Dispersant-free Dyeing of PTT Fabric with Temporarily Solubilized Azo Disperse Dyes

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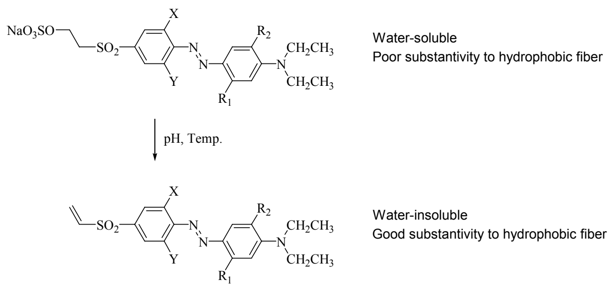
1. INTRODUCTION

Poly(trimethylene terephthalate), PTT, is a kind of aromatic polyester fibers along with poly(ethylene terephthalate), PET, and poly(butylene terephthalate), PBT. It has several attractive properties as a fiber such as good softness and resilience, easiness of dyeing, and great soil resistance and antistaticity [1-2]. Dyeing of hydrophobic fibers such as PTT and PET with disperse dye is usually performed in the presence of dispersant. Dispersants are added to the dyebath in order to increase solubility of disperse dye and to maintain dispersion stability during dyeing procedure. However, they may cause staining of the fabric. They are also discharged as effluents with the residual dyeing liquor, which increases the COD and BOD values of the effluent [3].

In an effort to overcome the environmental problems associated with the use of dispersant, development of temporarily solubilized azo disperse dyes containing β-sulfatoethylsulfonyl group was reported and the feasibility of dispersant-free PET dyeing with the dyes was investigated [4-5]. The terminal sodium sulfate group of the dye confers on sufficient water solubility at room temperature so that milling process is not needed during manufacturing of dye, and the dyebath can be prepared without the dispersants. During the dyeing procedure, the soluble dye is gradually converted to insoluble form as the β-sulfatoethylsulfonyl group is hydrolyzed into vinylsulfone group through β-elimination reaction (Scheme 1). Then the water-insoluble form of the dye having substantivity to hydrophobic polyester fiber such as PTT and PET can be adsorbed onto the fiber.

Recently, many researchers had reported a paper about PTT dyeing with disperse dyes [6-7]. However, application of the temporarily solubilized azo disperse dye to PTT fiber has not been studied yet. In this study, dispersant-free dyeing of the temporarily solubilized azo disperse dyes on PTT fabric was investigated. Color fastness and build-up properties of the dyes have also been examined. Environmental aspect of the dyes was evaluated by measuring COD value of the dyeing effluent.



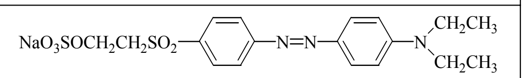
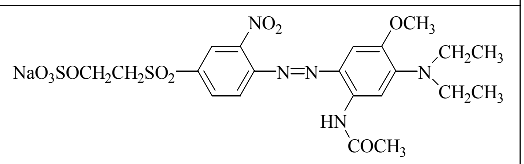
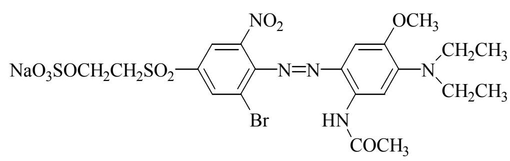
Scheme 1. Conversion of β-sulfatoethylsulfone group into vinylsulfone group of the temporarily solubilized azo disperse dyes.

2. EXPERIMENTAL

Materials

Scoured, woven PTT fabric (plain, warp : SDY 75d/72f, weft : SDY 75d/72f, weight : 116.3g/m^2) was obtained from Huvis Co. Temporarily solubilized azo disperse dyes were prepared by previous method [8-9], and their structures are given in Table 1.

Table 1. Temporarily solubilized disperse dyes used in this study

Dye	Structure
1	
2	
3	

Dispersant-free dyeing of PTT

PTT fabrics were dyed in an IR dyeing machine without using any dispersant. The dyebaths were prepared with dyes (0.5 - 3.0% owf) and buffered as follows: at pH 4 and 5 with sodium acetate (0.05M)/acetic acid; at pH 6, 7 and 8 with sodium dihydrogen phosphate (0.05M)/disodium hydrogen phosphate; at pH 10 with sodium dihydrogen phosphate (0.05M)/trisodium phosphate. Liquor ratio was 20:1. Dyeing was commenced at 70°C. The dyebath temperature was raised 1.5°C/min to 110-130°C, maintained at this temperature for 60min and rapidly cooled to room temperature. The dyeings were reduction cleared in an aqueous solution of 2g/L sodium hydroxide and 2g/L sodium hydrosulfite at 80°C for 10min.

Measurement of color yield and fastness

The color parameters of the dyed PTT fabric were determined on a Macbeth coloreye 3100 spectrophotometer. The dyed fabrics were subjected to wash (ISO 105-C06/C1S) and light (ISO 105-B02) fastness tests after stentering at 160°C for 60s.

COD analysis of dyeing effluent

PTT fabrics was dyed with temporarily solubilized disperse dyes without using dispersant and also dyed with commercial disperse dyes using dispersant. COD_{Mn} value of the dyeing liquor was measured according to the test method in KS M 0111.

3. RESULTS AND DISCUSSION

Fig. 1 shows the color yield of Dye 1 on PTT fabric at various pH values. At pH 4, dyeing rate was slow and color yield was unsatisfactory which is due to the low conversion rate of the soluble dye into the insoluble form. Good color yields were obtained at pH 5 and over and final K/S values were similar to one another although dyeing rates were different.

In Fig.2, COD levels of dyeing liquor after dyeing for commercial dyes were high while those for Dyes 1-3 were much lower. Low COD levels of dyeing effluents for the temporarily solubilized disperse dyes are probably due to the fact that dispersant were not used when applying the dyes to PTT fabric.

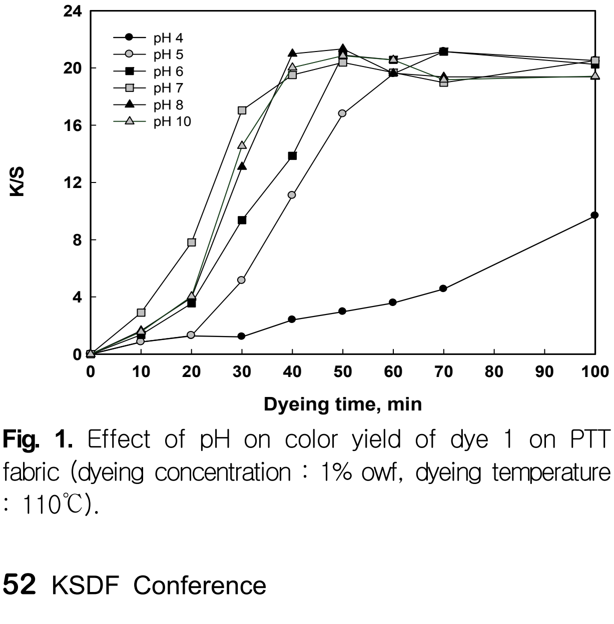


Fig. 1. Effect of pH on color yield of dye 1 on PTT fabric (dyeing concentration : 1% owf, dyeing temperature : 110℃).

Washfastness of Dyes 1-3 were good for the color change but moderate for the staining on multi-fabrics. Lightfastness of Dyes 1-3 were somewhat poor.

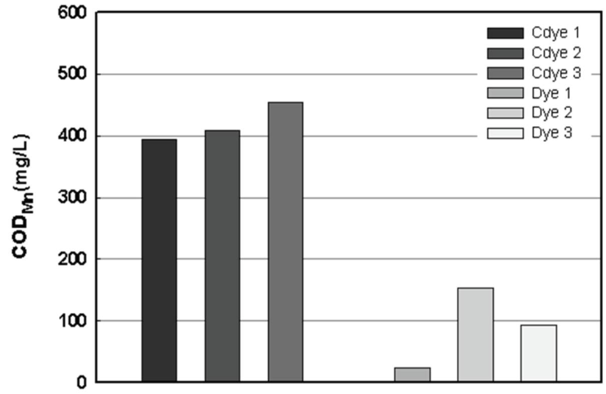


Fig. 2. CODMn levels of PTT dyeing liquor after dyeing for temporarily solubilized dyes (Dyes 1-3) and commercial dyes (Cdyes 1-3).

4. CONCLUSIONS

PTT fabric was successfully dyed with the dyes without using any dispersant. The color yield of the dyes on PTT fibric was found to be highly dependent on dyebath pH. The optimum dyeing condition was decided as pH 5-6. Washfastness of PTT dyed with Dyes 1-3 were only fair to moderate and lightfastness were somewhat poor. The COD levels of the dyeing effluent from the temporarily solubilized disperse dyes were remarkably smaller than those from commercial disperse dyes, which is probably attributed to whether dispersants are used or not.

5. REFERENCES

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