INFLUENCE OF WASHING OF WOVEN LABELS PREPARED FROM POLYPROPYLENE AND POLYAMIDE PHOTOLUMINESCENT FIBRES ON INTENSITY OF LIGHT EMISSION

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Abstract: *The contribution focuses on examination of photoluminescent effect of woven labels prepared from polypropylene and polyamide photoluminescent fibres using concentrate containing 0.10 wt.% of photoluminescent blue organic pigment. The photoluminescent polypropylene and polyamide fibres are incorporated into construction of the label directly in the technological process of weaving. Photoluminescent effect of blue pigment has been evaluated before and after 20 washing cycles. Influence of washing on change of intensity of blue light emission in the woven labels has been assessed by two methods, using FLUOTEST device in the region of electromagnetic radiation in short-wavelength and long-wavelength ultraviolet radiation and by evaluation of b* colour coordinate in the CIE LAB colour space using ULTRASCAN XE device. Intensity of light emission of the photoluminescent polypropylene and polyamide fibres allows distinct identification of photoluminescent fibres in the labels aimed at protection of products against counterfeiting.*

Keywords: *photoluminescent fibres, photoluminescent pigment, originality protection, change of colour expression, electromagnetic radiation.*

1 INTRODUCTION

World`s leading companies in all industrial fields try to protect their sophisticated products against counterfeiting. Clothing and fashion accessories represent a significant share of counterfeiting and it is estimated that counterfeiting constitutes more than 10% of the world fashion-related trade [1].

One of affordable and cost-effective access to originality protection of products is application of photoluminescent dyestuffs and pigments, which besides colour change emit also light under ultraviolet (UV) lamp. Phenomenons involving absorption of energy and subsequent light emission are classified generally as luminescence. Photoluminescent (FL) dyestuffs and pigments, available in organic as well as inorganic form are particularly interesting for the purpose of protecting product originality [2, 3].

Originality protection of textile products made of unmodified polymer fibres can be ensured using various safety protective patterns from photoluminescent polymer fibres in the products, e.g. logo of the manufacturer, safety protective label, extra courses in the clothing products etc. This way authentication of textile products can be ensured in the cases where it is necessary to prove their originality. Basic way of designation is a structured code with an identification mark. The mark is made of a thread/yarn incorporating photoluminescent fibre reflecting light backwards when exposed to UV light [4].

The aim of this contribution is to examine permanency of photoluminescent (FL) effect of a protective identification component in the labels containing 0.10 wt.% of blue organic pigment in polypropylene (PP) and polyamide (PA6) photoluminescent fibre (FLV).

2 EXPERIMENTAL PART

2.1 Materials used

Following fibre types with linear density of about 90 dtex have been used to prepare the woven labels:

- PP fibre containing FL blue pigment with concentration of 0.10 wt.% in the fibre (**PP/FLV**);
- PA6 fibre containing FL blue pigment with concentration of 0.10 wt.% in the fibre (**PA/FLV**);
- textured standard (unmodified) PP fibre without content of FL pigment (**PP**);
- textured standard (unmodified) PA6 fibre without content of FL pigment (**PA**).

Workability of the above-mentioned fibres has been evaluated in an assortment of woven labels. Base of the label was made from black polyester fibre on which a pattern in a shape of full circle with 32 mm diameter has been woven using PP and PA FLV (Figures 3, 6 and 7). Weaving of the labels was performed on a width of 1.2 m and length of 0.5 m.

Edges of the labels remained smooth, undamaged when cutting the labels to a final width of 40 mm with a content of PP FLV and PA FLV.

2.2 *Methods used to evaluate efficiency of blue light emission*

Photoluminous expression and intensity of blue light emission has been evaluated on the prepared labels using methods as follows:

- objectively by a change of colour expression by means of b* colour coordinate in the CIE LAB colour space using ULTRASCAN XE device according to the standard STN ISO 105-J03 [6]. The more negative b* value is measured the stronger intensity of emission is observed [5].
- optically by a form of photoexcitation after light exposure in the device FLUOTEST with UV lamp in short-wavelength (UV-C region) and long-wavelength ultraviolet radiation (UV-A region). Region of the electromagnetic radiation in shown in Figure 1.

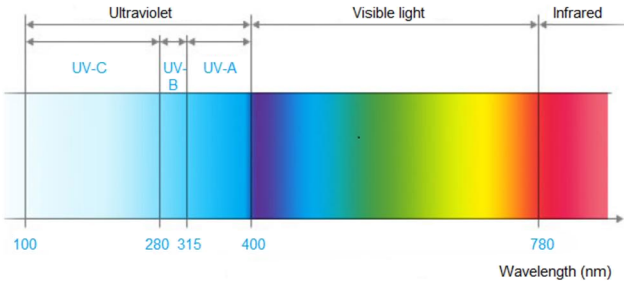

Figure 1 Electromagnetic radiation fields

3 RESULTS AND DISCUSSION

Intensity of blue light emission on the prepared woven labels made from PP FLV and PA FLV containing 0.10 wt.% of FL pigment has been evaluated by an objective instrumental method using b* colour coordinate in the CIE LAB colour space on ULTRASCAN XE device. This device enables to evaluate influence of blue FL pigment and its concentration on change of photoluminescent expression of the FLV. Degree of efficiency of FL pigments in the woven labels before washing without content (standard) and with 0.10 wt.% content of FL pigment in PP FLV and PA FLV is shown in Figure 2.

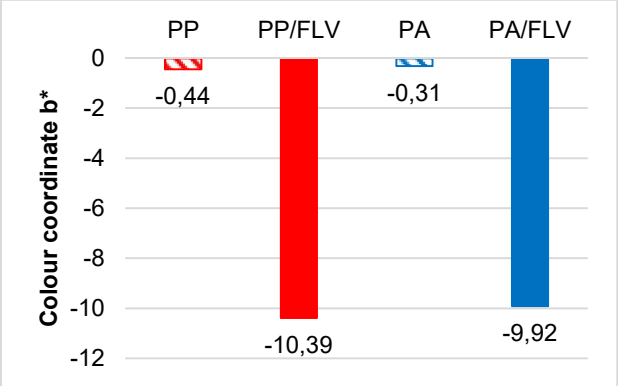

Figure 2 Intensity of light emission on the labels made of standard PP/PA fibre and PP FLV, PA FLV containing 0.10 wt.% of blue FL pigment in the fibre before washing

More remarkable intensity of blue light emission has been achieved with PP fibre containing 0.10 wt.% of FL pigment. The b* colour coordinate of the used PP FLV is at the level of -10.39. PP FLV containing 0.10 wt.% of FL pigment used in the label has higher intensity of blue light emission by 4.52 % than PA FLV (-9.92) with the same content of FL pigment.

Intensity of blue light emission (Figure 3) has been demonstrated optically on the prepared labels using FLUOTEST device to confirm photoluminescent effect of the used FL pigments.

Figure 3a) indicates that the labels with FLV as well labels without FLV have white colour in the daylight and they are not distinguishable with naked eye of an observer. The labels made of PP FLV and PA FLV shined brighter in UV region with long-wave radiation than in UV region with short-wave radiation. Optical excitation emitting brighter blue light is observed by naked eye allowing clear identification of labels containing FLV in comparison with the labels without content of FLV (Figures 3b, 3c).

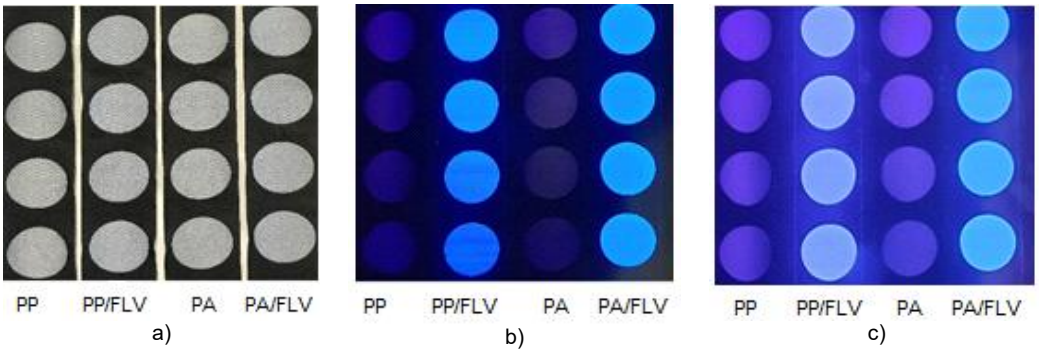

Figure 3 Woven labels: a) in visible spectrum of solar radiation, b) in UV-C region with short-wave radiation, c) in UV-A region with long-wave radiation

Permanency of blue photoluminescent pigment in PP FLV and PA FLV used in construction of the woven labels has been evaluated after the 1st, 2nd, 3rd, 5th, 10th, 15th, and 20th cycle of washing and drying with subsequent assessment of b* colour coordinate and optical expression of photoexcitation under UV lamp. Washing and drying of the labels has been performed according to the standard STN EN ISO 6330: 2012 [7] under 4N procedure at water temperature of (40±3°C) using a reference detergent (phosphate-free powder detergent without optical brightening agent and without enzymes). Drying has been performed under C procedure, i.e. flat drying in horizontal position. Influence of washing on change of b* colour coordinate of the woven labels is shown in Figures 4 and 5.

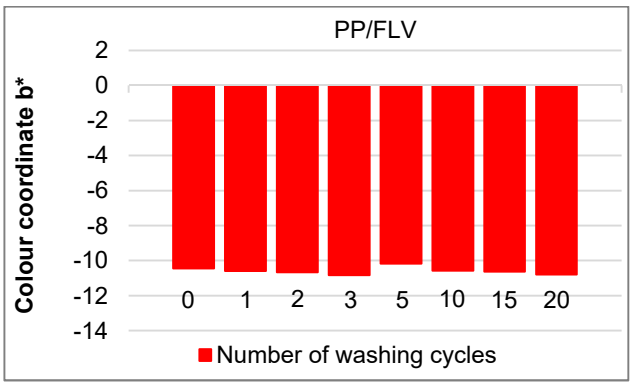

Figure 4 Influence of washing and drying of the woven labels from PP FLV containing 0.10 wt. % of pigment in the fibre on change of b* colour coordinate

The photoluminescent effect of any woven label has not been changed with increasing number of washing and drying cycles. Washing and drying of the labels has no influence on reduction of intensity of blue light emission. There is no reduction of intensity of blue light emission of the labels from FLV, which has been confirmed by the measured values of b* colour coordinate (Figures 4 and 5).

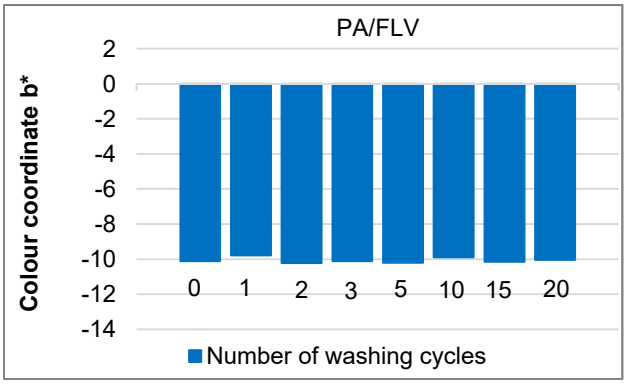

Figure 5 Influence of washing and drying of the woven labels from PA FLV containing 0.10 wt. % of pigment in the fibre on change of b* colour coordinate

Continuous decrease/increase of intensity of blue light emission before and after 20 washing and drying cycles is comparable. We consider resulting difference in intensity of light emission on a level of ±3% to be negligible as it can be caused by measurement error, device, influence of knitted construction – its density after washing etc.

Intensity of blue light emission on the prepared labels from PP FLV before and after washing and drying (1 – 20 cycles) is shown in Figure 6. Intensity of blue light emission on the prepared labels from PA FLV before and after washing is shown for comparison in Figure 7.

As established with labels prepared from PP FLV containing blue organic pigment, more pronounced intensity of blue light in UV region with long-wave radiation has been noted in the case of the labels from PA FLV as well.

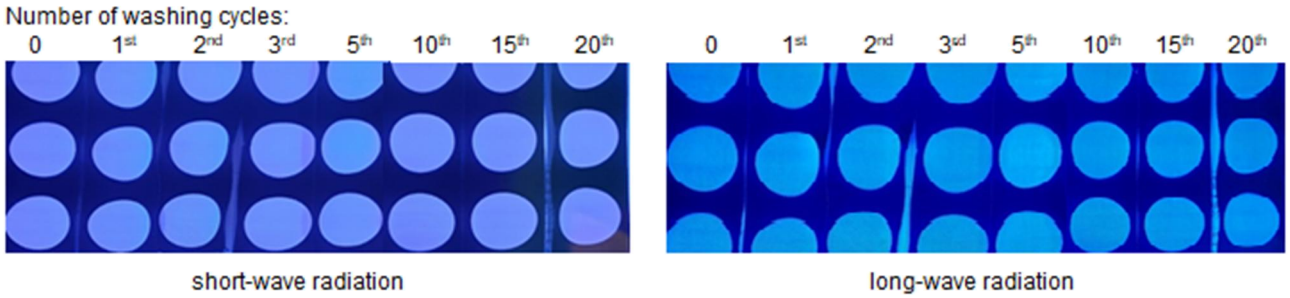

Figure 6 Photoluminescent effect of the woven labels from PP fibre containing 0.10 wt.% of pigment before washing up to the 20th cycle

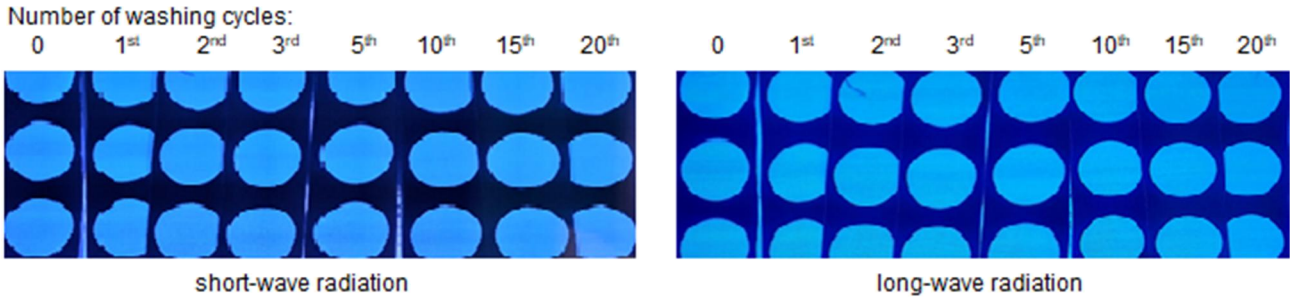

Figure 7 Photoluminescent effect of the woven labels from PA fibre containing 0.10 wt.% of pigment before washing up to the 20th cycle

4 CONCLUSION

The woven labels prepared from PP fibres containing 0.10 wt.% of photoluminescent pigment have retained the same intensity of blue light emission after 20 washing cycles as before washing. As far as intensity of blue light emission is concerned, intensity of emission of the labels from PA FLV is comparable with intensity of emission of those made of PP FLV. The woven labels prepared from PP FLV are characterized by visibly lower intensity of blue light emission in short-wave radiation than labels from PP FLV of the same quality in long-wave radiation. Equally, woven pattern on the label from PA FLV has visibly brighter intensity of blue light emission in long-wave radiation. Continuous decrease/increase of intensity of photoluminescent blue pigment emission in PP and PA fibre before and after 20 washing cycles is comparable. Intensity of blue light emission of the woven labels containing blue photoluminescent pigment has not decreased visibly from the 1st washing cycle. Intensity of blue light emission on the labels with incorporated PP FLV and PA FLV containing 0.10 wt.% of FL pigment is as significant before washing as after the 20th washing cycle. With increasing number of washing cycles of the labels washing out the photoluminescent pigment from PP FLV and PA FLV did not occurs, the proof is optical expression of photoexcitation of these FLV after lighting in the optical device FLUOTEST with UV lamp with short-wave and long-wave radiation.

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