THE MEASUREMENTS OF DIELECTRIC PROPERTIES OF ACETONITRILE-BENSOLE SOLUTIONS IN THE MICROWAVE REGION

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The results of the measurement of the dielectric properties of solutions, technique and definition algorithm ε', ε'' are given in the article. The existence of the concentration spectrum in these solutions, at which the chosen nonreflecting absorption of the falling radiation appears, it is established.

Introduction

The investigations of dielectric properties of polar liquid solutions in the region of their wave dispersion allow to obtain the information about their molecular structure. Besides, as it is shown in the ref [1], these investigations give the possibility to study the revealing of nonreflecting absorption of electromagnetic radiation, which reveals in the dissolved solutions of polar molecules.

Technique of investigation

In this connection, the investigations of solution dielectric characteristics of acetonitrile-bensole in the microwave range, at λ=1,5 cm and temperature T=20°C have been carried out.

The measurements are carried out on the installation, working at the wave length λ=1,5sm. In the installation, the panoramic meter of stationary wave P2-66 and indicator device JA2P-67, are used. The acetonitrile-bensole solution is put in the specially constructed short-circuit measuring waveguide cell on the end the last is thermostated and includes the mechanism of smooth regulation of layer width.

The obtained experimental data about minimums of taken dependence η on l, and also η_∞ are used for the calculation of ε', ε'''. For their finding, the method, based on the information parameter measurement of taken dependence of stationary wave coefficient η on the substance layer width, taken in the experiment has been applied. These parameters are substance layer widths l_m and value η_m in the minimal points of $\eta(l)$ function, and also the values η_∞ at the liquid widths, at which the η value reaches its limit value η_∞. The necessity in the usage of η_∞ at the definition of ε', ε''' of strongly absorbing polar liquids and their solutions, which ?

The algorithm and realizing its calculation program, working in the dialogue mode of the investigator with the personal computer IBM have been treated. They base on the use of data in the refs [2,3,4] of equations, establishing the functional connection between measure η_m, l_m, η_∞ and decisions ε', ε''' parameters, which is equitable for every number N of function minimum $\eta(l)$. The following equations are used for abnormal region (6) of function $\eta(l)$,

$$\varepsilon_1 = n^2\left(1-y^2\right);\ \varepsilon_2 = 2n^2 y;\ \varepsilon_1 = \left(\varepsilon' - p\right)/\left(1-p\right);\ \varepsilon_2 = \varepsilon''/\left(1-p\right) \tag{1}$$

$$x = \frac{l_m}{\lambda_g} = \frac{l\cdot n}{\lambda_b};\ x = \frac{2N-1}{4} + \Delta;\ \lambda_b = \frac{\lambda}{\sqrt{1-p}} \tag{2}$$

$$\Delta = \frac{1}{2\pi} arctg\left[\frac{\sqrt{1+A^2}-1}{2A} th 2\pi x y\right];\ A = \frac{y}{n^2\left(1+y^2\right)^2 - \left(1-y^2\right)} \tag{3}$$

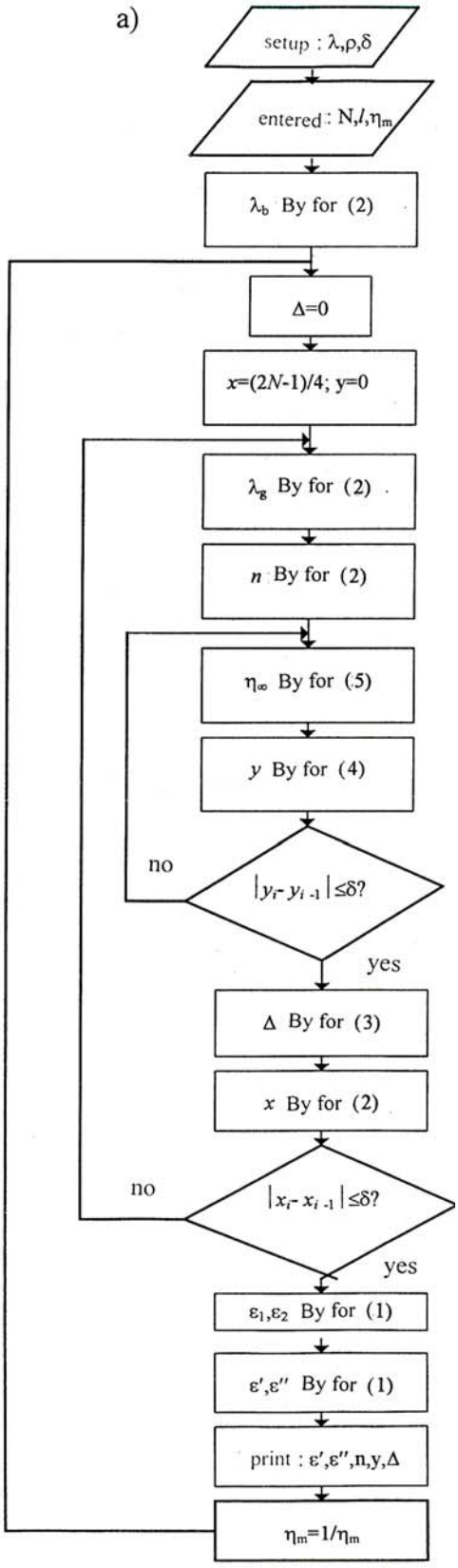
$$y = \frac{1}{4\pi x}\ln\frac{\eta_m\eta_\infty + 1}{\eta_m\eta_\infty - 1} \tag{4}$$

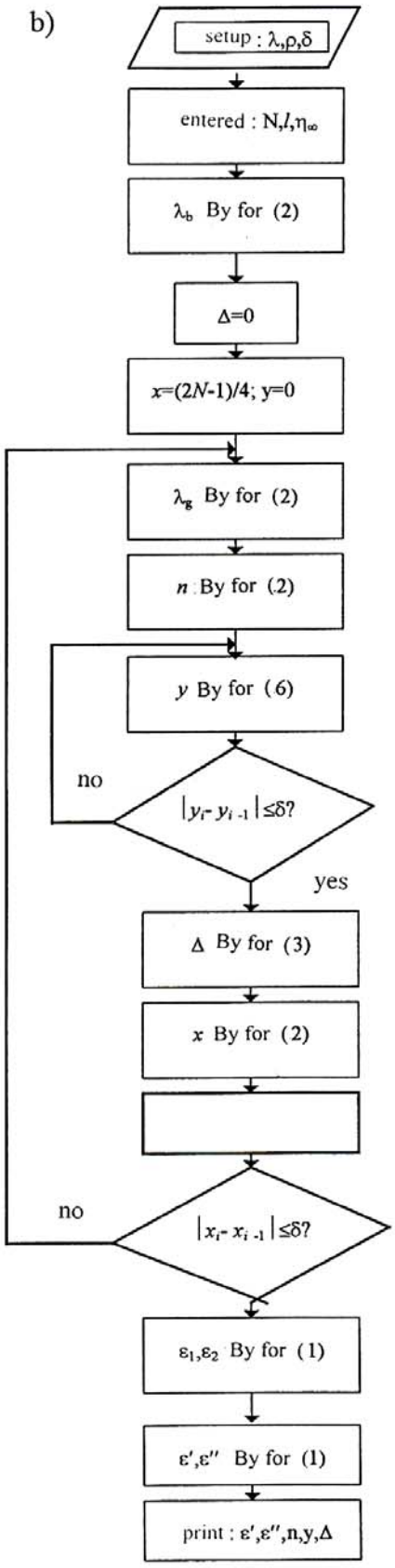
and the ratio for η_∞, obtaining from Frenel equation, but is expressed with the use of given denotes:

$$\eta_\infty = \frac{\sqrt{1+q}+\sqrt{1-q}}{\sqrt{1+q}-\sqrt{1-q}};\quad q = \frac{2n}{n^2\left(1+y^2\right)+1} \tag{5}$$

$$y = \frac{1}{n}\sqrt{n\cdot\frac{\eta_\infty^2+1}{\eta_\infty} - \left(n^2+1\right)} \tag{6}$$

$$n=\frac{1}{2\left(1+y^2\right)}\left[\frac{\eta_{\infty+1}^2}{\eta_\infty}+\sqrt{\left(\frac{\eta_{\infty+1}^2}{\eta_\infty}\right)^2-4\left(1+y^2\right)}\right] \tag{7}$$





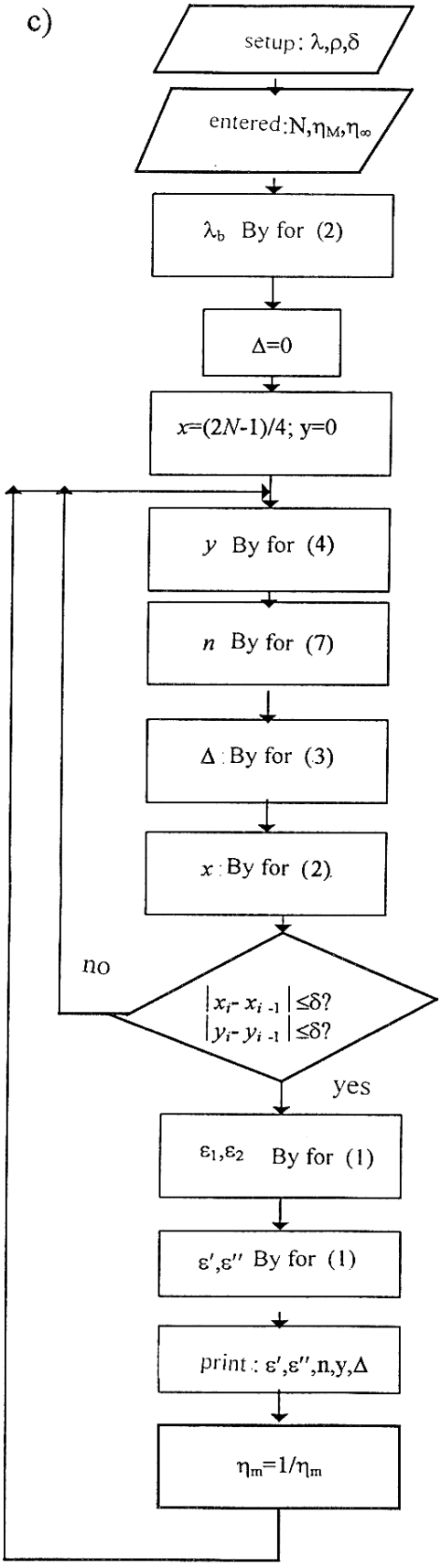


Fig.1. The block scheme of the calculation algorithms of the dielectric coefficients of polar liquids and their solutions: a) algorithm of the subprogram A, b) algorithm of the subprogram B, c) algorithm of the subprogram C.

For the improvement of exactness and reliableness of the carried out measurements and calculations on them, and also for the escape of the probable appearance of two-valued property in the calculation of ε', ε''', the program system includes three subprograms, the every of which is oriented on the calculation carrying out of ε', ε''' on the one from the couple of the measured parameters l_m, η_m (subprogram A); l_m, η_∞ (subprogram B); η_∞, η_m (subprogram C) (fig.1.). Every of these subprograms include the entering procedures of the values, including in the initial equations of the aprioristicly famous parameters λ, λ_b, $p=(\lambda/\lambda_k)^2$ in the operating computer memory, depending on the type of applied experimental installation and frequency, at which the measurements are carried out. The input of the given measurements η_m, η_∞, l_m carried out the input of the number N of the function $\eta(l)$ minimum, chosen at the measurements. The use of this or that subprogram is defined by the attenuation character of the experimental dependence η on l of the investigated objects. Thus, for the liquids with the value of the dielectric loss factor higher than 0,5 is better to use of subprogram C. At the measurements of the weak absorbing dissolved solutions of polar liquids, it is need to use the subprogram A. Independently on the subprogram choice, the search of the values ε', ε''' is ended at the carrying out of the conditions

$$|x_i - x_{i-1}| \le \delta; \quad |y_i - y_{i-1}| < \delta$$

where б is the reasonable error value in the calculations of the intermediate parameters x and y; x_i, x_{i-1}, y_i, y_{i-1} are the values of the intermediate parameters x and y on i-m and j-m repeating steps.

The discussion of results

The obtained data of the solutions ε', ε''' are given in the table 1 and on the fig.2. The solutions of polar acetonitrile in the nonpolar bensole, the dielectric properties of which are well enough studied in the high-frequency range, have been chosen in the capacity of the objects. Earlier, in the refs [5,6], by the investigations of dielectric properties and reflection characteristics of acetone-bensole and water-dioxan solutions in the centimeter wave range, the probability of the observation of the total absorption effect of the electromagnetic radiation has been proved. It is established, that at the given frequency of falling radiation and solution temperature, the total nonreflecting wave absorption appears at the strong defined layer widths and solution compositions. Taking into consideration, that dispersion regions of acetonitrile are in the centimeter and millimeter wave ranges, the investigations are carried out at the wave length λ=1,5sm and temperature 20°C. For the prediction of the layer width and solution composition, at which the appearance of the total absorption of the falling radiation in the chosen solutions is expected, the given measurements of their dielectric constants ε' and dielectric losses ε''', represented in the ref [7], are used.

Found by the calculation way, with the help of the above mentioned method, the resonance values of the layer width and solution compositions are compared with the similar data, obtained from the experimental investigations of the

dependences η on l at the different concentrations of bensole in the solutions.

The obtained in the experiment values of ε' and ε''' at the different bensole concentrations are used for the construction of the dependences of the values ε' and ε''' of the corresponding solutions in the same coordinate ox.

The experimental x and calculated x_p values of resonance molar concentrations of polar component of acetonitrile solutions in the bensole at the temperature 20°C and wave length 1,5 cm. The ε_0, $\tau \cdot 10^{12}$ s is the statistical dielectric constant and relaxation time of solution polar component; the critical wave length λ_k=2,3 cm.

Table 1

Solutions	Acetonitrile-bensole	
ε_0 , τ	36,8	3,3
Number of zero minimums N	X_P	X
1	19,4	19,4
2	7,4	6,6
3	4,8	4,6
4	3,6	3,4

The coordinates of the cross-section points of the experimental and theoretical dependences fig.2 are found by the graphical way by their combination with the values of the curve family of resonance values ε', ε''', obtained by the calculated way, and on the last values are found the corresponding resonance values of bensole concentrations in the solutions.

The calculated by such graphical method, the values of resonance concentrations of polar component in the chosen solutions are given in the table 1. For the comparison there are also the values, but obtained from the behavior analysis of the experimentally taken concentration dependences of wave reflection coefficient module in the minimum points of the curves ρ on l.

The given in the table calculated and experimental values of resonance concentrations of solution polar component are in well agreement between each other.

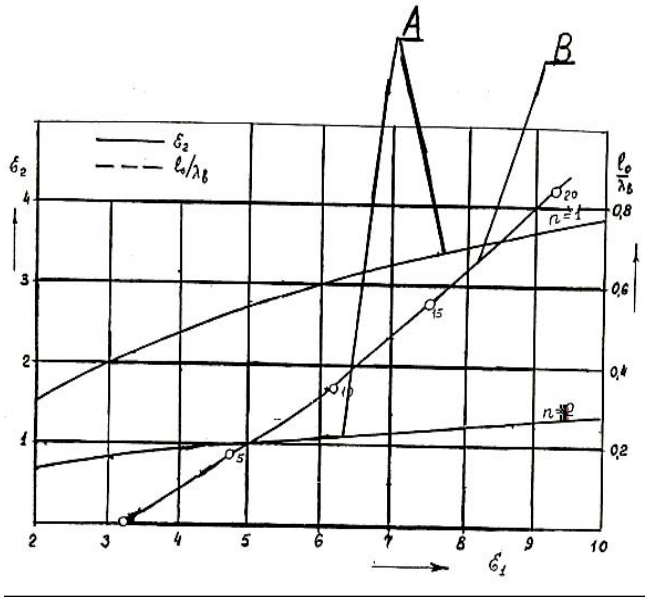


Fig.2. The experimental dependencies of ε' on ε''' of the acetonitrile solution in the bensole at the temperature T=20°C and the wave length λ=1,5 sm.

Conclusion

The investigated effect of the resonance nonreflecting absorption of electromagnetic waves in the solution has the general character and can be revealed in many solutions of polar dielectrics at the definite measurement frequency selection, temperature and composition of the investigated solution. The method and calculation algorithm of the dielectric properties and characteristics of polar substances and their solutions is also treated.

[1] *E.Salaev, E.Gasimov, S Azizov, Ch. Qajar.* Turkish journal of Phisiks, vol. 22, №5,1998, p. 389-393.
[2] *R.M. Kasimov, Ch.O. Kadjar*. Dokladi AN Azerb., 1999, №5-6.
[3] *P.I. Dvoretskiy, S.B. Popov, I.G. Yarmakhov.* Radiotekhn. i electron., 1996 т.41, №12, с. 1448-1461.
[4] *I.P. Kozlov.* Radiotekhn. i electron., 1997, т. 42, №2, с. 142-146.
[5] *R.M. Kasimov, Ch.O.Kadjar, M.A.Kalafi, E.R. Kasimov, E.Yu. Salaev.* JTF, t.66, №5,1996, c.167-171.
[6] *R.M. Kasimov, Ch.O. Kadjar, M.A. Sadikhov, E.R. Kasimov.* Izmeritelnaya tekhnika, №5,1999, c. 45-47.
[7] *Ya.Yu. Akhadov.* Dielectricheskiye svoystva binarnikh rastvorov. Moskva, Nauka,1977, 400 c.

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MİKRODALĞALI DİAPAZONDA ASETONİTRİL-BENZOL MƏHLULLARININ DİELEKTRİK XASSƏLƏRİNİN ÖLÇÜLMƏSİ

Məqalədə ε', ε''-in təyin olunması metodu və alqoritmi, məhlulların dielektrik xassələrinin ölçülərinin nəticələri göstərilib. Bu məhlullarda konsentrasiya spektrinin mövcud olması təyin olunub və bunun əsasında düşən şüanın seçilmə əksolunmayan udulması baş verir.

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ИЗМЕРЕНИЯ ДИЭЛЕКТРИЧЕСКИХ СВОЙСТВ РАСТВОРОВ АЦЕТОНИТРИЛ-БЕНЗОЛ В ДИАПОЗОНЕ МИКРОВОЛН

В статье приведены результаты измерения диэлектрических свойств растворов, методика и алгоритм определения ε', ε''. Установлено существовавние в этих растворах спектра концентраций, при которых возникает избирательное безотражательное поглощение падающего излучения.

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