

Supporting Information

**Solar Cell with PbS Quantum Dots Sensitized TiO₂-Multiwalled Carbon Nanotubes
Composite, Sulfide-titania gel and Tin Sulfide Coated C-fabric**

Ramesh K. Kokal, Melepurath Deep, Ankarao Kalluri, Shristhi Singh, Isaac Macwan,*

Prabir K Patra, Jeff Gilarde

Table S1 Solar cell parameters of cells by considering standard deviation, exposed cell area: 0.15 to 0.18 cm², under 1 sun illumination (AM 1.5, 100 mW cm⁻²) with the listed photoanodes and counter electrodes with 0.1 M Na₂S, 0.1 M KCl, 0.1 mmol TiO₂ NPs and 10 wt% of PVA in water as electrolyte.

| Photoanode | Counter Electrode | V _{oc} (mV) | J _{sc} (mA cm ⁻²) | FF(%) | η _{avg} (%) |
|----------------------------------|-------------------|----------------------|--|-------|----------------------|
| TiO ₂ /PbS/ZnS | C-fabric | 827.9 | 11.28 | 36.51 | 3.41 |
| | | 829.6 | 11.42 | 37.78 | 3.58 |
| | | 831.3 | 11.56 | 39 | 3.75 |
| | SnS/C-fabric | 874.7 | 13 | 34.74 | 3.95 |
| | | 877.4 | 13.41 | 35.7 | 4.20 |
| | | 880.1 | 13.82 | 36.6 | 4.45 |
| TiO ₂ -MWCNTs/PbS/ZnS | C-fabric | 830.5 | 17.61 | 37.67 | 5.15 |
| | | 832.1 | 17.96 | 35.33 | 5.28 |
| | | 833.7 | 18.31 | 35.4 | 5.41 |
| | SnS/C-fabric | 878 | 18.7 | 36.53 | 6 |
| | | 895.2 | 19.41 | 34.64 | 6.02 |
| | | 897.6 | 19.72 | 34.8 | 6.16 |
| | | 900 | 20.03 | 35 | 6.30 |

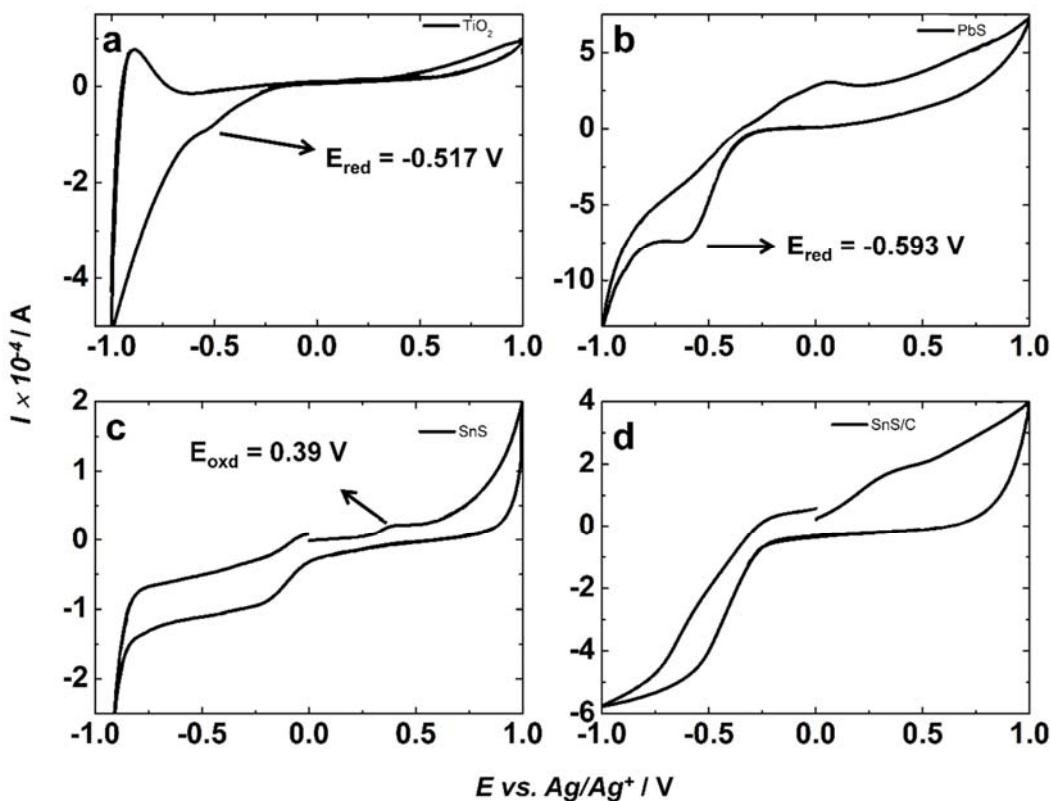


Figure S1 Cyclic voltammograms of (a) a pristine TiO_2 electrode, (b) a pristine PbS electrode, (c) a SnS/FTO electrode, and (d) a SnS/C -fabric electrode serving as working electrodes. All CV plots were recorded in a 0.1 M KCl solution as electrolyte, with a Pt sheet as the counter electrode and an $\text{Ag}/\text{AgCl}/\text{KCl}$ as the reference electrode, at a scan rate of 10 mV s^{-1} .

Cyclic voltammograms of pristine- TiO_2 , PbS , and SnS films (as working electrodes), recorded in an aqueous 0.1 M KCl solution, with a Pt rod as the counter electrode and a $\text{Ag}/\text{AgCl}/\text{KCl}$ as the reference electrode are shown in Figure S1. For pristine TiO_2 , a reduction peak was observed in the cathodic sweep at -0.517 V versus $\text{Ag}/\text{AgCl}/\text{KCl}$, and this E_{red} can be equated to the CB (conduction band) or LUMO (lowest unoccupied molecular orbital) position of TiO_2 . The electrode potential of the reference is $+0.197 \text{ V}$. So, E_{red} (versus NHE (normal hydrogen electrode)) of $\text{TiO}_2 = -0.517 \text{ V} + 0.197 \text{ V} = -0.32 \text{ V}$. The value of -0.32 V (versus NHE) in eV is given by: $-4.5 \text{ eV} (\cong 0 \text{ V versus NHE}) - (-0.32 \text{ V}) = -4.18 \cong -4.2 \text{ eV}$. The position of the valence band (VB) or HOMO (highest occupied molecular orbital) of TiO_2 is determined by addition of the pre-determined optical band gap energy value to the CB energy, i.e., $-4.2 \text{ eV} + (-3.11 \text{ eV}) = -7.29 \text{ eV}$. For pristine PbS , a reduction peak was observed in the cathodic sweep at -0.593 V versus $\text{Ag}/\text{AgCl}/\text{KCl}$, and this E_{red} can be equated to the CB

or LUMO (lowest unoccupied molecular orbital) position of CIS. So, E_{red} (*versus* NHE) of CIS = $-0.593 \text{ V} + 0.197 \text{ V} = -0.396 \text{ V}$. The value of -0.396 V (*versus* NHE) in eV is given by: $-4.5 \text{ eV} - (-0.396 \text{ V}) = -4.1 \text{ eV}$. By adding the optical E_g of PbS to the CB energy level ($-4.1 \text{ eV} + (-1.09 \text{ eV})$), the VB energy level is calculated to be at $-5.19 \cong -5.2 \text{ eV}$. For pristine SnS, a oxidation peak was observed in the anodic sweep at 0.39 V *versus* Ag/AgCl/KCl, and this E_{oxd} can be equated to the VB or HOMO (highest occupied molecular orbital) position of SnS. So, E_{oxd} (*versus* NHE) of SnS = $0.39 \text{ V} + 0.197 \text{ V} = 0.587 \text{ V}$. The value of 0.587 V (*versus* NHE) in eV is given by: $-4.5 \text{ eV} - (0.593 \text{ V}) = -5.08 \cong -5.1 \text{ eV}$.

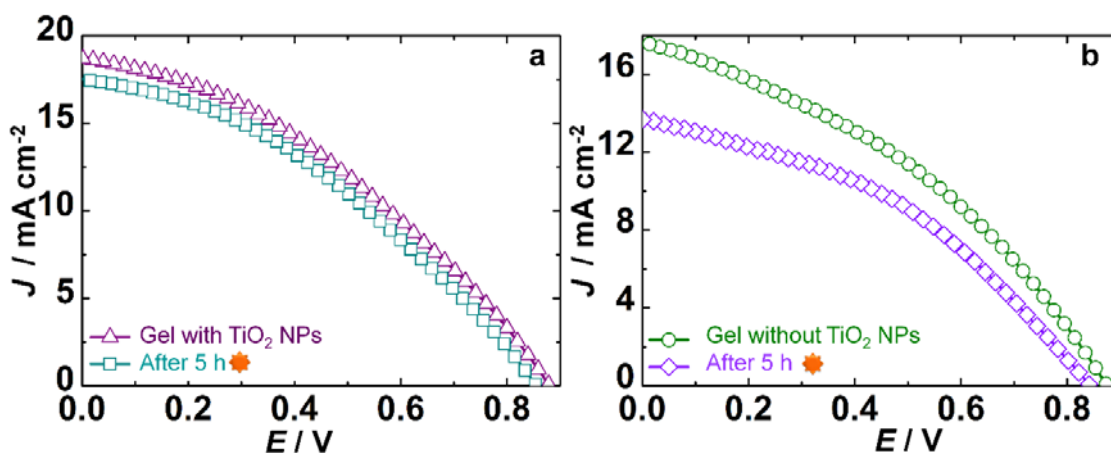


Figure S2 J-V characteristics of TiO₂-MWCNTs/PbS/ZnS-electrolyte-SnS/C-fabric cells with two different electrolytes: (a) gel with TiO₂ NPs (0.1 M Na₂S + 0.1 M KCl + 0.1 mmol TiO₂ NPs + 10 wt% of PVA in water) and (b) gel without TiO₂ NPs (0.1 M Na₂S + 0.1 M KCl + 10 wt% of PVA in water), before and after exposure for 5 h to sunlight.

Table S2 Stability tests for TiO₂-MWCNTs/PbS/ZnS-electrolyte-SnS/C-fabric cells with two different electrolytes.

| Electrolyte | V _{oc} (mV) | J _{sc} (mA cm ⁻²) | FF (%) | η (%) |
|--|----------------------|--|--------|-------|
| With 0.1 mmol TiO ₂ NPs (As-fabricated) | 878 | 18.7 | 36.53 | 6 |
| With 0.1 mmol TiO ₂ NPs (6% Cell: After exposure to sunlight for 5 h) | 853.6 | 17.52 | 36.84 | 5.51 |
| Without 0.1 mmol TiO ₂ NPs (As-fabricated) | 872.8 | 17.65 | 37.2 | 5.73 |
| Without 0.1 mmol TiO ₂ NPs (5.73% Cell: After exposure to sunlight for 5 h) | 841 | 13.7 | 39.6 | 4.56 |

Table S3 Fitting parameters for EIS spectra of three different electrolytes.

| Electrolyte | R _b (Ω) | R _{ct} (kΩ) | C _{dl} (μF) | Y _o (S) |
|-------------------------------------|--------------------|----------------------|----------------------|-------------------------|
| Gel without TiO ₂ NPs | 18.3 | 6.86 | 314 | 2.20 × 10 ⁻³ |
| Gel with TiO ₂ NPs | 16.4 | 4.01 | 479 | 4.43 × 10 ⁻³ |
| Liquid without TiO ₂ NPs | 13.3 | 4.20 | 250 | 1.89 × 10 ⁻³ |