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ABOUT FEATURES OF VELOCITY DISPERSION AND SIGNAL ATTENUATION OF ULTRASOUND IN POLYMER BLENDS

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Measurements of phase velocity and decay factor of ultrasound by frequency 2, 5 and 8 MHz in standard samples of polymers blends, such as polypropylene - impact polystyrene and polypropylene - polythene high densities were lead at change of a mixture ratio from zero up to 100 %. The analysis of the gained effects has shown, that in studied frequencies interval for polymer compounds velocity diminution and signal attenuation increase of ultrasonic waves with frequency pinch takes place, and at the further magnification of frequency, velocity ceases to change. Thus, the basic mechanisms of ultrasound signal attenuation in polymeric compounds are viscous losses and dispersion on internal defects, and in intermixtures with crystalline polymeric compounds – dislocation uptake. At some relations of intermixture builders, there are the maximums of the signal attenuation caused by magnification of concentration and the sizes of internal defects or resonant dispersion of ultrasound at a certain relation of a wavelength and the sizes of flaws.

Polymeric composite materials find more and more wide and manifold application. The important place among them is borrowed with intermixtures of polymeric compounds, which enable to gain materials with the refined properties in comparison with initial builders (the raised shock strength, water resistance, smaller density, etc.) [1]. Therefore examination of physical properties of polymeric compositions is rather actual problem. Use for this purpose of ultrasonic methods allows gaining the information on mechanical properties and interior structure of these materials [2-4]. Frequency characteristics of mechanical properties of the filled polymers bear the important information about interfacial layers in which interaction of formulation constituents is carried out, and defects of internal structure of a composition. Bias of these dependences on a frequency axis with growth of concentration of filler [1] takes place. Besides, in mechanical behavior of polymeric compounds the temperature – time analogy is realized: pinch of frequency renders the same influence, as well as depression of temperature. Therefore, the knowledge of the frequency dependences allows predicting temperature behavior of mechanical performances of polymeric compounds. The theory [2] and effects of experimental researches [1, 2, 5, 6] the frequency dependences of polymeric compounds have shown, that with pinch of frequency elastic modules and phase velocity of ultrasonic waves are incremented, and the decay factor all over again is incremented up to the peak value at $\omega\tau = 1$ (τ -a relaxation time), and then decreases. In polymer blends, these characteristics depend not only on frequency, but also from properties and a mixture ratio. In connection with greater variety of polymeric compositions and stationary occurrence, new acoustic properties of their majority are not investigated. The purpose of the present operation was the observational studying the frequency dependences of velocity and signal attenuation of ultrasound in intermixtures in polymer blends with a various degree of a crystallinity.

Experimental researches were spent on polypropylene (software) in mixes with impact polystyrene (PS) and polyethylene (PE) of high density at change of their mass contents to software from 0 up to 100 %. Some data about starting materials are brought in table 1, whence it is visible, that software and PE are crystal polymers with high degree of crystallinity and at ambient temperature are in a high-elasticity (rubber-like) condition. Under same conditions IPS represents amorphous polymer in a glassy state. Therefore use of PE and PS as fillers for software should result in to essentially various results.

At reception of a polymeric mix the granulouse initial components all over again mixed in a mechanical agitator, then pelletisings were exposed and in the further were manufactured by injection moulding on an automatic injection machine. The standard samples obtained at it{this} for physical and chemical tests represented plates thickness of 3,3 mm and width 13 mm. For definition of density, ρ samples weighed on assay balances, measured their sizes by a micrometer, and then counted volume and density. The error of measuring ρ did not exceed 1 %. In connection with small thickness of

Polymer	Crystal-linity degree	Glass transition, °C	Density, kg/m^3	Molecular mass, 10^3	Velocity, km/c (2 MHz)	Decay factor, dB/mm (2 MHz)
SOFT-WARE	75 %	-10	880	60-200	2,6	1,1
PS	0	100	1020	70-100	2,2	0,4
PE	60 %	-130	930	50-800	2,4	0,28

Tab. 1. Characteristics of mixed components

samples the measurements of velocity and signal attenuation of ultrasound were carried out by a buffer method. The mechanical part of the observational installation and a substantiation of a used measuring procedure of a decay factor are in detail featured in [7]. Definition of phase velocity of longitude ultrasonic waves in explored materials was carried out on a delay time of a signal which is equal to a difference of arrival times of the first ultrasonic impulses in systems the buffer-sample-buffer and the buffer-buffer. The decay factor α was defined under the attitude of amplitudes U_0 and U the signals which have transited accordingly systems the buffer-sample-buffer and the buffer-sample-sample the buffer. Measuring of ultrasonic performances was spent on frequencies 2, 5 and 8 MHz at an ambient temperature. The continuance of impulse following was made 500μc and their duration – about 5 continuances of oscillations. The Relative accuracy of velocity measuring did not exceed 0,5 %, a decay factor – 5 %.

On fig. 1 effects of density measuring versus percentage PS and PE in software are given. In case of PS filling this dependence is close to additive, and small diminution of density at PS content from 40 up to 80 % speaks, how have shown electronic photos of microedges, formation in this field of more defective interior structure. At filling by PE the significant diversion from the additive dependence aside diminutions of density (is observed especially at 10-20 % of PE content). Such dependence testifies about разрыхлении interior structure that can be caused by formation of interfacial layers with the depressed package density and decrease in degree of crystallinity of a mix due to infringement of the long-range order in an arrangement of software macromolecules.

Effects of measuring of phase velocity V and decay factor α of longitudinal waves in explored samples depending on content PS are given on fig. 2 and 3 accordingly. Apparently on fig. 2, for an intermixture of software with PS crystalline and amorphous polymeric compounds) in an explored frequency interval with pinch of frequency velocity decreases, and then remains to a stationary value. It testifies to approach of ultrasound frequency to a limit at which distribution of a wave to the given

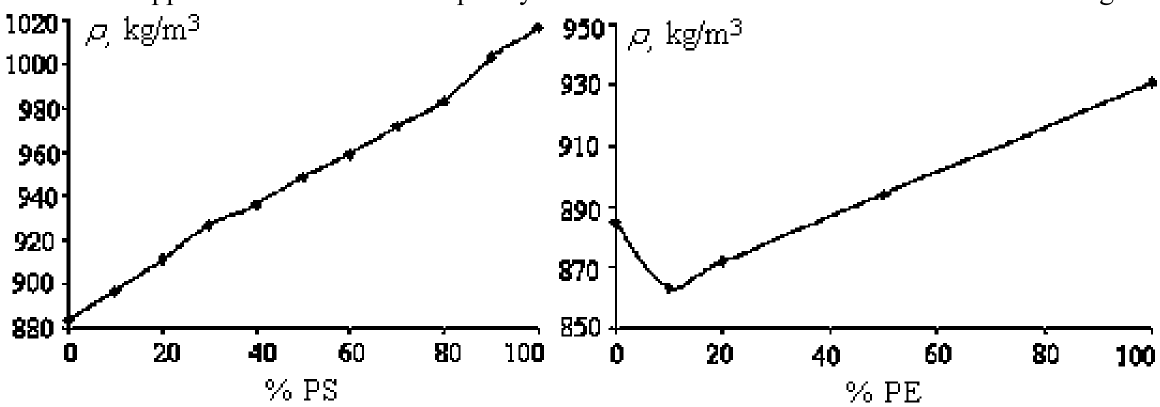


Fig. 1. Density of samples versus content PS and PE in software

materials is possible, caused by a commensurability of a wave length with distance between the next macromolecules [8]. This can explain and practical concurrence of velocity diagrams on frequencies 5 and 8 MHz. The contribution to reduction of dispersion can bring and mechanical glass transition of software [9]: since increase of frequency to equivalently depressing of temperature on frequency of 5 MHz and above software and its mixes behave as vitreous polymers. Therefore, in this case we deal with a mix of two vitreous polymers. Graphs on fig. 3 testify to propagation of decay at increase of ultrasound frequency for the yielded polymeric composition. Maxima of decay on all frequencies fall to area of phase's inversion (50 % PS). It is connected by that software and PS have the various chemical nature and consequently possess bad mutual solubility. At mixture between their macromolecules, it is formed large interfacial layer and small bed on size of segmental compatibility. As a result inside of a material microcavities are formed, concentration and which sizes are maximal at 50 % PS contents (fig. 4a). Dispersion of ultrasound on these defects brings the additional contribution to decay and has resonant character - the peak of decay is most expressed on frequency of 5 MHz. The second maximum of decay on frequency of 8 MHz at 80 % PS maintenance is caused by presence more minor defects (fig. 4b) on which there is a resonant dispersion at the yielded frequency. The smaller height of this maximum is caused by weakening of defects since this mix can be considered as PS with addition of 20 % of software.

The same dependences for an intermixture of software-PE are shown on fig. 5 and 6. In these intermixtures the same mechanism of internal defects formation, as in a composition of software-PS is realized. However unlike these materials of software and PE are the crystal polymers which are being accordingly in vitreous (due to mechanical glass transition) and high-elasticity conditions. Features of formation of internal structure of these mixes are described above by consideration of their density

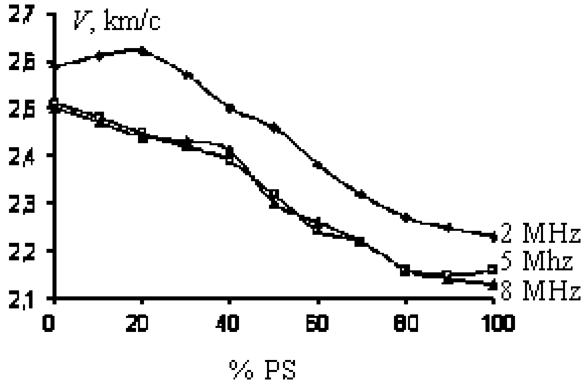


Fig. 2. Phase velocity V versus PS content in software at various frequencies

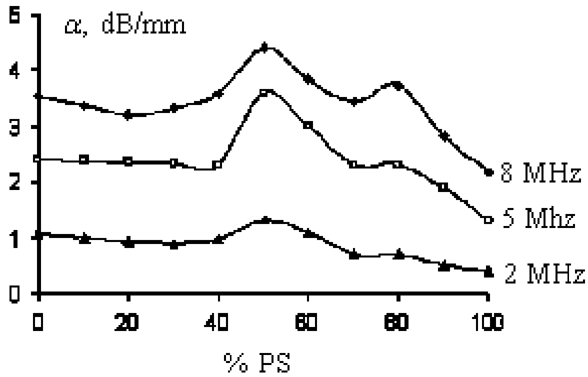
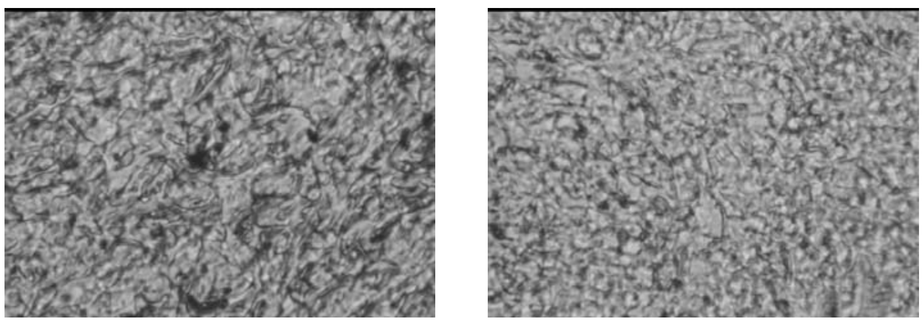


Fig. 3. Decay factor α versus PS content in software at various frequencies



50 % PS 80 % PS

a) **b)**

Fig. 4. Electronic photos of samples microedges for an intermixture PP-PS at various PS content

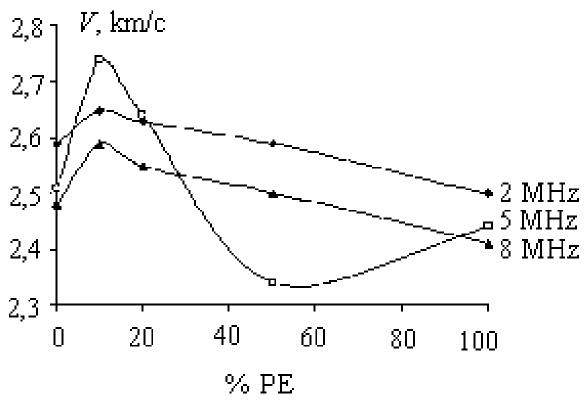


Fig. 5. Phase velocity V versus PE content in software at various frequencies

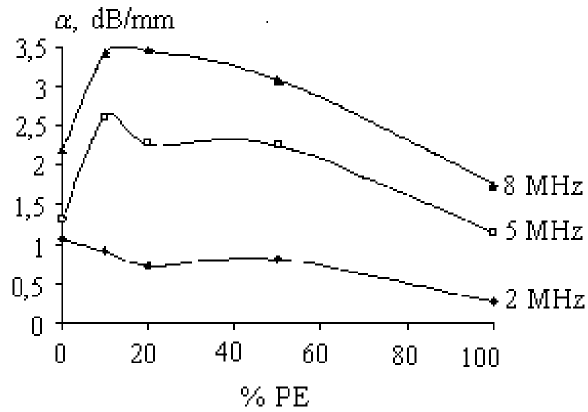


Fig. 6. Decay factor α versus PE content in software at various frequencies

behavior. Here the greatest interest represents the graph of speed on frequency of 5 MHz (рис.5). It is visible, that for 100 % of software and 100 % of PE decrease of speed takes place at increase of frequency, as well as in mixes of software and PS. In a mix of software-PE abnormal increase of speed on frequency of 5 MHz with a maximum takes place at 10 % and a minimum at 50 % the maintenance of PE. In the field of 10 % the peak of decay (fig. 6) takes place also. Such behavior can be explained by formation in crystal software of dislocations [10]. Fluctuations dislocate loops under action of ultrasound can be the reasons of an abnormal dispersion of speed and additional decays on frequencies smaller in ten and more times of dislocations resonance frequency. So, in mixes of crystal polymers except for viscous losses and dispersion on defects, the contribution to decay bring dislocate absorption of ultrasound.

The gained effects have shown that in MHz frequency interval for intermixtures of polymeric compounds velocity diminution increase of signal attenuation of ultrasonic waves with frequency pinch takes place. The basic mechanisms of ultrasound signal attenuation of in intermixtures of polymeric compounds are viscous losses, dispersion on internal defects, and in intermixtures with crystalline polymeric compounds – dislocation uptake. At some relations of intermixture builders, there are the maximums of the signal attenuation caused by magnification of concentration and the internal defects sizes or resonant dispersion of ultrasound at a certain relation of a wavelength and the flaws sizes.

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