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COMPONENTS USING ENERGY TECHNOLOGIES FOR AUTOMOBILE TRANSPORT

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Abstract: The prerequisites for the formation of a special energy state of components of metal-polymer systems and components are considered composite materials based on high-molecular matrices (polymer, oligomeric, combined). The greatest prospects in the creation of functional composite materials and their large-scale production based on high-molecular matrices are dispersed particles obtained on the basis of natural compounds of layered, frame, chain structure and fibrous natural, synthetic and artificial semi-finished products using traditional and special technologies that ensure the formation of the morphology of the surface layer with nanosized components with an optimal level of energy activity.

Key words:values of thermally stimulated current , pulsed laser radiation, polytetrafluoroethylene , structure, mechanical activation of particles, dispersed modifiers.

The most important criteria for a reasonable choice of technology for modifying components of functional materials based on polymers are the availability and efficiency of equipment, the safety of its operation, and the possibility of use in the conditions of an established production process.

Objects and methods of research. The use of laser radiation (LR) in materials science and technology for producing polymer composites and metal-polymer systems allows not only to carry out operations of dimensional cutting and formation of specified geometric parameters of products, but also carry out complex modification of the surface layers of products to give them specified parameters of adsorption, electrophysical, tribotechnical and other characteristics [1,2].

Results and their discussion. Analysis of literary, patent and commercial sources indicates the predominant use of laser technologies in processing processes characterized by deep transformations of polymer matrices due to melting, thermal-oxidative destruction, ablation, and thermolysis.

These areas of application of LI have made it possible to develop a technology for producing composite coatings for friction units [3, 4], methods for producing ablation products with specified adsorption characteristics, and a technology for modifying the surface layer of carbon fiber (CF) fragments used for filling PTFE in the production of tribological and sealing composites “ Fluvis ”, “ Superfluvis ” [5].

Film semi-finished products in the state of industrial supply with a thickness of 120 to 200 μm obtained by blown extrusion or extrusion through a flat-die from low-density polyethylene (HDPE), high-density polyethylene (LDPE), polypropylene (PP), polyethylene terephthalate (PET) were used for the research. Dispersed particles of modifiers widely used in polymer materials science were also modified - particles of clays, silicates, colloidal graphite preparation KGP S-1, etc. To modify samples from polymer materials, a laser installation "Quantum- 15" was used , generating laser radiation with a wavelength of $\lambda_o = 1.06$ μm and a pulse duration of $2 \cdot 10^{-3}$ s, and a GOR-100M laser with $\lambda_o = 0.69$ μm and a free-running pulse duration of $1.2 \cdot 10^{-3}$ s. The number of pulses during processing varied from 1 to 10. When using the Quantum-15 installation, the pulse repetition rates varied from 1 Hz to 20 Hz. Both diffusely scattering materials and materials with a graphite coating were used as

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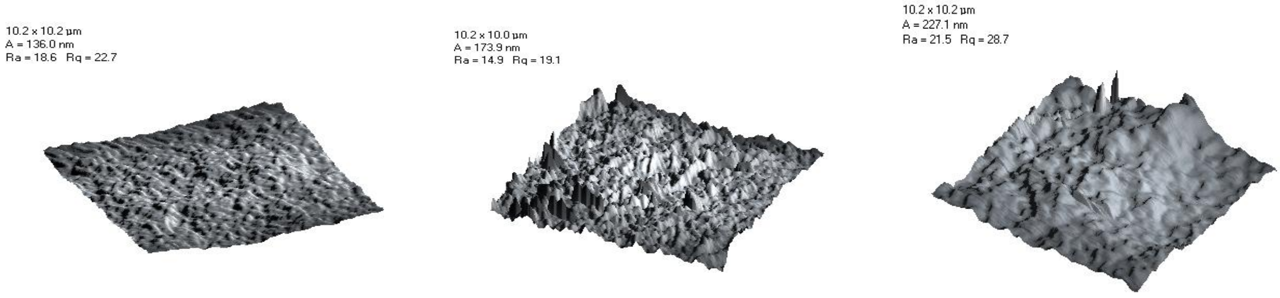
substrates on which the film samples were placed. The energy of one pulse of the acting radiation varied from 0.6 to 6 J. The diameter of the beam of the acting radiation varied from 4 to 10 mm.

Experimental data indicate an ambiguous effect of LI on the parameters of composites based on PET, HDPE, and PTFE.

the influence of LI have a significant impact on the parameters of the deformation and strength characteristics of composite materials based on thermoplastic matrices .

The complex impact of LI on parameters is manifested in changes in the molecular and supramolecular structure.



A) b) V)

Fig. 1. Characteristic morphology of the surface of a film sample made of high-density polyethylene (HDPE) initial (a) and after a single exposure to GOR-100M laser radiation with a free-running pulse energy of 30 J (b) and 2 J (c)

Similar changes in the morphology of the surface layer are characteristic of other polymer samples – PA, PET, PP [6].

Simultaneously with the change in the morphology of the surface layer during LI processing, a change in the parameters of the energy state of the polymer samples is observed, which is manifested in the appearance of extremes in the TST spectra that are not characteristic of the original samples, as well as a change in the values of the contact angle of wetting with model liquids - water and vaseline oil [6].

Laser exposure of varying intensity changes the morphology of dispersed particles – fragments of carbon fibers (CF), graphite (Fig. 2 and 3).

The surface layer of the CF fragment after LI treatment undergoes a significant transformation, which is characterized by the formation of a large number of nanosized components that change the adsorption and adhesive activity in interphase processes. In addition, as a result of the pulsed effect, the process of fragment degradation occurs with the formation of through cracks, which changes the parameters of the deformation-strength characteristics of the CF and has a favorable effect on the processes of its mechanical dispersion to obtain fractions that ensure the achievement of optimal values of the parameters of the deformation-strength and tribological characteristics of composite materials based on thermoplastics - polyamides, polytetrafluoroethylene [7].

Model studies of the influence of LI on the morphology of dispersed fillers were carried out using a common modifier of polymer, oligomeric and combined matrices, which increases the parameters of tribological and deformation-strength characteristics - colloidal (powdered) graphite grade C-1.

Samples of the colloidal-graphite preparation of the S-1 brand were subjected to two types of energy exposure: thermal at temperatures of 973 ÷ 1273 K for 1 hour and laser at a pulse energy of the Quantum- 15 laser, operating in a pulse-periodic mode, of 140 mJ and an exposure duration of 1 ÷ 2 s.

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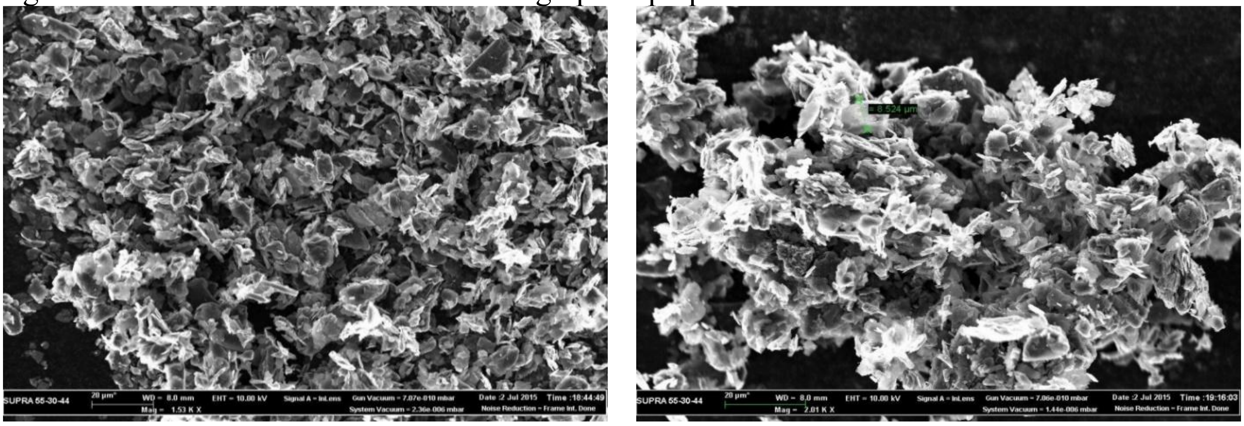
As follows from the experimental data presented in Fig. 2, the energy impact of both types changes the cluster structure of the colloidal graphite preparation.



A) b)

Fig. 3 Cluster structure of colloidal graphite preparation C-1, heat-treated (a) and exposed to laser radiation (b)

Thus, the conducted studies indicate the efficiency and prospects of using pulsed laser radiation for targeted modification of fillers and modifiers used in the creation of functional materials with specified parameters of service characteristics. The efficiency of laser modification of fibrous and powder components consists in the complex transformation of the parameters of structure, morphology and energy state [8].

Analysis of the morphology of dispersed particles of modifiers of various compositions, production technologies and structures indicates the presence of significant features that unite substances of natural, artificial and synthetic origin. It has been established that the products of organic synthesis –polytetrafluoroethylene (PTFE) and thermogasdynamic synthesis (UPTFE), as well as mineral substances – clay, tripoli, shungite , and products of metallurgical processes, plasma-chemical (CNT) and inorganic synthesis have a characteristic cluster structure of macroparticles . The characteristic morphology of dispersed particles, which have found wide application in materials science of polymer composites – tripoli and shungite , is presented in Fig. 4 and 5.

The cluster structure is also characteristic of other studied highly dispersed particles. Thus,

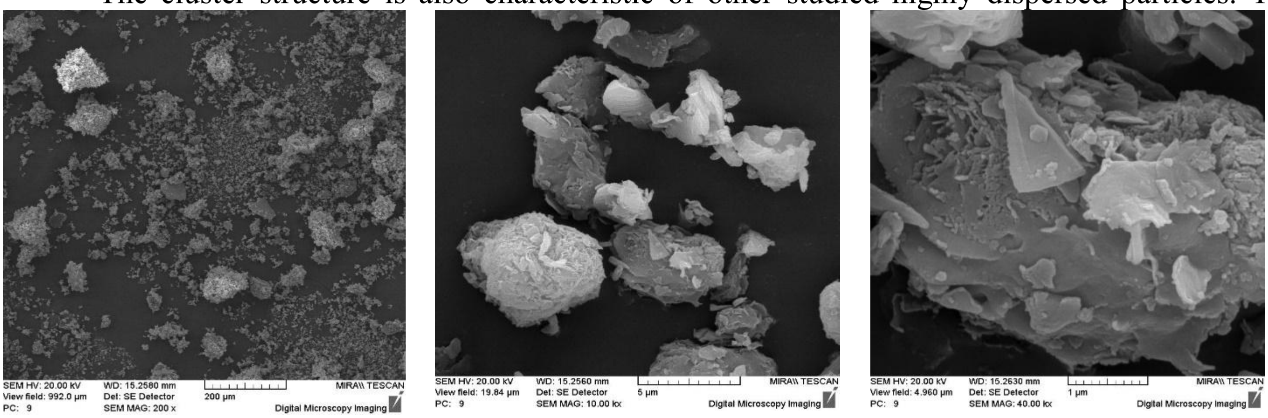


Fig. 4. Characteristic morphology of natural tripoli particles

particles of blue clay , natural tripoli, shungite , which are natural products of geochemical processes, are aggregates formed from lamellar and whisker fragments . [9] . The lamellar structure is typical for layered geosilicates such as micas and clays. The structure of tripoli contains both framework (zeolites) and layered (clays) components.

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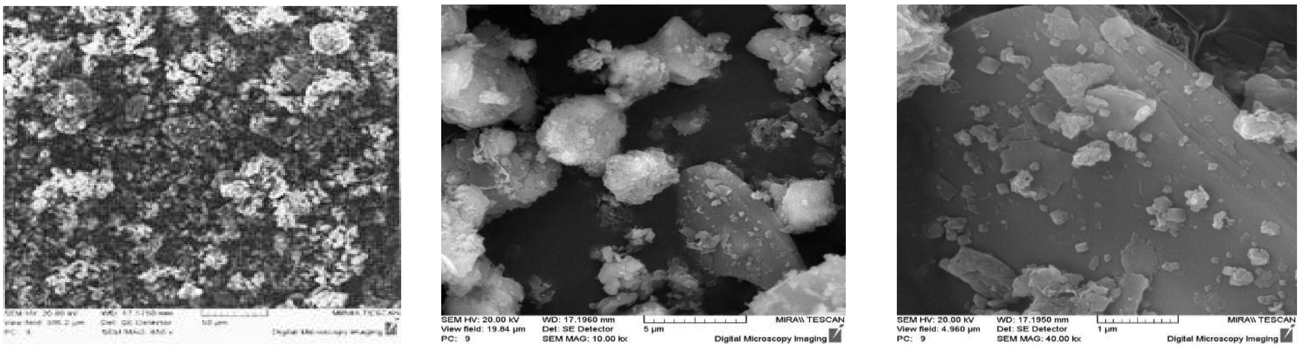

Fig. 5. Structure of shungite particles unheat treated

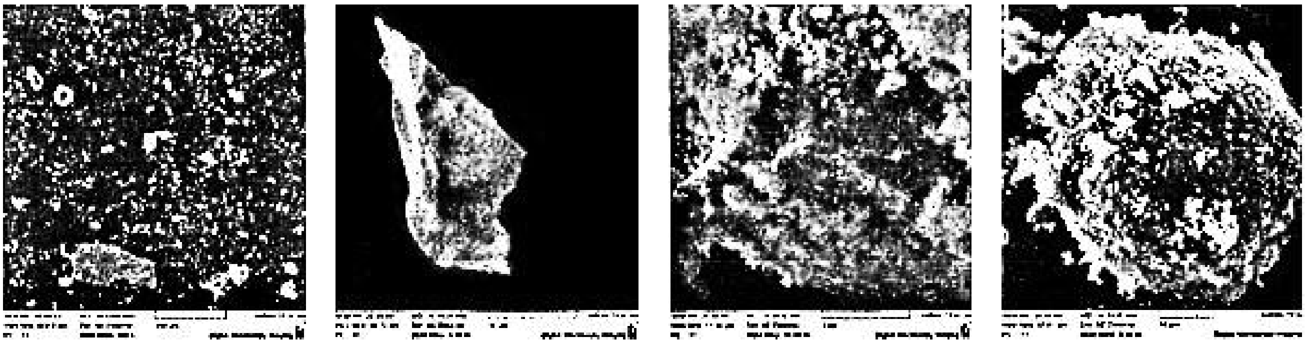

Fig. 6. Morphology of mechanically activated silicon particles obtained at different magnifications using scanning electron microscopy

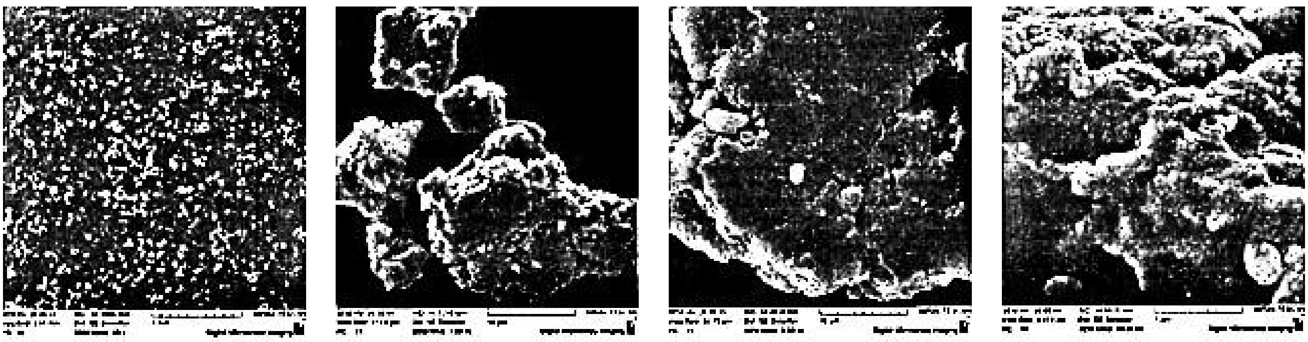

Fig. 7. Morphology of mechanically activated particles of ultradispersed silicon oxide obtained at different magnifications using the scanning electron microscope.
electron microscopy

Mechanical activation of particles of different composition and structure in the high-energy installation AGO-2 leads to the formation of a large number of nanosized fragments with a size of about 1 nm , which form cluster structures [9]. The characteristic appearance of mechanically activated particles of silicon and silicon oxide is shown in Figures 6 and 7.

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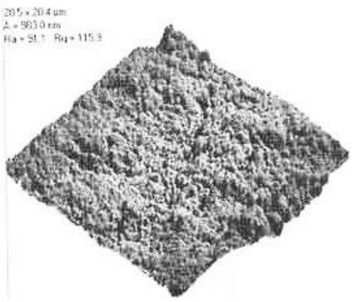
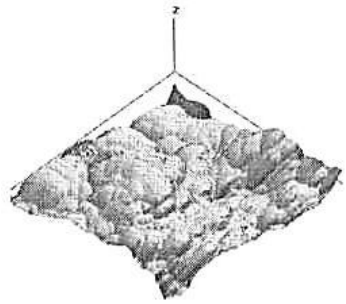


A)



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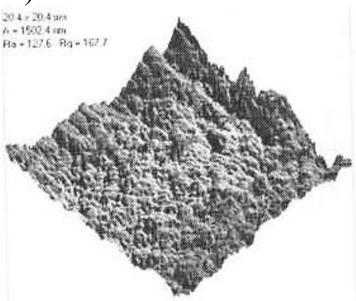

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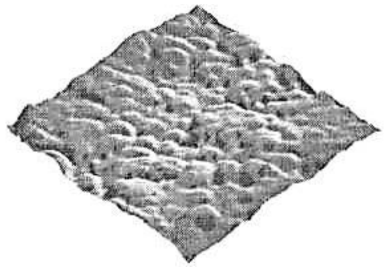

G)

Initial particles of the modifier (a, b) and after heat treatment at a temperature of 400 °C in air (c, d))
Fig. 8. Characteristic morphology of carbon-containing filler of shungite (a, c) and silicon-containing filler of natural flint (b, d)

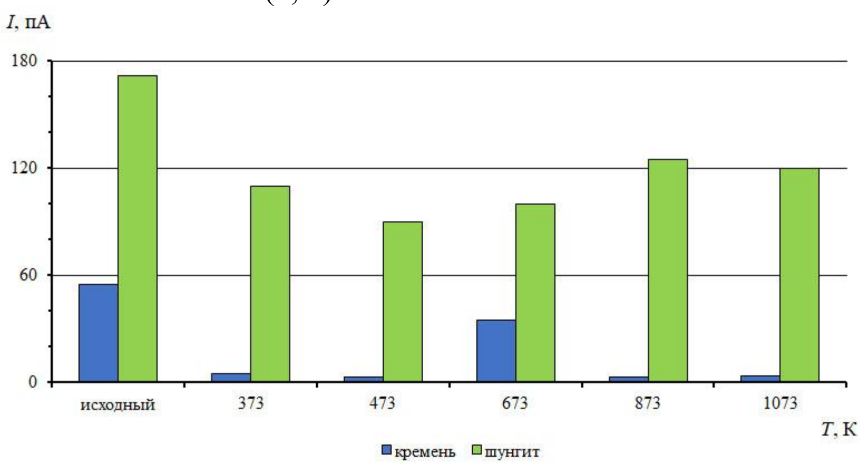

Fig. 9. Dependence of the maximum thermally stimulated current Imax on the processing temperature of dispersed particles of silicon, shungite

A change in the morphology of dispersed particles also occurs during thermal exposure of semi-finished products in the temperature range of 373 ÷ 1073 K (Fig. 8), which leads to a change in the energy state of these polymer matrix modifiers (Fig. 9).

Structure and composition of components nanometer dispersion suggest their high activity in reactions with the environment technological or matrix environment. This activity is manifested in the chemisorption of oxygen with the formation of oxide compounds, the formation of oriented structures of large geometric dimensions from gaseous and liquid-phase substances (including oligomeric and polymeric), physicochemical and structural transformations of the original nanoparticles , which lead to the formation of cluster aggregates, etc.

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The studied dispersed modifiers of different composition, structure and production technology have different activity, estimated by the intensity of current flow in different temperature ranges. Therefore, when choosing a modifier for a specific application, in order to achieve the optimal effect, it is necessary to take into account the temperature range of its activity.

For example, when forming tribotechnical coatings on the surfaces of tribosystem elements , such as rotaprints, it is effective to use UPTFE particles, which maintain an active charge state up to temperatures of 408 ÷ 433 K and ensures the formation of a stable separating nanocomposite film in the frictional contact zone due to the possibility of alternating transfer of fragments in the active state.

Dispersed geosilicate particles such as tripoli, flint, marble flour, and mica have a pronounced energy state in the temperature range 283 ÷ 343 K, therefore they are most effective in the formation of cold-curing composites based on oligomers of cross-linking resins.

Carbon-containing modifiers (products of detonation synthesis of UDAG, nanotubes , shungite) are characterized by a wide temperature range of activity 288 ÷ 403 K and are effective for use in both cold curing composites and materials processed using energy impacts.

Conclusion: The prerequisites for the formation of a special energy state of components of metal-polymer systems and components are considered. composite materials based on high-molecular matrices (polymer, oligomeric, combined). The factors that determine the manifestation of a special energy state in dispersed particles of materials and components of metal-polymer systems are systematized. It is shown that the factors that determine the nanostate dispersed particles of condensed media are: geometric parameters, structure, composition, morphology surface layer, which determine the choice of technology for the formation of the necessary energy parameters that ensure the manifestation of the optimal mechanism of modifying action.

When selecting a method for activating highly dispersed particles that ensures optimal modification, it is necessary to establish the prevailing mechanism for the formation of a transition (boundary) layer of a given structure and parameters of deformation-strength and adhesion characteristics and the unconditional implementation of the principle of "reasonable sufficiency" in relation to a specific combination of materials science, environmental and economic factors.

The greatest potential in the creation of functional composite materials and their large-scale production based on high-molecular matrices is shown by dispersed particles obtained on the basis of natural compounds of layered, frame, chain structure and fibrous natural, synthetic and artificial semi-finished products using traditional and special technologies that ensure the formation of the morphology of the surface layer with nanosized components with an optimal level of energy activity.

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