Formulating Ultra-Low-VOC Wood Furniture Coatings

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It is estimated that the annual U.S. market for wood coatings is approximately 240,000 m^3 (63 million gallons). On this basis, between 57 and 91 million kilograms (125-200 million pounds) of volatile organic compounds (VOCs) are emitted into the air each year from the use of presently used water-borne and solvent-borne systems. The use of VOC-free formulations, where possible, would reduce air pollution while providing new markets for industries.

The South Coast Air Quality Management District (SCAQMD) Rules 1104 and 1136 — Wood Products Coatings require reduction of VOCs from such sources. It is estimated that SCAQMD-wide compliance with these rules would reduce VOC emissions by about 18 Mg (20 tons) per day through a gradual shift from high to low-VOC coatings. By phasing in low-VOC coatings, instead of requiring installation of add-on controls, SCAQMD believes that furniture manufacturers will be able to comply with SCAQMD's rules without increased costs. To remain competitive in the regulated South Coast Air Basin, coatings formulators and furniture manufacturers have expressed interest in seeing further developments in low-VOC coatings technology.

Adhesive Coatings Co. (ADCO), San Mateo, Calif., a small firm specializing in low-VOC, two-component, water-based epoxy coatings, is currently developing coatings which will comply with and/or exceed the emissions standards set forth in Rules 1104 and 1136. The company holds patents on some of these formulations.

Several large companies that manufacture and supply products used in the wood coatings industry have been contacted. The product marketing discussions have centered on how best to commercialize specific ultra-low-VOC finished coating applications. Discussions are under way with two major corporations, both of which are worldwide suppliers of industrial products and services to the coatings, adhesives, and polymer industry, and are recognized as leaders in providing coatings and ancillary products for the wood industry.

Objectives

The objective of this project is to develop new low/no VOC wood coatings through continuing research, formulation adjustments, and application testing. In addition to the basic development of the coatings, a marketing plan will be developed to get the products of this project into the public's use.

Efforts are dedicated to conduct joint research into new promising technologies that are sufficiently mature for demonstration to wood product manufacturers. The high

TABLE I. VOC Content of Wood Coatings

Sample Described As:	Adhesive Coatings Co.. Part B 65-99 (Clear) Part A 76-64 (White)
Source:	2755 Campus Drive, Suite 125 San Mateo, CA 94403

Analytical work performed, method of analysis and results:
Volatile content by ASTM-D-2369-81[1], density by ASTM-D-1475-60, water by ASTM-D-3792 (GC), and calculations by ASTM-D-3960-81 Section 8.2.4.

VOCs content[2]
VOCs, g/l (of coating) = <10
VOCs, g/l (of material) = <10

1. The detection limit for VOCs is 10 g/l.
2. The two products (76-64 and 65-99) were mixed 5: 1 prior to actual analysis.

value-added coating products are developed using existing technical know-how, data and patents related to the new technologies.

Project Description

This new wood coating system consists of an epoxy component (Part A) and an amine curing component (Part B). The complete absence of organic solvents means that this new coating system is not only less hazardous to use, but emits practically no VOCs and therefore does not significantly contribute to air pollution. The ultra-low-VOC content of these new wood coatings was confirmed by tests at the Center for Emissions Research and Analysis, as shown in Table I. This new two-component water-based epoxy wood coating system has the potential to set a new standard and therefore replace a significant share of current organic solvent systems in use.

TABLE II. Physical Properties of Applied Finish

Color	Clear or pigmented white
Service Temperature Limits	–18 to 120° C (O to 250° F). May discolor over 60°C (140°F) after a long period of baking
Gloss	Clear coating — 90 @ 80° meter Pigmented coating — 75 @ 80° meter
Hardness	Pass 2H pencil
Flexibility	Pass 3 mm (1/8 in.) mandrel bend on steel
Impact Resistance	Direct — Pass 3 m/kg (60 in./lb) Indirect — Pass 1.5 m/kg (30 in./lb)
Adhesion	Pass crosshatch 100 percent
Stain Resistance (After 1 hour of exposure)	Coating is resistant to: Coffee Grape juice Mustard Ketchup Carbonated cola beverage 100 proof vodka Shoe polish Laundry spot cleaner Detergent 1,1,1 trichloroethane Acetone Petroleum solvents Ethyl alcohol

Coating Characteristics

This new ultra-low-VOC wood coating system is a high-performance, two-part, chemically cured, water-reducible, fast-drying, epoxy product used as a wood coating. It is a hard, durable primer coating that can be applied to a variety of wood surfaces. The coating system, as it now stands, has the following performance properties:

- less than 10 g/l (0.1 lb./gal.) VOCs,
- liquid with rapid initial drying characteristics upon application,
- hardness,
- flexibility,
- chemical resistance,
- effort still required to improve sandability, and
- effort still required to lessen wood discoloration.

Technical Approach

The coating development steps are to make the necessary formulation adjustments, continue with application testing to improve the product characteristics, and overcome the shortcomings. The goal of the project is to develop a wood coating system that will set new industry standards for VOC levels.

The results of the research procedures and laboratory tests are documented and written status reports are prepared detailing the work completed to date along with the identification of areas that may require further investigation.

The technical approach has centered around the following activities:

- Work towards reformulating ADCO's patented epoxy polymer in combination with different curing agents;
- Identify those compositions that yield the best overall coating performance in terms of gloss value, drying time, hardness/flexibility, and chemical and stain resistance;
- Conduct the emission tests required to determine whether the compositions selected have less than 10 g/l VOCs;
- Formulate emulsions with white pigment for those compositions that meet the performance criteria and emissions limits;
- Identify those pigmentations that yield the best overall coating performance in terms of gloss value, drying time, hardness/flexibility, and chemical and stain resistance;
- Conduct the emission tests required to determine whether the pigmentations selected have less than 20 g/l VOCs;
- Prepare different finished wood panel coupons, both clear and pigmented, to demonstrate finished coatings that meet the performance criteria and emissions limits; and
- Assess the market acceptance by a written survey and develop two annual marketing reports to summarize the survey results, manufacturer acceptance, cost benefits, and any application limitations.

Task Description

The program for making formulation adjustments and undertaking the necessary application testing to meet the desired product characteristic goals are outlined in the following tasks:

Task 1 — Formulation Variations

Polymer composition variations of the basic epoxy polymer in combination with each of several curing agents were conducted. The resulting emulsion was analyzed through laboratory tests to measure gloss value, drying time, hardness/flexibility, level of solvents, and chemical and stain resistance. All test results were documented.

Product coating characteristic criteria used in this project included:

- The product will contain VOCs <20 g/l.
- The product will have a gloss value in the 90-100 range as measured on an 80 degree gloss meter.
- The product will dry to the touch in 10 minutes or less and dry to handle in 15 minutes or less for temperatures in the range of 45 to 60°C, with a relative humidity not to exceed 80 percent.
- The product will have a demonstrated pencil hardness of at least 2H.
- The product will have a demonstrated chemical, water stain, and chip resistance comparable to other products for the same general use.

Task 2 — Variations in Pigmentation

An emulsion was formulated with white pigment for the best epoxy

TABLE III. Physical Properties (in the can)

Appearance	Milky white, single-phase, creamy liquid
Viscosity	Part A: 0.9 Pa.s (900 centipoise) Part B: 0.9 Pa.s
pH	5.5 to 7.5
Type	Two components: Part A — Epoxy emulsion Part B — Curing agent
Density	Clear: 1030 g/l (8.60 lb/gal) White: 1500 g/l (12.5 lb/gal)
Solids	50 percent by volume
Flash Point	over 150° C (300° F)
Shelf Life	>6 months
VOC Content	<10.0 g/l (0.1 lb/gal)

TABLE IV. Application Properties

Mix Ratio	Part A — 5 parts Part B — 1 part
Thinning Solvent	Water
Cleanup	Warm soapy water
Film Thickness	75-125 µm (3.0-5.0 mils) wet 40-65 µm (1.5-2.5 mils) dry
Theoretical Coverage	9 m2/l (360 ft2/gal) @ 50 µm (2 mils)
Drying Time @ 50°C	To touch. 10 min. To recoat: 20 min. Tack free: 15 min. Full cure: 60 min.
Recoatability	Very good

polymer/curing agent ratios selected in Task 1. Laboratory tests were conducted to measure gloss value, drying time, hardness/flexibility, level of solvents, and chemical and stain resistance. All test results were documented.

Task 3 — Preparation of Finished Coating Samples

The existing two-component spray application system developed by Binks Manufacturing Inc. was modified and the application of the coatings evaluated to determine if it meets the production requirements of wood furniture manufacturers. The results are shown in Table II.

Task 4 — Market Development

Several wood furniture manufacturers and coating suppliers were contacted to identify wood coating concerns, current application methods, costs and critical areas for product improvements. Marketing information related to the wood coatings market was collected. The market segments in turn are subsegmented into wood furniture, kitchen cabinets, new case goods, plywood (hardboard), regenerated wood products, flat stock finishes and specialty finishes. This information was reviewed to establish specific data still to be collected, and how it should be used in structuring the planned market survey of wood coating suppliers.

Two market development reports will be prepared to summarize how the new wood coatings address the concerns of the marketplace, potential cost benefits, and limitations.

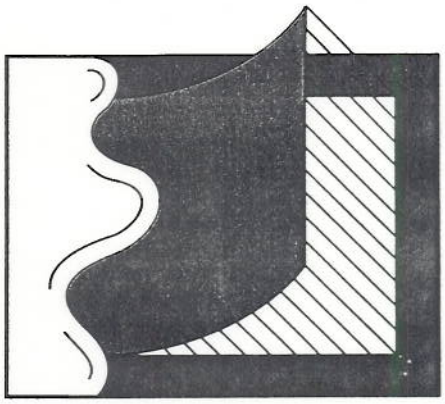
Results and Future Development

Work on variations of the patented epoxy polymer in combination with different curing agents was finalized, as shown in Table III. The synthesis of the resin into a new resin was completed and followed by the emulsification of the product in water. Analysis was expanded by selecting those additional curing agents not previously evaluated but which were known to be sufficiently reactive to achieve proper film formation and acceptable properties. Each resulting film is characterized as to its properties (see Table IV).

Various formulations of curing agents in combination with the various epoxy polymers were evaluated to precisely identify those combinations that yield the best overall coating performance and meet the desired coating characteristic criteria, as shown in Table IV.

The Center for Emissions Research and Analysis will also develop a low/no VOC sanding sealer wood coating so that a complete low/no VOC wood coating system will be available for public use. The extra developmental work will be focused on reformulating wood base coatings, determining performance characteristics, and conducting application and emission testing for a new fast-drying, solvent-free wood sanding sealer.

Cure conditions, including curing rate, extended pot-life and rheology modifications to include use of thickeners in the formulation for adjusting the flow of coatings, will be evaluated. Both clear and white finished wet samples for emission testing will be prepared utilizing a two-component variable ratio spray application gun. ❐



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