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A novel reactive printing paste urea-free for various cellulosic fabrics

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Abstract

A novel printing paste for linen and viscose fabrics with reactive dyes was applied attempting to tackle the issue of water contamination caused by using urea excessively in cellulosic fabric reactive dye printing. This novel paste eliminated urea entirely and allowed for the maximum fixation of reactive dyes on the fabrics. In place of 150g/kg urea, an amalgamation of nonionic and anionic wetting agents was used to print reactive dye on linen and viscose textiles. Comparing the samples printed with the novel printing paste to the ones that were printed using the conventional paste which contained urea, the color strength of the printings printed using the novel paste rose by about 189.78% and 168.95% for linen and viscose textiles, respectively. The wetting agent concentration, steaming temperature, and steaming duration were all determined via variable appraisals. examined the effects of these factors on the fabric's fastness, color strength, elongation, and tensile strength. Investigated how these factors impacted the fabric's color strength, fastness, elongation, and tensile strength.

Keywords: Linen fabric; Viscose; Textile printing; Reactive dye; Wetting agent; Urea elimination**.**

Introduction

One of the most popular cellulosic printing techniques is reactive printing, which yields vibrant colors, a range of hues, excellent color fastness, and a soft handling. [1] Reactive printing accounts for around a quarter of global print production. Ten to twenty weight percent urea is added to traditional reactive printing paste to provide the optimum color and fixing for printed materials [2, 3]

In addition to helping to dissolve reactive dye in the paste and cause swollen in the printed film and cellulosic textiles during the fixing procedure, urea additionally assists in to increase the water content of cellulosic fabrics. It further minimizes agglomeration of dye molecule, resulting in enhanced the dye's capacity for propagation and transfer to cellulosic fabrics swiftly and readily. [4, 5] Even while urea plays a significant role in cellulosic printing, it contributes to environmental contamination. Urea is removed from the fabric and washed into the wastewater throughout the process's washing, unfixed colors, thickeners as well as other additional chemicals. [6] The high quantities of ammonia-nitrogen in wastewater, may contribute to environmental problems like eutrophication, are caused by ammonia-nitrogen compounds that are created as urea breaks down. [7, 8]

A greener alternative for reactive printing on cellulosic textiles is reactive urea-free printing, that has become increasingly popular. Alternatives to urea are investigated by this sustainable technology. Due to their propensity to solubilize dyes, absorb moisture and swell fibers, these substitutes can facilitate the fixing, dyeing of fibers as well as thaw of reactive dyes in the color film. [9-11]

Linen is one of the most important textile materials and a necessary natural, eco-friendly resource. It could be the world's oldest cloth. [12-14] It is taken from the woody stalks of the flax plant. [15, 16] Linen almost eliminates sun radiation by protecting the human body from it. Because of its excellent moisture absorption, cooling effect, air permeability, and heat-transfer ability, linen fabric is a fantastic material for practical applications. [17] Because linen materials absorb a lot of water, the temperature of the body is controllable, which is crucial to both coziness along with health. The considerable moisture absorption of linen fibers causes them to dry quite fast. It also reduces the likelihood of electrostatic charging. [18, 19]

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The widest variety of structures and properties among all textile fibers is found in cellulose fibers. The important cellulosic fiber viscose is mostly used in textiles. Viscose is currently seeing a renaissance. [20-22] Viscose, often known as cellulose, is a material present in all terrestrial plants. [20-23] To create viscose rayon, cellulose is derived from a range of dissolving grade wood pulps. Viscose is meant to address the problems that have been becoming worse over time: rising worldwide cotton prices; increased demand for fiber, including the need to expand the market for the wood and pulp industry; and the need to identify new sources of fiber. [24]

Experimental

Materials

Fabrics: Viscose and raw linen were graciously supplied via Textile Industries Egyptian Co. Ointex, Egypt.

Thickeners and Dyes: Sodium alginate and reactive dye "Bezaktiv Red Go" were freely offered via Dystar.

Wetting agents: Anionic wetting agent "Foryl WAN" was provided via Newtrac trading as well as nonionic wetting agent "Tanaterge Advance" was provided via Tanatex Chemicals.

Every additional chemical that was employed in this investigation was of commercial laboratory grade.

Technical proceedings

Printing technique

The flat screen-printing technique was used to print reactive dye on linen and viscose textiles.

Printing paste

Using the flat screen-printing method, two distinct printing pastes were used to print linen and viscose fabrics: the standard printing paste, which was made using the formulation listed in table [1], and a new printing paste that contained 30g/kg anionic wetting agent and 30g/kg nonionic wetting agent without urea were enhancing the efficacy and efficiency of dyeing, printing, and finishing processes is the main purpose of wetting agents in textile processing. For the fixation stage, all printed samples were steam for 10 minutes at 100°C.

Fixation

Saturated steam was used to fix the printed textiles for ten minutes at 100°C.

Washing off

The viscose and linen printed samples were scrubbed with 6 ml/l non-ionic detergent at 60 ˚C for ten minutes after being washed with cold running water. Samples were then allowed to dry at room temperature after being washed with cold water.[4]

Table 1. Formulation of conventional printing paste.

Components	Weight/gm
Sodium alginate	750
Reactive dye	30
Sodium carbonate	20
Urea	150
Water	Y
Total	1000

Measurements

Colorimetric characteristic assessment

Kubelkae-Munk's equation has been applied for assessing color strength in the visible spectrum (400–700 nm)

$$\frac{K}{S} = \frac{(1-R)2}{2R} \ldots\ldots\ldots\ldots (1)$$

Where, "K" is adsorption coefficient, "R" is reflectance of dyed sample and "S" is scattering coefficient. [25, 26]

Tensile strength

Using a tensile strength apparatus of the type FMCW 500 [VebThuringer Industries Work Rauenstein 11/2612 German], the test was conducted in accordance with ASTM Standard Test method D 2261 – 13: 2017, at 25 ± 2 °C and 60 ± 2 % relative humidity. [27]

Viscosity

The viscosity of the conventional and novel printing paste was measured at different rate of shear at 25°C with Brookfield model DV-111 programmable rheometer, USA, at National Research Center, Cairo, Egypt.

Fastness characteristics

Fastness characteristics to light, rubbing, washing and perspiration of the printed samples were measured according to AATCC standard test methods. [24-27].

Results

Effect of anionic wetting agent "Foryl WAN":

In order to eradicate urea from the printing paste, the impact of an anionic wetting agent was investigated. In order to print raw linen and viscose textiles, various concentrations of "Foryl WAN," which were 0, 20, 40, 60, 80, and 100 ml/kg, were applied to the printing paste without additionally urea. Fig. (1) showed that the highest color strength values for printed viscose and linen textiles were 25.45 and 15.38, respectively, at a concentration of 60 ml/kg of the anionic wetting agent.

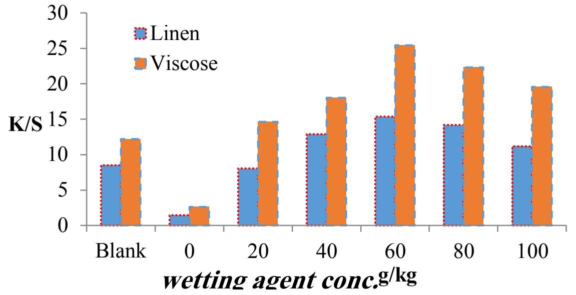

Fig. (1): Effect of different conc. of Foryl WAN

Effect of nonionic wetting agent "Tanaterge Advance"

By adding several quantities of 0, 20, 40, 60, 80, and 100 ml/kg to the printing paste without additionally urea, the impact of "Tanaterge Advance" has been investigated. Fig. [2]. showed that the highest K/S values for viscose and linen textiles were 23.43 and 17.67, respectively, at a specific concentration of 60 ml/kg of the nonionic wetting agent.

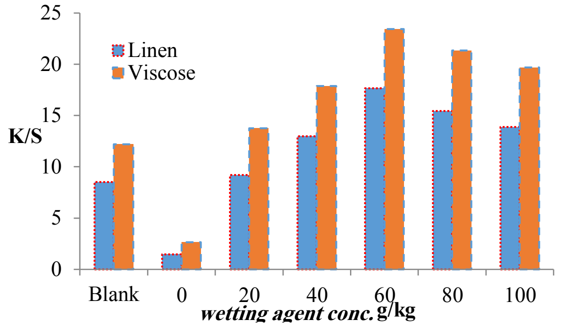

Fig. (2): Effect of different conc. of "Tanaterge Advance"

Effect of mingling two distinct kinds of wetting agents

Anionic "Foryl WAN" and nonionic "Tanaterge Advance" wetting agent concentrations were blended to figure out the maximum K/S. Raw linen and viscose fabrics were printed without urea leveraging the following mixture of the two wetting agents: [20% a + 80% b], [30% a + 70% b], [50% a + 50% b], [70% a + 30% b], & [80% b + 20% c] where the total amount of the two wetting agents was 60g/kg. As seen in fig. [3], the highest achievable K/S values for printed linen and viscose samples were recorded when 50% anionic "Foryl WAN" and 50% nonionic "Tanaterge Adance" were mixed together. For linen and viscose textiles, the corresponding maximum K/S values were 24.69 and 32.84."

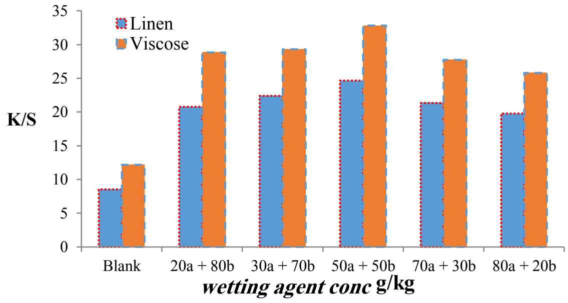

Fig. (3): Effect of mingling two distinct kinds of wetting agents

The color strength measurements of printings using conventional printing paste that contained 150g/kg urea, were compared to the prior findings. It became apparent that color strength values for linen and viscose printings rose by around 189.78% and 168.95%, respectively.

Wetting agents are primarily used to reduce surface tension between two surfaces. [28].[28] This is also the case when wetting agents are used in linen and viscose textiles printing paste, because they lessen the surface tension that exists between those textiles and water that is raised in the printing film while it is being steamed. Since water condensation on the surface of the printed fabrics causes the printing film to absorb a lot of water, the reactive dye's solubility and the absorption of linen and viscose materials are both increased.

Effect of steaming temperature

50% anionic "Foryl WAN" and 50% nonionic "Tanaterge Adance" were used to print linen and viscose textiles. The materials were then steamed for 10 minutes at various temperatures 90, 95, 100, 105, and 110ºC.

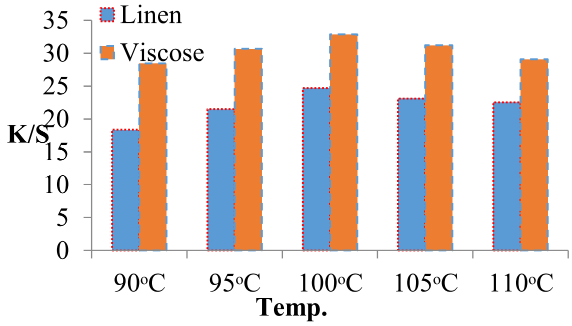

Fig. (4): Effect of steaming temperature

Fig. (4). exemplifies the comparable behaviour of the two materials as the steaming temperature was raised. For both textiles, the highest dye fixing has been achieved at 100°C. Color strength was observed to rise by approximately 34.47% and 15.51% for linen and viscose samples, respectively, when the steaming temperature was raised from 90ºC to 100ºC.

Effect of steaming time

Steaming was done at 100˚C for 5, 10, 15, and 20 minutes on linen and viscose samples that were printed with 50% anionic "Foryl WAN" and 50% nonionic "Tanaterge Adance". After 10 minutes, color strength value reached its maximum, as seen in fig. [5] as it shows that prolonging steaming period from 5 to 10 minutes enhanced dye fixing by around 38.55 and 53.67% for the linen and viscose samples, respectively. Since longer steaming times are known to boost dye hydrolysis, continuing the steaming for longer than ten minutes results in less dye fixing, which may be related to an increase in the pace of the hydrolysis process.

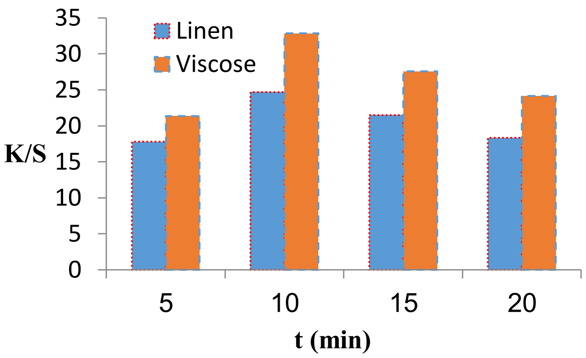

Fig. (5): Effect of steaming time

Table 2: Handle properties

Fabric		Tensile Strength [Kg/f].	Elongation [%].
Linen	A	120	40
	B	120	40
Viscose	C	110	30
	D	110	30

A: Traditional paste, B: 50% + 50% two distinct kinds of wetting agents, C: Traditional paste,
D: 50% + 50% two distinct kinds of wetting agents

Table 3: Viscosity measurement of sodium alginate before and after adding wetting agents

The viscosities of pure sodium alginate and sodium alginate with the addition of 50% nonionic and 50% anionic wetting agents were shown in Table(3). The results show that adding a wetting agent causes a modest drop in viscosity.

RPM	1	2	4	5	9
Rate of share (sec^{-1})	0.34	0.68	1.36	1.7	3.06
Viscosity (C.P) Sod. Alg.	42553	36680	32500	27650	21883
Viscosity * (C.P)	41362	35753	31548	27036	20754

*** Viscosity C.P:** (Sod. Alg. + 50% anionic wetting agent + 50% nonionic wetting agent)

Sod. Alg.: Sodium alginate

Fastness characteristics

Table (4) lists the color fastness characteristics for light, washing, rubbing and perspiration. Generally speaking, the fastness outcomes of the prints using the novel paste for the two textiles were either same or superior to those of the prints using the conventional paste. For the newly applied printing paste, there is a noticeable improvement in both wet rubbing fastness and color alteration of washing fastness.

Discussion

The printing paste, which has a high viscosity, dissolves dyes during the printing process. Therefore, one of the most crucial elements affecting the Steadiness of printing is the solubility of dyes. Typically, urea is used in reactive dye printing paste as a disaggregating and dye solubilization agent. This work focusses on removing urea from cellulose fabric reactive dye printing paste. The objective was to use a novel printing paste that contained a combination of two different kinds of wetting agents as an additive in place of urea to print on today's popular linen and viscose fabrics, which is in demand and ecologically sustainable. All the earlier data, which clearly indicate an improvement in color strength for all the printings printed utilizing the novel printing paste when compared to the samples printed with the conventional ones, demonstrate how promising the experiment is.

Table [4]: Color fastness properties

Samples		K/S	Light	Washing			Rubbing		Perspiration					
									Alkaline			Acidic		
				St.1	St.2	Alt.	Dry	Wet	St.1	St.2	Alt.	St.1	St.2	Alt.
Linen	A	8.52	5-6	3-4	3-4	3-4	4	3	4	4	3-4	4	4	3-4
	B	24.69	6	5	4-5	5	5	4-5	4-5	4-5	4-5	4	4-5	4-5
Viscose	C	12.21	5-6	4-5	4	4	4-5	3-4	4	4	4-5	4	4	4
	D	32.84	6	5	4-5	5	5	4-5	4-5	4-5	4-5	4-5	4-5	4-5

A: Traditional paste, B: 50% + 50% two distinct kinds of wetting agents, C: Traditional paste, D: 50% + 50% two distinct kinds of wetting agents St.1: Staining on cotton, St.2: Staining on wool

Conclusions

In light of growing environmental consciousness, this article looks at an attempt to entirely eradicate urea from printing paste that uses reactive dyes and substitute it using alternative components which don't compromise the printings color strength. Wetting agents can be used to reactive dye printing for linen and viscose textiles to improve the dye's disaggregation and solubility.

In comparison to urea, the printed textiles' color strength values have been greater when utilizing a combination of nonionic and anionic wetting agents. Wetting agents were great substitutes for urea in reactive dye printing paste. In particular, when 50% nonionic and 50% anionic wetting agents are used, 150gm/kg of urea may still produce the same printing qualities, such as color yield and fastness.

The novel paste's ingredients, which include a wetting agent, have the capacity to cause printed film and cellulosic fiber to puff up when steamed. Because of the strong penetration as well as quick dye transfer from the printed film to linen and viscose textiles, the rate of dye hydrolysis is lowered, allowing for more dye solubilization, and fixing.

The conclusion is that urea may be removed from the printing paste by substituting a combination of nonionic and anionic wetting agents, in comparison to the color strength values of the printings printed with the typical paste containing urea, the optimal color strength of the printings has been raised to about 189.78% and 168.95% for linen and viscose textiles, respectively.

This suggests that wetting agents have contributed to the dye's even and deep penetration into the fibers, giving the cloth a more consistent and vivid color and enhancing the dye's adherence to the fabric, which improves colorfastness and wash resistance. Also, the tensile strength and elongation of the samples printed using the novel and traditional printing pastes remains unchanged. Findings in Table (3) show that adding a wetting agent causes a small drop in viscosity.

Funds

The author declares that there is no funder.

Conflict of Interest

There is no conflict of interest in the publication of this article.

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عجينة طباعة جديدة بالصبغات النشطة خالية من اليوريا لمختلف الأقمشة السليلوزية

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المستخلص

تم تطبيق عجينة طباعة جديدة لأقمشة الكتان والفسكوز مع الصبغات النشطة في محاولة لمعالجة مشكلة تلوث المياه الناجم عن استخدام اليوريا بشكل مفرط في طباعة الصبغات النشطة لأقمشة السليلوز. هذه العجينة الجديدة تقضي على اليوريا تمامًا حيث تسمح بأقصى تثبيت للصبغات النشطة على الأقمشة. بدلاً تم استخدام مزيج من عوامل الترطيب غير الأيونية والأنيونية للطباعة بالصبغات النشطة على منسوجات الكتان والفسكوز. وبمقارنة العينات المطبوعة باستخدام عجينة الطباعة الجديدة بتلك التي تمت طباعتها باستخدام العجينة التقليدية التي تحتوي على اليوريا، وجد أن شدة اللون للمطبوعات المطبوعة باستخدام العجينة الجديدة قد ارتفعت بنحو 189.78٪ و 168.95٪ لمنسوجات الكتان والفسكوز على التوالي.

الكلمات المفتاحية: الكلمات المفتاحية: قماش الكتان؛ الفسكوز؛ طباعة المنسوجات؛ الصبغة النشطة؛ عامل الترطيب؛ إزالة اليوريا.