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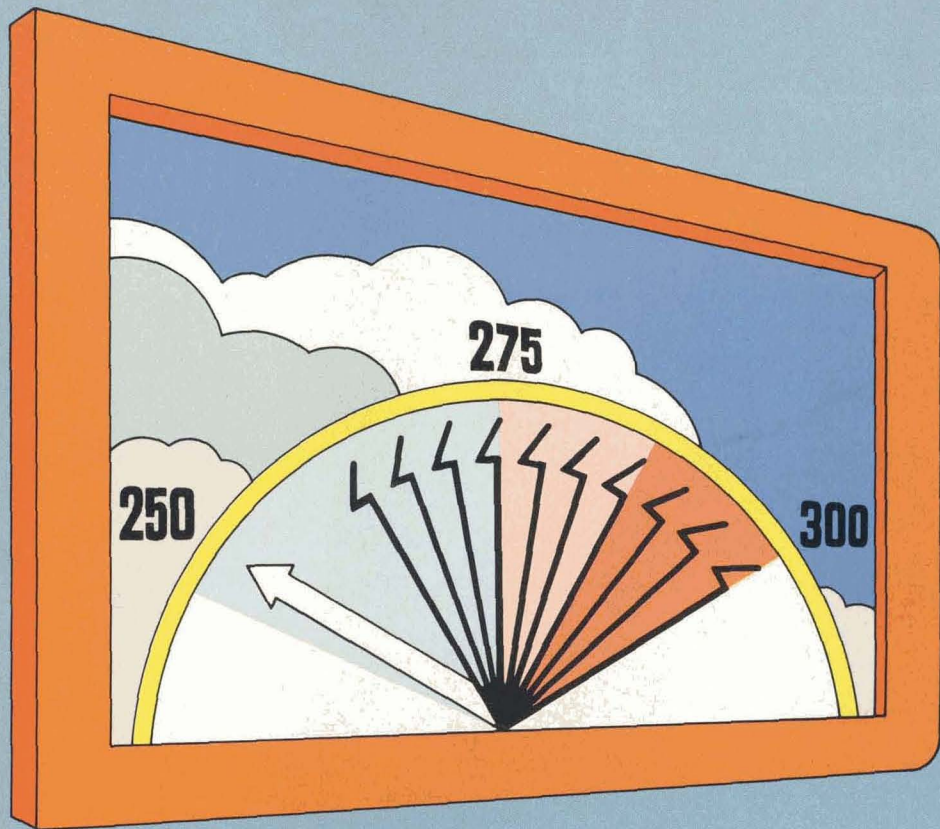
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NOVEMBER 1982



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**JOURNAL OF
COATINGS
TECHNOLOGY**

VOLUME 54 NUMBER 694

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The Federation's First Seminar

The first seminar under the complete sponsorship of the Federation has been aimed directly at the workplace of many Federation members—the Laboratory.

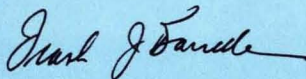
The “lab” is where paint and coatings products get their start—where they are developed and the means by which they are maintained at a uniform level of quality.

In times like the present, when business could be better and competition is keen, all paint makers should take a fresh look at their laboratories.

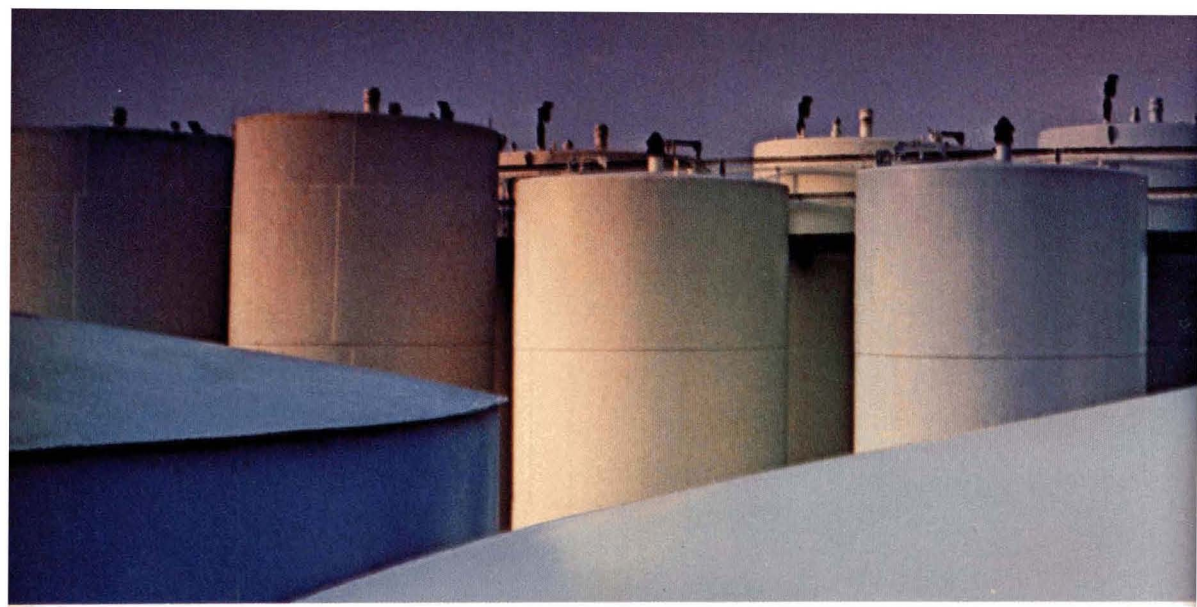
The April 26–27 seminar on “The Efficient Operation of an Up-to-Date Paint and Coatings Laboratory” will cover all phases of laboratory planning and operation. The dozen or more speakers will represent the best in their fields of expertise. The program sessions will be under the direction of Roy Brown, Federation Technical Advisor.

Personnel from all-size companies will benefit from the seminar and will leave Kansas City on April 27 with new and valuable ideas to put to work in their company's laboratory.

Check this issue (page 16) and future JCTs for more details. The Federation's first seminar has been a long time in coming—but well worth the wait.



Frank J. Borrelle,
Executive Vice-President



CIBA-GEIGY epoxy resins vs. the toughest applications around

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.

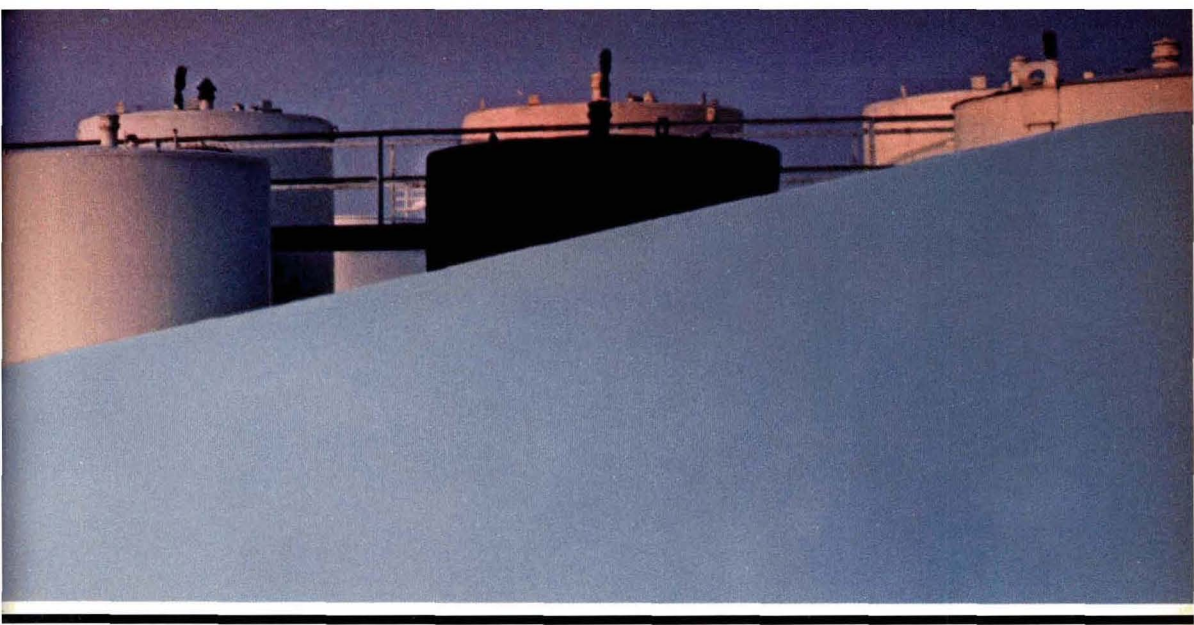


XU-252 based coating.

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 coated surface.

As you can see in the panels, an XU-252 based coating showed no 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.

Tell us about your toughest applications.

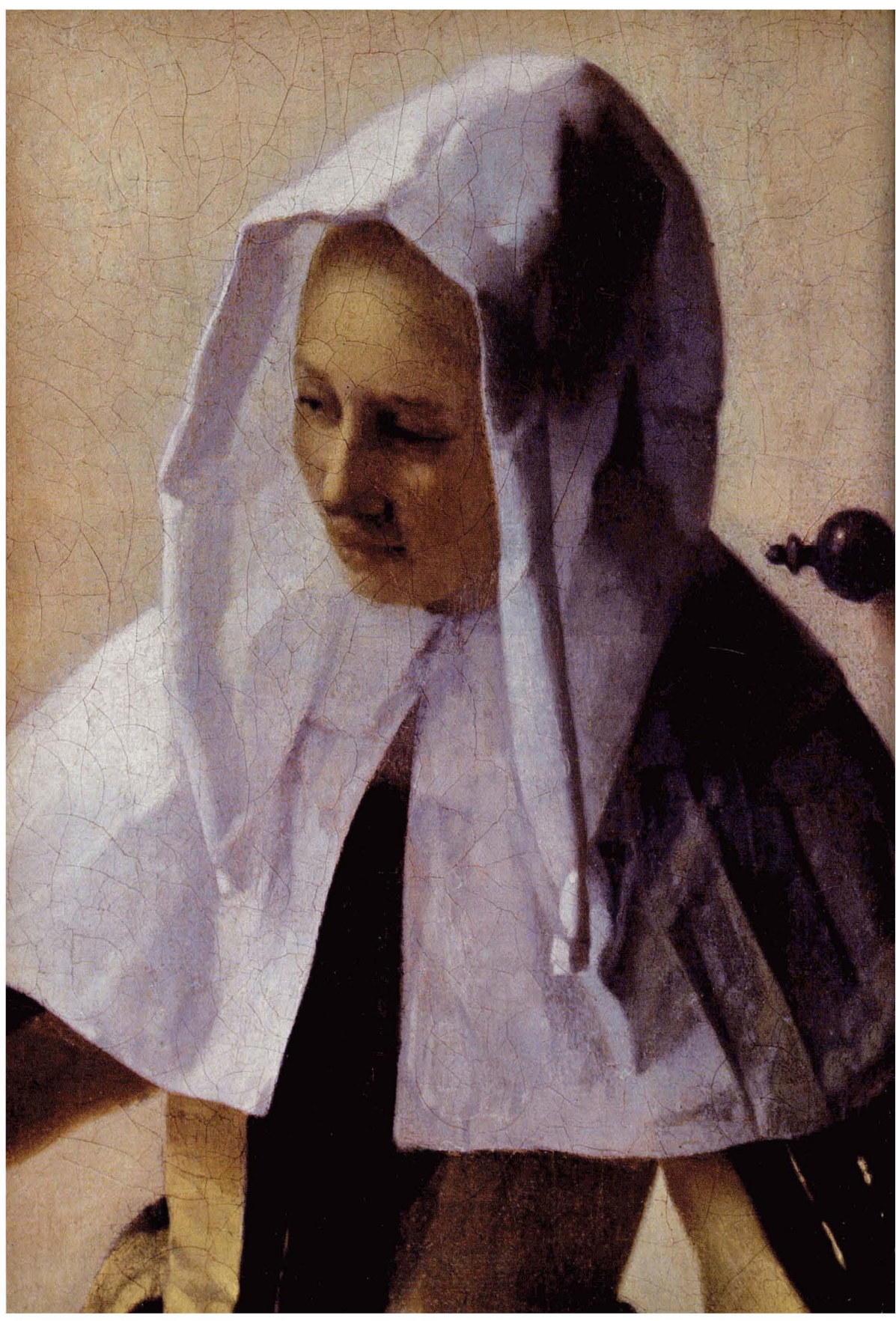
Storage tank linings are only one of the tough applications CIBA-GEIGY epoxy resins and hardeners can handle. They're also ideal for such applications as pickling lines, hot waste disposal and nuclear containment areas, pollution control equipment, and flooring in pulp and paper mills.

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.

Chemical and solvent resistance of XU-252 based coatings							
Reagents	Months to date/test duration 8 months						
	1	2	3	4	5	6	7
Acetic acid (10%)							Failed
HCl (36%)							
NH ₄ OH (30%)							
Acetone							
Methylene chloride							
Methanol							

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

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PORTRAIT OF AN AGE-OLD PROBLEM.

The deterioration of a fine work of art. Most people see it as a shame.

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You'll find that protecting a valuable paint job is just as important to us as protecting a valuable painting.



Coatings Materials

Abstracts of Papers in This Issue

BROOKFIELD VISCOMETERS FOR DETERMINATION OF LOW-SHEAR VISCOSITY AND LEVELING BEHAVIOR—R. E. Smith

Journal of Coatings Technology, 54, No. 694, 21 (Nov. 1982)

Viscosity at low shear rates is important in the formulation of organic coatings but has been difficult to measure. A stress relaxation technique is described which is suitable for trade sales paints at shear rates of $0.001 - 1.0 \text{ sec}^{-1}$. The method is essentially Patton's (1966) cone-and-plate technique adapted for other rotational viscometers, especially the Brookfield instruments. The technique can also be used to measure very high viscosities, above the normal range of the instrument. Procedures are described for processing the data with a computer, including corrections for the finite viscometer gap. The effect of inertia of the viscometer is calculated but found to be insignificant. Leveling of brushmarks is described as an example of the importance of low-shear viscosity measurements.

DEPENDENCE OF SURFACE PROPERTIES IN PMMA COATINGS ON PREPARATION HISTORY—A. Carré and H.P. Schreiber

Journal of Coatings Technology, 54, No. 694, 31 (Nov. 1982)

Thin films of well-characterized poly (methyl) methacrylate (PMMA) were deposited onto metal and polymer substrates from solutions using pure solvents and solvent-mixtures of varying thermodynamic interaction with the polymer. The critical surface tension of polymer films at the air interface was essentially independent of solvent medium, showing that equilibrium chain configuration was attained at the interface, regardless of the chain configuration in solution. In contrast, the penetration rates into the PMMA films of polar and non-polar fluids varied widely with the solvent. In general, PMMA films formed from thermodynamically good solvents were found to be very much less penetrable by fluids than were films formed from weaker solvents. It is postulated that chain configuration in the bulk of the film is similar to that in solution, and that this leads to differences in chain packing which account for the observed barrier properties. PMMA films cast onto low-surface energy solids (e.g. PTFE) have the same surface tensions at the air and at the substrate interface. However, the surface tensions of PMMA removed from metal substrates (e.g. pure Hg) are significantly higher than those at the air interface. Such films therefore, are considered to be non-isotropic and subject to time-dependent changes in properties ("aging"), as the thermodynamic demands of equilibrium configurational states are attained.

ELECTROPHORETIC CHARACTERIZATION OF FUNCTIONAL LATEXES BY QUASIELASTIC LIGHT SCATTERING—Cleveland Society for Coatings Technology

Journal of Coatings Technology, 54, No. 694, 37 (Nov. 1982)

Measurement of particle size and electrophoretic mobility of four, acid-functional latexes were made using quasi-elastic light scattering technique (QELS). Details of the instrumentation and data analysis for electrophoretic QELS are discussed. The technique provides a rapid and precise tool to assess the transport properties and stability of latexes with a wide range of particle sizes (10 to 3000 nm). The acid-functional latexes were deposited onto steel by the autodeposition process and the rates of deposition are discussed in terms of the results of the QELS measurements.

COMBUSTIBILITY OF WATER-BORNE PAINTS AND PRINTING INKS—W. Hansen

Journal of Coatings Technology, 54, No. 694, 45 (Nov. 1982)

In the investigation carried out, the lacking correlation between flash point and combustibility of solutions of organic solvents in water and water-borne paints and inks has been demonstrated. The difference between flash point and combustibility is due to the dynamic fueling of the fire, which is controlled by the evaporation rate of the solvent. The evaporation rate is influenced considerably by the heat capacity of the product and the presence of other components (e.g., binders). While other factors influence combustibility, the flash point seems influenced only by the concentration of the solvent and the temperature of the solution, because the flash point is determined under static conditions.

PRACTICAL CONSIDERATIONS IN THE DRYING OF WATER-REDUCIBLE ALKYDS—R. Hurley and F. Buono

Journal of Coatings Technology, 54, No. 694, 55 (Nov. 1982)

The differences in drying characteristics between solvent and water-borne alkyds are discussed. Generally, higher active metal levels are required for water-borne alkyds since both the neutralizing base and the presence of water as the primary solvent contribute to slower dry time. Functional drier systems based on precomplexed cobalt and cobalt/zirconium/calcium have been developed and data demonstrating their utility in several commercial alkyds are presented. The problem of loss of dry is considered and is attributed to both drier adsorption on the pigment and hydrolytic degradation of the resin. Careful pH control is presented as the best way to prevent resin degradation.

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A. Clarke Boyce, of Toronto Society Becomes Sixty-First Federation President

A. Clarke Boyce, of Nacan Products Ltd., Toronto, Ont., Canada, became the 61st President of the Federation of Societies for Coatings Technology on November 5 at the Federation's Annual Meeting in Washington, DC.

Terryl F. Johnson, of Cook Paint & Varnish Co., Kansas City, MO, was named President-Elect; and Joseph A. Bauer, of Porter Paint Co., Louisville, KY, was elected treasurer.

President Boyce

Mr. Boyce is a Past-President of the Toronto Society. He has served as Society Representative on the Federation's Council and, later, Board of Directors. He was Chairman of the Toronto Technical and Educational Committees, where he helped institute the current coatings courses at George Brown College.

After graduating from Western Ontario University with a B.S. Degree in Chemistry, Mr. Boyce began working in the paint industry with Langmuir Paints and, in 1962, joined National Starch (Nacan Products) as Chief Chemist. He is now the Technical Service Manager for the Resin Div., directing Nacan's resin R&D activities.

He and his wife, Marjorie, reside in Oakville, Ontario.

President-Elect Johnson

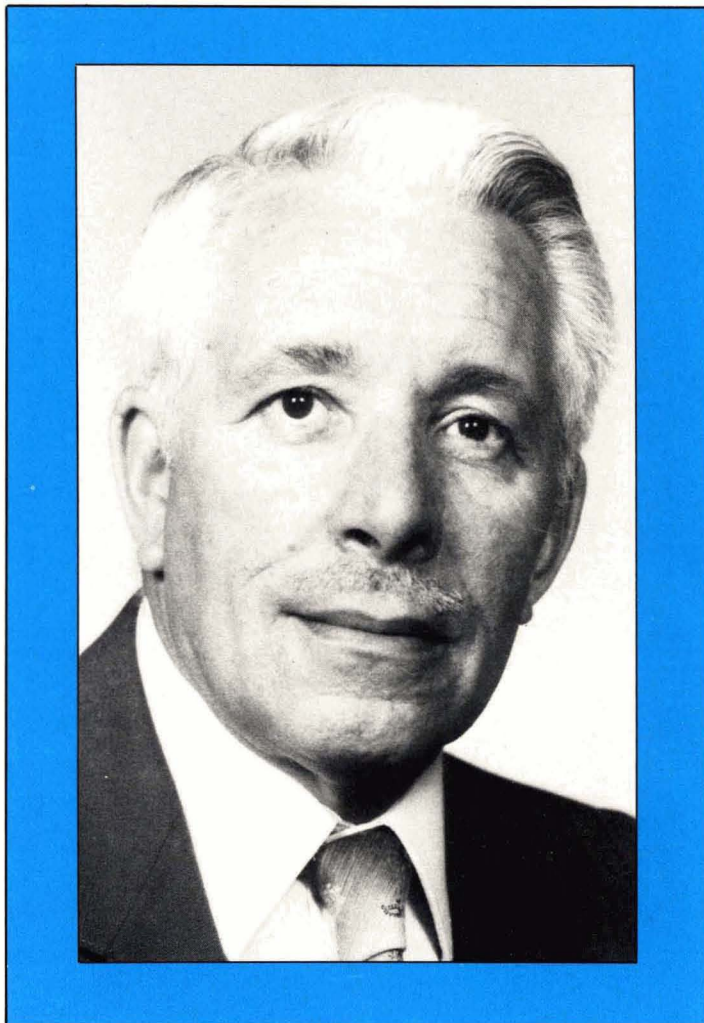
Mr. Johnson is a Past-President of both the Kansas City Society and Kansas City PCA. He was Society Representative to the Federation Board of Directors for eight years. He served as a member of the Federation Executive Committee and Chairman of the Materials Marketing Associates Awards Committee.

Mr. Johnson has been with Cook since 1947. He is a graduate of the University of Missouri.

Treasurer Bauer

Mr. Bauer is a Past-President of the Louisville Society and has been Society Representative to the Federation Board of Directors since 1973. He has served on numerous committees at both the Society and Federation levels, including the Federation Executive Committee.

Mr. Bauer joined Porter Paint in 1952. He is a graduate of the University of Louisville.



T.F. Johnson



J.A. Bauer

Montreal Is 1983 Site Of FSCT Annual Meeting

The 1983 Annual Meeting and Paint Industries' Show of the Federation will be held at the Hotel Bonaventure in Montreal, Quebec, Canada, on October 12-14.

This is the first time that these events will be held outside of the United States and the Host Committee for the Annual Meeting will consist of members of both the Toronto and Montreal Societies.

HOW TO SATISFY THE EPA, YOUR CUSTOMERS AND YOURSELF.

The Clean Air Act is a tough act to follow, especially when customers are demanding better and better performance. Fortunately, Dow Corning offers technology to everyone's satisfaction.

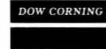
We've recently introduced an 80%-solids silicone blending resin that improves the heat and weathering resistance of a wide range of organic vehicles. Its inherent low solvent content provides greater freedom in formulating VOC compliant coatings.

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WATER-REDUCIBLE TECHNOLOGY

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Company name

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Dept. B-2010, Midland, MI 48640.

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President Boyce Announces Committee Chairmen for 1982-83

Chairmen of the 28 committees of the Federation of Societies for Coatings Technology for 1982-83 have been announced by President A. Clarke Boyce. A complete roster of all committees will be published in the 1983 Year Book.

An asterisk (*) indicates re-appointment for 1983.

A.F. VOSS/AMERICAN PAINT & COATINGS JOURNAL AWARDS—Carl Knauss, Kent State University, Kent, OH.

BRUNING AWARD—Ruth Johnston-Feller, Pittsburgh, PA.*

BY-LAWS—Fred Schwab, Coatings Research Group, Cleveland, OH.*

CORROSION—Saul Spindel, D/L Laboratories, Inc., New York, NY.*

DEFINITIONS—Stanley LeSota, Rohm and Haas Co., Philadelphia, PA.*

EDUCATION—James Hoecck, Reliance Universal, Inc., Louisville, KY.*

ENVIRONMENTAL CONTROL—Sidney Rubin, Empire State Varnish Co., Brooklyn, NY.

FINANCE—Howard Jerome, Spatz Paint Industries, Inc., St. Louis, MO.

HECKEL AWARD—Stanley LeSota.

HOST (Annual Meeting)—Horace Philipp, Sherwin-Williams Co., Montreal, Ont., Can.

INTER-SOCIETY COLOR COUNCIL—Jacqueline Welker, PPG Industries, Inc., Springdale, PA.

INVESTMENT—Neil Estrada, Reichhold Chemicals, Inc., S. San Francisco, CA.*

LIAISON—John J. Oates, Troy Chemical Corp., Newark, NJ.*

MANUFACTURING—Richard Max, Synkote Paint Co., Elmwood Park, NJ.*

MATTIELLO LECTURE—Steven Bowell, Glidden Coatings & Resins Div., SCM Corp., Strongsville, OH.

MEMBERSHIP—R.H. Stevenson, Tenneco Chemicals Canada Ltd., Bramalea, Ont., Can.

MEMORIAL—Elder Larson, Shell Development Co., Houston, TX.

MMA AWARDS—Al Heitkamp, Cargill, Inc., Minneapolis, MN.*

NOMINATING—Howard Jerome.

PAINT INDUSTRIES' SHOW—Deryk R. Pawsey, Rohm and Haas Canada Ltd., Vancouver, B.C.*

PROGRAM—Peter Hiscocks, C-I-L Paints, Inc., Toronto, Ont., Can. Vice-Chairman—Darlene Brezinski, DeSoto, Inc., Des Plaines, IL.

PROGRAM AWARDS—Take Anagnostou, Wyandotte Paint Products, Inc., Troy, MI.

PUBLICATIONS—Thomas J. Miranda, Whirlpool Corp., Benton Harbor, MI.*

ROON AWARDS—Darlene Brezinski.*

SPECIFICATIONS—Lothar Sander, Amchem Products Co., Philadelphia, PA.*

TECHNICAL ADVISORY—William F. Holmes, DeSoto, Inc., Garland, TX.*

TECHNICAL INFORMATION SYSTEMS—Helen Skowronska, Cleveland, OH.*

TRIGG AWARDS—Barry Oppenheim, McCloskey Varnish Co., Philadelphia, PA.

Delegates to Other Organizations

NATIONAL ASSOCIATION OF CORROSION ENGINEERS—Thomas Ginsberg, Union Carbide Corp., Bound Brook, NJ.*

NATIONAL PAINT & COATINGS ASSOCIATION, SCIENTIFIC COMMITTEE—Colin Penny, Hampton Paint Mfg. Co., Hampton, VA.

STEEL STRUCTURES PAINTING COUNCIL—Sid Levinson, D/L Laboratories, Inc., New York, NY.*

NATIONAL PAINT & COATINGS ASSOCIATION AND GOVERNMENT AGENCIES (ENVIRONMENTAL CONTROL)—Sidney Rubin.

INTERNATIONAL UNION OF PURE AND APPLIED CHEMISTRY—Milton A. Glaser, Glencoe, IL.*

'Paint/Coatings Dictionary' Nears 3,000 Mark in Sales

One of the most popular—and useful—items ever published by the Federation is the *Paint/Coatings Dictionary*. Produced initially in 1978 this fountain of information is rapidly approaching a milestone—3,000 volumes sold!

The 632-page book contains more than 5,500 entries and an extensive bibliography defining the technical terms and jargon of the coatings industry and its allied fields of technology.

The Federation's Definitions Committee members, working under the chairmanship of Stanley LeSota, of Rohm and Haas Co., labored over a 12-year period compiling the consensus definitions of the terms most widely used in the industry.

The popularity of the Dictionary has fostered an offspring, the *Color Glossary*. Approximately 400 definitions of color terms, detailing color difference equations, optical phenomena, gloss, hiding, color instrumentation, etc., were taken from the Dictionary and published separately for the convenience of those working in color-related fields.

The price of the *Paint/Coatings Dictionary* is \$30 to members; \$50 to non-members. The *Color Glossary* is \$6. Both are available from Federation headquarters.

Paint Lab Planning and Operation Will Be Discussed At FSCT Seminar Scheduled For April 26-27

The many and varied aspects of designing and operating a modern paint and coatings laboratory will be explored in a 1½-day seminar sponsored by the Federation of Societies for Coatings Technology.

The seminar on "The Efficient Operation of an Up-to-Date Paint and Coatings Laboratory" will be held April 26-27, 1983 at the Hilton Plaza Inn, Kansas City, MO.

Discussions will be designed to help paint and coatings manufacturers reevaluate the efficiency of their laboratory design, equipment, and operating procedures.

Included among the subject areas to be covered are:

- Designing a laboratory to fit the product mix.
- Planning the R&D budget—what % of sales is optimum?
- Quality assurance and quality control for both raw materials and finished products.
- Equipment and instrumentation needed for analytical, R&D, and quality control work.
- Approach to formulation—architectural, maintenance, and product finish coatings.

- Color control—personnel and instrument requirements.
- Resins and polymers—make or buy?
- Equipment and personnel requirements.
- Pigment dispersion research.
- Remodeling an old laboratory.
- Checking and standardizing test methods and instruments.
- Laboratory safety—protective equipment and materials, instrument operation, training, etc.
- Recycling of wastes and obsolete materials.
- Relationship of technical personnel to management, sales, and production.
- Training new chemists and technicians.

Speakers will be well-known coatings industry personnel, experienced and knowledgeable about the specific topic.

Program sessions are under the direction of Royal A. Brown, FSCT Technical Advisor, in cooperation with the Federation staff, which is responsible for other arrangements.

To obtain further information on the program or registration, contact Federation of Societies for Coatings Technology, 1315 Walnut St., Suite 832, Philadelphia, PA 19107.

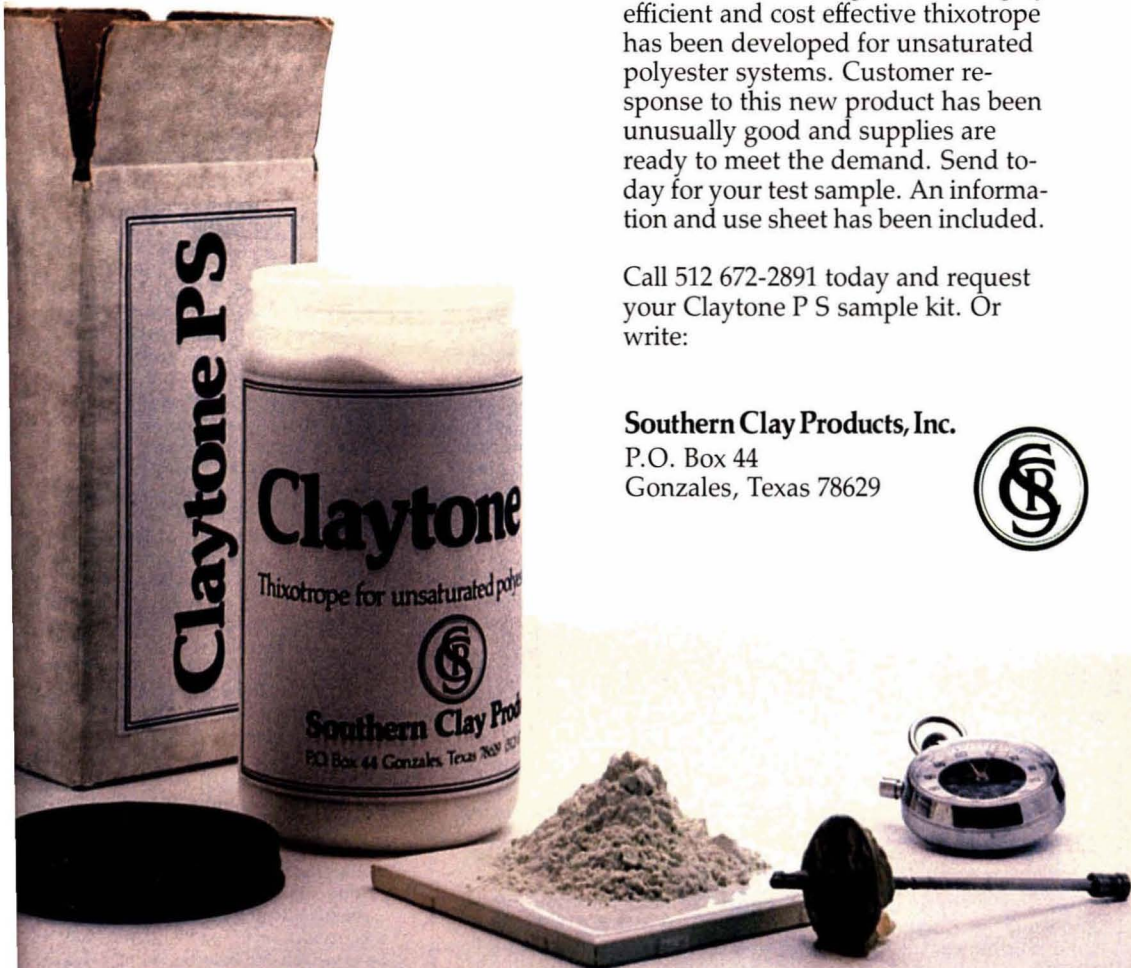
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NPCA Issues Safety Guidelines for Use of Halogenated Hydrocarbon Solvents

There is potential explosion risk from using paints formulated with halogenated hydrocarbon solvents in aluminum pressurized spray application equipment or in closed manufacturing systems featuring aluminum storage tanks or transfer pumps, according to a bulletin just released by the National Paint and Coatings Association (NPCA). The bulletin also cautions against the use of halogenated hydrocarbon solvents to clean up pressurized aluminum equipment, although this warning does not pertain to cold cleaning or vapor degreasing of aluminum.

The bulletin warns the industry that halogenated hydrocarbon solvents react corrosively with aluminum and when a reaction takes place within pressurized or enclosed equipment, the resulting increase in temperature and generation of trapped gasses can cause an extremely powerful pressure explosion.

Two halogenated hydrocarbon solvents, methylene chloride and 1,1,1-trichloroethane, have been especially cited by the Association because they are beginning to be widely used in coatings to permit these products to meet lowered solvent emission limits under the Clean Air Act.

NPCA recommends that companies using these solvents should inform their end users, distributors and customers to use coatings products formulated with halogenated hydrocarbon solvents with application equipment made of black iron, mild steel or stainless steel and to warn these individuals not to use the solvents for cleanup of pressurized aluminum equipment.

NPCA is working with the National Spray Equipment Manufacturers Association and the Halogenated Cleaning Solvents Association to prepare safety alerts designed to inform all appropriate persons of these hazards and to recommend proper materials of construction for equipment.

NPCA's Safety and Health Bulletin No. 47, "Halogenated Hydrocarbon/Aluminum Hazard," explains both the problem and the background chemistry, and gives examples of appropriate hazard warning statements. Free copies of the bulletin, one per company, may be obtained from Ken Zacharias, Technical Representative, Technical Div., NPCA, 1500 Rhode Island Ave., N.W., Washington, D.C. 20005.

Solvent Limit Increased For San Diego District

The San Diego Air Pollution Control District Hearing Board has granted a variance increasing the solvent limit permitted in non-flat architectural coatings manufactured and sold in that District from 250 grams per liter to 380 grams per liter. The Board took this action following paint industry testimony requesting the higher limit at a July 8 hearing. The variance is scheduled to be in effect through April 28, 1983 to permit sufficient time for the San Diego Board of Supervisors to consider an amendment to the current architectural coatings regulation.

Battelle Develops New Process for Alkyd Resins

An improved process for preparing air-driable alkyd resins widely used in paints, inks, and coatings has been developed at Battelle's Columbus Laboratories. The new process improves the quality of the resins while reducing the energy and time necessary to prepare them. Battelle recently received a U.S. patent (U.S. 4,335,027) for the process and now hopes to commercialize it. It was developed as part of an internally supported research program.

According to Battelle co-inventors George A. Cremeans and Richard A. Markle, air-driable alkyd resins are widely used in paints and other products because when exposed to air the resins form a tough coating that cannot easily chip or break. To prepare paints, the resins are mixed with organic solvents, pigment, and drying agents.

With the new Battelle process, the organic anhydrides and glycidyl esters initially are mixed with metal salt catalysts. The mixture is heated in reactors at temperatures not exceeding 100° C for between two and four hours. In the reactors the compounds polymerize and form a resin. With conventional processing, different compounds are used as the resin feedstock. These compounds require heating at between 230 and 250° C for as long as 12 hours.

In addition to energy and time savings, the new process also offers several other advantages over conventional methods.

First, under the new process the resins are colorless, they said. This is important if the resins are used in white or light-colored paints. Under conventional methods the finished resins take on a darker color that is difficult to remove. The color often results because substantial amounts of side products are produced during the long heating periods.

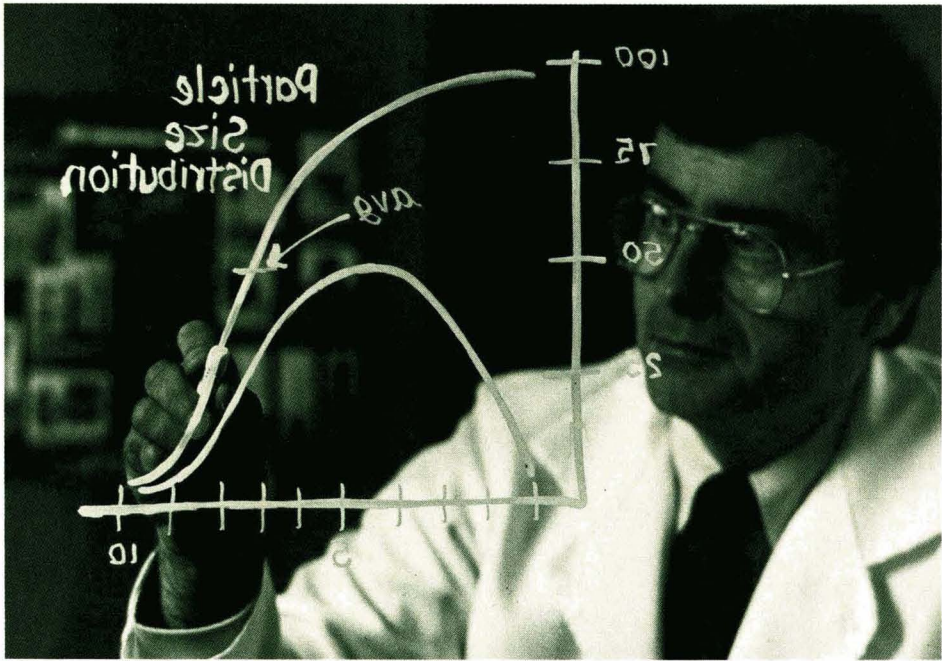
Also, the alkyd resins produced with the new Battelle process have a narrower molecular weight range, imparting excellent leveling or flow-out characteristics to coatings formulated using these resins.

Additional information on the process is available from George A. Cremeans or Dr. Maynard M. Baldwin, Battelle, 505 King Ave., Columbus, OH 43201.

TSCA Inventory Supplement II Is Available

The EPA has announced the availability of the latest supplement to the Toxic Substances Control Act Chemical Substances Inventory Cumulative II, which lists all newly added substances along with all previously announced chemicals.

The Cumulative Supplement II can be ordered through the Government Printing Office. Order No. 055-000-00218-5. The cost is \$17. To order, write: Superintendent of Documents, U.S. G.P.O., Washington, D.C. 20402.



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Chemicals



Brookfield Viscometers For Determination of Low-Shear Viscosity And Leveling Behavior

Ronald E. Smith
PPG Industries, Incorporated*

Viscosity at low shear rates is important in the formulation of organic coatings but has been difficult to measure. A stress relaxation technique is described which is suitable for trade sales paints at shear rates of 0.001–1.0 sec⁻¹. The method is essentially Patton's (1966) cone-and-plate technique adapted for other rotational viscometers, especially the Brookfield instruments. The technique can also be used to measure very high viscosities, above the normal range of the instrument. Procedures are described for processing the data with a computer, including corrections for the finite viscometer gap. The effect of inertia of the viscometer is calculated but found to be insignificant. Leveling of brushmarks is described as an example of the importance of low-shear viscosity measurements.

INTRODUCTION

Coatings usually are non-Newtonian liquids—their viscosity depends on the rate of shear. Under some conditions, such as application by brushing, the shear rate is very high, about 10,000 sec⁻¹. After application, when leveling and sagging occur, the shear rate is much lower, about 0.001 to 1.0 sec⁻¹.

Determination of viscosity at moderate or high shear rates is relatively simple, but measurements at shear rates less than 1.0 sec⁻¹ are more difficult. Research instruments can do this but are quite expensive. More common instruments such as the Brookfield viscometers can be geared down to give low shear rates, but this procedure is impractical with coatings such as trade sales paints. One problem is that at low rpm, several minutes may be required to reach a steady state, partly to get the sample

moving, and partly to allow the spring to wind up. Paints may skin over during this period. Also, taking readings over several minutes is tedious even if a recorder is available. If the sample possesses a time-dependent rheology (thixotropy), this makes measurements even more difficult.

One way to avoid these problems is to use a stress relaxation method in which the sensor is wound up against the spring with the instrument turned off. The sensor is then released, and, as the sensor unwinds, the sample is subjected to a gradually decreasing rate of shear. The procedure is especially attractive because it can be used to simulate the process of leveling.

Relaxation tests have occasionally been used to study paints. Kreider¹ used the relaxation of a Brookfield LVF spindle to do so, and Beferman and Bergren² similarly used a Haake Roto-Visco. However, neither of these authors actually calculated viscosity. The method was quantified by Patton³ who calculated viscosity of trade sales paints over the range of 0.001 to 1.0 sec⁻¹. Patton's method has received surprisingly little attention, and a search of Citation Index from 1974 to 1980 produced only nine citations of his publication. One problem may be that Patton's procedure was described specifically for the Wells-Brookfield cone-and-plate viscometer, which is not as well known as, for example, the Brookfield Synchroelectric RVT or LVT. A more serious problem is the conversion of the raw data to viscosity, which was accomplished by a tedious, graphical procedure. With the general availability of computers, it is no longer necessary to process the data by hand.

Referring to Patton, Sylvester and Ludwico⁴ noted that the relaxation technique cannot distinguish between the effects of shear-thinning and time dependency (thixotropy). This is a valid objection if results are to be related to situations where the liquid is subjected to steady, low shear rates. However, for problems such as leveling of brushmarks, the fluid experiences a gradually decreasing stress over a period of time during which viscosity can also increase due to thixotropic effects. It has been pointed out by Colclough and coworkers⁵ that

Presented at the 25th Technical Conference of the Cleveland Society for Coatings Technology, March 23, 1982, Berea, OH.
* Allison Park, PA 15101.

Table 1—A and M Factors for Brookfield Viscometers With SC-4 Small Sample Adapter and UL Adapter

Viscometer	Sensor ^a	A	M
LVT.....	UL	0.0734	1.224
LVT.....	SC4-18	0.396	1.32
LVT.....	SC4-21	0.436	0.93
LVT.....	SC4-27	0.797	0.34
RVT.....	UL	0.783	1.224
RVT.....	SC4-18	4.22	1.32
RVT.....	SC4-21	4.65	0.93
RVT.....	SC4-27	8.50	0.34

(a) SC4 Sensors were used with Chamber SC4-13R; UL Sensor was used with UL4 Chamber.

the relaxation method measures the net resistance to flow under conditions that are realistic with respect to leveling. If it is important to determine effects of shear history, the relaxation test can be repeated under several conditions.

Colclough and coworkers⁵ recently described a new low-shear viscometer that utilizes the stress relaxation principle. It processes data automatically, and uses the results to predict leveling. However, this instrument is not yet commercially available. Also, the authors assume Newtonian behavior. This assumption is generally invalid for paints and can be quite misleading.

In this paper, a computer-assisted method is described for handling stress relaxation data in which the assumption of Newtonian behavior is avoided. It is shown that the procedure can be used with Brookfield and Roto-Visco viscometers. Tests with both Newtonian and non-Newtonian fluids are shown to give the correct results. Finally, to illustrate how the data can be used, it is shown how the leveling of brushmarks can be predicted.

EXPERIMENTAL PROCEDURES

The procedure described is not limited to a single viscometer, but the Brookfield LVT and RVT viscometers are preferred because of their simplicity and low cost. These instruments have frequently been criticized because, when used with the standard spindles, the design is undesirable for testing non-Newtonian fluids. The problem is that the gap between the spindle and container is very large, and shear rate varies greatly across the gap. In some cases, the shape of the spindles makes the interpretation even more difficult. However, the new Small-Sample Adapter and the UL Adapter provide a narrow-gap cup-and-bob geometry, making the Brookfield comparable to much more expensive viscometers. These adapters also allow better control of temperature and require small samples. The relaxation procedure can be used with standard Brookfield spindles, but in that case it is especially important to correct for the gap error. Such corrections are described in this paper.

Except for using different viscometers, the raw data was obtained using the Patton procedure. That is, the test liquid was loaded into the viscometer cell and

allowed to come to temperature. Then, the sample was sheared at a high rate in the viscometer, to simulate application. Our LVT viscometer was modified by the manufacturer to allow a top speed of 760 rpm for this purpose. Then, with the instrument turned off, the spindle was turned full-scale by hand, then released. The scale reading (S) was recorded as a function of time (t) as the spindle relaxed. The data were recorded by hand, using a stopwatch, but it is easier if viscometer output can be sent to a strip-chart recorder.

To process the data, it is necessary to relate the scale reading (S) to the shear stress (τ , dyne/cm²):

$$\tau = A \cdot S \quad (1)$$

where A is a constant that depends on viscometer characteristics. The apparent shear rate ($\dot{\gamma}_a$, sec⁻¹) is proportional to the speed of rotation (n, revolutions per minute):

$$\dot{\gamma}_a = M \cdot n \quad (2)$$

where M is also a viscometer constant. The subscript emphasizes that $\dot{\gamma}_a$ is the apparent shear rate that is exactly correct only for an infinitely narrow gap between the cup and bob. Corrections for this error are often ignored but they can easily be made by procedures described later in this paper. The corrections are especially important for the standard Brookfield spindles.

Haake, Inc. supplies factors A and M for each Roto-Visco sensor. Constants for Brookfield viscometers can be obtained from the manufacturer's literature but are not given explicitly. They are listed in Table 1 for Small-Sample and UL Adapters. If standard Brookfield spindles are used in a large container, such as a quart can, the factor M for all spindles is $4\pi/60 = 0.21$. The factor A can be determined from the relation:

$$A = \frac{GM}{100} \quad (3)$$

where G is the factor for calculating viscosity according to:

$$\eta \text{ (in cps)} = \frac{GS}{n} \quad (4)$$

Values of G were tabulated by Pierce⁶ and are also found in the manufacturer's literature.

A third constant that depends on the viscometer is C, the number of scale graduations in a complete revolution. According to the manufacturer, all Brookfield Synchroelectric and Wells-Brookfield dial reading viscometers use the same scale of 0–100 that encompasses 312°. Therefore,

$$C_{\text{Brookfield}} = \frac{100}{312/360} = 115.4 \quad (5)$$

The new Brookfield Digital Viscometers have a different sensing angle. For our Roto-Visco RV-3, C was estimated to be 380 graduations per circumference.

Patton³ showed that the angular velocity (ω) in radian/sec can be obtained from the rate of change of the scale reading:

$$\omega = \frac{-2\pi}{C} \frac{dS}{dt} \quad (6)$$

The negative sign was omitted by Patton but is necessary

because S is decreasing, so dS/dt is negative. Using the relation between n and ω :

$$n = \frac{60 \omega}{2 \pi} \tag{7}$$

one can obtain the shear rate:

$$\dot{\gamma}_a = -60 \frac{M}{C} \frac{dS}{dt} \tag{8}$$

Thus, by measuring S and determining instantaneous values of dS/dt over time, one can calculate τ and $\dot{\gamma}_a$ over the range of the experiment. Then, viscosity (η) in centipoise can be calculated as:

$$\eta_a = 100 \frac{\tau}{\dot{\gamma}_a} \tag{9}$$

to give viscosity as a function of shear rate.

Patton³ integrated equation (6) after appropriate substitution to obtain a linear relationship between $\ln S$ and t . Sylvester and Ludwico⁴ pointed out that, in performing this integration, viscosity was assumed to be independent of time and shear stress, and, therefore, the integration is valid only for Newtonian fluids. In Patton's procedure the validity of this step is not important because he did not actually use the integrated form in his calculations. However, Colclough⁵, et al., did calculate viscosity using the integrated equation.

CALCULATIONS

Two approaches are possible in the problem of converting the raw data to viscosity. A general approach is to make no assumptions about rheology of the coating, and obtain a large number of data points and calculate viscosity at each point. The second, simplified, approach requires only a few data points but assumes that the coating obeys a power law relationship over the whole range of shear rates being measured. It has been found that the simplified method is satisfactory with most coatings. In any investigation it would be best to test a few samples using the general method; then, if possible, proceed with the simplified method.

The simplified procedure assumes that the sample obeys a power law model:

$$\tau = K \dot{\gamma}^N \tag{10}$$

Although the relationship will generally not hold over a wide range of shear rate, it usually is a good model within the low shear rates determined by this test method. If τ and $\dot{\gamma}_a$ are expressed in terms of S and dS/dt using equations (1) and (8), the resulting differential equation can be integrated to give:

$$S \binom{N-1}{N} = S_0 \binom{N-1}{N} - \binom{N-1}{N} \frac{C}{60M} \left(\frac{K}{A}\right)^N t \tag{11}$$

Provided two or more data points are known, a regression analysis can be used to obtain the best values of K and N .

Most computer installations have a nonlinear regression procedure available. In this approach, a direct grid search was used as described by Beech,⁷ who provides a FORTRAN subroutine. Although this technique can

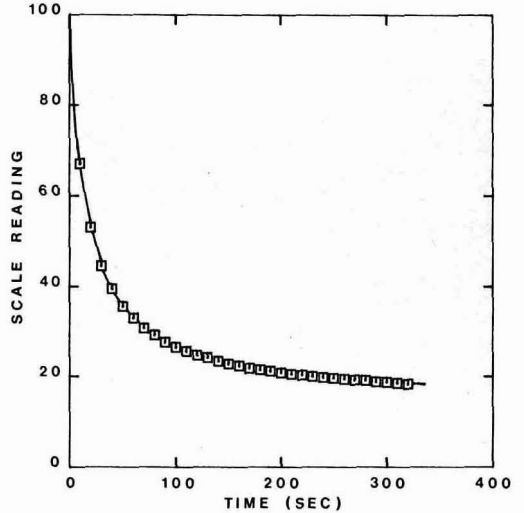


Figure 1—Typical raw data obtained in a stress relaxation test of an interior latex flat enamel. Brookfield LVT viscometer with SC4-18 sensor

be slow if a large number of parameters must be determined, it is not a problem in this case. The method is simple and avoids some of the problems that may be encountered with more sophisticated methods.⁸ Once the K and N parameters have been determined, viscosity is known as a function of shear rate, from equations (9) and (10).

The more general approach does not assume that the material obeys the power law. Such an approach was used by Patton³ who plotted the data and obtained the slope of the resultant curve at several points. An alternative approach is to assume that no matter how complex the rheology, the t, S data can be approximated by a quadratic equation over small portions of data:

$$S = k_1 t^2 + k_2 t + k_3 \tag{12}$$

Thus, a regression procedure can be used to determine k_1 , k_2 , and k_3 over small segments, thereby determining dS/dt . Once S and dS/dt are known as functions of time, viscosity and shear rate are calculated using equations (1), (8), and (9). If a large number of data points is available, a convenient technique for analysis by computer is that of Savitzky and Golay.⁹ A very simple subroutine can be written to calculate S and dS/dt at each point. The data are smoothed by this procedure to remove experimental error, so the smoothed value of S may be used in equation (1) rather than the actual value.

With the Brookfield LVT, data was obtained at 10-second intervals, and it was noted that a good fit with the quadratic equation is obtained by taking nine-point segments. Thus, the first nine data points are fit to the quadratic equation using a least-squares criterion to obtain the best values of the coefficients k_1 , k_2 , and k_3 . These coefficients are then used to calculate a smoothed value of S and the derivative dS/dt at the midpoint (point 5) of the segment. These values of S and dS/dt are used to calculate viscosity and shear rate at the midpoint.

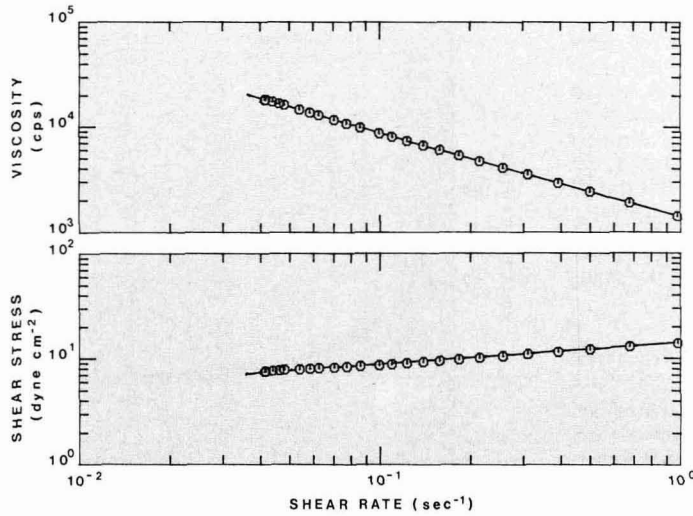


Figure 2—The viscosity profile calculated from the results shown in Figure 1, using point-by-point smoothing

Then the first data point is dropped, the next (tenth) point is added, and the process is repeated across the whole set of data. This procedure is especially simple but has two disadvantages. First, since values are only obtained at the midpoint, the first four points and the last four points are lost in a nine-point smooth. Second, the procedure assumes that points have been obtained in uniform increments, such as 10-second intervals. In practice these disadvantages have not been serious problems.

RESULTS AND DISCUSSION

Typical raw data is shown in Figure 1, where the large number of points was obtained so that the general data processing method could be used. Results are shown in Figure 2. Note that the results are very close to a straight line, showing that the power law, equation (10), would have been a reasonable assumption.

The same data was also processed using the simplified

approach that assumes power law behavior, and is appropriate for a small number of data points. The results show that good estimates of the power-law parameters K and N can be obtained from as few as three data points.

	K	N
Results using all 32 points	22.6	0.307
Using 6 points	22.6	0.306
Using 3 points	22.8	0.316

Several tests were made to demonstrate that the relaxation technique gives results that are consistent with conventional methods. For example, results with standard test fluids obtained from Brookfield Engineering Laboratories are shown in Figure 3. These fluids are assumed to be Newtonian, and the relaxation results agree well with the viscosity specified by the supplier.

Also tested were non-Newtonian materials using both methods. Figure 4 shows results with a polymer latex containing a polyurethane thickener. To obtain the steady-state results, the Roto-Visco RV-3 was operated

Figure 3—Relaxation tests with standard Newtonian oils, using the Brookfield LVT. Points are experimental, lines are correct viscosities as specified by the supplier

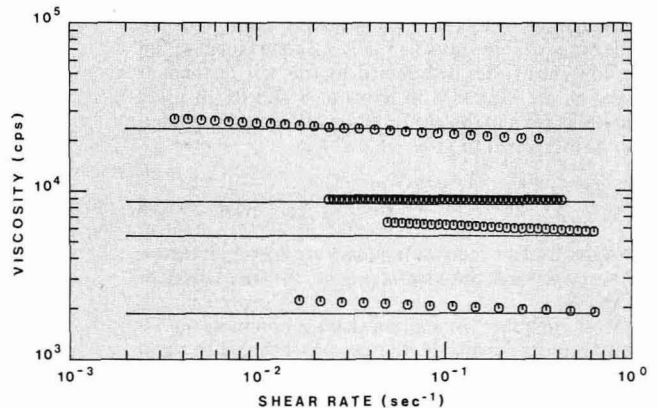
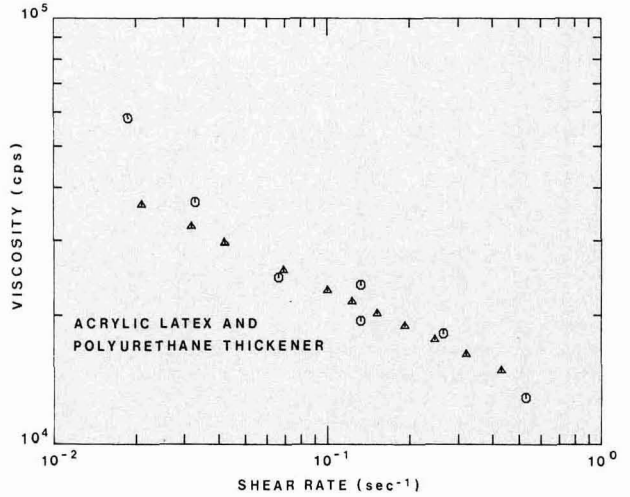


Figure 4—Comparison of relaxation and steady-state results. ○ = Steady-state, Roto-Visco RV-3; MV-I sensor, 0.004–0.23 rpm. △ Relaxation, Brookfield LVT; SC4–27 sensor



with a gear reducer at speeds of 0.004-0.23 rpm. At such low speeds, several minutes were required to reach a steady state.

Measurements over a much larger range of shear rates are shown in Figure 5. By using three instruments (LVT, RVT, RV-3) and two techniques (relaxation and steady-state) it is possible to examine six decades of shear rate.

A different use of the relaxation technique is illustrated in Figure 6. This experimental paint colorant had such a high viscosity that it could not be tested at steady speed with a Brookfield RVT with Small-Sample Adapter. Even at 0.5 rpm, the reading was off-scale. Yet, the relaxation method was used to measure viscosity of over one million centipoise.

Two potential sources of error are discussed in the Appendix. The first relates to the size of the gap between the spindle and cup, and results from variation of shear rate across this gap. This error can be significant and should be considered for both relaxation and steady-

state procedures. Corrections have been included in the results reported in this paper.

The second potential source of error is unique to the relaxation procedure. The inertia of the viscometer and sensor causes the viscometer to respond slowly. This means that scale readings are too high at the beginning of the test, and viscosity appears to be too great. The opposite effect is observed at the end of the test. The error resulting from this effect is low, less than 1%, and can be ignored. Detailed calculations are in the second section of the Appendix.

Similar tests have been performed using the Roto-Visco RV-3 viscometer. However, the Brookfield LVT is often preferred because it is more sensitive and viscosity can be measured at lower shear rates. Also, the relaxation of the LVT is smoother than the Roto-Visco. At the end of the test, the Roto-Visco will stop at an apparent yield stress, whereas the LVT will continue to relax. This illustrates the point made by many authors

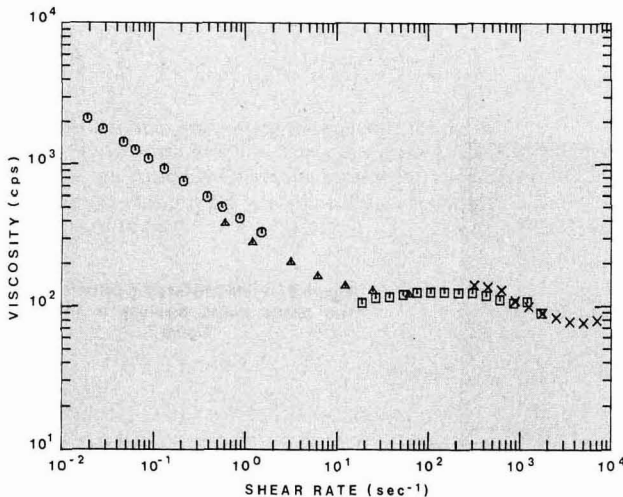


Figure 5—Viscosity profile of a latex coil coating, obtained using both relaxation and steady-state techniques. ○ = Relaxation; Brookfield LVT/UL. △ = Steady State; Brookfield RVT/UL. □ = Steady State; Roto-Visco MV-I. X = Steady State; Roto-Visco HS-I

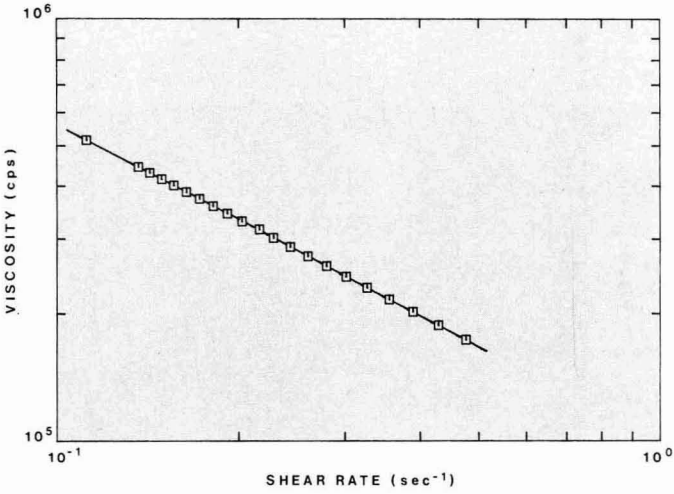


Figure 6—Relaxation results obtained with a very high viscosity, experimental paint colorant

Figure 7—Low-shear viscosity profiles of a latex flat enamel (X) and a high-gloss enamel (O)

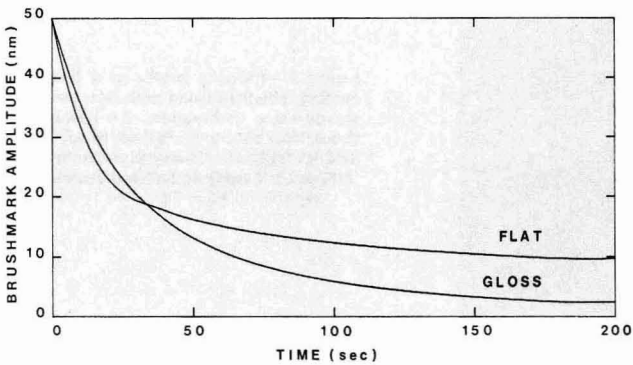
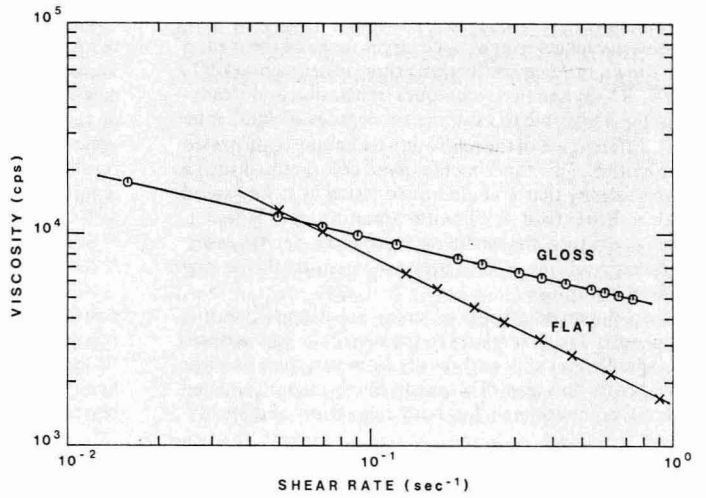


Figure 8—Predicted leveling behavior of the two paints whose rheology is shown in Figure 7

that an apparent yield stress is often characteristic of the particular test method rather than a property of the sample itself.

A potential problem in the stress relaxation procedure is the lag time of the sensing system. With Brookfield Synchroelectric viscometers this is no problem because there is a direct mechanical link between the spindle and the scale. The Roto-Visco also appears satisfactory. The new Brookfield Digital Viscometers do not respond instantaneously, however, and it is possible that the digital viscometers may not be suitable for this test.

LEVELING OF BRUSHMARKS

As an example of the usefulness of low-shear viscosity data, it is shown how leveling of brushmarks can be predicted. There have been several publications which claim to do this, however, in most cases viscosity was not actually measured at low shear rates. A more serious problem is that Newtonian behavior is usually assumed, although this assumption has not always been stated. In the procedure outlined below this assumption has been avoided. It is assumed that the paint can be described by the power law. As described above, this is a realistic assumption over low shear rates. Then, to predict leveling one uses the equation of Murphy given by Camina and Howell¹⁰ which assumes power-law behavior:

$$\frac{da}{dt} = \frac{-N}{2N+1} \left(\frac{\sigma a}{K} \right)^{\frac{1}{N}} \left(\frac{2\pi}{\lambda} \right)^{\frac{3+N}{N}} h \left(\frac{2N+1}{N} \right) \quad (13)$$

This equation predicts brushmark amplitude (a) as a function of time (t). K and N are the power law parameters, and for the other parameters the estimates of Colclough,⁵ et al. were used:

- σ = surface tension = 30 dyne/cm
- λ = brushmark wavelength = 0.25 cm
- h = wet film thickness = 0.01 cm
- a₀ = initial amplitude = 0.005 cm

These dimensions are also those that are expected for the initial film profile created by a Leneta Leveling Test Blade.*

If all parameters except a and t are constant, equation (13) may be integrated to give:

$$a \left(\frac{N-1}{N} \right) = a_0 \left(\frac{N-1}{N} \right) - \frac{(N-1)}{2N+1} \left(\frac{\sigma}{K} \right)^{\frac{1}{N}} \left(\frac{2\pi}{\lambda} \right)^{\frac{3+N}{N}} h \left(\frac{2N+1}{N} \right) t \quad (14)$$

Calculations were made using this equation for the two paints whose viscosities are shown in Figure 7. These coatings are especially interesting because the viscosity curves cross each other. The power law parameters were determined to be:

	K	N
Latex flat enamel.....	22.4	0.294
Gloss enamel	58.8	0.673

Substitution of these values in equation (14) yields values of brushmark amplitude as a function of time, with the results shown in Figure 8.

Although the initial leveling rate of the flat enamel is greater, it slows down after about 30 seconds. After two to three minutes, the gloss enamel has leveled better than the flat coating. At three minutes, only 5% of the initial brushmark amplitude is retained by the gloss enamel, compared to 19% for the flat enamel. These predictions are consistent with the behavior of the two paints in actual brushing tests, and emphasize the importance of considering the non-Newtonian behavior of paints. If viscosity were assumed to be constant over shear rate, the calculations would have been entirely different. In particular, if viscosity had been measured at a shear rate greater than 0.06 sec⁻¹, the higher viscosity of the gloss enamel would have suggested poorer leveling.

CONCLUSIONS

The relaxation technique can be used with Brookfield rotational viscometers to measure viscosity at low shear rates of 0.001 to 1 sec⁻¹. The data can readily be processed by computer, and corrections for a finite viscometer gap can be incorporated into the calculations. Corrections for the inertia of the viscometer are insignificant and can be ignored. The technique is especially useful for predicting leveling behavior of trade sales paints. The method can also be used with extremely viscous materials that produce off-scale readings when tested by steady-state methods.

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*Item I.TB-2, The Leneta Company, Ho-ho-kus, N.J.

(Please turn page for Appendix)

APPENDIX

SHEAR RATE CORRECTIONS

As mentioned previously, use of equation (2) yields an apparent shear rate which results in an apparent viscosity in equation (9). Corrections for this error have been discussed by Krieger.¹¹ For a power-law fluid, the true shear rate is given by:

$$\dot{\gamma} = \frac{2\bar{N}\omega}{1 - \bar{S}^{-2\bar{N}}} \quad (\text{A1})$$

where \bar{N} describes the rheology of the fluid and \bar{S} describes the viscometer. Specifically, \bar{N} is the exponent in the particular form of the power law used by Krieger¹¹:

$$\dot{\gamma} = k \tau^{\bar{N}} \quad (\text{A2})$$

The relationship between this power law and the form we used, equation (10), is such that:

$$\bar{N} = \frac{1}{N} \quad (\text{A3})$$

The other parameter, \bar{S} , characterizes the viscometer according to:

$$\bar{S} = \frac{R_c}{R_b} \quad (\text{A4})$$

where R_c and R_b are the radii of the cup and bob, respectively. It is most convenient to use the quantity \bar{S}^{-2} which has values between 0 (for a large gap) and 1 (for an ideal narrow gap). It is not necessary to actually measure R_c and R_b , since \bar{S} is related to the viscometer constant M by:

$$\bar{S}^{-2} = 1 - \frac{4\pi}{60M} \quad (\text{A5})$$

Substitution of equations (2) and (A5) in (A1) yields:

$$\dot{\gamma} = \bar{N} \dot{\gamma}_a \frac{(1 - \bar{S}^{-2})}{(1 - \bar{S}^{-2\bar{N}})} \quad (\text{A6})$$

Note that for standard Brookfield spindles, \bar{S}^{-2} approaches 0, so:

$$\lim_{\bar{S}^{-2} \rightarrow 0} \dot{\gamma} = \bar{N} \dot{\gamma}_a \quad (\text{A7})$$

as pointed out by Pierce.⁶

Thus, the true shear rate is proportional to the apparent shear rate. The parameter \bar{N} may be a constant or may be allowed to vary with shear rate, but equation (A6) holds in either case. In the techniques described above for handling raw data, the simplified procedure assumed that N (hence \bar{N}) is constant. In the more general procedure where the data is fit to parabolic segments, \bar{N} can be calculated from:

$$\begin{aligned} \bar{N} &= \frac{d \ln \dot{\gamma}}{d \ln \tau} \\ &= \frac{d \ln (-dS/dt)}{d \ln S} \\ &= \frac{S (d^2 S/dt^2)}{(dS/dt)^2} \end{aligned} \quad (\text{A8})$$

This expression for \bar{N} is easily calculated using the smoothing technique of Savitsky and Golay⁹ since, at every midpoint,

S and its derivatives are calculated. However, this is only feasible if a large number of data points is available, as when automated equipment is used. If only a limited number of points (less than 100) is obtained manually, the calculation of the second derivative of S is too uncertain. In that case it is better to use an average value of \bar{N} obtained by fitting the entire data to the power law.

To summarize the procedure for making the correction, the exponent N is determined as described previously and \bar{N} is calculated using equation (A3). \bar{N} may be a constant or may be determined at each point. The constant \bar{S} is known from the type of viscometer used. Knowing \bar{N} and \bar{S} , the true shear rate is calculated from equation (A6), and is used to calculate the true viscosity.

INERTIA CORRECTIONS

The inertia of the viscometer and sensor will affect the relationship between S and t according to:

$$I \frac{d^2 S}{dt^2} + \frac{60M}{100C} \eta \frac{dS}{dt} + AS = 0 \quad (\text{A9})$$

where I is the moment of inertia and the other terms have their previous meanings, with η given in centipoise. Note that if $I = 0$, then the equation reduces to:

$$\lim_{I \rightarrow 0} \eta = \frac{-AS}{\left(\frac{60M}{100C} \frac{dS}{dt}\right)} \quad (\text{A10})$$

as would be expected from combining the previous equations (1), (8), and (9).

Equation (A9) is a standard second-order homogeneous linear differential equation, whose roots m_1 and m_2 are given by:

$$m = \frac{-\frac{60M}{100C} \pm \sqrt{\left(\frac{60M}{100C} \eta\right)^2 - 4IA}}{2I} \quad (\text{A11})$$

If viscosity is greater than the critical viscosity, i.e., if:

$$\frac{60M}{100C} \eta \geq \sqrt{4IA} \quad (\text{A12})$$

then the general solution to equation (A9) is:

$$S = K_1 e^{m_1 t} + K_2 e^{m_2 t} \quad (\text{A13})$$

To proceed further, a value is required for I . This may be estimated using the relation:

$$I = \frac{A}{\omega^2} \quad (\text{A14})$$

where ω is the angular resonance frequency. It was observed that the Brookfield LVT oscillates about 0 at a frequency of about 0.5 cycles/sec, or $2\pi(0.5)$ radian/sec, so:

$$I = \frac{A}{\pi^2} \quad (\text{A15})$$

This yields a critical viscosity of 37 cps for the LVT with Small Sample sensor SC4-18. In any practical test the actual viscosity will be well above the critical viscosity, and this will be assumed below.

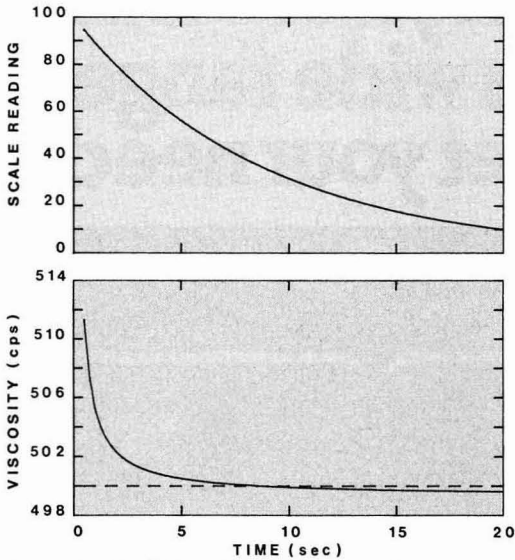


Figure A1—Calculations showing the effect of error due to inertia of the viscometer, for an assumed 500 cps Newtonian fluid tested with a Brookfield LVT and SC4-18 spindle. Top graph shows predicted raw data, bottom graph shows viscosity that would be calculated from this data if inertia were ignored

To evaluate the constants K_1 and K_2 in equation (A13) one uses the initial condition that at $t = 0$, $S = 100$, and $dS/dt = 0$. This yields:

$$K_1 = \frac{100 m_2}{m_2 - m_1}; K_2 = \frac{-100 m_1}{m_2 - m_1} \quad (A16)$$

It is now possible to calculate the error that results from ignoring inertia. For any viscometer, the constants A , M , C , and I are known. Assumption of a Newtonian viscosity η allows calculation of m_1 and m_2 , and then K_1 and K_2 . Equation (A13) is used to calculate the S , t data that would be expected with proper consideration of inertia effects. Then, this data may be used in equation (A10) to calculate the apparent viscosity if inertia is ignored. The difference between the assumed viscosity and that calculated with equation (A10) is the error under discussion.

Calculations are shown in Figure A1 for a 500 cps fluid tested with a Brookfield LVT with SC4-18 sensor. The low viscosity was chosen to magnify the error, although in this case relaxation would be too rapid to be followed manually. The resulting error in viscosity is a fraction of 1%, after the initial relaxation. Similar calculations for a 5000 cps fluid show that even at the initial data point of 10 seconds, the error in viscosity is only 0.001%. Thus, the effect of inertia can generally be ignored.

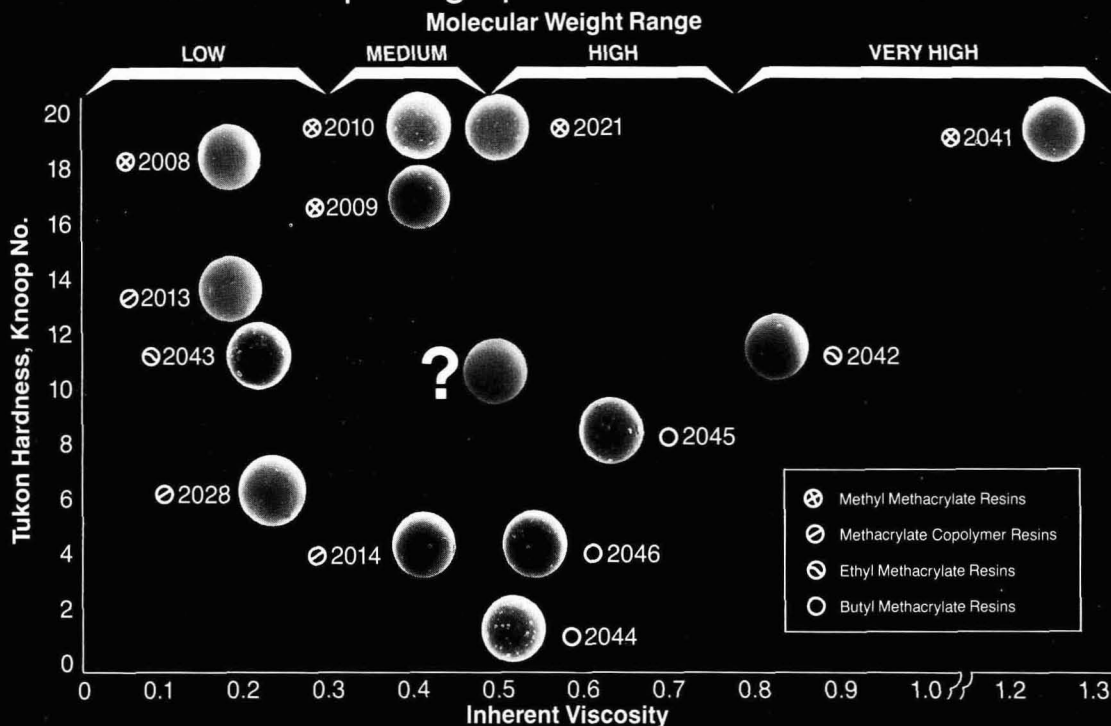
ERRATA

It was published that the author of "Optimal Pigmentation of Emulsion Coatings for Steel in Corrosive Environments" (July 1982, pp 51-56) was Dr. Roger A.H. Penne. Mr. Penne did not receive a doctor's degree but an engineering degree from a technical high school, making his title Ing. Roger A.H. Penne.

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Dependence of Surface Properties In PMMA Coatings on Preparation History

A. Carré[†] and H.P. Schreiber
Ecole Polytechnique*

Thin films of well-characterized poly (methyl) methacrylate (PMMA) were deposited onto metal and polymer substrates from solutions using pure solvents and solvent-mixtures of varying thermodynamic interaction with the polymer. The critical surface tension of polymer films at the air interface was essentially independent of solvent medium, showing that equilibrium chain configuration was attained at the interface, regardless of the chain configuration in solution. In contrast, the penetration rates into the PMMA films of polar and non-polar fluids varied widely with the solvent. In general, PMMA films formed from thermodynamically good solvents were found to be very much less penetrable by fluids than were films formed from weaker solvents. It is postulated that chain configuration in the bulk of the film is similar to that in solution, and that this leads to differences in chain packing which account for the observed barrier properties. PMMA films cast onto low-surface energy solids (e.g. PTFE) have the same surface tensions at the air and at the substrate interface. However, the surface tensions of PMMA removed from metal substrates (e.g. pure Hg) are significantly higher than those at the air interface. Such films therefore, are considered to be non-isotropic and subject to time-dependent changes in properties ("aging"), as the thermodynamic demands of equilibrium configurational states are attained.

INTRODUCTION

It is widely recognized that polymer properties depend on the preparation and use histories of the material at the time of testing. Film-forming polymers, such as PMMA and acrylic copolymers, are no exception to this

rule. For example, surface and interfacial properties of polymers can be influenced by physical and mechanical treatments¹ and the importance of processing conditions on polymer orientation at surfaces has been reported recently.² In previous work from our laboratories we have shown that the surface properties of PMMA, as indicated by the retention volumes of vapors measured by inverse gas chromatography, depend on the solvent from which the polymer was formed³ and that, as a result of this effect, time-dependent variations in surface properties must and do occur.⁴ It may be concluded from the cited studies that the properties of solid polymers depend on the chain configuration adopted by the polymer in solution.

The present paper is an extension of this combined fundamental and practical issue of interest. Examined is the extent to which the choice of solvent and preparation history influences the property balance in film-forming polymers. Accordingly, PMMA has been cast onto reference substrates and the critical surface tension has been determined as a parameter descriptive of polymer surface condition. In addition, the penetration rates of selected liquids deposited on the polymer films have been measured and the surface properties of the polymer film at the air and the substrate interface have been compared. Significant information on the physico-chemical nature of polymer films is contained in the results of such studies.

EXPERIMENTAL

Materials

A commercial PMMA specimen, already used in earlier work,⁵ was employed here. Its $T_g = 105^\circ\text{C}$ (scanning calorimetry) and it has a reported nominal molecular weight of 1.0×10^5 . The solvents selected for this study were chloroform (c), toluene (t), and a 1:1 (volume) mixture of toluene and butanol (t/b). The polymer was

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Table 1—Viscosity Characterization of PMMA at 30°C

Solvent	η Solvent (cp)	$[\eta]$ dl/g	Mv
Chloroform	0.514	0.420	98,000
Toluene	0.526	0.260	105,000
Toluene/butanol	1.110	0.230	—

characterized in these solutions at 30°C, by intrinsic viscosity, $[\eta]$, data using an Ostwald viscometer. The availability of Mark-Houwink expressions for (c) and (t) solutions⁵ permitted calculation of polymer Mv. The data, given in Table 1, show that the polymer is in significantly chain-extended configuration⁶ in chloroform. More pronounced chain coiling occurs in the other solvents, but this falls short of the θ -condition which, for this polymer,⁷ corresponds to $[\eta]_{\theta} = 0.165$ dl/g.

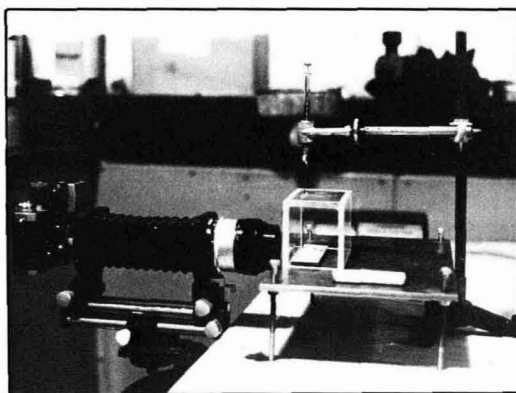
Filming Procedures and Property Characterization

Except as discussed later, 10% (wt) solutions of the polymer in the identified solvents were used to prepare films, by casting onto freshly degreased and dried, 10 cm. \times 3 cm. steel panels. A doctor blade was used to draw down films with uniform wet thickness, the final solid film thickness being about 0.003 cm. Films were dried for 48 hr under vacuum at 50°C, and in some cases at 23°C. Initial exploratory work had shown that this exceeded minimum conditions for bringing the system to constant weight (± 0.05 mg). Furthermore, analysis of infrared spectra for dried films failed to show peaks associated with the solvents used, and it was concluded, therefore, that no significant traces of solvent were entrapped in films prepared for surface analyses.

Surface characterization and barrier properties of the films involved the use of apparatus shown in Figure 1. Surfaces were characterized by the critical surface tension parameter,⁸ γ_c . To evaluate γ_c , supported polymer samples were placed on a stage in the Perspex enclosure shown in Figure 1. The lid of the enclosure accepts microsyringes which dispensed 2 μ l volumes of nominally non-interacting fluids onto the film. Water (W , $\gamma_L = 72.6$ mJ/m²), formamide (F , $\gamma_L = 58.2$ mJ/m²), di-iodomethane (DM , $\gamma_L = 50.8$ mJ/m²) and α -bromonaphthalene (BN , $\gamma_L = 44.6$ mJ/m²) were the test liquids in this sequence. The volume of the enclosure was saturated with respect to vapors of the test liquids by placing open vials of these in the enclosure. Droplets were photographed in a plane parallel to the film surface and photos were taken up to contact times in excess of one hour. Each photograph gave a 60 \times enlargement of the droplet profile and allowed for a measure of the height, h , and radius, r , of the droplet. To avoid errors due to possible polymer-liquid interaction, values of h_0 and r_0 at zero contact time were extrapolated and used to calculate the contact angle θ_0 from

$$\tan \frac{\theta_0}{2} = \frac{h_0}{r_0} \quad (1)$$

γ_c was then obtained by the familiar Zisman method⁸ of

Figure 1—Apparatus for γ_c and penetration rate studies

plotting $\cos \theta_0$ versus γ_L and extrapolating the linear segment to the intercept at $\cos \theta_0 = 1.0$.

The same photographic method also was suited for evaluating the barrier properties of PMMA films cast from diverse solvent media. As already noted, water, formamide, di-iodomethane and α -bromonaphthalene droplets were photographed as a function of contact time with the polymer surface. Calibration experiments, in which drops of these fluids were placed on clean glass slides, showed that over a period of 1 hr. the volume of droplets did not change by more than $\pm 6\%$. In contrast, significant changes in droplet profiles occurred when these were in contact with PMMA films. These changes were recorded, as illustrated in Figure 2 (F on PMMA cast from t/b medium), and quantified by the ratio of droplet volume at contact time t to the initial volume, V_0 , at $t = 0$, by

$$\frac{V}{V_0} = \frac{h(3r^2 + h^2)}{h_0(3r_0^2 + h_0^2)} \quad (2)$$

RESULTS AND DISCUSSION

Surface and Barrier Properties

Previously referred to chromatographic studies^{3,4} showed clearly that the interaction thermodynamics involving PMMA and such vapor probes as aliphatic and aromatic hydrocarbons, depended significantly on the "solvent history" of the polymer. In contrast, the contact angles of probe liquids seem not to be sensitive to the solvent environment from which the PMMA was formed. This is demonstrated in Table 2, which summarizes the contact angle data of this study. The reported values are essentially independent of the solvent medium used for the preparation of PMMA films. Further, no appreciable difference exists between contact angles on films dried at 50°C and at 23°C. Therefore it was concluded that both of the present vacuum drying procedures resulted in a steady-state of surface morphology, and in films free of entrapped solvent.

As a consequence of the data in Table 2, a unique value of γ_c was to be expected for the PMMA film surfaces. Indeed, the linear sections of Zisman plots based on data

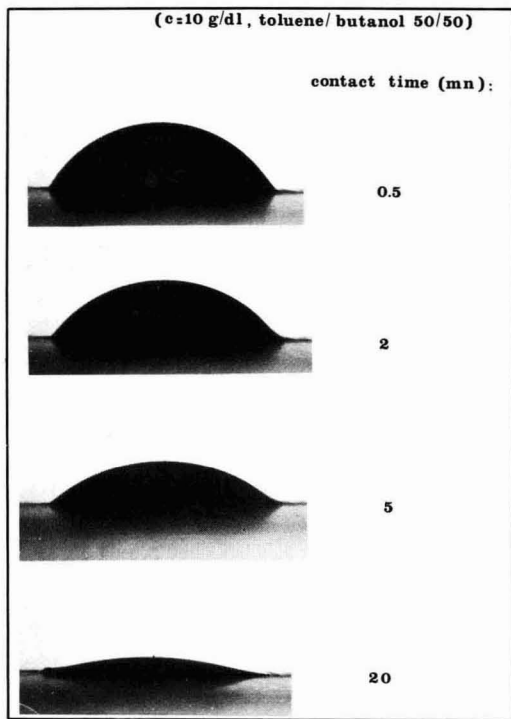


Figure 2—Time-dependent change in droplet shape: Formamide on PMMA cast from solution in t-b

in Table 2 led to a value of $\gamma_c = 41.5 \text{ mN}\cdot\text{m}^{-1}$, again independent of the polymer's solvent history. This γ_c value is in excellent agreement with expectations, and may be considered to represent a minimum value of the parameter for this polymer.

The apparent inconsistency between the present constant γ_c values and the variable chromatography results focuses attention on the size of "probes" used to monitor surface and interfacial properties of the polymer. The sensitivity to solvent history effects, displayed by retention volume data, indicated the existence of variations in polymer chain configuration in the various PMMA specimens and thus, the existence of relationships between polymer chain configuration in solution and in the solid state. Evidently, initial contact physics between the polymer surface and a liquid droplet are not sufficiently sensitive to detect the alleged differences in chain configuration.

The postulated chain configurational differences should, however, influence the degree of close packing attainable by the polymer chains in the solid films, and should, therefore, produce differences in film morphology and in barrier properties. To elaborate on this supposition, studies were made on the kinetics of liquid spreading or penetration, as already noted above.

In essence, we assumed that the penetration of liquid through the barrier films could be considered as a problem of diffusion through a porous medium, in which the mean pore size was influenced by polymer chain configuration. Spreading and penetration rates, when

Table 2—Summary of Contact Angles for Liquids on PMMA

All contact angle data at 30°C, for "zero" contact time. All films cast from constant initial concentration @ 10 g.dl⁻¹

PMMA from:	c	t	t/b (1:1)
48 hr vacuum dry @ °C:	23 50	23 50	23 50
Contact liquid:	θ_0	θ_0	θ_0
α -Br naphthalene	19 18	— 19	19 19
di-Iodomethane	37 35	36 36	35 38
Formamide	55 55	53 56	56 59
Water	75 77	76 79	77.5 76

viewed in this light, call for a relationship involving the square root of contact time.⁹ Accordingly,

$$\frac{V}{V_0} = 1 - K t^{1/2} \dots \quad (3)$$

The parameter K in this expression will depend on the viscosity of the contacting fluid and, ostensibly, on the thermodynamic interaction for the polymer-liquid pair. The latter may be expressed by solubility parameters or similar functions; any explicit use of such descriptors would, of course, modify the above equation.

A more detailed test of the validity of suppositions on which equation (3) is based will be given in a forthcoming publication. In this paper, we demonstrate that the basic concepts are consistent with experiments. This may be illustrated by the excellent linearity of relationships between V/V_0 and $t^{1/2}$, and by the very profound effect on these relationships due to variations in polymer preparation history. Present illustrations are restricted to PMMA films prepared from solutions in which the initial concentration was 10 g.dl⁻¹, and to films with uniform "thermal history", referring to 23°C drying temperature and to a constant (25°C) temperature for the measurement of droplet shape effects. It is probable that these will be variables in the barrier performance of polymer films.

The first of these illustrations is to be found in Figure 3. This documents the behavior of DM in contact with PMMA films cast from the three solvent media. The barrier properties of PMMA films to this fluid vary greatly with polymer-solvent interaction, as indicated by $[\eta]$ in Table 1. The film cast from chloroform presents a strong barrier to the DM molecule; toluene-cast films are more readily penetrated, while very considerable porosity to the fluid is apparent in the t/b-cast film. Although the slopes of relationships obtained was a function of the contacting liquid, close analogy was observed in each case to the set of data in Figure 3. In other words, the chloroform-cast film consistently represented the best barrier to fluid spreading or penetration, while PMMA cast from t/b equally consistent was most permeable to these fluids. This tendency is made quantitatively evident by calculating the "diffusion parameter" of equation (3), with results compiled in Table 3. The data clearly suggest that a very porous, solid-state morphology, readily penetrated by contacting fluids, is attained when PMMA is cast from a thermodynamically unfavorable solvent medium, while progressively denser, close-packed structures seem to be attained when the

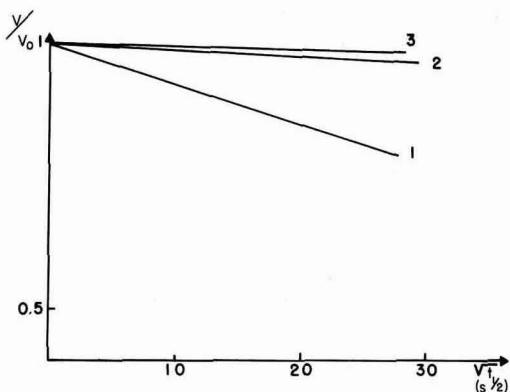


Figure 3—Penetration of di-iodomethane into PMMA films: (1) cast from t/b; (2) cast from t; and (3) cast from c. (Initial polymer conc. = 10 g.dl⁻¹ in all cases)

polymer in solution is in more extended chain configuration.

Further elaboration on this is provided by Figure 4, in which the rates of droplet volume change for each of the test liquids in contact with the t/b-cast film are compared. This makes evident the strong apparent dependence of penetration/spreading rates on the force of interactions between the polymer-liquid pair. Although, as already noted, the kinetics of droplet volume change will depend on the viscosity of the liquids, we assume that in the present case this effect will be of relatively small importance. Once again, the relationship suggested by Figure 4 may be made more explicit by calculating K parameters and comparing these with the differences in solubility

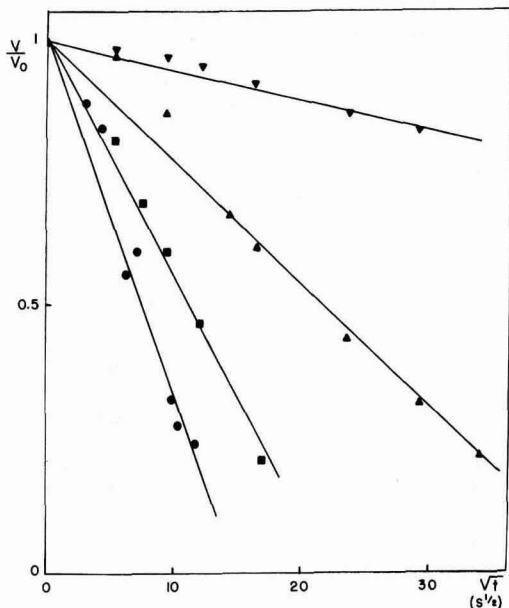


Figure 4—Penetration of NB (●), DM (■), F (▲) and W (▼) into PMMA cast from t/b

Table 3—Comparison of K Values for PMMA-Fluid Pairs

K · 10 ⁴ (min ^{1/2}) for PMMA from:	Chloroform	Toluene	Tol/Butanol
Contact fluid			
α-Br naphthalene	-12.60	-94.0	-660
di-Iodomethane	- 5.80	-52.0	-456
Formamide	- 3.70	-23.6	-207
Water	- 1.15	-17.5	- 57.5

parameters for PMMA and the contact liquids. For these purposes, δ_{PMMA} was taken¹⁰ to be 9.1 (cal. cm⁻³)^{1/2}; those for the contact liquids from literature tabulations,¹¹ as 10.6, 10.2, 19.2, and 23.4 (cal. cm⁻³)^{1/2} for BN, DM, F, and W, respectively. A tentative relationship linking K and $\Delta\delta$ is then readily generated, as shown in Figure 5.

Film Properties at Substrate Interface

In combination, cited chromatography results^{3,4} and the penetration rate data in Table 3 present strong evidence in support of a relationship linking the morphology of polymer films with the chain configuration of the polymer in solutions from which the film is cast. An intuitively interesting question then arises: Does the polymer chain configuration respond to the presence of a substrate and if so, are then the properties of the polymer at the substrate interface significantly different from those in the bulk of the polymer or at the air interface? An inquiry into this matter was begun by casting PMMA films against substrates from which the dried film was readily separated. Two such surfaces were chosen for initial studies: (a) Doubly-distilled, pure mercury, kept dust-free after purification, and (b) Freshly lath-smoothed, cleaned polytetrafluoroethylene (PTFE).

Polymer films were cast onto these high and low surface energy substrates from solutions and via drying procedures (23°C) already described above. On drying, the films were carefully withdrawn from the substrate and rapidly fastened against microscope slide glass with adhesive tape; the film surface which had been at the substrate interface now facing out. Following an equilibration period of about 30 min in the apparatus of Figure 1, Zisman determinations of γ_c were performed as before. The results of these studies are summarized in Table 4.

The critical surface tension of PMMA at the air interface and at the low-energy PTFE interface appears to be identical. When the polymer is cast against a high surface energy substrate, however, a response is observed which seems analogous to that reported by Schonhorn and co-workers¹² for polyolefin films cast onto various substrates; thus, γ_c now increases, in the case of the present PMMA by some 5 mN.m⁻¹.

An apparent reason for this may be a shift in the configurational state of the PMMA molecule in the force-field of the high energy substrate. This morphological change may be required in order to minimize the interfacial tension between Hg and PMMA. Clearly, the constraint would not be present in the case of a PTFE substrate, the surface tension of which (near 20 mN.m⁻¹) is less than that of PMMA.

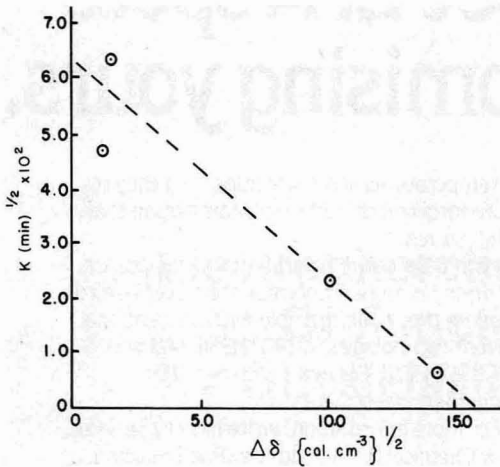


Figure 5—Suggested relation between penetration rate constant and interaction of polymer-liquid pairs, as given by solubility parameters

The consequences of different surface tensions in a thin film may be far reaching. Such a film is obviously non-isotropic and hence under internal strains which must be released. Indeed, PMMA films drawn from Hg release the excess surface energy of the substrate interface by deforming ("curling") within a few minutes of being withdrawn from the substrate. No such effect was observed with PMMA films drawn from PTFE. This observation coupled with the quantitative (γ_c) evidence for film non-isotropy also implies the existence of physico-chemical (i.e. thermodynamic) driving forces for the failure, in practice, of thin-film coatings. A non-isotropic film of the type produced by casting PMMA onto a high surface energy substrate would remain stable as long as polymer and substrate remain in intimate (molecular) contact—a condition readily met when the substrate is a carefully purified liquid. Strong, short-range interaction forces (polar, H-bond, etc.) would then maintain stability. When the distance between coating and substrate is increased so that van der Waals forces become dominant, then the thermodynamic requirement for the minimization of surface free energy would result in mechanical deformation tending to separate the polymer film from the substrate, thus causing or accelerating "failure". Surface roughness, impurities, dust particles, etc. are among the commonplace factors in coating operations. Thus, in such operations, the seeds of failure for organic coatings appear to stem, partly at least, from fundamental thermodynamic considerations. Further study of the phenomena reported here is warranted and currently underway.

CONCLUSIONS

Films of PMMA cast from solutions using solvents of different thermodynamic quality are morphologically distinct. While configurational changes due to the use of varying solvent media are not detected by simple measurements of critical surface tension, important

Table 4—Critical Surface Tension of PMMA Films At Air and Substrate Interfaces

$\gamma_c \text{ m.N.m}^{-1}$:	Air Surface	PTFE Surface	Hg Surface
Polymer from:			
c:	41.2	41.8	46.6
t:	42.0	41.3	47.2
t/b:	41.7	42.0	47.2

variations have been documented in the barrier properties of PMMA films to selected contact liquids. It is postulated that the effect arises from different effective packing densities possible with polymer chains in configurational states ranging from extension, when films are cast from thermodynamically strong solvents, to coiling when (PMMA) films are cast from poor solvents (e.g. 1:1 volume mixtures of toluene/butanol). It has further been shown that PMMA films cast on high energy substrates are non-isotropic, the critical surface tensions of the polymer at air and substrate interfaces being significantly different. We speculate that polymer chain configuration at the interface of a high energy substrate is determined by the force field of the substrate rather than by the solvent medium. Non-isotropy of such films is considered to be a contributing factor to the failure of polymer film coatings.

ACKNOWLEDGMENTS

We thank the National Research Council of Canada, the Natural Sciences and Engineering Research Council, Canada, and the Paint Research Institute for their support of this work. The experimental aid of Mr. D. Gamet is also acknowledged.

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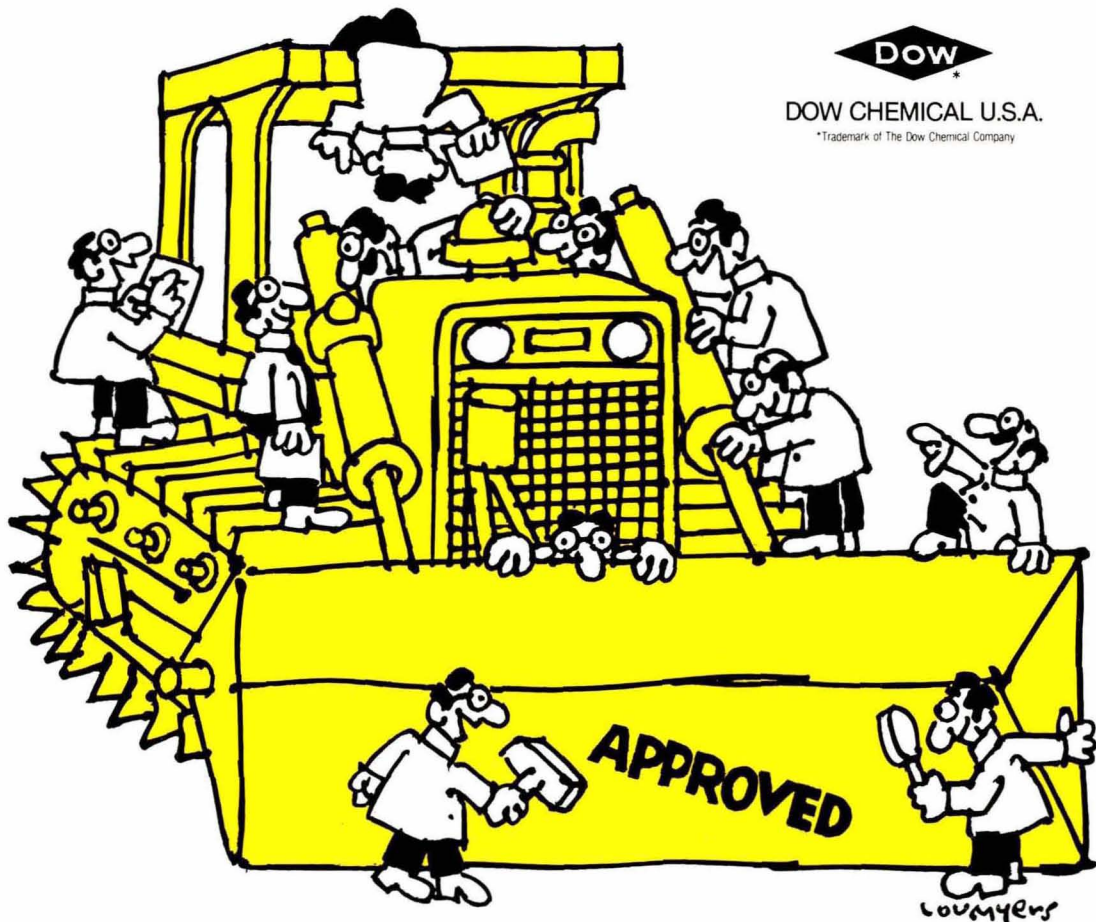
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Electrophoretic Characterization Of Functional Latexes By Quasielastic Light Scattering

M.I. McElroy, F.B. Malihi, T.A. Pukelnick, J.T. Kondilas, and A.M. Jamieson
Cleveland Society for Coatings Technology
Technical Committee

Measurement of particle size and electrophoretic mobility of four, acid-functional latexes were made using quasielastic light scattering technique (QELS). Details of the instrumentation and data analysis for electrophoretic QELS are discussed. The technique provides a rapid and precise tool to assess the transport properties and stability of latexes with a wide range of particle sizes (10 to 3000 nm). The acid-functional latexes were deposited onto steel by the autodeposition process and the rates of deposition are discussed in terms of the results of the QELS measurements.

INTRODUCTION

Electrophoretic quasielastic light scattering is a relatively new method of measuring the size and electrophoretic mobility of colloidal particles. The technique is a combination of electrophoresis, the motion of charged particles in an electric field, with quasielastic light scattering, a method for studying motion of particles by measuring the Doppler shift of laser light scattered from them.

A proposed mechanism for the autodeposition of latex particles implies that the rate may be affected by differences in the electrophoretic mobility of different latexes. The purpose of this study is to characterize a series of four, acid-functional latexes using quasielastic light scattering and to measure rate of autodeposition onto steel for each. Results are discussed in terms of the mechanism of autodeposition.

Quasielastic Light Scattering

Quasielastic light scattering (QELS), also referred to as Laser Doppler velocimetry, can provide simultaneous measurement of particle size and electrophoretic mobility of charged, dilute, colloidal suspensions. It has potential for widespread use in the coatings industry because of advantages of rapid measurement time (less than five minutes), ability to determine a wide range of particle sizes (10 to 3000 nm), and high sensitivity.

In contrast to classical light scattering, which is concerned with the average intensity of scattered light, QELS permits an analysis of the fluctuations in the scattered intensity caused by the motion of the scatterers. By analyzing the intensity fluctuations, one obtains the information on this motion which can ultimately be related to size, shape, and charge of the scattered particles. Details of QELS technique have been discussed in recent books and articles,¹⁻⁴ and a brief review is presented here.

Figure 1 shows a schematic of the QELS apparatus. A laser beam is focused on a dilute suspension of particles and the scattered light is collected at a known angle by a photomultiplier. The analysis of the scattered light involves a special detection method called light beating spectroscopy at the photomultiplier and a subsequent autocorrelation analysis by a digital autocorrelator.¹⁻⁴ A special cell is used which permits the application of a pulsed electric field to the sample for electrophoresis experiments.^{4,5} A timer circuit controls the application of the electric field and the operation of the autocorrelator.

Digital autocorrelation as used in QELS provides an efficient method for processing of the fluctuating signal.² The result is an autocorrelation function, $C(t)$, which is a measure of the time dependence of the fluctuations in the scattered light intensity. $C(t)$ is a time-averaged sum

Presented by Mr. Malihi at the 59th Annual Meeting of the Federation of Societies for Coatings Technology in Detroit, MI, October 29, 1981.

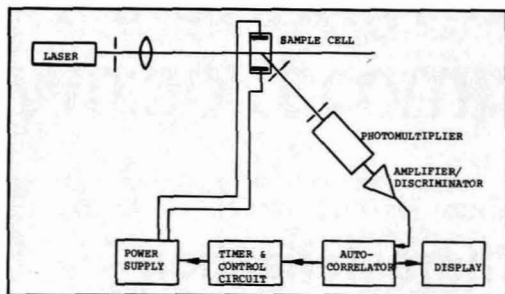


Figure 1—Schematic diagram of the electrophoretic quasielastic light scattering apparatus

of the product of the intensity at an arbitrary time with the intensity at a *later* time. This function is what is measured in a QELS experiment. It contains the information on the size and velocity of the particles.

When no electric field is present, the particles undergo thermal diffusion. In this case, and for a uniform particle size distribution, $C(t)$ is a single exponential decay as shown in Figure 2a. The mean decay rate, τ , is related to the translational diffusion coefficient, D , by

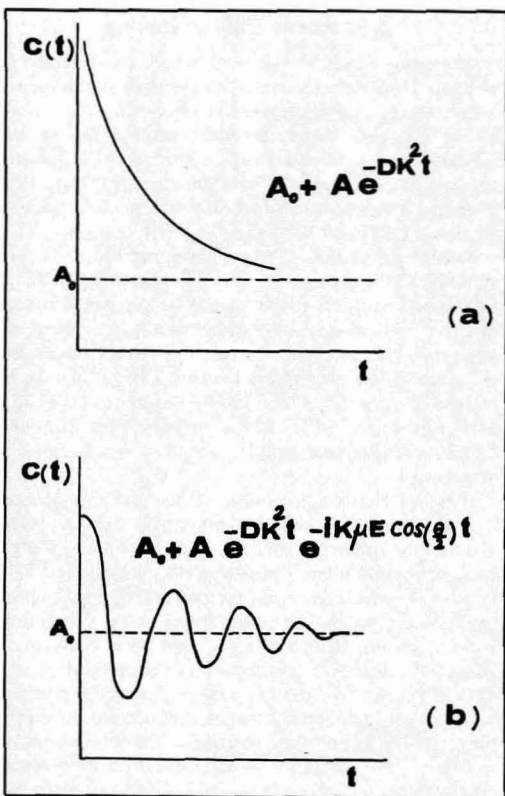


Figure 2—Autocorrelation function of the scattered light intensity; (a) in the absence of the electric field, (b) under electric field, E

$$\tau = \frac{1}{DK^2} \quad (1)$$

$$K = \frac{4\pi n}{\lambda} \sin(\theta/2) \quad (2)$$

where K is an optical constant defined in terms of the laser wavelength, λ , the solvent refractive index, n , and the scattering angle, θ .^{1,2} For spherical particles in dilute suspensions, the particle size, d , can be obtained by the Stokes-Einstein equation,

$$d = \frac{kT}{3\pi\eta D} \quad (3)$$

where k is the Boltzman constant, T is temperature, and η the solvent viscosity. For polydisperse samples, an average particle size is determined by QELS which is related to the Z-average diffusion coefficient of particles.^{2,3}

In the presence of an electric field, E , the scatterers move with a velocity, v . The autocorrelation function $C'(t)$, in this case will be an exponentially damped cosine function,⁴ Figure 2b, with a period, $\Delta\tau$, defined as

$$\Delta\tau = \frac{1}{Kv \cos(\theta/2)} \quad (4)$$

where K is defined in equation (2) and the velocity can be expressed in terms of the electric field, E , times the electrophoretic mobility, μ , of the particles

$$v = \mu E \quad (5)$$

Combining equations (2), (4), and (5) gives the working equation of analysis of the autocorrelation function

$$\Delta\tau = \frac{\lambda}{\mu E n \sin \theta} \quad (6)$$

Quantity $2\pi/\Delta\tau$ is known as the "Doppler shift" which is the drift in the frequency of the scattered light compared to the incident light.³

Autodeposition

Autodeposition is a relatively new method of applying latex-based coatings. In comparing it with electro-deposition, the differences are more noteworthy than the similarities. Hall⁷ points out that this process simultaneously pretreats and deposits a film on metal without application of an external voltage. The physical states of the polymers differ: solubilized polymers for electro-coat and those for autodeposition being finely dispersed, insoluble, solid polymers.

In a typical autodeposition process,⁸ steel objects are coated by dipping into a bath composed of 5–10% latex solids in a dilute solution of an oxidizer such as hydrogen peroxide and an acid such as hydrofluoric. The dissolution of the metal by the oxidizing system is the driving force for deposition.

Prieve, Gerhard, and Smith,⁸ who prefer to call this method "chemiphoresis," have studied the mechanism of deposition. It was first proposed that deposition was caused by neutralization of the negative charge of the latex particles by hydrolyzed iron cations.⁸ Further investigation of deposition on zinc resulted in a new hypothesis. This stated that the rate limiting step for

deposition of the latex particles is migration in an electric field which arises near the metal surface as a result of simultaneous diffusion of ionic reactants and products of dissolution toward or away from the metal.⁹⁻¹⁰ The charged polymer particle is attracted to the metal surface. If this hypothesis is correct, then a change in the electrophoretic mobility of the latex should cause a change in the interaction of the particle with the local electric field and affect the rate of autodeposition.

Latexes with different levels of acid functionality might have different surface charges resulting in differences in zeta potential, ζ , which is directly related to electrophoretic mobility by the Smoluchowski equation.^{11,12}

$$\mu = \frac{\zeta \epsilon}{4\pi\eta} \quad (7)$$

where ϵ and η are the dielectric constant and viscosity of the medium, respectively. Equation (7) applies to the systems with high ionic strength in which the particle size is much larger than the thickness of the ionic atmosphere surrounding the particle. At the limit of low ionic strength, where the dimension of the particle is much smaller than the thickness of the ionic layer, one should use the Huckel equation,¹³

$$\mu = \frac{\zeta \epsilon}{6\pi\eta} \quad (8)$$

EXPERIMENTAL

Latexes

Four acrylic latexes containing 1% (A), 3% (B), 5% (C), and 7% (D) methacrylic acid were synthesized using potassium persulfate initiator. The monomer composition of styrene and ethylacrylate was adjusted to maintain a Fox-Tg of 0°C. The anionic surfactant employed in the polymerization was sodium bis-tridecyl sulfosuccinate (Mona Industries). Levels of surfactant, ammonium bicarbonate buffer, initiator and chaser were held constant throughout the series. The temperature of polymerization was held between 74–76°C with monomer fed over a period of 3.5 hours. Conversions for the four systems were $98 \pm 1\%$.

For QELS measurements the latexes were diluted to 10^{-3} percent solids with deionized water. Specific conductivities at 25°C in $\mu\text{mho/cm}$ for these solutions of latexes A, B, C, D were 1.5, 0.72, 2.80, and 1.48, respectively; pH of each was $5.9 \pm .1$. These differences in conductivities are related to charges on the particles and the presence of small amounts of ionic contaminants such as fragments of initiator, surfactant, etc. For measurements under conditions similar to autodeposition baths, latexes were made up at $10^{-3}\%$ solids and adjusted to pH 2 and specific conductivity of $980 \mu\text{mho/cm}$ at 25°C by dropwise addition of a 20% HCl solution. Baths for autodeposition rate measurements were made up at 5% solids with deionized water.

QELS Apparatus and Method

The electrophoretic quasielastic light scattering was carried out using a photon correlation spectrometer as

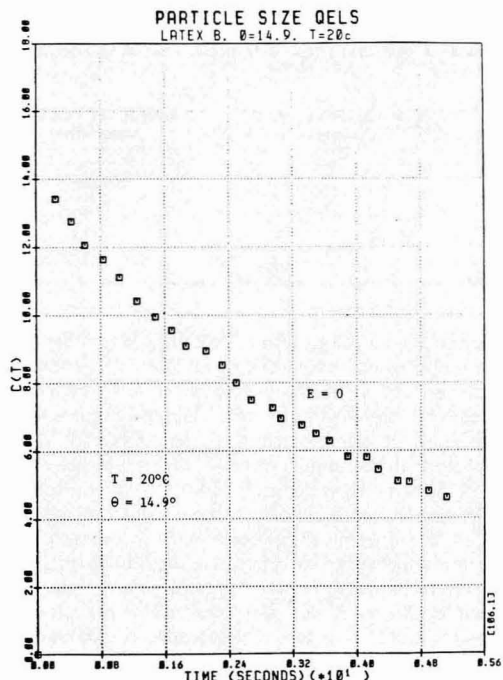


Figure 3—Autocorrelation function for Latex B in the absence of electric field

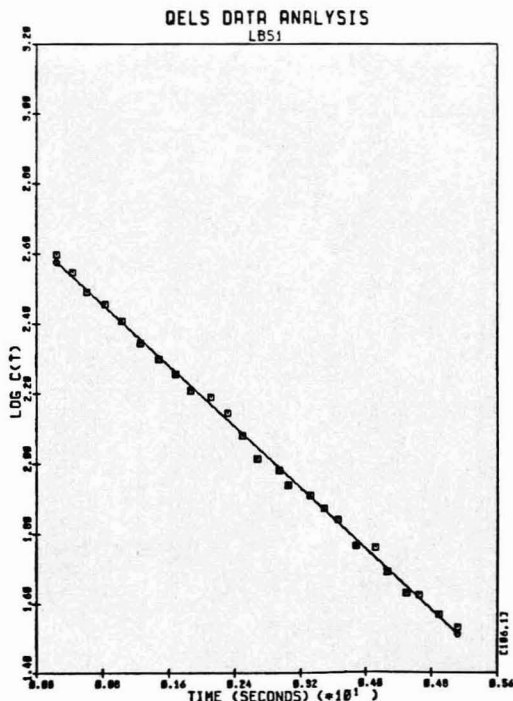


Figure 4—Analysis of the correlation function of Figure 3 for determination of particle size

Table 1—Results of Particle Size Analysis by QELS and DCP

Latex	Average Size by QELS (Nanometers)	Average Size from DCP (Nanometers)
A	234	202
B	213	208
C	245	235
D	256	214

shown in Figure 1. The system includes a 15 mW He-Ne laser source (wavelength 633 nm), an ITT FW130 photomultiplier, and a 100 channel Saicor 42A digital autocorrelator. An electronic timer circuit controls the application of electric field and the timing for data acquisition by the autocorrelator. Measurements were run in the heterodyne detection mode at 14.9° scattering angle. In addition, a number of homodyne runs at 90° and 14.9° scattering angles were made to calibrate the instrument and verify the heterodyne mode of operation.¹ For electrophoresis measurements, a sample cell, designed by Ware, et al.,⁶ was used which permits the application of electric field to the sample. The cell can be cooled during each run to avoid the adverse affects of Joule heating.⁴

The power supply permits the application of up to 30 volts to the cell. This translates to an electric field range of approximately 0–80 volts/cm for this cell geometry.

Table 2—Results of Electrophoretic QELS Analysis

Latex	Specific Conductivity (micromhos/cm)	$\Delta\tau$ (sec.)	Electrophoretic Mobility (cm ² /v-sec)	Zeta Potential (mv)
A	1.50	8.4×10^{-3}	2.90×10^{-4}	-56
B	0.72	8.0×10^{-3}	3.03×10^{-4}	-59
C	2.80	8.9×10^{-3}	2.74×10^{-4}	-53
D	1.48	9.6×10^{-3}	2.53×10^{-4}	-48

Electric Field: 76 v/cm
Scattering angle: 14.9

The timer circuitry permits the application of the field in a pulsed mode for heat dissipation between pulses. The ON and OFF times were selected as four and 28 seconds, respectively, in order to get optimum resolution.

Deposition of Coatings

A 5% solids bath of latex was made up in a solution of 0.15% H₂O₂ and 0.15% HF with a calculated pH of 2. Reagent grade chemicals were used. The bath was gently stirred in a plastic beaker with a Teflon®-coated magnetic stirrer at 75°F. Untreated mild steel panels, 10 × 6 × 0.1 cm were washed with acetone, air-dried, weighed, and dipped so that an area approximately 6 cm × 6 cm was coated. After immersion for timed periods, the panels were hung by a corner to drain and the last drop removed by touching it to the side of a beaker. After 30 minutes air dry, the panels were force dried 20 minutes @ 200°C.

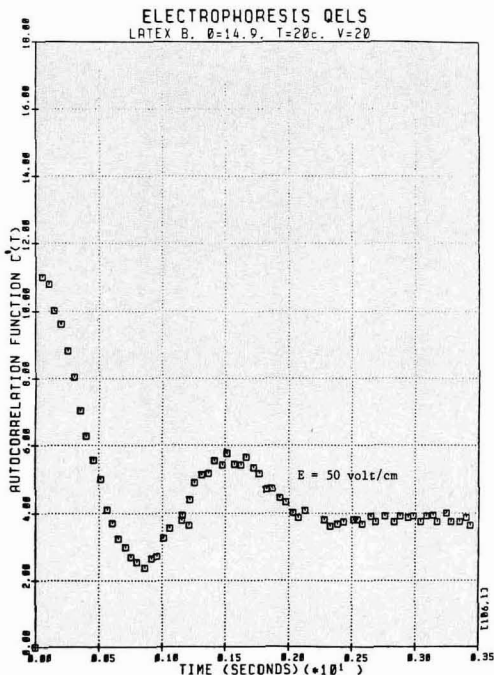


Figure 5—Autocorrelation function for electrophoretic QELS analysis of Latex B

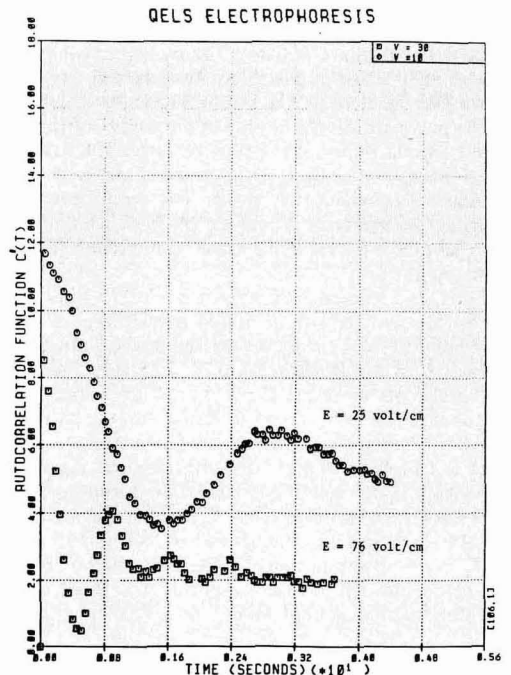


Figure 6—Autocorrelation function for electrophoretic QELS analysis of Latex B under different electric fields

Table 3—Results of Microelectrophoresis Analysis with Zeta Meter

Latex	Specific Conductivity (micromhos/cm)	Electrophoretic Mobility (cm ² /v-sec)	Zeta Potential (mv)
A	2000	5.39×10^{-4}	-69
B	2600	4.92×10^{-4}	-63
C	2850	4.84×10^{-4}	-62
D	2900	4.77×10^{-4}	-61

The weight of the coated panels was measured. Film weights were corrected for the amount of iron dissolved because Prievé⁸ has shown that for these types of latexes, 95% of the dissolved iron enters the coating bath. Correction factor was determined by immersing a panel in acid solution without latex and measuring the amount of iron dissolved at given time periods.⁹

RESULTS AND DISCUSSION

Particle Size Analysis

Figure 3 illustrates the autocorrelation function, C(t), obtained for Latex B in the absence of the electric field. Without the field C(t) is a single exponential with decay rate related to the diffusion coefficient and hence, the average particle size of the latex. Linear regression analysis of the curve Log C(t) vs t, Figure 4, gives a diffusion coefficient of 2.17×10^{-8} cm²/second. Particle sizes of 213 nm are obtained from the Stokes-Einstein equation.

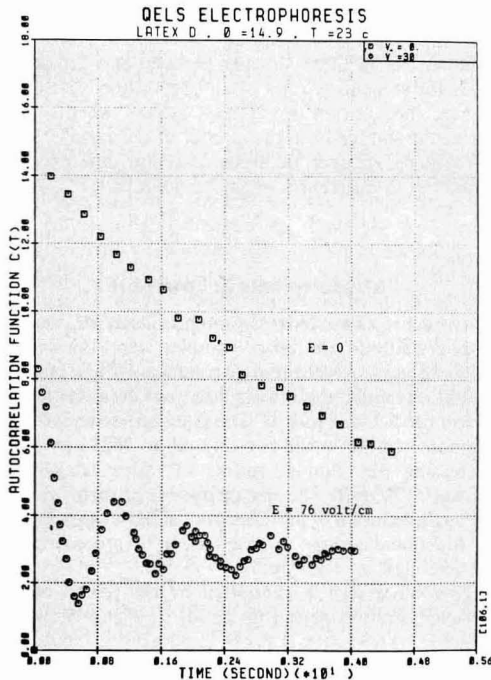


Figure 7—Autocorrelation function for Latex D

Table 4—Average Particle Size at pH 2

Latex	Size (Nanometers)
A	2233
B	2623
C	2282
D	2243

The results for other latexes are summarized in Table 1. In addition, Table 1 provides the size measurements obtained by Disc Centrifuge Photosedimentometer (DCP). Compared to the weight average size determined by DCP, the average size obtained by QELS is higher. The average particle size determined by QELS is related to the Z-average diffusion coefficient, and has a value between the weight average and Z-average particle size for a given size distribution. This is due to the higher moment average obtained by the QELS method. Both methods are expected to have precision better than 5%.

Electrophoresis

With an electric field applied, the autocorrelation function, C'(t), is an exponentially damped cosine wave. C'(t) obtained for Latex B at E = 50 volt/cm is shown in Figure 5. From the frequency of oscillation, the quantity $[\lambda/\mu E \eta \sin\theta]$ can be determined (see Figure 2b). Since η , E, and θ are known experimental conditions, μ , the electrophoretic mobility, can be calculated.

Figure 6 shows the results for Latex B at E = 25 and

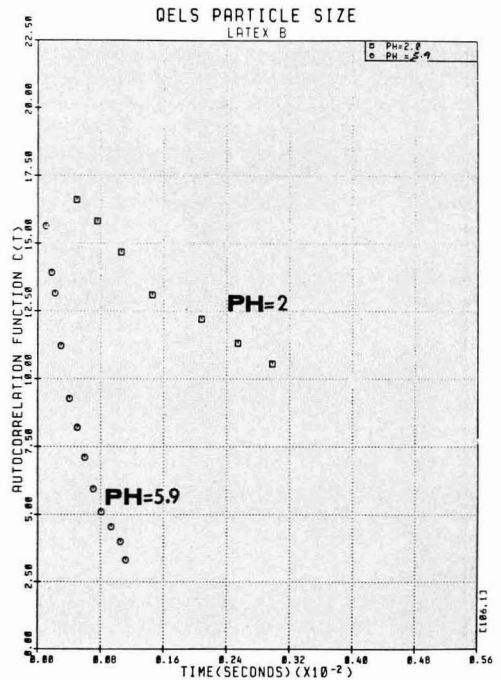


Figure 8—Autocorrelation function without applied field for Latex B at pH 2 and at pH 5.9

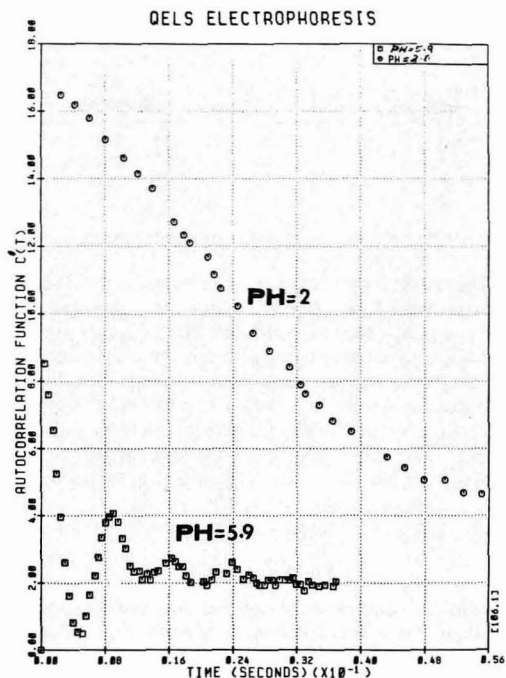


Figure 9—Autocorrelation function with electric field applied for Latex B at pH 2 and pH 5.9

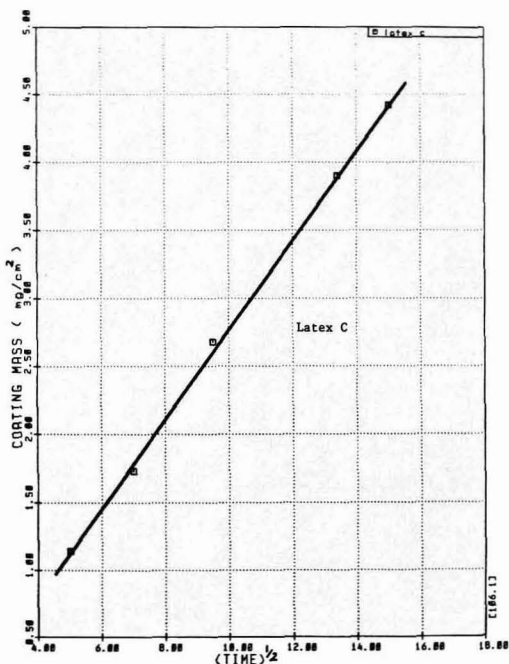


Figure 10—Mass of autodeposited coating vs square root of time for Latex C

76 volt/cm. A comparison with Figure 5 shows the effect of changes of the field on the oscillation frequency which directly relates to changes in the velocity of the particles. The frequency of Doppler shift² increases linearly with increasing electric field as dictated by equation (6).

Figure 7 illustrates the autocorrelation function for Latex D with and without electric field of 76 volts/cm. A comparison with $C'(t)$ for Latex B under the same field (Figure 6) shows the differences in the frequency of oscillations and hence the electrophoretic mobility.

Table 2 summarizes the electrophoretic QELS analysis for all the latexes in terms of mobility and zeta potential. Table 3 contains measurements made by another laboratory using a microelectrophoresis technique with a Zeta Meter (Zeta Meter, Inc.).

The QELS zeta potential results are about 20% lower. These differences may be caused by dilution techniques used to make up samples. In the QELS experiments, samples were diluted with deionized water which may have caused dilution effects such as surfactant desorption. This has been shown to give lower electrophoretic mobilities.¹¹ For the Zeta Meter analysis, sample dilutions were made using the latex serum extracted by centrifugation. A comparison of conductivity values supports this argument.

In calculation of the zeta potentials from the mobility data we have used the Huckel equation, see equation (8), for QELS data, and the Smoluchowski equation, see equation (7), for the microelectrophoresis data. The choice of each equation, as discussed earlier, is determined by the ionic strength, hence, the conductivity of samples used for electrophoresis.

Comparing the results obtained by QELS, the latex electrophoretic mobilities are ranked $B > A > C > D$. This shows a general trend of lower mobility for higher acid content of these polymer particles and provides a basis for comparing rates of autodeposition. The question of the location of carboxyl groups, whether they are at the surface or in the interior of the particle, must be explored further in order to relate differences in mobilities to differences in acid content.¹⁴

Measurements at Lower pH

In order to characterize the samples under the coatings bath conditions, the initial samples were adjusted to pH 2. Figures 8 and 9 compare results of QELS. Figure 8 indicates considerably slower decay of $C(t)$ at pH 2 relative to pH 5.9 for Latex B. This translates to an increase of about tenfold in the size, 213 nm to 2623 nm, upon decreasing pH. Similar results for other latexes are shown in Table 4. The size increase is probably due to the agglomeration of particles since at pH 2 the carboxylic functional groups are ineffective in protecting the particles against aggregation.

This conclusion is supported by the results of the electrophoresis experiments at pH 2. Figure 9, which shows $C'(t)$ for Latex B at pH 2 and pH 5.9, indicates a considerable decrease in the frequency of the oscillation upon decreasing pH. For Latex B, this results in a drop in the mobility from 3.03×10^{-4} to 3.0×10^{-5} cm²/volt-

sec. Consequently, the zeta potential drops from -39 mv at pH 5.9 to -4 mv at pH 2, indicating an unstable condition at the latter pH.⁹ One would expect similar electrophoresis results for other latexes, however, comparison of mobilities at pH 2 was not possible due to the low resolution caused by the large particle size and increased polydispersity of the latexes.

Autodeposition

Dependence of C , mg/cm² of coating deposited, is linear with the square root of deposition time for all of the latexes. This is shown in Figure 10 for Latex C and is consistent with a diffusion-controlled process.⁷

Figure 11 shows the deposition rate, dC/dt vs reciprocal film weight, $1/C$, for the four latexes. At high film build (low values of $1/C$) the deposition rates become indistinguishable because, as the film grows, diffusion of H₂O₂ through the film, the rate limiting step, decreases and "shuts down" the deposition. At low film weights, there is a clear distinction between the deposition rates in the following order: $D > C > A > B$. This ranking is the reverse of that for electrophoretic mobilities and zeta potentials measured at pH 5.9 by QELS; the latexes with lower mobilities (zeta potentials) deposit at higher rates.

A possible explanation for this behavior may be found if one considers that under conditions of autodeposition, the latexes studied are in a destabilized state. Measurements of electrophoretic mobilities on the order of 3×10^{-5} cm²/volt-sec corresponding to a zeta potential of -4 mv at pH 2 clearly indicate this. If one assumes that at pH 2 the rankings of zeta potentials of the latexes are the same as at pH 5.9, then one could postulate that the most destabilized latex, the one with the lowest zeta potential, would deposit the fastest.

Results of this work compare favorably with Prieve's⁸ theory of a local electric field. From calculations of this local electric field under conditions of autodeposition, Smith⁶ has predicted very low values of electrophoretic mobilities ($\sim 3 \times 10^{-6}$ cm²/volt-sec). Our results, although higher by an order of magnitude, show this same trend.

In comparing this study with reports of commercialized autodeposition systems, it must be kept in mind that these results do not imply that autodeposition systems are unstable. Rather, they imply that commercial systems have been optimized to provide a proper balance of stability and deposition properties. Also, it appears that characterization of electrophoretic mobilities would be a useful tool for commercial development.

SUMMARY

Quasielastic light scattering (QELS) can readily be used to characterize latexes. Measurements of size and electrophoretic mobility for four, acid-functional latexes were made at pH 5.9 and pH 2 by QELS. The electrophoretic data, i.e., mobilities and zeta potentials, obtained by QELS method compared favorably with those of microelectrophoresis measurements. It was

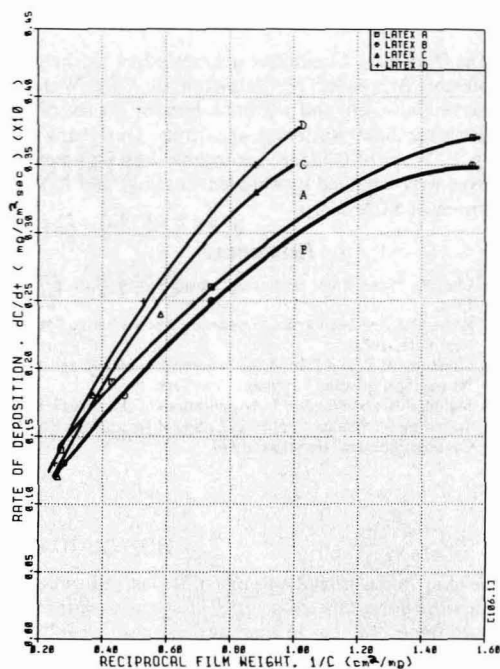


Figure 11—Rate of coating deposition vs reciprocal film weight for Latexes A, B, C, and D

shown that differences in latex electrophoretic mobility and particle size, as a result of differences in latex composition and sample conditions, can be rapidly and precisely determined by this technique. Large increases in particle size and decrease in zeta potential at pH 2 indicated some destabilization of the carboxylated latexes at low pH.

These latexes were also autodeposited onto steel. Rates of autodeposition were inversely related to electrophoretic mobilities, implying that the tendency of a latex to destabilize at the metal surface is an important deposition characteristic. Lower values of electrophoretic mobility, measured under conditions of autodeposition, are consistent with predictions based on the local electric field hypothesis.

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Mattiello Volumes

A complete set of Joseph J. Mattiello's series, "Protective and Decorative Coatings," is being offered for sale. This historical set, Volumes I-V, was published 1941-46. Anyone interested in obtaining this work should contact, Ken G. Probst, 3300 Narvaez Ave., #7, San Jose, CA 95136.

Combustibility Of Water-Borne Paints And Printing Inks

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For products classified in inflammability class I (DK) having flash points below 21°C, agreement between flash point and combustibility is normally found. Water-borne products with a flash point between 21°C and 55°C (inflammability class II (DK)), however, often demonstrate a considerable difference between the flash point and the temperature where the ignition and continuous combustion takes place.

Since products classified according to flash points in inflammability class II often do not burn, or burn only after heating to a temperature significantly higher than the flash point, a classification according to combustibility instead of flash points is proposed. The combustibility of a product is determined in an open tray, which results in the highest possible evaporation of the solvent. A simple instrument for determination of combustibility has been constructed.

In the investigation carried out, the lacking correlation between flash point and combustibility of solutions of organic solvents in water and water-borne paints and inks has been demonstrated. The difference between flash point and combustibility is due to the dynamic fueling of the fire, which is controlled by the evaporation rate of the solvent. The evaporation rate is influenced considerably by the heat capacity of the product and the presence of other components (e.g., binders). While other factors influence combustibility, the flash point seems influenced only by the concentration of the solvent and the temperature of the solution, because the flash point is determined under static conditions.

The concentration of residual solvent in water solutions after ended, self extinguishing combustion has been determined. This residual concentration is also dependent on other components in the product.

INTRODUCTION

Classification according to combustibility of products containing solvents, such as paints and printing inks, is traditionally done on the basis of the flash point of the product and, eventually, its miscibility with water.

Water-borne paints and printing inks, i.e., products primarily containing water as solvent but also containing small amounts of organic solvents, have in a number of cases demonstrated a lack of correlation between the flash point of the products and their combustibility.

This investigation of the combustibility of water-borne paints and printing inks has the purpose partly to establish if a relationship between flash point and combustibility exists for water-borne products, partly to work out a method for determination of combustibility independent of flash point measurements for water-borne products, and partly to try to give a suggestion for classification of water-borne products concerning their combustibility.

LITERATURE

The evaluation of the combustibility and fire hazards of a substance or a product has traditionally been based on the flash point of the substance or the product. Investigations in the past few years have shown that the flash point of a composite product (e.g., a solvent mixture) sometimes deviates considerably from the expected value. Furthermore, it has been demonstrated that the presence of noncombustible solvents in a product (e.g., halogenated hydrocarbons or water) can result in a product not being combustible in spite of the possibility of measuring a flash point for the product.

The investigations described in the literature over the past years concern: (1) Determination of flash points (methods and equipment); (2) Calculation of flash points for mixtures of combustible components; (3) The influence of polymers (binders) on the flash point of paints and printing inks; (4) Determination of the flash point of products containing noncombustible solvents (haloge-

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Table 1—Flash Points Determined Experimentally for Solvents Mixed with Water (°C)

Solvent	Ratio Solvent:Water				Remarks
	1:0	9:1	1:1	1:9	
Toluene	5.5	5	5	5	Not miscible with water. Measurement in upper phase
Isopropanol	12	19	24	41	Miscible with water
Ethanol	10	19	25	51	Miscible with water
EGMEE	46	57	72	—	Miscible with water
Benzine 80/120	-9	-8	-8	-8	Not miscible with water. Measurement in upper phase
Ethylacetate	-5	-5	-5	—	Not miscible with water. Measurement in upper phase
Methylethylketone (MEK)	-9	-7	-6	5-9	Miscible with water in ratio 1:9
Ethanol:Isopropanol:Ethylacetate 1:1:1	-1	1	0	14	
Toluene:Isopropanol 5:1	0.5	0.5	3	4	
Ethanol:Ethylacetate 3:1	-0.5	3	1	17	
Toluene:Ethanol:Ethylacetate 4:1:1	-2.5	-2	-0.5	1	
Toluene:MEK 7:1	1	3	1	2	
Isopropanol:Ethylacetate 3:1	-1	5	2	15	
Ethanol:EGMEE:Ethylacetate 5:1:2	0.5	3	2	16	
Isopropanol:Benzene 2:1	-7	-6	-5	-5	

nated hydrocarbons or water); and (5) Combustibility of products containing water.

In the literature there exists a theoretical possibility to use existing equations (with eventual modifications) in calculation of flash points for products containing organic solvents and water. Furthermore, a number of investigations demonstrate that products with flash points below 21°C (class I) show an agreement between flash point and combustibility while water-borne products with flash points between 21°C and 55°C (class II) will often show a considerable difference between flash point and combustibility. In this case, the actual combustion can only take place at a temperature which is considerably higher than the flash point.

EXPERIMENTAL

A great number of measurements of flash point and combustibility has been made for mixtures of organic solvents with water in various concentrations. The measurements have primarily concerned solvents which are miscible with water, but in a few cases also solvents which are not miscible with water have been used.

Determinations of combustibility and flash point have included partly mixtures of only solvent and water, and partly mixtures including a dissolved polymer (binder). Finally, flash point and combustibility has been determined for some ready made paints and printing inks.

Flash Points for Mixtures Of Organic Solvents and Water

Introductory investigations were made determining the flash point of a number of mixtures of solvents with water. The results are given in Table 1.

As expected, solvents which were totally miscible with water demonstrated a considerable increase in the flash point when the water content was increased. Solvents which are not miscible with water showed no measurable changes of the flash point for increased content of water (up to 90% water).

It is, however, remarkable that if a solvent which is miscible with water (e.g., ethanol) is mixed with a solvent which is not miscible with water (e.g., ethylacetate) and diluted with water, the flash point has in a number of cases been found to increase considerably.

Combustibility Measured In a Flash Point Instrument

An obvious method for determination of the combustibility of solvent mixtures diluted with water is to measure how long a period of time the solvent mixture burns in a flash point instrument at a predetermined temperature. Such measurements were carried out for a series of solvent mixtures, including solutions of varnishes, printing inks, and paints. The measurements were done partly on an Abel-Pensky instrument and partly on a Setaflash instrument. The measurements included determination of flash point and the burning time at various temperatures higher than the flash point. Some of the results obtained are indicated in Table 2.

These measurements also showed the following:

(1) Except for mixtures of water and ethylacetate (not miscible with water), none of the mixtures (solvent/water), varnish solutions, printing inks, or paints showed any tendency to continue to burn at the flash point. The flash point was determined by ignition of the mixture followed by an almost immediate self-extinguishing of the fire.

(2) The measurements indicated, furthermore, that a longer period of time for the burning of the mixture (more than ca. 10 sec) normally was obtained only after heating the mixture to a temperature, which was more than 20°C higher than the flash point.

(3) Determination of flash points using the Abel-Pensky instrument showed good agreement with measurements on the Setaflash instrument.

(4) Determinations of the time of burning made on the Abel-Pensky instrument and the Setaflash instrument demonstrated considerable deviations, since the Seta-

Table 2—Combustion Time in Flash Point Instrument for Solvents Mixed with Water

No.	Water (%)	Isopropanol (%)	Ethanol (%)	EGMEE (%)	Ethyl-acetate (%)	Varnish A (%)	Flash Point °C	Combustion Time (sec)					Flash Point Instrument
								35° C	45° C	55° C	65° C	75° C	
1	10	90					<23	9	15	59	300	—	Abel-Pensky (90 ml)
2	30	70					<23	4	10	32	300	—	Abel-Pensky
3	50	50					23	4	12	31	300	—	Abel-Pensky
4	70	30					26	2	8	21	300	—	Abel-Pensky
5	90	10					40	0	5	15	63	33	Abel-Pensky
6	10		90				<23	10	19	135	300	—	Abel-Pensky
7	30		70				<23	8	18	89	300	—	Abel-Pensky
8	50		50				26	3	10	45	300	—	Abel-Pensky
9	70		30				33	0	10	24	300	—	Abel-Pensky
10	90		10				51	0	0	2	7	40	Abel-Pensky
11	10	54		36			<23	5	4	18	200	300	Abel-Pensky
12	30	42		28			27	1	3	17	145	300	Abel-Pensky
13	50	30		20			29	0	0	14	83	300	Abel-Pensky
14	70	18		12			32	0	0	10	63	300	Abel-Pensky
15	90	6		4			48	0	0	0	6	8	Abel-Pensky
11	10	54		36			<23	3	10	211	300	300	Setaflash (2 ml)
12	30	42		28			25	3	5	56	300	300	Setaflash
13	50	30		20			28	3	4	14	278	245	Setaflash
14	70	18		12			32	0	4	12	98	114	Setaflash
15	90	6		4			47	0	0	0	7	5	Setaflash
21	10	67			23		<23	31	300	300	300	300	Setaflash
22	30	52			18		<23	21	77	300	300	300	Setaflash
23	50	37			13		<23	6	83	300	300	300	Setaflash
24	70	22			8		<23	7	45	89	156	103	Setaflash
25	90	7			3		<23	4	5	8	56	12	Setaflash
P 3		70		20		10	<23	5	24	149	300	—	Setaflash
P 4		80		0		20	<23	7	53	300	—	—	Setaflash
P 5		70		10		20	<23	5	26	300	—	—	Setaflash
P 6		60		20		20	<23	4	14	62	300	—	Setaflash
P 7		60		0		40	<23	4	48	100	169	168	Setaflash
P 8		50		10		40	23	4	45	65	146	140	Setaflash
P 9		40		20		40	23	2	4	48	63	132	Setaflash
^a Ink A	84	16					34	0	4	11	22	60	Setaflash
Ink B	85		15				49	0	0	2	3	3	Setaflash
Ink C	90			10			60	0	0	0	2	0	Setaflash
Paint 1							47	0	0	2	4	5	Setaflash
Paint 2							33	1	2	3	5	8	Setaflash
Paint 3							57	0	0	0	2	3	Setaflash

(a) Only composition of solvent (60% of ink).

flash instrument showed a considerably longer time of burning of the liquids than the Abel-Pensky instrument.

It has, in this way, been established that the temperature where an actual combustion starts is considerably higher than the flash point for a water/solvent-mixture.

The disagreement between determinations of time of burning made on the Abel-Pensky instrument relative to the Setaflash instrument is most likely due to a considerably greater amount of liquid used in the Abel-Pensky instrument (90 cm³) than in the Setaflash instrument (ca. 2 cm³). This greater amount of liquid results in a higher heat capacity, preventing the evaporation of combustible solvents even though heat is supplied through the combustion at the surface of the liquid. On the contrary, the little volume of the Setaflash instrument will easily be heated through the combustion, promoting the evaporation of combustible solvents and feed the combustion in the surface.

Since flash point instruments generally use a relatively small volume of liquid and the surface of the liquid relatively small, and at the same time the time of burning is strongly dependent on this volume, it was decided not to use flash point instruments for determinations of combustibility. Instead the results were used only to establish the lack of correlation between flash point determinations and combustibility of water-borne products.

Combustibility Determined in an Open Tray

Time of burning (combustibility) measurements made in flash point instruments clearly demonstrated that the time of burning is dependent on the volume of the liquid containing water. Furthermore, since the evaporated amount of combustible components will increase with increasing surface area, time of burning will depend on

Table 3A—Combustion Time for Water/Solvent Mixture in an Open Tray

No.	Water (%)	Ethanol (%)	Isopropanol (%)	EGMEE (%)	Varnish (%)	Flash Point (°C)	Combustion Time (sec)			
							15° C	23° C	35° C	45° C
101	50	50				26	0	250	—	—
102	60	40				28	0	218 ^a	—	—
103	70	30				32	0	0	195	185
104	75	25				33	0	0	0	167
105	80	20				37	0	0	0	155
106	70		30	0		26	0	0	160	—
107	70		20	10		32	0	0	195	188
108	70		10	20		39	0	0	0	1
109	60		40	0		23	0	195	—	—
110	60		30	10		25	0	0	165	—
111	60		20	20		31	0	0	0	202
112	60		10	30		40	—	—	—	0
113	50		50	0		23	0	204	—	—
114	50		40	10		<23	0	230	—	—
115	50		30	20		29	0	0	230	—
116	50		20	30		31	—	—	1	270
117	50		10	40		41	—	—	0	0
118	40		40		20 A	24	0	280	—	—
119	40		30	10	20 A	26	—	1	100	107
120	40		20	20	20 A	30	—	0	58	50
121	50		30		20 A	24	0	2	122	122
122	50		20	10	20 A	29	0	0	75	61
123	20		40		40 A	<23	5	283	—	—
124	20		30	10	40 A	26	0	5	15	63
125	20		20	20	40 A	31	—	0	0	7
126	40		40		20 B	24	0	196	—	—
127	40		30	10	20 B	26	—	0	210	—
128	40		20	20	20 B	31	—	—	1	210
129	50		30		20 B	24	0	2	156	—
130	50		20	10	20 B	30	—	0	1	175
131	20		40		40 B	25	0	225	—	—
132	20		30	10	40 B	26	—	0	203	—
133	20		20	20	40 B	30	—	—	215	—
134	20	40			40 A	23	1	70	60	—
135	20	30		10	40 A	25	—	39	31	—
136	20	20		20	40 A	35	—	0	18	0?
137	20	40			40 B	26	3	288	—	—
138	20	30		10	40 B	29	0	295	—	—
139	20	20		20	40 B	34	—	0	0	21

(a) Ignition only after several attempts.

the area of the surface of the liquid. Within limits given by the total amount of the combustible components, the measured time of burning for a given mixture of solvent and water will be proportional to the surface area of the liquid and inversely proportional to the volume of the liquid.

Other factors influencing the time of burning or the combustibility is the temperature of the mixture, the evaporation rate of the combustible solvent, and the absorption of the solvent on other components in the liquid (e.g., varnish and pigment in a printing ink or a paint).

Under these circumstances, the combustion time for a given volume (e.g., one liter) of a mixture of water and

solvent, at a temperature which is lower than the boiling point of the components, will be shorter, if, for example, the mixture is placed in a can with a surface of ca. 50 cm² than if the mixture is spread over 1000 cm² by running out on a floor. Another reason is that the "back radiation" of heat is smaller in the can than on the floor.

As a consequence, it was decided to determine the combustibility or the combustion time by setting fire to the water-solvent-mixture in an open tray with a surface area of ca. 400 cm² in order to obtain a relatively large surface of the fluid. In order to limit the heat capacity of the mixture, the tray was only filled with ca. 200 cm³ of fluid, corresponding to a height of the fluid in the tray of about 5 mm. The source of ignition was a lighter

placed on the middle of one of the sides of the tray. This lighter was ignited for 2–3 sec at a time. The combustion time for the water/solvent-mixtures was determined at various temperatures below as well as above the flash point of the mixtures. The results obtained are given in *Table 3*.

The measurements carried out indicated the following:

(1) For mixtures of alcohol and water with more than 25–30% alcohol (ethanol or propanol), the ignition of the mixture and the continued combustion took place at temperatures for the mixture corresponding to the flash point or a few degrees higher.

(2) For water-alcohol-mixtures with less than 25–30% alcohol, ignition and continued combustion took place at temperatures which were significantly higher than the flash point.

(3) Replacement of water with ethyleneglycol mono-ethylether (EGMEE) in some cases resulted in an increased combustion temperature without affecting the flash point of the mixture:

Water (%)	Isopropanol (%)	EGMEE (%)	Flash Point (°C)	Combustion Temperature (°C)	Combustion Time (sec)
70	20	10	32	35	195
60	20	20	31	35	0
60	20	20	31	45	202
50	20	30	31	35	1
50	20	30	31	45	270

(4) Addition of a printing ink varnish instead of water affected the combustion time and the combustion temperature considerably. The influence was dependent on the type of varnish (Varnish A: Solution of a polymer in water, Varnish B: Water thinnable (does not contain water)), the amount of varnish added, and the presence of EGMEE. EGMEE reinforced the increase of the combustion temperature:

Water (%)	Isopropanol (%)	Varnish	EGMEE (%)	Flash Point (°C)	Combustion Temperature (°C)	Combustion Time (sec)
60	40	0	0	23	23	195
40	40	20%A	0	24	23	280
40	30	20%A	10	26	35	100
20	30	40%A	10	26	35	15
40	40	20%B	0	24	23	196
40	30	20%B	10	26	35	210
20	30	40%B	10	26	35	203

In this way, the combination of varnish A and EGMEE is "combustibility reducing" (increase of combustion temperature and decrease of combustion time), while varnish B is without significant influence on the combustion time.

For a number of the mixtures investigated it was found that ignition and burning took place only after several attempts to ignite the mixture. This has been interpreted that the mixture needs heating (from the lighter) to a higher temperature before ignition can take place.

When arranging the values given in *Table 3* according to the flash points of the mixtures, the following was found:

(1) Mixtures with 20–30% isopropanol have flash points between ca. 25°C and ca. 32°C and combustion temperatures of 35–45°C. The combustion time strongly depends on the content of other components. Specifically, a content of varnish A will reduce the combustion time considerably, even at a content of 30% isopropanol.

(2) Mixtures containing more than 20–30% isopropanol have combustion temperatures which are not significantly higher than the flash point. All mixtures have combustion temperatures below 35°C, flash points below ca. 25°C, and relatively high values of combustion times.

(3) For mixtures containing 10% isopropanol, no ignition takes place below 45°C and their flash points are ca. 40°C.

Put together, the measurements illustrate that since an actual ignition often takes place only at a temperature which is significantly higher than the flash point, the flash point of a solution is not an unambiguous description of the combustibility of the solution. Additionally, the solution can be self-extinguishing after a very short time, even in an open tray.

Attempts to ignite three printing inks and three paints (*Table 2*) after heating to 65°C demonstrated that the inks were set on fire, but were self-extinguishing immediately, while the paints could not be ignited.

Rest Concentrations of Solvents After Combustion

The rest concentration of solvent in a mixture of solvent and water (plus possible other components), when the mixture self-extinguished after the combustion, was investigated. This was done by carrying out a series of combustion experiments supplemented by a gaschromatographic analysis of the content of solvents in the mixtures after combustion. The solvents investigated were ethanol and isopropanol (and in some cases EGMEE). Results are given in *Table 4*.

These measurements demonstrate that:

(1) For water/isopropanol-mixtures self-extinguishing takes place at a residual concentration of 3–6% isopropanol irrespective of the concentration of isopropanol before the combustion and the possible presence of EGMEE.

(2) For water/isopropanol-mixtures containing varnish A the residual concentration of isopropanol increases proportional with the content of varnish A. This corresponds to a faster self-extinguishing with increasing content of varnish A:

Water (%)	Isopropanol (%)	Varnish A (%)	Residual Concentration of Isopropanol (%)
70	30	0	ca. 5.5
50	30	20	ca. 14
30	30	40	ca. 20

Table 3B—Combination Time for Water/Solvent Mixtures in an Open Tray

No.	Water (%)	Isopropanol (%)	EGMEE (%)	Varnish (%)	Flash Point (°C)	Combustion Time (sec)			
						15°C	23°C	35°C	45°C
1	90	10			40	0	0	0	0
2	80	20			30	0	0	4	173
3	75	25			27	0	1	160	—
4	70	30			26	—	0	—	—
5	65	35			24	—	175 ^a	—	—
6	60	40			23	0	167	—	—
7	80	10	10		41	0	0	0	2
8	70	20	10		25	0	0	195	188
9	65	25	10		27	—	0	—	—
10	60	30	10		25	—	210 ^a	—	—
11	55	35	10		25	—	205 ^a	—	—
12	50	40	10		23	0	220	—	—
A- 1	55	25		20 A	26	0	0	115	—
A- 2	50	30		20 A	24	—	1	—	—
A- 3	45	35		20 A	23	—	200	—	—
A- 4	40	40		20 A	23	—	285	—	—
A- 5	45	25		30 A	26	0	0	83	—
A- 6	40	30		30 A	25	—	1	—	—
A- 7	35	35		30 A	24	—	90 ^a	—	—
A- 8	30	40		30 A	23	—	125	—	—
A- 9	50	20	10	20 A	29	0	0	75 ^a	—
A-10	45	25	10	20 A	27	—	1	—	—
A-11	40	30	10	20 A	26	—	2	—	—
A-12	35	35	10	20 A	—	—	80 ^a	—	—
A-13	30	40	10	20 A	—	—	72	—	—
A-14	25	45	10	20 A	—	—	88	—	—
A-15	40	20	10	30 A	—	0	0	55 ^a	—
A-16	35	25	10	30 A	—	—	2	—	—
A-17	30	30	10	30 A	—	—	4	—	—
A-18	25	35	10	30 A	—	—	54	—	—
A-19	20	40	10	30 A	—	—	51	—	—

(a) Ignition only after several attempts.

(3) The presence of varnish B does not influence the residual concentration of isopropanol.

(4) The residual concentration of EGMEE corresponds approximately to the concentration before combustion and is independent of other components in the mixture.

(5) The residual concentration of ethanol in mixtures depends on the concentration of ethanol before combustion as well as the presence of varnish A. A high start concentration of ethanol leads to a relatively low end concentration and vice versa. Presence of varnish B and EGMEE do not affect the final concentration of ethanol.

These results demonstrate that some components (e.g., varnish) in a printing ink or a paint can influence the evaporation of a solvent to a very high degree, and in this way reduce or totally eliminate a possible ignition. In spite of this, eventually the solution will produce a concentration of solvent vapors over the mixture which is sufficiently great to result in the measurement of a flash point. This, however, does not mean that the solution (printing ink or paint) can be ignited and burn.

Water Solutions Containing Solvents Not Soluble in Water

Further investigations of the combustibility of water solutions containing solvents included determination of flash point and combustibility for a series of solutions containing small amounts of acetone, MEK, MIBK, ethylacetate, benzene,* and toluene. Since the concentrations were relatively small, only relatively short combustion times were found in all cases. The results indicated the following:

(1) In concentrations of less than 5% in water, acetone is not combustible at temperatures below 65°C (flash point = 36°C).

(2) A concentration of 5% MEK in water showed combustibility at 35°C (flash point = 23°C).

(3) MIBK showed no combustibility at a concentration of 1% in water, but was combustible at a concentration of more than 3%.

(4) Ethylacetate demonstrated a very limited combustibility at a concentration of 3% in water (flash

* Benzene = mixture of aliphatic hydrocarbons.

torch was kept in the sample for more than 10–15 sec, the sample ignited and burned continuously. After heating the sample to 40°C (16°C over the flash point), it ignited and continued burning for more than 30 sec.

The investigations show that it was not possible to ignite a sample which had a flash point of 39°C, although the torch was kept in the sample for a very long time (more than 30 sec).

For the products which could be ignited, it was found that ignition occurs very slowly at temperatures close to or a little above the flash point (10–15°C over the flash point). The samples can be ignited by heating them to a higher temperature, if necessary over a longer period of time (10–15 sec).

Due to the relatively violent generation of heat from the torch, a strong heating of the products takes place when the torch is kept close to the product for a longer period of time. In this way, the chance of ignition will naturally increase. In some cases it will, therefore, be more relevant to classify water-borne products as "fire feeders" rather than "inflammable" (analogous to wood). Other water-borne products can be "fire extinguishers," although their flash points are below 55°C.

DISCUSSION

The investigations carried out concerning the combustibility of water-borne products have demonstrated that although the products have flash points in the range from 21°C to 55°C, their combustion characteristics vary considerably.

An important reason for this is that the determination of the flash point takes place at a temperature where the concentration of combustible vapors over the surface of the product is sufficiently large to cause a short ignition. On the other hand, in many cases the product is not able to deliver further vapors to feed the fire, and to cause continuous burning, making the flame go out spontaneously.

Furthermore, the investigations have illustrated that the products after the combustion still contain a certain amount of the combustible component, although the product acts self-extinguishing. The concentration of the combustible component remaining after self-extinguishing depends on the other components in the product, e.g., the binder or varnish in a printing ink. These polymers can in some cases absorb the combustible component in such a quantity that a mixture, which normally should be combustible, can not be ignited and burn.

The heat capacity of the product naturally has a great influence on the combustibility, since a condition for combustion is a "current delivery" of combustible vapors. If the heat from the source of ignition is absorbed in the product without significant influence on the evaporation, ignition and burning will only take place after a longer period of heating from the source of ignition. In this case the flame from the flash point instrument will be far from sufficient to start an actual combustion process.

The actual background for the very different results obtained for water-borne products must, however, be

looked for in the evaporation rates of the combustible components. In the determination of flash points, the evaporation rate is of minor importance, since the measurement is carried out so slowly that the head-space over the product will contain a certain concentration of the combustible vapors. This concentration in the head-space will, however, almost exclusively depend on the concentration of the combustible component in the solution and the temperature of the solution; the evaporation rate itself will be of less importance.

For a continuous combustion, the evaporation rate must be high enough to feed the flame continuously. The many other factors, except for concentration and temperature, which influence the evaporation rate, will have a great importance. This means that the flash point depends on the concentration of combustible components and the temperature of the product. The combustibility, in addition, depends on the evaporation rate. This is influenced by the heat capacity of the product, absorption of combustible components in other components (polymers), and interactions between the combustible components, and other components including water, binders and pigments, and solvents.

Accordingly, one can not be expected to find an agreement between flash point and combustibility (combustion temperature), and the difference can be so great that a product with a relatively low flash point can not burn at all at temperatures considerably higher than the flash point. As the investigation demonstrates, this is the case for a large number of water-borne products, but must be expected also to be the case for other mixtures of combustible and noncombustible substances and products.

PROPOSAL FOR A CLASSIFICATION OF WATER-BORNE PRODUCTS

The investigations of water-borne products described above have demonstrated that the classification concerning fire hazards of a product based only on the flash point of the product leads to indication of a fire hazard, which in a number of cases does not exist. In those cases, where a considerable disagreement between flash point and combustibility has been found, the products have had flash points indicating a class II fire hazard (Danish classification) with flash points between 21°C and 55°C.

According to the existing (Danish) classification, class II is divided into subclass 1 (products not miscible with water) and subclass 2 (products miscible with water). The products having disagreement between flash point and combustibility are mainly in class II,2.

In order to obtain a realistic evaluation of the combustibility of water-borne and water-thinnable products, it is suggested, on the basis of the investigations carried out, to make a subdivision in the following subgroups:

Class II, 2A: Water-miscible products having a flash point between 21°C and 55°C and combustibility (ignition and combustion for at least 5 sec in an open tray) at a temperature lower than 55°C. This class corresponds to the existing class II,2.

Class II, 2B: Water-miscible products having a flash point between 21°C and 55°C and combustibility (ignition and combustion for at least 5 sec in an open tray) at a temperature between 55°C and 100°C. This class should be included in class III (flash point over 55°C) using a combustibility criterion instead of the flash point for the classification.

Class II, 2C: Water-miscible products having a flash point between 21°C and 55°C and which at a temperature below 100°C can not be ignited and burn for more than 5 sec in an open tray. This class should not be considered as a fire hazard group, and should be excluded from previous classification of fire hazard according to flash point. Class II, 2C products will in practice represent a smaller fire hazard than many products classified in class III (flash point above 55°C).

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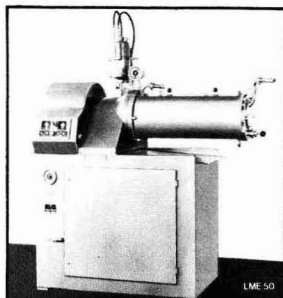
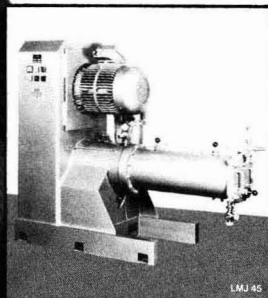
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Practical Considerations in the Drying Of Water-Reducible Alkyds

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The differences in drying characteristics between solvent and water-borne alkyds are discussed. Generally, higher active metal levels are required for water-borne alkyds since both the neutralizing base and the presence of water as the primary solvent contribute to slower dry time. Functional drier systems based on precomplexed cobalt and cobalt/zirconium/calcium have been developed and data demonstrating their utility in several commercial alkyds are presented. The problem of loss of dry is considered and is attributed to both drier adsorption on the pigment and hydrolytic degradation of the resin. Careful pH control is presented as the best way to prevent resin degradation.

INTRODUCTION

The drying of oleoresinous and alkyd coatings has been the subject of a great deal of study and much is known about the mechanism of autooxidation as it applies to drying.^{1,2} It is generally agreed that a quiescent period precedes oxygen absorption by the unsaturated resin. This is followed by hydroperoxide formation, hydroperoxide decomposition, and polymerization resulting in increased resin molecular weight and eventually a cured film. In a mechanism proposed by Girard,³ et al., the energy of activation for oxygen absorption is reduced by cobalt drier. The use of driers and their contribution to drying and related coating properties is well known in the industry and a practical treatment of their use is presented by Stewart.⁴ With the use of water-borne coatings on the increase and the continued introduction of new and/or improved resin systems, there has been an increased interest in the drying characteristics of water-reducible alkyds.

Although essentially the same mechanism of drying applies in both water-borne and solvent-based alkyd

coatings, there are some very important differences which must be considered. It is the purpose of this paper to review the pertinent differences between solvent and water-borne alkyds and to present applications data for the use of driers in water-reducible alkyds.

DRY TIME

Before considering the parameters which influence dry time, a brief discussion of the measurement of dry time is warranted. Drying is the changing of a liquid coating to a solid and, in the case of alkyds, is due to solvent evaporation and oxidative polymerization. The drying process is characterized by an increase in hardness of the applied paint film. Devices ranging from an ultrasonic impedometer⁵ to a finger⁶ have been used to monitor drying time. The *Paint/Coatings Dictionary*⁷ defines drying time as the "time required for an applied film of a coating to reach the desired stage of cure, hardness, or nontackiness." It also contains definitions for 12 stages of drying. Eight stages of drying and several methods of determining each are described in ASTM D1640.⁸ Clearly, the measurement of dry time is not a universally defined procedure and, therefore, the end point reported must be defined along with the method and conditions under which it has been obtained.

An improved Gardner Circular Dry Time Recorder has been used in this work to evaluate dry time. It functions by rotating a teflon stylus at a controlled rate of travel so as to scribe an arc shaped pattern in the film as it dries.⁹ This pattern can be used to determine set to touch, surface dry, and through dry. Since most commercial water-reducible alkyds are of short or medium oil length, they develop much of their early hardness due to lacquer type dry (evaporation of volatiles). Therefore, the early stages of drying (i.e., set to touch and surface dry) are most dependent upon solvent evaporation. Although driers have some effect on each of the stages of drying, they have the greatest impact on through dry. Consequently, this is the endpoint given the most emphasis in this work.

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Table 1—Performance of Eight Commercial Neutralizing Amines in a Test Varnish^a

Amine	lbs. Amine	Through Dry ^{b,c} (Hours)	Pencil Hardness 24 Hr	Gardner Viscosity 25° C
	100 lbs. Resin Solids			
Ammonia (28%)	4.8	8	B	1-J
Triethylamine	7.9	10½	B	D-E
N,N-Dimethylethanolamine	7.0	12½	B	A-A
Monoethanolamine	4.8	21½	3B	G-H
Triethanolamine	11.7	>24	6B	A-B
2-Amino-2-methylpropanol	7.0	13	2B	L-M
Mixed Isopropanolamines	12.0	>24	6B	D-E
Diethanolamine	8.2	>24	4B	D-E

(a) Resin reduced to 25% solids with water/butyl cellosolve (80:20).

(b) Through dry determined on 0.003" wet film at 70° F and 50% relative humidity.

(c) Drier system consisted of 0.08% Co/0.08% Mn - 0% metal on resin solids.

FACTORS INFLUENCING DRY PERFORMANCE

The factors¹⁰⁻¹³ which are considered to have an effect on drying of alkyd paints include resin type, drier metal amount and type, organic component of the drier, humidity, temperature, and solvent. Additionally, dry time stability is affected by storage duration and temperature as well as pigment and solvent type, since these factors influence the amount of drier adsorbed by the pigment during storage. It is generally agreed that water-borne alkyds dry slower than their solvent-borne counterparts and are more prone to loss of dry on aging. This difference was investigated¹⁴ by comparing the dry time of a water-reducible alkyd coating with that of a coating based on the same alkyd reduced with solvent. Data were presented which fit the general equation $y = 1.5x + 1$ where y is the dry time in hours of a water-reducible alkyd coating and x is the dry time of the same alkyd in solvent. These data clearly illustrate the slower dry time of the water-reducible system.

If one compares a water-reducible alkyd formulation to a solvent alkyd formulation, there are two obvious differences which affect dry time. The water-reducible alkyd contains a neutralizing base, and there is water present as the primary solvent. A discussion of the importance of these factors as they pertain to drying follows.

Neutralizing Base

The neutralizing base influences dry time both directly and indirectly as well as affecting other coatings proper-

ties. For this reason the coatings formulator must make a careful selection. The primary function of the neutralizing agent is to solubilize the resin. Woods¹⁵ uses a pyramid to demonstrate the four way dependence of resin solubility on acid value of the resin, the cosolvent level, resin molecular weight, and amine efficiency. Amine efficiency is determined by base strength, molecular weight of the amine, and the amine solubility parameter. When formulating with a specific resin, molecular weight and acid value remain constant and resin solubilization becomes dependent upon amine efficiency and cosolvent level. To facilitate the selection of a suitable amine, eight neutralizing agents were screened for their effect on dry time, hardness development, and viscosity in a water-reducible alkyd coating. As indicated in Table 1, only ammonia (NH₃), triethylamine (TEA), dimethyl ethanolamine (DMEA), and aminomethylpropanol (AMP) gave reasonable dry times and 24-hour hardness when dried at ambient temperature with a constant drier system (0.08% Co/0.08% Mn). Important properties of these four neutralizing bases are listed in Table 2. The correlation between dry time obtained with the test alkyd and rate of amine loss from an acrylic copolymer as reported by Wicks¹⁶ is good. As expected the rate of amine loss from the coating exerts a direct effect on dry time.

The neutralizing base (particularly ammonia) can also indirectly affect dry time by complexing the cobalt drier and in some cases render it less effective. The addition of ammonia to a cobalt salt and the formation of complex

Table 2—Properties of Four Candidate Neutralizing Amines for Ambient Temperature Dry

	Molecular Weight	pKa 20° C	Boiling Point (°C)	% Amine Loss From Acrylic Copolymer in 20 Min ¹⁶		Yellowing
				25° C	90° C	
Ammonia	17 ^a	9.24	-33	16	83	Considerable
Triethylamine	101	10.78	89	6	26	Trace
N,N-Dimethylethanolamine	89	9.31	134	0	18	Trace
2-Amino-2-methylpropanol	89	9.82	165	0	3.5	Moderate

(a) For calculating amount of ammonia (28%) required for neutralization, an apparent molecular weight of 60.7 can be used.

Table 3—Effect of Ammonia Neutralization on Cobalt Versus Manganese Drier Activity Dry Time (Hours)

% Metal on Vehicle Solids	Un-Neutralized Resin	Ammonia Neutralized Resin	TEA Neutralized Resin
0.2 Cobalt.....	3.5	12	10
0.2 Manganese.....	6	8	12

amines is well known.¹⁷ Such complexes demonstrate none of the typical cobalt reactions. Laitinen and Kivalo¹⁸ have shown that the polarographic reduction of hexamine cobalt (III) ion to the divalent form appears to proceed irreversibly. Such complexes could clearly interfere with the cobalt drier action which relies on repeated transitions between Co II and Co III.³

The impact of neutralization of the resin (ammonia) on cobalt as a drier is illustrated in Table 3. This impact is best seen by comparing the relative performance of cobalt to manganese. In the un-neutralized resin, as expected, cobalt gives faster dry than manganese. However, when the same resin is neutralized with ammonia and reduced with water, manganese gives faster dry than cobalt, suggesting that the cobalt has been deactivated by the ammonia. When this resin is neutralized with triethylamine, the cobalt is slightly more effective than manganese.

The formation of active cobalt complexes with diamines such as 1,10-phenanthroline has been thoroughly discussed in the literature¹⁹ and such complexes have been used commercially to prevent deactivation of cobalt driers in water-reducible coatings. However, this approach is limited by high cost and resin discoloration. Recently it has been found that bimetallic complexes of cobalt²⁰ enhance its activity and prevent deactivation in water-reducible coatings²¹ without the negative side effects associated with amine complexing agents. The effective use of a cobalt-potassium complex is illustrated in Table 4.

Solvent System

In the case of water-reducible alkyds, the water/cosolvent combination is selected for optimum application properties, stability, and dry rate. The rate at which solvents evaporate from an applied film exerts a major influence on the drying rate. The evaporation rate depends on humidity, temperature, and air movement. Also, the ratio of water to cosolvent may change during drying depending on humidity and critical relative humidity.²² Critical relative humidity depends on the composition and concentration of cosolvent as well as the conditions of evaporation. If the humidity is higher than critical relative humidity, the water enriches during evaporation and if the humidity is less than critical, the cosolvent enriches. If the water-cosolvent ratio changes drastically, sagging or premature resin insolubility may result. It is obvious that the drying of water-reducible alkyds is more sensitive to relative humidity than are their solvent-borne counterparts.

Table 4—Complexed Cobalt in Ammonia Neutralized Resin

% Metal on Vehicle Solids	Through Dry 70°F, 50% Relative Humidity
0.2% Cobalt	12 hr
0.2% Cobalt	8 hr
Precomplexed with Potassium	

There is evidence that water depresses the oxygen uptake of the alkyd relative to other solvents and thus slows the dry. This is in part due to the low solubility of oxygen in water (Table 5). Proposed mechanisms for autooxidation include exciting oxygen from the triplet ground state to the singlet state.²⁴ The longer oxygen remains in the excited state the more likely a productive encounter with the alkyd will occur. It has been found that the lifetime of singlet state oxygen (the excited state) is a very short 2μ sec in water compared to 24μ sec in benzene²⁵ and 700μ sec in carbon tetrachloride.²⁶ It follows that the low solubility of oxygen combined with the short lifetime of excited oxygen in water will contribute to slower oxygen uptake by the alkyd. Of course this affects drying only until the solvent has evaporated but it has the effect of slowing the rate of dry of water-reducible alkyds and places increased demands on the drier system.

DRIERS

Driers are required to accelerate the cure rate of alkyd coatings; however, before discussing their use in water-reducible alkyds, a brief review is in order. Driers are classified as either active or auxiliary and are composed of a metal soap in a solvent system. The active drier metals at ambient temperatures are cobalt and manganese with cobalt being the more active of the two. Iron, vanadium, and cerium function as active driers at elevated temperatures. The auxiliary driers which are used in combination with an active drier include zirconium, lead, calcium, and zinc. Bismuth is also finding increased usage for special applications. The common drier acids include naphthenic, 2-ethylhexoic, neodecanoic, and isononanoic. It is the metal portion of the soap which promotes drying while the acid renders the metal soluble in the resin. Experience with thousands of different paint formulas demonstrates that the acid portion (when considering the common drier acids) exerts very little influ-

Table 5—Mole Ratio Solubilities Of Oxygen in Various Solvents²³

Water	0.000023
CCl ₄	0.00120
nC ₇ H ₁₆	0.00215
(C ₂ H ₅) ₂ O	0.00193

P = 1 atm at 25°C

Table 6—Zirconium Drier/Resin Compatibility

Commercial Resin	No Drier	Zirconium 0.1% Metal	Zirconium/Calcium 1:1 Metal
A	OK	ppt	OK
B	OK	Haze	OK
C	Sl. Haze (OK)	Sl. Haze (ppt)	Sl. Haze (OK)
D	OK	OK	OK
E	OK	OK	OK
F	OK	ppt	OK
G	OK	Haze	OK
H	OK	ppt	OK
I	OK	OK	OK
J	OK	ppt	ppt
K	OK	ppt	ppt
L	OK	ppt	ppt

All resins neutralized with ammonia and reduced to 25% solids. Driers added as % metal (by weight) on vehicle solids.

ence on drier performance. This is verified by data.¹⁰ The data available to date suggest that the same can be said about the acid portion of the drier when used in water-reducible coatings.

Differences between water-reducible alkyds and solvent-borne alkyds necessitate changes in driers and drier combinations used in water-reducible alkyds. The first obvious difference is that conventional driers dissolved in mineral spirits are not readily dispersed into a water-cosolvent system. If conventional driers are used, they must be dissolved in the resin before neutralization and this can lead to premature gelation of the resin and processing problems. Driers can be made water miscible by adding a suitable dispersing agent and diluting with cosolvent (i.e., mono butyl ether of ethylene glycol) before addition to the coating. This approach allows for ease of incorporation at any point of manufacture with no adverse effect on paint properties.

Drier metal combinations do not always give the expected responses in water-reducible alkyds and a discussion of some of the pitfalls and methods of overcoming them follows. Zirconium driers will form an insoluble soap in many commercial water-reducible alkyds and precipitate from the coating. This is shown in Table 6 which shows zirconium drier precipitating to some degree from nine of 12 commercial resins screened. In all but three of these cases, the zirconium can be stabilized by premixing it with calcium drier at an equal weight of metal. Calcium drier causes a viscosity increase in many water-reducible alkyds and in some cases the viscosity is directly proportional to the level of calcium drier present. Figure 1 shows the linear dependence of the viscosity on calcium concentration in a test varnish and can be summarized by the general equation:

$$y = mx + b$$

where y = viscosity, m = slope (65.0 KU/% Ca), x = weight % of 6% calcium drier, and b = y intercept (79 KU) which is the viscosity of the varnish with no calcium present. When zirconium drier is used in combination with calcium, the viscosity increase attributed to the calcium is suppressed to some extent. As a general rule, when a drier system contains zirconium and

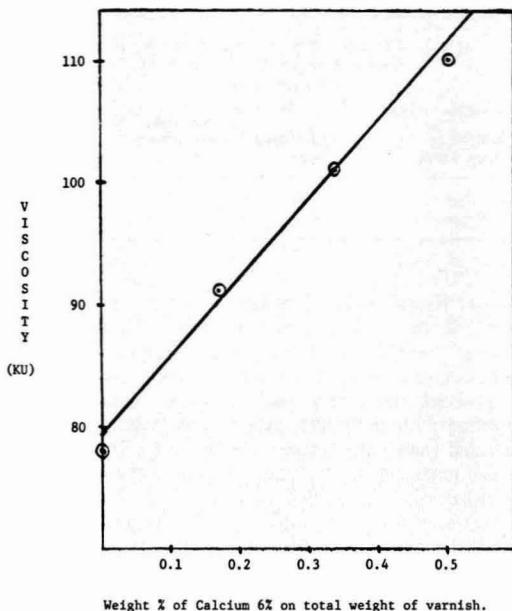


Figure 1—Viscosity (KU) vs concentration calcium 6% clear test varnish

calcium, a 1:1 metal ratio by weight should be used to prevent problems.

Manganese drier will contribute to increased yellowing and has been observed to cause seeding in some water-reducible coatings on extended shelf storage. If an attempt is made to stabilize manganese with a chelating agent such as 1, 10-phenanthroline, yellowing is further increased. When resin yellowing is not a primary concern, such as in a black coating, manganese is a cost effective drier. However, manganese should not be used as the sole active drier in a water-reducible coating since it is prone to loss of dry on long term storage. Therefore, all drier systems for water-borne coatings should contain cobalt. Although the potential for cobalt to be deactivated exists, this can be minimized by using zirconium and calcium in combination with cobalt. Bi-metallic precomplexed cobalt further reduces cobalt deactivation making cobalt the active drier of choice in most cases.

Drier Optimization

As indicated, if the drier system for a water-reducible coating is selected indiscriminately, there exists the potential for many problems. Although it is important to avoid difficulties, it is also important to obtain the maximum dry performance from the drier system. This leads to the formidable task of drier system optimization. Even after eliminating the drier systems which will cause problems, a large number of reasonable combinations can exist. For example, if one considers five use levels of cobalt and six use levels of zirconium, calcium and zinc along with all their combinations, there are 1080 possible systems to evaluate.

In order to reduce the experimental systems to a reasonable level, a Computer Optimized Experimental

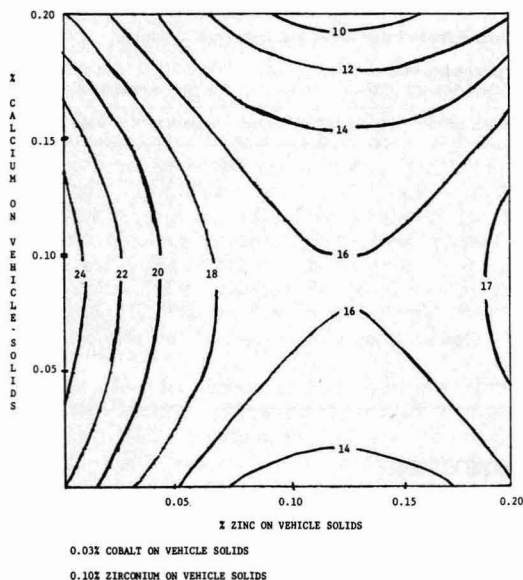


Figure 2—Response surface for dry time (hours) as a function of calcium and zinc concentrations (by weight)

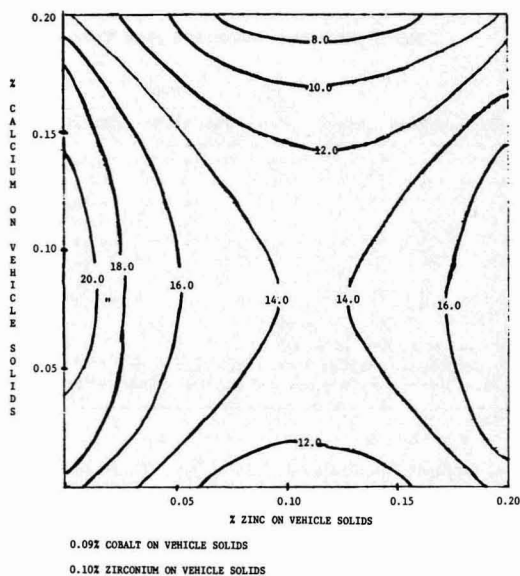


Figure 3—Response surface for dry time (hours) as a function of calcium and zinc concentrations (by weight)

Design* was utilized. From this, approximately 23 systems were recommended. These experiments were performed in a test varnish and the data was analyzed using response surface methodology† (RSM). RSM can analyze and quantify the simultaneous effects of several measurable characteristics and in this case was used to determine the effect of four drier metals on dry time. Figures 2, 3, and 4 illustrate the response surface for dry time at a fixed level of zirconium (0.1% metal on vehicle solids) and three different fixed levels of cobalt (0.03%, 0.09%, and 0.15%, respectively) while varying calcium and zinc. By comparing the three contour diagrams, the decrease in dry time at increased cobalt levels can be seen. The response surface for dry time only applies to the specific alkyd used in these experiments with the four drier metals shown. If a bimetallic cobalt complex is used, as expected, the response surface for dry time would be different. However, each of these three graphs demonstrates the interactive effects of zinc and calcium and clearly demonstrates that optimum metal ratios exist.

The above drier experiments and other follow up experiments suggest several good drier systems for general use in water-reducible alkyds. Candidate drier systems expressed as % metal on vehicle solids include 0.10% cobalt/0.15% calcium/0.15% zirconium, 0.4% bimetallic cobalt complex, and 0.3% bimetallic cobalt complex/0.15% zirconium/0.15% calcium. In order to minimize the number of experiments and because the effect of zinc with bimetallic cobalt is not as pronounced as with cobalt alone, zinc has not been included in the candidate drier systems. Of course effective drier sys-

tems containing zinc are possible and work optimizing its use is presently in progress. Also in some alkyds the weight ratio of zirconium to calcium does not have to be 1:1. This, however, is a good starting point for drier performance with minimal risk for drier related problems (i.e., viscosity increase and seeding). To determine if the candidate drier systems were universal in their application, the first two were screened in eight commer-

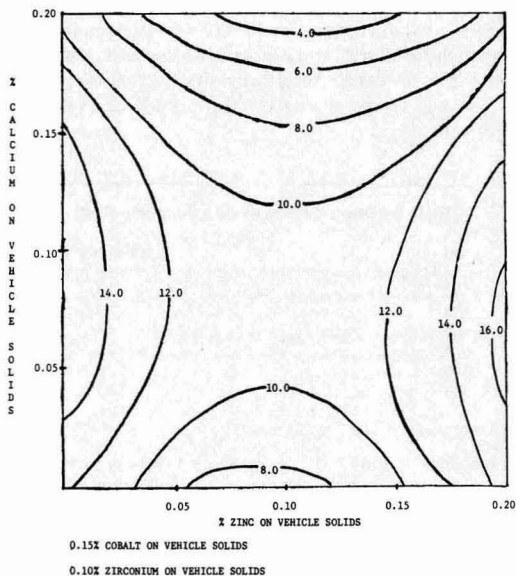


Figure 4—Response surface for dry time (hours) as a function of calcium and zinc concentrations (by weight)

*Computer Optimized Experimental Design is available through Compu Serve, Inc., Columbus, OH.
† RSM is a data analysis tool available from Compu Serve, Inc., Columbus, OH.

Table 7—Drier Performance in Several Water-Borne Resins Used in Both Trade Sales and Industrial Coatings

Commercial Resin System	Control			Through Dry Hours 0.1 Co/0.15 Ca/0.15 Zr			0.4 Precomplexed Co		
	Initial	1 Mo./120°F	4 Mo. @ RT	Initial	1 Mo./120°F	4 Mo. @ RT	Initial	1 Mo./120°F	4 Mo. @ RT
A	8	11	13	6	6	8	8	8	11
B	4	9	10	2	6	6	3	5	6
C	4	9	10	2	6	6	3	5	6
D	5	8	10	10	12	13	2	6	7
E	10	13	24	9	9	12	8	8	8
F	15	21	24	7	7	8	8	8	8
G	7	10	14	6	6	6	7	7	7
H	18	20	24	16	16	19	8	8	10

All resins were ammonia neutralized.

Drier systems expressed as % metal on vehicle solids.

Control drier systems were obtained from the product literature of the resin manufacturer.

cial ammonia neutralized resins (Table 7). Included in the evaluation was a control drier system which was obtained from product literature of the resin manufacturer. Dry times were evaluated initially, after one month storage at 120°F, and four months storage at 75°F. The candidate systems offered equal or better performance in every case. In several cases the control systems demonstrate very poor performance and this can generally be correlated to the relatively low active drier levels. In solvent based alkyds, diminishing returns in drier performance are often experienced as one exceeds 0.05% active drier. However, in water-reducible alkyds active drier levels higher than 0.15% are often required for adequate performance. This is probably due to the lower molecular weight of water-reducible alkyds versus conventional alkyds, combined with the increased demands caused by the solvent system (water) and the presence of a neutralizing agent. It is interesting to compare the data obtained after one month storage at 120°F and four months at ambient temperatures (Table 7). As indicated, although the correlation is good in some cases, it is quite poor in other cases. Accelerated dry time stability tests at elevated temperatures, therefore, must be evaluated with care.

Table 8—Resin Hydrolysis as a Function of pH

pH	% Hydrolysis
7.0	2.3
7.5	2.3
8.0	2.3
8.5	2.4
9.0	3.6
9.6	7.5

Samples stored at 120°F for 14 days.

$$\% \text{ Hydrolysis} = 100 \frac{\Delta V_K N}{E V_S} \quad \text{where } \Delta V_K = \text{Volume of KOH} \\ N = \text{Normality of KOH} \\ E = \text{Ester concentration} \\ V_S = \text{Volume of sample}$$

Turpins²⁹ procedure was modified to demonstrate the pH effect. pH was adjusted with ammonia and titrations were performed in Toluene/IPA. ΔV_K is the difference in volume of KOH required to reach a phenolphthalein endpoint initially and after 2 weeks storage.

LOSS OF DRY

After aging on a shelf, the dry time of alkyd coatings often becomes much slower, a problem known as loss of dry. The main cause of loss of dry in conventional alkyd coatings is due to the adsorption of drier metals on the surface of the pigment.²⁷ Pigments with large surface areas, such as carbon black, are the worst offenders. Loss of dry also occurs in water-borne coatings but at an accelerated rate. The solvent system is known to affect the rate at which driers are adsorbed by pigment²⁸ and historically, solvent alkyds which contain large amounts of water have been notorious for losing dry. There are generally two approaches to resolving this problem. The first is to incorporate a sacrificial drier such as calcium in the grind, to be preferentially adsorbed by the pigment. This approach is limited in water-reducible coatings because of the viscosity increase associated with the presence of large amounts of calcium drier. The second approach is to include a feeder drier such as cobalt hydroxy naphthenate in the formulation. Such materials are initially not completely soluble and slowly solubilize by reacting with acid functionality in the vehicle, thus replacing drier which is adsorbed by the pigment. This approach has been found effective in water-reducible coatings.

Another cause for loss of dry in water-reducible alkyds is hydrolysis of alkyd ester groups. This results in lower resin molecular weight and subsequently slower dry. Degradation can be greatly accelerated at elevated temperature as demonstrated by gel permeation data and dry time data.¹⁴ Hydrolysis occurs because of nucleophilic attack on the ester group and is dependent upon ester design.²⁹ Hydrolysis is also dependent upon pH and this is demonstrated in Table 8. Clearly the pH of water-reducible alkyds must be carefully controlled and not allowed to exceed 8.5 to prevent excessive hydrolysis.

SUMMARY

Several important differences between water-borne alkyds and solvent alkyds were investigated before attempting to develop optimized drier systems. Water-borne alkyds contain water as the primary solvent and

must be neutralized to become water-reducible. The ambient temperature drying rate is directly related to the volatility of the neutralizing agent from the coating and the neutralizing agent's ability to deactivate cobalt can indirectly affect dry time. Eight neutralizing agents were screened for dry performance and four of these demonstrated reasonable dry times in a test varnish. Ammonia, TEA, DMEA, and AMP yielded the fastest dry times in increasing order. There is evidence that the presence of water as the primary solvent not only makes the drying of water-reducible alkyds more sensitive to relative humidity, but also contributes to slower oxygen adsorption. This has the effect of slowing dry time and contributes to the increased active drier levels required in water reducible-alkyds.

Drier related formulating problems were investigated and candidate drier systems were developed. Potential problems include zirconium precipitation and calcium induced viscosity increase. Calcium was found to prevent zirconium precipitation while zirconium suppressed the viscosity increase caused by calcium in many instances. This complementary effect was utilized in developing candidates drier systems. Cobalt deactivation by the neutralizing agent was discussed and data was presented demonstrating the use of bimetallic cobalt complexes in preventing cobalt deactivation. Data demonstrating the utility of two candidate drier systems (0.1% cobalt/0.15% calcium/0.15% zirconium or 0.4% precomplexed cobalt) in eight commercial resins was presented.

Loss of dry was acknowledged as being a problem of greater magnitude in water-reducible alkyds than in solvent-borne alkyds. This is attributed to increased rate of drier adsorption on the pigment compounded by resin hydrolysis. Hydrolysis can be minimized by careful pH control and feeder driers can be used to replace adsorbed driers.

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(Please turn page for Appendixes)

**APPENDIX I
RESIN TYPE LISTED IN TABLE 6**

Commercial Resin	Resin Type
A	Water dispersible alkyd—General purpose
B	Water dispersible alkyd—Table sales
C	Water reducible short oil alkyd
D	Water reducible industrial alkyd
E	Water reducible oil modified polyurethane
F	Water reducible short oil alkyd
G	Water reducible medium oil alkyd
H	Water soluble short oil alkyd
I	Water soluble urethane modified alkyd
J	Water dispersible oil modified urethane
K	Water soluble acrylic modified alkyd
L	Water reducible alkyd

**APPENDIX II
RESIN TYPE AND CONTROL DRIER SYSTEM
LISTED IN TABLE 7**

Commercial Resin	Resin Type	Drier System (% Metal on Vehicle Solids)
A	Water dispersible alkyd—General purpose	0.1 Co/0.1 Mn
B	Water dispersible alkyd—Trade sales	0.1 Co/0.1 Mn
C	Water dispersible alkyd—Trade sales	0.1 Co/0.1 Mn
D	Water dispersible oil modified urethane	0.02 Co/0.02 Mn/0.18 Activ 8
E	Water soluble alkyd—General purpose	0.02 Co/0.02 Mn/0.1 Zr
F	Water reducible chain stopped alkyd	0.15 Co/0.15 Zr
G	Water reducible medium oil alkyd	0.06 Co/0.06 Mn/0.1 Zr
H	Water soluble acrylic modified alkyd	0.05 Co/0.05 Ca/0.05 Zr

Resin description from suppliers literature.

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Introduction

I suspect that most people think that the International Commission on Illumination (Commission Internationale de l'Éclairage—CIE) is an organization set up to serve the community of lighting engineers and lamp manufacturers. So it does, but the activities and contributions of the CIE do not stop there. For more than 50 years the CIE has furnished major guidance to all industries involved in color measurement, with the protective and decorative coatings industry being no exception! A recent article¹ in this journal told the story of the early days of color in the CIE; in this commentary I shall bring you up to date on CIE activities of interest to the coatings industry.

This is a pertinent time to review activities of the CIE, since several major CIE events of interest in the color area are occurring right now. They will help shape the future of colorimetry, over the next decades, in new and exciting ways.

Fine-Tuning of CIE Organization

Following the 19th quadrennial CIE Congress in Kyoto, Japan, in 1979, a more efficient and effective organization of the CIE has been devised. It will be largely in place and operating by the time of the 20th Congress in Amsterdam, August 31–September 8, 1983. The basic structure of the CIE has not been altered.

It will, for example, continue to operate through international technical committees (TC's) consisting of one voting member from as many of the 36 CIE member countries as have interest and expertise in the committee's field. Larger TC's also have a number of consultants to tap the expertise of more than one person per country. In larger countries, the TC member will chair a national TC on the same topic, whose consensus he represents at the international level.

The most visible evidence of the CIE reorganization is a regrouping of the TC's into the seven divisions listed in Table 1, selected to group related activities together more effectively. TC activities of interest to the coatings industry take place in at least the following of these divisions:

Division 1. Vision and Color. Terms of reference: to study visual responses to light and to establish standards or response functions, models and procedures of specification relevant to photometry, colorimetry, and visual assessment of light and lighting. This is the division within which much of the work on colorimetry and related topics is concentrated. The major activities of the

colorimetry committee are described below.

Division 2. Measurement of Light and Radiation. Terms of reference: to study standard procedures for the evaluation of UV, visible and IR radiation, global radiation, and the optical properties of materials and luminaires; to study optical properties and performance of physical detectors and other devices required for this evaluation. This division treats not only measurement methods, but also the light sources and detectors involved (including colorimeters and spectrophotometers in TC-2.2), and the interaction of light with materials (in TC-2.3).

Division 4. Lighting and Signaling for Transport. Terms of reference: to study lighting and visual signaling and information requirements of transport and traffic; such as road and vehicle lighting, delineation, signing and signaling, for all types of public roads and all kinds of users and vehicles, and visual aids for modes other than road transport. TC-1.6 activities include work on the specifications for surface colors for visual signaling.

Division 7. General Aspects of Lighting. Terms of reference: to study and

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*Dept. of Chemistry, Troy, NY 12181. Dr. Billmeyer is Chairman of the USNC-CIE Publicity Committee.

Table 1—New Divisions of CIE Technical Committee Activity

Division	Technical Committees of Interest to the Coatings Industry
1. Vision and Color	1.3, Colorimetry 1.4, Vision 3.2, Color Rendering
2. Measurement of Light and Radiation	2.2, Detectors 2.3, Materials
3. The Interior Environment and Lighting Design	
4. Lighting and Signaling for Transport	1.6, Visual Signaling
5. Exterior and Other Lighting Applications	
6. Photobiology and Photochemistry	
7. General Aspects of Lighting	1.1, Terminology

evaluate activities regarding terminology, education, and economics of lighting, and to provide information on development in light sources. This division includes TC-1.1, Terminology, whose important International Lighting Vocabulary, 3rd edition, (CIE Publication No. 17) is currently nearing completion of a major revision.

Division 6, Photobiology and Photochemistry, may be of special interest since it represents two excursions of the CIE into new fields not directly related to illumination or color. Its terms of reference are: to study and evaluate the effects of optical radiation (exclusive of vision) on biological and photochemical systems. There are two TC's in this division: TC-1.7, Actinic Effects of Optical Radiation, is concerned with the vast number of ways that radiation influences the human being *outside of* vision. This is a fascinating area indeed. TC-1.8, dealing with Photochemistry and Plant Growth, has been formed only recently. We do not have word that it has yet set up a working program. The U.S. member reports that he has not been successful in locating U.S. photochemists with the capability and interest to contribute in this area.

Revisions of CIE Recommendations On Colorimetry

Perhaps of greatest interest to the coatings industry is the work of CIE TC-1.3, Colorimetry. This committee has had responsibility for the widely used CIE recommendations in the area of color measurement since their inception in 1931. These recommendations have undergone a series of changes in the last 50 years, as new data bases, materials, and techniques were developed. In 1971, the CIE published a compilation of all current recommendations in colorimetry as Publication No. 15. Two supplements were issued, in 1972 and 1978, and a third one, at least, would be due now. Instead,

it was decided that Publication 15 be revised in its entirety, incorporating much new material and providing the opportunity for updating many details. This effort has now reached the draft stage, in which we can see what the changes are likely to be.

First, two sections will be split out and issued separately as CIE Standards, the first of a series of documents containing fundamental data that are not likely to be altered or replaced in the foreseeable future. These will be a CIE Standard on Colorimetric Illuminants, specifying illuminants A (incandescent) and D_{65} (daylight); and a CIE Standard on Colorimetric Observers, giving the data defining the 1931 and 1964 standard observers, the fundamental definitions of tristimulus values, and the definition of the (white) standard of reflectance.

The remaining recommendations will go into Publication 15.2, the second edition of No. 15. It will include much of the content of the first edition, plus the material in the supplements on index of metamerism and on the 1976 CIELAB and CIELUV uniform color spaces and color-difference equations. The controversial term psychometric, originally used to describe these spaces, equations, and related color terms, has been

dropped. New material to be added includes a recently agreed whiteness equation and two contributions supplied by the U.S. colorimetry committee: (1) a section on methods of tristimulus integration, spelling out in more detail exactly how to carry out this important step for uniformity of practice, and (2) sections defining standard geometric conditions for measuring transparent and translucent samples. An appendix will list obsolete recommendations, including illuminant and source B (but C remains in the list of standard illuminants and the sources to realize them), the 1960 u,v UCS diagram, and the 1964 $U^*V^*W^*$ color space and color-difference equations.

Technical Committee Work In Progress

In addition to the revision of Publication 15, CIE TC-1.3, Colorimetry, has active work in several subcommittees. Progress in the prediction of chromatic adaptation has been rapid in the last few years, and the TC-1.3 subcommittee dealing with this subject is now considering an official recommendation based on the nonlinear model of Nayatani. The standard sources subcommittee has just provided new tables of the spectral power distributions of various types of fluorescent lamps, expected to lead to the first international standards for calculating tristimulus values for these illuminants. The subcommittee on metamerism is making good progress toward defining an index of metamerism for change in observer, and the color-difference subcommittee is evaluating several new contributions to the eventual solution of this difficult problem.

In TC-2.3, Materials, several projects of interest to the coatings industry are being studied. The subcommittee on gloss is working toward the specification of the dimensionality (number of different attributes) of gloss in systems

Table 2—Recent CIE Publications of Interest to the Coatings Industry

Number	Title and Date	Price
38	Radiometric and Photometric Characteristics of Materials and their Measurement (1977)	\$ 22.00
39	Surface Colors of Visual Signaling (1978)	9.50
41	Light as a True Visual Quantity: Principles of Measurement (1978)	26.00
44	Absolute Methods for Reflection Measurements (1979)	23.50
46	A Review of Publications on Properties and Reflection Values of Material Reflection Standards (1979)	12.00
50	Proceedings of the 19th CIE Session (Kyoto) (1979)	115.00
51	A Method for Assessing the Quality of Daylight Simulators for Colorimetry (1981)	24.00
53	Methods of Characterizing the Performance of Radiometers and Photometers (1982)	11.00

of interest, such as automotive paints, and toward the development of visual gloss scales and corresponding instrument scales for each of these. The subcommittee on luminescence looks forward to developing an official recommendation on fluorescence measurement in the near future. Subcommittees on retroreflection and polarization have recently completed tasks, and CIE publications will be issued soon.

Twentieth CIE Congress, Amsterdam, 1983

The CIE holds its major technical meeting every four years, the last being in Kyoto, Japan, in 1979. The 20th congress will be held in Amsterdam, August 31-September 8, 1983. The meeting will be divided into roughly equal periods devoted to TC and other committee meetings and to technical papers. The program has not been selected at this writing, but it is known that U.S. authors have submitted prospectuses on the following topics of interest to the coatings industry: color vision (an invited paper by Robert M. Boynton), methods of tristimulus integration, color rendering of line sources, the beneficial action of light on the psychobiological system of man, the influence of geometric (angular) tolerances on bidirectional reflectance measurement, and the measurement of colored self-luminous displays.

Attendance at CIE Congresses is not limited to CIE technical committee members, but those who are interested should contact the U.S. National Committee of the CIE (USNC-CIE), which follows:

Recent CIE Publications of Interest

Table 2 lists the titles of a few recent CIE publications that should be of interest to the coatings industry. These publications may be ordered from Dr. Klaus D. Mielenz, Secretary, USNC-CIE, c/o National Bureau of Standards, B306, Metrology Bldg., Washington, DC 20234. The publicity committee of the USNC-CIE routinely sends press releases on all new CIE publications to the JOURNAL OF COATINGS TECHNOLOGY and other important journals in the industry.

Particular attention is called to Publication No. 50, the CIE Kyoto Proceedings. That volume contains a number of papers of special interest to the coatings industry, and should be in the libraries of major paint companies along with the others listed in Table 2, Publication 15 referred to above, and still more. Table 3 lists a few of the 86 papers in Publication 50 that may be of particular interest.

Table 3—Papers of Interest to the Coatings Industry in CIE Proceedings

<i>Actinic Effects of Light.</i> L. Thorington (USA).
<i>Practical Standard Illumination Representative of Interior Daylight.</i> F. J. J. Clarke (G.B.).
<i>Comparison of Perceived Colour Differences of Colour Chips With Their Colorimetric Ones in the CIE 1976 L*a*v* and the CIE 1976 L*a*b* Uniform Colour Spaces.</i> K. Ikeda, M. Nakayama, K. Obara (Japan).
<i>A Comparison of Methods for Visual Determination of Whiteness.</i> A. S. Stenius (Sweden).
<i>On the Measurement of Reflectance and Transmittance With Directional and Diffuse Incidence of Light.</i> J. Krochmann (Germany, FR).
<i>Specification of Luminescent Colours for Visual Signalling.</i> H. Terstiege (Germany, FR).
<i>Evaluation of Methods for Predicting the Colors Under Standard Illuminants of Fluorescent Samples Measured Under an Arbitrary Source.</i> F. W. Billmeyer (USA), T. F. Chong (Hong Kong).
<i>Estimation of Adaptation Effects by Use of a Theoretical Nonlinear Model.</i> Y. Nayatani, K. Takahama, and H. Sobagaki (Japan).
<i>Measurement of Slightly Suprathreshold Color Difference Steps.</i> R. M. Boynton (USA), and N. Kambe (Japan).

CIE Journal

The former CIE Bulletin has recently been upgraded and retitled the *CIE Journal*. The first issue has just been seen, and subscription arrangements are being worked out. It is expected to be a biannual publication, at a price of \$20 per year. Evidence that it will contain papers of interest to the coatings industry was seen in the paper by David L. MacAdam (1965 Mattiello Lecturer) which appeared in the first issue, "The Influence of Professor A. C. Hardy and His Spectrophotometer on Colorimetry."

The U.S. National Committee Of the CIE

The work of the U.S. technical committees of the CIE is coordinated by the U.S. National Committee, which has about 250 members, in several classes, whose dues supply most of the monetary support for not only the USNC, but also the Central Bureau of the CIE located in Paris, through a dues structure apportioned among the CIE member countries. President of the USNC-CIE is Franc Grum, Eastman Kodak Company; Vice-President is Charles Amick, Day-Brite Lighting; Secretary is Klaus Mielenz, NBS; and Treasurer is Benn Hartmann, GTE Sylvania.

In addition to individual members, the USNC-CIE has two classes of member bodies that should be called to the attention of the protective and decorative coatings industry.

Constituent Societies are national societies with objectives consistent with those of the USNC. They pay dues of \$600 per year and are represented by delegations of three USNC members, one of whom is designated chairman. The Federation is, unfortunately, not a

Constituent Society of the USNC-CIE, thereby denying the industry a voice in CIE affairs; it is indeed hoped that this situation can be changed.

Contributing Organizations can be commercial and industrial companies, schools and universities, laboratories, and even individuals, that is, any person or group that is in sympathy with the objectives of the CIE but does not meet the requirements for Constituent Societies. Contributing Organizations pay dues of \$100 per year, and have one representative appointed by the Executive Committee. This representative is a member of the USNC.

The USNC members representing Constituent Societies or Contributing Organizations do not pay individual member dues (a nominal \$15 per year). They do receive advance notices of new CIE publications, the *CIE Journal*, and the USNC-CIE Newsletter, which reports on technical committee activities and meetings, among many other topics.

It has often been thought by those not familiar with the CIE that it is an "ivory tower" organization that, like Jove, sends down bolts of lightning in the form of official recommendations. Nothing could be farther from the truth. It is a group of ordinary people, even as you and I, contributing through committee work to try to solve practical problems in ways that are useful to all concerned with color and light. Come join us, and encourage your organization and society to do the same, for the benefit of your industry world wide.

Reference

- (1) W. David Wright, "Experimental Origins of the 1931 CIE System of Colorimetry," JOURNAL OF COATINGS TECHNOLOGY, 54 No. 685, 65-71 (1982).

Future Society Meetings

Birmingham

(Dec. 2)—“MICRONIZED WAXES AND WAX DISPERSIONS”—R. Koehler, G.M. Langer & Co.

(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

(Nov. 16)—“GENERAL OVERVIEW—RADIATION CURING OF COATINGS INCLUDING PLASMA TREATMENTS”—Dr. V. McGinniss, Battelle Columbus Labs.

(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.

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.

New England

(Nov. 18)—“FUMED SILICA FOR THE RHEOLOGY CONTROL OF HIGH SOLIDS COATINGS”—Dennis Miller, Cabot Corp.

Piedmont

(Nov. 17)—“AN INVESTIGATION OF ABRASION RESISTANCE”—W.M. Neuberger, Shamrock Chemicals Corp.

(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

(Dec. 6)—“QUALIFICATION TESTING VERSUS PERFORMANCE TESTING”—Rich Burgess, Pittsburgh Testing Laboratory.

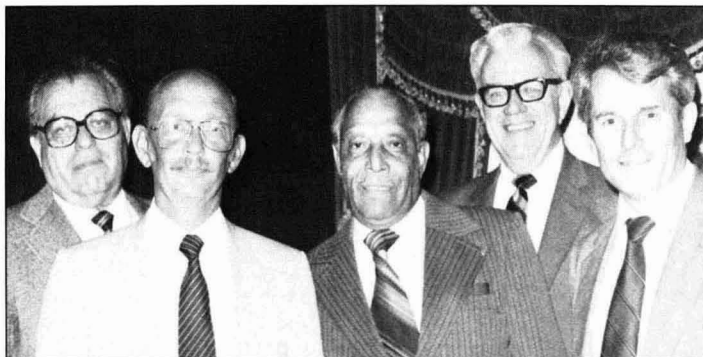
(Jan. 3)—“FACTORS THAT AFFECT COATINGS PERFORMANCE ON METAL SUBSTRATES”—Bruno Perfetti, U.S. Steel Research Laboratories.

(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 TECHNOLOGY IN COATINGS”—Jed Fulkerson, Dow Chemical Co.

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



Los Angeles Society Officers for 1982-83 (left to right): Secretary—Michael Gildon; President—Romer E. Johnson; Society Representative—Dermont G. Cromwell; Treasurer—Earl B. Smith; and Vice-President—L. Lloyd Haanstra

Theme Announced for Southern Society's 47th Annual Meeting, March 23-26

"From Laboratory to Customer, Bridging the Gap Through Creativity" is the theme for the Southern Society for Coatings Technology's 47th annual meeting to be held March 23-26 at the Peabody Hotel, Memphis, TN (host of the Society's 1950 meeting).

The theme for the meeting will emphasize creativity, and the need to utilize this valuable tool throughout the industry, from the mind of the formulator to the hands of the customer.

Two panels are being planned, with brief presentations on laboratory design and the latest on industrial application. Other presentations will feature subjects such as marketing, microcomputers, and plant safety.

The formal meeting will be preceded on Wednesday, March 23, with a golf and tennis outing. The Society Reception will be held on Thursday evening. The Annual Southern Society Luncheon and Awards Banquet will be held Friday in the same hall that was used 32 years ago by the Southern Paint and Varnish Production Club.

Members of the Planning Committee included: SSCT President-Elect—William G. Early, Piedmont Paint Mfg. Co.;

Chairman—Ken Haagenson, Buckman Laboratories, Inc.; Program and Speakers—Jim Geiger, Sun Coatings, Inc.; Registration—Sal Sanfilippo, RCI Technical Service Lab; Spouses Program—Valerie Johnson, Union Chemical Co.;

Publicity—Terrence J. Walsh, Kinsmen Corp.; Printed Materials—Phillip Aultman, Alcan Ingot & Powders; Mailings—Sheryl Neal Cobb, Rico Chemicals, Inc.; and Advertisements—John R. Dawson, Kerr-McGee Chemical Corp.

New Features Highlight WCS Symposium and Show

Two new sections have been added to the exhibit show being held during the Western Coatings Societies' Symposium at the Hyatt Regency-Embarcadero Center, San Francisco, February 23-25.

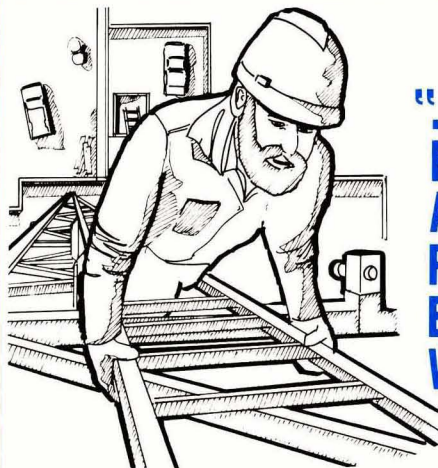
The show, which is two-thirds sold out, will feature a computer section demonstrating their value to the coatings industry. Also featured, will be a section on paint applications equipment.

For information on exhibiting, write to Western Coatings Symposium, 50 California St., Suite 3110, San Francisco, CA 94111.

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Constituent Society Meetings and Secretaries

BALTIMORE (Third Thursday—Eudowood Gardens, Towson, MD).
BIRMINGHAM (First Thursday—Calthorpe Suite, Edgbaston). D. H. CLEMENT, Holden Surface Ctg. 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, Jeffersonville, 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.

UMR Coatings Courses To be Held in Minn.

The University of Missouri-Rolla is offering two, three-day short courses in February at the Marriott Hotel, Bloomington, MN. "Maintenance Painting" will be held February 15-17 and "Estimating for Painting Contractors and Maintenance Engineers" is scheduled for February 22-24.

"Maintenance Painting"

Designed for painting contractors, maintenance engineers, paint specifiers, architects, painting foremen, and paint sales personnel, the course will introduce new materials, equipment, and methods of preparing surfaces for applying maintenance coatings. Sessions will include paint composition; surface preparation; cementitious, wood, and metal surfaces; application methods; and government regulations. In addition, the course will feature, for the first time, a workshop on communication skills for jobsite management.

Instructors for the session will be John A. Gordon, Jr., Director of Coatings Continuing Education and lecturer in chemistry at UMR; Parker H. Young, Principal Corrosion Engineer for Sherwin Williams Co.; and Joe Ancona, President of Ancona and Associates Inc.

Fee for the course is \$485.

"Estimating for Painting Contractors And Maintenance Engineers"

The course is designed for painting contractors, crew foremen, architects, and maintenance engineers. Sessions will feature blueprint reading, specifications, quantity take-off, and pricing structure. In addition, participants will have the opportunity to practice bidding skills using actual plans in simulated real-life situations.

Course instructor is Len A. Hijuelos, Regional Field Coordinator for the National Joint Apprentice Shop Committee.

Fee for the course is \$475.

For further information, contact Arts & Sciences Continuing Education, G-7 Humanities-Social Sciences Bldg., UMR, Rolla, MO 65401.

**Advertise in The
JCT Classified Ads**

**Program Announced
For 'Corrosion/83', Apr. 18-22**

An advance program has been announced for "Corrosion/83", sponsored by the National Association of Corrosion Engineers (NACE) to be held April 18-22 in Anaheim, CA.

NACE Technical Committees have put together the largest technical program ever organized for the annual international corrosion conference and exhibition. Over 300 papers are planned in the technical program alone.

A series of educational lectures centered around the theme, "Impact of Corrosion on the Consumer," will also be featured. According to the Chairman of the Educational Lectures Series Lyle D. Perrigo, of Battelle Alaska Operations, the lectures will (1) identify the effects of consumer corrosion problems; (2) describe what causes these problems; (3) estimate their costs; and (4) tell how to reduce losses. Three separate lectures will be given entitled: "Areas of Concern"—Lyle D. Perrigo; "Corrosion Science and the Consumer"—H.H. Webster; and "Application of Corrosion Technology"—Peter Elliott.

For copies of the advanced program or for further information, contact NACE, P.O. Box 218340, Houston, TX 77218.

**Federation Publishes Southern Society's
'Consumer Guide to Trade Paint Quality'**

A *Consumer Guide to Trade Paint Quality*, produced to help promote an appreciation of paint quality features and an understanding of paint application, has been published by the Federation of Societies for Coatings Technology.

The guide, entitled "Know Paint Quality Before You Buy," focuses on latex interior flat paint and depicts the performance characteristics of low, average, and high-quality products.

Written and developed by the Southern Society for Coatings Technology, the pamphlet is designed for point-of-purchase use to help the consumer understand what to look for in paints. Full-color reproductions illustrate the effects of paint quality features on staining and washability-durability, as well as spreading rate, application, and wet & dry hiding.

Cooperating with the Federation in the distribution of the guide will be the National Decorating Products Association and its member paint store dealers.

The price of the guide is 10¢ each, minimum order of 100 copies. Order from the Federation of Societies for Coatings Technology, 1315 Walnut St. Philadelphia, PA 19107.

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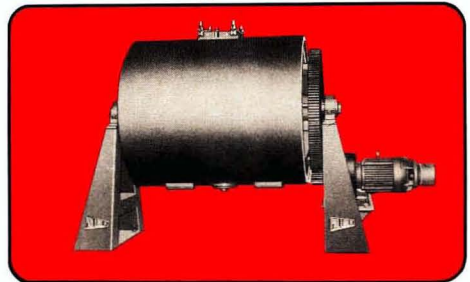
A limited number of bound volumes of the *Journal of Coatings Technology* are available for sale. These books, which make a handsome and lasting addition to any library, cover the years 1973, 1974, 1977, 1979, and 1980. Price—\$50.00

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PAUL O. ABBÉ INC.

Cypress Color and Chemical, Inc., Westwood, MA, has announced the promotion of **Robert Marderosian** to the position of Manager of Equipment Sales. Mr. Marderosian joined the firm in 1978 as a Sales Representative and most recently was involved in the sale of raw materials and equipment. He is a member of the New England Society.

Robert L. Collins has been named Technical Manager for the O'Brien Corp. In this new position, Mr. Collins will act as Laboratory Manager for Fuller-O'Brien Paints, South Bend, IN, as well as Technical Manager for Trade Sales Products for the firm nationally. He is a member of the Chicago Society.

Richard C. Chodnicki has joined the Kerr-McGee Chemical Corp., Pigment Div. He will be responsible for titanium dioxide pigment sales. Mr. Chodnicki is a member of the Baltimore Society.

Air Products and Chemicals, Inc. has named **Leo J. Thielmann** and **David L. Cincera** Development Managers for the Commercial Development Department at the Polymer Chemicals Div. Mr. Thielmann served previously as Midwest Regional Manager. He is a member of the Chicago Society.

At their annual meeting in Dearborn, MI, the Chemical Coaters Association Board of Directors announced the appointment of **Richard Fricker** as President of the Association for 1982-83. Mr. Fricker is Technical Marketing Director for the Coatings Division of Valspar Corp., Minneapolis, MN. He is a member of the Northwestern Society.

Other officers elected were: First Vice-President—**Floyd Young**, Motor Wheel Corp.; Second Vice-President—**Gary Frazier**, Hentzen Chemical Coatings, Inc.; Secretary—**Tom McCardle**, Kolene Corp.; and Treasurer—**Philip Vadeboncoeur**, Heatbath Corp.

Red Devil Paints & Chemicals, Mt. Vernon, NY, has announced the appointment of **John M. Lonergan** as National Distributor Sales Manager. In his new position, Mr. Lonergan will be responsible for the development of the firm's distributor network.



R. Marderosian



R.L. Collins



D. Smith



J.S. Wiseheart

Applied Color Systems, Inc., Princeton, NJ, has named **Don Smith**, President of Colorsmith, Inc., Naperville, IL, as Regional Sales Representative for Northern Indiana, Northern Ohio, and Michigan. Mr. Smith is a member of the Inter-Society Color Council.

Willard (Bill) A. Burns has retired effective November 1, 1982 following a career of 34 years with Reichard-Coulston, Inc., of New York City. He joined the company as Plant Superintendent and Engineer and subsequently served as Sales Manager, Vice-President, Corporate Secretary, and as a member of the Board of Directors.

Mr. Burns was graduated from the Rochester Institute of Technology and from Clarkson College with a Bachelors Degree in Mechanical Engineering. A registered professional engineer, he served as an engineering officer in the U.S. Army Ordnance Dept., retiring with the rank of Captain in the Naval Reserve.

He is a member of the Philadelphia Society for Coatings Technology, ASTM, and the National Concrete Masonry Association.

Thomas F. Wagner has been named Vice-President—Chemical Coatings of SCM Corporation's Glidden Coatings & Resins Division. He replaces **Arne C. Lindholm**, who has retired. Mr. Wagner joined the firm in 1959 and most recently served as Regional Director of Glidden's eastern region in Reading, PA. Replacing Mr. Wagner in that capacity is **James D. Russell** who will direct the manufacturing, administration, product development, and sales for the Eastern region.

Other promotions announced by the firm were the appointments of **Allen A. Aungst** to the position of Regional Trade Sales Manager and **Larry S. Silliman**, to the position of Regional Manager-Dealer Operations.

Jeffrey S. Wiseheart has joined the Coatings Division of Ferro Corp., Cleveland, OH, as a Technical Service Representative for VEDOC^R Powder Coatings. Mr. Wiseheart will be responsible for field technical support, troubleshooting, customer assistance as well as, liaison between the Ferro laboratory in Cleveland and customer requests.

Stepan Chemical Co., Northfield, IL, has announced the appointment of **Dennis E. Lietz** as Senior Research Chemist. Mr. Lietz, formerly with Daubert Chemical Co., is a member of the Chicago Society.

Dr. Raymond R. Myers, of Kent State University, was elected as an Honorary Member of the Cleveland Society. Currently, Dr. Myers is Research Director of the Paint Research Institute.

Morton D. Kellert was appointed Technical Director of the Chemical Coatings operation of Reliance Universal, Inc., Houston, TX. He will assume responsibility for the direction of research, product development, and quality control. Mr. Kellert is a member of the Houston Society.

Robert F. Wilkinson has been elected Vice-President of Manufacturing for PPG Industries, Inc., Coatings and Resins Div. He is responsible for operations in the United States and Canada.

Also announced by the firm were the appointments of **John G. Fong** as Engineering Associate and **Dr. Joanne H. Smith** as Research Associate.

Daniel B. Robertson, Director of U.S. sales for NL Chemicals/NL Industries, Inc., has announced his retirement from the paint and coatings industry effective September 1, 1982.

Glenn E. Taylor has joined the Minerals & Chemicals Division of Engelhard Corp. as Director of Manufacturing for the Pigments & Extenders Group. Based in McIntyre, GA, Mr. Taylor assumes responsibility for all manufacturing activities of the Group's kaolin processing operations.

Also, **Dan L. Breen** was promoted to the position of Sales Manager, Eastern Region, for the Pigments & Extenders Group. Mr. Breen, formerly Account Representative in the Eastern Region, assumes responsibility for sales of the Group's products to the paper, paint, plastics, rubber, and other industries in New England, the mid-Atlantic States, Ohio, West Virginia and Virginia, and Canada.

George J. Bagot has joined the Bareco specialty waxes group of Petrolite Corp. as an industrial Coatings Sales Engineer. Mr. Bagot most recently served in the same capacity with the corporation's Tretolite industrial group.

Obituary

Frank C. Atwood, 89, Federation Past-President, died on July 31. Mr. Atwood's distinguished career began in 1914, when he received a degree from Massachusetts Institute of Technology in Electrochemical Engineering. He remained at MIT for two years as an instructor.

After doing scientific research for the U.S. government during World War I, he joined Kalnus, Comstock, and Wescott, a Boston research firm, where he helped to develop technicolor film. He later became Chief Chemist of Craftex of Boston where, as head of research and development, he devised a water-based paint using the milk by-product casein. Mr. Atwood became an authority on casein and its uses, and was appointed director of research for national dairy products with the Kraft Co. of New York.

During World War II, in response to a shortage of wool, he developed from casein, a substitute fiber named Aralac. The fiber was used in the manufacture of military uniforms.

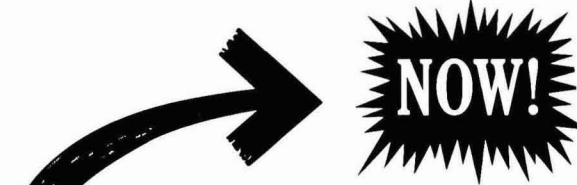
Mr. Atwood was a 50-year, plus, member and Past-President of the New England Society for Coatings Technology. He served as President of the Federation in 1933-34. Mr. Atwood's outstanding achievements include his efforts to found the Federation Paint Show, in 1932.

Southern Protective Products Co., Atlanta, GA, has appointed MBI as sales representatives in Ohio, Indiana, West Virginia, and Western Pennsylvania. MBI consists of **Kenneth G. Morton, Kenneth D. Morton, Jr., Nancy Morton, Jim and Nancy Bacon, Tom Sayman, Burl Spurlock, Wayne Lloyd, and Sally Lazar.**

Ellen A. Gerrity was named Northeastern Region Applications Engineer for the Color Communications Group of Macbeth, a division of Kollmorgen Corp., Newburgh, NY.

Frank L. Dray was appointed to manage the North Carolina Office for The George E. Missbach & Co., located in the Research Triangle Park. The company is a sales representative for Netzsch, Inc.

Volstatic, Inc. has announced the appointment of Reeves & Co. as their representative for Idaho, Montana, Wyoming, Utah, Eastern Nevada, and Arizona. **Pat Reeves** and his associates, **Pat Conner** and **Bob Thomas**, will offer professional engineering and design services.



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Slip-Antiblock Agent

Information is available which features Emerwax 9380, an unsaturated monoamide (Erucamide) used as a slip-antiblock agent in polyethylene and polypropylene. Contact Emery Industries, Plastics Group, 1300 Carew Tower, Cincinnati, OH 45202 for more information.

Color QC System

Literature is available which announces a new color QC system which takes full advantage of digital computer power and an advanced spectrophotometer, the Spectro Sensor II. For more information, contact Applied Color Systems, Inc., P.O. Box 5800, Princeton, NJ 08540.

Transmitter System

The Electrochemical Two-Wire Transmitter and Sensors, which accurately measure pH, ORP, and conductivity for process industries, are illustrated in an eight-page brochure. A variety of designs and configurations available are charted throughout the brochure along with the corresponding applications for pH, ORP, and contacting and electrodeless conductivity measurements. For a free copy of the brochure, contact Foxboro Analytical, Div. of The Foxboro Co., P.O. Box 5449, S. Norwalk, CT 06856.

Aluminum Pigment

Information and product data has been published on an aluminum pigment paste for water-borne coatings that resists gassing for extended periods after formulation. Contact Andrew J. Poklemba, Marketing Manager, Custom Chemicals Co., 30 Paul Kohner Place, Elmwood Park, NJ 07407.

Resin

A technical data sheet is available for Arakote 3006, a new solid thermosetting resin developed for curing either with adducts of blocked isocyanates or dianhydrides such as pyromellitic dianhydride. Data includes: typical properties, starting formulations and test results derived from those formulations including impact resistance, flexibility, whiteness, and humidity resistance. To receive the data sheet, write Resins Dept., Ciba-Geigy Corp., 3 Skyline Dr., Hawthorne, NY 10532.

Mixers

A new eight-page brochure has been published which describes an extensive line of mixing and size reduction equipment. Illustrations, major advantages, and applications are featured. For a free copy of Bulletin DM-85, write Day Mixing Co., 4932 Beech St., Cincinnati, OH 45212.

Methyl Esters

A new eight-page booklet, intended to serve as a guide to the selection of fatty acid methyl esters, has been released. Properties and applications of these esters are featured. For a copy, contact Emery Industries, Dept P, 1300 Carew Tower, Cincinnati, OH 45202.

Corrosion Inhibitor

Literature is available introducing a new corrosion inhibitor, Empol 1052 polybasic acid. A 20-page booklet describes Empol 1052's properties and how the compound or end user may utilize this new corrosion inhibitor to its fullest potential. For a copy of the booklet, contact Emery Industries, Dept. P., 1300 Carew Tower, Cincinnati, OH 45202.

Wt/Gal Cups

A new descriptive four-color leaflet is available which features weight per gallon cups which are used to quickly determine the weight per gallon and also the specific gravity of paints, varnish, lacquer, pastes, semi-pastes, and other liquid or semi-liquid products or materials. For a copy of the literature, contact Paul N. Gardner Co., Inc., 218 Commercial Blvd., Lauderdale By-The-Sea, FL 33308.

Viscosity Measuring Element

Literature is available announcing Model M8BO Viscosity Measuring Element which is used with an appropriate controller for a wide variety of applications where the process requires automatic solvent additions. Typical applications are listed which include: flow coating, dipping, and curtain coating in finishing processes; wire coating; flexographic and rotogravure printing; paper and textile sizing; and various coating processes for fabrics, paper, metals, and plastics. For information, contact Norcross Corp., 255 Newtonville Ave., Newton, MA 02158.

Thickness Gauges

Descriptive leaflets are available which feature new, all metal, dual scale wet film thickness gages with three readings: conversion chart for wet to dry thickness; directions for use; and a metric guide table. Contact Paul N. Gardner Co., Inc., 218 Commercial Blvd., Suite 205, Lauderdale By-The-Sea, FL 33308.

Phthalo Green

A new and improved Phthalo Green B.S., 10-30-AC-0326, which disperses easier and offers 25 to 30% tinctorial strength, providing cost economies, is the subject on recent literature. For additional information, write The Hilton-Davis Chemical Group Pigments Dept., P.O. Box 37869, Cincinnati, OH 45222.

ASTM Standards

ASTM, developers of over 6000 active voluntary consensus standards used worldwide, recently announced the release of new Part(s) 27, 28, 29 of the *Annual Book of ASTM Standards*. The publication(s) contains over 630 standards covering paint, pigments, fatty oils, and related coatings and components.

Part 27—"Paint—Tests for Formulated Products and Applied Coating" highlights information on the physical testing of paint, varnish, and lacquer; analytical testing; panel specifications and preparation of surfaces for painting; and film preparation. Also featured are data on drying and curing; dry film properties; and schedules of examination for testing paint products. Part 27 is available for \$50.

Part 28—"Paint—Pigments, Resins and Polymers" features information on pigment specifications; pigment test methods; resins and polymers; and general methods of testing. This book is available for \$34.

Part 29—"Paint—Fatty Oils and Acids, Solvents, Miscellaneous; Aromatic Hydrocarbons; Naval Stores" discusses topics such as the drying and nondrying types of fatty oils and acids; fatty nitrogen products; solvent specifications; solvent test methods; miscellaneous raw materials; aromatic hydrocarbons and related materials; naval stores; and general methods of testing. Cost for Part 29 is \$49.

For additional information, or to order, contact ASTM, 1916 Race St., Philadelphia, PA 19103.

Silicone Coating

A silicone white enamel which withstands both internal heat generated by conductors carrying 2,000 amp current and external heat from the sun on electrical reactors is the subject of recently published literature. Additional information is available from Dow Corning Corp., Midland, MI.

Enamel

Information has been published featuring ULTRON polyurethane enamel, a finish which provides outstanding durability on trucks, commercial vehicles, and automobiles. Contact Nason Automotive Finishes Division, The O'Brien Corp., S. San Francisco, CA 94080, for additional information.

Anti-cratering Additive

A new, anti-cratering additive, Crater-X, has been introduced in recent literature. Product data sheets feature uses, applications, and advantages of the additive. Information can be obtained from U.S. Paint, Div. of Grow Group, Inc., 331 S. 21st St., St. Louis, MO 63103.

Agents

A bulletin entitled, "Use of Titanate Coupling Agents for Improved Properties and Aging of Plastic Composites and Coatings," is now available. Information is provided on processing and rheology of diverse plastics composites; adhesion and composite properties of various polymers to various substrates; polyolefin composites; titanate effects in polyvinyl chloride, epoxy, acrylic, and urethane; commercial products; mechanisms for a new generation of urethane catalysts; and composite properties. Bulletin KR-0682-10 is available from Kenrich Petrochemicals, Inc., E. 22nd St., P.O. Box 32, Bayonne, NJ 07002.

Polybutenes

"Amoco Polybutenes—The Versatile Liquid Polymers to Improve Your Product" is available which describes Amoco Chemical's complete line of polybutenes. This new full-color, 36-page brochure lists the polybutenes' unique properties, formulations, and application uses. Copies of Bulletin I2-J are available from Amoco Chemicals Corp., Dept. ADV-JCT, Mail Code 4002, 200 E. Randolph Dr., Chicago, IL 60601.

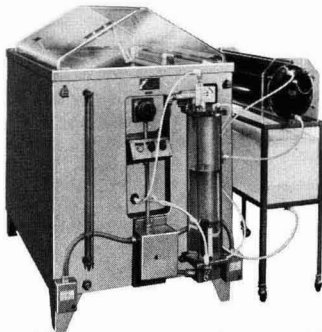
Polyterpene Resin

Literature announces the introduction of ZONAREZ® M-1115 polyterpene resin, a water-clear, light-colored thermoplastic polymer that imparts superior tack to KRATON® 1107 adhesive systems. Featured are the resin's properties and recommended uses. For more information, write for Bulletin No. 6303, Arizona Chemical Co., 16-00 Rt. 208, Fair Lawn, NJ 07410.

Additive and Pigment

Literature is available featuring BENTONE SD-1, a super dispersible rheological additive used in aliphatic solvent-based paints and coatings, and NALZIN 2 pigment, an improved non-lead/nonchrome zinc phospho oxide corrosion inhibiting pigment. BENTONE SD-1 additive is described as simplifying paint making and providing greater formulating and production flexibility. NALZIN 2 is featured as providing paint formulators with greater latitude in developing high solids coatings, higher gloss finishes, and more stable latex paints. For more information, contact NL Chemicals/NL Industries, Inc., P.O. Box 700, Hightstown, NJ 08520.

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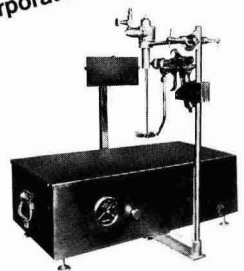


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Infrared Systems

A new catalog describing non-focused infrared systems for solder reflow and thick film drying/firing applications is now being offered. Information is provided on pertinent specifications and representative applications on a versatile range of six conveyerized systems for solder reflow, as well as thick film drying and firing. Organized in folder format, the catalog features a data sheet and price list for each of the six units. For a free copy, write to Vitronics Corp., 126 Merrimac St., Newburyport, MA 01950.

Plastics/Chemicals

"Plastics and Chemicals Publications 1982" is a new, 32-page, illustrated catalog from Technomic Publishing Co., Inc. The catalog describes over 80 books on subjects such as chemical processing, chemical pollution control, coatings, composite materials, films and packaging, fire retardance of plastics, non-wovens, plastics engineering, polymer science, foamed plastics, elastomers, and biomedical plastics. A free copy may be obtained from Technomic Publishing Co., Inc., Marketing Dept., P.O. Box 913, Westport, CT 06881.

Laboratory Services

A free brochure-folder, containing colorfully illustrated information sheets which describe the laboratory services available for nine major industries (including the paint industry) is now being offered by Hauser Laboratories, Box G., Boulder, CO 80306.

Coatings Product Selector

A guide to the full range of Bee Chemical Company's coatings and finishes is now available. "Coatings Product Selector" provides information on coatings and finishes for product types such as: appliance, automotive, business machine, specialty, vacuum metallizing systems, and wood simulation. Uses, method applications, and product recommendations are featured. For additional information, contact Bee Chemical Co., 2700 E. 170th St., Lansing, IL 60438.

Sheet Formation Tester

Technical information is available which describes a unique, new sheet formation tester that uses a laser beam to measure all kinds of unevenness over the entire sheet specimen area, and analyzes distribution of variation, size, etc., of the unevenness. Write to Testing Machines, Inc., 400 Bayview Ave., Amityville, NY 11701 for more information.

Flow and Level Meters

A new catalog has been introduced which contains a complete line of flow and level measurement products. The 10-page catalog is a useful reference for specifying float type flowmeters, flow controllers, magnetic-inductive flowmeters, liquid level meters/controllers, ultrasonic sludge-monitoring level meters, and density meters. For more information, contact Harry Lund, Krohne-America, 11 Dearborn Rd., Peabody, MA 01960.

NACE Standards

Information Handling Services has announced the availability of National Association of Corrosion Engineers (NACE) standards documents in their Industry Standards Service. Supplied in both 16mm microfilm cartridges and 24X microfiche, the NACE standards are automatically updated every 60 days, assuring users the availability of current data. Alpha-numerical indexing provides fast access to documents of interest. An optional subject index is also available to speed searches. For more information, contact Information Handling Services, 15 Inverness Way East, P.O. Box 1154, Englewood, CO 80150.

General Use, Shield, And Micro-Clean Products

A colorful, 32-page catalog describing a complete line of general use, shield, and micro-clean limited use products for a wide range of industrial applications and sensitive environments is now available. The general use products are described as ideal for numerous maintenance, manufacturing, and processing/handling operations. The shield products are designed for maximum safety, durability, and protection, while the micro-clean products are specifically engineered for use in controlled environments where high technology, and special processing requirements demand extremely clean working standards. For information, contact American Convertors Industrial Products Marketing Dept., 1740 Ridge Ave., Evanston, IL 60201.

Resins

Multifunctional epoxy cresol novolac resins which have been found to produce coatings with excellent solvent and chemical resistance at high service temperatures and heat deflection temperatures in excess of 500° F are the subject of new literature. Technical data includes solubilities, chemical resistance, recommended cure cycles, and storage stability. For additional information, contact Resins Dept., Ciba-Geigy Corp., 3 Skyline Dr., Hawthorne, NY 10532.

Coming Events

FEDERATION MEETINGS

1983

(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. Queen Elizabeth Hotel, Montreal, Quebec, Canada. (FSCT, 1315 Walnut St., Suite 832, Philadelphia, PA 19107).

(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. 22-23)—"Advances in Coatings Technology." 26th Annual Technical Conference of the Cleveland Society for Coatings Technology. Baldwin-Wallace College, Berea, OH.

(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.

(May 5-7)—Pacific Northwest Society Symposium. Thunderbird Inn, Portland, OR. (Chairman Gerry McKnight, Lilly Industrial Ctg. 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.

SPECIAL SOCIETY MEETINGS

1983

(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).

OTHER ORGANIZATIONS

(Nov. 15-19)—ASTM D33 Coatings for Power Generation Facilities and UNCWC Utilities Nuclear Coating Work Committee Meeting. Huntington Sheraton, Pasadena, CA. (Ken Pearson, ASTM, 1916 Race St., Philadelphia, PA 19103).

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Superior Materials, Inc.
Garden City, N.Y.

Van Horn, Metz & Co., Inc.
Conshohocken, PA, Baltimore, MD,
Pittsburgh, PA.

(Nov. 16-18)—"Estimating Workshop for Painting Contractors" Short Course. Sheraton St. Louis Hotel, St. Louis, MO. (Norma Fleming, Senior Coordinator, Arts & Sciences Continuing Education, University of Missouri—Rolla, Rolla, MO 65401).

(Nov. 16-18)—"Strategy of Experimentation" Seminar. Boston, MA. (DuPont Statistical Seminars, Room X-39573, Wilmington, DE 19898).

(Nov. 18-19)—"Fundamentals of Color" Seminar. Cincinnati, OH. (Jeanne M. Dolan, Macbeth, Div. of Kollmorgen Corp., Little Britain Rd., P.O. Box 950, Newburgh, NY 12550).

(Nov. 29-Dec. 3)—"Principles of Industrial Coatings" Short Course. Sheraton St. Louis Hotel, St. Louis, MO. (Norma Fleming, Senior Coordinator, Arts & Sciences Continuing Education, University of Missouri—Rolla, Rolla, MO 65401).

(Nov. 30-Dec. 2)—"Focus on Data" Seminar. Cincinnati, OH. (DuPont Statistical Seminars, Room X-39573, Wilmington, DE 19898).

(Dec. 7-9)—Fifth Annual Western Plastics Exposition. Long Beach Convention Center, Long Beach, CA. (Western Plastics Exposition, 1625 17th St., Unit 2, Santa Monica, CA 90404).

(Dec. 7-9)—"Strategy of Experimentation" Seminar. San Francisco, CA. (DuPont Statistical Seminars, Room X-39573, Wilmington, DE 19898).

(Dec. 14)—"Powder Coatings: How It Will Work for You" Workshop. Fort Worth, TX. (Susan Buhr, Technical Activities Dept., Society of Manufacturing Engineers, One SME Dr., P.O. Box 930, Dearborn, MI 48128).

1983

(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. Blossch, 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 Non-metallic 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. Thornton, Westinghouse Lamp Div., One Westinghouse Plaza, Bloomington, 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. 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. (Ken Pearson, ASTM, 1916 Race St., Philadelphia, PA 19103).

(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).

(Sept. 28–Oct. 1)—Oil & Colour Chemists' Association's Silver Jubilee Convention and Exhibition. Southern Cross Hotel, Melbourne, Australia. (O.C.C.A.A., 1983 Pacific Coatings Convention, C/- Tioxide Australis Pty. Ltd., Private Bag 13, Ascot Vale, Victoria, 3032, Australia).

(Oct. 11–13)—"Finishing '83" sponsored by the Association for Finishing Processes of the Society of Manufacturing Engineers. Cincinnati Convention Center, Cincinnati, OH. (Susan Buhr, AFP/SME Administrator, One SME Dr., P.O. Box 930, Dearborn, MI 48128).

(Nov. 2–3)—Resins and Pigments Exhibition. Europa Hotel. London, England. (Polymers, Paints & Colour Journal, Queensway House, Redhill, Surrey, RH1 1QS, England).

1984

(Sept. 23–28)—XVIIth Congress of FATIPEC (Federation of Associations of Technicians in the Paint, Varnish, Lacquer and Printing Ink Industries of Continental Europe). Lugano, Switzerland. (C. Bourgey, Secretary General, FATIPEC, Maison de la Chimie, 28 Rue St.-Dominique, 75 Paris (7), France).

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I certify that the statements made by me above are correct and complete. (signed) Robert F. Ziegler, Editor.

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'Humbug' from Hillman

Notes from that old reliable Sid Lauren, Frank Borrelle, and one other thoughtful friend (whose name shall go unmentioned) found their way to Humbug's Nest in Vermont.

Sid Lauren, keeping his record intact with this monthly contribution comes forward with what he calls "the astringent wisdom" of Professor Ross K. Baker, of Rutgers University.

"Legislation is a series of catastrophes that results in a policy."

"The humble bureaucrat, like the bass, dwells at the bottom of the pond but grows fat."

"Demanding a direct answer from a bureaucrat is like eating with rubber chopsticks."

"There is no truth that cannot be obscured by public relations."

"It is wise to have one's own lawyer as attorney general, for it is written that the eunuch will not molest the concubines."

• • •

As an example of my desperate search for material, I am reduced to the necessity of featuring the following as sent in by none other than Frank Borrelle.

Definitions of different political systems given:

COMMUNISM—You have two cows. The government takes both of them and gives you part of the milk.

SOCIALISM—You have two cows. The government takes one of them and gives it to your neighbor.

FASCISM—You have two cows. The government takes both of them and sells you the milk.

NAZISM—You have two cows. The government takes both of them and shoots you.

BUREAUCRACY—You have two cows. The government takes both of them, shoots one and milks the other, then pours the milk down the drain.

CAPITALISM—You have two cows. You sell one of them and buy a bull.

Oak Ridge TN Chamber Newsletter

From "Association Management", Frank sends "A Eulogy to Someone Else." If I didn't know he was hail if not hearty, I'd swear it was about him!

Eulogy to Someone Else

In its March newsletter, the American Society of Hospital Pharmacists, Bethesda, Maryland, reported the tragic death of Someone Else.

"We were saddened to learn this week of the passing of one of the Society's most valuable members—Someone Else. Someone's passing has created a vacancy that will be difficult to fill. Else worked with the Society for many years and did far more than the normal person's work. Whenever leadership was mentioned, this wonderful person was looked to for inspiration as well as results.

"Whenever there was a job to do or a position to be filled or a meeting to attend, one name was on every-

one's lips. 'Let Someone Else do it.' Someone is survived by all current society members and will be especially missed by its inactive members. We hope everyone will actively keep Someone Else's memory alive.

• • •

The following was submitted by a friend who shall go nameless since I expect that his driving inspired at least some of these comments.

The following are actual statements found on insurance forms where car drivers attempted to summarize the details of an accident in the fewest words possible:

"Coming home I drove into the wrong house colliding with a tree I don't have."

"The other car collided with mine without giving warning of his intentions."

"I thought my window was down, but I found out it was up when I put my head through it."

"I collided with a stationary truck coming the other way."

"A truck backed through my windshield into my wife's face."

"The guy was all over the road. I had to swerve a number of times before I hit him."

"I pulled away from the side of the road, glanced at my mother-in-law, and headed over the embankment."

"I had been shopping all day for plants and was on my way home. As I reached an intersection, a hedge sprang up, obscuring my vision and I didn't see the other car."

"I had been driving for 40 years when I fell asleep at the wheel and had an accident."

"I was on my way to the doctor with rear end trouble when my universal joint gave way causing me to have an accident."

"As I approached the intersection, a sign suddenly appeared in a place where no sign had ever appeared before. I was unable to stop in time to avoid the accident."

"To avoid hitting the bumper of the car in front I struck the pedestrian."

"My car was legally parked as it backed into the other vehicle."

"An invisible car came out of nowhere, struck my car and vanished."

"I told the police I was not injured, but on removing my hat, found that I had a fractured skull."

"I was sure the old fellow would never make it to the other side of the road when I struck him."

"The pedestrian had no idea which direction to run, so I ran over him."

"I saw a slow moving sad faced old gentlemen, as he bounced off the hood of my car."

"The indirect cause of the accident was a little guy in a small car with a big mouth."

"I was thrown from my car as it left the road. I was later found in a ditch by some stray cow."

"The telephone pole was approaching. I was attempting to swerve out of its way, when it struck my front end."

—Herb Hillman

Color-matching Aptitude Test



Color-matching Aptitude Test Set was created by the Inter-Society Color Council and sponsored by the Federation. It is in world-wide use as a means for estimating color-matching skill. The 1978 edition contains minor refinements over the previous editions (1944, 1953, 1964), and these bring it closer to the original ISCC plan, making it a still more successful tool for evaluating color-matching skill.

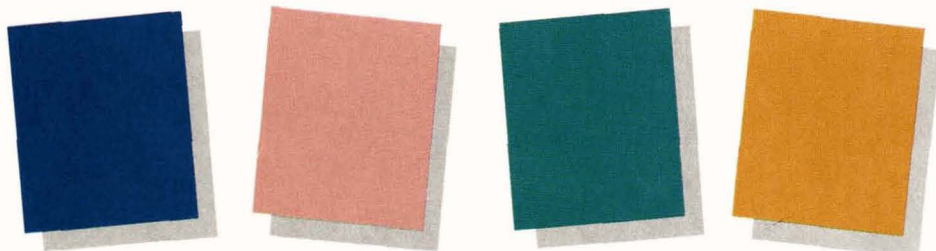
The basic aim of the Test is to provide an objective measure that will aid in determining an individual's ability for performing color-matching tasks accurately. Changes in a person's color-matching skill may occur over a period of time, improving due to training, experience, and motivation, or lessening when removed from practice, or as a result of health disorders. Retesting at regular intervals will provide an indication of any such changes in an individual's ability.

The Test is not designed to indicate or measure "color-blindness" (anomalous color vision). Special tests designed for this purpose should be used.

The Color-matching Aptitude Test Set consists of a carrying case, an easel on which are mounted 48 color chips, a dispenser which holds 48 matching chips, score sheets, and a scoring key.

Brochure available upon request. Price: \$400.

Orders must be prepaid. U.S. and Canada—Add \$10.00 shipping. All others—Add \$50.00 shipping.



Federation of Societies for Coatings Technology

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Switch to DuPont DBE...get major savings in solvent costs.

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You'll discover that DBE is compatible with most common resin systems. Also, Dibasic Ester solvent can give you higher solids formulations without adversely affecting paint rheology. In fact, DBE has been found to improve the rheology of high solids coating systems by reducing viscosity and improving leveling properties. This makes DBE suitable for a wide range of industrial and automotive coatings.

Along with cost reduction and versatility, DBE solvent is exempt from Rule 442 (photochemically nonreactive) and can be stored indoors without restriction.

Get assistance in your R&D evaluation.

Let us show you how you can use DuPont's DBE in your coating application. We can help you formulate a DBE blend tailored to fit your existing paint system or a new paint line. For further information and samples, write: DuPont Company, Room G39261, Wilmington, DE 19898.

*Mixed dibasic esters of adipic, glutaric and succinic acids.

