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Temperature-Frequency Characteristics of the Composition HDPE + x vol.% InP

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Authors' contributions

This work was carried out in collaboration between all authors. Author MIA contributed to supply problems and participated in the discussion of the results. Author EMG took part in bringing experimentation and discussion of the results. Author SMR managed the preparation of samples, conducting experiments and participated in the discussion of the results. Author SSR managed the selection of filler and participated in the preparation of composites. All authors read and approved the final manuscript.

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ABSTRACT

In the work obtained new matrix composite materials of high density polyethylene (HDPE) with a semiconductor additive. With a measuring instrument bridge E8-7 and E7-20 studied temperature and frequency dependence of the permittivity (ε) and the dielectric loss tangent (tgδ) composites HDPE + x vol.% InP at 290-440K temperature and frequency 25-10^6Hz intervals. Revealed that with increasing the volume content of the filler InP semiconductor is increased and ε tgδ. This occurs so that with increasing the volume content of the filler component the structure becomes unstable and the number of formed clusters is increased, and this leads to an increase the dielectric characteristics.

Keywords: InP; HDPE; the dielectric constant; dielectric permittivity; dielectric loss; Maxwell-Wagner theory.

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1. INTRODUCTION

Creation of composite materials is one of the main directions in the development of advanced materials. In special, fine fillers in polyethylene contribute to the issue of novel structural components that can serve as charge carrier traps: interracial loosened absorption polymer layer near the airfoil of the filler. Filling polymers leads to alterations in the characteristics of high molecular structuring and packing density as superfine solid excipients may serve the adjustable seed crystals or imperfections in [1-4]. Fillers have a substantial impact on the mobility of the various kinetic units of the polymer and its relaxation time spectrum. Filler particles play the role of the center the structure and boundary layer of the polymer with the filler has a curious structure of saturation. These trapping centers with different activation energies, which are stabilized as a effect of electrons and is an improvement of the properties of the electro active polymer. It should be mentioned that depending on the nature, size, form and dispersion of the filler, the resulting resin composition can be electrically conductive or antistatic dielectric [5-9].

It is revealed that, using as fillers ternary compounds of $TlInSe_2$ and $TlGaSe_2$ were obtained, new classes of composite materials being qualitative electrets with high lifetime, and having fluorescent properties [10-12].

We describe here the results of a survey of the dielectric properties of composite materials HDPE + x vol.% InP.

2. METHODS OF CALCULATION

By mechanically mixing powders of HDPE and semiconductor InP (with a particle size of ≈50 mm) produced a homogeneous mix. This mix is then subjected to hot pressing under a force per unit area of 10 MPa at a temperature T =413 K 15 minimum and quickly cooled, samples are prepared from a mix of a thickness of 120 mkm between two fluoroplastic.

Samples for measurement of dielectric characteristics of the distribution according to the in alternating electric field were prepared in the form of discs 20 mm in diameter and about 120 mkm deep. Reliable electrical contact electrodes made of stainless steel with a diameter of 20 mm provide the use of electrodes made of extruded aluminum foil thickness of 9 mkm. Permittivity measurement - ε and dielectric loss tangent - tgδ conducted in the temperature range 290-440 K for linear growth temperature at a rate of 2.5ºC/min using a setup block diagram is described in Fig. 1. The frequency dependence of the dielectric constant - ε and dielectric loss tangent - tgδ carried out in the frequency range from 25 to 10^6 Hz, the amplitude of the test voltage 1 B.

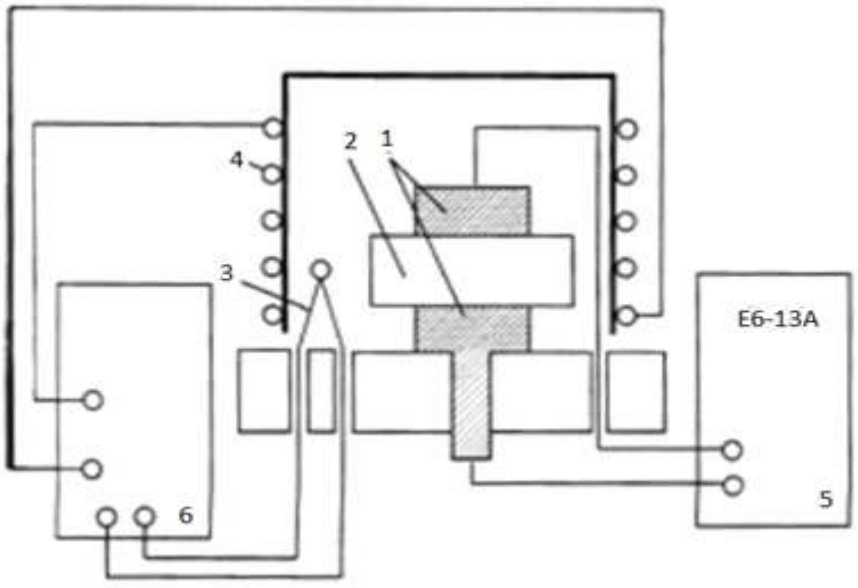

Fig. 1. Setting for the measurement of electrophsical parameters

The measurements were posted out ε and tgδ using the bridge E8-7 at alternating current a frequency of 1 kHz and meter E7-20. Sample (2) is installed between two electrodes (1) in the measuring cell. The sample was then fired up using a heater box (4) which is risen in the chapeau of the cubicle. The sample temperature was recorded with a thermocouple (3) a system (6) which controls the heater (4). Measurement error, ε and tgδ were 5 and 9% respectively.

3. RESULTS AND DISCUSSION

The outcomes of the study of temperature and frequency dependence of the dielectric permittivity and dielectric loss of HDPE + x vol. % in (0≤h≤9) are presented in Figs 2 and 3. Fig. 2 shows the temperature dependence of the dielectric permittivity of the dielectric loss of HDPE + x on. % InP in the temperature range 290-440 K. As shown schematically in Fig. 1a in the temperature range studied the dielectric permittivity with increasing temperature, typical for all investigated composites decreases almost linearly. With the growth in the volume content of the file is increasing in permittivity values, especially for high density polyethylene pure ε at room temperature was 2.07 (curve 1), the composite with the increase of 1 vol.% InP 2,5 (curve 2),3 of the composite 3 vol.% InP 2,57 (curve 3), for about 5 composites. 5 vol.% InP 2,75 (curve 4), and 7 in. 7 vol.% InP 3,24 (curve 5).

Characteristic changes in the investigated composites with increasing temperature with the addition of InP (pic. 2 a) shows the influence of the isomerism carbonized kernel, on the dipole polarization. This behavior of ε with temperature indicates a decrease in M-phase polymer chain due to increase conformation set.

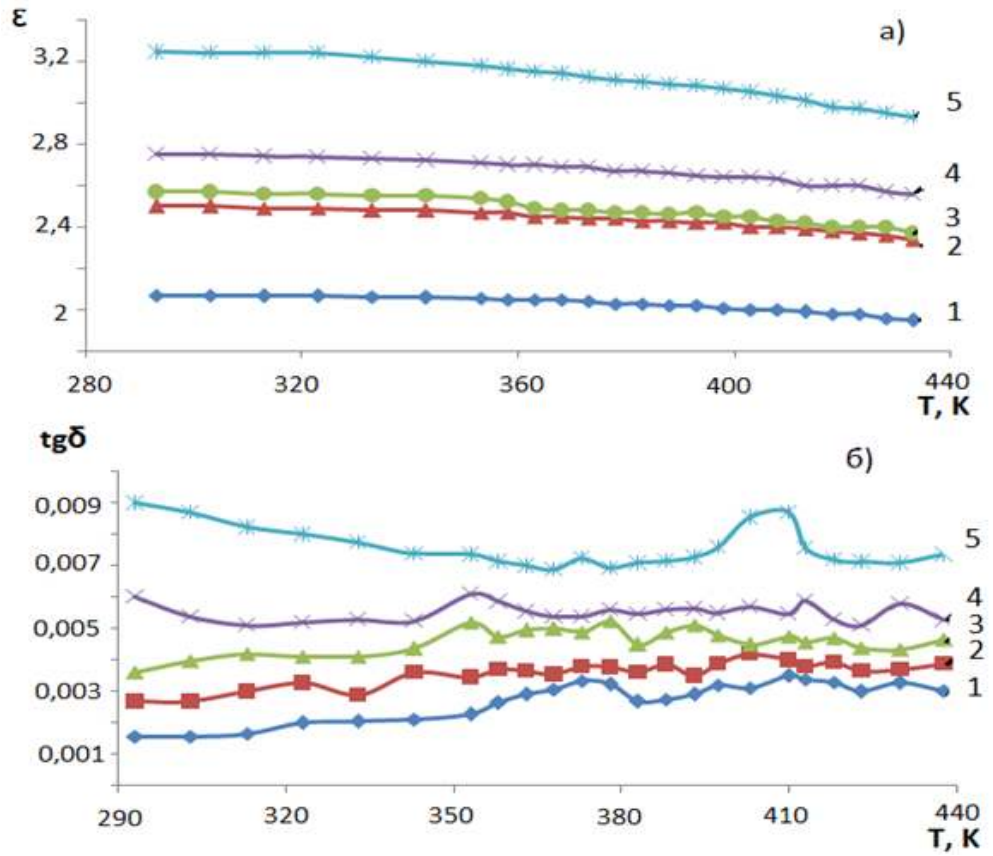

Fig. 2. Temperature dependence of the dielectric permittivity (a) and dielectric loss tangent composite HDPE+x vol.% InP, here 1-x=0; 2-x=1; 3-x=3; 4-x=5; 5-x=7

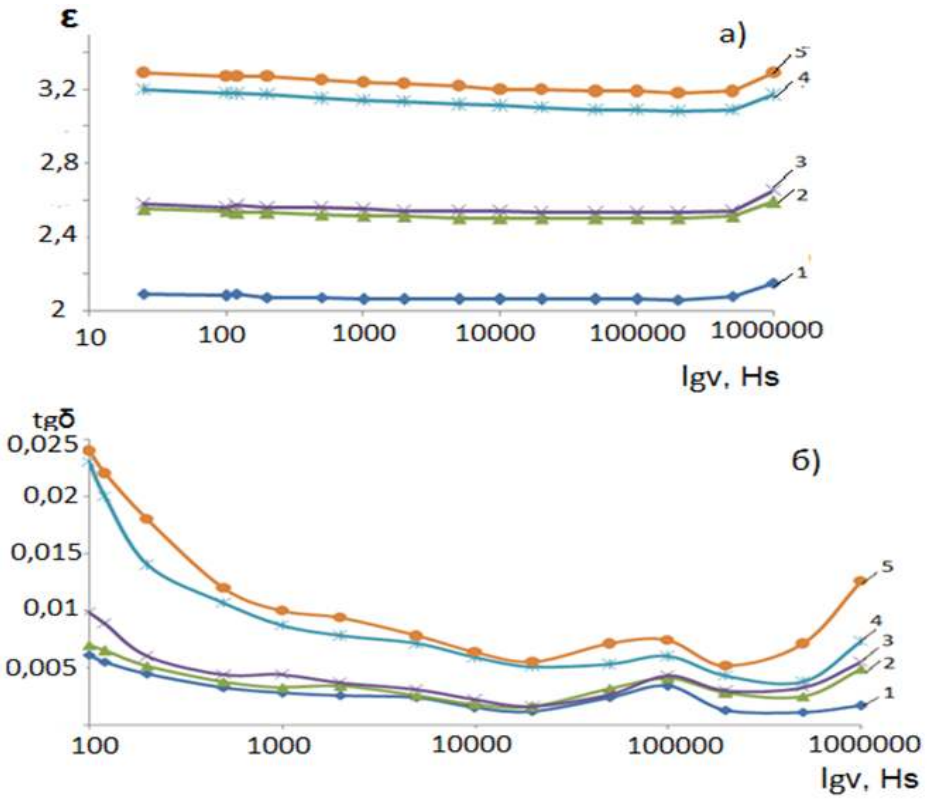

Fig. 3. Frequency dependence of the dielectric permittivity (a) and dielectric loss tangent composite HDPE+x vol.% InP, here 1- x=0; 2- x=1; 3- x=3; 4- x=5; 5- x=7

The terminations of the written report the temperature dependence of the dielectric loss tangent of composite materials HDPE + x vol.% InP is shown in Fig. 2b. As can be seen from Fig. 2b tgδ composites change with temperature is comparatively complicated. In particular, depending on the pure HDPE tgδ (T) (curve 1) increases tgδ, at 378 K, a maximum diffuse, at least 383K, and weak peaks at a temperature of 395 K, 412 K and 430 K, respectively, and the minima at 390 K and 425 K. For the composite with the increase of 1 vol.% InP in (curve 2) on the curve tgδ (T) at 323 K, 342 K, 390 K and 402 K observed mild maxima and minima at 353 K and 391 K. For the composite with the addition of 3 vol.% InP in (curve 3) peaks were observed at temperatures of 353 K, 378 K and 390 K and 362 K minima at 380 and K. For the composite with the increase of 5 vol.% InP in curve tgδ (T) weak maxima are observed at 370 K and 410 K (curve 4). To this composite, a decrease tgδ from room temperature up to 380 K.

Fig. 3 shows the frequency dependence of the dielectric permittivity and dielectric loss of the composites of HDPE + x. vol.% InP in the frequency range 25-10^6GHz.

As can be determined from the data in Fig. 3a investigated in the frequency range characteristic for all composites and pure ε HDPE virtually change with increasing frequency. A slight increase in ε, is observed at a frequency of about 10^6 Hz.

Note that in this case, with increasing filler content InP bulk increases the magnitude of the dielectric constant. When the filler content in the composition of InP 0, 3, 5, 7 and 9 vol.% At the same frequency (25 Hz) the dielectric constant is 2.09, 2.55, 2.60, 3.2 and 3.29 respectively, and at a frequency of $5 \cdot 10^5$ Hz, these values are 2.08, 2.51, 2.54, 3.09 and 3.19, respectively. Typical for all investigated composites since this frequency is increased ε.

The results of a study of the frequency dependence tgδ (v) are shown in Fig. 3b. As can be seen from Fig. 3b and in this case with increasing the filler content increases tgδ, so at a frequency of 100 Hz, for composites with fillers 0: 3: 5, 7 and 9 in. % InP, tgδ is 0.0061: 0.0071: 0.0098: 0.023 and 0.024, and at 106 Hz frequency of the same value becomes 0.0017: 0.0046: 0.0053: 0.0073 and 0.0126. For pure

HDPE curve tgδ (v) at 10^5 Hz is observed variance tgδ (v) (curve 1). Maxima on the curves 2, 3, 4 and 5 are also observed at the same frequency. Notice that for the composites studied since the frequency of 10^5 Hz tgδ (v) increases.

Psychoanalysis of the results show that with the growth in the volume content of input is an increase in ε and tgδ. This conduct of the dielectric parameters of composites HDPE + x vol.% InP is largely shaped by the Maxwell-Vagnerskoy polarization [3,6], the surface energy components. With an increment in the filler content of the composite structure becomes unstable and the InP particles form clusters whose surface are smaller than the entire surface of the particles comprising them. Increasing the number of clusters with increasing volume filler content decreases the dielectric layer between the particles and leads to increased electrical capacity and thus ε and tgδ.

4. CONCLUSION

Investigation of the temperature-frequency dependence of the dielectric constant and dielectric loss tangent of composite materials with semiconductor fillers HDPE + xvol.% InP, found that with variation in temperature, frequency and volume content of the filler can obtain materials with desired dielectric parameters.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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