

Influence of dispersing agents on adsorption and desorption rate of a disperse dye on polyester

Abstract

Dispersing agents play important roles in polyester dyeing with disperse dyes. The purpose of this work is to determine the influence of dispersing agents on the adsorption and desorption rate of polyester dyeing with CI Disperse Blue 284. Polyester fabric was dyed at HTHP method using two types of dispersing agents at different concentrations. The performances studied were the changes in dye transfer rate, K/S values of the dyed samples and dye bath concentration. The rate of adsorption and desorption of disperse dyes were affected significantly not only by the type but also the concentration of dispersing agents.

Keywords: disperse dyes, dispersing agents, adsorption and desorption rate, polyester dyeing

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Introduction

Polyester fibre generally consisting of linear chain polymers containing ester groups¹ and is derived from dicarboxylic acids and diols.² It is the highest volume synthetic fiber produced globally due to its unique end use and easy care properties.^{3,4} The polyester fibres are highly crystalline and are usually even and rod like shapes.⁵ Owing to their hydrophobic nature they are therefore difficult to dye at low temperatures and dyeing is usually carried out at high temperatures, regularly around 130°C.^{6,7}

Disperse dyes usually used to dye polyester fibres which are non-ionic in nature and have limited water solubility even at high dyeing temperatures.⁸ Therefore, require the presence of a dispersing agent, which improves their solubility.⁹ These agents produce energy barriers maintaining dispersions in their meta-stable condition, thus, avoiding the aggregation of dispersed particles thus improves the dispersion stability, solubility, leveling, and fastness properties.¹⁰ Since the dispersion of disperse dyes is thermodynamically unstable, the particle sizes tend to increase due to the decreased free energy of the system.¹¹ The stability of the dye dispersion and the rate of dyeing are all affected by the type and concentration of the dispersing agents.⁸

So the incorporation of dispersing agent which usually a surfactant in the dyebath is a very important factor in the application of disperse dyes. The hydrophobic tails inside the micelle of the surfactant molecules which actually reduce the particle size and solubilize the disperse dye molecules. Then soluble dyes as soon as transferred to the fibre free the micelles results they re-form and dissolve more dyes from the dye reservoir.¹²

The stabilization of the dispersion is based on several effects depending on the dispersion agent used. It may be either an electrostatic stabilization, where the charge of the dispersing agent plays an essential part, or a steric stabilization, where the chemical construction and the molecular weight of the dispersing agent are the key factors.¹³

Polyester fibers dyeing with disperse dyes is a complex process and the rate of dye uptake, solubility and the dispersion of the dye

in the dye bath are depends on the different auxiliaries used in the bath.^{14,15} The aim of this study is to analyze the dependency of dispersing agents on the adsorption and desorption of disperse dyes on the dyeing of polyester fabric.

Experimental

Material

Factory washed double jersey 100% polyester knitted fabric (250g/m²) was used. A commercial disperse dye sample of CI Disperse Blue 284 was used without further processing. Anionic and nonionic type dispersing agents were used and described in the Table 1.

Table 1 Specifications of dispersing agents used in this study

Agent No.	Type	Chemical Nature
1	Anionic	Mixture of aromatic sulphonates and carboxylic acid polyglycol ester
2	Nonionic	Product of APEO free ethoxylates

Dyeing

Before dyeing polyester fabric was washed with acetic acid at 60°C for 10 minutes to remove impurities. Dyeing was carried out for 3% shade in Data colour Ahiba IR sample dyeing machine at 130°C for 70 minutes. Three different concentrations of each dispersing agent were selected accordingly from the provided manufacturing brochure. For anionic and nonionic dispersing agent the concentrations used were 1/2/3g/L and 0.25/0.5/0.75g/L respectively.

Adsorption/desorption rate and colour strength

The rates of adsorption and desorption were calculated from the relevant absorbance curves from the dyed liquor after 6 (six) predetermined time intervals at 130°C. Colour strength values (K/S) of the dyed samples were measured using the Kubelka-Munk equation of the same time intervals. Data Colour Dual-Beam Spectrophotometer 650 was used. For accuracy 6 (six) different dyeing baths were set

maintaining exactly the same configuration. At each time interval one bath was taken out for assessment. 1st bath was assessed at 1 minute after reaching 130°C consequently 2nd, 3rd, 4th, 5th and 6th bath were assessed at 15, 30, 45, 60 and 70 minutes respectively.

Results and discussion

According to Beer-Lamberts law the absorbance of a solution at a given wavelength is directly proportional to its concentration. Table 2 and Figure 1 presents the absorbance/concentration values and curve of the disperse dye used in this work. The attenuation co-efficient of the dye at λ_{340} nm was $3 \times 10^{-3} \text{ Lg}^{-1} \text{ cm}^{-1}$.

Table 2 Absorbance Values at different concentration

Sample	Concentration (mg/L)	Absorbance
1	25	0.268
2	30	0.2876
3	50	0.351
4	100	0.535
5	150	0.7121
6	200	0.9179

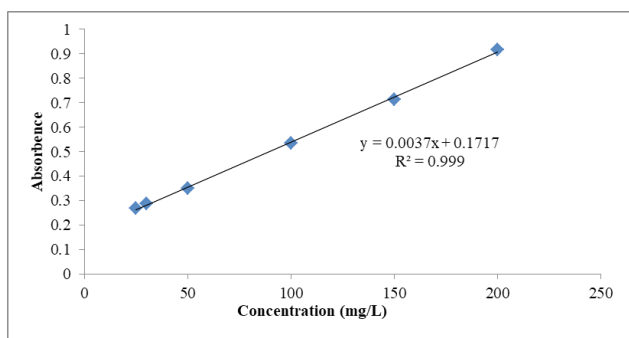


Figure 1 Absorbance vs concentration curve.

Figure 2 and Figure 3 presents the adsorption and desorption rate at 130°C of used disperse dyes on polyester influenced by different dispersing agent. The initial adsorption rate for anionic dispersing agent (AD) was found almost 30 to 40% where as in case of nonionic dispersing agent (ND) it was quite high and almost 55 to 60%.

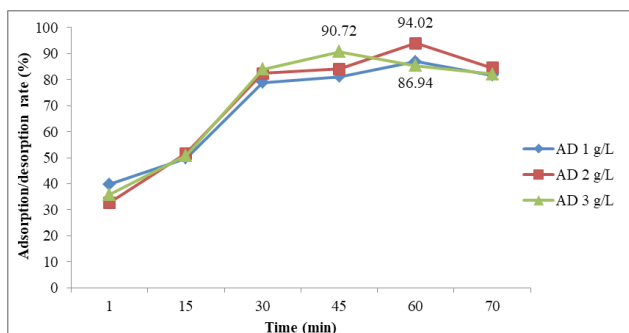


Figure 2 Adsorption/desorption rate (%) influenced by anionic dispersing agent (AD).

In case of anionic dispersing agent the maximum adsorption achieved after 60 minutes of dyeing at 130°C for 1 and 2g/L but for 3g/L the maximum adsorption achieved after 45 minutes of dyeing.

Same trend observed in case of nonionic dispersing agent. Maximum adsorption achieved after 30 minutes of dyeing at 130°C for higher concentration. It's clear that in case of nonionic dispersing agent the adsorption rate is higher that achieved in case of anionic dispersing agent. At high concentration of dispersing agents took less dyeing time to achieve the maximum adsorption.

Maximum adsorption found 94.02% for 2g/L concentration of anionic dispersing agent at 60 minutes of dyeing where as 92.88% found for 0.5g/L concentration of nonionic dispersing agent at 45 minutes of dyeing. It can be concluded that the adsorption rate is quite high when used nonionic dispersing agent compare to anionic dispersing agent.

Figure 2 and Figure 3 also presents the desorption rate of the dyes. The desorption rate of anionic dispersing agent is higher than nonionic dispersing agent. After 70 minutes of dyeing around 10-15% desorption of dyes occurred when anionic dispersing agent was used which is quite higher than nonionic dispersing agent and also desorption occurred at slower rate.

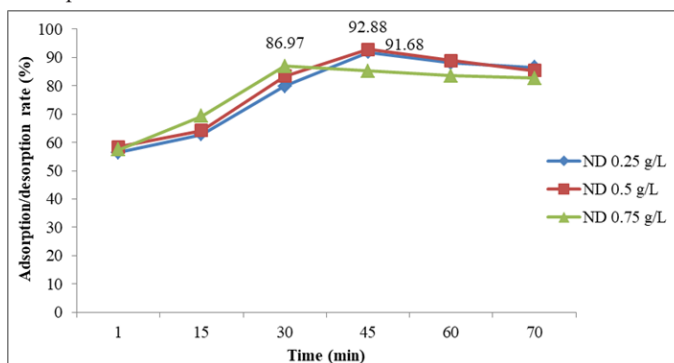


Figure 3 Adsorption/desorption rate (%) influenced by nonionic dispersing agent (ND).

At different concentration of dispersing agent the adsorption rate is similar but at higher concentration dye desorption occurred little faster. In both cases medium concentration showed good and stable results.

Figure 4 and Figure 5 presents the colour strength values of the dyed samples at time intervals. Maximum colour strength achieved after 45–60 minutes of dyeing. After 60 minutes of dyeing colour strength of dyed samples started to fall. In case of anionic dispersing agent the the initial dye pick up rate is low and desorption rate also high after 60 minutes of dyeing.

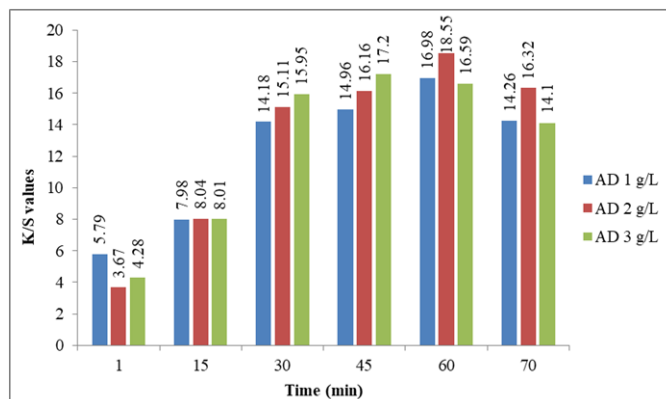


Figure 4 Colour yield values influenced by anionic dispersing agent (AD).

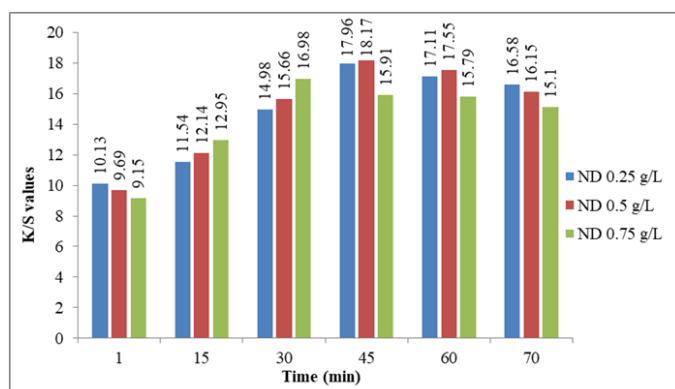


Figure 5 Colour yield values influenced by nonionic dispersing agent (ND).

The initial dye pick up is quite high for nonionic dispersing agent and the desorption rate is also low after 60 minutes of dyeing.

Conclusion

This work clearly shows that different types of dispersing agents have different adsorption and desorption rates on polyester dyeing with disperse dyes. The dyeing process is quite complex and the dispersing agents plays an important role which can't be ignored. Not only the type but also the concentration of dispersing agents can affect the rate of adsorption and desorption of disperse dyes. The proper selection of the type of dispersing agent and their concentration are very crucial for efficient and successful dyeing.

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Conflicts of interest

The authors have no conflicts of interest regarding the publication of this paper.

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