

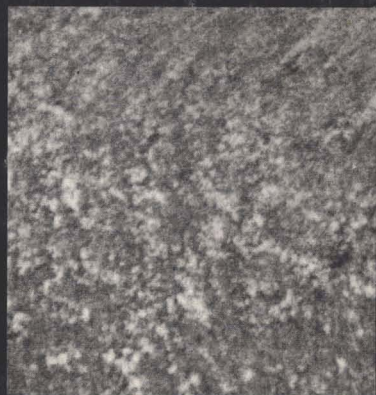
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JCTAX 61 (773) 1-82 (1989)

June 1989

Color Nonuniformity as a Coating Defect

Prevention and Cure.





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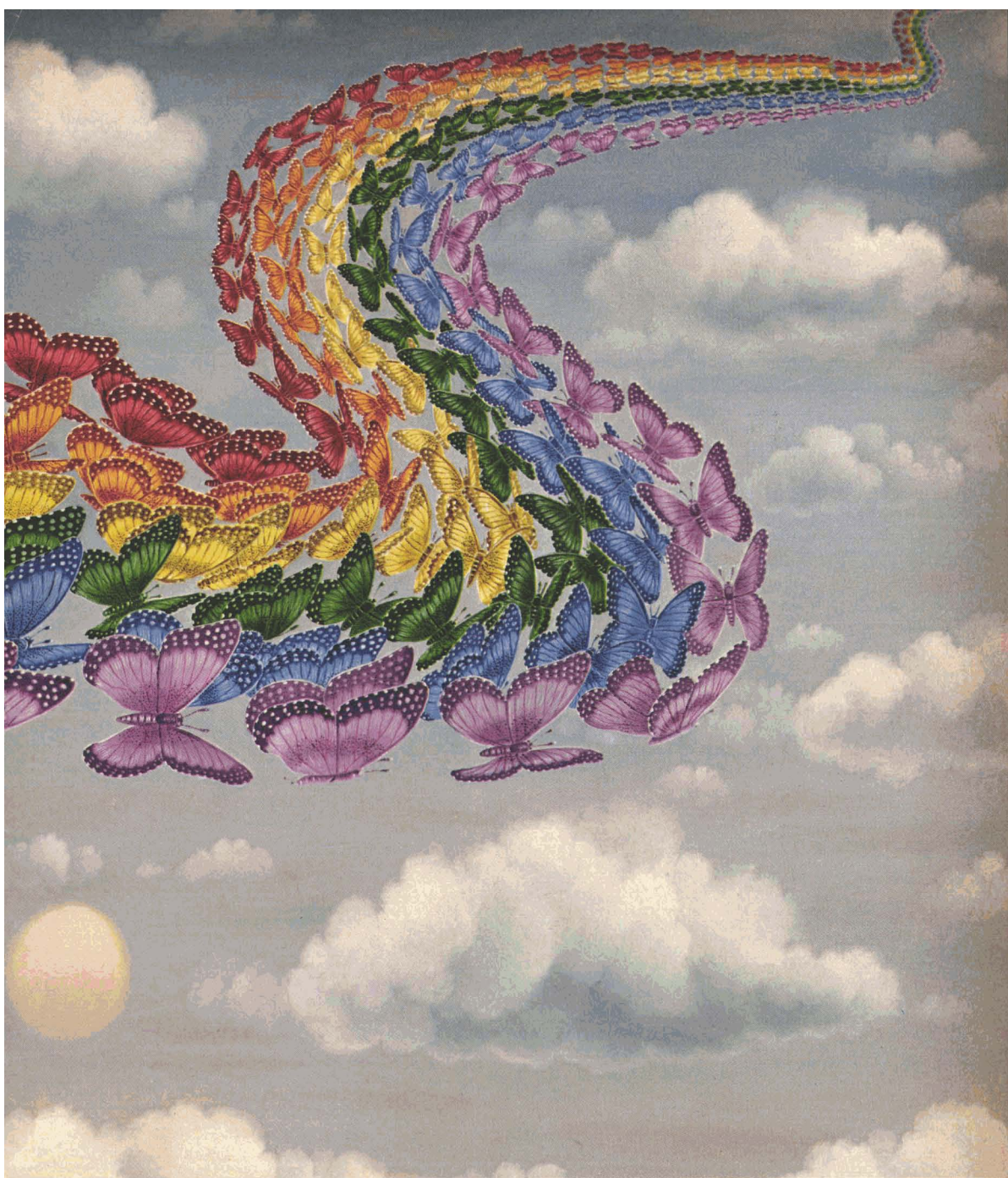


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The Spirit of Professionalism

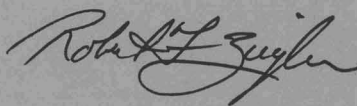
Since the Middle Ages, a person who labored to perfect his expertise at a particular task, who studied the intricacies of his job, and who was able to become so proficient that he could teach others, was known as a professional. These tradesmen worked and lived according to established standards and ethics, and although this concept has been diluted with time and sheer numbers, it still rings as true today as when first practiced.

All people who labor for a living and who take pride in what they do would like to be called a "professional." The word gives an aura of honesty and knowledge, and its use presents a responsibility to always perform well.

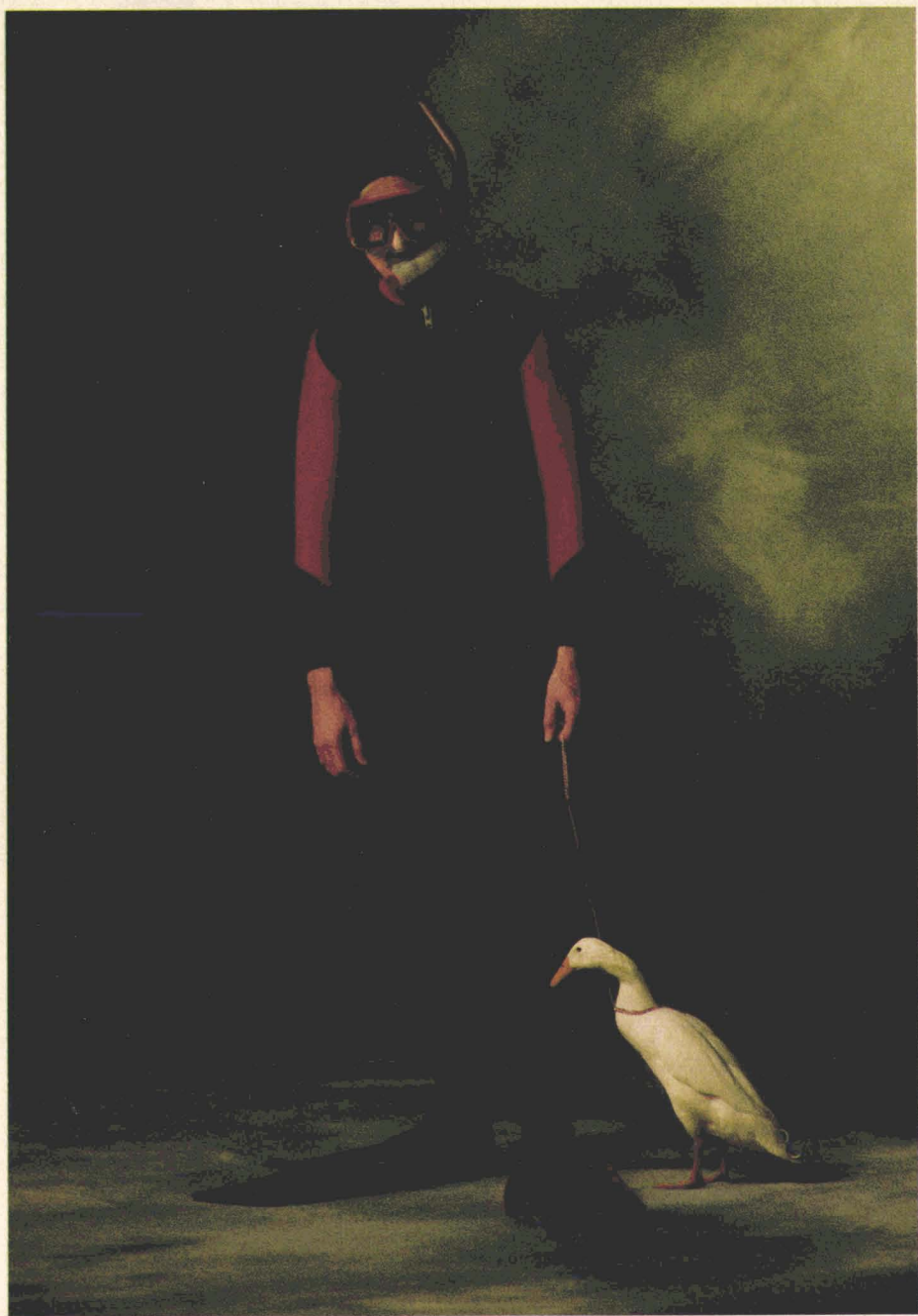
An obligation of that responsibility is the continuance of education in one's profession. To reach a certain level of expertise is simply not good enough any longer (if, in fact, it ever was). To stand still in the stream of knowledge that flows daily, is to be swept away by progress. To remain a "professional" requires a periodic renewal of learning.

The Federation and, to a larger extent, its Constituent Societies provide the opportunity for professionals in the coatings industry to update their knowledge and proficiency. The Federation, through its Annual Meeting and Paint Industries' Show, this publication, and the many other publications and services provided to its membership, and the Societies, through their monthly meetings, and annual symposia and seminars, are prime sources for the necessary ingredients for success in the coatings professions.

While education and proficiency are required for any profession, the ability to instruct and, by extension, to participate in the on-going education of others is just as vital. By teaching and participating one learns that Volunteerism and Professionalism are opposite sides of the same coin.



Robert F. Ziegler,
Publisher



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Abstracts of Papers in This Issue

COLOR NONUNIFORMITY AS A COATING DEFECT— PREVENTION AND CURE—M. Schnall

Journal of Coatings Technology, 61, No. 773, 33 (June 1989)

Pigment floating and pigment flocculation are two mechanisms which, separately or in combination, are primary causes of color nonuniformity defects. The factors involved in both mechanisms are described, as well as methods of improving color uniformity through formulation modifications and additive usage.

PHENOMENON OF COSOLVENCY AND SOLUTION PARAMETERS OF POLYAMIDE RESINS—G. Narender and M. Yaseen

Journal of Coatings Technology, 61, No. 773, 41 (June 1989)

This paper deals with the phenomenon of cosolvency and synergistic effects of cosolvents. Considering the synergistic action of cosolvents, solution parameters of polyamide resin are determined in cosolvent mixtures consisting of poor, good, and non-solvent. A special case of synergism has been observed in the case of cosolvent systems consisting of both non-solvents, i.e., cyclohexanol-cyclohexane and cyclohexanol-toluene. Unperturbed dimensions of resin are determined in cosolvent mixtures consisting of a poor and a non-solvent as well as in mixtures of non-solvents. The phenomenon of cosolvency has been explained in terms of structural parameters and preferential adsorption of individual solvent components on polymer coils. Mark-Houwink and Stockmayer Fixman equations are used for determining solution parameters of the resin in cosolvent mixture. The dependence of unperturbed dimensions and long-range interaction parameters on solvent nature has been explained in terms of preferential adsorption of individual solvent molecules and intermolecular interactions. Since polyamide resin is soluble only in a few solvents, its solubility parameter has been determined by using the data on intrinsic viscosity, resin-binary solvent interaction parameter, and other solution parameters. The estimated value of solubility parameter of polyamide resin is found to be $9.90 \text{ (cal/cc)}^{1/2}$

Suitable solvent bleeds for polyamide resin can be designed with the knowledge of its solubility parameter. In doing so, various other parameters like hydrogen bonding, polarity, and dispersion forces of resin and solvents are to be taken into account. This practice may help the industry in using relatively economical solvent blends for polyamides.

CHEMILUMINESCENCE ANALYSIS: A NEW QUALITY ASSURANCE TOOL FOR THERMOSETTING COAT- INGS—J.P. Hysell and J.A. Farmer

Journal of Coatings Technology, 61, No. 773, 53 (June 1989)

Chemiluminescence Analysis is described as a method for the determination of nitrogen in thermosetting coatings systems. Its superiority to the Kjeldahl technique in the areas of simplicity, speed, and safety is discussed. These advantages may make it an obvious choice for the quality control laboratories of coatings manufacturers who would like to verify or certify the level of nitrogenous crosslinker in every batch prior to shipment.

CONCEPT OF INTRINSIC VISCOSITY AND ITS PRACTI- CAL SIGNIFICANCE—D.R. Provder

Journal of Coatings Technology, 61, No. 773, 57 (June 1989)

The intrinsic viscosity of three acrylic acid-type copolymers was studied as a function of pH. The classical problem of the curvature, encountered in extrapolating reduced viscosity values to infinite dilution, was alleviated by using an ideal time value for solvent flow obtained by doing a least squares plot on concentration time data. From the molecular weight dependence of the hydrodynamic volume, the Mark-Houwink constants were determined. Results indicated that the copolymers approximated a rigid rod structure at a pH of 8.7.

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ASTM Seeking Participants for Committee D-1 On Paint and Related Coatings and Materials

Standards-writing Committee D-1 of the American Society for Testing and Materials (ASTM), Philadelphia, PA, invites all paint and paint component producers and users to join the committee.

Committee D-1 on Paint and Related Coatings and Materials offers the paint and coating professional the opportunity to work with industry colleagues, developing standards for paint, varnish, lacquer, printing ink, and other coatings and their com-

ponents. Committee D-1 also will analyze the preparation of surfaces to which coatings are applied, coating-substrate systems, and paint application tools.

D-1's technical subcommittees include: Quality Assurance and Statistics, Chemical Analysis, Health and Safety, Physical Properties of Applied Paint Films, Physical Properties of Liquid Paints, Pictorial Standards of Coating Defects, Optical Properties, Accelerated Testing, Biodeterioration, Pigment Specifications, Drying Oils, Polymers and Resins, Naval Stores, Solvents, Plasticizers and Chemical Intermediates, Cellulose and Cellulose Derivatives, Purchase of Paints, Architectural Finishes, Traffic Coatings, Marine Coatings, Indus-

trial Protective Coatings, Masonry Treatments, Powder Coatings, Factory-Coated Wood Building Products, Coil Coated Metal, Factory-Applied Coatings on Preformed Products, Printing Inks, Artists' Paints and Related Materials, and Paint Application Tools.

Committee D-1 meets twice a year to develop standards and sponsor technical symposia.

For a brochure including membership benefits and an application, contact Dave Bradley, ASTM, 1916 Race St., Philadelphia, PA 19103. More information is available from Committee Chairman John Weaver, Case Western Reserve University, 309 Olin Bldg., Cleveland, OH 44106.

Aexcel Builds New Headquarters

Aexcel Corporation, a producer of specialty industrial paints headquartered in Willoughby, OH, has announced plans to move to an expanded headquarters and production facility in Mentor, OH. The multi-million dollar building will house the firm's paint and coatings production plant, research and development laboratory, warehouse, and sales and administration offices.

The company will produce all its product lines and custom finishes at the new plant, which is equipped with the latest in worker safety systems and environmental controls.

Aexcel changed its name from DeSantis Coatings in 1988. The firm has sales offices in Toledo, OH; Cincinnati, OH; and Charlotte, NC.

Colwell/General Expands Plant

Colwell/General, Inc., a producer of color marketing tools and color sampling materials for the paint and coatings industry, has expanded its operations with a new 60,000 square foot manufacturing facility in Kendallville, IN.

The new facility incorporates the latest standards for safety and fire protection and construction. A newly designed and constructed coating and drying line is a key element in the expansion. It includes a coater platform that accommodates the standard coater used for color cards as well as other coaters, such as a gravure, a reverse roll coater for the application of silicones, adhesives, UV curing, or other specialty coatings. The multi-zone drying unit includes a laminating station, rewind capability, online sheeting and both infrared and ultra-violet curing.

3M Forms New Electro Products Group

As a result of a reorganization designed to bring greater technical and marketing focus to bear on the distinct telecommunications and electrical/electronic markets, 3M has formed two new operating groups of businesses, both to be located at the company's headquarters in Austin, TX.

The Electro Products and Telecom Systems groups of divisions were formed by this reorganization. The Electro Products Group consists of the company's Electrical Products and Electronic Products divisions. Russell J. McNaughton, formerly Division Vice President of the Electrical Products Division, has been elected Group Vice President of the Electro Products Group.

Businesses of the Electro Products Group include products for the connection,

insulation, and termination of electrical circuits for applications ranging from high-voltage power transmission to appliance manufacturing. Also included are electronic interconnect products for connection of integrated circuit chips, ribbon cables and discrete wires, IC packages, circuit boards and intercabinet applications. Products and systems for minimizing the damaging effects of static electricity in a range of applications and protective products for corrosion resistance are also included.

The Telecom Systems Group is comprised of businesses addressing the needs of the telecommunications industry. Gerald D. Pint has been named Group Vice President of this group. He formerly served as Group Vice President of the Electro-Telecommunications Group.

Akzo Chemicals Announces Recent Acquisitions

Akzo Chemicals Inc., Chicago, IL, has purchased the benzoyl peroxide paste business of the U.S. Peroxygen Division of Witco Corporation in Richmond, CA. The equipment and technology will be moved from California to Akzo's Chemicals' plant in Burt, NY. Organic peroxides are used in metal repair applications such as curing auto body putty and in mine bolt resins.

In addition, Akzo Chemicals B.V., headquartered in The Netherlands, and the

Pennwalt Corp., located in the U.S., have reached an agreement on the transfer of ownership of Pennwalt Italia s.p.a. to Akzo. The company markets methylamines and its derivatives and a wide range of accelerators for the rubber market.

Pennwalt Italia employs 180 people and will continue its present activities in close cooperation with Akzo subsidiaries in Italy.

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"Theme" Sessions Will Be Among Features Of Annual Meeting Program in New Orleans

Three days of technical sessions keyed to the theme, "Coatings Worldwide: Meeting the Needs of the Nineties," will highlight the 1989 Federation Annual Meeting at the New Orleans Hilton Hotel, November 8-10. Program Committee Chairman George R. Pilcher, of Hanna Chemical Coatings Corp., has announced presentations that cover a variety of topics of interest to industry personnel.

Several aspects of the theme topic will be addressed in extended sessions.

A symposium on the uses of computers will feature a presentation by Dr. Peter J. Hunt, President, Productivity Management Consultants, who will discuss development of a Quality Management System which is numerically oriented and computer supported. He will focus on the need to be quantitative, the computer support available, and what some companies are doing. Dr. Hunt, who has conducted a series of statistical process control seminars on behalf of the Federation, specializes in in-plant training and implementation of SPC systems, particularly for batch operations, and has provided such services for a number of coatings manufacturers as well as Ford Motor Co. Also featured will be a presentation on measurement and analysis of coatings properties, by Dr. T.F. Rehfeldt, of The Sherwin-Williams Co.

The global outlook for raw materials will be explored in another symposium, which will focus specifically on supply and demand for petrochemical/agricultural feedstocks and TiO₂ and how they will impact the coatings industry in the coming decade.

In a third symposium, industry speakers will discuss regulatory concerns from a worldwide perspective.

Other scheduled program features include:

- Keynote Address
- Mattiello Lecture, "Learning to Leap: Rising to the Technical Challenge of Today's Coatings Industry," by Dr. Marco Wismer, formerly Vice President, Science and Technology, PPG Industries, Inc. (see April *JCT*).
- Symposium on "Advanced Topics in Coatings Research."
- Seminar on "Manufacturing for Quality and Profitability."
- Seminar on "New Approaches to Corrosion Evaluation."
- Roon Awards Competition papers.
- Constituent Society papers.
- Papers presented on behalf of affiliated overseas coatings organizations.

Serving with Mr. Pilcher on the Program Committee are: Vice-Chairman—Gary Gardner, Tnemec Co., Inc.; Adrian Adkins, Schoofs Inc.; Mary G. Brodie, The Sherwin-Williams Co.; David Graham, Lilly Industrial Coatings, Inc.; Richard M. Hille, General Paint & Chemical Co.; Richard J. Himics, Daniel Products Co.; Terry Johnson, Cook Paint & Varnish Co.; and Percy E. Pierce, PPG Industries, Inc.

Paint Industries' Show

The Paint Industries' Show—the largest and best international exhibit of its kind in the world—will feature attractive exhibitor displays devoted to a wide variety of raw materials, production equipment, containers, laboratory apparatus, testing devices, and services furnished to the coatings manufacturing industry.



The purpose of the Show is to provide attendees with an opportunity to learn of the latest developments in these products and services. Key personnel from the top technical and sales staffs of exhibitors will be on hand. More than 220 exhibitors from the U.S., Canada, and Europe, will utilize almost 74,000 net square feet of exhibit space at the Show. Exhibit hours will be 11:00-5:30 on Wednesday; 9:00-5:30 on Thursday; and 9:00-3:00 on Friday.

The Paint Show will be held at both the New Orleans Hilton's Exhibition Hall and at the adjacent Rivergate Exhibition Center.

Hotels and Reservations

Nine hotels in New Orleans have reserved blocks of rooms for the Annual Meeting and Paint Show. The Federation co-headquarters hotels will be the Marriott and the New Orleans Sheraton.

The other cooperating hotels are: Meridien, Monteleone, Omni Royal Orleans, Westin Canal Place, Doubletree, Holiday Inn Crowne Plaza, and the Hilton River-

side and Towers. The Monteleone and Omni Royal Orleans are located in the French Quarter. All hotel reservations will be processed by the Greater New Orleans Tourist and Convention Commission, which will accept only the official housing form furnished by the Federation.

Special Air Fares

Delta Air Lines, in cooperation with the FSCT, is offering a special discount fare which affords passengers a 40% minimum savings off their round trip, undiscounted day coach fares for travel to the FSCT Annual Meeting and Paint Industries' Show on the airlines' domestic systems. The discount from Canada is 35%.

To take advantage of this discount, you must: (1) Travel between November 4-14, 1989; (2) Purchase tickets at least seven days in advance; (3) Phone 1-800-241-6760 for reservations. Immediately reference the FSCT file number: **U0235**. The special fares are available only through this number.

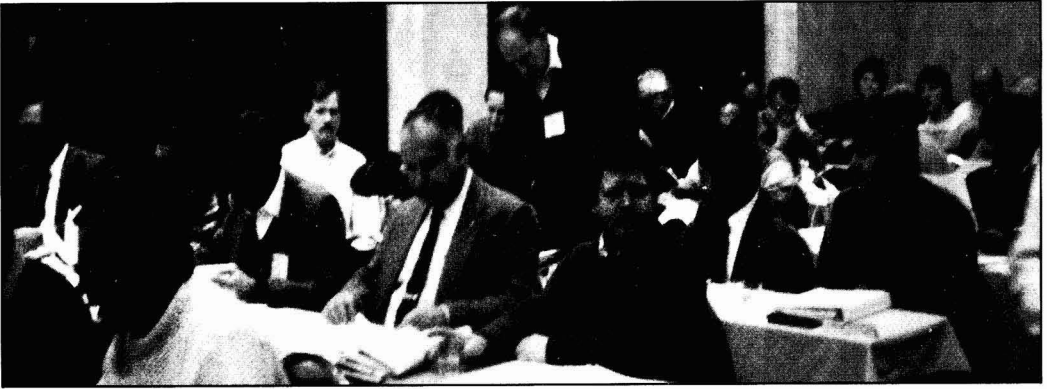
Discounts are good for both direct and connecting flights to New Orleans. If you use a travel agent, have your reservations placed through the toll-free number to obtain the same fare advantages.

Spouses Activities

The Spouses Program of Activities will begin on Wednesday, November 8, with a get-acquainted wine and cheese social in the Mardi Gras Ballroom of the Marriott. On Thursday, there will be a deluxe motor coach tour of the city, featuring the French Quarter, the elegant Garden District, the shores of Lake Pontchartrain, the unique St. Louis III Cemetery, and a visit to Germaine Wells' Mardi Gras Museum. Lunch will be served during the tour at the famous Arnaud's Restaurant in the French Quarter. Spouses' registration also includes Continental Breakfast which will be served at the Marriott on Thursday and Friday mornings.

NPCA to Meet Same Week

The National Paint and Coatings Association will hold its annual meeting on November 6-8, 1989, at the New Orleans Hilton. Persons wearing NPCA badges (who sign up at special registration desks at the Hilton and the Rivergate) will be admitted to the Paint Show on Wednesday only, with the compliments of the Federation.



A total of 179 registrants took part in the introductory and intermediate-level SPC seminars, held at regional locations under the auspices of the Professional Development Committee

Federation Seminars Explain Application Of SPC Methods to Coatings Operations

The Federation recently sponsored a series of introductory and intermediate-level seminars on Statistical Process Control, designed for personnel working in coatings manufacturing and related areas (e.g., chemicals, pigments) which employ a batch process.

Held in Philadelphia, Chicago, and Toronto, under the auspices of the Professional Development Committee, the seminars were conducted by Dr. Peter J. Hunt, President of Productivity Management Consultants, Clearwater, FL, who specializes in in-plant training and implementation of SPC systems, particularly for batch operations. Dr. Hunt conducted a similar

series of SPC seminars on behalf of the Federation in 1987 and 1988.

Statistical Process Control is critical to the new manufacturing concept of the way to define and achieve product quality—to make it right the first time. It is a quality management tool which takes information regarding process variances and uses this information to gauge trends over periods of time.

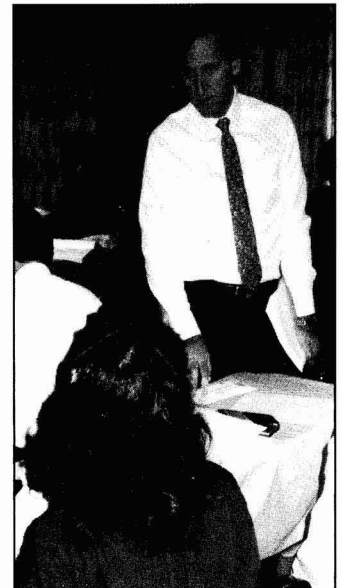
One of the most significant factors contributing to the industrial and economic success of Japan was the willingness of that country's manufacturers early on to incorporate SPC in their operations, to reduce variation, and improve quality.

Many U.S. manufacturers have implemented SPC and are requiring that their suppliers do so. This "trickle down" effect is beginning to have a major impact and, within a few years, companies wishing to sell to major manufacturers (e.g., automotive firms) will be required to demonstrate SPC capability and its related management practices.

The SPC plan is to monitor consistency of the process and the resulting product. By



Statistical techniques can be applied in a variety of paint manufacturing areas. Shown analyzing data on resin cook operations are Daniel Benoit (Director, Quality and Color, SICO, Inc.) and FSCT Past-President A. Clarke Boyce (Technical Service Manager, Nacan Products Ltd.)



Dr. Peter Hunt, seminar instructor, clarifies a point on interpreting control chart variations

achieving consistency batch-to-batch, a great deal of time and money can be saved. A typical rework of a defective batch can cause additional costs in many areas—raw materials, labor, disposal costs, and loss of operating time, as well as potential loss of business. In the coatings industry, the cost of this rework has been estimated at 25-30% of sales.

Fundamental to understanding SPC is the concept of variation, which implies that no two items will be perfectly alike or that no two batches will be absolutely identical. With sufficiently precise measurement, variation will be found.

Variation can be categorized as either inherent to the manufacturing process or assignable to some cause.

Inherent variation is variability which is always present in a manufacturing process. It can come from random variation in raw materials, from mechanical characteristics of the equipment, from slight variation in an operator's performance, and from many other sources. It is always present.

Assignable cause variation is usually due to non-random factors. It is identified through SPC techniques and resolved through sound engineering, management, or hourly worker action. Minimizing or eliminating assignable cause variation can significantly improve the uniformity of the product.

Once identified, the task of eliminating the variation is undertaken. This may involve changes in engineering, job procedure, testing, materials, as well as other efforts. Once assignable cause variation has been eliminated, a "constant cause system" is said to exist.

There are two principal applications of SPC: process control and process capability.

Process control involves gathering data on key characteristics, plotting this data



Michael Kolakowski (Pilot Plant Manager) and Louis Chang (Senior Chemist), of Hüls America, plot data to determine how much pigment is actually being delivered in 50-lb bags

on a control chart which displays variation, and using a set of statistical rules to interpret the control chart plot and look for assignable cause variation. Reducing assignable cause variation increases the degree of process control which decreases product variation and helps one become more capable of manufacturing to customer specification.

Process capability is a measure of the degree to which a process is capable of manufacturing a product within established specifications. It is based on a quantified prediction of process adequacy, and is a measure of the performance potential of the process itself.

If one wishes to predict process adequacy, the assignable cause variation in the process should first be eliminated or

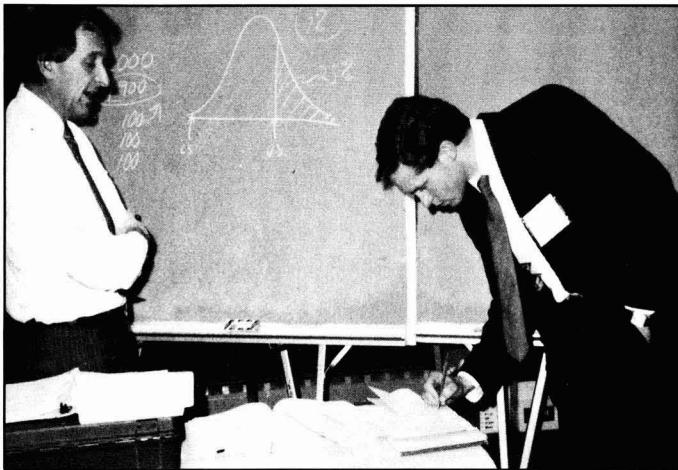
minimized, which is the process control step of SPC. Process capability is a measure of the performance potential of the process itself when the process is being operated in a state of statistical control. Capability is usually expressed as the proportion or percent of output that will be in tolerance. What is or is not acceptable is a management judgment. Zero defects is an ideal situation but may not be practical to achieve. Situations judged not acceptable then require management corrective action.

The introductory seminar focused on identifying appropriate product and machine variables to measure, plotting and interpreting control charts, evaluating process capability, and implementing an SPC system.

The intermediate-level seminar featured explanations of statistical techniques, when to use a particular technique, and how to interpret and use the results to improve product quality.

SPC, however, is not just charts and numbers. Attitude changes are required. Everyone must "buy into" the concept, so that all understand they play a role in product consistency, and that everyone is responsible for quality. It is a system which gets operators on the plant floor involved in gathering data from their own machines and cooperatively solving problems. They work with their supervisors, in a Quality Circle approach, to identify problems and take corrective action.

Dr. Hunt noted that the coatings industry has been slow to accept SPC, but that progress is being made. Implementation takes time, and he cautioned against the tendency to expect that SPC will change things overnight. The effort should be undertaken, he said, in reasonable steps: "How do you eat an elephant? One bite at a time!"



In a break between sessions, Dr. Hunt discusses variance component analysis with Bill Lutz (Process Engineer, Essex Specialty Products)

Regulatory UPDATE

JUNE 1989

This digest of current regulatory activity pertinent to the coatings industry is published to inform readers of actions which could affect them and their firms, and is designed to provide sufficient data to enable those interested to seek additional information. Material is supplied by Roy F. Weston, Inc., Washington, D.C.

EPA Promulgates Final SNUR—EPA is promulgating a significant new use rule (SNUR) for pentabromoethybenzene (PEB, CAS No. 85-22-3). This rule requires EPA notification of at least 90 days before commencing to manufacture, import, or processing of PEB. The information will be used by EPA to evaluate any intended use or associated activity to protect against any potential adverse exposure.

Under a SNUR, those persons affected by the new rule need to comply will be the same notice requirements outlined in pre-manufacture notices (PMNs). The export of a chemical substance identified in a final SNUR is subject to export provisions of TSCA. In addition to the above SNUR requirements, any prospective manufacturer, importer, or processor of PEB who intends to distribute the substances in commerce must submit a significant new use notice.

This final rule was promulgated for the purposes of judicial review on May 12, 1989, and becomes effective on June 12, 1989. For further information, contact Michael Stahl, Director, TSCA Assistance Office, (TS-799), Office of Toxic Substances, U.S. EPA, Room EB-44, 401 M Street, S.W., Washington, D.C. 20460, (202)554-1404.

EPA Proposes to Delete Nonfibrous Form of Aluminum Oxide from Community Right-to-Know List—EPA partially granted a petition from the Aluminum Association by proposing to delete nonfibrous aluminum oxide (Al_2O_3) from the list of toxic chemicals under Section 313 of the Superfund Amendments and Reauthorization Act of 1986 (SARA). See 54 Federal Register 16377 (April 24, 1989). EPA has concluded that there is no evidence of adverse human health or the environment from nonfibrous aluminum oxide. However, the fibrous forms of aluminum oxide have been retained on the list.

Comments are due on or before June 23, 1989, in triplicate, to OTS Docket Clerk, TSCA Public Docket Office, (TS-793), U.S. EPA, Room NE-G004, 401 M Street, S.W., Washington, D.C. 20460. Mark comments Attn: Docket Control Number OPTS-400029. For further information, contact Robert Isreal, Acting Petition Coordinator, Emergency Planning and Community Right-to-Know Hotline, U.S. EPA, Mail Stop OS-120, 401 M Street, S.W., Washington, D.C. 20460, (800)535-0202, or in Washington, D.C. and Alaska, (202)479-2449.

NTP Extends Public Comment Period on Carcinogens—The National Toxicology Program (NTP) has extended the public comment period on 13 chemicals proposed for addition to the Sixth Annual Report on Carcinogens and on other proposed actions pertaining to this document. The comment period was extended to May 16, 1989. See 54 Federal Register 15266 (April 17, 1989). (For the original notice letter, see 54 Federal Register 8399, also see May 1989 FSCT *Regulatory Update*.)

Comments should be sent to National Toxicology Program Public Information Office, MD B2-04, P.O. Box 12233, Research Triangle Park, NC 27709.

Food and Drug Administration (FDA) Approves Use of Slimicide in Paper and Paperboard Components—The FDA has changed its regulations to allow for the safe use of 2-bromo-2-nitropropane-1, 3-diol as a slimicide in the manufacture of paper and paperboard for food-contact use. See 54 Federal Register 18102 (April 27, 1989). This action was in response to a petition filed by Betz Laboratories Inc. The amendment was effective April 27, 1989. Written objectives and requests for hearings were due by May 30, 1989 to Docket Management Branch, (HFA-305), Food and Drug Administration, Room 4-62, 5600 Fishers Lane, Rockville, MD 20857. For further information, contact Marvin D. Mack, Center for Food Safety and Applied Nutrition, (HFF-335), Food and Drug Administration, 200 C Street, S.W., Washington, D.C. 20204, (202)472-5690.

Food and Drug Administration Approves Use of Antioxidants for Polymer—(FDA) has changed its regulation to allow for the safe use of di-tert-butylphenyl phosphonite condensation product with biphenyl as an antioxidant for 4-methylpentene-1 copolymers used in contact with food. See 54 Federal Register 17704 (April 25, 1989).

The action was in response to a petition filed by Sandoz AG. This re-evaluation was effective May 26, 1989. Written objections and requests for hearings were due May 25, 1989, to Dockets Management Branch, (HFA-305), Food and Drug Administration, Room 4-62, 5600 Fishers Lane, Rockville, MD 20857. For further information, contact Hortense S. Macon, Center for Food Safety and Applied Nutrition, (HFF-335), Food and Drug Administration, 200 C Street, S.W., Washington, D.C. 20204, (202)472-5690.

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

Proposed Rulemaking Affects Ozone Depleting Chemicals—

EPA issued an advanced notice of proposed rulemaking (ANPRM) which considers adding methyl chloroform (1,1,1-trichloroethane) and carbon tetrachloride (CCl₄) to the list of ozone-depleting chemicals already regulated by the Montreal Protocol on Substances that Deplete the Ozone Layer and the EPA rule implementing the Protocol. The production and consumption of these chemicals may be reduced or kept at current levels as a result of inclusion on the list.

As part of the ANPRM, EPA wants to encourage producers and users of listed chemicals not to replace them with other chemicals which are also considered ozone depletors or possible human carcinogens. In addition, the following chlorinated solvents are under investigation by EPA: methyl chloroform, methylene chloride, perchloroethylene, trichloroethylene, and carbon tetrachloride. Currently, the Montreal Protocol, which is implemented through EPA regulation, [see 53 Federal Register 30566 (August 12, 1988)] requires a 50% phase-in reduction in the production and consumption of specified fully-halogenated CFCs by 1998, and a freeze at 1986 levels of specific halons beginning in 1992.

This notice also seeks comments on EPA's analysis and on the possible impact of placing limits on methyl chloroform and carbon tetrachloride by adding them to the list of chemicals regulated under the Protocol. Specifically the following points should be addressed:

- (1) What substitutes exist for methyl chloroform in the following use categories: metal; precision and electronic cleaning; aerosols; and adhesives?
- (2) What can EPA do to expedite and assist in finding substitutes for methyl chloroform in these use categories? What are the barriers to such substitution?
- (3) Will the demand for methyl chloroform increase when the initial reduction in CFC use is effective in July 1989?
- (4) Should the international response be to freeze, reduce, or eliminate methyl chloroform and carbon tetrachloride? How and why or why not? Over what time period?

Comments were due on May 15, 1989, and sent to Docket (A-89-09), Air Docket, 1st Floor, Waterside Mall, Room 1500, LE131, U.S. EPA, 401 M Street, S.W., Washington, D.C. 20460. For further information, contact Karla Perri, Division of Global Change, OIAIP, Office of Air and Radiation, (ANR-445), U.S. EPA, 401 M Street, S.W., Washington, D.C. 20460, (202)475-7496. To expedite review of submitted comments, send a copy to Karla Perri at the above address.

EPA Grants Temporary Administrative Relief for CAIR—

EPA has granted temporary administrative relief where compliance with provisions under the Comprehensive Assessment Information Rule (CAIR) will result in the disclosure of trade secrets

concerning a substance. Otherwise, reporting is still required as provided in the final rule. (See the February 1989 FSCT *Regulatory Update* for more information.) See 54 Federal Register 15324 (April 10, 1989).

This action was in response to a petition from the Synthetic Organic Chemical Manufacturers Association (SOCMA) to reconsider several aspects of CAIR and to stay the application of certain provisions of CAIR during reconsideration of these provisions by EPA. The aspects of CAIR being reconsidered are: relief from Sec. 704.208; confidentiality of chemical identity; low volume cutoff; and, *de minimis* exclusion for mixtures. Any person seeking relief from Sec. 704.208 should notify EPA in writing with the necessary information. This rule is effective April 10, 1989. For further information, contact Michael Stahl, Director, TSCA Assistance Office, (TS-799), Office of Toxic Substances, U.S. EPA, Room EB-44, 401 M Street, S.W., Washington, D.C. 20460, (202)554-1404.

EPA Proposes to Add Chemicals to Community Right-to-Know List—

EPA is proposing to add 10 chemicals to the Community Right-to-Know list of toxic chemicals under Section 313 of the Superfund Amendments and Reauthorization Act of 1986. The reason EPA is adding these chemicals to the toxic chemicals list is because nine are carcinogenic or are chronic toxics. The other substance, mixtures of toluenediisocyanate (mixed isomers), has been added because it is expected that this substance would have the same adverse environmental and health effects and the individual isomers already on the Section 313 list. See 54 Federal Register 16138 (April 21, 1989).

Chemicals	CAS No.
2,3-Dichloropene	78-88-6
m-Dinitrobenzene	99-65-0
p-Dinitrobenzene	100-25-4
Allyl alcohol	107-18-6
Diethylamine	109-89-7
Isosafrole	120-58-1
o-Dinitrobenzene	528-29-0
Creosote	8001-58-0
Dinitrotoluene (mixed isomers)	25321-14-6

Written comments are due by June 5, 1989, and should be marked with the docket control number OPTS-400021 and should be sent to: OTS Docket Clerk, TSCA Public Docket Office, U.S. EPA, Mail Stop TS-793, Room NE-G004, 401 M Street, S.W., Washington, D.C. 20460. For further information, contact Robert Isreal, Project Manager, Emergency Planning and Community Right-to-Know Hotline, U.S. EPA, 401 M Street, S.W., Mail Stop WH-562A, Washington, D.C. 20460, (800)535-0202, or in Washington, D.C. and Alaska, (202)479-2449.

SUMMARY CALENDAR OF REGULATORY ACTIONS

- April 10, 1989 EPA postpones compliance on some CAIR requirements. (See this issue, and also see February 1989 issue.)
- April 19, 1989 FDA admendments allowing use of propylene glycol dibenzoate for use in contact with food effective. (See this issue.)
- April 27, 1989 FDA admendments regarding use of slimicide effective. (See this issue.)
- May 15, 1989 Comments were due on EPA's advanced notice of proposed rulemaking regarding carbon tetrachloride and methyl chloroform and possible addition to Montreal Protocol. (See this issue.)
- May 16, 1989 Comments were due on the National Toxicology Programs's Sixth Annual Report on Carcinogens. (See this issue, and also see May 1989 issue.)
- May 26, 1989 FDA admendments regarding use of antioxidants for polymer effective. (See this issue.)
- June 5, 1989 Comments due on EPA proposal to add 10 chemicals to Community Right-to-Know List. (See this issue.)
- June 12, 1989 EPA significant new use rule (SNUR) on PEB becomes effective. (See this issue.)
- June 23, 1989 Comments due on EPA's proposal to delete nonfibrous aluminum oxide from Community Right-to-Know List. (See this issue.)
- June 30, 1989 EPA extends date until mandatory use of new manifest form and OMB burden disclosure statement will begin to be required. (See April 1989 issue.)

Federation of Societies for Coatings Technology

67th Annual Meeting ★ 54th Annual Paint Industries' Show

Housing and Advance Registration Forms



The New Orleans Hilton ★ The Rivergate

Wednesday, Thursday, Friday ★ November 8, 9, 10, 1989

New Orleans, Louisiana

**67th Annual Meeting
54th Paint Industries' Show
November 8, 9, 10, 1989
The New Orleans Hilton and
The Rivergate
New Orleans, Louisiana**

**TO OUR MEMBERS AND FRIENDS
OF THE FEDERATION EVERYWHERE:**

It is a pleasure for me to invite all those associated with the coatings manufacturing industry to attend the Federation's 67th Annual Meeting and 54th Paint Industries' Show in "The Crescent City," New Orleans, November 8-10.

This year marks the initial visit of these popular Federation events to New Orleans. The Paint Industries' Show, coming off a record year in 1988, will be even bigger, with almost 74,000 net square feet of exhibit space at the New Orleans Hilton Exhibition Hall and at the adjacent Rivergate Exhibition Center.

Running concurrently with the Paint Show will be the technical Program Sessions with the theme - "Coatings Worldwide: Meeting the Needs of the Nineties." Presentations will focus on the increasingly international aspects



of the coatings industry and the technology required for future progress.

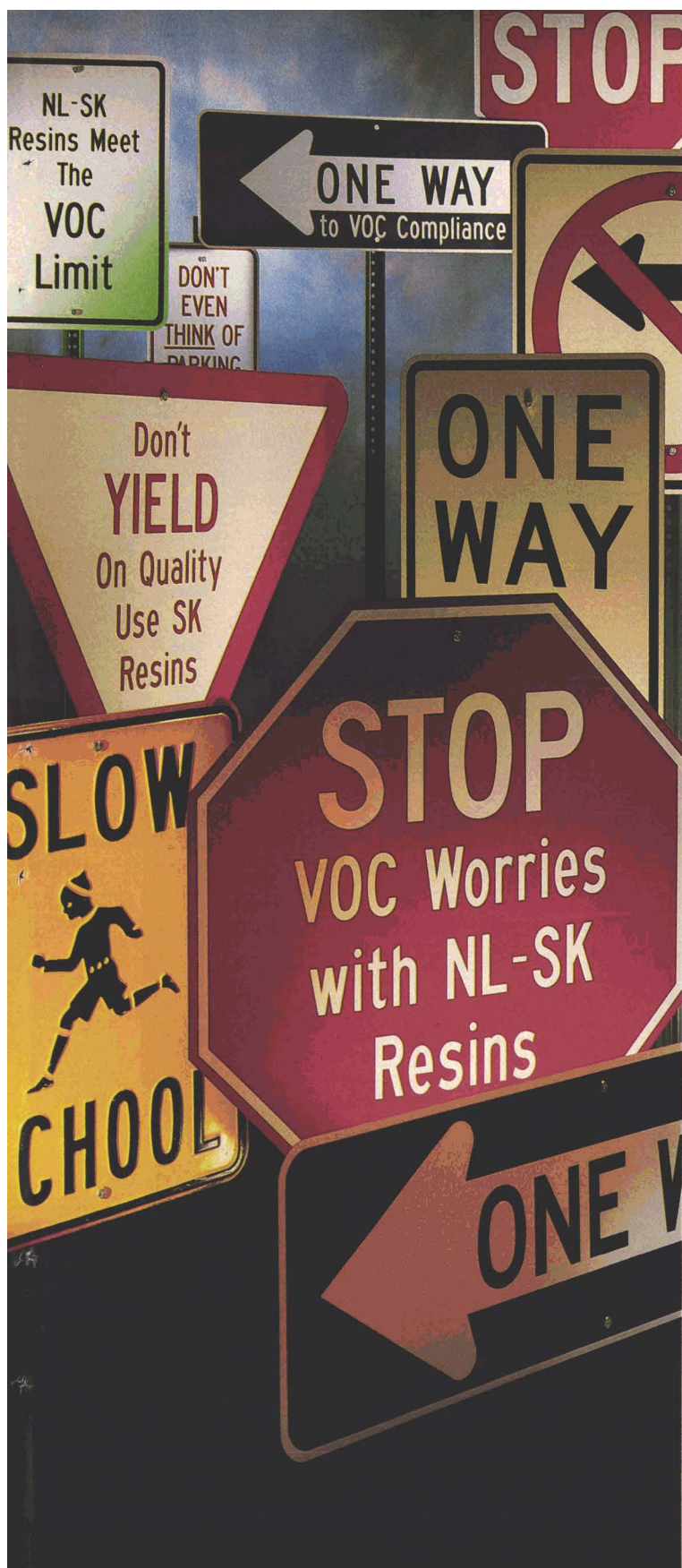
The locals call it "The Big Easy"; everyone else calls it "Fun." To the Coatings Industry in 1989, New Orleans means the largest and finest exhibition of materials, equipment, and services in the world - and - programming to help you to better prepare for the future.

James E. Geiger

James E. Geiger
President, FSCT



Rivergate Exhibition Center



All signs lead to NL high performance resins.

Regulations regarding VOC emissions can be confusing and vary from state to state. But one thing's for sure. Compliant coatings are here to stay. And NL's growing line of resins assure you the *ultimate in performance*, while meeting low VOC requirements.

Try these high performance resins for compliance without compromise:

SPENLITE® High Solids Aliphatic Urethanes

SPENKEL® High Solids Aromatic Urethanes

AROPLAZ® High Solids Alkyds and Polyesters

KELSOL® Water Dispersible Alkyds and Polyesters

SPENSOL® Water Dispersible Urethanes

AROLON® Water Dispersible Alkyds, Polyesters and Acrylic Emulsions

NL Chemicals, Inc. is a major producer of titanium dioxide pigments, specialty resins, rheological additives and anticorrosive pigments.

NL Chemicals

SPENCER KELLOGG RESINS
Compliance without compromise.

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P.O. Box 700
Hightstown, NJ 08520
Tel: (609) 443-2500
Telex: 642240

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**FEDERATION OF SOCIETIES FOR COATINGS TECHNOLOGY
1989 ANNUAL MEETING AND PAINT INDUSTRIES' SHOW
THE NEW ORLEANS HILTON AND THE RIVERGATE
WEDNESDAY, THURSDAY, AND FRIDAY, NOVEMBER 8, 9, 10, 1989**

The combined Annual Meeting and Paint Industries' Show is a major educational activity of the Federation. This international coatings manufacturing industry event consists of three days of technical program sessions and exhibits, running concurrently. Registration is required for admission.

"COATINGS WORLDWIDE: MEETING THE NEEDS OF THE NINETIES"

The theme of the 1989 Annual Meeting underscores the coatings industry's heightened awareness that it is part of a global marketplace, and that all areas of interest and endeavor are being viewed from an increasingly international perspective. Programming will focus on such areas pertinent to the "Decade of the Nineties" as raw material availability, uses of computers, environmental regulations, new approaches for corrosion control, manufacturing for excellence, and advanced topics on the "cutting edge" of the industry.

Also on the program will be the Mattiello Memorial Lecture, Roon Award Papers, Society Papers, and Seminars. Speakers will come from throughout the world of coatings science and manufacture.

ANOTHER RECORD PAINT SHOW WILL FEATURE LATEST PRODUCTS/SERVICES OF MORE THAN 220 EXHIBITORS

The Paint Industries' Show — the largest and best international exhibit of its kind in the world — will feature attractive exhibitor displays devoted to a wide variety of raw materials, production equipment, containers, laboratory apparatus, testing devices, and services furnished to the coatings manufacturing industry.

The purpose of the Show is to provide attendees with an opportunity to learn of the latest developments in these products and services. Key personnel from the top technical and sales staffs of exhibitors will be on hand. More than 220 exhibitors from the U.S., Canada, and Europe, will utilize almost 74,000 net square feet of exhibit space at the Show. Exhibit hours will be 11:00 - 5:30 on Wednesday; 9:00 - 5:30 on Thursday; and 9:00 - 3:00 on Friday.

The Paint Show will be held at both the New Orleans Hilton's Exhibition Hall and at the adjacent Rivergate Exhibition Center.

HOTELS/RESERVATIONS: MARRIOTT AND SHERATON CO-HEADQUARTERS

Nine hotels in New Orleans have reserved blocks of rooms for the Annual Meeting and Paint Show. The Marriott and Sheraton will be the co-headquarters hotels.

The other cooperating hotels are: Meridien, Monteleone, Omni Royal Orleans, Westin Canal Place, Doubletree, Holiday Inn Crowne Plaza, and the Hilton. The Monteleone and Omni Royal Orleans are located in the French Quarter.

Rooms are subject to an 11% occupancy tax plus a \$2.00 per room night city ordinance tax. All hotel reservations will be processed by the FSCT Housing Bureau. Phone reservations will not be accepted. You will receive an acknowledgment of your reservation from the Housing Bureau. This is not the hotel confirmation; that will be sent to you directly from the hotel to which you have been assigned.

Reservations for the Hilton will be accepted for arrival beginning Wednesday, November 8, only. Any reservations requesting the Hilton for arrival prior to November 8 will be assigned to another hotel.

Requests for accommodations at either the Marriott or Sheraton will be limited to ten rooms per company. A parlor counts as one room. All hotels require deposits. Please mail your deposit directly to the hotel! Additions, changes, and cancellations must be submitted in writing directly to the hotel in which you have been confirmed. (All hotels are in New Orleans, LA — zip codes in parens.)

Marriott Canal & Chartres Sts. (70140)	Westin Canal Place 100 Rue Iberville (70130)
Sheraton 500 Canal St. (70130)	Doubletree 300 Canal St. (70140)
Meridien 614 Canal St. (70130)	Holiday Inn Crowne Plaza 333 Poydras St. (70130)
Monteleone 214 Rue Royale (70140)	Hilton Poydras at the Mississippi River (70140)
Omni Royal Orleans 621 St. Louis St. (70140)	



THE POT OF GOLD AT THE BEGINNING OF THE RAINBOW

Milton Roy Color Matching Systems give you color quality before you go on-line.

Match Scan 2 All you'll ever need in a color matching system. Match Scan@2 is the only spectrophotometer in the world to incorporate reversible optics that allow you to use diffuse polychromatic and monochromatic illumination of both sample and reference.

Color Graph and Color Graph 45 For high-volume environments, the Color Graph™ and the Color Graph™ 45 spectrophotometers give you the speed and accuracy you need to keep production moving along.

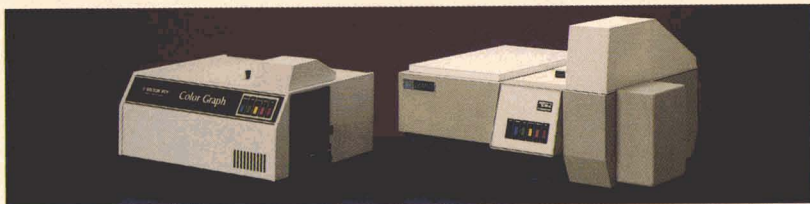
Milton Roy has meshed research-level accuracy

with production-environment simplicity to create the more affordable Color Graph.

Its dual-beam scanning provides accurate results of incoming, in-process and finished product color analysis.

Free demonstration Telling you about Milton Roy Color Matching Systems doesn't do our technology justice. We want to show you. Pick up your phone today and call 1-800-922-0826 for a no-obligation demonstration of either the Match Scan 2 or the Color Graph.

Or if you would just like more information, let us know that. We'll mail you a copy of our free brochure.



COLOR MATCHING SYSTEMS
Milton Roy Color Matching Systems contain dual-beam spectrophotometers that provide fast, precise measurements—even in dark color determinations.



MILTON ROY
Diano Color Products

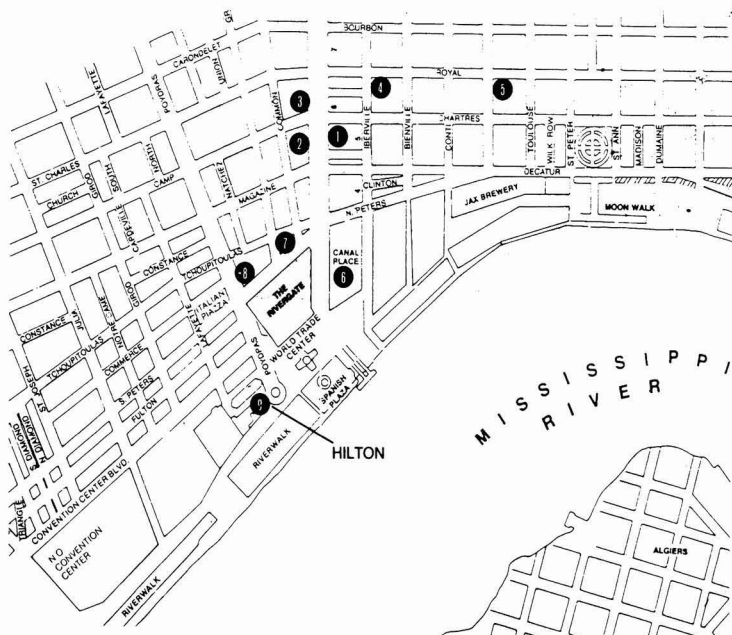
HOTEL ROOM AND SUITE RATES

Map No.	Hotel	Suites			
		Singles	Doubles/Twins	1 BR	2 BR
1	Marriott	\$112	\$128	\$360-400	\$488-528
2	Sheraton	115	130	183-310-480	310-705
	Towers	135	170	480-600	705
3	Meridien	95	105	275 & up	500 & up
4	Monteleone	92	104	215-425	325-550
5	Omni Royal Orleans	99,140,165	160,185	310,350	475,515
6	Westin Canal Place	115	130	350-425	525-600
7	Doubletree	85	95	160-200	300-400
8	Holiday Inn Crowne Plaza	95	110	226-446	349-592
9*	New Orleans Hilton	115	135	290-950	375-1125
	Towers	165	185	575-950	725-1100

Note: Rates subject to 11% occupancy tax plus a \$2.00 per room night city ordinance tax.
All hotels require a first-night room deposit. Please send directly to hotel.

*Reservations at the Hilton will be accepted for arrival beginning Wednesday, November 8, only.

- | | | |
|---|---|---|
| (1) Marriott
Canal & Chartres Sts. (70140) | (4) Monteleone
214 Rue Royale (70140) | (7) Doubletree
300 Canal St. (70140) |
| (2) Sheraton
500 Canal St. (70130) | (5) Omni Royal Orleans
621 St. Louis St. (70140) | (8) Holiday Inn Crowne Plaza
333 Poydras St. (70130) |
| (3) Meridien
614 Canal St. (70130) | (6) Westin Canal Place
100 Rue Iberville (70130) | (9) New Orleans Hilton
Poydras at the Mississippi
River (70140) |



**1989 FSCT ANNUAL MEETING AND PAINT INDUSTRIES' SHOW
 NEW ORLEANS HILTON AND RIVERGATE, NEW ORLEANS, LA
 WEDNESDAY, THURSDAY, AND FRIDAY, NOVEMBER 8, 9, 10**



APPLICATION FOR HOTEL ACCOMMODATIONS

Mail to: FSCT Housing Bureau
 1520 Sugar Bowl Dr.
By 10/5/89 New Orleans, LA 70112

Please indicate below the type of accommodations desired and the choice of hotels. (Refer to the hotel map and rates on opposite page.) All reservations will be processed by the FSCT Housing Bureau. Hotel assignments will be made in accordance with the prevailing availability. You will receive an acknowledgment of your reservation from the Housing Bureau. This is not the hotel confirmation. That will come to you directly from the hotel to which you have been assigned. Changes/additions/cancellations must be submitted in writing to the hotel.

TYPE OF ACCOMMODATION	NUMBER	RATE REQUESTED
Single (1 person)		
Double (2 persons)		
Twin (2 persons)		
Suite (parlor and 1 bedroom)		
Suite (parlor and 2 bedrooms)		

CHOICE OF HOTELS
1ST
2ND
3RD
4TH

NAMES OF ROOM OCCUPANTS AND DATES OF ARRIVAL/DEPARTURE

Type of Room	Name	Dates	
		Arrive	Depart

Please Type Additional Reservations on a Separate Sheet and Attach to This Form

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- Note:** (1) Requests for accommodations at either the Marriott or the Sheraton will be limited to 10 rooms per company.
 (2) Reservations for the Hilton will be accepted for arrival beginning Wednesday, November 8, only.

SPECIAL FARES AVAILABLE FROM DELTA AIR LINES

Delta Air Lines, in cooperation with the FSCT, is offering a special discount fare which affords passengers a 40% minimum savings off their round trip, undiscounted day coach fares for travel to the FSCT Annual Meeting and Paint Industries' Show on the airlines' domestic systems. The discount from Canada is 35%.

To take advantage of this discount, you must: (1) Travel between November 4-14, 1989; (2) Purchase tickets at least seven days in advance; (3) Phone 1-800-241-6760 for reservations. Immediately reference the FSCT file number: U0235. The special fares are available only through this number.

Discounts are good for both direct and connecting flights to New Orleans. If you use a travel agent, have your reservations placed through the toll-free number to obtain the same fare advantages. Delta has a variety of other promotional fares, some of which may represent even greater savings. When you phone for reservations, ask for the best discount applicable to your itinerary.

FEDERATION BOARD OF DIRECTORS TO MEET ON TUESDAY AT MARRIOTT

The Board of Directors of the Federation will meet on Tuesday, November 7, at 9:00 a.m. in the Marriott.

HILTON EXHIBITS – SITE OF DELTA FIRST-CLASS TICKETS DRAWING

The Federation will offer a special door prize during the Paint Show: a pair of Delta Air Lines first-class, round-trip tickets for any destination in the continental United States. Entries must be made at a special location at the Hilton Exhibition Hall. The drawing will be held at the Hilton Exhibition Hall at 11:00 a.m., Friday, November 10. Winner need not be present, however, the announcement of the winning entry will be made at the Federation's Annual Luncheon.



Hilton Riverside and Towers Hotel



St. Louis Cathedral, Jackson Square

FEDERATION ANNUAL LUNCHEON WILL BE HELD ON FRIDAY

The annual Federation Luncheon will be held on Friday, November 10, at the New Orleans Hilton.

SPOUSES PROGRAM INCLUDES TOUR OF FRENCH QUARTER

The Spouses Program will open on Wednesday with a get-acquainted wine and cheese social in the Mardi Gras Ballroom of the Marriott Hotel. On Thursday, there will be a deluxe motor coach tour of the city, featuring the French Quarter, the elegant Garden District, the shores of Lake Pontchartrain, the unique St. Louis III Cemetery, and a visit to Germaine Wells' Mardi Gras Museum. Lunch will be served during the tour at the famous Arnaud's Restaurant in the French Quarter. Also included in the spouses' registration is Continental Breakfast served at the Marriott on Thursday and Friday mornings.

NPCA TO MEET SAME WEEK AT NEW ORLEANS HILTON

The National Paint and Coatings Association will hold its annual meeting on November 6-8, 1989, at the New Orleans Hilton Riverside and Towers. Persons wearing NPCA badges (who sign up at a special registration desk at the Hilton) will be admitted to the Paint Show on Wednesday only, with the compliments of the Federation.

1989 Advance Registration

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Please fill out this form and mail with a check in the correct amount (made payable to the FSCT) **to the Federation address shown above.** All checks must be payable in U.S. Funds. Any that are not will be returned. **DEADLINE DATE FOR ADVANCE REGISTRATION IS OCTOBER 13. NONE WILL BE ACCEPTED AFTER THAT DATE.**

A \$10.00 charge will be made for cancellations received prior to October 13. No refunds will be made after that date.

INDUSTRY REGISTRATION FEES:

INFORMATION FOR REGISTRATION BADGE:

A **MEMBER** **\$60.00**

Please name the Federation Society in which you are a paid-up member:

Federation Constituent Society

B **NON-MEMBER** **\$75.00**

G **SPECIAL FEE FOR RETIRED MEMBERS** **\$25.00**

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D **SPOUSE** **\$40.00**

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1989 Paint Industries' Show

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Amoco Chemical Co.
Angus Chemical Co.
Applied Color Systems, Inc.
Aqualon Co.
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- B&P Environmental Resources**
B.A.G. Corp.
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Blackmer Pump/Dover Resources Co.
Bohlin Reologi, Inc.
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Brookhaven Instruments Corp.
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CDF Corp.
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DSA Consulting, Inc.
DSET Laboratories, Inc.
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Dow Chemical USA, Latex Prods. Div.
Dow Chemical USA
Dow Corning Corp.
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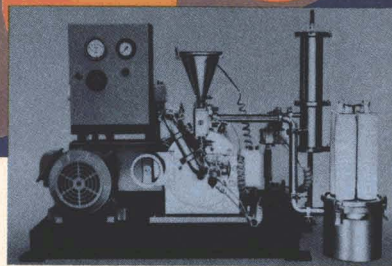
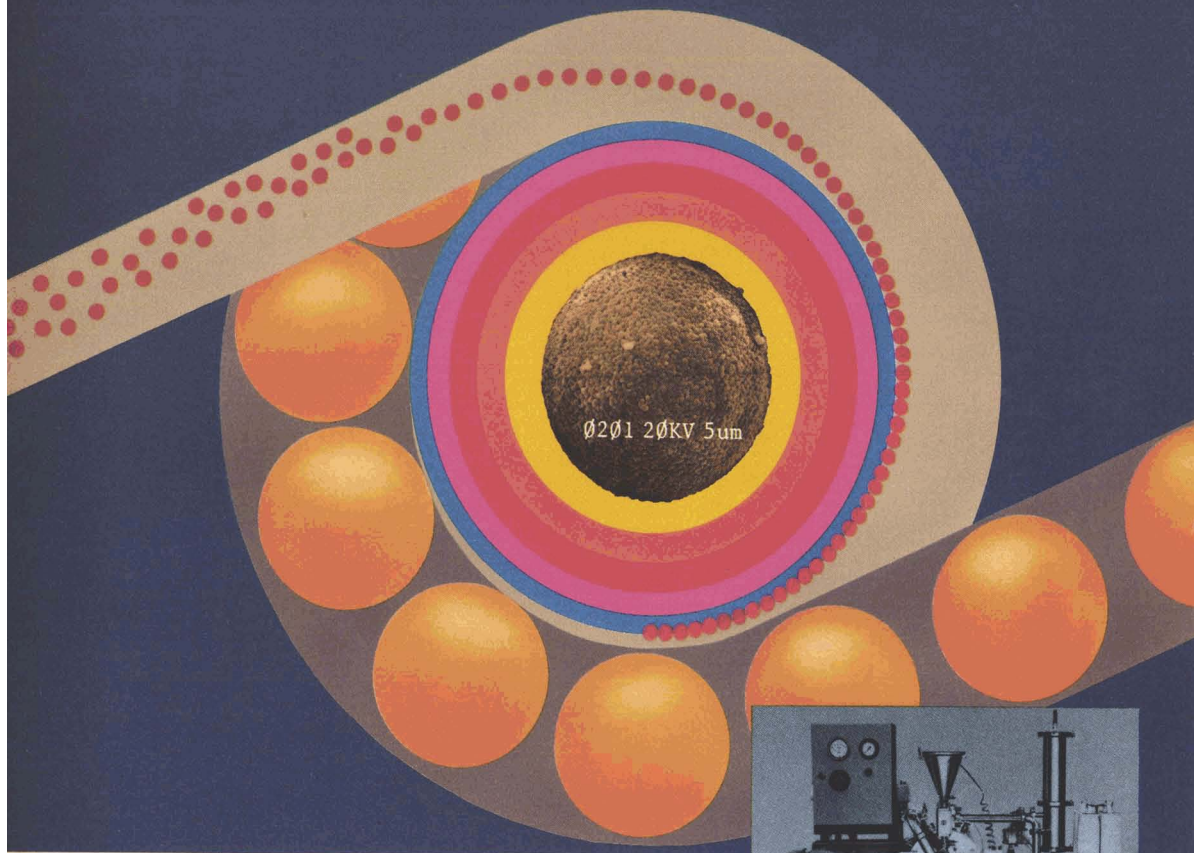
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Color Nonuniformity as a Coating Defect— Prevention and Cure

Marvin Schnall

Troy Chemical Corporation*

Pigment floating and pigment flocculation are two mechanisms which, separately or in combination, are primary causes of color nonuniformity defects. The factors involved in both mechanisms are described, as well as methods of improving color uniformity through formulation modifications and additive usage.

INTRODUCTION

Nonuniformity of color is a defect that is fairly common in all types of coatings: solvent- and water-based, trade sales, and industrial. Since appearance is a major attribute of coatings from the consumer's standpoint, it is important to have some understanding of the reasons for the occurrence of color nonuniformity problems and to review methods of correction.

Color nonuniformity may be defined as a nonuniform distribution of two or more different colored pigments in a coating film. This could occur as in *Figure 1*, which shows two paint films that appear to be different in color and are apparently uniform. However, when the wet film is disturbed as was done toward the bottom of both samples, it can be noted that the film on the right is uniform in color while the film on the left is not. Actually, these are two samples of the same paint in which the poor color uniformity shown on the left was corrected by an additive on the right. In practice, this type of color nonuniformity becomes a problem in brush or roller application where an overlapped area develops a change in color, or in industrial applications where a sprayed part has a different color than a part that is dipped in the same coating. This

type of problem can also make color matching much more difficult.

Color nonuniformity can also be more obvious than the previous example. This is shown in *Figure 2*, where the applied, undisturbed film has a mottled or streaky appearance. This again represents two samples of the same coating in which nonuniformity shown on the left is corrected by an additive shown on the right. This type of problem is even more objectionable than the first example, but both require correction. The intention of this paper is to outline some causes and possible cures of color nonuniformity.

The mechanisms causing color nonuniformity are complex and not fully understood. However, it is convenient to divide the overall problem into two general categories: flooding and floating on one hand and color flocculation or "rub-up" on the other. Admittedly, this is an oversimplification and it will be noted that the two categories sometimes overlap.

MECHANISMS OF FLOODING AND FLOATING

Both flooding and floating involve the separation of different colored pigments in a wet film of a coating. In flooding, the separation is primarily horizontal or in layers and becomes apparent only when the surface of the film is disturbed, disclosing a different color underneath. With floating, the separation is both vertical and horizontal and results in a mottled, streaky, or blotchy appearance at the film surface.¹

The physical processes occurring during flooding and floating have been described by Patton² and others, and can best be understood with the aid of the sketches in *Figure 3*. When a coating film is applied, solvent begins to evaporate at the surface. The solvent-richer paint in the bulk of the film then rises to the surface to replace the evaporated solvent, setting up a turbulent flow somewhat like a series of erupting volcanoes. This effect has been

Presented at the Spring Meeting of the Federation of Societies for Coatings Technology, in Orlando, FL, on May 17-18, 1988.

*One Avenue L, Newark, NJ 07105.



Figure 1—Rub up of acrylic latex enamel. Left—control; right—wetting agent

confirmed by microscopic examination of wet paint films. The solvent-rich paint erupts at points throughout the film surface and then flows out from these points in the form of cells, called Benard cells.

As the paint flows over the surface of the cell, more solvent evaporates. This increases the surface tension of the paint so that the edges of the cells formed are higher in surface tension than the centers. Since liquids flow away from areas of low surface tension toward areas of high surface tension, this surface tension gradient will reinforce and increase the flow patterns that have been set up. Therefore, the flow of paint in the wet film will continue until sufficient solvent has evaporated to reduce the surface tension gradient or until viscosity increases to the point where flow is restricted.

This type of flow will occur in all films during solvent evaporation and does not necessarily result in floating or flooding. An additional requirement for the occurrence of floating or flooding is the presence of two or more differ-

ent colored pigments that vary in particle size. As the currents described previously are up in the wet film, the smaller, less dense pigment particles are more easily moved while the larger, more dense particles tend to be left behind. This develops a separation of pigments in the wet film which is more pronounced as the difference in particle size is increased. As an example, floating or flooding is most common when relatively large particle sized titanium dioxide is combined with much smaller particle sized organic pigments, such as carbon black or phthalocyanine blue.

Figure 4 shows the difference in the distribution of the pigment particles with flooding as compared to floating. In flooding, there is a horizontal separation due primarily to the different particle sizes. In floating, the currents at the surface described previously also create a vertical separation resulting in the mixed pattern shown.

FACTORS GOVERNING FLOODING AND FLOATING

The coating characteristics governing the occurrence of flooding or floating are outlined in Table 1 and may be summarized as follows:

(1) **SOLVENT EVAPORATION:** Faster evaporating solvents increase flooding and floating by creating a stronger surface tension gradient across the surface of the drying film.

(2) **SURFACE TENSION:** In addition to the gradient effect, higher surface tension of a coating film increases the driving force, tending to bring the solvent-rich paint to the film surface. In addition, higher surface tension tends to hold more of the fine particle size pigments at the surface, preventing them from descending back into the film.

(3) **PIGMENT SIZE DIFFERENCE:** The greater the difference in particle size and density among the different colored pigments, the greater is the tendency for them to undergo separation as the currents within the film are set up.

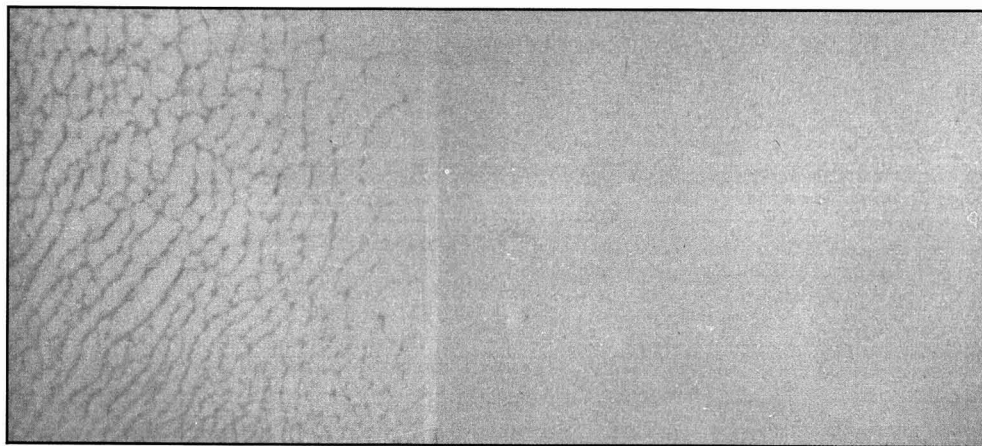


Figure 2—Pigment floating of air-drying alkyd. Left—control; right—0.4% anti-float agent

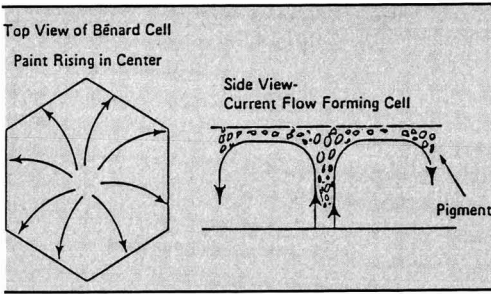


Figure 3—Processes occurring during flooding and floating

(4) **VISCOSITY AND THIXOTROPY:** These factors influence the ability of the currents created by evaporation to move through the wet film. The higher the viscosity or the higher the degree of thixotropy, the more this movement is restricted.

(5) **FILM THICKNESS:** Increasing film thickness increases the time during which floating and flooding can occur before solvent evaporation proceeds sufficiently to end the process.

(6) **PIGMENT FLOCCULATION:** This process will be described in more detail, but it is sufficient here to indicate that pigment flocculation may influence pigment floating and that it can either increase or reduce the problem.

Considering the factors of solvent evaporation and viscosity, it becomes apparent why pigment floating is much more common in solvent-based coatings than in water-based latex systems. The slow evaporation rate of water as well as the more thixotropic structure of latex paints would tend to reduce floating tendencies as compared to a typical solvent coating.

REDUCING FLOATING THROUGH REFORMULATION

Based on the previous discussion, it follows that the formulation or application changes indicated in Table 2 will reduce pigment floating and flooding. However, it is also apparent that these changes may not always be practical or that they may have adverse effects on other coating properties.

Slower evaporating solvents may reduce floating as indicated previously, but they will also increase drying time and may increase sagging on vertical application. Resins and solvents are generally chosen for reasons other than their surface tension, including film strength and integrity, solvency, etc. Consequently, the procedure of

Table 2—Reducing Floating Through Reformulation

- (1) Slower evaporating solvents
- (2) Vehicles with lower surface tension
- (3) Pigments closer in particle size
- (4) Higher viscosity and thixotropy
- (5) Thinner films
- (6) Nonflocculating pigments

changing a resin or a solvent to a lower surface tension type is usually not a practical approach.

Pigments are chosen to give a specific color, and while substitutions can sometimes be made, such as replacing a very fine particle sized carbon black with a coarser one to produce a gray color, the formulator's ability to make this type of change is decidedly limited. Increasing the viscosity of a formulation may reduce pigment floating, but this may also create application difficulties, including poor brushability or poor sprayability.

Applying thinner films may reduce pigment floating, but obviously, this also reduces the hiding and protective qualities of the coating. The use of nonflocculating grades of pigments will help only if the flocculation of a specific pigment is a factor in the floating of the system. Therefore, it is apparent that all of these approaches have definite limitations.

REDUCING PIGMENT FLOATING THROUGH ADDITIVES

The advantages of using an additive rather than a formulation change to affect a change in a coating property include savings in formulating time, greater ease of formulating, and, frequently, less effect on other desirable coating properties. This is particularly true of pigment floating and flooding. A variety of additives are available and these can be divided into four categories, as indicated in Table 3.

The importance of surface tension as a factor in floating and flooding has been stressed and, therefore, surface

Table 1—Factors Influencing Flooding and Floating

More Floating		Less Floating
faster	← Solvent evaporation rate →	slower
higher	← Surface tension →	lower
greater	← Difference in particular size →	less
lower	← Viscosity/thixotropy →	higher
higher	← Film thickness →	lower
either	← Flocculation →	either

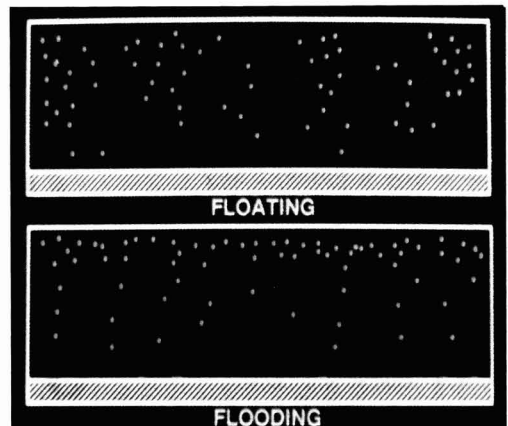


Figure 4—Difference in distribution of particles in floating (top) and flooding (bottom)

Table 3—Additives That Reduce Floating

- | |
|-------------------------------------|
| (1) Surface tension reducing agents |
| (a) Liquid types |
| (b) Powder types |
| (2) Bodying agents |
| (3) Pigment wetting agents |
| (4) Co-flocculating agents |

tension reducing additives may well be the most effective single means of overcoming the problem. This has been the experience of numerous coating formulators, and has been verified by reports from independent sources.³ Surface tension reducing additives occur in two forms: liquids and powders.

The liquid additives, which are often solutions of dimethyl silicones, have the advantage of easy post-addition. However, it has been noted that the distribution of the active ingredients of these additives into coatings may not always be satisfactory, leading to reduced efficiency and the increased possibility of adverse side effects.

The powder types consist of surface tension reducing agents absorbed onto the surface of extender pigments. This is done to insure that the active ingredients are thoroughly dispersed into the coating along with the pigment, providing the best distribution for maximum efficiency and minimum adverse effect. These additives are generally recommended for use as formulation ingredients in paints which are to be tinted with colorants that are prone to floating and flooding.

In the second category, bodying agents restrict the flow of pigments in the wet film by providing structure, thereby reducing both flooding and floating. They are particularly useful in flooding problems and also in combination with surface tension reducing agents. However, their usage is limited in industrial coatings, where viscosity increase and thixotropy are generally undesirable.

The third category includes pigment wetting agents which are helpful where pigment flocculation is contributing to floating. Co-flocculating additives, in the fourth category, have an opposing but sometimes desirable effect.⁴ The activity of both will become clearer during a review of the second basic mechanism of color nonuniformity—pigment flocculation. Chemically, co-flocculating agents include high molecular weight unsaturated polycarboxylic acids and salts of polyamine amides and high molecular weight acidic esters.

MECHANISMS INVOLVED IN PIGMENT FLOCCULATION

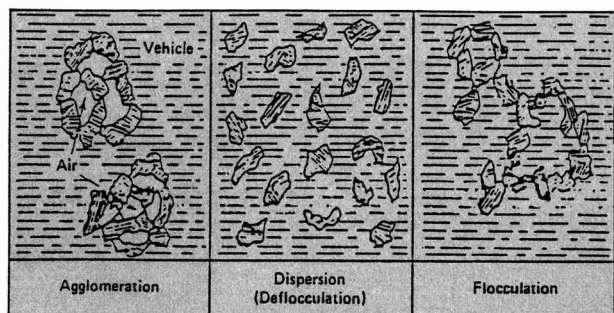
A brief review of the pigment dispersion process, as outlined in *Figure 5*, may be helpful to our understanding of flocculation. Pigments as received from the manufacturer are in the form of large clumps of particles or aggregates surrounded by air and moisture envelopes. The pigment dispersion process involves breaking down these pigment aggregates into individual pigment particles, or more commonly, into smaller aggregates. The process also involves replacing the air and moisture around the pigment particles with the grinding vehicle of the formulation. This process requires a high input of energy, which is supplied by dispersion equipment, including ball mills and media mills.

After completion of the dispersion process, there is often a tendency for the dispersed pigment particles to be attracted to each other, forming loosely associated groups of particles called flocculates, as shown on the right in *Figure 5*. These attractive forces are much weaker than the forces which attracted the pigment particles before dispersion, and they can be overcome with less energy than was required for the dispersion of the pigment. Two characteristics of pigment flocculation are that the process occurs over a period of time, which can vary from seconds to months, and that the process is reversible through the application of moderate energy.

For purposes of this paper, it is convenient to divide pigment flocculation into two categories: overall flocculation of the total pigment and flocculation of a single pigment in a mixture of different colored pigments, which will be designated as color flocculation.

Overall Pigment Flocculation

It is common for paint chemists to regard flocculation as both a qualitative and an undesirable condition. However, flocculation is a quantitative condition, in that different degrees of flocculation, varying from slight to severe, can occur in systems. Further, as is illustrated in *Table 4*, flocculation can have beneficial as well as adverse effects on coating properties. Moving a system away from complete deflocculation and toward a flocculated state will improve sag resistance and ease of brushing, and will also result in softer pigment settling, which is more readily remixed in the coating. On the other hand, this movement toward flocculation may adversely affect

Figure 5—Pigment dispersion process

flow, gloss, hiding, film durability, and color uniformity. A slight degree of flocculation is often desirable, particularly in trade sales coatings, but excessive flocculation can have the adverse effects indicated.

It was noted previously that bodying agents or rheology modifiers may reduce pigment floating by providing structure to restrict flow. Inducing a slightly controlled degree of flocculation will frequently have this effect, and indeed some bodying agents function by inducing a degree of pigment flocculation. Flocculation may also be induced by some dispersants which de-flocculate at optimum levels, but may actually increase flocculation above this level. Soya lecithin is an example of a wetting agent which may either deflocculate or flocculate a system, depending on the characteristics of the system and on the level employed.

Co-Flocculation as a Means Of Overcoming Floating

In an excellent article, Fred Daniel⁵ described in some detail the phenomenon of co-flocculation, including a series of experiments in which co-flocculation was induced. He showed that the specific vehicles, solvents, and additives employed have a considerable influence on whether or not co-flocculation will occur. It was mentioned previously that co-flocculating agents represent one category of additives which can be effective in overcoming flooding and floating problems. By acting as a bridge between two or more different colored pigments, they restrict their relative mobility and a more uniform color results. However, this approach can be very specific, in that an agent which co-flocculates one system may have no effect in a similar system with a slightly different resin or solvent. Further, excessive co-flocculation can have the adverse effects noted previously of reducing gloss, hiding, and flow.

Single Pigment or Color Flocculation

Apart from the limited role of pigment flocculation as a factor in flooding and floating, the flocculation of a single pigment in a mixture of colors is a major cause of color nonuniformity. Unlike floating and flooding, which occur primarily in solvent-based systems, color flocculation occurs frequently in both aqueous and nonaqueous coatings, and in both trade sales and industrial systems. Unlike floating, which occurs primarily in applied films

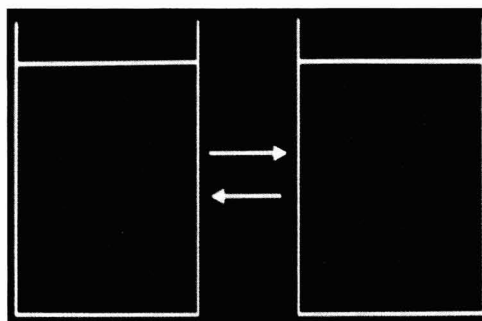


Figure 6—Typical color flocculation

during the drying process, color flocculation occurs in the bulk coating on storage, although its effect may be intensified during application.

Figure 6 illustrates in simplified form a typical color flocculation. The left portion shows a system pigmented with a combination of large red and small green particles. The pigments have been thoroughly dispersed and are uniformly distributed, resulting in good color uniformity. In the right sketch, the small green pigment particles have been attracted to each other, forming loose clumps or flocculates. These flocculates act as a single pigment particle from a color standpoint, and the net effect is to reduce the green or increase the red color of the coating.

Flocculation is reversible, and the application of sufficient energy to the system, as with intensive high speed mixing, will break up the flocculates and restore the coating to its initial uniform color.

However, with most flocculations, this is a temporary correction and the coating on storage, for time periods varying from seconds to months, will re-flocculate and revert to the condition shown on the right side of the figure. The high shear forces applied to coatings during application, including brushing, roller coating, and spraying are often sufficient to de-flocculate pigments, leading to the nonuniform color, particularly on overlapping of painted area, spraying vs dipping, etc. Color matching of a flocculated paint is also made more difficult. On drawdowns, the problem is observed when a wet film is rubbed with the finger. As the solvent evaporates, the film becomes more viscous and frequently reaches the stage where vigorous rubbing with the finger applies sufficient energy to de-flocculate the pigment, causing a change in the color of the rubbed area. This is the origin of the familiar term, "rub up," to describe color flocculation.

Table 4—Effect of Dispersion State on Paint Properties

Property	Dispersion State	
	Flocculated	De-Flocculated
Pigment settling	soft	hard
Flow	poor	good
Sag resistance.....	good	poor
Hiding	poor	good
Color development.....	poor	good
Brushability	good	poor
Gloss.....	poor	good
Film durability	fair	good

CAUSES OF COLOR FLOCCULATION

The precise mechanisms involved in pigment flocculation are not completely understood, but we do know that the attractive forces existing between pigment particles are the basic cause, and experience indicates that the factors listed in Table 5 can contribute to color flocculation. The nature of the pigment is important. Smaller

Table 5—Causes of Color Flocculation

- (1) Nature of pigment
 - (a) Particle size
 - (b) Pigment surface
- (2) Compatibility
 - (a) Pigment—vehicle
 - (b) Vehicle—vehicle
- (3) Resin solubility
- (4) Paint processing

pigment particles are more likely to flocculate than larger particles for at least two reasons. Firstly, they have more surface per unit weight and since the attractive charges are at the pigment surface, this results in more attractive force for unit weight. Secondly, smaller particle size results in more mobility or more rapid movement of the pigment particles toward each other. The high flocculating tendency of small particle organic pigments, such as phthalocyanine blue or carbon black, is well known.

Incompatibility is a frequent cause of color flocculation. This can occur as incompatibility of a specific pigment with a vehicle of the coating. An acid-base theory of pigment wetting has been proposed, in which both pigments and vehicles are designated as either acidic or basic in nature. Incorporation of an acidic pigment into an acidic vehicle or a basic pigment into a basic vehicle creates wetting problems which may lead to flocculation.

In coatings where separately dispersed tinting pastes are used, incompatibility of the dispersion vehicle with the base vehicle may lead to color flocculation. This has been observed frequently with universal tinting pastes designed to be used in both aqueous and solvent-based coatings. An interesting case observed by the author involved flocculation of the green pigment in an alkyd oil olive drab coating, which occurred in some but not all batches of the same formulation. Closer examination indicated that both penta and glycerol long oil alkyds were used interchangeably in the formulation. Flocculation occurred when the penta alkyd was used but not with the glycerol alkyd. Apparently a borderline incompatibility between the penta alkyd and the linseed oil used in the formulation caused the flocculation.

Solubility of the vehicle in the solvents employed may be a factor. It was noted by the author that the frequency of color flocculation problems increased during the transition period to Rule 66 solvents, which tended to have poorer solvency than the solvents previously employed.

And finally, the procedure of manufacturing, including the order of addition of ingredients, can be a factor. The occurrence of "pigment shock," due to faulty dispersion composition or to poor let down procedure, is a common experience. Addition of a high viscosity tinting paste to a low viscosity base must be done carefully to avoid poor development of color strength. Color uniformity problems have occasionally been submitted to our laboratories, which have been corrected simply by applying sufficient energy to the coating to incorporate the tinting paste properly. There are undoubtedly other causes of color flocculation, but those mentioned are some which have been observed frequently.

Table 6—Reformulation to Reduce Color Flocculation

- (1) Change pigment
 - (a) Larger particle size
 - (b) Surface treatment
- (2) Change vehicle
 - (a) Base vehicle
 - (b) Tinting paste vehicle
- (3) Improve solvency of solvents
- (4) Change manufacturing procedure
- (5) Co-grinding of pigments

CORRECTION OF COLOR FLOCCULATION THROUGH REFORMULATION

Steps which may be taken through reformulation to reduce color flocculation follow directly from the discussion of the causes of the problem, and are indicated in Table 6. Since flocculation is more likely to occur with small particle size pigments, it follows that replacement with a pigment of larger size, when possible, will reduce flocculation. "Nonflocculating" grades of organic pigment are now available which have been surface treated to reduce the tendency toward flocculation.

The use of a resin with better wetting characteristics toward flocculating pigments will reduce flocculation, although this is frequently limited by the film strength and resistance requirements of the coating. Reformulation of the solvents may be helpful, but this is also limited by a number of factors, including evaporation rate requirements and the need to conform with governmental regulations.

Improvement of the manufacturing procedure is effective where the problem has originated from faulty procedure. Co-grinding of the prime and tinting pigments will generally reduce color flocculation as compared to separate addition of tinting paste, although we have often observed color flocculation with co-dispersed pigments as well.

PIGMENT WETTING AGENTS AS FLOCCULATION CORRECTIVES

The type of additive most likely to correct color flocculation is a pigment wetting agent or dispersant. The mechanism by which pigment wetting agents reduce flocculation is shown in Figure 7.

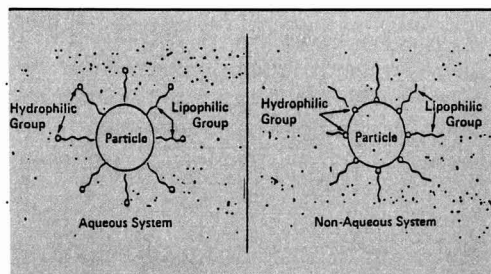


Figure 7—Mechanism by which pigment wetting agents reduce flocculation in aqueous (left) and nonaqueous (right) systems

culation is indicated in *Figure 7*, which depicts typical situations in both aqueous and nonaqueous systems. Pigment wetting agents contain polar and nonpolar constituents. In aqueous systems, the nonpolar portion tends to be attracted to the pigment surface, while the polar portion extends out into the vehicle. In nonaqueous systems, the reverse is more likely, with the polar portion of the wetting agent attached to the pigment surface and the nonpolar portion extending into the surrounding vehicle.

This action of the pigment wetting agent has two effects which may reduce flocculation. One is neutralization of the charges on the pigment surface which tends to attract the pigment particles to each other. The other is a coupling effect, tending to improve the compatibility of the pigment in the dispersion vehicle.

The importance of determining the proper level of dispersant is indicated in *Figure 8*. Ideally, the dispersant level should be sufficient to completely surround the pigment particle with a single layer of wetting agent. If additional dispersant is added, there will be a second layer formed around and in opposition to charges on the first layer. This could lead to poorer compatibility of the pigment in the vehicle, and thus increase the possibility of flocculation.

In order to perform its function most efficiently, the pigment dispersant should be added to the grinding medium prior to the addition of pigment. This insures the most efficient coating of the pigment particle with the wetting agent. Post-addition of pigment wetting agent to finished paint systems has occasionally corrected the color uniformity problem, in particular, where the problem has resulted from an incompatibility. However, this is not the preferred procedure for correction of flocculation.

SELECTION OF PIGMENT WETTING AGENTS

Although theories have been proposed, such as the acid base concept which may eventually put the selection of the proper pigment wetting agent on a more scientific basis, the coatings chemist must still rely primarily on a "trial and error" procedure. One concept which is helpful in narrowing the choices of wetting agents is the HLB system developed by Atlas Chemical, now a Division of ICI.⁶

HLB is an abbreviation of hydrophilic-lipophilic balance, which is a measure of the degree to which a surfactant is hydrophilic ("water loving") or lipophilic ("oil loving"). A scale of 1-20 is used, with increasing numerical values indicating increasing water solubility, as shown in *Table 7*. The HLB value of a surfactant is

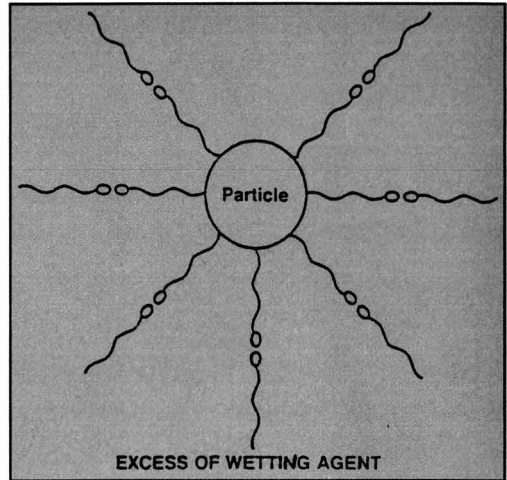


Figure 8—Level of dispersant surrounding the pigment particle

determined by mixing it in water and noting whether the mixture separates, forms a cloudy emulsion, or forms a clear solution.

A group of researchers at the Du Pont Company⁷ has applied the HLB concept to the determination of optimum surfactants for the dispersion of pigments. The results of their work are outlined in *Table 8*. The use of a surfactant with the optimum HLB value for the specific pigment results in the dispersions with maximum color strength, minimum viscosity, and maximum compatibility. This procedure was found to work equally well with water- and solvent-based coatings. The use of the HLB system can narrow the choice of wetting agents that need to be evaluated for color flocculation problems.

With regard to laboratory procedures, experience has indicated that dispersion of pigment wetting agents into samples of finished paints exhibiting color flocculation, using "Quickie" shot mills or laboratory high speed dispersers, is a fairly reliable method of evaluating prospective candidates. Since dispersion alone may temporarily correct color flocculation, it is important to include a control sample, dispersed without wetting agent, and to allow an aging period sufficient to determine whether re-flocculation will occur. Pigment wetting agents showing efficiency by this procedure must be evaluated further by incorporation into the initial pigment dispersion of the formulation.

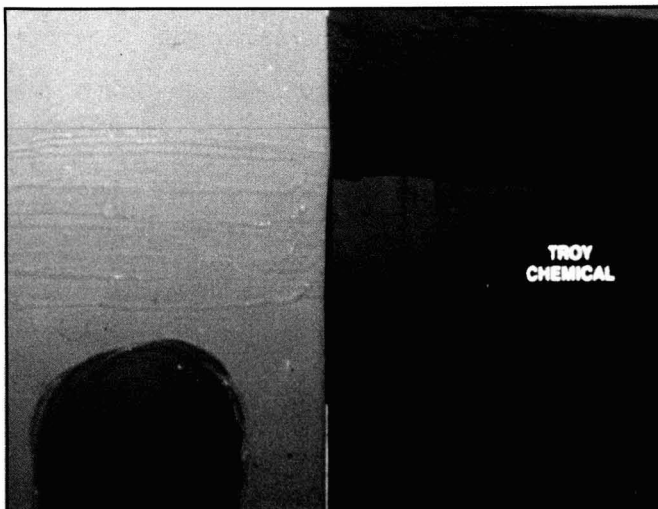
Table 7—HLB System for Surfactants

Hydrophilic—Lipophilic Balance or Degree of Water—Oil Solubility	
Water Solubility	HLB Range
None	1 - 4
Poor	3 - 6
Milky	6 - 10
Translucent	10 - 13
Clear solution	Above 13

Table 8—HLB Requirements of Pigments

Toluidine red	8 - 10
Phthalo green	12 - 14
Phthalo blue	14 - 16
Quinacridones	11 - 14
AZO yellows	13 - 15
Lampblack	10 - 12
Titanium dioxide	17 - 20
Yellow iron oxide	20 +

Figure 9—Laboratory test to identify a problem as either flooding (right) or flocculation (left) by casting a coating film on a substrate and disturbing the film



DIAGNOSIS OF COLOR UNIFORMITY PROBLEMS

The proper diagnosis of a problem is an essential first step in determining a cure, and this is true of color nonuniformity. The mechanisms involved are obviously complex and difficult to classify. In particular, the previous discussions suggest that distinguishing between pigment flooding and color flocculation may be difficult, since both become apparent upon disturbing a wet film of the coating.

A simple laboratory test illustrated in *Figure 9* has been found useful in identifying a problem as either flooding or flocculation. This involves casting a film of the coating on to a substrate and disturbing the film at various stages during the drying process.

With the two samples shown in *Figure 9*, both were rubbed lightly with the finger at the top early in the drying period, and both were rubbed vigorously at the bottom, in the circular areas, late in the drying process, when the films were almost set.

With the film on the right, the color differences were similar whether rubbed lightly or vigorously, since horizontal separation of the pigments in the wet film was involved. Therefore, the color difference is essentially the same at the top and the bottom of this drawdown. The film on the left indicates flocculation of the black pigment. Light rubbing at the top, while the film was still very fluid, produced essentially no color change, but vigorous rubbing at the bottom, in the circular area, when the film was almost set and therefore highly viscous, imparted enough energy to the coating to overcome the black flocculation and develop the true color. This is a fairly simple, although by no means foolproof method of distinguishing between pigment flooding and color flocculation. Pigment floating is fairly simple to diagnose, since the streaking or mottling of color at the surface of the film is readily apparent.

Distinguishing between flooding and color flocculation is important in determining the type of additives to be evaluated as possible remedies for color nonuniformity problems. Flooding, as well as floating, is most likely to be corrected or prevented through the use of the additives shown in *Table 3*, including surface tension reducers, bodying agents, and co-flocculating agents, while color flocculation generally requires the addition of the proper pigment wetting agent.

SUMMARY

This paper has outlined some of the major mechanisms involved in the occurrence of color nonuniformity problems in coating systems. Methods of correcting or preventing these problems through proper formulation and the effective use of additives have been suggested. It is hoped that this information will enable coatings chemists to deal with this problem more intelligently and efficiently.

References

- (1) Federation of Societies for Coatings Technology, "Paint/Coatings Dictionary," pp. 186-187 (1978).
- (2) Patton, T.C., "Paint Flow and Pigment Dispersion," Second Edition, John Wiley & Sons, pp. 592-596, 376-378 (1979).
- (3) Laporte Industries Ltd., "Flooding and Floating in Alkyd Paints," Technical Information Booklet, S.C.T. 15, London, UK.
- (4) Vash, R., "Wetting and Dispersing," *Handbook of Coating Additives*, Marcel Dekker Inc., Chapter 14, pp. 511-540 (1987).
- (5) Daniel, F.K., "Flocculation and Related Pigment Interactions in Paints," *JOURNAL OF PAINT TECHNOLOGY*, 38, No. 497, 309 (1966).
- (6) Product Brochure, "The HLB System," ICI Americas, Inc., Wilmington, DE, Revised Aug. 1984.
- (7) Pascal, R.H. and Reig, F.L., "Pigment Colors and Surfactant Selection," article of Pigments Dept., E.I. du Pont de Nemours & Co., Mar. 16, 1964.

Phenomenon of Cosolvency and Solution Parameters of Polyamide Resins

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This paper deals with the phenomenon of cosolvency and synergistic effects of cosolvents. Considering the synergistic action of cosolvents, solution parameters of polyamide resin are determined in cosolvent mixtures consisting of poor, good, and non-solvents. A special case of synergism has been observed in the case of cosolvent systems consisting of both non-solvents, i.e., cyclohexanol-cyclohexane and cyclohexanol-toluene. Unperturbed dimensions of resin are determined in cosolvent mixtures consisting of a poor and a non-solvent as well as in mixtures of non-solvents. The phenomenon of cosolvency has been explained in terms of structural parameters and preferential adsorption of individual solvent components on polymer coils. Mark-Houwink and Stockmayer Fixman equations are used for determining solution parameters of the resin in cosolvent mixture. The dependence of unperturbed dimensions and

long-range interaction parameters on solvent nature has been explained in terms of preferential adsorption of individual solvent molecules and intermolecular interactions. Since polyamide resin is soluble only in a few solvents, its solubility parameter has been determined by using the data on intrinsic viscosity, resin-binary solvent interaction parameter, and other solution parameters. The estimated value of solubility parameter of polyamide resin is found to be $9.90 \text{ (cal/cc)}^{1/2}$.

Suitable solvent blends for polyamide resin can be designed with the knowledge of its solubility parameter. In doing so, various other parameters like hydrogen bonding, polarity, and dispersion forces of resin and solvents are to be taken into account. This practice may help the industry in using relatively economical solvent blends for polyamides.

INTRODUCTION

In organic coating formulations, solvents used for dissolving resins play a major role in controlling dispersion properties as well as physico-chemical properties of the finished products. Interaction of solvents with the resin essentially promotes dissolution, reduces viscosity, and eases the application process. A prime solvent alone can solvate the resin coil but the addition of non-solvents, diluents, and latent solvents in limited quantities may enhance its solvency power and also increase the tolerance limit of resin solutions. The primary objective for the use of cosolvent mixtures in the coating industry is that they possess optimum solvency power, acceptable evaporation rates, and often being least expensive, com-

ply to the pollution regulations. The best solvent blends for resins can be designed with good knowledge about interaction and solubility parameters as well as physico-chemical properties of the components.

Usually, solution parameters of polymeric materials are estimated by using their dilute solution data in single solvents. In the case of materials like polyamides, such studies are limited because of their insolubility in common solvents. However, they could be dissolved in solvent blends and characterized by various techniques.¹⁻³ Because of the synergistic effect of cosolvents, an appropriate mixture of two liquids may dissolve the polymer which is insoluble or poorly soluble in either of the two. A special case of synergism is observed in some cosolvent mixtures of poor solvents (essentially non-solvents) which possess enhanced solvency power for the high molar mass polymer compared to that of primary sol-

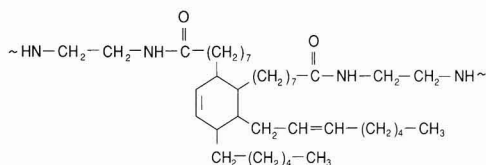
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vents.⁴⁻⁶ The synergistic action of cosolvents influences the solubility of the polymer as well as its hydrodynamic and thermodynamic properties in solution. In the absence of strong specific interactions, the polymer-cosolvent systems normally exhibit smooth monotonic changes in solution properties as a function of solvent composition.⁶⁻⁷ Several workers^{1,2,8-10} have studied the enhanced solvation of the polymer coil in cosolvent systems by traditional solution techniques like viscometry,^{1,2} light scattering,⁹ differential refractometry,⁹ phase separation,¹⁰ etc.

The phenomenon of cosolvency has been known for some time and mathematical expressions based on lattice theory have been developed for evaluating the basic thermodynamic properties of polymers in solvent blends. Pouchly, et al.¹¹ have extended the original Flory-Huggins theory to polymer solutions in mixed solvents by introducing a ternary interaction parameter, χ_7 . However, the basic deficiencies¹² of the lattice model cannot be alleviated by the extension of this type. A more adequate thermodynamic theory of polymer solutions based on the ideas of Prigogine and co-workers¹³ was proposed by Flory¹² and Patterson.¹⁴ The Flory, Prigogine, and Patterson (FPP) theory abandons the rigid lattice model and takes into account free volume differences of simple liquids and polymers. It was first applied to polymers in mixed solvents by Pouchly and Patterson¹⁵ to calculate intrinsic viscosity, heat of mixing to infinite dilution and total sorption, and later by Horta¹⁶ who calculated preferential sorption.

Several workers,¹⁷⁻²⁸ while studying the solution properties of polar and non-polar polymers in various cosolvent systems, discussed the phenomena of cosolvency,²²⁻²⁴ preferential adsorption,²⁴⁻²⁶ and variations in unperturbed dimensions.^{27,28} In most of the studies, cosolvent systems were composed of good and poor solvents for the polymer. In such systems, size of the macromolecular coil grows with the increase of good solvent proportion due to excluded volume effects. Not many cosolvent systems consisting of poor or non-solvents for the polymer were used for studying coil dimensions. If non-solvents in the mixture act as cosolvents, the coil expansion takes place in spite of the negative excluded volume effects of the individual solvent components. Then the interaction between two non-solvent molecules is the deciding factor in promoting dissolution and coil expansion.

In the present study, polyamide resins used are the reaction products of dilinoleic acid and ethylene diamine.



Structure of Polyamide Resin

They are soluble in a few common solvents like chloroform and n-butanol. Hence, mixtures of polar (alcohols) and non-polar (hydrocarbons) solvents were selected for

dissolving the resin and conducting determinations. Mark-Houwink constants, unperturbed dimensions, and other thermodynamic solution parameters, as well as solubility parameter of the resin, were estimated and discussed.

Intrinsic viscosity $[\eta]$, the inherent property of the polymer in the state of infinite dilution, is expressed as a function of molecular weight for a given polymer-solvent system at a constant temperature²⁹:

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

the empirical Mark-Houwink constants, K and a , depend not only on the properties of polymer and solvent molecules but also on their interactions.

In θ -state of solution (i.e., the condition of limiting solubility of the polymer in solvent, the constant $a = 0.5$) dimensions of the polymer molecule are unperturbed and the $[\eta] - \bar{M}_w$ relationship is expressed as:

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

Here, $[\eta]_\theta$ is intrinsic viscosity in θ -state and K_θ is the unperturbed conformational parameter.

It is ideal to determine unperturbed dimensions using viscosity data of dilute polymer solutions in θ -solvents. However, measurements on solutions in non- θ -solvents can be used with suitable extrapolation of data.³⁰⁻³⁵ In the present study, solution parameters of the resin are determined by the following Stockmayer-Fixman³¹ equation:

$$\frac{[\eta]}{\bar{M}_w^{0.5}} = K_\theta + 0.51 \phi_0 B \bar{M}_w^{0.5} \quad (3)$$

Here, B is the long-range interaction parameter and Flory universal viscosity constant, $\phi_0 = 2.68 \times 10^{-21} \text{ mol}^{-1}$. This is a widely accepted equation for single as well as binary solvent systems^{1-3,6,36} because of its practical form as a basis for treating data covering the usual range of molecular weights encountered in experiments.

The parameter K_θ is also related to the characteristic ratio C_∞ by the expression³⁴:

$$C_\infty = \left(\frac{K_\theta}{\phi} \right)^{2/3} \frac{M_b}{2\ell^2} = \frac{(\tau_0^2)}{n\ell^2} \quad (4)$$

Here, M_b is molecular weight of the repeating unit, n is the total number of backbone bonds, and ℓ is the bond length.

The Flory-Huggins interaction parameter, χ_{12} , applicable to polymer-solvent systems, can also be extended to the polymer-cosolvent systems ($\chi_{12} \rightarrow \chi_m$) on the assumption that the mixture of two solvents behaves like a single solvent with the mean of their properties.³⁷⁻³⁹ Its relationship with long-range interaction parameter B is expressed as:

$$B = \frac{2\bar{v}_2^2}{N_0 V_m} (0.5 - \chi_m) \quad (5)$$

Here, \bar{v}_2 is partial molar specific volume of the polymer, N_0 is the Avogadro number, χ_m is the polymer-cosolvent interaction parameter, and V_m is the molar volume of mixture of the two solvents.

The relationship between the second virial coefficient, A_2 , and the Flory-Huggins interaction parameter, χ_{12} , in a single solvent has been extended to the polymer-cosolvent systems as⁴⁰:

$$A_2 = \frac{\bar{v}_2^2}{V_m} (0.5 - \chi_m) \quad (6)$$

The following equation reported by Lipson and Guillet⁴¹ for estimating solubility parameter of the polymer in a series of single solvents has been extended to polymer-cosolvent systems⁶:

$$\left(\frac{\delta_m^2}{RT} - \frac{\chi_m}{V_m} \right) = \left(\frac{2\delta_p^2}{RT} \right) \delta_m - \left(\frac{\delta_p^2}{RT} + \frac{\chi_s}{V_m} \right) \quad (7)$$

Here, δ_m and δ_p are solubility parameters of solvent mixture and polymer and χ_s is entropic contribution to χ_m .

EXPERIMENTAL

Solvents and Cosolvents

Analytical reagent grade solvents used for viscosity measurements are: cyclohexane ($\delta = 8.18$), toluene ($\delta = 8.91$), chloroform ($\delta = 9.24$), n-butanol ($\delta = 11.30$), and cyclohexanol ($\delta = 11.40$). Among them, polyamides are soluble in n-butanol and chloroform and insoluble in cyclohexane, toluene, and cyclohexanol. The cosolvent systems used are: butanol-toluene, butanol-cyclohexane, cyclohexanol-toluene, and cyclohexanol-cyclohexane. The solubility parameter of solvent mixture, δ_m , was calculated by using the relation⁴²⁻⁴⁴:

$$\delta_m = \phi_1 \delta_1 + \phi_2 \delta_2 + \dots \quad (8)$$

Here, $\delta_1, \delta_2, \dots$ are solubility parameters of individual solvents and ϕ_1, ϕ_2, \dots are their volume fractions.

Resin Fractions

The polyamide resin was fractionated by the fractional precipitation method using chloroform (solvent) and toluene (non-solvent).³⁵ Five fractions having their molecular weight, M_w , in the range of 16,000-58,000 were selected out of 10 fractions of the resin.

Viscosity Measurements and Intrinsic Viscosity

Viscosity measurements of polyamide solutions (concentration 0.1-1.5 gdl⁻¹) in individual solvents and solvent blends were conducted at $25 \pm 0.004^\circ\text{C}$ (Schott Geratte thermostatic control) using a calibrated Ubbelohde capillary viscometer and an AVS/N system for automatic recording of flow time to 0.01 of a sec. The extrapolated plots of Huggins' equation⁴⁵ were used for determining the transport parameter intrinsic viscosity, $[\eta]$, of the resin in solution:

$$\frac{\eta_{sp}}{c} = [\eta] + k_H [\eta]^2 c \quad (9)$$

Here, η_{sp} is specific viscosity, c is concentration in gdl⁻¹, and k_H is Huggins' constant.

RESULTS AND DISCUSSION

The mechanism of cosolvency is still a matter of open discussion. The simple explanation for cosolvency is based on the original Hildebrand concept of additive solubility parameters approach, $\delta_m = \phi_1 \delta_{s1} + \phi_2 \delta_{s2} + \dots$,

(i.e., the dissolution could be expected when δ_m of cosolvent mixture is closer to δ_p of the polymer rather than the solubility parameters of individual solvents). This theory^{2,4,46} implies that the cosolvent mixture is likely to be more effective when $\delta_{s1} < \delta_p < \delta_{s2}$. However, for some systems^{20,22,47,48} cosolvency is observed where both δ_{s1} and δ_{s2} are greater or smaller than δ_p . A possible cosolvent action has also been suggested by the modifying effect of the third component on a binary polymer solvent system in which the regular molecular order may be present.^{7,9,49}

Cosolvency has been explained in terms of broken associated structures of polymer coils in solvent blends.^{7,9,49} Unfavorable interactions between individual solvent molecules, due to some degree of antipathy, may lead to the individual interaction of solvent molecules with polymer coil, which consequently promotes the cosolvent action.^{4,5,47,50} Cowie and McEwen⁴⁸ suggested a possible mechanism of cosolvency in terms of establishment of potential interaction sites between polymer coil and cosolvent molecules. In cosolvent mixtures,

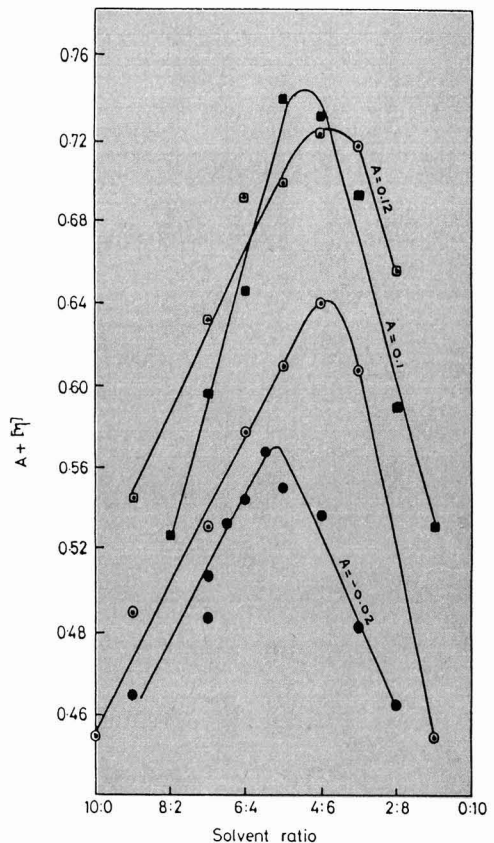


Figure 1—Intrinsic viscosity dependence on solvent composition for the polyamide resin in cosolvents. \circ —butanol-toluene, \bullet —butanol-cyclohexane, \square —cyclohexanol-toluene, and \blacksquare —cyclohexanol-cyclohexane cosolvent systems. "A" is an arbitrary constant used to displace plots for clarity

Table 1—Intrinsic Viscosity $[\eta]$: Its Dependence on Solubility Parameter, δ_m , of Different Cosolvent Systems

Solvent Ratio	n-Butanol-Toluene		n-Butanol-Cyclohexane		Cyclohexanol-Cyclohexane		Cyclohexanol-Toluene	
	δ_m (cal/cc) ^{1/2}	$[\eta]$ dlg ⁻¹	δ_m (cal/cc) ^{1/2}	$[\eta]$ dlg ⁻¹	δ_m (cal/cc) ^{1/2}	$[\eta]$ dlg ⁻¹	δ_m (cal/cc) ^{1/2}	$[\eta]$ dlg ⁻¹
10:0	11.3000	0.4293	11.3000	0.4293	—	—	—	—
9:1	11.0747	0.4887	11.0670	0.4685	—	—	11.1301	0.4248
8:2	—	—	—	—	10.6760	0.4256	—	—
7:3	10.6156	0.5296	10.4065	0.5070	10.4068	0.4969	10.7064	0.5129
6.5:3.5	—	—	10.2424	0.5529	—	—	—	—
6:4	10.3817	0.5781	10.0735	0.5642	10.2424	0.5468	10.3370	0.5729
5.5:4.5	—	—	9.9201	0.5879	—	—	—	—
1:1	10.1439	0.6107	9.7500	0.5696	9.9201	0.6399	10.1038	0.5805
4:6	9.9064	0.6411	9.4390	0.5570	9.7500	0.6328	9.8570	0.6047
3:7	9.5704	0.6070	9.1202	0.5017	9.4390	0.5948	9.6169	0.5983
2:8	—	—	8.8240	0.4621	9.1202	0.4901	9.4160	0.5368
1:9	9.1635	0.4304	—	—	8.7201	0.4233	—	—

the polymer coil provides a number of potential interaction sites which, as such, are not available in individual solvents.

In a poor solvent, polymer-solvent contacts, which promote miscibility, compete with polymer-polymer contacts and, as a result, either dissolution or precipitation occurs. However, in a cosolvent system, the polymer coil develops several different potential contact sites which in turn interact with appropriate solvent molecules; the combined S1-P and S2-P contacts lead to enhanced solvation of the chain. The size and type of solvent molecules and nature of contact sites are important factors in comparing the efficiency of cosolvents. In practical terms, it is suggested that cosolvent effects are likely to occur in blends of poor or non-solvents where each individual component favorably interacts with sets of different sites on the

polymer coil. Thus, cosolvency is found when component solvent molecules are dissimilar in polarity and possess functional groups of differing chemical nature or their other physico-chemical parameters differ from each other.

The criterion of cosolvency appears to be much more sound if the excess thermodynamic functions are also taken into consideration. It is suggested from the observations that almost all cosolvent mixtures could be characterized by high and positive excess Gibbs free energy of mixing, G_m^E implying that S1-S2 liquid contacts are energetically unfavorable^{4,5,51-53}. When $G_m^E > 0$ the two liquids are relatively incompatible and S1-P-S2 contacts are favored. The cosolvency is explained by incompatibility between liquids of the binary solvent mixture which prefer to interact more with the polymer molecule than with themselves. Dondos and Patterson³⁸ have found a good qualitative relationship between $\Delta[\eta]$ and G_m^E . $\Delta[\eta]$ is the difference between actual and ideal intrinsic viscosities of a polymer in binary solvent mixture.

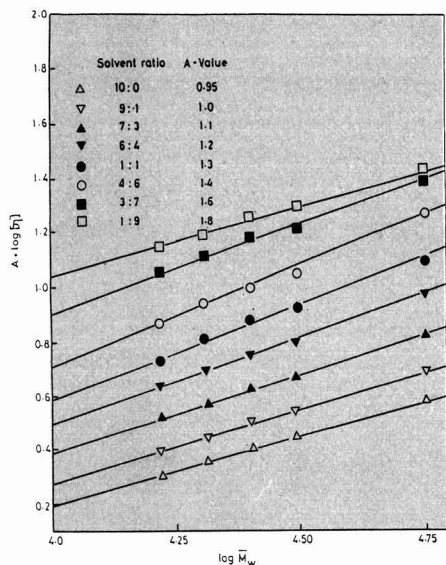


Figure 2—Plots of Mark-Houwink equation. Logarithmic dependence of intrinsic viscosity, $[\eta]$, on the molecular weight, M_w , of the polyamide fractions in n-butanol-toluene mixtures. "A" is an arbitrary constant used to displace plots for clarity

Intrinsic Viscosity and Cosolvency

Hydrodynamic properties of the polymer coil are influenced by synergistic action of cosolvents. One such property, intrinsic viscosity $[\eta]$, is found to depend on interactions among individual components in the cosolvent mixture. In Figure 1, plots of $[\eta]$ as a function of solvent composition attain maxima at certain cosolvent compositions where the resin has good compatibility and optimum interaction with cosolvent molecules. Several workers^{18, 54-56} observed similar features where the synergistic effects of cosolvents are manifested as maxima in the limiting viscosity number, $[\eta]$. Horta, et al.⁵⁷ observed that the replacement of cosolvent by a suitable non-solvent produced enhanced solubility and an increase in hydrodynamic volume of the solute. Similarly, values of $[\eta]$ of polyamide in various cosolvent mixtures are higher than the corresponding $[\eta]$ in pure solvent, i.e., butanol or chloroform (Figure 1). $[\eta]$ attains an optimum value with increasing content of non-solvent and then it decreases continuously with further increase of non-solvent (Table 1). The positive deviations in $[\eta]$ relative to the pure solvents indicate that the excess free energy of mixing,

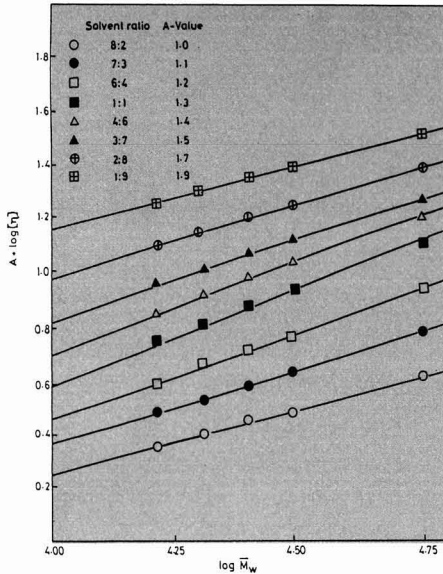


Figure 3—Plots of Mark-Houwink equation. Logarithmic dependence of intrinsic viscosity, $[\eta]$, on the molecular weight, M_w , of the polyamide fractions in cyclohexanol-cyclohexane mixtures. "A" is an arbitrary constant used to displace plots for clarity

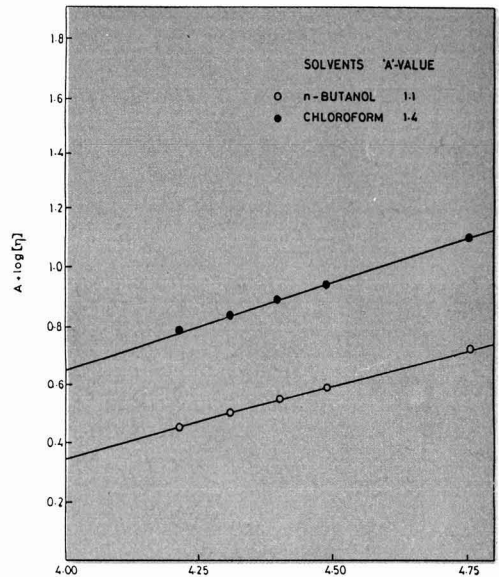


Figure 4—Mark-Houwink plots. Logarithmic dependence of intrinsic viscosity, $[\eta]$, on the molecular weight, M_w , of the polyamide fractions in individual solvents. "A" is an arbitrary constant used to displace plots for clarity

G_m^E of solvent mixture, is greater than zero, i.e., $G_m^E > 0$, for the cosolvent systems.

Cosolvency and Polyamide Solubility

Solubility of polyamide resin in cosolvents can be explained by taking into account thermodynamic and structural aspects of the polymer in solution. Primary solvents for polyamide are those organic liquids which contain electron-accepting groups such as alcohols, amines, and acids. In order to act as a solvent for polyamide, the solvent molecules must contain 3-4 carbon atoms and an electron-accepting group. Chloroform is an exception regarding the number of carbon atoms, but here polarity of the chlorine atom aids in the dissolution. Solubility of the resin is reduced if electron-accepting capacity of the solvent molecule is very high, e.g., it is insoluble in more

polar alcohols such as methanol, ethanol, cyclohexanol, and others. The dissolution of polyamide resin takes place only when the electron-accepting power and hydrocarbon solubilizing ability of solvent molecules are maintained suitably.

The observed cosolvency of blends of butanol-toluene, butanol-cyclohexane, cyclohexanol-cyclohexane, and cyclohexanol-toluene for polyamides can be explained by

considering the fact that the amidic $\begin{matrix} O & H \\ || & | \\ -C & -N- \end{matrix}$ group gets solvated by alcoholic groups. These alcohols have appropriate electron-accepting power and the interaction among their individual molecules is not so strong that they get weakened by the introduction of toluene or cyclohexane (non-solvent) molecules. The non-polar toluene and cyclohexane (hydrocarbon) molecules may cause a shift in the dissociation of polar butanol and

Table 2—Intrinsic Viscosity, $[\eta]$, Mark-Houwink Constants a and K , and Viscosity Expansion Factor, α_{η} ; Their Dependence on the Solubility Parameter, δ_m , of n-Butanol and Toluene Cosolvent Systems

Solvent Ratio	δ_m (cal/cc) ^{1/2}	$[\eta]$ dl g ⁻¹ of Different Polyamide Fractions					Mark-Houwink Constants		Expansion Factor α_{η}
		F_1 $M_w=57,237$	F_2 $M_w=30,813$	F_3 $M_w=25,371$	F_4 $M_w=20,499$	F_5 $M_w=16,517$	a	$K \times 10^4$ dl g ⁻¹	
10:0	11.3000	0.4293	0.3102	0.2832	0.2528	0.2257	0.50	17.478	1.0000
9:1	11.0747	0.4887	0.3470	0.3139	0.2788	0.2481	0.55	11.852	1.0441
7:3	10.6156	0.5296	0.3715	0.3325	0.2948	0.2625	0.59	8.379	1.0724
6:4	10.3817	0.5781	0.4018	0.3597	0.3169	0.2783	0.65	4.934	1.1042
1:1	10.1439	0.6107	0.4185	0.3715	0.3270	0.2903	0.70	3.238	1.1246
4:6	9.9064	0.6411	0.4450	0.3938	0.3468	0.3052	0.74	1.828	1.1430
3:7	9.5704	0.6070	0.4165	0.3702	0.3267	0.2890	0.67	3.941	1.2230
1:9	9.1635	0.4304	0.3100	0.2798	0.2488	0.2230	0.50	17.378	1.0080

Table 3—Intrinsic Viscosity, $[\eta]$, Mark-Houwink Constants a and K , and Viscosity Expansion Factor, α_η ; Their Dependence on Solubility Parameter, δ_m , of Cyclohexanol and Cyclohexane Cosolvent Systems

Solvent Ratio	δ_m (cal/cc) ^{1/2}	$[\eta]$ dl g ⁻¹ of Different Polyamide Fractions					Mark-Houwink Constants		Expansion Factor α_η
		F_1	F_2	F_3	F_4	F_5	a	$K \times 10^4$ dl g ⁻¹	
		$\bar{M}_w = 57,237$	$\bar{M}_w = 30,813$	$\bar{M}_w = 25,371$	$\bar{M}_w = 20,499$	$\bar{M}_w = 16,517$			
8:2	10.6760	0.4256	0.3103	0.2834	0.2538	0.2282	0.50	17.782	1.0000
7:3	10.4068	0.4969	0.3502	0.3138	0.2811	0.2490	0.56	10.779	1.0529
6:4	10.2424	0.5468	0.3759	0.3358	0.2994	0.2634	0.63	5.553	1.0871
1:1	9.9201	0.6399	0.4258	0.3775	0.3307	0.2917	0.72	3.854	1.1456
4:6	9.7500	0.6328	0.4227	0.3705	0.3315	0.2911	0.68	3.894	1.1413
3:7	9.4390	0.5948	0.4047	0.3613	0.3176	0.2800	0.60	9.204	1.1180
2:8	9.1202	0.4901	0.3532	0.3150	0.2750	0.2443	0.56	12.178	1.0481
1:9	8.7201	0.4233	0.3093	0.2812	0.2517	0.2264	0.50	17.579	1.0000

cyclohexanol (alcohol) molecules. The free butanol or cyclohexanol molecules develop (polymer-solvent) contacts with amidic sites of the polyamide chain breaking inter- and intra-chain hydrogen bondings. This causes breaking of polymer coil association and then the hydrocarbon portion of the chain skeleton is solvated by non-polar hydrocarbon solvent molecules. In this way, moderately hydrogen bonded polyamide chains are solvated by suitably designed cosolvent mixtures of polar alcohol and non-polar hydrocarbon molecules.

Coil expansion and $[\eta]$ are likely to be optimum when polymer-cosolvent interactions are maximum because of the balancing action of hydrogen bonding of solute and solvent molecules. Dissolution of the polymer in mixtures of non-solvents or poor solvents takes place as molecules of the two liquids tend to solvate the poly-

mer coil at different sites and result in reinforcement of solvation.

Cosolvency and Mark-Houwink Constants

Mark-Houwink constants a and K obtained from double logarithmic plots of $[\eta]$ vs \bar{M}_w (Figures 2-4) show large variations in their values with cosolvent compositions (Tables 2 and 3). Cosolvency power of each composition for polyamides can be assessed by taking into account changes in the values of exponent a . The value of a is minimum ($a = 0.5$) in butanol as well as in the 1:9 composition of butanol and toluene. In the case of the cyclohexanol-cyclohexane cosolvent system, $a = 0.5$ for the polyamide resin in its 8:2 and 1:9 compositions. This feature indicates the θ -state of resin solutions in these

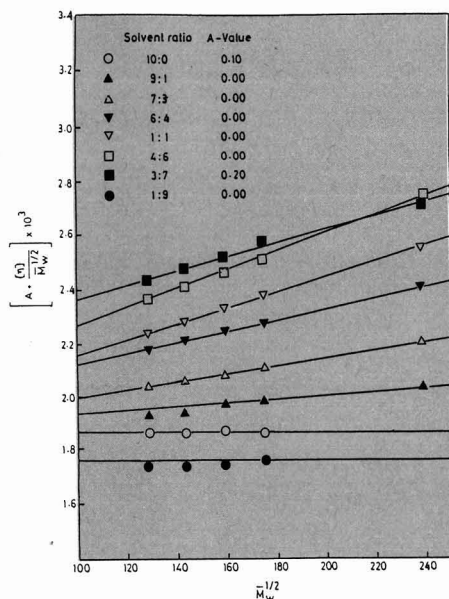


Figure 5—Plots of Stockmayer-Fixman equation. Determination of unperturbed dimensions of the polyamide fractions in n -butanol-toluene mixtures. "A" is an arbitrary constant used to displace plots for clarity

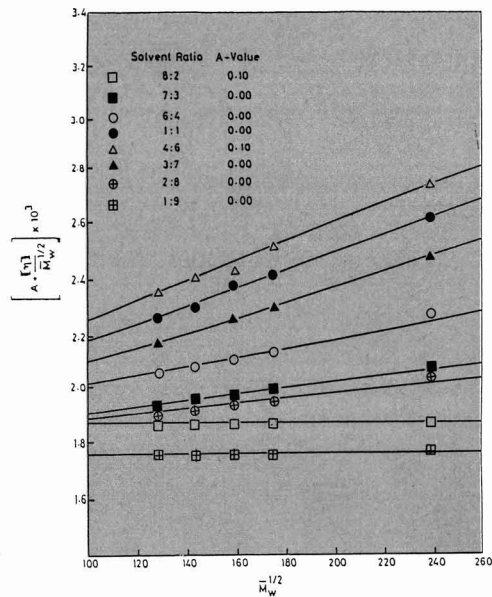


Figure 6—Plots of Stockmayer-Fixman equation. Determination of unperturbed dimensions of the polyamide fractions in cyclohexanol-cyclohexane mixtures. "A" is an arbitrary constant used to displace plots for clarity

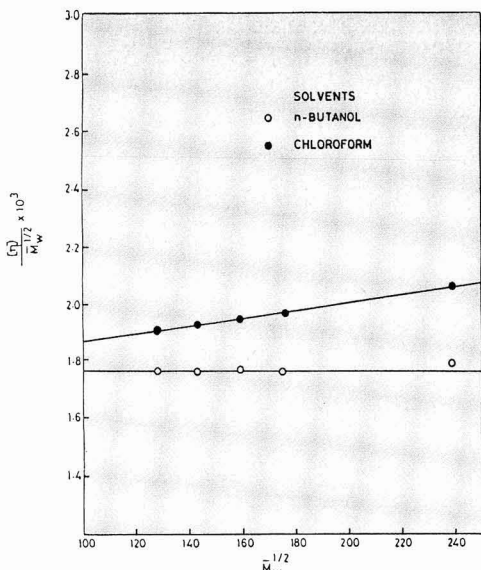


Figure 7—Stockmayer-Fixman plots. Determination of unperturbed dimensions of the polyamide fractions in single solvents. "A" is an arbitrary constant used to displace plots for clarity

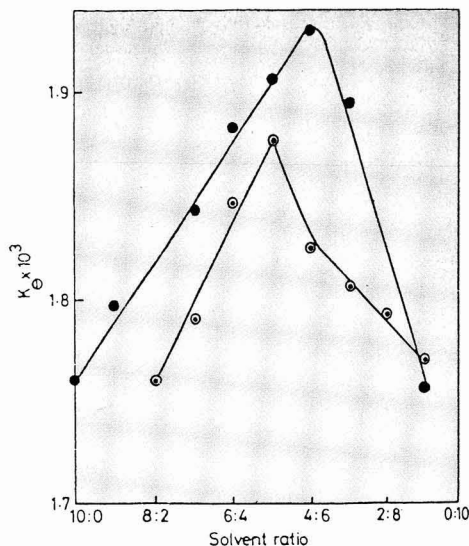


Figure 8—Dependence of unperturbed dimension, K_u , on the solvent ratio for polyamide in cosolvents. \circ —cyclohexanol-cyclohexane and \bullet —butanol-toluene cosolvent systems

cosolvent compositions where coils retain their unperturbed or compact conformations. Consequently, pure butanol, 1:9 butanol-toluene mixture and 8:2, and 1:9 cyclohexanol-cyclohexane mixtures are θ -cosolvent systems for the resin. In θ -state, polymer solution possesses zero partial molar free energy due to polymer-polymer and polymer-solvent interactions.⁵⁸ This is the limiting state of dissolution below which precipitation occurs as polymer-polymer interactions are more favored and lead to more compact or deswelled configurations of the coil and also to the tendency of intermolecular chain association.

The value of exponent a rises gradually above 0.5 and reaches the maximum of 0.74 in 4:6 butanol-toluene composition and 0.72 in 1:1 cyclohexanol-cyclohexane. This is because of the excluded volume effects induced by the cosolvency which expands the polymer coil besides disrupting the tendency of association. The gradual increase

of non-solvent content enhances polymer coil solvation and, after optimum expansion, further addition results in negative excluded volume effects due to the excessive presence of non-solvents and their repulsive effects.

The Mark-Houwink constant, K , is also found to vary with cosolvent compositions. For example, its value in butanol is $17.4 \times 10^{-4} \text{ dl g}^{-1}$ and, in 1:9 butanol-toluene, it is $17.3 \times 10^{-4} \text{ dl g}^{-1}$ which are θ -solvent compositions for polyamides. In 4:6 butanol-toluene, the best composition for polyamides value of K is $1.8 \times 10^{-4} \text{ dl g}^{-1}$. In θ -compositions of cyclohexanol-cyclohexane blends (8:2 and 1:9 compositions), values of K are $17.7 \times 10^{-4} \text{ dl g}^{-1}$ and $17.6 \times 10^{-4} \text{ dl g}^{-1}$. Whereas, in their best composition (1:1), $K = 3.8 \times 10^{-4} \text{ dl g}^{-1}$. In all cosolvent compositions, the high value of a and low value of K indicate the good cosolvency power of blends. When these values of a and K are compared with those of polyamide solutions in chloroform ($a = 0.60$

Table 4—Short-Range, Long-Range Interaction Parameters and Characteristic Ratio of Polyamide Resin: Their Dependence on the Solubility Parameter, δ_m , of n-Butanol and Toluene Cosolvent Systems

Solvent Ratio	δ_m (cal/cc) ^{1/2}	Short-Range Interaction Parameters		Long-Range Interaction Parameters		Characteristic Ratio C_∞	Total Sorption Potential Υ	
		$K_0 \times 10^4 \text{ dl g}^{-1}$	$\left(\frac{r_0^2}{M_w}\right) \times 10^{17}$	$B \times 10^{27} \text{ dl g}^{-2} \text{ mol}^2$	χ_m			$A_2 \times 10^4 \text{ dl mol g}^{-2}$
10:0	11.3000	17.600	6.1324	0.0000	0.5000	0.0000	75.50	0.0
9:1	11.0747	17.968	6.3853	1.0070	0.4809	3.0416	78.61	0.0120
7:3	10.6156	18.416	6.4167	1.5357	0.4635	4.6308	79.00	0.0150
6:4	10.3817	18.812	6.5547	2.1147	0.4444	6.3791	80.70	0.0670
1:1	10.1439	19.052	6.6383	2.9707	0.4388	8.9466	81.73	0.0380
4:6	9.9064	19.304	6.7261	3.4742	0.4138	10.4623	82.81	0.0280
3:7	9.5704	18.941	6.5996	2.6434	0.4195	7.9594	81.25	0.0070
1:9	9.1635	17.550	6.1149	0.0000	0.5000	0.0000	75.28	0.0

Table 5—Short-Range, Long-Range Interaction Parameters and Characteristic Ratio of Polyamide Resin: Their Dependence on the Solubility Parameter, δ_m , of Cyclohexanol and Cyclohexane Cosolvent Systems

Solvent Ratio	δ_m (cal/cc) ^{1/2}	Short-Range Interaction Parameters			Long-Range Interaction Parameters		Characteristic Ratio C_s	Total Sorption Potential Y
		$K_\theta \times 10^4$ dl g ⁻¹	$\left(\frac{r_o^2}{M_w}\right) \times 10^{17}$	$B \times 10^{27}$ dl g ⁻² mol ²	χ_m	$A_2 \times 10^4$ dl mol g ⁻²		
8:2	10.6760	17.600	6.1320	0.0000	0.5000	0.0000	75.49	0.0
7:3	10.4068	17.888	6.2327	1.2084	0.4877	1.2516	76.74	0.0195
6:4	10.2424	18.466	6.4341	1.7623	0.4849	1.8178	79.21	0.0350
1:1	9.9201	18.762	6.5372	4.6755	0.4320	4.8223	80.48	0.0550
4:6	9.7500	18.232	6.3526	3.4238	0.4616	3.5193	78.21	0.0610
3:7	9.4390	18.062	6.2933	2.7693	0.4713	2.8608	77.48	0.0860
2:8	9.1202	17.925	6.2456	0.9315	0.4929	0.9639	76.89	0.0800
1:9	8.7201	17.700	6.1672	0.0000	0.5000	0.0000	75.93	0.0

and $K = 7.0 \times 10^{-4}$ dl g⁻¹), it is found that cosolvent blends of 4:6 butanol-toluene and 1:1 cyclohexanol-cyclohexane have better solvency power for polyamide than that of chloroform.

The analysis of results indicates that excluded volume effects for polyamide in butanol-toluene solvent are more than that of the cyclohexanol-cyclohexane system or chloroform. This implies that solvency power of butanol-toluene > cyclohexanol-cyclohexane > chloroform for polyamides.

Cosolvency and the Viscosity Expansion Factor

The expansion of the hydrodynamic radius of polymer coil due to excluded volume has been estimated in terms of viscosity expansion factor, α_η :

$$\alpha_\eta^3 = \frac{[\eta]}{[\eta]_0} \quad (10)$$

Values of α_η for polyamide reported in Tables 2 and 3 show that, at a constant temperature, excluded volume is

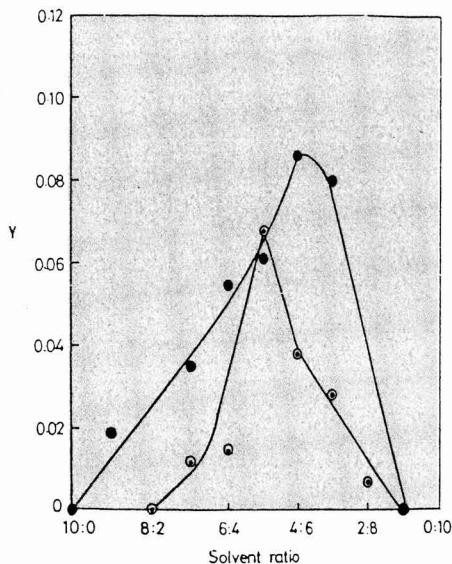


Figure 9—Dependence of total sorption potential, Y , on the solvent ratio for polyamide in cosolvents. ○—cyclohexanol-cyclohexane and ●—butanol-toluene cosolvent systems

a function of cosolvent composition. The value of α_η increases with cosolvent composition and it attains an optimum value of 1.143 in 4:6 composition of butanol-toluene and 1.145 in 1:1 cyclohexanol-cyclohexane. The value of α_η decreases after attaining the optimum value and it reaches to the minimum value ($\alpha_\eta = 1$) in θ -state of polyamide solutions in pure butanol, 1:9 butanol-toluene and 8:2, and 1:9 cyclohexanol-cyclohexane systems. The observations indicate that the polymer coil exhibits isothermal transition from a contracted conformation ($\alpha_\eta \leq 1$) to an expanded one ($\alpha_\eta > 1$) and back again to contracted state ($\alpha_\eta \leq 1$) on successive variations in cosolvent composition.

Cosolvency and Short-Range Interaction Parameters

Values of unperturbed dimension, K_θ , obtained from Stockmayer-Fixman plots (Figures 5-7) for polyamide are found to vary with the composition of cosolvents. It attains minimum value in θ -state of solution and reaches to the optimum in cosolvent mixtures having good interaction and compatibility with the resin. For example, K_θ values of 17.55, 17.6, 17.6, and 17.7 $\times 10^{-4}$ dl g⁻¹ in 8:2, 1:9 blends of cyclohexanol-cyclohexane and 1:9, and 10:0 butanol-toluene cosolvent systems show that they are θ -compositions. The optimum value of $K_\theta = 19.3 \times 10^{-4}$ dl g⁻¹ in 4:6 composition of butanol-toluene shows the high order of interaction and compatibility of the resin with the cosolvent mixture. Values of $K_\theta = 18.6 \times 10^{-4}$ dl g⁻¹ in chloroform and $K_\theta = 18.7 \times 10^{-4}$ dl g⁻¹ in 1:1 cyclohexanol-cyclohexane exhibit the intermediate level of interaction of solvents with the resin. These features are also illustrated in Figure 8.

Several workers^{27,28,59-68} have also observed variations in unperturbed dimensions for different polymers in binary solvents and correlated the same to the thermodynamic characteristic of cosolvent systems. To interpret the variation of K_θ with solvent composition in cosolvents, Dondos and Benoit⁶⁴ assumed that unperturbed dimensions of polymer coil depend on thermodynamic interactions between the two liquids. In case of cosolvents having positive G_m^E , the molecules of the two liquids repel each other and their interactions⁶⁷ tend to expand the polymer chain and result in an increase in the value of K_θ . Pouchly and Patterson⁶⁹ have interpreted

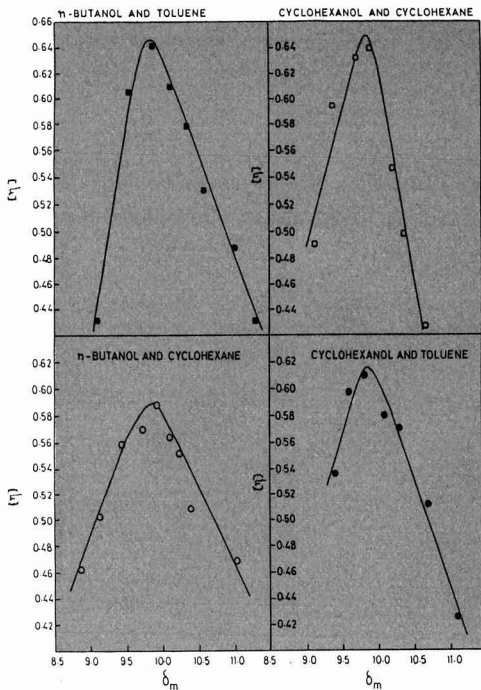


Figure 10—Dependence of intrinsic viscosity, $[\eta]$, of the polyamide solution on the solubility parameter, δ_m , of solvent blends

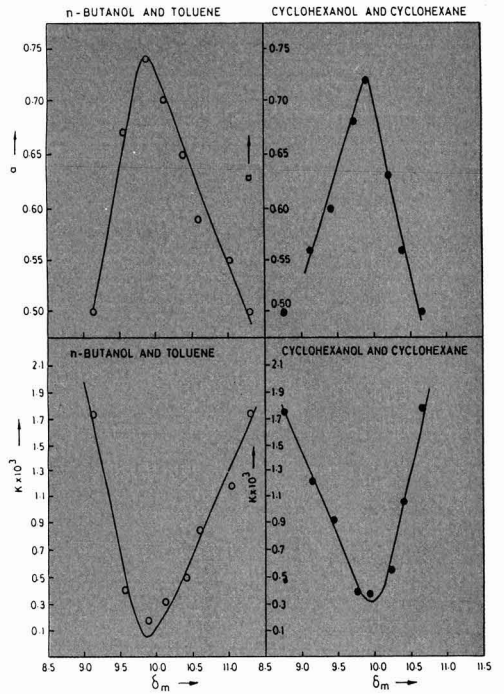


Figure 12—Dependence of Mark-Houwink constants a and K on the solubility parameter, δ_m , of solvent blends

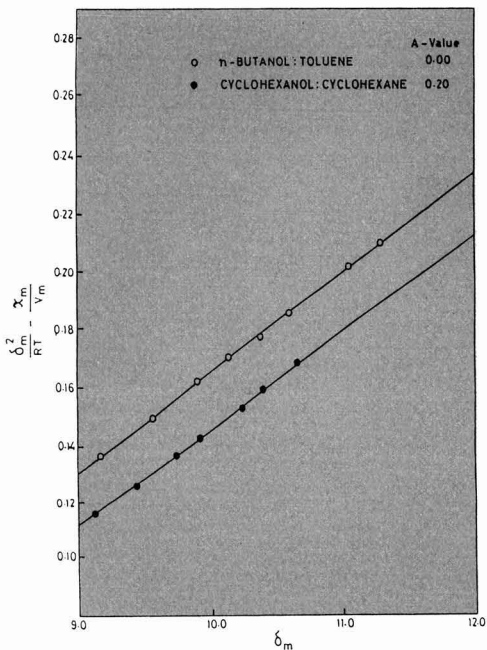


Figure 11—Plots of Lipson and Guillet equation. Interaction parameter, χ_m , vs the solubility parameter, δ_m , of different solvent blends. "A" is an arbitrary constant used to displace plots for clarity

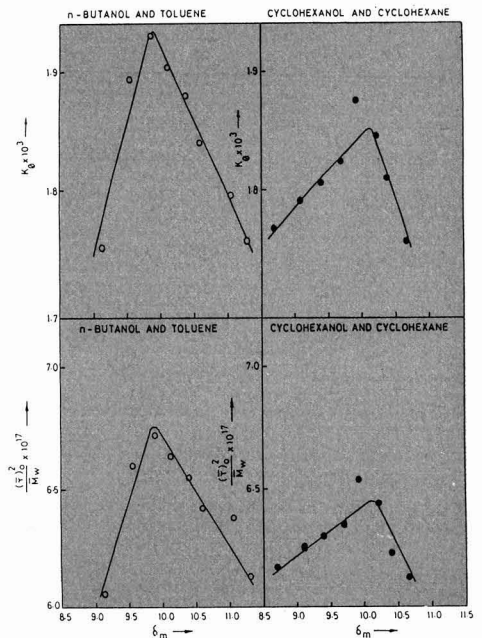


Figure 13—Dependence of unperturbed dimensions on the solubility parameter, δ_m , of solvent blends

variation of K_{θ} with cosolvent composition in terms of the long-range interaction parameter, χ_m . Variations in K_{θ} with cosolvent composition can be attributed to the preferential adsorption of individual solvent molecules on the polymer coil.

The characteristic ratio, C_{∞} , calculated by using equation (4) is also found to be influenced by cosolvent compositions (Tables 4 and 5). It has optimum value in cosolvent compositions which have good interactions with the resin and minimum value in θ -compositions.

Cosolvency and Long-Range Interaction Parameters

Data on the long-range interaction parameter, B, Flory-Huggins polymer-cosolvent interaction parameter, χ_m , and the second virial coefficient, A_2 , have been used in explaining the thermodynamic behavior of resin-cosolvent systems and cosolvency power of binary solvent mixture. In θ -state of solution or in the absence of excluded volume effects, values of parameters B and A_2 become 0 and $\chi_m = 0.5$. Whereas, with the increase of cosolvency power, values of B and A_2 increase and that of χ_m decreases. This is because the action of cosolvents produces large excluded volume effects and results in polymer coil expansion.

Values of long-range interaction parameters estimated by using equations (3), (5), and (6) are: B = 0, $\chi_m = 0.5$, and $A_2 = 0$ for polyamide in cosolvent mixtures of 10:0, 1:9 butanol-toluene and 8:2, and 1:9 cyclohexanol-cyclohexane indicate the θ -state of resin solution (Tables 4 and 5). Values of B = 3.47×10^{-27} dl g⁻² mol², $A_2 = 10.46 \times 10^{-4}$ dl mol g⁻², and $\chi_m = 0.4138$ in 4:6 butanol-toluene support the view that it is a good cosolvent system for the polyamide resin. Values of B = 3.42×10^{-27} dl g⁻² mol², $A_2 = 4.82 \times 10^{-4}$ dl mol g⁻², and $\chi_m = 0.4616$ in the 1:1 cyclohexanol-cyclohexane cosolvent system, indicate its intermediate solvency power for the resin. The results show that polymer coil expansion due to excluded volume effects varies from one cosolvent system to another. In one type of cosolvent system optimum cosolvency power for the resin is attained at a particular composition.

Cosolvency and Total Sorption Potential

The second virial coefficient, A_2 , is related to total sorption potential, Y, as ^{7,46}:

$$Y = \frac{V_m A_2}{v_2^2} \cdot \frac{1}{F(x)} \quad (11)$$

Where F(x) the excluded volume dependence is practically equated to unity.^{24,46} Values of Y reported in Tables 4 and 5 and plotted in Figure 9 show its variations with cosolvent compositions. Usually, optimum coil expansion occurs in mixed solvent compositions where there is no preferential adsorption. Y = 0.086 in 4:6 butanol-toluene and Y = 0.067 in 1:1 cyclohexanol-cyclohexane derived from equation (11) indicate their optimum cosolvency power. In these compositions, polymer-polymer contacts are minimum due to the cosolvent action. This is because individual solvent molecules in the cosolvent mixture solvate polymer coil at different sites. However,

total solvation is possible only in certain compositions. Any deviation in cosolvent composition leads to preferential adsorption of one liquid over the other and results in compact configuration of polymer coil due to negative excluded volume effects of non-solvent molecules. Consequently, solvency power of the mixture is adversely affected.

Cosolvency and Polymer Solubility Parameters

Because of its limited solubility in pure solvents, the solubility parameter of polyamide has been estimated by using cosolvent mixtures. The dependence of intrinsic viscosity, $[\eta]$, on the solubility parameter of cosolvent mixture, δ_m , (Figure 10) has been used for determining the solubility parameter of the resin. The solubility parameter of cosolvent mixture at $[\eta]_{\max}$ has been equated to that of the polymer since at this composition the polymer has good compatibility and maximum interaction with cosolvent mixture.⁷⁰ The solubility parameter of the polyamide resin obtained from maxima of plots in Figure 10 is 9.9 (cal/cc)^{1/2}.

The dependence of χ_m on δ_m , in accordance with the Lipson and Guillet equation (7), has been used for estimating the solubility parameter of the resin. The value of δ_p obtained from the slopes of plots in Figure 11 for polyamide resin is also found to be 9.90 (cal/cc)^{1/2}.

The dependence of solution parameters, a, K, K_{θ} , and $\left(\frac{r_0^2}{M_w}\right)$ on δ_m of cosolvent mixtures has also been used for determining the solubility parameter of the resin. Plots of a, K_{θ} , and $\left(\frac{r_0^2}{M_w}\right)$ as function of δ_m pass through a maximum, while those of K vs δ_m pass through a minimum (Figures 12 and 13). Polymer-solvent interactions are likely to be high in either maximum or minimum regions and corresponding δ_m is equated to that of the polymer. Solubility parameter values of the polyamide resin derived from these plots are equal to 9.90 (cal/cc)^{1/2}.

References

- (1) Prolongo, M.G., Masegosa, R.M., Hernandez-Fuentes, I., and Horta, A., *Macromolecules*, **14**, 1526 (1981).
- (2) Katime, I. and Ochoa, J.R., *European Polymer J.*, **20**, 99 (1984).
- (3) Ochoa, J.R., Caballero, B., Valenciano, R., and Katime, I., *Mater. Chem. Phys.*, **9**, 477 (1985).
- (4) Cowie, J.M.G. and McEwen, I.J., *J. Chem. Soc. Faraday Trans. I.*, **70**, 171 (1974).
- (5) Cowie, J.M.G. and McEwen, I.J., *Polymer*, **24**, 1449 (1983).
- (6) Ram Mohan Rao, M.V., "Study of Interaction and Other Physico-Chemical Parameters of Solvents and Polymeric Materials Used in Organic Coatings," Ph.D. Thesis, Osmania University, India (1986).
- (7) Wolf, B.A. and Blaum, G., *J. Polymer Sci., Polymer Phys. Edn.*, **13**, 1115 (1975).
- (8) Deb, P.C. and Palit, S.R., *Makromol. Chem.*, **128**, 123 (1969).
- (9) Horta, A. and Fernandez-Pierola, I., *Macromolecules*, **14**, 1519 (1981).
- (10) Horta, A. and Fernandez-Pierola, I., *Polymer*, **22**, 783 (1981).
- (11) Pouchly, J., Zivny, A., and Sok, K., *J. Polymer Sci., Part C*, **23**, 245 (1968).
- (12) Flory, P.J., *Discussions Faraday Soc.*, **49**, 7 (1970).
- (13) Prigogine, I., "The Molecular Theory of Solutions," North Holland Publishing Co., Amsterdam, 1957.
- (14) Patterson, D. and Delmas, G., *Discussions Faraday Soc.*, **49**, 98 (1970).

- (15) Pouchly, J. and Patterson, D., *Macromolecules*, 9, 574 (1976).
 (16) Horta, A., *Macromolecules*, 12, 785 (1979).
 (17) Deb, P.C. and Palit, S.R., *Makromol. Chem.*, 166, 227 (1973).
 (18) Radic, D., Boys, D., and Gargallo, L., *Polymer*, 18, 121 (1977).
 (19) Munk, P., Abijaoude, M.T., and Halbrook, M.E., *J. Polymer Sci., Polymer Phys. Edn.*, 16, 105 (1978).
 (20) Maillois, H., Bardet, L., and Gromb, S., *European Polymer J.*, 14, 1015 (1978).
 (21) Spychaj, T., Lath, D., and Berek, D., *Polymer*, 20, 437 (1979).
 (22) Cowie, J.M.G. and McCrindle, J.T., *European Polymer J.*, 8, 1325 (1972).
 (23) Deb, P.C., Prasad, J., and Chatterjee, S.P., *Makromol. Chem.*, 178, 1455 (1977).
 (24) Gargallo, L., Radic, D., and Katime, I., *European Polymer J.*, 16, 383 (1980).
 (25) Dondos, A., *European Polymer J.*, 12, 435 (1976).
 (26) Dondos, A. and Benoit, H., *J. Polymer Sci., Polymer Phys. Edn.*, 15, 137 (1977).
 (27) Vira, F., Viras, K., Aroni, F., and Dondos, A., *European Polymer J.*, 10, 891 (1974).
 (28) Gargallo, L., *Colloid Polymer Sci.*, 253, 288 (1975).
 (29) Houwink, R.J., *Prakt. Chem.*, 157, 15 (1941).
 (30) Flory, P.J. and Fox, T.G. Jr., *J. Am. Chem. Soc.*, 73, 1904 (1951).
 (31) Stockmayer, W.H. and Fixman, M., *J. Polymer Sci., Part C, I*, 137 (1963).
 (32) Kurata, M. and Stockmayer, W.H., *Fortschr. Hochpolymer. Forsch.*, 3, 196 (1963).
 (33) Inagaki, H., Suzuki, H., and Kurata, M., *J. Polymer Sci., Part A1*, 4, 409 (1966).
 (34) Flory, P.J., "Statistical Mechanics of Chain Molecules," Interscience, New York, 1969, pp. 36-38.
 (35) Smith, D.A., "Addition Polymers: Formation and Characterization," Butterworths, London, 1968.
 (36) Azim, A.A. and Huglin, M.B., *Polymer*, 25, 803 (1984).
 (37) Schultz, A.R. and Flory, P.J., *J. Polymer Sci.*, 15, 231 (1955).
 (38) Dondos, A. and Patterson, D., *J. Polymer Sci., Part A-2*, 7, 209, (1969).
 (39) Maldovan, L. and Strazielle, C., *Makromol. Chem.*, 140, 201 (1970).
 (40) Campos, A., Celda, B., Mora, J., and Figuerwelo, J.E., *Polymer*, 25, 1479 (1984).
 (41) Lipson, J.E.G. and Guillet, J.E., "Measurement of Solubility Parameters for Small Organic Solutes in Polymer Films by Gas Chromatography," *JOURNAL OF COATINGS TECHNOLOGY*, 54, No. 684, 89 (1982).
 (42) Gee, G., *Trans. Faraday Soc.*, 40, 465 (1944).
 (43) Scott, R.L. and Magat, M., *J. Chem. Phys.*, 13, 172 (1945).
 (44) Small, P.A., *J. Appl. Chem.*, 3, 71 (1953).
 (45) Huggins, M.L., *J. Am. Chem. Soc.*, 64, 2716 (1942).
 (46) Cowie, J.M.G. and McCrindle, J.T., *European Polymer J.*, 8, 1185 (1972).
 (47) Palit, S.R., Colombo, G., and Mark, H., *J. Polymer Sci.*, 295, (1951).
 (48) Cowie, J.M.G. and McEwen, I.J., *Macromolecules*, 7, 291 (1974).
 (49) Schuster, R.H., Cantow, H.J., and Klotz, S., *Polymer Bull.*, 8, 351 (1982).
 (50) Wolf, B.A., *Makromol. Chem.*, 179, 2265, (1978).
 (51) Brown, I. and Smith, F., *Australian J. Chem.*, 7, 269 (1954).
 (52) Das, N. and Palit, S.R., *J. Polymer Sci.*, A2, 7, 209 (1969).
 (53) Fernandez-Pierola, I. and Horta, A., *J. Chem. Phys.*, 77, 271 (1980).
 (54) Burrell, H., *Official Digest*, 27, 726 (1955).
 (55) Prolongo, M.G., Masegosa, R.M., Hernandez-Fuentes, I., and Horta, A., *Polymer*, 25, 1307 (1984).
 (56) Gargallo, L. and Radic, D., *Polymer Commn.*, 26, 149 (1985).
 (57) Horta, A., Prolongo, M.G., Masegosa, R.M., and Hernandez-Fuentes, I., *Polymer*, 22, 1147 (1981).
 (58) VanKrevelen, D.W. and Hoftyzer, P.J., *J. Appl. Polymer Sci.*, 11, 1409 (1967).
 (59) Elias, H.G. and Etter, O., *Makromol. Chem.*, 66, 56 (1963).
 (60) Cowie, J.M.G. and Bywater, S., *J. Makromol. Chem.*, 1, 581 (1966).
 (61) Dondos, A. and Benoit, H., *European Polymer J.*, 4, 561 (1968).
 (62) Dondos, A. and Benoit, H., *Makromol. Chem.*, 129, 35 (1969).
 (63) Dondos, A. and Benoit, H., *European Polymer J.*, 6, 1439 (1970).
 (64) Dondos, A. and Benoit, H., *Macromolecules*, 4, 279 (1971).
 (65) Vira, F., Viras, K., Aroni, F., and Dondos, A., *European Polymer J.*, 10, 891 (1974).
 (66) Ram Mohan Rao, M.V. and Yaseen, M., *JOURNAL OF COATINGS TECHNOLOGY*, 58, No. 743, 49 (1986).
 (67) Dondos, A., Rempp, D., and Benoit, H., *J. Polymer Sci.*, (c), 30, 9 (1970).
 (68) Dondos, A. and Benoit, H., *Macromolecules*, 6, 242 (1973).
 (69) Pouchly, J. and Patterson, D., *Macromolecules*, 6, 465 (1973).
 (70) Song, W.R. and Brownawell, D.W., *Polymer Eng. and Sci.*, 10, 222 (1970).

APPENDIX

DATA TREATMENT PROCEDURES

SOLUBILITY PARAMETERS OF SOLVENT MIXTURE, δ_m : δ_m was calculated by substituting volume fractions ϕ_1 , ϕ_2 and solubility parameters δ_1 , δ_2 of individual solvents in equation (8).

INTRINSIC VISCOSITY, $[\eta]$: Dilute solution viscosity measurements provide data on flow rate of solvent (t_0) and resin solution (t_1). Specific viscosity η_{sp} is calculated as:

$$\eta_{sp} = \left(\frac{t_1 - t_0}{t_0} \right)$$

Extrapolation of the plot of reduced viscosity, $\frac{\eta_{sp}}{c}$, vs concentration, c , to infinite dilution provides $[\eta]$ in accordance with equation (9).

MARK-HOUWINK CONSTANTS a and K : On taking logarithms, equation (1) becomes $\log [\eta] = \log K + a \log M_w$. a and K are obtained from the slope and intercept of the plot of the equation.

VISCOSITY EXPANSION FACTOR: This can be derived from equation (10) in which $[\eta]_0$ is the value of intrinsic viscosity in theta solvent when $a = 0.5$ and $[\eta]$ is the intrinsic viscosity in non-theta solvents.

SHORT-RANGE INTERACTION PARAMETERS: Stockmayer-Fixman equation (3) has been used for estimating the short range interaction parameters, K_θ , and was obtained from the intercept of the plot of $\frac{[\eta]}{M_w^{1/2}}$ vs M_w [equation (3)]. K_θ is the value of the Mark-

Houwink constant K in theta solvent. $\left(\frac{r_0^2}{M_w} \right) = \left(\frac{K_\theta}{\phi} \right)^{2/3}$ where ϕ is the Flory universal viscosity constant.

LONG-RANGE INTERACTION PARAMETERS: Values of B were derived from the slope of the Stockmayer-Fixman equation (3) plots. χ_m is obtained by substituting B , partial molar specific volume of resin v_2 , molar volume of solvent mixture v_m , and Avagadro's number N_0 in equation (5). The partial molar specific volume of the resin was calculated from the relationship:

$$\text{Partial molar specific volume} = \frac{\text{soln. volume} - \text{solvent volume}}{\text{wt of resin}}$$

The second-virial coefficient, A_2 , was calculated by substituting values of \bar{v}_2 , V_m , and χ_m in equation (6).

CHARACTERISTIC RATIO: C_∞ was calculated by substituting values of K_θ , ϕ , molecular weight of repeating unit M_b , and bond length l in equation (4).

TOTAL SORPTION POTENTIAL: Total sorption potential was calculated by substituting V_m , A_2 , and \bar{v}_2 in equation (11) where the function $F(X) = 1$.



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Chemiluminescence Analysis: A New Quality Assurance Tool For Thermosetting Coatings

J. Philip Hysell and Joseph A. Farmer
Hi-Tek Polymers, Incorporated*

Chemiluminescence Analysis is described as a method for the determination of nitrogen in thermosetting coatings systems. Its superiority to the Kjeldahl technique in the areas of simplicity, speed, and safety is discussed. These advantages may make it an obvious choice for the quality control laboratories of coatings manufacturers who would like to verify or certify the level of nitrogenous crosslinker in every batch prior to shipment.

INTRODUCTION

Finding efficient and economically feasible ways of making certain that a product or raw material meets customer's requirements can be a difficult task. Ideally, a test should be fast enough to permit a smooth transition through the various checkpoints of the coating's manufacturing process or, for the user, fast enough to allow a correction before hundreds of dollars worth of unuseable coated product is generated. The test should also be simple and safe enough for plant quality control personnel to handle with a reasonable amount of training.

From this standpoint, certifying the level of nitrogenous crosslinker in a thermoset coating system could be a serious problem in many quality control laboratories, particularly if these labs had to rely on the classic Kjeldahl nitrogen analysis.¹ Although very dependable and accurate, the Kjeldahl technique requires the use of boiling sulfuric acid, heavy metal catalysts, and a hood to withdraw the fumes generated. It can also be extremely labor intensive and time consuming. Waste disposal can be an additional concern.

However, more than 10 years ago, workers in the petroleum industry began using a nitrogen analysis method based on combustion and chemiluminescence to monitor the purity of various petroleum fractions.² Since that time, the technology has found its way into applications for dairy and agricultural products, wastewater, lubricants, and drugs. Instrumentation is now commercially available to perform such analyses routinely.

BASIC OPERATION OF THE CHEMILUMINESCENCE INSTRUMENTATION

The technique involves the controlled combustion of a nitrogenous compound above 1000°C in an oxygen atmosphere, with the subsequent production of water, carbon dioxide, and nitric oxide. *Figure 1* is a schematic diagram depicting what occurs chemically within the chemiluminescence instrumentation. The sample undergoes a two-stage controlled combustion process, the first stage taking place in a partial oxygen atmosphere (chamber 1) and the second in a pure oxygen environment (chamber 2). This reduces the possibility of explosive decomposi-

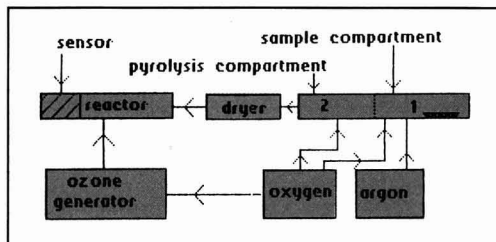
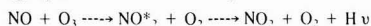


Figure 1—Schematic of chemiluminescence nitrogen analyzer

*Technical Center, 9800 E. Bluegrass Parkway, P.O. Box 99038, Jeffersonstown, KY 40299.

tion. A microprocessor controlled furnace with temperature ramping capability further adds to this control by allowing a stepwise, incremental temperature increase to gently boil off solvents before going to a "pre-burn" stage to prepare the sample for outright pyrolysis.

Once the sample is pyrolyzed (chamber 2), the gases are fed through a dryer to remove water and finally into a reaction chamber. Also fed to the reaction chamber is ozone gas from an internal generator. When the nitric oxide from the combustion process reacts with the ozone, it forms unstable nitrogen dioxide. This unstable species quickly releases its energy in the form of light to return to a stable state. The emitted light is detected and amplified by a photomultiplier tube in the reaction chamber. The following equation shows the sequence of reactions:



Many of the chemiluminescence applications in current use deal with parts per million or, at most, a few tenths of a percent nitrogen. Since most thermoset coatings systems contain crosslinking materials with very high nitrogen levels, this presented a problem which is the opposite of that usually faced by an analytical chemist. The instrumentation possessed too high a sensitivity for this type product. This was easily remedied by the manufacturer by placing a small, permanent mask over the photomultiplier window to block out most of the light emitted by the usually high levels of unstable nitrogen dioxide.

The instrument utilized for this work was the Antek Model 707C Pyrochemiluminescence™ Analyzer. This system consists of a Model 772C furnace, a Model 730C microcontroller, and a Model 720C detector.

APPLICATION OF CHEMILUMINESCENCE TO THERMOSET COATINGS

To show the applicability of chemiluminescence to the monitoring of crosslinker levels in coatings, three different types were selected: two solvent-based coatings and one water-borne coating. One of the two solvent-based coatings was pigmented, while the other coatings were unpigmented. All were comprised of epoxy resin and an alkylated melamine formaldehyde crosslinker and will be referred to as coating A, coating B, and coating C.

Unlike the Kjeldahl analysis, the chemiluminescence method does not give an absolute nitrogen value. Instead, a photomultiplier tube response, usually read as thousands of counts on a digital meter, is obtained. This value in itself, expressed in relationship to milligrams of a

Table 1—Kjeldahl vs Chemiluminescence Nitrogen Results—Effects of Coating Type on Precision and Accuracy

Coating	Type	Kjeldahl Nitrogen (%)	Chemiluminescence Nitrogen (%)	RSD* (%)
A	Solvent-based epoxy/melamine unpigmented	0.88	0.89	3.6
B	Solvent-based epoxy/melamine pigmented	0.67	0.68	2.5
C	Water-borne epoxy/melamine unpigmented	0.85	1.12	2.2

(a) Relative standard deviation of chemiluminescence measurements.

coating, would be perfectly acceptable for QA purposes once a permissible range had been established with regard to coating performance. However, if a customer requires certification of a specific nitrogen level in the product, then the response has to be correlated with an actual nitrogen value from another analytical source. To accomplish the latter, a sample of the solvent-based, unpigmented coating A was analyzed via the Kjeldahl procedure. This material was then used as a control with which to evaluate the other products. The results of these analyses are shown in Table 1.

In the course of this work, several things were learned which may be used as guidelines in method development. Samples can sometimes be diluted with acetone or water to reduce the nitrogen level to within the instrument's operating range. A nitrogen level that is too high or too low may result in a nonlinear photomultiplier response. The dilution also allows more precise weighings to be made to the quartz sample boat. Although dilution was not feasible for the coatings studied here, the optimum loading was found to be approximately 10-40 milligrams of coating having a one percent or less nitrogen content. Direct weighings using a four place analytical balance were acceptable.

REPRODUCIBILITY AND SIMPLICITY OF THE CHEMILUMINESCENCE TECHNIQUE

In addition to determining the correlation of the chemiluminescence analysis with Kjeldahl, the reproducibility of the technique under varying conditions was also evaluated. Three key points become apparent when looking at the data in Table 1. The reproducibility of the chemiluminescence method is excellent. Twenty-one determinations on coating A exhibited a relative standard deviation (RSD) of 3.6%. The second point is that pigmentation had no effect on the nitrogen values obtained from the chemiluminescence analysis. Coating B, the pigmented system, showed the same excellent correlation with Kjeldahl and reproducibility as good as the unpigmented coating A. Finally, coating C, the water-borne system, did not behave the same as the solvent-based systems even though the reproducibility was still very good. The apparent nitrogen levels for the water-borne coatings were

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consistently higher via the chemiluminescence technique than those obtained with the Kjeldahl method, even considering the nitrogen from amines present in the water-borne coatings.

Contrarily, others who have worked with chemiluminescence^{2,3} have reported a reduced response for nitrogen in water-containing systems. This was theorized to be due to the fact that water, unlike solvent carriers, did not produce enhanced temperatures at the burner tip in the combustion process. Indeed, Jones and Daughton felt that their use of a 1100°C furnace temperature eliminated this difference.

It should be pointed out that there are several variables which can be changed in order to tailor the chemiluminescence instrumentation to a particular product type.⁴ These include oxygen and argon flow rates, temperature of the pyrolysis compartment, ozone generator flow rate, sample compartment temperature, and carrier solvent.

Since it was highly desirable to develop a single method which a quality control laboratory could utilize for as many coating types as possible, all these variables were optimized in a fixed set, which included a single furnace temperature profile. Then, a simple factor was developed to address the different detector responses for the solvent-based and water-borne products. The furnace profile represents only the temperature of the sample furnace compartment (chamber 1 in Figure 1). A fixed temperature, 1050°C, is maintained in the pyrolysis compartment of the equipment which immediately follows the sample compartment (chamber 2 in Figure 1). It is important to start at a temperature that will not cause violent sample vaporization or explosive decomposition. The temperature profile shown was designed to allow sample decomposition, including solvent and/or water loss, to take place gradually. It represents a compromise of parameter settings to accommodate a wide range of both solvent-based and water-borne coatings systems without further modification. As can be seen from Figure 2, the entire

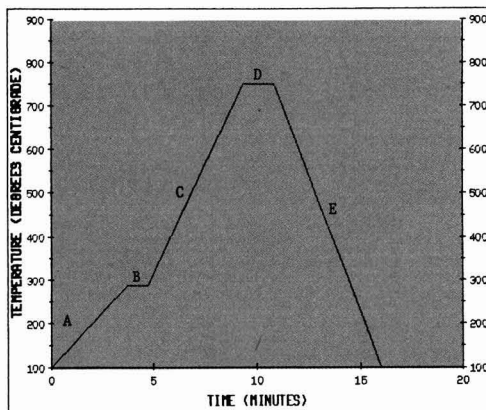


Figure 2—Profile of chemiluminescence sample oven heating and holding periods. Legend: A—First heating ramp starting at 100°C and increasing to 285°C at a rate of 50°C/min; B—30 sec hold period at 285°C; C—Second heating ramp from 285°C to 750°C at a rate of 100°C/min; D—90 sec hold period at 750°C; and E—Cool down to 100°C

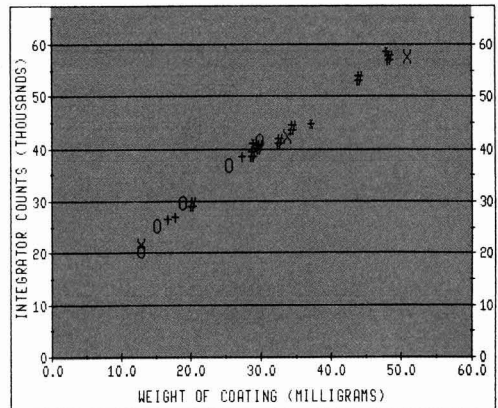


Figure 3—Reproducibility of chemiluminescence technique shown by plot of three operators' results over period of about one month. Legend: # = 5/14, operator 1; * = 5/15, operator 2; X = 5/26, operator 1; O = 6/16, operator 2; and + = 6/17, operator 3

cycle from heat-up to cool down is completed within about 16 minutes.

The real test of the chemiluminescence methodology came about when several lab personnel were allowed to generate data over several days with minimal training. Figure 3 shows the results from this study. The work included that of three different operators in five different days over a period of one month. Average training time was usually about one to two hours. Analysis of the data plotted in Figure 3 shows excellent linearity between 10 and 50 milligrams of coating, with a correlation coefficient of better than 0.99.

Experience has shown that the instrument maintains its calibration extremely well. The detector counts obtained from a specific sample are normally reproducible within plus or minus three percent from one day to the next. Generating a standard curve about once every week using three Cymel standards containing nitrogen levels 10 or 20% above and below the analyte should be sufficient if the instrument is kept in a standby mode. If the instrument is shut down to a cold start state, then a recalibration would be needed more often.

SELECTION OF A CONTROL MATERIAL

Once the chemiluminescent approach to nitrogen analysis for thermoset coatings was shown to be feasible, a decision was made to develop a method that would incorporate the use of a more appropriate standard material. Since it was desirable to maintain a control matrix which was as close as possible chemically to that found in the coatings and which would be readily available, Cymel 303®, a methylated melamine formaldehyde from American Cyanamid, was chosen.

Figure 4 shows the standard curve prepared from a series of injections of from 1 to 15 microliters of an acetone solution of Cymel 303. The Cymel was characterized by Kjeldahl analysis as having 22.7% nitrogen. Each injection of a certain amount of the Cymel 303

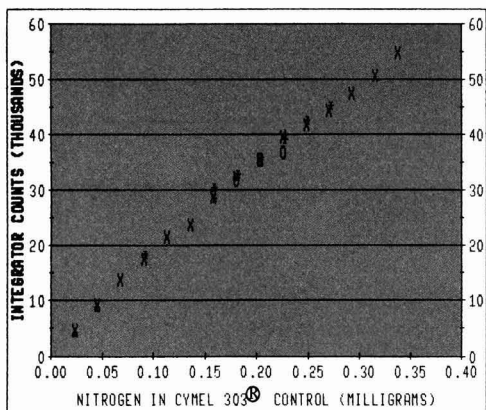


Figure 4—Plot of responses obtained from injections of varying concentrations of Cymel 303® showing excellent linearity of standard curve. Legend: X = First injection series; O = Duplicate injections of X; and * = Second injection series

could therefore be related to a specific amount of nitrogen and plotted as such. Although a slight nonlinear nature is present in the curve, there is not enough to cause a problem as long as one operates within a reasonable span of the curve. The minimal scatter of multiple injections made at several points on the curve indicates a consistent, reproducible integrator response. The correlation coefficient of the plot is better than 0.998.

Table 2 shows the results of using Cymel 303 as the nitrogen control. Three lots each of coating A and coating C were analyzed several times by both the chemiluminescence technique and the Kjeldahl method. Correlating integrator counts obtained from the chemiluminescence

instrument for the two coatings systems with those obtained from the Cymel 303 standard curve produced the values shown.

Since the photomultiplier response for the nitrogen in coating A was identical to that for the nitrogen in the Cymel 303, the percent nitrogen content could be determined from the standard curve shown in Figure 4 without the use of a factor. However, as was pointed out in the earlier example, coating A (the water-borne system) gave an enhanced nitrogen count. Therefore, to obtain the true nitrogen content, each value derived from the standard curve had to be multiplied by a factor. This factor was determined by dividing the Kjeldahl nitrogen result by the apparent nitrogen level from the chemiluminescence analysis. The average value of this factor, derived from the three sets of determinations, was 0.78. In future analyses, one can use this factor without resorting to rerunning the Kjeldahl test. If needed, a factor can be developed for any coating system. Whether or not this is necessary should be the first judgment made in the process of adapting the chemiluminescence technique to each new thermoset coating system. Therefore, according to the data derived from this experiment, the actual equations that a quality control laboratory would then need to use to determine the nitrogen in future batches of these two coatings are shown at the bottom of Table 2.

Although it was not tried, it would appear that by utilizing the versatile temperature programming capabilities of the chemiluminescence analyzer, one could selectively pyrolyze lower boiling nitrogenous components such as amines first and then proceed to the higher boiling nitrogenous components. This would provide additional QA certification information for products containing several sources of nitrogen. This will be the subject of future work with this instrumentation.

Table 2—Comparison of Kjeldahl and Chemiluminescence Nitrogen Results Using Cymel 303 as a Control

Coating System	Chemiluminescence Nitrogen (%)	RSD (%)	Kjeldahl Nitrogen (%)	Factor
Coating A (Using calculation 1 below)				
Lot 1	0.87	3.5	0.89	—
Lot 2	0.89	2.5	0.90	—
Lot 3	0.88	2.5	0.87	—
Coating C (Also using calculation 1 below for comparison)				
Lot 1	1.10	4.1	0.87	0.79
Lot 2	1.09	1.8	0.85	0.78
Lot 3	1.05	0.8	0.81	0.77
			Avg.	0.78

Calculations which would be used by the QA laboratory to determine nitrogen levels in future batches of the thermoset coating systems shown above:

$$(1) \frac{\text{mg of nitrogen from graph in Figure 4}}{\text{mg of solvent-based coating}} \times 100 = \% \text{ N}$$

$$(2) \frac{\text{mg of nitrogen from graph in Figure 4}}{\text{mg of water-borne coating}} \times 100 \times 0.78 = \% \text{ N}$$

Note: The numerator of each equation would be determined by matching the chemiluminescence detector response from the pyrolysis of each coating with the milligrams of nitrogen from the graph in Figure 4.

CONCLUSIONS

Chemiluminescence analysis has been utilized for a number of years in the petroleum, agriculture, and drug fields for the determination of nitrogen content in these types of products. The work discussed in this paper shows the technique to be a safer, faster, and easier approach than the standard Kjeldahl method for maintaining quality assurance standards of nitrogenous water-borne and solvent-based thermoset coatings systems. At the same time, it maintains the proven accuracy and precision characteristics of the Kjeldahl analysis.

References

- (1) Bradstreet, R.B., "The Kjeldahl Method for Organic Nitrogen," Academic Press, New York and London, 1965.
- (2) Drushel, H.V., "Determination of Nitrogen in Petroleum Fractions by Combustion with Chemiluminescence Detection of Nitric Oxide," *Anal. Chem.*, 49, No. 7, 932 (1977).
- (3) Jones, B.M. and Daughton, C.G., "Chemiluminescence vs Kjeldahl Determination of Nitrogen in Oil Shale Retort Waters and Organonitrogen Compounds," *Anal. Chem.*, 57, No. 12, 2320 (1985).
- (4) Shay, J.Y. and Woodward, P.W., "A Chemiluminescent Method for Determination of Nitrogen Content of Petroleum Residua," *International Laboratory*, 38 (January/February 1987).

Concept of Intrinsic Viscosity And Its Practical Significance

Diana R. Provder*
Kent State University

The intrinsic viscosity of three acrylic acid-type copolymers was studied as a function of pH. The classical problem of the curvature, encountered in extrapolating reduced viscosity values to infinite dilution, was alleviated by using an ideal time value for solvent flow obtained by doing a least squares plot on concentration vs time data. From the molecular weight dependence of the hydrodynamic volume, the Mark-Houwink constants were determined. Results indicated that the copolymers approximated a rigid rod structure at a pH of 8.7.

INTRODUCTION

Characterization of polymer chain size as a function of environment is important for understanding polymer/solvent interactions. This basic knowledge is important for understanding the relationship between coatings formulation and application properties. Dilute solution viscosity is an excellent way to probe polymer chain size as a function of environment. Dilute solution viscometry is widely used for the characterization of polymer molecular weight because simple instrumentation is required and measurements are rapid and precise. The viscosity of a polymer in solution is higher than that of the pure solvent. The viscosity increase depends on the temperature, the nature of the solvent and the polymer, the polymer concentration, and the sizes of the polymer molecules.¹ The polymer solution has a higher viscosity than the solvent because the polymer solution is composed of many macromolecules, each surrounded by solvent molecules. In this study, acid functional polymers are studied as a function of ionic strength, concentration, and pH.

THEORY

A suspended particle or macromolecule in solution is wetted by the fluid. The suspension is so dilute that the disturbance of the flow pattern of the suspended medium by one particle does not overlap with that caused by another particle.¹ When a fluid alone flows through a tube, the tube's dimensions are large compared to the fluid elements. The fluid's velocity is stationary on the walls of the tube and flow is fastest in the center of the tube. Equation (1) illustrates that when one layer of fluid moves faster than the next layer, it undergoes a retarding force, F , which is due to intermolecular attractions between the two layers.¹

$$F = \eta (dv/dr) A \quad (1)$$

Equation (1) defines η as the coefficient of viscosity, A as the innerlayer area, and dv/dr as the velocity gradient. A fluid that has flow obeying equation (1) is denoted as a Newtonian fluid. When a particle is suspended in solution and flowing down a tube, it also is rotating. "Since the particle surface is wetted by the liquid, its rotation brings adhering liquid from a region with one velocity into a region with another velocity and into a volume element which is flowing at a different speed."¹ The resulting readjustments of momenta cause an expenditure of energy which is greater than that required to keep the same volume of fluid moving with the particle velocity gradient, and with the suspension medium.¹ Equation (2) is Einstein's explanation for the viscosity increase

$$\eta = \eta_0 (1 + \omega\phi) \quad (2)$$

where η is the suspension viscosity, η_0 is the suspending liquid viscosity, ϕ is the volume fraction of the suspended material, and ω is a factor that depends on the shape of the solvated macromolecule.¹

A polymer in solution can be related to the suspended particle in solution in the sense that the polymer in solution has a higher viscosity than just the solvent. The

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Table 1—Material Parameters for S/αMS/AA Copolymers

Sample	Molecular Weight (g/mole)	Acid Number	T _g (°C)
A	10,000	190 ± 10	102
B	8,000	200 ± 10	104
D	4,900	215 ± 10	84

polymer usually exists in solution as a random coil in which the solvent can get trapped, which causes the polymer and solution not to reach the velocities attained by the solvent alone. The radius of a suspended particle is constant, whereas the volume and shape of a polymer coil is constantly changing because there is free rotation about the single bonds of the chain. Equation (3) shows that the solvent-swollen polymer can be taken to be equal to the equivalent smaller, spherical particle,

$$\eta/\eta_0 - 1 = 2.5\omega \tag{3}$$

where ω in equation (2) is 2.5.

Solution viscosities are measured in very dilute solution approximating infinite dilution conditions, so molecules are far enough apart in order to eliminate the effects of macromolecule-macromolecule interaction. The intrinsic viscosity (η) is defined in equation (4).

$$(\eta) = \lim_{c \rightarrow 0} (1/c) (\eta - \eta_0/\eta_0) = \lim_{c \rightarrow 0} 2.5N_0 V/M \tag{4}$$

This equation defines V as the equivalent volume of the solvated molecule, M is the molecular weight, and N₀ is

Avogadro's number. This equation shows the contribution of the polymeric solute to the intrinsic viscosity to be the difference between the viscosity of the mixture and that of the solvent.¹

When a polymer is in its theta (θ) condition, the polymer coil is not perturbed by the solvent and, therefore, it is not in a contracted or expanded state. Equation (5) shows the relationship of intrinsic viscosity to the molecular weight at theta conditions,

$$(\eta)_\theta = K_\theta M^{0.5} \tag{5}$$

where K_θ is a constant for c specific temperature, polymer type, and solvent.² In a theta solvent, the exponential value of the molecular weight is 0.5. This value is a measure of the interaction of the solvent and polymer. If a polymer is in a good solvent, it will expand and the exponential value of the molecular weight can be greater than 0.5.

Staudinger was the first to cite the viscosity of polymer solutions as evidence of their long-chain and high molecular weight character. He wrote $\eta = KcM$.⁴ Staudinger's equation implied that the reduced viscosity is independent of concentration, which is known today to be incorrect. Later, Staudinger's equation was modified, as shown in equation (6),

$$(\eta) = KM^a \tag{6}$$

which is known as the Mark-Houwink equation, where K and a are empirical parameters and M_v is the viscosity average molecular weight of the polymer.² Equation (6) illustrates the dependence of intrinsic viscosity on molecular weight.

The intrinsic viscosity of a polymer can be related to a molecular volume through the Flory-Fox relation,¹

$$(\eta) = \phi (\bar{S}^2)^{3/2}/M \tag{7}$$

where \bar{S}^2 is the radius of gyration, ϕ is a constant, and M is the molecular weight. From equations (4) and (7), it can be seen that the product $[(\eta)M]$ is dimensionally

NOMENCLATURE

η	.....	Coefficient of viscosity
η_0	.....	Suspending liquid viscosity
ω	.....	Factor depending on shape of solvated macromolecule
ϕ	.....	Volume fraction of suspended material
c	.....	Concentration
N ₀	.....	Avogadro's number
V	.....	Equivalent volume
M	.....	Molecular weight
F	.....	Retarding force
dv/dr	.....	Velocity gradient
A	.....	Inner layer area
(η) _θ	.....	Intrinsic viscosity at theta conditions
K _θ	.....	Constant for fixed polymer type and solvent
(η)	.....	Intrinsic viscosity
M _v	.....	Viscosity average molecular weight
(S/αMS/AA)	.....	Styrene-alpha-methyl styrene-acrylic acid copolymers
NaOH	.....	Sodium hydroxide
NH ₄ Cl	.....	Ammonium chloride
η_r	.....	Relative viscosity
η_{sp}	.....	Specific viscosity
T _g	.....	Glass Transition temperature
pH	.....	Log of hydronium concentration
θ	.....	Theta condition
K	.....	Empirical Mark-Houwink parameter
a	.....	Empirical Mark-Houwink parameter
\bar{s}^2	.....	Radius of gyration
$[(\eta)M]$	.....	Hydrodynamic volume

Table 2—Experimental Viscosity Data at pH = 8.72 ± 0.1

Sample	Concentration (g/dl)	η_{sp}/c (dl/g)	t ₀ Used (sec)	(η) (dl/g)
A	5.00	.075	58.25	.042
	3.30	.045		
	2.50	.040		
	2.00	.042		
B	1.67	.042	61.24	.010
	4.91	.074		
	3.29	.035		
	2.48	.022		
	1.99	.016		
	1.66	.013		
D	1.42	.010	60.21	.015
	1.24	.009		
	0.99	.010		
	4.95	.055		
	3.31	.032		
	2.49	.021		
	1.99	.023		
	1.66	.021		
	1.42	.017		
	1.25	.017		
	1.11	.016		
	0.91	.018		

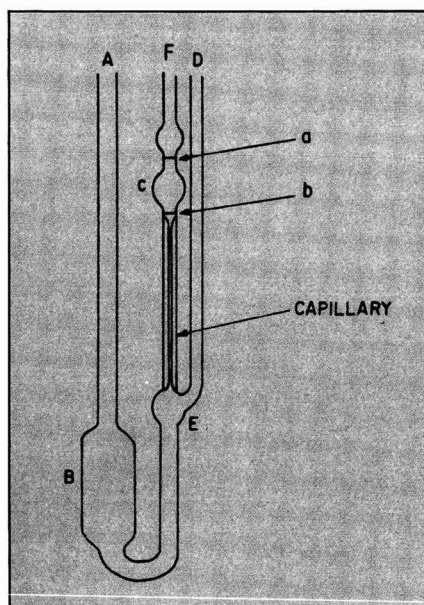


Figure 1—Ubbelohde suspended level viscometer

proportional to a volume $(\bar{S}^2)^{3/2}$, known as the hydrodynamic volume. Often, the hydrodynamic volume provides a common basis for comparing polymers with different polymer chain configurations as a result of different polymer chain architectures or differences in the placement of polar pendant groups. For linear homopolymers, the hydrodynamic volume can be expressed as

$$[\eta]M = KM^{a-1} \quad (8)$$

The value of a , therefore, is greater than 0.5 for polymers in a good solvent, usually on the order of 0.7 for random coils, and up to 2.0 for rigid rods.

EXPERIMENTAL

Three styrene-alpha-methyl styrene-acrylic acid copolymers (S/αMS/AA) were obtained from S.C. Johnson & Son Company, Racine, WI. The material parameters for these copolymers are shown in Table 1. Stock solutions were made as follows; 1.000 g of polymer was diluted in 10.0 mL of NaOH (1M) and 10 mL of NH₄Cl(2M). A constant ionic strength was maintained during dilution of the stock solution with the dilution solution composed of equal volumes of H₂O and NH₄Cl(2M) solution.

The measurements of intrinsic viscosity were done with a glass capillary viscometer, specifically an Ubbelohde suspended level viscometer, shown in Figure 1. The viscometer was vertically suspended in a constant temperature bath of 25°C. A timer with three significant figure precision was used for measuring flow times. The sample polymer solution was pipetted into opening A to bulb B. By applying suction to F and closing off D, the fluid used flowed through bulb E past the capillary and the fiducial mark a . The time it took the solution to flow from fiducial mark a to b was measured. The solution in B

was diluted directly by adding more solvent to the polymer solution.

The intrinsic viscosity (η) is the ratio of specific viscosity (η_{sp}) to the weight concentration of the solute (c). There are many equations which can be used to determine (η) by calculation or by graphing. The best known equation for dilute solutions are those of Kraemer [in equation (7)], Huggins [in equation (8)], and Schultz and Blaschke [in equation (9)].

$$\ln \eta_r/c = (\eta) + (K - 0.5) (\eta)^2 c \quad (7)$$

$$\eta_{sp}/c = (\eta) = K(\eta)^2 c \quad (8)$$

$$\eta_{sp}/c = (\eta) + K(\eta) \eta_{sp} \quad (9)$$

In equation (7), η_r is the relative viscosity (which is the ratio of solution viscosity of the solvent) and c is the polymer concentration.³

In this investigation, the data was plotted by a nonconventional method. A plot of flow time vs polymer concentration was made and is shown in Figure 2. A least squares calculation was performed on the linear part of the curve in the low concentration region in order to obtain an ideal flow time for the solvent (t_0). This value was used to obtain reduced viscosity and a plot of η_{sp}/c vs concentration is shown in Table 2 and in Figure 3. A least squares calculation was performed on the linear part of the η_{sp}/c vs c curve in order to obtain the intercept, which is the intrinsic viscosity.

RESULTS AND DISCUSSION

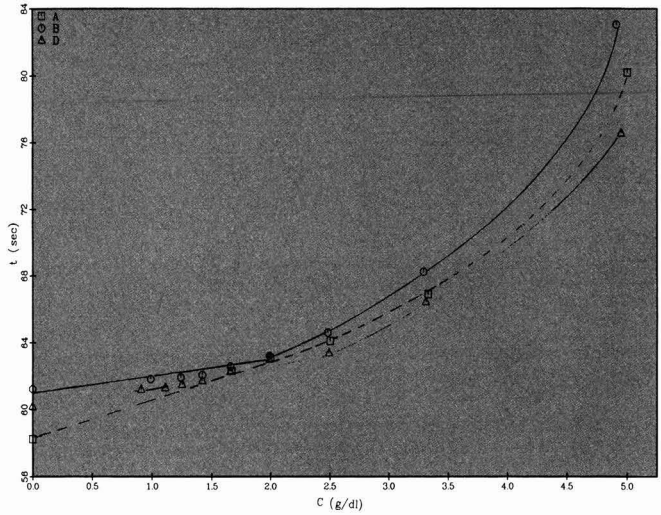
Often, conventional methods of plotting and calculating data are not valid when low solution concentrations are used. A conventional graph of η_{sp}/c vs c may curve upward at low concentrations.¹ This was the case with this experimental data. This effect may be due in part to absorption of the polymer on the capillary walls. Another reason for the curvature in data at low concentrations is due to the polyelectrolyte effect, which involves an expansion in the polymer coil size as the solution concentration decreases. "The origin of the molecular expansion is now accepted to be the electrostatic repulsive force among fixed charges on the poly-ion."² Therefore, this electrostatic repulsion of forces caused an expansion of the poly-ion to several times its original polymer size.

DIANA PROVDER graduated in May 1988 from Kent State University, Kent, OH, with the B.S. Degree in Chemistry and a specialization in coatings science. Ms. Provder was the recipient of a Federation of Societies for Coatings Technology coatings scholarship while at KSU. She obtained experience with the practical application of coatings science and technology while working for the Sherwin-Williams Company during summers while attending college.

Ms. Provder currently is employed as a Chemist with Sherwin-Williams and is involved with the formulation technology of architectural coatings. Her future goal includes obtaining the M.B.A. Degree to prepare herself for a marketing career in the coatings industry.



Figure 2—Flow time vs concentration



This varies with the concentration of the added neutral salt. When the amount of the solvent is increased, it absorbs onto the polymer by hydrophobic attraction, which causes the anionic heads to repel each other. As a result, there is an expansion of the polymer and an increase in viscosity.⁴

The data analysis procedure previously described to obtain t_0 and (η) eliminates or reduces error from contamination or absorption on the capillary walls. For samples A and B in Figure 3, at a pH of 8.7 ± 0.1 , the molecular weight increases directly with the intrinsic viscosity (the intercept value on the η_{sp}/c axis). Sample D does not follow this pattern and may have a different

spacing of acid groups on the polymer chain. Also, by looking at the glass transition temperatures (T_g) in Table 1, one notices that samples A and B have about the same T_g values, but sample D has a T_g about 20°C lower. The lower T_g indicates that the backbone of sample D may not be as stiff as that for samples A and B, possibly due to different spacing of the pendant acid groups.

For samples A, B, and D of $\text{pH } 8.7 \pm 0.1$, the Mark-Houwink parameters a and K were obtained from the hydrodynamic volume relation in equation (8). This was used in preference to equation (6), since the hydrodynamic volume tends to measure the volume of the polymer molecule on a common basis irrespective of differences in

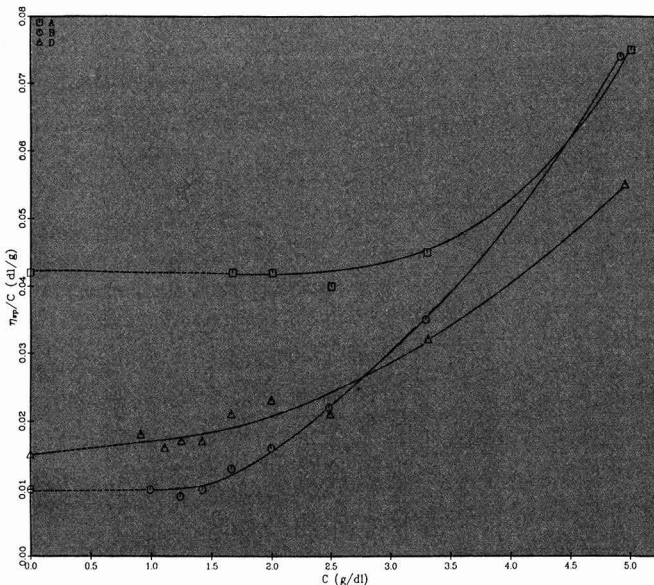


Figure 3—Intrinsic viscosity-concentration plot for S/αMS/AA copolymers at pH=8.7±0.1 (■-A, ●-B, ▲-D)

the spacing of pendant acid groups along the polymer chain. The data in Table 3 is plotted in Figure 4 along with the corresponding least squares line. The least squares calculation yielded a value of $K = 1.368 \times 10^{-6} \text{ mL/g}$ and $a = 1.07$ with a correlation coefficient of 0.77. With only three data points, there is a large error in the calculated values.

With an a value of 1.07, this implies that the copolymer solution conformation falls between a well-coiled polymer with $a = 0.5$ and a rigid rod polymer with $a = 2.0$ if the polymer molecular weight was above the chain entanglement molecular weight ($\approx 20,000$). The a value is significantly larger than for most high polymers in nonaqueous solvents ($0.6 \leq a \leq 0.7$). Since the molecular weight of these polymers is well below the chain entanglement region, it indicates that their lower molecular weight acid-containing polymers indeed have solution conformations approximating rigid rods.

Intrinsic viscosity data for these three polymers as a function of pH over a narrow pH range (7.34-9.26) was obtained. The intrinsic viscosity for samples A and D decreased as pH increased, while for sample B the intrinsic viscosity increased with pH. This anomalous behavior requires additional experimentation to delineate the pH dependence of the intrinsic viscosity for these samples.

APPLICATION TO COATINGS INDUSTRY

The intrinsic viscosity also has practical utility for the coatings industry. For example, there are viscosity considerations in choosing amine solubilizers for water soluble acrylic baking enamels. To avoid water sensitivity of cured coatings, the level of solubilizing groups in water soluble polymers is kept as low as solubilization and viscosity considerations will permit.⁵ Therefore, by water dilution, the viscosity variations can be very useful in determining the morphology of these systems.

Table 3—Hydrodynamic Volume—Molecular Weight Data for (S/αMS/AA) Copolymers

Sample	Log M	Log (η) M
A	4	2.62
B	3.9	1.90
D	3.69	1.87

Viscosity considerations are important for certain low molecular weight resins like alkyds, urethanes, phenolics, and epoxies which are used in the coatings industry.⁶ By using the viscosity-concentration relationship, the intrinsic viscosity of these resins at low concentrations can be determined, which will aid in deciding the best solvent to use for obtaining the lowest viscosity and best compatibility of the solvent and resin.

The knowledge of intrinsic viscosity for high solids and UV-curable coatings is of practical importance to the coatings industry. In high solids coatings, there is a need to increase the percent solids and reduce the percent solvent, while keeping the coating's viscosity in a useable application viscosity range. This is of critical importance for low volatile organic compound coatings. One factor which determines this application viscosity is the intrinsic viscosity.^{7,8} Knowledge of the coating's intrinsic viscosity will facilitate the efficient use of reactive solvents for decreasing the coating's application viscosity.

SUMMARY

The concept of intrinsic viscosity and its practical significance in dilute solution viscometry has been investigated. The intrinsic viscosity behavior for three styrene- α -methyl styrene-acrylic acid copolymers was determined with respect to molecular weight and pH values. Existing equations and procedures for the graphical

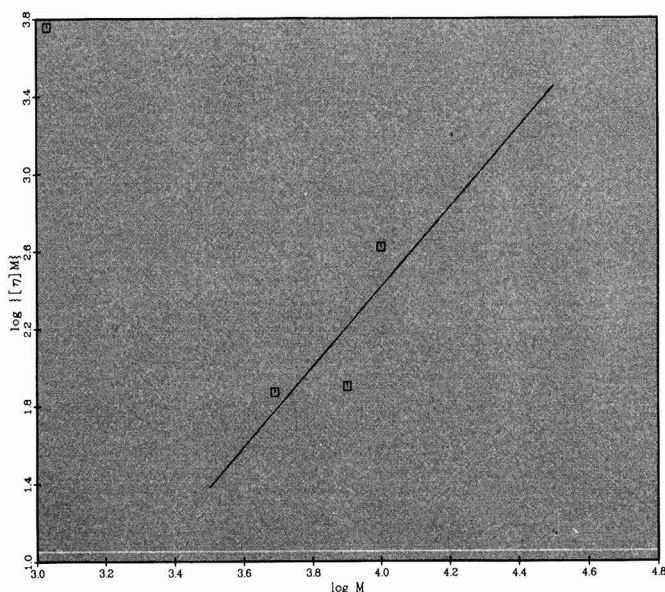


Figure 4—Log [(η)M] vs log M for S/αMS/AA copolymers

determination of intrinsic viscosity were analyzed. It was shown that conventional methods for determining intrinsic viscosity cannot be used because of the polyelectrolyte effect involved with the low polymer solution concentrations used. A new data analysis method was used in order to eliminate this effect and to reduce errors from contamination or absorption of the polymer on the capillary walls. The data analysis method involved obtaining an ideal solvent time from a plot of time vs concentrations. The intercept obtained from a least squares calculation of the linear part of the curve was used as the "ideal" solvent time. Using this time value, the intrinsic viscosity could be determined from a plot of the calculated η_{sp}/c vs c . From the linear part of this graph, a least squares calculation yielded the intercept which was the intrinsic viscosity. From the hydrodynamic volume and molecular weight data, the Mark-Houwink parameters were determined for the styrene-alpha-methyl styrene-acrylic acid copolymers. The exponential parameter indicated that the copolymers approximated a rigid rod structure at a pH of 8.7.

ACKNOWLEDGMENTS

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course of this project. Also acknowledged is the S.C. Johnson & Son Company for supplying the experimental ($S/\alpha M/AA$) copolymer samples.

References

- (1) Rudin, A., "The Elements of Polymer Science and Engineering," Academic Press, New York, 1982, 93-121.
- (2) Takahashi, A. and Nagasawa, M., "Excluded Volume of Polyelectrolyte in Salt Solution," *J. Am. Chem. Soc.*, 86, 543-548 (1964).
- (3) Ibrahim, F.W., "Correct Determination of Staudinger's Index (Intrinsic Viscosity) and of Huggins' Constant," *J. Polymer Sci.*, 3, 469-478 (1965).
- (4) de Sa, T.G.L., Fernandez, L.M.G., and Riano, J.L.A., "Interaction Between Polyvinylpyrrolidone and Surfactant from Viscosimetric Data," *British Polymer J.*, 20, No. 1, 39-42 (1988).
- (5) Hill, L.W. and Wicks, Z.W. Jr., "Amine Solubilizers for Water-Soluble Acrylic Baking Enamels," *Progr. Org. Coatings*, 8, 161-182 (1980).
- (6) Pierce, P.E. and Armonas, J.E., "Rheology of Alkyds and Low Molecular Weight Resin Solutions," *JOURNAL OF PAINT TECHNOLOGY*, 38, No. 503, 710 (1966).
- (7) Erickson, J.R. and Garner, A.W., "Viscosity of Concentrated Oligomer Solutions I," *ACS Organic Coatings and Plastic Chemistry Preprints*, 37, No. 1, 447-452 (1977).
- (8) Garner, A.W. and Erickson, J.R., "Viscosity of Concentrated Oligomer Solutions II," *ACS Organic Coatings and Plastic Chemistry Preprints*, 39, 401-406 (1978).

Society Meetings

BALTIMORE..... MAR.

"Predicting Coating Failure"

The speaker for the evening was Larry Masters, of the National Institute of Testing Materials. The topic of his presentation was "PREDICTING COATING FAILURE."

The speaker stated that one reason for not being able to predict coating failure correctly is the use of irrelevant data; reliable data is a necessity. Also, many tests are needed to accumulate that data. He said to consistently predict service life, the previously mentioned requirements are needed.

In conclusion, Mr. Masters focused on five ways to overcome technical barriers: (1) lack of problem definition; (2) lack of definition of measurable service life; (3) lack of knowledge of properties; (4) lack of adequate samples or data points; and (5) lack of avoidance of the correlation trap.

GARY MORGERETH, *Secretary*

BIRMINGHAM..... FEB.

Membership Amendment

An amendment to incorporate affiliate (Class C) membership in the Club was proposed by Membership Committee Chairman Gerry J. Gough, of Holden Surface Coatings Ltd. The Article IV Membership, 3 Class C (Affiliate Membership) was carried. The amendment reads as follows: "any individual not eligible for Class A Membership and who would normally qualify for Class B Membership, but is precluded by the condition under Article IV, subsection 2c, shall be eligible." The Club voted to add the words "except Class C" to various sections of the Club By-Laws.

D.A.A WALLINGTON, *Secretary*

CLEVELAND..... MAR.

Federation Visit

A moment of silence was observed in memory of Robert F. Hall, Past-President of the Cleveland (1952-53) and Southern Societies.

The nomination of officers for 1989-90 is as follows: President—Ilna Nemes, of Sherwin-Williams Co.; Vice President—Richard J. Ruch, of Kent State University;

Secretary—Benjamin J. Carlozzo, of Tremco Corp.; Treasurer—Roy A. Glover, of Jamestown Paint & Varnish Co.; Society Representative—Fred G. Schwab, of Coatings Research Group, Inc.; Assistant Treasurer—Freidun Anwari, of Coatings Research Group, Inc.; and Member-at-Large—Robert K. Schlutzer, of B.F. Goodrich Co.

The meeting was attended by Federation officers, including: President-Elect John C. Ballard, of Kurfees Coatings, Inc.; Executive Vice President Robert F. Ziegler; and JOURNAL OF COATINGS TECHNOLOGY Editor Patricia Viola.

Mr. Ballard talked about Federation activities. He focused on the Federation-sponsored Statistical Process Control seminars conducted by Dr. Peter Hunt and Spring Week '89 in Los Angeles, CA, highlighted by the seminar Modern Analytical Resources. Mr. Ballard also spoke about the possibility of additional foreign membership in the Federation. In conclusion, he noted the success of the *Regulatory Update*, a regular monthly insertion in the JOURNAL OF COATINGS TECHNOLOGY which features current environmental regulatory activity pertinent to the coatings industry.

Executive Vice President Ziegler discussed the 54th Paint Industries' Show to be held in New Orleans, LA, on November 8-10, 1989 and gave a list of projected locations for future shows. Also, he reported on the progress of the Federation Building Committee in selecting a site for the new headquarters. Mr. Ziegler gave a brief outline of the building specifications, including square footage and cost.

Mrs. Viola briefly spoke about the JCT and its purpose—to communicate and educate. She announced that the 13th booklet of the new Federation Series on Coatings Technology would soon be published and stated that the intent is to have a total of 35 new booklets in the Series.

Tom Holland, of the Ford Motor Company, was the meeting's speaker. His topic was "Q-1, SPC, AND COMPETITIVE NEW VEHICLE QUALITY (CNVQ) STUDIES."

Mr. Holland commented on how CNVQ studies are affecting production at Ford, Chevrolet, and Chrysler. The CNVQ questionnaire contains 180 items and is sent to persons who have owned a new vehicle for three months. The speaker used graphs, which showed Ford's improvement in quality over the past decade as indicated by CNVQ, to illustrate his point.

Mr. Holland stated that Ford's priorities are quality, production, productivity, people, plant, and safety.

Suppliers to Ford that do not have a Q-1 plant in effect by December will likely be passed up for bids next year, according to Mr. Holland. The importance of Q-1 is that it reduces scrap and waste. A supplier has to have 85-100 points to make Q-1 and must have customer acceptance.

Also, Mr. Holland noted that all personnel at the Ford Sandusky, OH, plant had at least 12-16 hours of training over the past two years with Dr. Peter Hunt on Statistical Process Control.

RICHARD J. RUCH, *Secretary*

NEW ENGLAND..... FEB.

"Titanium Dioxide"

Rebecca Craft, of Du Pont Co., was the meeting's speaker. Dr. Craft presented "CROWDING AND SPACING, TITANIUM DIOXIDE THEORY AND EXAMPLE."

The speaker explained some tools used to evaluate and develop hiding power and scattering of light in paints. Dr. Craft said the tools include the Kubelka-Monk theory and PVC and its relationship to critical PVC. Concerning PVC and critical PVC, she stated that at a formula's critical PVC, the properties of the coating change dramatically due to the introduction of air spaces into the dry film. Dr. Craft classified paints according to their range of PVC: (1) paint formulas below 20 PVC (gloss



TECHNICAL SPEAKER—Southern Society member Thad T. Broome, of J.M. Huber Co., presents a talk on "Kaolin Clays" at the Los Angeles Society March meeting

Constituent Society Meetings and Secretaries

BALTIMORE (Third Thursday—Snyder's Willow Grove, Linthicum, MD). GARY MORGERETH, McCormick Paint Works, 2355 Lewis Ave., Rockville, MD 20851.

BIRMINGHAM (First Thursday—Strathallen Hotel, Birmingham, England). D.A.A. WALLINGTON, Ferro Drynamels Ltd., Westgate, Aldridge, West Midlands, England WS9 8YH.

CDIC (Second Monday—Sept., Dec., Mar. in Columbus; Oct., Jan., Apr. in Cincinnati; and Nov., Feb., May in Dayton). W.E. "BUDDY" WHITLOCK, Ashland Chemical Co., P.O. Box 2219, Columbus, OH 43216.

CHICAGO (First Monday). KARL E. SCHMIDT, Premier Paint Co., 2250 Arthur Ave., Elk Grove Village, IL 60007.

CLEVELAND (Third Tuesday—meeting sites vary). RICHARD J. RUCH, Kent State University, Dept. of Chemistry, Kent, OH 44242.

DALLAS (Thursday following second Wednesday—The Harvey Hotel, Dallas, TX). RHONDA MILES, Union Carbide Corp., 2326 Lonacker Dr., Garland, TX 75041.

DETROIT (Second Tuesday—Ukrainian Cultural Center, Warren, MI). LIANA CALLAS ROBERTS, A.T. Callas Co., 1985 W. Big Beaver, Suite 308, Troy, MI 48043.

GOLDEN GATE (Monday before third Wednesday—Alternate between Francesco's in Oakland, CA and Holiday Inn in S. San Francisco). JACK DUIS, Pacific Coast Chemical, 2424 Fourth St., Berkeley, CA 94710.

HOUSTON (Second Wednesday—Look's Sir-Loin Inn, Houston, TX). MICHAEL G. FALCONE, International Paint (USA) Inc., 17419 Little Shoe Ln., Humble, TX 77396.

KANSAS CITY (Second Thursday—Cascone's Restaurant, Kansas City, MO). MARK ALGAIER, Hillyard Chemical, P.O. Box 909, St. Joseph, MO 64501.

LOS ANGELES (Second Wednesday—Steven's Steak House, Commerce, CA). JAMES D. HALL, Sinclair Paint Co., 6100 S. Garfield Ave., Los Angeles, CA 90040.

LOUISVILLE (Third Wednesday—Executive West Motor Hotel, Louisville, KY). JAMES SIMPSON, Reliance Universal, Inc., Resins Div., 4730 Crittenden Dr., P.O. Box 37510, Louisville, KY 40233.

MEXICO (Fourth Thursday—meeting sites vary). GERARDO DEL RIO SEC. G.B.W. De Mexico, S.A., Poniente 116 No. 576, Nueva Industrial Vallejo, 02610 Mexico, D.F., Mexico.

MONTREAL (First Wednesday—Bill Wongs Restaurant, Montreal). ROBERT BENOIT, NL Chemicals Canada Inc., 4 Place Ville-Marie, Ste. 500, Montreal, Que., H3B 4M5 Canada.

NEW ENGLAND (Third Thursday—Sheraton, Lexington, MA). ARTHUR LEMAN, Samuel Cabot Co., 100 Hale St., Nebr. MA 01950.

NEW YORK (Second Tuesday—Landmark II, East Rutherford, NJ). ROGER P. BLACKER, Whittaker, Clark & Daniels, Inc., 1000 Coolidge St., So. Plainfield, NJ 07080.

NORTHWESTERN (Tuesday after first Monday—Jax Cafe, Minneapolis, MN). TERRY STROM, Ti-Kromatic Paints, Inc., 2492 Doswell Ave., St. Paul, MN 55108. **WINNIPEG SECTION** (Third Tuesday—Marigold Restaurant, Winnipeg). EDWIN R. GASKELL, Guertin Bros. Coatings & Sealants Ltd., 50 Panet Rd., Winnipeg, MB, R2J 0R9 Canada.

PACIFIC NORTHWEST (PORTLAND SECTION—Tuesday following second Wednesday; SEATTLE SECTION—the day after Portland; BRITISH COLUMBIA SECTION—the day after Seattle). JOHN BERGHUIS, NL Chemicals Canada Inc., 3450 Wellington Ave., Vancouver, B.C., V5R 4Y4 Canada.

PHILADELPHIA (Second Thursday—Williamson's GSB Bldg., Bala Cynwyd, PA). CHRISTOPHER H. HUHN, Loos & Dilworth, Inc., 61 E. Green Ln., Bristol, PA 19007.

PIEDMONT (Third Wednesday—Ramada Inn Airport, Greensboro, NC). GARY L. WATERS, Sadolin Paint Products, Inc., P.O. Box 669, Walkertown, NC 27051.

PITTSBURGH (Second Monday—Montemurro's Restaurant, Sharpsburg, PA). CAROL STORME, Valspar Corp., 2000 Westhall St., Pittsburgh, PA 15233.

ROCKY MOUNTAIN (Monday following first Wednesday—Holiday Inn North, Denver, CO). BRUCE REHMANN, Komac Paint, 1201 Osage St., Denver, CO 80204.

ST. LOUIS (Third Tuesday—Salad Bowl, St. Louis, MO). TERRY GELHOT, Spatz Paint, 1439 Henley Industrial Court, St. Louis, MO 63144.

SOUTHERN (GULF COAST SECTION—third Thursday; CENTRAL FLORIDA SECTION—third Thursday after first Monday; ATLANTA SECTION—third Thursday; MEMPHIS SECTION—bi-monthly on second Tuesday; and MIAMI SECTION—Tuesday prior to Central Florida Section). JAMES R. SALISBURY, Union Carbide Corp., 2043 Steel Dr., Tucker, GA 30084.

TORONTO (Second Monday—Cambridge Motor Hotel, Toronto). GERRY PARSONS, DeSoto Coatings Ltd., 895 Rangeview Rd., Mississauga, Ont., L5E 3E7 Canada.

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

and semi-gloss paints); (2) paint formulas between 20 PVC and critical PVC (semi-gloss and duller finishes); and (3) paint formulas over critical PVC (flat paints).

According to Dr. Craft, paints below 20 PVC get their hiding from refractive index only (e.g., TiO₂ pigment). Paints between 20 PVC and critical PVC can get hiding from the proper use of both TiO₂ and exterior pigments. Paints over the critical PVC can get their hiding from entrapped air in the dry film.

The speaker presented some basic rules to achieve higher hiding for a particular paint formula, including: (1) apply over a lighter substrate; (2) tint the paint; (3) apply a thicker film; and (4) improve light scattering.

Dr. Craft stated that the new investigation in optimizing TiO₂ concerns the improvement of light scattering by optimizing the spacing of TiO₂ particles. Extender pigments that are used to help "space" TiO₂ particles are most efficient when they have the same particle size and oil absorption as TiO₂.

Q. What is the best PVC for TiO₂?

A. Optimum hiding and scattering from TiO₂ is achieved below a TiO₂ PVC of seven. At PVC above seven, the scattering ability of TiO₂ begins to decrease. However, above a TiO₂ PVC of 23, no significant improvement in hiding is made by further addition of TiO₂.

Q. Why do you sometimes need more than two pounds per gallon of TiO₂ in paint for full hiding?

A. Again, it all depends on the formula, the extenders used, and the PVC of TiO₂. Also, if the paint is low solids or is applied as a thin film, it will be difficult to achieve full hiding.

ARTHUR A. LEMAN, *Secretary*

PHILADELPHIA DEC.

"Isocyanates"

J. Richard Kiefer, Jr., of McCloskey Corp., gave the second reading of the set of by-law revisions to change the start of the fiscal year and the officers' term of office from August 31-June 30 of each year. The proposed changes were seconded and unanimously adopted.

Eric J. Percy, of Cray Valley Products, Inc., was the evening's speaker. Dr. Percy, a member of the New York Society, gave a presentation on "ISOCYANATE — FREE ALTERNATIVES TO TWO-PACKAGE URETHANES."

The speaker discussed some of the benefits of an acrylic/epoxy system: long pot-life, fast drying, superior polishing properties, excellent weathering, good chemical



PAST-PRESIDENTS—Attending Past-Presidents' Night at the Los Angeles Society March meeting are: Standing (l-r): Kenneth J. O'Morrow (1975-76); Albert Seneker (1979-80); Jan P. Van Zelm (1981-82); Fred Croad (1978-79); Earl B. Smith (1984-85); Clyde L. Smith (1946-47); Gerald L. West (1976-77); William H. Ellis (1971-72); Donald I. Jordan (1980-81); and Alan U. Hershey (1961-62). Seated (l-r): Dermont G. "Duke" Cromwell (1970-71); Romer E. Johnson (1982-83); Henry J. Kirsch (1986-87); Ray DiMaio (1987-88); Trevelyan Whittington (1969-70); Michael Gildon (1985-86); Clarence J. Meyers (not a Past-President); and Leonard S. Feldman (1960-61)

resistance, and good color retention. Dr. Percy noted that these characteristics indicate a use in automotive finishes and showed several slides for illustration purposes. He stated that these systems are better than previous urethane refinishing systems. Additionally, they provide excellent adhesion to engineering plastics of the G.P.P., A.B.P., and R.I.M. types.

Dr. Percy explained how several of these types of products were developed in response to specific requirements for more or less gloss and for more or less open time.

The speaker said that, compared to previous urethanes, the initial test results are similar. The acrylic/isocyanate retained gloss longer, but the coating was never as hard.

CHRISTOPHER H. HUNN, *Secretary*

PITTSBURGH JAN.

"High-Solids Coatings"

Cliff Schoff, of PPG Industries, Inc., was the speaker for the evening. His topic was "FLOW BEHAVIOR OF HIGH-SOLIDS COATINGS."

The presentation focused on high-solids coatings and how the rheology is very dependent on resin molecular weight and glass transition temperature, solvent viscosity, pigmentation, and resin-solvent interactions. According to Dr. Schoff, a variety of flows are important in the use of these materials and these can be controlled through adjustment of the various components and the use of additives. He stated that such control is not simple, but it is necessary to achieve superior appearance.

Q. Flow properties—how do they relate to a high-solids formulation? Could you briefly discuss flow characteristics of a thixotropic coating?

A. A true thixotropic coating is a real problem in the paint industry. When people say thixotropicity, they mean shear thinning. Thixotropicity means time effects. If a coating is thixotropic, that means if you shear it, viscosity goes down with time. Or, you stop shearing and viscosity goes up in time. It depends on how much of the additive you put in. Put in a very small amount and have almost no noticeable effect, or load it up and have it take quite a lot of time to shear out and build up. It's a time effect. It takes time for the coating to drop in viscosity at a given shear rate. It takes times for it to build up. The types of formulations we use for industrial coatings tend to build quite rapidly. In fact, with some of them, it is almost instantaneous. Those are the ones where it just does not flow at all. There are a lot of coatings that when you spray them they do not look good. We actually use the flow in the ovens to give us some flowout and levelling. The trouble is, if there is any contaminants, dirt or gell or silicone, droplets of silicone fluid, or greasy substrate, then you will get flow and levelling in some areas and surface tension driven flow that hurts you in other areas. The really thixotropic is a matter of what you use and what you put in. You can have a situation that has so much structure that nothing you do can change that. It will shear out when you spray it and set up immediately. So, it is really one of these tests with any other formulating activity; a matter of balancing things out. Add a little bit and a little bit more until you get the effect you want.

M. CAROLE STORME, *Secretary*

PITTSBURGH FEB.

"Defoamer Selection"

Chuck D'Amico, of Ultra Additives, Inc., was the speaker for the evening.

Mr. D'Amico presented a talk and slide presentation on "DEFOAMER SELECTION AND TESTING."

M. CAROLE STORME, *Secretary*

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CLEVELAND

Active

AZIZ, MOHAMMED A.—Sherwin-Williams Co., Cleveland, OH.
BOBERSKI, WILLIAM G.—PPG Industries, Inc., Cleveland.

CHRISMAN, DAVID W.—Sherwin-Williams Co., Cleveland.
FRANO, DOUGLAS J.—Sprayon Products, Inc., Bedford Heights, OH.
HILOVSKY, ROWLAND T.—PPG Industries, Inc., Cleveland.
KINSTLE, GEORGE P.—Sherwin-Williams Co., Cleveland.

WELKER, JACQUELINE K.—PPG Industries, Inc., Cleveland.

Associate

NOVACK, CLAUD A.—Cargill, Inc., Carpentersville, IL.
WHITTAKER, JAMES E.—Thor Chemicals, Inc., Norwalk, CT.
ZAMLER, BRIAN K.—Reliance Universal, Inc., Louisville, KY.

LOS ANGELES

Active

CABRERA, GEORGE A.—Kop-Coat Inc., Commerce, CA.
FORSTER, WENDELL C.—Akzo Coatings, Inc., Orange, CA.
GRINT, GARY D.—Cardinal Industrial Finishes, So. El Monte, CA.
KING, DAVID K.—Manville Sales Corp., Lompoc, CA.
RAY, ROBERT W.—Crown Metro Aerospace, Temple City, CA.
SHIER, D. SCOTT—Byk Chemie, Fontana, CA.
SIV, ENRIQUE C.—Whittaker Corp., Bauer Div., Los Angeles, CA.

Associate

BERMOSK, GREGORY M.—Soco-Western Chemical, Los Angeles, CA.
HUTCHINS, WARD F.—P.T. Hutchins Co. Ltd., Los Angeles.
MARTIN, JEFF S.—E.T. Horn Co., La Mirada, CA.
RISSIER, HENRY A.—Ropak Corporation, Fullerton, CA.
VAN OTTEN, GARY W.—Lipscomb Chemical Co., Long Beach, CA.

NEW ENGLAND

Associate

HEBERT, DOROTHY A.—Graco Inc., South Windsor, CT.

PHILADELPHIA

Active

CHMIELEWSKI, BOGUMILA—The McCloskey Corp., Philadelphia, PA.
GINEZ, ANDRES RAFAEL—M.A. Bruder & Sons Inc., Philadelphia.
HETZELL, ROBERT L.—Reichhold Chemicals, Inc., Dover, DE.
TRUITT, PATRICIA W.—Reichhold Chemicals, Inc., Dover.

Associate

MACK, THEODORE C. JR.—Engelhard/Harshaw Color, Matawan, NJ.
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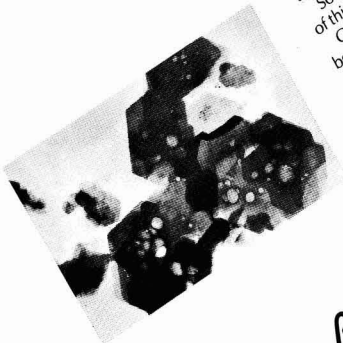
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SEPTEMBER 89—Featured are the Preliminary Program of Technical Sessions, floor plan of show exhibitors, registration forms, housing forms and hotel information, as well as general show information.

OCTOBER 89—This special Annual Meeting and Paint Show Issue, which is distributed at the show in addition to our regular circulation, contains Abstracts of Papers to be presented; the Program of Technical Sessions; floor plan of show exhibitors; a list of exhibitors and their booth numbers, classified by product/service; an alphabetical list of exhibitors and their booth numbers; and general show information.

JANUARY 90—This Annual Meeting and Paint Show Wrap-up Issue features information on all exhibitors, with emphasis on products and special booth features; photo displays of award-winning booths; as well as a complete review of important Annual Meeting and Paint Show happenings.

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Satish K. Wason has been named President of J.M. Huber Corporation's Chemicals Division, headquartered in Havre de Grace, MD. Dr. Wason most recently served as Vice President and Head of the Chemicals Division. He has specialized in the field for 18 years and is the author of several publications.

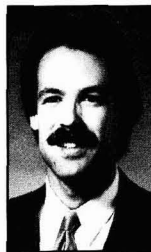
In addition, **Harold E. Vickers** has been appointed Plant Manager of the Chemicals Division. He returns to Huber after 14 years with the P.Q. Corporation in Avenel, NJ, where he was involved in plant operations management.



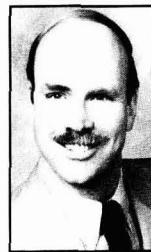
S.K. Wason



D. Schauer



D. Heflin



S.S. Mitchell

The Chemical Coatings Division of The Sherwin-Williams Co., Chicago, IL, has named **Dolores Schauer** Product Specialist for the General Products Business Unit. In this position, she will be responsible for business relating to hardcoats technology in non-automotive areas.

Dorothy Hazinski has been appointed Technical Service Specialist for the Customer Service Group of The O'Brien Corp.'s South Bend, IN, office. In her new position, Ms. Hazinski will provide technical information and assistance to dealers, specifiers, architects, salespeople, and end-users of the company's products. She has been with the firm since 1984.

In addition, **Sandra Kinne** has joined the staff of O'Brien as Paint Sundries Buyer in the Trade Sales Division. Prior to this position, Ms. Kinne served as buyer of paint, paint sundries, and associated decorative items for a retailer in the northwestern United States.

3M has announced the creation of a new division with the elevation of its Do-It-Yourself Business Unit to division status and the appointment of **Charles H. (Bud) Dock** as its General Manager. Established in 1986, DIY manufactures and markets household do-it-yourself products. The product areas are abrasives, energy savings, caulks, wood refinishing, and retail automotive, and Dr. Dock has managed the business since its inception.

Fischer Technology, Inc., Windsor, CT, has named **John Stanwick** to the position of Sales Engineer. Mr. Stanwick will assume responsibility for the areas of eastern Massachusetts, New Hampshire, Vermont, and Maine.

Akzo Coatings Inc., Troy, MI, has appointed **David Heflin** to the position of General Motors Account Manager. In his new position, Mr. Heflin will be responsible for the sales and marketing activities of the firm's automotive coatings for the General Motors account.

Jeffrey Blaisdell and **Paul Molvar** have been appointed to positions in the Research and Development Group of Sannor Industries, Leominster, MA. Both men will report to **Howard S. Bender**, Director of Research and Development. Dr. Bender is a member of the New England Society.

William J. Hughes has joined Troy Chemical Corporation, Newark, NJ, as Purchasing Manager. He will be in charge of purchasing all raw materials, production machinery, laboratory equipment, and packaging materials for the company.

Hercules Incorporated, Wilmington, DE, has announced the appointment of **Edward L. Martin** to the post of Northeastern District Sales Manager of its Coatings & Additives Group. Mr. Martin most recently served as Product Supervisor—Nitrocellulose. He succeeds **Norman C. MacArthur**, who has retired after more than 34 years with the firm. Mr. MacArthur joined Hercules in 1954 as a Research Chemist, earned numerous patents, and switched to sales in 1973, where he was involved with the company's specialty elastomers.

In addition, **Jeffrey S. Wolff** has been named Product Supervisor—Nitrocellulose, replacing Mr. Martin. He will report to **J. Stephen Bryce**, Product Manager—Nitrocellulose.

Samuel S. Mitchell has joined Red Devil, Inc., Union, NJ, as National Sales Manager of the Machinery & Instrument Division. His duties will include sales and marketing of the company's paint mixers and colorant dispensers for the U.S. market.

Cabot Stains, Newburyport, MA, has expanded its sales force in the southeast with the appointment of a new regional manager and three sales representatives: **Nelson Reynolds**—Regional Sales Manager; **Bill Hanka**—Sales Representative in the state of Florida; **Travis J. Dyer**—Sales Representative for Georgia, southeastern Alabama, and the Florida Panhandle; and **Randy Duncan**—Sales Representative for both North and South Carolina.

Daniel N. Simon has been named Director of Marketing and Development for Velsicol Chemical Corporation's Chemical Group. He joined Velsicol in 1987 as Product Manager for dibasic acids.

As a result of the recent reorganization of its Oleochemical Product Group, Unichema Chemicals, Inc., Chicago, IL, has announced several promotions. **Alfredo Islas**, Vice President of Marketing, will assume responsibility for oleochemical and international sales. In addition, **Brian Shaughnessy** has been appointed Marketing Manager for Performance Products, which includes esters, dimers, isostearic and fatty acid amides and **Barbara Ulrich** has been promoted to Product Manager, with responsibility for the company's glycerine product line.

M.A. Bruder & Sons, Inc., Broomall, PA, has appointed **Orville E. Brown** to the position of Corporate Technical Director. Mr. Brown formerly served as Laboratory Manager, Industrial Coatings, with the firm. Prior to this, he was employed by the Rust-Oleum Corp. and with Union Carbide Corp.



President-Elect of the Philadelphia Society, Mr. Brown is a member of the FSCT Corrosion Committee, as well as Chairman of the Surface Tolerant Coatings Committee of the Steel Structures Painting Council.

Hitox Corporation of America, Corpus Christi, TX, has appointed **Andrew J. Panozzo** as Regional Sales Manager for the midwestern United States and Canada. He will be responsible for direct and distributor sales of the firm's line of pigments. A member of the Chicago and Detroit Societies, Mr. Panozzo has over 25 years of experience in the coatings industry.

John J. McDevitt has been promoted to National Sales Manager—Industrial Gases for Liquid Carbonic Industrial/Medical Corporation, Chicago, IL. In his new position, Mr. McDevitt will be responsible for pricing and policy for the company's industrial gas products.

Bee Chemical Company, Chicago, IL, has promoted **William Kalnes** to Director of Materials. Mr. Kalnes brings more than 13 years of related experience to the position. He will report to **Rod K. Sohrbeck**, Vice President of Manufacturing.

SCM Chemicals, Baltimore, MD, has announced the retirement of **J. Corson Smith**, Vice President, Sales. Mr. Smith joined the company in 1961 as National Accounts Manager, served as Industry Manager for Coatings, Marketing Manager, and Vice President, Marketing, before assuming his most recent position.

Cron Chemical Corporation, Houston, TX, has named **Don Madere** to the post of Director of Corporate Sales and Marketing. Bringing 18 years of experience in general chemical distribution to this position, Mr. Madere will be responsible for the development and implementation of sales and marketing strategies for the firm.

Witco Corporation, New York, NY, has announced the following five managerial appointments in its Corporate Engineering Department: **Peter J. Colella**—Director of Project Operations; **Joseph Kricena**—Director of Corporate Engineering Services; **Stephen Kohlhasse**—Manager of Design Engineering; **Michael J. Grosso**—Manager of Cost Estimation; and **Walter Krzastek**—Assistant Manager of Cost Estimation.

In addition, Witco has appointed **Kristen Fitzpatrick** to the position of Assistant Manager of Corporate Public Relations. She assumes responsibility for employee communications, and will assist in shareholder, community, and media relations.

Bill Simmonds has joined The Valspar Corporation, Minneapolis, MN, as Vice President, Consumer Group. In this position, he has responsibility for all consumer coatings sales, marketing, manufacturing, and research functions.

Obituary

Otto John Hartwick, formerly Technical Director of the Houston Paint Division of PPG Industries, died on March 19. He was 93 years old.

Mr. Hartwick began his distinguished career in the coatings industry as a Lacquer Chemist at PPG in 1928. Following assignment to the Technical Department of the firm's Milwaukee plant in 1933, he was transferred to Houston to assume the post of Chief Chemist in 1941. Mr. Hartwick was promoted to Technical Director in 1948. He retired from PPG in 1961, having served the company for 33 years. Following his retirement, he worked at Ribelin Sales Co., in Houston, for 10 years.

Mr. Hartwick was a Past-President and the first recipient of the Life Membership Award of the Houston Society.

Svend Stubb, Vice President of Manufacturing for Kelly-Moore Paint Co., died on March 17.

Mr. Stubb, a member of the coatings industry for over 33 years, began his career in Los Angeles with Dutch Boy Paints. He joined Kelly-Moore in 1976 as Plant Manager and was appointed Vice President in 1977. Mr. Stubb was active in the Coatings Research Group and was a member of the Golden Gate Society.

Rick Fischer has joined Eiger Machinery, Chicago, IL, as a member of its sales and marketing team. Mr. Fischer brings eight years of experience in colorants and additives from the plastics industry to this position.

Henkel Polymers Division, a wholly owned subsidiary of Henkel KGaA, West Germany, has appointed **Bob Vora** to the position of Manager of International Sales. He will serve as the key contact for all export business, representing the line of Henkel polymer products to customers located outside North America.

Ellen P. Mann has been named Manager of Colortrend Systems/Warehousing & Distribution Center for Colwell/General, Inc., Kendallville, IN. Ms. Mann previously has held positions in sales and as a graphic artist and production supervisor for graphic studios.

Louis A. Kaplan, former Vice President of Cellomer Operations of Reichhold Chemicals, Inc., died on April 5. He was 65 years old.

Mr. Kaplan served as Vice President of Operations for the Cellomer Division of Polychrome Chemicals, Inc. from 1966 until it became part of Reichhold Chemicals in 1988. Previously he held technical positions with other coatings companies for about 14 years. Mr. Kaplan received a B.Ch.E. Degree from the City College of New York. He was a member of the New York Society, as well as the American Institute of Chemical Engineers, and the American Chemical Society.

Ed Teuscher, former Director of Purchasing at Akzo Coatings Inc., died on March 26. He was 61 years old.

Mr. Teuscher began his career in the coatings industry at Cook Paint and Varnish. He later joined Pratt & Lambert where he pursued his purchasing career. In 1972, Mr. Teuscher joined Wyandotte Paint Co. (now Akzo Coatings Inc.) as a Purchasing Agent. He remained in the Purchasing Department for 17 years where he served as Director of Purchasing until his death. Mr. Teuscher was a Past-President of the Detroit Paint and Coatings Association.

Paint Volatile Organic Compounds To be Focus of ASTM Workshop

ASTM has scheduled a two-day workshop designed to assist participants in determining if paints or coatings meet U.S. Environmental Protection Agency VOC requirements. The workshop will be held July 19-20 in Chicago, IL, and on November 1-2, in Philadelphia, PA.

The workshop is intended for chemists and others who use U.S. EPA tests to determine VOC, as well as individuals from the paint industry, governmental regulatory bodies, commercial labs, and paint users.

At the workshop, attendees will be instructed on the basic principles of ASTM methods used to measure VOC under the U.S. EPA New Source Performance Standard. Topics to be discussed included how to: obtain good representative samples; prepare samples; run VOC measurements of coatings; and identify the variables in each test method. In addition, information will be given on calculating VOC whether it is to be reported as grams per liter, grams per liter minus water, or as kilogram of VOC as applied solids, etc., and on improving the precision with which these test methods can be run.

ASTM standards on which this course is based were developed and are maintained by ASTM Committee D-1 on Paints and Related Coatings and Materials. Included in the program outline are the following subjects: Sampling Method: ASTM Standard D 3925; Density Measurements: ASTM Standard D 1475; Volatile Content: ASTM Standard D 2369; Water Content by Gas Chromatography: ASTM Standard D 3792; Water by Karl Fischer Method: ASTM Standard D 4017; Halohydrocarbon

Content: ASTM Standard D 4457; Calculation of VOC: ASTM Standard D 3960; Volume of Nonvolatile Matter: ASTM Standard D 2697; and Precision: ASTM Standards E 180 and D 3980.

Instructors of the workshop are Hiroshi Fujimoto, of BASF Inmont Division's Analytical Services Laboratory; Richard

W. Scott, formerly of Sherwin-Williams; and William C. Golton, of the Marshall Research Laboratory, E.I. du Pont de Nemours & Co., Inc.

For additional information, contact Kathy Dickinson, ASTM Standards Technology Training, 1916 Race St., Philadelphia, PA 19103.

Electrochemical Techniques Are Topic Of Short Course, Offered June 19-23

EG&G Princeton Applied Research, Princeton, NJ, in conjunction with the Baltimore-Washington Section of the National Association of Corrosion Engineers, is sponsoring a course on "Electrochemical Techniques in Corrosion Engineering," presented by The Johns Hopkins University Corrosion and Electrochemistry Research Laboratory. The seminar will be held at Johns Hopkins University, Homewood Campus in Baltimore, MD, on June 19-23.

The five-day program will introduce the use of electrochemical techniques in corro-

sion application. Special emphasis will be placed on the proper use of modern instrumentation. Participants will have the opportunity to operate state-of-the-art instruments in laboratory sessions designed to complement the lecture material. Techniques for the proper interpretation of data for use in corrosion prediction and prevention, and examples of where these methods have been successfully utilized will also be presented.

For additional details, contact Marc Rothstein, EG&G Princeton Applied Research, CN 5206, Princeton, NJ 08543.

CALL FOR PAPERS

13th Annual Meeting of the Adhesion Society February 18-21, 1990 Savannah, GA

Papers are being accepted for the 13th Annual Meeting of the Adhesion Society to be held February 18-21, 1990, at the Sheraton Savannah Resort and Hotel, Savannah, GA. Papers in all areas of adhesion science are welcome. Of particular interest is work on the following topics:

Rheology of Adhesives—including pressure sensitive adhesives, polymer/filler interactions, adhesive processability, adhesive curing, and adhesive toughening

Thin Film Adhesion—including coatings and adhesion in electronics

Interfaces—surface analysis, surface modification, and fiber-matrix papers are solicited

Adhesive Testing and Analysis—new tests, nondestructive testing, finite element analysis, evaluation of adhesive tests, and durability testing

Adhesion—including papers on how to avoid adhesion and lubrication.

In addition, a poster session has been scheduled for February 19 and posters are being accepted for presentation.

Persons interested in presenting a paper or poster should submit a title and one-page abstract to the Program Chairman before June 15. Long abstracts must be submitted no later than November 1 for inclusion in the Meeting Program. Papers and posters should be forwarded to: Dr. David R. Speth, 1712 Building, Dow Chemical, Midland, MI 48674.

A short course on "The Principles of Adhesion," scheduled for February 17 and 18, will proceed the meeting. For additional information on the course, contact Prof. Gary Hamed, University of Akron, Dept. of Polymer Science, Akron, OH 44325.

Further details on the Annual Meeting are available from the President of the Adhesion Society, Prof. Jim Wightman, Dept. of Chemistry, VPI & SU, Blacksburg, VA 20461.

ACS Donates Equipment To Univ. of Missouri-Rolla

Applied Color Systems, Inc., Princeton, NJ, recently donated color control equipment to the University of Missouri-Rolla for use in its Coatings and Polymer Science program, directed by Dr. Michael Van De Mark.

The donation includes: a spectrophotometer and a set of ACS Chroma-Calc Software for the paint, plastics, and ink industries.

The equipment will be used for teaching and research of coatings courses ranging from the Bachelor's through the Doctoral degree as well as industrial short courses.

CALL FOR PAPERS

American Society for Testing and Materials Symposium on Analysis of Paints and Related Materials May 14-15, 1990 Pittsburgh, PA

The ASTM Committee D-1 on Paints and Related Coatings and Materials is requesting papers for a two-day Symposium on Analysis of Paints and Related Materials, to be held May 14-15, 1990, in Pittsburgh, PA.

The purpose of the symposium is to present and publish the latest developments in coatings analysis under the following headings:

- Overview of application of modern analytical techniques to paint problem solving
- Analysis of volatile materials
- Contaminant analysis
- Defects and other failures
- Separations
- Vehicle characterization
- Analysis of additives
- Pigment analysis

Papers should be problem and/or formula oriented as opposed to being technique oriented.

Prospective authors are requested to submit a title, a 300-500 word abstract, and the ASTM Submittal Form by July 1 to: Dorothy Savini, Symposia Coordination, ASTM, 1916 Race St., Philadelphia, PA 19103-1187. Paper Submittal Forms are available from Ms. Savini.

A Special Technical Publication (STP) based on the symposium proceedings is anticipated by ASTM. Papers not accepted for presentation may be considered for publication. Final manuscripts for the STP based on this symposium are due by March 1, 1990.

More information is available from Symposium Chairman William C. Golton, E.I. du Pont de Nemours & Co., Inc., Marshall Laboratory, P.O. Box 3886, Philadelphia, PA 19146.

Basic Coatings Sales Course Offered by UMR, July 19-21

The short course "Basic Coatings for Sales and Marketing Personnel" is being sponsored by the University of Missouri-Rolla, Rolla, MO. The course is scheduled for July 19-21, at the Ramada Inn Westport, St. Louis, MO.

Due to an overwhelming response, "Basic Coatings" is being offered a second time. Course content has been modified based on feedback from the first class.

The course is designed for sales or marketing personnel in raw materials or coatings. An introduction and history of the coatings industry along with definitions and basic science will be covered at the outset of the class. Other topics to be covered include: resins, solvents, pigments, additives, testing, water-borne coatings, high-solids coatings, labeling/Material Safety Data Sheets, waste disposal, manufacturing, paints of the future, market share, new product introduction, and the technical market place.

For more details on the "Basic Coatings" short course, write Coatings and Polymer Science Program, Dept. of Chemistry, University of Missouri-Rolla, Rolla, MO 65401.

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Color Measurement System

A new, six-page, four-color brochure describes an on-line spectrophotometer. The system is designed to measure color continuously on the manufacturing line. To receive the Spectra-Probe brochure, write HunterLab, 11491 Sunset Hills Rd., Reston, VA 22090.

Safety Guide

A new resource guide detailing safety training materials, seminars, and consulting services designed to help companies improve safety performance has been published. The 57-page, spiral-bound guide describes more than 30 safety courses and features a matrix to help select the appropriate product or service to meet specific safety and training needs. For a copy of the publication, write to: Safety Services Resource Guide, Du Pont Management Services, Montgomery Bldg., Room 290, P.O. Box 80800, Wilmington, DE 19880-0800.

Fabrication Standard

A revised standard which recommends practices for the design, fabrication, and surface finish of metal tanks and vessels that are to be lined for corrosion resistance and to prevent product contamination has been issued. The standard includes appendices on acceptable and unacceptable design practices on tanks, a list of suggested responsibilities for the coating applicator to ensure the best protective coating system available, and visual and written descriptions of the degree of surface preparation of welds in tanks and vessels prior to lining. For Standard RP0178-89, write National Association of Corrosion Engineers Publications Order Dept., P.O. Box 218340, Houston, TX 77218.

Specialty Acrylic Polymers

Two new specialty acrylic polymers designed for hard, block-resistant floor paints and sealers are the subject of a product bulletin. The latexes provide alkali resistance, wet adhesion, and rapid development of hardness. Further details on UCAR® Latex 421 and 422, including formulations for high sheen, semigloss floor paints, and a clear concrete sealer, can be obtained from Union Carbide Corp., UCAR Emulsion Systems, Dept. L4488, 39 Old Ridgebury Rd., Danbury, CT 06817-0001.

Polymeric Resins

A data sheet provides information on two versions of polymeric surfactants designed for use by the coatings industry. The surfactants feature water brush cleanup in nonaqueous alkyd coatings and humidity and water staining resistance in aqueous coatings. For additional facts on Hypermer™ ABC and WSR, contact Philip Reitano, ICI Americas Inc., Wilmington, DE 19897.

Filling Machine

A new style filling machine for paints, coatings, and chemicals is highlighted in a data sheet. The Machine is designed to fill one to five gallon open top or closed top metal and plastic containers. All wetted parts are made of stainless steel. For more information on the Mod 1 filler, write Monmouth Tool & Machine Co., Inc., 2-12 Memorial Dr., Asbury Park, NJ 07712.

Color Control Systems

A product bulletin introduces a new line of color control systems which features color spectrophotometers. For more details on the Series 2000 models, write Applied Color Systems, Inc., P.O. Box 5800, Princeton, NJ 08543.

Surface-Modified Particles

A product bulletin introduces new surface-modified particles designed to enable polymer composites to replace many engineering plastics and metals. Initial uses of the particles have been in cast polyurethane parts for applications in materials handling, mining, transportation, and mechanical tools. Write Air Products and Chemicals, Inc., Composite Products Business Area—Advanced Materials, 7201 Hamilton Blvd., Allentown, PA 18195-1501 for more details on the Primax™ UH-1000 series or a complimentary one-pound sample.

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The logo for Olin, featuring a stylized 'O' with a diamond shape inside, followed by the word 'lin' in a bold, lowercase sans-serif font.

Plant Floor Computers

A technical bulletin features two new industrial computers designed to offer increased memory and fast speed to plant floor computing. The environmentally-hardened bench-top processors come rack-mounted, which enables multiple processors to be housed together, resulting in configuration flexibility and space savings. Details on the Micro Channel™ architecture-based computers can be obtained from IBM Corp., US Marketing & Services, 1133 Westchester Ave., White Plains, NY 10604.

Commerical Silicones

A 23-page brochure which details silicone fluids and their uses has been issued. The booklet highlights six classes of silicone fluids and a selection guide helps the user choose the specific silicone for functions ranging from antifoam to lubrication to working media. A copy of the brochure is available from Hüls America, Inc., 2570 Pearl Buck Rd., Bristol, PA 19007.

Viscometers

A new, 28-page booklet on the subject of viscosity is in print. The booklet is an expansion of an earlier edition and features information on new instruments and measuring techniques. Intended as a handy digest, the publication acts as a guide and offers practical advice on viscometer use and maintenance. For a copy of "More Solutions to Sticky Problems," write Brookfield Engineering Laboratories, Inc., Dept. NR-67, 240 Cushing St., Stoughton, MA 02072.

Control Valves

A 70-page handbook, written to serve as a practical working tool for process engineers who are responsible for cost efficient operation of steam and water systems, has been published. The text describes a unique line of self-contained, temperature actuated control valves. For a copy of the "Temperature Control Valve and Steam Trap Applications Handbook," write Ogontz Corp., 141 Terwood Rd., P.O. Box 479, Willow Grove, PA 19090.

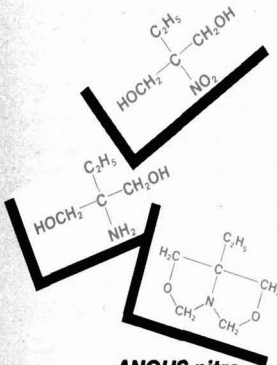
Rust Preventive Concentrates

Three products in a line of rust preventive concentrates are the subject of a technical bulletin. The concentrates qualify for use on new motor vehicles and trailers under MIL-C-62218. They are dispersions of modified overbased sulfonates used to formulate coatings for the automotive industry. Further information on SACI® 552, 552A, and 2452 may be obtained from Witco Corp., Sonneborn Div., 520 Madison Ave., New York, NY 10022-4236.

Coatings and Additives

A new, 16-page, four-color brochure which features current technology in coatings and additives has been published. The literature describes a series of cellulosic and peroxide products used by many industry segments. The publication is geared toward the aerospace, automotive, plastics, electronics, industrial finishes, wire and cable, furniture, graphic arts, and tire and rubber industries. For a copy of "Hercules Coatings & Additives," write Hercules Incorporated, Product Information, Hercules Plaza, Wilmington, DE 19894.

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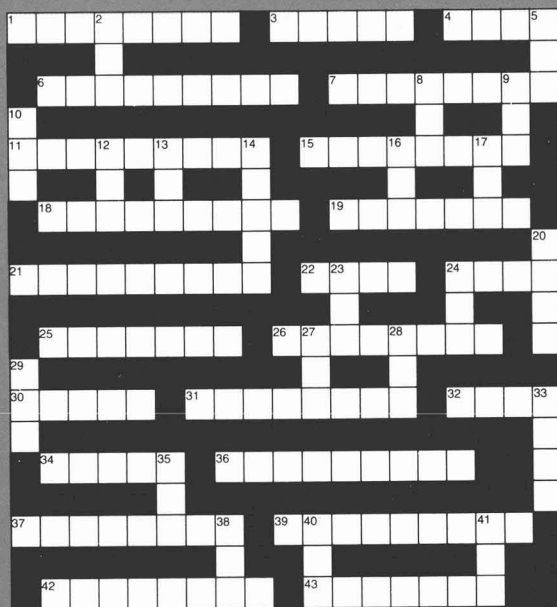
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by Earl Hill



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Published in
July issue

No. 30

ACROSS

1. Derived from glass
3. An area where two materials overlap
4. What is a metallic bond?
6. Calcium oxide (Chem.)
7. Amine used to make M-F resins
11. Greenish corrosion product on copper
15. Sparkling imperfection in a high gloss enamel
18. A form of viscosity involving density
19. A natural resin source
21. Natural American asphaltum
22. The highest boiling fraction of a solvent
24. Minute void
25. Volatile liquid; an adulterant
26. Containing numerous 24 Across
30. To set glass, as with putty
31. The science dealing with fungi

32. Post in the framework of a wall
34. Substance in a gaseous state
36. Base surface for painting or bonding
37. Natural silicate mineral ($K_2O \cdot Al_2O_3$)
39. A foreign substance present in a finished material
42. Extremely fine divided particles
43. Cellulose solution

DOWN

2. Financial yardstick, R____ (Abr.)
5. A colorant, usually organic
8. To put in
9. The amount left over, e.g., after taxes
10. Pigment volume ____ (Abr.)
12. German equivalent of our ASTM (Abr.)
13. G____ rosin
14. Moist, sticky substance; fungi created
16. A batch (Syn.)
17. Plastics engineer's group
20. Color of the spectrum (475nm)
23. When pressurized, used to spray paint
24. The strength of a shellac solution
27. Vegetable ____
28. A bean which is a source of 27 Down

29. A type of stain for wood (Abr.)
33. To smear on (unskillfully)
35. A salesperson (Slang)
38. A slender round or rectangular bar
40. The vehicle part that isn't volatile
41. A source of minerals

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_____	Paint/Coatings Dictionary	(Mbr. -\$30; Non-Mbr. -\$50)	_____
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Pictorial Standards of Coatings Defects			
_____	Complete Manual	(\$90)	
_____	Individual Standards (\$3 ea., plus \$3 per photo as noted)	_____	
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_____	Checking (1)	Cracking (1)	Erosion (1)
_____	Fillform Corrosion (3)		Flaking (2)
_____	Mildew (3)	Print (1)	Rust (4)
_____	Traffic Paint Abrasion (2)	Traffic Paint Chipping (2)	
_____	Record Sheets (pad of 100 sheets)	(\$3.50)	_____
_____	Glossary of Color Terms	(\$6.00)	_____

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Addendum

The original figures (1-4) for "Effect of Substrate and Paint Layers on the Roughness and Appearance of a Silver Base Coat/Clear Coat System," which appeared in the March issue of the JOURNAL OF COATINGS TECHNOLOGY, 61, No. 770, 65 (1989), did not reproduce well. Improved reproductions are given below.

G. DALE CHEEVER
 PHUONG-ANH P. NGO
 General Motors Corp.
 Warren, MI

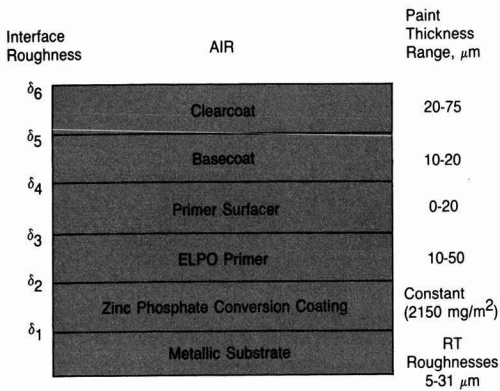


Figure 1—Representation of a typical multilayer paint system on metals

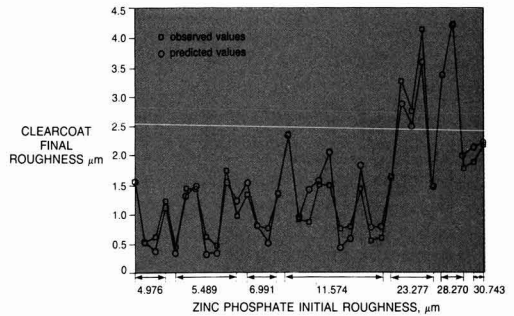


Figure 2—Predicted and observed clear coat final roughness as a function of initial zinc phosphate roughness

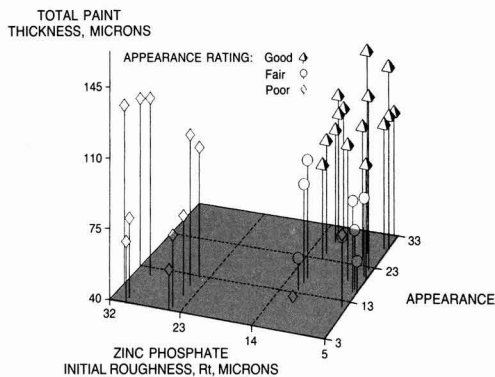


Figure 3—Effects of final clear coat roughness on appearance ratings as a function of initial zinc phosphate roughness and total paint thickness

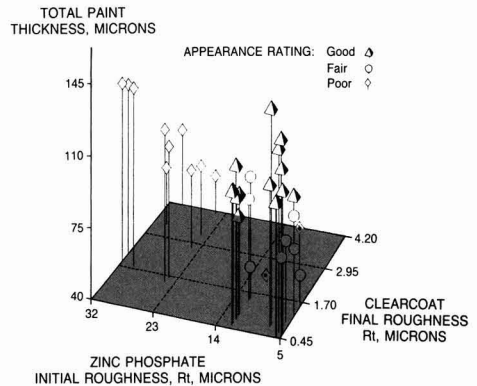


Figure 4—Appearance ratings as a function of initial zinc phosphate and final clear coat roughness

Book Review

INTRODUCTION TO PAINT CHEMISTRY AND PRINCIPLES OF PAINT TECHNOLOGY, Third Edition

By
G.P.A. Turner

Published by
Chapman and Hall
29 W. 35th St.
New York, NY 10001 (1988)
xii + 252 Pages, \$87.50

Reviewed by
Robert F. Brady, Jr.
Naval Research Laboratory
Washington, D.C.

The third edition of this respected book, like the two before it, is intended to provide a textbook for students and an introduction to paint technology for those with little or no prior background in the field.

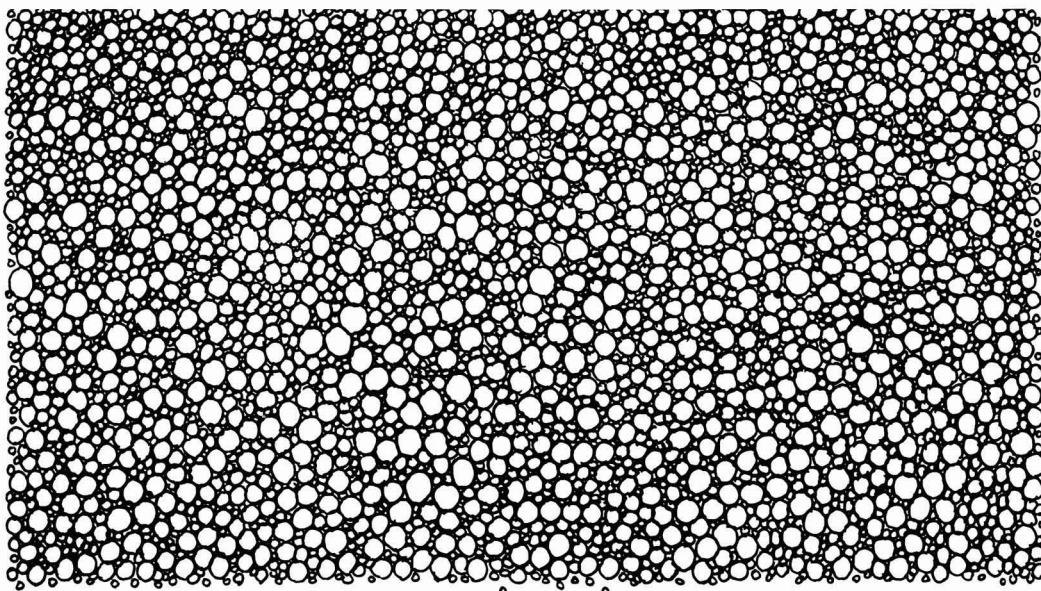
The book successfully achieves this goal by demonstrating the connection between paint technology and the chemistry and physics which underlie it.

The book is divided into two parts. Part one, on general science, contains six chapters devoted to selected basic elements of chemistry and physics. This part comprises one-third of the book and is intended to be an essential minimum preparation for the materials which follow. The topics are selected from a formulator's point of view; many of the most important, especially the discussions on polymers and color measurement, may well be missing from many undergraduate chemistry degree programs.

The second part of the book contains 11 chapters on applied paint technology. The first four of these discuss the desired properties of wet and dry paint; types and properties of pigments, including introductions to dispersion and color matching; solvents; and additives. The latter two chapters are particularly strong, and offer useful insights even to experienced formulators. The following six chapters cover resins for coatings, grouped according to the mecha-

nisms by which they form dry films. Each of these chapters contains an admirably clear and complete discussion of the chemistry of the particular resins being considered. Eleven major resins and many less important ones are discussed, including resins for water-borne, emulsion, baking, and high-solids coatings. The chapters on resins also contain many illustrative formulations. A final chapter covers the chemical treatment of plastic, wood, and metal substrates prior to painting. This chapter contains, for example, descriptions of the chromating of aluminum, the phosphating of steel, and the corona discharge treatment of plastics.

The book is bound in a soft cover, and is well written and easy to read. It contains 33 clear figures, many tables, a complete index, and an appendix giving suggestions for further reading. This third edition sustains and extends the reputation of its earlier versions, and is strongly recommended to those who seek an elementary, clear, and readable introduction to paint technology.



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Coming Events

FEDERATION MEETINGS

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

1989

(Nov. 8-10)—67th Annual Meeting and 54th Paint Industries' Show. New Orleans Hilton and The Rivergate, New Orleans, LA.

1990

(Oct. 29-31)—68th Annual Meeting and 55th Paint Industries' Show. Convention Center, Washington, D.C.

1991

(Nov. 4-6)—69th Annual Meeting and 56th Paint Industries' Show. Convention Center, Toronto, Ontario, Canada.

SPECIAL SOCIETY MEETINGS

1989

(June 19)—Golden Gate Society. "Conference '89—Image Building through Communications." Holiday Inn, S. San Francisco, CA. (Ron Hughes, Ashland Chemical, 8600 Enterprise, Newark, CA 94560).

(Aug. 29-30)—Chicago Society SYMCO '89. "Coatings in Compliance." Holiday Inn, Lisle, IL. (Rich Braunhausen, Rust Oleum, 2301 Oakton St., Evanston, IL 60204).

1990

(Mar. 14-16)—Southwestern Paint Convention. Houston and Dallas Societies. Doubletree at Post Oak, Houston, TX. (Neil McBride, P.O. Box 841156, Houston, TX 77284-1156).

(Apr. 4-7)—Southern Society. Annual Meeting. Sandestin Beach Hilton, Destin, FL. (James R. Salisbury, Union Carbide Corp., 2043 Steel Dr., Tucker, GA 30084).

1991

(Feb. 18-20)—Western Coatings Societies' 20th Biennial Symposium and Show. San Francisco Hilton, San Francisco, CA.

OTHER ORGANIZATIONS

1989

(June 18-21)—63rd Colloid and Surface Science Symposium. Sponsored by American Chemical Society Division of Colloid and Surface Science. University of Washington, Seattle, WA. (John C. Berg, Symposium Chairman, University of Washington, Dept. of Chemical Engineering, BF-10, Seattle, WA 98195).

(June 19-23)—"Corrosion Control by Coatings." Short Course sponsored by Lehigh University, Bethlehem, PA. (Henry Leidheiser, Jr., Zettlemoyer Center for Surface Studies, Sinclair Lab #7, Lehigh University, Bethlehem, PA 18015).

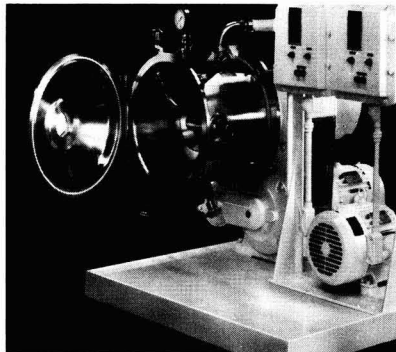
(June 19-23)—Electrochemical Techniques in Corrosion Engineering course, sponsored by EG&G Princeton Applied Research and the Baltimore-Washington Section of NACE. Presented by The Johns Hopkins University Corrosion and Electrochemistry Research Laboratory. Johns Hopkins University, Homewood Campus, Baltimore, MD. (Marc Rothstein, EG&G Applied Research, CN 5206, Princeton, NJ 08543).

(June 21-23)—Oil and Colour Chemists' Association Biennial Conference. Grosvenor Hotel, Chester, England. (Mr. Christopher Lacey-Day, Director, OCCA, Priory House, 967 Harrow Rd., Wembley, Middlesex HA0 2SF, England).

(June 25-28)—ASTM Committee D-1 Meeting. Sheraton St. Louis, St. Louis, MO. (David Bradley, ASTM, 1916 Race St., Philadelphia, PA 19103).

(June 28-30)—"Chemically Modified Oxide Surfaces" Symposium. Holiday Inn, Midland, MI. (W.T. Collins, Mail Stop C41C00, Dow Corning Corp., Midland, MI 48686-0994).

(July 10-14)—15th International Conference on "Organic Coatings Science and Technology." Athens, Greece. (Angelos V. Patsis, Institute in Materials Science, CSB 209, State University of New York, New Paltz 12561).



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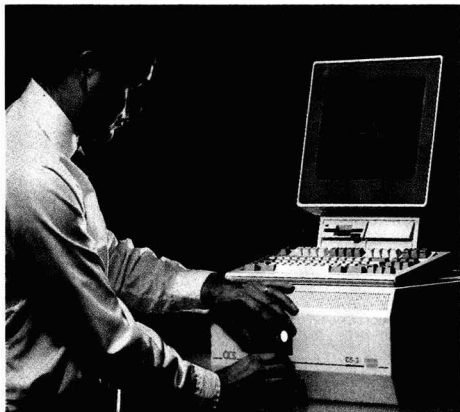
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(July 19-20)—"Paint Volatile Organic Compounds (VOC)" Workshop sponsored by ASTM Standards Technology Training. Holiday Inn—Chicago, Des Plaines, IL. (Kathy Dickinson, ASTM Standards Technology Training, 1916 Race St., Philadelphia, PA 19103).

(July 27-29)—27th Annual Convention of the Oil and Colour Chemists' Association New Zealand. Rotorua, New Zealand. (Mike Rowlands, OCCANZ, P.O. Box 5192, Auckland, New Zealand).

(Aug. 3-6)—31st Annual Convention of the Oil and Colour Chemists' Association Australia. Fairmont Resort, Leura, New South Wales. (Peter Parsons, Tioxide Australia P/L, 2A/6 Tooronga Terrace, Beverly Hills, NSW, Australia 2209).

(Aug. 9-11)—"Radiation Curable Coatings." Short Course sponsored by North Dakota State University, Fargo, ND. (Frank N. Jones, NDSU, Fargo, ND 58105).

(Aug. 21-25)—12th Annual "Advances in Emulsion Polymerization and Latex Technology" Short Course. Schatzalp Berghotel, Davos, Switzerland. (Gary W. Poehlein, Graduate Office [Savant], Georgia Institute of Technology, Atlanta, GA 30332-0265).

(Aug. 21-25)—"Electroplating and Surface Finishing for Electronic Applications." Course sponsored by the American Electroplaters and Surface Finishers Society. Hyatt Palo Alto, Palo Alto, CA. (Sylvia L. Baxley, AESF, Central Florida Research Park, 12644 Research Parkway, Orlando, FL 32826).

(Aug. 22-26)—"Surface Phenomena and Fine Particles in Water-Based Coating and Printing Technology." International Symposium sponsored by the Fine Particle Society. Marriott Copley Place, Boston, MA. (Mahendra K. Sharma, Research Laboratories, Eastman Kodak Co., Box 1972, Kingsport, TN 37662, or F.J. Micale, Sinclair Laboratory, Bldg. 7, Lehigh University, Bethlehem, PA 18015).

(Sept. 6-7)—"Introduction to Electroplating and Surface Finishing." Training course sponsored by the American Electroplaters and Surface Finishers Society. Ramada Inn Oakbrook 3, Elmhurst, IL. (Sylvia L. Baxley, AESF, Central Florida Research Park, 12644 Research Parkway, Orlando, FL 32826).

(Sept. 11-15)—"Laboratory Corrosion Testing." Short Course sponsored by the Southwestern Ohio Section of NACE and NACE/Fontana Corrosion Center at Ohio State. Ohio State University, Columbus, OH. (John Beavers, 2704 Sawbury Blvd., Columbus, OH 43235, or Steve Corey, 1020 W. Park Ave., Kokomo, IN 46901).

(Sept. 12-14)—Haztech International Fourth Annual Conference and Exhibition. Cincinnati Convention Center, Cincinnati, OH. (Rachelle Scheinbach or Ursula Barril, Haztech International, 13555 Bel-Red Rd., C-96870, Bellevue, WA 98009).

(Sept. 14-15)—"Waste Treatment Simplified." Course sponsored by the American Electroplaters and Surface Finishers Society. Ramada Inn Chandler, Chandler, AZ. (Sylvia L. Baxley, AESF, Central Florida Research Park, 12644 Research Parkway, Orlando, FL 32826).

(Sept. 18-22)—"Electroplating and Surface Finishing." Training course sponsored by the American Electroplaters and Surface Finishers Society. Ramada Inn Oakbrook 3, Elmhurst, IL. (Sylvia L. Baxley, AESF, Central Florida Research Park, 12644 Research Parkway, Orlando, FL 32826).

(Sept. 23-28)—12th World Conferences on Non-Destructive Testing sponsored by the Dutch Non-Destructive Testing Society. RAI International Exhibition and Congress Center, Amsterdam, The Netherlands. (RAI International Exhibition and Congress Center, Europaplein, 1078 GZ, Amsterdam, The Netherlands).

(Sept. 25-27)—Third Annual Hazardous Materials Management Conference and Exhibition of Canada (HazMat/Canada '89). Harbour Castle Westin Conference Centre, Toronto, Ont., Canada. (Tower Conference Management Co., 800 Roosevelt Rd., Bldg. E—Suite 408, Glen Ellyn, IL 60137-5835).

(Sept. 25-29)—"Electroplating and Surface Finishing for Electronic Applications." Course sponsored by the American Electroplaters and Surface Finishers Society. Sheraton University Center, Durham, NC. (Sylvia L. Baxley, AESF, Central Florida Research Park, 12644 Research Parkway, Orlando, FL 32826).

(Sept. 25-30)—American Chemical Society. 196th National Meeting. Los Angeles, CA. (B.R. Hodson, ACS, 1155—16th St. NW, Washington, D.C. 20036).

(Sept. 26-27)—Finishing '89. Telford Exhibition Center, Telford, Shropshire, England. (Nigel Bean, Turret Group Plc, Turret House, 171 High St., Rickmansworth, Herts, WD3 1SN).

(Sept. 26-28)—"Inspection of Coatings and Linings for Immersion Service" Course sponsored by KTA-Tator, Inc., Pittsburgh, PA. (KTA-Tator, Inc., 115 Technology Dr., Pittsburgh, PA 15275).

(Sept. 27-29)—Liquitec Expo '89 (Carolyn Mesce, Liquitec Expo, P.O. Box 630, West Paterson, NJ 07424).

(Sept. 27-29)—Haztech International Fourth Annual Conference and Exhibition. San Francisco Civic Auditorium, San Francisco, CA. (Rachelle Scheinbach or Ursula Barril, Haztech International, 13555 Bel-Red Rd., C-96870, Bellevue, WA 98009).

(Oct. 4-6)—National Coil Coaters Association (NCCA) Fall Meeting. Hyatt Regency at O'Hare Airport, Chicago, IL. (NCCA, 1900 Arch St., Philadelphia, PA 19103).

(Oct. 23-25)—"High-Coatings." 9th International Conference of the Paint Research Association. Sheraton Hotel, Frankfurt, West Germany. (Dip Dasgupta, Head of Information Dept., PRA, 8 Waldegrave Rd., Teddington, Middlesex TW11 8LD, England).

(Oct. 24-26)—8th International Conference on the Internal and External Protection of Pipes. Cosponsored by BHRA and Snamprogetti. Florence, Italy. (Conference Organizer (Pipe Protection), BHRA, The Fluid Engineering Centre, Cranfield, Bedford MK43 0AJ, England).

(Oct. 31-Nov. 2)—"Maintenance/Industrial Painting Practices" Course sponsored by KTA-Tator, Inc., Pittsburgh, PA. (KTA-Tator, Inc., 115 Technology Dr., Pittsburgh, PA 15275).

(Nov. 1-2)—"Paint Volatile Organic Compounds (VOC)" Workshop sponsored by ASTM Standards Technology Training. ASTM Headquarters, Philadelphia, PA. (Kathy Dickinson, ASTM Standards Technology Training, 1916 Race St., Philadelphia, PA 19103).

(Nov. 6-7)—25th Annual Symposium of ASTM Committee G-1. Orlando, FL. (Symposium Chairman Robert Baboian, Texas Instruments, Inc., Electrochemical and Corrosion Laboratory, Mail Station 10-13, Attleboro, MA 02703, or Sheldon W. Dean, Jr., Air Products and Chemicals, Inc., P.O. Box 538, Allentown, PA 18105).

(Nov. 6-8)—National Paint & Coatings Association Annual Meeting. New Orleans Hilton Hotel, New Orleans, LA. (NPCA, 1500 Rhode Island Ave., N.W., Washington, D.C. 20005).

(Nov. 7-9)—Hazardous Materials Management West Conference and Exhibition. Long Beach Convention Center, Long Beach, CA. (Brenda O'Neal, Show Manager, Tower Conference Management Co., 800 Roosevelt Rd., Bldg. E—Suite 408, Glen Ellyn, IL 60137-5835).

(Nov. 18-20)—National Decorating Products Show sponsored by the National Decorating Products Association. McCormick Place, Chicago, IL. (Lillian Smysor, NDPA, 1050 N. Lindbergh Blvd., St. Louis, MO 63132-2994).

(Nov. 28-30)—"Level II—Industrial Maintenance Course" sponsored by KTA-Tator, Inc., Pittsburgh, PA. (KTA-Tator, 115 Technology Dr., Pittsburgh, PA 15275).

(Nov. 28-Dec. 1)—The Inter-Society Color Council Williamsburg Conference. Williamsburg, VA. (Roy Berns, Rochester Institute of Technology, P.O. Box 9887, Rochester, NY 14623-0887).

1990

(Feb. 18-21)—Adhesion Society Annual Meeting. Sheraton Savannah Resort and Hotel, Savannah, GA. (Adhesion Society President Jim Wightman, Dept. of Chemistry, VPI & SU, Blacksburg, VA 20461).

(Mar. 25-29)—RadTech '90—North America. Radiation Curing Conference and Exposition. Hyatt Regency Chicago, Chicago, IL. (RadTech International North America, 60 Revere Dr., Suite 500, Northbrook, IL 60062).

(Apr. 2-6)—11th International Corrosion Congress. Florence, Italy. (AIM—Associazione Italiana di Metallurgia, Piazzale Rodolfo Morandi, 2, I-20121 Milano, Italy).

(May 14-15)—"Analysis of Paints and Related Materials." Symposium sponsored by ASTM Committee D-1. Pittsburgh, PA. (Marsha Firman, ASTM, 1916 Race St., Philadelphia, PA 19103).

1991

(Feb.)—Inter-Society Color Council Williamsburg Conference. Williamsburg, VA. (Louis A. Graham, Lou Graham & Associates, Inc., 1207 Colonial Ave., Greensboro, NC 27408).

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'Humbug' from Hillman

I trust that Humbug's students are, again, ready to absorb the weighty lessons to be found in the 1974 *Farmers' Almanac*. You remember, of course, that philosopher Roy Tasse was kind enough to share this source of some of his wisdom with us.

Capsules of Wisdom

- If you don't change direction, you will wind up where you're going.
- Alimony is like making payments on your car—after it has been wrecked.
- A bargain is something you can't use at a price you can't resist.
- *Loser*: A would-be suicide who turns on the gas, changes his mind and lights a cigarette.
- *Confucius say*: Girl who buys clothes on installment, gets dressed on time.
- *Pessimist*: One who looks on life through woe-colored glasses.
- Prejudice is a time saver; it enables you to pass judgement without getting the facts.

The judge read the charges and then asked, "Are you the defendant in this case?"

"No sir, your Honor. I got me a lawyer to do the defendin'. I'm the guy who done it."

Topless suits and peek-a-boo clothes
Mini skirts and see-through hose
If Godiva made her ride today
Would you even glance her way?
Yes, I guess you would, of course.
People seldom see a horse.

A man, we'll call him Jones, is riding to work on the subway in New York City and there's a guy who keeps bumping into him. After a while, Jones gets apprehensive and thinks, "This can't be what I think it is!"

He checks for his wallet and it's gone.

"That's it! Nine o'clock in the morning and already I get ripped off in the subway. Things are really getting bad and I'm not going to take it."

He grabs the guy, shakes him hard, and says, "All right, cough up, give me that wallet."

The guy is petrified and hands over a wallet. Jones goes off to work, telling everyone of his good fortune in being so tough and alert.

After a while, his wife calls and says, "Honey, you left your wallet on the bureau this morning."

● A bridegroom is one who has lost his liberty in the pursuit of happiness.

● *Taxpayer*: A government worker with no vacation, no sick leave, and no holidays.

● It may be true that man does not live by bread alone, but look at those getting along on crust.

● Small boy's definition of conscience: Something that makes you tell your mother before your sister does.

● Food prices are so high that even the vegetarians are starting to beef.

● One thing about early marriages is that they shorten the generation gap.

The aforementioned Roy Tasse sent us a list of additional candidates for honorary membership in the Federation:

A number of Ethyls, but we think Ethyl Cellulose is the most deserving.

Flo Coater

Ben Zoll

"Red" Lead

"Fatty" Acid

Annie Leen

There were several others but Humbug thinks the matter should end here!

● *Committee*: A group that keeps minutes but squanders hours.

● Living in the lap of luxury isn't bad except that you never know when luxury is going to stand up.

● Kids are grown up when they stop asking where they came from and refuse to tell you where they're going.

● The best time in a family's life is when the kids are old enough to help with the chores and too young to drive.

● A parking space is an area that disappears as you are making a U-turn.

—The Lion

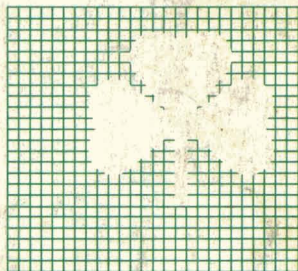
[*Aside to Joe B. Sheraton (or his nameless sponsor): Your insurance claim was published in Humbug, October 1984. If you haven't collected yet, forget it.*]

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



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