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\cite{3}, dyeing of nanofibrous web with dispers- dyes by pad-dry and bake method \cite{4}, dyeing of nanofibers using cold-pad and batch\cite{5}, dyeing of nanofibers using dual padding process \cite{6} polyurethane nanofibrous web were also dyed by pad-dry and bake method \cite{1}. Using ultrasonic energy with batchwise method cellulose Nanofibrous web was dyed with a dye namely CI-reactive black 5. Parameters for dyeing optimization were, dyeing time dyeing temperature and 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 acetylene percentage 39.8 and having average molecular weight = 30kDa. Dye CI-Reactive black 5 bissulphato-ethyl-sulphone having molecular weight of 991.82 g/mol. Structure as shown in fig 1. CA nanofibrous web were produced by electrospinning and converted into Cellulose using Deacetylation process to have pure cellulose nanofibers.

2.2 Color Measurement

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

\[
K/S = \frac{(1 - R)^2}{2R} \quad \text{(A)}
\]

Thus, \(R\) = decimal fraction, \(K\) = coefficient of absorption and \(S\) = coefficient of scattering.
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 °C at constant time 60 minutes and 2% of dye used because k/s values were strong and time was optimum at 30 min because cavitation of ultrasound waves breaks aggregates of dye and aids to enhance uptake of dye used [2].

3.2 Color 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 as 2, 3, 4, 5 and 6% at optimized time and temperature. As the dye concentration was increased it shown higher color yield and linear graph determines cellulose nanofibrous web attains dye build-up attributes. The results achieved by dyeing using ultrasonic energy show higher color build-up than the conservative method of dyeing.
3.3 Ultrasonic 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 morphology whereas nanofibers dyed ultrasonically shown a little increment in nanofiber diameter, surface becomes uneven comparing to undyed samples. Ultrasonic energy may be reason for this little morphological change because its energy can swell nanofiber diameter.

4. Conclusion
Nanofibrous web were ultrasonically dyed with CI-reactive black 5 dye using batch-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.

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References:
APPENDIX

1. Introduction

2. Experimental
   2.1 Materials & Methods
   2.2 Color Measurement

3. Results and discussion
   3.1 Time and temperature effect on color yield of dyeing
   3.2 Color yield properties of conventional dyeing against color yield of properties of nanofibers.
   3.3 Ultrasonic effect on morphology of dyed nanofibrous web.

4. Conclusion

Acknowledgements

References

Fig. 1 Chemical Structures of C0-reactive black 5
Fig. 2 Dyeing Temperature Effect on K/S value
Fig. 3 Dyeing Time Effect on K/S values
Fig. 4 Dye concentration effect on K/S values
Fig. 5 Comparison of color build (ColorYield) properties between Ultrasonic and Conventional Dyeing
Fig. 6 Morphology of (a) Undyed Cellulose nanofibers, (b) Dyed cellulose nanofibers

Table: 1 Color fastness to light test ISO 105-BO2 and color fastness to washing test ISO 105-C10:2006