Ultraviolet/Electron Beam Inks Modernize Packaging

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Abstract
Ultraviolet/Electron Beam (UV/EB) technology is changing the ink industry rapidly. As the technology continually improves and expands, it will soon overpower traditional ink systems. The cost of UV/EB materials and machinery are coming down because the volume is going up. There is also a reduction in operation costs when switching to this technology. UV/EB inks are better for the environment than most conventional ink systems because they reduce energy and do not emit volatile organic compounds (VOCs). They have a quick turnaround rate due to the quick cure and fast press speeds, as well as they improve the overall performance by enhancing mechanical properties and providing a better shelf appeal.

Introduction

Magazines, compact discs, credit cards, automotive headlights and dental fillings; there is some sort of Ultraviolet/Electron Beam (UV/EB) technology everywhere. With the rising demands of environmentally friendly packaging, UV/EB inks are becoming very popular. Figure 1 (below) shows how UV/EB ink usage has grown since 1995.

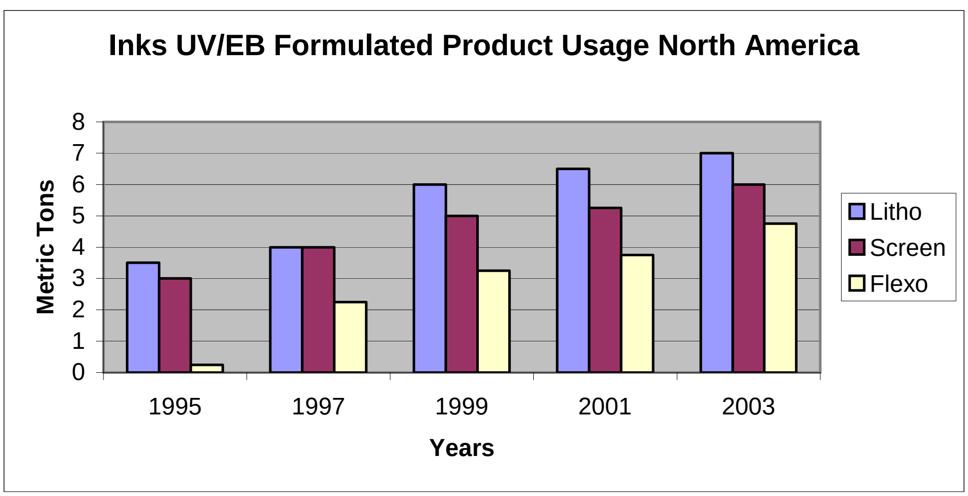

Figure 1. Ink Usage in Previous Years (Cohen, 2004).

There are four main points that demonstrate why these inks will continue to see increased usage in the industry. They reduce overall cost, are better for the environment, save time, and have overall better performance with shelf appeal and physical properties.

Background

UV/EB inks have been around since the 1960's. While having become widely accepted, they are still considered "new" technology. Most conventional ink systems need to go through a drying process by either absorbing, evaporating the excessive ink, or a combination of both. UV/EB inks go through a different process called "curing." Utschig (2004) describes curing as the chemical reaction that a material goes through to get from the wet to the dry stage. UV and EB are two separate types of curing as shown below in Figure 2.

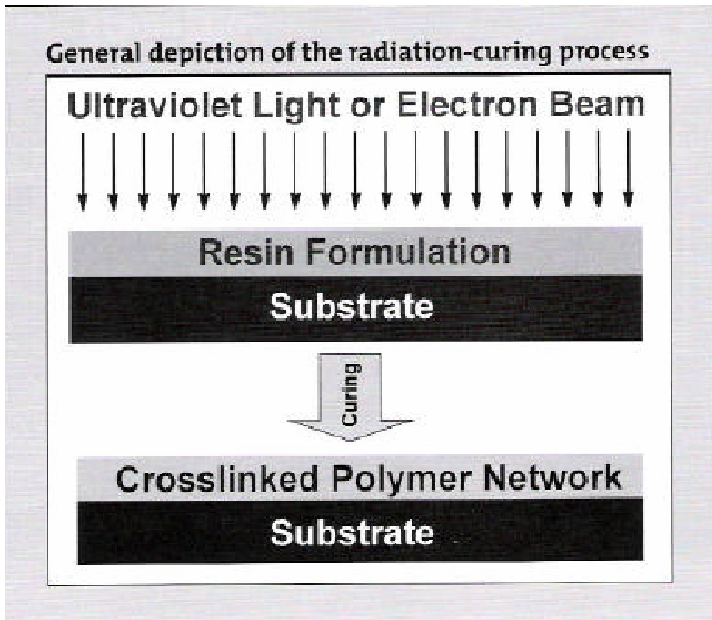

Figure 2. Radiation-Curing Process (Miller, 2005).

UV curing uses "high-intensity UV radiation to start the free-radical cross linking of the prepolymers and acrylate oligimers" (Utschig, 2004, Section 2, ¶ 1). The light is absorbed and converted into free radicals, which cause the ink to polymerize. EB curing uses a beam of electrons instead of the UV photo-inhibitors to cause the same reaction. The first reason these technologies may see increased usage is that they reduce cost.

Reduces Cost

UV/EB inks are considered to be very expensive. Biro and Sanders said it best by stating, "you get what you pay for" (Biro & Sanders, 2004, p.55). This technology is still new and in years to come the price should drop to compete with other ink systems. This is because the volume of these inks has grown. Podhajny (2005) says that these technologies have reached a mature point, and that the prices should be going down. While still somewhat costly, there are some cases when using this technology could actually reduce cost; such as lower equipment and operation costs.

Lowers Equipment Cost

The equipment cost for UV/EB inks were not always as low as they are today. Because the technology is growing, the price has gone down significantly. EB capital costs can allow companies to research other ideas, "Because the capital costs of EB units have come down, many packaging converters have also begun looking at using EB for the web printing of folding cartons and flexible packaging" (Pianoforte, 2005, Section 2, ¶ 10).

EB technology equipment cost has gone down dramatically, but the cost can also relate to UV technology. According to RadTech International North America (2005), "As a result of these energy efficiency advances, the study notes that the savings offered by UV/EB technology translated into not only big energy savings, but also as much as a 55 percent reduction in capital and installation costs" (Section 1, ¶ 2).

Because of this cost reduction, UV/EB curing has become a viable option for food packaging applications, which include adhesives, coatings, and inks (Lin, 2006).

Another item is equipment size. UV/EB machinery tends to be much smaller than conventional ovens. Conventional ovens take up around 500 to 1,000 square feet. At a floor space cost of $0.50/ft2/month, it will cost roughly $3000-6000 per year in comparison to UV machinery, which only takes up about 50 to 100 square feet (RadTech International North America, n. d.). This is a significant difference.

Although these statements show that the cost of the equipment has gone down, the question is, will these savings get passed down to the end-user? That is a question that only the converters can answer.

Lower Operation Cost

Operation cost is a main concern for many companies. By using UV/EB inks, a converter can cut their costs extremely. Fontelera (2005) states that "this technology lowers overall operation cost by 10 to 20 percent by eliminating the lacquering step, one film layer and laminating adhesive" (Section 1, ¶ 3). She continues by saying that they can have a 20 to 30% cost savings by having the print substrate double as the release substrate. There is a cost savings through the reduction in the number of laminate layers (Lapin, 2006).

Another reason these technologies lower operation cost is they can be placed in-line. EB inks do not require an inter-station for curing, which increases efficiency, speed, and cost savings (Fontelera, 2005). It allows converters to "start with a roll of paper or plastic film at one end of the press and produce individual packages or rolls of printed/coated matter at the other end, which can be slit in line and then immediately shipped out to the customer" (Biro & Sanders, 2004, p. 54).

This process also reduces the need for print job re-runs because the prints can be seen instantaneously (Pianoforte, 2005). Every production line should have a quality check. If the quality of some parts of one run is not online with specifications, those parts can be removed and the run can be extended to make up for them. With a conventional system, a converter will have to wait until it is dry to see the quality, which can take many days. If the specification is off, they will need to restart the print run and create more to make up for the loss. This takes time and money, and also causes waste.

These cost savings usually offset the slightly higher costs of the actual material. Because of reduced operating costs, the support for the growth of UV/EB inks continues. But costs are not the only driving factor for these inks, helping the environment is a great seller for UV/EB.

Better for the Environment

The first thought that comes to mind when discussing UV/EB inks is that they are bad for the environment. In fact, the exact opposite is true. RadTech, which is an Association for UV/EB technologies, was awarded the 17th Annual Clean Air award in 2005 (Cohen, 2005). Because these inks are more environmentally friendly, several states encourage the use of these technologies. Some even have financial incentives, which include reducing taxes of companies that utilize them (Biro & Sanders, 2004). These inks are better for the environment than conventional ink systems for a couple of reasons, they reduce energy and they do not submit volatile organic compounds (VOCs).

Reduces Energy

Packaging converters are always trying to find ways to reduce energy, especially after Hurricane Katrina hit in the fall of 2005. In one study, a US manufacturer found an 80% reduction in the total amount of energy used compared to a conventional system (RadTech International North America, 2005). One of the main reasons companies want to reduce how much energy they use is because it saves money.

RadTech International North America (n. d.) breaks down the cost savings when reducing energy. They said when using a conventional (solvent or water-based) system, an average of about $44,736 per year is spent. In a typical system, the dryers use elevated temperatures to evaporate either the solvent or moisture. There also needs to be a high airflow to aide in the removal of the solvent/moisture from the substrate and the oven. Afterwards, there are chill rolls or air blowers used to cool down the substrate (Sanders, 2006). The $44,736 accounts for both the ovens and the cooling system. When using an electric UV system, only $22,560 was spent in a year (RadTech International North America, n. d.).

No VOCs

Another reason EB/UV inks are good for the environment is that they give off fewer and sometimes even no VOCs. These are emitted as gases from some sort of solid or liquid: “VOCs include a variety of chemicals, some of which may have short- and long-term adverse health effects” (Environment Protection Agency, n.d., Section 1, ¶ 1).

VOCs affect the ozone layer, which the EPA estimates is the third largest contributor to climate change. Many try to eliminate VOCs by incinerations, but in turn generate greenhouse gases (RadTech International North America, 2005). These types of gases can be generated by nature, but most are caused by human activities, including carbon dioxide and methane gas (Environment Protection Agency, n.d.).

Another plus of not having VOCs is it allows converters to avoid permits that are normally required to maintain or expand their operations (Pianoforte, 2005). Solvent printers need an air scrubber that cleans the fumes through a charcoal filter every 5-10 seconds. This means that the solvent printer will have to be placed in a separate room with vents that take the fumes out of the building (Leesemann, 2006). UV/EB ink systems can be placed in the same room, since fumes are not an issue, allowing them to be placed in-line.

Not only do UV/EB inks pave the way to a better environment, but they also allow for a quicker turnaround rate.

Quick Turnaround Rates

Quick turnaround rates go hand-in-hand with cost savings. Typically, the faster the converter can develop and release the product to the customer, the less expensive it becomes. That is why many companies press for this. There are two reasons that UV/EB technologies have a quick turnaround rate; quick curing and faster press speeds.

Quick Curing

Using UV/EB curing of inks is a very efficient process. They are known for the “quick cure.” As stated by Biro and Sanders (2004), “you start with a mixture of monomers, oligomers, resins, colorants, additives and photoinitiators (for UV) to form a crosslinked ‘photoset’ matrix with incredible properties…Converters like to use UV and EB chemistry because it generates an instantly cured or set film of ink” (p. 53).

Pianoforte (2005) explains that instantaneous drying is one of the most notable benefits of using energy-cured inks. It speeds up the manufacturing process and allows for faster finishing and shipping: “This instantaneous curing improves job turnaround, allows quicker secondary conversion which reduces inventory” (Pianoforte, 2005, Section 3, ¶ 1).

Faster Press Speeds

Because this technology has quick cure, the equipment can be placed inline. As previously stated, there is no inter-station curing. In a traditional ink system, the material is printed in a separate room and it is given time to cure. Once it is dried, the material will be placed back on the line to finish the converting process. Because the ink stations for UV/EB are placed in-line, it allows the converters to do other post-printing operations in-line as well, such as embossing (Podhajny, 2005).

The inks are also easier to clean. Leeseman (2006) stated, “since the inks cure by UV light, the ink does not dry on the heads like solvent inks” (p. 24). Companies that use solvent inks are constantly cleaning the print heads and trying to keep them moist; “in the morning with the UV-curable printer, we quickly wipe, push a little air through, then run a test print and we’re ready to go” (Leeseman, p. 24).

UV/EB inks can be printed directly on any substrate. This is great news for companies that use rigid substrates: “Water-based and solvent-based inks do not adhere well to rigid substrates” (Leeseman, page 23). Because of this, these inks need to be printed on a flexible material that has an adhesive back. They also need to be cut, lined, and mounted (Leeseman, 2006).

Overall Better Performance

UV/EB technology is known for their graphics and print quality. Many companies may use them because of these reasons alone. They enhance properties and have better shelf appeal.

Enhance Mechanical Properties

UV/EB inks improve many properties of the finished product such as fade resistance, scuff resistance and heat resistance.

The Scotts Miracle-Gro Company has used this technology for many years now. As most of their products are placed outdoors, they need to have excellent fade-resistance. With the traditional ink systems placed outdoors, the colors would fade within a week, but when using UV/EB inks, the colors would last up to three to four months in direct sunlight. This was enough to last an entire lawn/gardening season. Leeseman (2006) discusses fade-resistance indoors, “UV inks are fade resistant for three-plus years and when printed on outdoor materials are waterproof” (p. 24).

Scuff resistance, also known as abrasion resistance, is another big plus of UV/EB inks. This allows products to go through distribution without showing much damage from being moved around, such as scratches.

Another functional property that UV/EB inks have is heat resistance. Lapin (2006) mentioned that this affects the heat seal of the packaging. Conventional inks tend to “pick off” of the substrate under conditions of high heat and pressure.

Visual

One notable benefit of UV/EB inks is the shelf appeal: “When it comes to packaging for the company’s Xbox product, a paperboard sleeve with a matte green-and-black color scheme plus ultraviolet curing of the pack’s carton helped provide shelf appeal at a reasonable cost” (Butschli, 2004, Section 1, ¶ 5). This could include the bright colors, the glossy look, and printing advantages.

The bright color of these inks is due to the fact that they are highly pigmented. Traditional ink systems either have water or solvents mixed in with the pigments to make the ink. But with UV/EB technology, the inks are 100 percent solids. This means they will not be diluted with the water or solvents. Because these inks are not diluted, the same amount of ink will not have to be applied to the substrate. This translates into another cost savings.

One of the most notable shelf appeals of UV/EB is the “glossy” look, “UV and EB technology has enabled The Scotts Company to differentiate ourselves from our competitors in the market,” said Haynes “The technologies deliver gloss and edge-to-edge printing [that compares favorably] to surface printing, which is not as glossy” (Butschli, 2004, Section 1, ¶ 7, as cited in Haynes, 2004).

Lin et al. (2006, Section 4, ¶ 3) explains, “In the graphic art/print finishing area, specialty and surface effect UV coatings such as integrated labels, printable magnets, pseudo-embossing, and foil-like surface effects have been catching the attention of designers, printers, and end-users.”

UV/EB printing is comparable to gravure, which is known for its print quality (Rangwalla, 2006). One of the reasons that the print quality is superior is because the inks have a high viscosity. The dots do not spread out before they are cured. The ink dots could be placed on the substrate on a Friday and on Monday the dots would still be in the same spot to be cured (Schrew, 2006). This means that the inks are not likely to move during production, which will cause less quality issues.

Conclusion

EB/UV technologies are used for magazines, compact discs, credit cards, automotive headlights and dental fillings. There are many reasons these inks are revolutionizing the ink industry, which include cost reductions from equipment and operations; they are better for the environment because they reduce energy and have little or no VOCs; they have quick turnaround rates due to quick curing and faster press speeds; and they have overall better performance because they enhance properties and provide a better shelf appeal.

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