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# PROPAGATION OF ULTRASOUND IN DISPERSE, POROUSE AND COMPOSITE MATERIALS

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The subject of this paper is experimental investigation of attenuation coefficient, scattering and velocity of ultrasonic waves at 3 MHz for suspensions of glass globes and for composites formed with 10% gelatin and glass spheres. Average radius of particles was R=25 micrometers. The investigations have demonstrated the possibility of getting information about structural rearrangements and interchange processes in heterogeneous systems using ultrasound.

Attenuation and velocity of ultrasonic waves in heterogeneous systems are closely connected with interchange processes taking place between phases forming the system. Intensity of these processes is determined by physical properties of phases (viscosity η, density ρ, compressibility β, heat conductance etc.), constructive parameters (size, form, volume concentration of particles) and parameters of influence (frequency, pressure, temperature).

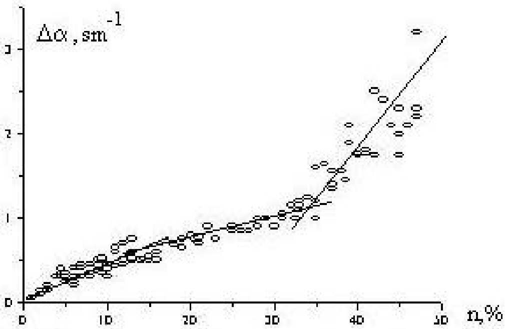

Fig.1 Dependense of Δα on concentration in suspension of glass globes.

At present there is no theory allowing to calculate the variations of velocity and attenuation of ultrasonic waves in heterogeneous media for wide range of concentrations, when the structural roles of phases change in accordance with the concentration variations. The dispersed phase becomes a matrix, and the disperse one turns to be the pores-filling medium. In the most outstanding theoretical works equations are obtained allowing to calculate velocity *c* and excess attenuation Δα of ultrasonic waves only for low range of nonuniformities (*resp.* particles and pores) concentration [1-3].

The subject of this paper is experimental investigation of attenuation, reflection, scattering and velocity of ultrasonic waves in water and polymeric disperses, where structural roles of phases are changing with the growth of concentration.

Attenuation and scattering were measured with standard pulse method. Ultrasonic velocity was measured with both pulse and interference methods [4]. Data presented were obtained at frequency of ultrasonic waves 3 MHz. Glass globes and glass spheres were used as dispersed phase. Average radius of particles was R=25 micrometers, much less then the ultrasonic wave length.

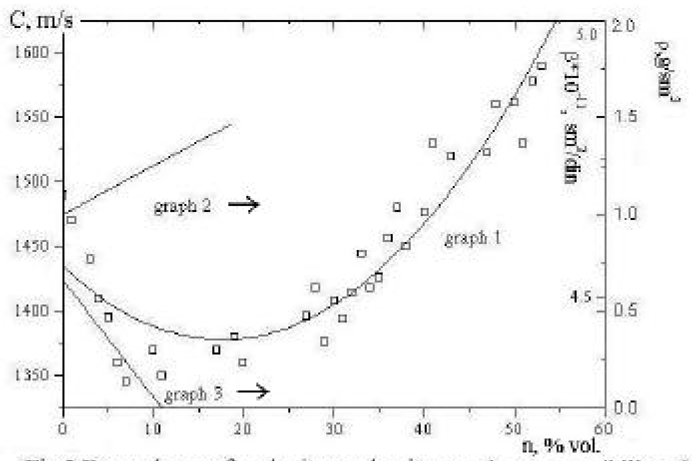

Fig.2 Dependence of velocity c, density ρ and compressibility β on concentration of glass globes in the suspension.

Fig. 1 shows the concentration dependence of Δα for suspension of glass globes. Concentration was varied from a fraction of percent up to 55%. As one can see from this graph, there are three characteristic regions for Δα dependence as a function of concentration Δα = *f*(*n*). In the range 1 of concentrations ($n \in$ 0,01-10%) where the distance between particles is larger then their size, dependence Δα on concentration is linear. When clusters appear in suspension, there are two breaks in linear dependence of Δα on *n*. In the

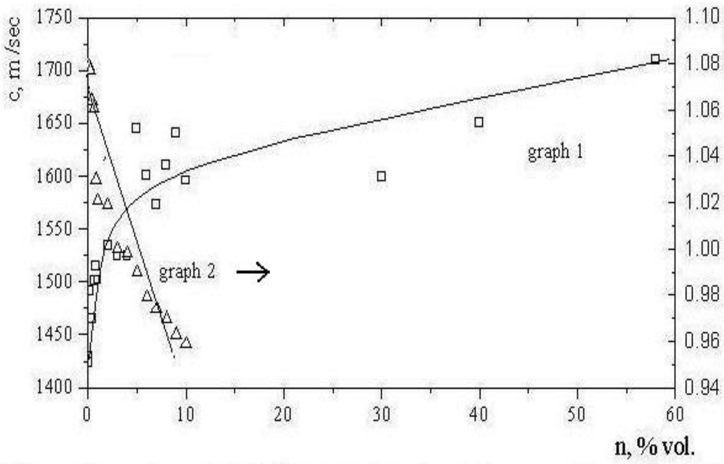


Fig. 3 Dependence of velocity of USW on concntration in the suspension of glass spheres.

range 2, where only discrete are formed, ($n$ ∈ 10-20%) the concentration coefficient is smaller, $(\partial\Delta\alpha/\partial n)_2 < (\partial\Delta\alpha/\partial n)_1$ , and in the region 3 ($n$ > 20%), when infinite cluster has emerged, $(\partial\Delta\alpha/\partial n)_3 > (\partial\Delta\alpha/\partial n)_1$ [5].

Fig. 2 shows concentration dependence of ultrasonic waves velocity $\tilde{n}=(\rho_{eff}\ \beta_{eff})^{-1/2}$ for the same suspension (graph *1*). One can see from this graph, that changes in the character of concentration dependence of $\tilde{n}$ on $n$ take place in the same regions of structural rearrangements in suspension. In the same fig. 2 $n$-dependencies for $\rho_{eff}$ (graph *2*) and $\beta_{eff}$ (graph *3*) are shown. Comparision these graphs with graph *1* permits to assume that transition from negative ($\partial\tilde{n}/\partial n < 0$) to positive ($\partial\tilde{n}/\partial n > 0$) concentration coefficient of velocity indicates the transition from dominating influence of $\rho_{eff}$ on the variation of $c$ to that of $\beta_{eff}$ .

Quite different character of concentration dependence has been detected for a region of low and medium concentrations in the case of suspension of glass spheres. The results of measurements for velocity in such suspensions are shown in fig. 3 (graph. *1*). One can see from this graph, that $\partial\tilde{n}/\partial n > 0$ in the whole measured range of concentrations $n$ Î 0,10-55%. In the same fig.3 concentration dependence $\rho_{eff} = f(n)$. is shown (graph *2*); one can see that $\partial\rho_{eff}/\partial n < 0$ for all measured concentrations. Comparing graphs 2 and 3, it is possible to conclude that effective compressibility coefficient decreases with the growth of concentration, i. e. $\partial\beta_{eff}/\partial n<0$.

In fig. 4 the results of ultrasonic waves back-scattering from composites, i.e. layers of 10% gelatin with “infrozen” glass spheres, are presented. In the range of low concentrations, back-scattering signal value is oscillating with moving the sensor along the layer’s border. These oscillations are originated by interference of waves scattered from the particles. A similar picture was obtained for back-scattering from a rough metal surface [6].

Rearrangement of particles in the gelatin matrix by remelting of the sample changes the interference picture of back-scattering. With increasing the particle concentration in composites the interference maxima and minima are smoothed out and the intensity of back-scattering stabilizes, which allowes measurement of reflection coefficient. It has been shown by measurements of scattering indicatrixes for these composites that with growing glass spheres concentration the forward scattering decreases while back-scattering increases.

Scattering indicatrixes have allowed to determine the energy balance in the systems studied, separating the contribution of dissipative losses connected with heat and viscous processes.

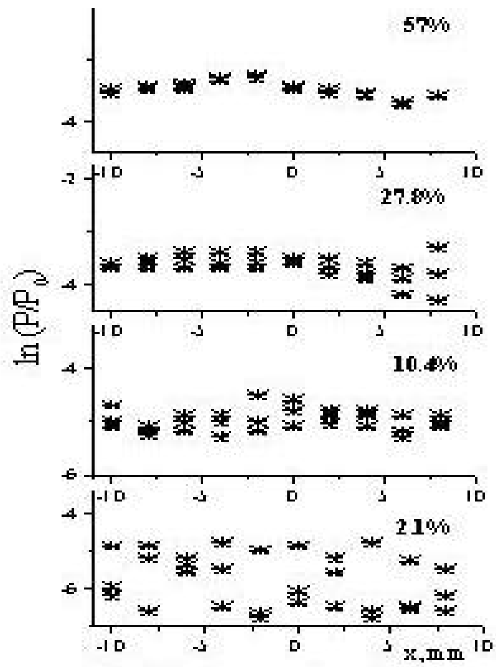


Fig .4 Back-scattering from the composites

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