HP Scitex UV Curable Inks

Since UVC inks are very different than inks based on water and organic solvents, it is important to understand what they are and how they work.

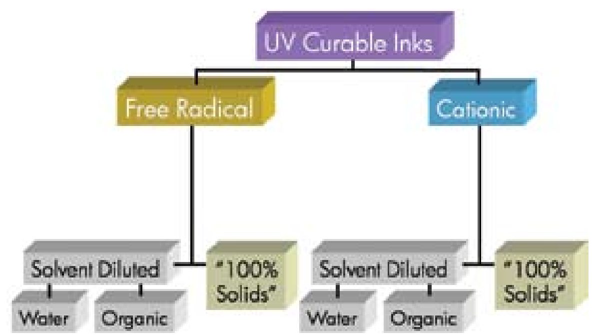
UV Curable Inks

Industrial inkjet printers can print hundreds of square meters per hour, but expanding markets for colorful, high-quality, and durable point-of-purchase, vehicle and building graphics will push productivity needs to even higher levels. Because the printhead and inks are the key components of any inkjet printer, higher productivity must be built on printhead[1] and ink technologies that offer reliable performance and high image quality at high print speeds.

While a printhead can be designed to use different types of industrial inkjet inks, that doesn't mean that the printhead and printer can produce acceptable and dependable results with any ink. Only when printhead, ink, and printer are designed and developed together as a system can the user expect high levels of performance and dependability.

HP Scitex developed UV Curable (UVC) inks, the HP Scitex X2 printhead, and wide-format printers to meet the developing needs of industrial inkjet printing.

There are two main types of UV curable ink used in industrial inkjet printing: "Free Radical" and "Cationic". Today, about 95% of UVC inks are based on Free Radical chemistry. A key difference between Free Radical and Cationic systems involves the solidification process under exposure to UV light, and this will be discussed further under "Curing". Free Radical and Cationic UVC inks are offered in Solvent Diluted and the so-called "100% Solids" formulation.[2]



Solvent Diluted UVC inks use a volatile component, either water or an organic solvent, to lower ink viscosity for drop ejection and to get greater ink spread (dot gain) on the print medium. The volatile component is then evaporated in a dryer using hot air or infrared (IR) lamps, and the ink components remaining on the print medium are then cured by exposure to ultraviolet (UV) light to produce a solid film. The drying/evaporation process produces either water vapor or volatile organic compounds (VOCs). In solvent-based systems, the release of VOCs involves

[1] See the companion White Paper: HP Scitex X2 Printhead.

[2] The term "100% Solids" should not be confused with a hot-melt ink, also called a "solid ink". Solid inks are a waxy solid at normal temperatures. They are heated and melted for jetting, and then solidify by freezing on the substrate.

		Machine Lenght (m)	Machine Footprint (sq.m.)	Maximum Power* (kW)
	HP Scitex TJ8500 UVC inks	8	32	90
	HP Scitex TJ8300 Solvent inks	19	57	80

legal requirements to meet local, state, and federal environmental, heath, and safety regulations relating to worker VOC exposure and to material handling, use, storage, and disposal.

With 100% Solids UVC inks all the ink printed onto the print medium converts into a solid without any material loss to evaporation. Since no VOCs are released, 100% Solids UVC inks have significantly lower environmental, health, and safety issues compared to conventional solvent-based inks and UVC inks diluted with organic solvents.[3]

Inks and the System

Prints made with aqueous or solvent inkjet inks "dry" when volatile ink components evaporate leaving behind colorants and other materials on the print medium to form an image. Because industrial inkjet printers can produce 100's of square meters per hour, a dryer is used to ensure that most of the volatiles are evaporated or, at least, prints are sufficiently dry for handling. Dryer power consumption, concerns about solvent ink vapor ignition, and the response of print media to high temperature (e.g., shrinkage, curl, blistering, etc.) impose practical limits on the rate of drying. Since the drying process must take several seconds, printers with high linear feed rates may need dryers that are several meters long.

A key difference between 100% Solids UVC inks and other types of inks is that UVC inks don't dry: they solidify in about 0.1 second upon exposure to intense UV light. This means that an in-line print dryer is not needed, and a printer using 100% Solids UVC inks requires less production floor space than a similar printer using aqueous, solvent, or solvent-diluted UVC inks.

The figures and chart at the right compare two similar HP Scitex printers: the TJ8300, which uses solvent inks and the new TJ8500, which uses UVC inks. The TJ8500 offers the same level of productivity, but needs only about half the floor space as the TJ8300.

Because they do not evaporate, 100% Solids UVC inks can improve printhead operation and reliability. Unlike aqueous and solvent-based inks, 100% Solids not do not form a solid crust when exposed to air and so require less maintenance of the printhead nozzle plate. This characteristic reduces printer design complexity compared to machines using aqueous and solvent inks, and this is a significant consideration in industrial inkjet printers that can use 100's or even a 1000 or more printheads arranged in a large nozzle array.

Industrial inkjet printing places high demands on system productivity, reliability, and quality. To meet these levels of performance, HP Scitex designs, develops, and manufactures inks, printheads, and wide-format printers as a system with end-to-end engineering and quality control. Inks are a critical element of the system solution, and not just any UVC ink will meet all industrial printing performance requirements.

To demonstrate the importance of each ink component to the system, consider that every change in HP Scitex UVC ink formulations undergoes exhaustive testing both in the laboratory and in production environments. That investment in quality control means that every liter of HP Scitex UVC ink comes with the confidence that the inkjet printing system performs to HP Scitex standards.

[3] Refer to the Material Safety Data Sheet for instructions on handling, use, and disposal of HP Scitex UV Curable Inks.

In fact, the physical, chemical, and colorimetric properties of ink affect everything in the printing system. The table below lists some primary ink-system interactions. Failure to perform in any one of these aspects means an industrial inkjet printing system will not deliver the necessary level of productivity, reliability, and quality.

Ink physical properties (e.g., surface tension, viscosity, pigment particle size and distribution) affect

- printhead maximum drop frequency (productivity)
- ink supply pressure drops at high ink flow rates (printhead ink starvation, productivity)
- drop formation and break-off (satellites, drop placement errors, quality)
- wetability of the nozzle plate (reliability of drop ejection, drop placement errors, quality)
- wetability of the print medium (wet dot-dot interactions, dot coalescence, quality)
- dot gain (virtually everything related to image quality)
- feathering (edge sharpness)
- substrate penetration (optical density)
- stability of pigment dispersion (pigment settling in the printhead and ink delivery system)
- consistent printhead operation over the industrial temperature range (dependability)
- Ink chemical properties affect
- resistance of printhead and ink delivery system components to damage from ink exposure
- stability of pigment dispersion
- robustness of the UV cure process (complete and rapid conversion of monomer to solids)
- dot gain
- flexibility, hardness, adhesion, and durability of cured print
- fade resistance
- environmental, health, and safety considerations in handling, use, storage, and disposal
- shipping restrictions due to hazardous components and world-wide product availability

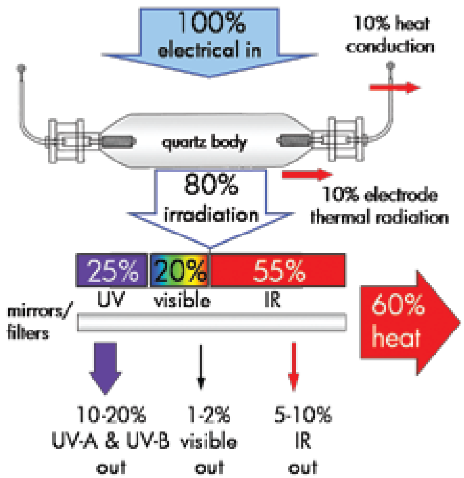
Ink colorimetric properties affect

- color consistency
- color accuracy
- color saturation
- color gamut

UVC inks offer a number of important image quality benefits. Once on the print medium and exposed to UV light, drops of UVC ink undergo a rapid increase in viscosity from a jettable liquid to a durable solid. This minimizes dot spread, feathering, and ink penetration into absorbent media. This characteristic allows UVC inks to print with high quality on any substrate with precise dot control for sharp lines and edges and repeatable dot properties for color halftoning algorithms. High color saturation is achieved because UVC inks form a film of colorant on the surface of print media.

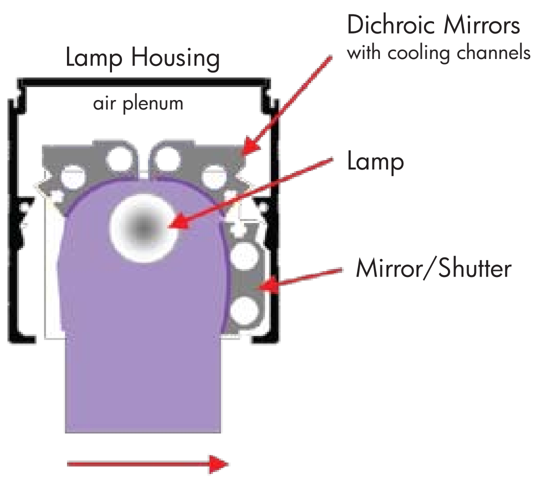
After curing, UVC inks form a durable, mechanical bond to the print surface: the solidified ink "keys" into microscopic pores in the print medium. Prints come out of UV cure ready-to-use and odor-free.[4]

[4] Some post-cure polymerization can occur, meaning that maximum image durability may be achieved a few hours after printing.



Curing

The UV cure station has a Lamp Housing assembly that provides power, cooling, and beam control for a lamp that emits intense UV radiation. This assembly is shown schematically at right. UV light is typically broken into three bands from the longest to shortest wavelengths: UV-A, UV-B, and UV-C. UV-A and UV-B are used in curing, UV-C is absorbed by air and produces ozone, which can be effectively trapped and eliminated by filtration. The Lamp Housing contains optical elements, such as mirrors with dichroic coatings, that reflect UV-A and UV-B but absorb IR and some visible wavelengths. This minimizes heating of the print medium during cure.

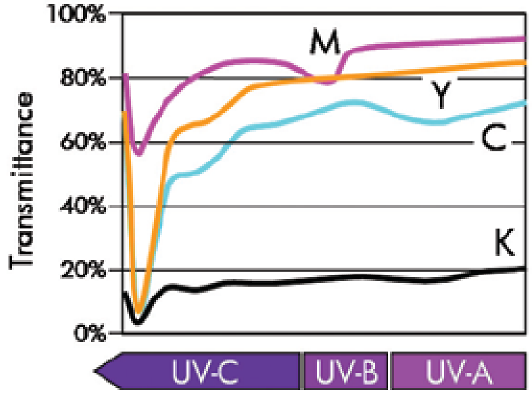


Mercury vapor lamps offer high efficiency at UV-A and UV-B wavelengths. But, as summarized in the figure at left, only about 10-20% of the input electrical power is delivered to the print medium as UV-A and UV-B radiation. The rest is lost as IR (infrared) radiation and heat. Heat is removed by forced-air cooling of the lamp and by air or water cooling of mirrors and other components in the Lamp Housing.

The curing process begins by exposing printed dots of ink to UV light. This causes an ink component called a *photoinitiator* to break down into reactive species that cause liquid *monomers* to link together to form chains, called *polymers*, and polymers to crosslink forming a solid ink film.

For Free Radical chemistries, the photoinitiator produces negatively-charged species (free radicals) that are consumed as monomers link and polymers crosslink. Continuous exposure to high-intensity UV light is required to produce free radicals as long as monomer is available for conversion.

In addition to reflecting different wavelengths of visible light to produce a colored image, ink pigments absorb different wavelengths of UV. This is shown in the plot of %Transmittance versus wavelength at the right.



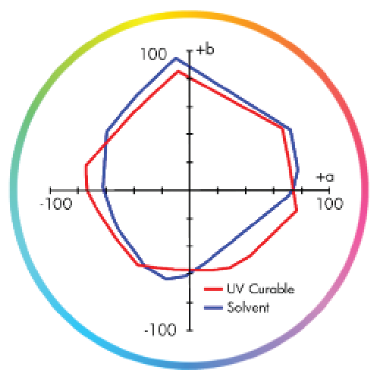
Notice that these four pigments (CMYK) pass UV-A and UV-B wavelengths to varying degrees, but cyan, yellow, and black inks are nearly opaque to short wavelengths of UV-C. UV light is said to be "blocked" by the pigments at wavelengths with lower %Transmittance.

For a complete cure and adhesion to the substrate, Free Radical chemistries require UV light to penetrate the entire ink layer from the outer surface to the ink-substrate interface. To minimize the effect of pigment blocking, the photoinitiator is made of several different materials, each having sensitivity to different UV wavelengths produced by the lamp.

Most pigments transmit UV-A efficiently, and this allows UV-A energy to penetrate the ink layer down to the ink-substrate interface.

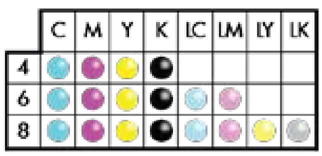
For Cationic chemistries, the photoinitiator breaks down into positively-charged cations. Once initiated by UV light, Cationic chemistries undergo a self-sustaining chain-reaction that can continue in the dark until all the monomer is converted. This "dark cure" needs less UV energy for curing and avoids the effect of pigment blocking, which could prevent the conversion of all monomer into crosslinked polymers with Free Radical chemistry. Cationic chemistries may require heating of the substrate to ensure a reliable cure.

On the other hand, Cationic chemistry requires formulations with high thermal stability and resistance to triggering under low levels of UV light (e.g., sunlight, fluorescent lights, etc.). While a manageable risk, the exposure of any part of a Cationic UV ink system to initiation-levels of UV light could potentially solidify the ink throughout the ink delivery system from the printhead to the ink bottle.



HP Scitex UV Curable Inks

HP Scitex formulated and developed UV Curable inks to work with the HP Scitex X2 printhead and with OEM printheads in wide-format industrial inkjet printers. These inks use a 100% Solids, Free Radical formulation and are offered in 4- and 6- ink configurations for different HP Scitex wide-format industrial inkjet printers.



The inks are produced by HP Scitex in its own state-of-the-art factories to strict quality-control standards. Each batch is tested and certified to meet an array of rigorous physical, chemical, and colorimetric specifications.

HP Scitex UV Curable inks offer 24 months outdoor fade resistance[5], high durability, resist abrasion, and can be cleaned with soaps and other common solvents. Images are waterfast, and have excellent adhesion to a wide variety of rigid and flexible substrates.

Color gamut is a key measure of ink performance, and HP Scitex UVC inks deliver brilliant, saturated colors comparable to HP Scitex solvent inks. The figure at left shows the color gamuts in the a-b plane of the CIE Lab color system for 6-ink systems[6] of HP Scitex UVC and solvent inks.

Summary

HP Scitex UV curable inks are formulated and manufactured by HP Scitex to work together with HP Scitex X2 printheads and wide-format industrial inkjet printers. These dependable systems produce dry, ready-to-use, durable images with a large color gamut on a wide variety of rigid and flexible substrates.

Designed for high-volume printing, HP Scitex UV Curable inks and wide-format printers do not release volatile organic compounds and offer reduced production floor space requirements compared to aqueous- and solvent-based industrial printing solutions.

[5] Based on tests conducted by HP Scitex according to ASTM 2565–99 protocols.

[6] These 6-ink systems use cyan, light cyan, magenta, light magenta, yellow, and black inks.

http://www.hp.com/go/graphic-arts

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