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Project Summary

Low-VOC Coatings Using Reactive Diluents Demonstration Project

Gregory Roche

Reactive diluents are compounds that might be used to replace organic solvents in conventional high-VOC (volatile organic compound) coatings. Reactive diluents function like solvents in adjusting coating viscosity for various applications. However, rather than evaporating like conventional solvents, reactive diluents participate in a chemical reaction with the coating resin during the curing process, and become incorporated into the cured coating. Earlier results had indicated that a natural vegetable oil derived from the vernonia plant could serve as a reactive diluent, but it is not grown commercially. Further studies indicated that partially epoxidized soy and linseed oils could serve as low cost substitutes for vernonia oil. This project investigated the possibility of replacing a fraction of conventional solvents with one-third, two-thirds, and fully epoxidized vegetable oils. Three applications were investigated: in an aerosol product, in a 55 gal (208L) drum refinishing operation, and in a dry film lubricant. For the aerosol, dry time was too extended. The drum refinisher found that the reformulated coating did not have sufficient corrosion resistance. The dry lubricant manufacturer could not get acceptable chemical resistance with the new coating. There may be other, less demanding applications where the reformulated, lower VOC coating would be satisfactory.

This Project Summary was developed by EPA's National Risk Management 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).

Overview

Coatings and solvents are a significant source of stationary and area volatile organic compound (VOC) emissions. Rules promulgated by South Coast Air Quality Management District (SCAQMD) and other agencies have resulted in reduced VOC content for many coatings. However, significant additional reductions are required to meet future air quality goals.

In addition, the production phase-out of 1,1,1-trichloroethane due to ozone depletion concerns has eliminated this chemical solvent as a low-VOC technology for coatings. The Clean Air Act Amendments of 1990 have also created incentives to reduce the hazardous air pollutant (HAP) content of coatings and solvents. Many HAP compounds are also VOCs.

This project addressed VOC reductions in coatings for metal substrates. While many metal coating applicators have converted to low-VOC technologies such as powder and water-base, many others have not been able to make this conversion because of performance requirements, technology conversion issues, and cost. A significant and broad range of metal coating applicators are still in need of low-VOC alternatives.

The SCAQMD, EPA, and others have sponsored a series of research projects that investigated vegetable-oil-based reactive diluents as a means to reduce VOC

content in traditional solvent coatings. The general term “reactive diluents” refers to compounds that undergo cross-linking reactions as part of the coating curing process. In this document, “reactive diluents” refers to vegetable-oil-based reactive diluents unless otherwise specified. This project, sponsored by the SCAQMD and EPA, was the third and final phase of the research program. A Technical Advisory Committee (TAC), with representation from coating companies, resin suppliers, applicators, and other interested parties, provided guidance to the project contractors.

Technology Description

Reactive diluents are compounds that might be used to replace solvents in conventional high-VOC coatings. Reactive diluents function like solvents in adjusting coating viscosity for various applications. However, rather than evaporating like conventional solvents, reactive diluents participate in a chemical reaction with the coating during the curing process. Coatings are extended since the reactive diluent becomes part of the coating rather than evaporating like solvents.

It appears that reactive diluent coatings could potentially be used by applicators without major technology conversion issues. This is in contrast to other low-VOC technologies that can require significant changes to production processes.

In Phase 1, work by the Eastern Michigan University (EMU) Coatings Research Institute (CRI) found that reactive diluents formulated from vernonia oil offered VOC reductions and some property improvements. Vernonia oil is obtained from a rare plant so that commercial supplies are not currently available. Further work by CRI in the Phase 2 research program suggested that readily available soybean and linseed oils could be partially epoxidized to imitate vernonia oil properties. In Phase 3, this project continued the research and development of partially epoxidized soybean and linseed oils as reactive diluents. This report focuses on Phase 3 work, but includes brief summaries of the work completed under Phases 1 and 2.

Results

In Phase 3, project subcontractor PRA Laboratories performed applied laboratory development studies (Task 1) to advance the basic academic research performed by CRI. This work investigated partially epoxidized soybean and linseed oils to formulate both alkyd and epoxy coatings. The purpose of this effort was to transfer the technology from the academic research environment to the applied research arena. Laboratory development and testing was performed on alkyd and epoxy systems. Pigmented and clear coatings were tested. Testing involved substituting solvents in standard coating systems. Test variables included the amount of solvent replaced, types of reactive diluents used, pigment types, and performance additives. Solvent substitutes were one-third, two-thirds, and fully epoxidized soy and linseed oils. Results from the PRA work indicated that it is feasible to use partially epoxidized vegetable oil as a reactive diluent in alkyd and epoxy coatings.

Initially five companies, all TAC members, volunteered to participate in Task 2. All five received samples of fully or partially epoxidized linseed or soybean oil. For various business reasons, only three companies actually reported working on the samples obtained.

A diverse group of products were evaluated in Task 4. One company was very interested in being able to lower the VOC of aerosol products. Another company was interested in developing new business in the drum finishing market. The third company was interested in dry film lubricants. These company interests represented three distinct product types. The aerosol product was a quick air dry product. The drum coating was to be a black, forced-air dry alkyd coating. The dry film lubricant was a baked epoxy coating.

The aerosol manufacturer was unable to obtain an acceptable dry time of the applied product. After numerous attempts using various drier combinations and seeking help from drier suppliers, they were not able to obtain an acceptable product.

The company developing a drum enamel was initially encouraged that their work might lead to a viable product with lower VOC. However, upon further testing it was found that corrosion resistance was not acceptable and their work was discontinued.

The dry film lubricant manufacturer found that the inclusion of the epoxidized oil in epoxy systems lowered the chemical resistance to an unacceptable level. It was necessary for them to evaluate exempt solvents. They remain convinced that the basic concept of a reactive diluent is viable. But, at least for their requirements, epoxidized vegetable oils are not acceptable.

It appears that competing technologies (e.g., exempt solvents) provide a quicker/better solution at the present level of development. Even commercially available reactive diluents are not finding success in the market place.

For differing reasons, none of the participating companies was able to develop a commercially viable product using the epoxidized vegetable oils. While the basic research and development efforts appear to indicate that this approach to formulating lower VOC products has merit, in practical product development it has not proven to be acceptable at this time.

Conclusions

Reactive diluents trade VOC reductions for property changes. In practical formulations, reactive diluents exhibit increased dry times and reduced hardness. While the significance of property changes depends on the specific coating application, these changes are generally undesirable. Because of these limitations, the commercial coating companies that participated in this project determined that the

G. Roche is with Ecotek, Seal Beach, CA 90740.
***Robert C. McCrillis** is the EPA Project Officer (see below).*
The complete report, entitled "Low-VOC Coatings Using Reactive Diluents Demonstration Project," (Order No. PB98-137383; Cost: $41.00, subject to change) will be available only from
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650
The EPA Project Officer can be contacted at
Air Pollution Prevention and Control Division
National Risk Management Research Laboratory
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711

United States
Environmental Protection Agency
Center for Environmental Research Information
Cincinnati, OH 45268

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