EFFECT OF NON-REFLECTIVE ABSORPTION OF MICROWAVE RADIATION IN SOLUTIONS OF ACETYL ACETONE IN N-HEPTANES

M.I. VALIYEV, R.M. KASIMOV, Ch.O. KADJAR
Institute of Physics of National Academy of Sciences of Azerbaijan,
Az-1143, H. Javid av., 33

The dielectric properties of solutions of acetyl acetone in n-heptanes were researched in a range of microwaves. The existence of a spectrum of concentrations and thicknesses of the solutions layer at which resonant non-reflective absorption of radiation in these solutions occurs has been established.

Preparation and research of the materials absorbing electromagnetic radiation without its appreciable reflection on the basis of solutions of polar substance in non-polar solvent is of scientific and practical interest. Such materials can be applied as composite materials for reception of non-reflective absorbing coverings.

On the basis of the analysis of the results represented in works [1,2] it has been shown that under certain conditions in polar dielectric possessing wave dispersion and placed on a metal substrate, can take place full (non-reflective) absorption of the electromagnetic radiation passing through it and reflected from a conducting surface. As experimental detection of the given effect in pure dielectric liquid is complicated because of necessity of application of more complex technical equipment, solutions of polar substances in non-polar solvent have been used as an object of research. The effect of non-reflective absorption in this case is reached by variation of the structure of solution and its thickness.

According to carried out experimental studies and taking into account that dispersive area of acetyl acetone occurs in the microwave range, non-reflective absorption of electromagnetic radiation has been investigated in solutions of acetyl acetone in n-heptanes at wavelengths λ=4,28; 10,0 and 20,0 mm and at temperature T=293 K. Measurements of reflective characteristics of the given solutions were carried out with use of panoramic measuring instruments for the standing wave factor P2-66, P2-67 and P2-69 and connected with them short-circuited on the end measuring wave guide cells which, in turn, were equipped by the device of fine regulation of solution layer thickness. From the experimentally obtained dependences of the module of wave reflection factor ρ on thickness l of the solution layer in a cell the minimal values of wave reflection factor ρ_{min} were determined and their dependence on concentration of a polar component in a solution was obtained. At the same time the quantitative estimation of dielectric properties of studied solutions was carried out with application of the measurement method described in [3] based on determination of dielectric permittivity ε' and dielectric losses ε'' of a solution on the base of experimental measurement of standing wave factor η and thickness l of a solution layer in extreme points of dependence $\eta(l)$.

Results of measurements of ε' and ε'' for solutions of acetyl acetone in *n*-heptanes are given in Table 1.

Dielectric properties of pure acetyl acetone are sufficiently good described in the field of a dispersion by Debye's equation. The average concentrations of polar component in the studied solutions are best described by Debye-Cole's equation [4].

Table 1

Dielectric permittivity ε' and dielectric losses ε'' of solutions of acetyl acetone in n-heptanes at wavelengths λ=4.28; 10,0 и 20,0 mm and at temperature T=293 K.

φ, %	λ=4.28 mm		λ=10,0 mm		λ=20,0 mm	
	ε′	ε′	ε′	ε′	\ε′	ε′
100	5,62	4,65	7,32	8,13	13,04	12,64
90	5,21	3,93	6,84	6,56	11,73	10,17
80	4,87	3,40	6,40	5,51	10,49	8,00
60	4,20	2,32	5,54	3,92	8,06	4,95
50	3,89	1,95	5,06	3,18	6,80	3,76
40	3,52	1,55	4,65	2,49	5,70	2,72
20	2,92	0,81	3,65	1,08	3,75	1,04
10	2,68	0,52	3,09	0,55	2,83	0,56
5	2,59	0,41	2,79	0,31	-	-

Found experimental concentration dependences of ε' and ε'' at λ=4,28; 10,0 and 20,0 mm and temperature 293 K have been used for calculation of conditions at which in studied solutions probably the effect of non-reflective absorption of electromagnetic radiation occurs. According to [2], this effect could be realized in points of minima of dependence of the module of reflection factor ρ_{min} on thickness l of the substance layer while fulfilling the following conditions:

$$(1+y^2)\frac{\lambda_b}{\lambda_g} = th(\frac{2\pi y l_0}{\lambda_g}) - ytg(\frac{2\pi l_0}{\lambda_g})$$
$$ysh(\frac{4\pi y l_0}{\lambda_g}) + sin(\frac{4\pi l_0}{\lambda_g}) = 0 \qquad (1)$$

where

$$y = tg\frac{\Delta}{2},\ \Delta = arctg\frac{\varepsilon''}{\varepsilon' - p};$$
$$p = (\frac{\lambda}{\lambda_k})^2,\ \lambda_b = \frac{\lambda}{\sqrt{1-p}}; \qquad (2)$$

λ_b, λ_g – lengths of waves in empty and filled by researched substance directing system correspondingly; $\lambda_к$ – critical wavelength of directing system; l_0 – thickness of a layer of substance at which reflection of a wave is absent.

The value l_0, included in (1) is close to $(2n\text{-}1)\lambda_g/4$ and differs from it by the small size dependent on properties of substance and number n of a minimum of $\rho(l)$ dependence. In reduced coordinates $\varepsilon_1=(\varepsilon'\text{-}\rho)/(1\text{-}\rho)$; $\varepsilon_2=\varepsilon''/(1\text{-}\rho)$ the equations (1) are transformed to family of lines for set numbers of minima of dependences ρ on l at which condition ρ=0 (curve B, fig.1) is realized. It is typical that with increase in number n these lines come nearer to X axis. Last circumstance specifies an opportunity of non-reflective absorption of electromagnetic radiation by substance, even with very small value of dielectric losses that as follows from fig.1, is realized at significant thickness of substance layer.

Put on a coordinate plane [ε',ε''] experimental data of various concentration solutions determine a behavior of experimental dependence ε'' from ε' of studied solution of acetyl acetone in n-heptanes (curve A, fig.1).

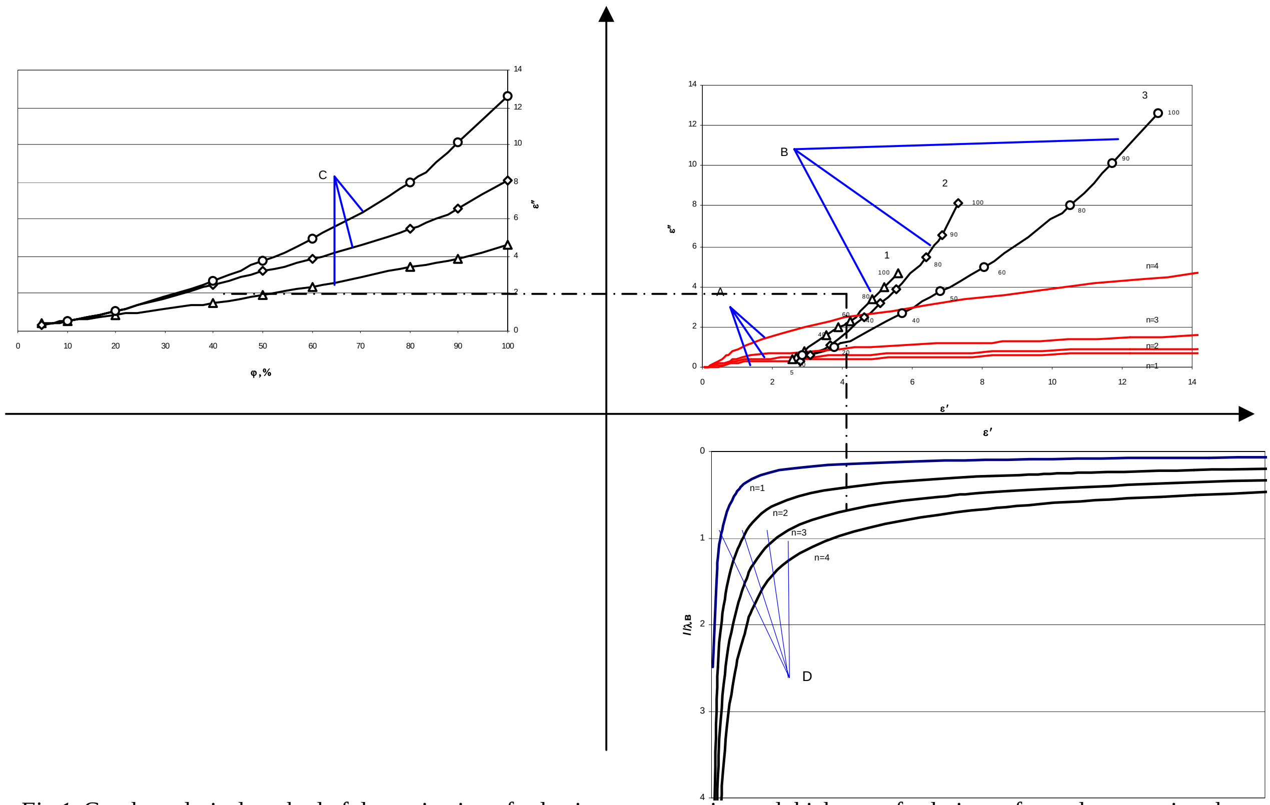


Fig.1. Graph-analytical method of determination of selective concentration and thickness of solutions of acetyl acetone in n-heptanes at which in them take place non-reflective absorption of electromagnetic radiation.

A – theoretically estimated dependences ε'' from ε' corresponding to conditions of non-reflective absorption of electromagnetic radiation in polar dielectrics.

B - experimental dependences of ε'' from ε' in solutions of acetyl acetone in n-heptanes at wavelengths λ=4,28 (1); 10,0 (2) and 20,0 (3) mm and at temperature T=293 K. Signatures to points designate values of weight concentration of a solution in percents (%). n - number of a minimum.

C – experimentally found dependence of ε'' of the solutions on concentration at λ=20,0 (1); 10,0 (2) and 4,28 (1) mm.

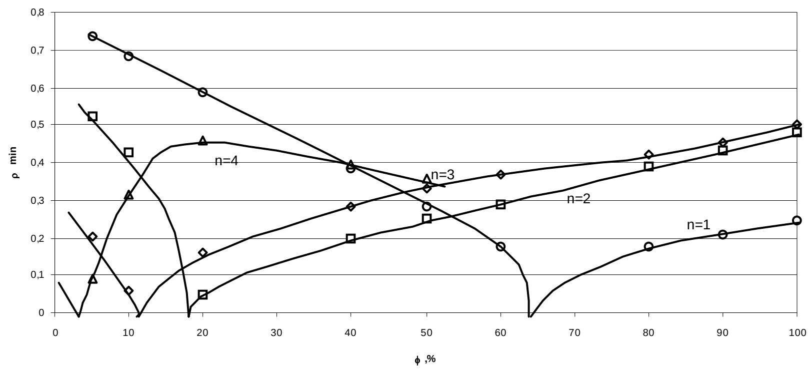
D – theoretically estimated dependences of ε' from $l_0/\lambda_в$ corresponding to conditions of non-reflective absorption of electromagnetic radiation in polar dielectrics.

As ε''≈0 for n-heptanes, with the growth of concentration of acetyl acetone in a solution the curve of the dependence of ε'' from ε' in solutions of acetyl acetone in n-heptanes begins from a point laying on an X axis, and comes to an end in the top part of a plane [ε',ε''] at point with the coordinates corresponding to the pure acetyl acetone. At the movement to this coordinate point the curve will cross family of lines of resonant non-reflective absorption of radiation of the solutions described by the equation (1). Taking into account the specified character of an arrangement of lines of resonant values ε' and ε'', it is necessary to expect existence of infinite lines of concentration of acetyl acetone in non-polar n-heptanes and a thickness of a reflecting layer of a solution at which an effect of full absorption of the reflected radiation occurs. Unfortunately, behavior of ε' and ε'' in binary solutions with change of their structure is difficult to express analytically. Therefore, for calculation of resonant concentrations φ_0 of acetyl acetone in solutions and corresponding resonant values ε'_0 and ε''_0 graph-analytical method has been applied for the solution of the equations (1) with use of experimentally obtained data from measurements of ε' and ε'' in solutions of acetyl acetone in n-heptanes at various concentrations. Results of these calculations for several first zero minima ρ_{min} are given in Table 2.

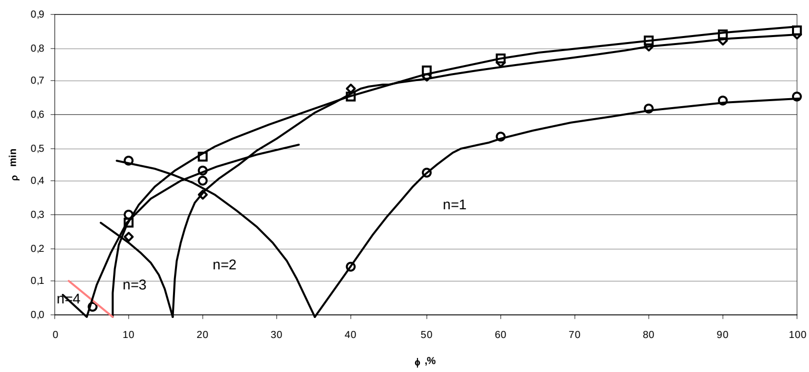
Table 2

Dielectric permittivity ε'_0, dielectric losses ε''_0, thickness of a layer l_0 and concentration of acetyl acetone φ_0 in its solutions with n-heptanes in points of zero minima of the module of reflection factor ρ_{min} at wavelengths λ=4,28; 10,0 and 20,0 mm and temperature T=293 K.

n	λ=4.28 mm					λ=10,0 mm					λ=20,0 mm				
	ε'_0	ε''_0	l_0/λ	φ_0	φ_m	ε'_0	ε''_0	l_0/λ	φ_0	φ_m	ε'_0	ε''_0	l_0/λ	φ_0	φ_m
1	4,31	2,47	0,552	63,6	63,4	4,75	2,60	1,23	42,0	42,0	5,97	2,95	2,24	42,7	42,5
2	2,86	0,76	1,939	18,6	18,3	3,42	0,83	4,13	17,1	18,6	3,44	0,83	8,22	16,6	16,8
3	2,66	0,50	3,321	9,3	10,4	3,04	0,50	7,24	9,0	7,9	2,76	0,76	15,16	14,7	13,5
4	2,54	0,33	4,704	2,4	3,2	2,83	0,33	10,48	5,4	4,6	-	-	-	-	-



a)



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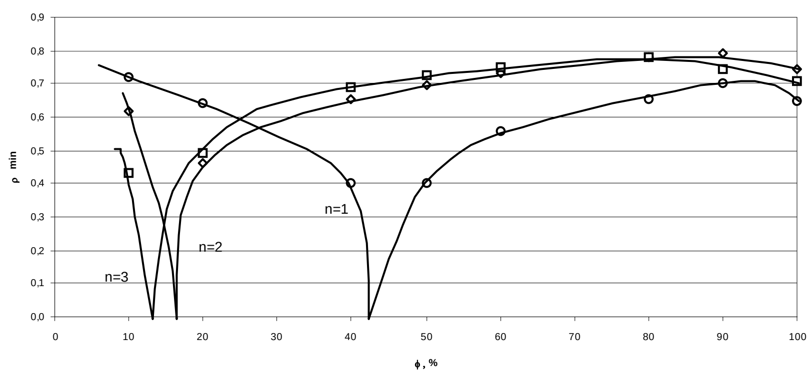

c)

Fig. 2. Dependence of the module of reflection factor ρ of an electromagnetic wave on concentration φ of acetyl acetone in solution with *n*-heptanes for first minima ρ_{min} of lines for different thickness of solution layer at wavelengths λ=4,28 (a); 10,0 (b) and 20,0 mm (c) and temperature T=293 K.

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M.İ. Vəliyev, R.M. Qasımov, Ç.O. Qacar

ASETİLASETONUN N-HEPTANDAKİ MƏHLULLARİNDA İFRAT YÜKSƏK TEZLİKLİ ŞÜALANMA ZAMANİ ƏKSOLUNMAYAN UDULMA EFFEKTİ

Asetilasetonun *n*-heptandakı məhlulullarının dielektrik xassələri mikrodalğa diapazonunda tədqiq olunmuşdur. Məhlulun müxtəlif qalınlıqlı laylarında və konsentrasiyalarında şüalanmanın əksolunmadan rezonansla udulmasının yarandığı müəyyənləşdirilmişdir.

М.И.Велиев, Р.М.Касимов, Ч.О.Каджар

ЭФФЕКТ БЕЗОТРАЖАТЕЛЬНОГО ПОГЛОЩЕНИЯ СВЕРХВЫСОКОЧАСТОТНОГО ИЗЛУЧЕНИЯ В РАСТВОРАХ АЦЕТИЛАЦЕТОНА В Н-ГЕПТАНЕ

Исследованы диэлектрические свойства растворов ацетилацетон-гептан в диапазоне микроволн. Установлено существование в этих растворах спектра концентраций и толщин слоя раствора, при которых возникает резонансное безотражательное поглощение электромагнитного излучения.

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