Tetrapentylammonium Iodide Based Novel Gel Polymer Electrolytes for Dye Sensitized Solar Cells

T.M.W.J. Bandara [1,2], W.J.M.J.S.R. Jayasundara[2,4], M.A.K.L. Dissanayake[3], P.S.L. Fernando[1], H.D.N.S.Fernado[1] and B.-E. Mellander[2]

Department of Physical Sciences, Rajarata University of Sri Lanka, Sri Lanka.[1]
Department of Applied Physics, Chalmers University of Technology, Gothenburg, Sweden.[2]
Institute of fundamental studies, Hantana Road, Kandy, Sri Lanka.[3]
Postgraduate Institute of Science, University of Peradeniya, Sri Lanka.[4]

Dye sensitized solar cells (DSSCs) have been under extensive research. The simplicity, relatively high efficiency and the low cost of the device have drawn much attention of the research community. Conventional DSSCs use liquid type electrolytes but with many disadvantages. Gel or quasi solid electrolytes are interesting alternatives to substitute liquid electrolytes in DSSCs. Recent improvements achieved by the modification of the composition of the electrolyte by the introduction of mixed salts[1]. As far as we know, there are no reports that can be found with electrolytes containing tetrapentylammonium iodide in DSSCs. This electrolyte was studied further by mixing MgI_2 to the electrolyte.

Polyacrylonitrile (PAN) based gel polymer electrolytes were made using the salt tetrapentylammonium Iodide ($Pent_4N^+I^-$) and the binary mixture of salts $Pent_4N^+I^-$ and MgI_2. Ethylene Carbonate (EC) and Propylene Carbonate (PC) were used as plasticizers. The samples were prepared using hot press method. Current voltage measurements were done with the DSSCs fabricated with these electrolytes. Differential scanning colorimetric (DSC) and conductivity measurements were carried out to characterize the electrolyte.

The conductivity of the electrolyte containing only the salt $Pent_4N^+I^-$ is 2.610^3 S cm^{-1} at 30°C and glass transition temperature (T_g) value is -101.82°C. Addition of MgI_2 leads to decrease the conductivity of the electrolyte but an enhancement of the solar cell efficiency was observed. The conductivity of the electrolyte containing the binary mixture of salts ($Pent_4N^+I^- + MgI_2$) is 2.210^3 S cm^{-1} at 30°C. Decrease in conductivity can be due to the cross linking of polymer chains by small Mg^{+2} ions.

The DSSC fabricated with the electrolyte containing the binary mixture of salts showed an energy conversion efficiency of 3.7 %, short circuit current density of 9.1 mA cm^{-2}, open curcuit voltage (V_{oc}) of 0.766V and fill factor of 52.99 % while $Pent_4N^+I^-$ alone gave an energy conversion efficiency of 3.6%, short circuit current density of 9.2 mA cm^{-2}, open curcuit voltage of 0.780 V and fill factor of 50.25 % under the irradiation of 1000 W m^{-2} light.

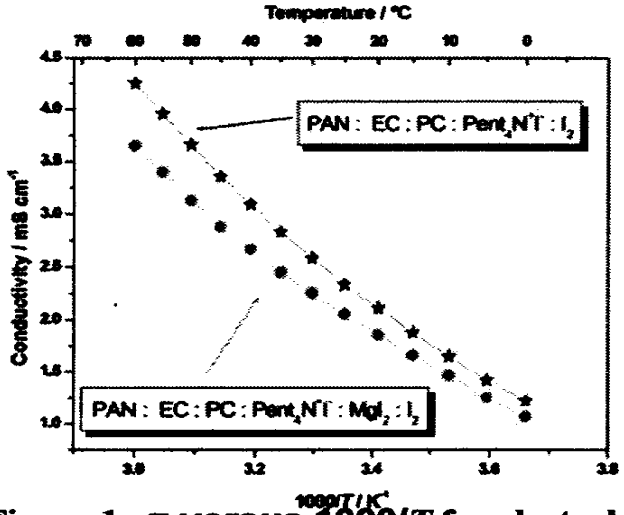

Figure 1: σ versus 1000/*T* for electrolytes

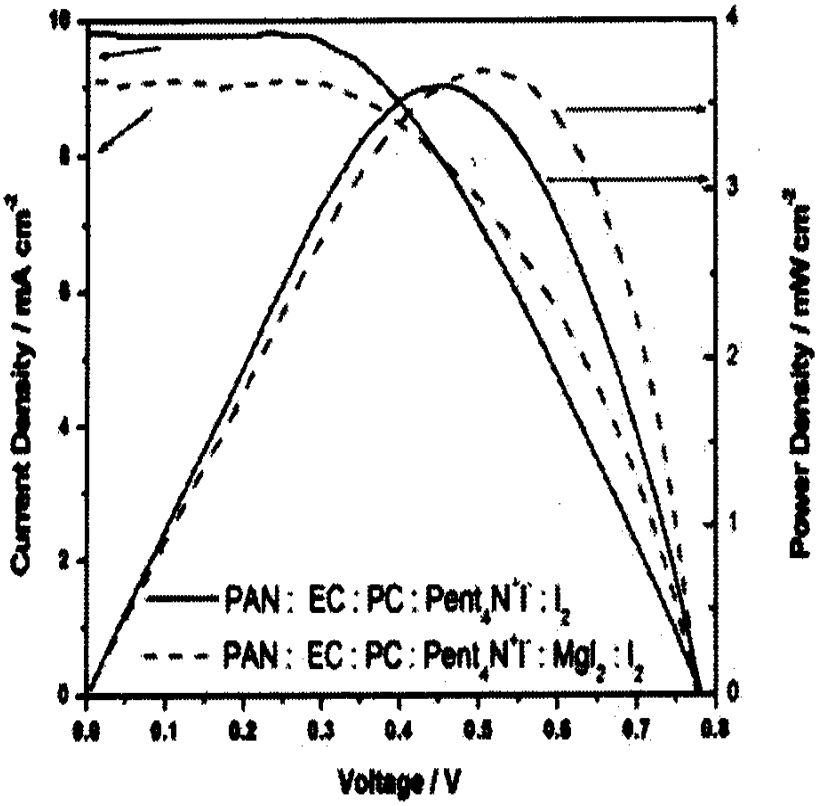

Figure 2: *I-V* characteristic curves of DSSCs fabricated

The electrolyte with the highest conductivity did not give the highest efficiency showing that the effect of the cation to the efficiency of the DSSCs is equally important. $Pent_4N^+I^-$ is a salt which has a bulky cation. When the size of the cation increases it enhances the salt dissociation and anion transference number leading to high iodide ion conductivity and the V_{oc} increases with the increase of cation size[ii]. When the size of the cation decreases it enhances electron injection,

charge separation,dye regeneration process. By mixing MgI_2 to the electrolyte we can observe the combine effect f cations with different sizes on the performance of the DSSCs. Small-radius cations can deeply penetrate into the mesoporous nanocrystalline TiO_2 film which leads to decrease the V_{oc}[iii]. Hence the DSSC having the electrolyte containing only the salt $Pent_4N^+I^-$ have shown the highest open circuit voltage compared to the other. The high current density of that electrolyte may be due to the high conductivity of the electrolyte.

REFERENCES

1. C.A. Kelly, F. Farzad, D. W. Thompson, J. M. Stipkala and G.J. Meyer,, *Langmuir*, 15 (1999) 7047.