METHODS OF PREPARATION POLYPROPYLENE FIBERS WITH PHOTOCHROMIC PIGMENTS

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Abstract

On the basis of the photochromic pigment, a simple textile sensor of UV radiation was developed which is useful for visual identification of UV radiation [1]. The photochromic materials are generally formed of unstable organic molecules, which changed the molecular configuration of the effects of certain exerted radiation. The change in configuration causes the change in the absorption spectrum, resulting in the change in color. Textiles containing photochromic pigments belong to the active smart textiles [2]. Protective clothing based on smart textiles has its particular advantages in that the textile structure is easily adaptable e.g. sewing and easily maintainable e.g. washing and drying. The great advantage of incorporating UV sensors (photochromic pigments) in structure of fiber is the resistance to elution compared of surface print. The other advantages are the low density, good strength, elongation and elasticity [3]. Polypropylene is a semi-crystalline thermoplastic polymer with wide applications. In the textile industry, the polypropylene is used to produce work wear, various sports clothing with special functional properties. Due to the fact it is appropriate to use polypropylene as a matrix for the preparation of fibers incorporating photochromic pigments [2].

The aim of this work was to verify the possibility of preparing PP fibers dyed in to the mass with photochromic pigments having satisfying mechanical and physical properties. The prerequisite is that in the fibers prepared this way, pigment is bonded to the matrix polymer and more stable than the surface-dyed fibers where the pigment is gradually eliminated.

The following metallocene polypropylene (PP) was used for the production of fibers: Metocene HM562R (PP), granules from LyondellBasell Industries, c.o., Italy. Basic characteristics of the PP:
- (MFR) melt flow rate, 230°C/2,016 kg) - 25 g/10 min
- melting temperature $T_m$ (DSC) - 145°C

PP HM562R is a homopolymer with a very narrow molecular weight distribution. It is suitable for the production of nonwovens and filaments. It is especially suitable for the production of high-strength fibers [4].
In the experimental work commercially available photochromic pigments Photopia® were used, which are capable of reversible color changes due to sunlight or ultraviolet (UV) radiation: Photopia® Aqualite Purple Ink AQ-R (PURPLE), manufactured by Shikiso Matsui Chemical Co., Ltd., Japan (Figure 1.). The pigment was available as a paste with the composition:

<table>
<thead>
<tr>
<th></th>
<th>component</th>
<th>amount</th>
</tr>
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<tbody>
<tr>
<td>A</td>
<td>photochromic microcapsules</td>
<td>30 – 50%</td>
</tr>
<tr>
<td>B</td>
<td>tetrakis(1, 2, 2, 6, 6-pentamethyl-4-piperidyl)-1, 2, 3, 4-butantetraarboxylate*</td>
<td>25%</td>
</tr>
<tr>
<td>C</td>
<td>other not further specified ingredients</td>
<td>remnant</td>
</tr>
</tbody>
</table>

* component B is inside the component A

**Figure 1.** Tetrakis (1, 2, 2, 6, 6-pentamethyl-4-piperidyl)-1, 2, 3, 4-butantetraarboxylate

Before spinning of fibers, PP had to be mixed in the form of granules with a photochromic pigment, which was in the form of paste. Mixing was done in two ways. In the first method, the photochromic pigment was directly added to the granules and the mixture was mechanically mixed. In the second method, the photochromic pigment at first dissolved in a small amount of ethanol (EtOH), and then was applied to the PP granules. The pigment was added in the amount corresponding to the final concentration in the fibers. The concentrations of pigment in the fibers were 0.5; 1; 1.5; 2 and 3 wt. %. In the next step of processing the prepared mixtures were dried and then they were spun. Pigment distribution, changes in the surface and cross section of the fibers were evaluated by light microscopy at different magnification.
On the following Figure 2 the surface of the prepared PP/PURPLE fibres can be seen. Pure PP has its surface smooth and shiny. With increasing concentration of the photochromic pigment in the fibres, the number of particles on the surface of the fibers increases. Some areas contain larger amounts of these particles than others, which are related to uneven dispersion of the photochromic pigment in the fibres. Figure 3 shows cross-sections of pure PP fibres. We can see that the fibres in their structure do not contain any particles or agglomerates. Figure 4 shows the cross sections of the fibres with the highest concentration of the photochromic pigment - 3 wt. %. We can see that throughout the mass of fibres are dispersed photochromic pigment particles in the form of small or larger agglomerates. These agglomerates indicate a not very uniform distribution of photochromic pigment in the mass of the fibre.

**Figure 2.** Surface of PP and PP/PURPLE fibres drawn at $\lambda_{\text{max}}$ observed by light microscope (magnification 60x)

**Figure 3.** Cross section of PP fibres drawn at $\lambda_{\text{max}}$
The results obtained by experimental work have confirmed that it is possible to prepare the mass pigmented PP fibres containing photochromic pigment. Results showed that there was no difference in the preparation of fibers with photochromic pigments mixed mechanically or mixed with EtOH. The methods of preparing pigmented fibres may be refined in future by optimization of the processing conditions of PP fibers in the process of mixing the granules with the pigment as a powder designed specifically for spinning and the conditions during the spinning and drawing.

Acknowledgements

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References
