VEREFICATION OF THE METHOD FOR THE EVALUATION OF DIELECTRIC RELAXATION PARAMETER

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ABSTRACT

An easier and simple method has earlier been proposed for the evaluation of dielectric relaxation parameter from ITC spectrum. This method utilizes the maximum depolarization current and total charge released during ITC measurement. In this paper the method is verified using experimental data.

Keywords: Depolarization, Dielectrics, activation

INTRODUCTION:

The re-orientational behavior of impurity vacancy (IV), dipoles can be suitably studied using ionic thermocurrent (ITC) measurements proposed by Bucci, Fieschi, and Guidi [1]. There are various method proposed by different authors for analysis of ITC spectrum. Few of these methods are proposed by Bucci, Fieschi, and Guidi (BFG Method) [1] and Prakash at el [2] etc.. The author has proposed simple and convenient method for the evaluation of dielectric relaxation parameter from the ITC spectrum [3]. In the present paper, the proposed method is verified using experimental data of various authors. The evaluated parameters are found to be in good agreement with the reported values.

PROPOSED METHOD OF ANALYSIS:

A brief discussion of method proposed by author [3] is as follows

In the ITC measurement, the depolarization of current is given by

$$I(T) = \frac{Q}{\mathcal{C}_\tau} \exp\left[-\frac{1}{\mathcal{C}_{b\,\tau 0}} \int_{T_f}^{T} \exp\left(-\frac{\mathrm{E_a}}{\mathrm{kT}}\right) dT'\right] \qquad (1)$$

Where T_F is the temperature wherefrom the depolarization current starts to appear, τ_0 is the pre-expotantial factor, E_a is the activation energy, Q is total charge released in ITC measurement and **b** is linear heating rate.

The temperature T_M at which depolarization current is maximum is given by

$$T_M = \left[\frac{bE_a\,\tau\,\mathcal{C}_M}{k}\right]^{\frac{1}{2}} \qquad (2)$$

Where $\tau\mathcal{C}_M$ is relaxation of time at T_M.

The temperature dependence of relaxation time τ is expressed by Arrhenius relation

$$\tau\,\mathcal{C} = \tau\mathcal{C}_O Exp\left[\frac{E_a}{kT}\right] \qquad (3)$$

Eqn.(1) can be solved [3] and written as

$$I(T) = \left(\frac{Q}{\tau}\right) exp\left[-\frac{kT^2}{bE_a\mathcal{C}\tau}\right] \qquad (4)$$

With the help of eqn. (1) and (2), the maximum depolarization current is given by

$$I_M = \frac{Q}{\mathcal{C}_{\tau M}} exp[-1] \qquad (5)$$

The total charge released in ITC measurement is given by

$$Q = (1/b)\int_{(T_F)}^{\infty} I(T)dT$$

$$Q = \frac{Area\ enclosed\ in\ ITC\ Spectrum}{corresponding\ linear\ heating\ rate} \qquad (6)$$

After calculating the total area of ITC spectrum , Q is calculated by using eqn.(6) which turn give the value of $\tau\mathcal{C}_M$ using eqn.(3) at T_M i.e., by equation

$$\tau\mathcal{C}_M = \mathcal{C}_{\tau 0} Exp\left[\frac{E_a}{kT_M}\right] \qquad (7)$$

This $\tau\mathcal{C}_M$ is used to evaluate E_a using eqn. (2). Once E_a is known, $\tau\mathcal{C}_0$ is calculated by equation (7).

RESULT AND DISCUSSION:

The suggested method of analysis has been applied to a number of cases and the evaluated parameters are present in Table 1.

Table: 1: Values of the dielectric relaxation parameter in different systems.

System	Reported		Calculated		Reference
	E_a (eV)	τ_0 (s)	E_a (eV)	τ_0 (s)	
$NaCl:Cd^{2+}$	0.67	2.8×10^{-14}	0.67	2.8×10^{-14}	4
$NaCl:Ca^{2+}$	0.695	8.3×10^{-15}	070	5.4×10^{-15}	5
$KCl:S^{2-}$	0.77	1.3×10^{-14}	0.76	1.6×10^{-14}	6
$KCl:Mg^{2+}$	0.49	3.9×10^{-12}	0.49	5.4×10^{-12}	7
$KBr:S^{2-}$	0.70	5.4×10^{-14}	0.68	1.6×10^{-13}	8
$KBr:Sr^{2+}$	0.66	4.0×10^{-14}	0.68	1.3×10^{-14}	9
$KI:S^{2-}$	0.61	10×10^{-14}	0.61	9.9×10^{-14}	10

KI:Ca^{2+}	0.49	1.0 x 10^{-11}	0.49	7.1 x 10^{-12}	11
AgCl:Mn^{2+}	0.31	6.2 x 10^{-13}	0.32	3.5 x 10^{-13}	12
AgCl:Pb^{2+}	0.333	10.5x10^{-14}	0.34	5.6 x 10^{-14}	12

It is obvious from the table that a very good agreement exists between the evaluated parameters and those obtaining following BFG method. The extent of agreement shown in Table 1 between the evaluated and reported values gives a testimony to the suitability of the suggested method of analysis.

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