

RELATIONSHIP BETWEEN PIEZOELECTRIC, THERMOPHYSICAL PROPERTIES AND INTERPHASE PHENOMENA IN THE POLYMER-PIEZOELECTRIC COMPOSITES

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Thermal and piezoelectric properties of composites based on the polar and non-polar polymers and piezoceramics of different structure and researched. It is found that composites with high temperature conductivity, low thermal expansion coefficient and specific heat have the increased piezoelectric properties. Thermal and piezoelectric properties of composites were regulated by the change of the temperature-pressure regime of crystallization and piezophase structure.

Many new works are appearing in literature every year on study and use of the polymer-piezoelectric and polymer-semiconductor compositional systems, which have various properties [1-3]. The physico-chemical base of the obtaining of composite piezoelectric materials connected to volume electron-ionic, polarization and interphase phenomena and the formation of the supermolecular structure elements on the polymer-active filler phase boundary is considered very few today. Therefore, on the example of concrete composites obtained on the base of polar (polyvinylidene fluoride - PVDF) and non-polar (low density and high density polyethylene - LDPE, HDPE) polymers and piezoceramics of different structure (rhombohedral - PCR-3M and tetragonal - PCR-7M), we analyse the relationship between piezoelectric and thermo-physical properties and interphase phenomena.

The obtaining of composites, their polarization and measurement of thermal and piezoelectric properties and described in [4].

Temperature dependences of temperature conductivity (D) of the composite components are presented in Fig.1 (a). It is shown that temperature conductivity of polymers and piezoceramics is quite differ and this difference remains in the all investigated temperature range. Temperature conductivity of composites substantially depends on a polymer phase (Fig.1, b). Composites based on HDPE have higher temperature conductivity than composites based on PVDF. Comparison a and b on Fig.1 shows that this difference of values of D of composites could not explained only by the difference of D in starting polymers - HDPE and PVDF. The phase boundary phenomena plays the main role here [2,5].

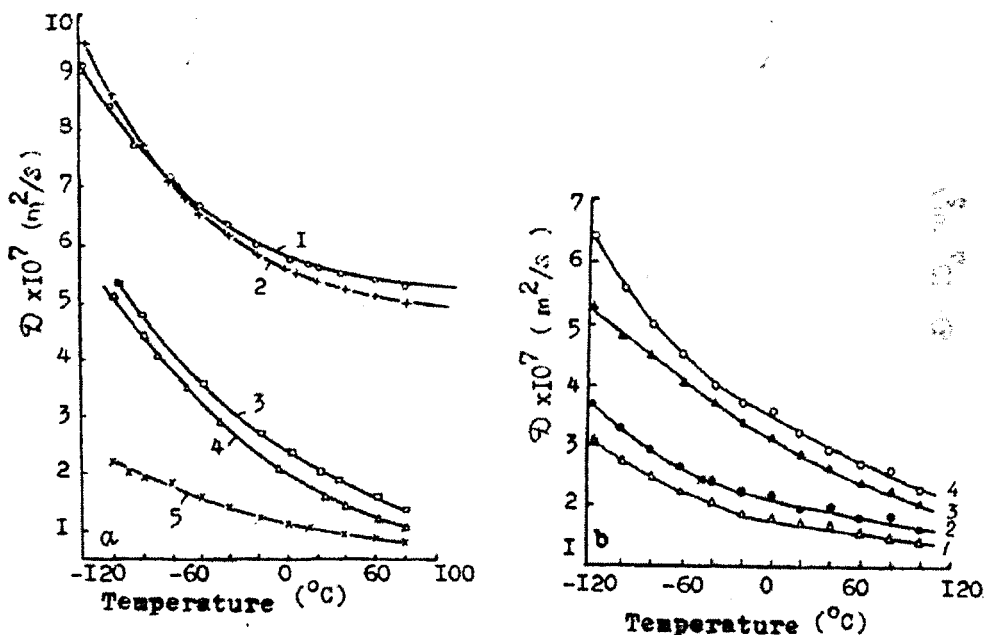


Fig.1. The temperature dependences of temperature conductivity (D) of polymers, piezoceramics (a) and composites (b).

a) 1 - PCR-7M; 2 - PCR-3M; 3 - HDPE; 4 - LDPE; 5 - PVDF.

b) 1 - PVDF/PCR-7M; 2 - PVDF/PCR-3M; 3 - HDPE/PCR-7M; 4 - HDPE/PCR-3M. Volume fraction of the piezoceramics $\phi=60\%$

The parameter of D is sensitive to a relation of phases in composite. The value of temperature conductivity of PVDF/PCR-3M and PVDF/PCR-7M composites in dependence on volume fraction of piezoparticles with the size of $63 \div 100 \mu\text{m}$ are presented in Table 1. It is seen that the com-

posite based on PVDF and PCR-3M has a higher temperature conductivity in comparison with PVDF/PCR-7M composite. Noticeable spread of temperature conductivity of composites in dependence on the piezoceramics particles size are observed. Also, with the increase of the piezoparticle size this factor rai-

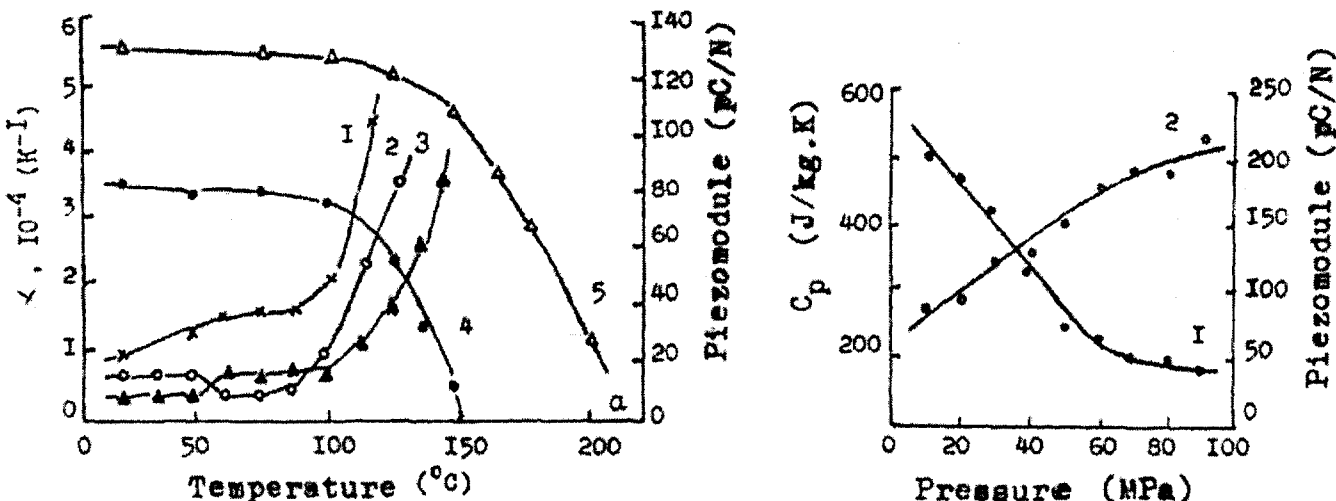


Fig.3. a) The temperature dependences of thermal expansion coefficient (1,2,3) and piezoelectric modulus (4,5) of composites based on HDPE.

1 - HDPE; 2,4 - HDPE/PCR-3M; 3,5 - HDPE/PCR-7M. $\phi = 50 \text{ vol.}$

b) The dependences of specific heat (1) and piezoelectric modulus (2) on pressure for composite PVDF/PCR-3.

Particle size $63+100 \text{ }\mu\text{m}$

also confirmed by the temperature conductivity of composites with PCR-3M is higher than with PCR-7M one. The results of measurement of specific heat and piezoelectric modulus (d_{33}) of composites are found according to this. Really, the temperature of d_{33} relaxation and α growth temperature practically coincide. Moreover, d_{33} of the composite with the small α and high D is high, which is connected to the increase of the probable charges' flows in the polarization process to the polymer-piezofiller boundary, which is determined by the ordered structure of the polymer phase. As it is shown in [8], the composite specific heat is determined mainly by filler specific heat, polymer matrix and interphase layer. Investigations show that C_p and d_{33} of composites on the basis of LDPE, PVDF and PCR-3M, PCR-7M quite differ (Table 3).

The indicated factors substantially depend on the composite obtaining conditions, for example, on the obtaining pressure (Fig.3,b). It is seen that specific heat of PVDF/PCR-3M composite decreases with the increase of P , but piezoelectric modulus increases and tends to saturation.

Table 3. Specific heat and piezoelectric modulus of the composites.

Composites	Specific heat C_p , J/kg.K	Piezoelectric modulus d_{33} , pC/N
PVDF/PCR-3M	264	150
PVDF/PCR-7M	350	95
LDPE/PCR-3M	600	80

Thus, the increase of temperature conductivity, the decrease of thermal expansion coefficient (α) and specific heat with the increase of the obtaining pressure of the composite based on the piezoceramics of rhombohedral structure shows the interphase interaction increase favoring to the decrease of heat scattering on the phase boundary. The increase of piezoelectric modulus with the growth of thermal conductivity and the decrease of specific heat and α also shows the amplification of interphase interaction favoring to an effective transmission of mechanical perturbation on the composite piezoparticle.

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POLİMER-PYEZOELEKTRİK KOMPOZİTLƏRİN PYEZOELEKTRİK, İSTİLİK XASSƏLƏRİ VƏ FAZALAR ARASI HADİSƏLƏR ARASINDA ƏLAQƏ

Polyar və qeyri-polyar polimerlər və müxtəlif strukturlu pyezokeramikalar əsasında alınmış kompozitlərin istilik və pyezoelektrik xassələri tədqiq edilmişdir. Müəyyən edilmişdir ki, yüksək temperaturkeçirmə əmsalı, alçaq termik genişlənmə əmsalı və istilik tutu-

mu olan kompozitlər yüksək pyezoelektrik xassələrə malikdir. Kompozitlərin istilik və pyezoelektrik xassələri polimer-pyezoelektrik fazaların strukturunun və kristallaşmasının temperatur-təzyiq rejimini dəyişməklə nizama salınmışdır.

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ВЗАИМОСВЯЗЬ МЕЖДУ ПЬЕЗОЭЛЕКТРИЧЕСКИМИ, ТЕПЛОФИЗИЧЕСКИМИ СВОЙСТВАМИ И МЕЖФАЗНЫМИ ЯВЛЕНИЯМИ В КОМПОЗИТАХ ПОЛИМЕР-ПЬЕЗОЭЛЕКТРИК

Исследованы теплофизические и пьезоэлектрические свойства композитов на основе полярных и неполярных полимеров и пьезокерамик различной структуры. Найдено, что композиты с высоким коэффициентом температуропроводности, низким коэффициентом термического расширения и теплоемкостью обладают повышенными пьезоэлектрическими свойствами. Теплофизические и пьезоэлектрические свойства композитов регулировались путем изменения температурно-барического режима кристаллизации и структуры фаз полимер-пьезоэлектрик.

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