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DETERMINATION OF THE ADIABATIC COMPRESSIBILITY □s OF A SERIES OF ALCOHOLS FROM THE VELOCITY OF HYPERSOUND AT DIFFERENT TEMPERATURES

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Abstract *A great contribution to the study of the liquid state can be made by elucidating the nature of structural changes in the molecules of a liquid at various state parameters. Optical methods will give us the opportunity to obtain more complete information about the nature of structural changes in molecules. One of these methods is based on the study of the spectra of Mandelstam- Brillouin scattering of light. By investigating the Mandelstam - Brillouin scattering of light in liquids at various temperatures, one can obtain valuable information about adiabatic fluctuations. The main reason causing molecular scattering of light is fluctuations in dielectric constant. The purpose of this work is to determine the adiabatic compressibility of a number of alcohols from the spectra of Mandelstam-Brillouin light scattering and based on the hypersonic velocity and density at various temperatures. At high temperatures, the quantitative difference in hypersonic velocity and adiabatic compressibility in normal alcohols tends to decrease. In the case of an increase in temperature, we associate such a tendency with the destruction of the probability of the formation of H-bonds.*

Key words: *Compressibility, adiabatic compressibility, fluctuation, dielectric constant, hyper sound, scattering, liquid, alcohols, temperature, spectrum, intermolecular interaction.*

Introduction

The development of the molecular theory of the liquid state of matter contributes to the solution of applied problems in many branches of science and technology. However, the molecular theory of the liquid state of matter is far behind in its development from such

theories of gases and solids.

A great contribution to the study of the liquid state can be made by elucidating the nature of structural changes in the molecules of a liquid at various state parameters.

Optical methods will give us the opportunity to obtain more complete information about the nature of structural changes in molecules. One of these methods is based on the study of the spectra of the Mandelstam- Brillouin scattering of light. By studying the Mandelshtam - Brillouin scattering of light in liquids at various temperatures , one can obtain valuable information about adiabatic fluctuations. The main reason for the molecular scattering of light is the fluctuations in the permittivity $\Delta\varepsilon$.

The intensity of scattered light, taking into account $\Delta\varepsilon$, is determined by the formula;

(1)

The purpose of this work is to determine the adiabatic compressibility of a number of alcohols from the Mandelstam-Brillouin light scattering spectra based on hypersonic velocity and density at various temperatures.

Normal alcohols have been the subject of acoustic research many times. However, the study was mainly ultraacoustic parameters. Hyperacoustic parameters with variation of state parameters have not been adequately studied. In the work /1/, the acoustic properties of a number of alcohols were studied in the temperature range of 180-293 K. It was shown that in strongly associated liquids, including normal alcohols, at frequencies up to 10 GHz, the mechanism of structural relaxation in sound absorption prevails, due to redistribution of intermolecular hydrogen bonds.

To solve this problem, we used a spectral apparatus assembled on the basis of a Fabry-Pierrot interferometer with a dispersion region of 0.625 cm ^{2} . The excitation light source was a helium-neon laser with a wavelength λ = 6328 A ^{0} .

The hypersonic velocity is determined from the shift of the Mandelstam- Brillouin scattering spectrum with the formula:

$$\vartheta_{\text{гз}} = \frac{\Delta\nu \cdot c \cdot \lambda}{2 \cdot n \cdot sin\frac{\theta}{2}} \quad (2)$$

r de, $\Delta\nu$is the displacement of the Mandelstam-Brillouin component (cm $^{-1}$), c is the speed of light, is the wavelength of laser radiation, is $n$the refractive index of the liquid , $\frac{\theta}{2}$is the scattering angle

In order to study the relationship between successive changes in the structure and hyperacoustic parameters , as well as the influence of the complex formation through hydrogen bonding on them were studied a number of normal alcohols at different temperatures.

An increase in the molecular weight of alcohol in the homologous series corresponds to an increase in the hypersonic velocity, and this dependence is non-linear. Based on this, the adiabatic compressibility is determined by the formula (3)

$$\beta s = 1/\rho\ \vartheta_i^2 \quad (3)$$

g de , $\boldsymbol{\rho}$ is the density of alcohols at different temperatures, $\vartheta_i$is the hypersonic velocity calculated from the Madelstamm -Brillouin spectra , at the corresponding temperatures

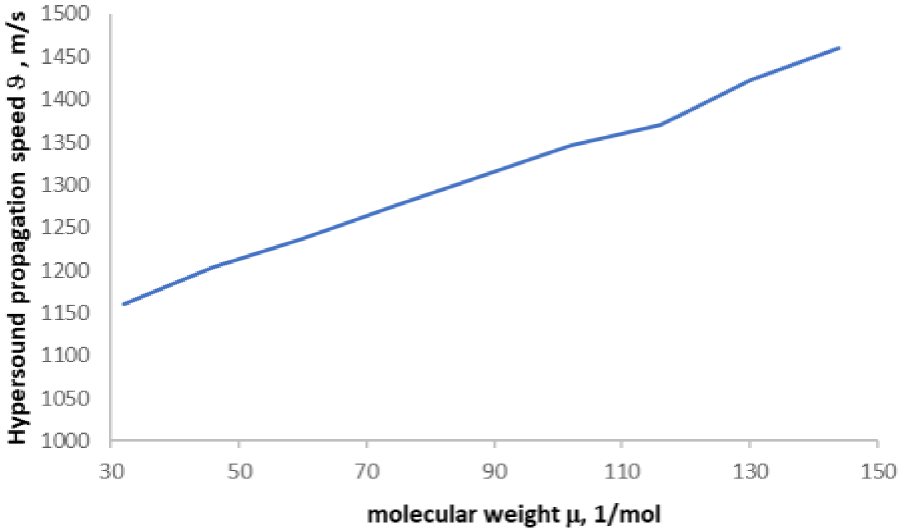
The results of measurements of the hypersound propagation velocity, density and value of adiabatic compressibility at different temperatures are shown in Table 1.

Table 1.

T, K	$\boldsymbol{\rho}$, kg / m ^{3}	$\delta_{r,i}$, m/s	□s _ , 10 ^{11} , Pa $^{-1}$
	Methyl alcohol		
323	753	1072	115
303	783	1108	104
289	787	1160	95
273	803	1208	85
263	812	1248	79
250	826	1290	74

243	837	1320	68
	Ethanol		
350	735	1068	119
323	764	1124	105
303	782	1164	94
291	795	1203	96
273	814	1250	78
253	835	1340	66
243	844	1380	63
	propyl alcohol		
350	750	1100	109
323	775	1148	98
303	796	1204	87
291	809	1236	82
273	826	1292	72
260	841	1350	65
243	860	1416	58
	Butyl alcohol		
350	752	1124	105
323	781	1184	91
303	801	1240	81
293	810	1274	76
273	832	1346	67
253	852	1419	58
243	863	1450	55
	Amyl alcohol		
350	760	1170	96
323	784	1212	87
303	808	1272	77
293	814	1310	72
273	836	1376	63
263	845	1412	59
253	860	1450	56
243	872	1490	52
	Hexyl alcohol		
400	710	1110	115
350	760	1210	90
325	790	1252	81
303	816	1316	71
293	819	1346	67
273	841	1426	58
243	878	1540	48
	Heptyl alcohol		
400	714	1140	104
350	765	1230	86
323	791	1284	77
303	820	1340	68
293	826	1370	64

273	843	1448	56
243	888	1576	45
	nonyl alcohol		
400	718	1230	92
350	770	1280	79
325	796	1330	71
300	823	1400	62
290	832	1422	59
270	860	1500	52
	Decyl alcohol		
400	722	1280	84
375	746	1296	80
350	776	1320	74
325	797	1352	69
300	823	1410	60
280	843	1481	54



Rice. 1. Dependence of the hypersonic velocity on the molecular mass of alcohols.

As can be seen from the table, with increasing temperature, the hypersonic velocity decreases, while the adiabatic compressibility, on the contrary, increases. With an increase in the molecular weight of alcohols, the speed of hypersound propagation also increases (Fig. 1). Such a change is qualitatively the same in all alcohols, and the tendency is that the higher the temperature, the closer the hypersound velocities and adiabatic compressibility in these alcohols. The dispersion value for the first members of the homologous series is small, however, for the higher members there is a tendency to increase.

As we know, aliphatic alcohols are typical representatives of associated liquids with intermolecular hydrogen bonds. An increase in pressure leads to an increase in the number of H-bonds. This is consistent with the principle of Le Chatelier / 2 /, according to which H bonds reduce the volume occupied by molecules, therefore, their formation is facilitated by those processes that lead to a decrease in the volume per molecule / 3 /.

An increase in temperature, on the contrary, leads to the destruction of associates . The results of the experiments showed that with increasing temperature, the hypersonic velocity and adiabatic compressibility in normal alcohols change non-linearly, and at high temperatures the ends $\vartheta_{гз}$of the T-dependence curves at 450 K approach each other. It can be concluded that at high temperatures the quantitative difference in the hypersonic velocity of normal alcohols tends to decrease, and, accordingly, the adiabatic compressibility tends to increase. In the case of an increase in temperature, we associate this trend with destruction, the probability of the formation of H-bonds.

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