OPTICAL PROPERTIES OF PHOTOCHROMIC PIGMENT INCORPORATED POLYPROPYLENE FILAMENTS: INFLUENCE OF PIGMENT CONCENTRATIONS AND DRAWING RATIOS

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Extended abstract

This paper reviews the impact of different concentration of photochromic pigment as well as different drawing ratio with respect to the optical properties of multifilament. Temperature variation may induce very significant and different effects on the behavior of the photochromic system, so there is a special device such as LCAM FOTOCHROM, which is available in LCAM-TUL which helps us to measure the various optical properties like kinetics of the growth and decay. The results are showing there is a significant change in the optical properties of polypropylene fibers with respect to drawing ratio.

Key words: photochromism, colorimetry, functional dyes, smart fabrics, polypropylene.

Photochromism denotes a reversible color change upon exposure to light. Photochromic materials have received extensive attentions since they are applicable to photoactive media, such as optical storage, optical switches, sensors, smart windows, and so forth. Generally, photoproducts absorb at shorter wavelengths than their precursor. This is termed negative photochromism; the photochromic mechanism was illustrated in (Fig.1). A more common scenario is that the initial photochromic species absorbs in the UV and on photolysis produces a colored photoproduct absorbing in the visible region of the spectrum (positive photochromism), and the process involves interconversion of a single molecule between two chemically distinct forms. The activating radiation generally is in the UV region (300 to 400 mm) but could be in the visible (400 to 700 nm). The most prevalent photochromic systems are established to be uni-molecular reactions ($A \rightarrow B$) Reversibility is the main criterion for photochromism. The back reaction ($B \rightarrow A$) can occur predominantly by a thermal mechanism. For this present study, four different concentrations of photochromic pigment were used to produce PP filaments with six drawing ratios. The main goal for this study was to find the relationship between concentration of photochromic pigments & drawing ratio with respect to optical properties of polypropylene filaments.
Figure 1. Absorption spectra for two-state photochromic system.\(^7\)

The photochromic pigments incorporated polypropylene multifilament was produced and the production parameters are illustrated in the (Tab.1 and 2). The photochromic pigment was mechanically mixed with polypropylene granulate and the mixture added in the hopper of the extruder;

Table 1, various parameters which are used in Melt spinning

<table>
<thead>
<tr>
<th>Melting temperature ((T_m))</th>
<th>220 °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Photochromic Pigment</td>
<td>Photopia AQ-INK BLUE</td>
</tr>
<tr>
<td>Pigment concentration in fiber ((c_{pigm}))</td>
<td>0; 0,5; 1; 3; 5% (on weight basis)</td>
</tr>
<tr>
<td>Speed of worm (rev/min)</td>
<td>50</td>
</tr>
<tr>
<td>Dosage</td>
<td>100/0</td>
</tr>
<tr>
<td>Drawing temperature ((T_d))</td>
<td>120°C</td>
</tr>
</tbody>
</table>

Table 2, Drawing ratio and concentration of photochromic pigments

<table>
<thead>
<tr>
<th>Sample</th>
<th>Composition</th>
<th>Drawing ratio (\lambda)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>PP 562 R</td>
<td>2  2,5  3  3,5  4,0</td>
</tr>
<tr>
<td>2</td>
<td>PP 562 R + 0,5% Blue</td>
<td>2  2,5  3  3,5</td>
</tr>
<tr>
<td>3</td>
<td>PP 562 R + 1% Blue</td>
<td>2  2,5  3  3,5  4,0</td>
</tr>
<tr>
<td>4</td>
<td>PP 562 R + 3% Blue</td>
<td>2  2,5  3  3,2</td>
</tr>
<tr>
<td>5</td>
<td>PP 562 R + 5% Blue</td>
<td>2  2,5  3  3,2</td>
</tr>
</tbody>
</table>

After production, the spectral and colorimetric data set was determined by using of unique spectrophotometer Fotochrom LCAM, Which was developed by LCAM Team in Technical University, Liberec and the picture of the instruments were shown in the (Fig. 2 and 3). Color measuring instrument (spectrophotometer) determines the K/S value of given filaments through Kubelka-Munk equation in (1)\(^{14,1}\).
\[
\frac{K}{S} = \frac{(1-R)^2}{2R}
\]  
(1)

Where \( R \) = reflectance percentage, \( K \) = absorption and \( S \) = scattering of dyes.

This unique spectrophotometer is able to measure the kinetics of color changing in the photochromic samples as indicated in (Fig. 3), where the dependence of Kubelka-Munk function on the concentration of photochromic pigment and the drawing ratio in time can be seen. Temperature variation may induce very significant and different effects on the behavior of the photochromic system, so we keep the temperature constant (20 °C ±2 °C) for all the samples. The produced samples were shown in the (Fig. 4).

The results are shown in (Fig.5 and 6) and they clearly explain the relationship between Kubelka-Munk function with respect to the drawing ratio along with the concentration of photochromic pigment. It has clearly shown that increasing of drawing ratio decreases the Kubelka-Munk value. This situation can be described as the effect of the attenuating of multifilament and the reduction of fineness and the concentration of photochromic pigment in the mass of used polypropylene polymer.

The transformations of Kubelka-Munk function maximum value with respect to the drawing ratio as well as concentration are shown in (Fig. 5).
Figure 5. Dependence of K/S function on time - growth and decay phase of photochromic change for different drawing ratio \( \lambda \) and concentration of pigment is 3%.

Figure 6. Dependence of the maximum K/S function of photochromic change for different drawing ratio \( \lambda \) and concentration of pigment is 5%.

Note: More results are available to be discussed during the presentation.

Conclusion

This research work describes the impact of K/S values on concentrations of photochromic pigment and various drawing ratio. From this work, we conclude the following points:

- Increasing the drawing ratio decreases the K/S values.
- Even though at same concentration different K/S values are observed by various drawing ratios, it seems there is a huge impact on K/S values with respect to drawing ratio.

References


