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XVI МІЖНАРОДНА КОНФЕРЕНЦІЯ З ФІЗИКИ І ТЕХНОЛОГІЇ ТОНКИХ ПЛІВОК ТА НАНОСИСТЕМ
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(dedicated to memory Professor Dmytro Freik)

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Quasi-Equilibrium Thermal Fluctuations of the Electromagnetic Field in Flexbly Polymers Filled With Nanodispersion Metal or Semimetal

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From the point of view of thermodynamics of nonequilibrium processes described by the dynamics of electromagnetic phenomena in heterogeneous polymer systems (HPS). At the same nanodispersed metals (Cu, Ni, CR, W) and semimetals (graphite various modifications) act as a source of violation of the quasi-equilibrium structure of the elements of flexible polymers (PVC – a typical representative of them).

Schematically, the structure of HPS presented in the form of components: the nanosized particles of metal or semimetal, boundary layer (BL) and a polymer volume; the results of a statistical description of electromagnetic processes in each of them. With regard to the temporal delay and spatial non locality, analyzed the mechanism of current passage through the filler, polymer and BL and the synthesis of the composite. It is shown that for HPS you can create niccu minority carriers of the opposite sign of the conductivity of the matrix. In such a bipolar conduction process the passage of current is accompanied by the modulation and the fluctuations of the electromagnetic field. Analyzed the interaction of electromagnetic radiation with HPS. On the basis of balance equations for the energy density of the microscopic fields hown that the kinetics of the elements of the composite structure is satisfactorily described by the Langevin equation for the harmonic oscillator, taking into account the dissipation of energy. Accordingly, consideration of the density of internal energy of the PVC-systems have shown that between the structure-sensitive characteristics of the polymer and composite microplasticity there is a quantitative relationship. Therefore:

$$P = \frac{c\rho}{2\beta}\frac{\pi}{\omega\tau},$$

where P is the internal pressure; C – specific heat; ρ – density; β – temperature coefficient of volume expansion of the composite; in accordance ω, τ – frequency oscillations ($0<\omega<\infty$) and the time of the Maxwell relaxation, as a reference to the speed setting field in the system.

Waystouse PVC composites as HPS in the externalelectric (0,1 KHz≤ω≤100,0 KHz), mechanical ($\nu = 0{,}4\cdot10^6$ s^{-1}) and thermal ($T_C \le T \le T_C+10$ K, where T_C – temperature of glass transition) fields.

Structure, Morphology and Conductive Properties of C-Al_2O_3 Composites

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The structure, morphology and electrical properties of C-Al_2O_3 composites are explored in the work using small-angle X-ray scattering (SAXS), low-temperature porometry (LTP) and impedance spectroscopy. Composite materials were obtained by encapsulation of 5, 10, and 30 % of fumed Al_2O_3 into carbon matrix. For this purpose a dispersion of oxide material in a saccharose solution was caramelized and heated at 400°C. The resulting composite mixture was activated at 800°C for 30 minutes in the limited access of air.

According SAXS-studies there is a correlation between porosity of samples *w*, content of Al_2O_3 and the fractal dimension of structure *n* (Table 1). It is found that increasing the volume of porous material leads to a reduction of its fractal dimension. The formation of fractal structure caused by aggregation of carbon clusters formed on the surface of aluminum oxide.

Table 1. Parameters of C-Al_2O_3 composite materials

Al_2O_3, %	*w*	*n*	S_{SAXS}, m^2/g	S_{LTP}, m^2/g	V_{LTP}, cm^3/g	σ, $Ohm^{-1}\cdot m^{-1}$
0	0.61	2.80	426	356	0.187	26.2
5	0.60	2.45	300	121	0.081	16.5
10	0.75	2.10	440	192	0.106	14.4
30	0.79	1.90	330	14	0.010	0.4

Comparing SAXS and LTP data, we can conclude that closed porosity dominate in nanocomposite materials. The fraction of pores inaccessible to nitrogen molecules increases from 16.4 % (for carbon) to 95.8 % (for 30% content of Al_2O_3).

Adding non-conductive fumed Al_2O_3 (according to [1] its conductivity is 4.3 $\mu Ohm^{-1}\cdot m^{-1}$) results in decreasing of composite conductivity σ due to destruction of conduction channels in the carbon matrix.

1. V.I. Mandzyuk, I.F. Myronyuk, V.V. Gumenyak. Electrochemical intercalation of lithium ions into composite material Al_2O_3-graphene // Bulletin of Vasyl Stefanyk Precarpathian National University. Chemistry. – 2012. – V. XVI. – P. 95-101.