: Super Desothane Clear Polyol 820X307; Isocyanate 910X331A.

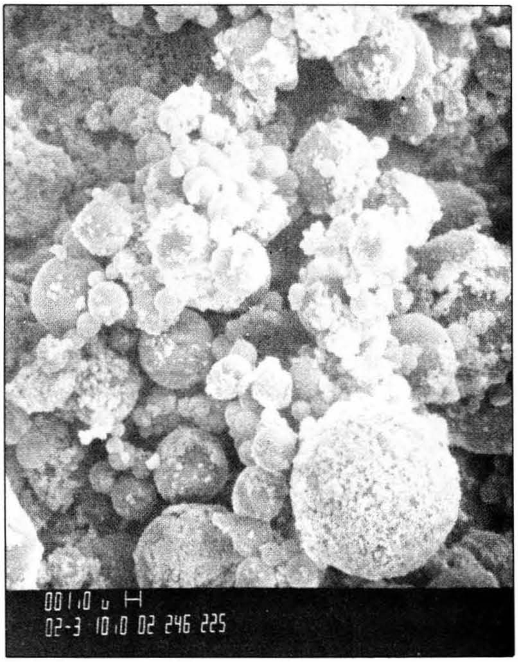

Figure 3—Styrene/polyester solid beads: 2000X

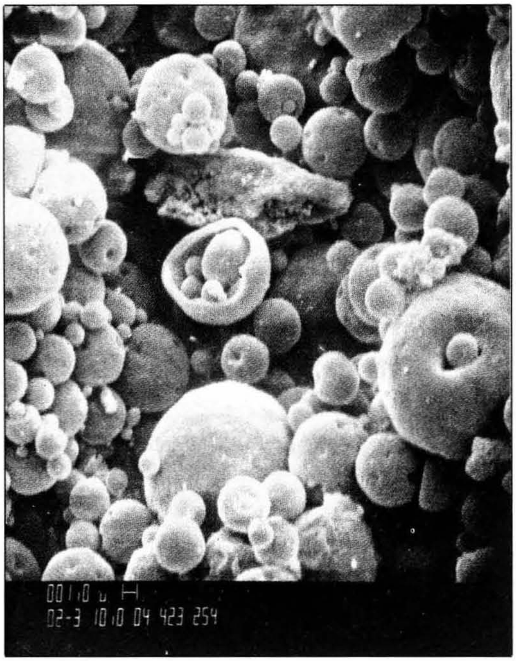

Figure 4—Styrene/polyester vesiculated beads: 2000X

is the color change on accelerated or normal weathering caused by oxidative degradation of the coating. In camouflage coatings, this is especially troublesome as color stability is very crucial to their usefulness. The "chalking," or color change caused by coating degradation, is often caused by UV induced oxidation of the coating polymer.[14] In this situation, the color change is due to air voids forming in the film about the pigment particles catalyzing the polymer oxidation.[15] The major criteria for durability of a flat camouflage coating is color maintenance across the entire wavelength spectrum of importance. The spectral region of interest in this paper is the visible spectrum, or 380–740 nm as used in the figures shown. This reflectance curve defines the color of the coating.[16] Any 85° gloss change in flat coatings was insignificant because of the small gloss total. These coatings all had 85° gloss below a reading of three before exposure and only decreased on exposure. Obviously, chalking in this type of coating would not cause a gloss problem, only a color change problem and loss of protection. Chalking, as usually understood, was not a problem in these coatings. The polymer system used in these studies was a two component urethane (see preceding footnote) passing MIL-C-83286. This type of system is also described in literature from Mobay Chemical Co. (Desmodur®/Desmophen® RR 2481, RR 2400/2, RR 2445/1, RR 2333/2). In these systems, no specific UV stabilizers, etc. were used in the coating formulations. There are, of course, other changes in these coatings with weathering besides the reflectance. Mechanical properties change (usually embrittlement), but the coating polymer system passes MIL-C-83286 before and after 500 hours Weather-Ometer® (WOM).

Matte coatings are especially vulnerable to the "chalking" failure because these coatings are formulated at a PVC/CPVC ratio close to unity and thus, there is little coating polymer that is not adsorbed on the pigment surface or filling interstices in the pigment packing structure.[12,13] If any of the polymer in a matte coating is photo-oxidized, the coating will have local areas where the PVC/CPVC exceeds one, causing the localized air voids. The same effect can occur in a gloss coating, but, of course, will take longer to occur.

In *Figure* 7, the reflectance in the visible wavelength is given for a standard matte gray aircraft coating before and after several periods of exposure in a Weather-

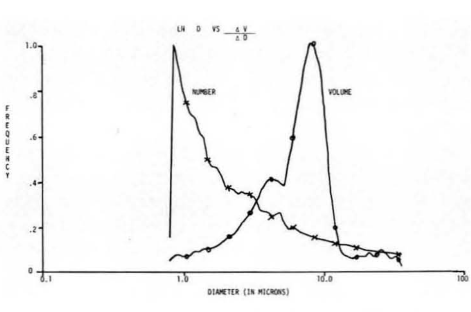

Figure 5—Particle size distribution for typical bead sample

Weather-Ometer is a registered tradename of Atlas Electric Devices Co.

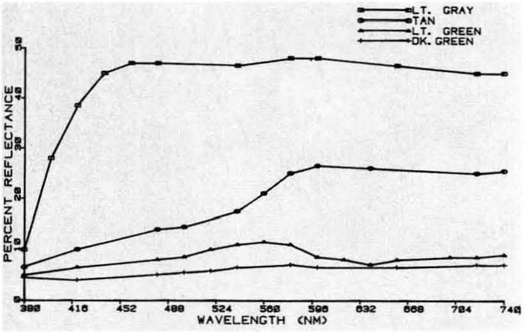

Figure 6—Reflectance vs wavelength for unexposed bead coatings of various camouflage colors

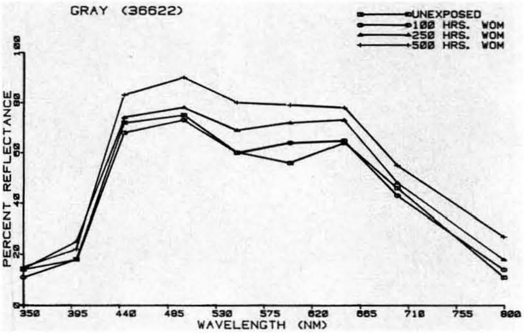

Figure 7—Reflectance vs wavelength for standard camouflage coating (gray)

Ometer (WOM).[17] *Figure* 8 shows the same for a dark green polyurethane camouflage coating. A considerable increase in reflectance has occurred in exposure in the WOM in all of these coatings, indicating that considerable coating degradation (chalking) has occurred. Since the resin system in these coatings by itself is known to have good weatherability properties, the pigmentation appears to be causing or catalyzing most of this degradation.

WOM data may not be considered totally predictive of actual exterior exposure. However, with military aircraft, actual measured exposure is very hard to document because of storage in and out of hangars, washing between missions, exposure at various bases, etc. 500 hours WOM has been defined by the U.S. Air Force as sufficiently predictive of durability to use in setting its coating specification. Our experiments of side by side or at least equal comparative exposure in WOM are some of the best numerical data available on exposure of this class of coating. Further work is in progress within this laboratory under contracts F33615-79-C-5031 and F33615-81-C-5091 on developing further methods for measuring and documenting true durability in this class of coatings.

PERFORMANCE OF BEAD BASED COATINGS

By blending a small amount of pigment in the polyurethane coating matrix and using mainly pigmented polymer beads, a wide range of matte camouflage colors could be formulated.[9,18] These coatings passed the specifications of U.S. Air Force specification, MIL-C-83286 (qualified suppliers are DeSoto and Deft). Both solid and vesiculated polyester/styrene (PE/S) pigmented polymer beads were used. In this present work, the vesiculated, pigmented polymer beads gave better coating durability as assessed by color stability. This is illustrated in data for gray coatings as shown in *Figures* 9 and 10. The bead level for the specific color of *Figure* 9 was 57.7% bead volume concentration (BVC), for *Figure* 10 it was 50.0% BVC. The only other pigmentation in these coatings besides the beads and their internal pigmentation was trace amounts of carbon black used for exact color matching. *Figure* 9 shows a coating based on solid PE/S beads, and *Figure* 10 shows a coating based on vesiculated PE/S beads. Even though the gray colors are different, one can see that the vesiculated bead coating performs better than the solid beads, and both systems show considerably more color stability than the regularly pigmented coatings shown above. This increase in durability in bead coatings shown in these gray coatings carries over through a wide range of camouflage colors. Similar data has been obtained for other colors also indicating the efficacy of pigment encapsulation for increased color durability.

Comparisons between the data of *Figures* 9 and 10 (bead coatings) and *Figures* 7 and 8 are possible on the basis of percent change in reflectance at zero and 500 hours of exposure. For the light gray bead coating of *Figure* 9, the maximum percent reflectance (color) change was ≈12%, while a similar light gray standard coating (*Figure* 7) had changes of up to 25%. For the standard dark green of *Figure* 8 the percent reflectance (color) changes vs wavelength were 15 to 20% while for the beaded dark gray coatings (*Figure* 10) the percent reflectance changes were less than 3%. The comparisons are not exact and direct because this contract research was not focused on direct comparison but on general feasibility of bead based camouflage coatings and general trends in durability of color. Color durability was defined as a prime criteria for MIL-C-83286 class coating effective lifetime because this coating class had very high performance levels in most other areas. Further specific documentation, as discussed above, is in preparation and will be published at a later date. The purpose of the article is to indicate the feasibility of use of and general trends observed in, beaded coatings versus standard coatings in color durability specifically, and over-all performance in general.

ANALYSIS AND INTERPRETATION OF RESULTS

It is apparent that the use of beads greatly enhances coating durability as assessed by color change on 500 hours of WOM exposure. Good field data on tactical airplanes is quite hard to come by, but 500 hours WOM exposure tracks field color change quite well. We believe this is due to the encapsulation of the pigments within the crosslinked matrix of the bead polymer. Many of the

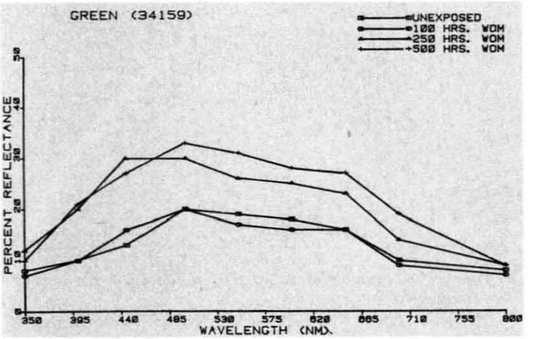

Figure 8—Reflectance vs wavelength for standard camouflage coating (green)

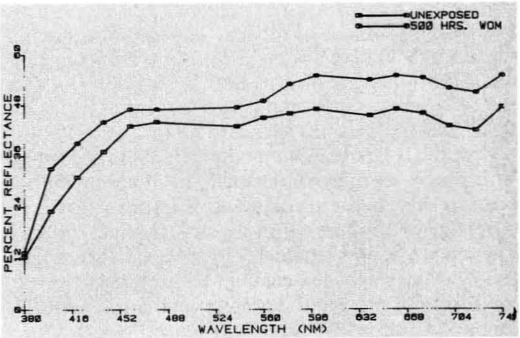

Figure 9—Reflectance vs wavelength for light gray bead coating

camouflage pigments seem to act in a manner similar to untreated titanium dioxide in that they catalyze photo-oxidation of the coating polymer when exposed to the ultraviolet radiation of the sun.

Some bibliographies[19,20] of durability studies are available but, in general, paint researchers have put little effort into the elaboration of photochemical mechanisms. There have been some efforts in this direction, for example. The work of Pappas[14] is well known. Allen, et al.[21] have made similar studies in pigmented plastics. Kampf, of Bayer, has studied the mechanism of TiO_2 mediated oxidation and proposes the scheme[22]:

$$Ti^{+4} + O_2 + h\nu(UV) \rightarrow O_2^- + Ti^{+3} \xrightarrow{water} HO_2\cdot + OH\cdot$$

The latter radicals are the key moieties in the oxidative degradation of the polymer matrix. TiO_2 is considered a photosensitive semi-conductor, as are the metal oxide camouflage pigments, and one can assume that the photoinduced oxidation processes are similar. The surface treatments on rutile TiO_2 are added to inhibit this UV/oxidation process. Encapsulation of this type of pigment will cause an increase in durability due to the fact that local photo-oxidative degradation of the crosslinked bead polymer will not cause an air void to develop in a coating as in a coating with the PVC/CPVC ratio near one. It will cause only local oxidation in a highly crosslinked polymer which, in turn, will cause little change in reflectance since no void will form and the degraded polymer cannot wash away.

It can be seen from this evidence that the use of pigmented polymer bead enhances the exterior durability and performance of matte aircraft coatings. This durability is related to the encapsulation and subsequent isolation of the pigment particles. The encapsulation subsequently isolates the photo-oxidation about the pigment particles due to UV radiation and prevents the degradation from affecting coating performance by causing air voids and a porous network to form in the coating.

The air voids about the pigments and the increase in porosity they cause, lead to low stain resistance[11] if they form in the coating polymer. If the porosity forms in the bead, it will have no effect on the integrity of the coating polymer matrix and lowered stain penetration results throughout most of the coating lifetime. The increased performance thus seen in the bead based coatings is due to both longer maintenance of optical properties (lower air void formation) and decreased staining and water penetration.

The observed weathering (WOM) data indicate that coating lifetimes of military aircraft coatings can potentially be extended several years, especially in those coatings in which durability is color limited. The other performance criteria of this class of coatings are not the limiting features, in most cases, of the performance lifetime of this class of coatings. Individual peeling, corrosion, and cracking failures, of course, occur in MIL-C-83286 coatings but color stability was the specific focal problem of this study. This is not to say it was easy to formulate beads into these coatings to give the specified properties but the main aim was to achieve past properties with improved durability in color. The trends of the WOM data have been recently confirmed in exterior panel exposure. These data will be presented more completely at a later date [Air Force Materials Laboratory, Wright-Patterson AFB, Ohio, Contract F33615-79-C-5031].

ECONOMIC IMPLICATIONS

Field results for present USAF coatings on Air Force transport aircraft indicate present matte camouflage coatings have a service lifetime of four years. For these aircraft an average of 625 man-hours are required to

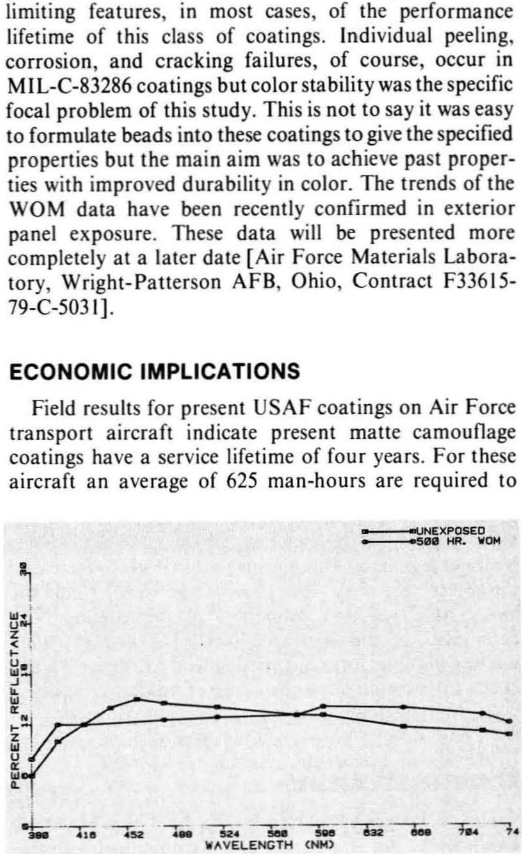

Figure 10—Reflectance vs wavelength for dark gray bead coating

remove the old coating and primer completely, and an average of 625 hours to repaint. The planes require on the average 100 gallons of primer and 100 gallons of topcoat. An average of two years increased use lifetime for the coating would imply a 33% reduction in labor and materials over the aircraft lifetime. In a 12-year period, this is 1250 man-hours and 200 gallons of coating. In addition, there is considerable touch-up on aircraft coatings done between repainting operations. Increased durability will reduce touch-up also. (Military aircraft are stripped completely and fully recoated, rather than simply overlaying a new coating. This practice is mainly for corrosion protection purposes and is not normally followed in the civilian airlines.)

Military aircraft are also to be washed after each mission, and if there are problems with water penetration, this practice exacerbates them. Improved maintenance of water and stain resistance will reduce coating life costs in this manner also.

Thus, the important issue to consider is the high cost to the Air Force of repainting aircraft relative to coating cost, giving high economic value to true durability. For example, the protective function (including corrosion and abrasion resistance as well as camouflage) of a coating on a fighter aircraft, which can be valued in excess of $10 million,[23] places a high value on the coating. Paint scientists should consider this in R&D on coatings. If one focuses on the true value added by a coating to the substrate or total object, then the raw material cost of coating components are not limiting to a researcher and new coating systems or materials (such as pigmented beads in aircraft coatings) can be considered and an unlimited range of materials become feasible.

CONCLUSIONS AND SUMMARY

The use of solid and vesiculated pigmented polymer beads as matting agents in polyurethane camouflage aircraft coatings has shown that increases in durability and maintenance of performance in these coatings can be achieved. The subsequent economic advantages are a decrease in the need for stripping and recoating and lower use of coating due to increased coating operational lifetime. The beads were produced by suspension polymerization processes and used in formulation in a manner similar to standard matting agents. Encapsulation of the metal oxide camouflage pigments decrease photo-oxidative degradation of the coating matrix catalyzed by these pigments. This encapsulation leads to increased durability of both the camouflage color and the water/stain resistant properties of the coating. The economies of this increased durability and extended coating lifetime occur largely due to the decreased labor needs for stripping and recoating of military aircraft.

ACKNOWLEDGMENT

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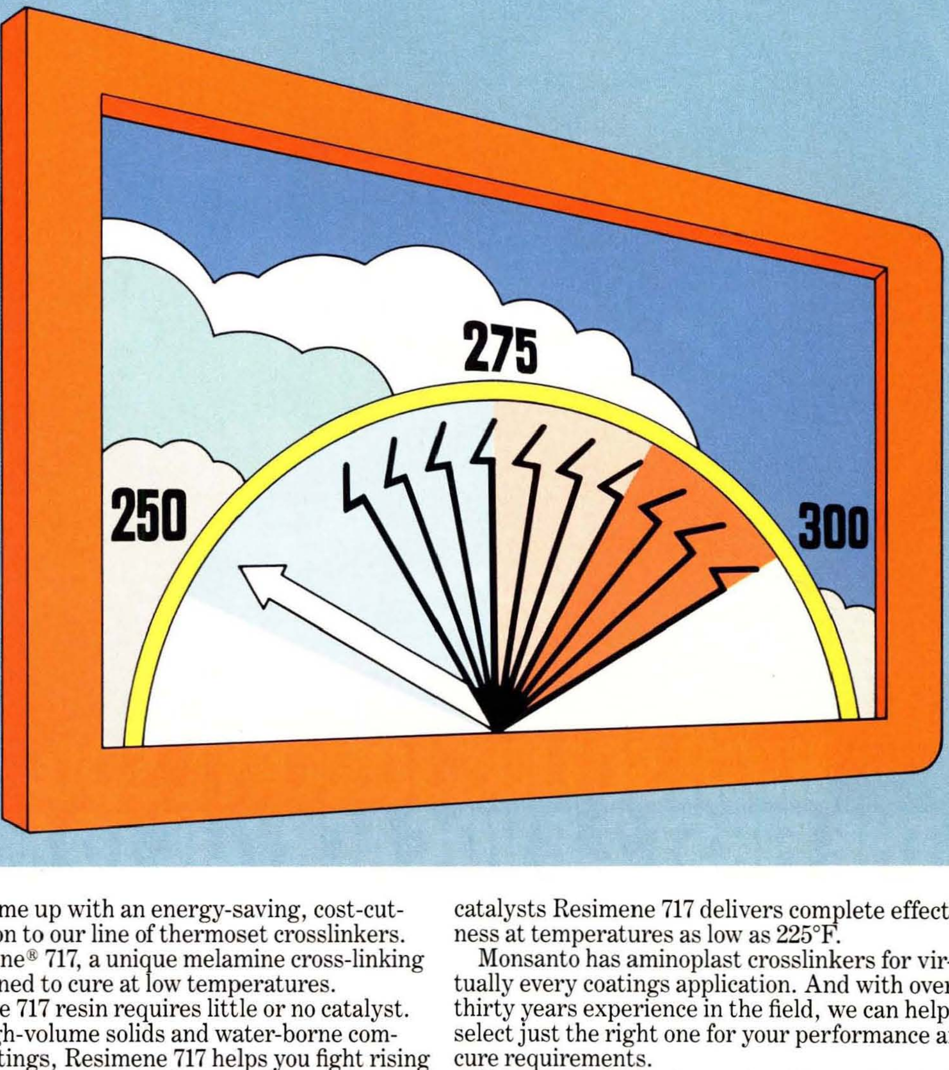

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Influence of Light Stabilizers On Maintaining Surface Integrity And Preventing Biological Defacement of Polymers

P.D. Gabriele, J.R. Geib, J.S. Puglisi, and W.J. Reid
Ciba-Geigy Corporation*

When a polymer is exposed outdoors in a fairly humid environment, the surface is subject to degradation with subsequent accumulation of mildew. The degraded surface (i.e., fissures, cracks, erosion) creates a microbial growth environment by virtue of allowing organic contaminants to accumulate. The carbon scavenging mildew organism *(A. pullulans)* then establishes growth. We have now established that by the addition of certain light stabilizers, polymer surfaces remain intact for many years when exposed outdoors. This surface integrity dramatically reduces the potential for dirt pick-up and the organism's ability to establish a habitat.

INTRODUCTION

Photodegradation caused by the ultraviolet portion of terrestrial solar radiation has been studied extensively.[1] Polymer photodegradation has been examined mainly through changes in various physical properties such as physical strength, impact resistance, color, and gloss retention. Many changes in the physical properties of exposed polymers have been directly related to chemical changes induced by UV radiation.

The purpose of this paper is to discuss the apparent role of ultraviolet light stabilizers in controlling sunlight-induced surface deterioration and in preventing subsequent microbial infestations such as mildew. Mildew is often mistaken for dirt and to the untrained observer this growth is interpreted as a soiled or weathered surface. This study presents information which indicates that biological defacement of polymers during weathering is a condition propagated through the physical alteration of polymer surfaces. Sunlight induced erosion and fracture of polymer surfaces creates a micro-environment which is conducive to moisture and exogenous carbon source accumulation. Furthermore, the maintenance of surface integrity through the use of certain light stabilizers like hindered amines and hydroxy phenylbenzotriazoles has demonstrated dramatic reduction in the accumulation of biological growth.

Biological defacement of plastics and coatings has been well stated in the literature. This kind of defacement is both aesthetically unpleasant and economically disastrous.[2] The dominant mildew agent associated with surface defacement is the ubiquitous black yeast fungus, *Aureobasidium pullulans.*[3] The characteristic appearance of this organism is dark green to black, depending upon the nutrient environment from which it feeds. The exact chemical and physical nature of the environment in which the organism resides are parameters which affect the characteristics of its growth. These conditions include substrate chemistry, free moisture, exogenous carbon, and nutrient sources which accumulate during the weathering process. Isolation of *A. pullulans* has been reported[4] from such substrates as painted surfaces, deteriorated greenhouse plastic, tygon tubing, soil, petroleum, fruits and vegetables, and human lymph tissue. The physical environment appears to play a major dynamic role in the organisms' growth and development. It is now apparent that control of the physical environment is an important factor in the reduction of growth accumulation on polymer surfaces beyond (or at least as important as) the classic incorporation of a toxicant to control growth.

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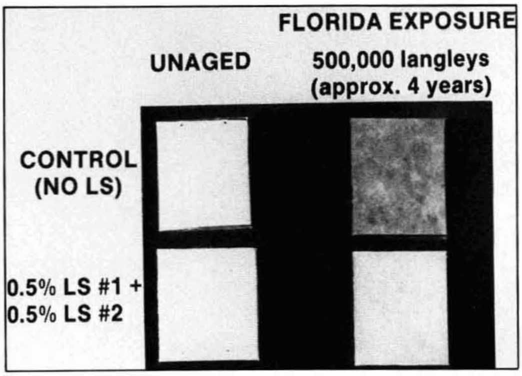


Figure 1A—Effect of Florida exposure on a modified styrenic terpolymer after 500,000 langleys

EXPERIMENTAL

Preparation and Light Exposure Of Polymer Samples

MODIFIED "WEATHERABLE" STYRENIC TERPOLYMER: The granular terpolymer was formulated by having the additives which were dissolved in minimum amounts of methylene chloride added dropwise to the stirred polymer. After the solvent had evaporated, the terpolymer was extruded at 430°F to ensure homogeniety of the additives and then was compression molded at 430°F into ⅛" thick plaques. The plaques were weathered at 45° facing south in Florida.

POLYPROPYLENE: Commercial polypropylene homopolymer pellets (Profax 6501) were cryogenically granulated. The granulated PP was formulated by having the additives which were dissolved in minimum amounts of methylene chloride added dropwise to the stirred PP. After the solvent had evaporated, the PP was extruded at 450°F to ensure homogeneity of the additives and then was injection molded at 450° into ⅛ in.–thick bars. The bars were weathered at 45° facing south in Florida.

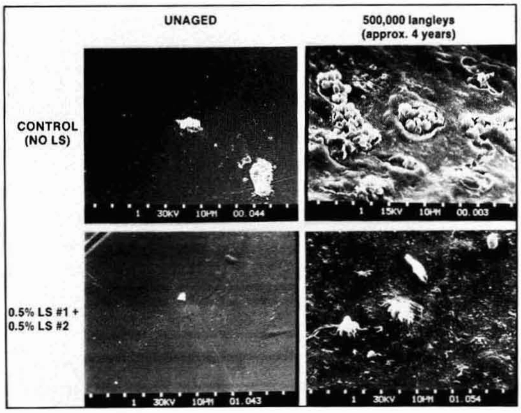


Figure 1B—Scanning electron micrographs (1000×) of a modified styrenic terpolymer after 500,000 langleys in Florida

THERMOPLASTIC URETHANE FILMS: Commercial thermoplastic polyurethane (Estane® 5707 from B. F. Goodrich) was dissolved in a 1:1 (w/w) mixture of DMF/toluene to form a 20% solution. Light stabilizers were separately dissolved in a minimum of the 1:1 solvent mixture and then were added to the resin solution. Drawdowns of the resin solutions were prepared to obtain a resultant 1.5 mil thick film after drying. The drawdowns were flashed for five minutes at room temperature and then were forced-air dried for 15 minutes at 75°C. Subsequently the films were exposed at 45° under glass facing south in Florida.

Scanning Electron Microscope (SEM)

Each sample was cemented to a specimen holder and then was coated with approximately 200 Å of aluminum in an EFFA Rotary Vacuum Evaporator. The photomicrographs were obtained from a Cambridge Model S180 Scanning Electron Microscope.

Organism Characterization

Materials exposed to terrestrial weathering are almost never exposed to a single species of microorganism. However, depending upon circumstances, certain microorganisms manage to dominate particular environments. The major factor in biological attack of polymers is the particular biochemical profiles of the indigenous microbial species population. Other factors affecting microbial attack are varied and include such conditions and circumstances as geography, climate, substrate chemistry, and accessability

The predominate organism associated with all our samples appears to be *Aureobasidium pullulans*. Several methods were used to identify the attacking organisms. Low magnification (140×) examination of these samples demonstrated the typical black vegetative hyphal projections from areas of intense growth. Additionally, sample pieces and scrapings were incubated on Sabourand malt agar (Difco) pH 5.6 at 28°C for two weeks. During the incubation period, the characteristic "wet" black-yeast culture developed. However, there was additional contamination of mold and filimentouse fungi which supports the idea of more than one organism attacking.

RESULTS

Traditionally, samples returned after aging in Florida have had surface dirt on them which was cleaned off prior to evaluation for impact, color, or surface defects. Recently, we decided to take a closer look at these surface defects which then led to the discovery that some surface discoloration was actually a biological phenomena. This microscopic examination has identified the presence of various microorganisms. Generally, polymeric systems, when unprotected to exterior conditions, degrade by forming cracks and fissures on their surfaces. These cracks tend to gather dirt and debris from the environment and so provide a potential organic source for the carbon-scavenging microbes.

Some of the previously observed "dirt" has now been identified microscopically to be these microbes. Additionally, it was discovered on the uncleaned, exposed, unstabilized samples that the microbes were present both in the cracks as well as on the surfaces. Optimally stabilized samples did not develop these cracks and fissures and thus, the accumulation of the microbes did not occur.

Modified "Weatherable" Styrenic Terpolymer

This polymer system contains styrene, acrylonitrile, and a saturated rubber in order to make the polymer more UV light resistant. The material, however, still requires additional UV stabilizer to remain viable for extended periods outdoors. Consequently, ultraviolet light stabilizers, e.g., hydroxy phenylbenzotriazoles, benzophenones, and hindered amines, are added to give the necessary additional light stability.

Unstabilized samples and the various stabilized systems were exposed for four years in Florida (500 kilolangleys). All samples except the optimally stabilized sample (*Figure* 1A) had heavily defaced and dirty surfaces within three years of outdoor exposure. The optimally stabilized sample (0.5% LS 1 + 0.5% LS 2) maintained its surface integrity with no build up of dirt or mildew. Closer examination of exposed, unstabilized materials demonstrates widespread contamination by the black yeast *Aureobasidium pullulans* (*Figure* 1B). The presence of this organism appears to be more highly localized within areas of severe surface erosion. These eroded surfaces increase the surface area by formation of ridges and troughs in which these organisms thrive because of the accumulation of organic debris. No such environment exists for the optimally stabilized samples as their surface has been left intact. Once the organism has become established, enzymatic degradation of the polymer surface ensues. This is apparent in *Figure* 1B in which these spores appear to have dissolved the polymer substrate, giving the appearance of residing in a crater. In contrast, the optimally stabilized samples do not exhibit this mode of microbial attack.

Polypropylene

Figure 2A shows the unstabilized polypropylene samples to be dark after two and a half years exposure in Florida, while stabilized samples show minimal color change after the same exposure period. On closer examination the major surface differences between the two samples becomes apparent. In the unstabilized case, deep troughs have formed creating cracks for atmospheric pollutants to accumulate. Additionally, moisture can be retained more readily in these structures, thereby creating an ideal environment for microbial habitation. Under SEM analysis (*Figure* 2B), nestled in the trough-like valleys, biological contamination is apparent. Emerging from one of the troughs is a hyphal structure (part of *A. pullulans'* vegetative structure) as well as several spore-forms distributed over the surface area of the degraded polymer. Additional regions examined show pollen spores as well as hyphae. When stabilized from photodegradation, the polymer maintains its surface integrity eliminating the opportunity for organic accumulation and the subsequent microbial infestation.

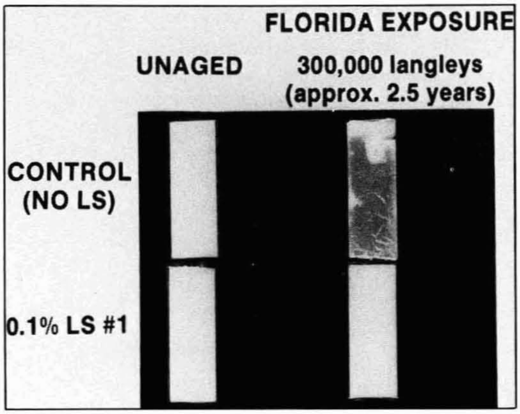


Figure 2A—Effect of Florida exposure on polypropylene after 300,000 langleys

Thermoplastic Polyurethane

Figure 3A shows color changes in unstabilized as well as in stabilized thermoplastic polyurethane samples. Clearly the change is more pronounced in the unstabilized case. Additionally, the unstabilized sample shows surface defacement which is exhibited by dark spotting. In contrast, the stabilized sample shows no surface defacement of this type. On closer examination it is apparent that the unstabilized surface is covered by the common mildew organism. Again using SEM analysis, differences can be seen in crack propagation between the two samples. In the unstabilized case, severe cracking in the form of fissures is present. The stabilized sample shows what may be the onset of cracking. Nevertheless, the service life of a coating and maintenance of the film properties has been extended. As in the other polymer systems, the greater the surface degradation the more attractive an environment for biota. In the case of the unstabilized samples, surface mildew is apparent, with major accumulation surrounding cracks. This is more likely due to the presence of water within the surface

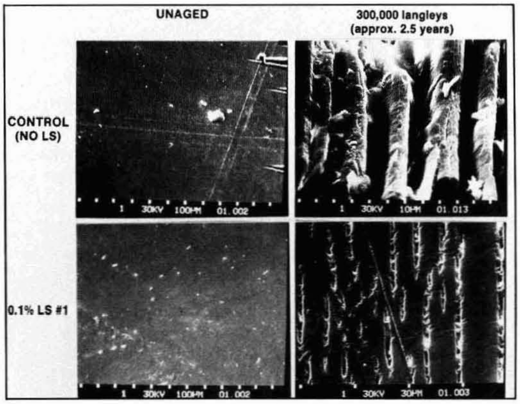


Figure 2B—Scanning electron micrographs (1000×) of polypropylene after 300,000 langleys in Florida

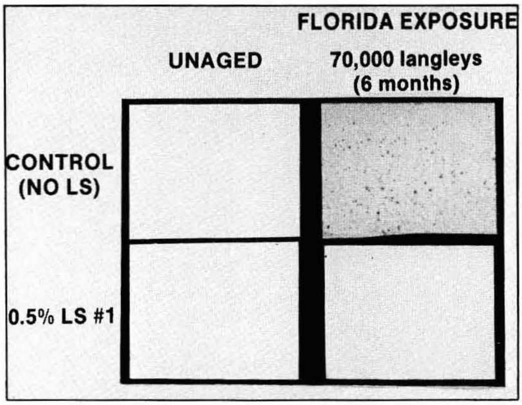


Figure 3A—Effect of Florida exposure on a thermoplastic polyurethane after 70,000 langleys under glass

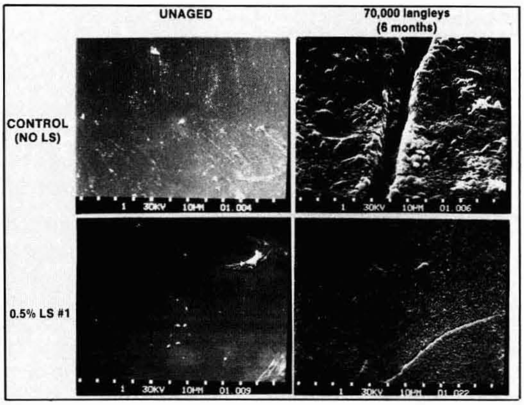


Figure 3B—Scanning electron micrographs (1000×) of a thermoplastic polyurethane after 70,000 langleys under glass in Florida

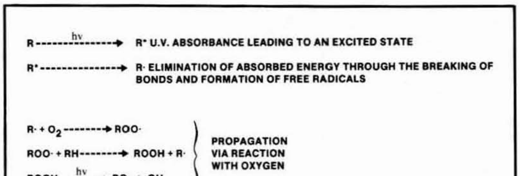
defects. Stabilized samples, in contrast, exhibit a clean surface with no major accumulation of growth. The presence of a narrow fissure in the lower right hand corner of *Figure* 3B may represent early stages of crack formation. Up to this point, absence of major surface defects and maintenance of film properties prevent the accumulation of biota.

DISCUSSION

Zabel[5] has indicated that in paint systems, clean, dry surfaces minimize the accumulation of mildew. Moreover, he states that moisture control of surfaces may be the key to microbial control. Film design may therefore be important in reducing surface defects which should subsequently minimize organic accumulation and free water. This present study has indicated that photophysical degradation preceeds biological accumulation. We have seen this to be the case with three different polymer systems. In all three cases, the maintenance of surface integrity by the addition of ultraviolet light stabilizers has dramatically reduced biological defacement.

Essentially, ultraviolet degradation is a multi-step process leading to free radical initiation and propagation via interaction with oxygen. This free radical propagation will eventually lead to the destruction of many organic polymers both from a physical as well as an aesthetic viewpoint. A stepwise schematic of this process is presented in *Figure* 4.

In attempting to control this degradation process, a number of different types of UV light stabilizers have been developed. In our work we have shown the efficacy of two different types: 2(2′-Hydroxy-5′-methylphenyl) benzotriazole (LS II) and bis [2,2,6,6-tetramethyl-4-piperidinyl] sebacate (LS I).



$R \xrightarrow{h\nu} R^{*}$ U.V. ABSORBANCE LEADING TO AN EXCITED STATE

$R^{*} \longrightarrow R\cdot$ ELIMINATION OF ABSORBED ENERGY THROUGH THE BREAKING OF BONDS AND FORMATION OF FREE RADICALS

$$\left.\begin{array}{l} R\cdot + O_2 \longrightarrow ROO\cdot \\ ROO\cdot + RH \longrightarrow ROOH + R\cdot \\ ROOH \xrightarrow{h\nu} RO\cdot + \cdot OH \end{array}\right\} \text{PROPAGATION VIA REACTION WITH OXYGEN}$$

Figure 4—Photo-oxidation mechanism

CONCLUSION

It is now established that by the addition of certain light stabilizers polymer surfaces remain intact for many years when exposed outdoors. This surface integrity dramatically reduces the potential for dirt pick-up and the mildew organism's ability to establish a habitat. For example, after 500 kilolangleys (four years) exposure in Miami (Florida), a saturated rubber styrenic terpolymer has retained its color, surface integrity, and impact when it was stabilized with 0.5% of bis [2,2,6,6-tetramethyl-4-piperidinyl] sebacate (LS I) combined with 0.5% of 2(2′-hydroxy-5′-methylphenyl) benzotriazole (LS II). The unstabilized materials, however, had been biologically attacked since the photochemically degraded surface provided an environment in which the mildew could thrive. Other polymers, such as polypropylene and thermoplastic polyurethane films, are also shown here to be capable of keeping their surfaces intact (and free from mildew attack) by utilizing LS I.

The unstabilized samples are covered with *A. pullulans* with their surfaces pitted and distorted.

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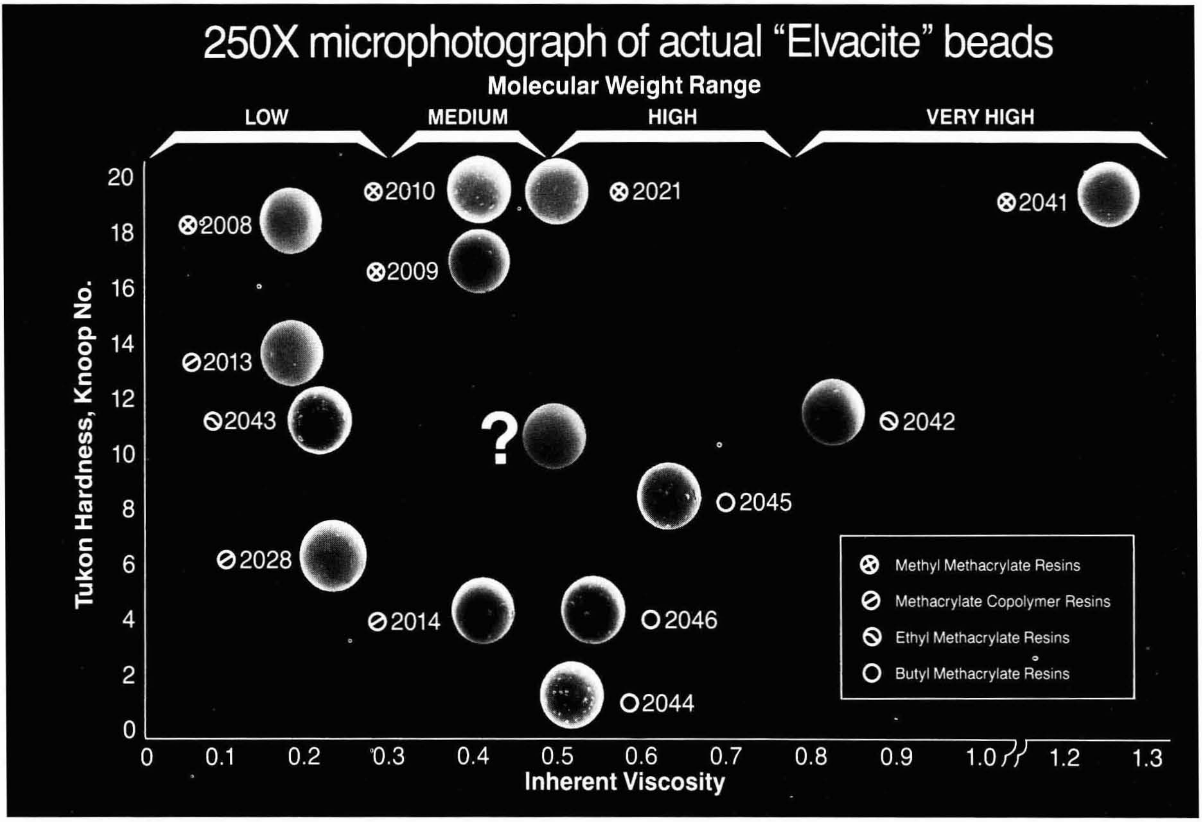
250X microphotograph of actual "Elvacite" beads
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Inherent Viscosity

Electroultrafiltration Of a Cationic Electrodeposition Paint

John M. Radovich and I-Meen Chao
University of Oklahoma*

Additional studies of the effects of the electric field on the membrane flux when ultrafiltering a cationic electrodeposition paint, ED-3002 (PPG Industries, Inc.) have been completed. The magnitude of the gel layer, boundary layer, and membrane resistance and the electroosmosis contribution to the flux through the membrane were determined for three commercial ultrafiltration membranes as a function of paint concentration, transmembrane pressure drop, and electric field strength. The results confirmed the assumptions made in previous work that each resistance (with the exception of electroosmosis) predominates at different values of the applied electric field strength.

INTRODUCTION

Ultrafiltration is a very effective method for recovering paint particles from the rinse in the electrocoating process.[1] The rinse, with 0.5 ~ 3.4% by weight of drag-out solids, is ultrafiltered, the retentate is recycled to the electrocoating tank (generally with a paint concentration range from 5 to 15% by weight), while the ultrafiltrate is reused as the rinsing fluid. By this arrangement, the main disadvantages caused by rinsing, i.e., excess water consumption (300 L/min), excess paint consumption (around 20% in excess), and water pollution, are all minimized.

Concentration polarization, which is the build-up of the retained paint particles on the membrane surface decreases the effectiveness of the ultrafiltration process.[2] The steady state solute balance dictates that the convective transport of the solute towards the membrane with the bulk solution (due to the pressure gradient) be equal to the diffusion rate of the solute (due to the concentration gradient) away from the membrane. Since the diffusion rate of the paint particles is very slow, the convective transport through the membrane is greatly reduced. When the paint concentration at the membrane surface is high enough for a gel layer to form, the ultrafiltration rate becomes independent of the pressure drop. The gel layer resistance dominates the process by controlling flux and selectivity. We have been able to remove or disrupt this concentration polarization layer by combining electrophoresis with the ultrafiltration.[3,4] An electric field applied across the membrane pulls the charged paint particles away from the membrane, thus preventing the accumulation of these retained particles and the formation of a gel layer.

THEORY

The mathematical model of electroultrafiltration as described in detail earlier[3-6] is based on the gel layer model of ultrafiltration[7,8] and the cross-flow electrofiltration model.[9] The resulting equation for the total solution flux through the membrane, J, (vol./time-area) is

$$J = \frac{\Delta P}{\left[1 + \dfrac{R_{om}}{\dfrac{R_{om}\,K_m\,E}{\Delta P}}\right] + \left[\dfrac{\Delta P}{K_s \ln (C_m/C_b) + \mu E}\right] + \left[\dfrac{R_{og}\,\Delta P}{1 + K_g E R_{og}}\right]} \qquad (1)$$

where

ΔP = transmembrane pressure drop
R_{om} = membrane resistance in the absence of an electric field
K_m = membrane electroosmotic constant
E = electric field strength
K_s = mass transfer coefficient of paint solids
C_m = paint concentration at the membrane surface
C_b = paint concentration in the bulk solution
μ = electrophoretic mobility of the paint particles
R_{og} = gel layer resistance in the absence of the electric field
K_g = gel layer electroosmotic constant

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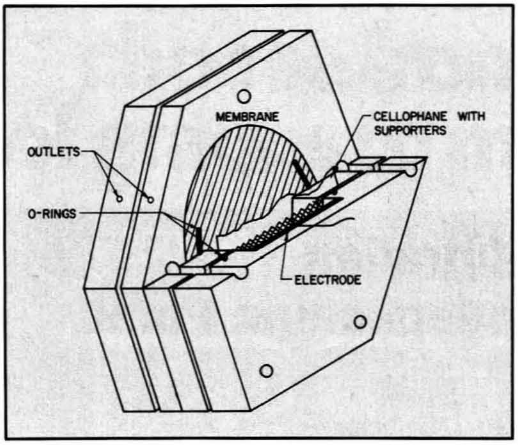

Figure 1—Open view of EUFC

This equation is in the general form

$$\text{FLUX} = \frac{\text{DRIVING FORCE}}{\text{Sum of Resistances}}$$

In equation (1), ΔP is the driving force while the three bracketed terms in the denominator are the membrane (R_m), boundary layer (R_b), and gel layer resistances (R_g) to membrane flux in the presence of an electric field, respectively.

The performance of the ultrafiltration system with an applied electric field can be separated into four steps:[5]

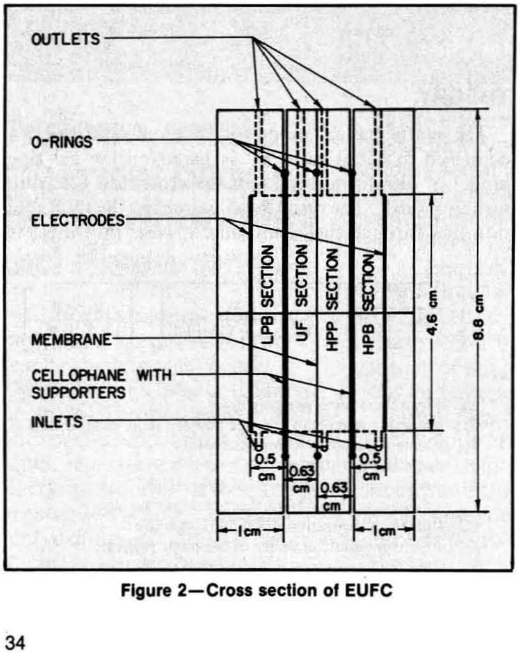

Figure 2—Cross section of EUFC

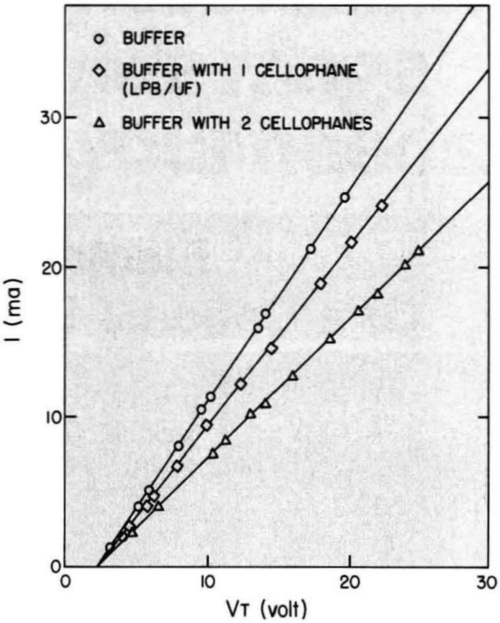

Figure 3—Current-voltage lines for components in the EUFC

STEP 1: *Gel Layer Controlled Region*—In the gel layer controlled region, the gel layer resistance is much greater than the other two resistances, so equation (1) reduces to the following form:

$$J = \frac{1}{R_{og}} + K_g E \tag{2}$$

The relationship between J and E is linear. Electro-osmosis in, and electrophoretic dissociation of the gel layer both occur in this region until the gel layer is disrupted.

STEP 2: *Boundary Layer Controlled Region*—Once the gel layer has been disrupted, the ultrafiltration flux is controlled by diffusion due to the concentration gradient in the boundary layer. The ultrafiltration flux equation becomes:

$$J = K_s \ln (C_s/C_b) + \mu E \tag{3}$$

The relationship between J and E in this region is non-linear. The concentration gradient decreases as the electric field strength increases until the migration due to electrophoresis is much greater than the diffusion due to the concentration gradient.

STEP 3: *Electrophoresis Controlled Region*— If E is large enough that transport by diffusion is small compared to electrophoresis, the ultrafiltration flux equation becomes:

$$J = \mu E \tag{4}$$

Since R_b is still greater than R_m, increasing E will linearly increase the ultrafiltration flux in this region until the total resistance approaches the membrane resistance.

STEP 4: *Membrane Controlled Region*—When E is

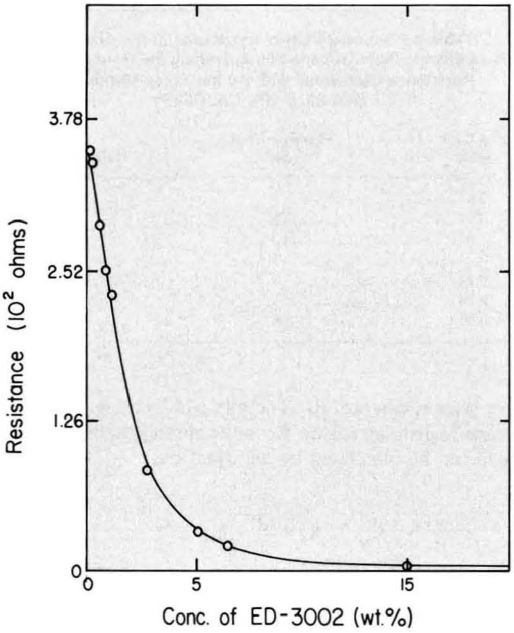

Figure 4—Resistance in the HPP section vs paint concentration

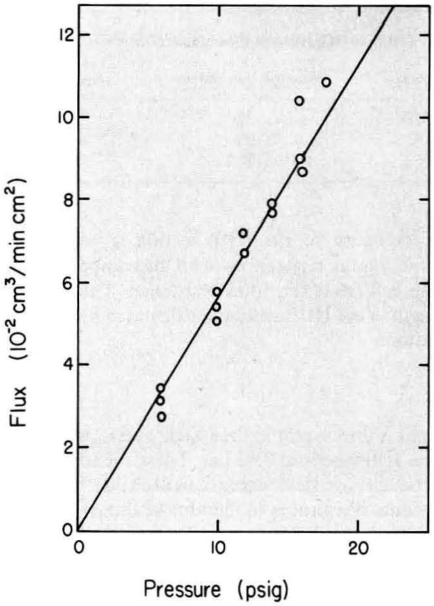

Figure 5—Buffer ultrafiltration rate under different pressure drop for S-20K-CA membrane

very large, R_m becomes much greater than R_b, and equation (1) becomes:

$$J = \frac{\Delta P}{R_{om}} + K_m E \qquad (5)$$

The ultrafiltration flux of the solution under these conditions is controlled by the membrane resistance, so that it is equal to the flux of solvent under the same conditions.

All the electroultrafiltration steps discussed above are subject to the unique constraint of the limiting field strength.[4] The limiting field strength, $E_{\ell im}$, is the maximum electric field strength that can be reached in the high pressure ultrafiltration section. When E is equal to $E_{\ell im}$, a paint film with high electrical resistance is formed on the cellophane surface in the high pressure ultrafiltration section. Further voltage increases only increase the thickness of this film, which reduces the electric field strength further. The steady state solute balance at the cellophane surface yields the following equation:

$$\mu E_{\ell im} = K_s \ln (C_f / C_b) + J \qquad (6)$$

$$C_f = \text{film concentration}$$

As the concentration gradient decreases, the limiting field strength also decreases. The magnitude of C_f or the dependence of $E_{\ell im}$ on the nature of the cellophane surface has not been determined.

EXPERIMENTAL DESIGN

The electroultrafiltration cell (EUFC) consists of four hexagonal plates with two parallel electrodes (*Figure* 1). *Figure* 2 is a cross section of the EUFC, which has an effective membrane area of 16.6 cm^2 and a distance of 2.26 cm between the electrodes. The plexiglas cell has four compartments: two buffer compartments which contain the electrodes, a retentate and an ultrafiltrate compartment. Cellophane separates the electrodes from the retentate and the ultrafiltrate in order to prevent contamination of the paint solution and electrocoating of the electrodes. The electrodes are made of platinum.

The electroultrafiltration flow system as described previously was pressurized by nitrogen. Retentate and ultrafiltrate from the system were recycled into the feed reservoir to maintain a constant paint concentration in the feed. A cationic, electrodeposition primer made by PPG, ED-3002, was the model paint. Solutions of various concentrations were obtained by dilution with the acetic acid buffer. The anistropic membranes used in this study were S-20K-CA (Osmonics, Inc.), XM-50 (Amicon Corp.), and PSVP (Millipore Corp.).

Experiments were designed to determine the effect of electroosmosis on the membrane flux as well as the magnitude of the individual resistances to membrane flux. Previous work[3,4] only demonstrated that the electric field improved the total flux, but those results were only suited to determining the total resistance not the individual resistances to flux.

DATA ANALYSIS

The electric field strength in the high pressure ultrafiltration section, the HPP section, was calculated according to a method of Gidding's.[10] The current-voltage relationship for each component in the cell is linear. The electrical resistance of the corresponding component can be obtained from the slope of the line.

Table 1—Membrane Electroultrafiltration Properties

Membrane	R_{om} (psi min cm²/cm³)	K_m (cm/min-volt/cm)
S-20K-CA	90	−0.000307
XM-50	99	0.000109
PSVP	56.5	0.00851

The resistance of the HPP section r_h, is obtained by subtracting the resistances of all the components present in the cell from the total resistance. The electric field strength in the HPP section is calculated by the following equation:

$$E = \frac{Ir_h}{L_h} \tag{7}$$

where I is the current in the system and L_h is the thickness of the HPP section: 0.63 cm. These measurements give the true electric field strength in each compartment. The individual resistances to membrane flux were calculated from the following measurements:

(1) Ultrafiltration of the buffer—The relationship between buffer ultrafiltration flux and pressure drop is linear for every membrane. The inverse of the slope of the line is R_{om} for the corresponding membrane.

(2) Electroultrafiltration of the buffer—The relationship between buffer electroultrafiltration flux and electric field strength is linear for a zero pressure drop. The slope of the line is K_m for that membrane.

(3) Ultrafiltration of paint solutions—(a) Boundary layer controlled region: Before the formation of the gel layer, the ultrafiltration flux is controlled by the boundary layer resistance, R_b. The flux will increase when the pressure drop increases. R_b in the absence of the electric field can be calculated by the equation:

$$R_b = \frac{\Delta P}{J} - R_{om} \tag{8}$$

(b) Gel layer controlled region: When the gel layer is formed, the ultrafiltration flux is independent of the pressure drop. The flux at a given bulk concentration becomes a constant above a certain pressure drop. The inverse of the constant ultrafiltration flux is R_{og} for that concentration.

(4) Electroultrafiltration of paint solutions—(a) Step 1: The relationship between J and E in this region is linear at a constant pressure drop. The slope of the line is K_g; (b) Step 2: The relationship between J and E is nonlinear at a constant pressure. Due to the complex nature of

Table 2—Boundary Layer Resistance in the Absence Of an Electric Field Obtained by Averaging the Boundary Layer Resistance Calculated with All the Three Membranes (XM-50, S-20K-CA, PSVP)

Paint Conc. wt %	Pressure Drop psi	R_b psi cm² min/cm³
0.07	4	84.5
0.07	6	125.7
0.07	10	247.8
0.24	4	105.3
0.24	6	204.2
0.24	8	283.9
0.56	4	227.2

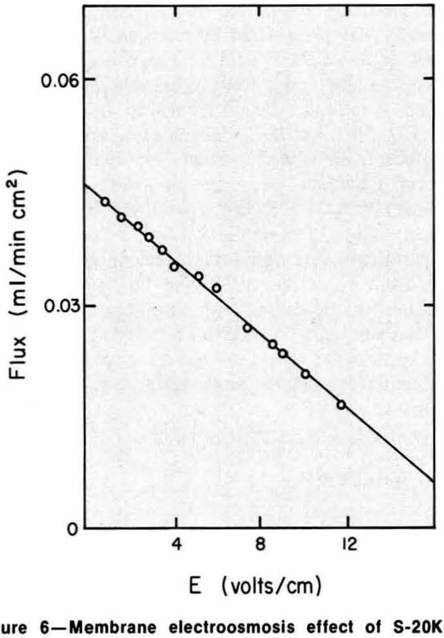

Figure 6—Membrane electroosmosis effect of S-20K-CA membrane

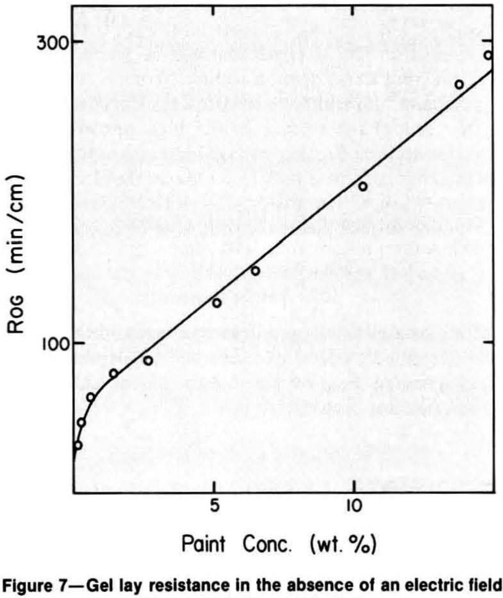

Figure 7—Gel lay resistance in the absence of an electric field, R_{og}, vs paint concentration

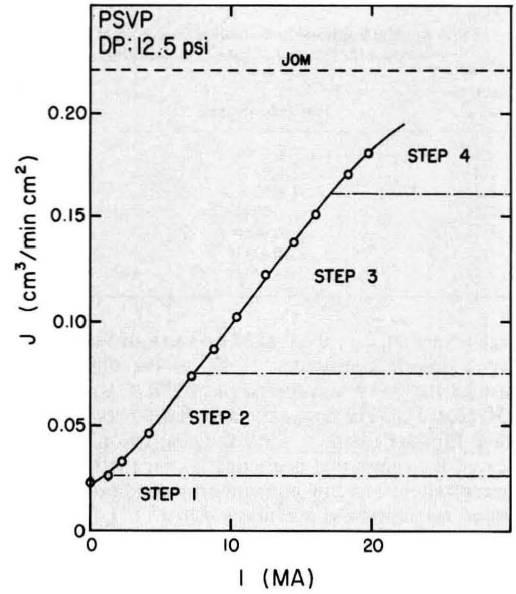

Figure 8—Electroultrafiltration at 0.24% wt ED-3002

diffusion, prediction of J in this region can not be made yet; and (c) Step 3: The relationship between J and E in this region at a constant pressure drop is linear. The slope of this line is μ.

The limiting point is defined as the point beyond which the current-voltage relationship deviates from Ohm's Law. The corresponding electric field strength is the limiting field strength, ($E_{\ell im}$).

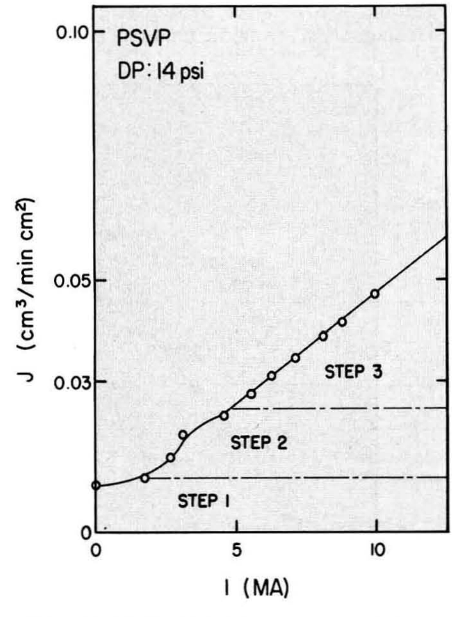

Figure 9—Electroultrafiltration at 1.15% wt ED-3002

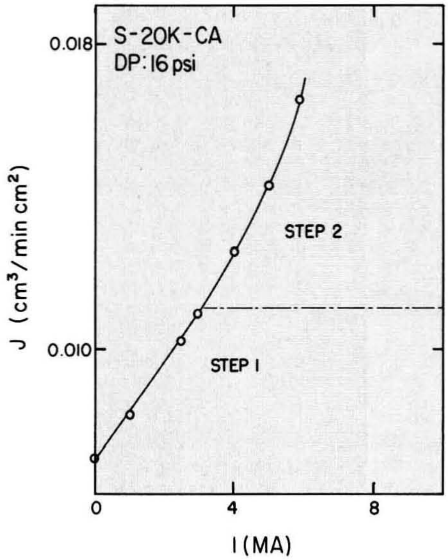

Figure 10—Electroultrafiltration at 5.16% wt ED-3002

RESULTS

Three examples of the electrical resistance measurements of the cell components are shown in *Figure* 3. Electrolysis of the buffer and membrane surface properties cause the current-voltage lines to deviate from the origin. The electrical resistance of the HPP section is the resistance of the paint solution in this section. The electrical resistance of the HPP section vs paint concentration (% by weight) is shown in *Figure* 4.

An example of the expected linear dependence of buf-

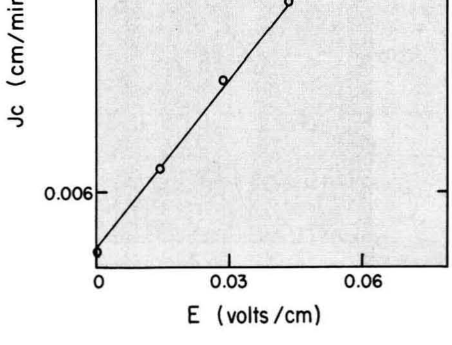

Figure 11—Gel layer electrosmosis effect at 10.37% wt ED-3002

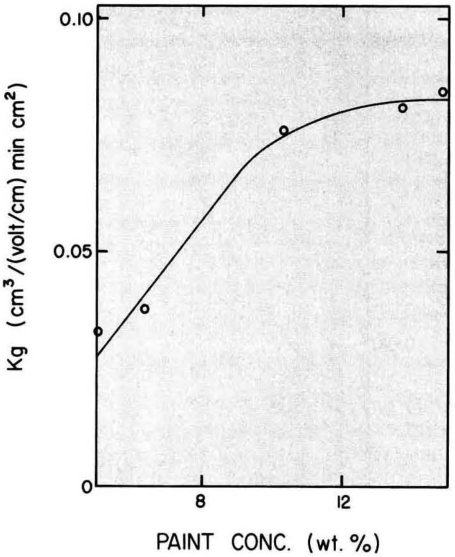

Figure 12—Electroosmotic constant, K_g, vs paint concentration

fer flux on ΔP is shown in *Figure* 5. Membrane resistances in the absence of an electric field R_{om} are listed in *Table* 1. The membrane electroosmosis effect is shown in *Figure* 6. Since the influence of the electric field on the buffer flux depends on the charge of the membrane pores, the charge of the pores in the S-20K-CA membrane is negative. Membrane electroosmotic constants are also listed in *Table* 1. Quantitatively K_m can be neglected as compared to R_{om}, for the S-20K-CA and XM-50 membranes. However, the K_m of PSVP is too large to neglect, e.g., at ΔP of 10 psi and E of 5 volts/cm, electroosmosis contributes 19.4% of the buffer flux through the PSVP membrane (in S-20K-CA, 0.3%; in XM-50, 0.1%). The boundary layer resistances to membrane flux are listed in *Table* 2. Comparison between R_b and R_m shows that neglecting R_m for the low paint concentrations and low pressure drop conditions is not a good assumption as previously stated.[4]

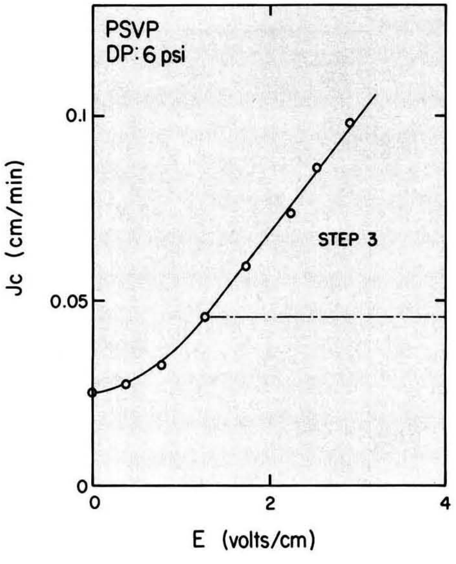

Figure 13—Resulting electroultrafiltration rate J_c vs electric field strength, E, at 0.96% wt ED-3002

Table 3—Electrophoretic Mobilities and Critical Field Strengths for Different Paint Concentrations

Paint Conc. wt %	μ cm/(min volt/cm)	E_{cr} Volts/cm
0.07	0.0309	4.52
0.24	0.0430	4.13
0.56	0.0345	3.33
0.96	0.0303	2.22
1.14	0.0189	—
1.15	0.0233	1.90
2.74	0.0227	0.79

The gel layer resistance in the absence of an electric field, R_{og}, vs paint concentration (% by weight) is shown in *Figure* 7. The linear dependence of R_{og} with respect to paint concentration when the paint concentration is above 3%, shows that increasing the bulk paint concentration increases the gel layer resistance, which is directly proportional to the gel layer thickness. At higher bulk concentrations, the thickness of the gel layer is greater.

The influence of the electric field on the ultrafiltration flux is shown in *Figures* 8—10. The limiting field strength effect prevents any further increases in J with E in *Figures* 9 and 10. The various steps in the electroultrafiltration flux performance are shown in these figures. In order to focus on the electric field influence in the HPP section, a corrected flux, J_c, is used in the paint ultrafiltration flux equation. J_c is obtained by subtracting the membrane resistance effect from the total flux equations:

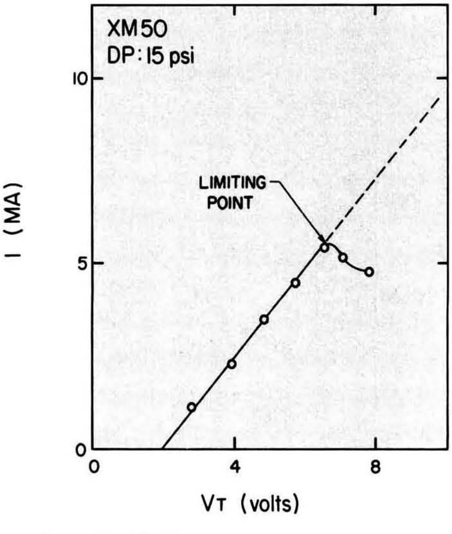

Figure 14—Limiting point at 14.95% wt ED-3002

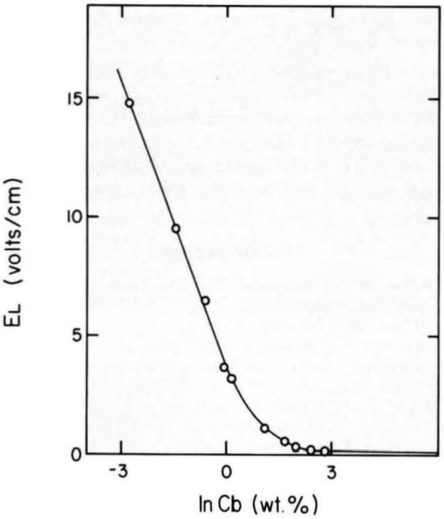

Figure 15—Limiting field strength, $E_{\ell im}$, vs ℓn Cb

$$\frac{1}{J_c} = \frac{1}{J} - \frac{R_{om}}{\Delta P + R_{om} K_m E} \qquad (9)$$

An example of the J_c vs E curve for Step 1 performance is shown in *Figure* 11. The slope of the line is the gel layer electroosmotic constant, K_g. K_g as a function of paint concentrations is shown in *Figure* 12. When the paint concentration is above 10%, K_g becomes constant. If the paint concentration is below 10%, the electric field influence on the gel layer is mostly due to the electrophoretic dissociation effect, so K_g is smaller.

An example of the J_c vs E curve for Step 3 performance is shown in *Figure* 13. The slope of the line is μ. μ and E_{cr} for different conditions are listed in *Table* 3. We are unable to explain the variation of μ with respect to the paint concentration for the different operating conditions.

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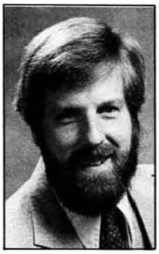

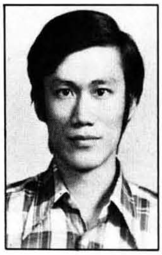

I-MEEN CHAO, a native of Taiwan, received his B.S. Degree in 1979 and M.S. Degree in 1981 both in Chemical Engineering from the University of Oklahoma, School of Chemical Engineering and Materials Science. He is currently employed by Eickmeyer Associates, an engineering firm in Overland Park, KS.

The determination of the limiting point is shown in *Figure* 14. The corresponding electric field strength in the HPP section is the limiting field strength. Prediction of the limiting field strength can not yet be made. However, the experimental relationship between $E_{\ell im}$ and paint concentration (% by weight) is shown in *Figure* 15. When the paint concentration increases, the limiting field strength decreases. This indicates a narrower operating voltage range for high paint concentrations.

Predictions of J in Step 1, see equation (2), and Step 3, see equation (4), were made using the data for the individual resistances. Summaries of the comparisons between the predicted and the experimental values for

Table 4—Deviations Between the Predicted and the Experimental Values as Percentage Of the Predicted Values for Different Membranes in the Gel Layer Controlled Region

Membrane (#)	C (wt %)	E (Volts/cm)	Deviation Range (%)	Average Absolute Deviation (%)
XM-50	5.16 ~ 14.95	0.0156 ~ 0.311	−5.3 ~ 17.85	9.30
S-20K-CA	5.16 ~ 14.95	0.0149 ~ 0.260	−8.9 ~ 12.34	5.73
PSVP	5.16 ~ 14.95	0.0208 ~ 0.335	−7.38 ~ 13.94	6.44

Table 5—Deviations Between the Predicted and the Experimental Values as Percentage of the Experimental Values For Different Membranes in the Electrophoresis Controlled Region

Membrane (#)	C (wt %)	E (Volts/cm)	Deviation Range (%)	Average Absolute Deviation (%)
XM-50	0.07 ~ 2.74	0.85 ~ 10.83	−12.46 ~ 19.63	9.00
S-20K-CA	0.56 ~ 2.74	0.84 ~ 6.03	− 7.23 ~ 8.78	5.78
PSVP	0.07 ~ 2.74	1.08 ~ 16.19	−10.63 ~ 19.93	11.03

different membranes under different conditions are listed in *Tables* 4 and 5. A mathematical average of all the electrophoretic mobilities, 0.00282 (cm/(min volt/cm)), was used to simplify the calculations for *Tables* 4 and 5. The variations between the predicted and the experimental values are all within 20% of the experimental values even after using an average mobility. The applicability of the mathematical model developed earlier[3,4] has been extended from a paint concentration range of 1–3 wt%[4] to a range of 0.07–15 wt%.

Additional studies must be made to determine the complex behavior of the boundary layer. The combination of fluid management techniques and the electric field in the ultrafiltration system also deserves further study. An electric field in the electroultrafiltration system membrane, which gives different field strength at different radii, may be a good method of controlling the field strength in the HPP section to avoid the limiting point.

SUMMARY

When ultrafiltering a ED-3002 paint solution with an electric field applied across the membrane, the flux depends on the membrane, boundary layer, and gel layer resistances. The magnitude of these individual resistances varies with the electric field strength. One or more of these resistances can be neglected at a given E. The mathematical model developed by Ho and Radovich[4] is able to predict the total solution flux when operating the electroultrafiltration system in the gel layer-controlled and electrophoresis-controlled regions. The model is reasonably accurate for these regions at bulk paint concentration from 0.07 wt % to 15 wt %. The electroosmotic contribution to the total solution flux is not always negligible. It must be evaluated for each membrane.

The ideal operating regime is when the electric field strength, E, is great enough to completely eliminate concentration polarization, but less than the limiting field strength, at which the electrocoating of the paint on the cellophane membrane occurs. As the paint concentration (by wt %) increases, the limiting field strength, $E\ell_{im}$ decreases, so the operating regime becomes smaller. We are not able to model this phenomena as of yet.

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Effect of Water Immersion On the Acoustic Emission and Failure Of Automotive Finishes

J.A. Rooum and R.D. Rawlings
Imperial College*

Acoustic emission monitoring of tensile tests, complemented by other techniques, has been used to study the failure of automotive finishes containing either an anodic or cathodic electrocoat, both dry and after soaking in water for 96 hours. Systems with a cathodic electrocoat were found to be more susceptible to water; they absorbed more water and retained the water for longer times than the anodic systems. Cathodic systems failed at considerably lower strains during a tensile test after immersion than when dry.

INTRODUCTION

When the atoms in a material undergo an abrupt rearrangement, for instance, during cracking, a stress wave is formed which propagates through the material and the small displacements caused on the surface can be detected by a piezoelectric transducer. The electronic signal produced is known as acoustic emission and can be amplified, recorded, and analyzed, usually in terms of ringdown counts, events, and amplitude distributions[1] (See Appendix). It has been previously established that this technique can be used to distinguish between various paint coatings as they are deformed[2,3] and also between the failure mechanisms that occur in the coating.[4,5]

Previous work[4] on dry automotive finishes has shown that systems with anodic and cathodic electrocoats have two regions of acoustic activity as they are strained, which appear as distinct peaks in the strain dependence of the ringdown count rate. Observations during straining, together with post-test microscopical examination, indicated that the low strain acoustic emission was associated with microcracking and minor adhesion loss and the higher strain acoustic emission with gross damage, which was visible on the surface as wrinkling, cracking, and peeling. Analysis of the amplitude distributions in terms of overlapping Lorentzian peaks showed that each failure mechanism was characterized by events centered around specific amplitudes (as shown in *Table* 1).

The properties of paint systems after water soaking are of industrial importance, and the results of an investigation of the acoustic emission and failure modes during tensile testing of steel substrates with automotive finishes, that had been immersed in warm water for some time prior to testing, are discussed. Results from systems with an anodic and a cathodic electrocoat are reported.

EXPERIMENTAL

Materials Preparation

Mild steel panels were degreased and phosphated using the Granodine® 16S treatment, to give a zinc phosphate coating weight of 2.6 gm^{-2}. The panels were then rinsed in Deoxylyte® 76, electrocoated, and finally a surfacer and a topcoat were applied. In some cases the rinsing of the phosphate was omitted and, further, the surfacer and topcoat were not applied to all panels. In addition, two types of electrocoat were used, one an anodic electrocoat and the other a cathodic electrocoat. The anodic electrocoat was applied at 150V to a thickness of $\sim 30 \mu m$ and then stoved for 20 min at 165° C. The cathodic electrocoat was $\sim 20 \mu m$ thick and was applied at 300V followed by stoving for 20 min at 190° C. The systems tested are summarized in *Table* 2.

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Table 1—Peak Positions in the Amplitude Distributions and Associated Failure Mechanisms for Dry Automotive Finishes[4,5]

Peak Position (dB)	22 ± 1	26 ± 1	35 ± 1, 47 ± 2	54 ± 1	>60
Failure process	Hopeite cracking	Adhesion loss	Peeling and microcracking	Microcracking in cathodic electrocoat	Microcracking in anodic electrocoat, surfacer and topcoat

Each system was tested dry and also immediately following (within 10 min of) immersion in a water bath at 40 ± 3°C for 96 hr.[6] The bare edges of the specimens were protected during immersion with petroleum jelly which was wiped off, along with surplus water, prior to testing.

Tensile Testing, Acoustic Emission, And Post Test Examination

The panels were cut into strips (15 mm × 80 mm × 0.7 mm) and tensile tested in an Instron machine (model number 1115) at a strain rate of $4 \times 10^{-4} s^{-1}$ at room temperature. During the test acoustic emission was monitored using a PZT transducer,* (resonant frequency 150 kHz) coupled to the center of the specimen through a thin layer of vacuum grease and held in place with a spring clip. The resulting signal was amplified and recorded as ringdown counts, events, and amplitude distributions.* Each test was repeated at least five times.

Specimens, before and after tensile testing, were examined in cross-section in a scanning electron microscope after mounting in resin and polishing with diamond paste.

Capacitance Measurements

The times for the coatings to dry after immersion were determined by measuring the dielectric constant at various times after soaking, the specimens being stored in a dessicator between measurements. The capacitance was determined using the steel substrate as one plate of a capacitor and a layer of mercury on the paint as the other. The percentage of water (V) in the film is then:

$$V = \frac{100 \log (C_1 / C_0)}{\log 80}$$

where C_1 is the measured capacitance and C_0 is the capacitance of the same coating when dry.[7]

RESULTS

The results of the capacitance experiments are shown in *Figure* 1. It can be seen that the systems with the cathodic coat absorbed more water and retained it for longer times than those with the anodic coat.

The acoustic emission events versus strain curves for the specimens with an anodic electrocoat are presented in *Figure* 2 and show that there were no major differences in the magnitude or the strain dependence of the emission from the dry and wet states. Furthermore, no significant variation in the behavior was detected between the rinsed and unrinsed phosphate systems by the acoustic emission monitoring. The similarity in the emission from specimens in the wet and dry conditions and the negligible effect of rinsing are also demonstrated by the ringdown count versus strain plots (*Figure* 3) and the amplitude distributions (*Figure* 4). A small change that was observed was that the full systems gave more ringdown counts when tested wet than dry, which was also reflected in the amplitude distributions, with more events of higher (>40 dB) amplitude for the wet state. The ringdown

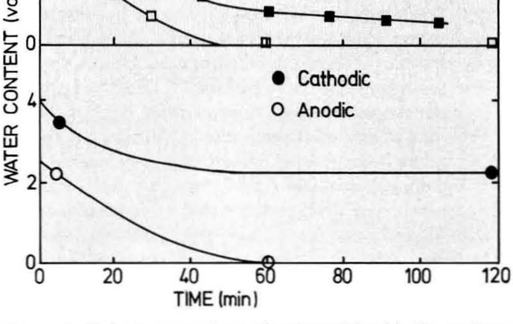

Figure 1—Volume percentage of water retained in the systems as a function of time after immersion

Table 2—Systems and Codes Used in the Present Investigation

Phosphate	Electrocoat	Surfacer	Topcoat	Code
Rinsed	Anodic	✓	✓	Full System Anodic (Rinsed)
Not Rinsed	Anodic	✓	✓	Full System Anodic
Rinsed	Anodic			Anodic (Rinsed)
Not Rinsed	Anodic			Anodic
Rinsed	Cathodic	✓	✓	Full System Cathodic (Rinsed)
Not Rinsed	Cathodic	✓	✓	Full System Cathodic
Rinsed	Cathodic			Cathodic (Rinsed)
Not Rinsed	Cathodic			Cathodic

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*Dunegan Endevco equipment.

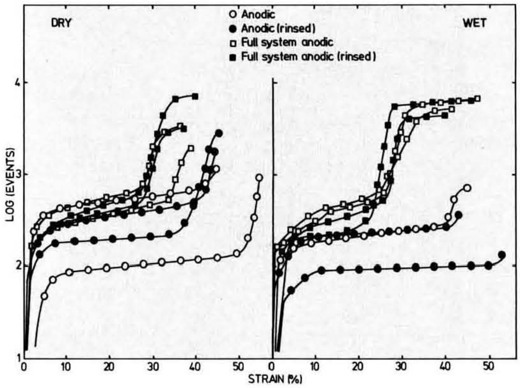

Figure 2—Accumulative events as a function of strain for systems with an anodic electrocoat. The two curves for each system are the maximum and minimum curves recorded out of five tests

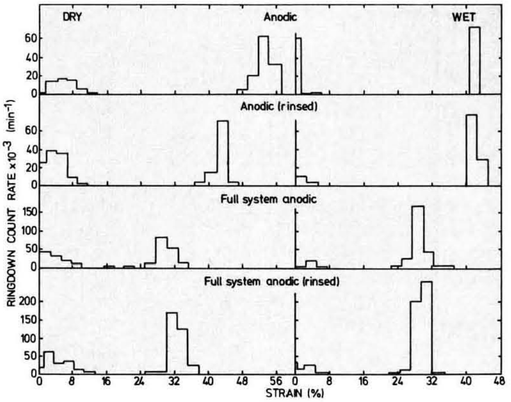

Figure 3—Typical plots of the ringdown count rate as a function of strain showing the strain ranges over which there was acoustic activity for systems with an anodic electrocoat

count rate plots consist of two distinct peaks, the higher strain peak was shown previously to be associated with gross damage in dry specimens. There was a tendency for this peak to occur at slightly lower strains in the wet condition and visual observation confirmed that the onset of gross damage was earlier after immersion.

Less emissions were recorded from specimens containing a cathodic electrocoat when tested after immersion than when tested dry (*Figures* 5 and 6). The strain dependence of the ringdown count rate of the dry cathodic systems was similar to that observed for the anodic systems, with two peaks. Whereas after immersion the higher strain peak occurred at lower strains, merging with the low strain peak (*Figure* 7). Gross damage was visible on the surface of wet specimens at very low strains, which is consistent with the early onset of the high strain emission peak.

The acoustic emission differed between the rinsed and unrinsed phosphates in only one of the systems examined. This exception was the full system with a cathodic electrocoat when wet, which was quieter when the phosphate had been rinsed.

DISCUSSION

The acoustic emission data, complemented with visual observations and microscopical examination, indicate that immersion in water has little effect on the behavior of automotive systems with this anodic electrocoat. In contrast, immersion of systems with the cathodic electrocoat studied here results in marked changes in acoustic emission and in the strain required for the onset of gross damage.

The main difference between the wet and dry cathodic systems was that the second region of high acoustic activity (associated with gross damage) occurred at much lower strains after immersion and merged with the low strain peak. The earlier onset of acoustic emission after water soaking has also been reported for powder-coated

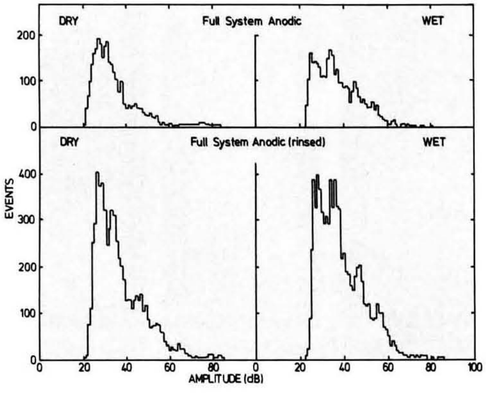

Figure 4—Comparison of typical amplitude distributions for wet and dry full systems with an anodic electrocoat

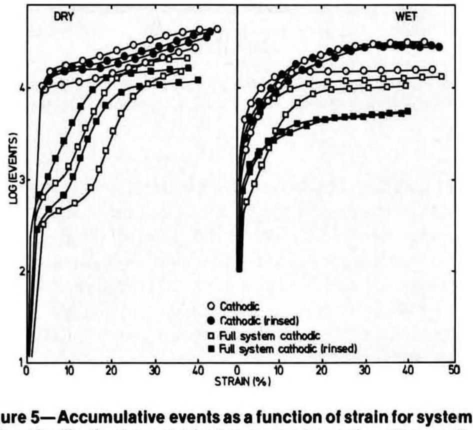

Figure 5—Accumulative events as a function of strain for systems with cathodic electrocoat. The two curves for each system are the maximum and minimum curves recorded out of five tests

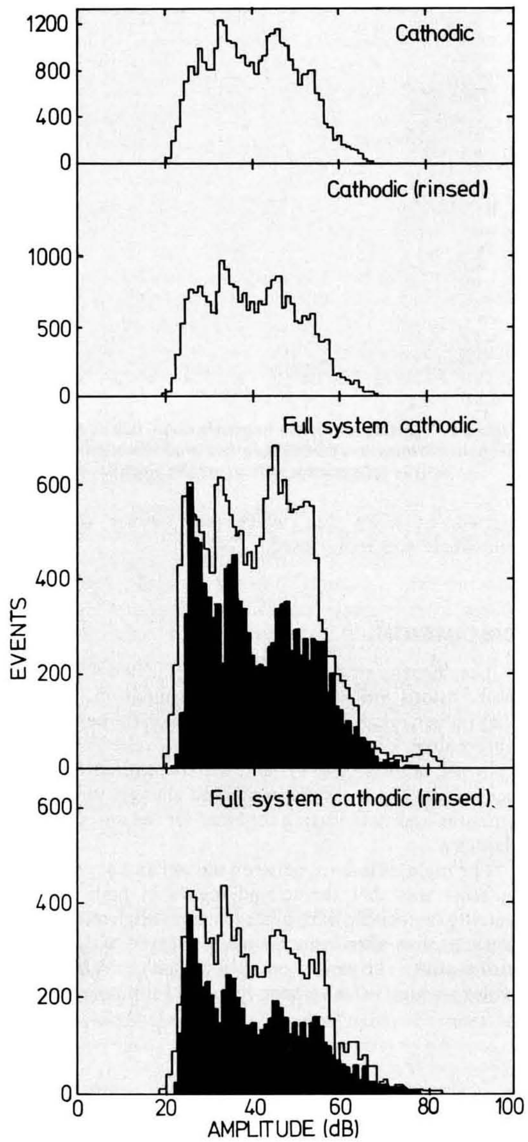

Figure 6—Comparison of typical amplitude distributions for wet (shaded) and dry full systems with a cathodic electrocoat

steel sheet by Mosle and Wellenkotter,[3] who suggested that this was caused by the condensation of water at the interface between the steel substrate and the paint. This condensation led to an enlargement of existing pores at the interface and hence to a loss of adhesion. However, this does not appear to be a major factor for the automotive cathodic systems investigated in the present study for three reasons:

(1) Scanning electron microscopy failed to reveal the presence of large pores at any of the interfaces of the multicomponent systems after immersion.

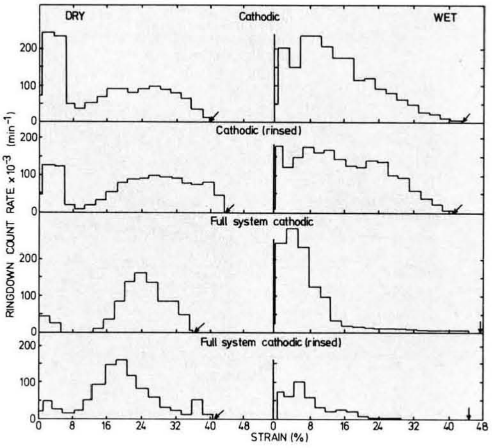

Figure 7—Typical plots of the ringdown count rate as a function of strain showing the strain ranges over which there was acoustic activity for systems with a cathodic electrocoat

(2) For both wet and dry systems failure was mainly between the hopeite and the underlying phosphophyllite (hopeite crystals, which had become detached during testing and remained implanted in the electrocoat, were detected by scanning electron microscopy in both wet and dry states).

(3) The amplitude distributions show that, although immersion reduced the number of acoustic emission events, the events were of similar amplitudes to those from dry systems; suggesting similar source mechanisms in both wet and dry states.

It is proposed that the failure mechanism is basically the same in the wet and dry conditions and that the reduction in the number of emissions after soaking is simply a consequence of the water, which was taken up,

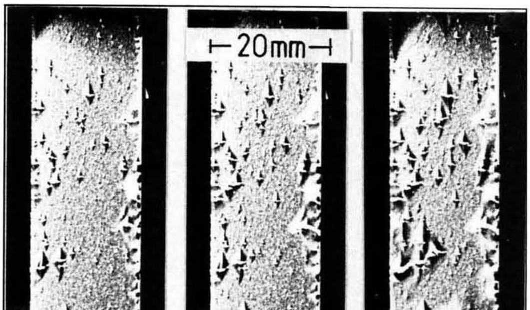

Figure 8—Diamond shape damage on full system cathodic tested dry

dissipating the stress waves by scattering and absorption. It was found from film thickness measurements, on the wet and dry cathodic systems, that the paint coats swelled during immersion. It is likely that the earlier onset of gross damage occurred due to the coatings swelling with the absorbed water, and hence, altering the stress state, rather than a change in mechanism. *Figure* 8 shows the typical surface damage that was observed in both the wet and dry cases; this type of diamond shaped peeling is indicative that the paint coating was in compression on the substrate.[5] The effect of water is to put the coating into greater compression and hasten the growth of the gross damage. Thus, the greater susceptibility of the cathodic systems to immersion is in accord with the capacitance measurements, which showed that the cathodic systems absorbed more water and retained it for longer times than the anodic systems. Since only two electrocoats have been studied it is not possible to generalize to all anodic and cathodic systems. This investigation does, however, draw attention to the fact that not all cathodic electrocoats are better than all anodic electrocoats.

The difference in behavior between the rinsed and unrinsed specimens of the full system cathodic when tested wet must be the consequence of an additional detrimental factor coming into play in the unrinsed case. Work on systems with various combinations of phosphates and electrocoats demonstrated that, as a general rule, the better the adhesion the acoustically quieter the system on straining,[5] suggesting that rinsing improves adhesion. Cooke[8] has investigated a cathodic electrocoat system and found, using conventional tests, poorer adhesion when the phosphate was not rinsed. Clearly residuals from the electrolyte on the nonrinsed phosphate may contaminate the cathodic electrocoat and/or the phosphate-electrocoat interface, but the exact role of these residuals is not yet understood.

SUMMARY

Anodic systems absorbed less water and retained it for shorter times than cathodic systems. As a consequence anodic systems were not greatly affected by immersion in water.

The acoustic emission associated with gross damage occurred at lower strains when the cathodic systems were wet than when they were dry. It is proposed that this was mainly due to the swelling, which accompanied the absorption of water, putting the coatings into greater compression and hence, hastening the onset of damage.

ACKNOWLEDGMENTS

The authors would like to thank I.C.I. Paints Division for supplying the test panels and the facilities for carrying out the capacitance measurements, and Mr. A. G. Norman for assistance. The authors gratefully acknowledge Professor D. W. Pashley for providing research facilities and the S.R.C. for financial support.

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APPENDIX

Stress waves produced by a material as it deforms are quite commonly used to give advance warning of failure, such as when a piece of wood creaks during cracking. Such stress waves are formed in many materials but generally of lower amplitude and higher frequency than those in wood, making them less audible. However, using the advanced electronics that developed in the 1960s, these stress waves can be investigated and it is possible to distinguish between the various failure modes that can occur in a material.[9]

A transducer (usually piezoelectric) is attached to a sample through a layer of grease or glue and is held in place with a spring clip or rubber band. The sample is then tested (eg. in a tensile test) and if an abrupt change takes place within the sample (like a crack growing or the onset of corrosion), stress waves will be formed which propagate through the material and appear as small, temporary displacements on the surface. The signal generated by the piezoelectric crystal, in response to these displacements, is very small and has to be amplified prior to any analysis. It is also filtered to remove any low frequency background noise present and to cut out the high frequency signal, which is subject to large attenuations.

For each source event in the sample (eg., each crack increment) the transducer will produce a decaying sinusoidal

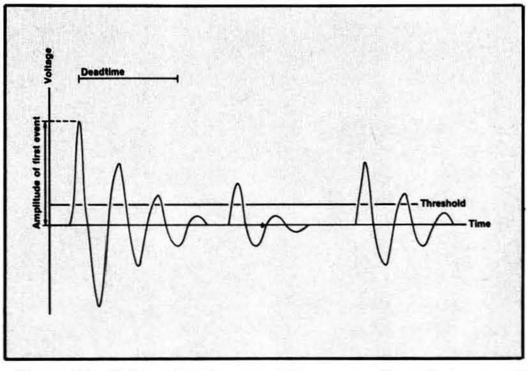

Figure A1—Schematic diagram of three acoustic emission event pulses. Shown as voltage v. time

signal. *Figure* A1 shows a schematic diagram of three such events (typically thousands of events occur during one test). The simplest way to analyze the signal is in terms of "ringdown counts." A ringdown count is recorded each time the signal exceeds a preset threshold; the example shown would give six ringdown counts but only three event counts. The recording of "events" is rather electronically more complex, involving the use of a deadtime in order to count each decaying sinusoid as one event. "Amplitude distributions" give a record of the highest voltage attained in each event in the test and are usually presented as a histogram with each column representing the number of events with amplitudes within the interval shown, eg., 20 to 21 dB

$$\text{where dB} = 20 \log (V/Vo)$$

Vo is a reference voltage.

Acoustic emission has found widest application in the field of nondestructive testing, allowing large structures to be monitored continuously. The same technique is also used to investigate the details of failure on a smaller scale in the laboratory and studies involving metals, ceramics, composites, polymers, and even rocks have been reported.[10]

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Ellipsometric Studies On the Cathodic Delamination Of Organic Coatings on Iron and Steel

Joseph J. Ritter
National Bureau of Standards*

A number of mechanisms have been proposed to explain the cathodic delamination of organic coatings from iron and steel undergoing corrosion. Ellipsometric studies carried out on these substrates protected by either collodion, acrylic lacquers, or polybutadiene indicate that dissolution of the interfacial oxide in the highly alkaline cathodic environment constitutes the predominant mode of delamination. Moreover, the spatial development of cathodic areas has been probed both ellipsometrically and through subcoating electrochemical pH measurements.

The oxide dissolution proposition is supported by independent experiments with uncoated iron in a highly alkaline medium.

INTRODUCTION

The corrosion related failure of organic coatings on iron or steel is brought about through two destructive processes: the anodic dissolution of metal and the cathodic delamination of the coating. The development and effects of these phenomena have been treated in detail by a number of workers.[1-4] While in a practical sense, the anodic dissolution of metal is relatively well understood, the mechanisms for coating delamination are still not resolved. For example, previous authors have proposed various delamination mechanisms ranging from an active role by water molecules in displacing substrate-polymer bonds to cohesive failure of the polymer.[5-7] Each of these ideas can be supported by experimental evidence from specific coating-substrate systems. Thus, perhaps it is most reasonable to consider a predominant mode of delamination in connection with a given coating-substrate system. The purpose of the study described here is to present evidence for yet another mechanism of delamination, the dissolution or alteration of the interfacial air-formed oxide films.†

In an earlier publication from our laboratory we suggested this possibility based on ellipsometric observations of the iron/collodion system.[8] Workers at Lehigh University have arrived at a similar conclusion for other systems through independent means.[9] We have shown in previous work how qualitative ellipsometry combined with electrochemical pH measurements and microanalyses can provide valuable information about subcoating phenomena and chemistry.[4,8,10] While this early work focused on the iron/collodion system, the results presented in this report are derived from both iron and steel substrates protected by either collodion, polystyrene, acrylic lacquers, or polybutadiene. In addition, the use of our newly automated ellipsometer system[11] has provided detailed insights into the real time evolution of the phenomena surrounding cathodic delamination. The interpretations are supported by independent experiments, described here, with uncoated iron in simulated subcoating environments.

EXPERIMENTAL

All iron specimens were mounted in epoxy and finished on a series of SiC papers of 320, 400, and 600 grit. Final polishing was done with 6, 1, and 0.05 μm abrasives.

Low carbon stamping quality steel, supplied by Dr. Henry Leidheiser, Jr., Lehigh University, as 0.71 mm sheet, was used with the as-received 600 grit finish. The sheets were sectioned into 2 cm squares, coated, and cast in epoxy in a recessed manner, so that only one face of the material was exposed. Dr. Leidheiser also supplied

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† For the purpose of this publication, the term "air-formed oxide film" refers to the oxide present on the metal surface at the end of the surface preparation regimen.

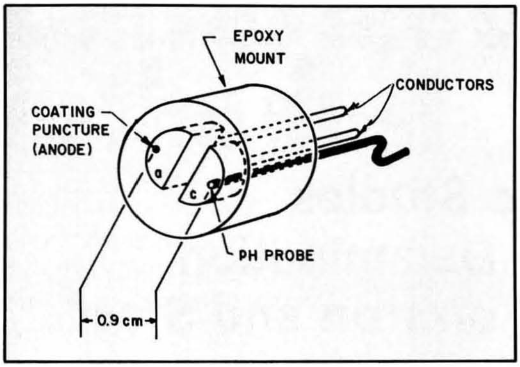


Figure 1—Drawing showing the relationships of components for the segmented specimen. "a" and "c" are sections of iron formed by dividing an iron cylinder along its altitude and diameter

specimens of this same steel with 20 μm of heat-cured polybutadiene applied. The coated specimens were mounted in epoxy in a similar recessed fashion.

With respect to other coating materials, collodion was diluted 1:1 with methanol, while the polystyrene, and two proprietary acrylics, designated A and B were dissolved and/or thinned with toluene. These materials were applied by dipping, usually resulting in a 25 to 100 μm cured coating after 18 hr at room temperature (22 to 25°C). Heat-cured acrylic coatings were prepared in the same manner but subjected to 200°C for 40 min after the 18 hr room temperature cure.

The details of specimen arrangement and the ellipsometric technique have been described previously.[8,10] In brief, the technique involves the passage of elliptically polarized light through the transparent coating and reflection from the substrate surface. In some experiments, a miniature pH probe is used to simultaneously monitor the environment at the coating–substrate interface. Changes in the phase ($\delta\Delta$) and amplitude ($\delta\Psi$) of the reflected light have been shown to be indicative both of alterations in surface texture (roughness) and changes in the thickness of the surface oxide films. Thus, the technique is of value in studying the behavior of the substrate under the coating as the corrosion process proceeds.

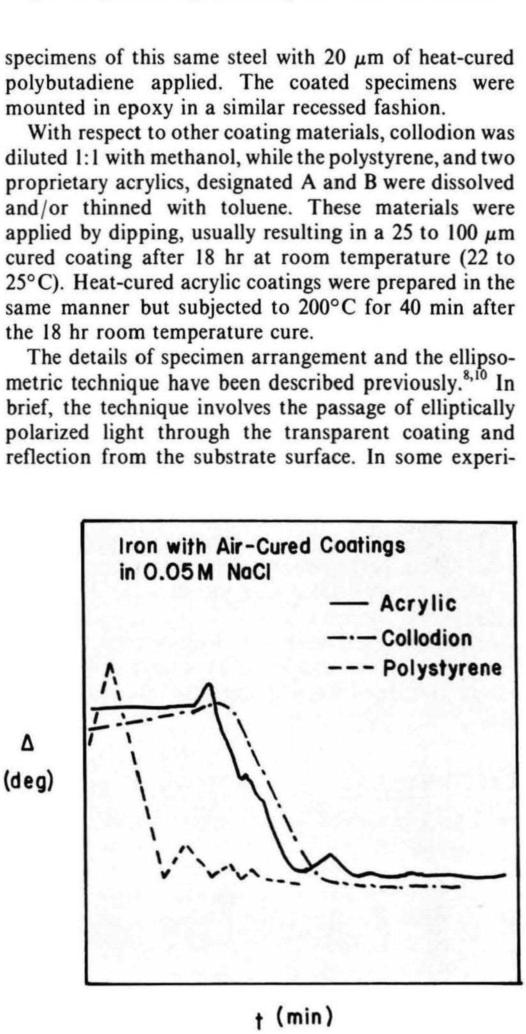


Figure 2—Plots of phase retardation (Δ) vs time for three iron/coating systems undergoing corrosion in a dilute chloride medium. The coatings were cured in air at room temperature

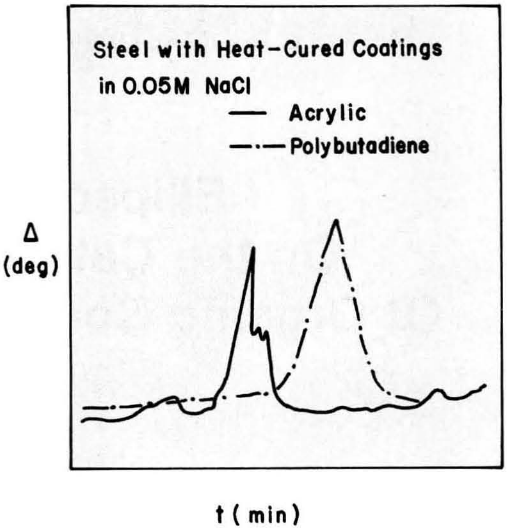


Figure 3—Plots of phase retardation (Δ) vs time for two steel/coating systems undergoing corrosion in a dilute chloride medium. The coatings were cured in air at 200° C

All coated specimens were studied in 0.05 M NaCl at 25°C. The corrosion process was initiated by damaging the coating in a single area with either a 0.07 cm drill point or incising a 1 mm slit with a scalpel. Uncoated iron specimens were examined in aerated, saturated NaOH at 25°C.

Preparation of Segmented Specimens

Segmented specimens were devised as one means to examine the spatial development of subcoating-cathodes. This technique permits the initial isolation of remote and proximate (relative to an anode) cathodes for independent study. A 1 cm diameter × 1 cm long iron cylinder was divided into two parts, each part fitted with a copper conductor and cast into a single epoxy slug as shown in *Figure* 1. An opening was drilled through one of the segments (c), to accommodate a miniature (1.5 mm dia.) pH probe. The drilled hole was temporarily closed with a polytetrafluoroethylene plug and the entire slug face coated with acrylic lacquer "A" which was air-cured at 25°C for 18 hr. The specimen was mounted horizontally in an ellipsometer cell and immersed in 0.05 M NaCl. The cell mount permitted horizontal translation of the specimen so that either segment a or c could be examined ellipsometrically.

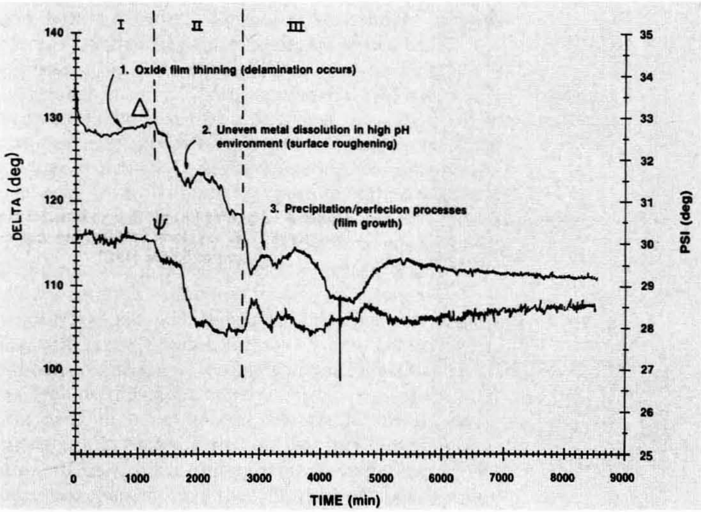


Figure 4—(Δ) and (Ψ) plotted vs time for the iron/collodion system undergoing corrosion in 0.05M NaCl

RESULTS AND DISCUSSION

General Effects of Coating Cure Procedure

Figures 2 and 3 schematically show the responses of the ellipsometric phase retardation (Δ) parameter with time for coated iron and steel specimens. For the room temperature cured coatings, the curve shapes are similar but the heat-cured coatings show a very different ellipsometric response. The interpretation of these responses with respect to subcoating phenomena are given below.

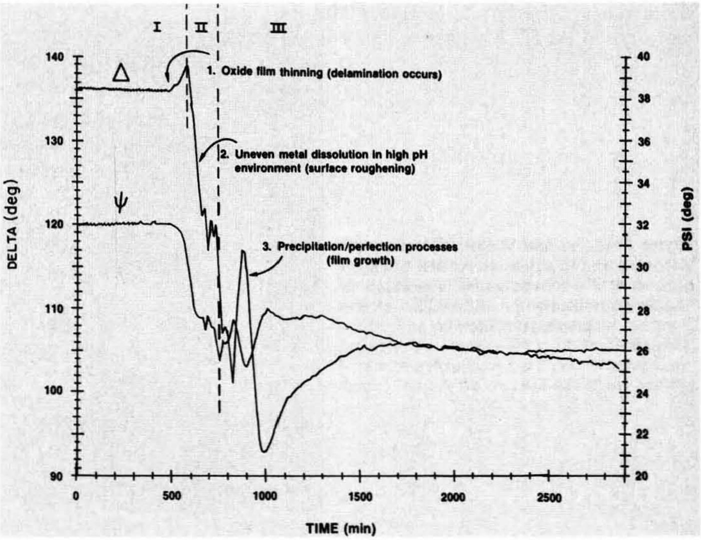
Ellipsometric Response For Room Temperature Cured Coatings

Figures 4, 5, and 6 show the detailed real time behavior of the ellipsometric parameters Δ and Ψ for room temperature cured collodion and the two types of proprietary acrylic coatings. Overall, the curves show similar behavior on different time scales. Since the coated metal systems are optically quite complex, the ellipsometric results are interpreted in a qualitative sense.[10]

Within Region I each of the three systems show a rise in Δ and a concomitant decline in Ψ as corrosion sets in. This type of behavior is interpreted as a change in oxide film thickness and the direction of change is indicative of a film thinning process. The interpretation of the Δ and Ψ changes is derived from the behavior of these parameters for uncoated iron in saturated NaOH (see *Figure* 7). Saturated NaOH represents a reasonable subcoating environment based on *in situ* pH measurements.[8] These changes are related to the dissolution of the oxide film in the highly alkaline cathodic environment. Since the coating is bonded to this oxide layer, delamination has occurred.

Within Region II, Δ and Ψ decline sharply in concert.

Figure 5—(Δ) and (Ψ) plotted vs time for the iron/acrylic "A" system undergoing corrosion in 0.05M NaCl



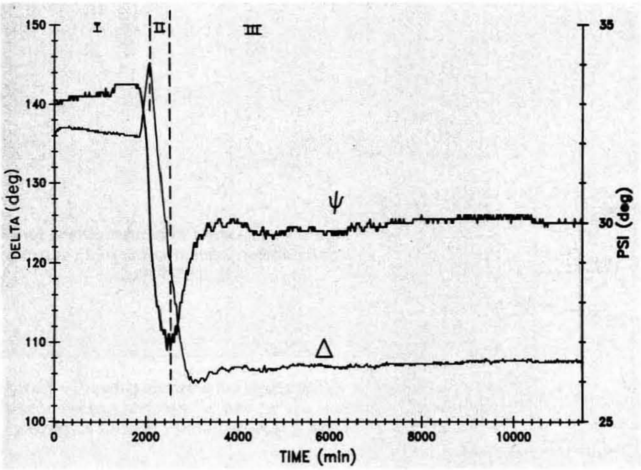


Figure 6—(Δ) and (Ψ) plotted vs time for the iron/acrylic "B" system undergoing corrosion in 0.05M NaCl

This concerted response is typical of a change in surface texture (roughening). The interpretation of the behavior of Δ and Ψ is based on our observations of uncoated iron in borate buffer solution after potential cycling,[8] which, in effect, gives a smoother surface. In the potential cycling experiments, Δ and Ψ *rise* in concert, which is the opposite effect from that observed for coated metals. Since phenomenon described in Region I was a thinning of the oxide layer, it is reasonable to postulate the presence of patches of film-free metal. The high pH environment promotes direct metal dissolution from these patches and the surface becomes roughened.

Within Region III, Δ and Ψ are again in opposition. The overall result is indicative of an increase in film thickness. Since the phenomena in Regions I and II derive from the dissolution of iron either from the oxide or from the metal itself, we postulate that soluble iron species,* like the OH^- ions, accumulate under the coating. Ultimately, solubility product constants are exceeded and precipitation occurs. The complexity of the ellipsometric response in Region III for *Figures* 4 and 5 may arise from one or both of the following factors: the deposition of metastable films which partially redissolve and reprecipitate until a stable format is achieved; or the precipitation of a film which undergoes massive changes in its refractive index with respect to its immersion medium as it thickens.

Ellipsometric Responses for Heat-Cured Coatings

Figure 3 shows typical ellipsometric responses for steel with either polybutadiene or an acrylic lacquer which

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*The exact nature of these species is under investigation.

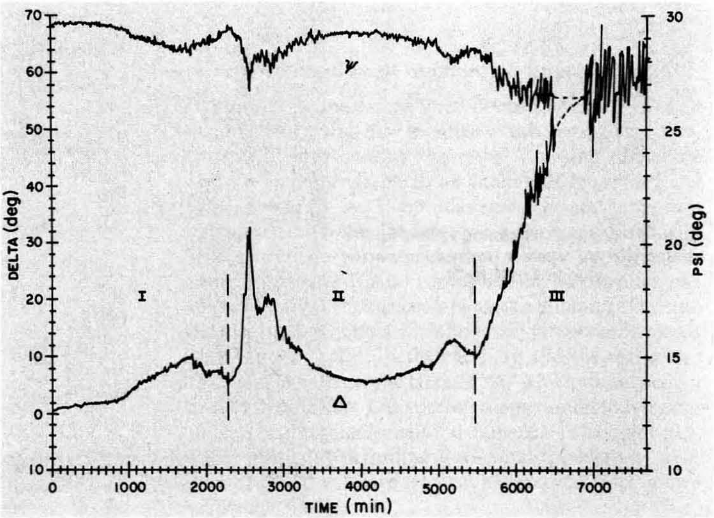

Figure 7—Δ, Ψ, and V plotted vs time for uncoated iron in saturated NaOH. Changes in Δ and Ψ when potential is lowered to −1200 mV indicate the dissolution of the air-formed oxide film

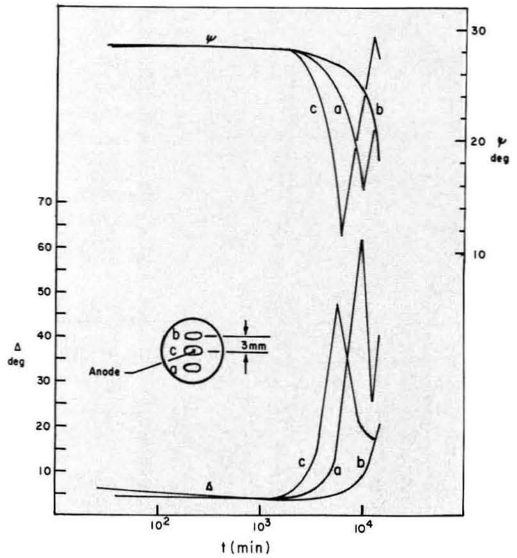

Figure 8—(Δ) and (Ψ) plotted vs time for the steel/acrylic "A" system undergoing corrosion in 0.05M NaCl. Acrylic "A" was heat-cured

have been heat-cured. Several factors should be considered initially using a steel specimen with a heat-cured acrylic coating as an example.

Although the acrylic coating material "A" which was used was the same as that used to generate *Figure* 5, the heat treatment process undoubtedly modifies the final polymer structure. In addition, recent evidence points to a "zone" of iron ions in that portion of the heat-cured polymer nearest to the oxide layer.[12] Moreover, the oxide layer under the polymer thickens considerably during the curing process. Measurements in our laboratory by cathodic reduction of stripped specimens show typically a 14 nm oxide film, while an ordinary air-formed film will range between 2.5 to 3.5 nm. The utility of cathodic reduction to estimate oxide film thicknesses has been described previously.[8]

In examining the general features of the Δ and Ψ parameters in *Figure* 8, we note that they move in opposition to each other throughout the experiment. The suggestion here is that the observed changes are due predominantly to alterations in the oxide layer and that changes in surface texture (roughening) are insignificant. This interpretation is supported by lack of evidence from potential cycling experiments[8] for surface roughening at the conclusion of these measurements.

A detailed interpretation of this type of curve must remain somewhat speculative until more evidence can be accumulated. In Region I, the initial increase in Δ and decrease in Ψ at ~ 1800 min indicate an oxide film thinning in the high pH environment estimated at ~ 5 nm (total film ~ 14 nm). Coating delamination probably occurs at this point, but the metal itself is still protected by ~ 9 nm of film. Thus, metal dissolution leading to surface roughening does not occur.

The events beyond 2000 min are not well understood. The sharp rise of Δ and decline in Ψ maximizing at ~ 2500 min (Region II) is believed to arise from changes in the polymer near the interface. The subsequent reversal of Δ and Ψ may be related to the precipitation process noted earlier for the room temperature cured systems. The substantial rise of Δ and leveling of Ψ along with the concomitant signal deteriorations in Region III (beyond 5300 min) may be related to the accumulation of a substantial liquid layer at the interface.

Dissolution of Air-Formed Oxide Films on Iron

It is well known that air-formed oxide films on iron can be removed by cathodic reduction in borate buffer solutions at ~ pH 8.5. Results in our laboratories have shown that both air-formed and thermally grown films on iron and steel can also be dissolved in aerated saturated NaOH (pH > 14) at −1200 mV S.C.E.

Typical ellipsometric evidence for this process on uncoated iron is shown in *Figure* 7. Note that when the cathodic potential is applied, Δ and Ψ move in opposite directions as the film is removed. These observations

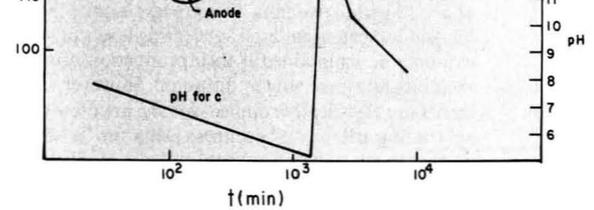

Figure 9—Phase retardation (Δ) and amplitude attenuation (Ψ) plotted vs time for the steel/polybutadiene system undergoing corrosion in 0.05M NaCl. The coating was heat-cured. The open ellipses shown in the inset indicate the three regions on the specimen face where ellipsometric measurements were made. The curves are labeled corresponding "a," "b," and "c"

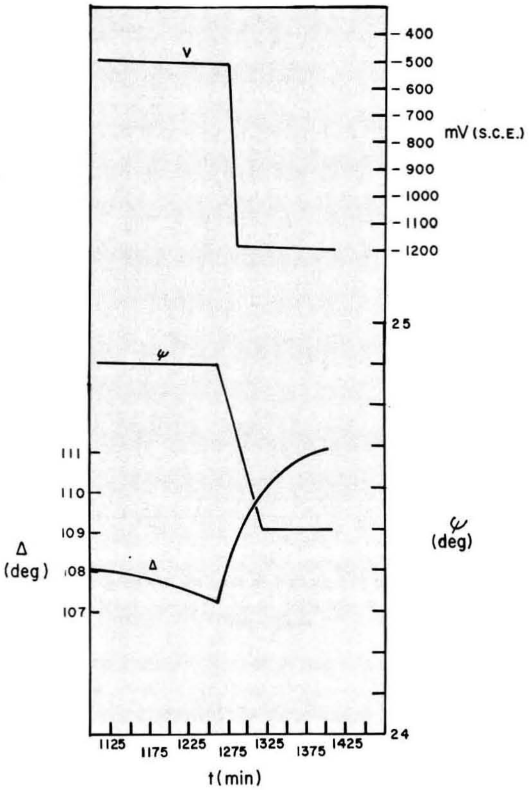

Figure 10—Δ, Ψ, and pH plotted vs time for the segmented iron/acrylic "A" system in 0.05M NaCl. Inset shows a facial view of the specimen and open ellipses indicate regions studied ellipsometrically

are consistent with those mentioned earlier for coated specimens undergoing cathodic delamination, i.e., the presence of a highly alkaline environment promoting dissolution of the interfaced oxide film. Unfortunately, the potential at the coating/substrate interface is not known, so that it is not presently possible to simulate the subcoating conditions exactly. However, these simulation experiments suggest that oxide film dissolution is a reasonable process to expect in cathodic regions.

Development of Cathodic Areas

Since cathodic regions under coatings ultimately become the sites for coating delamination, it is important to understand the development of these regions. The following experiments were designed to probe, in a preliminary fashion, the spatial disposition of cathodes in the vicinity of an active anode.

POLYBUTADIENE ON STEEL: *Figure* 9 shows a study of PBD coated steel undergoing corrosion. The specimen was arranged to be translated ~ 3 mm to either side of a central position to observe the progress of subcoating events at different regions. In this manner, the experiment becomes a study in triplicate under identical conditions. The coating was damaged at the specimen center at ~ 1350 min. It will be noted that significant changes in the ellipsometric Δ and Ψ parameters occur first at the center "c" position. The general shape of the curves is similar to that for the heat-cured acrylic shown in *Figure* 8. As mentioned previously, a detailed analysis of the ellipsometric responses for the heat-cured coating systems has not yet been possible. Again we propose that at least a part of the initial rise of Δ and decline in Ψ is due to oxide film thinning. From this effect we infer that delamination has taken place. The first evidence for film thinning is manifested in the cathodic region immediately surrounding the induced anode. Further evidence for this activity gradually appears in regions "a" and "b," some 3 mm distant, on somewhat different time scales. An asymmetric development of the delamination process is apparent. While, as a first approximation, it can be proposed that the cathodic regions develop radially outward from the central anode, the possibility of cathodes developing and propagating remotely cannot be excluded. Thus, the asymmetry can arise from either a true preferred propagation of the delamination front from the central holiday towards region "a" or from the progress of a remote cathode in or near region "a." Evidence for the existence of remote cathodes has been obtained in experiments with a segmented substrate.

SEGMENTED FE SPECIMEN WITH ACRYLIC COATING "A": In dealing with the corrosion of coated metal systems the location of the anodes is usually apparent. However, the location of cathodes which support these anodes is often more difficult to ascertain. Intuitively, one might expect cathodes to develop initially in the region immediately surrounding an anode. Our experiments with a coated, segmented iron specimen indicate that the real time development of cathodes can be a relatively complex process.

Figure 10 shows the phase retardation (Δ) and pH data for the segmented iron sample. While the coating is intact during the first 1400 min, Δ for both segments changes only slightly while the pH is erratic and ranges between 5 and 8. The coating on segment "a" is punctured at 1400 min, while that of segment "c" is left intact. If segments "a" and "c" are coupled electrically by joining the copper conductors attached to each, the pH on "c" rises to about 13.5 while the ellipsometric Δ parameter for "c" is relatively constant. Delta for "a" shows the typical response described and interpreted earlier for this substrate-coating system (*Figure* 5): a brief rise followed by a substantial decline. If the conductors joining "a" and "c" are uncoupled, the subcoating pH drops to a value near eight within a few minutes. Rejoining the conductors results in a subcoating pH reading of above 13 within five min. This process is quite reproducible and indicates that high subcoating levels of OH^- ions can only be maintained if their production rate exceeds their loss rate (probably by diffusion). However, if the segments are electrically coupled, for the next few days, the subcoating pH on "c" declines. Delta for "a" decreases markedly while Δ for segment "c" also declines, but to a much lesser extent.

These responses are interpreted as follows: oxygen and water permeate the coating in some areas and reach the surfaces of "a" and "c" during the first 1400 min. Thus, two of the three components to effect the cathodic reduction of O_2 are in position under the coating. Moreover, small quantities of adsorbed O_2 and water were undoubtedly present on the surface before the coating was applied. When the coating on "a" is damaged, an anode develops rapidly at the puncture site and supplies the final component, electrons, for O_2 reduction. For "a" the electron flow is through the metal sector itself, while for "c" the electrons must take the longer path through the coupled conductors. There is a net accumulation of product OH^- ions under the coating in both sectors. Initially, the rate of the reduction reactions is probably limited by the rate of Na^+ ion permeation[13] since these ions serve to transport charge through the coating and maintain electroneutrality with the subcoating OH^- ions. However, a second transport mechanism develops on "a" in the vicinity of the puncture. Oxygen, water, and Na^+ ions start to migrate laterally and establish proximate cathodes surrounding the active anode.[9] As these proximate cathodes grow they gradually consume a larger portion of the anodically generated electrons. Eventually the remote cathodes on "c" are no longer needed and cease to function. Undoubtedly, the presence of low resistance pathways within "a" and relatively higher resistive pathways between "a" and "c" contribute to the relative viability of these cathodic regions.

At the conclusion of the experiment, the acrylic coating was stripped with toluene and each segment individually subjected to cathodic reduction in borate buffer solution. Segment "a" showed a net oxide film growth of 7.7 nm and evidence of surface roughening. Segment "c" showed a net oxide film growth of only 2.7 nm and little if any evidence of surface roughening. These results are consistent with the picture of extensive cathodic activity on "a" and limited cathodic activity on "c" provided by the ellipsometric responses.[8]

SUMMARY

(1) Iron and steel specimens with selected organic coatings bonded to their air-formed oxide films have been studied while undergoing corrosion. Ellipsometric evidence on these systems with room temperature cured coatings indicate that dissolution of the interfacial oxide film is the predominant mode of coating delamination.

(2) Similar studies on systems where the coatings were heat cured, suggest that a similar delamination mechanism may apply. The complexities of a thickened interfacial oxide and probable modification of the polymer during the curing process have rendered the ellipsometric data difficult to fully interpret.

DR. JOSEPH J. RITTER is a Research Chemist at the National Bureau of Standards. He currently directs a project concerned with fundamental aspects of corrosion phenomena and chemistry which occur when painted metals corrode. Dr. Ritter holds a Ph.D. in Inorganic Chemistry from the University of Maryland, and has been working in the corrosion field for about four years.

(3) Air and thermally formed oxide films on iron and steel can be dissolved in strong NaOH solution at cathodic potentials. This observation supports the oxide dissolution mechanism proposed for cathodic delamination.

(4) Ellipsometric experiments combined with subcoating pH measurements and specimen modifications have been utilized to probe the development of cathodic areas. The results suggest that remote cathodes are important during the early stages of corrosion but that proximate cathodes tend to dominate as corrosion progresses.

ACKNOWLEDGMENT

The author is grateful to Dr. J. Kruger for many helpful discussions. This work was partially supported by the Office of Naval Research under contract No. NAONR 18-69.

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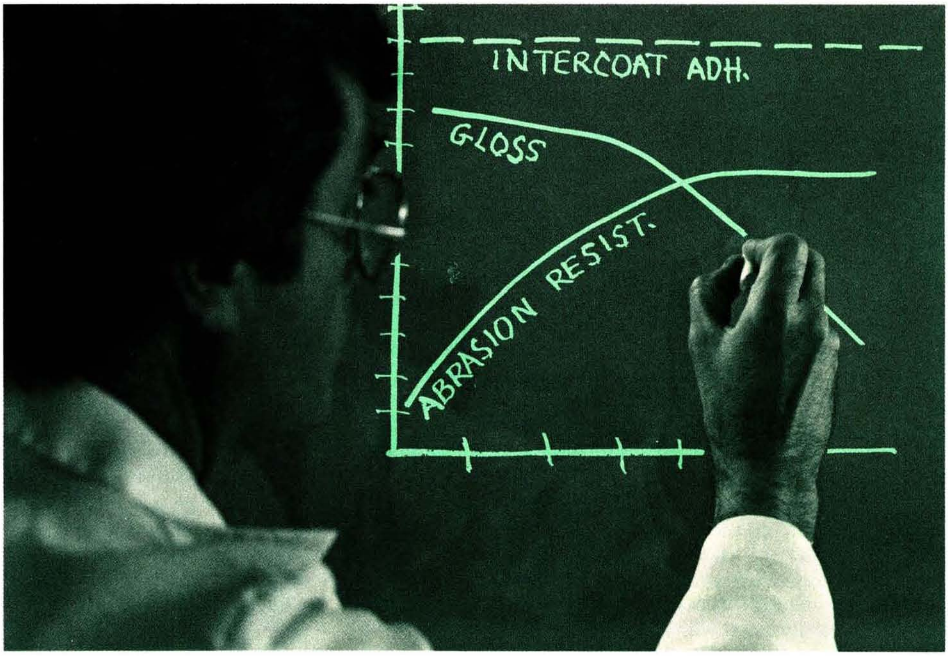
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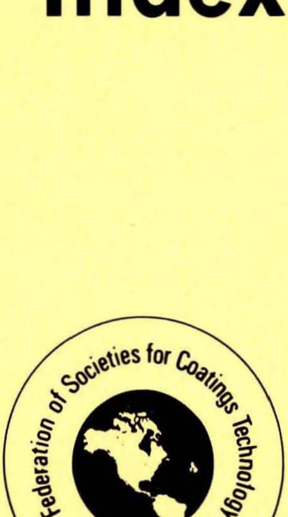
Annual Index



Volume 54
Numbers 684–695
January thru December, 1982

Journal of Coatings Technology 1982 Annual Index

Keyword Subject Index

Prepared by Technical Information
Systems Committee

Alphabetical Listing of Papers

Author Index

Proceedings Of the Paint Research Institute

No. 149—Report of the Research Director, Apr., p. 21.

No. 150—Synthesis of Fungicidal Monomers, Polymers, and Latices, July, p. 27.

No. 151—Preliminary Evaluations of the Biological Activity of Polymers with Chemically Bound Biocides, July, p. 41.

No. 152—Dependence of Surface Preparation in PMMA Coatings on Preparation History, Nov., p. 31.

Society Meetings

BALTIMORE SEPT.

"Driers for Water-Borne Coatings"

Thomas Mitchell, of Tenneco Chemicals Co., presented the Tenneco gavel to President Donald Keegan, of Valspar Corp. Other officers for 1982-83 are Vice-President—Joseph Giusto, of Lenmar, Inc., and Treasurer—Robert M. Hopkins, of Glidden Pigments Group.

Samuel J. Bellettiere, of Tenneco Chemicals Co., presented "DRIERS FOR WATER-BORNE COATINGS."

A review of the function and mechanism of the various metallic driers in paint films was given. Mr. Bellettiere then described their use in water-soluble alkyds.

EDWARD B. COUNTRYMAN, *Secretary*

Chicago Society Officers for 1982-83 are: Seated from left to right: Vice-President—John Ingram; President—Layton F. Kinney; and Marty Balow. Standing from left to right: Immediate Past-President—John Petty; Secretary—Fred Foote; Society Representative—John Vandeberg; and Treasurer—Orville Brown

HOUSTON SEPT.

"PRI Mildew and Corrosion Research"

Dr. C. Malcolm Hendry, of Hempel Technology and Vice-President of the Paint Research Institute (PRI) discussed "PRI MILDEW AND CORROSION RESEARCH." His talk was divided into two parts: "Fungal Disfigurement of Paint Film" and "Mechanism of Corrosion Inhibitors in Organic Coatings by Oxidizing Inhibitors."

Dr. Hendry stated that mildew is not restricted to any specific type of coating, including water-reducible resin emulsions and solvent-borne. Many different fungi have been isolated from paint films, but one, *Aurobasidium Pullulans (A. Pullulans)* accounts for most disfigurement. *A. Pullulans* has the ability to withstand extreme dryness and temperatures; it has pigmented spores and hyphae that protect it from U. V., and a sticky cell wall exudate that facilitates its adherence to surfaces, said Dr. Hendry.

A. Pullulans must have a source of carbon, nitrogen, phosphorous, oxygen, and certain minerals and vitamins, most of which are found in paint films, except nitrogen, which is easily supplied by other detritis (crud) found on paint films. The rate growth of *A. Pullulans* varies significantly based upon the type of paint involved. Linseed oil and other vegetable drying oils and paints are more conducive to fungal growth than are synthetic resinous paints. The most important growth factor for *A. Pullulans* on paint films is available moisture.

According to Dr. Hendry, the most important deterrent to fungal growth to date has been the presence of one or more antimicrobial agents in the paint formulation. These include both organic and inorganic fungicides and fungistats, with the most effective being those with a slight solubility in water. Unfortunately, this solubility has ultimately caused the fungicide to be leached from the paint film, thus, leaving the film vulnerable to fungal growth. What is needed is a longer lasting fungicide that inhibits none of the other characteristics of the paint either in its liquid or converted state.

PRI's work on the problem of mildew is presently funded by a consortium of companies and organizations, stated Dr. Hendry. When research in the mildew problem was begun by PRI several years ago it was quickly discovered that the industry really knew very little about the microorganisms which cause mildew. A number of grants, funded by PRI, were given to researchers and a tremendous amount of basic information necessary for a scientific approach to the problem was developed.

The problem of mildew growth on paint did not develop overnight and probably causes the greatest number of complaints on architectural paints in the U.S. today. PRI-sponsored research on mildew is encouraging and has brought us a long way towards solution of the problem.

Dr. Hendry began the second part of his talk by stating that there are four major classes of corrosion inhibitors in organic coatings: oxidizing inhibitors, organic compounds, metallic cations, and nonoxidizing inorganic salts.

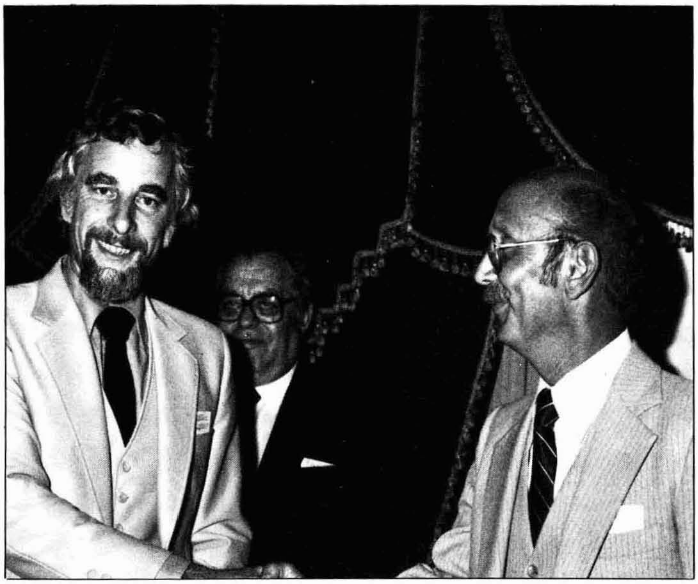
Chromate is the most widely used oxidizing inhibitor and lead the most widely used metallic cation. However, it is not really known how chrome or lead work as an inhibitor. According to Dr. Hendry, from what is known there are six requirements for an *ideal inhibitor*: (1) Must be effective at Ph's in the range of 4 to 10; (2) Should react with the metal surface such that a product is formed with a much lower solubility than the unreacted inhibitors; (3) Should have a low but sufficient solubility; (4) Should form a film at the coating/substrate interface that does not reduce the adhesion; (5) Must be effective both as an anodic and a cathodic inhibitor; and (6) Should inhibit the two important cathodic reactions:

$$H_2O + \tfrac{1}{2}O = 2OH^-$$
$$2H^+ + H_2$$

Some of the important unsolved problems in corrosion of painted metals are:

(1) The development of an accelerated atmospheric corrosion test, the results of which correlate well with service experience.

(2) The development of a satisfactory test for screening inhibitors for use in coatings.



Los Angeles Society incoming President Romer Johnson (right), is welcomed to the office by Immediate Past-President Jan Van Zelm. Newly-elected Secretary, Mike Gildon, looks on

(3) The development of a corrosion monitor that gives information about the progress of corrosion and allows one to predict the lifetime before repainting is necessary.

(4) What is the mechanism of corrosion or adhesion loss of coated metals in the hot water test?

(5) What is the reason for the poor performance of some coatings when the coatings are applied over steel substrates that are abrasively cleaned with steel grit?

(6) Development of a better understanding why cathodically electrodeposited organic coatings provide such good protection against delamination in chloride-containing environments.

(7) Development of a method for the detection of condensed water at the coating/substrate interface.

(8) Achieving a better understanding of the potential distribution within a delaminating region.

(9) Development of information about ionic transport through the coating when the metal substrate is polarized cathodically.

(10) Development of a better understanding of the chemical nature of the bond between the organic coating and the substrate metal and how the bond changes with time.

R.D. BATCHELOR, *Secretary*

KANSAS CITY SEPT.

"Solvent Reclamation"

Immediate Past-President Mike Bauer, of Tnemec Co., Inc., presented incoming President Mel Boyer, of Patco Coating Prod., with the 50th Anniversary attache case. President Boyer also received the Tenneco gavel from Ted Terherst, of Abner-Hood Inc. After accepting the gavel, President Boyer presented Mr. Bauer with a Past-President's pin.

President Boyer introduced the 1982–83 officers: Vice-President—Mike Bauer; Secretary—Gene Wayenberg, of Tnemec Co., Inc.; and Treasurer—Dennis Mathes, of Cook Paint & Varnish Co.

Larry Kytasaari, Chairman of the Manufacturing Committee, reported on the committee's plans to update a slide/tape presentation on sand mill operation. He explained how the committee has recently circulated a questionnaire concerning straining and filtration methods. The results from this survey will be available when completed, according to Mr. Kytasaari.

Earl Pifer, of Finish Engineering, discussed "SOLVENT RECLAMATION."

Mr. Pifer gave a brief summary of why the company was involved in solvent reclamation.

A chart illustrating sources of organic wastes revealed that approximately 50% of all organic wastes were industrial solvents. According to Mr. Pifer, current regulations make the generators, storers, transporters, and disposers of industrial wastes responsible forever.

The best way to dispose of solvents is to reclaim them, said Mr. Pifer. He presented the following example: In 1973, the cost of acetone was 35¢/gal. To dispose of this, it would be sold to a reclaimer or someone who would burn it for 5¢, for a total cost of 30¢/gal. Today the solvent costs over $2.50 and it would cost over $1.00 to dispose of it. By using your own still, you can pay for the equipment and save money in a short period of time.

Mr. Pifer discussed the various types of stills and introduced his company's new Little Still, which reclaims about 15 gal/8-hour shift for a smaller user of solvent. Safety, design features, and operating costs (about 12¢/gal) were discussed.

Q. When the Little Still shuts off automatically, can you tell what is wrong?

A. Yes. The lights and dials would show you what and where the problem is.

Q. When the still shuts off, would you have to shut down the operations to restart?

A. Yes. Although this problem does not happen often, this still has easy access and is easily cleaned.

Q. Do you have fractionating capability with this still?

A. It is not standard with this unit, but a fractional column could be added. It would have to be designed on an individual basis, depending on the solvents.

Q. Do you have to have a permit to run this still?

A. Current EPA and California regulations require no permit if you reclaim your own solvent for your own reuse. If you are reclaiming solvent for someone else, then you would need a permit. Some states require registration of this still, but not a permit.

GENE A. WAYENBERG, *Secretary*

LOS ANGELES SEPT.

"Corrosion Inhibitor"

Immediate Past-President Jan Van Zelm installed the officers for 1982–83: President—Romer Johnson, of Dorsett & Jackson, Inc.; Vice-President—L. Lloyd Haanstra, of Ameritone Paint Corp.; Secretary—Michael Gildon, of Guardsman Chemicals; and Treasurer—Earl B. Smith, of Spencer Kellogg Div.

Hans Roest, of Tenneco Chemicals, presented the new gavel to President Johnson. Mr. Van Zelm was awarded with the Past-President's Plaque.

A moment of silence was observed for Joe Ellsworth and Clifford Ford, two pioneer members in the industry who recently died.

Lloyd Haanstra spoke on the CARB 113 regulation. He stated that on September 1 the Board passed the same regulation essentially passed in San Diego; allowing a 380 level for nonflat coatings and 250 level for flats. Also, the exception for quick drying enamels was passed—the same as San Diego.

Bob Athey, Education Chairman, discussed the Education Program and the Course offerings for this year.

Ken Haagenson, of Buckman Laboratories, Inc., spoke on "NON-LEAD, NON-CHROMATE CORROSION INHIBITOR FOR WATER-THINNED COATINGS."

Wood textures, hot rolled steel exposure, cold rolled steel, galvanized steel, and aluminum were discussed. A slide presentation featured the many studies and evaluations which were made in the Warehouse in Memphis, TN. Although there are several non-lead, non-chromates on the market, Mr. Haagenson stated that in the future newer and partly non-chromates will be marketed.

Q. Does the moderately soluble barium metaborate present any problem in compatibility with standard dispersants—during dispersion or during oven drying?

A. Any of the non-lead and non-chromate and chromate lead pigments are going to require the use of dispersants that are compatible to the active pigments. There are a wide range of dispersants that can be used. There are a few that should not be used as stability problems could result.

Q. What work of exposure data do you have on Rhoplex MV-23?

A. MV-23 on test fence looked as good or better than the best of the alkyd coating we put on in the past. In our experience it is a quite acceptable product.

Q. What is the correlation between film thickness and salt spray performance for latex vehicles and for solvent vehicles?

A. Solvent vehicles—generally speaking if you have less than 0.7 mils you start finding failures due to variation in the film or the vehicle, rather than to corrosion, but once you get up to 1–1.5 mils thickness, seems to make little difference until you get to 3 to 4 mils. With latex vehicle—the biggest difference we find there is how long do you let the thing dry. Most films are about 0.7 to 0.8 mils drying with the latex; but specification calls for a two week cure period with roughly 50% relative humidity and 75° to 80°.

Pat Shaw, of Athey Technologies, announces that the Los Angeles Society will present three papers at the 1982 Annual Meeting. Pat is Chairman of the Society's Technical Committee

Q. Have you done any studies on aluminum? We have conducted two evaluations of non-lead, non-chromated systems over the past 10 years but found none that provide good corrosion inhibition on aluminum.

A. Have had some latex over aluminum for 12 to 15 years with good results.

Q. Are non-lead and non-chromate pigments as effective as lead and chromate only in certain vehicle systems? In other words, is the vehicle the primary protective agent?

A. It is a combination. Like anything else I do not think you are going to find one product that is going to do everything in every system.

Q. Exterior exposures of latex systems exposed in low temperature ambient climate can give misleading results. Do you cure exposure panels prior to exterior exposure during low temperature winter months?

A. Our panels are dried inside so that everything gets an even chance of curing. I cannot give you a good correlation.

Q. What is your estimate of correlation between salt fog chamber hours and days of actual Memphis exposure for barium metaborate?

A. No correlation.

Q. Most of the BMB modified coatings I have seen in the New Jersey test fences show a mottled appearance, i.e., gloss and flat on the same panel? Have there been any recent changes in the manufacture to overcome this?

A. I believe there has been.

Q. Have substantial improvements been made with regards to performance with recent latex technology?

A. That, I would refer back to my comments to Rhoplex MV-23 and say we have seen some good things but I cannot speak on the technology involved.

MICHAEL GILDON, *Secretary*

NEW ENGLAND SEPT.

"Water-Borne and Higher Solids Industrial Coatings"

Officers for 1982–83 were installed. They included: President—John Fitzwater, Jr., of Polyvinyl Chemical Industries, Inc.; Vice-President—N. Bradford Brakke, of Lilly Chemical Prod.; Secretary—Charles J. Hoar, of Union Chemical Div.; and Treasurer—Robert C. Hicks, Jr., of Fish Chemical & Equipment, Inc.

Donald Aikman, of the B.H. Litter Co., presented the Tenneco gavel to President Fitzwater.

Charles H. Hamilton, retired society member, was awarded a 50-year membership pin for his service to the Federation and the society. Mr. Hamilton served as society President in 1952–53.

"IDENTIFYING SURPRISES OR IRREGULARITIES IN WATER-BORNE AND HIGHER SOLIDS INDUSTRIAL COATINGS" was presented by Al Heitkamp, of Cargill Research Lab.

A background was given on water-borne and higher solids coatings that have reached the technical development and use phase where they perform as well as or better than conventional industrial coatings. The variety and versatility of these newer coating systems have grown very rapidly, said Mr. Heitkamp. However, as with every specific liquid coating system, film irregularities occur. Some of these are similar to conventional solvent industrial coatings and some water-borne and high solids film irregularities are surprises that were not previously major coating drawbacks. He described some of these "surprises" and recommendations in how to overcome or minimize them. The prompt identification and resolution of these film irregularities is necessary for application acceptance. Some of these are resolved through paint formulation and some are resolved best in other ways.

1982–83 Montreal Society Executive Committee. Seated (left to right): Vice-President—Bert Papenburg; Dave Gerelus; J. Brunet; Secretary—M. Megelas; President—John Flack; Treasurer—D. Yokota; and D. Monaghan. Standing (left to right): Gilles Bernicky; Luigi Cutrone; B. Payette; V. Pedersen; R. Paczos; Walter Kolanitch; R. Cabral; and Society Representative—Horace Philipp

In water borne systems the "new" surprises are, according to Mr. Heitkamp, noticeable telegraphing; greater influence of temperature and humidity in application; foam; microscopic wrinkling; and picture framing.

In higher solids coatings the "new" surprises are: noticeable telegraphing; greater influence of temperature and humidity on application; air entrapment; and microscopic wrinkling.

The coating technologist with keen observation, insight, and persistence is the most important factor in resolving film surprises, stated Mr. Heitkamp. Some formulators emphasize a formula additive approach while others concentrate on solvent and pigment reformulation. Often, there are several approaches to resolving a specific film irregularity. Frequently there is only a limited time available to correct an industrial coating film abnormality. Common surprises have been described to help the coating manufacturer and user with a head start in resolving them.

CHARLES J. HOAR, *Secretary*

PHILADELPHIA SEPT.

"Aircraft Surface Coatings"

Honored guest attending the meeting was Dr. Seymore Hochberg, who has accepted appointment by the Federation as Executive Director of PRI.

William Fabiny, Educational Committee Chairman, reported that the Society is presenting the ACS short course on organic polymers in 8, 2-hour sessions. Dr. Hochberg is the instructor for the sessions.

Officers for 1982–83 were installed. They included: President—Ralph Myers, of Del Val Ink & Color Co.; President-Elect—Frank Vartusevic, of Chapman Industrial Finishes; Secretary—William Georgov, of J.M. Huber Corp.; and Treasurer—Robert L. Tozer, of Delkote, Inc.

Francis Gaffney, of H.B. Gaffney, Inc., presented President Myers with the Tenneco gavel. Mr. Myers then presented Willis Johnston with a Past-President's pin.

Mark Mosser, of Sermetel, Inc., discussed "AIRCRAFT SURFACE COATINGS—PROTECTION OF JET ENGINE COMPONENTS."

WILLIAM GEORGOV, *Secretary*

PIEDMONT SEPT.

"A Practical Approach To Understanding Emulsions"

Officers for 1982–83 were installed by Dave Bouldin, of Lilly Co. They included: President—Sara Robinson, of Inland-Leidy; Vice-President—James Husted, of Mobil Chemical Co.; Secretary—Phillip Wong, of Reliance Universal, Inc.; and Treasurer—Michael Davis, of Paint Products Co., Inc.

The Tenneco gavel was presented to Sara Robinson by Tom Mitchell, of Tenneco Chemicals, Inc.

"A PRACTICAL APPROACH TO UNDERSTANDING EMULSIONS was presented by P.J. McDonald, of Reichhold Chemicals, Inc.

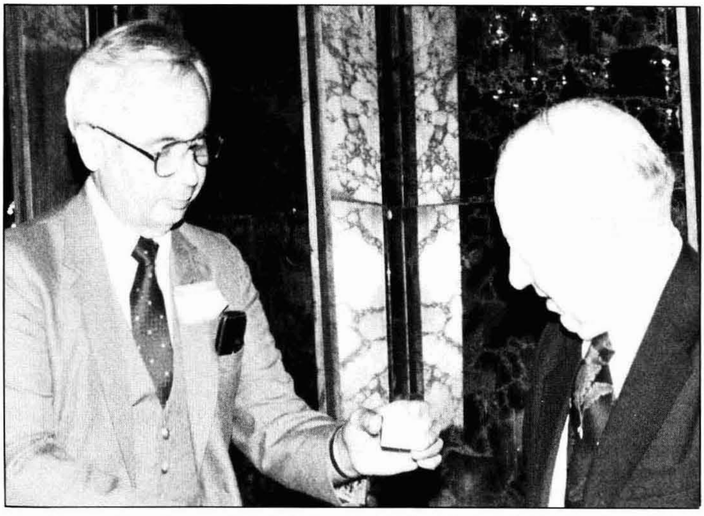
Mr. McDonald reviewed condensation and addition type polymerization chemistry. He stated that latex emulsions used in the paint industry are generally derived from vinyl type homopolymers reacted under controlled conditions. Specific concentrations of monomer, catalyst, solvent, water, colloid, surfactant, and buffer under set processing variables of agitation, temperature, and rates of addition will yield a latex polymer of uniform size and molecular weight, according to Mr. McDonald. The properties of scrubbability, freeze/thaw stability, viscosity, and enamel hold out in paint formulation are optimized with latex emulsions of very fine particle size and high molecular weights.

J.E. HUSTED, *Secretary*

PITTSBURGH SEPT.

"Filtration of Industrial Coatings"

Dennis Dempsey, of Allan Zoller Co., presented President William Cibulas, of Mobay Chemical Co., with the Tenneco



New England Society Immediate Past-President Robert Modrak (left), of Benjamin Moore Co., presents long-time member Charles H. Hamilton with his 50-year pin

gavel. Other 1982–83 officers include: Vice-President—Michael Gillen, of Van Horn & Metz Co.; Secretary—Clifford Schoff, of PPG Industries, Inc.; and Treasurer—Joseph Mascia, of Campbell Chemical Co. President Cibulas awarded Past-President Richard Trudel, of Mobil Chemical Co., with a Conestoga wagon carved from coal.

Ed Vandevort, Society Representative, discussed a number of items pertaining to the Federation and the Paint Research Institute.

"EFFECTIVE FILTRATION OF INDUSTRIAL COATINGS" was presented by Carney Likens, of Kennecott Corp.

Mr. Likens pointed out that effective filtration saves time, money, and energy, and enables the paint manufacturer to better meet the demands of customers by improving paint quality. He showed that truly effective filtration accomplishes a great deal, including particle removal control, faster packaging, minimum rework, improved productivity, labor savings, equipment conservation, product consistency, cost efficiency, and improved customer acceptance. He felt that the latter two items were the most important in the long run.

Mr. Likens then discussed filtration technology pointing out that filtration was the process by which insoluble particles are removed from a liquid. A filter is comprised of a filter housing which holds the filter medium (a bag, cartridge, or other unit). Bags provide high flow rates but are not as efficient as cartridges. Bags are acceptable for rough filtration or prefiltration for cartridges. Cartridges are made for critical applications such as coatings applied as thin films where dirt and other foreign matter must be removed if the coating is to give good appearance. Most cartridges are made of resin-bonded fibers. Different fiber orientations and lengths are possible, but Mr. Likens felt that a randomly oriented long fiber matrix was the best in terms of cartridge life, efficiency at high particle sizes, and flow rate capability.

Mr. Likens then discussed techniques to get the best out of fibers. He recommended considering the use of oversized vessels in new, high volume installations in order to get a low pressure drop. This would extend the life of the cartridge and save energy and labor. In all applications, the lower the flow rate, the higher the efficiency and the longer the cartridge life. Filtering warm gives better flow, yet also gives longer life. Two stage filtration improves overall filtration and extends life, explained Mr. Likens.

CLIFFORD SCHOFF, *Secretary*

Incoming New England Society President John Fitzwater, Jr. (left), of Polyvinyl Chemical, is presented his gavel by Don Aikman, of D.H. Litter Co.

ROCKY MOUNTAIN JUNE

"Chlorite: A New Extender Pigment"

Larry Lewandowski, of J.D. Mullen Co., presented incoming President, Don Bagge, of George C. Brandt, Inc., with the Tenneco gavel. Other officers for 1982–83 are: Vice-President—Don Shillingburg, of Union Oil of California; Secretary—Luis O. Garcia, of Kelly-Moore Paint Co.; and Treasurer—Larry Lewandowski.

"CHLORITE: A NEW EXTENDER PIGMENT FOR THE COATINGS INDUSTRY" was presented by Bill Meadows, of Cyprus Minerals.

Mr. Meadows stated that chlorite is similar in morphology to talc but that it also has significant structural differences. Most important is that chlorite combines many of the properties of talcs and clays.

A video presentation was shown featuring the Paint Research Institute. Peter Robinson dealt with PRI's function, operation, and its financing.

"HOW COLOR AFFECTS HUMAN BEHAVIOR" was discussed by Sherry Robb.

LUIS O. GARCIA, *Secretary*

ROCKY MOUNTAIN SEPT.

"Corrosion Inhibitor Pigments"

Kenneth A. Haagenson, of Buckman Laboratories, Inc., discussed "CORROSION INHIBITOR PIGMENTS IN LATEX PAINT SYSTEMS—HOW WELL THEY PERFORM WITHOUT THE USE OF LEAD PIGMENTS."

LUIS O. GARCIA, *Secretary*

ST. LOUIS SEPT.

"Iron Oxide Pigments"

Fran Wagner, of Mozel Chemical Products Co., presented President Joseph J. Wrobel, of Ciba-Geigy Corp., with the Tenneco gavel. Other officers for 1982–83 are: Vice-President—Robert J. Giery, of Spatz Paint Industries, Inc.; Secretary—William Truszkowski, of Mozel Chemical Products Co.; and Treasurer—Charles L. Grubbs, of Rockford Coatings. John Kemper, of Sterling Lacquer Mfg. Co., was presented with the Past-President's pin by President Wrobel.

A moment of silence was observed for George Robbins, Sr., Past-President and Honorary Member, who died this past summer.

"IRON OXIDE PIGMENTS—THEY STOOD THE TEST OF TIME" was discussed by David Keller, of Pfizer, Inc.

Mr. Keller described the differences between natural and synthetic iron oxides. The chemical compositions were given to establish the properties of the different hues of oxide pigments.

The basic reaction used to produce synthetic oxide involves combining iron sulphate and sodium hydroxide to recipitate the crystals, said Mr. Keller. The first crystals are needle-like and transparent. Further processing opacifies these and controls particle size to produce a more uniform pigment than natural products. Mr. Keller described new slurry oxides as a new and cleaner way of delivering the pigments.

WILLIAM A. TRUSZKOWSKI, *Secretary*

Future Society Meetings

Birmingham

(Jan. 13)—"A New Method of Paint Production"—F. Tennant, Carrs Paints Ltd.

(Feb. 3)—"Formaldehyde—Release and Analysis in Amino Resins"—U. Naess, Dyno Industries A.S.

(Mar. 3)—"The Role of the Analytical Laboratory in a Modern Paint Company"—Dr. S. Bryan, Donald MacPherson & Co. Ltd.

(Apr. 14)—"Transport as It Applies to the Paint Industry"— O. Thomas, Freight Transport Assoc.

(May 5)—"Use of Anti-Static Devices in the Paint Industry"—G. Wheatcroft, 3M Co.

Chicago

(Jan. 10)—"Ultraviolet Electron Beam Curable Resins"—W.J. Morris, Celanese Polymer Specialties. "Current Use and Trends of Accelerated Weathering Tests in the U.S."—R. Metzinger, Atlas Electric Devices.

(Feb. 7)—Federation Officers Visit.

(Mar. 7)—"Custom Computer Systems for Coatings Chemists"—Bruce Banther, East Chester Corp. "Experimental Design and Statistical Analysis of Data—Dr. R.D. Snee, E.I. duPont de Nemours Co.

(Apr. 4)—"Acid Rain Trends in the U.S."—Dr. Gary Stensland, University of Illinois. "Aspects of Rheology in Coatings"—Dr. J.E. Glass, North Dakota State University.

Cleveland

(Jan. 20)—Joint Meeting with CPCA.

(Feb. 15)—"Dispersants: Basic Concepts and Effect on Paint Properties"—Dr. W.K. Asbeck.

(Apr. 19)—"Attritor Grinding and Dispersing Equipment"—Arno Szegvari.

(May 17)—"A Funny Thing Happened on the Way to the Coatings Technical Meeting"—Frank Borrelle, FSCT Executive Vice-President.

Golden Gate

(Jan. 17)—"Water Extendable High Solids Systems. Can Get VOC and Viscosities Down by Extending with Water"—R. Johnson, Cargill Corp.

(Feb. 14)—Joint Meeting with the GGPCA.

(Mar. 14)—"Recent Development in Epoxy Resin"—Dr. Ron Bauer, Shell Development Co.

(Apr. 18)—"Chlorinated Solvents in Compliance Coatings"—Hank George, Consultant.

(May 16)—"Benefits of Composite Dispersants in Coatings and Colorants"—Elio Cohen, Daniel Products Co.

(June 13)—Manufacturing Committee's Seminar.

Houston

(Jan. 12)—"Quality and Consistency From an Easier Dispersing Rheological Additive"—Bob Dey, NL Chemicals.

(Feb. 12)—"Ladies Night/Valentine's Dance."

(Mar. 9)—Education Committee Symposium. "Security: EDP (Computer), Plant, and Personnel"—Mark Dante, Chairman, Shell Development Co.

(Apr.)—"Past President's Night."

(May 11)—"Impact of the Superfund Law on the Paint Industry"—Tom Graves, NPCA Legal Staff.

Kansas City

(Jan. 13)—"Rheology Modifiers"—Dr. Louis B. Freimiller, Rohm & Haas Co.

(Feb. 10)—"Processes and Properties of Silica Leading to Ideal Flatting Agents"—Jim Gracie, W.R. Grace, Davison Div.

(Mar.)—Ladies Night.

(Apr. 14)—"High Solids Coatings—Past, Present, and Future"—Speaker from Spencer Kellogg, Div. of Textron, Inc.

(May 12)—Federation Officers' Visit. Update on Federation Activities; Education Committee will present Science Pioneer Awards; and Election of Officers.

(June 10-11)—Joint Meeting of the Kansas City/St. Louis Societies.

Northwestern

(Jan. 4)—"Rheology Modifiers"—Dr. Louis B. Freimiller, Rohm and Haas Co.

(Feb. 8)—"Technical Presentation—Northwestern Society"—Dan DeChaine, Chairman.

(Mar. 8)—"Society Symposium"—H.C. Ting, Chairman.

(Apr. 5)—"Education Night"—James Lawlor, Chairman.

(May 3)—"Manufacturing Program"—Richard Mundinger, Chairman.

SSPC PUBLISHES STUDY ON LOW-SOLVENT COATINGS

A new study, entitled "Evaluation of Low-Solvent Maintenance Coatings for Structural Steel", and sponsored by the Federal Highway Administration, has been published by the Steel Structures Painting Council.

This SSPC study makes recommendations about the timing of regulations restricting the use of organic solvents in coating formulations for structural steel, and describes the adaptations that industry and government must face in procurement, costs, application, and exposure zones, should the use of volatile organic compounds be more widely restricted.

The report reviews the state of the art for water-base coatings; zinc-rich paints, alternative solvents; high-solids coatings; non-silica blast media, and non-lead, non-chromate inhibitive pigments. It is available ($40.00 postpaid) from the Steel Structures Painting Council, 4400 Fifth Ave., Pittsburgh, PA 15213. For further information, contact John D. Keane, Executive Director, Steel Structures Painting Council.

Philadelphia

(Jan. 19)—Joint Meeting with PPCA. "ECONOMIC OUTLOOK FOR 1983 AND BEYOND"—John J. Clutz, Jr., Rohm and Haas Co.

(Feb. 10)—"FUMED SILICA FOR THE RHEOLOGY CONTROL OF HIGH SOLIDS COATINGS"—Dennis G. Miller, Cabot Corp.

(Mar. 10)—FEDERATION VISIT.

(Apr. 15)—AWARDS NIGHT.

(May 12)—"NEWER TECHNOLOGICAL AREAS OF WATER-BORNE RESINS"—Don Hogan, Polyvinyl Chemical Corp.

Piedmont

(Dec. 15)—"ORGANIC PIGMENTS: PAST, PRESENT, AND FUTURE"—H.M. Smith, Sun Chemical Corp.

(Jan. 19)—"ECONOMIC FORECASTING AND TAX ADVANTAGED INVESTMENTS FOR THE INDIVIDUAL"—T. Broadwater, Thomson McKinnon Securities, Inc.

(Feb. 16)—JOINT MEETING WITH PIEDMONT PCA.

(Mar. 16)—FEDERATION OFFICER VISIT.

(Apr. 20)—"PLANT SAFETY-HANDLING SOLVENT AND NITROCELLULOSE"—Speaker from Hercules, Inc.

(May 18)—"SOLVENTS FOR HIGH SOLIDS COATINGS"—R. Readshaw, Union Carbide Corp.

(June 15)—"FINISHING POLYOLEFIN PLASTICS"—T.E. Parsons, Eastman Chemical Products, Inc.

Pittsburgh

(Jan. 3)—"FACTORS THAT AFFECT COATINGS PERFORMANCE ON METAL SUBSTRATES"—Bruno Perfetti, U.S. Steel Research Laboratories.

(Feb. 7)—"CONCERNING THE QUALITY OF TRADE SALES COATINGS"—Tom Greer, PPG Industries, Inc.

(Mar. 7)—"RELATIONSHIPS BETWEEN PARTICLE SIZE AND OPTICAL PROPERTIES OF IRON OXIDE PIGMENTS"—Dr. Rolf Odenthal, Mobay Chemical Corp.

(Apr. 4)—"CHLORINATED SOLVENTS —AN ALTERNATIVE TECNOLOGY IN COATINGS"—Jed Fulkerson, Dow Chemical Co.

(May 2)—"WHAT IS THE STRUCTURAL STEEL PAINTING COUNCIL?"—John Keane, Mellon Institute.

St. Louis

(Feb. 15)—"LAS VEGAS NIGHT."

(Mar. 16)—"HIGH SOLIDS COATINGS" —Speaker from Freeman Chemical Co.

(Apr. 20)—"EDUCATION NIGHT."

(May 18)—"MANUFACTURING NIGHT."

Constituent Society Meetings and Secretaries

BALTIMORE (Third Thursday—Eudowood Gardens, Towson, MD).

BIRMINGHAM (First Thursday—Calthorpe Suite, Edgbaston). D. H. CLEMENT, Holden Surface Ctgs. Ltd., Bordesley Green Rd., Birmingham B9 4TQ, England.

CHICAGO (First Monday—meeting sites in various suburban locations). FRED FOOTE, U.S. Gypsum Co., 700 N. Rte. 45, Libertyville, IL 60048.

C-D-I-C (Second Monday—Sept., Jan., Apr., June in Columbus; Oct., Dec., Mar., May in Cincinnati; Nov., Feb., in Dayton). ROBERT A. BURTZLAFF, Potter Paint Co. of Ind., P.O. Box 265, Cambridge City, IN 47327.

CLEVELAND (Third Tuesday—meeting sites vary). RAY PODLEWSKI, Mansfield Paint Co., P.O. Box 998, Mansfield, OH 44901.

DALLAS (Thursday following second Wednesday—Steak & Ale Restaurant). T. LEON EVERETT, Dan-Tex Paint & Ctg. Mfg., Inc., P.O. Box 18045, Dallas, TX 75218.

DETROIT (Fourth Tuesday—meeting sites vary). PETER BURNETT, Wyandotte Paint Products, Inc., 650 Stephenson Hwy., Troy, MI 48084.

GOLDEN GATE (Monday before third Wednesday—Alternate between Sabella's Restaurant on Fisherman's Wharf and the Sea Wolf at Jack London Square, San Francisco). ROBERT MILLER, Frank W. Dunne Co., 1007 41st St., Oakland, CA 94608.

HOUSTON (Second Wednesday—Sonny Look's, Houston, TX) RICHARD D. BATCHELOR, Valspar Corp., 2503 W. 11th St., Houston, TX 77008.

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

LOS ANGELES (Second Wednesday—Steven's Steak House, Commerce, CA). MICHAEL GILDON, Guardsman Chemicals, 9845 Miller Way, Southgate, CA 90280.

LOUISVILLE (Third Wednesday—Howard Johnson's, Louisville, KY). W. JERRY MORRIS, Celanese Plastics & Specialties Co., P.O. Box 99038, Jeffersontown, KY 40299.

MEXICO (Fourth Thursday—meeting sites vary). TERESA SUAREZ, Sherwin-Williams Co., Mexico, D.F.,Mexico.

MONTREAL (First Wednesday—Bill Wong's Restaurant). M. MEGELAS, International Paints Ltd., P.O. Box 190, Outremont, Que., Can., H2V 4M9.

NEW ENGLAND (Third Thursday—Fantasia Restaurant, Cambridge). CHARLES J. HOAR, Union Chemicals Div., 67 Walnut Ave., Clark, NJ 07066.

NEW YORK (Second Tuesday—Landmark II, East Rutherford, NJ). MICHAEL ISKOWITZ, Koppers Co., Inc., 480 Frelinghuysen Ave., Newark, NJ 07114.

NORTHWESTERN (Tuesday after first Monday—Boulevard Cafe, Golden Valley, MN). ROBERT MADY, George C. Brandt, Inc., 2975 Long Lake Rd., St. Paul, MN 55113.

PACIFIC NORTHWEST (Portland Section—Tuesday following second Wednesday; Seattle Section—the day after Portland; British Columbia Section—the day after Seattle). WILLIAM SHACKELFORD, Gaco-Western, Inc., P.O. Box 88698, Seattle, WA 98188.

PHILADELPHIA (Second Thursday—Riverside East, Philadelphia, PA). WILLIAM GEORGOV, J.M. Huber Corp., P.O. Box 310, Havre de Grace, MD 21078.

PIEDMONT (Third Wednesday—Howard Johnson's Coliseum, Greensboro, NC). JAMES E. HUSTED, Mobil Chemical Co., P.O. Box 2438, High Point, NC 27261.

PITTSBURGH (First Monday—Skibo Hall, Carnegie Mellon Univ.). CLIFFORD SCHOFF, PPG Industries, Inc., R&D Center, P.O. Box 9, Allison Park, PA 15101.

ROCKY MOUNTAIN (Monday following first Wednesday—Gusthaus Ridgeview, Lakewood, CO). LUIS O. GARCIA, Kelly-Moore Paint Co., 3600 E. 45th Ave., Denver, CO 80216.

ST. LOUIS (Third Tuesday—Salad Bowl Restaurant). WILLIAM TRUSZKOWSKI, Mozel Chemical Products Co., 4003 Park Ave., St. Louis, MO 63110.

SOUTHERN (Gulf Coast Section—Various Dates; Central Florida Section—Third Thursday after first Monday; Atlanta Section—Third Thursday; Memphis Section—Second Tuesday; Miami Section—Tuesday prior to Central Florida Section). S.G. SANFILIPPO, Reichhold Chemicals, Inc., Technical Services Lab., P.O. Box 1610, Tuscaloosa, LA 35401.

TORONTO (Second Monday—Cambridge Motor Hotel). R.H. STEVENSON, Tenneco Chems., Canada Ltd., 235 Orenda Rd., Bramalea, Ont., Can., L6T 1E6.

WESTERN NEW YORK (Third Tuesday—The Red Mill, Clarence, NY). DONALD M. KRESSIN, Spencer Kellogg Div., Textron, Inc., P.O. Box 210, Buffalo, NY 14225.

Elections

BALTIMORE

Associate

Brown, Robert R.—Colloids, Inc., West Point, VA.

C-D-I-C

Active

Dotson, Daniel J.—Ashland Oil Co., Ashland, KY.

Fischer Jr., Edward J.—Fischer Industrial Ctgs., Cincinnati, OH.

Kelly, John H.—DeSoto, Inc., Columbus, OH.

Marvuglio, Paul—Hilton-Davis Chemical Co., Cincinnati, OH.

Miller, Thomas H.—Fischer Industrial Ctgs., Cincinnati.

Wiseman, P. Marshall—Michelman Chemicals, Cincinnati, OH.

Yocum, William—Penn Color, Cincinnati, OH.

CLEVELAND

Active

Thomas, Robert D.—PPG Industries, Inc., Barberton, OH.

Associate

Rocco, James—AT&T, Long Lines, Cleveland, OH.

NEW ENGLAND

Active

Boise, Lawrence H.—Raffi & Swanson, Inc., Wilmington, MA.

Killen, William R.—Polychem Corp., Cranston, RI.

Laramee, Wendy L.—White Pigment Corp., Florence, VT.

Piwowarski, Gene—Metalflake, Inc., Haverhill, MA.

Raker, Andrew—Clark Paint & Varnish, West Springfield, MA.

Associate

Baggesen, Fred—Chemical Specialties, Westboro, MA.

Benning, P. Scott—Spencer Kellogg Div., Textron, Inc., Malden, MA.

NEW YORK

Associate

Bell, Dean G.—Union Chemicals Div., Clark, NJ.

Butchyk, Roger J.—Kramer Chemicals, Inc., Clifton, NJ.

Davis, Richard W.—Sandoz Colors & Chemicals, East Hanover, NJ.

Dobrenski, Donald A.—Pluess Staufer International, New York, NY.

Gan, Barbara M.—Drew Chemical Corp., Boonton, NJ.

Holtzer, Mitchell T.—Rohm and Haas Co., Piscataway, NJ.

Karlson, James—Caschem, Inc., Bayonne, NJ.

PIEDMONT

Active

Trethaway, Scott—Thiele-Engdahl, Inc., Winston-Salem, NC.

Associate

Jordan, Mike—Chemicals and Solvents, Greensboro, NC.

Mitchell, Thomas W.—Tenneco Chemicals, Inc., Baltimore, MD.

Technical Program Announced for WCS Symposium

Western Coatings Societies will present their 16th Biennial Symposium and Show on February 23–25, at the Hyatt Regency-Embarcadero Center in San Francisco, CA.

The Symposium, "Spectrum '83—Tomorrow's Technology: Today," will feature both technical papers and workshops. Individual papers will be followed by a discussion and question-and-answer period.

A. Gordon Rook, of O'Brien Corp., is serving as Chairman of the Symposium's Technical Program Committee, and he announced that the following papers are scheduled for presentation:

"Light Scattering Extenders"—William S. Stoy, Engelhard Corp., Minerals and Pigments Div.

"Modification of Organic Pigments for Greater Opacity"—Louis A. Brincat, American Hoechst Corp.

"Water-Borne Coatings for Plastics—The Best Alternative"—John E. Fitzwater, Jr., Polyvinyl Chemical Industries.

"Acrylic Blend Latices"—Dr. Del Donno, Rohm and Haas Co.

"Characterization of Thermosetting Coatings Films by Dynamic Mechanical Analysis"—Dr. Loren W. Hill, Monsanto Plastics & Resins Co.

"Revolutions in the Coatings Industry"—Donald Brody, Skiest Laboratories, Inc.

"Changing Technologies for Industrial Coatings"—George H. Wilhelm, Spencer Kellogg, Textron Div.

"Performance of Silicone Modified Organic Resins in Maintenance Applications"—William A. Finzel, Dow Corning.

"Hydrolysis of Alkyl Silicates"—Thomas Ginsberg, Union Carbide Corp.

"Low Energy Conversion Systems—Comparison of Acrylate Functional Oligomers"—W. Jerry Morris, Celanese Plastics and Specialties Co.

"Zirconium Complex as a Rheological Modifier for Latex"—John E. Haddock, Manchem, Inc.

"Associative Thickeners: Optimizing Rheology and Performance of Water-Borne Coatings by Thickener Design"—William Glancy, Union Carbide Corp.

"Solvent Selection for Electrostatic Application on Wood"—G.P. Sprinkle, Eastman Chemical Products.

"A Method to Lower the CLSS in Water-Based Paint Manufacturing"—Milton Golden, Major Paint & Varnish Co.

"Economics of Developing Technology"—Abel Banov, *American Paint & Coatings Journal.*

"The Role of Biocides in Coatings Protection"—Jane Yuster, Troy Chemical Corp.

"Microbiology of Modern Coatings Systems"—John A. Jakubowski, Merck & Co., Inc.

"Presence and Effects of Anaerobic Bacteria in Water-Based Coatings, Part II"—Milton Goll, Cosan Chemical Corp.

"Visual Color Technology Development in the Coatings Industry"—James T. DeGroff, Applied Color Systems, Inc.

"Agrisource Resins in Water-Borne Exterior Trade Sales Coatings"—Al Heitkamp, Cargill, Inc.

Presentation by John D. Keane or Bill Johnson, of the Steel Structures Painting Council.

For more information on the Symposium and Show, write to WCS Symposium, 50 California St., Suite 3110, San Francisco, CA 94111.

Coatings for Steel Structures Symposium To Be Held January 26, Orlando, FL

The Symposium for "New Concepts for Coatings Protection of Steel Structures," which is cosponsored by ASTM Committee D-1 on Paint and Related Coatings and Materials and the Steel Structures Painting Council, will be held at the Dutch Inn, Orlando, FL, January 26.

State-of-the-art advances in the evaluation of new coating materials, developing application methods, and surface preparation in the corrosion protection of steel structures will be presented and discussed. The program which is scheduled from 8:30 am to 5:00 pm is divided into three sessions: Surface Technology Concepts; Applied Coatings Systems; and Safety Practices.

According to Symposium Chairman Dean M. Berger, of Gilbert/Commonwealth, 13 papers will be presented. The program and presentations are as follows:

Keynote Address—"Corrosion Protection in the 1980's"—S.L. Lopata, Carboline Co.

"Surface Technology Concepts"

"Quantitative Evaluation of Organic Coatings' Performance on Metallic Substrates Using Infrared Thermography"—M.E. McKnight and J.W. Martin, National Bureau of Standards.

"Blast Cleaning with Zinc-Coated Abrasives"—K.W. Lowrey, Colebrand Ltd.

"Deleterious Materials at the Steel Paint Interface"—W.C. Johnson, KTA-Tator, Inc.

"Effects of Impact Peening and Nonwoven Abrasives on Steel Surfaces"—J.J. Claus, 3M Co.

"A Controlled Cavitation Erosion System for Surface Preparation of Structural Steel"—A.A. Hochrein, Jr., Daedalean Associates, Inc.

"Applied Coating Systems"

"Zinc-Plus-Paint Systems for Corrosion Protection of a Steel Bridge."—M.I. Lwin, State of Washington, Dept. of Transportation.

"Spray Applied Fluoroelastomers for Protection of Carbon Steel in Flue Gas Desulphurization Service"—C. McLain and T.K. Dolan, Carboline Co.

"100% Solids Room Temperature Curing Polyurethane Elastomers"—S.J. Oechsle, Tegman, Inc.

"Precision Underwater Reactivation of Anti-Fouling Coatings"—I. Poretz, Jotun Baltimore Copper Paint Co.

"Minimum Film Thickness for Protection of Hot-Rolled Steel—Results After 23 Years Exposure at Kure Beach, North Carolina"—M. Marcillo, Ciudad University, Madrid, Spain.

"Safety Practices"

"ASTM Safety Alert Standard for Multi-Employer Construction Sites"—S.J. Oechsle, Metalweld, Inc.

"Effects on Worker Productivity and Safety in Construction of Coatings on Steel"—T. Clarkson, International Association of Bridge, Structural and Ornamental Iron Workers.

"Three Mile Island—Two Years Later"—S. Lefkowitz, Pentek, Inc.

For more information on the symposium, contact Rufus F. Wint, Hercules, Inc., 910 Market St., Wilmington, DE 19898.

OCCA Australia Publishes Surface Coatings Textbook

The Oil and Colour Chemists' Association Australia has prepared a textbook in two volumes covering the subject of surface coatings.

The first volume, consisting of 30 chapters, deals with raw materials and includes a paint glossary of terms. It will be available in early 1983.

The second volume discusses formulating principles, paint manufacture, and types of coatings systems in 28 chapters. It will be available in late 1983.

The volumes were written by Australian industry experts and the books have been technically edited, edited for continuity, metricated, and indexed.

Cost of the volumes is $29.95 (Australian) [$28.15—U.S.] per copy, plus postage.

Following is a list of chapter titles:

VOLUME I

Past and Future of the Surface Coatings Industry
Introductory Polymer Science (Applicable to Surface Coating Technology.)
Vegetable Oils
Oleoresinous Media
Introduction to Alkyd Technology
Manufacture of Alkyd Resins
Application of Alkyd Resins
Polyesters
Amino Resins
Phenolic Resins
Polyurethane Resins
Epoxy Resins
Water Dispersible Epoxy Resins
Silicone Resins
Acrylic Solution Resins
Emulsion Polymerisation Theory
Emulsion Properties (1): Effect of Monomer Composition
Emulsion Properties (2): Effect of water phase and particle size
Emulsion Properties (3): Film Formation
Emulsion Polymers: Manufacture and Testing
Applications of Emulsion Polymers (with particular emphasis on surface coatings)
Water Reducible Resins
Water Soluble Resins
Solvents
Inorganic Pigments
Titanium Dioxide
Organic Pigments
Extender Pigments
Paint Driers
Paint Additives

VOLUME II

Colour Matching (Using Computerised Techniques)
Testing and Quality Control
Substrates and Preparation
Metal Cleaning and Pretreatment
Selection of Decorative Paints
Corrosion and Prevention
Industrial Paint Application and Curing
Defects in Surface Coatings and Paint Removal
Analysis of Polymeric Materials in Coatings
Technical Service
Computers in the Surface Coatings Industry
Standardization, Inspection and Accreditation in Australia
The Paint Industry—Statutory Requirements
Rheology
Formulation Principles
Paint Manufacture—Pigment Grinding
Paint Manufacture—Processing Operations
Architectural Coatings
Heavy Duty Protective Coatings
Antifouling Paints
Industrial Coatings
Automotive Coatings
Lacquers
Conversion Coatings
Powder Coatings
UV Radiation Cured Coatings
Printing Inks
Components & Technical Aspects of a Paint Tinting System

For more information, or to order, please contact Mr. Brian J. Lowrey, Federal President, OCCAA, c/o British Paints (Aust.) Pty Ltd., P.O. Box 43, Bankstown, N.S.W. 2200.

Cleveland Society Reschedules 1983 Technical Conference

The 26th Annual Technical Conference, "Advances in Coatings Technology," of the Cleveland Society will be held April 26-27 at the NASA-Lewis Research Center in Cleveland, OH.

The conference was originally scheduled for March 22-23 at Baldwin-Wallace College, Berea, OH.

For information on attending, write Dr. Richard P. Eley, Glidden Coatings and Resins Div. of SCM Corp., P.O. Box 8827, Strongsville, OH 44136.

People

Thomas G. Brown, formerly with Engelhard Corp., has been appointed Director of Sales for Zeelan Industries, Inc., St. Paul, MN. Mr. Brown has over 20 years of experience in the pigment and coatings industries and has authored several papers and addressed numerous technical societies. He is a member of the New York Society.

Alipio R. Rubin, Jr. has joined the Hilton-Davis Chemical Co. as Director of Color and Pigment Dispersion Research, based in Cincinnati, OH. Prior to joining the firm, Mr. Rubin was with Tenneco Chemicals, Inc. He is a member of the New York Society.

Also **Charles M. Donohue** has joined the Hilton-Davis Chemical Group, Cincinnati, OH, as President.

Ultra Adhesives Inc. has appointed **William M. Young** as a Sales Representative throughout Maryland and Virginia for its specialty additives. Based in Wayne, PA, Mr. Young's agency will represent more than 200 Ultra defoamers, driers, protective colloids, thickeners, surfactants, wetting agents, and dispersing aids to customers throughout the coatings and related industries. Mr. Young was formerly employed with Borden Chemical Co. and Monsanto Chemical Co. and was founder/director of his own firm, Monarch Chemical Co. He is a member of the Philadelphia Society.

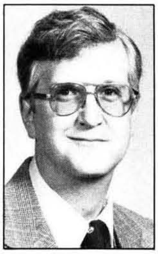
Vernon Lo, a member of the Pacific Northwest Society, has been appointed Laboratory Manager of Flecto Coatings, Ltd., in Vancouver.

Charles H. Hamilton, a Retired Member of the New England Society, was awarded the Federation's 50-year membership pin at the Society meeting in September. Mr. Hamilton was President of the Society in 1952 and 1953 and was associated with the Raffi & Swanson and Easter Lacquer Companies at the time.

Dr. Teresa Kennelly has joined the Minerals & Chemical Division of Engelhard Corp. as Research Chemist and Project Leader in the New Business Research Group.

T.G. Brown

A.R. Rubin, Jr.



J. Muse, Jr.

W.J. Belanger

Dr. Joel Muse Jr. was named to replace the late Dr. William L. Cox as Manager of Organic Chemical Research in the Elastomer and Chemical Research Division of Goodyear.

Morehouse Industries, Inc., Fullerton, CA, has announced the establishment of a Southeast Regional sales engineering office, located in Atlanta, GA and headed by **Rocky Courtain**. Mr. Courtain, a Morehouse veteran with extensive sales experience, is a member of the Los Angeles Society.

The Cordano Chemical Co., Inc., has been accepted into Membership of Materials Marketing Associates, Inc. **William C. Cordano**, President of the company is its official representative to MMA. He is a member of the Pacific Northwest Society.

Joseph A. Boelter was appointed Vice-President, Marketing for Kay-Fries, Inc., Rockleigh, NJ.

Hercules Incorporated, Wilmington, DE, has announced the appointment of **Robert I. Mason** as Marketing Director of Industrial Programs, Marketing Division. Also, **Robert E. Ketten** was promoted to the position of Manager, Customer Support Services, Water Management Chemicals.

Omar K. Skiver was promoted to Vice-President—Marketing, Coil and Extrusion Coatings for Whittaker Corporation's Chemicals Group. He formerly served as National Product Manager, adding to the growth of the firm's coil coatings program. Mr. Skiver is a Past-President of the National Coil Coater Association and currently is a member of the organization's board of directors.

Dr. William J. Belanger, Vice-President—Technical Director of Celanese Plastics & Specialties, has retired after 14 years of service with the firm. Dr. Belanger has been involved in the paint and coatings industry for 29 years, holding various technical positions, and is the recipient of 32 U.S. Patents, many of which are coatings related. He has been active in the NPCA as a member of the Scientific and Scientific Steering Committees and was also the first Mission Manager of the NPCA's Toxic Substances Task Force which was organized in 1976. Dr. Belanger will remain active in the industry as a consultant for coatings and specialty chemicals.

Progress Paint Manufacturing Co., Inc., Louisville, KY, has announced the promotion of **Ken Lawrence** to Sales Manager—Industrial Coatings. Mr. Lawrence will also manage sales of Production Finish Coatings for Blatz Paint Co., a recently acquired division of Progress.

Spencer R. Arrowood has been appointed Senior Applications Chemist for the Union Chemical Div., Union Oil Co. of California, at the division's new Technical Service Center in Charlotte, NC.

Witco Chemical Corp., New York, NY, has announced the following promotions. **Dennis Galbreath** was named Manager of Research & Development for the Isoform® Systems Group of its Organics Div., New Castle, DE. **Joe E. Graves** was appointed Southwest Regional Sales Manager of the Organics Div., based in Houston, TX.

Obituary

Federation Past-President **Newell P. Beckwith** died in Savannah, GA, on October 18. He was 67 years old.

Dr. Beckwith retired on January 31, 1980, after 43 years in the coatings industry, 40 of them with Inmont Corp. (initially Rinshed-Mason Co.) in Detroit; Windsor, Ont., Canada; and Europe.

After graduating from North Dakota State University in 1937, he joined the Paint Methods Dept. of the Chrysler Corp. He became affiliated with Rinshed-Mason three years later and was Technical Director from 1946-53.

In 1954, Dr. Beckwith was promoted to President and Manager of Rinshed-Mason Canada Ltd. and served in that position for 12 years. Following that he was made Vice-President and Manager of Operations of Inmont Corp., U.S., (1967-70) and Vice-President of International Marketing (1971-79).

During World War II, he served as a G-3 Plans & Training Officer and was discharged in 1946 as a Lt. Colonel.

His alma mater, NDSU, awarded him the Honorary Doctor of Science Degree in 1955.

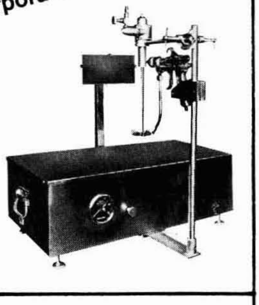
He served as President of the Federation in 1954-55. A member of the Detroit Society for 42 years, he was its Council Representative in 1947 and was elected an Honorary Member in 1981. He was a founding member of the Paint Research Institute and served as a Trustee from 1957-70, the first six years as Secretary.

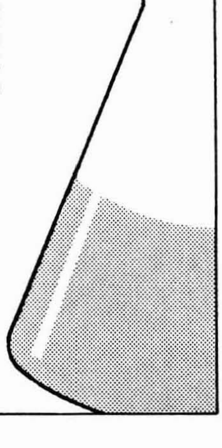
He is survived by his wife: Priscilla; three daughters: Pam (Mrs. Richard Montre), Lynn (Mrs. James Lenihan), Barbara; a son: Fred, and three grandchildren.

M. Claire Flanagan, 64, died September 6 in Orleans, MA. Miss Flanagan was Secretary-Treasurer of the Wet Ground Mica Association, Inc.

Harold Martin Brez, 71, died on September 14. Mr. Brez, Past-President of the Golden Gate Paint and Coatings Association (1969-70), had also been active in both the Chicago and Golden Gate Societies for Coatings Technology.

Mr. Brez received his degree in chemistry from the University of Chicago, and after doing graduate work there and at the University of California, he became a Chemist with the Sherwin-Williams Co. In 1938 he joined the California Ink Co. and later joined the Manning Mitchell Co. as Vice-President, Research. In 1948 he founded the Pacific Coast Chemicals Co., where he served as President until 1969; and in 1979 he founded Brez Chemicals. He continued there as Vice-President for American Operations.





Literature

Resin Dispersions

Auracryl™ resin color dispersions, a liquid colorant which assists coatings manufacturers in the manufacture of water-based coatings for OEM and industrial maintenance needs, are highlighted in an eight-page brochure. Product information, performance data, and a physical characteristics chart for the 14-color line of dispersions are featured. For a free copy, contact The Harshaw Chemical Co., 1945 E. 97th St., Cleveland, OH 44106.

Industry Standards Cross-Reference

A 28-page Cross-Reference of Industry Standards is available from Testing Machines Inc. for their extensive line of physical test equipment. The cross-reference contains hundreds of standards established by organizations such as the American Society for Testing and Materials, The American Association of Textile Chemists and Colorists, U.S. Department of Commerce, and the International Standards Organization. Also included are standards to meet applicable MIL, FS, and UL specifications. For a free copy, contact Testing Machines Inc., 400 Bayview Ave., Amityville, NY 11701.

Pumps

A new technical engineering brochure introduces a line of Pyroite® Reinforced Composite Vertical Turbine Pumps. Information is provided on corrosives and erosives; pump sizes and capacity data; pump performance; and technical and engineering data. For further information, contact Arlene Higgins, Pyroite Pumps, Inc., 951 Jaycox Rd., Avon, OH 44011.

Ovens

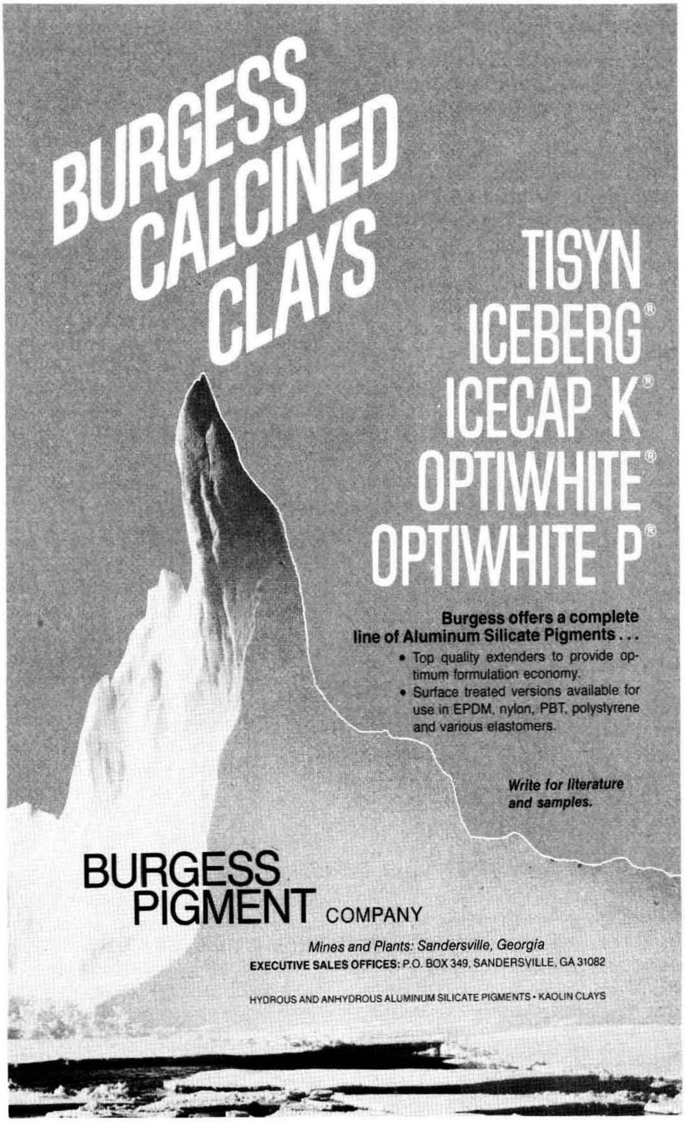
A new, compact, pocket-size, 24-page catalog describing a complete line of ovens of various types and sizes such as: laboratory, bench, floor, universal, shelf, and cabinet ovens, has been published. Complete descriptions of all models are given which include applications, features, specifications, accessories, and price lists. A free copy is available from Paul N. Gardner Co., Inc., 218 Commercial Blvd., Lauderdale By-The-Sea, FL 33308.

Grinding Mills

Grinding mills, featuring solvent-resistance, non-contaminating TEFZEL® linings, are described in a one-page technical bulletin now available. For a copy, write SWECO, Inc., Robert W. Kenagy, 6033 E. Bandini Blvd., P.O. Box 4151, Los Angeles, CA 90051.

Product Catalog

Ashland Chemical Co. has published its 1982–83 Product Catalog, representing its broad product line of industrial chemicals and specialties. For a copy of Bulletin 1535, write Ashland Chemical Co., Dept. AC, P.O. Box 2219, Columbus, OH 43216.



Organosilicon Compounds

Edition S-5 of the Petrarch Register & Review of Organosilicon Compounds has just been published. The 210-page document provides structural, physical and available toxicity data on more than 800 organosilanes which find use as synthetic reagents, derivitizing and blocking agents, reactive intermediates and surface treating agents. Also included are copious data on over 200 silicones including inert fluids, functional prepolymers, catalysts, resins, and gums. Pertinent information on applications is included as well. Copies of Edition S-5 of the Register & Review are available from Petrarch Systems, Inc., Bartram Rd., Bristol, PA 19007.

Laboratory Products

An illustrated brochure covering a complete line of products for the industrial laboratory is now available. The 20-page brochure describes instrument systems, accessories, and chemicals, as well as customer support capability. For a free copy of Bulletin 8500, "Products for the Industrial Laboratory," contact Beckman Laboratories, Inc., Analytical Instruments Sales and Service Div., 2500 Harbor Blvd., Fullerton, CA 92634.

Dust Collectors

A new brochure on Arrestall® self-contained dust collectors, with air flow capacities from 800 to 3,200 CFM, is now available. The 12-page brochure provides the basic operating and construction characteristics of this line of dust collectors that includes hopper bottom, flat bottom, bin vent, and downdraft bench models in the various sizes. The air cleaning technique using a fabric filter cartridge, dust collector reconditioning method, using a shaker mechanism, and equipment options are discussed. Fan performance, dimensional data, and dimensional drawings also are included. For a copy of the brochure, order APCP-1-115, entitled "The Versatile Arrestall," from American Air Filter Co., Clean Air Div., P.O. Box 35260, Louisville, KY 40232-5260.

Resin

Literature announcing a new type 5778 water-reducible high-solids polyester resin, designed to be reduced, in part, with water for formulation into paints and protective coatings, is available. Recommended uses, specifications, and formulating information are provided. Write to Marketing Dept., Cargill, Inc., Chemical Products Div., P.O. Box 5630, Minneapolis, MN 55440.

Liquid Exclusion Chromatography

Information on the technique of liquid-exclusion chromatography is presented in the Atomic/Molecular Data Series, *Bibliography on Liquid Exclusion Chromatography (Gel Permeation Chromatography),* (AMD 40-S2) recently published by ASTM. This comprehensive bibliography, the second supplement to the original publication AMD 40, provides a systematic access to a substantial amount of literature that references the technique. This series has expedited research for chromatographers and laboratory personnel involved in the study of polymers, elastomers, rubber, tires, and paints.

This newest supplement contains 751 references that span literature from 1976 through 1978. Included is information on polymer applications (elastomers, plastics, cellulosics, and fibers), applications—low molecular weight substances and miscellaneous materials, application to fundamental studies—composition, molecular structure, and reaction mechanism; reference to comparative techniques, methodology, reviews and text; and mechanism, operational variables, phenomenology and theory. Also, calibration, correction data analysis, detection, and resolution, as well as equipment—column packing material, components, model compounds, solvents, and systems are covered. Further information can be obtained from ASTM Sales Services Dept., 1916 Race St., Philadelphia, PA 19103.

Panel Meter

A four-page brochure describes a low-cost, full performance, 3½-digit digital panel meter. The publication includes specifications, dimension drawings, and application data on the new Model 40 DPM, which offers large, high-brightness LED display, snap-in DIN/NEMA case, and a wide range of CEM performance options. Free copies are available from LFE Corp., Process Control Div., 55 Green St., Clinton, MA 01510.

Chromatography

The second issue of a bulletin reporting the latest information and developments in equipment and supplies for chromatography is now available. The 12-page *Analytical Specialist* features articles on fused silica capillary columns, a new liquid phase, micro-bore LC information, a compact tubing cutter, and other items of interest to anyone involved in chromatography. For a free copy, contact: The Anspec Co., 122 Enterprise Dr., P.O. Box 7730, Ann Arbor, MI 48107.

Specialty Additives

New literature available from Ultra Adhesives Inc., provides comprehensive technical information on the firm's complete line of specialty additives. Designed to serve as a convenient reference tool, the literature package consists of a brochure containing information on the firm, and of newly designed data sheets on all Ultra Adhesives products, which are used by manufacturers of coatings, inks, adhesives, and textiles. Data sheets provide information on the firm's unique ULTRACAT line of nonhydrolizable driers for waterborne systems, and CALCICAT and Zircat auxiliary driers. For a free technical data pack, write Ultra Adhesives Inc., P.O. Box 98, Park Stations, Paterson, NJ 07543.

Inerting Systems

A new, fully automatic inerting system which offers absolute protection for explosive atmospheres, such as mixing tanks, reactors, ball mills, and storage vessels where static electricity is a common problem, is featured in recent literature. For additional information, contact Neutronics Inc., 450 Drew Court, King of Prussia, PA 19406.

Silicone Products

An updated and expanded "Guide to Dow Corning Products" makes product selection easier for nearly 300 silicone products. The 48-page guide is conveniently arranged in two sections: one industry related and one for product selection. Applications in 27 major industries are featured, including silicones for the chemical, construction, electrical and electronic, mining, textile, and transportation industries, as well as for manufacturers of personal care products, medical products, appliances, plastics, and metal products. Product selection tables list benefits, features, and important technical properties for 37 types of Dow Corning products. Reader service cards bound into the guide offer additional sources of information on silicones, including a free subscription to *Materials News,* a bimonthly magazine featuring the latest information and application ideas for silicones. Also offered are two Dow Corning general interest brochures: "Silicones: Energy Savers" and "Silicones: Materials for Fire Safety." The publication also summarizes Dow Corning's contract research and development capabilities. The guide is available free from Dow Corning Corp., Midland, MI 48640. Ask for Form number 01-404-82.

Purifying Systems

Literature is available describing a complete line of powered air purifying personal protection systems, which provide portable, wearable combinations of head, eye, face, and respiratory protection for a variety of industrial applications. The two-page, two-color sheet featuring photos and text, is available from Racal Airstream, Inc., 7309A Grove Rd., Frederick, MD 21701.

Spectrocolorimeter

LabScan™, HunterLab's newest spectrocolorimeter designed to measure the reflectance color of objects and incorporates advanced technology that results in vastly superior performance at previously unknown levels of stability, repeatability, and inter-instrument agreement, is featured in recent literature. Basic advantages, standard features, and recommended uses are highlighted. Contact HunterLab, Hunter Associates Laboratory, Inc., 11495 Sunset Hills Rd., Reston, VA 22090.

Nonionic Surfactants

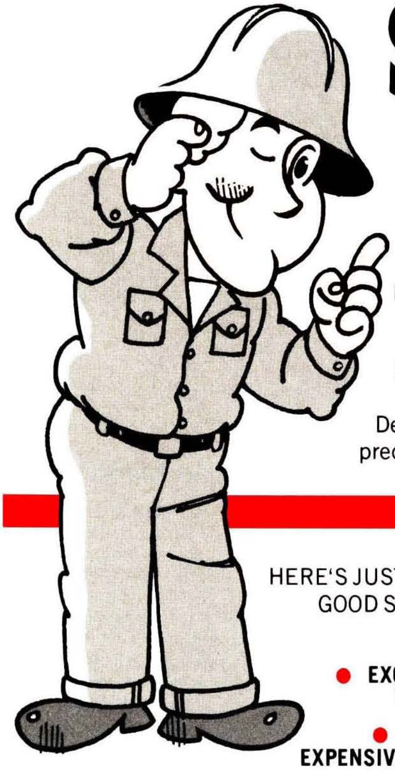
A 10-page technical bulletin on IGEPAL CO surfactants is now available. This brochure details and explains the 22 products in the IGEPAL CO family of nonionic surfactants. Information includes the products' physical data, surface activity, solubility, typical applications, biodegradability, toxicity, and regulatory conformances and exemptions. For a copy of bulletin #2303-015R1, write to GAF Corp., Surfactants Group, 140 W. 51 St., New York, NY 10020.

Red Pigment

A new quinacridone red pigment to help automotive manufacturers improve the gloss and appearance of car finishes is introduced in recent literature. Monastral red RT-859-D is described as are its improved flow properties. Contact E.I. Du Pont de Nemours & Co., Inc., Wilmington, DE 19898 for more information.

Spectrophotometer

A rapid-scanning computing spectrophotometer is the subject of a new illustrated brochure. DU®-7 UV/Vis computing spectrophotometer is depicted and its features and accessories are highlighted. For a copy of Bulletin 7703, contact Beckman Instruments, Inc., Scientific Instruments Div., Campus Dr. at Jamboree Blvd., P.O. Box C-19600, Irvine, CA 92713.



Odor Masks and Fragrances

Technical data sheets containing detailed lists of odor masks and fragrances for coatings, paints, laminates, plastics and rubber, adhesives, and inks are now available. These sheets describe specially formulated compounds, some which cover up (mask) or neutralize objectionable and undesirable nontoxic odors in products; others impart a distinctive odor which enhances the product and increases its sales appeal. Free copies can be obtained from Stanley S. Schoenmann, Inc., P.O. Box 977, Clark, NJ 07066.

X-Ray Diffraction Systems

A new 20-page products catalog featuring a complete line of x-ray diffraction system configurations, components, and accessories has been published. Over 50 products are described and included are detailed descriptions and illustrations. To obtain a copy, contact the Analytical X-Ray Group, Philips Electronic Instruments, 85 McKee Dr., Mahwah, NJ 07430.

APCA Proceedings

The Air Pollution Control Association (APCA) has released a new publication entitled "Continuous Emission Monitoring: Design, Operation and Experience", the proceedings of an APCA specialty meeting. The case bound volume contains 30 original technical presentations and a subject index. The fully illustrated publication defines the state of the art of continuous emission monitoring from four specific topical areas: industry experience; regulatory position and approaches; instrumentation and testing, and quality assurance and system operation. The publication also summarizes a panel discussion on current and proposed approaches of regulatory agencies to the performance specifications test requirements and the question and answer period held during the meeting. Prices are $20 for APCA members and $25 for nonmembers. All orders must be prepaid and mailed to: Publications Department, APCA, P.O. Box 2861, Pittsburgh, PA 15230.

Inerting Systems

Inerting systems for continuous automatic oxygen analysis and control are discussed in a new brochure. Oxygen/Analyzer/Controllers in Single, Five, and 24 Channel designs, which maintain a safe atmosphere in mixing vessels, reactors, ball mills, and storage tanks by monitoring the oxygen concentration and controlling the flow of inert gas, are featured. For information, write Neutronics Inc., 450 Drew Court, King of Prussia, PA 19406.

Slatecoat

A new, unique synthetic slate coating, which is a very economical solution to many industrial and construction requirements for a fireproof and corrosion protective coating, is highlighted in literature. Components of Slatecoat are featured as are suggested applications. For information, contact William E. Lowery, American Slate Products, Inc., 1990 S. California Blvd., No. 830, Walnut Creek, CA 94848.

Letters to the Editor

Monodisperse Polymer Particles Also Made on Earth

TO THE EDITOR:

Recent descriptions of CPI technology on board the Space Shuttle (August 1982 JCT, pp 12–13) has brought forward information on an apparently impressive experiment to produce monodisperse polymer particles in space. The accompanying comments to state-of-the-art in this field, however, are grossly misleading. Whereas it is a remarkable feature to produce these particles in space, it is a fact that such, and much larger polymer particles, have been produced *with* the presence of gravity, in Norwegian Laboratories for more than 3 years.

Professor John Ugelstad has together with his group at SINTEF, Trondheim, and Dyno Industrier A/S, Norway, developed methods which allows the preparation in relatively large scale of monodisperse particles from a number of monomers and mixtures of monomers. The first Norwegian patent application was filed in February 1976 (NPA 760554) (US Pat. 4.113.687) followed by NPA 763984 (US Pat. 4.186.120) and NPA 780561 (US Pat. appl. 186.008). The products so far produced include monodisperse particles from different monomers in the range 2-50 um with standard deviation generally less than 2%. A limited number of types of these particles are marketed by Dow in USA.

Also the particles are delivered as macroporous particles and are being used by the Swedish company Pharmacia in their equipment for Fast Liquid Protein Chromatography where the extreme monodispersity is the key property for achieving the exceptional speed and resolution which are obtained by this new system.

The particles have moreover been accepted by the Commission of the European Communities, Bureau of Reference, for use as calibration standards mainly for blood cell counters. In this connection particles in the range up to 10 μm have been investigated by a large number of institutes in Europe which have specialized in measurements of particle size and size distribution. The results of these measurements on our particles is a standard deviation of about 1%.

The fact that Ugelstad's method allows the preparation of monodisperse particles of such a variety of monomers has led to a great interest for application in immunological analysis, especially in cases where monodispersity is an important requirement.

Also monodisperse particles have been prepared containing magnetic materials and such particles have found application in cell separation procedures, in particular, in connection with cancer research and have demonstrated their potential for cancer treatment.

The basic theoretical principles behind these new methods of preparing monodisperse particles as well as practical preparation and application of these particles have been presented at a number of international conferences and have also been published in several international journals.

Thus it will appear that the work with these new monodisperse particles, which are made "on earth" and have a monodispersity which can hardly be improved by a space production, already is far advanced. Obviously there are a number of interesting possibilities for application of these particles in small and also in large scale and it would seem obvious that further work with these possibilities will take place on earth. Production in space may be interesting as a curiosity but will certainly not from any point of view be of any practical importance.

DR. CONRAD KROHN, *Director*
SINTEF, Applied Chemical Div.
Trondheim, Norway

Coming Events

FEDERATION MEETINGS

(Apr. 26–27)—Federation Seminar on "The Efficient Operation of an Up-to-Date Paint and Coatings Laboratory." Hilton Plaza Inn, Kansas City, MO. (FSCT, 1315 Walnut St., Suite 832, Philadelphia, PA 19107).

(May 19–20)—Spring Meetings. Society Officers on 19th; Board of Directors on 20th. Terrace Hilton Hotel, Cincinnati, OH. (FSCT, 1315 Walnut St., Suite 832, Philadelphia, PA 19107).

(Oct. 12–14)—61st Annual Meeting and 48th Paint Industries' Show, Place Bonaventure, Montreal, Quebec, Canada. (FSCT, 1315 Walnut St., Suite 832, Philadelphia, PA 19107).

SPECIAL SOCIETY MEETINGS

(Feb. 7–9)—10th Annual "Water-Borne and Higher-Solids Coatings" Symposium sponsored by the Southern Society for Coatings Technology and the University of Southern Mississippi. New Orleans, LA. (Dr. Gary C. Wildman, University of Southern Mississippi, Southern Station, Box 5165, Hattiesburg, MS 39406).

(Feb. 23–25)—16th Biennial Western Coatings Societies' Symposium and Show. Hyatt Regency, San Francisco, CA. (Ted Favata, Chairman, Triangle Coatings Co., 2222 Third St., Berkeley, CA 94710).

(Mar. 23–26)—Southern Society Annual Meeting. Peabody Hotel, Memphis, TN. (William E. Early, Piedmont Paint Mfg. Co., P.O. Box 6223, Stn. B, Greenville, SC 29606).

(Apr. 13–15)—Southwestern Paint Convention. Dallas, TX.

(Apr. 26–27)—"Advances in Coatings Technology." 26th Annual Technical Conference of the Cleveland Society for Coatings Technology. NASA-Lewis Research Center, Cleveland, OH. (Dr. Richard R. Eley, Glidden Coatings & Resins, P.O. Box 8827, Strongsville, OH 44136).

(May 4)—Detroit Society for Coatings Technology FOCUS—"Corrosion Resistance." Michigan State University Education Center. (Peter Burnett, Wyandotte Paint Products Co., 650 Stephenson Hwy., Troy, MI 48084).

(May 5–7)—Pacific Northwest Society Symposium. Thunderbird Inn, Portland, OR. (Chairman Gerry McKnight, Lilly Industrial Ctgs. Inc., 619 S.W. Wood St., Hillsboro, OR 97123).

(June 10–11)—Joint meeting of Kansas City and St. Louis Societies. Holiday Inn, Lake of the Ozarks, MO.

OTHER ORGANIZATIONS

(Jan. 13–14)—"Fundamentals of Color" Seminar. Cincinnati, OH. (Jeanne M. Dolan, Macbeth, Div. of Kollmorgen Corp., Little Britain Rd., P.O. Box 950, Newburgh, NY 12550).

(Jan. 17–21)—"Design and Evaluation of Industrial Hygiene Ventilation Systems" Short Course. Rocky Mountain Center for Occupational and Environmental Health, University of Utah, Salt Lake City, UT. (K. Blosch, University of Utah, Bldg. 512, Salt Lake City, UT 84112).

(Jan. 23–24)—ASTM Committee E-13 on Appearance of Materials Meeting. Dutch Inn, Orlando, FL. (Kitty Riley, ASTM, 1916 Race St., Philadelphia, PA 19103).

(Jan. 23–27)—Semi-Annual Meeting of the American Society for Testing and Materials Committee D on Paint and Related Coatings and Materials. Dutch Inn, Orlando, FL. (ASTM, 1916 Race St., Philadelphia, PA 19103).

(Jan. 26)—ASTM Committee G-3 on Durability of Nonmetallic Materials Meeting. Dutch Resort Hotel, Orlando, FL. (Phil Lively, ASTM, 1916 Race St., Philadelphia, PA 19103).

(Jan. 26)—"New Concepts for Coating Protection of Steel Structures" Symposium sponsored by ASTM Committee D-1 on Paint and Related Coatings and Materials and the Steel Structures Painting Council. Dutch Inn, Orlando, FL. (Cochairman R.F. Wint, Hercules Incorporated, 910 Market St., Wilmington, DE 19899).

(Feb. 3–4)—"Fundamentals of Color" Seminar. Miami, FL. (Jeanne M. Dolan, Macbeth, Div. of Kollmorgen Corp., Little Britain Rd., P.O. Box 950, Newburgh, NY 12550).

(Feb. 6–9)—Conference on Color and Illumination sponsored by the Inter-Society Color Council and the Illuminating Engineering Society of North America. Colonial Williamsburg Lodge, Williamsburg, VA. (General Chairmen, Charles W. Jerome and William A. Thorton, Westinghouse Lamp Div., One Westinghouse Plaza, Bloomfield, NJ 07003).

(Feb. 15–17)—"Maintenance Painting" Short Course. Marriott Hotel, Bloomington, MN. (Arts & Sciences Continuing Education, G-7 Humanities-Social Sciences Bldg., University of Missouri-Rolla, Rolla, MO 65401).

(Feb. 22–24)—"Estimating for Painting Contractors and Maintenance Engineers" Short Course. Marriott Hotel, Bloomington, MN. (Arts & Sciences Continuing Education, G-7 Humanities-Social Sciences Bldg., University of Missouri-Rolla, Rolla, MO 65401).

(Feb. 24–25)—"Fundamentals of Color" Seminar. Houston, TX. (Jeanne M. Dolan, Macbeth, Div. of Kollmorgen Corp., Little Britain Rd., P.O. Box 950, Newburgh, NY 12550).

(Mar. 1–4)—Fourth International Cadmium Conference. Bayerischer Hof Hotel, Munich, West Germany. (Cadmium Council Inc., 292 Madison Ave., New York, NY 10017).

(Mar. 10–11)—"Fundamentals of Color" Seminar. Birmingham, AL. (Jeanne M. Dolan, Macbeth, Div. of Kollmorgen Corp., Little Britain Rd., P.O. Box 950, Newburgh, NY 12550).

(Mar. 24–25)—"Fundamentals of Color" Seminar. Charlotte, NC. (Jeanne M. Dolan, Macbeth, Div. of Kollmorgen Corp., Little Britain Rd., P.O. Box 950, Newburgh, NY 12550).

(Apr. 10–12)—Inter-Society Color Council Annual Meeting. Louisville, KY. (Fred W. Billmeyer, Dept. of Chemistry, Rensselaer Polytechnic Institute, Troy, NY 12181).

(Apr. 11–12)—23rd Annual Symposium of the Washington Paint Technical Group. Marriott Twin Bridges Motel, Washington, DC. (Mildred A. Post, Publicity Chairperson, WPTG, P.O. Box 12025, Washington, DC 20005).

(Apr. 12–14)—ASTM Committee C-22 on Porcelain Enamel and Related Ceramic-Metal Systems Meeting. ASTM/Philadelphia Centre, Philadelphia, PA. (Drew Azzara, ASTM, 1916 Race St., Philadelphia, PA 19103).

(Apr. 14–15)—"Fundamentals of Color" Seminar. Seattle, WA. (Jeanne M. Dolan, Macbeth, Div. of Kollmorgen Corp., Little Britain Rd., P.O. Box 950, Newburgh, NY 12550).

(Apr. 18–22)—Corrosion/83 sponsored by the National Association of Corrosion Engineers. Anaheim, CA. (NACE, P.O. Box 218340, Houston, TX 77218).

(Apr. 20–22)—ASTM Committee C-3 on Chemical Resistant Nonmetallic Materials Meeting. Galt House, Louisville, KY. (Jim Dwyer, ASTM, 1916 Race St., Philadelphia, PA 19103).

(Apr. 28–29)—"Fundamentals of Color" Seminar. Don Mills, Ont., Can. (Jeanne M. Dolan, Macbeth, Div. of Kollmorgen Corp., Little Britain Rd., P.O. Box 950, Newburgh, NY 12550).

(May 9–11)—RADCURE '83 Conference sponsored by AFP/SME. Palais de Beaulieu, Switzerland. (Susan Buhr, Society of Manufacturing Engineers, One SME Drive, P.O. Box 930, Dearborn, MI 48128).

(May 12–13)—"Fundamentals of Color" Seminar. Newton Lower Falls, MA. (Jeanne M. Dolan, Macbeth, Div. of Kollmorgen Corp., Little Britain Rd., P.O. Box 950, Newburgh, NY 12550).

(May 19–20)—"Fundamentals of Color" Seminar. Cherry Hill, NJ. (Jeanne M. Dolan, Macbeth, Div. of Kollmorgen Corp., Little Britain Rd., P.O. Box 950, Newburgh, NY 12550).

(May 23–25)—ASTM D-33 Coatings for Power Generation Facilities Committee Meeting. Galt House, Louisville, KY. (Dean M. Berger, Gilbert/Commonwealth, P.O. Box 1498, Reading, PA 19603).

(May 24–26)—8th Annual Powder and Bulk Solids Conference/Exhibition. World Congress Center, Atlanta, GA. (Cahners Exposition Group, 222 W. Adams St., Chicago, IL 60606).

(June 2–3)—"Fundamentals of Color" Seminar. Rosemont, IL. (Jeanne M. Dolan, Macbeth, Div. of Kollmorgen Corp., Little Britain Rd., P.O. Box 950, Newburgh, NY 12550).

(June 15–18)—Oil & Colour Chemists' Association Biennial Conference on "The Efficient Use of Surface Coatings." Viking Hotel, York, England. (R.H. Hamblin, Director and Secretary, OCCA, Priory House, 967 Harrow Rd., Wembley, Middlesex, HAO 2SF, England).

(June 19–22)—Dry Color Manufacturers' Association Annual Meeting. The Greenbrier, White Sulphur Springs, WV. (P.J. Lehr, DCMA, Suite 100, 117 N. 19th St., Arlington, VA 22209).

(Aug. 31–Sept. 8)—20th Commission Internationale de l'Eclairage Congress. RAI Congress Center, Amsterdam, The Netherlands. (U.S. National Committee, CIE, c/o National Bureau of Standards, Washington, D.C. 20034).

CALL FOR PAPERS

XVII FATIPEC Congress

"Coatings, Paints, and Printing Inks— Today and Tomorrow"

September 23–29, 1984

Lugano, Switzerland

The Swiss Colour and Paint Chemists' Association is now calling for papers to be presented at the XVII FATIPEC Congress.

Sessions

Plenary sessions: There will be 10 plenary sessions, with seven papers presented by the technical associations of member countries and three papers by affiliated organizations: FSCT, OCCA, and SLP. Fifty minutes will be allowed for each presentation.

Group sessions: Twenty minutes will be allowed for the presentation of short papers with 10 minutes for discussion.

Poster Sessions: These sessions will open up new possibilities of audio-visual communication. They encourage face-to-face contact between author and attendees and offer incentives for spontaneous, rewarding technical discussions. Each author will have a booth and will present a 30-minute discussion of his topic.

Deadlines

Provisional submission: with name of author and title of paper by March 1, 1983.

Definite submission: with abstracts by October 1, 1983.

Final submission: receipt of papers to be printed with abstracts in three languages by April 1, 1984.

All communications should be sent to the President of the Scientific Committee, Erich V. Schmid, Hohenweg 13, CH-9000 St. Gallen, Switzerland.

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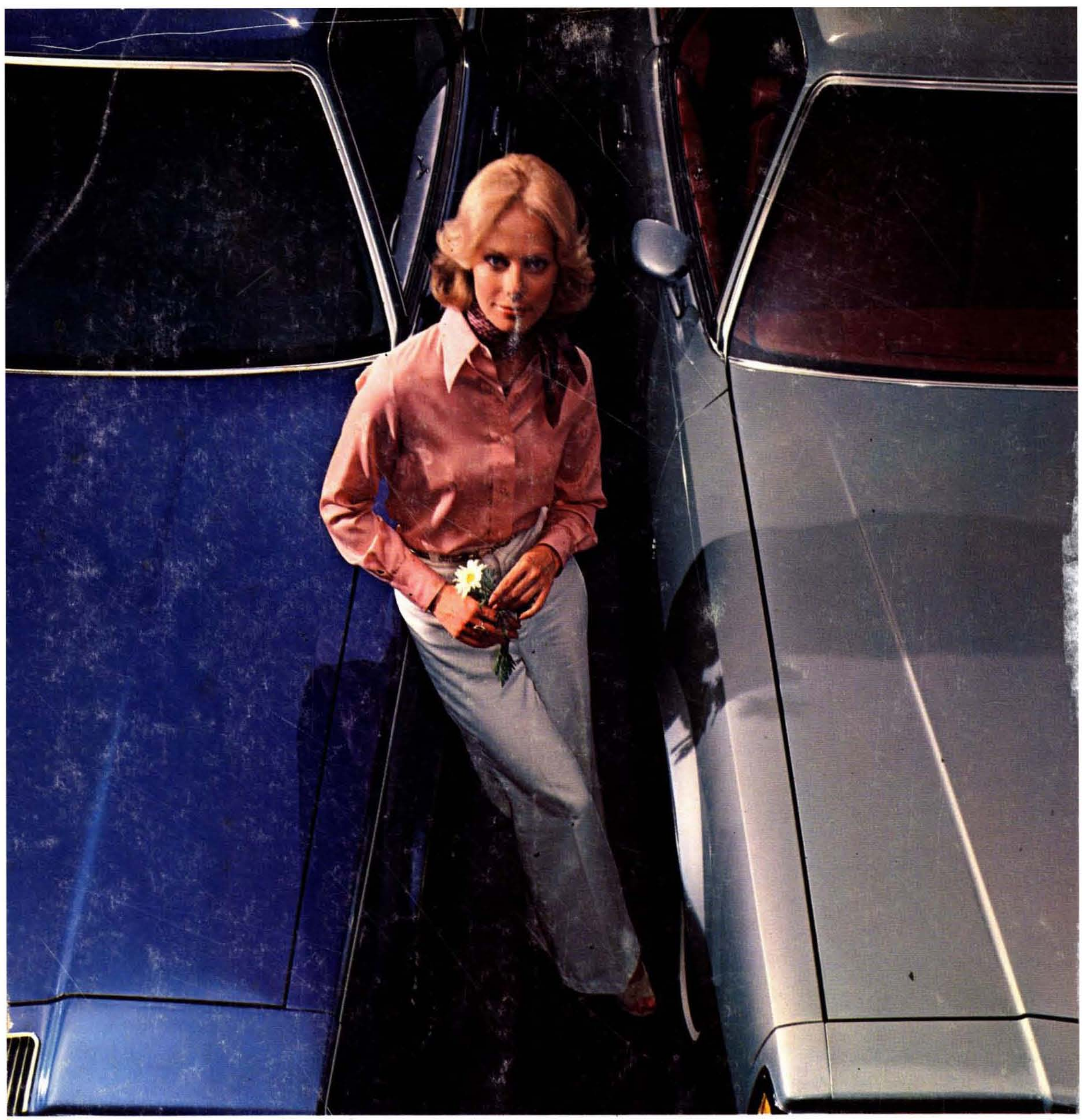

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