Iranian Polymer Journal (2020) 29:117–132
https://doi.org/10.1007/s13726-019-00781-9

ORIGINAL RESEARCH

Photochromic microcapsules by coacervation and in situ polymerization methods for product-marking applications

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Received: 28 August 2019 / Accepted: 31 December 2019 / Published online: 18 January 2020

Abstract
Photochromic materials can change their colour quickly and reversibly when exposed to light of certain wavelengths. These materials have recently been of great interest for intelligent and functional textile applications. In this study, two different photochromic dyes, including 1′,3′-dihydro-1′,3′,3′-trimethyl-6-nitro-spiro[2H-1-benzopyran-2,2′-(2H)-indole] and 1′,3′-dihydro-8-methoxy-1′,3′,3′-trimethyl-6-nitrospiro[2H-1-benzopyran-2,2′-(2H)-indole], were microencapsulated by coacervation and in situ polymerization methods. Ethyl cellulose and melamine–urea–formaldehyde were used as polymers. The Fourier transform infrared spectroscopy, particle size and size distribution analysis, scanning electron microscopy, and ultraviolet spectrophotometry evaluations were utilized to characterize the structure, morphology, size distribution, and absorbance maxima of the photochromic microcapsules. The results indicated that photochromic microcapsules were in spherical shape, smooth, and homogeneous characteristics. These microcapsules were applied successfully onto cotton fabric using printing technique. Then, the activities of photochromic microcapsules on the fabrics were analysed by colour analysis under different light sources, fatigue resistance, washing, and rubbing fastness tests. After printing, the colours of the fabrics changed very quickly under different light sources. At the same time, these fabrics showed a reversible photochromic response and good fatigue resistance. Mechanical and physical properties of the fabrics such as thickness, air permeability and tensile and tear strength were also investigated. It can be concluded that photochromic microcapsules are well appropriate for brand protection and prevention of imitation in textile materials.

Keywords Photochromic dye · Ethyl cellulose · Melamine–urea–formaldehyde · Coacervation · In situ polymerization · Microencapsulation

Introduction

Photochromism is a reversible transformation of chemical species included in one or both directions by absorption of electromagnetic radiation. It occurs between two states with light absorption that can be observed in different regions of the spectrum. Reversibility is the main criterion for photochromism. The colour changes are schematized as below [1–3]:

$$A\,(\text{colourless}) + h\nu_1 \rightarrow B\,(\text{colourful}),$$
$$B\,(\text{colourful}) + h\nu_2 \rightarrow A\,(\text{colourless}).$$

Extensive research has been made on photochromic compounds and polymer systems. In these studies, possible interactions between photoactive form and polymer chain are investigated [4–6]. Larkowska et al. [7] have focused on investigation of the temperature influence on reversible isomerization of spirooxazine in polymer matrices. Ding et al. [8] have synthesized a new photochromic azo amphiphilic diblock copolymer for biological application and studied the photochromic behaviours of the polymers in different environments.

In the last few years, various approaches to spiropyran-bound polymers have been developed. The spiropyran group is compatible with most polymerization conditions; therefore, both polymerization of spiropyran-based monomers and grafting in preformed polymer chains have been

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