ENERGY FACTOR OF TECHNOLOGY OF NANOCOMPOSITE MATERIALS BASED ON POLYMERIC MATRICES

ЭНЕРГЕТИЧЕСКИЙ ФАКТОР ТЕХНОЛОГИИ НАНОКОМПОЗИЦИОННЫЪ МАТЕРИАЛОВ НА ОСНОВЕ ПОЛИМЕРНЫХ МАТРИЦ

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Abstract: *There were considered physical preconditions of appearance of dispersed particles activity in the process of the high molecular matrix modifying. The existence of a non-linear function* $S(r) = f(r)$ *defining the dependence of the parameters of the characteristic physical properties of the particle of its geometrical parameters was shown. The expediency of use as modifiers dispersed particles with developed morphology of the surface layer, which provides a special energy state, was shown. Methodological approaches the optimum choice of effective modifiers while creating functional composites were developed. Practical applications of the developed approaches were exemplified*.

KEYWORDS*: DISPERSED PARTICLES, MODIFYING ACTION, MATRIX, ENERGY STATE, NANOSIZED CRITERION.*

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].

As a rule, when creating composites is realizing the traditional labor-intensive approach based on the use of the results of experimental studies to determine the modifying effect mechanisms of components of different composition, structure, particle size and obtaining technology. The practical implementation of this approach is not only costly, but also, as a rule, does not provide an achievement of the optimal technical effect. Moreover, in some cases are forming conditions of the "structural paradox" manifestation, the essence of which is inadequate change the service characteristics parameters of an composite materials, even when using high-efficiency, including high strength and heat resistance, components. An example of a manifestation of such structural paradox is given in [4].

The obvious is the need to develop criteria for reasonable choice of components to create functional materials that take into account the most common features, characteristic for all types of condensed matter, which form the physical paradigm of modern materials science.

The aim of this work was to analyze the possibility of assessing the effectiveness of the modifiers in the macromolecular matrix on the energy state criteria.

2. Methods of research

As binders for composites were used thermoplastic polymers - polyamide 6 (PA 6) and polyamide 11 (PA 11), low-density polyethylene (HDPE), polypropylene (PP), polytetrafluoroethylene (PTFE) in the industrial delivery state. To control the parameters of energy state and dispersion of components used technological methods based on mechanical dispersion, mechanochemical combining, the impact of energy flows in the heat treatment, exposure to a corona discharge, microwave and laser beam using the original settings. Selection of the energy impact type and modes for carrying out the activation process was due to the composition, structure and chemical and dimensional parameters of components, the functionality of the coatings or products.

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. Meanwhile set features a number of modifying effect of nanoparticles of different composition, structure and obtaining technologies that determine the efficiency of use. These features can be systematized by the characteristic features [1-4]:

1) increasing the dispersion degree nonlinearly effects on the energy state of the particles and the effectiveness of their modifiing action;
2) when increasing the degree dispersion of the particles increases the tendency to the formation of cluster structures of different structure;
3) modifying effect activity nonlinearly depends not only on the composition, structure and technology of disperstd particles, but also external, including process, factors acting on the components in the process of receiving, storing, processing and manufacture of composite materials;
4) increasing the dispersion degree of the particles causes nonlinearity of economic costs of their production, storage and practical use;
5) fine-grained particles of the modifiers of high-molecular matrix are generally necessitated the development of special technologies and equipment for their practical application;
6) superfine (including nano-sized) particles have a negative impact on the environment and require special measures to comply with safe conditions of their production and use;
7) long-term (long-acting) effects of the action of fine-grained (including nanosized) particles on the mechanisms and kinetics of physical and chemical (including biochemical) processes studied not in full;
8) the effectiveness of modifying action of fine-grained (including nanosized) particles in some cases, inadequate forecasts due to technological constraints of the optimal (calculated) conditions of interfacial interactions at various levels of the structural organization of the composite material.

Distinctive features of the practical application of nanoscale modifiers indicate the need for systematic analysis of their action mechanism, which will establish the most characteristic features of their effective action and conditions for their manifestation in practical technology of polymer nanocomposites.

In order to establish these common characteristic studied of the morphology of dispersed particles of different composition, structure, and obtaining technology, widely applied in practice. The presence of nanoscale components in the surface layer of all modifiers is established.

The presence of such nanoscale components in the structure of the dispersed particles causes the manifestation of the characteristic energy state of the surface layer, which causes the structuring of the surrounding binder macromolecules to form a quasi-crystalline structure [3-4].

The research allowed offering effective approaches to optimal selection of high-dispersed particles of modifier of high-molecular matrices:

1. It is advisable to use fine particles of micron range mainly with developed morphology of the surface layer formed by nanoscale components of different composition and structure;
2. The ratio of geometrical parameters of the surface layer components and volume of dispersed particle must be determined by physical criteria which characterize nanostate of selected material objects (matrix and modifier);
3. In order to ensure effective modifying action fine particles need to give particular energy state due to the combined effect of structural, chemical, dimensional and technological factors. Selecting the prevailing factor determined by a combination of operational, energy, economic and environmental parameters that determine the effectiveness and appropriateness of industrial application in accordance with the terms of reference;
4. When choosing a method of activation of fine-grained particles, providing optimal modification, it is necessary to establish the prevailing mechanism of formation of a transitional (the boundary) layer of a given structure and parameters of deformation strength and adhesion characteristics and unconditional implementation of "reasonable sufficiency" principle for a particular combination of materials science, environmental and economic factors;
5. The most perspective when creating functional composite materials and large-tonnage production on the basis of high-molecular matrices are dispersed particles derived from natural compounds laminate, frame, chain structure and fibrous natural, synthetic and artificial semi-finished products using traditional and special technologies, providing formation of surface layer morphology with nanoscale components with an optimal level of energy activity;
6. For composites based on high-viscosity and high melting matrix preferably using technology joint mechano-chemical activation of components and multi-level modification using particles of different composition, structure and dispersion.

4. Conclusion

Practical testing of the proposed methodological approaches have been implemented to create composite materials based on thermoplastic matrices and greases for heavy-duty friction units of machines and technological equipment used at the enterprises of mechanical engineering, building industry, chemical and mining industries.

5. Literature

1. Goldade, V. Metal-wear inhibitors, Moscow, Chemistry, 1993, 240 p.
2. Struk, V. Tribochemical concept of anti-friction material on the basis of tonnage produced polymer binders: diss. ... doctor. tehn. Science, Minsk, 1988, 323 p.
3. Avdeychik, S. Introduction to the physics of nanocomposite materials engineering, Grodno, GGAU, 2009. - 439.
4. Avdeychik, S. The polymer-silicate engineering materials: physico-chemistry, technology, application, Minsk: Tehnalogiya, 2007. - 431 p.