

Creep Behavior of Linear Low-Density Polyethylene Films

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Abstract

The Creep of biaxially-orientated linear low-density polyethylene (LLDPE) non-crosslinked and crosslinked with β -irradiation was studied as a function of the draw ratio and irradiation dose. The creep results have shown an increase in the creep strain after the polymer irradiation with a dose below 4 Mrad (MR) in comparison with a non-irradiated film. This increase corresponds to the disorientation in the amorphous phase, which takes place as a result of the film heating during irradiation. This disorientation was demonstrated by differential scanning calorimetry (DSC) and X-ray analysis.

Key words: polyethylene films, orientation, β -irradiation, crosslinking, creep.

Introduction

Biaxially-oriented polyethylene films are widely used in the packaging industry. These films are extensively used for flexible packaging of a broad spectrum of products. They provide a very good combination of physical and mechanical properties, which meet the demands and technical requirements of the packaging industry.^(1,2)

There are several processes for the production of oriented films, among them biaxial orientation by the double-bubble process, or tubular orientation process. During this process the primary extruded tube is quenched, reheated to a temperature below the melting point and then simultaneously oriented in both machine direction (MD) and transverse direction (TD). The stretching (orientation) that takes place below the melting point is the most important difference between this process and the well-known blown process. During the winding of films at various stages of the technological process, stress is applied to the film in order to wind it smoothly. When the film is wound into reels, the film constituting the inner layers of the reel cannot release its elastic deformation because the outer layers compress it. It has been found that when the film is kept under stress without a possibility to release its deformation, wrinkling takes place in the film,

making it unsuitable for subsequent use. This phenomenon is caused by the viscoelastic behavior of the polymer, which can be characterized by the creep and stress relaxation. Therefore, the study of viscoelastic properties and the morphology of oriented films is necessary from both scientific and technological viewpoints.

A potential problem associated with the long-term use of polyethylene is its tendency to "creep", that is, to deform gradually under sustained load. It is especially prevalent in polyethylene with modest levels of crystallinity.⁽³⁾ The poor creep performance of polyethylene can exclude it from a wide range of applications. During orientation, considerable structural changes in polyethylene occur, e.g. its transformation from the spherulitic into the fibril structure.⁽⁷⁻⁹⁾

Earlier, the influence of irradiation (mainly γ) on the creep behavior of polyethylene was studied by:^(4, 12, 1, 12, 3, 4) The results for ultra-high molecular weight polyethylene manifest a decrease in the creep strain with the growth of the irradiation dose. Ward with coauthors (1986, 1994, 2003) studied the influence of β -irradiation on the creep behavior of uniaxially oriented polyethylene film. The influence of the morphology on creep behavior of melt-extruded polyethylene films was investigated by:⁽¹⁴⁾ However, the creep behavior of

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