ELSEVIER

Dyes and Pigments 45 (2000) 161–168

DYES and PIGMENTS

Dyeing of jute and jute/cotton blend fabrics with 2:1 pre-metallised dyes

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Received 1 December 1999; received in revised form 16 December 1999; accepted 4 February 2000

Abstract

Metal complex dyes are renowned for their excellent light fastness properties on dyed polyamide fibres. Utilisation of pre-metallised dyes to stabilise dye shades on jute and jute/cotton blends was attempted by means of a pretreatment with a commercial product, Polymer PL. The modified cellulosic fabrics exhibit significantly improved dyeability and fastness properties. As a result, cellulosic fibres can be successfully dyed with pre-metallised dyes and cellulosic blends may be dyed with pre-metallised dyes in a one-bath procedure. The light fastness ratings achieved on the modified and dyed jute fabrics were as high as 6. © 2000 Elsevier Science Ltd. All rights reserved.

Keywords: Jute; Jute/cotton blend; Dyeing; Pre-metallised dyes

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1. Introduction

Cotton and jute occupy the first and second places, respectively, in terms of world production levels of cellulosic fibres. However, compared with cotton, the diversified application of jute has been greatly handicapped due to the inherent shortcomings of the fibre. In recent years, serious attempts have been made to develop alternative end-uses for jute in specialty and value-added products. Jute/cotton blends have been highlighted as one of the main outlets for jute towards an entirely new sector of the textile furnishing and apparel industries [1–5]. To generate more profits from jute and jute/cotton blend products, appropriate commercially feasible technologies must be developed to overcome the problems associated with the processing of jute and jute/cotton blends.

One of the major problems that restricts the application of jute products is that jute suffers seriously from light-induced discolouration. Few dyestuffs will attain the same light fastness on jute as achieved on cotton, the fastness ratings often being 0.5–1.5 points lower than that on cotton and, in some cases, a drop of 2–3 points is observed [4,5]. By blending jute with cotton, the problem can be somewhat alleviated by the cotton component; however, the blended fabric on its own does not fulfil the requirements of apparel or furnishing fabrics, especially when the jute content is relatively high in the blend.

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PII: S0143-7208(00)00019-X

In order to achieve a high level of photostabilisation in jute containing products, 2:1 metal complex dyes (commercially named Lanasyn dyes), which are renowned for their excellent light fastness properties on dyed polyamide fibres [6,7], have been employed in this work for the dyeing of jute and jute/cotton blends. However, the following problems associated with the application of metal complex dyes on jute and jute/cotton blends were identified:

1. Jute/cotton blend fabrics could not be dyed properly due to the fact that the cotton component is not dyeable with 2:1 pre-metallised acid dyes. Only when cotton is rendered dyeable by metal complex dyes, can cotton/jute blends be dyed simultaneously by means of a one-bath/one-step process to achieve a high level of light fastness.
2. Although jute can be dyed with 2:1 pre-metallised acid dyes, the dyeing quality is far from satisfactory. The wash fastness of the dyed jute is generally low, often rated at approximately 2–3, leading to a poor durability of the photoprotective effect.

Chemical modification using the commercial product, Polymer PL, was therefore employed for the purpose of rendering cotton dyeable by this class of dyestuff and hence improving the photostability and wash fastness of the dyed jute product. This modification technique has been previously reported for improving the dyeability of cotton with reactive dyes [8].

2. Experimental

2.1. Substrates

The cellulosic fabrics used in this project are given in Table 1.

2.2. Chemicals

The reagent grade chemicals and commercial auxiliaries used in this work are listed in Table 2. All chemicals were used without further purification.

2.3. Dyestuffs

The dyestuffs used are listed in Table 3.

2.4. Scouring and bleaching

The jute, jute/cotton blend and hemp fabrics, supplied in an unbleached form, were initially

Table 2
Chemicals used in this work

Chemical	Supplier
Sodium carbonate	Aldrich
Ammonium sulphate	AJAX
Hydrogen peroxide 30%	BDH
Sodium metasilicate	AJAX
Acetic acid	AJAX
Basolan F (polyquaternary amine derivative)	Ciba
Polymer PL (acrylic copolymer, 30% solids)	Precision Processes Textiles

Table 1
Specifications of the substrates used in the present work

Substrate	Supplier	Weave	Weight (g/m^2)	Chemical Treatment
100% cotton fabric	Charles Parsons, Australia	Twill (2/1)	197.0	Bleached
100% jute fabric	ATIRA, India[a]	Plain	260.8	Unbleached
Jute/cotton (30/70) blend fabric	ATIRA, India	Plain	405.6	Unbleached
100% hemp fabric	Charles Parsons, Australia	Plain	253.7	Unbleached
100% ramie fabric	GTI, China[b]	Plain	103.1	Bleached

[a] ATIRA, Aahmedabad Textile Industry's Research Association.

[b] GTI, Guangxi Textile Institute.

Table 3
Pre-metallised dyes[a]

Trade name	C.I. name
Lanasyn Red GS	C.I. Acid Red 399
Lanasyn Blue BGL	C.I. Acid Blue 250
Lanasyn Red 2GLN	C.I. Acid Red 216
Lanasyn Yellow 2GLN	C.I. Acid Yellow 129
Lanasyn Navy Blue S-BL	C.I. Acid Blue 296

[a] Supplier: Clariant.

subjected to scouring and bleaching prior to the dyeing studies, with the methods specified below.

All 100% jute and jute/cotton blend fabrics were initially scoured for 1 h at 85–90°C in a solution containing 2 g l^{-1} sodium carbonate and 2 g l^{-1} Lissapol TN 450 (a wetting and scouring agent from ICI). The fabrics were then bleached with 1 vol. H_2O_2, LR 30:1, at 80°C for 1.5 hours using a laboratory scale winch dyeing machine (Hope, Australia).

2.5. Dyeing of treated and untreated fabrics with metal complex dyes

Dyeing was commenced at 30°C, the temperature was then raised to the boil at 1.5°C min^{-1} and dyeing was continued at the boil for a further 60 min. The dyeing recipe is described below:

Dye	2% o.m.f.
$(NH_4)_2SO_4$	4% o.m.f.
LR	40:1
Wetting agent	0.3 g l^{-1}
pH	6.5

2.6. Exhaustion measurements

The uptake of dye by both pretreated and untreated samples was measured by sampling the dyebath before and after the dyeing process. The absorbance of the diluted dye solution was measured at the wavelength of maximum absorption ($\lambda_{\max}$) of the dye using a Cary 3 UV–visible spectrophotometer. Percentage dyebath exhaustion, $E\%$, was calculated using Eq. (1):

$$E\% = 100\left(1 - \frac{A_1}{A_0}\right) \tag{1}$$

where A_0 = absorbance of dye solution before dyeing, and A_1 = absorbance of dye solution after dyeing.

2.7. Color strength of the dyed fabrics

The color strength of the dyed samples was determined from the K/S values calculated from the sample reflectance (R):

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

The reflectance (R) of the dyed samples were measured on a Gardner/Neotec Spectrogard colour measurement system, at the wavelength of minimum reflectance, under CIE Illuminant D65 and d/8° illumination/observation.

2.8. Fastness testing

The light fastness of the dyed samples was determined by exposing fabric samples to a mercury vapour, tungsten filament, internally phosphor-coated lamp (MBTF lamp, AS 2001.4.21). Light fastness ratings are quoted according to the rating scales of the Blue Light Fastness Standards (LFS No. 1 to No. 7) as specified in BS 1006, 1990.

Colour fastness to washing was determined by the method specified in AS 2001.4.15-1987, Test K3. Assessment of the change in colour of the samples was made using the Grey Scales as specified in AS 2001.4.1-1987. In addition to visual assessments, the samples were also evaluated objectively by measuring the CIE LAB values (L^*, a^* and b^*) of the dyed samples before and after washing using a Gardner/Neotec Spectrogard colour measurement system, and then calculating the colour change, ΔE. Illuminant D_{65} and 10° observer geometry were used throughout for the colour measurement.

3. Results and discussion

3.1. Dyeing of Polymer PL treated and untreated cellulosic fabrics with 2:1 pre-metallised acid dyes

The well-known class of 2:1 pre-metallised dyes, commercially named Lanasyn dyes (Clariant), was employed in this work in order to achieve a high level of light fastness in jute containing products. The dyeing behaviour of unmodified jute and jute/cotton fabrics was initially investigated.

The results given in Fig. 1(a) show that the exhaustion of the dyes on untreated jute varied considerably. Relatively low exhaustion values (ranging from 50 to 80%) were observed for many dyes such as C.I. Acid Red 399 and C.I. Acid Yellow 129, when 2% o.m.f. dyestuff was utilised, which indicated a relatively low affinity between the dyestuff and jute fibre. The colour yields given in Fig. 1(b) correlate well with the exhaustion results.

A marked increase in the dye exhaustion and color yield, however, can be achieved by utilising

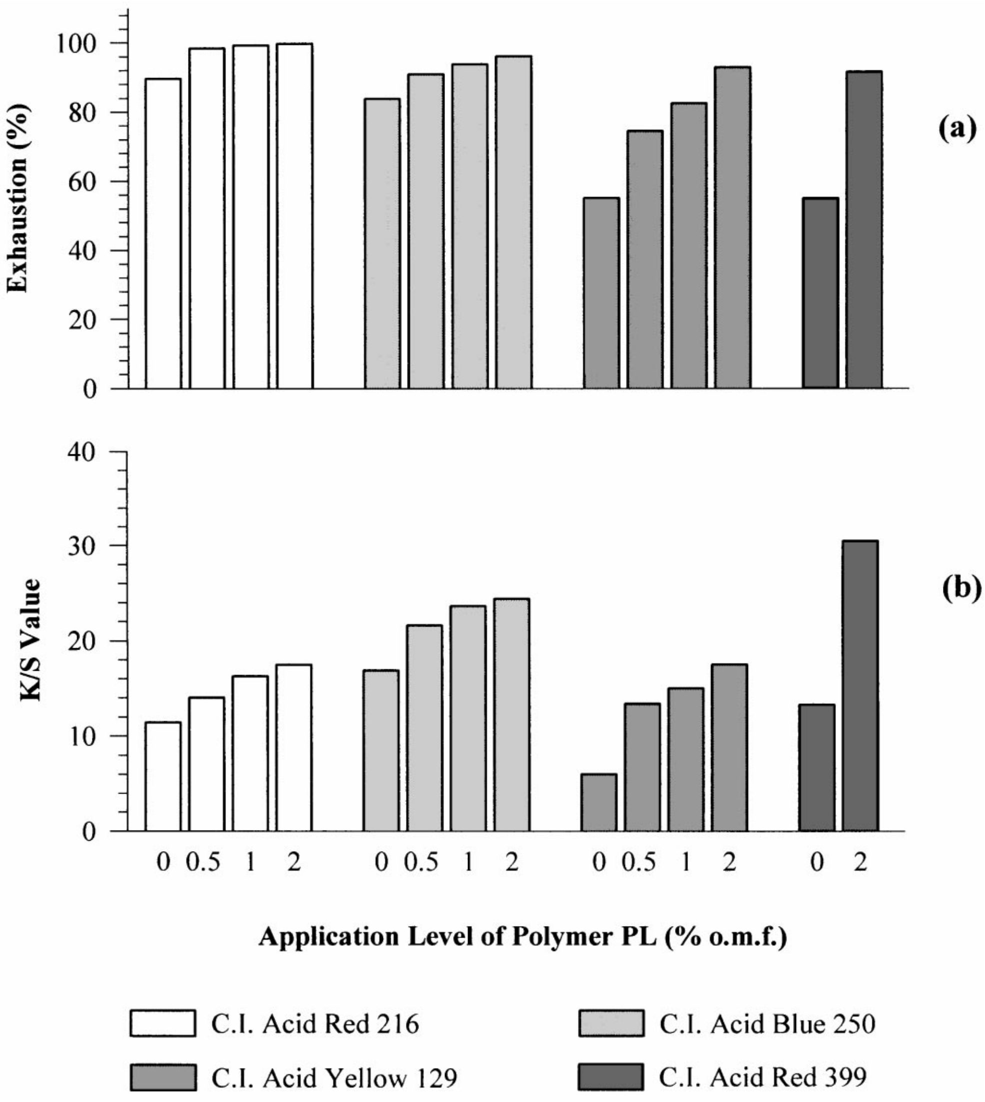

Fig. 1. Exhaustion/colour-yield of 2:1 pre-metallised acid dyes on jute fabrics pretreated using different Polymer PL concentrations (o.m.f.).

Polymer PL as a pretreatment, even at a low application level, for all of the dyes examined.

The dyeability of other cellulosic fibres before and after Polymer PL treatment was also examined. It is clearly demonstrated in Fig. 2 that untreated cellulose fabrics generally do not dye well, except for jute, while the Polymer PL treated fabrics can be successfully dyed. The treated cotton exhibits the best dyebath exhaustion while the treated jute shows relatively low exhaustion values for the corresponding dyes. By comparison, the K/S values for treated and dyed jute are considerably

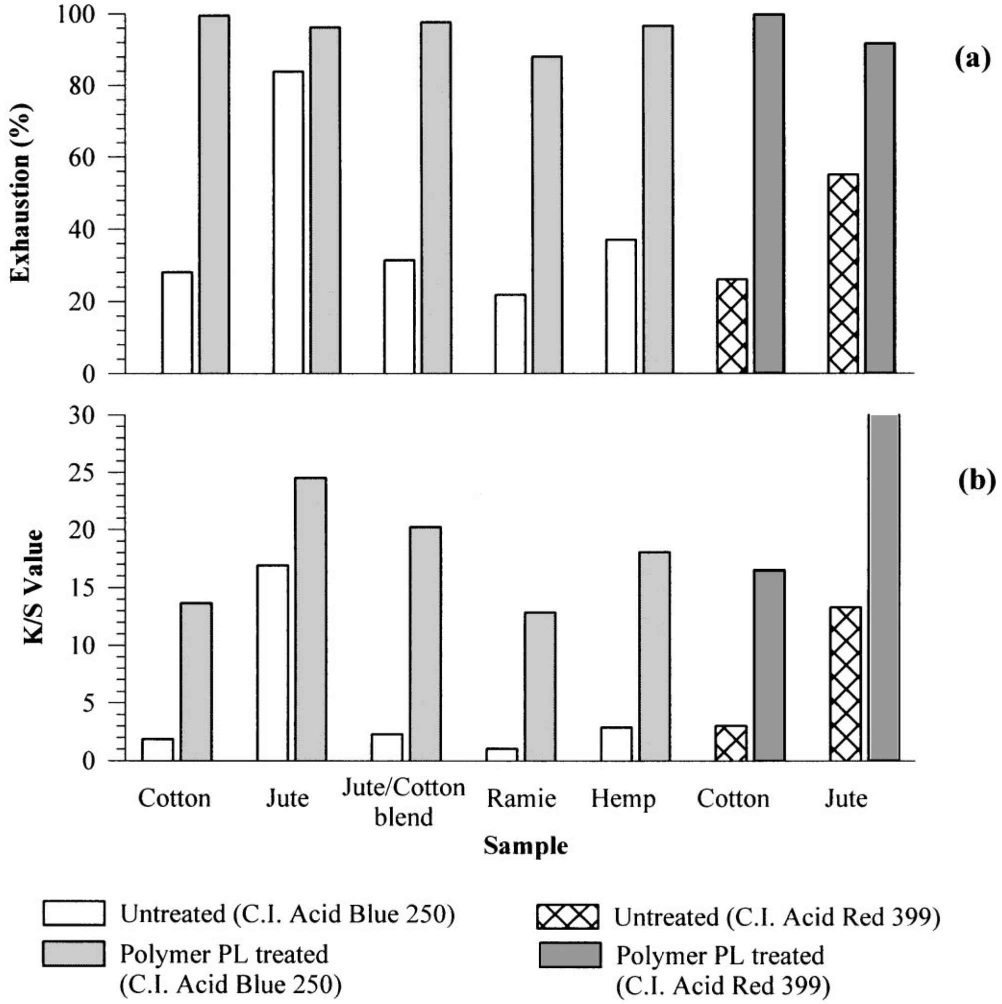

Fig. 2. Exhaustion/colour-yield of 2:1 pre-metallised acid dyes on Polymer PL treated and untreated cellulosic fabrics.

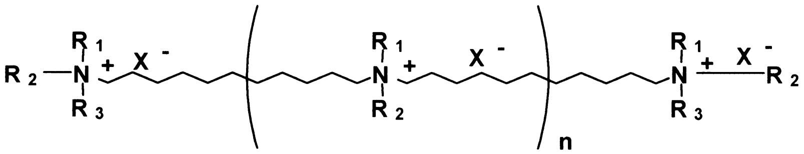

Fig. 3. Schematic structure of Basolan F.

higher than those of treated and dyed cotton. This may be explained by the respective initial colours of jute and cotton, where, cotton is much whiter and thus has a lower initial *K*/*S* value, compared to jute, before dyeing.

It should also be pointed out that the results given in Fig. 2(b) do not represent the actual colour difference of the two components in the dyed blend. This is because the dyeing of the individual fibre components is different from union dyeing

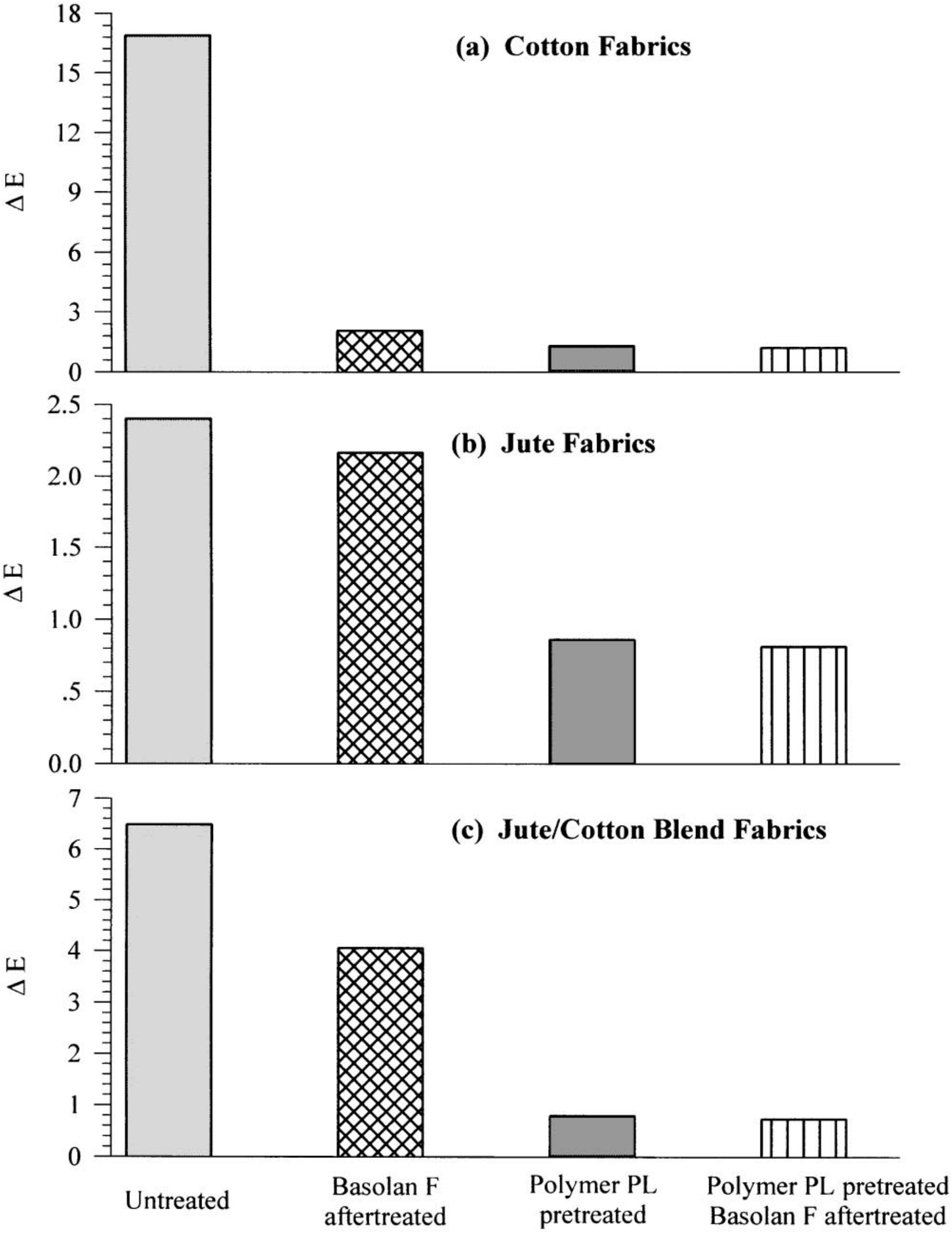

Fig. 4. Effect of Polymer PL pretreatment and Basolan F aftertreatment on wash fastness (expressed as ΔE) of the fabrics dyed with C.I. Acid Blue 250.

(competitive dyeing) of the fibre blends where dye partition is involved. In addition, the cotton and jute samples used in the individual dyeings were not the same cotton and jute fibres made of the blend. However, the results do indicate the different dyeing behaviours of the two fibres and the potential problems for achieving a solid shade.

This study focuses essentially on rendering cotton fibre dyeable. More work needs to be done to achieve a solid shade on the dyed blends.

3.2. Effect of Polymer PL treatment and Basolan F aftertreatment on the wash fastness of the dyeings

Recently, many cationic agents have been developed and applied on a variety of fibres to improve the wet fastness of dyed substrates. Basolan F is one of these effective products, belonging to a group of polyquaternary amine derivatives, of the general structure shown in Fig. 3. It is usually applied after dyeing for improving the wet fastness of anionic dyes, especially milling and 2:1 metal complex dyes, on wool [9]. In this investigation the aftertreatment of the dyed cellulosic fabrics with Basolan F was also examined. The results given in Fig. 4 firstly show that, in addition to the improved colour yield and dyebath exhaustion, the Polymer PL pretreatment results in a marked increase in the wash fastness of the dyeings. The wash fastness was objectively assessed by measuring the CIE LAB of the dyed substrate before and after washing. Hence, a low ΔE value represents a high level of wash fastness. In this treatment process, when Basolan F was incorporated into the aftertreatment, a further improvement in the wash fastness of all the cellulosic dyeings (Fig. 4) was observed, where the resultant fabrics exhibited wash fastness ratings as high as 4–5.

3.3. Effect of Polymer PL treatment and Basolan F aftertreatment on the light fastness of the dyeings

The light fastness ratings are given in Table 4. It can be seen that the Polymer PL pretreated and dyed fabrics also exhibit substantially improved light fastness ratings. This is attributable to the increased uptake of the photostable dyes on the fibres. The Basolan F aftertreatment does not have any appreciable influence on light fastness.

It is worthwhile pointing out that an advantage of utilising metal complex dyes, instead of reactive dyes, on cellulosic fibres, especially jute, is to achieve higher light fastness of the dyeings. Modification with Polymer PL has therefore made it possible for all the cellulosic fabrics and their blends to be successfully dyed with metal complex dyes. Light fastness ratings of 6 are clearly achievable on the treated and dyed jute samples.

3.4. Effect of Polymer PL and Basolan F on the shade of the dyed jute

The Polymer PL treatment results in a much higher K/S value, compared to the untreated fabric, due to the significantly improved dye uptake, but little hue change is observed between Polymer PL treated and untreated jute dyed with the premetallised acid dyes.

Table 4
Light fastness of cotton and jute fabrics dyed with 2% o.m.f. 2:1 pre-metallised acid dyes

Dyestuff	Light fastness					
	Polymer PL treated cotton		Polymer PL treated jute		Untreated jute	
	–[a]	+[a]	–	+	–	+
C.I. Acid Red 399	6–7	6–7	6–7	6–7	5	5
C.I. Acid Blue 250	6	6	5–6	5–6	4–5	4–5
C.I. Acid Red 216	6–7	6–7	6–7	6–7	5	5
C.I. Acid Yellow 129	6–7	6–7	6	6	5	5
C.I. Acid Blue 296	6–7	6–7	6	6	5	5

[a] –, without Basolan F aftertreatment; +, with Basolan F aftertreatment.

Table 5
Effect of Polymer PL and Basolan F on the shade of the dyed jute

Sample	L^*	a^*	b^*	K/S	h°
Untreated	37.75	37.50	19.11	13.26	27.00
Basolan F aftertreated	35.65	38.71	15.37	14.03	21.66
2% Polymer PL	26.40	36.67	18.45	30.45	26.71
2% Polymer PL–Basolan F	26.35	36.64	18.41	30.48	26.68

Basolan F aftertreatment was found to change the shade of the dyes on the jute fabrics, imparting a deeper shade in most cases. The change in hue was obvious for some dyes, which is undesirable. A typical example is given in Table 5 where the dyeing on untreated jute dyed with C.I. Acid Red 399 appears light in shade, whereas when aftertreated with Basolan F, the shade is rendered deeper with an obvious hue change. The change in hue is demonstrated by a relatively lower hue angle found for the aftertreated jute. Compared to the colour of untreated and dyed jute sample, the relatively higher a^* and lower b^* values in the aftertreated jute indicate the presence of greater red and blue components in the colour, respectively. However, in the case of the Polymer PL pretreated and dyed samples, a Basolan F aftertreatment imparts only a very marginal change in the shade.

4. Conclusions

Fibre modification with Polymer PL has importance in the dyeing of jute and jute/cotton blends with metal complex dyes. The treatment significantly improves the uptake of the dyes and color fastness properties of dyed jute. Furthermore, the treatment also renders cotton, ramie and hemp dyeable with metal complex dyes, with a satisfactory dyeing quality. As a result, cellulosic blends may be dyed with pre-metallised dyes in a one-bath/one-step process. The improved light fastness ratings achieved on the modified and dyed jute are as high as 6. The modified jute also exhibits increased dye uptake and improved wash fastness of the dyeings.

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