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STUDY OF THE INFLUENCE OF GRAPHENE NANOFILLERS ON THE PROPERTIES OF COMPOSITES BASED ON POLYPROPYLENE

***Abstract**: The paper studies the effect of graphene nanofillers on the physical and mechanical properties of composites based on polypropylene. Methods for the homogeneity of the system with the introduction of nanofillers are proposed. The possibility of using graphite nanofillers to obtain composites based on polypropylene is shown.*

***Key words**: graphene, polypropylene, modification, physical and mechanical properties.*
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Introduction

Methods for obtaining polymer composite materials depend and are determined, first, by the state of aggregation, as well as the type and type of filler introduced [1]. Most of the methods for producing polymer composites include the stage of making so-called press powders either by the wet method, for example, by impregnation with resins, or by the dry method, for example, by rolling. These technological solutions are multi-stage and expensive, environmentally harmful, and lead to wear and tear of technological equipment. Today in developed countries, it is used, showing the prospects for the use of graphite nanotubes, nanofibers, graphene particles as effective modifiers [2]. Despite the availability of a number of results obtained in this field, until now there is no general concept of filling polymers with graphene nanofillers. Combining graphite nanofillers with a polyolefin matrix is a very successful way to combine the mechanical properties of nanostructures with the advantages of composite materials based on polyolefins. The unique properties of graphite nanostructures make them ideal reinforcing agents in polymer matrices [3].

It is difficult to incorporate graphene particles into a polymer matrix. In order to realize the properties of graphite nanostructures, an extended interfacial area between the nanostructures and the polymer is required. The use of solution technology does not allow achieving the goals of nanomodification, and the properties of such a composite are significantly low. The physical and mechanical properties of polyolefins reinforced with graphene nanofillers do not significantly improve, since weak interfacial adhesion at the polymer – nanofiller phase interface interferes with the connection [4].

The introduction of nanofillers into the melt under intense loads is an alternative method for thermoplastic polymers. The advantages of this technology are high productivity, compatibility with standard polymer processing technologies, and standard equipment. Therefore, there is growing interest in the inclusion of graphite nanoparticles in polymer matrices to obtain materials with improved characteristics [5].

Our research is devoted to the creation of composites based on polypropylene and graphite nanoparticles. For the study, we used Chinese-made nano graphene powders [6,7,8].

Polypropylene (grade 01030) was used as a polymer matrix. A laboratory extruder (temperature from 150 to 20 ° C) was used to move the nanocomposites. After dry mixing, all components were added simultaneously to the hopper. To assess the properties, samples were obtained under pressure at 185–225 ° C on an LMU-500 injection-molding machine [9,10,11].

Commercially produced graphene nanofillers inevitably contain impurities, have different defectiveness, high van der Waals interaction, which leads to the aggregation of graphite structures and complicates their uniform distribution in the polymer matrix. For uniform dispersion of nanofillers in a polypropylene matrix, an UZS-01 ultrasonic mixer was additionally used. Polypropylene nanocomposites were prepared by diluting a propylene glycol-based concentrate, a nanofiller, in a polypropylene matrix while mixing in a melt. Then, standard samples were prepared under pressure by the casting method [12,13,14].

The physical and mechanical properties of polymer nanocomposites largely depend on the dispersion of the filler and the interfacial interaction at the interface. Efficient stress transfer at the polypropylene - nanofiller interface determines the high strength characteristics of the material. Table 1 shows the properties of nanofilled polypropylene.

Table 1. Influence of graphite nanofillers on the properties of composites based on polypropylene

Composition	Melt flow rate, g / 10 min	Flexural strength, MPa	Impact strength, kJ / m^2	Strength at rupture, MPa
Polypropylene	2,7	36	70	38
Polypropylene + graphite nanoparticles, 4:1 wt rel.	3,1	44	86	49

It can be noted that in the case of using graphene, the effect of significant strengthening of the composite and an increase in its impact toughness at a degree of filling of 0.01 wt. % can presumably be associated with two circumstances: both graphene surfaces are used in the formation of contacts between the matrix and the filler; not excluded are "through" interactions "matrix - matrix" through the graphene layer, the thickness of which approximately corresponds to the atomic diameter of carbon [15,16,17].

In addition, when using ultrasonic action, when graphene particles are introduced, they are disaggregated due to the so-called wedging effect. As you know, an ultrasonic emitter creates waves with a high frequency, macromolecules and aggregates begin to vibrate under the action of a sound wave, alternately pressure and vacuum are created in the medium, high local pressures arise, spherical shock waves are formed, which lead to the destruction of nanofiller agglomerates.

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