

ION TRANSPORT PARAMETERS IN POLYMER ELECTROLYTES BY MEANS OF DIELECTRIC RELAXATIONS FOR PHOTOELECTROCHEMICAL SOLAR CELLS

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During last few decades, electrolytes have gone through a remarkable development due to comprehensive research stimulated by their potential in numerous energy conversion and storage devices. Secondary batteries, photo-electrochemical solar cells, fuel cells and super capacitors are examples¹. Intensive research in this field has led to development of new solid and gel polymer electrolytes with improved stability, durability, efficiencies and wide operating temperature range for device application. Characterization of such electrolytes is extremely important with a need for solid or gel polymer electrolytes since their transport mechanism is different from liquid types³. Bandara *et. al.* (Solid State Ionics 189 (2011) 6368) has introduced a method to calculate the diffusion coefficient, the mobility and the density of charge carriers in an electrolyte, by means of complex dielectric and electrical data. This method is employed using dielectric loss tangent data of gel polymer electrolytes.

Deferent electrolyte compositions were studied by varying the amount of tetrahexylammonium iodide with respect to Polyacrylonite (PAN) weight in the electrolyte. Mass fraction $x\%$ in the text and figures corresponds to the weight ratio

PAN:tetrahexylammonium iodide = 100: x . The temperature dependent conductivity in the electrolyte is shown in the Figure 1. The conductivity variation of this electrolyte shows more or less Arrhenius behavior.

Reliable values were obtained for the mobility and the density of charge carriers. The behavior of dielectric relaxation of the electrolytes was deeply analyzed using real and imaginary parts of the dielectric constant. The formulas for calculating diffusion coefficient (D);

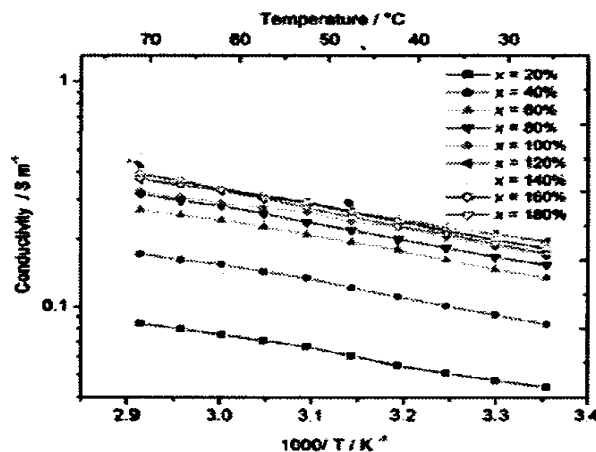


Figure 1: Conductivity variation as a function of 1000/temperature

$$D = \frac{\left(\frac{1}{2}\right)^2}{\tau \epsilon^2} \quad \text{I} (\quad \text{M e h s i t h s e n k d i h s i p e n d .}$$

$$t = \frac{\tau}{2\pi} \quad (2)$$

$$\delta = \frac{d}{\lambda} \quad (3)$$

Where, t is characteristic time constant, T is absolute temperature, d equals to $l/2$, and λ is mean thickness of the electrical double layer.

$$\mu = \frac{e \left(\frac{l}{2}\right)^2}{k T t \delta^2} \quad (4)$$

Where, μ is mobility, e is charge of an electron, k is Boltzmann constant.

$$\sigma = \frac{4 l}{R \pi d^2} \quad (5)$$

Where, σ is conductivity, R is resistance, and d is diameter of the sample.

$$n = \frac{\sigma k T t \delta^2}{e^2 \left(\frac{l}{2}\right)^2} \quad (6) \quad \text{Where, } n \text{ is charge density.}$$

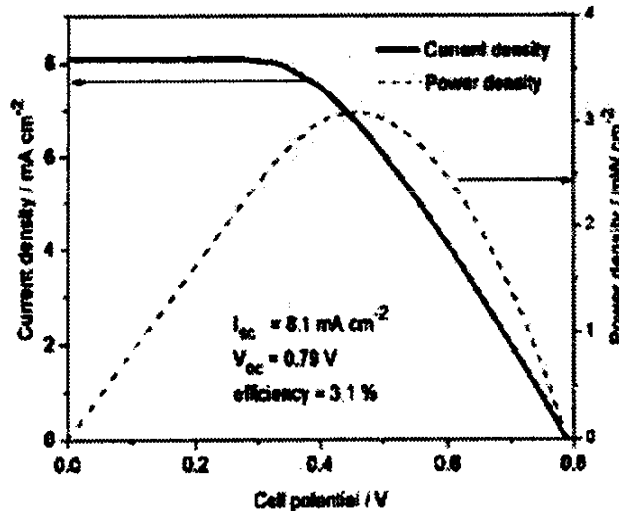


Figure 2: The current voltage curve and output power density of the cell.

The highest conducting electrolyte (weight ratio PAN: Salt/10:12) was selected to fabricate quasi-solid state dye-sensitized solar cells using N 719 dye. The cell showed an energy conversion efficiency of 3.1% and a short circuit current density of 8.1 mA cm^{-2} under irradiation of one sun. The current voltage curve, and output power density of the cell is shown in the Figure 2.

REFERENCES

1. A.S. Arico, P. Bruce, B. Scrosati, J.M. Tarascon, W. Van Schalkwijk, *Nature Materials* 4 (5) (2005) 366-377
2. A.M. Christile, S.J. Lilley, E. Staunton, Y.G. Andreev, P.G. Bruce, *Nature*, 433 (2005) 50-53
3. T.M.W.J. Bandara, M.A.K.L. Dissanayake, P.S.L. Fernando, W.J.M.J.S.R. Jayasundara, and B.E. Mellander, *Estimation of ion transport parameters by modeling space charge relaxation in PEO based solid polymer electrolyte intended for photoelectrochemical solar cells*, (2011)