MECHANOCHEMICAL TECHNOLOGY IN MATERIALS SCIENCE OF FUNCTIONAL METAL-POLYMER COMPOSITES

МЕХАНОХИМИЧЕСКИЕ ТЕХНОЛОГИИ В МАТЕРИАЛОВЕДЕНИИ ФУНКЦИОНАЛЬНЫХ МЕТАЛЛОПОЛИМЕРНЫХ КОМПОЗИТОВ

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Abstract: *There were studied mechanisms interfacial interactions in composite systems based on dispersed particles of polymer materials (polyolefins, polyamides, fluorcontaining polymers) and modifiers of various composition and structure in the combination process in the units with intense mechanical action. There were established the effects of formation of products of mechanochemical interaction of active centers of modifiers particles and radical fragments of macromolecules degradation. The obtained results allow changing the technological paradigm of the creation of high-strength and highly filled engineering nanocomposites based on high-molecular matrix.*

KEYWORDS*: DISPERSED PARTICLE, POLYMER MATRIX, MECHANOCHEMICAL INTERACTION, NANOCOMPOSITE.*

1. Introduction

In a wide range of engineering materials a special place occupy composites of various purposes, which are obtained by modifying the matrix polymer, oligomeric and combined bindings by target components based on silicon, carbon, metal-containing compounds with a given dispersion and form [1-4]. In all cases the use of modifiers of high-molecular matrix generalizing (basic) criteria of their reasonable choice is given effectiveness of action necessitates technically significant effect of improving the parameters of deformation strength, tribological, thermal, adhesive, etc. service characteristics with minimal economic costs, taking into account in material, energy capacity and staffing processes of production and consumption of the target.

An obvious is the condition of fulfillment of this criterion, suggesting the achievement of optimal structural state at a given level of organization of the composite material at a particular combination of matrix binder, modifier type and technology of its combining and processing.

The purpose of this study was to assess the prospects of using mechanochemical technologies to produce nanocomposite materials based on polymeric materials.

2. Methods of research

For research have been used thermoplastic matrices dispersed particles and of silicon containing modifiers. The combination of the components was carried out in blending machine AGO-2 type under acceleration 2-20 g.

3. Results and discussion

An analysis of the literature sources devoted to materials science and technology of polymeric composites [1-4], shows promising use of modifiers that are in the nanometer range, so-called nano-sized particles of different composition, structure and technology. In the presence of a large number of studies on the mechanisms of modifying action of nanoparticles in the polymeric, oligomeric and combined matrices, it is necessary to underline the ambiguity of the results and the lack of common concepts that define the dimension and concentration ranges of the optimal effective operation of the dispersed particles in the matrix binders, differing in molecular weight, chemical structure of macromolecules, peculiarities of structural organization under the influence of technological factors - temperature, pressure, exposure time, etc. The most effective multi-purpose modifiers are natural silicon compounds - clays and zeolites, fine products of detonation, thermo gas dynamic and plasma chemical synthesis – nanoceramics, sialons, nano-diamonds, diamond-containing burden, fullerenes, nanotubes, thermally split graphite, mica, clays, and nanosized particles of metals and oxides obtained by thermolysis of metal-containing precursors in molten thermoplastics [1-4].

A particular interest presents the particles of inorganic natural substances, which, when exposed to a special technology to forms nanosized assemblies of single particles or components with a thickness of single plates around 1 nm - clay, mica, graphite etc. (figure 1). At the introduction of such fillers in an amount of 3 – 5 wt. % in a polymeric matrix such as aliphatic polyamides provided 1.5-2 times increase of strength characteristics of the composite material. The mechanism of the observed effect is associated with the formation of graft polymers on the active surfaces of nanoplates of layered minerals [4].

Among the especially promising areas of target modification components is their mechanochemical activation for given conditions of energy impact [1]. Due to mechanical stresses of certain intensity is ensured not only the formation of the active centers of the surface layers of the matrix and the modifying components but their interaction with the formation of the combined product of the boundary layer the optimal structure (figures 2-3).

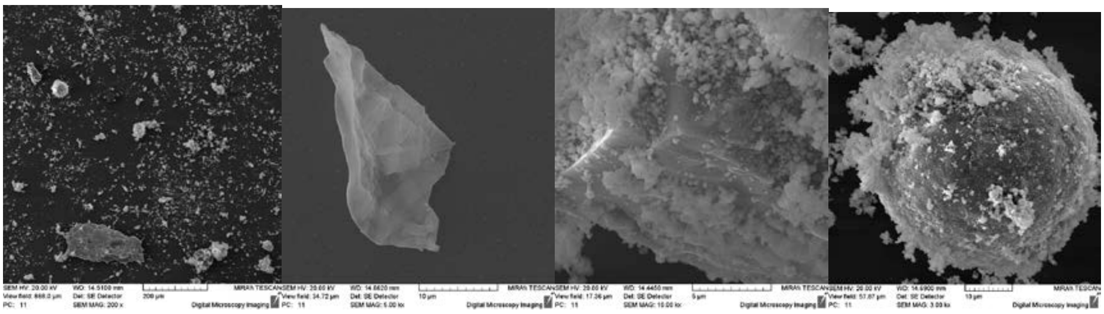


Figure 1 *- The morphology of mechanically activated particles of natural silicate flint obtained at different magnifications*

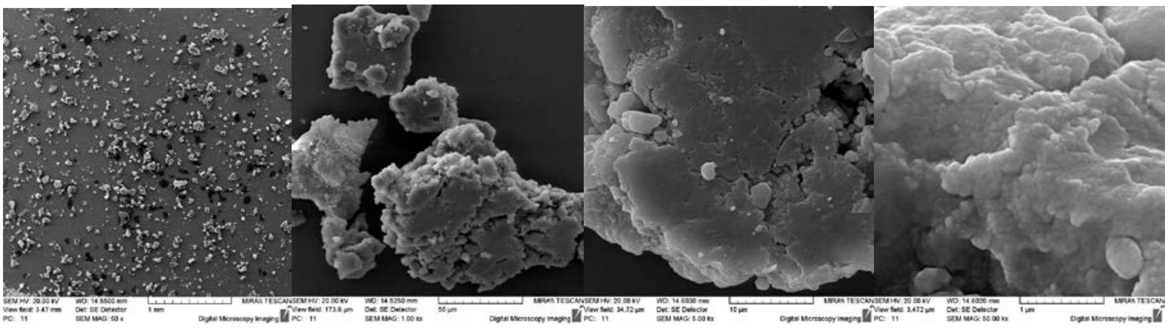
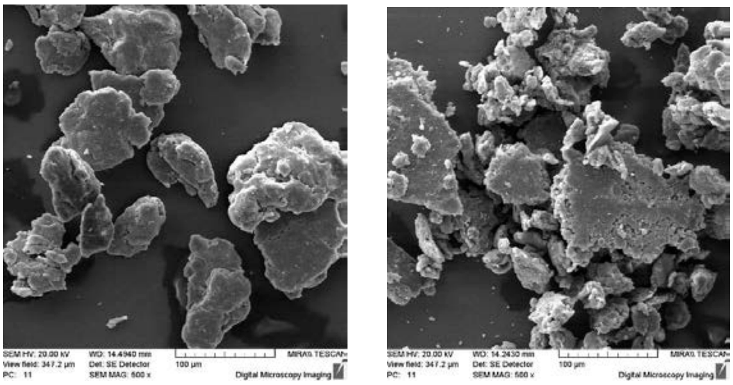


Figure 2 *- Morphology of mechanically activated particle of ultrafine silica oxide*

Using the method of scanning electron microscopy studied the morphology of the particles of mechanically activated polyamide 6 and kaolinite before and after exposure to ionizing radiation (Figure 3, a-b).



a **b**

a - composition (30% wt.: 70 wt.%) PA6 + kaolinite (mixture was mechanically activated for 4 min at 60 g); b - composition (30% wt.: 70 wt.%) PA6 + kaolinite mechanically activated for 4 min at 60 g

Figure 3 *- The morphology of the mechanically activated particles of polyamide 6 and kaolinite*

The initial particles (polyamide, kaolinite) until the mechanical activation operation had a dispersion, which is in the range of 50 microns to 200 microns. The morphology of the particles in the delivery condition has a shape characteristic of whisker particles.

A joint mechanical activation of particles of polyamide 6 and kaolinite leads to changes in the morphology and the formation of particles with a morphology close to a globular form. This conclusion is confirmed by the calculations to determine the form factor values for the particles investigated.

At mechanical activation of kaolinite mixed with polyamide is going the process of disordering kaolinite structure due to rupture of (Al)-OH bonds and respectively bonds violations in octahedral and tetrahedral grids of layer. Meanwhile are formed the surface active centers. Presumably the active centers of a basic character of silicate interact with the active centers of PA6. During the activation process produced a polymer composition in which the polymer and kaolinite chemically linked. Water formation during mechanical activation confirms the absorbance increase in 3550-3350 cm^{-1}, whereby the ν(-NH-) strip of amide group becomes asymmetric.

4. Conclusion

The resulting products of mechanochemical combining were used as the polyamide matrix modifier (PA6) and as an intermediate in the obtaining of dispersible powders for coating metal substrates. Studies have shown that the mechanochemical combination of components achieves a synergistic effect increase of parameters of deformation strength and adhesion characteristics, with a marked (1.5-2.0 times) increase in the wear resistance of coatings during operation without an external supply of lubricant. Studies indicate the prospects of the use of mechanochemical technologies in functional materials science.

5. Literature

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