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The Study of Electrolytes on the Dye Uptake of Bifunctional Reactive Red Dyes on a Cellulosic Substrate (Cotton K-68)

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Abstract. For obtaining optimum conditions for dyeing a cellulosic substrate (cotton K-68) with bifunctional reactive dyes, it was investigated as to how the dyeing results depended upon the properties of the dyes and the substrate. A cellulosic substrate (cotton K-68) was dyed by varying the nature and quantity of electrolytes. Experimental findings indicated that sodium chloride and sodium sulphate produced good dye exhaustion. An increase in the concentration of electrolytes (sodium chloride, sodium sulphate and potassium chloride) also improved the fastness properties of the dyed substrate.

Keywords: cellulose dyeing, dye exhaustion, dye uptake

During the recent years, demand of reactive dyes is increasing for the dyeing of cellulosic fibres because of their bright shades and excellent fastness properties. For the dyeing of cellulosic fibres with bifunctional reactive dyes, salts as well as alkalis are added at different stages. During the primary exhaustion stage, the dye is taken-up into the fabric in the presence of added inorganic salts. During the secondary exhaustion stage, alkali is added to the dyebath and the dye-fibre reaction takes place (Imada and Harada,1992). When the dyeing is performed in an alkaline medium, the electrolytes tend to reduce the charge on the fibre, thus the transfer of dye from solution into the fibre is facilitated (Vickerstaff, 1954). UV-visible spectroscopy is a versatile technique of quantitative analysis for dye concentration, either in the dyebath or on the fabric. Measurements can be performed by absorbance spectrophotometery of the dye solution. The quantity of dye, which disappears from the bath during the dyeing process, may be determined by taking the absorbance of the solution (Venkataraman, 1995). An earlier work (Croft *et al.,* 1992) for the determination of dye uptake was based on taking the absorbance spectrum of the dye solution. The dye uptake was then defined in terms of the quotient of the dye covalently bounded to the fibre and the total amount of dye initially present in the bath:

$$T = (1-A_s/A_b) \times 100 \qquad (1)$$

where:

T = dye uptake

A_b = the maximum absorbance of the bath solution at dyeing

A_s = the absorbance of bath after stripping with 25% aqueous pyridine

In this connection it is further significant to refer to the studies of alkali metal electrolytes on the dye uptake of cellulosic fabrics. The results obtained by taking absorbance, at different electrolyte concentrations (Guo *et al.*, 1993), leads to the conclusion that sodium chloride was the most efficient salt for a short dyeing time. At an electrolyte concentration of 100 g/l, the dye uptake decreased in the order NaCl > KCl > CsCl > LiCl. It is well known that cellulosic fibres, when immersed in aqueous alkaline media, acquire a negative charge because their dielectric constant is lower than that of water. Due to a decrease in the negative surface potential of the fibre, the relative fibre-dye potential remains negative and involves a repulsive effect. By the addition of electrolytes, the adsorption of dyes on cellulosic fibre is influenced by the cations present in the dyebath (Peters, 1975). These cations influence the dye adsorption by disrupting the structure of hydrated water around the hydrophobic parts of the dye molecules and the structure of water bound to the surface of the fibre. This enables the dye anions to come closer to the surface of the cellulosic fibre thus making adsorption easier by virtue of their strong affinity for cellulose (Noah and Braimah, 1986).

The present study was conducted to assess the influence of electrolytes on the dye uptake of a bifunctional reactive dye on the cellulosic substrate (cotton K-68), which is a very low-grade cotton of Pakistan. Five electrolytes were used in order to assess their effectiveness in the dye uptake. Sodium chloride, lithium chloride, potassium chloride, caesium chloride

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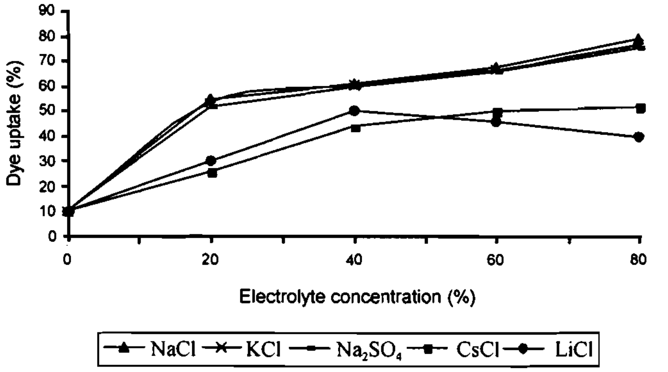

Fig. 1. Dye uptake of bifunctional reactive dye CI Red 194.

and sodium sulphate were used for this purpose. A series of measurements were carried out, at set intervals, until equilibrium was attained so that the optimum dyeing could be identified by the influence of the electrolyte addition. Dyeing was performed at 60 °C for 60 min. The values of the dye uptake, after 30 min, were determined and were calculated from UV-visible spectrophotometric measurements. It was observed that by using univalent electrolytes, the dye uptake increased with increasing electrolyte concentration, but with lithium chloride the dye uptake reached the maximum value at about 40 g/l, beyond this concentration the dye uptake of lithium chloride decreased (Fig. 1).

At an electrolyte concentration of 80 g/l, the value of (T) decreased in the order NaCl > KCl > Na_2SO_4 > CsCl > LiCl. Hence, increase in the electrolyte concentration always enhanced substantivity without impairing reactivity, provided the dye remained completely dissolved. It was also observed that an increase in the concentration of electrolytes improved the fastness properties (wash fastness and light fastness) of the reactive red dye on cotton K-68.

The present studies have shown that sodium chloride and sodium sulphate produced good dyebath exhaustion during the complete dyeing process. It is also evident that increased electrolyte concentration improved the fastness properties of the dye on the cellulose substrate (cotton K-68). These results may give useful information for better use of electrolytes.

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