Coloration of pure polypropylene fiber with super hydrophobic dyes; application of anthraquinone derivatives with linear alkyl substitutents

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1. Introduction

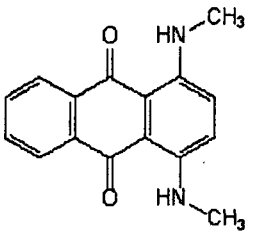
Polypropylene fiber is an extremely hydrophobic substrate and it is said to be undyeable. Therefore, host of the polypropylene yarn and staple currently available in the market is colored through pigmentation.

In order for dyes to have affinity to polypropylene, the dyes need to be extremely hydrophobic just like polypropylene. However, such dyes would not be dissolved and even dispersed in water owing to their extremely hydrophobic nature.

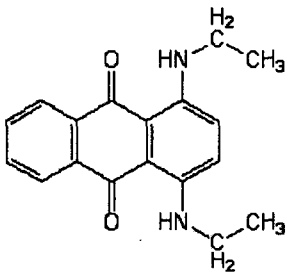
In this study, several super hydrophobic dyes which have linear alkyl substituents were examined to dye unmodified pure polypropylene fiber and a double-tailed cationic surfactant was utilized to form a dye-surfactant complex that was dispersed in water.

2. Experimentals

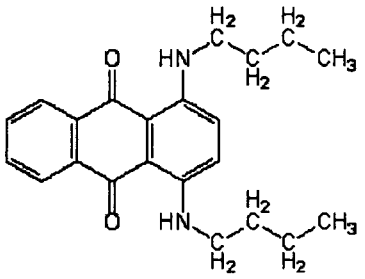
The unmodified pure polypropylene fabric was used. The dyes used are presented below. Dilauryldimethylammonium bromide(DDAB), which is the double-tailed cationic surfactant, was used to disperse the dyes and its chemical structure was shown below.



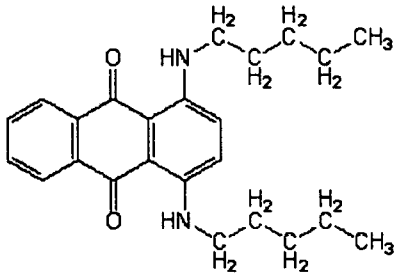
Disperse Blue 14



Solvent Blue 59



Solvent Blue 35



Oil Blue N

Fig. 1. Chemical structure of dyes

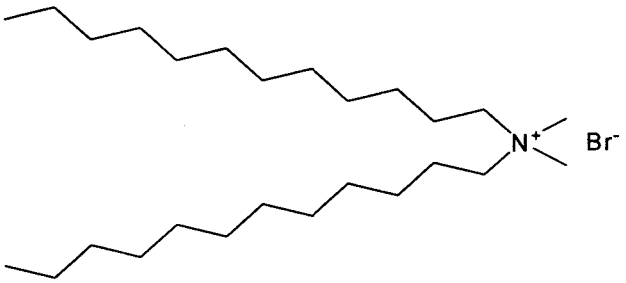


Fig. 2. Dilauryldimethylammonium bromide(DDAB)

The dye-surfactant complex was prepared through several stages;

(Dye+DDAB)/THF → Evaporation → Adding water → Ultrasonication → Dye+DDAB complex

Dyeing was carried out by exhaustion method under various condition. At the end of dyeing, the dyed fabrics were washed with cold acetone 3~5 times and then dried.

3. Results and Discussion

The characteristics of the dyes that is used are presented in Table 1. As the length of alkyl substituents increases, melting points are decreased. However, molar extinction coefficients and λmax of the dyes does not varied, because all the dyes that is used in this experiment have the same anthraquinone chromophore and the length of alkyl substituents do not affect the absorption of visible light.

Table 1. Characteristics of the dyes used

Dyes	Length of alkly chain	M.W. (g/mole)	T_m (℃)	molar ε	λ_{max} (nm)
Disperse Blue 14	methyl	266.29	220~222	18079	643~645
Solvent Blue 59	ethyl	294.35	215~217	18144	643~645
Solvent Blue 35	butyl	350.45	120~122	18451	643~645
Oil Blue N	pentyl	378.51	112~114	18184	643~645

Fig.3 shows the relationship between dye adsorption(dye uptake) and relative ratio of Oil Blue N and DDAB in dye-DDAB complex. Below the molar ratio of 1:1 (dye:DDAB), the dye-DDAB complex was not formed successfully and it took quite long time to disperse the dye. The maximum dye adsorption was obtained at molar ratio of 1:1.5 and over the range dye adsorption was decreasing gradually.

At the molar ratio of 1:1.5, the color strength of polypropylene fabric dyed with 4 dyes which have different length of alkyl group was shown in Figure 4. As the length of alkyl chain increases, which means that the dyes are getting even more hydrophobic, the adsorption on polypropylene fabric increases dramatically and the color strength of the fabric is getting higher. Although extremely hydrophobic dyes were applied in water phase, the formation of dye-DDAB complex makes it possible to obtain high level-dyeing.

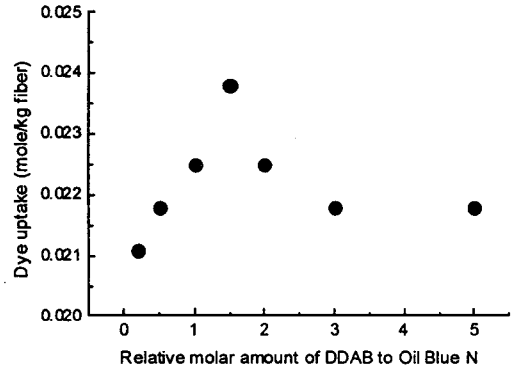


Fig. 3. Relationship between dye adsorption and relative ratio of Oil Blue N and DDAB in dye-DDAB complex.

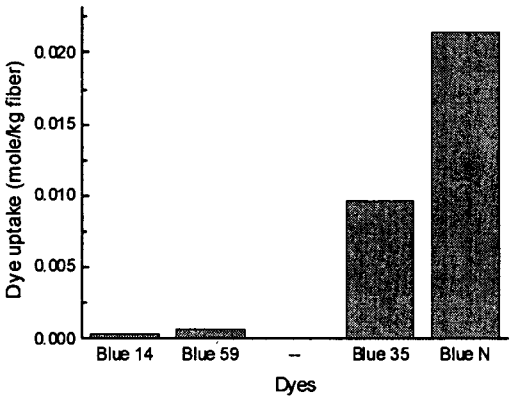


Fig. 4. Dye uptake of polypropylene fabric dyed with 4 dyes which have different length of alkyl group.