Printable polymer-based quasi-solid state electrolytes including cobalt redox shuttles for dye-sensitized solar cell application

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There has been much attention towards dye-sensitized solar cells (DSSCs) for the past decades due to their attractive features such as high energy conversion efficiency of about 12 % and low energy production costs [1,2]. Although a respectable photon-to-electricity conversion efficiency has been achieved for photovoltaic cell employing organic liquid electrolyte, the leakage of liquid solvent from such cells has been suggested as the one of the critical factors limiting the long-term stability of the DSSC. Therefore, traditional volatile liquid electrolytes have been tried to be replaced with ionic liquid based gel or polymer gel electrolytes (PGEs) [3-6]. For practical use of highly viscous gel electrolytes, however, their performances such as the ion conductivities and physicochemical properties should be more improved and optimized. Moreover, the electrolyte filling process is significantly important to commercialize DSSC. Unfortunately, however, the effective filling process for highly viscous gel electrolytes has not been established yet. One of the most promising electrolyte filling processes may be a vacuum filling or printing process. For the application of these electrolyte filling processes in DSSC fabrication, the physical properties of electrolytes such as the viscosity should be optimized. Moreover, the selection of redox couples which are one of the essential components of electrolyte is very important in terms of both the energy conversion efficiency and the long-term stability of the DSSCs. Recently, cobalt complexes (*e.g.* $[Co(bpy)_3]^{2+/3+}$, bpy=2,2'-bipyridine) have been suggested as the most promising candidate for replacing conventional iodide/iodine (I^-/I_3^-) redox shuttles owing to their high voltage characteristics (open-circuit voltage) [7].

In this work, we have developed printable polymer-gel electrolytes including cobalt redox couples. The PGEs have been made from ternary medium components including low-volatile liquid solvent, polymer additive, and nano-filler. The addition of polymer additive can promote the gelation of the electrolyte and simultaneously reduce the dark current. Moreover, the viscosity of the electrolyte is easily controllable by changing the content or the molecular weight of polymer. The addition of nano-fillers can also induce greatly enhanced redox transport, resulting in the increase in the short-circuit current. Moreover, the optimal electrolyte composition and the electrode structures have been investigated in terms of both the energy conversion efficiency and the durability. The photovoltaic characteristics of DSSCs employing the electrolytes were investigated by *J-V* curve and *a.c.* impedance measurements and their long-term stabilities were also evaluated.

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