

Electret Properties of Polyethylene Composite Films with Talc

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The electret properties of polyethylene films with nanodimensional particles of talc have been investigated. The stable of electret state of polyethylene was improved with the addition of talc. This result can be explained by the fact that hydroxyl groups, which absorbs water, are locate on the peripheral area of talc particles. Accordingly, number water molecules in the polymer volume become less, and, therefore, the conductivity of a material should be decrease, and the stability of the electrets state should be increase.

The adding of talc in polyethylene leads to a new relaxation process, that it is visible on the spectra thermally stimulated depolarization. The peak in this area can be associated with the process of accumulation and relaxation of charge on the border of phases of polymer-filler.

Keywords: Polyethylene, Composite materials, Electret Effect, Talc.

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1. INTRODUCTION

Polymeric electrets widely used in instrument-making industry, medicine, packaging industry. The improvement of electret properties widely known polymers, such as polyethylene and polypropylene, is very important problem. One of the methods of changing the electret properties of polymers is the introduction of dispersed fillers in polymeric matrix. The purpose of this work was to research the influence of dispersed filler talc on electret properties of polyethylene.

2. EXPERIMENTAL RESULTS

2.1 Samples and experimental methods

High-pressure polyethylene (LDPE) films with talc fillers were investigated. Samples were made by forge-rolling at a temperature of 150°C and the next pressing at the temperature of 170°C within 10 minutes. The thickness of the samples were 250 μm and volume percentage of talc is 0, 2, 4, 8 and 10%.

Properties of the samples were investigated by the methods of thermally stimulated depolarization, isothermal relaxation of potential and infrared spectroscopy.

2.2 Experimental data

Electret properties were investigated by isothermal relaxation of potential. The samples were polarized by corona discharge to the potential around 1 kV. There are results of measuring in Fig. 1. Adding talc increased the stability of the electrets state of polyethylene. The optimum quantity of talc is 8 volume percent. A greater quantity of talc leads to a decrease in the stability of the electret state almost to the initial level.

Talc particles have lamellar form with the size of the flat side up to several tens of microns. The outer surface of the particle doesn't contain hydroxyl groups. It leads to hydrophobicity of talc. However peripheries of talc particles are hydrophilic, because their surfaces contain OH-groups. Therefore, the improvement of electret properties of polyethylene may be due to the adsorption of water molecules by the peripheral areas of filler par-

ticles. Accordingly, the water molecules in the polymer volume become less, and, therefore, the conductivity of a material should be decrease, and the stability of the electrets state should be increase. The accumulation of charge on the boundary of polymer-filler can be another factor influencing of the electret properties of the polymer.

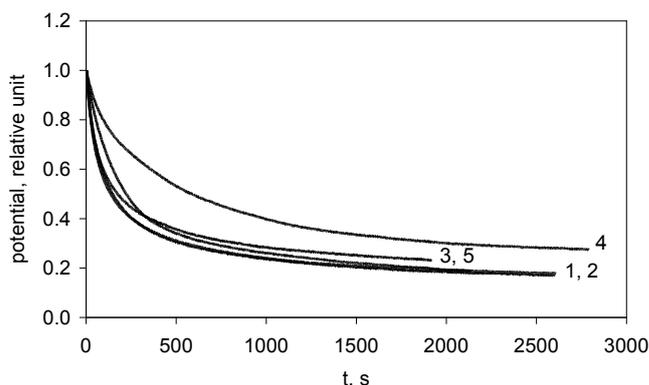


Fig. 1 – The time dependence of the surface potential for the samples charged in the negative corona discharge. $T = 70^{\circ}\text{C}$. 1 – pure PE; 2 – PE + 2 vol.%; 3 – PE + 4 vol.%; 4 – PE + 8 vol.%; 5 – PE + 10 vol.% of talc

IR-spectra of composite samples confirm of the presence of hydroxyl groups on the surface of the filler particles. The IR-spectra shows bands corresponding to vibrations Si-O bond (Fig. 2): the band 1016 cm^{-1} (stretching vibrations), 423 cm^{-1} and 450 cm^{-1} (deformation vibrations), 670 cm^{-1} . The Si-O bond can capture hydrogen ions produced in the dissociation of water molecules, thereby forming OH-groups.

The investigations of relaxation processes in the pure and composite polymers were performed using the method of thermally stimulated depolarization (TSD). Introduction filler in polymer led to essential changes in the spectra of depolarization currents. Spectrum of TSD pure polyethylene is shown in Fig. 3. There are two relaxation process with maxima at $T_1 = 45^{\circ}\text{C}$ and $T_2 = 80^{\circ}\text{C}$ in the spectra.

Spectra of TSD composite samples are shown in Fig. 4. Two relaxation processes are observed in these spectra. Low-temperature process is the same process that occurs in pure polyethylene. It is not visible in Fig. 3 because it combined with a peak at 45°C, but is clearly visible on the spectra of other grades of polyethylene. High-temperature maximum shifts to the high temperature region if quantity of filler is increase. This peak is wide enough that can explain the broader distribution of electrically active defects in the activation energy and/or the frequency factor.

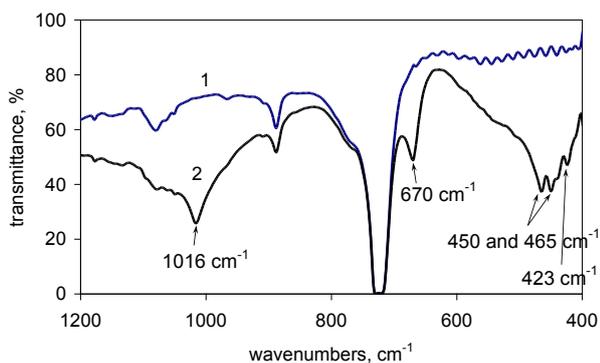


Fig. 2 – IR-spectra of pure polyethylene (1) and polyethylene with talc (2)

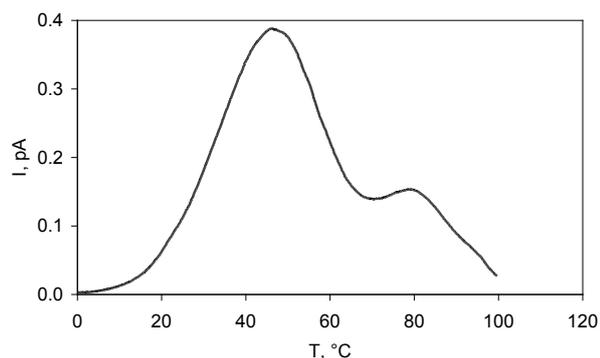


Fig. 3 – The dependence of depolarization current from temperature. Temperature of polarization 70°C. $T_{\max 1} = 45^{\circ}\text{C}$, $T_{\max 2} = 80^{\circ}\text{C}$

The dependence of depolarization currents from the filler share correlated with the surface potential, measured under isothermal conditions for the entire temperature range. The larger current flows in the samples

with higher stability of the electret state. This behavior of the current and potential can be explained by the appearance of new electrically active defects in composite polymer. Border phases of polymer-filler can play the role of such defects. The accumulation of charge occurs at this boundary. Increase the content of filler is leads to increase the area of the border. Consequently, increases the charge that accumulates on it.

Relaxation of this charge leads to increase of the current through the sample with one hand. And on the other hand, the number of charges, that remain at the border, may increase too. If the conductivity of polymer decreases, we observe an increase of current by increasing the number of filler, and improvement of electret properties of the polymer.

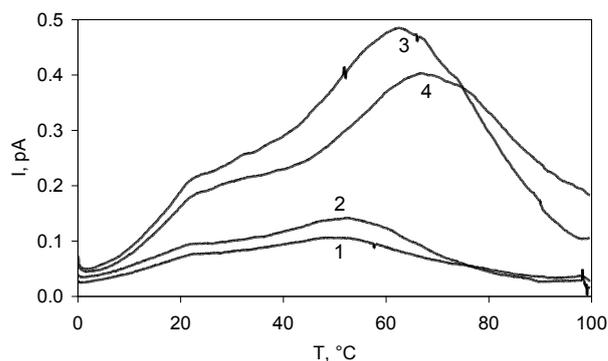


Fig. 4 – The dependence of depolarization current from temperature for composite polymer. Temperature of polarization 70°C. 1 – pure PE; 2 – PE + 2 vol.%; 3 – PE + 4 vol.%; 4 – PE + 8 vol.%; 5 – PE + 10 vol.% of talc

3. CONCLUSION

Adding talc in polyethylene leads to an increase in stability of the electret state. This result can be explained by two factors: decrease in the conductivity of the polymer and the accumulation of charge on the boundary of polymer-filler. Bands in the IR spectra, which belong to the Si-O relations, indicate of the first factor. On the surface of the particles are formed OH-groups that capture water molecules from the volume of the polymer. Relaxation process observed in the spectrum of the TSD composite samples indicates of the second factor.