Critical Pigment Volume Concentration Measurements . . . A Very Fast Method

by Walter K. Asbeck
Coatings Consultant

Because of the importance of knowing the Critical Pigment Volume Concentration (CPVC) for maximum performance of all pigmented coating systems, a large number of methods to measure CPVC have been proposed. All attempts to predict the critical point on theoretical grounds have been unsuccessful. Some tests for CPVC are quite accurate and reliable in showing where the break in the formulating ladder exists. Some require considerable judgment.

All tests for CPVC, unfortunately, require the preparation of the coating compositions, including pigments used, vehicles (both solution and latex type), and their grinds. The composition must then be deposited on some substrate and dried—either by air or bake—before the classical tests can be used. All facets of the coatings manufacture must be included in the test samples. The required sample may be produced relatively fast in the case of baked systems or very slow in the case of some air-dried systems.

All of the classical tests made on these PVC ladders are relatively time consuming and total testing time may require many hours. A new method of testing on the PVC ladder, which is both very fast and requires minimal instrumentation, is proposed here. For the most part, the tests on each sample can be made in less than one minute.

CRITICAL PIGMENT VOLUME CONCENTRATION MEASUREMENTS — A VERY FAST METHOD

Since its introduction over 50 years ago,[1] the concept of Critical Pigment Volume Concentration has been completely confirmed in coatings literature. It influences the behavior of coatings systems directly or indirectly. Performance, coatings application, production, and storage characteristics all are affected by CPVC.

Although the concept was developed for solution-type coatings, it works equally well for dispersion-type (latex) systems. The details of the two systems, however, are different.[2]

The CPVC has been defined[1] as: "the transition point above or be-

301 Knollwood Trail, Richmond Heights, OH 44134.

low which substantial differences in the behavior and appearance of a paint film are encountered. It is that point in a paint system at which just sufficient binder is present to fill completely the voids left between the pigment particles incorporated in the film after volatilization of thinner or water, respectively. It represents the densest degree of packing of the pigment particles commensurate with their degree of dispersion."

Below the CPVC, the coating is coherent and relatively impermeable. Above the CPVC, the coating becomes progressively more porous.

Thus, most of the desirable properties of coatings systems deteriorate very rapidly above the critical point. Almost all coatings properties such as protective qualities, gloss, blistering, rusting, surface roughness, enamel holdout, hiding, tensile strength, elongation, stain removal, scrubbability, cleanability, dirt absorption, water sorption, electrochemical impedance, DC resistance, and many more change radically at this point. It has been found that many desirable properties are at a maximum at the CPVC.

As a consequence of this situation, measuring any or all of the coatings properties listed above can be used to determine the CPVC of a paint system. All measurements require testing the exact formulation, grind, and drying of a paint ladder spanning the expected value of the CPVC made and applied to a suitable substrate.

This coatings ladder preparation, then, is always the first step for any of these tests. The time required for this phase obviously depends on the methods of preparation and drying of the test coating. This may be relatively short in, for instance, the case of baked coatings, or very long for air-dried systems.

Table 1 lists some of the possible test methods employing the coatings failure characteristics previously listed. Others could be suggested. The order of the listing is arbitrary and includes the relative times required, limitations of substrates, and reliability of the tests to show substantial recognizable differences just below and above the CPVC. The characterization of each testing method is judgmental. Other researchers may differ on the conclusions that are presented.

A NEW TEST METHOD

Special attention is drawn to the Saline DC conductivity listing (number 15). The method was developed for use at a large coatings manufacturer. It is extremely fast compared with all of the other methods listed. It should take less than one minute to test each of the samples of the previously prepared PVC ladder. Furthermore, the testing method is nondestructive.

The method requires a conductive substrate. Any conductive, fairly smooth, solid surface can be employed. This would encompass all of the metals, including iron, aluminum, copper, zinc plate, tin plate, and others. Inherently conductive coatings cannot be measured. The equipment required is remarkably simple and consists of a small container such as a petri dish to hold a mild saline solution, a small piece of porous paper, and a small, ordinary analog multi-meter having resistance measuring capabilities. The time required for a measurement, as already mentioned, is minimal. It should take 45 seconds or less per sample for someone with minimal experience.

The exact procedure is as follows: (1) A piece of household paper towel about four inches square is folded four times into an approximately one-inch square "pad." (2) The pad is soaked briefly in a saline solution of about 50 ml of water containing about one to two grams of salt. A little more or less of the water or salt is acceptable. Also, other materials can be used for the pad, such as small sponges.

Table 1—Possible Test Methods

Test Method	Substrate Limitations	Equipment	Relative Time	Reliability
1 .....Permeability	Permeable	Humidity cabinet	Long	High
2 .....Rusting	Iron	Salt cabinet	Long	High
3 .....Blistering	Any	Humidity cabinet	Long	High
4 .....Gloss	Any	Gloss meter	Medium	Low
5 .....Surface roughness	Any	Profile meter	Medium	Low
6 .....Enamel holdout	Any	Gloss meter	Medium	Low
7 .....Hiding	Any	Gloss meter	Medium	Low
8 .....Tensile strength	Pealable	Tensile tester	Long	High
9 .....Elongation	Pealable	Tensile tester	Long	Low
10 .....Stain removal	Any	Scrub tester	Long	Low
11 .....Scrubbability	Any	Scrub tester	Long	Low
12 .....Cleanability	Any	Scrub tester	Long	Low
13 .....Dirt absorption	Any	Scrub tester	Long	Low
14 .....Electrochemical impedance	Permeable	Impedance bridge	Long	High
15 .....Saline DC conductivity	Conductive	Volt/ohm meter	Short	High

However, the pad must be sufficiently wet to saturate the paint coating but not so wet that the saline solution runs onto other test areas of the ladder.

The soaked "pad" electrode is laid onto the surface of the paint sample to be tested. The meter reading resistance circuit is then closed by touching one probe to the pad and the other to some uninsulated portion of the sample substrate. This could be, for instance, the uncoated back of the substrate. If this is not available, a scratch can be made through the coating to obtain a metallic contact. Although it is unimportant whether the positive or negative electrode is touched to the pad, slightly better excursions on the meter needle are found if the negative electrode is used. This is due to the enhanced migration of the salt ions through a porous coating under test as a result of the small potential applied.

The "pad" electrode area can be enhanced by placing a small, conductive object, like a copper penny, on it. However, this does not change the meter readings substantially. Also, clip type electrode probes can be used to hold and manipulate the pad.

The cohesive coating below the CPVC will show very high resistance and the meter needle will barely move. The 1K (1000) ohm setting on the meter is the preferred range. Above the CPVC, the reading will show large excursion of the meter indicating resistances in the order of 5 to 10 ohms. This, of course, shows that the coating is porous.

If for some reason the return electrode cannot be touched to a conductive portion of the substrate—for instance, where the sample is very large or a scratch cannot be tolerated—a second pad can be used to complete the circuit. However, attention must be paid to not allow the saline solution from the two pads to touch. This would indicate a porous coating when indeed it may not be.

CONCLUSIONS

The classical methods for measuring CPVC are discussed. Advantages and disadvantages are described as well as estimates of relative testing times.

A new, very fast, and simple method is described to measure the Critical Pigment Volume Concentration on a PVC ladder of the coating applied to a conductive substrate.

References

(1) Asbeck, W.K. and Van Loo, M., *Ind. Eng. Chem.*, 41, 1470 (1949).

(2) Asbeck, W.K., "Dispersion and Agglomeration: Effects on Coatings Performance," JOURNAL OF COATINGS TECHNOLOGY, 49, No. 635, 59 (1977).

Calendar

March 2005

15-17 **Expo Coating 2005 International Exhibition and Conference—Coatings and Surface Treatment.**
World Trade Center, Moscow, Russia
ITE Group plc
Voice: +7.812.380.6002
Email: coating@primexpo.ru

22-23 **Powder Coating Technology Training Course.**
Middlesex, U.K.
Paint Research Association (PRA)
Voice: +44.0.20.8614.4815
Email: e.brown@pra.org.uk

April 2005

11-12 **Colour Measurement & Colour Control Training Course.**
Middlesex, U.K.
Paint Research Association (PRA)
Voice: +44.0.20.8614.4815
Email: e.brown@pra.org.uk

11-15 **Powder Coating Europe 2005: Surface Technology.**
Trade Fair at Exhibition Grounds
Hannover, Germany
Voice: +49.511/89.31100
Web: www.surfacetechnology-pce.de

12-13 **6th Asia Coatings Market Conference.**
Omni Saigon Hotel, HCM City, Vietnam
Voice: +65.6345.7322
Email: nancy@cmisp.com.sg

13-14 **2nd European Congress for Surface Technology.**
Convention Centre on the Exhibition Grounds, Hannover, Germany
Vincentz Network
Voice: +49.511.9910.231
Web: www.coatings.de/icc/press.cfm

17-20 **2005 TAPPI Coating Conference and Exhibit.**
Sheraton Centre Hotel
Toronto, Ont., Canada
Voice:770.209.7292
Email: exhibits@tappi.org

25-28 **European Coatings Show 2005 plus Adhesives, Sealants, Construction Chemicals.**
Exhibition Centre, Nuremburg, Germany.
Vincentz Verlag
Voice: +49.0.5.11.9910.270
Email: schwencke@coatings.de

Go to www.coatingstech.org/Programs/Events.html for a full listing of Industry Events.

European Coatings Show 2005 plus Adhesives, Sealants, and Construction Chemicals to Be Held April 26–28

The 2005 European Coatings Show plus Adhesives, Sealants, and Construction Chemicals, is scheduled for April 26–28 in the Exhibition Centre in Nürnberg, Germany. Products to be exhibited include: coating raw materials, printing ink raw materials, adhesive raw materials, intermediates for construction chemicals, laboratory and production equipment, testing and measuring equipment, application, environmental protection and safety at work, and various services. Organized again by NürnbergMesse GmbH , Nürnberg, Germany, and Vincentz Network, Hannover, Germany, the 2005 event hopes to exceed the numbers recorded at the 2003 event: 646 exhibitors and over 16,000 trade visitors from 85 countries.

In conjunction with the show, a program of congresses and supporting events will be held April 25–27 at the CCN Ost, the new congress center at NürnbergMesse. The program includes: The 8th Nürnberg Congress; Stick! The 4th European Congress on Adhesive and Sealant Raw Materials; The 5th European Congress on Construction Chemicals; and The 2nd European Congress for Purchasers in the Coatings Industry. Other events include: The 3rd Ink Makers' Forum and The 3rd Workshop on Production Technology. In addition, receptions will be held for the trade visitors from India and Eastern Europe on April 26 and April 27, respectively.

The 8th Nürnberg Congress will be held April 25–26. Focusing on the theme "Creative Advances in Coatings Technology," international scientists from coatings industry companies, institutions, and universities will present new developments and research work on coatings.

Stick! The 4th European Congress on Adhesive and Sealant Raw Materials will feature "Innovative Raw Materials for Structural Adhesives." The congress, to be held April 27, is designed to create dialogue between manufacturers of raw materials, adhesives, and sealants while focusing on "sticking" as a multifunctional jointing technique for the rational production of composite joints of different materials with exceptional properties.

The 5th European Congress on Construction Chemicals is scheduled for April 27. Developed around the keynote of EU Enlargement, the congress will explore a variety of new opportunities, especially for the international building industry and intermediates for construction chemicals. In addition, new developments for functional surfaces and their growing innovation potential for the construction chemicals industry will be discussed.

Purchasers' Day—The 2nd European Congress for Purchasers in the Coatings Industry will explore the "Current Issues in Coatings Procurement." To be held April 26, the congress will feature keynote addresses on the resulting challenges of worldwide raw materials trade, such as effective negotiation, optimization of own purchasing structures, and handling monopolists.

The 3rd Ink Makers' Forum is scheduled for April 27. Developed around the theme "Formulating the Future of Printing Inks," the forum invites international printing ink producers and their suppliers to discuss current and key innovations in the formulation and production of printing inks. Discussion topics will include the rapid developments in printing technology, the environmental regulations, and the cost situation influencing the printing systems of the future.

The 3rd Workshop on Production Technology will focus on "Trends and Prospects of Modern Coatings Manufacturing." To be held April 27, production decision-makers from the international paint and coatings industry will meet to discuss the key theme of manufacturing new coatings materials, e.g., nano coatings. Speakers from machinery, plant manufacturing, and the coatings industry will present innovations on more efficient functional flows in the coatings factory.

A "one-day entrance pass" costs EUR 35. A "permanent entrance pass" costs EUR 45 (cost includes the exhibition catalog). Admission is free for students/trainees from the coatings industry (proof of ID is necessary). Entrance passes and catalogs may be ordered online at www.european-coatings-show.de/ticketshop. Advance tickets may be purchased until April 12.

The official printed exhibition catalog may be purchased for EUR 15 plus shipping and handling.

Detailed information is available at www.european-coatings-show.de and www.coatings.de. For additional information about the congresses contact Vincentz Network Events Division at +49.0.511.9910.276; fax: +49.0.511.9910.279; events@coatings.de. For additional information about the exhibition contact NürnbergMesse GmbH Visitor Information at --49.0.911. 8606.4900; fax: +49.0.911.8606.4901; besucherinfo@nuernbergmesse.de.

RadTech Europe 2005 Seeks Exhibitors for UV/EB Event

RadTech Europe 2005 is inviting interested companies to exhibit at their event to be held October 18–20 at the International Convention Center in Barcelona, Spain. A discount will be extended to those applications received by April 15. Organized jointly by RadTech Europe, the European Association for the advancement of radiation curing by UV, EB, and laser beams, The Hague, The Netherlands, and Vincentz Network, Hannover, Germany, the exhibition will include the following segments: raw materials for radiation curing coatings; radiation curing coatings; radiation curing equipment; testing equipment; coating, laminating, and printing equipment; and services.

The event will also include a conference that will be run parallel to the exhibition. Focused on the theme "UV/EB—Join the Winning Technology," more than 120 paper and poster presentations will demonstrate the results and technical merits of recent R&D, new processes, equipment, and products.

For more information, contact Amanda Beyer, Vincentz Network, at Amanda.beyer@coatings.de, +49.511.99.10271 or fax: +49.511.99.10279; or visit www.coatings.de/rte or www.radtech-europe.com.

ABRAFATI 2005 Issues Call for Papers

The Brazilian Association of Paint Manufacturers will host ABRAFATI 2005 on September 14–16, 2005 at the ITM-Expo Center in São Paulo, Brazil. The biennial event, incorporating the 9th International Paint Industry Suppliers Exhibition and the 9th International Paint Congress, will fill more than 200,000 sq. ft. with over 130 booths representing the main suppliers of raw materials, equipment, technology, and services. Products to be exhibited include: resins, emulsions, pigments, emulsifiers, solvents, drying agents, additives, vegetable oils, packaging, machines, and laboratory equipment. Industry professionals from Brazil, the Americas, Asia, and Europe are expected to attend.

In preparation of the congress portion of the event, a Call for Papers has been issued. Technicians, professors, researchers, and other industry professionals are encouraged to submit an abstract for evaluation by the Congress Scientific Committee by March 30. In addition to the submitted presentations, industry specialists from both the FSCT and SATER, Sociedad Argentina de Technólogos en Recubrimientos, will speak at the Congress. ABRAFATI reports that their 2003 Congress included 75 paper presentations, three opening session presentations, 21 poster presentations, and 1000 congress participants.

For more information, contact ABRAFATI at 5511.3845.0598 or congress@abrafati.com, or visit www.abrafati.com.

CPMA to Host Color Technology Conference; Speakers to Focus on "Innovation in Color"

The Color Pigments Manufacturers Association, Inc. (CPMA), Alexandria, VA, will host the 2005 CPMA International Color Pigments Conference on April 20-22 at the Hyatt Regency Baltimore at the Inner Harbor, Baltimore, MD. Exploring the theme, "Innovation in Color," the conference has confirmed over 20 speakers to date, including Wes Lucas, president, CEO and chairman of the board, Sun Chemical Corporation; Alan Farer, vice president, research, Coty Cosmetics; and Brian West, vice president, color technology, Techmer PM.

The two-day conference is designed to focus on new developments in technology and innovations available from pigments manufacturers, and investigate new developments in pigments, end use industries, materials, color measurement and evaluation, trade issues, and business/economic developments.

In addition to speaker presentations, the conference will also include exhibitors, sponsors, and networking receptions.

The conference is being held in association with Rodman Publications, publishers of *Coatings World*, *Ink World*, and *Happi* magazines.

Registration closes March 31. For complete details about the conference, contact CPMA at 703.684.4044 or visit www.pigments.com.