Electron Beam Curing in Packaging —Challenges and Trends

By Mikhail Laksin

Electron Beam (EB)-curable inks and coatings have been used in the packaging industry and, specifically, in food packaging markets for many years. In the early 1980s, TetraPak and a few smaller converters adopted EB-curing technology for manufacturing low odor and low migration packaging. The initial applications for EB—gable top cartons for dairy and fruit juice packaging, folding cartons for frozen foods and dry food (cookies) packaging—have continued to make up the bulk of EB applications. While new packaging applications utilizing alternative EB-curable systems have grown significantly over the last 20-30 years, the total volume of EB packaging inks, coatings and adhesives still does not exceed 4-5% of the total volume of formulated product consumed by the packaging markets.

Over the years, several factors have had a negative effect on the growth of EB-curing technology—excessive capital cost and limited competitive availability of EB-curing equipment, technological limitations of multicolor printing, and poor understanding of the food law compliance associated with new chemistry. This is changing.

The cost of EB equipment has come down significantly over the last decade; new manufacturers are offering competitive EB equipment; and overall reliability of the curing units has increased significantly. The efforts by RadTech in submission and obtaining FCN 772 in 2008, leading to approval of several acrylate functional monomers for direct food contact, has had a strong favorable effect on the perception of EB-curing technology by the food packaging market. While the original selection of monomers and resins listed in FCN 772 is not necessarily suitable for designing a broad range of inks, coatings and adhesives for flexible packaging, they lay a path for broadening the scope of energy-curable chemistries required for delivering high-performance products with targeted rheology, good adhesion to plastics, enhanced flexibility, low odor and migration.

Web offset was the first printing technology to adopt EB-curing. In offset, multicolor printing can be achieved without interstation curing, utilizing wet trapping of consecutive colors on the top of each other. The introduction of Variable Sleeve Offset Press technology in 2005 by Drent Goebel has helped expand EB offset printing beyond folding carton and paper packaging to include some flexible packaging applications. The major limitation of this technology is the in-line press configuration that limits its use to flexible substrates with good stretch resistance, leaving out some large segments of the packaging markets which utilize more extensible substrates.

Another limitation of EB offset printing is generally poor adhesion to a variety of plastic substrates such as PET, BOPP, polyamide and some other films that are frequently used in packaging applications. Poor adhesion is usually a result of significant lithographic constraints (ink/water balance, selective plate wetting, etc.) that exclude the use of many adhesion-promoting functional compounds.

Flexography and gravure are the dominant printing technologies used for flexible packaging. Both technologies use liquid inks. Transitioning from high-viscosity EB offset inks to significantly lower viscosities of flexo and gravure comes with another set of ink formulation challenges. Evidently, lower viscosity can be achieved by using high concentrations of monomers in the ink formulation. This, however, is not the most practical approach. A polymer network, formed by EB-cured acrylate monomers, often has excessively high crosslinking density and shrinkage, resulting in poor adhesion and flexibility of the cured ink film.

Replacing monomers with water seems to be a more elegant approach to lowering ink viscosity without using monomers or significantly reducing their concentration in the ink formulation. This approach has led to the development of the EB flexo printing concept that is based on using water as the diluent in the ink composition. Use of water and its partial evaporation during printing creates ink viscosity gradients necessary for consistent wet trapping.

In the case of gravure printing, wet trapping is not an option. The moving web makes turns after each printing station and the ink must be completely dry prior to accepting another color. Recent development of EB gravure printing by IdeOn LLC and Amgraph Packaging is based on utilization of water as a diluent for EB-curable gravure inks, capable of fast drying and subsequent curing upon exposure to EB irradiation. This technology offers enhanced mechanical properties, adhesion and flexibility of the printed image.

Overprint coatings are the faster growth segment of EB-curing technology partially because implementation of this technology is much easier in comparison to converting to a completely new printing process. EB coatings work well not only with EB-curable inks but also in combination with solvent- and water-based liquid ink systems. The major technological challenges are efficient spreading and leveling of the coating over the underlying ink system, good intercoat adhesion, controlled gloss level and targeted coefficient of friction. Once these challenges are met, EB coatings offer a very good functional and economical alternative to the multilayer lamination structure of the packaging material.

Lamination using EB-curable adhesives is another attractive option for manufacturing of various multilayer packaging materials that cannot be replaced by a monolayer structure with EB coating. The incumbent lamination technology, based on use of the two-part solventless adhesive technology—is typically implemented off-line and the final bond forms over 48 to 72 hours after lamination takes place. Instantaneous cure and immediate bond give EB adhesives a significant advantage in regard to manufacturing productivity and cycle time.

As we look at the penetration of EB curing into different segments of the packaging market, it is quite evident that early adopters of this technology in printing, over print coating or lamination have built up industry confidence and have laid the groundwork for much broader acceptance throughout the industry. EB-curing processes hold the potential to deliver a single converting technology appropriate for multicolor printing, in-line coating or lamination. This flexible curing platform can enable a new level of highly functional and aesthetically attractive package designs. ◗

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