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Effect of Process Parameters and Bath Composition on the Dyeing of Cotton in Catalases Treated Bleaching Bath

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Abstract : An alternative method was developed to treat bleaching bath containing fabric with catalases enzymes (Bactosol SAP) along with designing a process that required less washing cycles needed after the bleaching process. The objective was to decompose hydrogen peroxide residues in the bleaching bath with catalases enzyme to be reused again for dyeing of cotton fabrics. Enzyme dyes and auxiliaries dosage was optimized to get neutral pH of bleached bath in relation to process parameters such as concentration (1-5 g/l), temperature (40-80 °C) and time (5-25 min). For dyeing in bleached bath effluent, reactive dye, electrolyte and alkali amounts were also optimized to acquire same color strength value as that of conventional dyeing method. The catalases was treated at 60°C for 20 min with 5% dosage, which transpired that the peroxide residues could be decomposed enough to give accurate neutral pH. It was also observed that with an increase in the concentration of dyes and auxiliaries (dye, salt, alkali) the color strength (k/s) increased significantly, resulting in better dyeing without excessive washing and rinsing cycles. The results of this research work suggested that bleaching bath can be reused for dyeing of cotton fabrics with reactive dyes if optimum amount of dyes and auxiliaries are used.

Keywords: Catalases, enzymes, colour strength, Bleaching bath, peroxide residues.

1. INTRODUCTION

The washing process after bleaching consumes large amount of water, since any residual hydrogen peroxide has to be removed to avoid problems in subsequent dyeing processes. Minor modification of the dye molecules can result in colour loss (Barry *et al.*, 2005). The demands to reduce water consumption by reducing or eliminating the washing cycles after bleaching while ensuring good reproducibility of dyeing can be met by the application of catalases. Catalase is widely distributed enzyme in nature and well known for its ability to catalyze the conversion of hydrogen peroxide to water and gaseous oxygen (Jenkins *et al.*, 2006). A new unconventional dyeing technique, i.e. dyeing within the bleaching bath, is in current practice (Cooper *et al.*, 2000). During this technique, bleaching bath contains the fabric that is treated directly with catalases to decompose the residual hydrogen peroxide, which can be reused for reactive dyeing. There are two particular limitations to this approach: the low stability of the catalases at high temperature and pH, and the influence of the bleaching bath components on enzyme efficiency and on dye uptake (Kemmere *et al*., 2002). Though hydrogen peroxide is completely destroyed by the enzyme, the bleaching bath formulation caused unacceptable color change of dyed fabrics (Kemmere *et al*., 2002). Temperature increases cause significant change in the structure of catalases, which is related to thermal unfolding and denaturing of enzyme (Costa and Tzanov *et al.*, 2001). Hence, color change of dyed textiles is attributed to the temperature dependent dye-enzyme precipitation, as well as to the bleaching bath composition. Bath liquors contains various substances that are extracted from the cotton e.g. oils and waxes, pectin, proteins, organic acids, minerals and natural coloring matter. Optimizing the dyeing process, i.e. dye, salt, alkali and enzyme concentrations, is the key to successful dyeing in bleaching bath along with considerable water and energy conservation gained by avoiding an extensive washing cycles after bleaching (Palmer *et al*., 1995). The aim of the proposed work was to dye a scoured, 100% woven cotton fabric in an enzymatic treated bath containing bleaching effluents. The bleaching-enzymatic treatment and reactive dyeing were carried out in a single bath without any washing or rinsing. The effect of salt alkali and dye in single bath was compared with the effect of these auxiliaries in separate bath dyeing.

2. MATERIAL AND MATHOD

Two reactive dyes, Drimarene black PS-SG and Drimarene CL HF-CD, with same mono-chloro-triazine chemical structures were used in this study. These dyes were applied in an 'all-in' dyeing on previously bleached 100% cotton woven fabrics. The fabrics were bleached at 80 °C for 45 min with the recipe that included: 3 ml /l H_2O_2, 2 g/1 wetting agent, 3mL/1 NaOH,0.5 g /1 stabilizer, 1.5 g/l chelating agent (Sirrix ANT OX IN liq). The bleaching bath was treated with 1- 5 ml/l of the catalases for 5-20 min. The presence of hydrogen peroxide in the bleaching bath after treatment with catalases was detected with pH test strips (Merck). The dyeing was performed at 1- 5% owf of dye. This depth of shade was chosen because dyeing

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in lighter shades, 1 and 2% owf, gave too large a colour difference. Dyeing with Reactive dyes was carried out in the presence of salt (30-70 g /l Nacl) and soda ash (15 g/l-25 g/l) at 60 °C for 1 hr. Both dyeing and bleaching were carried out in HT dyeing machine apparatus at a liquor ratio 20:1. Each dyeing experiment was repeated three times. Dyed fabrics were washed-off at the same liquor ratio with non-ionic detergent Hostapal MRN for 30 min at 90 °C to remove the unfixed dye. The Color strength (k/s) of the dyed fabrics was determined using a reflectance measuring apparatus x-rite color eye 7000A spectrophotometer.

3. RESULTS AND DISCUSSION

3.1 Peroxide decomposition by catalases enzymes.

The enzyme amount was optimized for reducing hydrogen peroxide via a series of trials. After bleaching five different enzyme concentrations (1 g/l, 2 g/l, 3 g/l, 4 g/l and 5 g/l) were taken for reducing hydrogen peroxide at cooling temperature of bath with different values from 80-30°C temperature for 5-25 min. After this reducing process the residual hydrogen peroxide was tested and the results showed that no hydrogen peroxide content was detected in the bleached bath at 5 g/l of enzyme concentration when treated at 60 °C for 20 min. This temperature was chosen since the trials where the catalases was added immediately after bleaching at 80 °C or after the bath was cooled to 60 °C resulted in a considerable shade change in the dyed fabrics, as shown in the **Table 1**. It was observed that the higher the catalases concentration used more neutral was the pH of bleached bath prepared for dyeing. In addition, it was also found that with an increase in the enzyme dosage above the optimum limit major color strength differences were observed (Shenai, 2003). This observation could be related to some interaction between the denatured enzyme and the reactive dye, resulting in dye aggregation and consequently reduced dye uptake.

Table 1: Effect of parameters on peroxide residues of bleached bath

Concentration g/l	Bath Temperature, °C	Process time (min)	Bath pH
1	80	5	9.5-10
2	70	10	9
3	60	15	7-8.5
4	50	20	7.5-8
5	40	25	7-8.5

3.2 Effect of reactive dye on color strength (k/s) values

It is general observation that color strength (k/s) value increases gradually with increase in the amount of dye concentration. In the present work, it was noticed during the experiments that by increasing the amount of Drimarene CL reactive dye up to a certain possible value it was possible to balance the difference between the colour strength (k/s) of fabrics dyed in a catalases treated dye bath. Moreover, at 5% dye concentration a major reduction in difference of colour strength was observed. The effect of dye concentration on colour strength (k/s) values is shown in **Fig. 1.**

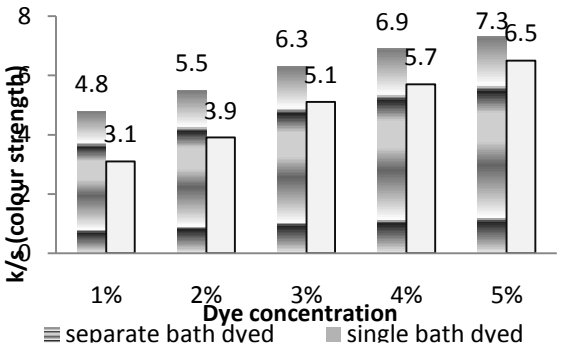


Fig. 1: Effect of dye concentration on the colour strength (k/s) values of separate and single bath dyed fabrics

Fig. 2 shows that as the concentration of sodium chloride in catalases treated a dye bath is increased, the electrostatic force of retardation decreased which enhanced the exhaustion of dyes onto the fabric. By increasing the electrolyte, dosage was usually interrelated to increased dye absorption or moreover dye uptake of fabric (Syed, 2002). While on the same time by increasing the amount of electrolyte, the development of strong ionic charges on the fabric surface also supports dye aggregation. In the present work, it was observed that by increasing the amount of salt the colour strength of fabrics dyed in enzymatic treated bleached dye bath was gradually increased due to increase in exhaustion of dye molecules. However, the addition of sodium chloride more than 25% renders the dyeing process fairly non eco- friendly.

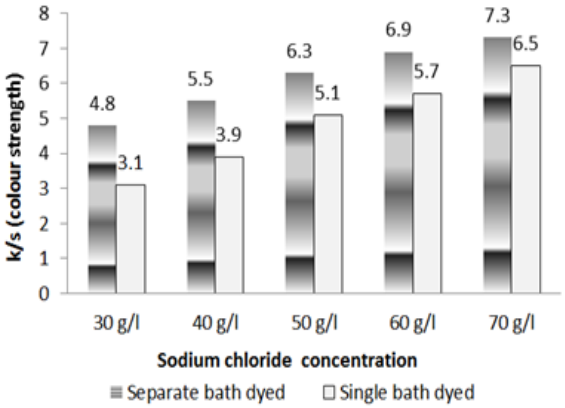


Fig. 2: Effect of sodium chloride on the colour strength (k/s) values of separate and single bath dyed fabrics

3.3 Effect of Alkali on color strength (k/s) values

In the present work, it seemed that increase in the alkalinity of the dye bath was not so good to bring better dyeing results as shown in **Figure 3,** which shows the effect of soda ash on the color strength. The other parameters such as the concentration of dye and electrolyte played an important role for uniform dyeing results. It is clear that the k/s value of dyed fabrics was reduced to some extent as the amount of soda ash was used above the optimum limit.

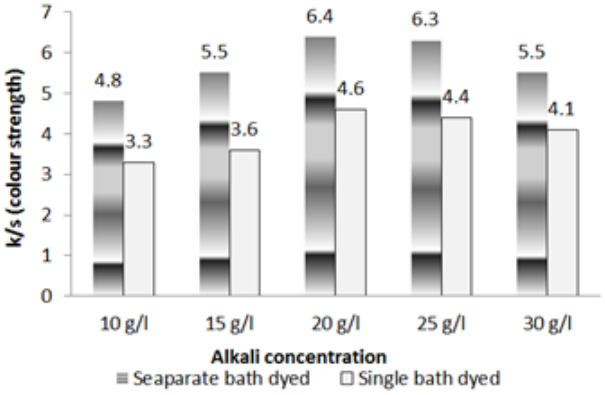


Fig. 3: Effect of Alkali on the colour strength (k/s) values of separate and single bath dyed fabrics

4. CONCLUSIONS

Enzymes are proteins that catalyze biochemical reactions. In these reactions, the compounds on which the enzyme acts are called substrates and the resulting compounds are called products. Both temperature and pH can affect the rate of the reaction catalyzed by an enzyme. It is concluded that we can use catalases enzyme (Bactosol SAP) for the decomposition of peroxide residues from the bleaching bath after reducing the temperature of the bath up if amount of enzyme taken was 5 g/l for 20-25 min at 60°C. Also, at the same temperature range dyeing can all the dyes and auxiliaries put into the bath without any rinsing operation. It was observed that there is a slight difference occurs in colour strength of fabrics dyed in catalases treated bath and in conventional bath. From the practical point of view we observed that it is possible to increase the colour strength values of fabrics dyed in combine system by increasing the dosage of dyes and auxiliaries. The effect of these on the colour strength of the dyed fabrics could be regarded as an outcome of their compound action. It is also emphasis that by selecting the proper proportion between each of these auxiliaries, more successful dyeing results could be achieved in catalases treated bleached bath.

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