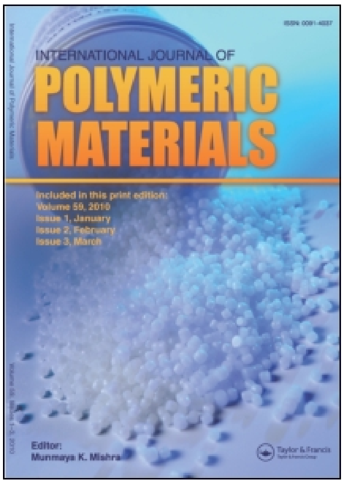

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The Peculiarity of Polyethylene Degradation during Processing with Polystyrene

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The degradation of polyethylene during processing in the blends with various contents of polyethylene by disk-screw extruding at different temperatures is studied. The dependence of processing conditions and the correlation between the components of the polymer's composition and degradation of polyethylene are discussed.

KEY WORDS Degradation, processing, polystyrene.

DISCUSSION AND RESULTS

One of the actual problems in polymer technology is to obtain good materials from polymer blends. Such materials can be produced by mixing of melts during processing. The main requirement of this processing is a high degree of homogenization of polymers. High shear velocities are used in the machinery for this purpose. This results in both very good mixing and in an increase of macromolecular scission.

Numerous papers[1–3] have been published in this field and the considerable increase in their number can be explained by the immense practical importance of the problem. There is much research establishing the influence of temperature and shear velocity during processing on the degradation of different polymers.[4,5] However, degradation of the polymer in the blend with other polymers, which also degradate, is rather peculiar.

So, the rate of this process (degradation) and its degree depend not only on processing conditions (temperature and shear velocity), but also on the correlation between the components of the polymer's composition.

The aim of our research is to investigate the degradation of polyethylene during processing in the blend with different contents of polystyrene by disk-screw extruding at 190°C, 170°C and 150°C. Evaluation of the degree of PE degradation was carried out by changing the molecular mass. Analysis of molecular characteristics was carried out using the method of temperature fracture in the dilute solution of θ-dissolver.[6]

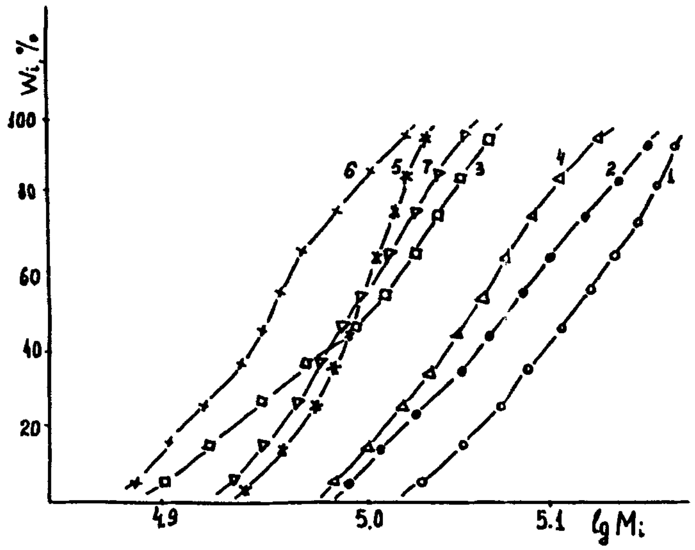

FIGURE 1 Integral MWD of polyethylene after processing in a disk-screw extruder, with contents: 1-0%; 2-5%; 3-20%; 4-40%; 5-50%; 6-80%; 7-95%. PS mass in the blends. T = 150°C; the rate of rotation is 70 min^{-1}.

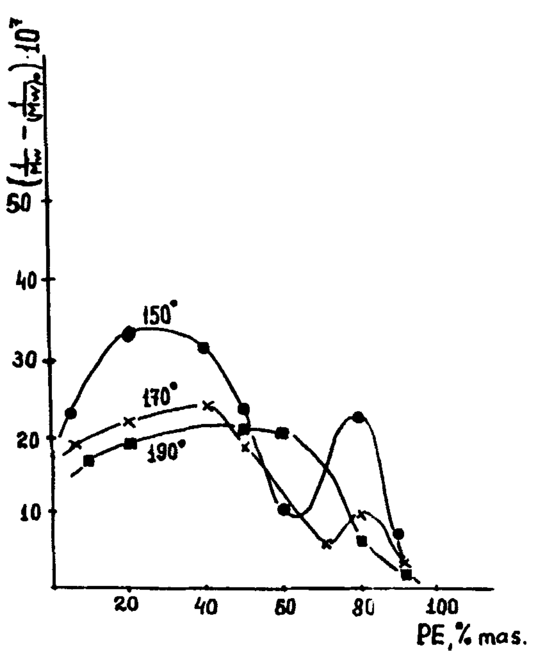

FIGURE 2 Degradation of PE as a function of PE–PS blend composition after processing in a disk-screw extruder at 70 min^{-1}.

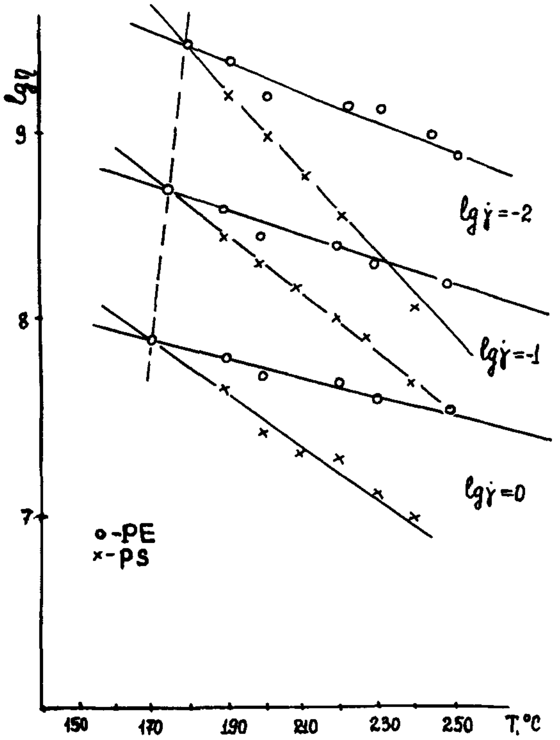

FIGURE 3 Dependence viscosity of PE and PS melts on temperature.

The temperature distribution transforms into molecular weight one according Flory's formula: $M_i = b^2T_i^2/(\theta - T_i)^2$. The magnitudes of b^2 and θ for low density PE are 550 K and 425 K, respectively.[6]

Processing of PE with PS (Figure 1) results in a shift of the molecular weight distribution of PE to lower molecular weights. Maximal effect takes place at the blend composition PE–PS = 20:80; minimal effect takes place at the composition PE–PS = 95:5. The width of distribution is practically constant for composition with 95%, 60%, 20%, and 5% PE. A decrease in width is observed for 50% PE, and an increase is observed for 80% PE. The molecular weight magnitude dependence of blend composition is complicated enough.

The amount of degradation is characterized by parameters $(1/M_w - 1/M_{w0})$. Figure 2 shows these parameter dependencies of the blend composition. These functions have extreme for 20% and 80% PE at 150°C and 170°C; for 190°C it does not have extreme.

Viscosity behavior is illustrated in Figure 3. The viscosity of PS is lower than that of PE in this temperature region. But there is a special point when PS viscosity is equal to PE one. This point shifts to lower temperature when the shear rate increases. Extrapolation to real shear rate gives 150°C as temperature of equal viscosity.

Viscosity significance of components in the blend and their correlation at definite conditions determine the morphology of a system along with its general viscosity.

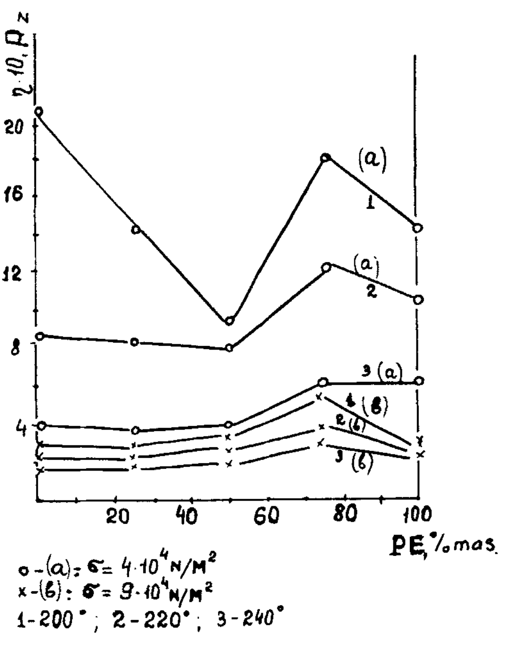

FIGURE 4 Influence of composition of PE–PS blends on melt viscosity.

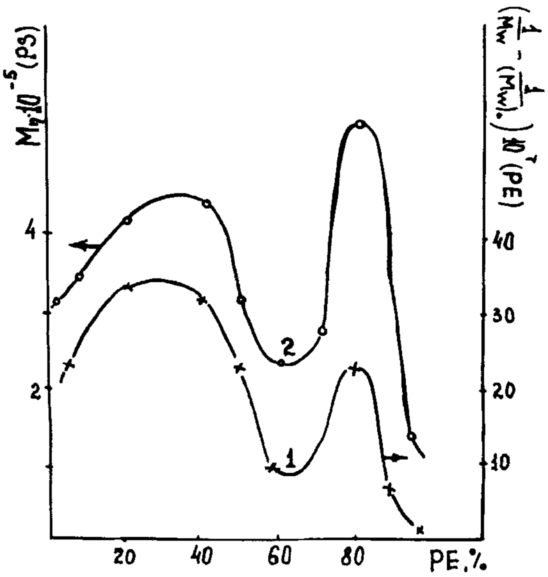

FIGURE 5 Comparison of the degree of PE degradation (1) and change in the molecular mass of PS (2) during processing in the blends. T = 150°C; N = 70 min^{-1}.

Figure 4 presents the general viscosity as a function of the blend composition at different temperatures and stress. They have a maximum of 75% PE content. Han and Kim have explained these maximums as being the results of morphological changes in the blend from "drops of PS in the PE dispersion phase" to the system, where components are interlaced. The amount of mechanodegradation increases as polymer viscosity decreases. Extreme take place for blends with 75–80% PE as in both Figures 2 and 4. This fact shows that PE degradation increases with the growth of melt viscosity during the processing of PE–PS blends. However, this dependence is not correct for another component in the blend—PS.

Moreover, the decrease in the molecular mass of PE of the components is accompanied by an increase in the molecular mass of PS. So, Figure 5 demonstrates the dependence of PE degradation in the concentration and the increase of PS molecular mass during processing in the disk-screw extruder at 150°C. The curves in Figure 5 reflecting changes in molecular mass of PE and PS is explained by radical reactions, which take place in the blends of PE and PS during processing.

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