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Fig. 1

Figure 1: Fig. 1

Fig. 2

Figure 2: Fig. 2

Abstract

Full Text

PHYSICAL CHEMISTRY

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ELECTRICAL CONDUCTIVITY OF A POLYAMIDE MELT

In most cases, the study of the electrical conductivity of polymers is limited to investigating the electrical conductivity only of the solid phase ([1]). As for polymer melts, at present the electrical properties of such systems have hardly been studied. It has only been established that, near the melting temperature of certain polymeric materials, a characteristic change in the magnitude of the dielectric constant is observed; this is evidently connected with the orientation of dipoles in the crystalline phase ([2]).

Fig. 1. Dependence of the specific electrical conductivity of molten "Kapron" amide on temperature: 1 –unirradiated specimen; 2 and 3 –after γ-irradiation.

Fig. 2. Dependence of the specific electrical conductivity of the melt on the holding time of the specimen at the corresponding temperature. 1 –at 240°; 2 –255°; 3 –270°; 4 –285°.

The study of the electrical conductivity of polymers at various temperatures is associated with the difficulty of measuring the current passing through the specimen under conditions of constant voltage. The magnitude I may change with time, and the value σ cannot be determined. The electrical conductivity of a substance depends on the presence in it of loosely bound and free charges and may vary with various variable factors, such as the composition and chemical structure of the polymer, temperature, and ionizing radiation. Thus,

the ice factor affects the concentration and mobility of current carriers. Low-molecular-weight substances, for example water and various plasticizers, sharply increase the electrical conductivity of solid polymers ([3]). The electrical characteristics of many dielectrics are associated with the stability of the crystal lattice or with the energy of intermolecular bonds ([4]).

In the present communication we present the results of a study of the electrical conductivity of molten polyamide "kapron" in the temperature range 230–290°. We studied the dependence of the specific electrical conductivity of the melt on temperature and on the heating time at constant temperature. The melt of kapron chips, 2-3 mm in size, from a single batch was investigated. Melting was carried out under vacuum for 50 min in order to remove moisture from the samples and to attain a dynamically equilibrium state of the system at the given temperature. To avoid oxidation of the kapron, the measurements were conducted in an inert medium (argon). Temperature fluctuations during the experiments did not exceed 1-2°. The dependence of σ on $1/T$ is given graphically in Fig. 1; 1.

Attempts to increase the conductivity of the melt by exposing solid kapron to various doses of γ-radiation (curves 2 and 3) did not produce large changes in the value of σ, although there are indications in the literature ([5]) that in some cases, after γ-irradiation of polymers, their conductivity can reach the conductivity values of known inorganic semiconductors. On the basis of the curves in Fig. 1, the activation energies were calculated; they are respectively equal to: 1 $-\Delta E_1 = 0.40$ eV; 2, 3 $-\Delta E_2 = 0.35$ eV (after γ-irradiation with 302.5 krad), $\Delta E_3 = 0.32$ eV (after γ-irradiation with 1.21 Mrad).

The specific electrical conductivity of molten kapron depends nonlinearly on the holding time of the samples at the given temperature (Fig. 2). This phenomenon is apparently associated with the gradual removal from the melt of residual water and low-molecular-weight compounds.

As can be seen from the data presented, the specific electrical conductivity of kapron upon heating changes from that of a dielectric (solid sample) to a specific conductivity characteristic of semiconductors.

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Note: Figure translations are in progress. See original paper for figures.