# 126. Dyeing of Nanofibers Using Ultrasonic Energy

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**Abstract**

Cavitation is generated by high power ultra-sonication in liquids and enhance chemical process efficiency. Dyeing of Nanofiber is becoming useful day by day. Dyeing of Nanofibrous web using ultrasonic energy is done. The cellulose-acetate electrospun in the form of nanofibrous web and converted into cellulose followed by deacetylation. Parameters for dyeing optimization were, dyeing time dyeing temperature and concentration of dye. By using ultrasonic energy the efficiency of dyeing was increased and successful dyeing of nanofibers took place having enhanced color yield and color fastness properties comparing to dyeing method used conventionally without any change in morphology.



***Keywords:*** *Ultrasonic energy; Nanofibers; Electrospinning; Dyeing; Color yield;*

## 1. Introduction

Recently ultrasonic energy is being used to enhance the efficiency of many of the chemical processes. In parallel dyeing of nanofibers are also getting more attention because of its novelty these days and recent research in dyeing reactive dyeing using batchwise method[3], dyeingof nanofibrous web with dispers- dyes by pad-dry and bake method [4], dyeing of nanofibers using cold-pad and batch[5], dyeing of nanofibersusing dual padding process [6] polyurethane nanofibrous web were also dyed by pad-dry and bake method [1]. Using ultrasonic energy with batch-wise method cellulose Nanofiberous web was dyed with a dye namely CI-reactive black 5. Parameters for dyeing optimization were, dyeing time dyeing temperatureand concentration of dye.A little change in fiber diameter due to ultrasonic energy could be observed in the nanofibers.

## 2. Experimental

### 2.1 Materials and Methods

Main polymer used is Cellulose acetate (CA) containing acetyle percentage 39.8and having averagemolecular weight = 30kDa, Dye CI-Reactive black 5 bissulphato-ethyl-sulphonehaving molecular weight of 991.82 g/mol. Structure as shown in fig 1. CA nanofibrous web were produced by elecrospinningand converted into Cellulose using Deacetylation process to have pure cellulose nanofibers.

### 2.2Color Measurement

Data color spectrophotometer was used to identify K/S values and below given formula were used.

$$K/S = \frac{(1-\mathrm{R})^2}{2\mathrm{R}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(A)}$$

Thus, R = decimal fraction, K = coefficient ofabsorption and S = coefficient of scattering.

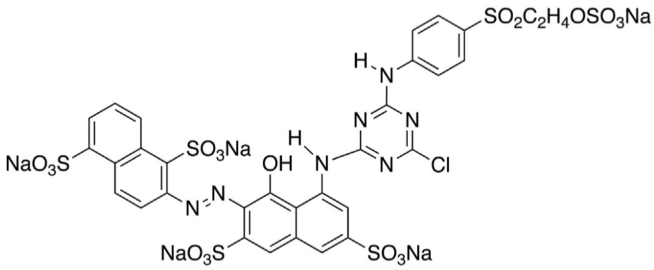


**Fig.1**Chemical Structures of CI-reactive black 5

## 3. Results and discussion

### 3.1 Time and temperature influence on color yield

Process of dyeing nanofibrous web using ultra-sonication method is a unique work that's why it requires several optimizations such as dyeing temperature and time.Optimized temperature 70 °Cat constant time 60 minutes and 2% of dye used because k/s values were strong and time was optimum at 30 minbecause cavitation of ultrasound waves breaks aggregates of dye and aids to enhance uptake of dye used [2].

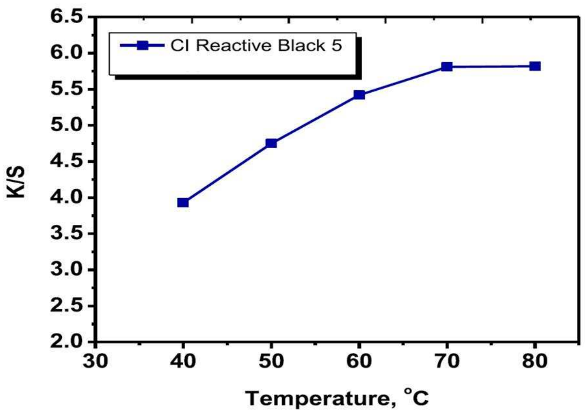


**Fig. 2** Influence of Temperature on K/S values

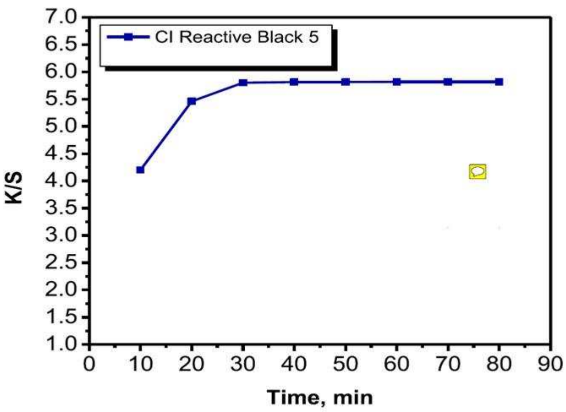


**Fig. 3**Influence of Time Effect on K/S values

### 3.2Color yield properties of conventional dyeing against color yield of properties of nanofibers.

K/S values were measured to analyse the influence of different dye concentrations on color yield .Dye concentrations were taken as2, 3, 4, 5 and 6%at optimized time and temperature. As the dye concentration was increased it shown higher color yield and linear graph determinescellulosic nanofibrous webattainsdye build-up attributes. The results achieved by dyeing using ultrasonic energy show higher colorbuild-up than the conservativemethod of dyeing.

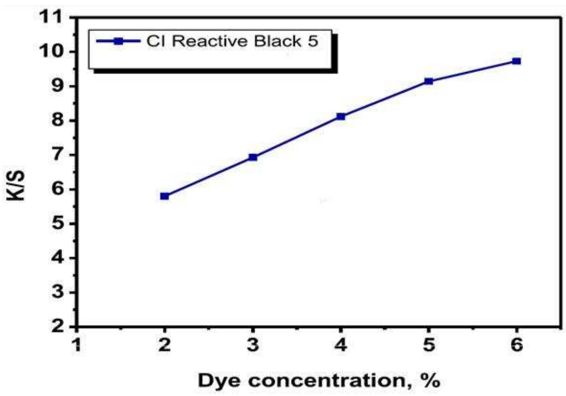


**Fig. 4**Dye concentration effect on K/S values

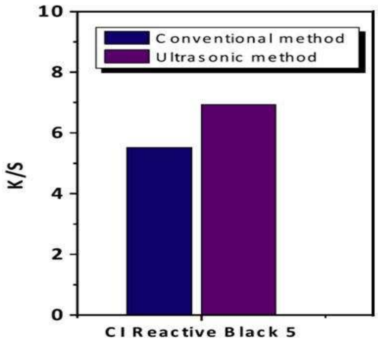


**Fig. 5** Comparison of color build (ColorYeild) propertiesbetween Ultrasonic and Conventional Dyeing

### 3.3Ultrasonic effect on morphology of dyed nanofibrous web.

Scanning Electron Microscope (SEM) were used to compare the morphological effect on ultrasonically dyed and undyed samples. Undyed nanofibrous web in (Fig. 6a) determine smooth morphologywhereas nanofibersdyed ultrasonically shown a little increment in nanofiber diameter, surface becomes unevencomparing to undyed samples. Ultrasonic energy may be reason for this little morphological change because its energy can swell nanofiber diameter.

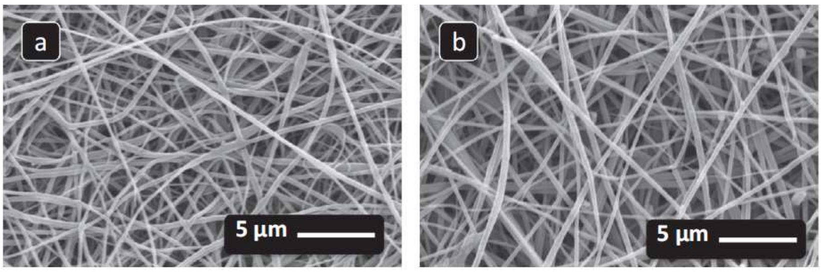


**Fig. 6**Morphology of (a) Undyed Cellulosic nanofibrous web, (b) Dyed cellulosic nanofibrous web

## 4. Conclusion

Nanofibrous web were ultrasonically dyed with CI-reactive black 5 dye usingbatch-wise dyeing process .Using ultrasonic energy enhanced color build-up properties comparing to conventional dyeing process. nanofibers dyed ultrasonically shown a little increment in nanofibrous diameter and the texture on surface becomes uneven against undyed samples.

**Acknowledgments**

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**References:**

[1] A. Khatri, et al Dye-ability of polyurethane nanofibres with disperse dyes, Color. Techno. 131 (2015) 374-378.

[2] N. D. Tissera, et al, Ultrasound energy to accelerate dye uptake and dye–fiber interaction of reactive dye on knitted cotton fabric at low temperatures, Ultrasono. Snochemi. 29 (2016) 270-278.

[1] Z. Khatri, et al, Cationic cellulose nanofibers: Preparation and dye-ability with anionic reactive dyes for apparel application, Carbohydra. Polyme. 91 (2013) 434– 443

[2] Z. Khatri, et al, Pad dyeing of cellulose-acetate nanofibres with disperse-dyes, Color. Technol. 128 (2012) 1-5.

[3] Z. Khatri, et al, Cold-pad batch dyeing of cellulose-nanofibers with reactive-dyes, Cellulose 21 (2014) 3089-3095.

[4] Z. Khatri, et al, Dyeing and characterization of cellulose nanofibers to improve color yields by dual padding method, Cellulose 20 (2013) 1469–1476.

## APPENDIX