



Various Printing Techniques of Silk Fabric to Enhancing its Performance Properties

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Abstract

The environmental effects of the textile industry, as well as the use of raw materials and natural resources, are quickly becoming top priorities. It is no longer sufficient to have a completed product that is simply safe for humans; the product must also be ecologically safe throughout its full life cycle. The study aims to get environment-friendly printing on silk fabrics by a new thickener based on s-triazine di-sulfanilic xanthan for reactive printing of double-sided designs on silk fabric and Printing properties of a novel nitrogen-free urea replacement in reactive dye silk printing

Keywords: silk fabric, printing technology, printing techniques.

Introduction

Silk is regarded as the queen of fabrics. Because of its durability, premium appeal, grace, and comfort are all present [1]. It is a natural polymer consisting of repeated hydrophilic and hydrophobic chains that are used as a filament fiber by the silkworm [2]. Determining wettability is critical for characterizing liquid transport, fiber surfaces, and polymer adhesion [3, 4]. Unfortunately, silk has weak wetting characteristics [5]. The many techniques used in the textile production business contribute significantly to pollution. Businesses contribute significantly to pollution. Fluctuate in both amount and feature regularly arise in the textile wet processing sector. In silk printing with reactive dyes, GBPA, [58] a novel printing additive made of glycerol and 1,4-butanediol, was employed.[59,60] The printing performance of GBPA in reactive silk fabric printing was investigated and compared to that of urea[61,62,63]. The results revealed that in deep printing of Reactive Turquoise K-GL on silk satin, GBPA achieved the same color stability as urea at printing

To obtain effective double-sided printing patterns on silk fabric, a novel thickening s-triazine di-sulfanilic xanthan (TDG) was created by

chemically modifying xanthan gum (XG) with alkali and monochlorotriazine di-sulfanilic acid (TS)[21,22]

Textile printing

Textile printing is almost definitely as ancient as civilization the textile industry has a substantial influence on national economies. [23] The use of color in dyeing and printing methods has also played an important role in all civilizations. [24] The coloration of fabric has become an important procedure in the creation of textile material. [25, 26]

Classification of printing techniques

Direct printing and indirect printing are the two types of textile printing methods. [23]

Direct printing

The most common way of adding a color pattern is direct printing. It may be done on white fabric or over already colored fabric. [27]

Block printing

In India, one such old art form is block printing. This technology is used to create a wide range of items, notably in the clothing industry. The procedure is continued with different colors and designs until the pattern is complete. [23, 28]

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Screen printing

Screen printing is an evolution of the stenciling method in which a colorful image is generated by transferring color (printing paste) via open areas in the silk screen placed on the fabric surface. [29, 30]

Flat-screen printing

A flat printing process in which the screen printing mesh is attached to a rectangular frame made of wood or metal, and the printing substrate is also flat. The printing material is spread across the screen with a squeegee. The screen is cleaned to bring the paste into contact with the cloth. [31]

Rotary screen printing

One of the most common types of fabric printing equipment is the rotary cylinder printing machine. Rotary screen printing machines operate on the same principles as flat-screen printing machines, except that instead of flat screens, the color is communicated to the fabric via lightweight metal foil screens in the shape of cylinder rollers made of stainless steel or nickel. [31, 32]

Burn-out printing

Burnout printing is a method of creating elevated graphics on a sheer backdrop. Burnout printing uses a paste comprising chemicals, mainly acids, capable of dissolving or destroying one of the fiber components of a blended material. [31,33]

Digital printing

It is one of the most intriguing developments Digital textile printing can reproduce an endless number of colors and tints while also providing exceptional print fastness. [31,34]

Inkjet printing

It is a digital printing technology that enables printing on a range of textile substrates without touching the substrate or the ink. [34]

Transfer printing

Is a technique that involves printing a design on a flexible, non-textile substrate and then transferring it to a textile material using a different procedure [35]

Indirect printing techniques

It includes resist and discharge printing. [31]

Resist printing

Separating pattern to fabric. The resist printing method is still as popular now as it was in the past. Separating pattern to fabric. The resist printing method is still as popular now as it was in the past. [36]

Discharge printing

also known as "extract printing" is a method of printing that involves bleaching or removing particular colors in a pattern after it has been printed. [27]

Silk

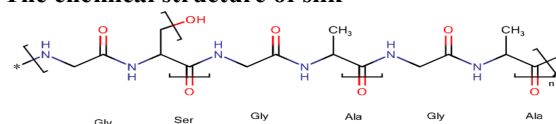
Silks are protein polymers found in the glands of arthropods such as silkworms, spiders, scorpions, mites, and bees and spun into fibers during their metamorphosis. The content, structure, and characteristics of silks gathered from various sources varied [38, 39]. Silk from *Bombyx mori* (silkworm) has received a lot of attention in recent years because of its biocompatibility, robust mechanical performance, tunable degradation, ease of processing, ample supply, and ease of acquisition from the established sericulture sector[38,39,40,41]. Silkworm silk has been used in traditional textiles for over 4000 years and is prized for its smooth, pearly luster and strong mechanical characteristics [38, 42]. Silk fibroin (SF) and sericin are the two main proteins found in silk. The glue-like protein sericin

How Is Silk Fabric Used?

Silk may be utilized in a plethora of ways. Silk is most commonly used in the creation of clothing. Silk has been revered for thousands of years for its amazing softness and durability, and customers still prefer real silk over synthetic versions. [40, 41]

Scarves, shirts, blouses, and eveningwear are examples of silk consumer clothing items. Silk is also a popular material for men's undergarments and pants due to its lightweight and silky qualities. Silk may be used to construct ornamental cushions, drapes, or wall hangings in the house. [42]

The chemical structure of silk



New thickener based on s-triazine di-sulfanilic xanthan for reactive printing of double-sided designs on silk fabric.

A novel thickener, s-triazine di-sulfanilic xanthan, was developed to create good double-sided printing patterns on silk fabric.

(TDG) was created by modifying xanthan gum (XG) chemically using alkali and monochlorotriazine di-sulfanilic acid. [43]

Xanthan gum

Xanthan gum is an extracellular polysaccharide. Gum is formed during the fermentation of *Xanthomonas* sp. bacteria. It is a biopolymer composed of D-glucose, D-mannose, and D-glucuronic acid in the ratio 3:3:2. The acetyl and pyruvic acid groups there are also present. Xanthan gum may be used in either cold or hot water. Gum

dissolves fast, resulting in an incredibly If the concentration is low, the solution becomes viscous. PH and Temperature have very no effect on the viscosity of a solution. Because of these characteristics, xanthan gum is an excellent choice. Thickening agent for use in foods, textiles, and other products as well as pharmaceuticals. It is used as an example. Emulsifiers are used in a variety of industrial processes, and secondary oil recovery methods are advantageous, especially in terms of efficiency. Xanthomonas The plant campestris PV manihots was used to create the xanthan gum, which was used to make high-quality gums in viscosity, pH, and temperature stability. Fermentation occurred in a medium. Made up of sugar, dipotassium phosphate, and and96 hours of 250 rpm magnesium sulfate. The temperature was set at 30°C, and the pH was set to 7. [65]

By, two main groupings were formed.

Gums with distinct subunits; one set includes subunits with different side chain acetylation and pyruvate levels residues. These are referred to as acetylated and are no acetylated tetrameric repeat forms utet and natet are abbreviations. [66]

The most significant properties of XG include

- It has a high viscosity in small concentrations.
- Compatibility with the vast majority of metallic salts.
- The organized structure provides exceptional elasticity.
- Resistance to a broad variety of temperatures, acids, alkalis, and pH levels.
- It is resistant to sunlight, washing, light, and abrasion.

Chemical structure of xanthan:

The repeating pent saccharide units made up of two glucose units, two mannose units, and one Dglucuronic acid unit are the major structural component of XG, which is generated by the bacterium Xanthomonas campestris [67]. Every other unit in the main chain, which is composed of (1-4)-b-Dglucan cellulose, has a charged trisaccharide side chain replaced at C-3. The trisaccharide side chain has a b-D-glucuronic acid residue between two D-mannose units. An acetyl group connects the inner a-D-mannopyranoside to the main chain at position C-6. A pyruvic acid residue linked by a keto group to the 4 and 6 positions of one-half of the terminal b-D-mannopyranoside [68].

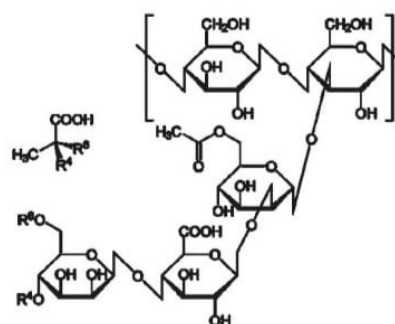


Figure1. Chemical structure of xanthan

Applications of xanthan gum

- 1) Xanthan gum, combined with fungicides, has been studied as an elicitor in agriculture to prevent *Bipolaris sorokiniana*, which affects barley cultivars. [69]
- 2) Xanthan gum is used as an emulsifier and thickening ingredient in a variety of foods, including juice, fruit pulp and powder drinks, chocolates, candies, jellies, dairy products, margarine, yogurt, bread goods, frozen dinners, sauces, and gravies.
- 3) Guar gum and locust bean gum are mixed with xanthan gum to reduce manufacturing costs. [70]
- 4) Xanthan gum provides texture, viscosity, flavor release, appearance, and water management attributes that are required by modern food products.
- 5) Xanthan gum improves the rheology of final goods due to its increased Newtonian characteristics and pseudoplastic activity in solutions. [71]
- 6) When drilling in the oil industry, a 0.5% xanthan glue solution can maintain the viscosity and control the rheological properties of the water-based drilling fluid, allowing tiny bit parts to rotate at high speeds while maintaining high viscosity, significantly reducing power consumption, preventing borehole wall collapse, and making cutting debris discharge effects easier.
- 7) It outperforms gelatin, CMC, seaweed gum, pectin, and other common food additives in the food industry, adding 0.2% to 1% to juice to improve adhesion, flavor, control penetration, and flow; When used as a bread additive, it can provide bread with a stable, smooth texture while saving time and money. Using 0.25% in bread filling, food filling, and frosting can improve taste and flavor, make product organization easier, and lengthen shelf life. shelf life and improve product stability when heated and frozen; ice cream with 0.1% to 0.225% added can have a good stabilizing influence in

dairy products; provides good viscosity control in canned goods.

- 8) It can substitute for some starch; 3 to 5 parts starch can be substituted with 1 part xanthan gum. Xanthan gum is also commonly used. utilized in the fields of liquid food, frozen food, sweets, and flavorings.
- 9) Biochemical research. Emulsifiers and stabilizers for cosmetics, non-food goods, and food applications.

Preparation of TDG

In a three-necked flask (1000 mL), a 0.01 mol/L XG solution was produced and incubated in an orbital shaker at 600 rpm at 90°C. The NaOH to molar ratio The number of repeating pent saccharide units was kept under control at 0.917:1, followed by the normal NaOH solution Drop by drop, they were introduced to the XG solution. 4 hours later, The TS solution was applied quantitatively to the flask at 90°C. The TS modifier was created by the Cyanuric chloride and sulfanilic acid reaction According to the literature [44]. The TS molecular ratio the ratio of the modifier to the repeating galactomannan unit was set at 1:1. Then 1.2 g/L sodium carbonate solution was added. Was dropped into the flask one at a time. After 75 minutes Three times, the modified sample was precipitated using alcohol, dried, and crushed into powder. The uncooked Dimethylformamide alcohol was used to purify the finished product. To obtain TDG powder. [44]

Preparation of printing pastes and screen printing techniques

The thickening solution was made by combining the thickener mixed into deionized water using a mixer and then refrigerated overnight to achieve complete swelling. To make the printing paste, combine 20 g/kg dyestuff, 50 g/kg urea, 10 g/kg reserve has S, and 10 g/kg sodium hydroxide.

The thickening solution was enriched with bicarbonate. For around 10-15 minutes [44]. A beautiful design and a 10 10 cm² square pattern were used. A beautiful design and a 10 10 cm² square pattern were used. , which was carried out employing a flat screen with a mesh of 150 and a 10-mm diameter magnetic rod printing speed of 6 m/min force grade 3. All printed samples were dried at 80 degrees Celsius for 2 min. The following were the after-treatments: the squared samples were collected and steamed in a high-heat steam oven, for 10 minutes at 102°C, then Soaped in hot water with a bath ratio of 1:50 at 95 degrees Celsius for 10 minutes for the thickener and unfixed dyes to be removed. [45]

TDG Rheological Characteristics

After chemical treatment, the rheological properties of XG unavoidably changed. The thickener's rheology influences printing properties such as screen ability, color yield, penetration, levelness, and outline sharpness. As a consequence, the double-sided printing effects of thickening on silk fabric were closely related to the rheological properties.

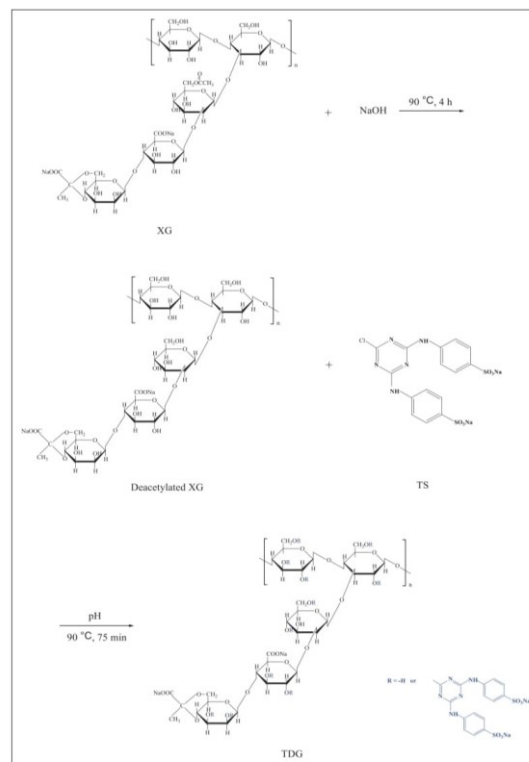


Figure 2. Chemical modification of XG by deacetylation and TS modifier. TDG: s-triazine di-sulfanilic xanthan; TS: monochlorotriazine di-sulfanilic acid; XG: xanthan gum.

Large pattern quality of printed silk satin thickened with TDG and XG at various concentrations

CVC: color variation coefficient; **K/S:** color yield; **PR:** penetration rate; **TDG:** s-triazine di-sulfanilic xanthan; **XG:** xanthan gum

TDG printing capabilities for double-sided patterns this thickening is great for double-sided printing. Must have high screen ability and be bright color and level, as well as great penetrability into the fabric, as well as achieving the best outline sharpness. TDG and XG double-sided printing characteristics at various speeds and concentrations. The rheological properties of the thickening solution varied depending on its concentration. This resulted in the various effects of double-sided printing on silk fabric. Table 1 shows the double-sided printing options. TDG and XG characteristics at various concentrations on Satin silk. Distinct amounts of thickening solutions have distinct rheological qualities, resulting in diverse printing results.

Because the concentrations of the number of thickening solutions rose, so did the screen ability. Worse, the PR gradually declined. It's possible.

This is due to the emergence of more elastic properties as the concentration of thickening increases.

Table 1 shows that the paste add-on and color yield (K/S) of TDG substantially improved in comparison to XG, with 3 wt.% TDG offering the highest result; those of 3 wt.% TDG rose by 90% and 93%, respectively. TDG PR values reached more than 90%, suggesting the strong penetrability of TDG. Furthermore, the CVC values of TDG were within 10%, showing a good color level. However, XG showed significantly worse screen ability and levelness, particularly as concentrations rose. It might be linked to XG's high elastic properties, which hampered the successful flow through the screening aperture onto the cloth.

As a result, TDG at various doses had very diverse effects. Silk satin has better big pattern printing characteristics than XG at various concentrations.

Furthermore, indicates that TDG at various concentrations produced distinct drawing patterns. The bleeding phenomena were observed at low doses of XG. The results from XG's VRR revealed that XG has a lower viscosity recoverability. The viscosity of XG at low concentrations did not return to a high level after shearing, resulting in bleeding of the printing paste at the patterns. Mesh blockage and breakpoints occurred at high concentrations, which might be attributed to XG's poor gel structure.

Table 1. Large pattern qualities of the printed silk satin using TDG and XG as thickeners at different concentrations

Paste	Concentration (wt %)	Paste add-on (g/m ²)	K/S	PR (%)	CVC (%)
TDG	2.5	80.41	13.33	92.34	4.51
	3	82.02	13.61	91.27	4.02
	3.5	80.65	12.36	92.13	5.62
	4	80.72	12.65	89.84	6.67
	4.5	74.53	12.01	88.65	6.85
XG	1	50.25	7.42	83.68	9.98
	1.5	48.32	7.34	83.02	9.37
	2	48.68	7.64	77.52	9.18
	2.5	46.41	7.87	79.89	11.21
	3	43.21	7.05	71.23	14.89

CVC: color variation coefficient; K/S: color yield; PR: penetration rate; TDG: s-triazine di-sulfanilic xanthan; XG: xanthan gum.

TDG's double-sided printing capabilities with various reactive dyes. Table 2 shows the big pattern quality of TDG, XG, and SA with various reactive dyes. The paste add-on, color yield, and PR values of XG were much lower than those of SA, which might be attributed to XG's high elasticity. However, after chemically modifying XG, the double-sided printing capabilities of TDG for big designs were significantly superior to XG and even exceeded

those of SA. TDG's color yield on silk satin with red, yellow, blue, and black reactive dyes improved by 29%, 38%, 28%, and 11%, respectively, when compared to SA. TDG PR levels (more than 90%) were somewhat higher than SA PR values.

Moreover, how the pattern edges were obscured when XG was used as a thickening. TDG, on the other hand, got crisp outlines comparable to SA. TDG's desired double-sided printing capabilities were linked with appropriate rheological properties, giving it considerable promise as a thickening on silk fabric with attractive double-sided designs.

Table 2. Large pattern qualities of the printed silk satin using TDG, XG and SA as thickeners at the same concentration 3 wt % with different reactive dyes

Reactive dyes	Thickeners	Paste add-on (g/m ²)	K/S	PR (%)	CVC (%)
C.I. Reactive Red 245	TDG	82.02	13.61	91.27	4.02
	XG	43.21	7.05	71.23	14.89
	SA	78.65	10.54	90.86	4.35
C.I. Reactive Orange 13	TDG	78.68	7.23	93.32	5.32
	XG	40.41	2.18	81.74	12.31
	SA	68.34	5.53	91.36	3.29
C.I. Reactive Blue 49	TDG	80.32	6.42	92.73	6.58
	XG	46.19	3.47	83.04	11.19
	SA	67.92	5.01	91.19	4.82
C.I. Reactive Black 39 and Brown 11	TDG	84.63	16.63	95.13	6.26
	XG	45.37	9.66	84.17	12.86
	SA	80.07	15.04	90.80	4.69

CVC: color variation coefficient; K/S: color yield; PR: penetration rate; SA: sodium alginate; TDG: s-triazine di-sulfanilic xanthan; XG: xanthan gum.

Printing properties of a novel nitrogen-free urea replacement in reactive dye silk printing

Because of the rich colors, perfect chromatography, and color fastness that can be obtained, reactive printing is the dominating process in silk printing [46]. The dye concentration in the printing paste is high. As a result of the hydrogen bonds between the dye molecules, the dye molecules are prone to forming dimers, trimers, and even multimers. [50, 51]

Because urea aids in the breakdown of dyes into a monomolecular form, significant volumes of it must be added to the printing paste. During steaming, the urea absorbs moisture and promotes color redissolution and fiber swelling.

The reactive dyes in the color film will redissolve in water before adsorbing, diffusing, and dyeing the fibers. However, the usage of urea results in ammonia nitrogen emissions in the environment. [52, 53]

A new nitrogen-free additive (GBPA) was developed in the laboratory, instead of urea to evaluate its application potential, the color performance concerning the dosage, structure, and hue of the reactive dyes was compared, as were different types of fabrics. The nitrogen content of printing wastewater when using GBPA as the

additive was tested to assess its potential impact on the environment. [54.55]

Reactive printing

Printing paste preparation. To achieve complete swelling, the distilled water and thickener were combined. The reactive dye, sodium met nitrobenzene sulfonate, and printing additive was first dissolved in distilled water before being added to the thickening solution. The paste was well blended. Finally, sodium bicarbonate was added to the aforementioned paste. Table 1 contains the formula for reactive printing paste. Using a rotating viscometer with rotor No. 4 at 30 r/min at room temperature, the viscosity of the printing pastes ranged from 12,000 mPa s to 15,000 mPa s.

Screen printing is a printing process. A laboratory printing machine (MINIMD/767, Zimmer, Austria) was used to print a fine pattern and a 15 15 cm² square design on silk materials. The printing procedure was completed.

Color performances of different dosages of GBPA in reactive printing of silk fabric

GBPA and urea's influence on color performance in the Reactive Turquoise K-GL deep printing on silk satin. As the GBPA dose or urea grew to nearly 10% by weight, K/S values of the printed satin remained at 78, and the surface color of GBPA reached the level of urea. However, when the GBPA dose was within the 28 wt. % range, the color performance of GBPA was unsteady. When the GBPA dosage topped 10% by weight, K/S values began to fall. This might be attributed to the interaction of high levels of GBPA with Reactive Turquoise K-GL. As a result, the optimal GBPA dose for deep printing Reactive Turquoise K-GL on silk satin was determined to be within 8_10 wt.%.

Color performances of GBPA using different thickeners in reactive printing of silk fabric

Color performances of GBPA in reactive deep printing on silk satin. When SA, the most often used thickener in reactive printing [63], was utilized, the K/S value of GBPA reached the level of urea. The K/S values of GBPA were somewhat lower than those of urea when CSA, CMS, and CGG were used as thickeners. GBPA, on the other hand, has substantially greater penetration levels than urea. Higher penetration, as is well known, indicates that more dye, along with the flow of printing pastes, will color the back of the cloth, correspondingly. To a greater (K/S) b value and a lower (K/S) f value. The results showed that regardless of the thickener utilized, GBPA generated an acceptable surface color in reactive deep printing on silk fabric.

Color performances of GBPA in silk printing using different reactive dyes

The effects of Reactive Turquoise K-GL dose on color performance utilizing GBPA and urea as printing additives on silk satin [64]. At all doses of Reactive Turquoise K-GL, GBPA generated almost the same color yield and penetration as urea. This proved that GBPA achieved color performance comparable to urea for various color shades in reactive deep printing on silk fabric.

Color properties of reactive blue dyes with various structures. Color performance on printed cloth is also affected by the structure of reactive dyes. Reactive Blue P-3R from the mono triazine group, Reactive Blue KN-R from the vinyl sulfone group, and Reactive Blue BF-RS with double reactive groups were used. Demonstrates that the GBPA K/S values outperformed urea utilizing Reactive Blue P-3R and Reactive Blue BF-RS, and were comparable to urea. GBPA was appropriate for use as a printing additive instead of urea for reactive printing with dyes of various structures.

Printing performances of reactive dyes with different colors

Table 2 shows the color properties of GBPA and urea when deep printing on silk satin with reactive red, orange, blue, and black dyes. The findings for K/S and color brilliance (C) demonstrate that GBPA had higher K/S and C values than urea with different colored reactive dyes. According to the results for color unevenness, the printed silk satin using GBPA and urea as printing additives had acceptable levelness and outline sharpness.

The color performance of GBPA was found to be close to or superior to that of urea in the deep printing of silk fabric with various reactive dyes.

Printing performance of GBPA in deep reactive printing on different silk fabrics

To further evaluate the potential of GBPA in instead of urea, reactive printing on silk fabric GBPA's overall printing performance on different various silk materials was researched and compared with Urea. The color performances of GBPA and urea on various silk materials in Reactive Deep Printing. The K/S GBPA values on silk habutae and satin (thick) were somewhat smaller than those of urea because of the increased penetration. Nonetheless, the K/S values of GBPA on silk satin (thin) and twill exceeded those of urea. Based on the facts on color asymmetry. the printed silk textiles made with GBPA. As the printing additive was discovered to obtain good Levelness. Furthermore, the delicate patterns on the GBPA and urea-printed silk materials passed visual scrutiny.

Conclusions

The rheology and printability of XG changed dramatically after chemical treatment. TDG's flow properties improved as compared to XG, and its structural viscosity recoverability increased

significantly. TDG always developed more viscous features as stresses increased, but XG underwent a shift from elasticity to viscosity. TDG's screen ability, color yield, and levelness increased significantly when used as a thickening on silk printing with reactive dyes. TDG's PR was greater than 90%. TDG achieved satisfactory double-sided printability on silk fabric for big and fine designs, even outperforming SA, and has considerable application potential as a suitable thickener in double-sided printing.

In the deep printing of Reactive Turquoise K-GL on silk satin, GBPA achieved color stability comparable to urea at doses of 810 wt. % in the printing paste. Using SA as a thickener, GBPA achieved the same color performance as urea. In the deep printing of silk satin with several reactive dyes, the color performance of GBPA was comparable to or better than that of urea. Furthermore, GBPA produced extensive printing results on several silk materials. When GBPA was used as a printing additive, the ammonia nitrogen and total nitrogen content in the printing effluent were significantly lower than with urea. GBPA has a lot of potential as a urea alternative in silk printing with reactive colors. GBPA research rather than urea research reactive printing of different fabrics and dyes should be further implemented.

Conflicts of interest

There are no conflicts to declare

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There is no fund to declare

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تقنيات الطباعة المختلفة للنسيج الحريري لتعزيز خصائص أدائه

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الملخص

سرعان ما أصبح التأثير البيئي لصناعة النسيج ، وكذلك استخدام المواد الخام والموارد الطبيعية من الأولويات القصوى. لم يعد كافيا أن يكون لديك منتج مكتمل آمن ببساطة للبشر. يجب أن يكون المنتج أيضا آمنا بيئيا طوال دورة حياته الكاملة. تهدف الدراسة إلى الحصول على طباعة صديقة للبيئة على الأقمشة الحريرية بواسطة مثن جديد يعتمد على الزائنان s-triazine di-sulfanilic للطباعة التفاعلية للتصميمات على الوجهين على القماش الحريري وخصائص الطباعة لبدل جديد خال من النيتروجين في الطباعة الحريرية ذات الصبغة التفاعلية

الكلمات الدالة: نسيج الحرير ، تكنولوجيا الطباعة ، تقنيات الطباعة