Alternatives to Petroleum- and Solvent-Based Inks

Substitute inks available for lithographic, flexographic, and gravure printing can reduce concerns associated with the use of conventional petroleum-based lithographic inks and solvent-based flexographic and gravure inks. This fact sheet summarizes these substitution alternatives. It describes the composition of substitute inks and some use considerations and includes an alternatives matrix that provides comparative information on each alternative, including operational, cost, and quality considerations. Articles, guides, and industry case studies are also listed.

Although inks are not always considered the major source of VOCs and solvents in the printing industry, the decision to use substitute inks can be a beneficial part of an overall toxics use reduction program and can help reduce the use of hazardous or toxic substances in other materials such as cleaning solutions.

Ink substitutions include:

- **Vegetable oil inks**
- **Radiation-curable inks**
- **Water-based inks**

The substitution alternatives presented in this fact sheet are not all-inclusive, nor is one ink substitute recommended over another. Examination of substitute inks should involve thorough consideration of environmental and health and safety tradeoffs at all stages of printing, including raw materials acquisition, processing, and recycling or disposal, and any new or unknown hazards in the alternative materials.

Alternative Ink Materials

Vegetable oil inks contain vegetable oils as a replacement for some or all of the petroleum oil in lithographic inks. They are available for heatset and non-heatset web presses and for sheetfed presses and generally require no equipment changes. While various compositions of oils such as linseed, soy, and tung may be used, many vegetable inks today are soy-based. Because vegetable inks penetrate paper more slowly and set primarily by oxidation, they generally have longer drying times. Most vegetable inks contain some petroleum oil to hasten drying or setting time to acceptable standards. The amount of vegetable oil replacing the petroleum oil varies with the manufacturer and also depends on:

Press type — for example, heatset inks require more petroleum oil than non-heatset inks.

Paper type — with more absorbent paper a higher percentage of vegetable oil may be used.

Ink color — black soy-based inks dry more slowly than color soy-based inks.

Because soy oil is clearer than petroleum or linseed oils, soy ink may provide better print quality and brighter colors. The American Soybean Association (ASA) has set standards for the percentage of soy oil in inks and permits use of its "SoySeal" for those that meet minimum requirements for soy oil content, depending on ink type. Although some new color soy inks contain non-toxic pigments and other additives, soy or other vegetable inks may contain hazardous or toxic materials in the pigments, drying compounds, and additives.

Radiation-curable inks include **ultraviolet ink** and **electron beam** ink. They consist of one or more monomers and oligomers that polymerize on exposure to radiation. They generally contain no solvent and are particularly recommended for some applications in lithography and letterpress.

Water-based inks are usually composed of pigmented suspensions in water and film formers. Their best application is in flexographic printing on paper, but they are also recommended for some types of gravure printing. Both low-solvent and100% water-based inks are available.

Substitute Inks by Type

Heatset Inks

Use of vegetable-based heatset inks provides some reduction in VOCs compared with conventional heatset inks. Because heatset printing relies on evaporation and vegetable inks dry primarily by oxidation, substitute heatset inks usually contain a higher level of VOCs than do substitute inks for non-heatset or sheetfed presses. Vegetable oil heatset inks commonly contain 30-35% petroleum oils by weight. Increasing the vegetable oil content increases dryer temperature requirements and can cause scorching of paper and dulling of finished ink film. The dryer heat also volatilizes the ink oils, generating VOC emissions. Ink cost can be 5-8% higher. Soy heatset inks receiving the ASA SoySeal must contain a minimum of 7% soy oil by weight.

University of Massachusetts Lowell • One University Ave • Lowell, Massachusetts 01854-2881
Telephone: (978) 934-3275
FAX: (978) 934-3050

Non-Heatset Inks

Vegetable oil inks can be used for both non-heatset web and sheetfed presses and can contain a higher vegetable oil content than heatset inks. They can provide better print quality and brighter colors. Soy-based color inks have a lower overall oil content than soy-based black inks, and therefore dry faster. A higher percentage of the oil in color inks can be soy-derived. Printing on uncoated paper also permits a higher vegetable oil content than printing on coated paper. Ink cost is often higher than that of conventional inks, but is expected to decrease. Non-heatset inks receiving the ASA SoySeal must contain a minimum of 30% soy oil (web inks) or 20% soy oil (sheetfed inks).

Newsprint Inks

Newsprint inks can contain a high vegetable oil content due to the absorbency of newspaper. Because the ink dries solely by absorption, it is possible to substitute all of the petroleum oil with vegetable oil, and 100% soy formulations are available. For color newsprinting, soy inks provide brighter colors, better color control, and less rub-off. Soy inks are less likely to build up on the plate, have less tendency to skin over, and greater stability. They permit greater latitude in ink-water balance, allowing more flexibility in press settings, and provide greater coverage per pound of ink. Although black soy-based ink can cost up to 30% more than conventional ink, the higher cost may be offset by greater coverage and reduced newsprint spoilage due to its smoother flow. Newsprint inks must have a minimum soy content of 40% (black ink) and 30% (color ink) to receive the ASA SoySeal.

Form Inks

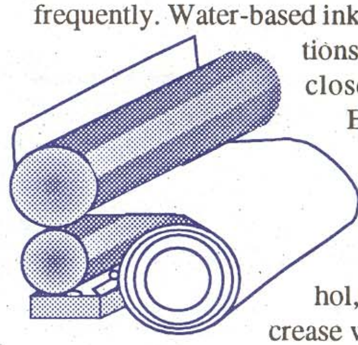
The absorbency of forms paper permits a fairly high vegetable oil content in form ink. Vegetable oil form inks provide brighter colors than conventional inks. To receive the ASA SoySeal, form inks must contain at least 20% soy oil by weight.

Radiation-Curable Inks

Ultraviolet (UV) and electron beam (EB) inks cure by polymerization on exposure to UV or EB energy. Because they contain no solvents, they release no VOCs. They can be used on both web and sheetfed presses. Because the inks do not dry on the press, they can remain in ink fountains for long periods and reduce press cleaning frequency. Main disadvantages are the high cost of capital equipment and the potential for worker exposure to UV or EB light, which necessitates shielding and other safety devices built into the equipment. Radiation-curable inks may contain toxic chemicals, and prolonged contact can cause dermatitis and skin sensitivity. The cost of UV ink can be twice that of conventional solvent-based inks; EB ink cost is also higher, although less than UV ink. Paper printed with radiation-curable inks cannot be de-inked by conventional means.

Flexographic and Gravure Inks

The use of water-based inks in flexographic and gravure printing can reduce worker health and safety risks, air pollution control requirements, and liability and waste disposal costs associated with the use of alcohol solvents. Water-based inks permit replacement of solvent-based cleaners with non-VOC-containing substitutes. They hold their color and viscosity for longer periods during print runs and may provide better print quality. Because these inks cannot be cleaned with water when dried, equipment must be cleaned more frequently. Water-based inks are less forgiving of imperfections in equipment and may require closer monitoring of operations. Equipment and process modifications may be necessary. Currently, even inks labeled 100% water-based may contain low levels of solvent, usually alcohol, to enhance adhesion and increase wetting. In some cases, pretreatment may be required before discharging water-based inks to POTWs. Some water-based inks may still contain heavy metal pigments that must be disposed of as hazardous waste. De-inking of material printed with water-based inks may be difficult.



A new water-washable ink with a "solubility conversion mechanism" has been formulated for lithographic printing. This vegetable-oil-based ink acts as a conventional insoluble lithographic ink during printing but can be converted to a soluble state and removed from press equipment with a simple water solution. The ink can be used with conventional equipment.

SUMMARY OF PRODUCT SUBSTITUTION ALTERNATIVES TO PETROLEUM- AND SOLVENT-BASED INKS

Alternative	Applications	Toxics Use Reduction Benefits	Operational Advantages	Operational Disadvantages	Cost	Product Quality	Limitations
Vegetable Oil Heatset Inks	Lithographic web presses	Reduced VOC emissions and worker exposure to petroleum oils		Slower drying time; poor drying can result in set-off, marking, and poor rub resistance	No capital cost; ink cost can be 5-8% higher	Similar quality	Heatset requirements limit replacement of petroleum oils; ink dryer contributes to VOC emissions; ink waste may still be hazardous
Vegetable Oil Non-heatset Inks	Lithographic non-heatset web and sheet-fed presses	Reduced VOC emissions and worker exposure to petroleum oils	Can provide better print quality, brighter colors, better pickup and transfer	Slower drying time	No capital cost; ink cost slightly higher	Similar quality, brighter colors and improved clarity	Usually contain some petroleum oils; ink waste may still be hazardous
Vegetable Oil Newsprint Inks	Lithographic web presses	Reduced VOC emissions and worker exposure to petroleum oils; 100% replacement of petroleum oils possible	Better color reproduction; better color control; less rub-off; less tendency to build up or skin over; greater stability; smoother flow; better coverage; greater ink-water balance parameters permit more latitude in press settings	Usually slower drying time	No capital cost ; higher ink cost may be offset by reduced newsprint spoilage	Higher quality color printing; similar quality black printing	May contain some petroleum oils; ink waste may still be hazardous
Vegetable Oil Form Inks	Lithographic non-heatset web presses	Reduced VOC emissions and worker exposure to petroleum oils	Smoother flow, better coverage	Slower drying time	Slightly higher ink cost	Higher quality color printing	May contain some petroleum oils; ink waste may still be hazardous
UV Curable Inks	Lithographic web and sheet-fed presses	No ink-derived VOC emissions or worker exposure to petroleum oil; reduced process waste	No ink drying on press reduces frequency of press cleaning; rapid curing; no set-off; no need for ventilation of printed sheets		Capital equipment cost; higher ink cost; lower energy use than thermal drying; increased productivity	Good gloss and durability; print quality may be less clear; possible adhesion problems on some materials (aluminum, steel, some plastic)	Workers must be protected from UV light; some toxic chemicals in inks; may cause skin sensitivity; ventilation needed to reduce ozone buildup; paper difficult to recycle
EB Curable Inks	Lithographic web and sheet-fed presses	No ink-derived VOC emissions or worker exposure to petroleum oil	No ink drying on press reduces frequency of press cleaning; rapid curing; no set-off; no need for ventilation of printed sheets		Capital equipment cost; considerably higher ink cost	Print quality less clear	Workers must be protected from EB light; some toxic chemicals in inks; may cause skin sensitivity; often degrade paper; paper difficult to recycle
Water-based Inks	Flexographic and gravure presses	Little or no ink-derived VOC emissions or worker exposure to alcohol; allow replacement of solvent-based cleaners and fountain solutions with safer substitutes	Hold color and viscosity longer during press runs; more coverage per pound of ink; reduce need for make-up solvent during printing	Require more frequent equipment cleaning; less forgiving of equipment imperfections; may cause paper curl	May require new capital equipment, greater energy use; reduced hazardous waste disposal and liability costs	Similar quality with new equipment; low ink gloss on porous substrates	May contain low level of solvent; ink waste may still be hazardous; greater energy use for drying

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.

Bazzon, Catherine. "Vegetable Oil-Base Inks and the Small Commercial Printer." *Instant Printer,* March 1991.

Cunningham, Elizabeth. "Technology and Environment Drive Water-Based Development." *American Ink Maker,* April 1994.

Guides to Pollution Protection: The Commercial Printing Industry. EPA, August 1990.EPA/625/790/008.

Huber Printing Ink Division. "Why Do Soy Oil Inks Improve Colour Quality? The Answer is Dot Gain Reduction and Colour Purity." Reprinted in *Ink & Print*, Autumn 1990.

Kranz, Paul B., Thomas R. Williamson, III, and Paul M. Randall. *Replacement of Hazardous Material in Wide Web Flexographic Printing Process.* Cincinnati: Risk Reduction Engineering Laboratory, Office of Research and Development, EPA, 1992. CR-816762-02-0.

Loman, Pam. "Making the Decision to Go Soy." *High Volume Printing*, February 1991.

Pennaz, Thomas J. "The Development of a VOC-Free Lithographic Printing System." Presented at the Annual Meeting, Technical Association for Graphic Arts, May 1994.

Randall, Paul M., Gary Miller, W.J. Tancig, and Michael Plewa. *Toxic Substance Reduction for Narrow-Web Flexographic Printers.* Presented at 17th Annual Hazardous Waste Research Symposium, April 9-11, 1991. Cincinatti: Risk Reduction Engineering Laboratory, Office of Research and Development, EPA.

J.M. Rooney. "Vegetable Oils in Offset Printing Ink Formulations." Sun Chemical, 1990.

Scarlett, Terry W. "Soy Sense." *American Printer,* May 1991.

"Substitution Case Study: Alternatives to Solvent and Petroleum-Based Inks." Technical Report No. 5. Lowell, MA: Massachusetts Toxics Use Reduction Institute, May 1993.

"Toxics Use Reduction Success Story. Deluxe's Solvent-Free Printing System" (Fact sheet). Boston: Office of Technical Assistance, Massachusetts Executive Office of Environmental Affairs, 1994.

"Vegetable Inks Make the Grade." *In Business,* September/October 1992.

Industry Case Studies

The following case studies were produced by the U.S. EPA, Risk Reduction Engineering Laboratory, Office of Research and Development, Cincinnati, OH.

Miller, Gary D., William J. Tancig, Michael J. Plewa, and Paul M. Randall. "Ink and Cleaner Waste Reduction Evaluation for Flexographic Printers." (Project Summary). July 1993. EPA/600/SR-93/086.

Process Modification and Product Substitution for VOC Emission Reduction in the Flexographic Printing Industry. Amko Plastics, Inc." In Tillman, Joseph W., *Achievements in Source Reduction and Recycling for Ten Industries in the United States.* September 1991. EPA/600/2-91/051.

Reduction of VOC Emissions via Product Substitution and Recycling of Solid Waste in the Commercial Sheet-Fed Printing Industry. Terry Printing, Inc., Janesville, Wisconsin." In Tillman, Joseph W. *Achievements in Source Reduction and Recycling for Ten Industries in the United States*. September 1991. EPA/600/2-91/051.

Additional case studies:

"Kemp Furniture Industries, Inc., Print Division: Material Changes Can Reduce Hazardous Waste Generation" (Abstract). Raleigh, NC: North Carolina Pollution Prevention Pays Program.

"Product Labels: Company Has Reduced Waste Generation from Label Printing Operations" (Abstract). Raleigh, NC: North Carolina Pollution Prevention Pays Program.

Technical information in this fact sheet was drawn in part from Technical Report No. 5, "Substitution Case Study: Alternatives to Solvent- and Petroleum-Based Inks," prepared for the Toxics Use Reduction Institute by Tellus Institute. Technical guidance was also provided by George Frantz, Office of Technical Assistance, Massachusetts Executive Office of Environmental Affairs, Gary Jones, Graphic Arts Technical Foundation, Pittsburgh, PA, and Paul Volpe, National Association of Printing Ink Manufacturers, Hasbrouck Heights, NJ.

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: 508-934-3275
Fax: 508-934-3050

The Toxics Use Reduction Institute is a multi-disciplinary research, education, and policy center established by the Massachusetts Toxics Use Reduction Act of 1989. The Institute sponsors and conducts research, organizes education and training programs, and provides technical support to promote reduction in the use of toxic chemicals or the generation of toxic chemical byproducts in industry and commerce.

Printed on 100% non-deinked post-consumer recycled paper with soy-based inks.

24