

White Paper



Digital Textile Printing with Pigment Inks

SunChemical®

a member of the DIC group



Color & Comfort



1. Introduction

1.1 Background

Textile printing has evolved significantly over the years, transitioning from traditional methods to the incorporation of advanced digital techniques to produce a variety of products. Digital printing offers numerous advantages, including higher precision, reduced waste, and the ability to produce complex designs.

Among the various digital printing methods, the use of pigment inks has gained prominence due to its environmental benefits and versatility. Despite these benefits, digital pigment printing has some challenges achieving a conversion from analog techniques. While digital printing of textiles has been on an

upward trajectory and now accounts for 10-12% of printed fabrics, the share of pigment printing within the digital space is only at around 6%. Conversely, in analog printing, pigment inks represent 50% of the printed output.

1.2 Purpose of the White Paper

This white paper aims to provide an overview of digital printing with pigment inks, highlighting the benefits, challenges, and applications. It is intended for industry professionals, researchers, and businesses looking to adopt or understand this technology.



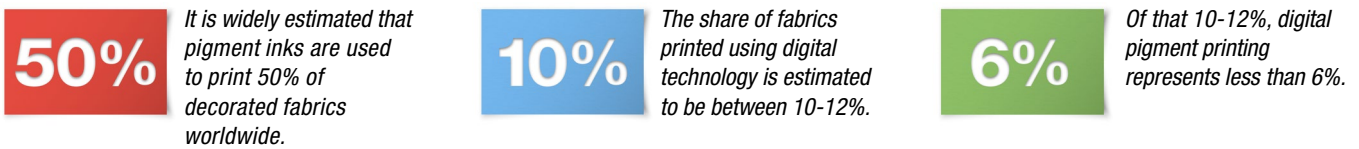
2. Digital Textile Printing Market

Digital pigment inks have the highest growth rate of all digital textile inks, however, current adoption remains low. It is generally accepted that digital printing represents around 10-12% of all textile printing. As of 2022, the World Textile Information Network reported that digital pigment printing represented around 6% having grown at a compound average growth rate of 9%.

The biggest adoption of digital pigment printing is in North America partly due to the lower investment and smaller footprint enabling more e-commerce and fulfillment businesses to thrive. In more traditional textile regions

where there is a stronger infrastructure of textile factories equipped with steaming and washing facilities for traditional printing, the adoption of pigment printing is growing but has a smaller current market share.

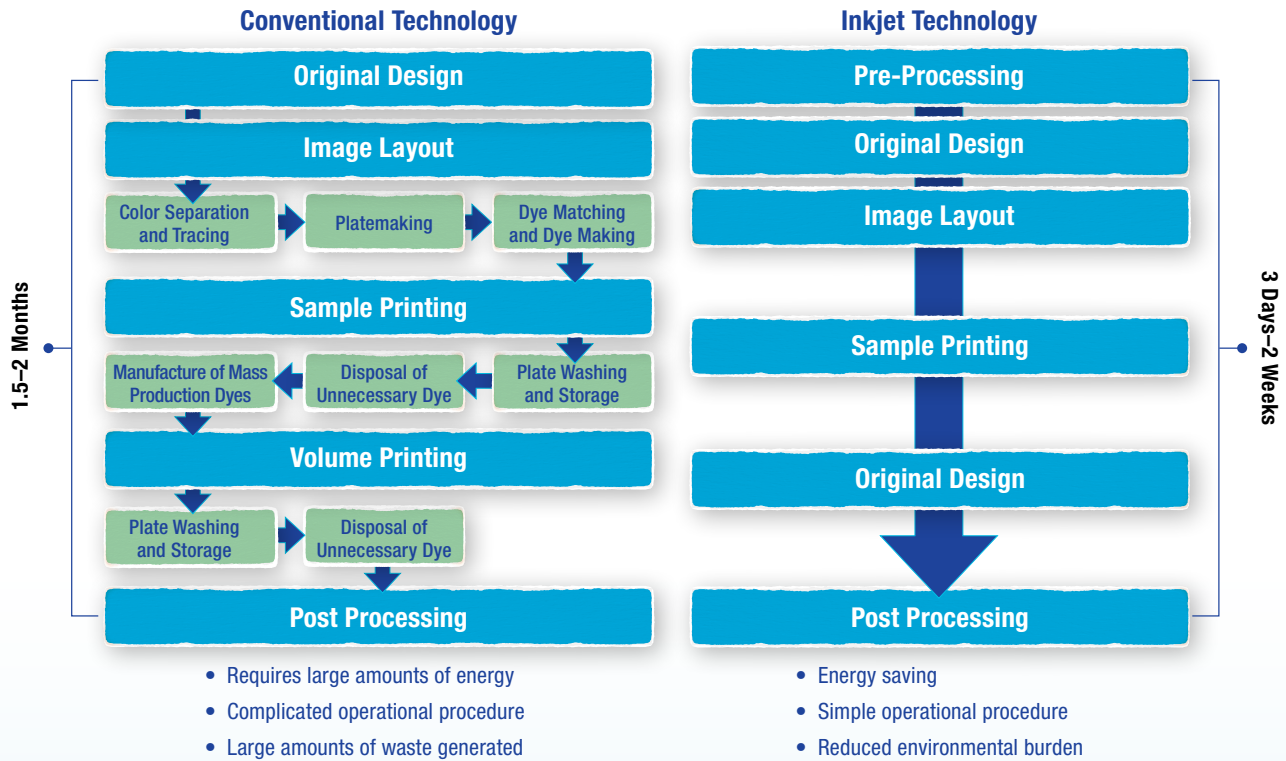
There continues to be a strong opportunity for growth in digital pigment printing as pigment inks remain the dominant technology in conventional printing, representing 50% of the printed output. The challenge for digital pigment printing to capture a significant market share lies in converting conventional users to digital users rather than in new adopters of the technology.



3. Digital Printing Technology

3.1 Overview of Digital Printing

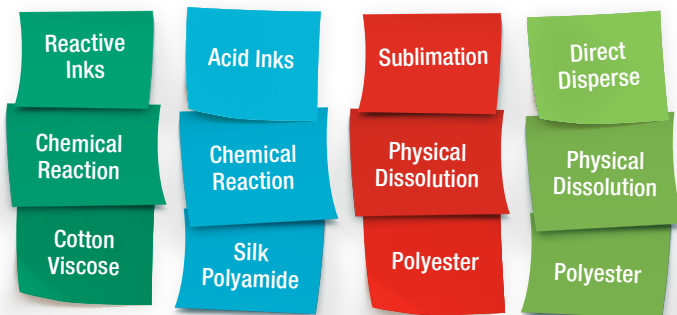
Digital printing involves the application of ink onto textiles using digital technology to print either directly to a fabric or in some cases via an intermediate substrate followed by the subsequent transfer of the printed design onto the textile. Unlike traditional methods, which require screens or cylinders, digital printing allows for on-demand production and customization by allowing you to go from a design file to the print stage without the intermediate step and without a limit on the colors or details used. This section compares digital printing with traditional methods, emphasizing the efficiency and flexibility of digital techniques.



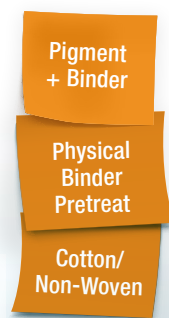
3.2 Types of Digital Printing Processes for Textile Decoration

- **Direct to fabric printing** utilizes inkjet technology to print ink directly onto the fabric. This is a commonly used technique for natural fibers such as cotton and silk as well as man-made fibers such as polyester and nylon using reactive dye, acid dye, disperse and pigment-based ink technology formulations.
- **Sublimation printing** occurs when a digital ink is printed onto a specific transfer paper and dried before being transferred onto the fabric under heat and pressure. This causes the dye molecules to sublime into a gas, penetrate the fibers and form the image on the textile. This process is only valid for printing on polyester textiles.
- **Direct-to-Garment (DTG) printing** is ideal for small batches and custom designs. As the name of this printing process implies, designs are printed directly onto pre-formed garments, predominantly t-shirts.
- **Direct to film (DTF) printing** uses a pigment ink to print a design onto a coated PET film, including a white ink backing layer before the application of a powder resin. The resin layer is set before the image is transferred to a garment or accessory under heat and pressure with the adhesive layer acting to bond the inks to the fabric.

Dye Based Inks



Pigment Based Inks

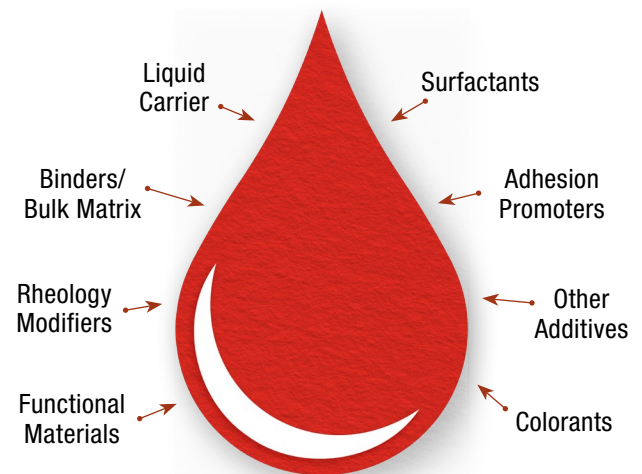


4. Pigment Inks in Textile Printing

4.1 Composition and Properties

Typical digital inks are relatively complex mixtures of components designed to produce a vibrant and durable print with the correct jetting performance, image quality, reliability and compliance to appropriate standards. The typical ingredient types for a pigmented ink for textiles include:

- **Pigment dispersions**, which provide the color. The most challenging inks to formulate are pigment-based as a lot of attention must be paid to stabilize pigment particles in a low viscosity fluid. To do this, the pigments are finely ground into small particles (typically below 0.5µm) that must remain suspended in the ink. This is usually managed by milling the pigment within a selected fluid with an optimized amount of dispersant to ensure the pigment particles cannot agglomerate, forming a larger cluster which may lead to nozzle blocking and unreliable printing.
- **Polymeric binders**, which provide adhesion. As pigments are inert substances, it is necessary to physically bind them to the fabric. Different mechanisms exist to do this and much of the intellectual property lies in a combination of resins and polymers that will give a durable print without affecting the feel of the fabric too much. Binders are either formulated into the ink or applied within a pre- or post-treatment of the fabric.
- **Co-solvents and humectants**, which help with jetting behavior. Various co-solvents may be incorporated into an ink to help drying and maintenance needs.
- **Additives**, such as surfactants and defoamers, to improve the ink's performance and stability.



4.2 Advantages of Pigment Inks

Digital pigment inks offer several benefits for textile printing and are growing in popularity and use as a result. These include:

- **Versatility:** Pigment inks can be used on a wide range of fabrics, including cotton, polyester, blends, and even silk. This flexibility allows for an increased diversity of applications in fashion, home textiles, and more.
- **Durable Prints:** Well formulated pigment inks produce sharp, vivid colors that sit on the fabric’s surface, ensuring excellent color accuracy and resistance to UV light fading, making them more suitable for outdoor use or for applications such as home furnishings.
- **Simplified Process:** Unlike other types of inks, pigment inks do not require extensive post-processing steps like steaming and washing. This simplifies the production process, saving time and reducing operational costs.
- **Environmental Sustainability:** Certain substrates such as cotton, where reactive inks are used, require fixation by steam as well as a post washing process. By contrast, digital pigment inks are typically fixed with dry heat and can save water and energy in the processing. This makes them a more sustainable option, reducing the environmental impact of printing.

4.3 Challenges and Limitations

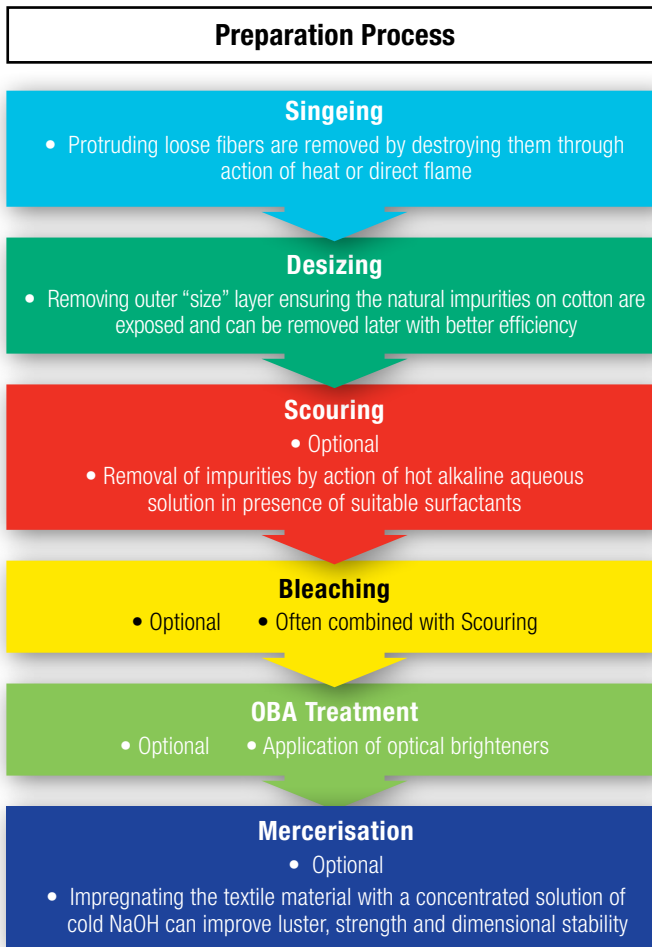
Digital pigment inks do have some market challenges to overcome, including:

- **Color Gamut:** Pigment inks generally have a smaller color gamut compared to dye-based inks due to the slightly lower chroma achievable.
- **Print Feel:** The “hand” or feel of the fabric can be altered with pigment inks. This is because the pigment particles are bound to the surface of the fabric with polymers, which can make it feel less soft.
- **Rub Fastness:** Pigment prints can have lower rub fastness, meaning the color can wear off more easily when the fabric is rubbed.
- **Perceived Cost:** Pigment inks are typically considered more expensive to produce than dye-based inks due to the requirement to disperse the pigments, however, savings in the overall process can reduce the impact.

5. Process of Digital Printing with Pigment Inks

5.1 Textile preparation

It is important that the fabric used for any digital print is prepared in the right way to ensure best results. Before a pre-treatment process is considered, a fabric has typically gone through multiple preparation processes:

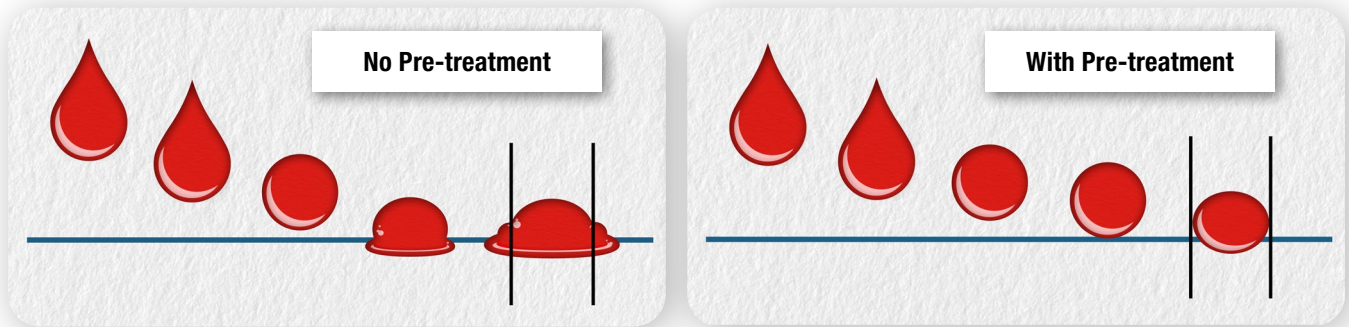


In addition whether the fabric is knitted or woven will impact ink penetration and drop spread. It is also important that, when presented for print, the fabric meets the following requirements:

- Free of any surface lint
- Free of broken fibers and filaments
- Uniform tension across the web and length
- No creases or wrinkles
- Pre-treated to specifications
- Free from variation in humidity and moisture content
- Dimensional stability (shrinking can be an issue after post processing)

5.1.1 Pre-treatment

A pre-treatment is required in most cases to get the best results from a digital pigment ink on textiles. While many inks can print directly to untreated fabrics, there is typically a compromise in performance in terms of color, image quality or fastness. The pre-treatment is designed to enhance the print by controlling drop spread and penetration, increasing the fixation potential and/or promoting color.

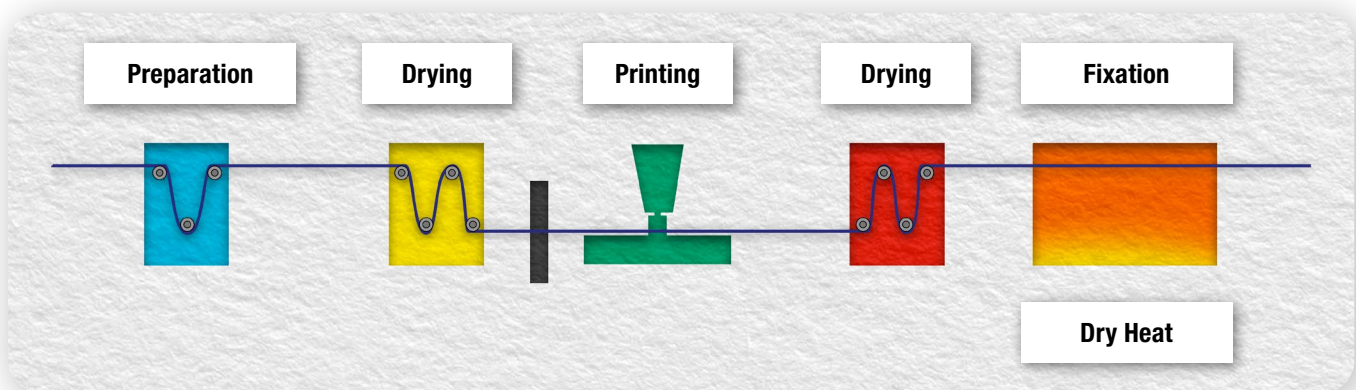


5.2 Printing Process

The printing process involves several steps:

1. **Design Preparation:** Creating digital designs using specialized software.
2. **Printing:** Using digital printers to apply pigment inks onto the fabric.
3. **Drying:** Ensuring the ink is properly dried to prevent smudging and the offsetting of ink onto the back side of the wound up roll.
4. **Fixation:** Part of the post-process.

The typical digital printing workflow for pigment inks is:



5.3 Post-Treatment

Post-treatment processes in textiles often refer to fixation and washing which is required for some dye-based solutions. For digital pigment inks, heat fixation is used to “set” the ink by activating the binder cross-linking mechanism to assure the pigment is adhered to the fabric in order to achieve the required fastness.

There are solutions on the market that may add a fixator or softener in line after printing to achieve binding and improve the hand feel. Usually there is no need for a post fixation washing process with pigment inks. Other additional processes may also be applied to the fabric after print to enhance the application performance such as flame retardants, waterproofing, etc.

6. Applications and Market Trends

6.1 Main Applications

- **Fashion and Apparel:** Custom clothing and fashion accessories
- **Home Textiles:** Bedding, curtains, and upholstery
- **Technical Textiles:** Functional fabrics for industrial use

6.2 Emerging Trends

There are a number of trends emerging in the area of digital textile printing with pigment inks as the technology evolves to meet the market challenges:

- **In-line pretreatment:** A number of printer manufacturers are offering solutions that include an in-line application of pre-treatment, either by spray or digitally applied in specific areas where there will be print. This can avoid waste but requires a specific system and process software to manage the screening and will typically increase the cost of the pre-treatment phase.
- **No pre-treatment solutions:** Some emerging technologies are promoting direct fabric printing without the need for a pre-treatment.
- **White inks:** While white inks for direct to garment (DTG) printing have existed for a long time, their application in a roll-to-roll printing process is an emerging trend, enabling decoration of colored fabric. White inks can create a more obvious change in the hand feel and as such tend to be used for t-shirt fabrics.
- **3D Printing:** There are emerging platforms for printing structures onto textiles by building up layers of print to simulate embroidery, for example.

7. Environmental and Economic Impact

7.1 Environmental Considerations

As discussed in previous sections, pigment inks are typically more sustainable than other inks and adopting the technology can contribute to reduced water and energy consumption and lowering CO2 emissions. Here are some environmental advantages of digital pigmented inks:

- **Reduced Water and Energy Usage:** Unlike dye-based printing, digital pigment printing requires significantly less water and energy in the fixation and washing processes.
- **Lower Carbon Footprint:** The process emits fewer greenhouse gases due to lower energy consumption, contributing to a decrease in the carbon footprint of textile production.
- **Minimal Waste:** Digital pigment printing generates less waste compared to analog methods. This is due to the precise application of inks, which minimizes excess and reduces the need for post-processing.
- **Fewer Harmful Chemicals:** Pigment inks often contain fewer harmful chemicals either in the ink or the pre-treatment.
- **Versatility and Efficiency:** The method is compatible with a variety of fabrics and eliminates the need for cumbersome post-processing steps such as steaming and washing. This leads to time savings and offers environmental benefits by reducing the use of materials and energy, and eliminating the need to treat effluents from washing processes.

7.2 Economic Analysis

While the initial investment in digital printing technology can be high, the long-term benefits include lower production costs and higher returns on investment

- **Cost Savings on Water and Energy:** Digital pigment printing uses significantly less water and energy compared to traditional methods, leading to lower utility bills and operational costs over time.
- **Reduced Waste and Material Costs:** The precision of digital printing minimizes waste, which means less money spent on excess materials and disposal. This efficiency can translate into substantial savings.
- **Lower Inventory Costs:** Digital printing allows for on-demand production, reducing the need to hold large inventories. This flexibility helps in managing cash flow better and reduces storage costs.
- **Shorter Production Times:** The streamlined process of digital pigment printing eliminates several post-processing steps, speeding up production times. Faster turnaround can lead to increased productivity and the ability to take on more orders.
- **Customization and Market Responsiveness:** The ability to easily customize and produce small batches allows businesses to respond quickly to market trends and customer demands, potentially increasing sales and customer satisfaction.

7.3 Certifications

To ensure visibility and clarity in terms of compliance to specific brand requirements and chemicals management requirements, many brands and suppliers require the inks used to conform to certain standards. While there are many regulatory bodies and brand specific requirements, three key requirements are outlined:

1. Global Organic Textile Standard (GOTS) v7.0 (March 2023)



GOTS Approved Additive
Approved by: Ecocert Greenlife
GOTS-Ecocert- 08-01479

GOTS is concerned with the testing and certification of textiles made from organic fibers and applies worldwide. During processing of GOTS-compliant products, all chemical inputs, including printing inks, have to be tested and approved by a GOTS certification body. GOTS certification of an ink essentially means it has been tested to ensure it does not contain any impurities listed in the GOTS standard v7.0 (March 2023) and are therefore suitable for use in organic textiles production.

Most of the fabrics used contain at least 70% of natural (organic) fibers and therefore mainly focus on cotton and polyester/cotton blends

containing lower amounts of polyester. Several of Sun Chemical's ink series are compliant with all aspects of GOTS v7.0 (2023) and thus can be used as inputs for textile processing.

GOTS approved inputs are listed on the GOTS Letter of Approval. A copy of this is available on request. This document is updated frequently with new products from Sun Chemical's product ranges. It covers mainly the company's reactive and acid dye inks, but also includes pigment inks. It is unusual to add sublimation inks or direct disperse inks to the GOTS certificate as they are predominantly for use on synthetic.

2. OEKO-TEX® ECO PASSPORT 01.2025

OEKO-TEX® is recognized as a very stringent set of textile standards which enable consumers and companies to make responsible decisions which protect the planet for future generations. There are seven different standards within the OEKO-TEX framework – OEKO-TEX Made in Green, OEKO-TEX STANDARD 100, OEKO-TEX ORGANIC COTTON and OEKO-TEX ECO PASSPORT.



The most relevant to Sun Chemical's inks is ECO PASSPORT. The ECO PASSPORT identifies chemicals, colorants and auxiliaries used in the textile and leather industries which are not harmful to health and which are environmentally friendly. This certification mainly covers Sun Chemical's sublimation inks and direct disperse inks but now also covers a newly launched series of reactive dye inks.

3. Zero Discharge of Hazardous Chemicals (ZDHC) MRSL v3.1



The ZDHC Roadmap to Zero program leads the fashion industry to eliminate harmful chemicals from its global supply chain by building the foundation

for more sustainable manufacturing to protect workers, consumers and the planet's ecosystems. Most Sun Chemical inks are listed on the ZDHC portal as Level 3 classified inputs for textile processing. This is the highest rating, meaning that the inks are compliant with the Manufacturing Restricted Substances List (MRSL). Sun Chemical's manufacturing facilities and quality systems have also recently been approved by full audit.

4. Chemicals to Zero (CtZ)

Chemicals to Zero is a ZDHC program designed to drive better chemistry in chemical formulations used in the textile, apparel, leather and footwear industries. It is a journey of chemical formulation through three levels: Foundational, Progressive and Aspirational.

8. Conclusion

8.1 Summary of Key Points

Digital printing with pigment inks offers numerous advantages, including environmental benefits, versatility, and high-quality output. The adoption of digital pigment printing is growing significantly and as the technology emerges, it has the potential to capture a significant market share of the printed textile market.

8.2 Future Outlook

The future of textile printing lies in continued innovation and adoption of sustainable practices of brands and converters. There is a huge investment into increasing the performance and sustainability credentials of digital pigment printing further with a view to enabling high quality, vibrant and durable prints for long lasting and sustainable manufacture of garments and home textiles.

Sun Chemical Solutions

Sun Chemical has been developing digital inks for a range of markets for more than 30 years, including a variety of pigment inks to offer peak performance in digital textile printing. Our knowledge of ink development alongside a deep understanding of the textile printing market has enabled our skilled team of chemists to develop a series of high-quality pigment dispersions that are used exclusively within our inks to ensure users get the maximum benefit from their print process and finished fabrics.

Key available products include:

- **Xennia Sapphire:** An innovative range of digital pigment inks for direct to fabric printing for low, medium and high viscosity printheads, enabling production on any digital textile printer. Using patent pending technology, Xennia Sapphire inks have been developed to have maximum durability with outstanding color performance and comply with the key textile standards.
- **Xennia Jade:** Xennia Jade is a series of pigment inks for direct to film (DTF) printing, including a high opacity white and vibrant color set enabling stand-out designs on any garment fabric. Optimized for stability, Xennia Jade ensures the best on-printer behavior and reliability, reducing waste and ensuring maximum printer up time for high output fulfilment businesses.

Learn more about our digital textile ink solutions by visiting www.sunchemical.com/digital_textiles

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