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Express diagnostics of polymeric petroleum products for its usage in latent watermarks of the smart packaging

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Abstract

The express-method of diagnostics and selection of polymeric petroleum products is substantiated. Such products are processed by hot melt extrusion into films with technical purposes and then used in packaging. Bright visual effects in layers of polyolefin film materials are used in packaging of consumer goods; they can be seen in polarized light and depend on chemical and phase composition of films. For films application in smart packaging, for example, frozen food products, input control and diagnostics is required not only of mechanical and optical properties, but also of sensitivity of their optical properties to heat treatment. The two-stage method is suggested for checking the suitability of polyolefin films for the latent marking in polarized light for their usage in the production of intelligent packaging for frozen foods or other products with a strictly regulated mode of storage.

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Keywords: method of polymeric petroleum products diagnostics; polyolefins; heat treatment; multilayer films; optical properties; latent marking

1. Introduction

The most common large-capacity secondary products of oil refining are polyolefins. They are used practically in all spheres of human activity: medicine, construction, engineering, production and processing of food products, military and space equipment.

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In every industry new innovative products are created with a high initial cost, the developers promote them to the world market at a significant cost. The intelligent packaging and a variety of protective marking methods are used to protect such products from the counterfeit [1].

We proposed [2] and economically substantiated [3] new methods of protective labeling for productpackages with films made of large-tonnage polymers such as polyethylene, polypropylene, polyvinyl chloride. The possibility of effective application of protective marking packaging, manufactured from these refined polymeric petroleum products, is determined by the peculiarities of polymers chemical structure, the fractional composition of macromolecules and the films supramolecular structure.

Manufacturers of polymer films characterize their products by a large set of quality indicators, including: density and MFR of the polymer, thickness and overall size, gloss, transparency, mechanical properties, etc. With such set of indicators it is impossible to determine the industrial suitability of polymer films for the optical marking, which is visible in polarized light [4].

The purpose of the research is to develop a method of industrial polyolefin films express diagnostic for material purposeful selection for smart packaging and for the assessment of its protective marking possibility.

2. Study subject

- 50±2 μm industrial high-pressure polyethylene films (PE-1), M_w=2x105, crystallinity 33-36% by MICROTHENE CR 89002 NEAT U.S.INDUSTRIAL CHEMICAL COMPANY, Melt Index= 150 G/10 min;
- 50±2μm industrial high-pressure polyethylene films (PE-2), M_w=2x105, crystallinity35-37 % by PETROTHENE NA 596 NEAT. U.S.INDUSTRIAL CHEMICAL COMPANY;
- polymeric polaroid films (Nitto Polarizing Film, G1220DUN, Nitto Denko Corporation, Osaka Japan) with high polarizing efficiency of 99.97% and integral light transmittance through the two films in parallel of 0.9 were studied in this paper.

3. Methods

The measurements of the films optical characteristics were carried out in three ways: the first one – visually, on a polarizing microscope POLAM R-312; the second one – using a portable spectrophotometer X-Rite SpectroEye in ‘reflectance D65 daylight mode’ and ‘polarized light mode’; and the third one – by using spectrophotometer SF-2000 in the mode‘on a gleam’ in daylight D65.

The FTIR spectrometry was carried out using a device brand FSM 1201.

The heat treatment of the films was carried out in three ways.The first way – by heating in a free state between the films of the polytetrafluoroethylene in the dry-air thermostat of the chromatograph Color–800 with an accuracy 0.1 ° C.The second way – by hot relief pressing.And the third way – by processing in the laminator using the special membranous envelope, limiting the warping of the film during the passing through the zone of heat radiation.

4. Results and discussion

Color and transparency of the two polyethylene film samples of different brands placed above and between the layers of the polarizer under the natural light (Fig. 1) and in the polarized light (Fig. 1) were compared. The polarizers were set in the position of maximum transmissive capacity, so that their own color had no significant effect on the color of three-layer package films in both set versions of the film [5].

Fig. 1 shows the lack of the film color in daylight and a different color of the original and heat-treated samples in polarized light. The difference between diagnosed samples of the polyethylene film of equal thickness and crystallinity degree, which were produced in identical conditions of the polymer hot melt extrusion, is explained by the technology of petroleum products secondary processing into polyethylene and thermal prehistory of the film particular brand.