ELECTRET PROPERTIES OF COMPOSITIONS PE+xvol.%$TlInSe_2$ AND PE+xvol.t%$TlInSe_2$+yvol.%Al

Kh. R. AKHMEDOVA
Azerbaijan Technical University, H. Javid ave.25, Baku
phd.khadija@gmail.com

The paper presents results of a study of electret characteristics of new composite materials *PE+xvol*.% $TlInSe_2$ and *PE+xvol*.t%$TlInSe_2$+yvol.%Al analyzed the effect of semiconductor compound $TlInSe_2$ and aluminum nanoparticles on electret properties of these compositions. Revealed that the composites *PE+xvol.* %$TlInSe_2$ and *PE*+xvol.t%$TlInSe_2$+yvol. %Al, filled content $TlInSe_2$ 3-5% composites are high-quality electret materials has lifetime 4,5÷6 times higher than the lifetime of original pure polyethylene. We investigated the effect of aluminum nanoparticles on electret properties of compositions *PE+xvol*.t%$TlInSe_2$+yvol. %Al, and found that the compositions *x=3-5%, y=7-5%* retain their polarization state 335÷400 days.

Keywords: Composites *PE+xvol*. %$TlInSe_2$ and *PE+xvol*.t%$TlInSe_2$+yvol. %Al, electret properties, fillers and nanoparticles.

INTRODUCTION

The electret properties of polymer compositions are widely used in electroacoustic devices, air cleaning devices, xerography, etc. The main characteristics of electret materials are the magnitude of the electric charge and its stability. Another important operational characteristic of an electret is the lifetime of electret charges, which characterizes its stability. To expand the range of materials with electret properties, composite materials obtained with organic and inorganic additives are widely used [1,2]. In recent years, based on semiconductor compounds of type $A^{III}B^{III}C_2^{VI}$, including $TlInSe_2$, a new class of composite materials has been obtained and studied, and it has been found that these materials have high electret characteristics.

This paper presents the results of experimental studies of the electrets properties of the compositions ($1 \leq x \leq 10$). The test samples were prepared as follows: a polymer powder is mixed with a powder of a semiconductor material. After that, the mixture placed between aluminum foil sheets is compressed into 100µm- thick films at the melting temperature of the polymer matrix and a press sure of 10–15*MPa*. The prepared samples with the foil are quenched in water, and the foil is removed. The obtained samples are useful for studying the properties of electrets. Research conducted at the facility described in [3]. Composites with additives investigated *x=0,1,3,5,7* and 10wt.%$TlInSe_2$. Analysis of the results showed that the compositions of *PE+(3-5)vol*.%$TlInSe_2$ surface density dependence of the lifetime ($\sigma_{eff}=f(t_{xp})$) is markedly different from the compositions with x = 0, 1, 7 and 10. The most optimal value of the surface density of charges is observed when the filler content is 3-5vol%$TlInSe_2$. Lifetime we investigated coronelectret polymer compositions of *PE+xvol*.%$TlInSe_2$ is much larger than pure PE, for compositions with additives $x = 0;1;3;5;7;10\,weight\%$ $TlInSe_2$ lifetime is 73; 165, 335, 400, 160, 102 days, respectively. The aim of this work is to study the effect of semiconductor compound $TlInSe_2$ and aluminum nanoparticles on the electret characteristics of composite materials based on low density polyethylene.

EXPERIMENTAL TECHNIQUE

These results indicate that the lifetime of the compositions electrets PE+(3-5)vol%$TlInSe_2$ respectively 4,5 and 6 times longer than the lifetime of the electrets of pure LDPE.

To obtain a polymer composite electret, the polymer powder is mixed with the semiconductor material powder and nanoparticles. Then the mixture is pressed at the melting temperature of the polymer matrix and a pressure of *10-15MPa* between aluminum foil and films with a thickness of 100μm are obtained. The obtained samples with foil are rapidly cooled in water and then the foil is removed. After that, these films are polarized in a corona discharge in a needle-plane electrode system with a voltage of 6*kV* for 3 102 *s*. The distance between the needle and the plane is ~1·10-2*m*.

The surface charge density of electrets is measured by a compensation induction method and is determined by the formula:

$$\sigma_{эфф} = \frac{\varepsilon \varepsilon_0 U_к}{d} ,$$

where σ_{eff} is the surface charge density (*C/m2*), ε is the permittivity of the sample, ε0 is the electrical constant 8.85 10-12 *F/m*, Uk is the compensation voltage (*V*), *d* is the thickness of the electret sample (*m*).

The dependence of $ln\sigma_{eff}$ on the storage time t_{xp} was used to determine the charge relaxation time τ. The addition of Al nanoparticles in a ratio of 3-7vol.% to the electret material, which is based on a polymer composition, in 90vol.% showing that the above features are significant and affect the technical result: an increase in the value and stability of the surface charge density obtained on the basis of a polymer compositions with the addition of nanoparticles i.e. are with the specified result in a causal relationship.

The solution to the problem is explained with the help of fig.1, which shows the dependence of the surface charge density $ln\sigma_{eff}$ on the charge storage time t_{xp} (in days) and fig.2 dependences of the charge relaxation time τ (in days) on the volume content (f, vol.%) of Al in the polymer composite, determined by the formula:

$$\tau = \frac{t_{xp1} - t_{xp2}}{\ln \sigma_{эфф2} - \ln \sigma_{эфф1}}$$

Fig. 1. shows the dependence of $ln\sigma_{eff}=f(t_{xp})$ for electrets from the polymer composition *PE*+$TlInSe_2$+Al with different content of filler polarized, other things being equal. The charge decay curves (dependence of the surface charge density on time) for the samples are shown:
100% *ASPE* (curve 1),
90 vol% *PE*+3 vol% TlInSe2 +7 vol % Al (curve 2),
90vol% *PE*+5 *weight* vol% TlInSe2 + 5vol% Al (curve 3),
90% *PE* + 7% TlInSe2 + 3% Al (curve 4).

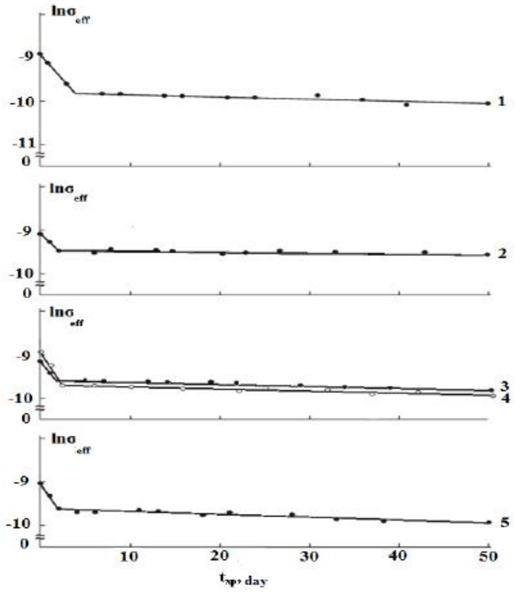

Fig. 1. Dependence $ln\sigma_{eff}=f(t_{xp})$ for electrets from the polymeric composition *PE*+TlInSe2+Al with different content of filler polarized, all other things being equal.

The value of the surface charge density *($ln\sigma_{eff}$)* of nanoelectrets of *PE*+$TlInSe_2$+Al polymer composites is greater than $ln\sigma_{eff}$ for pure polyethylene electrets.

In fig. 2 shows the dependence=*f(f)*, where f is the volume content of $TlInSe_2$ and Al in the polymer matrix. In this case, the most optimal charge value is observed at a content of 7vol.% Al (90 vol% *PE* + 3vol% $TlInSe_2$+7vol% Al). As can be seen, the lifetime of nanoelectrets of *PE*+$TlInSe_2$+Al polymer composites is 8 times longer than that of a pure polyethylene sample.

These values are comparatively higher than those of electrets made of polyethylene, as well as of composites based on it.

In addition, the proposed material for the electret from the polymer composition *PE*+$TlInSe_2$+Al is also distinguished by the simplicity of the technology for their production.

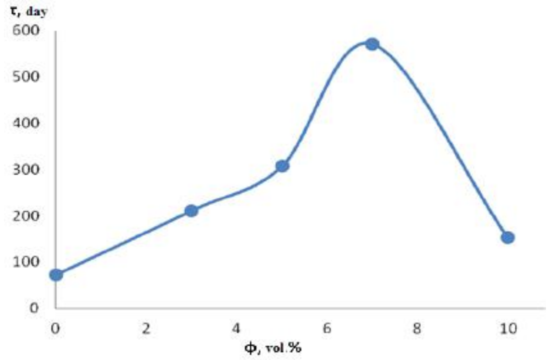

Fig. 2. Dependence τ = *f(f)*, where ϕ is the volume content of $TlInSe_2$ and Al in the polymer matrix

CONCLUSION

Studies of the electret characteristics of composite materials of the type *PE*+xvol.t%$TlInSe_2$ and *PE*+xvol.t%$TlInSe_2$+yvol. %Al revealed that the lifetime of electret compositions PE+(3-5)vol.%$TlInSe_2$ is 4.5-6 times longer (335,400 days), and the lifetime of electret compositions *PE*+(3-5)vol.%$TlInSe_2$+(7-5)vol.%Al is 4.7-6.3 times longer than the lifetime of an electret from pure. We also found that by varying the content of fillers and nanoparticles, it is possible to obtain the optimal material for high-quality electret.

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