

Paired Ink and Substrate Combinations Tailored for Ink Jet System Solutions

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Abstract

Photo-print longevity, textile durability, signage weatherability, and fine art archiveability have been greatly improved by selecting the substrate and the ink together, sometimes even including the finishing step in the process. As ink jet technology spreads from the desktop into a diversity of new markets, many improvements are being tied to the use of one vendor's matched ink and media.

Highlighting these approaches, this paper emphasizes the combined chemistry developed for the inks and media for specific applications, the impact of individual ingredients on the overall system, the criteria for selecting the pairs, and the benefits and the problems in developing matched sets for these system solution approaches.

Consideration of whether this specialized, selective ink and media approach, that is the norm in tradition industrial and commercial applications, will dominate ink jet as it gradually invades these applications will be discussed as well as whether this more limited matched system approach will displace efforts in items such as UV curing inks, and cross-linking emulsions, which are aimed at the ideal ink that is media independent, permanent and fast drying.

Introduction

Media and ink tailored as a matched set often open opportunities for new technologies. The initial monochrome thermal inkjet desktop system the HP Thinkjet, was introduced along with a special paper in 1984.¹ By 1988, the jet ink (and print head) were optimized to attain the smallest variation of printed dot diameters over a group of eight papers, representative of the then existing "plain" papers.² By the early 1990's, the sizing in plain papers was being selected to offer "multipurpose" plain paper signaling good image performance for both laser and ink jet printing.³ This remains the norm today. Ink jet image quality on plain paper meets the demand of many applications but selected sets yield greater durability and permanence even for the desktop. Coated desktop papers are also used for higher quality applications, or for specialized markets such as overheads, greeting cards and photo prints.

Ink jet applications are progressing from the SOHO to new industrial and production environments which have requirements for additional functionality--long run lengths,

speed, and durability.⁴ These applications are encouraging the use of selected or matched pairs of ink and media. Matched sets of ink and media are already the norm in many traditional industrial and commercial applications, such as offset printing, where high quality is equated to matched systems.

The main benefit of a matched pair approach for new applications is that it simplifies building the very specific, new requirements into one component. It speeds and simplifies the development cycle. The chemistry can be split between the two components, and the interactions tailored for the single set. The main disadvantage is the cost impact of smaller volumes for ink and substrates tailored for one machine or one application. When the market grows to an attractive volume, the competitive aftermarket also has a simpler path. For the large markets enabled by several of the new applications, for example, textiles and packaging, the upside can still be attractive. Initially pairs open up new markets faster. But as technology progresses more universal options may displace them.

Matched Pair Approaches

An early leader in offering a matched system for ink jet printed, large format applications was 3M. With the 3M MCS (Matched Component System) Warranty, for example, the finished graphic is guaranteed against harm due to temperature, moisture, pollution, UV rays, abrasion and other outdoor elements.⁵ Vendor provided inks, imaging media and overlaminates must be used; fabricators also are certified. Early patents show polymeric mordants with a guanidine functionality as key components for ink receptive sheets which inhibit bleeding at elevated temperatures and humidity. Follow on patents cover much more complex receptive sheets.⁶ Likewise Ilford was an early leader in offering photoprint longevity with matched inks and media, and offered an understanding of the pronounced impact of both the dye-based inks, media, environmental conditions, and the lamination step on image permanence.⁷ Wilhelm testing also offered an early standard testing service for print stability to the fine arts market, which emphasized the impact of the combination of the ink, media and environment.⁸

Today we see new patents covering inks and media sets together. Ink and media sets using UV radiation or heat

curing have repeatedly been explored for improvements in durability for high coverage prints. For example, dispersed pigment inks where the polymeric dispersant in the ink binds to the pigment and reacts with a component in the media yield greater durability and waterfastness.⁹ The media coating contains polyvinyl alcohol copolymers with hydroxy and carboxyl groups, and may have other crosslinkable groups to yield a durable image and non-image area. Likewise, high durability is achieved for overhead transparencies, glossy papers and films for high quality graphics and pictorial output using hardeners, or additives which cause chemical cross-linking in both the pigmented inks and the ink receptive sheet. An advantage of the matched set is that the hardener present in both the imaged and non-imaged areas, guarantees good wet adhesion in low or mid density areas of the image. An example of the hardener used is 2,3-dihydroxy-1,4-dioxane for acetoacetylated poly(vinylalcohol) substrate coatings.¹⁰ In textiles combinations of novel reactive dyes containing fiber reactive groups, which enable high color strength, fiber-dye bond stability, wet fastness and light fastness properties, while avoiding catalytic fading, are combined with treated cotton, viscose, fabrics to yield a system optimized for ink jet printing.¹¹ Traditional steam fixing, wash and dry are required. The combination of Dupont prepared pigment dispersion inks and fabric treated with a crosslinkable thermoplastic polymer containing both a carboxylic group and a crosslinkable group, or a mixture of polymers which contain the two functional groups, yields durable, high quality, wash fast and water fast printed fabric. Printing is followed by heating the textile which softens the hydrophilic thermoplastic polymer encapsulating the ink colorant, while the cross linkable polymer forms a hydrophobic matrix.¹²

Comparison to a Universal Ink and Media Approach

A major benefit of the universal ink or media approach is the convenience to the end user. Stocking, storing and loading one ink and one media for all applications is the ideal. This also leads to a large available market size, which is beneficial for the consumables and raw materials manufacturers. However the difficulty of this approach which enables use of any ink or media together, leads to large expenditures on product development, yields long times to market, especially with the intense testing cycles required. It also requires very specialized raw materials development, and formulations for ink and media components, to surpass existing approaches.

Universal media approaches today are targeting items such as low cost, high performance uncoated ink jet paper which approaches the print characteristics of fully coated ink jet papers. To attain the required improved coating rheology and higher coating solids, for example, improved clay-based coating pigments are being developed.¹³ The pigment composition contains tailored clay, leached calcined clay, and zeolites. Other approaches include,

highly focused polymer systems tailored for specific ink classes such as pigmented inks. For example, a recording sheet that contains a highly ink-absorbent copolymer of acrylic acid and vinyl alcohol, along with a self-crosslinking graft copolymer of polyvinyl alcohol in predetermined ratios, yields a highly water resistance, non-blurring or bleeding, non-cracking, and a uniform gloss media for the use of pigment inks.¹⁴

The universal ink approaches today center on the use of polymers to bring greater independence from media characteristics. A method is defined¹⁵ for producing colored microencapsulated-type aqueous jet inks containing fine pigment particles coated or encapsulated with a resin film with quaternary carboxyl groups on the surface which has a self dispersion property in water. This yields superior dispersion stability, ink jetting stability, and adherence of the microcapsules to the recording medium. Copolymers of methacrylate and a monomer selected from the group consisting of styrene, substituted styrene, and methacrylate-ester are used with a 30K to 100K molecular weight range. And likewise processes¹⁶ to produce crosslinked, polyurethane-polyurea pigmented particles for jet inks which are water and solvent resistance are being developed.

Before all requirements for universal inks or universal media are attained, use in a matched pair can offer an option to enable earlier entry into the market. However, many more producers are tailoring raw materials for ink jet requirements today than in the past. Breakthrough technology advances for ink jet materials can be expected by this focused effort of leading technical resources, while the ink and media volumes offer the promise of the required reward.

The Future

Considerations of matched sets highlight the importance of system issues, and the requirements for cost effective solutions for the complete system-from raw material providers and hardware manufacturers to the end user. Hardware manufacturers will see market advantages for enabling quick ink and media changes, more flexible substrate handling, and increased printhead reliability including ink durability and wider windows of jet operating parameters, all which support multiple ink and substrate use. New industrial printheads currently being introduced are being tailored for these parameters.

New opportunities exist for tailoring imaging chemicals for ink jet ink and media needs for both matched systems, and in the quest for universal inks and media. The result will be decided by application tradeoffs which often require a high sensitivity to total workflow cost as higher volume applications evolve. Matched pairs in a new application will open up markets but then evolve to more universal inks and media as technology matures and mainstream printheads and system requirements are established.

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Biography

Carol Keller heads Keller Associates which offers consulting services in consumables for color digital printing. Services include product development for ink jet inks and media, and business and opportunity analysis for color digital printing.

Ms Keller has worked extensively in color imaging systems, most recently heading the consumables business for Iris Graphics, a Scitex company. She previously lead product efforts in color ink jet and color electrophotography at Xerox Corporation, in digital photographic printers at Polaroid Corporation, and in charge deposition printing at a start-up.

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