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POLYMER COMPOSITE MATERIALS AS DISPERSED SYSTEMS

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Abstract

In this paper, the attempt of conceptual description of polymer composite materials as dispersed systems on the example of polymer latexes has been made. The pronounced similarities, like interphase boundary as well as difference in hydrophilic and hydrophobic properties of solid phase and medium allows to apply similar approaches to these systems.

Keywords

Nanoparticles – Adsorption – Polymers – Latexes

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Introduction

Phenomenological similarities of polymer composite materials and dispersed systems allow to develop a new approach for investigation of structure and properties of polymer composite materials[1]. In the framework of this approach, examination of colloid aspects of dispersions stability, surface phenomena, adsorption at interphases and mechanical treatment can provide valuable information. For stabilization of non-equilibric phase structures, application of both surfactants (physical and chemical approach) and intensification of heat and mass transfer by mixing and disintegration of components can be used[2]. One of such intensification techniques is wave treatment, allowing to initiate non-linear resonance vibrations in multiphase media[3].

Approaches for description of latex and suspension systems

Aqueous dispersed systems like latexes have been being widely applied as polymeric composite materials in technics, construction and various branches of industry[4]. Specific features of properties of such systems cause their great value for biology and medicine, too[5]. Among other applications, latex systems are being used as composite materials in chemical, pharmaceutical, food-processing industry, in medicine, including their application as various membranes (dividing and ionic) and also as the modelling systems, allowing to study exchange processes in alive organisms, microbiology, biochemistry, etc[6]. Biomaterials where latexes play role of components in the composite materials which are carrying out functions of a skeleton for biocarriers, are also of great interest[7].

The study of influence of vibrating treatment on dynamic behaviour of multiphase systems allowed to establish that the intensification of heat and mass transfer under the generation of nonlinear vibrations in polymeric dispersions can be accompanied by the relaxation phenomena (such as vibrorelaxation, vibroflowing, vibrotixotropy)[8].

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[1] A. A. Asratyan; S. A. Ambrozevich; O. S. Andrienko; N. A. Bulychev; A. G. Grigoryants; M. A. Kazaryan; S. M. Kazaryan; N. A. Lyabin; R. G. Mkhitaryan; G. A. Tonoyan; I. N. Shiganov y V. I. Sachkov, “Comparative analysis of parameters of pulsed copper vapour laser and known types of technological lasers”, Proceedings of SPIE Vol: 10614 num 02 (2018).

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Considering the crucial role of relaxation processes in behaviour of real polymeric materials, it is necessary to emphasize that the sensitivity of relaxation characteristics to structural inhomogeneties and to transformations under external influences that is most pronounced in such heterogeneous systems as polymeric mixtures and polymeric composite materials[9]. Features of a structure of macromolecules and supramolecular formations, causing variety of forms of molecular mobility in polymers, lead to a number of relaxation processes; all of them are related to a heat movement of kinetic units of the certain kind and can be described by a spectrum of times of a relaxation[10]. Therefore, spectral representations have been used by consideration of structural changes under influence of vibrating influence on polymers and polymeric composite materials[11].

In this work, the wave vibrations in sound and ultrasound frequency ranges were applied for treatment of multiphase systems such as emulsions and suspensions based on industrial oil and water, butadiene-styrene and acrylic latexes, water-soluble polymers (gelatin, starch, polyacrylic acid, polyacrylamide) with activated coal, silica, zeolite, composition of inorganic pigments (titanium dioxide and ferrous oxide) with polymer stabilizers based on cellulose ethers[12]. The wave treatment was demonstrated to affect rheological and colloid properties of these dispersed systems[13]. The decrease of cinematic and dynamic viscosity of polyacrylic acid, polyacrylamide and thickened compositions, increase of thickeners dispersity[14]. The increase of adsorption saturation of surface of dispersed particles as a result of ultrasonic treatment was exemplarily investigated on titanium dioxide and ferrous oxide solid particles[15]. This proves that intensive wave treatment provides the intensification of mass transfer processes, affecting the behaviour of polymer surfactants at interphase surface[16].

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Investigation of dispersity of latex compositions have shown the decrease of latex particle diameter after wave treatment[17]. Particles size distribution curves demonstrate narrowing the polydispersity, that proves the efficiency of wave treatment for disintegration of particle associates and increase the overall system stability. Ability to obtain more homogenic compositions allow to apply them as a base of paint materials and impregnated textile nonwoven materials with enhanced mechanical and functional properties[18].

It is obvious, that correlation of anisotropy of structure and physicomechanical parameters of properties is most pronounced in the presence of anisodiametric morphological formations. Comparison of physicomechanical properties of films obtained from latex treated by vibrowave action and in solid-phase mixturing of the same polymers, where defining criteria are stress and deformations of a shift, allows to prove the efficiency of vibrowave influence.

The wave effects concerning the organization of a controlled turbulization in a resonance regime in multiphase systems, three-dimensional current and deagglomeration of associates, lead to obtaining dispersions with narrower particle size distribution and, consequently, more homogeneous films with an increased level of physical and mechanical properties[19].

The explanation of observed effects of modifying influence of vibrowave treatment on multiphase systems which is carried out by the direct excitation of nonlinear vibrations in a resonant regime and is observed further at the formation of properties of films and other compositions based on the dispersions, undergone by the vibrowave treatment, it is possible to explain by the occurance of the factor of "memory" as an element of hereditary mechanics. The carrier of such a "memory" is the structural-morphological organization of the examined multiphase systems, and the influence of wave action in a sound range of frequencies is observed at different levels of the structural organization.

Conclusions

As a result of this research, a technology for creation of new filtered nonwoven materials with high sorption ability for cleaning of liquids from ions of heavy metals, surfactants, oil products, microorganisms has been developed. It is important to note that a range of practical valuable results, for example, development of medical bandages based on nonwoven materials and intensification of technology of paint materials is based on investigation of structure and dynamic behaviour of polymer compositions and their model systems and also on nanostructure aspects of interaction of macromolecules with interphase surface.

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