

Curing Inkjet Printed Pigments with Ultraviolet Light

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Ultraviolet light (UV) has been used to cure printed inks and various coatings for decades. The curing process is well established in both the flexography and lithography printing methods. UV curing has a number of advantages over conventional thermal methods, including low energy consumption, fast and reliable curing, low environmental pollution and energy and space savings. Unfortunately, there has been limited success in implementing UV curing into the textile printing process. However, recent research shows promise for using UV light to cure inkjet printed pigments on textiles.

Inkjet printing is a process in which droplets of ink are rapidly ejected from small orifices at relatively high speeds. Inkjet printing on fabric has a number of advantages, including the ability to produce photo-quality images, an unlimited number of colors, an unlimited length-wise repeat size and printed patterns that can be engineered to repeat across sewn seams. In addition, print designs are sent directly from the computer to the printing machine, eliminating the need to make or store screens for printing.

Both dyes and pigments are utilized to apply color to textiles in the inkjet printing process. The application of dyes is more complex because different dyes are used to apply color to different fibers, auxiliary chemicals are needed and post steaming processing is required to fix the dyes to the fiber. Pigments are an excellent alternative for coloring textiles. Today, about 65% of printing applications utilize pigments. Pigments produce quality prints, are applicable to almost every kind of fiber and fiber blend, have excellent light-fastness, are cheaper than dyes and do not require a steaming process.

Pigments do not have an affinity to textile fibers, therefore binders are incorporated into the print paste to adhere the pigments to the textile surface. The binder requires a curing process. In the conventional curing process the pigment printed textile is dried and cured to convert the soft organic base monomer and/or oligomer resin into a tough polymer. UV curing is a promising alternative to the thermal process.

A UV curing resin formulation contains oligomers, monomers and photoinitiators. The photoinitiator triggers a nearly instantaneous curing reaction upon exposure to the UV light—producing a completely polymerized network in seconds. The ability to successfully integrate UV curing with inkjet printing has presented some challenges, including fabrics with low crock fastness and a stiff hand, as well as low curing efficiency of the resin.

The effective and successful implementation of a UV curing/inkjet system requires that special attention be given to the UV chemistry.

UV Chemistry

Pigment and Resin Selection

Inkjet printing inks can be either dyes or pigments; however, UV curable inkjet inks are limited to pigments as the colorant. This is because the UV cured ink must have superior light fastness to withstand the high energy UV light source. Pigments have superior light fastness and therefore are the colorant of choice. In order to be ejected from the nozzle orifices, pigmented inkjet inks are usually limited to a particle size range of 1 μm . Pigments with a particle size that exceeds 1 μm will result in a likely build-up, causing obstruction in the orifices of the nozzle.

Viscosity is another parameter that must be considered. Viscosity of the ink is potentially one of the greatest challenges in the successful combination of UV curing and inkjet technology. To successfully eject the colorant from the small orifices within the printhead, a relatively low viscosity ink is needed. The viscosity range for an inkjet ink limits the kind of binders and additives that can be used. Acrylate oligomers which are the preferred binder used in the UV curing industry are often too viscous for inkjet printing. For this reason acrylate monomers are more often used.

Acrylate monomers have lower viscosity and a lower molecular weight than acrylate oligomers. Generally speaking

the lower the functionality, the slower the reactivity, therefore, as the functionality of the monomers decrease, the cure speed also decreases, making it difficult to cure low functional monomers. To compensate for the low functionality small amounts of a higher functional monomer (higher molecular weight) can be added. A fine balance is essential to maintain both the desired viscosity and curing properties.

The use of specific acrylate oligomers which are of lower viscosity than traditional oligomers has also been used with some success. However, research has shown that the ratio of oligomer and monomer components within the resin will affect the crockfastness and stiffness of the fabric. Preliminary experimentation is recommended to determine the appropriate resin formulation to achieve the desired fabric properties for the end use.

Photoinitiator Selection

Photoinitiator selection is an important factor in UV curing because it is the only component in the printing formula that reacts with the UV light. Each photoinitiator has a specific absorbance wavelength. Pigments also absorb UV light and can interfere with UV resin curing by blocking the UV light. This phenomenon can cause decreased crockfastness of the printed fabric. In this scenario the photoinitiator in the resin may not obtain sufficient light exposure to generate enough free radicals for resin polymerization to be completed.

Different pigments have different absorption spectra and therefore their ability to affect UV curing efficiency varies. To achieve a high UV curing efficiency the wavelength of the photoinitiator should be matched to the UV light output and the pigment absorbance should be minimized.

Other Variables

There are unique challenges to the resin formulation when UV curing is to be implemented in textile processing. UV curable resins can fully crosslink on a solid surface such as wood, paper and metal. However, textile materials have different structural properties from solid surfaces.

Textile fabrics are constructed with yarns which are made of fibers. When textile fabrics are printed, the print paste is deposited on the surface of the cloth as well as between the yarns and fibers. The binder in the print paste is sometimes deposited in the crevices of the yarns and fibers, where it is shielded from UV light exposure. The binder that is lodged in the crevices is not fixed during the curing process. This phenomenon has been one of the major challenges to the successful implementation of UV curing in the textile industry. Another challenge specific to textiles occurs in 100% polyester fabrics. The benzene rings in the polyester fiber absorb the UV light, removing enough UV intensity to adversely affect resin curing. To avoid these situations, the UV light exposure time and/or the intensity of the light source should be increased.

Health and Safety

Acrylates can irritate the eyes and skin. They can also have an unpleasant odor. Careful attention should be given to select non-irritant monomers. Proper ventilation is also important.

Conclusion

UV light has been used for decades for curing print designs on solid surfaces such as wood, paper and metal. Most of the current research has taken tried-and-true printing technologies for solid surfaces and adapted them to textiles. However, textile materials have different structural properties from solid materials. In order to successfully integrate the UV curing process with inkjet technology, the pigments, UV resin components (photoinitiators, monomers and oligomers) must be carefully selected.

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