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Dr. Harshita Chaudhary
Assistant Professor, Department of Fabric and Apparel Science, Institute of Home Economics, University of Delhi, New Delhi, India

Vinita Singh
Student, Department of Fabric and Apparel Science, Institute of Home Economics, University of Delhi, New Delhi, India

Correspondence
Dr. Harshita Chaudhary
Assistant Professor, Department of Fabric and Apparel Science, Institute of Home Economics, University of Delhi, New Delhi, India

Effects of alkali modification on polyester printed with disperse dyes and tamarind kernel thickener

Dr. Harshita Chaudhary and Vinita Singh

Abstract
Surface modification of polymer surfaces is a research field that has received a lot attention in order to enhance specific surface characteristics of polymers that are needed in a number of applications. In the present study, alkali modification has been used to enhance the functionality of inert polyester fabric whilst improving its printability with tamarind kernel thickener and disperse dyes. The results of the study show a marked improvement in the colour strength values of the samples printed post alkali modification. The samples exhibited sharp lines with uniform colour. With minimal weight loss of 6%, moisture regain properties of hydrophobic polyester were also found to improve.

Keywords: Polyester, printing, tamarind kernel powder, disperse dyes

1. Introduction
The process of surface modification of polyethylene terephthalate fibres by an alkaline solution, also known as 'weight reduction' or 'de-weighing' is a well-established process. Chemical modification using alkali causes hydrolysis of ester bonds producing carboxyl and hydroxyl polar groups. These functional groups also play the role of anchor groups and aid in fixing of the film of functional products on the surface of the fabric (Bendak and Marsafi, 1991, Prorokova *et al.*, 2009) [1, 7]. If the process of alkali modification is not well controlled it may lead to deterioration of the intrinsic mechanical and aesthetic properties of polyester, with occurrence of faults and overall reduction of product quality (Dave, 1987) [5]. Alkali treatment also results in the removal of hydrolyzed polyester material, leading to the formation and exposition of new surfaces. Pits or voids generated on the surface play a significant role in surface-related phenomena. Removal of hydrolysed polyester causes weight loss and considerable surface modifications resulting in better hand, silk like feel and drape of the fabric.

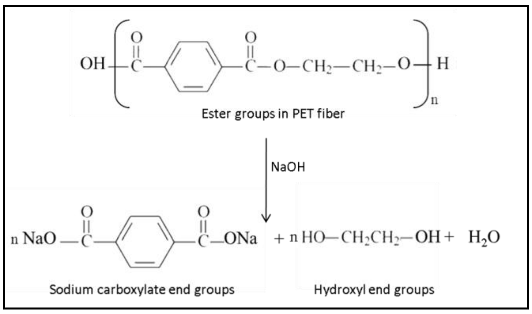

Fig 1: Alkali hydrolysis of polyester (Das *et al.*, 2007) [4]

Studies have been done by the researchers to improve the dyeability of inert polyester by giving suitable modification tretaments. However, limited work has been done on improving the printing ability of polyester samples post modification.
Printing is the branch of the textile wet processing industry & is becoming increasingly popular for all fibers & varieties of fabrics as well as garments. Basically, printing is a form of dyeing in which the colors are applied to specified areas instead of the entire fabric. The

resulting multicolored patterns have attractive and artistic effects which enhance the value of the fabrics much more than the plain dyed ones. The coloration is achieved with the incorporation of dyes or pigments in the printing paste (Bable *et al*., 2015) [2]. To restrict the coloring matter to the design area, it is pasted with a thickening agent. Thickeners impart stickiness and plasticity to the printing pastes so that it can be applied to a fabric surface without spreading and are capable of maintaining the design outlines even under high pressure. Thickeners may be a natural or synthetic polymers (Chinta and Chavan, 2012) [3]. While process optimization is a key factor for cleaner production, researchers and industrials are working on developing new natural alternatives of thickeners from environmental point of view. Tamarind seed gum is one such biodegradable thickener which has the potential to be explored as a source of natural thickening agent. It is a by-product of tamarind fruit and pulp industry, thus is sustainable. Thus, in the present study, an effort has been made to explore the suitability of thickening agent from tamarind kernel seed for printing of alkali modified polyester using disperse dyes.

2. Methodology

Materials

- Hundred percent polyester fabric having plain weave, 90g per square meter (gsm), 56 ends per cm; 34 picks per cm was used for the study.
- Sodium hydroxide was used for alkali modification.
- Tamarind kernel powder, procured from Tamarind Magic, Hyderabad, was used as thickener.
- Disperse blue dye procured from Kiran dyes and chemicals (India) was used for colouration.

Methods

Scouring of polyester- Polyester fabric samples were scoured using 1mL/L Lissapol N, 0.2g/L sodium carbonate (Na_2CO_3) at 50-55°C for 1hr.

Alkali modification of polyester- Alkali modification of polyester was carried out using 40g/L of sodium hydroxide, for 45min and 80°C. The material to liquor ratio was taken as 1:50. The samples were thoroughly washed, rinsed and dried (Gupta *et al*., 2015) [6].

Assessment of modified polyester

- **Determination of weight loss:** Weight loss was measured by calculating the difference in weight of the untreated and modified polyester samples, according to the equation,

$$\text{Weight loss (\%)} = \frac{(W1 - W2)}{W1} X\ 100$$

where w_1 and w_2 are the weights of the samples before and after modification treatments.

- **Moisture regain:** Moisture regain was measured in accordance with ASTM D629-99 by comparing the dry weight and moisture conditioning weight of modified polyester fabrics.

Printing of modified and non-modified polyester with tamarind kernel powder and disperse dyes

Alkali modified and control samples were screen printed with thickening paste of tamarind kernel thickener and disperse dyes. The recipe for printing is given in Table 1. The printed samples were dried at 60°C for 15 min. The fixation was carried out by steaming the samples at 130°C for 30 min. Reduction clearing of the samples was done at 60-70°C for 15 min in a solution of sodium hydrosulphite (2 g/L) and sodium hydroxide (2 g/L). The samples were further rinsed thoroughly and dried.

Table 1: Recipe for printing using disperse dyes and tamarind kernel powder

Chemicals	Recipe (amount)
Disperse dye	1.5
Water	3mL
Carrier	0.5
Glycerin	1
Resist salt L	0.5
Thickener (TKP)	X
TOTAL	100

Assessment of printed samples

- **Colour strength measurement-** The color strength (K\S) of the printed samples was evaluated by computer colour matching system at λ maximum.
- **Qualitative analysis-** Polyester samples were visually evaluated by a panel of 3 experts. The samples were evaluated on the basis of various parameters on a 5 point rating scale. The attributes for evaluation were as follows.
  - uniformity of colour
  - sharpness of line and
  - whiteness of ground

3. Results and discussion

Assessment of modified polyester

The samples modified using alkali treatment were assessed on the basis of their physical properties. The samples were tested for their weight loss and moisture regain values.

- **Weight loss-** Alkali modification resulted in weight loss of about 6%. The samples appeared to be softer and limper in handle. This might be due to the fact that alkali treatment results in the removal of hydrolyzed polyester material, leading to the weight loss. In addition to it, alkali modification also results in chain scission and formation of carboxyl and hydroxyl end groups.
- **Moisture regain-** Moisture regain is the tendency of fibers to pick up and give off ambient atmospheric moisture until they reach a state of equilibrium at a given temperature and humidity level. Control polyester has a low moisture content of 0.60 ± 0.10%. After modification, moisture regain values for all polyester samples were seen to improve. Modified samples exhibited moisture regain values of 0.98 ± 0.05%.

Assessment of samples printed with disperse dyes and tamarind kernel powder

- **Colour strength measurement-** The colour values of samples printed with fine and bold design exhibited colour value of 5.23 and 7.42. On modification, the colour values of the polyester samples was found to increase. Increase in disperse dye uptake on printing might be due to the increase in surface hydrophilicity by the generation of hydrophilic groups (carboxyl and hydroxyl groups) on the fiber surface due to alkali modification. The modified samples printed with fine design showed colour value of 7.42 and samples with bold design exhibited K/S of 11.88. The results are depicted in Figure 2.

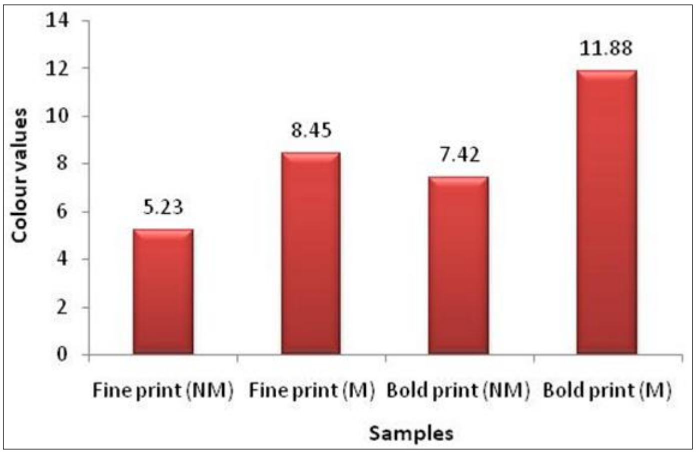

Fig 2: Colour value measurements of printed samples (NM- Non modified, M- Modified)

- **Qualitative analysis-** On the basis of the qualitative analysis results, given in Table 2, it can be seen that the samples printed after alkali modification exhibited better print quality than non-modified samples. Fine and bold printed non modified samples of polyester were scored 14/15 by the experts. On the other hand, modified samples exhibited improvement in sharpness of print lines and were rated 5/5. The modified printed samples also showed uniformity of colour and whiteness of ground and were rated 15/15 by the experts. The results are shown in Figure 3.

Table 2: Visual evaluation of modified and non-modified printed polyester samples (with carrier, steamed for 30min at 130^{O}C).

S. No.	Samples	Uniformity of colour	Sharpness of line	Whiteness of ground	Total
1.	Fine print (Non modified)	5	4	5	14
2.	Fine print (Modified)	5	5	5	15
3.	Bold print (Non modified)	5	4	5	14
4.	Bold print (Modified)	5	5	5	15

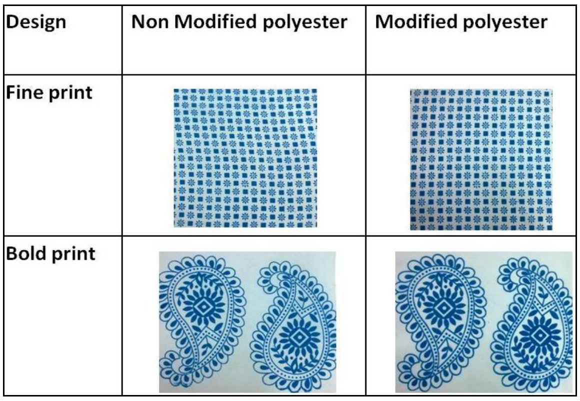

Fig 3: Modified and non-modified polyester samples printed with tamarind kernel thickener and disperse dyes

4. Summary and conclusion

Results of this study show that alkali hydrolysis proves to be an effective modification treatment for creation of new functional groups on the polyester surface without altering much of physical and chemical nature of the fiber. Alkali modification resulted in better colour uptake in printed samples whist making them softer and more hydrophilic. Apart from this, the study also highlighted that a novel printing thickener derived from the seeds of the tamarind, has the potential to be used for printing of polyester with disperse dyes.

5. References

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