**Formation procedures and characteristics of CuI layer in the solid-state dye-sensitized photovoltaic cells**

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The liquid electrolyte in the dye-sensitized solar cell (DSSC), leads to several technological problems such as: dye desorption, solvent evaporation and degradation, and seal imperfection, etc. Tennakone et al have developed a dye-sensitized solid-state cells (DSSSCs) using p-CuI as the hole-conductor.[1] Recently, it is found that incorporation of a small quantity of the molten salt 1-ethyl-3-methylimidazolium thiocyanate (EMISCN) to the CuI solution helps filling of the pores greatly improving the performance of the cell. This imidazolium salt acts as a CuI crystal growth inhibitor and being a molten salt the residue formed during evaporation of the solvent spreads over the crystallite grain boundaries.[2] In order to understand how such a salt additive affect the total performance of DSSSCs, it is necessary to consider many factors i.e. conductivity, morphology, and nature of the contact with porous $TiO_2$ surface, etc. In this paper, relation between the cell performance and the properties of CuI layer are also discussed.

At first, the conductivity and morphology of CuI layer deposited from CuI/acetonitrile solution with various amount of EMISCN were investigated. Figure 1 shows the conductivity dependence of CuI film on the content of EMISCN. With increasing amount of EMISCN, the conductivity of the CuI film was increased. Figure 2 shows morphology changes of CuI film with EMISCN. When the amount of EMISCN was 0.40 mol% to CuI (a), particle size of CuI was as large as that of CuI without EMISCN. In the cases of EMISCN amount of 1.98 mol% (b) and 3.96 mol% (c), the particle size of CuI reduced remarkably. With larger amount of EMISCN (d), CuI film became sticky and particles with different shapes were observed. When the content of EMISCN was 4.44 mol% in CuI layer, $TiO_2$/N3 dye/CuI cell afforded the best performance as shown in figure 3. From the results above, total cell efficiency should be related more closely to the particle size of CuI, i.e. the contact of the nano porous TiO2 film and the CuI film than to the conductivity of CuI film.

In conclusion, the conductivity of CuI film was greatly increased by the addition of the thiocyanate salts and the photoenergy conversion efficiency of DSSSCs made with this CuI film as a hole transporting material was greatly improved.

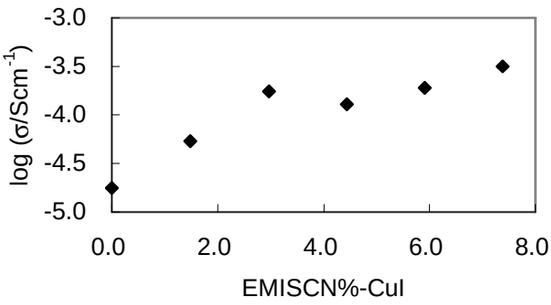


Figure 1. Conductivity of the CuI film with various amount of EMISCN.

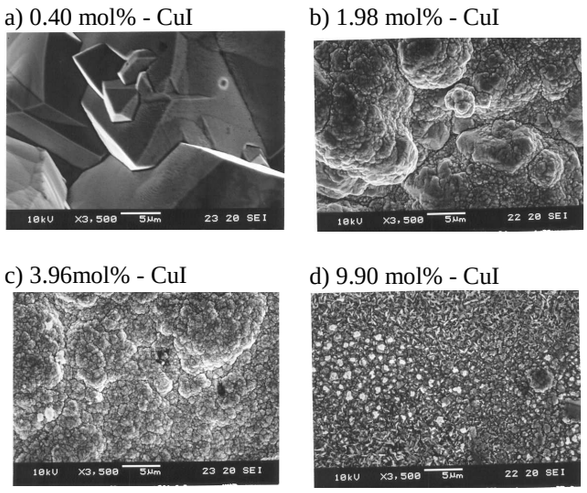


Figure 2. SEM photographs of CuI film with various amount of EMISCN deposited on nano-porous $TiO_2$ electrode.

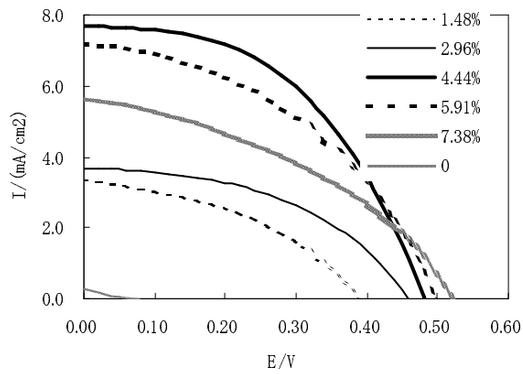


Figure 3 I-V characteristics of $TiO_2$/N3 dye/CuI cells with various content of EMISCN in the CuI layer.

**References**

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2. G. R. A. Kumara, A. Konno, K. Shiratsuchi, J. Tsukahara, K. Tennakone, *Chem. Mater*., **2002**, *14*, 954.