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The Study of Molecular Orientations in Polymer Films (PE) Induced by Crystallization under Thermal-Centrifugal Fields

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Abstract

This issue deals with inducing of alignment (orientation) in polymer films under centrifugal field. The new method consists in the film sedimentation on an inner side cylinder in rotation with fixed rotations per minute. Simultaneous application of centrifuge fields and thermal treatments induces transformations in preferential directions. The behaviour of orientation-induced by crystallization of PE (polyethylene) films from the thermal treatment in centrifugal field has been investigated. The orientation induced in this way was monitored by polarized IR spectroscopy and XRD.

Key words: *molecular orientation, polymer crystals, thin films*

Introduction

The alignment of polymeric chains with predefined conformations is one of the most important target in many field applications like: macromolecular crystal growth, optical grating with polymer chains in preferential orientation, photo-refractive materials, and mechanical properties. Actually only by drawing in fibbers of melted polymers induces the polymer orientation. Mechanical stresses induced by drawing confer the polymer a specific texture leaving free many other relaxations phenomena. This issue deals with inducing of alignment (orientation) in polymer films under centrifugal field.

Experimental Details

Getting Thin Films of PE

The polyethylene films have been obtained by through hot-pressing. For this purpose it has been used a lab (laboratory) hydraulic press [1]. The press has plates which can be electrically warmed up to 350^0C. The basic diagram of such press is presented in the figure 1. In case of getting of the PE thin films, the temperature of the warmed press was of 170^0C. PE powder used for getting these films is of HDPE type. The PE thin film obtained in this way has a thickness between 0,04-0,1 mm.

These films already crystallized are put on the revolving support of experimental device (figure 2) and are thermally treated to a higher temperature than the melting point (170^0C).This

temperature is maintained for 30 minutes, so that, during the distressing process the polyethylene will trend and crystallize again.

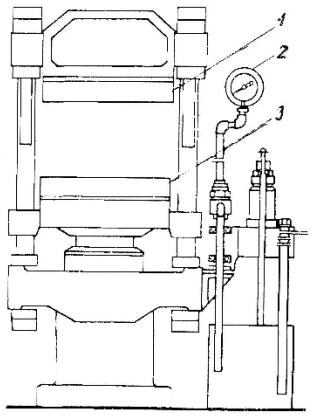

Fig. 1. The basic diagram of a hydraulic press: 1 -the upper plate,
2 - the manometer, 3 - the down plate

The re-crystallization process is done very slowly, by means of free oven cooling. For the study of molecular orientation films of polyethylene (PE), they were thermally treated at a temperatures between 100^0-400^0C in centrifugal field at speeds between 2000-6000 rpm.

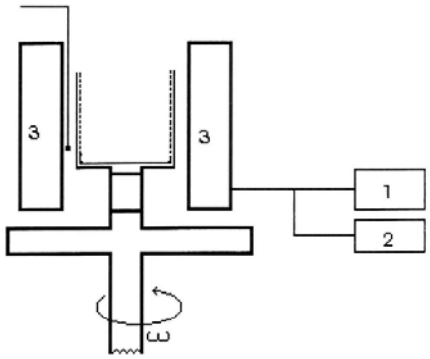

Fig. 2. The experimental device used for sedimentation on cylindrical surfaces.
1, 2- the electronic device for temperature and time setting. 3 – the oven

After the thermal treatment at 400^0C we can notice that polyethylene doesn't change the initial colour.

The Sedimentation Method on Cylindrical Surfaces

This method is relatively simple and consists of the sedimentation of the polymer solutions on a rotary support of cylindrical form. The method offers a much attentive control of the thickness and uniformity of the film and, especially by the centrifugal force created by the rotary sub layer, it makes possible the forming of a homogeneous film.

The films are layered on thin aluminium sheets. The use of aluminium sheets is necessary for taking off the deposited film from the rotary sub layer. The distribution of the centrifugal force created by the rotary sub-layer enables the formation of a homogeneous film with a high degree of molecular chain alignment, as well as reciprocal orientations of functional groups. The

essential characteristic of this method is that it assures the conditions of getting a smooth (plain) and clean surface.

Experimental Results

The PE films obtained were analysed through infrared spectroscopy with Fourier transform (FT-IR) in order to evidence the molecular orientation grace to thermal treatment in the centrifugal field [2]. In the polyethylene case, in order to notice the influence of the centrifugal field on molecular orientation in thermal treatment, the centrifugal action was done at two different speeds: 3500 rpm and 4500 4500 rpm.

Depending on these rotation speeds the samples were named: PE1 thermal treatment to 400^0C in centrifugal field with 3500 rpm; PE2 thermal treatment to 400^0C in centrifugal field with 4500 rpm. For the PE-1 film was obtained two spectra, the second one by turning the sample with 90^0, and we gave them the name PE1 - parallel and PE-1 perpendicular.

In figure 3 there are presented the spectral regions of samples PE1-parallel and PE1-perpendicular, from which can be observed that the turning of the sample doesn't drive to significant differences between the two spectra. The figure 4 presents the modifications inducted after the thermal treatment in centrifugal field at different rotation speeds compared with the standard PE film. The diffraction of ray X as well as the mechanical properties of PE films obtained by this method are in process of research.

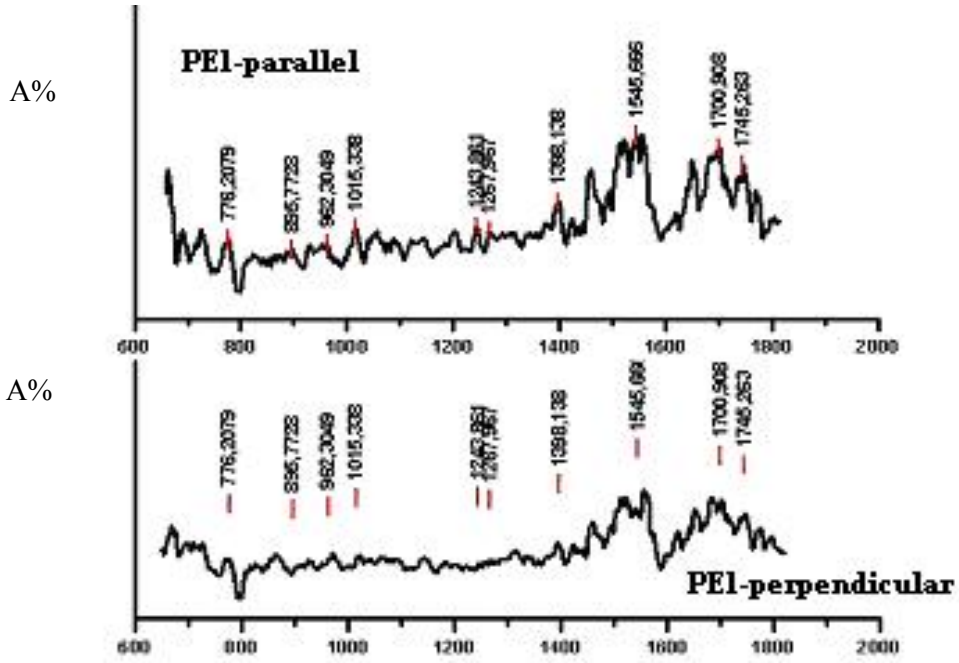

Fig. 3. The FT IR PE1- parallel and PE1-perpendicular spectra

Conclusion

The alignment of polymeric chains with predefined conformations is one of the most important target in many field applications like: macromolecular crystals growth, optical networks with polymer chains in preferential orientation, photo-refractive materials, and mechanical properties. Simultaneous application of centrifuge fields and thermal treatment induces transformations in preferential directions.

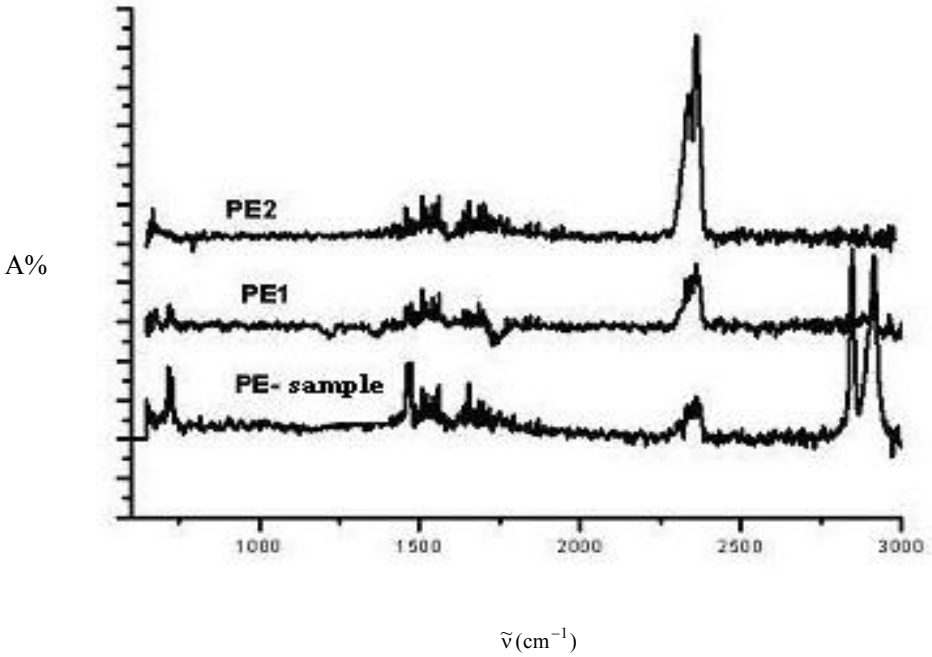

Fig. 4. The FT-IR spectra of PE-etalon, PE1 and PE2 films

References

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Studiul orientărilor moleculare apărute în filme de pe (polietilenă) prin cristalizare sub acţiunea câmpurilor termice şi centrifugale

Rezumat

Acest articol se ocupă de inducerea aliniamentelor (orientării) în filme de polimer sub acţiunea câmpului centrifugal. Noua metodă constă în depunerea de film pe un suport rotativ în formă cilindrică având fixate anumite rotaţii pe minut. Aplicarea simultană a câmpurilor centrifugale şi a tratamentelor termice determină transformările în direcţii preferenţiale. A fost analizată comportarea orientării produsă prin cristalizarea filmelor de PE (polietilenă) prin tratamentul termic în câmpul centrifugal. Orientarea determinată prin acest procedeu a fost monitorizată cu ajutorul spectroscopiei polarizate IR şi cu XRD.