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Research Article

REMOVAL OF COLOUR POLLUTIONS IN DYE BATHS WITH MORDANTS

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ABSTRACT

In the current study, the colour vitality, wash, rubbing and diaphoresis fastness were evaluated for cotton substrates with and without anionic (tannin) mordanting. It was found that pre-mordanting with tannic acid affect both the colour characteristics and fastness properties of the cationic dye. Overall, mordanting with tannic acid gave the best results in terms of both colour vitality and fastness properties.

Keywords: *Mordant, Tannic Acid, Cationic Dyes, Fastness Properties, Cotton*

1. INTRODUCTION

Cotton is the best plentiful of all instinctively resulting organic materials and is extensively consumed. It is used either alone or in conjunction with other synthetic fibers in differing ranges of clothing. This material specifically presents superior tangible and synthetically properties in terms of water absorbency, dyeability and stability (Preston, 1986; Shore, 1995).

During several classes of dye can be favorably applied to the cotton fibers, containing direct, azoic, vat and reactive dyes. The use of cationic dyes has not acquired widespread success. In this study, for applying cationic dye to the cotton fibers the anionic agent (tannic acid) containing glucose esters of gallic acid was consumed and its effect was determined.

Tannins are delimited as naturally resulting water-soluble polyphenols of varying molecular weight (Bhat *et al.*, 1998). Tannins are found to be resulting in vascular plant tissues of leaves, seeds, and flowers (Mingshu *et al.*, 2006). Tannins are considered nutritionally unacceptable because they restrict digestive enzymes and affect the exercise of vitamins and minerals. Swallow of large quantities of tannins may result in unfavorable health effects. However, the consumption of a small amount of the right kind of tannins may be advantageous to human health (Gu *et al.*, 2003). They are detached into two classes: soluble and shortened (not soluble) (Haslam, 1966). Soluble tannins are toxic to animals and matter poisoning if devoured by them in large aggregate (Garg *et al.*, 1992). Tannins restrict the growth of a number of microorganisms, oppose microbial attack, and are recalcitrant to biodegradation (Field and Lettinga, 1992).

Despite the antimicrobial properties of tannins, many fungi, bacteria, and yeasts are quite resistant to tannins and can grow and develop on them (Bhat *et al.*, 1998). The importance of tannin biodegradation in accordance to industrial and agricultural uses has been published earlier (Archambault *et al.*, 1996). By considering these facts, an effort has been made to isolate and recognize cold-adapted tannic acid debasing bacteria by optimizing various parameters of deterioration.

Treatment cotton fabrics with tannins propose supplementary hydroxyl groups on the fiber matrix. A textile fibre pretreatment with a mordant, in order to achieve dyeings of improved fastness and depth of shade, has been practiced since time immemorial. The tannins play an important role in cotton dyeing to absorb colouring matter forever (Gulrajani, 1999). With these reasons, tannin was chosen to improve dye fixation and to remove dye pollutions in dye bath.

2. EXPERIMENTAL METHOD

2.1. Materials

2.1.1. Fabric

100% Cotton woven fabric was consumed through out this work.

2.1.2. Cationic Dye

Cationic dyes under commerce name of Maxilon produced by Setap Specialty Chemicals Co. were used

through out this study: Setacryl Red P-4B(C.I. Basic Red 46)

2.1.3. Chemicals

Tannic acid ($C_{34}H_{25}O_{23}$), acetic acid, sodium sulphate, sodium carbonate were laboratory class chemicals. Non-ionic detergent was consumed in this work. Tannic acid powder (No.0.0773.1000-1kg),(Merck) pattern was consumed as supplied.

2.2. Methods

2.2.1. Scouring of Cotton Fabrics

Fabrics were washed in bath contain 1g/L of non-ionic detergent and 2 g/L Na_2CO_3 for 20 minutes at 60 °C. After washing the fabrics were rinsed and dried.

2.2.2. Treatment with Tannic Acid

The cotton fabrics were treated with tannic acid as a surface modifier to deliberate an anionic character to cotton fabric to improve its dyeability towards cationic dye. As shown in Fig. 1, the fabrics were treated with four diverse concentrations of tannic acid (zero, 5 %, 10 %, 15 %) before the dyeing process.

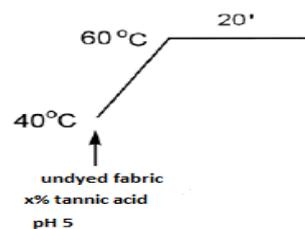


Fig. 1. Pre-mordanted fabrics with tannic acid

The treatments were carried out 20 minutes, 60 °C at 1:20 liquor to ratio; after which samples were stained with cationic dye.

2.2.3. Dyeing Process

The treated and untreated fabrics were dyed with % 4 cationic dye and 6g/L sodium sulfate Na_2SO_4 to ensure good and uniform allocation of the dye within the dyebath. The pH of the dye bath was adjusted at 4-6 by adding acetic acid.

The temperature of dye bath was evenly raised to (80-100 °C). The dyeing process was accomplished 60 minutes at 80 and 100 °C. The dyed fabrics rinsed well in cold water and then washed in bath containing 1g/L non-ionic detergent at liquor to ratio 1:50 for 20 minutes at 70 °C. The dyeing process is illustrated in Fig. 2.

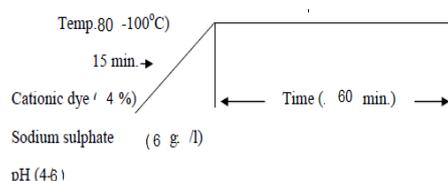


Fig. 2. Dyeing Process

2.2.4. Testing

The results of the dyeing experiments were obtained according to the color measurements of the samples with a X-rite CFS 57 CA reflectance spectrophotometer under D65/10° illuminant between 320-750 nm. The colour intensity, expressed as the K/S value, calculated by the Kubelka-Munk equation (1):

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

where K is a constant about the light absorption of the dyed fabric; S, a constant about the light scattering of the dyed fabric and R, the reflectance of the dyed sample. The higher the K/S value, the greater is the color intensity and, hence the better is the dye uptake.

2.2.5. Colour Fastness

Colour fastness to light was according to AATCC test method 16A-1971. Colour fastness to rubbing was accomplished in accordance with Colour fastness to rubbing dry & wet C8 consuming Crock-meter. Colour fastness to diaphoresis was carried out in accordance with AATCC test method 15-1973.

3. RESULTS AND DISCUSSION

3.1. Effect of Tannic Acid Treatment

The synthetical formula for commercial tannic acid $C_{34}H_{25}O_{23}$ is given in Fig. 3.

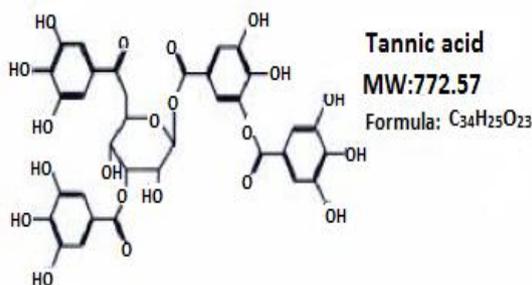


Fig. 3. Tannic acid formula

Its structure is based mainly on glucose esters of gallic acid. It is a yellow to light brown amorphous powder which is highly soluble in water. Treatment cotton fabrics with tannins introduce additionally hydroxyl and carboxyl groups on the fiber matrix. Tannic acid is an average mordant consumed in the dyeing process.

Increasing tannic acid concentration, dyeing pH value and dyeing temperature cause the cationic dye exhaustion to the cotton fibers to increase. With the time of dyeing, the colour vitality increases. For this reason, this process is accomplished 80-100 °C 60 minutes.

Fig. 4 shows the effects of tannic acid pretreated and untreated samples under changing dyeing pH on K/S values. It can be noticed that the colour vitality for all treated cotton fabrics showed higher colour vitality than untreated ones. The colour strength of dyed cotton fabrics

increases as the concentration of tannic acid enhance till reach 10% which is followed by some decrease in K/S.

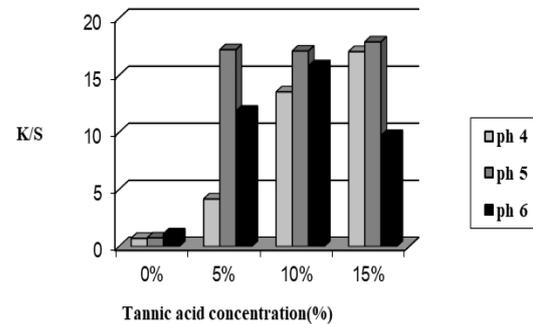


Fig. 4. K/S values of tannic acid-treated and untreated samples under different dyeing pH values.

In different circumstances, hydrogen bonding may also be produced between tannin and the hydroxyl groups of cotton cellulose as follows:

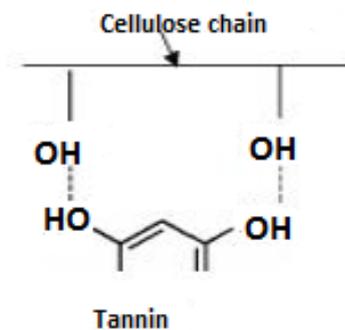


Fig. 5. Tannin compound

In these cases, the number of anionic sites on fibers i.e. cotton, will be enhanced as a result of pretreatment with tannic resulting in enhancing the responsiveness and approachability of cotton fibers to cationic dyes. At higher concentration of tannic acid, it would be expected that problems essential to aggregation would be much distinct, leading to decrease the substantivity of tannic acid to cotton fabrics and equilibrate its concentration in water and on fiber (Mahangad *et al.*, 2009). The effect of pH on the dyeing process with cationic dye, dyeing was carried out at different concentrations of treatment with tannic acid and under constant dyeing pH values. The colour vitality of the dyed samples were measured and the results are plotted in Fig. 6.

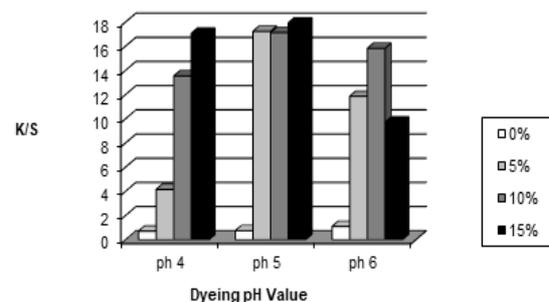


Fig. 6. K/S values of dyeing pH values under different tannic acid concentrations.

From Fig. 7, it can be seen that the colour vitality increases as the temperature increase till 100 °C. No substantial change in colour vitality is observed above 100 °C. It may be achieved from the results that 100 °C and pH 5 are found to be the most suitable dyeing conditions for giving maximum colour vitality with cotton fabrics.

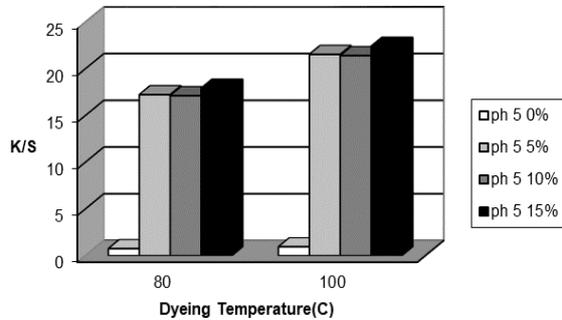


Fig. 7. K/S values of dyeing temperature under different tannic acid concentrations at dyeing pH 5.

3.2. Fastness Properties of Dyed Cotton Fabrics

The fastness properties (washing, rubbing, diaphoresis and light) of dyed cotton fabrics with cationic dye at the optimum condition after the treatment with tannic acid were cited in Table 1. It is clearly observed from Table 1 that the wash fastness, wet and dry rubbing fastness gave grades between 2 and 4-5 while fastness to acidic and alkaline diaphoresis showed good results as well as the fastness to light.

Table 1. Fastness properties of dyed cotton fabrics

Name of Cationic Die	Washing Fastness	Washing Fastness	Rubbing Fastness	Rubbing Fastness	Perspiration Fastness	Perspiration Fastness	Alkaline Medium		
	Color Change	Staining Cotton	Dry	Wet	Acid Medium Cotton	Color Change	Cotton	Color Change	Light Fastness
Setacril Red P-4B	1	3	4-5	2-3	3	4-5	3	4	1-2

Projected Mechanism For Composition of Tannic Acid–Cellulose Composite

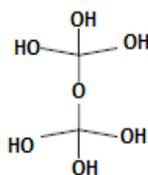


Fig. 8. Schematic representation of tannic acid

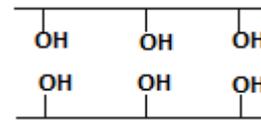


Fig. 9. Schematic representation of cellulose

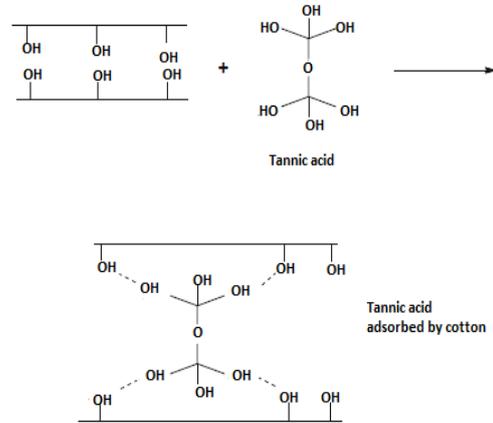


Fig 10. Composition of tannic acid-cellulose composite.

Fig. 10 describes the composition of tannic acid-cellulose composite Cotton fabric tannic acid from its liquid solution. In this case, the interplay between tannic acid and cellulose is mainly hydrogen bonding and minor Van-der-Walls interplay. The good washing fastness properties of cotton fabric treated with tannic acid is ascribed to two reasons:

(i) The strong bond coordination formed between dyestuff ions, tannic acid and hydroxyl group of cellulose particles.

(ii) The composition of large insoluble composite particles impeded in cellulose particles. These two factors contribute to more or less same amount of augmentation in the washing fastness of cotton fabric treated with tannic acid-dyestuff composition.

4. CONCLUSIONS

Cotton fabrics were dyed with 4% cationic dye and after the treatment with different tannic acid concentrations under different dyeing pH values. It was found that the treatment with 10% of tannic acid gave higher colour strength. The optimum condition of dyeing cotton fabric with cationic dye was 4% cationic dye, 6g/L Na₂SO₄, pH 5 at 100 °C for 60 minutes.

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