Electronic Supplementary Material (ESI) for Physical Chemistry Chemical Physics

Supplementary material

ZnO Hierarchical Structure for Efficient Quasi-Solid Dye-Sensitized Solar Cells

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SEM images of the photoanodes

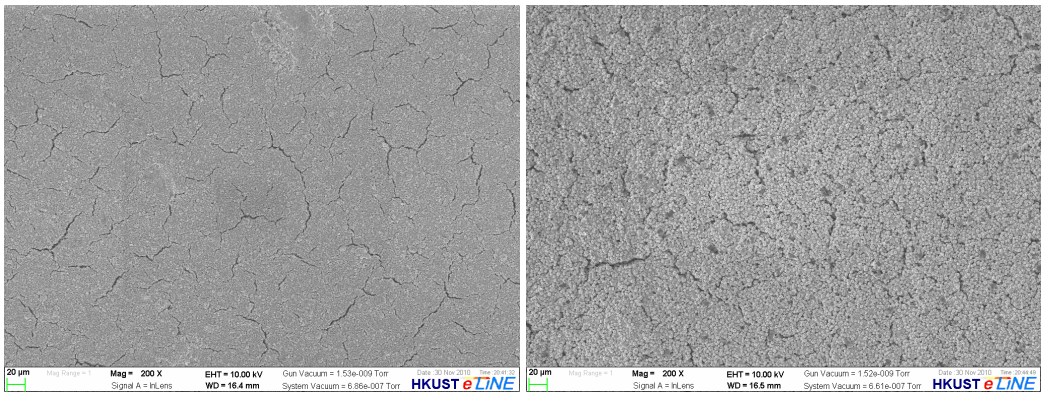

Figure S1. Top-view SEM images of the NP (a) and MF-based (b) photoanodes.

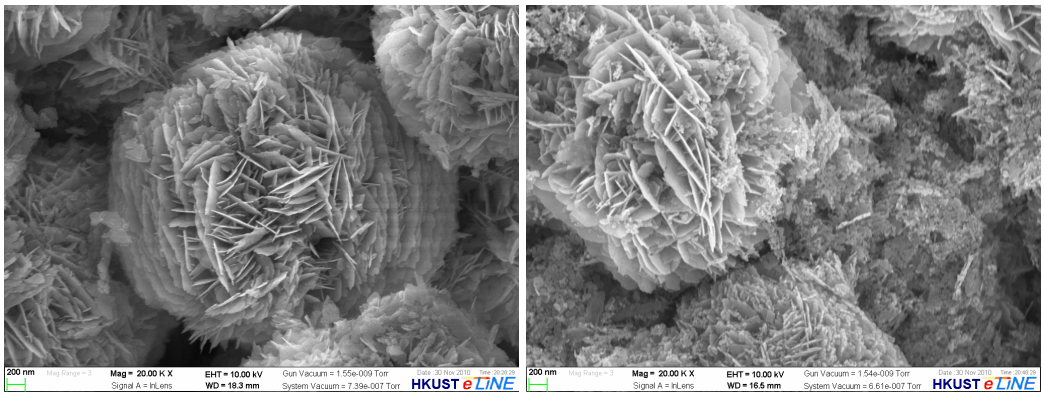

Figure S2. SEM images of the MFs before (a) and after (b) composited with small amount of NPs. The 20nm-sized NPs can serve as linkers to form a compact film

Fabrication of photoanodes and assemble of the quasi-solid DSCs:

The pastes was prepared by mixing 1.0g ZnO power with 2.0g distilled water and 0.5g absolute alcohol, besides, it should be mentioned that the MF-based paste was composited with small amount of 20nm-sized NPs (5wt%). Then, the resulted pastes were treated under ultrasonic and mechanical shock until the particles was dispersed homogeneously. In our experiment, doctor blade technique was used to prepare porous ZnO photoanode on FTO glass with the thickness being controlled by a 120μm adhesive tape.

The ZnO photoanode was sintered at 200^{o}C for 2h, then sensitized in 0.3 mM N719 absolute ethanol solution for 100min, followed by cleanning with absolute ethanol. A chemically platinized conductive glass was used as the counter electrode. The composition of the polymer gel electrolyte: LiI (0.1M), I_2 (0.1M), 1,2-dimethyl-3-propyl imidazolium iodide (0.6M), N-methyl-benzimidazole (0.45M), and the solvent was 3-methoxypropionitrile, PEO ($M_w = 2\times10^6$g mol^{-1}) weight ratio (Vs. liquid electrolyte) was 10%. When assembling DSC, the polymer gel electrolyte was sandwiched by a sensitized ZnO electrode and a counter electrode with two clips, the space between the two electrodes is controlled by an adhesive tape with a thickness of 30μm and the DSC was not sealed. Finally, the DSC was baked at 80^{o}C for 20min to ensure the polymer gel electrolyte can penetrate into the nanoporous electrode.

Characterication:

Morphologies of the ZnO particles and the photoanodes were characterized by scanning electron microscopy (SEM) and high-resolution transmission electron microscopy (HRTEM). In our experiments, to detect the dye-loading abilities of these

samples, their corresponding photoanodes were first sensitized with 0.3mM N719 dye and then desorbed with 0.05mol/L sodium hydroxide (NaOH) solution. Subsequent desorbed solutions were characterized with UV-vis spectrophotometer and wavelength of the characteristic absorption peak was denoted as 506nm. The pore distribution analysis was performed by a Mercury Porosimeter (Quantachrome, Autoscan-33). In this paper, light-scattering characterization was carried out in a UV-vis spectrophotometer equipped with an integrating sphere. IMPS test were carried out on a electrochemical work station (Thales, Zahner Zennium CIMPS-1) with a light wavelength of 530nm, selected light intensities were 41.60 mW cm^{-2}, 27.84 mW cm^{-2}, 18.63 mW cm^{-2}, 12.51 mW cm^{-2}, 8.38 mW cm^{-2}. Under different light intensities, the corresponding characteristic frequency $\boldsymbol{f}$ was obtained. Then, the electron collection time $\boldsymbol{\tau_c}$ was calculated using the equation $\boldsymbol{\tau_c = 1/2\pi f}$. Finally, the electron diffusion coefficient $\boldsymbol{D_n}$ was obtained from $\boldsymbol{D_n = L^2/2.35\tau_c}$, where L was the thickness of the photoanode. The photovoltaic performance of the DSC were measured by KEITHLEY Keithley 2400 sourcemeter under solar simulator (Newport, IEC Class A, Xe lamp, 100mW cm^{-2}, AM1.5G), and the incident light intensity was calibrated with standard crystalline silicon solar cell. The total active area of the DSC is 0.25 cm^2, three DSCs were assembled for each sample and intermediate value of the conversion efficiencies was used in this paper.