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Dielectric Permittivity Analysis of Mixtures of Polar Liquids by Impedance Spectroscopy

L. O Salmazo(1)*, F. S. Bellucci(1), A.. E. Job, M. A. L. Nobre(1)

(1) DFQB/FCT, UNESP. Presidente Prudente – SP, Brasil, e-mail: lesalmazo@yahoo.com.br
*Corresponding author.

Abstract – *The objective this work is the characterization dielectric of polar organic binary liquid mixtures of ethanol and acetone. Measurements were carried out by impedance spectroscopy, in the range of frequencies of 5 Hz to 3 MHz. The excess permittivity parameter of each mixture was derived and discussed.*

Polar organic binary liquid mixtures have been used in the colloidal processing of nanopowders and nanofluids preparing. However, polar liquids can exhibits some interaction degree with other polar liquids. In this sense, some kind of organization can be expected. Such phenomena can affects properties of colloids and nanofluids, when two or several polar solvents are present in the mixture. Dielectric permittivity of several polar mixtures of ethanol and acetone were investigated by impedance spectroscopy. Measurements were carried out using a cylindrical sample holder of the type coaxial capacitor, in the frequency range from 5 Hz to 3 MHz [1]. The static and infinite permittivity of the acetone, ethanol and its mixtures were derived. The type of molecular interaction of both liquids [2] can be evaluated, in accordance with the equation (1):

$$\varepsilon^E = (\varepsilon_s - \varepsilon_{00})_m - [(\varepsilon_s - \varepsilon_{00})_A X_A + (\varepsilon_s - \varepsilon_{00})_B X_B] \quad (1)$$

where, X is the molar fraction, and m represents the solvent mixture of A and B. The parameter ε^E is called of excess permittivity, which provides further evidences of the cooperative phenomena in the mixture. When $\varepsilon^E = 0$, the interaction between the solvents do not exist, if $\varepsilon^E < 0$ solvent and its interaction act with the total reduction of the effective doublets suggesting that it can have a formation of conducting multimers, and if $\varepsilon^E > 0$ both solvents interact in way that the moment of effective doublet increases due formation of multimers and dimers. The understanding of these features is fundamental to enhancement of several parameters correlated to colloidal and polar nanofluids processing. Figure 1 shows the evolution of the static permittivity (ε_s) and infinite (ε_{00}) in function of molar fraction of ethanol, X_E. Figure 2 shows the evolution of ε^E in function of X_E. Values of ε^E are negatives or positives depending on the fractional mixture that indicate an interaction between liquids. For $X_E > 0$ ($X_E \approx 0.7$ and 0.8), the interaction leads to the development of some order degree in the liquid, which can enhance the stability of nanoparticles in the nanofluid.

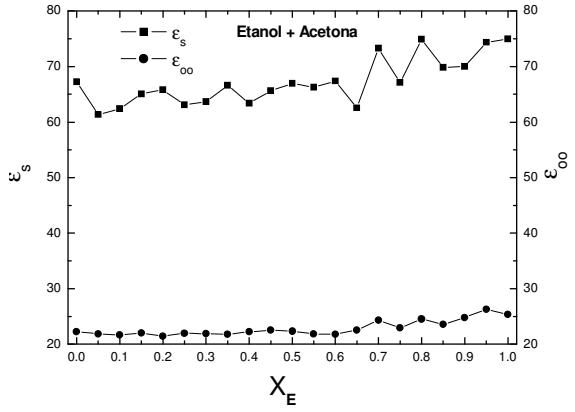

Figure 1. ε_s and ε_{00} in function of molar fraction of ethanol, X_E.

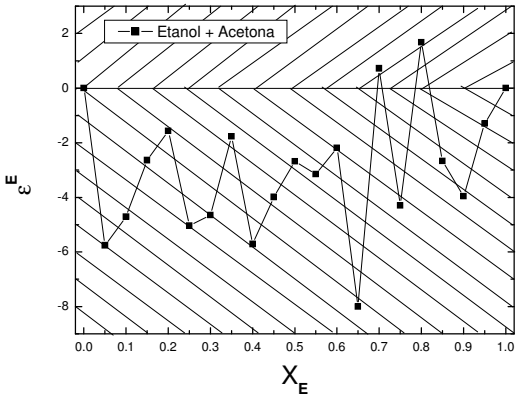

Figure 2. ε^E parameter in function of molar fraction of ethanol, X_E.

References
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[2] A. Chaudhari, H. C. Chaudhari, S. C. Mehrotra, Bull. Korean Chem. Soc. v. 25, n. 9 (2004) p. 1403.