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Recognition of a new permittivity function for glycerol by the use of the eigen-coordinates method

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Abstract

Measurements of real and imaginary parts of the relative complex permittivity of glycerol were carried out in the frequency range 1 mHz–1 MHz at different temperatures between 188 and 263 K. The permittivity data have been analyzed thoroughly by a new data curve-fitting approach that involves the so-called eigen-coordinates method in conjunction with a separation procedure and the inverse permittivity formulas. A new single permittivity function, based on the so-called recap element picture for a self-similar (fractal) structure, has been recognized to describe well such data over the entire frequency range studied. The recognized dielectric function enabled us to infer an electrical equivalent-circuit network for the glycerol sample studied that involves a series combination of two recap elements, reflecting the existence of two different dielectric relaxation processes in glycerol. The temperature dependence of the relaxation times $\tau_1(T)$ and $\tau_2(T)$ entering into the identified permittivity function was found to obey nearly an Arrhenius behaviour with activation energies $E_1 \approx 114$ kJ/mol and $E_2 \approx 94$ kJ/mol. The recognized permittivity function can be justified by presuming that the processes represented by the recap elements characterized by the parameters (ν_1, τ_1, E_1) and (ν_2, τ_2, E_2) are linked to 'donor-like' and 'acceptor-like' charges formed from the infinite hydroxyl hydrogen bonds. © 2002 Elsevier Science B.V. All rights reserved.

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1. Introduction

In recent years, dielectric relaxation phenomena in glass-forming glycerol and similar hydrogen-bonded molecular materials received a lot of attention from both experimental and theoretical aspects [1–9]. Most of the experimental studies show that the dielectric ac response of such glass-forming materials is hardly being explained by the 'classical' Debye dielectric function that gives the complex permittivity $\varepsilon^*(\omega)$ as [10,11]. The loss-peak angular frequency ω_p is generally temperature dependent and can be described by the Vogel–Fulcher–Tammann (VFT) formula [6,7, 11, 12]. Non-Debye ac response can classically be correlated with some distribution of relaxation times quantifiable in terms of purely empirical

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