# Influence of mechanically activated particles on the activity of polymer engineering materials and compositions based on themt

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**Abstract:** *The article presents the results of studies on the study of the physical and mechanical characteristics of polymeric materials modified with mechanically activated particles. It is shown that the use of mechanically activated nanosized particles makes it possible to achieve a significant effect of increasing operational characteristics at relatively low degrees of modification of 0.05% wt. – 3% wt. The use of modifiers at such concentrations in polymer matrices makes it possible to preserve the basic technology for the processing of polymeric materials and equipment in the manufacture of composite materials on a polymer matrix.*
***KEYWORDS:*** *POLYMER, VISCOSITY, STRENGTH, MECHANICAL ACTIVATION, STRUCTURE.*

## *1. Introduction*

The formation of functional composite materials based on thermoplastic and thermoplastic polymers is in most cases achieved by extensive modification of matrices with powders, fibers, agglomerates, clusters, etc. varying degrees of dispersion. The use of nanocomposite materials based on polymers is a promising trend in the development of modern mechanical engineering. To modify regular and irregular high-molecular compounds, various types of low-sized particles are used: micas, metals, metal oxides, clays, graphenes, sialons, graphite, etc. The geometric parameters of individual crystals of low-sized particles are in the range of 1-5 nm. The conducted studies on the study of the activity of nanoscale objects showed high values of the specific surface area, residual charge, which indicates a high modifying ability of these objects.

The energy state of nanosized particles essentially depends on the habitus of the nanomaterial, its composition, and the formation technology. The influence of these parameters has a significant effect on the structure of the surface layers of the particles of the resulting composite material, which determines the force interaction within the volume of the composite.

The influence of the force field of nanoparticles leads to a change in the predominant orientation of the modified polymer molecules in space, which makes it possible to obtain nanophases in the bulk of the material with a higher degree of orientation compared to other phases of the composite material. The main disadvantage of these materials is the loss of activity over time. In this regard, various technological methods are proposed for the activation of low-dimensional systems or the creation of systems of nanomodifiers with a prolonged lifetime of the active state.

Thus, the establishment of the mechanism of influence and interaction of mechanically activated particles with an uncompensated charge on the structure and properties of structural thermoplastics is of both theoretical and practical interest. The creation of these modifiers will make it possible to obtain composite materials with enhanced functional characteristics. As modifiers of polymeric materials, organic and inorganic dispersed particles of various kinds and origins are widely used. One of the current trends in purposeful changes in the structure and properties of polymeric materials is the use of nanodispersed particles with a high specific surface area, which contributes to a higher activity when interacting with a polymer matrix [1-4]. Nanodispersed particles of diamond-containing compounds obtained by blasting technology with a negative oxygen balance have found the widest application in industry.

The technology for obtaining such compounds has been developed at a sufficiently high level, and the structure and properties of diamond-containing nanoparticles have been well studied [1]. The disadvantage of this class of nanomaterials is the high cost of the final product (diamond nanoparticles), which ranges from $0.5 per carat and more. An alternative for obtaining low-dimensional active modifiers using existing technologies is the use of the mechanical activation (MA) method. Mechanical activation of organic compounds or mixtures of organic compounds and inorganic substances makes it possible to obtain composite nanosized, nanophase particles that meet the criteria of environmental friendliness, ergonomics, resource saving, financial savings. This technology makes it possible to carry out the reactions of high-molecular compounds of an ordered structure with surface layers of inert materials.

In the course of mechanochemical activation, the destruction of polymer molecules occurs with the formation of active radical groups, which can interact with hydroxyl groups of silicates to form composite particles of various dispersed compositions, including those in the nanometer range. The structure of these particles is a layered composite, in which the radical groups of polymeric materials are chemically bonded at the molecular level to the carrier metal ions of silicate. A number of works have previously shown the interaction of polymeric materials with layered silicates, including during mechanical activation, in which it is assumed that there is a relationship between the shape (habitus) of a particle and the charge activity of the obtained nanocomposite particles. The purpose of this work was to study the physical and mechanical characteristics of polyamide modified with composite mechanically activated particles.

A widely used polymeric material in mechanical engineering, in particular in the production of automotive and tractor equipment, is polyamide.

## *2. Preconditions and means for resolving the problem*

At present, polyamide 11 is widely used in the automotive industry. This material is used as a block product and coatings in automotive units manufactured by leading companies in the world, including. Mersedes Benz, Wabko, Comatsu, Ford, etc. Target additives are introduced into polyamide 11 (Rilsan) - antioxidants, dyes, dry lubricants, which are graphite, molybdenum disulfide, aliphatic amines. Polyamide 11, used for coating, is produced in the form of a powder with a particle size of 80-10 microns. To ensure a stable level of adhesive strength of the coating with a substrate of carbon steels, an undercoat ("primer") of Rilprim based on an epoxy resin oligomer is used. The sublayer is applied in the form of a solution by spraying or dipping on a thoroughly cleaned surface of a metal part, after which it is dried and heat treated in the temperature range of 290-340 ºC for 5-20 minutes. A Rilsan coating is applied to the metal part prepared in this way from a fluidized bed, which is melted to form a layer with a thickness of 100-500 microns. After cooling, the coatings are processed to size using special tools, such as broaches.

The disadvantages of this material for domestic manufacturers are due to the fact that: the lack of large-tonnage domestic production of polyamide 11 in the Union State, which does not allow mastering the industrial production of the powder component, which is the basis for the coating; insufficient adhesion of the coating to metal products and substrates without special preparation; the need to apply a special sublayer (“primer”) to the metal surface, which provides the necessary adhesive strength of the coating and substrate; complex coating technology, involving high energy costs; the need to use special methods for cleaning the environment due to the fact that during the application, heat treatment of the sublayer (Rilprim), a large amount of environmentally harmful components in the gaseous state are released. A replacement for an imported analogue can be found by using different dispersions of polyamide 6, modified with a mechanically activated mixture of polyamide 6 - kaolinite, with a content of nanometer-sized particles of 20-50 nm. Figure 1 shows the rheological characteristics of polyamide 6 modified with mechanically activated particles.

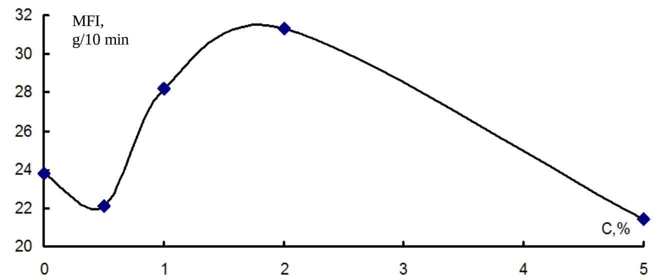


***Figure 1*** *- Rheological characteristics of polyamide 6 modified with mechanically activated particles polyamide 6-kaolinite*

The introduction of mechanically activated particles at low concentrations leads to an increase in the viscosity characteristics of the composite material. A further increase in the content of the modifier in the composition leads to a decrease in the values of the viscosity characteristics. The maximum increase in the fluidity of the modified polymer is observed at 2% wt. modifier content. Increasing the content of the modifier to 5% wt. increases the values of viscosity characteristics.

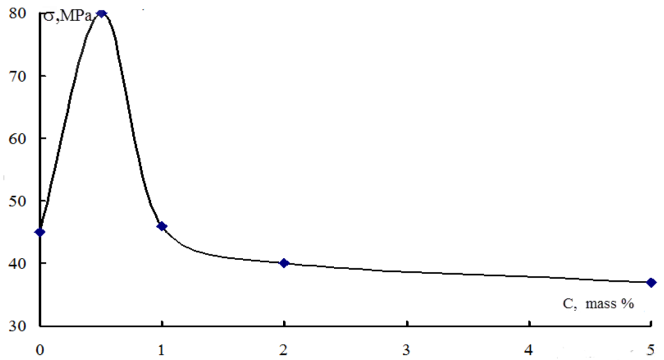


***Figure 2*** *- Dependence of the tensile strength of polyamide 6 modified with a mixture of mechanically activated particles of polyamide 6-kaolinite on the concentration of the modifier*.

The increase in viscosity with the content of the modifier at 0.5% wt. is explained by the formation of a labile network of physical bonds formed as a result of the interaction of electric charges of mechanically activated particles and dipole charges of polar polyamide 6 molecules. and plastic deformation of the surface layers of the polymer matrix both in the process of friction and in the process of mechanical destruction Increase in the fluidity of the composite material at 2% wt. is explained by an increase in the concentration of particles in the bulk of the polymer, as a result of which these particles begin to interact with each other with the formation of agglomerates capable of breaking down at low tangential shear stresses. A further increase in the concentration of the modifier, leading to an increase in the viscosity characteristics, is explained by classical concepts associated with the modification of polyamide materials with various types of modifiers. The introduction of mechanically activated particles into the polyamide matrix leads to a change in the strength characteristics of the composite material.

In the area of modifier concentration of 0.5 wt.%, an increase in strength characteristics up to 80 MPa is observed. A further increase in the concentration of the modifier in the polymer matrix leads to a decrease in the values of the ultimate tensile strength. This is due to the interaction between charge clusters, the formation of large agglomerates of mechanically activated particles with low cohesive strength in the bulk of the polyamide matrix, which leads to a decrease in strength characteristics.

Table 1 shows the physical and mechanical characteristics of polyamide 6 modified with a mechanically activated mixture of PA6-kaolinite.

***Table 1*** *- Physical and mechanical characteristics of polyamide 6 modified with mechanically activated particles "PA6-kaolinite"*

| Options | raw material | 0,5 % | 2 % | 5 % |
|---|---|---|---|---|
| Physical yield strength, MPa | 30,6 | 49,5 | 28,3 | 16,2 |
| Deformation at physical yield strength, % | 19,85 | 6,9 | 4,2 | 4,9 |
| Strength at maximum force, MPa | 48,6 | 77,6 | 30,2 | 37,6 |
| Deformation at maximum force, % | 133,4 | 81,6 | 5,6 | 9,2 |
| Breaking strength, MPa | 48,6 | 77,6 | 30,2 | 37,6 |
| Deformation at failure, % | 133,4 | 81,6 | 5,6 | 9,16 |

The use of mechanically activated nanosized particles makes it possible to achieve a significant effect of increasing performance at relatively low degrees of modification of 0.05 wt. – 3% wt. The use of modifiers at such concentrations in polymer matrices makes it possible to preserve the basic technology for the processing of polymeric materials and equipment in the manufacture of composite materials on a polymer matrix.

The main effect explaining the increase in the physico-mechanical characteristics of polymer nanocomposites upon modification with nanosized mechanically activated particles is the formation of a spatial network of labile physical bonds of the adsorption type in the polymer layer, as well as the influence of the modifier on the kinetics of the formation of the polymer layer from the liquid phase with the formation of supramolecular and pseudocrystalline ordered structures.

The conducted studies on the study of the structure of particles obtained using mechanical activation showed that the formed particles of both organic and inorganic structures differ significantly from each other depending on the technological processing modes and on the initial semi-finished products used.

Studies on the study of the structure of mechanically activated silicate particles with polymeric materials showed that with an increase in the time and modes of mechanical activation, amorphization of the structure of the resulting composite silicate-polymeric materials occurs, and the habitus of microparticles changes. In the course of mechanoactivation, the values of parameters corresponding to an increase in the activity of the resulting composite particles increase.

The developed compositions of composite materials based on polyamide 6 belong to the field of polymer materials science and can be used in mechanical engineering for the manufacture of coated friction parts used in automotive units such as a shock absorber, driveline, brake chamber, etc.

## *3. References:*

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