STRUCTURE AND PROPERTIES OF POLYPROPYLENE FILLED WITH METAL OXIDE FILLERS

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Abstract. Background of the problem. Polyolefins (PO) are the most large-tonnage, available and in demand from the entire range of polymers produced by the industry. Therefore, the search for technical solutions aimed at simplifying the processing of polyolefins and the creation of new types of composite materials based on them is an urgent task.

Target. The aim of the study is to study the possibility of creating thermoplastic composite materials (CM) based on polypropylene (PP) with improved properties (physico-mechanical, physico-chemical, thermophysical, electrophysical, magnetic, optical, etc.) determined to a greater extent by the introduction of fillers that can serve as artificial nuclei of crystallization.

Methodology. We studied the physical and mechanical properties of filled polypropylene and polyamide compositions, the determination of the melt flow index by viskisometric methods, the determination of flexural strength by the methods of two-bearing bending, the determination of Charpy impact strength.

Scientific novelty. The rheological characteristics of composite materials based on polypropylene with metal oxides have been determined.

Obtained data. To obtain a composite material based on PP, the content of metal oxides was changed from 1 mass to 5 mass parts. Assessment of the rheological properties of filled composites

showed that with an increase in the content of metal oxides, the fluidity of the compositions decreases, however, the resulting compositions can be processed by injection molding. The data obtained show that the optimal compositions are those containing: 5 wt.h. metal oxides.

The developed materials were tested for flammability by the oxygen index method.

Key words: polypropylene, metal oxides, atomic force microscopy, physicochemical and mechanical properties.

Peculiarities. We studied the physical and mechanical properties of the developed compositions.

For this purpose, metal oxides were used as fillers.

Introduction

Today, the rapid growth of production and world population leads to an increase in demand for polymers from year to year. The demand for polymers is growing day by day, especially in industry and manufacturing. In this regard, the automotive industry places high demands on the design of polymer materials. In solving this problem, in view of the low cost and scale of production, the modification of polymers and their widespread use in various fields of production of polymer composite materials that meet modern requirements are of great importance.

Obtaining composite materials that meet a number of requirements, such as modification of polymers, improvement of their physical and mechanical properties, addition of additives without changing their composition, is currently the basis of scientific research [1].

Scientific substantiation of the following solutions for the production of automotive and household plastic parts based on new composite materials: selection of various reactive modifiers for micro- and nano-sized mineral modifiers added to polymers; modification of polymers with the help of dispersed particles [2].

Methods and materials. The object of research is the obtained thermoplastic composite material (CM) based on polypropylene.

MFR (melt yield strength) was determined in accordance with GOST 11645-73 (ASTM D 1238) at a load of 2.16 kg and temperatures of 463 and 503 K for low pressure polypropylene, respectively.

We used an IIRT-M brand viscometer with a capillary length and diameter of 8 and 2.09 mm, respectively.

The determination of the bending strength of the composites was carried out in accordance with GOST 6806-73 (ASTM D 638) by the two-bearing bending method.

In this work, the Charpy impact strength (UHS) was determined in

in accordance with GOST 4647-80 (ASTM D 638).

Stress and relative elongation of the sample, corresponding to its

the gap was determined according to GOST 14236-81 (ASTM D 638). [3-7;]

Atomic force microscopy (AFM) was used to study the features of the topography and microstructure of the surface of composite materials.

Results and its discussion. In this work, the problem of improving the mechanical properties of filled mixtures of polypropylene with metal-containing compounds was solved. The aim of the work is to improve the mechanical properties of filled polyolefin thermoplastic elastomers based on polypropylene and metal acetate [8].

Development of studies on the obtained materials based on polypropylene containing nanoscale modifiers that affect the supramolecular packing of polymer macromolecules and thus on its physical and mechanical characteristics.

Experimental part.

Chemical modification of polypropylene, a directed change in its physical, mechanical or chemical properties by introducing new functional groups into the macromolecule, by crosslinking or copolymerization, is of great interest from a scientific and practical point of view [9].

In this work, using the method of destruction of metal oxides directly during compounding, we obtained PP + Me nanocomposites with a uniform degree of dispersity of the inorganic phase. The presence of metal nanoparticles in the polymer matrix transforms the properties of the base polymer as shown in tables No. 1

During the analysis of the results, it was found that the introduction of metal oxides into the polymer improves the complex of physical and mechanical properties of polyolefins. It should be noted that the presence of atomic metal particles contributes to a significant increase in heat resistance, the flexural modulus of the base polypropylene [10;11].

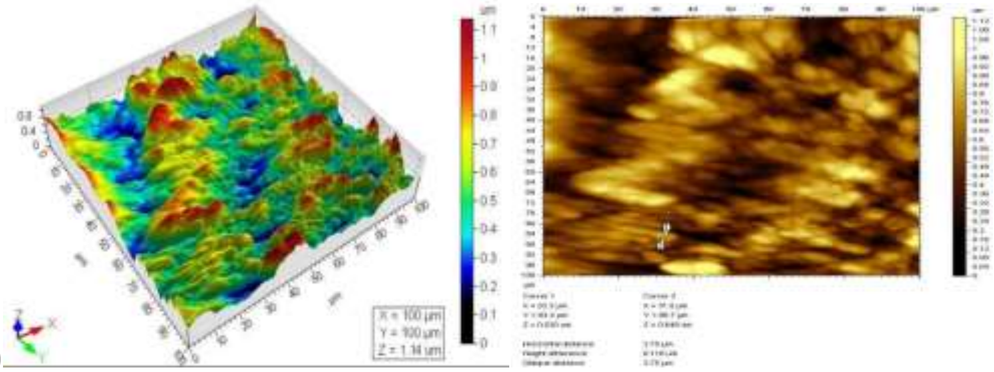
Thus, the improvement of the physico-mechanical properties and heat resistance of polymer composites based on polypropylene filled with zinc/nickel particles, the maximum effect is achieved when using 5 wt. % Zn oxide. Apparently, the result obtained can be explained by obstacles from metals with high
own strength and rigidity. Polymer composites from metals are promising functional materials with a wide range of possible applications as effective modifiers for polymers [12].

Table 1

Physical and mechanical properties of the obtained composite materials based on polypropylene

Options	Standards	PP-JM350	PP+5% aluminum oxide	PP+ 5% Nickel(II) oxide	PP+ 5% calcium oxide	PP+ 5% iron oxide	PP+5% zinc oxide
Density, g/cm^3	ASTM D1505	0,9	0,99	0,99	0,99	0,99	0,99
Modulus of elasticity MPa	ASTM D1238	1100	1270	1300	1180	1310	1355
Elongation %	ASTM D790	100	95	95	100	96	98
Elastic force, MPa	ASTM D638	24	26	25	25	25	24
Impact strength according to Izod s/n, at +23°C, kJ/m2	ASTM D638	6,5	6,4	6,2	6,1	6,4	6,51
Impact strength according to Izod s/n, at -30°C kJ/m2	ASTM D256	3	3	3,2	2,8	3,4	3,33
Tensile strength, MPa	ASTM D256	45	47	46	48	50	50
Shrinkage 24soat,%	ASTM D648	1,2	1,05	1,05	1,05	1,15	1,6
burning rate UL-94 mm	Sample thickness 3.2 mm	45	≤40	≤40	≤40	≤40	≤40

AFM is widely used to study the features of the topography and microstructure of the surface of various materials. This method is very sensitive to pixels and can form the surface of a sample obtained in the nanoscale range on a three-dimensional surface. The numbers show the changes in the size, shape, particle surface and mechanical properties of materials on the surface using the processing program [13]. In this section, the effect of modification of metal compound particles on the polymer surface morphology is studied. The study and analysis of the surface of modified polypropylene shows the distribution of metal particles between polymer macromolecules and their interaction properties. The results were obtained for a polymer composite material obtained from the reaction mixture of polypropylene (JM350-Uzkorgaz) 3% ammophos with cadmium oxide and polyamide PA-6 with nickel and cobalt oxides. The analysis was carried out at the AFM (Research Institute of Chemistry and Physics of Polymers) using silicon cantilevers with a tip turning radius of 10 nm [14–15].



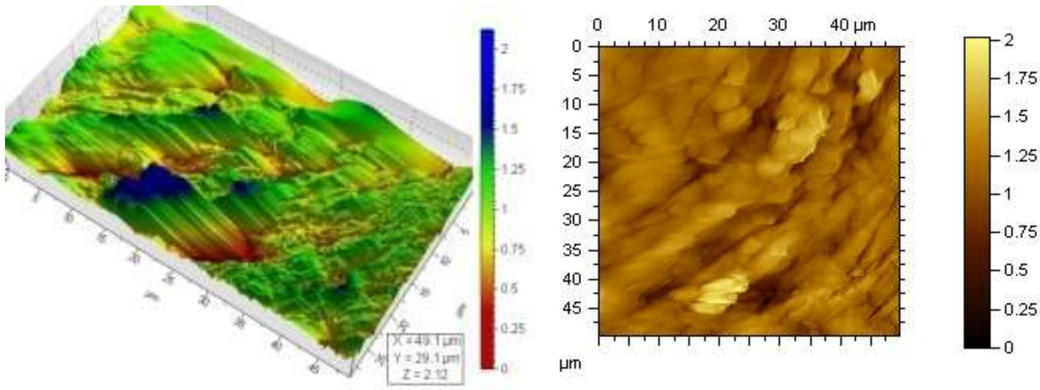
a) б)

Figure 1. Cadmium oxide / PP with ammophos: A) - three-dimensional image, B) - two-dimensional image.

The size of the scanned area was from 1 to 50 μm. Microscopy was carried out in air by a semi-contact method, registering changes in the amplitude of oscillations of the counting hand, which indicates the topography of the surface and oscillations of interfacial movement (phase detection), showing the adhesion of local surfaces to each other.

Figure 1 shows the surface of polypropylene modified with cadmium oxides.

The results show that the surface roughness of pure polypropylene is 100 nm, the surface roughness of polypropylene + 3% cadmium oxide is 210 nm[16].



a) б)

Figure 2. Nickel and cobalt oxide / PA-6 with ammophos: A) - three-dimensional image, B) - two-dimensional image.На рисунке 2 показана поверхность полиамида, modified ammophos based on nickel oxide and cobalt: A) - three-dimensional image, B) - two-dimensional image.

The results show that the surface roughness of pure polyamide-6 is 100 nm, the surface roughness of polypropylene + 3% cadmium oxide is 212 nm [17].

Conclusion

Thus, the improvement of the physico-mechanical properties and heat resistance of polymer composites based on polypropylene filled with zinc/nickel particles, the maximum effect is achieved when using 3 wt. % Zn oxide. Apparently, the result obtained can be explained by obstacles from metals with high intrinsic strength and rigidity. Polymer composites from metals are promising functional materials with a wide range of possible applications as effective modifiers for
polymers.The phase structure of polypropylene modified on the basis of ammophos compounds with metal oxides can be explained by strong adhesion between the matrix and particles of metal compounds, which leads to the formation of new adsorption layers at the phase boundary and at the junctions of amorphous components.

Modification of the polymer surface with metal particles leads to an increase in the degree of flammability on its surface.

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