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STRUCTURAL MODIFICATION OF POLYPROPYLENE AND PROPERTIES OF THE RESULTING MATERIALS

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Abstract: The article deals with polymeric materials widely used in industry and other spheres of social life, their structural modification, chemical and physical properties depending on the type of polymer matrices and fillers. Polymer composites can have optimal physicochemical parameters and lower cost than traditional composites. The paper describes the properties of polypropylene blends in this field.

Keywords: polymer composites, polypropylene, modified nanoparticles, nanocomposites, hydrophobization, intercalation, filler, nanotube, chains of polymeric macromolecules, plasticizer, deformation resistance, crack resistance.

Аннотация: В статье рассмотрены полимерные материалы, широко используемые в промышленности и других сферах общественной жизни, их структурная модификация, химические и физические свойства в зависимости от типа полимерных матриц и наполнителей. Полимерные композиционные материалы могут иметь оптимальные физико-химические параметры и меньшую стоимость, чем традиционные композиты. В статье описаны свойства полипропиленовых смесей в этой области.

Ключевые слова: полимерные композиты, полипропилен, модифицированные наночастицы, нанокомпозиты, гидрофобизация, интеркаляция, наполнитель, нанотрубка, цепочки полимерных макромолекул, пластификатор, деформационная стойкость, трещиностойкость.

Polymer composites in a broad sense can be represented as a system consisting of a dispersed medium and a dispersed phase. The first phase, as a rule, consists of a single material, inside the phase of which components of the second phase are scattered. hair nanocomposites are produced when nanoscale particle hairs are used as an extra component.

Analysis of the literature data of the last decade shows that the presence of nanoparticles in the polymer matrix in small amounts (up to 5%) leads to a significant change in the characteristics of the base material – the elastic modulus, strength, softening temperature increase, the coefficient of thermal expansion and the diffusion coefficient of various gases decrease. A significant amount of research has focused on the creation of nanocomposites using hydrophilic synthetic polymers filled with various types of layered silicates. Among polymer matrices, polyolefins occupy a special place, the global production of which is more than half of all plastics produced in the world. It is assumed that when solving the compatibility problem, changing the properties of filled polyolefins by introducingнаночlayered silicate nanoparticles into themcan lead to the creation of new cheap materials with a previously unattainable set of performance characteristics. In this regard, modification of layered nanosilicates by hydrophobization of their surface or partial hydrophilization of the polymer matrix by modification with functional monomers can lead to the creation of new polymer nanocomposites with a complex of improved operational properties, and the development of new approaches to solving this important practical problem and experimental results regarding the physical and mechanical properties of nanocompositesis undoubtedly relevant from the point of view of physical and mechanical properties of- chemistry of high-molecular compounds.

A polymer composite material is a composition of two or more components that have different chemical composition and structure [1, 2]. In the composition, the polymer is called a matrix, and the corresponding additives are fillers. In turn, fillers are divided into dispersed, layered and fibrous structures [2]. The system consisting of a matrix and nanoparticle filler nanoparticles belongs to polymer nanocomposites. Unlike traditional fillers, reducing their size to the level of nanoparticles and at low concentrations, in some cases, leads to an improvement in the physicochemical properties of the resulting composites, increasing elasticity, hardness, electrical conductivity modulus, heat resistance, moisture absorption and a number of other parameters. At the same time, the optimal values of the corresponding indicators are determined by the nature and amount of the additive. There are three types of fillers that differ in particle size. The first type includes particles with dimensions on the order of a nanometer in all three dimensions, which is called a zero-dimensional isosized nanoparticle. Such fillers include silicate nanoparticlesproduced in in situ by sol-gel technology, semiconductor nanoclusters [3], magnetic clusters, etc.

Fillers where two particle sizes have a nanometer scale and the third is significantly larger than the first two are called fillers of the second type. An example of this type of fillers is nanotubes or the so-called whisker [4]. Nanotube particles are mainly used for strengthening nanocomposites.

The third type of fillers (two-dimensional lamellar formations) is characterized by only one nanometer range of particle size. The filler consists of layers with a thickness of one or several nanometers and a length of hundreds or thousands of nanometers.

In turn, these nanocomposites with the use of fillers of the third type constitute a family of polymer-layered nanocomposites, formed by the introduction of polymer chains into the interlayer space of the main crystal. There are a large number of synthetic and natural layered minerals used as fillers for polymers. Table 1 shows examples of layered crystal structures where it is possible to insert (intercalate) chains of polymer macromolecules.

Table 1.

Layered crystalline fillers are a potential object for intercalation of polymer macromolecules.

Chemical nature of layered	Examples of fillers
Element	Graphite
Chalcogenide metals	$(PbS)_{1}$, $_{18}(TiS_2)$, MoS_2
Carbon monoxide	Graphite oxide
Metal phosphates	$Zr(HPO_4)$
Clays and layered aluminosilicates	Montmorillonite, hectorite, sapophyte, fluoromics, fluohectorite, vermiculite, kaolinite, etc.
Double layered hydroxides	$M_6Al_2(OH)_{16}CO_3 \cdot nH_2O$; M=Mg, Zn

To establish the production of polymer nanocomposite materials with specified properties, it is necessary to develop the methodological foundations and principles of their construction. In this regard, it is necessary to study the nature of the driving force of the process of intercalation of polymer chains into the interstructural space of filler nanoparticles, and to identify the types of chemical bonds between macromolecules and clay nanoparticles.

In order to meet the increasing demand for polymer materials with the required properties, it is sometimes quite acceptable to use structural modification methods or methods for selecting compositions from the group of multi -tonnage polymers. Targeted regulation of the supramolecular structure of polymers by introducing additives is considered one of the most effective methods for improving the properties of polymers [5].

Given the nature of the polymer, the choice of modifier and its content is made, and this is considered one of the most affordable and inexpensive methods for obtaining a polymer material that has a wide range of different characteristics and properties. One of the available and at the same time significantly improving the plastic properties of polymers is their plasticization.

Numerous experimental data [5] indicate that plasticized polymers are inferior to non-plasticized polymers in all property parameters, except elasticity. Therefore, when using plasticizers, a compromise is found that the minimum possible amount of additives is used.

Currently, methods have been developed for obtaining a wide range of nanocomposites based on polypropylene with high strength properties. This is due to the fact that reducing the particle size to the level of nanoparticles leads to an increase in the contact area of the polymer and filler[6]. The main structural transformations in polymers during the introduction of small amounts of modifiers are manifested in their amorphous regions, which is associated with an increase in the number and a decrease in the process of distribution along the length of load-bearing chains. As an example, the addition of organic silicon compounds to polyethylene leads to their localization in the amorphous region, enhancing the relaxation processes of supramolecular formations. It should also be noted that when polyolefins are modified with organic silicon compounds, the thermal stability of the composite improves, which is important for their processing [7].

Similarly, modification of polyolefins with small amounts of additives from low-molecular-weight compounds, oligomers, and polymers significantly improves their properties. When polyethylene is modified with thermoplastics [8], a more uniform transformation of the spherulite structure into a fibrillar structure is observed at the early stages of its formation. The corresponding products made of such composites have the best parameters of deformation and strength properties, crack resistance, durability, reduction of residual deformations, etc.

Recently, the variety of materials based on a mixture of polymers has noticeably increased, which is due to the simple technology and high availability of their production, the ease of obtaining new properties that the initial components of the mixture do not have separately. In this case, a polymer with flexible chains becomes a plasticizer for a polymer with rigid chains. For the production of such mixtures, no additional equipment is needed. By changing the amount and nature of the components, their polyethylenercentage content in the mixture, and the methods of preparing the mixture, it is possible to produce materials with a wide variety of properties.

Simultaneous introduction of ethylene and propylene into polypropylene, polyethylene, and their copolymers increases their impact strength and improves the parameters of physical and mechanical properties at low temperatures. When creating mixtures of polypropylene with polyisobutylene and rubber varieties [8], the strength of the material decreases, although the brittleness temperature drops significantly and the viscosity increases. With an increase in the polyethylenercentage of polyisobutylene mixed with polypropylene, the flow temperature decreases. The highly elastic nature of the mixture manifests itself in a wide range between the glass transition temperature of polyisobutylene and the melting point of polypropylene A number of parameters of mixtures show different character depending on the composition of the mixture. This series includes the dependence of the breaking elongation on the proportion of components in the mixture. The amorphous component in the mixture is capable of large reversible high-elastic deformations, an increase in the elastic modulus and a decrease in deformability are observed with the addition of a more rigid crystalline polypropylene. For example, when polypropylene is mixed, the content of the highly crystalline component – isotactic polypropylene-increases, and the ability to produce large forced highly elastic deformations at high stress values is shown. When an amorphous polymer is added to the polypropylene mixture, a decrease in strength and the apolypearance of a barrier to the occurrence of forced high-elastic deformations are noted. In addition, the values of the tensile elongation index of the corresponding composite will decrease. When the composition of the mixture changes, some deformation mechanisms are replaced by others. The heterogeneity of the structure of mixtures of polyethylene with isotactic polypropylene also affects their properties. The spheroidal structure of polypropylene-ethylene copolymers modified with small amounts of atactic copolymer has a smaller dimension and better uniformity in the amorphous polymer zones. In these zones, the mobility of macrochains increases, which leads to an improvement in physical and mechanical properties.

Acoustic studies show that modification of crystallizing polymers using thermoplastics leads to an increase in the ordering of the supramolecular structure, which is associated with a sharp increase in structural units at the time of structure formation, leading to the apearance of more polyethylenerfect and less defective supramolecular formations. When polyethylene is modified with thermoplastics having a branched structure, increased values of physical and mechanical parameters are manifested. At the same time, the process of producing composite products in the extruder becomes stable.

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