INFLUENCE OF DYE EXHAUSTION ON THE DYEING OF COTTON AND VISCOSE RAYON WOVEN FABRICS WITH DIRECT DYE

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Abstract
Before dyeing the two fabrics, preparatory processes was carried out for the two fabrics. These involve desizing, scouring and bleaching. The two fabrics were dyed at the same temperature, time, and concentration. The dyeing temperature was at 75ºC and at a concentration of 1% of the dye (direct dye) for 15mins. Calorimeter was used to measure the rate of dye exhaustion. At the end of the experiment, it was found that cotton fabric absorbed more dye than the viscose rayon fabric.

Keywords: Preparatory processes, Direct dye, Exhaustion, Properties

Introduction

Dyeing is one of the most ancient crafts and its history can be traced back at least 4000 years ago. It involved a high degree of skills and details of the methods used by dyers were jealously guarded because, it was considered a secret technology (Isah, 2009; Bird and Boston, 1976). A dye is defined as any substance which is deeply coloured soluble in water, and can impact the colour to it substrate when dissolved in water, or could be defined as an organic chemical of chiefly synthetic origin although some are also extracted from plant, most dyes were synthesized from raw materials (chemicals) derived from coal tar or petroleum (Gin et al, 2012; Giles, 1974; Nuhu, 1979; Vencataraman, 1972). Until the middle of the 19^{th} century, all dyes used were natural products, extracted in most cases from a variety of plants, but also from a few animal sources (Isah, 2009). Direct dyes were introduced in 1884 by Bottiger. Electrolyte were used to promote dye exhaustion and such dyes colour cotton and its derivatives directly (Abah, 2006; Meng and Jiliang, 2010). Direct dyes are anionic dyes substantive to cellulose when applied from an aqueous bath containing an electrolyte. They provide the simplest means of dyeing cellulose materials since they are normally applied from a neutral or slightly alkaline bath, near the boil, to which these electrolytes are added. Based on their application to cellulose, direct dyes give a wide range of shades and poor to moderate washing and light fastness properties (Abah, 2006; Nkeonye, 1994). Direct dyes provide the simplest means of dyeing cellulose materials. They are generally applied from a metal or slightly alkaline bath at or near the boil to which electrolyte could be added in small quantities and at such interval of times appropriate to the dyeing proper of individual dyes (Abah, 2006; Sani, 2010; Trotman, 1970). The purpose of this research is to dye cotton and viscose rayon fabrics and compare the rate of dye exhaustion of these fabrics using the optical densities obtained from UV spectroscopy machine.

Materials

The materials used includes grey cotton and viscose rayon fabrics, biolase (enzyme), sodium silicates ($NaSi0_3$), sodium hydroxide (NaOH), hydrogen peroxide (H_2O_2), sodium chloride (NaCl), sodium carbonate (Na_2CO_3), durazol orange 4R (direct dye)

Methods

Preparatory processes
Each of the fabric was weighed to 1.5g and a Liquor ratio of 100:1 was maintained throughout the preparatory processes.

Desizing
The fabrics were impregnated with 2% solution of enzyme biolase for 20 minutes at room temperature. The samples were removed and then rinsed in 2.5% NaOH solution at about 90^0C. Then, this was followed by rinsing in water at 90^0C. It was finally rinsed in cold water and dried. To test for the efficiency of the treatment, two drops of iodine was applied to the treated fabric and the untreated fabric. The sized piece turned blue black indicating the presence of starch while the desized piece retained the yellowish colour of iodine showing that starch has been removed during the desizing process.

Scouring
The samples were treated with 2% NaOH solution for 10min at the boil. The samples were removed and rinsed thoroughly with water and dried. The efficiency of scouring was tested by padding the desized and scoured fabric in water. It was found that the scoured got wet after 30-35 seconds while the desized took longer time to get wet.

Bleaching
The bleaching was done in a bath containing hydrogen peroxide bleaching agent, 3 to 5% o.w.f H_2O_2 (30%), 0.6 to 1.4% caustic soda and 2 to 3% o.w.f sodium silicate (79%), the bleaching was about 40-60mins at the boil. The samples were then removed properly rinsed and then dried.

Dyeing with Durazol orange 4R (direct dye)
Preparation of the dye bath: the weight of each fabric is 1.3g and the liquor ratio of 30:1 was used throughout the dyeing.
The dye bath contains:
1% of Durazol orange dye,
2.5% Percentage shade,
20% (5.85g) of salt concentration

Dyeing of viscose rayon and cotton woven fabrics with direct dye
The rate of exhaustion of viscose and cotton fabrics with direct dye were studied empirically with the help of calorimeter. The λ_{max} of the dye used is 505nm. The dyeing was carried out at 75ºC for 15mins at a constant concentration of 1% of dye used. The spectrophotometer is a highly sophisticated machine used for the determination of the absorbance (optical density) of substances. The machine makes use of a monochromatic light (Meng and Jiliang, 2010). This was used for taking the maximum absorbance of the dye.

Measurement of optical density
The visible spectrophotometer was used to take the wavelength of maximum absorbance of the dye which is 505nm. The optical densities of the dye bath before and after each dyeing were obtained with this instrument. It was ensured that the wavelength was set to the maximum wavelength of the dye used at that point while using the instrument. Distilled water was used as the blank to calibrate the instrument to zero absorbance in each case.

Determination of exhaustion

The spectrophotometer was used in determining the optical densities (absorbances) of the bath before and after dyeing. The machine was set to zero absorbance using distilled water. The exhaustion was calculated as follows:

$$\text{Exhaustion } (\%) = \frac{D_1 - D_2}{D_1} \text{ x } 100$$

D_1 = optical density before dyeing
D_2 = optical density after dyeing
$D_1 - D_2$ = amount of dye transferred into the fabric after dyeing.
The Dyeing was carried out at a constant concentration of 1% Durazol orange 4R, temperature of 75^0C and at a time of 15mins.

Results

Table 1: Rate of dye exhaustion of direct dye with cotton fabric

Samples	D_1(a)	D_2(b)	Rate of dye exhaustion (%) (a)	D_2(b)	Rate of dye exhaustion (%) (b)	Average rate of dye exhaustion (%)
1	0.678	0.084	87.61	0.071	88.35	87.98
2	0.678	0.085	87.46	0.084	87.61	87.54
3	0.678	0.037	94.54	0.034	94.77	94.77
4	0.678	0.032	95.28	0.03	95.58	95.43
5	0.678	0.027	96	0.03	95.58	95.79
6	0.678	0.036	94.69	0.034	94.85	94.85
7	0.678	0.047	93.07	0.048	92.92	93
8	0.678	0.034	94.99	0.036	94.69	94.84
9	0.678	0.023	96.61	0.025	96.31	96.46
10	0.678	0.041	93.95	0.042	93.81	93.88

Average rate of dyeing = 93.45%

Table 2: Rate of dye exhaustion of direct dye with viscose rayon fabric

Samples	D_1	D_2(a)	Rate of dye exhaustion (%) (a)	D_2(b)	Rate of dye exhaustion (%) (b)	Average rate of dye exhaustion (%)
1	0.678	0.09	86.73	0.081	86.61	86.67
2	0.678	0.081	88.05	0.105	84.5	86.28
3	0.678	0.075	89.3	0.069	89.82	89.56
4	0.678	0.041	93.95	0.028	95.87	94.91
5	0.678	0.037	94.54	0.041	93.95	94.25
6	0.678	0.058	91.45	0.053	92.18	91.82
7	0.678	0.048	92.92	0.051	92.48	92.7
8	0.678	0.043	93.66	0.04	94.1	93.88
9	0.678	0.032	95.28	0.039	94.25	94.77
10	0.678	0.045	93.36	0.047	93.07	93.22

Average rate of dyeing = 91.81%

Discussion of Results

The exhaustion of direct dye with viscose rayon and cotton fabrics is shown in Tables 1 and 2. The two Tables show how cotton and viscose rayon fabrics absorbed dye at the same time, temperature and concentration of dye. The exhaustion of the dye used was measured before and after dyeing. The reading of the dye exhaustion after dyeing was taken twice and the average rate of dyeing was calculated for both fabrics. The Tables also shows that the rate of exhaustion of cotton with direct dye is higher than the viscose rayon due to the fact that the dye enter the fabric in a molecularly dispersed state and then became aggregated to such a size that they cannot easily migrate out again.

Conclusion

The exhaustion properties of direct dye with viscose rayon and cotton fabrics were different. From the Tables, it shows that cotton absorbed direct dye more excellently than the viscose rayon fabric due to the amorphous nature of cotton fabric. The cotton structure is not orderly arrange and so compacted, so the dye was easily absorbed than the viscose which has a crystalline structure. However, cotton absorbed more direct dye than viscose rayon. For cotton fabric, the average dye exhaustion is 93.45%, while viscose rayon fabric the average dye exhaustion is 91.81% at the same temperature, time and concentration of dye used.

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