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Electronic Supplementary Information

Zinc Oxide Synthesis Via Microemulsions Technique: Morphology Control with Application to Dye–Sensitized Solar Cells

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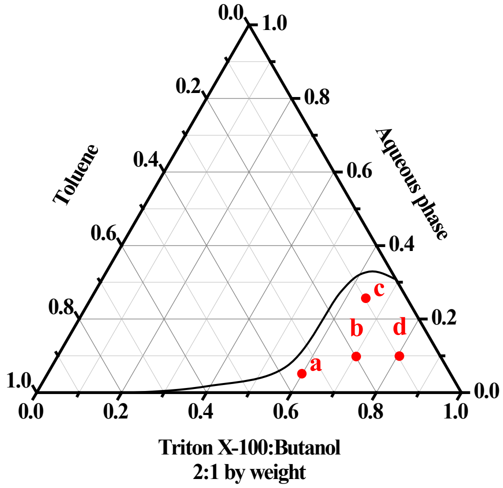
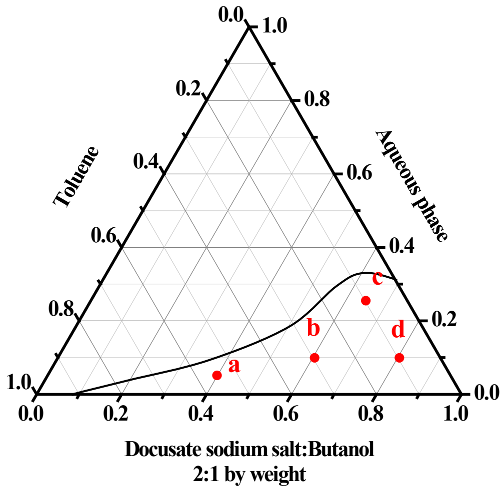
1. Phase diagrams constructed using surfactant Triton® X–100



2. Phase diagrams constructed using surfactant AOT



3. Experimental Procesures for fabrication of dye-sensitized solar cells

Commercial colloidal ZnO powder (4.23 g, Degussa VP AdNano®ZnO20) with an approximate nanoparticle size of 20 nm was thoroughly mixed with 20 ml solution of EtOH and DI-water (v/v=70/30). This colloidal solution was stirred for 3 days to obtain a well-dispersed suspension of 20 wt% ZnO; this paste was used for constructing 15 μm ZnO film on cleaned fluorine-doped SnO_2 conducting glasses (FTO, 7 Ω $sq.^{-1}$, transmittance ≧ 80%, NSG America, Inc., New Jersey, USA). A portion of 0.4×0.4 cm^2 was selected as the active area by removing the side portions by scrapping. The ZnO film was gradually heated to 450 °C in an oxygen atmosphere, and subsequently sintered at that temperature for 30 min. The coral–like ZnO photoanodes were prepared by the same procedure. After sintering at 450 °C and cooling to 80 °C, the ZnO photoanodes were immersed in a 3×10^{-4} M solution of D149 (Mitsubishi, Japan) in ACN and tBA (volume ratio of 1:1), at room temperature for 24 h. The thus prepared ZnO/dye electrode was attached to a platinum-sputtered conducting glass electrode (ITO, 7□ Ω $sq.^{-1}$, Ritek Corporation, Hsinchu, Taiwan). The two electrodes were separated by a 25 μm–thick surlyn® (SX1170-25, Solaronix S.A., Aubonne, Switzerland) and sealed by heating. A mixture of 0.1 M lithium iodide (LiI, synthetical grade, Merk), 0.6 M DMPII (Solaronix S.A., Aubonne, Switzerland), 0.05 M iodine (I_2, synthetical grade, Merk), and 0.5 M 4–tert–butylpyridine (TBP, 96%, Acros) in 3–methoxypropionitrile (MPN, Fluka)/ acetonitrile (ACN, 99.99%, Aldrich) (volume ratio of 1:1) was used as the electrolyte. The electrolyte was injected into the gap between the electrodes by capillarity.

4. Measurements of dye-sensitized solar cells

Surface of a DSSC was illuminated by a class A quality solar simulator (PEC–L11, AM1.5G, Peccell Technologies, Inc.) and the incident light intensity (100 mW cm^{-2}) was calibrated with a standard Si cell (PECSI01, Peccell Technologies, Inc.). Photoelectrochemical characteristics of the DSSCs were recorded with a potentiostat/galvanostat (PGSTAT 30, Autolab, Eco–Chemie, the Netherlands). Electrochemical impedance spectra (EIS) were obtained by the above-mentioned potentiostat/galvanostat equipped with an FRA2 module, under a constant light illumination of 100 mW cm^{-2}. The frequency explored was ranged from10 mHz to 65 kHz. Applied bias voltage was set at the open–circuit voltage of the DSSC between the ITO–Pt counter electrode and the FTO–ZnO–dye working electrode, starting from the short–circuit condition; the corresponding AC amplitude was 10 mV. The impedance spectra were analyzed using an equivalent circuit model. Photovoltage transients of the assembled devices were recorded with a digital oscilloscope (model LT322, LeCroy, USA). Pulsed laser excitation was applied by a frequency–doubled Q–switched Nd:YAG laser (model Quanta-Ray GCR–3–10, Spectra–Physics laser) with a 2 Hz repetition rate at 532 nm, and a 7 ns pulse width at half–height. The average electron lifetime could approximately be estimated by fitting a decay of the open–circuit voltage transient with exp ($-t\,\tau_{ae}^{-1}$), where t is the time and τ_{ae} is an average time constant before recombination.