

Supplementary data

Fabrication of the photocell

F-doped SnO₂ (FTO) conductive glass (sheet resistance 10 ohm per square, thickness of 1.1 mm) for the substrate of photo-electrode was supplied from Nippon Sheet Glass Co. In order to coat a mesoporous TiO₂ layer on the FTO glass, a commercial nanocrystalline TiO₂ paste (Nanoxide D, Solaronix, SA) was added polyethylene glycol (molecular weight 20,000) at 3.2 weight % to increase the binder content and the viscous paste was coated on the FTO at a wet-layer thickness of about 150 μm by the doctor-blade method using a stainless applicator. After dried at room temperature, the TiO₂ paste-coated FTO was sintered in an electric oven at 550 °C for 30 min to form a 7 μm-thick mesoporous TiO₂ layer (about 13 g m⁻² TiO₂) on FTO. The TiO₂ layer was sensitized by monolayer adsorption of a ruthenium complex dye (N719), cis-bis (isothiocyanato) bis (2, 2'-bipyridyl-4-carboxylicacid-4'-tetrabutylammonium carboxilate) ruthenium(II) (Peccell Technologies, Inc), at 42 °C for 1 hour.

The conductive polymer-carbon composite material was prepared as follows. The polyaniline-loaded carbon black was commercial material supplied from Sigma-Aldrich Inc., which contained 20 wt% polyaniline emeraldine salt (half oxydized and hydrogenetaed polyaniline doped with organic sulfonic acid). 30 mg of the polyaniline-carbon black composite (PACB) was triturated on an agate mortar in the presence of 250 mg of an ionic liquid, 1,3-diethyleneoxide derivative of imidazolium iodide (EOI), as shown in Fig. 1(a). Iodine, a solid powder, was added to the above mixture on agate mortar in the comparative experiments to investigate the effect of iodine concentration. This mechanical mixing was done by hand taking a sufficiently long time >5 min. Well-mixing process yielded a PACB-EOI composite in the form of a highly viscous black paste as displayed in Fig. 1(b). Counter-electrode was a FTO glass (1.1 mm-thick) same as that used for the above photo-electrode, the surface of which underwent no treatment for loading a catalyst, such as Pt, which is normally needed for FTO. 5-10 mg of this hard paste was applied and sandwiched between the dye-sensitized TiO₂ layer and a FTO glass counter-electrode to give a 90 μm-thick layer of the conductive PACB-EOI layer. All processes were conducted in aerated conditions. The black PACB-EOI composite layer tightly contacts the surface of dye-coated photo-electrode and FTO counter-electrode to form a solid-state photocell. No sealants or gasket films was used to seal the cell structure because the above solid composite layer separates the working and counter-electrodes blocking electrical short-circuiting. The total thickness of the photocell was 2.3 mm and an effective electrode area was 0.24 cm².