Technical white paper

Inks for HP PageWide Technology

New HP pigment inks for quality, speed, and reliability

HP PageWide Technology offers high quality at high printing speeds, reliable and robust operation, and economical print production. This is achieved using HP PageWide Printheads and new HP PageWide Pigment Inks formulated to meet the demanding requirements of pagewide printing.

Inkjet inks

For more than 20 years, HP pigment inks have supported high-performance printing solutions across a full range of markets and applications. As users' expectations for printing solutions evolve to higher levels of quality, productivity, reliability, and economy, so the ink formulations that enable these solutions must evolve as well. In fact, writing system and ink technologies evolve together as advances in one are generally not possible without advances in the other.

Chemists on HP's ink R&D teams collaborate closely with HP color scientists and engineers developing printheads, writing systems, ink delivery systems, and papers. Working together, these teams manage the design decisions and trade-offs required for the best system-level solution. The synergy coming from HP's vertical integration in the R&D and manufacture of inkjet printheads, inks, writing systems, and image processing produces results that are very difficult to achieve when developing printers based on integrating third-party inks with OEM components from several suppliers.

Ink components

Inkjet inks consist of a colorless *ink vehicle* that carries a *colorant* to the surface of the paper. The ink vehicle is important to the stability of the ink, the drop ejection process, reliable printhead operation, and controlling the behavior of ink on the paper's surface.[1] Volatile components of the ink vehicle are absorbed and evaporated leaving behind a layer of colorant and solids—including binders and resins— that produce the printed image and provide durability.

Ink vehicle

In water-based inkjet inks, the ink vehicle consists of water along with liquid and solid ingredients. Water can account for more than 60% (by weight) of some ink formulations. Liquid ingredients—humectants and surfactants—help keep the ink from drying out in the nozzles and allow the ink to wet the inside of the drop generator and surface of the paper. This promotes reliable drop generator refill by reducing bubble trapping, and regulates the spread and penetration of ink on the print to accelerate drying and to control dot size, feathering, and color-to-color bleed. In the printhead and ink delivery system, solid ingredients—polymers and resins—keep the pigment particles from aggregating. Once on paper, solids help bind the pigments to the surface and improve durability.

Colorants

Inkjet ink colorants are based on dyes, pigments, and sometimes a mixture of both. Colorants work by absorbing specific wavelengths of light and reflecting others. The choice of colorant has a significant effect on color quality, drop ejection reliability, ink cost, and environmental considerations.[2]

- Dyes are chemical molecules that dissolve in the ink vehicle. Dyes can have high color strength, and if they remain at or near the paper's surface, dyes can be more colorful than pigments. However, on absorbent papers, dyes can be carried by the ink vehicle deep into the paper structure. When this occurs, there may not be enough dye near the surface to produce dense blacks and saturated colors. High dye concentrations can counteract this effect, but this can lead to unreliable drop ejection—especially during extended decap time—that require frequent service cycles that reduce productivity and increase the amount of ink used in servicing. This is a particularly important issue for pagewide printing, where high productivity is expected, and failed nozzles may leave visible streaks down the page.[3]

[1] In this document, "paper" will be used to describe print media in general.
[2] In particular, colorants that have toxicity issues and contain heavy metals, such as nickel, are undesirable.
[3] Nozzle substitution compensates for the effects of weak or failed nozzles in HP PageWide printers with HP PageWide Pigment Inks.

While dyes usually lack the water-resistance, highlighter-resistance, and display permanence (fade resistance) of pigments on plain papers, dye-based inks can offer excellent color performance with improved durability on more expensive inkjet coated papers. These coatings are designed to hold the dyes near the surface and protect them from water, highlighters, ozone, and UV light.

- Pigments are particles that are on the order of 100 nanometers in diameter. Unlike dyes, pigments do not dissolve in the ink. Pigments are kept in a stable dispersion by the ink vehicle and surface charges that produce repulsive forces between particles. Once on the paper, the chemistry of HP pigment inks quickly immobilizes pigment particles on or near the paper surface as the ink vehicle is absorbed and evaporates. This allows HP pigment inks to produce high color saturation and high black optical density as well as control color bleed, feathering, and show-through.

  Compared to dye-based inks, pigment inks generally offer better resistance to water, highlighters, and light fade. Pigments are the colorant of choice for applications requiring the highest levels of durability, black density, and saturated color—especially on plain papers

  HP pigment inks typically contain 3% -10% pigment (by weight). The design and operation of printheads, ink delivery systems, and printhead service stations are more complicated for pigment inks than for dyes because of the particulate nature of pigments. Even pigment ink used in printhead servicing presents issues for service station components. Once the ink vehicle evaporates, pigments can form gummy deposits on wipers, spittoons, ink absorbers, and caps unless the service station is designed to handle pigments.

Reliable and robust operation

For high quality printing at high productivity, inkjet printheads must be both reliable and robust.

Reliable operation means that the printhead produces drops on-demand, and each drop must meet image quality specifications on weight, trajectory, and speed. Reliability also relates to operating life and low operational failure rates. For example, a more reliable printhead has fewer *nozzle errors*—drops that are missing, misdirected, or with high/low weight—and lasts longer measured by pages printed or liters of ink consumed before replacement is required.

Pagewide printheads need to be more reliable than scanning printheads because they must produce high-quality output in a single pass: they don't have multi-pass print modes to hide nozzle errors. High-speed drop detection systems—testing 1000's of nozzles per second—can find weak or failed nozzles, and the image processing pipeline in HP PageWide Technology Printers automatically substitutes good nozzles for failed ones to effectively hide nozzle errors.

In particular, pagewide printheads must be exposed to air—decapped—for extended periods and still reliably eject drops on-demand. Service cycles can improve reliability and may be able to recover failed nozzles. However, excessive servicing can reduce productivity and increase ink consumption.

Robust operation relates to the operational performance of the printhead. A printhead is robust if it ejects drops reliably over a wide range of operating conditions and duty-cycles. For example, a printhead that properly ejects drops after a long decap time is more robust than a printhead with a short decap time. A printhead that offers printing of high density area-fills at high speed is more robust than one that must slow down. And, a printhead that requires less servicing to operate reliably is more robust than one that requires more servicing.

Inks for HP PageWide Technology

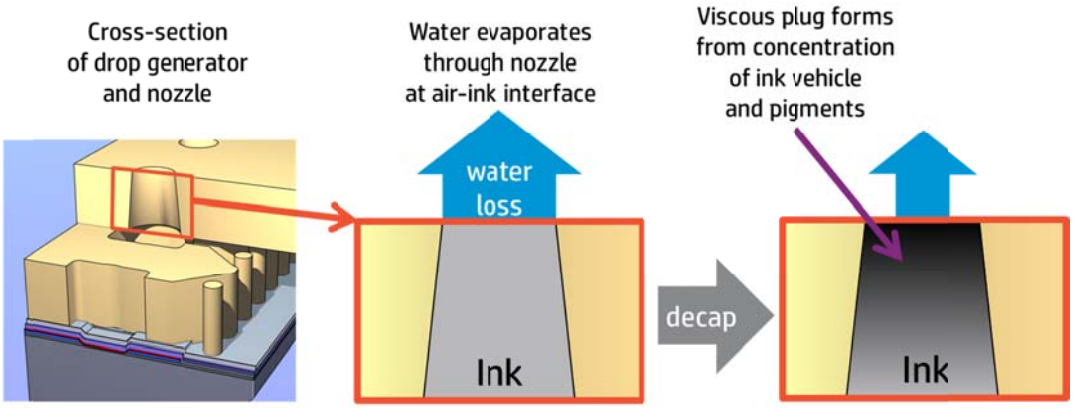
Pigment inks used in HP PageWide Technology Printers face performance challenges more severe than those used in printers where the printheads are mounted on a scanning carriage. Extended decap time becomes a driver for innovation in the design of pagewide writing systems and their inks.

Designing inks for extended decap time

Maintaining the ink's physical properties within tight specifications is essential to reliable inkjet drop ejection. When a printhead is decapped, water is lost from the nozzles by evaporation. All inkjet printing systems using water-based inks cap the printheads when not in use to prevent excessive water loss from the nozzles. The effects of decap are most pronounced in nozzles that are idle, because the ink is not refreshed by frequent drop ejection.

The nozzles on an inkjet printhead are very small—only about $1/5^{th}$ the diameter of a human hair—so evaporation can concentrate the inks in the nozzles in only one or two seconds. Figure 1 illustrates the effect of water loss from an idle nozzle. The pigments and less-volatile liquid components of the ink become concentrated, and the highest concentration occurs at the air-ink interface—called the "meniscus". Changes in the density, viscosity, and surface tension of the ink form a plug of viscous fluid that may become difficult to eject. Ultimately, this *viscous plug* may prevent drop ejection altogether and a service cycle will be required to restore operation.

Figure 1 – Effects during extended decap time: conventional pigment inks

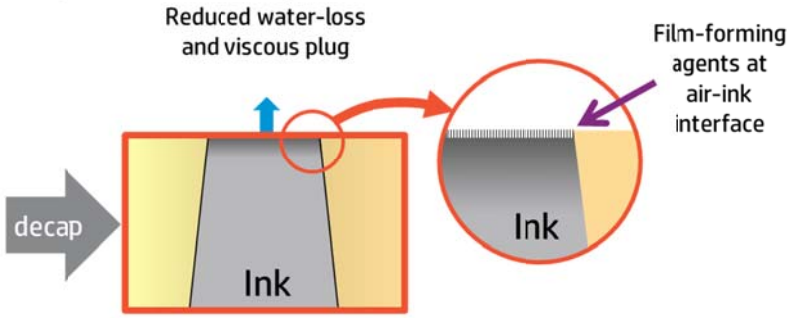


Designing an ink that dries quickly on the print—but doesn't dry out in the nozzles—is one of the conflicting requirements for inkjet inks. With sustained printing, a pagewide printhead may be decapped for minutes at a time.

The first-generation of HP pigment inks for desktop pagewide printing—HP 970/971 Pigment Inks—were developed for HP OfficeJet Pro X-series Printers that employ a 4-color, 8.57-inch (217.8 mm) printhead with 42,240 nozzles. Because this is a cut-sheet printer, decap effects can be managed by spitting a few drops of ink into a spittoon under the paper path during the gap between sheets. HP R&D engineers and chemists needed to extend decap time to about 10 minutes to meet the productivity requirements in large format applications, and they applied what was learned from the Officejet Pro-X program to formulate a new generation of inks for HP PageWide Technology: HP PageWide Pigment Inks.

Figure 2 is a schematic showing how HP PageWide Pigment Inks resist the effects of extended decap. After a drop is ejected, film-forming agents in the ink rapidly migrate to the meniscus to produce a vapor barrier that reduces the rate of water loss. This slows the rate of viscous plug formation *by nearly a factor of 10* compared to inks without film-forming agents. This preserves the ink's physical properties longer for reliable drop ejection. An important feature of this unique film-forming chemistry is that it works without impeding drop ejection—the film is designed to break down as ink moves out of the nozzle and the meniscus stretches to become the leading-edge of the drop.

Figure 2 – HP PageWide Pigment Inks: film-forming functionality



Spit-on-Page

Another tool HP writing system engineers use to provide reliable drop ejection under extended decap conditions is called "Spit-on-Page"—"SoP". If a nozzle is idle for longer than a specified time, it ejects a drop onto the paper to refresh the ink in the nozzle. When SoP is infrequent and random, it produces isolated dots that are virtually invisible. HP PageWide Technology achieves robust operation by combining a low rate of SoP with the properties of HP PageWide Pigment Inks.

Extending decap time through ink design reduces the frequency of SoP and any effect on output quality. In addition, it's good for the environment when less ink is used for printhead servicing because ink supplies last longer with fewer used ink cartridges to be recycled. Of course, higher ink efficiency reduces the cost of print production.

Drying the print

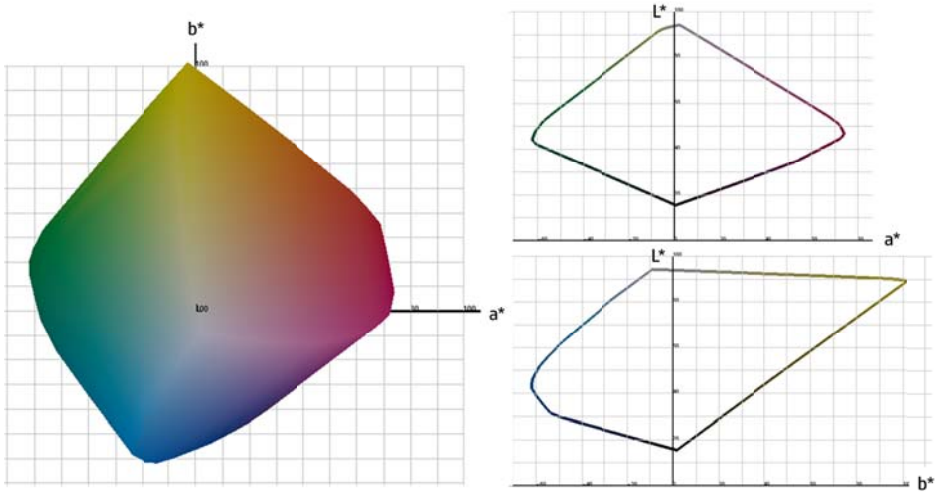
Producing a print that is dry to the touch and can be handled immediately without smudging or smearing the image is important to users. A built-in dryer is useful in printers designed for the highest-level of productivity or for applications requiring papers that are not very absorbent. HP PageWide Pigment Inks rapidly penetrate absorbent papers to reduce drying requirements, and they can produce ready-to-use prints without a dryer in printers designed for lower productivity.

In a scanning printhead system, dots of ink can be printed sparsely on multiple passes. This gives dots seconds to absorb into the paper before neighboring dots arrive. This reduces potential image quality defects from "wet-on-wet" dot interactions—mottling and color-to-color bleed. In pagewide printing, full ink coverage occurs in milliseconds: all dots go down wet-on-wet. HP PageWide Pigment Inks were formulated to produce high quality under these conditions.

Black optical density and color gamut

Inks for pagewide printing must deliver a wide color gamut and high black optical density (KOD) in a single pass. On HP Heavyweight Coated Paper, HP PageWide Pigment Inks produce a KOD of 1.7 and gamut volume of 430,717 CIELab units.

Figure 3 - Color gamut of HP PageWide Pigment Inks on HP Heavyweight Coated Paper



Print media

HP PageWide Pigment Inks were designed to provide high line, text, and graphics quality on bond paper, vellum, thick bond paper, low-cost photo papers, poster papers, natural tracing papers, and polypropylene.

Print durability

An important element of application versatility is print durability, which includes resistance to light fade, water, and highlighter smear. HP ink chemists chose pigments over dyes to achieve high durability, especially on plain papers. HP's years of experience in improving the light fade resistance of inkjet prints was fully leveraged in the development of HP PageWide Pigment Inks. And, proprietary polymeric binders in the inks form a tough film on the paper surface that protects and immobilizes the pigments. This improves highlighter smear resistance.

Lower cost per copy

By producing high color and black saturation at lower levels of ink coverage (compared to other HP pigment inks) on low-cost plain papers, HP PageWide Pigment Inks reduce the cost of print production. These inks are also designed for long printhead life, and this reduces printing costs and printer down-time spent in printhead replacement.

Summary

HP PageWide Technology forms the foundation for solutions—now and in the future—offering high-speed, reliable, robust, and economical printing on a wide range of papers and formats. These solutions are scalable in design and performance to meet the needs of a broad range of applications in office, commercial, and industrial printing. In order to deliver the performance that pagewide printing demands, HP developed water-based HP PageWide Pigment Inks with properties uniquely suited to the requirements of fast, high-quality printing in a single pass.

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