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Research and Development

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Project Summary

Research and Product Development of Low-VOC Wood Coatings

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This project was cofunded by the South Coast Air Quality Management District (SCAQMD) and the U.S. Environmental Protection Agency (EPA) to develop a new low-volatile organic compound (VOC) wood coating. Traditional wood furniture coating technologies contain organic solvents that become air pollutants as the coating cures; mitigation by add-on control devices would be energy intensive. Air emissions can be reduced through the pollution prevention approach of shifting to low-VOC coatings, avoiding the energy penalty.

In this project, a new low-VOC wood coating technology (a two-component water-based epoxy) was evaluated by determining its performance characteristics, conducting application and emissions testing, and assessing the cost benefits for energy conservation and air pollution reduction. The composition of the basic epoxy polymer was varied with several curing agents.

The resulting top coat was as good as or better than other low-VOC waterborne wood furniture top coats for adhesion, gloss value, dry time, hardness, level of solvents, and chemical and stain resistance. The VOC content of the clear and the white pigmented top coats was less than 10 g/l. Cost of this low-VOC wood coating is comparable to that of low-VOC coatings. Improved dry times were identified as being critical for product improvement. A marketing plan was developed. At least one major coatings manufacturer expressed interest in participating in a product feasibility study.

This Project Summary was developed by EPA's National Risk Assessment Research Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

The annual U.S. market for wood coatings is approximately 240,000 m^3 (63 million gal). Assuming an average VOC content of 600 g/l (5 lb/gal), 146 kg (315 million lb) of volatile organic compounds (VOCs) are emitted into the air each year from presently used waterborne and solventborne systems for coating wood. The use of "VOC-free" formulations would reduce such air pollution.

The worldwide coatings market is estimated to be in excess of $34 billion annually. The U.S. market is about $14 billion segmented in three main categories: (1) Architectural Coatings (AC); (2) Product Coatings used by original equipment manufacturers (PC-OEM); and (3) Special Purpose Coatings (SPC). In most markets, customers' needs are being satisfied by a relatively small number of coatings companies, many with sales approaching $1 billion. A significant number of coatings operations are part of large chemical groups such as AKZO, Ashahi, BASF, DuPont, ICI, Mitsubishi, and PPG Industries. The industry also includes a number of very large independents, like Beckers, Jotun, Kansai, Lilly, Nippon Oil & Fats, Nippon Paint, Reliance, Sadolin, Sherwin Williams, and Valspar. The profile of the

coatings industry and the markets it serves has undergone dramatic change in the last decade. The strongest thrusts have been forced by such things as huge business realignments, consolidations and reductions in the number of coatings companies, and the impact of environmental compliance.

The wood coatings industry can be separated into two categories having different requirements with respect to application technique: flat stock coating and the coating of three dimensional objects. Flat stock is usually coated on a continuous coating line of some type, while more complicated three dimensional objects, such as furniture, usually require spray application and batch drying. The kitchen cabinet industry uses nitrocellulose (N/C) for the high end products and conversion varnish/conversion lacquer for the bulk of its finishing needs. Conversion varnishes and lacquers contain up to 50% of urea or melamine formaldehyde resins which are only partially cured at the low temperatures allowable for wood surfaces; thus there is a significant level of free formaldehyde emanating from the coating throughout its use life. Formaldehyde has been designated by the EPA and California Air Resources Board as a suspected carcinogen. The N/C must be replaced to meet VOC regulations and the uncured urea/melamine formaldehyde containing coatings replaced to meet the very low concentration of “free formaldehyde” requirements.

Water based products have been introduced to much of the lumber industry to replace the high VOC materials previously used on plywood, hardboard, particle board, and regenerated wood-finger jointed wood products. These products, however, exhibit lowered performance properties such as hardness, toughness, adhesion, and solvent and stain resistance. Their second weakness is in energy consumption (i.e., they require long time/temperature exposure for cure). They may or may not meet the free formaldehyde requirements, which become more exacting each year.

The purpose of this study was to evaluate a new low-VOC wood coating technology by determining its performance characteristics, conducting application and emissions testing, and assessing the cost benefits for energy conservation and air pollution reduction. The low-VOC wood top coat selected for this demonstration project was a two-component, water-based epoxy coating developed by Adhesive Coatings Co. (ADCO), San Mateo, California. The composition of the basic epoxy polymer was varied in combination with each of several curing agents.

The resulting top coat showed excellent performance characteristics in terms of adhesion, gloss value, dry time, hardness, level of solvents, and chemical and stain resistance. The VOC contents of both the clear top coat and the white pigmented top coat were less than 10 g/l. The coating performance characteristics and properties in finished material were compared with those of other low-VOC waterborne wood coatings. Finally, the cost benefits of this low-VOC wood coating, critical areas for product improvement, the market development plan, and future research work are addressed in this report.

This new low-VOC coating’s high gloss and excellent chemical resistance are ideal for the wood manufacturing industry for flat stock, for particle, chip, and wood flower products; spray primers for door skins; and finishing systems for interior wood products such as furniture and kitchen cabinets. This material can be manufactured using readily available raw materials and standard resin manufacturing equipment without polluting the atmosphere.

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 underway with two major corporations, both of which are worldwide suppliers of industrial products and services to the coatings, adhesives, and polymer industry and recognized as leaders in providing coatings and ancillary products for the wood industry.

Project Description/Results

This new wood coating system consists of an epoxy component (Part A) and an amine curing component (Part B). It has the following performance properties:

(a) Less than 10 g/l (0.1 lb/gal) VOCs,
(b) Liquid with rapid initial drying characteristics upon application,
(c) Hardness,
(d) Flexibility, and
(e) Chemical resistance.

Four variations of EnviroPolymer—A-1 (EP 180-60), A-2 (EP 200-60), A-3 (EP 510-60), and A-4 (EP H-60)—were used in this project. Four proprietary curing agents—B-1 (80-70), B-2 (65-71), B-3 (65-99), and B-4 (81-93)—were identified as being the most likely to yield promising results. Formulations A-1/B-2 and A-2/B-1 were judged to be the most likely to yield promising test results when applied to a substrate for further determination of the coatings performance characteristics (dry time, gloss, parallel groove adhesion, and scrape/mar, chemical, and stain resistance).

The final, low-VOC coatings showed excellent performance characteristics in terms of adhesion, dry time, gloss, and scrape/mar resistance, as measured by standard ASTM methods. The VOC content of the final formulations was below the detection limit (10 g/l) of test method ASTM D 2369.

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. This information was reviewed to establish what specific data still need to be collected and how they should be used in structuring the planned market survey of wood coating suppliers. The product marketing discussions have centered on how to commercialize specific low/no-VOC finished coating applications resulting from this wood coating project.

Based on contacts to date with these marketing entities, at least one coatings manufacturer has expressed interest in participating in joint product feasibility studies. Upon development of priority high-value-added products for potential sale and use in the U.S. wood products market as contemplated at the conclusion of this project, ADCO is prepared to enter into either joint venture agreements or licensing arrangements for commercialization of low-VOC wood products worldwide.

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The complete report, entitled "Research and Product Development of Low-VOC Wood Coatings," (Order No. PB96-121520; Cost: $19.50, subject to change) will be available only from
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