The Effect of Some Solvents on the Morphology and Dye Up-Take of Cellulose and Regenerated Cellulose Fabrics

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Abstract

The grey cellulose (cotton) and regenerated cellulose (viscose rayon) fabrics of the same fabric particular were desized, scoured and bleached. Solvent treated under reflux and then dyed to the same shade with direct dye. The effect of solvent such as methanol, ethanol, propan-1-o1, chloroform, sodium hydroxide and water were investigated using Durazol R-150 a direct-dye. The adequate solvent to specimen ratio is 25:1 for the best result obtained. During refluxing the temperature range used was important especially in the use of chloroform where great care must be taken because of its high volatility. The effect of sodium hydroxide on both viscose rayon and cotton is very good and encourage dye up take to greater level. This is followed by those of alcohols, water also have outstanding effect on cotton fabric but less effect on viscose rayon and finally chloroform has good effect on viscose rayon but less effect on cotton.

Key words: Cotton**,** viscose rayon, solvent, dye

Introduction

Rayon is the oldest commercial man-made fibre (Sisson, 1946). The U.S trade commission defines rayon as man made textile fibre comprised by regenerated cellulose (Sisson, 1946). The most used natural fibre is cotton which is a hair attached to the seeds of certain plants of genius 'Gossypium'. The cotton plant is a shrub which grows to a height of 1.2 to 1.8 meters, hand is indigenous to many sub-tropical countries (Sadoretal, 1998; Nkeonye, 1993). The accessibility areas of cellulose are cotton, viscose rayon, etc defined as the amorphous areas plus the surfaces of the crystalline micelles (Leon,1971). The effect of alcohol on cotton has been investigated and it was found that absorbency of cotton increase with alcohol treatment. The increase absorbency after alcohol treatment has been proposed to be due to the formation of voids created by the dissolution of alcohol soluble fragment within the cellulose structure, which now become accessible to the smaller polar water molecules (Hardy, 1987; Christie, 2009). Scouring and bleaching with chemical agents in addition to imparting the desired degree of wetness also remove materials from the walls and leave behind voids. The presence of these voids has been demonstrated by many methods (Hardy, 1987). The most popular methods used is the nitrogen gas absorption, which has been of considerably value in elucidating the internal structure of many organic and iatrogenic materials (Hardy, 1987; Broadbent, 2001). A differential dye absorption method was used which indicate the formation of voids in cotton, following chemical treatment e.g during scouring and bleaching operations, as well as those due to physical treatment such as subjecting the bleaching viscose to alcohol (Harison, 1998; Fox and Summer, 1986).

Experimental

Materials

The materials used for this research work include viscose rayon and cotton woven fabrics obtained from the Department of Textile Science and Technology, Ahmadu Bello University, Zaria, Nigeria.

Methods

Preparatory Processes

Desizing

The fabric was immersed in a freshly prepared solution containing 0.1% by mass of non-ionic wetting agents together with an appropriate amount of 2% biolace was prepared using liquor ratio of 100:1. The pH of the solution was 6.0 and concentration of 2% biolace, the temperature was 85°C, the time of boiling was 20 minutes. The specimen was then rinsed properly in distilled water, tested with iodine solution and then dried.

Scouring

The material was immersed in a solvent (27% NaOH) for 1½ hours, heated gently to 60°C. The process was followed by boiling in water, rinsed and dried.

Bleaching

The bleaching was done in a bath containing 30% hydrogen peroxide bleaching agent 5% on the weight of fibre (5% o.w.f). 1.4% caustic soda and 79% sodium silicate (3% o.w.f), a wetting agent was also added approximately. The bleaching time was 60minutes at the boil. The specimen was then removed properly, rinsed and dried.
Volume of reagent = WP/C

Where;

W = weight of fabric
P = percentage shade
C = concentration of reagent

Fabric Treatment

Seven samples of fabric was taken and weighed. Six different treatment were given to the fabric samples, each got just one treatment and the seventh served as a control on percentage loss in water corresponds to the amount of impurities lost and proportion of the voids space created. It was calculated using the following equation:

$$\% \text{ loss in weight} = \frac{\text{Weight of grey fabric} - \text{weight of treated fabric}}{\text{Weight of grey fabric}} \times 100$$

Treatment with Ethanol

A sample of the prepared fabric was weighed on a top load balance and the weight was recorded. The fabric was refluxed using 200ml of ethanol and a liquor ratio of 25:1 was maintained at a constant temperature of 78.4°C for 1 hour. It was allowed to cool down slowly, and the excess ethanol was poured out. The excess ethanol was squeezed out and the fabric thoroughly rinsed in distilled water. The treated sample was then dried in the oven at 100°C for 48 hours after which the treated sample was conditioned for 24 hours. The weight of the treated sample was taken and recorded.

Treatment with Propan-1-Ol

A sample of the prepared fabric was weighed on a top load balance and the weight recorded. The fabric was refluxed using 200mls of propan-1-ol a liquor ratio of 25:1 maintained at a constant temperature of 81°C for 1 hour. It was allowed to cool down gently. The excess propan-1-ol was squeezed out and the fabric thoroughly rinsed in distilled water. The treated fabric was then dried in an oven at 100°C for 48 hours after which the sample was conditioned for 24 hours. The weight was taken and recorded.

Treatment with Chloroform

A sample of the prepared fabrics was weighted on a top load balance and the weight recorded. The fabric was refluxed using the fabric to liquor ratio of 25:1 maintained at a constant temperature of 100°C for 1 hour. It was allowed to cool down gently, excess chloroform was poured out, squeezed and the fabric thoroughly rinsed in distilled water. The treated fabric was then dried in an oven at 100°C for 28 hours, after which was conditioned for 24 hours and the weight was taken and recorded.

Treatment with Sodium Hydroxide

A sample of the prepared fabric was weighed on a top load balance and the weight recorded. The fabric was reflux using the fabric to liquor ratio of 25:1 maintained at a constant temperature of 50°C for 1 hour.

It was allowed to cool down gently, excess Na0H liquor was squeezed out and the fabrics thoroughly rinsed in distilled water. The treated sample was dried in an oven at 100°C for 48 hours, after which it was conditioned for 24 hours and the weight was taken and record.

Treatment with Methanol

A sample of the prepared fabric was weighed on a top load balance and the weight was recorded. The fabric was refluxed using the liquor specimen ratio of 25:1 maintained and cool down gently, excess methanol was dried in an oven at 100°C for 48 hours after which it was conditioned for 24 hours and the weight was recorded.

Treatment with Water

A sample of the prepared fabric was weighed on a top load balance and the weight recorded. The fabric was refluxed using the liquor to specimen ratio of 25:1, maintained at a constant temperature of 90 for about 1hours. It was allowed to cool down gently, excess of distilled water poured out, the fabric was squeezed, thoroughly rinsed in another fresh portion of distilled water. The treated fabric was dried in oven at 100C for 48 hours, after which it was conditioned for 24 hours and the weight was recorded.

For the control experiments, a portion of the prepared fabric was left untreated.

Dyeing with Durazol Orange R-150

The dye powder was mixed in beaker with some warm water, making sure that the dye completely dissolved to avoid unleveled dyeing. Some of the dye solution was placed in enough water to cover the materials. The amount of dye depends on the depth of shade being dyed. The concentration of the dye and sodium chloride are 10% and 5% respectively. The fabric was immersed into the dye bath and raised slowly to the boil making sure that the sample is being stirred to ensure an even dyeing. The sample was dyed at the boil for 40 minutes. Then removed from the dye bath, rinsed in cool water and examined for good shade.

Volume of Substance=WP/C

Volume of water = Total bath volume - (volume of NaCl + Dye)

Results

Table1: Preparatory Processes for Grey Cotton and Viscose Rayon Fabrics

Cotton fabrics				Viscose Rayon fabrics		
Processes	Untreated cotton fabric (g)	Treated cotton (g)	Impurities (%)	Untreated viscose rayon fabric (g)	Treated viscose rayon fabric (g)	Impurities (%)
Desizing	7.35	6.98	5.03	5.89	5.86	0.51
Scouring	6.50	6.43	1.08	4.87	4.84	0.62
Bleaching	6.43	6.41	0.31	4.71	4.71	0.00

Table 2: Solvent Treatment for Cotton and Viscose Rayon Fabrics

Cotton Fabric				Viscose Rayon Fabric		
Solvent	Untreated cotton fabric (g)	Treated cotton fabrics(g)	Absorption	Untreated viscose Rayon fabric (g)	Treated viscose Rayon fabric (g)	Absorption
Sodium hydroxide	0.376	0.377	0.002	0.267	0.269	0.002
Methanol	0.473	0.474	0.001	0.376	0.377	0.001
Ethanol	0.421	0.422	0.001	0.314	0.315	0.001
Propan-1-ol	0.474	0.475	0.001	0.411	0.412	0.001
Chloroform	0.348	0.348	0.00	0.357	0.358	0.001
Water	0.399	0.420	0.021	0.298	0.310	0.012

Table 3: Dye Absorption for Cotton and Viscose Rayon Fabrics

Solvent	Undyed cotton fabric (g)	Dyed cotton fabric (g)	Absorption	Undyed viscose rayon fabric (g)	Dyed viscose rayon fabric (g)	Absorption
Sodium hydroxide	0.377	0.380	0.003	0.269	0.271	0.002
Methanol	0.474	0.478	0.004	0.377	0.379	0.002
Ethanol	0.422	0.424	0.002	0.315	0.317	0.002
Propan-1-ol	0.475	0.478	0.003	0.412	0.415	0.003
Chloroform	0.348	0.350	0.002	0.358	0.359	0.001
Water	0.420	0.422	0.003	0.312	0.302	0.001
Untreated	0.407	0.408	0.001	0.311	0.312	0.001

Discussion of Results

The preparatory processes for grey cotton and viscose rayon fabrics as shown in the Tables1 indicate the presence of size, oil and wax. Also, Table1 shows the presence of more size in the grey cotton fabric, other impurities like oil, lubricant and wax were found to be more in grey cotton fabric. Table 1 shows the presence of more natural colouring matter in the grey cotton fabric than the viscose rayon fabric.

It can be observed in Table 2 that the absorbency of cotton and viscose rayon fabrics increases with alcohol treatment. This was proposed to be due to the formation of voids created by the dissolution of alcohol soluble fragment within the cellulose structures, which now become accessible to the smaller polar water molecules (Harrison, 1998; Reichardt and Welton, 2010). A differential dye absorption method was used to indicate the formation of void in cotton, following chemical treatment e.g. during scouring and bleaching operations, as well as those due to physical treatment such as subjecting the bleached viscose to alcohol boiling. The action of water, methanol, ethanol, propan-1-ol, chloroform and concentrated aqueous solution of sodium hydroxide on native regenerated cellulose (viscose rayon) and cotton fabrics were investigated as shown in Table 3. It was found that the penetration rate of dye particles depended on the structure of the accessible phase in cellulose (Hardy, 1987; Harison 1998; Hunger, 2003).

Conclusion

The effect of pretreatment with methanol, sodium hydroxide, ethanol, propan-1-ol and chloroform on the viscose rayon and cotton fabrics leads to an increase in the dye uptake.

Considering precaution within the experimental limit, the pretreatment with methanol on cotton woven fabrics showed the most increased absorption which was due to the formation of voids within the intermicrofibrile regions of cotton created through the dissolution of alcohol-soluble fraction which allows for further penetration of the lightly- polar water molecules. This also could be the reason for increased absorption of cotton woven fabric treated with ethanol and propan-1-ol. The chloroform pretreated viscose rayon fabric shows a very pale dyeing. The pretreatment sample with 2% NaOH shows dyeing that was better than the chloroform but not as good as those of the alcohol. This high absorbency was due to the swelling action of the scouring liquor on the fabric in which it's increase in absorption appear to be physical i.e due to the formation of voids within the fiber structure. Normally the absorption of cotton is greater than that of viscose rayon, and this pretreatment further increase the absorption of cotton because of high impurities in cotton. However, the absorption of viscose rayon is also reasonably increased.

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