NEW THICKENING AGENT BASED ON ALOE VERA GEL FOR DISPERSE PRINTING OF POLYESTER

Enas M R El-Zairy

Textile Printing, Dyeing and Finishing Division, Faculty of Applied Arts, Cairo, Egypt
E-mail:Ino_reda@yahoo.com

Abstract:

The technical feasibility of using Aloe vera gel as a new thickener for printing polyester with disperse dyes was examined. The results indicate that the properties of the printed fabric samples (colour strength, K/S, overall fastness properties, handling and sharpness) were dependent on gel concentration, the type and concentration of additive (i.e. urea or citric acid), as well as the fixation conditions using the super-heated steam technique. The optimum conditions for printing polyester fibre with disperse dyes using Aloe vera gel as a thickener were as follows: 30 g/kg disperse dye, 50 g/kg urea, 15 g/kg citric acid, 500 g/kg Aloe vera thickener and 50% drying at 100 °C for 3 min followed by steam fixation for 6 min at 180 °C.

Key words:

Aloe vera, thickener, polyester, disperse printing.

Introduction

Aloe vera leaves contain polysaccharides which are found in abundance in nature and are readily available from sources such as algae (e.g. alginates), plants (e.g. pectin, guar gum, mannan), microbes (e.g. dextran, xanthan gum) and animals (e.g. chitosan, chondroitin). These materials can also be produced by means of recombinant DNA techniques [1].

The aloe leaf can be divided into two major parts, namely the outer green rind, including the vascular bundles, and the inner colourless parenchyma containing the aloe gel [2]. The gel possesses some biological activities such as promotion of wound healing, antifungal activity, hypoglycaemic or anti-diabetic effects, as well as anti-inflammatory, anticancer, immunomodulatory and gastroprotective properties [2].

The central parenchyma tissue of aloe vera contains a bitter yellow exudate which contains 1, 8 dihydroxy anthroquinone derivatives and their glycosides [3]. The aloe parenchyma tissue or pulp contains proteins, lipids, amino acids, vitamins, enzymes, inorganic compounds and small organic compounds in addition to a variety carbohydrates [1,2,4-7].

Disperse dyes are mainly used in the dyeing and printing of polyester and its blended fabrics and can be used with all techniques. Disperse prints have excellent printing properties, excellent wet fastness and excellent colour strength [8-9].

The present work was undertaken with the aim of determining the ideal disperse printing conditions for attaining high performance polyester prints using Aloe vera gel as a new thickening agent.

Experimental

Materials

Substrates

Mill-scoured and bleached 100% polyester (250 g/m^2), polyester/cotton (70/30; 370 g/m^2), polyester/viscose (70/30; 230 g/m^2) and polyester/linen (70/30; 380 g/m^2) woven fabrics were used.

Thickening Agents

Aloe vera gel extracted from the plant as an eco-friendly thickening agent as well as Indrez(r) HTA series (a natural polymer based on guar gum produced by Encore Natural Polymers, a private limited company in India) were used as thickening agents.

Dyes

The disperse dyes used were Disperse Blue(r) 2 BL 56, Disperse Red(r) FB6 and Disperse Orange(r) 25 (Sinochem Ningbo, China), as well as Resocotton blue(r) G, a combination of selected disperse and reactive dyes (this dye was kindly supplied by Bayer Co.).

Auxiliaries and chemicals

Hostapal(r) CV (an anionic textile auxiliary based on alkylaryl polyglycol ether) was used as a clariant. Sodium bicarbonate, citric acid and urea were laboratory grade chemicals.

Methods

Printing pastes

The printing pastes for disperse printing of polyester were prepared using the following recipe:

Disperse dye	30 g
Stock thickening agent	500 g
Urea	75 g
Citric acid	10 g
Water	385 mL
Total weight of the paste	1000 g

The printing pastes for Resocotton printing of polyester containing fabric (P/C, P/V and P/L) were prepared using the following recipe:

Resocotton dye	30 g
Stock thickener	500 g
Urea	75 g
Sodium bicarbonate	10 g

Water	385 mL
Total weight of the paste	1000 g

Printing procedure

Printing was carried out using the flat screen technique. Printed samples were then dried at 100°C for 3 min and fixed by super-heated steam at 180°C for 6 min.

Printed samples were rinsed with cold water for 15 min and then hot water at 60°C for 15 min, followed by soaping with an anionic detergent (2 g/L), then rinsed well and finally dried at 85°C for 5 min.

Testing

The printed samples were evaluated for the depth of the prints (expressed as K/S, where K is the absorption coefficient and S is the scattering coefficient), as well as the fastness properties, e.g. washing, rubbing and perspiration using standard methods. The rheological properties of the thickening agent solutions were measured at 25°C + 0.1°C using a co-axial rotary viscometer (HAAK V2O, Germany). The apparent viscosity (η) of the printing pastes was assessed as in a previous study and calculated using the following formula:

$$\eta = \frac{T}{D}$$

where T is the shearing stress (dyne/cm^2) and D is the rate of shear (S^{-1}).

Results and discussion

Since the ultimate goal of this study was to evaluate the performance of a new thickening agent for disperse printing of polyester fabrics, as well as to search for the ideal printing paste components and fixation conditions for attaining darker prints with better overall fastness properties, a wide range of parameters were studied. The results along with their appropriate discussion follows.

Thickener concentration

Table 1 shows that: i) increasing the thickening agent concentration from 100 g/kg up to 500 g/kg resulted in an improvement in the K/S values of the disperse prints, which could be discussed in terms of higher paste viscosity and minimum undue penetration or flashing of the dye; ii) a further increase in the concentration of the thickening agent had practically no effect on the depth of the obtained prints and was accompanied with a negative impact on softness [10,11]; iii) the overall fastness properties of the printed polyester fabric samples showed that using Aloe vera at 500 g/kg as a thickening agent yielded the best improvement in the handling, sharpness and fastness properties of the printed samples.

Effect of urea concentration

Table 2 shows the K/S values of the disperse prints as a function of urea concentration in the printing pastes (0-75 g/kg paste). For given printing conditions, it was apparent that increasing the urea concentration up to 50 g/kg had a positive impact on the depth of the obtained prints. This reflected the positive effect of the urea component on enhancing the swellability of the fabric structure, retarding the evaporation of water during drying, overcoming moisture sensitivity, in addition to increasing water condensation of the prints during the steaming step, thereby enhancing both the extent of dye interaction and fixation on and/or within the fabric structure [11-13]. Beyond 50 g urea/kg in the paste, there was a noticeable decrease in the depth of the pigment, which could be explained by side interactions with the thickener, thereby altering the rheological properties of both components and facilitating

Table 1. Effect of thickening agent concentration on the printing properties of a polyester substrate

Thickening agent concentration g/kg	Viscosity (poise)	K/S	Washing at 95°C * 70°C			Rubbing*		Perspiration*						Light* fastness	Handling	Sharpness
								Acidic			Alkaline					
			Alt.	SC	SW	Wet	Dry	Alt.	SC	SW	Alt.	SC	SW			
100	3.86	2.53	3-4	3-4	3	3	3	3-4	3	3	3	3	3	5-6	S	B
200	7.00	4.43	4	4	3-4	3-4	3-4	4	3-4	3-4	3-4	3-4	3-4	5-6	S	B
300	8.30	8.10	4	4	3-4	3-4	4	4	3-4	3-4	3-4	3-4	3-4	6	S	G
400	10.94	11.32	4	4	3-4	3-4	4	4	3-4	3-4	3-4	3-4	3-4	6-7	S	VG
500	11.9	13.70	4-5	4-5	4	4	4-5	4-5	4	4	4	3-4	3-4	7	S	EX
600	15.6	13.75	4	4	4	4	4-5	4-5	4	4	4	3-4	3-4	6-7	H	EX

Disperse Blue® 2BL56 (30 g/kg); Citric acid (10 g/kg); Urea (75 g/kg); Drying at 100°C for 3 min; super-heated steam at 180°C for 6 min.

Table 2. Effect of urea concentration on the printing properties of a polyester substrate

Urea concentration g/kg	Viscosity (poise)	K/S	Washing at 95°C * 70°C			Rubbing*		Perspiration*						Light* fastness	Handling	Sharpness
								Acidic			Alkaline					
			Alt.	SC	SW	Wet	Dry	Alt.	SC	SW	Alt.	SC	SW			
0	11.9	7.20	3	2-3	2	2	2-3	3	2-3	2	3	2	2	5-6	H	VG
25	11.9	10.24	3-4	4	3-4	3	4	4	4	3-4	4	4	3-4	6	H	EX
50	11.9	13.70	4-5	4-5	4	4	4-5	4-5	4	4	4	4	3-4	6-7	S	EX
75	11.9	12.80	4-5	4-5	3-4	3-4	4	4	4-5	3-4	4	4	3-4	6	S	VG

Thickening agent 50% (500 g/kg paste); Disperse Blue® 2BL56 (30 g/kg); Citric acid (10 g/kg); Drying at 100°?C for 3 min; super-heated steam at 180°C for 6 min.

Table 3. Effect of citric acid concentration on the printing properties of a polyester substrate

Citric acid concentration g/kg	Viscosity (poise)	K/S	Washing at 95°C * 70°C			Rubbing*		Perspiration*						Light* fastness	Handling	Sharpness
								Acidic			Alkaline					
			Alt.	SC	SW	Wet	Dry	Alt.	SC	SW	Alt.	SC	SW			
0	12.57	4.80	2-3	2-3	2	2-3	3	3	2	2	3	2-3	2	5-6	H	VG
5	12.43	10.99	3-4	3-4	3	3-4	3	3-4	3-4	3	3-4	3	3	6	S	VG
10	11.9	12.02	4-5	4-5	4	4	4-5	4-5	4	4	4	4	3-4	6-7	S	EX
15	11.5	13.70	4-5	4-5	4	4	4-5	4-5	4-5	4	4-5	4	3-4	7	S	EX
20	10.85	13.45	4	4	3-4	3-4	4	4	4	3-4	4	3-4	3	6-7	S	EX

Thickening agent 50% (500 g/kg paste); Disperse Blue® 2BL56 (30 g/kg); Urea(75 g/Kg); Drying at 100°C for 3 min; super-heated steam at 180°C for 6 min.

Table 4. Effect of steam fixation temperature on the printing properties of a polyester substrate

Super-heated steam temp. °C	Viscosity (poise)	K/S	Washing at 95°C * 70°C			Rubbing*		Perspiration*						Light* fastness	Handling	Sharpness
								Acidic			Alkaline					
			Alt.	SC	SW	Wet	Dry	Alt.	SC	SW	Alt.	SC	SW			
140	11.5	8.12	3	3	2-3	3	3	3-4	3	2-3	3-4	3	3	6	S	G
160	11.5	11.30	4	4	3-4	3-4	4	4	4	3-4	4	4	3-4	6	S	VG
180	11.5	13.70	4-5	4-5	4	4	4-5	4-5	4	4	4	4	3-4	7	S	EX
200	11.5	13.72	4-5	4-5	4	4	4-5	4-5	4-5	4	4-5	4-5	4	7	H	EX

Thickening agent 50% (500 g/kg paste); Disperse Blue® 2BL56 (30 g/kg); Citric acid (15 g/kg); Urea (75 g/kg), Drying at 100°C for 3 min; super-heated steam for 6 min.

Table 5. Effect of fixation time on the printing properties of a polyester substrate

Fixation, time/ min	Viscosity (poise)	K/S	Washing at 95°C * 70°C			Rubbing*		Perspiration*						Light* fastness	Handling	Sharpness
								Acidic			Alkaline					
			Alt.	SC	SW	Wet	Dry	Alt.	SC	SW	Alt.	SC	SW			
3	11.5	8.73	3-4	3	2-3	2-3	3	3-4	3-4	3	3-4	3	2-3	6	S	VG
6	11.5	13.70	4-5	4-5	4	4	4-5	4-5	4	4	4	4	3-4	7	S	EX
9	11.5	13.00	4-5	4-5	4	4	4	4	4	4	4	4	3-4	6-7	H	EX

Thickening agent 50% (500 g/kg paste); Disperse Blue® 2BL56 (30 g/kg); Citric acid (15 g/kg); Urea (75 g/kg); Drying at 100°C for 3 min; super-heated steam at 180°C.

Table 6. Effect of storage time on the printing properties of a polyester substrate

Storage time/ days	Viscosity (poise)	K/S	Washing at 95°C * 70°C			Rubbing*		Perspiration*						Light* fastness	Handling	Sharpness
								Acidic			Alkaline					
			Alt.	SC	SW	Wet	Dry	Alt.	SC	SW	Alt.	SC	SW			
Freshly prepared	11.5	13.70	4-5	4-5	4	4	4-5	4-5	4	4	4	4	3-4	7	S	EX
3	11.5	13.63	4-5	4-5	4	4	4	4	4	4	3-4	4	3-4	7	S	EX
7	10.97	13.58	4	4	3-4	3	4	3-4	3-4	3	3-4	3-4	3	7	S	VG

Thickening agent 50% (500 g/kg paste); Disperse Blue® 2BL56 (30 g/kg); Citric acid (15 g/kg); Urea (75 g/kg); Drying at 100°C for 3 min; super-heated steam at 180°C for 6 min.

undue penetration of the disperse dye, i.e. leading to a lower extent of dye fixation.

Citric acid concentration

In terms of the change in K/S values of the printed fabric samples as a function of citric acid concentration, Table 3 shows that that: i) increasing the citric acid concentration from zero to 15 g/kg resulted in a dramatic improvement in K/S values of the obtained prints; ii) this improvement in K/S values was probably due to the positive impact of citric acid on the swellability of the fabric structure during steaming, as well as on dye fixation at acidic pH [14-16]; iii) a further increase in the citric acid component in the printing pastes had a negative impact on the K/S values of the obtained prints, which could be interpreted in terms of lower viscosity of the printing pastes, [14,17] as well as the dye-fibre bond stability, thereby minimising extent of dye uptake and subsequent fixation onto and/or within the printed substrate [14,18].

Super-heated steam fixation temperature

Table 4 shows that: i) increasing the steaming temperature from 140°C up to 200°C for 6 min was accompanied by a gradual sharp increase in the depth of the obtained disperse prints and ii) the outstanding improvement in the K/S value

Table 7. Effect of type of dyestuff and thickening agent on the printing properties of a polyester substrate

Type of dyestuff	Type of thickener	Viscosity (poise)	K/S	Washing at 95°C * 70°C			Rubbing*		Perspiration*						Light* fastness	Handling	Sharpness
									Acidic			Alkaline					
				Alt.	SC	SW	Wet	Dry	Alt.	SC	SW	Alt.	SC	SW			
Disperse Blue® 2BL56	Indrez® HTA	11.20	12.23	4-5	4	3-4	4	4	4-5	4	3-4	3	3-4	3-4	6-7	S	EX
	Aloe vera	11.5	13.70	4-5	4-5	4	4	4-5	4-5	4	4	4	4	3-4	7	S	EX
Disperse Red® FB60	Indrez® HTA	11.20	16.89	4	4	4	3-4	4	4	4	3-3	4	3-4	3-4	6-7	S	EX
	Aloe vera	11.5	18.20	4-5	4-5	4	4	5	4-5	4	3-4	4	4	3-4	7	S	EX
Disperse Orange® 25	Indrez® HTA	11.20	17.08	4	4	3-4	3-4	4	4	4	3-4	4	4	3-4	6-7	S	EX
	Aloe vera	11.5	18.25	4-5	4	4	4	4-5	4	4	3-4	4	4	3-4	7	S	EX

Thickening agent (Aloe vera 50% or Indrez® HTA 85%) (500 g/kg paste), Disperse Blue® 2BL56, Disperse, Red®FB60, Disperse Orange® 25 (30 g/kg); Citric acid (15 g/kg); Urea (75 g/kg); Drying at 100°C for 3 min; super-heated steam at 180°C for 6 min.

Table 8. Aloe vera as a thickening agent in printing polyester containing fabrics

Substrate	Viscosity (poise)	K/S	Washing at 95°C * 70°C			Rubbing*		Perspiration*						Light* fastness	Handling	Sharpness
								Acidic			Alkaline					
			Alt.	SC	SW	Wet	Dry	Alt.	SC	SW	Alt.	SC	SW			
P/C 70/30	11.5	14.85	4-5	4	3-4	4	4-5	4-5	4	4	4-5	4	4-5	6-7	S	EX
P/V 70/30	11.5	15.95	4-5	4	3-4	4	4-5	4	4	3-4	4	4	4	7	S	EX
P/L 70/30	11.5	13.40	4	3-4	3-4	3-4	4	4	4	3-4	4	4	4	7	S	EX

Thickening agent 50% (500 g/kg paste); Resocotton blue® G (30 g/kg); Citric acid (15 g/kg); Urea (75 g/kg); Drying at 100°C for 3 min; super-heated steam at 180°C for 6 min.

was a direct consequence of improving the swellability of both the thickener film and the polyester structure, facilitating the release of disperse dye from the thickener film, allowing sublimation and diffusion into the accessible area of the polyester structure, as well as enhancing the extent of dye retention and fixation, thereby giving rise to a more intense depth of shade (from 8.12 up to 13.72 values) [19-20].

Steam fixation time

Table 5 shows the effect of steam fixation time on the extent of dyeing polyester fabrics. It is clear that prolonging the steaming time up to 6 min at 180°C resulted in a remarkable increase in the depth of the obtained disperse prints. This outstanding increase in the K/S value reflected the positive role of proper steaming time on swelling the thickening film, enhancing the extent of release of dye molecules from the thickener film as well as dye sublimation, adsorption onto and diffusion within the substrate, thereby enabling the volatile components and dye vapour to be strongly adsorbed and retained by the hydrophobic polyester component [19-22].

Effect of storage time

The results demonstrate that: i) storing the printing pastes results in a decrease in the K/S values (see Table 6); ii) the decrease in K/S values due to storage can be explained by the variation in the structure of the thickener as well as in its rheological properties [23-24]; iii) the washing fastness properties of the prints were found to be marginally decreased, especially with a longer storage period, i.e. 7 days; iv) prolonging storage time up to 7 days brought about a decrease in the dry and wet rubbing fastness properties of the printed substrate, since the extent of the decrease in the rubbing fastness rate is governed by the extent of dye fixation; v) for a given storage time as well as printing conditions, the wet rubbing fastness was lower than the dry rubbing fastness, probably due to the presence of unfixed dye entrapped in the print and vi) storage time had a marginal or absent effect on perspiration, light fastness, handling and sharpness of the obtained prints.

Effect of type of dyestuff and thickening agent

In terms of the changes in the K/S values of the obtained prints along with their fastness properties as a function of kind of thickening agent and type of disperse dye, the data in Table 7 reveal that: i) the depth of the obtained prints was governed by the kind of thickening agent used, e.g. its molecular weight, chemical composition, functionality, rheological properties, thickener film properties, extent of releasing dye molecules in the steaming step, affinity for the used dye, etc. [10-11] such that Aloe vera was superior to Indrez HFAB regardless of the used dye; ii) the K/S values as well as the fastness properties of the obtained disperse prints were determined by the chemical composition as well as the molecular structure of the dye, the extent of release from the thickener film, the degree of penetration, interaction and subsequent fixation [11,21,23-24] and iii) using Aloe vera as a new thickening agent in disperse printing results in greater thickening efficiency as well as better depth and fastness properties of the obtained prints in comparison with the Indrez HFAB thickener.

Effect of the type of substrate

Changes in the K/S values of the obtained prints along with their fastness properties as a function of type of polyester containing fabric are shown Table 8, which demonstrates that the depth of the obtained prints was governed by the kind of substrate, its chemical structure, and its affinity for the used dye [10-11], the degree of penetration, interaction and subsequent fixation [12, 25].

Conclusion

This research focused on the application of a new thickening agent based on Aloe vera gel for disperse printing of polyester. On the basis of the experimental results, we have made the following conclusions:

– Increasing the concentration of the thickening agent, aloe vera gel, up to 500 g/kg, along with the addition of urea up to 75 g/kg paste and citric acid up to 10 g/kg paste with a disperse dye concentration up to 30 g/kg paste results in an enhancement in the depth of the obtained prints.
– Super-heated steam fixation at 180°C for 6 min was found to be effective for attaining improved depth of disperse prints.
– The K/S values as well as the fastness properties of the obtained prints depend on the type of the dyestuff and the thickening agent as well as the kind of polyester containing fabric.

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