

15.2.4 Redox Electrolyte

As described in Section 15.1.2.4, organic solutions containing iodine redox ions have been used as the redox electrolyte. Typical organic solvents are nitrile solvents having relative low viscosity, such as acetonitrile, propionitrile, methoxyacetonitrile, and methoxypropionitrile, which produce a high degree of ion conductivity. It has been reported that imidazolium derivatives, such as 1,2-dimethyl-3-hexylimidazolium iodide (DMHImI) and 1,2-dimethyl-3-propylimidazolium iodide (DMPImI), decrease the resistance of the electrolyte solution and improve photovoltaic performance [83, 84]. A typical electrolyte composition that produces high solar cell performance for the Ru complex photosensitizers reported by Grätzel's group is a mixture of 0.5 M DMHImI, 0.04 M LiI, 0.02 M I₂, and 0.5 M *tert*-butylpyridine (TBP) in acetonitrile [76]. As discussed earlier, TBP shifts the conduction-band level of the TiO₂ electrode to the negative direction and suppresses the dark current that corresponds to the reduction of I₃⁻ ions by injected electrons, leading to the improvement of the voltage [6, 52].

15.2.5 Counter Electrode

Sputtered Pt on a TCO substrate (5–10 μg cm⁻², or 200-nm thickness) has been usually employed as a counter electrode. When Pt is sputtered producing a mirrorlike effect, the photocurrent is slightly increased due to the light-reflection effect. In addition, the electrocatalytic activity of the Pt-sputtered TCO electrode for the reduction of tri-iodide ions is improved by the formation of Pt colloids on the surface [85]. Small amounts of an alcoholic solution of H₂PtCl₆ are dropped on the surface of the Pt-sputtered TCO substrate, followed by drying and heating at 385°C for 10 min, resulting in the formation of Pt colloids on the surface. The properties of the Pt counter electrode directly affect the fill factor of the solar cell. A desirable exchange current density corresponding to the electrocatalytic activity for the reduction of tri-iodide ions is 0.01 to 0.2 A cm⁻² [16, 85].

15.2.6 Assembling the Cell and Cell Performance

We can easily fabricate an unsealed DSSC and measure its PV performance. A spacer film, such as polyethylene (15- to 30-μm thickness), is placed on the dye-coated TiO₂ photoelectrode and then the electrolyte solution is dropped on the surface of the TiO₂ electrode using a pipette (one or two drops). The counter electrode is placed on top of the TiO₂ electrode, and then the two electrodes are fastened together with two binder clips. If a low melting point polymer film such as Surlyn is used instead of the spacer film, we can fabricate a sealed cell after packaging of the cell using a resin (e.g. ethylene vinyl acetate, EVA) for long-term stability.

Since Grätzel and coworkers reported high performance of a DSSC in 1991, many workers worldwide have tried to reproduce their result. Some reported performances are shown in Table 15.1. These cells were fabricated using a Ru complex photosensitizer, N3 dye, and a nanocrystalline TiO₂ electrode. In many cases, the light condition is AM1.5