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Research Article

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Effective permittivity of alcohol + water mixtures as influenced by concentration

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ABSTRACT

Dielectric properties of alcohol-water mixtures were measured at the selected microwave frequency by a sensitive sensor method using a network analyzer. The effects of concentration in terms of molar fractions on dielectric properties were investigated.

Keywords: methanol, ethanol, mixture, permittivity, concentration

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INTRODUCTION

The solvent mixtures of water and alcohol have special importance because of their unique physical and chemical[1] properties. With respect to the chemical properties, the formation of alcohol–water mixtures varies with the magnitude of the concentration of alcohol [2]. Such as density, viscosity, refractive index[3-5]permittivity and surface tension show positive deviations from ideality. The solvation of alcohol (methanol and ethanol) and other organics in several one component solvents has been a subject of detailed investigations, both theoretically and through simulations, for a considerably long time.

To our knowledge, dielectric study for this most [9]commonly used organic solvents (methanol, ethanol and etc.) has less been reported. The objectives of the present work were to study the dielectric properties of alcohol in mixtures water as a function of concentration. The information on dielectric properties of alcohol+water mixtures would be helpful to process industries to develop those based polar solvents by using microwave technology.

EXPERIMENTAL SECTION

Methanol, ethanol and de-ionize water were purchased from the Chengdu Kelong Chemical Factory. A vector network analyzer Agilent 3734A, with a sensitive sensor was employed to measure S-parameters of methanol+water and ethanol+ water mixtures. The two sets of mixtures are provided with different concentrations in terms of molar fractions (x_m ,x_e). x_m （x_e）is methanol（ethanol）molfraction of mixtures, where, x_m（x_e）=0.0, 0.2, 0.4, 0.6, 0.8,1.

The sensitive sensor is composed by two ways; one is the MUT (material of test) branch while the other is REF (reference) branch. The MUT and REF material is placed on the two branches respectively. During testing, the sensor is connected to the Agilent 3734A network analyzer through standard SMA connectors. A full two-port calibration procedure is conducted before measurements. Then, the REF and MUT will be placed on the two branches of the sensor. In this work, the REF is always de-ionize water and the MUT is methanol+water and ethanol + water mixtures with different concentrations in terms of molar fractions .The S-parameters are measured for these samples. Finally, complex permittivity of MUT is reconstructed by using a BP (back propagation) neural network procedure matching the measured S-parameters.

RESULTS AND DISCUSSION

The experiment effective permittivity data are listed in Tables 1 and 2. It has been observed that dielectric constant ε' declines with concentration of methanol (ethanol) of mixtures, and it is probably due to a increase in relaxation time of solvent molecules. From Tables 1 and 2, we also know the information about the dielectric loss of mixtures. That is, the bigger that the concentration of alcohol, the smaller that the dielectric loss of the two sets of mixtures. This means that two different alcohol molecules behave as the same molecule and the same chainlike cluster is formed in the mixture as that of pure alcohol. Therefore, dielectric relaxation of alcohol-water mixtures is of the Debye type. The mixture permittivity variation with convention of methanol and ethanol are shown in Fig.1 and 2.

Table 1 the real and imaginary parts of the effective permittivity (dielectric constant) for methanol +water mixtures (at5.65 GHz) with different concentration

x_m	ε'	ε''
0.05	62.897	25.099
0.2	52.098	30.988
0.4	29.946	25.876
0.6	18.231	19.031
0.8	13.868	14.901
1	11.226	11.023

Table 2 the real and imaginary parts of the effective permittivity (dielectric constant) for ethanol +water mixtures (at5.65 GHz) with different concentration

x_m	ε'	ε''
0.05	59.032	25.280
0.2	27.387	21.679
0.4	15.000	14.320
0.6	8.246	8.889
0.8	5.980	5.801
1	4.089	3.442

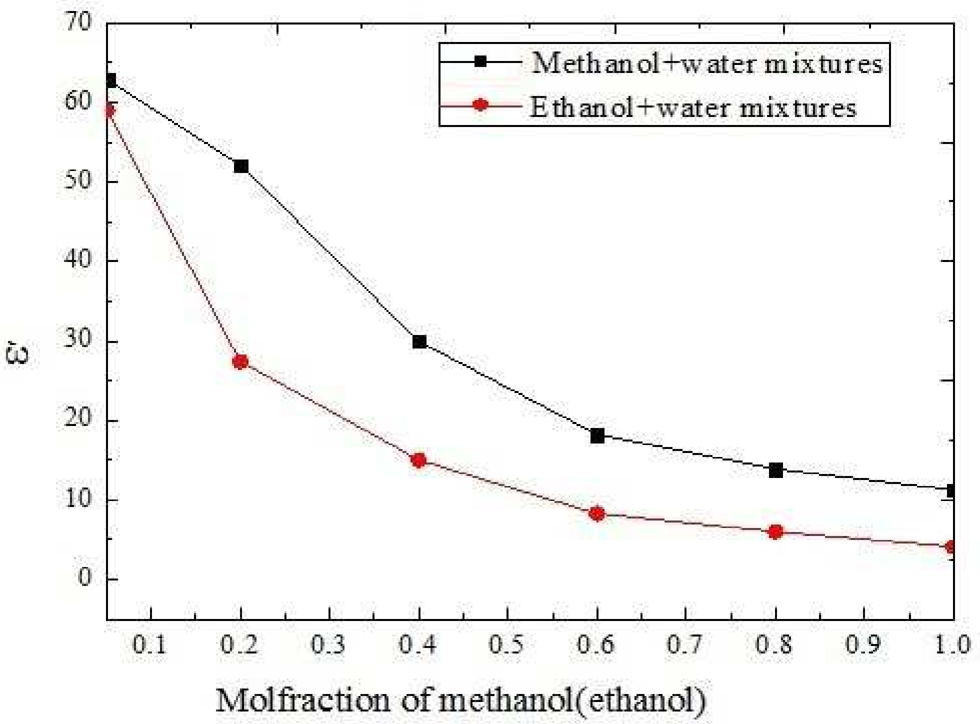

Fig. 1 the real parts of the effective permittivity of methanol (ethanol)-water mixtures at 5.65GHz

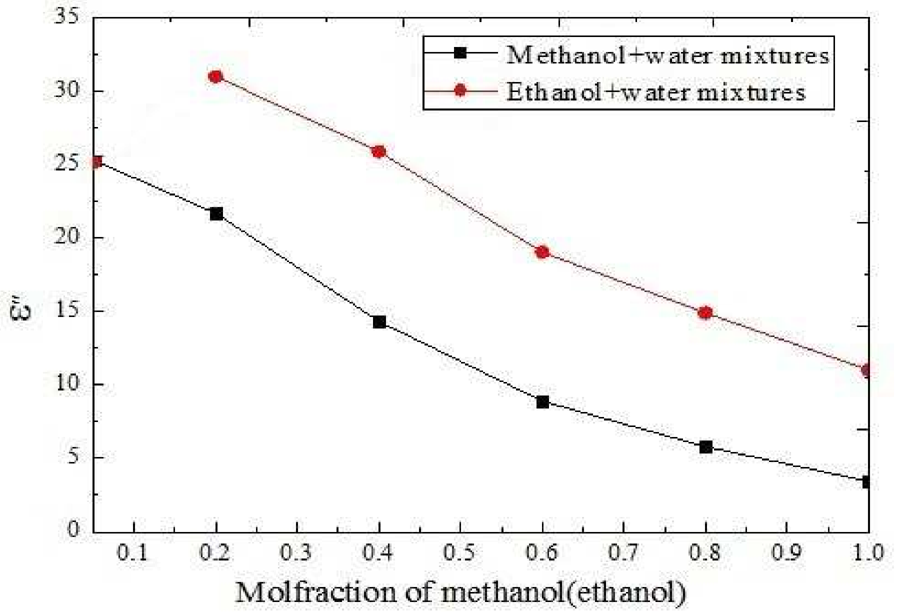

Fig. 2 the imaginary parts of the effective permittivity of methanol (ethanol)-water mixtures at 5.65GHz

CONCLUSION

Dielectric properties of alcohol-alcohol mixtures dispersions were studied as function of concentration in the microwave frequency (5.65GHz). Results indicated that dielectric parameters were influenced by concentration. Both dielectric constant and loss factor was decreased with concentration of methanol of mixtures. This study provides new information related to concentration dependence of alcohol-water mixtures dispersions dielectric properties that may be useful in product development applications. Alcohol+water mixtures also include methanol+water, ethanol+water and etc., however, the effect permittivity of these mixtures is still not elucidated and deserves further investigations.

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