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

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Abstract

The technical feasibility of using Aloe vera gel as a new thickener for printing polyester with disperse dyes was examined. Results obtained indicate that the properties of the printed fabric samples (colour strength K/S and over-all fastness properties, handle and sharpness are determined by jel concentration, type and concentration of additive, i.e. (urea, citric acid), as well as the fixation condition using super-heated steam technique.

The optimum conditions for printing polyester fibre with disperse dyes using Aloe vera jel as a thickener, were as follow: 30 g/kg disperse dye, 50g/kg urea, 15g/kg citric acid, 500g/kg Aloe vera thickener 50% ,drying at 100°C/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 is 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) and they 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] it has some biological activities such as promotion of wound healing, antifungal activity,hypoglycemic or antidiabetic effects antiinflammatory,anticancer, immunomodulatory and gastroprotective properties.[2]

The central parenchyma tissue of aloe vera contains yellow bitter exudates which contains, 1, 8 dihydroxy anthroquinone derivatives & their glycosides,[3]the aloe parenchyma tissue or pulp contain proteins, liqids, amino acids, vitamins, enzymes, inorganic compounds & small organic compounds in addition to the different carbohydrates. [1,2,4-7]

Disperse dyes are mainly used in the dyeing and printing of polyester and its blended fabrics in generally by all techniques. The disperse prints have excellent printing properties, excellent wet fastness and excellent color strength. [8-9]

The present work is undertaken with a view of looking for the proper disperse printing conditions for attaining high performance polyester prints using Aloe vera as a new thickening agent.

2- Experimental

2.1. Materials

2.1.1 Substrates

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

2.1.2 Thickenings Agents

Aloe vera gel extracted from the plant as an eco-friendly thickening agent, Indrez® HTA series (Natural polymer based on guar gum, Encore natural polymers private limited company, Indian) were used as thickening agents.

2.1.3 Dyes

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

2.1.4 Auxiliaries and Chemicals

Hostapal® CV (anionic –textile auxiliary based on alkylaryl polyglycol ether, clariant).Sodium bicarbonate, citric acid and urea were laboratory grade chemicals.

2.2. Methods

2.2.1. Printing pastes

The printing pastes for disperse printing of polyester were prepred using the following recipes:

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

The printing pastes for Resocotton printing of polyester cellulosic blended fabric (P/C, P/V and P/ L) were prepared using the following recipes.

Rescotton dye	30g
Stock thickener	500g
Urea	75 g
Sodium bicarbonate	10g
Water	385
Total weight of the paste	1000g

2.2.2. 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 anionic detergent (2g/ liter), then rinsed well and finally dried at 85°C for 5 min.

2.2.3. Testing

The printed samples were evaluated for 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, perspiration using standard methods. The rheological properties of the thickening agents solutions were measured at 25º + 0.1ºC 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}).

3. Results and Discussion

Since the ultimate goal of this study was to evaluate the performance of new thickening agent for disperse printing of polyester fabrics, as well as to search for the proper printing paste components and fixation conditions for attaining darker prints with better overall fastness properties, wide range of parameters have been studied. Results obtained along with their appropriate discussion follow.

3.1. Thickener concentration

Table 1. shows that: i) increasing the thickening agent concentration from (100 g/kg) up to (500 g/kg) results 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) further increase in thickening agent concentration has practically no effect on the depth of the obtained prints along with a negative impact on softness[10,11], iii) the overall fastness properties of the printed polyester fabric samples show that using aloe vera at 500g/kg as a thickening agent gives the best improvements in handling, sharpness and fastness properties of the printed samples.

3.2. 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 a given printing conditions, it is apparent that increasing the urea concentration up to 50 g/kg has a positive impact on the depth of the obtained prints. This reflects the positive effect of urea component on enhancing the swellability of the fabric structure, retarding the evaporation of water during drying, overcoming the moisture sensitivity, in addition to increase 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 50g urea/kg paste there is a noticeable decrease in the depth of shade, which could be discussed in terms of side interactions with the used thickener thereby altering their rheological properties and facilitating undue penetration of the used disperse dye, i.e. lower extent of dye fixation.

3.3. Citric acid concentration

As far as the change in K/S values of the printed fabric samples as a function of citric acid concentration of ,Table 3 discloses that: i) increasing citric acid concentration from zero up to 15 g/kg results in a dramatic improvement in K/S values of the obtained prints, ii) this improvement in K/S values is 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) further increase in citric acid component in the printing pastes has practically a negative impacts on the K/S values of the obtained prints, which could be interpreted in terms of lower printing pastes viscosity, i.e.,[14,17]as well as the dye-fiber bond stability, thereby

minimizing extent of dye uptake and subsequent fixation onto and/or within the printed substrate.[14,18]

3.4. Super heated steam-fixation temperature

Table 4 shows that: i) increasing the steaming temperature from 140 up to 200°C for 6 min is accompanied by a gradual sharp increase in the depth of the obtained disperse prints, and ii) the outstanding improve in K/S value is a direct consequence of: improving the swellability of both the thickener film and the polyester structure, facilitating the disperse dye release from the thickener film, sublime and diffuse into the accessible area of polyester structure, as well as enhancing the extent of dye retention and fixation thereby giving rise to darker depth of shade (from 8.12 up to 13.72 values).[19-20]

3.5. Steam-fixation time

Table 5 shows the effect of steam fixation time on the extent of polyester fabrics, it is clear that prolonging the steaming time up to 6 min at 180°C results in a remarkable increase in the depth of the obtained disperse prints. This outstanding increase in the K/S vlue reflects 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 and dye-vapor to be strongly adsorbed and retained by the hydrophobic polyester component.[19-22]

3.6. Effect of storing time

The results obtained signify 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 by storing can be discussed in variation in the thickener structure as well as in its rheological properties,[23-24] iii) the washing fastness properties of prints were found to be marginally decreased especially at longer storing period, i.e. 7 days, iv) prolonging storing time up to 7 days brings about a decrease in dry and wet rubbing fastness properties of the printed substrate and the extent of decrease in rubbing fastness rate is goveroud by the extent of dye fixation, v) for a giving storing time as well as printing conditions the wet rubbing fastness is lower than the dry rubbing fastness most probably due to the presence of unfixed dye entrapped in the print, vi) storing time has practically marginal or no effect on perspiration, light fastness, handle and sharpness of the obtained prints.

3.7. Effect of type of dyestuff and thickening agent

As far as 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 of Table 7 reveal that: i) the depth of the obtained prints is governed by the kind of thickening agent, e.g. molecular weight, chemical composition, functionality, rheological properties, thickener film properties, extent of releasing the dye molecules in the steaming step, affinity to the used dye… etc.[10-11] follows the descending order: Allovera > Indrez HFAB regardless of the used dye, ii) the K/S values as well as the fastness properties of the obtained disperse prints are determined by: the chemical composition as well as molecular structure of the dye, extent of release from the thickener film, degree of penetration, interaction and subsequent fixation [11,21,23-24] and iv) using aleovera as a new thickening agent in disperse printing of the gives higher thickening efficiency as well as better depth and fastness properties of the obtained prints in comparison with Indrez HFAB thickener.

3.8. Effect of type of substrate

As far as the changes in the K/S values of the obtained prints along with their fastness properties as a function of type of polyester containing fabric, Table 8 reveals that: the depth of the obtained prints is governed by the kind of substrate, its chemical structure, and its affinity to the used dye, [10-11] degree of penetration, interaction and subsequent fixation. [12, 25]

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

Thickening agent concentration g/Kg	Viscosity	K/S	Washing at 95°C * 70°C			Rubbing*		Perspiration*						Light* fastness	Handle	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 (30g/Kg):Citric acid (10g/kg): Urea (75g/kg): Drying at 100◦C for 3min.;super heated steam at 180◦Cfor 6 min.

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

Urea concentration g/Kg	Viscosity	K/S	Washing at 95°C * 70°C			Rubbing*		Perspiration*						Light* fastness	Handle	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% (500g/kg paste);Disperse Blue® 2BL56 (30g/Kg);Citric acid (10g/kg):Drying at 100◦C for 3min.;super heated steam at 180◦Cfor 6 min.

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

Citric acid concentration g/Kg	Viscosity	K/S	Washing at 95°C * 70°C			Rubbing*		Perspiration*						Light*	Handle	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% (500g/kg paste); Disperse Blue® 2BL56 (30g/Kg);Urea(75g/Kg); Drying at 100◦C/ 3min.; superheated steam at 180◦C for 6 min.

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

Super. Heated steam Temp. °C	Viscosity	K/S	Washing at 95°C * 70°C			Rubbing*		Perspiration*						Light*	Handle	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% (500g/kg paste); Disperse Blue® 2BL56 (30g/Kg);Citric acid (15g/kg);Urea (75 g/kg), Drying at 100◦C/ 3min.; superheated steam for 6 min.

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

Fixation time/ min.	Viscosity	K/S	Washing at 95°C * 70°C			Rubbing*		Perspiration*						Light*	Handle	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% (500g/kg paste); Disperse Blue® 2BL56 (30g/Kg); Citric acid (15g/kg); Urea (75 g/kg); Drying at 100◦C/ 3min.;
superheated steam at 180◦C.

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

Storing time/ days.	Viscosity	K/S	Washing at 95°C * 70°C			Rubbing*		Perspiration*						Light*	Handle	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% (500g/kg paste); Disperse Blue® 2BL56 (30g/Kg); Citric acid (15g/kg); Urea (75 g/kg); Drying at 100◦C/ 3min.; superheated steam at 180◦C for 6 min.

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

Type of dyestuff	Type of thickener	Viscosity	K/S	Washing at 95°C * 70°C			Rubbing*		Perspiration*						Light*	Handle	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
	Allo 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
	Allo 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
	Allo 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 (Aleo vera 50% or Indrez® HTA 85%) (500g/kg paste), Disperse Blue® 2BL56, Disperse, Red®FB60, Disperse Orange® 25 (30g/Kg); Citric acid (15g/kg); Urea (75g/kg); Drying at 100◦C/ 3min.; superheated steam at 180◦C for 6 min.

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

Substrate	Viscosity (cps)	K/S	Washing at 95°C * 70°C			Rubbing*		Perspiration*						Light*	Handle	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% (500g/kg paste); Resocotton blue® G (30g/Kg); Citric acid (15g/kg); Urea (75 g/kg); Drying at 100◦C/ 3min.; superheated steam at 180◦C for 6 min.

Conclusion

This research focused on application of new thickening agent, based on Aloe Vera Gel for disperse printing of polyester. On the basis of the experimental results, we concluded the following:

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

References:

1. Josias, H., Hamman, Composition and Application of Aloe vera Leaf Gel, Molecules 13, 1599-1616 (2008).
2. Ni, Y., Tizard, I.R., Analytical methodology: the gel-analysis of aloe pulp and its derivatives. In Aloes The Genus Aloe, T., Reynolds, Ed.; CRC Press: BocaRaton,111-126(2004).
3. Vazquez, B., Avila, G., Segura, D. and Escalante, B., Antiinflammatory activity of extracts from Aloe vera gel, J. Ethnopharmacol**,** 55, 69-75(1996).
4. Reynolds, T., Aloe chemistry. In Aloes the Genus Aloe, T.Reynolds, Ed.; CRC Press: Boca Raton, 39-74(2004).
5. Dagne, E., Bisrat, D., Viljoen, A. and Van Wyk, B-E. Chemistry of Aloe species. Curr. Org. Chem, 4, 1055-1078,(2000).

6. Femenia, A., Sanchez, E.S., Simal, S. and Rosello, C., Compositional features of polysaccharides from Aloe vera (Aloe barbadensis Mille) plant tissues, Carbohydr. Polym., 39, 109-117(1999).

7. Choi, S., Chung, M-H., A review on the relationship between Aloe vera components and their biologic effects,Semin, Integr. Med., 1, 53-62**(**2003).

8. Ragheb, A.A., Suitability of Nitfogen-Containing starch derivative in printing polyester fabrics with disperse dyes, American Dyestuff Reporter, 83 (2), 15-24, (1994) .

9. El-Kashouti, M.A., Elgemeie, G.H., El-Molla, M.M., El-Sayad, H.S. and Ahmed, K.A.E., Synthesis and application of some new diseperse azo dyes derived from 2-cyanomethyl benzothiazole, Pigment and Resin Technology, 36/6, 382-391, (2007).

10. Patnaik , M. and Chakraboryt, M., Thickeners in textile printing: An overview, Colourage, 58, 29-34, (1995).

11. Ibrahim, N.A., Rashad , M. M. and Abo-Shosha, M. H., Polyacrylamide guar gum adducts as a new thickener for reactive printing of wool and nylon 6, Polymer-Plastic Technology and Engineering. 42 (5), 757 (2003).

12. Provost, J. R., Effluent improvement by source reduction of chemicals used in textile printing, Journal of the Society of Dyers and Colourists, 108, 260-264 (1992).

13. Ibrahim, N. A., Abo Shosha, M. H., Allam and E., El-Zairy , E. M., New thickening agents based on tamarind seed gum and karaya gum polysaccarides, Carbohydrate polymers, 81, 2, 402-408, (2010).

14. Bruce, B.L. and N. V. Broad wood, (Kinetics of wool dyeing with acid dyes), Textile Research Journal, 70, 525-531 (2000).

15. Church, J.S., Darie, A.S, Scammells, P.J. and Tucker, D.J., Chemical interaction of α-bromoacrylamide reactive dyes with wool, Review of Progress in Coloration., 29, 85-93 (1999).

16. Gulrajami, M. L., Dyeing of silk with reactive dyes, Review of Progress in Coloration, 23, 51-56 (1993).

17. Kongliang, X. and Aigin, H. J., Application of a reactive cationic dye to wool, Soc. Dyer. Color. 114, 20-23 (1998).

18. Bell, V., Recent development in wool printing, Journal of the Society of Dyers and Colourists, 104, 159-172 (1988).

19. Choudhury, A. K. R., Textile preparation and dyeing, Enfield, NH, USA; Science publishers, (2006).

20. Ibrahim, N. A., Abo-Shosha, Elnagdy, M. H., S,and Gaffar, M. A, Eco-friendly durable press finishing of cellulose-containing fabrics, Journal of Applied Polymer Science, 84, 2243-2244, (2002).

21. Aspland, J. R., Textile dyeing and coloration, NC, USA: AATCC, 193-201, (1997).

22. Ibrahim, N. A., El Zairy, E. M. R, Union disperse printing and UV-protecting of Wool/polyester blend using a reactive β-cyclodextrin, Carbohydrate Polymers, 76, 244-249, (2009).

23. Ibrahim, N. A., El Zairy, M. R and Abo-Shosha, M. H., Preparation and rheology of new synthetic thickeners based on polyacrylic acid, Dyes and pigments, 25, 1 (1994).

24. Glover, B., Reactive dyes for textile printing, Annual LII: Colourage, 67-82, (2005).

25. Abo Shosha, M. H., Ibrahim N. A, Allam, E. and El-Zairy E. M., Preparation and characterization of polyacrylic acid/karaya gum and polyacrylic acid/tamarind seed gum adducts and utilization in textile printing, Carbohydrate polymers, 74, 241-249 (2008).