Quasi-solid dye sensitized solar cells

-Design of cross-linked gelators -

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1) Introduction

Solidification of liquid electrolytes contained in dye sensitized solar cells(DSC)[1] is one of the problems to be overcome before the DSC is put into practical uses. Solid electrolytes should be the best choice. Recent progresses on the solidification studies are remarkable. However, in spite of the extensive researches, the performance of solid-DSCs is not satisfactory. We have investigated gel electrolytes to fabricate Quasi-solid DSCs(Q-DSCs) exhibiting the performance corresponding to that of liquid type DSCs. Some physical gels for Q-DSCs have been reported so far[2,3]. Cross-linked gels have an advantage over these physical gels on the high heat resistant properties. The chemically-cross linked gels have not been reported except for one example which is featured by the unique fabrication process[4]. Extensive works on gel electrolytes have been made in the field of lithium ion batteries. Injection of gel electrolyte precursors containing liquid electrolytes and acrylic monomers(Gelators) into cells followed by cross-linking reaction is the most convenient method to solidify liquid electrolytes. These compositions and acrylic gelators previously reported by Matsumoto[4] are not able to be used for this simplest process because iodine in the electrolyte inhibits the cross-linking reactions. There is no report on the chemically cross-linked gelators applicable to the process.

Our purpose is to present cross-linked gel electrolytes which are fabricated directly in the DSC cells.

2) Gel electrolyte precursors and the fabrication process of gel electrolytes

Gel electrolyte precursors contain liquid electrolytes and gelators. The precursors, which are liquid states at room temperature, are injected into DSC cells in the same way as the conventional liquid electrolytes are treated with. Then, the cell is heated and gelation occurs directly in the cell. In order to decrease solvent volatility, we employed molten salts mixtures for the liquid electrolyte component.

3) Design of gelators and results

The following three factors(a,b and c) are discussed.

a) Gel electrolyte precursors should be a liquid state with low viscosity. This enables to impregnate nano-porous TiO_2 layers with the precursor and give good contracts between TiO_2 and the gel electrolyte.

b) After the impregnation, cross-linking starts and the gelation completes moderately even in the presence of iodine.

We tried various gelators conventionally employed to make gels. Epoxides, acrylates, maleimides, and silyl compounds to give polymers by hydrosilylation reactions or condensation reactions did not give gel electrolytes in the presence of iodine.

In order to fulfill the conflicting requirements, we propose the use of gelators giving ionomer structures. These reaction schemes and the representative compounds successfully giving gel electrolytes are shown in Figure 1. The cross-linking started and completes without generating any by-products decreasing the PV performance.

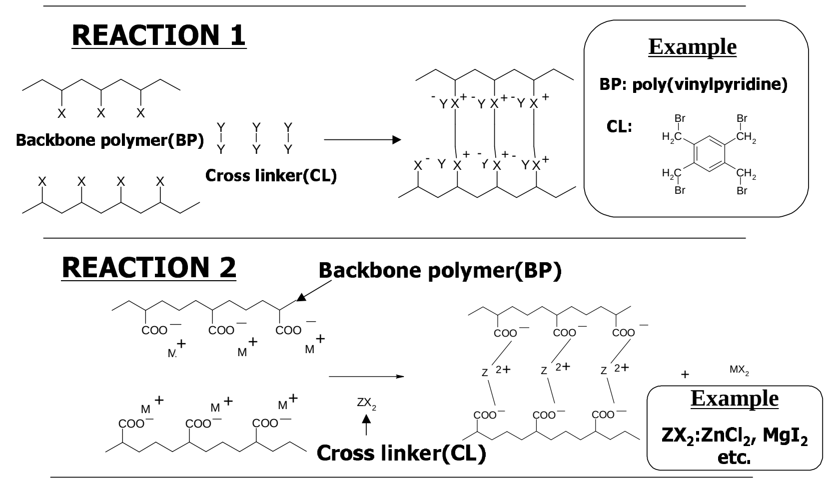

Figure 1 Gelators to make cross-linked ionomers

c) The amount of the gelator should be minimized to less than 5 weight %.

This was solved by use of a micro-phase separation technique during gelation.

Conductivities, I_3^- diffusion constants and interfacial resistances against electrodes did not decrease even after gelation. The gel electrolyte maintained their shapes at high temperature.

4) Concusions

We conclude that it is possible to solidity liquid electrolytes by cross-linking directly in DSC cells without decreasing the performance.

1)Hagfeldt, A. and Graetzel,M., *Chem.Rev.*, **1995**, *95*, 49; 2)Cao,F., at al., *J.Phys.Chem.*, **1995**, *99*, 17071; 3)Yanagida,S. et al., *Chem.Lett.*,**1998,** 1241; 4)Matsumoto,M., et al., *Solid State Ionics.*, **1996**, *89*, 263