Temperature, Frequency and Concentration Dependence of the Dielectric Permittivity of a Polar-Non-Polar and a Non-Polar - Non-Polar Phase Separating Binary Liquid Mixture

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Recently, some progress on the theoretical understanding of the critical behaviour of fluids and fluid mixtures has been made [1,2]. This motivated us to perform measurements of the dielectric permittivity ε, with a high resolution of both temperature (2 mK steps, stability better than 1 mK) and permittivity (better than 1 %), in the liquid-liquid critical region of binary mixtures. We selected the systems nitrobenzene – tetradecane (NB-TD) and perfluoromethylcyclohexane – methylcyclohexane (FMCH-MCH). The measurements covered different concentrations, including the critical concentration and extended several degrees above and below the critical temperature T_c. On approaching T_c from above, in the one-phase region, a critical anomaly is seen of the form $\tau^{1-\alpha}$, where $\tau = (T-T_c)/T_c$. and $\alpha = 0.109$. In NB-TD, this anomaly could only be detected after subtracting the contribution due to the critical Maxwell-Wagner relaxation. This relaxation stems from the formation of pretransitional fluctuations, which can be regarded as droplets. Under the influence of the electric field, charge builds up at the interface of the droplets, giving an extra contribution to the permittivity [3,4]. An additional result is the observation that the maximal strength of the relaxation is not at the critical concentration, but at a slightly higher concentration of the polar compound. Below T_c, our setup with two capacitors at different heights in the sample allows for a simultaneous measurement of ε for the two separated phases. From these results the coexistence curve, the critical concentration and the critical exponents can be accurately determined. In particular, for the diameter of the coexistence curve (the average over both phases), we find that the critical exponent 2β, with $\beta = 0.326$ is necessary to describe the critical behaviour, as predicted in [5].

[1] M. E. Fisher and G. Orkoulas, Phys. Rev. Lett. **85**, 696 (2000).
[2] C. A. Cerdeiriña, M. A. Anisimov, and J. V. Sengers, Chem. Phys. Lett. **424**, 414 (2006).
[3] J. Thoen, R. Kindt, and W. Van Dael, Phys. Lett. **76A**, 445 (1980).
[4] J. Thoen, R. Kindt, W. Van Dael, M. Merabet, and T. K. Bose, Physica A **156**, 92 (1989).
[5] P. Losada-Pérez, C.A. Cerdeiriña, J.V. Sengers, M.A. Anisimov, and J. Thoen, Contribution to this conference.