DIELECTRIC RELAXATION OF ABSORPTION SPECTRA OF ISOPROPYL, n-BUTYL AND ISOBUTYL ALCOHOLS IN MICROWAVE RANGE

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The investigation results of dielectric constant ε′ and absorption coefficient ε″ of isopropyl, n-butyl and isobutyl alcohols at wave lengths 3,22; 1,80 and 1,15 sm in temperature interval from –50°C up to +50°C are given in the article. The dielectric relaxation of absorption spectra of isopropyl, n-butyl and isobutyl alcohols is studied. It is shown that all studied objects of high-frequency dielectric constants $\varepsilon_{\infty,2}$ of the additional absorption region have the bigger value than the square of the optical refractive index.

Keywords: dielectric spectroscopy, dielectric relaxation, dielectric constant, isopropyl alcohol, n-butyl alcohol, isobutyl alcohol.
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INTRODUCTION

Nowadays, it is established that the dispersion low-frequency region of the electromagnetic waves in the prime aliphatic alcohols can be well described by the unique time of the dielectric relaxation in big temperature intervals [1]. Besides, the data proving the presence of additional absorption regions [2] are obtained. However, these data are limited and related to supercooled state because of which the problem of additional absorption stays open. According to [2,3] at room temperatures this absorption should be observed in the range of centimeter and millimeter waves where as it is known the carrying out of measurements is connected with the big technical and method difficulties.

The main aim of the present investigation is the study of the some dielectric aspects of local structures of the some aliphatic alcohols in microwave range, and also the study of absorption spectrum dielectric relaxation in the big temperature intervals.

THE MATERIALS AND INVESTIGATION METHODS

The some data obtained for isopropyl, n-butyl and isobutyl alcohols are given in the present work. The dielectric constants ε' and dielectric losses ε" of these alcohols at wavelengths 3,22; 1,80 and 1,15 cm in temperature interval from 50 up to –50° C are measured. The measurements are carried out on installations made by us by Malov-Poly method [4,5,6]. The error for the values of dielectric constants ε' doesn't increase 2-3% and for the values of dielectric losses ε" doesn't increase 3-5%. The measurement cell temperature with the sample is supported with the help of the thermostat and the cuprum is measured by the constantan thermocouple with accuracy 0,3°C. The investigated compounds after rigorous purification and drying are treated by triple distillation on rectifying column.

INVESTIGATION RESULTS

The measurement results of temperature dependence of dielectric constants ε' and dielectric losses ε" for isopropyl, n-butyl and isobutyl alcohols are given in table 1.

Table 1

The temperature dependences of dielectric constants ε' and dielectric losses ε" for isopropyl, n-butyl and isobutyl alcohols

t °C	Isopropyl alcohol						n-butyl alcohol					
	3,22 см		1,80см		1,15см		3,22 см		1,80см		1,15см	
	ε'	ε"	ε'	ε"	ε'	ε"	ε'	ε"	ε'	ε"	ε'	ε"
50	3,55	1,68	3,28	1,40	3,10	1,26	3,26	1,24	3,05	1,04	2,88	0,94
40	3,46	1,38	3,25	1,17	3,04	1,07	3,21	1,04	3,01	0,90	2,83	0,87
30	3,38	1,13	3,21	0,96	3,00	0,90	3,18	0,87	2,96	0,80	2,80	0,77
20	3,33	0,94	3,18	0,81	2,96	0,78	3,14	0,75	2,92	0,70	2,77	0,68
10	3,30	0,79	3,16	0,70	2,92	0,67	3,10	0,66	2,88	0,63	2,73	0,61
0	3,27	0,66	3,12	0,61	2,88	0,59	3,06	0,58	2,86	0,55	2,70	0,52
– 10	3,24	0,57	3,09	0,54	2,84	0,52	3,02	0,52	2,83	0,49	2,69	0,47
– 20	3,22	0,50	3,07	0,51	2,81	0,46	2,98	0,46	2,80	0,44	2,64	0,43
– 30	3,20	0,45	3,05	0,47	2,78	0,43	2,94	0,44	2,77	0,41	2,62	0,39
– 40	3,18	0,41	3,03	0,44	2,77	0,42	2,91	0,42	2,74	0,39	2,59	0,37
– 50	3,17	0,38	3,01	0,42	2,76	0,41	2,90	0,41	2,72	0,37	2,57	0,34

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t °C	Isobutyl alcohol					
	3,22 см		1,80см		1,15см	
	ε'	ε"	ε'	ε"	ε'	ε"
50	3,11	1,19	2,96	0,94	2,75	0,85
40	3,04	0,97	2,91	0,80	2,71	0,76
30	2,98	0,80	2,87	0,69	2,68	0,66
20	2,94	0,64	2,83	0,59	2,61	0,57
10	2,91	0,54	2,79	0,50	2,58	0,48
0	2,88	0,47	2,76	0,43	2,56	0,41
– 10	2,85	0,42	2,74	0,40	2,54	0,39
– 20	2,83	0,37	2,73	0,35	2,53	0,33
– 30	2,81	0,33	2,71	0,31	2,52	0,30
– 40	2,79	0,31	2,69	0,29	2,51	0,27
– 50	2,76	0,30	2,67	0,28	2,50	0,26

Supposing the additivity of contributions of the both dispersion regions into measured dielectric constants ε' and dielectric losses ε", it is easy to show that the values of dielectric coefficients corresponding to dispersion second region are defined by the following formulae:

$$\boldsymbol{\varepsilon_2' = \varepsilon' - \frac{\varepsilon_{0.1}-\varepsilon_{\infty,1}}{1+\left(f/f_{0,1}\right)^2}}\ ,\ \boldsymbol{\varepsilon_2'' = \varepsilon'' - \frac{\varepsilon_{0.1}-\varepsilon_{\infty,1}}{1+\left(f/f_{0,1}\right)^2}\left(f/f_{0,1}\right)} \qquad (1)$$

here $\boldsymbol{\varepsilon_{0,1}}$ and $\boldsymbol{\varepsilon_{\infty,1}}$ are the equilibrium and high-frequency dielectric constant of the dispersion main region correspondingly, $\boldsymbol{f_{0,1}}$ is critical frequency of this region, f is the frequency on which the measurement is done.

The parameter values of the main region of dispersion necessary for calculation corresponding with data in the limits of test errors [2] are given in table 2.

Table 2

The calculation values $\boldsymbol{\varepsilon_{0,1}}$ and $\boldsymbol{\varepsilon_{\infty,1}}$ of equillibrium and high-frequency dielectric constants of the main region of dispersion.

t ºC	Isopropyl alcohol					n-butyl alcohol				
	$\varepsilon_{0,1}$	$\varepsilon_{\infty,1}$	$10^{-8}f_{0,1}$,*Hz*	$\varepsilon_{\infty,2}$	10^{12}τ, sec	$\varepsilon_{0,1}$	$\varepsilon_{\infty,1}$	$10^{-8}f_{0,1}$,*Hz*	$\varepsilon_{\infty,2}$	10^{12}τ, sec
30	17,3	3,39	5,52	2,11	3,8	16,6	3,35	3,41	2,12	5,5
20	18,6	3,43	4,00	2,12	4,0	18,1	3,38	2,46	2,13	6,3
10	20,0	3,45	2,77	2,14	4,3	19,6	3,41	1,62	2,16	7,3
0	21,4	3,48	1,71	2,16	4,8	21,2	3,44	1,06	2,18	8,4
– 10	23,0	3,52	1,05	2,18	5,6	22,6	3,48	0,69	2,20	9,9
– 20	24,7	3,56	0,663	2,20	6,5	24,3	3,53	0,43	2,22	12,5
– 30	26,4	3,59	0,389	2,22	7,5	26,0	3,56	0,25	2,25	15,1
– 40	28,5	3,65	0,215	2,25	9,3	27,9	3,59	0,145	2,27	19,4
– 50	30,7	3,70	0,110	2,28	10,8	29,8	3,64	0,080	2,30	24,0

Isobutyl alcohol				
$\varepsilon_{0,1}$	$\varepsilon_{\infty,1}$	$10^{-8}f_{0,1}$,*Hz*	$\varepsilon_{\infty,2}$	10^{12}τ,sec
16,2	3,19	2,83	2,13	6,4
17,5	3,22	1,96	2,14	7,2
19,0	3,25	1,23	2,16	8,4
20,4	3,29	0,782	2,18	10,2
22,1	3,34	0,482	2,19	12,3
23,8	3,37	0,284	2,22	14,8
25,8	3,40	0,149	2,23	18,7
27,6	3,44	0,083	2,25	23,8
29,6	3,47	0,043	2,27	29,0

The further calculation is easy to carry out with the help of graphic method. Coal - Coal diagram [8,9] for the studied compounds at +20° and –20° C are shown in Fig.1.

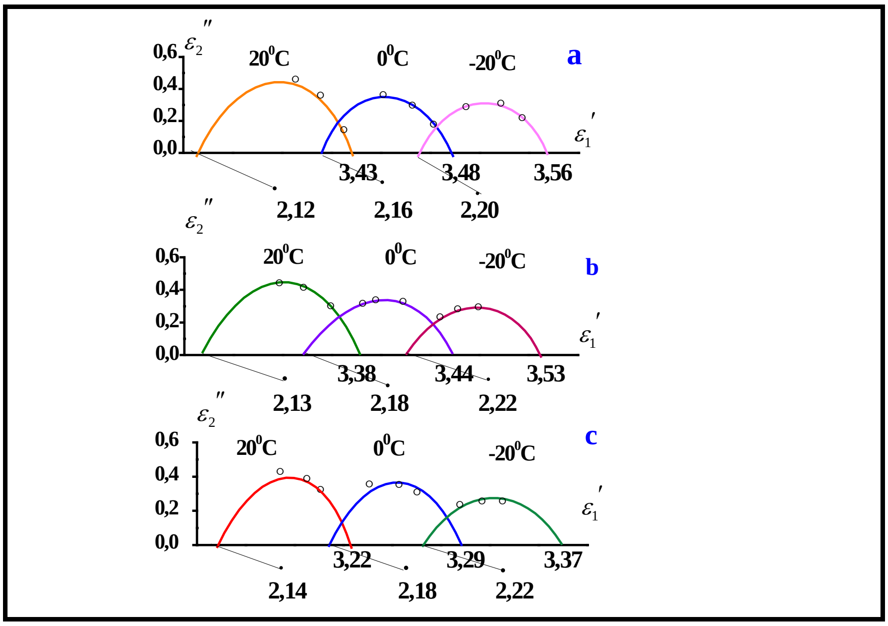

Fig.1. Coal-Coal diagrams: a is isopropyl alcohol; b is n-butyl alcohol; c is isobutyl alcohol.

RESULT DISCUSSION

At diagram construction it is shown that low-frequency limit of second region of absorption is equal to high-frequency limit of the main dispersion. As it is seen from the Fig.1 ε_2' and ε_2'' values calculated by formulae (1), are well lied on the semicircle arc with the center below X-axis that shows on the presence of symmetrical distribution of relaxation time near more probable one. The distribution increase is observed with the temperature decrease. The averaged relaxation times τ found from diagrams and also the high-frequency dielectric constants $\varepsilon_{\infty,2}$ of additional absorption region are given in table 2. The spread between values of relaxation time τ found on the different waves in average isn't more 10 – 15%. Such correspondence is well enough if we take under consideration the error of parameter distribution of main dispersion. The fact of the visible increase of the value of high-frequency dielectric constants $\varepsilon_{\infty,2}$ of addition absorption region under the value of square of optic refraction index of all studied objects attract attention because of which one can conclude the probable existence of one more high-frequency absorption region.

CONCLUSION

The microwave dielectric absorption in isopropyl, n-butyl and isobutyl alcohols in wide temperature interval is studied. The high-frequency dispersion region characterizing by the symmetrical distribution of dielectric relaxation time takes place in studied compounds. It is established that in all studied regions the values of high-frequency dielectric constants $\varepsilon_{\infty,2}$ of additional absorption region exceeds the values of the square of optic refraction index from which one can conclude the probable existence of one more high-frequency absorption region.

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