Application of Biotechnology in the Colouration of Jute Fabric Using Vinyl Sulphone Type of Reactive Dyes

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Abstract

Two sets of processed jute fabric viz, alkaline scoured-bleached and bioscoured-bleached jute fabrics were dyed separately with two nucleophilic addition type (vinyl sulphone type) of reactive dyes namely, Remazol Yellow FG and Amidazol Brown GR dyes. From the experiment it is revealed that bioscoured-bleached reactive dyed jute fabric shows higher dye uptake than that produced by alkaline scoured-bleached-reactive dyed jute fabric in case of both the vinyl sulphone type of reactive dyes. Biotreatment results in improvement of handle and wash fastness properties of jute fabric. Brightness of the shade was also improved in case of biotreatment-bleached-reactive dyed jute fabric.

Keywords: Bioscouring; Cellulase enzyme; Dyeing properties; Jute fabric; Handle properties; Tensile properties; Vinyl sulphone type of reactive dyes; Xylanase enzyme

Introduction

Jute is a biodegradable and renewable lignocellulosic fibre. It is very strong and used for application in technical textiles. Now a days this fibre finds use in making diversified and value added jute products like upholstery, furnishing textiles and even to some extent as apparel textiles. So, look and feel of the fabric is important now. Colouration of jute fabric improves look and aesthetic appeal whereas feel of the fabric is modified by different finishing treatments. Most of the dyes suitable for cellulosic fibre dyeing can be used for dyeing of jute fibre as well with some modifications of process parameters. Jute has been dyed with direct, sulphur, vat, acid, basic and reactive dyes for different end use requirements. Some work has also been done for imparting different functional properties by application of finishing treatments.

Reactive dyes [1] are very popular for dyeing and printing of lignocellulosic fibres particularly jute as this dye produce jute fabric with excellent fastness characteristics. Bioprocessing [2,3,4] of jute fabric makes the process ecofriendly and improves feel of the fabric by introducing some structural changes in jute fibre. In this work an attempt has been made to combine biotreatment and reactive dyeing process by sequential manner. The details are as under:

Methods

Chemical scouring: Grey jute fabric was scoured chemically with sodium hydroxide (2%, owf) and non-ionic surface-active agent (2 g/l) at 90°C for 1hour, keeping the material to liquor ratio at 1:20. Chemically scoured fabric was washed thoroughly in cold water and then treated with acetic acid (2 ml/l) for 20 minutes at room temperature to neutralize the residual alkali present in the fabric. Further cold washing and drying was carried out as usual.

Bioscouring: Grey jute fabric was scoured biochemically with cellulase enzyme (Ezysoft LCP, 4% owf), Xylanase enzyme (Texzyme J, 4% owf) and non-ionic surface-active agent (3% owf) in the same bath at a temperature of 50°C for 2 hours, keeping the material-to-liquor ratio at 1:10. The pH of the bath was maintained at 4.5 by using acetic acid and sodium acetate buffer. After this treatment, the temperature of the bath was raised to 90°C and maintained at that temperature for 15 minutes after which the samples were washed and dried.

Keywords: Bioscouring; Cellulase enzyme; Dyeing properties; Jute fabric; Handle properties; Tensile properties; Vinyl sulphone type of reactive dyes; Xylanase enzyme

Materials and Methods

Materials

Substrate: Grey jute fabric having the following specification was used for the study.

- Warp count: 155 tex, Weft count: 144 tex, Ends/dm: 67, Picks/dm: 65, Fabric mass: 205 gm/m² (at 65% RH and 27°C)

Chemicals: The following chemicals of analytical grade were used in the experiment: Hydrogen peroxide, trisodium phosphate, sodium hydroxide, sodium silicate, sodium acetate, acetic acid, non-ionic surface-active agent (Ultravon IU) and glaubers salt.

Enzymes: A commercial cellulase enzyme, EZYSOFT LCP (M/s Resil Chemicals Pvt. Ltd.) and xylanase enzyme, TEXZYME J (M/s Textan Chemicals Pvt Ltd.) were used for the study.

Dyestuffs: Two nucleophilic addition type (vinyl sulphone) of reactive dyes viz., Remazol Yellow FG (C.I. Reactive Yellow 42) and Amidazol Brown GR (C.I. Reactive Brown 18) were used in the experiment.

For dyeing of jute fabric, different pretreatments were given at sequential manner. The details are as under:

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Bleaching: Bleaching of chemically scoured and bioscourged jute fabrics were done separately in a closed vessel for 90 minutes at 80-85°C, keeping the material-to-liquor ratio at 1:20 with hydrogen peroxide (2 vol.), trisodium phosphate (5 g/l), sodium silicate (10 g/l) and non-ionic surface active agent (2 g/l). The pH of the bath was maintained at 10. After bleaching, the fabrics were washed thoroughly in cold water, neutralized with acetic acid (2 ml/l) for 15 minute at room temperature, again washed in cold water and dried.

Dyeing: Chemically scoured-bleached and bioscourged-bleached jute fabrics were dyed separately with vinyl sulphone type of reactive dyes viz Remazol Yellow FG and Amidazol Brown GR. Dye bath was made with dye (4% owf) and Glauber’s salt (80 g/l) and keeping the material-to-liquor ratio at 1:20. The bleached fabric samples were dipped into the dye bath and kept for 40 minutes with stirring at 30°C. After this treatment, alkali (Sodium hydroxide, 4 g/l) was added in the same bath and kept for one hour for fixation of dye under same condition. Thereafter the dyed fabric samples were washed with cold water, soaped with non-ionic surface active agent (2 g/l) for 15 min at boil followed by usual cold washing and drying.

Evaluation: Grey chemically scoured, bioscourged, chemically scoured-bleached, bioscourged-bleached, chemically scoured-bleached-dyed and bioscourged-bleached-dyed jute fabrics were evaluated by using different standards as under:

a) Whitness index: As per HUNTER scale
b) Yellowness index: As per ASTM D1925 scale
c) Brightness index: As per TAPPI 452 scale
d) K/S value: As per Kubelka-Munk equation
e) L, a, b values: As per computer colour matching system
f) Wash fastness: As per IS:3361-1979

g) Light fastness: As per IS:2454-1967
h) Handle properties: As per IS:6490-1971
i) Tensile properties: As per ASTM D1682-1975

Results and Discussion

Cellulose, hemicellulose and lignin are the main constituent of jute fibre. Bright coloured jute fabrics were produced by different routes namely i) chemically scoured-bleached-reactive dyeing and ii) bioscourged-bleached-reactive dyeing. Optical properties of chemically scoured, bioscourged, chemically scoured-bleached and bioscourged-bleached jute fabrics were studied thoroughly (Table 1).

It is clear from Table 1 that whiteness and brightness of chemically scoured-bleached and bioscourged-bleached jute fabric improves significantly in comparison to only chemically scoured and bioscourged jute fabric. Improvement of whiteness and brightness is more in case of bioscourged-bleached jute fabric.

| Jute Fabric | Whitness index (HUNTER) | Yellowness index (ASTM D 1925) | Brightness index (TAPPI 452) |
|-------------|-------------------------|-------------------------------|-----------------------------|
| Grey        | 48.32                   | 43.75                         | 18.99                       |
| Chemically scoured | 42.78                   | 39.70                         | 15.43                       |
| Bioscourged | 47.63                   | 43.51                         | 18.67                       |
| Chemically scoured-bleached | 81.98                   | 20.21                         | 62.03                       |
| Bioscourged-bleached | 83.11                   | 20.63                         | 63.16                       |

Table 1: Optical properties of grey, chemically scoured, bioscourged, chemically scoured-bleached and bioscourged-bleached jute fabric.
the processes.

bleached jute fabric. Total loss is about 14-15% after completion of all bleached jute fabric also shows loss in strength. This may be due to the reaction during conventional alkaline scouring process. Bioscouring-compared to grey jute fabric. This may be due to more drastic chemical are tabulated in table 4.
dyed fabrics were measured in a tensile testing machine and the results chemically scoured-bleached, bioscoured-bleached and their respective makes the fabric softer. Bending length, flexural rigidity and bending modulus values are not changing significantly after dyeing of both the portion of cellulose and hemicellulose constituent of the fibre, cleavage of ester linkage and shortening of cellulose chain during bioscouring results in easy access of the dye molecules inside the fibre structure.

3. Brightness of the shade was improved in case of biotreatment-bleaching-reactive dyed jute fabric.

4. Wash fastness properties are slightly better in case of biotreated-bleached-reactive dyed jute fabrics.

5. Biotreatment results in improvement of handle properties of jute fabric.

6. There is a small drop of tensile strength of after biotreatment

Conclusions

1. Sequential treatment like biotreatment-bleaching-reactive dyeing of jute fabric shows higher dye uptake compared to alkali treatment-bleaching-reactive dyed jute fabric in case of vinyl sulphone type of reactive dyes.

2. Removal of impurities as well as removal of small quantity of jute constituent during biotreatment results in easy access of the dye

Table 3: Handle properties of grey, chemically scoured-bleached, bioscoured-bleached, chemically scoured-bleached-dyed and bioscoured-bleached-dyed jute fabrics (Dyed with Remazol Yellow FG and Amidazol Brown GR dyes).

Table 4: Tensile properties of grey, chemically scoured-bleached, bioscoured-bleached, bioscoured-bleached-dyed jute fabrics (Dyed with Remazol Yellow FG and Amidazol Brown GR dyes).

| Jute fabric                          | Tenacity (cN/tex) | Extension (%) |
|--------------------------------------|-------------------|---------------|
| Grey                                 | Warp | Weft | Warp | Weft |
| Chemically scoured-bleached          | 4.67 | 5.18 | 5.38 | 5.32 |
| Bioscoured-bleached                  | 4.11 | 4.39 | 8.54 | 8.63 |
| Chemically scoured-bleached-dyed     | 4.21 | 4.35 | 9.41 | 9.74 |
| Bioscoured-bleached-dyed with Remazol Yellow FG dye | 3.96 | 4.02 | 9.66 | 9.85 |
| Chemically scoured-bleached-dyed     | 4.00 | 4.11 | 9.42 | 9.65 |
| Bioscoured-bleached-dyed with Amidazol Brown GR dye | 3.94 | 4.21 | 9.52 | 9.32 |
| Bioscoured-bleached-dyed with Amidazol Brown GR dye | 4.05 | 4.31 | 9.46 | 9.95 |

There is sufficient reduction of bending length, flexural rigidity and bending modulus of chemically scoured-bleached jute fabric compared to raw jute fabric. But these values are further reduced in case of biotreated-bleached jute fabric. Removal of impurities, removal of a portion of cellulose and hemicellulose constituent of the fibre, cleavage of ester linkage and shortening of cellulose chain during bioscouring makes the fabric softer. Bending length, flexural rigidity and bending modulus values are not changing significantly after dyeing of both the fabric with vinyl sulphone type of reactive dyes.

Tensile properties [9] like tenacity and extension values of grey, chemically scoured-bleached, bioscoured-bleached and their respective dyed fabrics were measured in a tensile testing machine and the results are tabulated in table 4. Chemically scoured-bleached jute fabric leads to loss in strength compared to grey jute fabric. This may be due to more drastic chemical reaction during conventional alkaline scouring process. Bioscouring-bleached jute fabric also shows loss in strength. This may be due to the enzyme action on the fibre. Dyeing operation shows very minimum loss in strength compared to chemically scoured-bleached and bioscouring-bleached jute fabric. Total loss is about 14-15% after completion of all the processes.

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