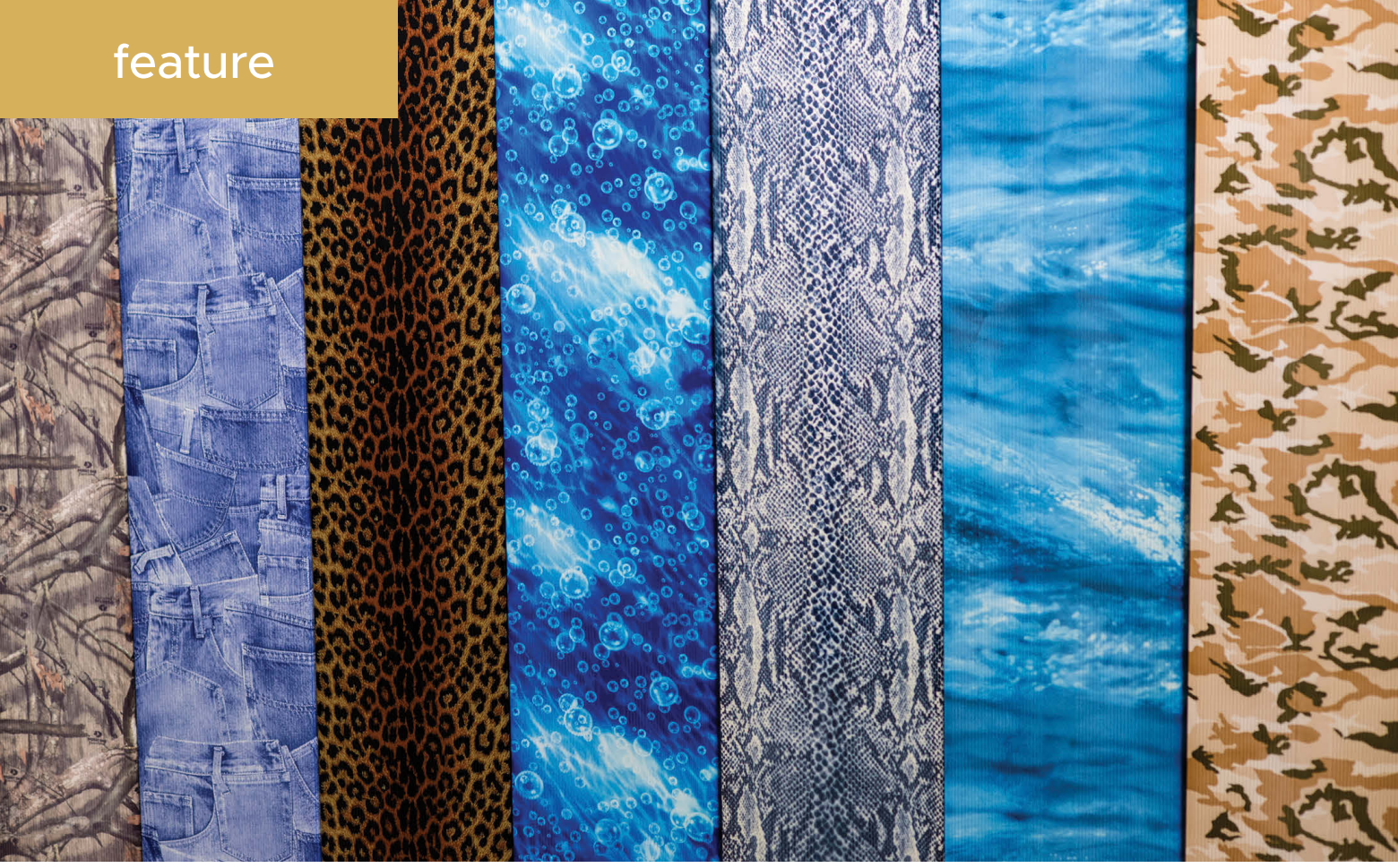

Dye-sublimation applications produced by A-Tex. Courtesy of Advanced Finishing USA.

Opportunities in Sublimation-Disperse Dye Printing

Exploring a growing market's progression and latest technologies and applications.

Transfer dye-sublimation (dye-sub) and direct disperse dye printing continue to grow both in market share and new application opportunities. Smithers' 2018 report, "The Future of Dye-Sublimation Printing to 2023," projected the worldwide market for dye-sublimation printing would grow from $7.83 billion in 2017 to $8.54 billion in 2018, and continue at a 10.2% compound annual growth rate to a market value of $13.9 billion in 2023. The report identified five dye-sub application categories for end users with garments constituting the largest market category by far, followed by visual communications, household, rigids, and technical textiles.[1]

The Evolution of Dye-Sub and Direct Disperse

Before the 1920s, clothing fabric was made of natural hydrophilic ("water-loving") fibers, such as cotton, linen, wool, and silk, primarily printed with aqueous dyes or colored in aqueous dyebaths. However, the introduction of cellulose acetate[2] — the first synthetic hydrophobic ("water-fearing") polymeric material — required a different method for coloring, dyeing, and printing, which came in 1924.

Building on discoveries of fellow chemists, James Baddiley and Arnold Sheperdsen of British Dyestuffs Corporation developed Duranol dyes, while Holland Ellis of British Celanese produced sulpho ricinoleic acid dyes and a dispersing agent for coloring acetate fibers.[3] About five years later, British Celanese's Valentin Kartaschoff observed that, when placed in contact and heated, these disperse dyes could color cellulose acetate. Officially named disperse dyes by the Society for Dyers and Colourists,

Digital printing technologies, particularly inkjet, have improved to a point where they can compete with analog printing processes for print quality and production speed.

By Vince Cahill and Claire Hunter, Owners, VCE Solutions

they were also eventually shown to color other chemist-formulated hydrophobic synthetic materials, including Nylon, polyethylene terephthalate polyester, acrylic Plexiglas, and other polymerics.

After Star Stampa Artistici di Milano developed a gravure-based heat and pressure transfer printed paper system in 1950, the heat transfer method for printing synthetic polymeric continued to evolve. Following on these developments, Noël de Plasse eventually described the transfer process as sublimation and founded Sublistatis SA to exploit the commercial potential of his printing technique.[4]

From personal experience navigating dye-sub transfer screen printing for decorating polyester-coated items and fabrics for customers in the 1980s, much knowledge on dye-sub and direct disperse dye printing technology has been gained by connecting with other users and industry suppliers, entrepreneurs, and chemists.

This has included printer, entrepreneur, and process engineer Roy Devries of Screen-Trans Development in Moonachie, N.J., who developed dye-sub inks for litho offset during the 1970s and, working with chemist Henry Lewis, began experimenting with inkjet dye-sub inks.

Collaboration among entrepreneurs, chemists, and engineers has been key in creating and improving the dye ink, substrate, transfer paper, printer, and press solutions that have enabled the dye-sub industry to prosper. Sawgrass Solutions' CEO and entrepreneur Nathan Hale and chemist Ming Xu opened the door to dye-sub opportunities for printers with their inks, supplies, and instruction. They worked with other entrepreneurs and suppliers, like David Gross at Condé Systems, who assembled one of the largest offerings of dye-sub-printable items and supplies, including dye-sub printers, software, inks, transfer papers, heat presses, and a comprehensive product catalog of dye-sub receptive blanks. The list of synthetic polymeric material applications includes fibers, garments, bags, polyester-coated mugs, cutting boards, polyester-covered mousepads, phone cases, dinner plates, ceramic tiles, skateboards, car hoods, flags, and powder-coated metals.

Condé, Sawgrass, Heat Press Nation, Heat Transfer Warehouse, and other suppliers provide online tutorials on how to use dye-sub for its many applications.

Dye-Sub vs. Disperse Dye Requirements

Aside from the transfer paper and process used with dye-sub, direct disperse dye printing has many of the same requirements as dye-sub printing. Both use virtually the same print technologies, one for depositing disperse dye images directly onto polymeric substrates and the other for depositing them as reversed images on paper for subsequent transfer to polymeric substrates. They both require heat setting to fix the dye into substrates.

Disperse dyes are nonionic colorants with very limited solubility in water at room temperature. Dye-sub transfer printing typically uses low-to-medium energy/molecular weight disperse dye inks that are printed onto transfer paper, which under heat and pressure and in contact with the intended substrate's surface, penetrate into receptive polymeric materials. Low molecular weight disperse dyes can reflect vibrant colors, but also offer limited outdoor exposure life to sunlight UV.

Though direct disperse dye printing often uses the same or similar energy disperse dye inks as dye-sub printing, it can also use higher energy/molecular weight disperse dyes for some applications requiring greater outdoor durability and resistance to UV exposure. However, high energy disperse dyes appear less vibrant compared to low energy dyes and they require higher temperatures and pressures to merge with print substrates, which must be able to tolerate such parameters. Meanwhile, very low energy disperse dyes can tend to migrate out of the receiving substrate over time. Only a limited number of the existing hundreds of disperse dyes are appropriate for direct or transfer printing.

Disperse dye types include monoazo, accounting for 80% of all disperse dyes; anthraquinones, 15%; and other types, including nitrodiphenylamine and heterocyclic ring, accounting for the remainder. Dystar is the major producer of the monoazo type while Huntsman is the major producer of anthraquinones. Clariant produces both types. These three disperse dye manufacturers account for most of the total worldwide production. Other major producers include Yorkshire, BASF, Archroma, Nippon Kayaku, Akik Dye Chem, Lonsen, and Runtu.

Sublimation dye ink providers include Sawgrass, DuPont Artistri Xite, Sensient, ▸

Dye-sublimated water bottle produced by A-Tex. Courtesy of Advanced Finishing USA.

Epson SCF570. Courtesy of Condé Systems.

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InkTec, Kiian Digital, STS Inks, Nutec, Marabu, and Lyson.

Digital Printing Methods

In addition to analog methods for printing dye-sub inks with gravure, offset lithography, thermography, and screen printing, dye-sub digital printing methods include thermal transfer, electrophotography, and inkjet.

Sublimation thermal transfer (TT) dye diffusion printers were developed for photo reproduction. HiTi Digital offers a line of seven commercial thermal transfer photo printers, such as its P525L, along with its four consumer TT and two ID card devices. Other TT sublimation photo printers include the Mitsubishi CP-D70DW, Kodak Dock, Canon's Selphy line of portable devices, and Canon's IX-R7000 ID card printer.

Electrophotographic dye-sub printers include the desktop narrow-format UniNet iColor 540, 550, and 600 laser printers. For wide-format, KIP's EST 480 can print 36"-wide transfer papers.

Narrow-format desktop dye-sub inkjet printer manufacturers and suppliers include Ricoh, Canon, Sawgrass, Epson, Roland, Mutoh, and Brother. Ricoh's Aficio SG 3110DN GelJet printer prints transfer paper with a maximum size of 8.5x14", while its SG 7100DN prints transfer paper up to 11x17". Sawgrass adopted the Aficio SG 3110DS gel inkjet for its SG400 dye-sub printer and the Aficio SG 7100DN gel inkjet for its SG800 gel dye-sub printer. Both printers use Ricoh's MH5220 PIJ head and built-in heater to liquify the gel ink and enable it to jet. Sawgrass adapted the Mutoh ValueJet 628 for its Virtuoso VJ628 dye-sub inkjet printer with a maximum width of 24".

In addition to thermal transfer and laser dye-sub photo printers, desktop sublimation inkjet photo printers are producing very high-quality color prints through wireless, USB drives, and other digital means from smart phones and digital cameras. Leading inkjet sublimation photo printers include Epson Work Force WF-7110 and WF-7610, Epson Artisan 1430 and Stylus C88+, and Kodak Verité line.

Manufacturers producing wide-format (24"-plus wide) inkjet printer systems that print disperse dyes directly and dye-sub transfers include d-gen, Mimaki, HP, Konica Minolta, Roland, Mutoh, and Epson.

Inkjet printhead driver developer TTP Meteor UK indicated that as of 2016, more than 50% of digital textile ink consumption was sublimation inkjet ink, approaching $500 million in value. It projected that inkjet sublimation ink value will exceed $730 million this year.[5]

Advances and Advantages

Digital printing technologies, particularly inkjet, have improved to a point where they can compete with analog printing processes for print quality and production speed. Sublimation and disperse dyes have also advanced to jet reliably through inkjet nozzles and inkjet printheads while printers have added features such as recirculation and nozzle condition monitoring

that ensure successful printer operation.

Ink manufacturers have advanced their milling and pulverizing dye particles to diameters of 1 µm and smaller for inkjet firing. In 2018, Xu said, "A great portion of the fast-growing applications of dye-sublimation is due to the engineering advancement in pulverizing machinery, and the fact that sublimation inkjet inks are most suitable for transfer printing processes that have relative low cost of entry, are easy to operate, support very broad substrate selections, are widely adopted, and are eco-friendly."[6]

HP's recent entry into the wide-format dye-sub arena with its Stitch S300 and S500 thermal inkjet (TIJ) dye-sub 64" roll width printer line with advanced features has raised the bar for its competitors. Along with their 1,200x1,200 dpi maximum resolution, these printers come with optical drop detection and Smart Nozzle Compensation procedures to eliminate visible dropouts. The printers' Color Smart feature uses an onboard iOne spectrophotometer that automatically accounts for environmental changes in the printer area and can detect when a print color is out of gamut and visually match colors with PANTONE emulation. HP has also introduced the Stitch S1000 126" superwide dye-sub printer. To enable dye-sub printing through its TIJ heads, the company modified its heads and inks to print at lower temperatures.

Several companies have begun to offer solutions for printing dye-sub on cotton. One of these solutions is ChromaBlast-R, which, when printed to ChromaBlast Transfer Media and heat transferred to cotton and cotton-blend fabrics, results in durable, breathable soft hand, brilliant color prints.

Another area where dye-sub is growing is heat transfer decoration of powder-coated metal surfaces for architectural building skins and trim, signs, public art, awards, and promotional product installations. Italy-based Decoral Systems developed and patented its system for transferring dye-sub to powder-coated surfaces. Its Quality Decoral Gold ink and transfer system have survived three-year outdoor/sun exposure testing in south Florida, thus expanding the durability of dye-sub. One of its licensees is Archi-Texture Finishing (A-Tex) of Fairview, Pa. ALTO of the SH Group produces dye-sub transfer-printed coated aluminum panels for colorful architectural installations. Another producer of decorated powder coated architectural and décor products is ATI Decorative Laminates of Greensboro, N.C., with its Fusion dye-sublimation process. Bison Coating & Supply of Joplin, Mo., produces ceramic and tumbled stone tiles, mugs, glass, steel, and porcelain, that are coated to receive dye-sub transferred images.

In an April/May 2017 *Screen Printing* magazine article, Eileen Fritsch described developments for dye-sub on rigid substrates.[7] She mentioned Avianix AvianiTrans 3D dye-sub vacuum films, 3D vacuum heat presses, and hydro/aqua dye-sub technologies. The introduction of transfer methods that can decorate as much as 350 degrees around 3D objects increases the scope of dye-sub's application opportunities.

As online shopping and market demand for customization, personalization, and just-in-time delivery continue ▸

Collaboration among entrepreneurs, chemists, and engineers has been key in creating and improving the dye ink, substrate, transfer paper, printer, and press solutions that have enabled the dye-sub industry to prosper.

to grow and become the norm, and as knowledge of the time, cost, color vibrancy, and rapid ROI advantages of sublimation dye and direct disperse dye printing spread, print providers and product decorators will step forward to capture the opportunities. ■

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Vince Cahill began screen printing in 1969. Subsequently, he printed for a sign business in Frederick, Md. In 1979, he and Claire Hunter opened The Colorworks, a custom screen printing business. In 1995, they established VCE Solutions, a print consulting business. In 2003, they formed Industrial Printing Solutions to distribute digital printers. In 2000, Vince served as CEO of Datametrics Corp., a digital printer manufacturer.

Sawgrass Virtuoso SG500. Courtesy of Condé Systems.

Sawgrass Virtuoso SG1000. Courtesy of Condé Systems.

Mutoh RJ900X. Courtesy of Condé Systems.