

Thermophysical Properties of Fluoropolymer Composites with Cobalt Nanoparticles

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INTRODUCTION

Composites based on polymers are widely used for metal products replacement. Polytetrafluoroethylene is a promising material with a number of unique properties: chemical and heat resistance, hydrophobicity, low friction coefficient, etc.

At the same time, its insolubility and high melt viscosity do not allow the use of liquid-phase technologies, used for other polymers, in the preparation of composites with a homogeneous distribution of non-agglomerated nanoparticles of the filler. Many properties of polymer composite materials (PCM), including operational ones, depend on the distribution of the filler in the composite. The team under the guidance of V.M. Buznik developed methods for the production of PTFE composites with nanosized fillers [1, 2]. In this way, inorganic particles of a few tens of microns in size, encapsulated by a fluoropolymer coating of a thickness on the order of a few microns, were obtained. Previously, the results of a study of the structure and properties of PTFE composites [3] were presented. Characteristics of the created composites exceed the original matrix of polytetrafluoroethylene.

In the present paper, the thermophysical properties (heat capacity, heat conductivity) of block composite materials based on polytetrafluoroethylene and cobalt nanoparticles were analyzed.

Suspension PTFE (GOST 10007-80) was used as a polymer matrix. Composites were prepared in mechanical mixing mode, then tableting and sintering with CoFP concentrations of 0.05; 0.1; 0.5; 1 and 5 wt. parts to 100 mass fractions (m.f.) of PTFE.

THERMAL CONDUCTIVITY OF COMPOSITES

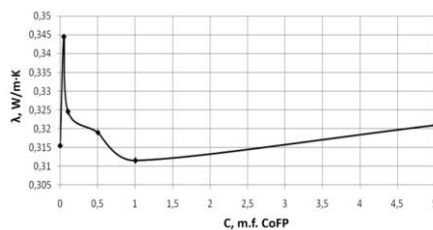


FIGURE 1. Thermal conductivity λ of polymeric nanocomposite F-4 + CoFP as a function of the C concentration of the CoFP.

CONCLUSIONS

Thermophysical studies of the polymer composite showed that the dispersed filler of CoFP at a concentration of up to 1.0 mass fractions sharply increases the interaction in the polymer-filler boundary layer, and it also makes the structure more rigid due to the formation of a large number of bonds between the polymer matrix and the active areas of the surface of the nanosized filler.

The extreme concentration dependencies of the thermophysical properties of the combined fluoropolymer material show both: the single-phase and multiphase structure of the polymer system F-4 + CoFP. The nature of the change in the thermophysical properties of the polymeric nanocomposite in the region of small additions of the CoFP modifier and an extremum point indicate the transition of the system from a single-phase structure to a two-phase (spinodal decomposition) and vice versa [7]. At the extremum point, the polymer system is in the metastable state, where the highest dispersion of the modifying additive in the polymer

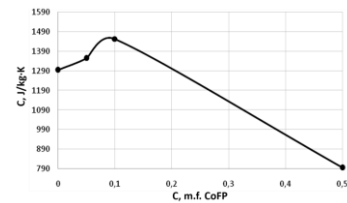


FIGURE 2. Dependence of the heat capacity c of the polymer nanocomposite F-4 + CoFP on the concentration C of the CoFP filler at a temperature $t = 200$ °C.

DIFFERENTIAL SCANNING CALORIMETRY

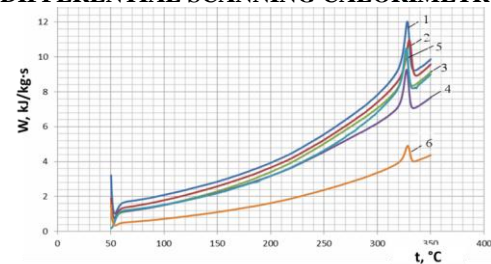


FIGURE 3. Dependence of the specific energy absorption rate of the original PTFE (6) and PTFE + CoFP composites on temperature, at the filler concentration: 0.05 (1); 0.1 (2); 0.5 (3); 1 (4); 5 (5) per 100 mass fractions PTFE.

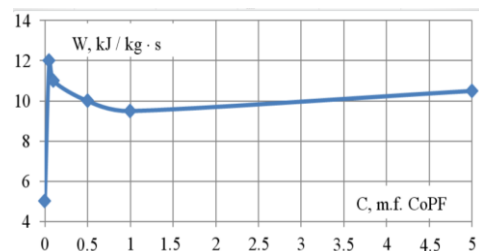


FIGURE 4. The energy absorption rate W_{max} of polymer composite PTFE+ CoFP on CoFP content.

matrix is noted and, consequently, the highest homogeneity of the system. Such physical mechanisms of structure formation were noted by us earlier for polymer mixtures and alloys, the components of which are in the nanostructured state [8]. When the system is transitioned from single-phase to two-phase (stratification), the evolving phase is in a highly dispersed state and forms a thermodynamically stable system with a particle size not exceeding several tens of nanometers. The interphase layer in such a polymeric system has a significant thickness, and the interphase surface is large. The highly developed phase interface and the presence of nanoparticles lead to an extreme change in the thermophysical properties of the polymer system at a given concentration region, i.e. are the determining factors.

The difference in the energy state of the nanocomposite comparing to the initial PTFE, caused by a change of the entire complex of the system's indicators: a decrease in the thermal conductivity λ and a decrease in the heat capacity c .