Effect Of Dispersed Fillers At Electret State In Polymers

Mirzakhmedov Botir Khusniddinovich, Komilov Kamol Akram ugli

Abstract: The article describes data on the electro physical and electret properties of composite polymeric materials based on polyethylene, modified with fillers. It is shown that the introduction of electrically conductive dispersed fillers into the polymer composition, depending on their electro physical nature at relatively low concentrations, can lead to increased electrification and the appearance of an electret state in them

Index Terms: composite polymeric materials, dispersed fillers, electrification, electret, specific volume electrical resistance, effective surface charge density.

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1. INTRODUCTION

At present, decrease in the level of contact electrization of polymers is considered as one of the ways to reduce friction losses and wear in metal-polymer friction units [1]. To do this, when creating antifriction materials based on polymers, electrically conductive dispersed fillers (graphite, metal powders) are widely used. In this connection, the effect of the concentration of dispersed filler in polyethylene coatings on the magnitude and relaxation kinetics of tribose charges arising from friction of coatings in pairs with metal was investigated. Graphite, iron oxide and kaolin with an average particle size of 10, 45 and 130 microns, respectively, were used as fillers.As a result of the experiments, it was established that with the introduction of fillers, the negative polarity of the material charging during friction interaction with the metal is preserved. Figures 1 and 2 present experimental data on the effect of the content of dispersed fillers on the value of the effective surface charge density (ESCHD) and the value of the specific volume electrical resistance of coatings. The introduction of dispersed graphite leads to a monotonous decrease in the value of the ESCHD, while the dependencies of the size of the ESCHD on the content of iron oxide and kaolin particles are more complex and extreme, with a maximum at concentrations of about 5.5-6 mass hours and 20-22 mass parts, respectively.

2 METHODS OF RESEARCH

The specific volume electrical resistance ρv of high density polyethylene (HDPE) when filled with a dispersed electrically conductive substance (graphite, iron oxide) in low concentrations varies slightly, and starting with a certain critical concentration of filler, the Kкp decreases sharply, which is usually associated with the formation of chain-like electrically conductive structures. The value of the Kкp depends on the electro physical properties and dispersion of the particles, with decreasing dispersion of the Kкp decreases [2]. From the

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experimentally obtained dependencies, it is possible to estimate the value of the Kкp, the value of which in the case of filling with graphite and iron oxide is 6–8 mass parts and 10–12 mass parts, respectively. The lower Kкp value for graphite is probably due to the high dispersion (the average particle diameter of graphite is 10 µm, and that of iron oxide is 45 µm) and the high tendency of graphite and agglomeration. Introduction to the polyethylene matrix of kaolin particles in an amount up to 10 wt. slightly changes the value of ρv. In accordance with the modern theory of surface states of a solid /4/. the magnitude of the surface density of the generated charge in a static contact linearly depends on the density of surface states DS and is determined by expression (1):

$$\sigma = e \, DS \, (Wm - WP) \qquad (1)$$

where: $Wм$ and Wp – are the electron work function of metal and polymer, respectively, e – is the electron charge. According to the band theory of dielectrics, surface and volume states (trapping levels) represent additional energy levels in the forbidden zone and arise primarily due to the defective structure of polymers and the presence of various impurities in them [3,4,5]. It is known [6] that the introduction of a dispersed filler leads to the formation of additional phase boundaries, a change in the supramolecular structure, the formation of intermediate boundary layers of the polymer, i.e. to an increase in the total defectiveness of the polymer. The growth of material defectiveness during filling leads to an increase in the density of surface and bulk states (trapping levels). Taking into account the fact that the experimentally fixed value of the residual charge is a part of the generated contact charge and depends on The relationship between the intensity of charge generation and scattering due to electrical conductivity, tunneling and gas discharge, the extreme nature of the dependencies of ESCHD on the concentration of the filler can be explained by the joint implementation of the processes of increasing the density of the generated contact charge in accordance with formula (1) due to the increase in the density of surface and bulk states and the intensification of charge scattering processes due to the growth of the polymer's electrical conductivityWhen HDPE is filled with graphite, charge scattering processes due to an increase in electrical conductivity dominate over the process of its increase, and with increasing graphite content, the magnitude of the ESCHD decreases monotonically (Fig. 1). The conductivity of HDPE filled with iron oxide and kaolin in the concentration range, respectively, up to 5-10 wt.h. and 20-25 wt.h. varies only slightly, and the magnitude of the ESCHD increases. Analysis of the data shows that the amount of

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graphite particles per unit volume of the polymer is almost two orders of magnitude higher than the amount of iron oxide particles with the same bulk concentration of filler. In the case of filling with iron oxide particles and kaolin particles, the maxima of the dependencies of the ESCHD value on the filler content are observed at values of the total surface of the filler of approximately the same order. This indicates the decisive contribution of the increase in the defectiveness of the polymer matrix to the observed increase in the magnitude of the ESCHD [7, 8].
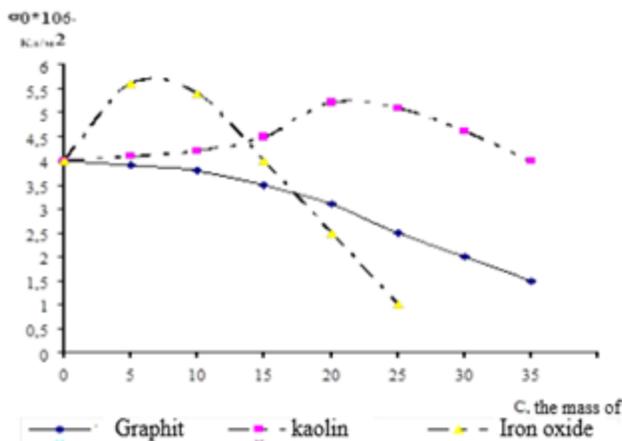

Fig.1. *The dependence of the initial ESCHD σ_o about samples based on HDPE from filler content*
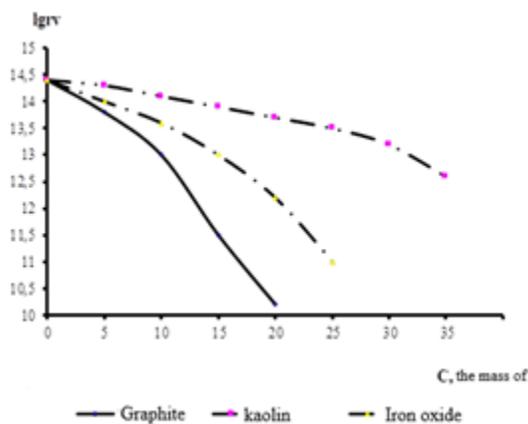
Fig.2 *Dependence $\log \rho_v$ models based on HDPE from the content of the filler*

This is long-established by the nature of relaxation of the tribocharge in filled polymer coatings. Figure 3 shows the kinetics of changes in the relative magnitude of the ESCHD - σt/σo   in the original HDPE coatings filled with dispersed graphite. An increase in the content of graphite leads to a decrease in the rate of decrease in the magnitude of the and a higher value of σt/ with all the exposure times investigated. A similar nature of the decrease in tribose charge is observed in coatings filled with kaolin. The experimental values of σt/σo for coatings containing kaolin higher than for the original HDPE coatings are characterized by a greater dispersion. The observed relaxation pattern of residual tribocharge in HDPE-filled coatings seems to be due to an increase in the share of strongly bound carriers due to the possible formation of higher energy capture levels with the introduction of filler particles.

This is evidenced by the dependences of the relaxation time of the charge discharge and the mobility of charge carriers, calculated as an example for coatings filled with graphite
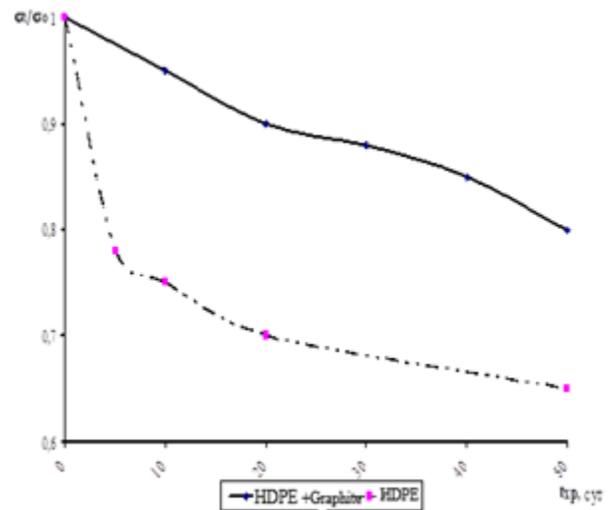
Fig.3. *Dependence of the relative magnitude of the ESCHD of triboelectrified HDPE coatings containing graphite and baseline from the exposure time*

The calculation of the mobility of charge carriers in triboelectretization HDPE coatings was carried out using the results of the kinetics of changes in the relative magnitude of the ESCHD σt/σo using the well-known Davis formula:

$$\sigma_t^{-1} - \sigma_0^{-1} = 5{,}66 \frac{10^{-12} bt}{\varepsilon L}$$

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where: σ_o- is the initial charge density b – is the mobility, ε – is the dielectric constant, L – is the sample thickness. With an increase in the content of graphite, an increase in the relaxation time and a decrease in the mobility of charge carriers are observed (for the exposure time t = 35 days).

3   CONCLUSION

Thus, it was found that the introduction of dispersed fillers in HDPE, depending on their electro physical nature at relatively low concentrations, can lead to increased electrification and an increase in the residual charge, as well as an increase in the lifetime of the triboelectric state. The detected effect must be taken into account when creating antifriction composite materials based on polymers, as well as materials with desired electrostatic properties. In addition, the results indicate that it is possible to create an electret state (for example, by thermo-electretization) in polymer composites containing an electrically conductive dispersed filler in an amount insufficient to form a conductive chain structure.

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