Alternatives to Solvent-Based Coatings

Substitute coatings are available that reduce or eliminate the use of VOC-containing solvents in the application of coatings and can decrease environmental impact, regulatory and reporting requirements, worker safety concerns, and corporate liability.

This fact sheet summarizes several opportunities for substitution in a variety of industries that apply coatings, including but not limited to original equipment manufacture, refinishing, and industrial and architectural maintenance.

- **Water-based coatings**
- **High solids coatings**
- **Powder coatings**
- **Radiation-cured coatings**
- **Supercritical fluid spray application**
- **Surface-coating-free materials**

The composition of the coatings alternatives and some use considerations are described below. An alternatives matrix on pages 3 and 4 provides comparative information on each alternative, including operational, cost, and quality cosiderations. Articles, guides, and industry case studies are listed on pages 5 and 6.

The options presented are not all-inclusive, nor is one option recommended over another. Examination of alternatives to solvent-based coatings should include thorough consideration of environmental and health and safety tradeoffs at all stages of production, including raw materials acquisition, processing, and recycling or disposal, as well as any new or unknown hazards in the alternative materials.

Product or Chemical Substitution Alternatives

Water-based coatings

Water-based coatings or water-borne coatings, are similar in composition to conventional solvent-based coatings, except that water supplements or completely replaces the solvent. They usually contain up to 80% water with small amounts of solvent to facilitate dispersion of the resin. There are three main types: water soluble or water-reducible coatings; colloidal or water-solubilized dispersion coatings; and, most commonly used, emulsion (latex) coatings.

Water-based coatings have been successfully applied to metal, wood, plastics, concrete, paper, and leather, and formulations are available for many specific applications. Application technology is generally comparable to that of conventional solvent-based coatings. Overspray is easily recovered and reused, and uncured coating can be cleaned from equipment with water. Some formulations or substrates may require special pumps and piping to prevent corrosion from water in the formulation. Some coatings are applied by electrodeposition for corrosion resistance and coating of hard-to-reach areas. Most water-based coatings are sensitive to surface conditions, temperature, and humidity. Longer drying time is needed unless a drying oven is used. Some resins may cause water spotting; additives to control water spotting may present worker safety hazards.

High solids coatings

High solids coatings have a lower VOC concentration and higher resin concentration than conventional solvent-based coatings. Solids content is typically 50-70% but can be as high as 100%. Formulations consist mainly of resins (usually of low molecular weight), pigments, extenders, and additives with a solvent carrier, and include saturated polyesters, alkyds, acrylics, polyurethane, and epoxies.

High solids coatings can be applied to wood, plastic, and metal. Their viscosity and physical properties are similar to those of conventional coatings, and they can be applied with some types of conventional equipment, although higher viscosity coatings require special spray equipment. High solids coatings have greater transfer efficiency and reduce paint wastes. Careful surface preparation and worker retraining in application techniques are necessary. Some formulations contain chlorinated solvents as substitutes for VOC ozone precursors; the toxics use reduction impact of these products should be considered in comparison to conventional solvent-based coatings and other alternatives.

Powder coatings

Powder coatings contain little or no solvent. They are composed of a finely pulverized powder of thermoplastic or thermosetting resins with a built-in curing agent mixed with pigments. Use of a reactive resin in dry powdered form eliminates the need for solvent. The powder is applied with an electrostatic gun or in a fluidized bed, and then melted or reacted to form a coating. **Thermoplastic powders,** applied in thick coatings, include cellulose acetate butyrate, polyesters, and polyamides. **Thermosetting powders,** applied in medium-thickness coatings,include epoxy resins, acrylics, and polyesters. Current technology permits successful application to plastics, glass, ceramics, wood, and metal.

Powder coatings produce a durable, high quality finish with good corrosion resistance. Their higher installation and unit costs are offset by savings in maintenance, materials, labor, energy, and waste disposal. Some ingredients, such as pigments and curing agents, may present skin contact or dust inhalation hazards. Precautions are needed to reduce the potential for the powders to form explosive mixtures with air.

Radiation-cured coatings

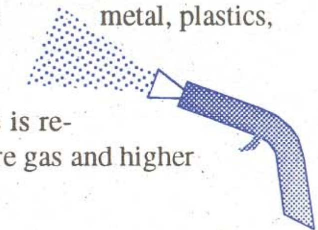
Radiation-cured coatings contain little or no solvent. In place of solvent are reactive molecules that polymerize when activated by high-energy radiation such as ultraviolet (UV) light, infrared light, or an electron beam (EB).

Radiation-cured coatings are applied to plastics, wood, paper, and metal. They have a considerably shorter curing time and give the same finish regardless of environmental conditions. UV- and EB-cured coatings are currently most commercially applicable. Flat materials cure best, but coating of three-dimensional objects is possible. Improvements in lamp systems now allow UV curing of pigmented coatings.

Acrylate materials (e.g., acrylonitrile), present in most radiation-cured coatings, are known skin and eye irritants and probable carcinogens; high exposures can cause collapse and death. Protective equipment is important in preventing skin and eye contact. Toxicity testing by a supplier and user panel is underway, and a family of vinyl ether substitutes with lower toxicity profiles has been developed, but performance information is incomplete.

Supercritical fluid spray application

Supercritical fluid spray application allows substitution of supercritical carbon dioxide for up to two-thirds of conventional solvents concentration in spray-applied coatings, reducing VOC emissions by 30-70%. The proportioning and supply (UNICARB) system from Union Carbide mixes supercritical CO_2 solvent with coating concentrate and supplies the material to a specially designed spray gun. The CO_2 solvent is compatible with high-molecular-weight resins and existing painting facilities and procedures. Supercritical fluid spray application may be used to coat metal, plastics, and wood. The applied coating has a higher viscosity that allows thicker coatings without runs or sags. Care is required in working with high-pressure gas and higher operating temperature (100-150°F).



Surface-coating-free materials

Surface-coating-free materials that are corrosion-and UV-resistant may in some situations be effective substitutes for materials that require coating. Currently available surface-coating-free materials include plastics, aluminum, titanium, and other metals. Many others, including cement-bonded particle boards, pultruded products from fiberglas-reinforced plastic, uncoated metals, weathering steel, and polymer film coatings, are under development for a wide range of industries.

Use of these materials where feasible eliminates VOC emissions and worker exposure from painting operations. These materials are often more expensive initially, although the initial increased expense may be offset by reduced maintenance or eliminated recoating costs.

SUMMARY OF ALTERNATIVES TO SOLVENT-BASED COATINGS

Alternative	Applications	Toxics Use Reduction Benefits	Operational Advantages	Operational Disadvantages	Cost	Product Quality	Limitations
Water-based Coatings	Metal, wood, plastics, concrete, paper, leather	Reduced VOC emissions; reduced fire and explosion hazards; reduced hazardous waste; solvent not required for cleanup	Most formulations can be applied with conventional nonelectrostatic spray equipment and techniques; overspray easily recovered and reused; equipment may be cleaned with water; decreased drying time with drying oven; low odor levels	Require careful temperature and humidity control; require careful surface preparation; may require longer drying time; corrosion inhibitor may be needed on metal substrate; bacterial sensitivity reduces shelf life; may become unstable if frozen; emulsion coatings susceptible to foaming	Higher costs per gallon; special equipment and techniques needed for electrostatic application; may require special pumps and piping; may require drying oven	Reduced gloss; may cause grain raising in wood; some resins may cause water spotting; impact resistance may be reduced; some forms may have reduced corrosion resistance	Reductions in VOCs may be offset by use of solvents in surface preparation; additives to control water spotting may present worker safety hazards
High Solids Coatings	Metal, wood, plastics	Reduced VOC emissions; reduced fire and explosion hazards; reduced hazardous waste	Can increase paint transfer efficiency; lower viscosity coatings compatible with conventional equipment	Narrow "time-temperature-cure" window; require careful surface preparation; generally require high cure temperatures; generally shorter pot life; may require worker retraining	Lower viscosity coatings applied with conventional equipment; higher viscosity coatings may require special equipment; reduced paint waste and supply needs; reduced energy use	Similar to that with solvent-based coatings	Reductions in VOCs may be offset by use of solvents in surface preparation; solvents still needed for cleanup
Powder Coatings	Mostly metals, but also wood, plastics, glass, and ceramics	VOC emissions and exposure eliminated or significantly reduced in application; no solvent required for cleanup; reduced fire hazard; reduced hazardous waste	High transfer efficiency; minimal solid waste; no dripping or running during application; thick coatings can be applied in one operation; overspray easily retrieved and recycled; no overspray with fluidized bed application; no mixing or stirring; requires little operator expertise	Color changes and matches can be difficult; potential for explosion must be minimized; some difficulty in applying thin coatings; requires handling of heated parts	Higher equipment and materials costs offset by savings in labor, maintenance, energy, waste, and pollution control	Durable, high quality finish with good corrosion resistance	May present skin contact or dust inhalation hazards; good ventilation and protective equipment required; potential for explosion must be minimized; resins may still produce low VOC emissions

Alternative	Applications	Toxics Use Reduction Benefits	Operational Advantages	Operational Disadvantages	Cost	Product Quality	Limitations
Radiation-cured Coatings	Plastics, wood, paper, metal	VOC emissions and fire and explosion hazards eliminated or greatly reduced; reduced hazardous waste	Rapid curing; high transfer efficiency; low heat requirement for drying, useful on heat-sensitive substrates; consistent performance; low maintenance; unreacted overspray can be collected for reuse	Requires new equipment and operating procedures; curing of pigmented coatings may be difficult; may be difficult to strip	High capital investment costs--considerably higher for EB systems; lower energy requirement; lower materials use; less waste	Similar to that with solvent-based coatings	Solvent still needed for cleanup; acrylate materials in most coatings present worker safety concerns and require protective equipment
Supercritical Fluid Spray Application	Metal, plastics, wood	Reduced VOC emissions; reduced fire hazard; reduced hazardous waste	Easily retrofitted into existing facilities; higher viscosity allows thicker coatings without runs and sags	High-pressure gas and operating temperature requires care in operation; lower fluid delivery rates than airless or spray guns	Replacement of fluid handling equipment; potentially reduced operating costs	Thicker coatings may be applied without runs and sags	Require care in working with high pressure and high temperature; still in testing phase for some industries
Surface-Coating-free Materials	Metals and plastics; other substrate materials under development	Elimination of VOC emissions, fire and explosion hazards, and hazardous material use	Stripping and repainting not required throughout service life; elimination of coating operation		Initial increased cost may be offset by reduced operating costs	Surface finish appearance limited	Substrate may contain other materials of concern

References

Resources listed are available from the publisher and may be viewed at the Technology Transfer Center of the Massachusetts Toxics Use Reduction Institute. To order U.S. EPA publications, call EPA's Pollution Prevention Information Clearinghouse (703) 821-4800. Information for contacting other publishers is available from the Institute.

Frick, Neil H., and Gerald W. Gruber. "Solvent Waste Minimization by the Coatings Industry." In *Solvent Waste Reduction Alternatives.* EPA Seminar Publication. EPA/625/4-89/021, September 1989.

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U.S. EPA. *Guides to Pollution Prevention: The Automotive Refinishing Industry.* October 1991. EPA/625/7-91/016. Cincinnati, OH: EPA, CERI Publications Unit.

U.S. EPA. *Guides to Pollution Prevention: The Marine Maintenance and Repair Industry.* October 1991. EPA/625/7-91/015. Cincinnati, OH: EPA, CERI Publications Unit.

Industry Case Studies

Elimination of Solvent Wastestreams in the Manufacturing of Power Equipment via Switch to Powder Paint Technology—Garden Way, Inc., Troy New York." In Tillman Joseph, *Achievements in Source Reduction and Recycling for Ten Industries in the United States.* Cincinatti: Risk Reduction Engineering Laboratory, Office of Research and Development, EPA. EPA/600/2-91/051, September 1991.

Environmental Research Briefs. EPA Risk Reduction Engineering Laboratory, Cincinnati, OH. Series describing facility site assessments and recommended waste minimization opportunities, including savings, implementation costs, and payback. Product or chemical substitution options for painting operations are described for manufacturers of the following products:

Military furniture: EPA/600/S-92/017 June 1992

Sheet metal cabinets and precision metal parts: EPA/600/S-92/021 May 1992

Motor vehicle exterior mirrors: EPA/600/S-92/020 May 1992

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Industry Case Studies (continued)

Environmental Research Briefs (continued)
Aluminum extrusions: EPA/600/S-92/018 and /010 April 1992
Brazed aluminum oil coolers: EPA/600/M-91/018 July 1991
Speed reduction equipment: EPA/600/M-91/046 October 1991
Automotive air conditioning condensers and evaporators:EPA/600/S-92-007 April 1992
Components for automobile air conditioners: EPA/600/S-92/009 June 1992
Permanent-magnet DC electric motors: EPA/600/S-92/016 May 1992

"For Aluminum Window/Door Fabricator: Powder Coating is Finish of Choice." *Plating and Surface Finishing,* July 1993.

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"Powder Coatings Play Major Role in Microwave Antenna Manufacture." *Plating and Surface Finishing,* October 1992.

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Technical information in this fact sheet was drawn in part from Technical Report No. 4, "Substitution Case Study: Alternatives to Solvent-Based Paints," prepared for the Massachusetts Toxics Use Reduction Institute by Tellus Institute.

For further information, please contact the Technology Transfer Center at the Institute.

Massachusetts Toxics Use Reduction Institute
University of Massachusetts Lowell
One University Avenue, Lowell, Massachusetts 01854
Phone: (978) 934-3275 Fax: (978) 934-3050

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