Bioligomers: A Review of Acrylates for Green Printing

By Rosalyn (Ros) Waldo

Sustainability means a variety of things to each of us, but we are all aware of its importance. The World Commission on Environment and Development defines sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their needs." For us, this means the products and services we use today should not compromise the future. With sustainability then, the goal is to make and use products that support our ecosystems, reducing the strain on the natural resources.

In this article, bioligomers (a new class of acrylated oligomers) will be discussed. These new oligomers were developed for inks and coatings, and are suitable for "green" printing. Sustainable or "green" printing encourages the use of renewable resources in the raw materials.

Bioligomers

Bioligomers are acrylated oligomers containing renewable resources in their building blocks. These specialty oligomers bring together two important facets of green printing. First, they are fully acrylated—they have lower VOCs and require lower energy consumption for curing. Secondly, these renewable resources are incorporated into the oligomer in such a way that their usefulness in inks and coatings is not adversely affected. The bioligomers contain 10% to 62% of raw materials based on renewable resources. Currently, bioligomers are available in epoxy and polyester acrylate classifications. In the future, urethane acrylate bioligomers will also be available (see Table 1).

Table 1

Product Classification	Viscosity, cP @ 25°C	Theoretical Functionality
Bioligomer A (polyester acrylate)	66100	4
Bioligomer B (polyester acrylate)	27500	5
Bioligomer C (polyester acrylate)	29200	5
Bioligomer D (epoxy acrylate)	2200	2
Bioligomer E (epoxy acrylate)	26500	4

Experimental

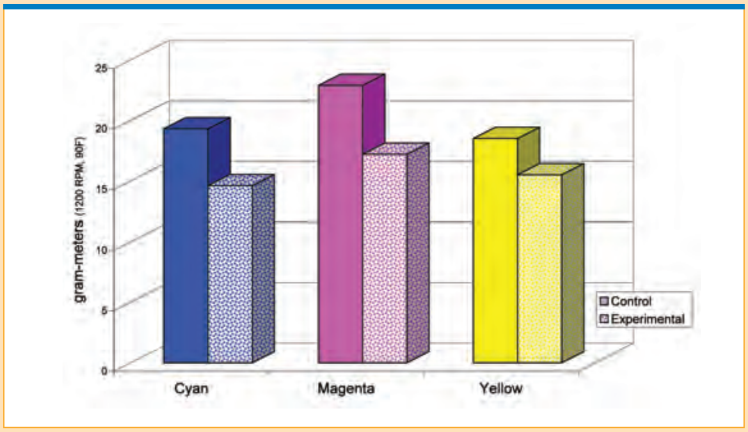
In this study, the bioligomers were used in a series of lithographic inks. Their performance was compared to the performance of inks made with commercially available polyester acrylates. The assessment included determining the abilities of experimental oligomers to satisfactorily wet pigments and to examine their overall performance.

For pigment wetting evaluations, dispersions were made in blends of the bioligomers and an acrylated monomer. Each mill base contained 60% bioligomer, 10% monomer and 30% pigment. After manually mixing the components, the dispersion process was completed using a 3-roll mill. An acceptable grind, ≤ 3 National Printing Ink Research Institute (NPIRI), was achieved with all of the experimental systems after three complete passes on the mill.

The inks were completed by adding inert filler, monomer, photoinitiator, and additional bioligomer to the pigment dispersion, as shown in the following ink formula.

Figure 1

Ink tacks



Ink Formula

Pigment dispersion 60%
Bioligomer 25%
Acrylated monomer 2%
Inert filler (magnesium silicate (talc)) 3%
Liquid photoinitiator blend 10%

Also of interest was the influence of the bioligomers on lithographic ink properties such as ink tack, ink misting and printability. Ink tack testing was performed on a Thwing-Albert brand electronic inkometer in accordance with ASTM test method, D 4361. The ink's tendency to mist was also measured on the inkometer. Misting is evaluated and compared using the ink's delta E (ΔE). This calculation is based on the difference in color of unexposed white chart paper and the color of chart paper placed beneath the ink rollers during tack testing. As the ink mists, a representative portion of that mist is deposited on the chart paper. Higher delta E values indicate a greater tendency for misting.

Printability of the experimental inks was evaluated on a Ryobi brand 2800 CD 2800 single color duplicator. The inks were grouped and printed by color. A reference or control ink was included in each group, allowing the performance of the bioligomer-based inks to be directly compared to the performance of known and established inks. Good printability involves several factors, including (but not limited to) achieving the target color density, exhibiting low dot gain, and obtaining quality prints without defects.

Our criteria for assessing printability includes the ability to achieve the target color density and print contrast, and the run ability or consistency of printing the ink. To make this assessment, sheets are randomly pulled during the trial and the color density and print contrast measured and recorded. Additional aspects of the printing criteria include make-ready time, appearance of the blanket and rollers at the conclusion of the trial, and ease of press cleanup.

Reactivity or the energy density required to achieve cure is another key performance attribute for inks. In this evaluation, cure was determined by the ink's mar resistance on porous substrate. The reactivity was recorded as the energy density needed to achieve cure or mar resistance using one 400 watts/inch medium-pressure mercury "H" lamp.

The bioligomers were also evaluated in overprint varnishes (OPVs). The OPVs were prepared by mixing the experimental oligomer with monomer and photoinitiator, as shown below. This blending required low speed mixing without heat.

OPV Formula

Bioligomer 55%
Acrylated monomer 30%
Liquid photoinitiator blend 15%

Lab drawdowns of the experimental OPVs were evaluated for reactivity, appearance, gloss and solvent resistance.

Discussions and Results

The bioligomers exhibited excellent performance in both the inks and the

Figure 2

Ink misting

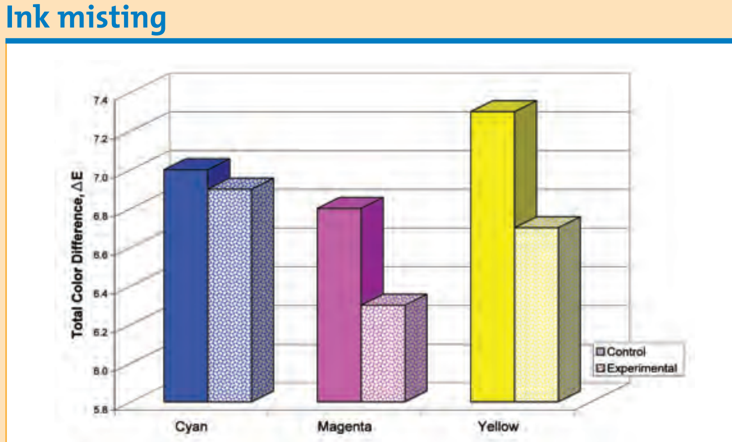


Figure 3

Bioligomers: lithographic inks reactivity

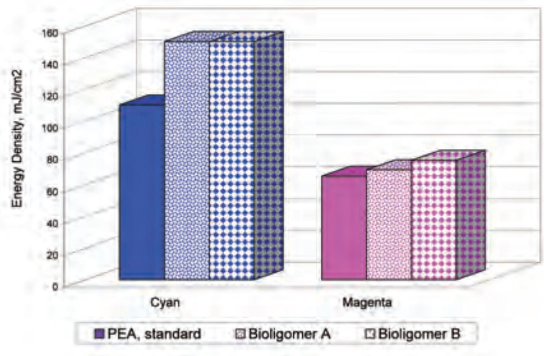


Table 2

Printability

		Cyan			Magenta	
	PEA, Standard	Bioligomer A	Bioligomer B	PEA, Standard	Bioligomer A	Bioligomer B
Target: Color Density		1.4			1.5	
Achieved: Color Density	1.5	1.4	1.4	1.5	1.5	1.5
Target: Print Contrast, %		> 36			> 36	
Achieved: Print Contrast%	40	37	37	39	41	39

Table 3

Bioligomer-based OPVperfomance results for reactivity, solvent resistance and gloss

	Standard OPV, epoxy acrylate	Bioligomer D, OPV
Viscosity, cP @ 25°C	230	360
Gloss, 60°	94-96	94-95
Functionality, oligomer	2	2
Reactivity, mJ/cm2 with 1- 400 watts/inch medium pressure Mercury "H" lamp	~100	~100
Solvent resistance, MEK double rubs	60+	50-55
Appearance	Clear and colorless	Clear and colorless

OPVs. The experimental pigment dispersions were glossy and soft, comparable to dispersions made with commercially available polyester acrylates.

The inks had good lithographic ink performance—moderate ink tack and ink misting, acceptable cure response and good printability. The tack of the bioligomer inks ranged from 12 to 20 gram-meters, making them lower in tack than the standard polyester acrylate inks. Unexpectedly, the lower ink tacks did not result in an increase in misting. The experimental inks had delta Es of 5-8, a typical degree of misting for energy-curable inks. Ink tack and misting data is shown in Reactivities of the bioligomer-based inks are slightly less than those of the control inks. As expected, more energy was required to cure the darker color inks than the lighter color inks, whether based on bioligomers or not. These data are shown on Figure 3.

Printability of energy-curable lithographic inks is strongly influenced by the oligomer. Fountain solutions and additives can impact printability, but the water window (or water balance) is an inherent property of the oligomer. It is essential that "green" inks print well and not place excessive demands on the printing process.

The bioligomer-based litho inks printed well. Make-ready was quick and without issues. The inks ran consistently, requiring few press adjustments. At the end of the trials, the blanket was clean with no indication of toning. Press cleanup was easy and accomplished without difficulty.

Table 2 shows the average color densities and print contrasts achieved during the trials. The bioligomer inks exhibited good color density (indicates good pigment wetting), and the print contrasts exceeded the targets. This is significant because the print contrast was used to assess the oligomer's water balance. The contrast is measured at the 70% tint and when the print contrast is at or above the target, the space in the tint is clean and the ink dots are well-defined.

The bioligomer-based OPV exhibited excellent performance. Reactivity, solvent resistance and gloss were all comparable to the standard system (based on epoxy acrylate diluted in monomer). Results are shown in Table 3.

Conclusion

The bioligomers provide a bona fide approach to formulating energy curable lithographic inks and overprint varnishes for "green" printing. The advantages and benefits of the bioligomers include:

- Increased use of renewable resources.
- Lithographic inks with good ink properties—tack, misting, reactivity and printability.
- OPVs with high gloss, reactivity and solvent resistance.

—Rosalyn Waldo is a research associate with Cytec Industries Inc., Technical Services and Development Radcure, Graphics, Smyrna, Ga.