Preparation of Fluorescent Acrylic Fabrics

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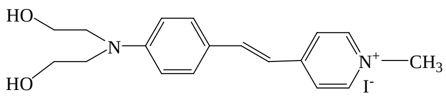
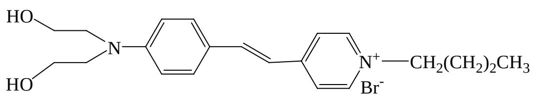
1. INTRODUCTION

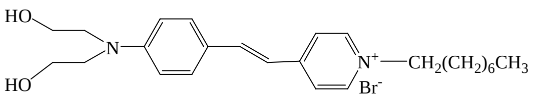
Most acrylic fibers are dyed with cationic dyes, moreover some commercial cationic dyes, such as C.I. Basic Yellow 40 (BY 40), C.I. Basic Red 12, C.I. Basic Red 13, C.I. Basic violet 7, can give dyed acrylic fibers fluorescent properties. In the authors' previous works, three hemicyanine dyes (dye 1, dye 2 and dye 3) had good fluorescent properties, excellent water solubility and higher dye exhaustion in some conventional fiber [1, 2]. Now, they were employed in dyeing acrylic fabrics, and authors expected to prepare new kinds of fluorescent fabric materials following the cationic dyeing process.



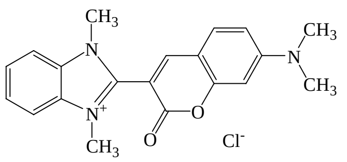
dye 1



dye 2



dye 3

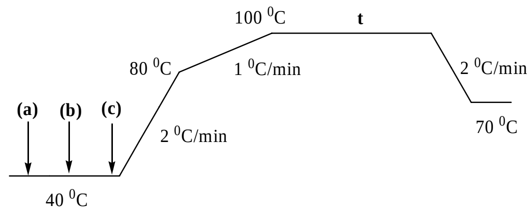


BY 40

2. EXPERIMENTAL

2.1 Dyeing rates

The dyestuff used was 1.0 %omf, the pH of the dyebath was adjusted to 5.0 with buffer solutions composed of acetic acid and sodium acetate (NaAc-HAc buffer solution), the concentration of AEO was 0.5 g/L, and anhydrous sodium sulfate (Na_2SO_4) was 4 g/L, the liquor ratio was 100:1. The dyeing procedure is shown as following figure ((a) auxiliary chemicals, (b) dye, (c) acrylic fabric) and the value of t is 75 min.



2.2. Equilibrium sorption isotherms

The dyes used was in the concentration range of 0.40-3.40 %omf, respectively, the pH value was 5.0, AEO was 0.5 g/L, Na_2SO_4 was 4 g/L, and the liquor ratio was 100:1. The dyeing procedure followed the procedure shown in the above-mentioned figure but the value of t is 50 min.

2.3. Measurements

The absorbance of the dyebath was measured using a Shimadzu 1800 UV-vis spectrophotometer. The concentration of the dyes on fibers was calculated according to the difference between the dye concentrations in the initial and residual dyebath as well as the weight of dried fibers. The reflectance spectra, the apparent color depth (K/S value) and the chromaticity values (X, Y, Z) of the dyed fabrics were measured using a HunterLab UltraScan PRO reflectance spectrophotometer (illuminant D65; 10° observer) at the wavelength of maximum absorption.

3. RESULTS AND DISCUSSION

Based on Fig.1a, the initial dyebath temperature may be raised quickly to 80 °C, after that, the temperature should be raised slowly. And the recommended holding time at 100 °C was 50-75 min to allow the complete diffusion of dye molecules into the fiber interior. Moreover, the uptake of dye 1 on acrylic fabric was the lowest, and that of dye 3 was the highest. Because the dyeing equilibrium of cationic dyes in acrylic fibers shifted to the less polar phase of the dyeing system (i.e., the fiber) and the dyeing affinity increased when the molecular polarity of the cationic dye decreased [3]. As the alkyl chain attached to the pyridine ring of dye 3 was the longest, the dye molecule had the strongest affinity to fibers because of its weak polarity, while dye 1 molecule had the weakest affinity to fibers.

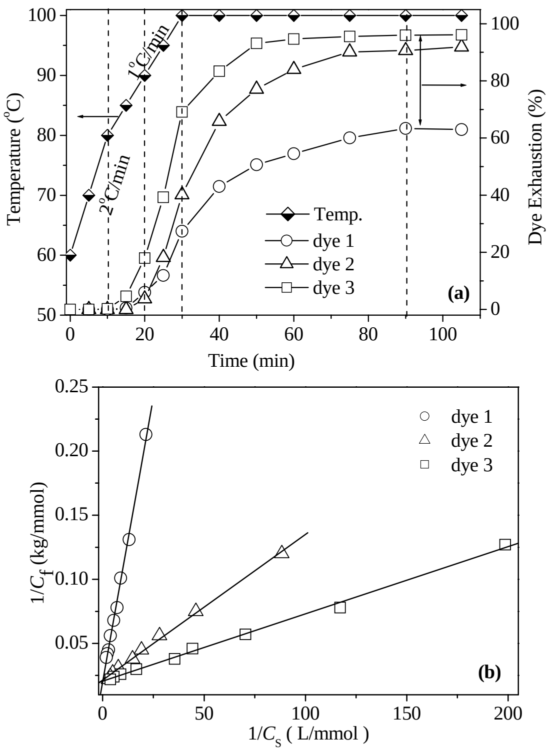


Fig.1. Adsorption rates (a) and isotherms (b) of three hemicyanine dyes (1% omf) for acrylic fabric at pH 5 using a 100:1 liquor ratio.

The adsorption isotherms of the three hemicyanine dyes at 100 °C are shown in Fig.1b, C_s (mmol/L) is the concentration of the dyes in the dyebath and C_f (mmol/kg) is the concentration of the dyes on the fibers at equilibrium, respectively. Then the uptake of three hemicyanine dyes on acrylic fibers followed the Langmuir adsorption mechanism. And the adsorption parameters are listed in Table 1. Where S is the saturation concentration of the dyes on acrylic fibers by Langmuir sorption, and K_L is the Langmuir affinity constant.

Table 1 Thermodynamic parameters of hemicyanine dye on acrylic fabric at 100 °C.

Dyes	K_L (L/mmol)	S (mmol/kg)	R^2
dye 1	2.26	49.75	0.9966
dye 2	19.54	46.51	0.9968
dye 3	41.20	48.54	0.9968

In addition, the reflectance of the dyed acrylic fabrics exceeded 100% in the emission range 550 - 750 nm in Fig.2a. Three hemicyanine dyes are as interesting as BY 40 in terms of the ability to provide fluorescence when employed in dyeing acrylic fabrics. As shown in Fig.2b, the chromaticity of acrylic fabric dyed with BY 40 can meet the requirements of fluorescent yellow according to the EN-471 standard (2003), while that of acrylic fabric dyed with three other hemicyanine dyes can meet the requirements of fluorescent orange when the dye concentrations are suitable. Then the dyed fabrics might have the chance to be used in high-visibility warning clothing.

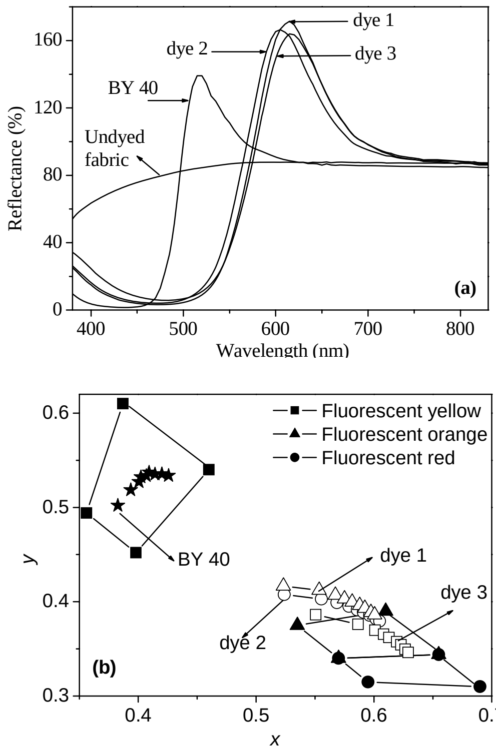


Fig.2. Reflectance spectra (a) and the chromaticity (b) of dyed acrylic fabrics.

4. CONCLUSION

Three hemicyanine dyes could be introduced into acrylic fabrics by following traditional cationic dyeing procedures. The dye uptake and sorption rate increased as the length of the alkyl chain attached to the pyridine ring of the dye molecule increased. In addition, the reflectance of the dyed acrylic fabrics exceeded 100%, and the chromaticity of dyed acrylic fabric could meet the requirements of fluorescent orange when the dye concentration was suitable according to the EN471 standard (2003).

5. REFERENCES

[1] C.X. Qin, M.Y. Zhou, W.Z. Zhang, X.M. Wang, G.Q. Chen; *Dyes Pigments*, 77, 678-685 (2008).
[2] C.X. Qin, X.M. Wang, G.Q Chen, et al; *Opt. Mater.*, 30, 1607-1615 (2008).
[3] G. Alberti, M.R. Degiorgi; *Text. Res. J.*, 54, 105-108 (1984).