**Supporting Information**

**Characterization techniques**

          The optical absorption of the gel electrolyte was measured in a UV–156 VIS-NIR spectrophotometers (V770 model). Fourier-transform infrared (FT-IR) measurement was carried out by a KBr pellet method in the Thermo Scientific Nicolet iS5 FT-IR spectrometer to identify the structure conformation. The crystalline phases of the samples were recognized by X-ray diffraction (XRD) analysis in a Bruker AXS D4 Endeavor using Cu-Kα radiation. The morphology and EDX (Energy-dispersive X-ray spectroscopy) analysis of the samples were analyzed by field emission scanning and transmission electron microscopic (FE-SEM) technique with the help of a JEOL (7401F) scanning electron microscope. High-resolution transmission electron microscopy (HR-TEM) was carried out in FEI Tecnai 20 G2. The electrochemical studies were performed by using Metrohm AUTOLAB12/FRA2 PGSTAT302N electrochemical analyzer assembly with NOVA software version 1.10 version. The DSSCs were fabricated using gel electrolyte to study the electrochemical impedance spectroscopy (EIS) studies and parafilm was used to separate the electrodes from contacting each other. The measurement was recorded at the frequency range of 0.1 to 105 Hz and the amplitude of the sinusoidal AC voltage was fixed to 10 mV. The *J-V* measurement of the fabricated DSSCs was characterized by AUTOLAB12/FRA2 PGSTAT302N associated with a solar simulator (85 mW cm-2, AM 1.5 G). QE-T (Enlitech, Taiwan) was used to record the incident photon to electron conversion efficiency (IPCE) spectra of the devices using Oriel 300 W Xe Arc lamp in combination with an Oriel Cornerstone 260\_¼m monochromator. The reference monocrystalline silicon diode was calibrated to calculate the number of incident photons for each wavelength. ZSimpWin software was used for equivalent circuit fitting of the EIS data.

The cyclic voltammograms (CVs) were measured using MnO2 and Cu doped MnO2 (drop-casted on the FTO glass plate of size 1 X 1 cm2) as working electrodes, Ag/AgCl as reference electrode, and Pt wire was used as the counter electrode in the electrolyte consisting of LiI/I2 (0.05 M/0.01 M), and LiClO4 (0.5 M) dissolved in 3-methoxy-propionitrile (potential range -0.4 V to 1.2 V at 10 mVs-1 ).

**Preparation of FTO/TiO2 plates**

The fluorine-doped conducting Tin oxide (FTO) glass plates (2 cm × 2 cm) were cleaned with soap solution, deionized water, acetone, and 2-propanol solution subsequently in an ultrasonic water bath (for each solvent ~10 min). The TiO2 blocking layer was coated by immersing the cleaned FTO glass plates (facing the conductive side upwards) in a 40 mM aqueous solution of TiCl4 for 30 min at 70°C. After cooling to room temperature, these TiO2 layer-coated FTO plates were rinsed with distilled water and ethanol; dried at 100°C for 10 min. Then the above plate was coated with TiO2 paste of thickness 55 µm (invisible tape), and the active cell area of 0.25 cm2 via the doctor-blade approach (TiO2 paste preparation procedure is as follows: 0.15 mg of PEG (MW 10000) was dissolved in 1M HNO3. Acetylacetone (0.3 mL), Triton-X (0.04 mL), and TiO2 (P25 Degussa) nanopowder (0.5 g) were added, and the solution mixture was sonicated for 1 h and stirred for 24 h. Finally, these FTO/TiO2 plates were sintered at 450°C for 30 min and those plates were used as photoanodes.

**Preparation of Copper-doped MnO2** **as a CE**

As-synthesized Copper-doped MnO2 materials (10 mg) were dispersed in 2- Propanol (IPA) and sonicated for 1h. Proximately, 80 μl of the solution was coated on the pre-cleaned FTO plates via the drop-cast method and dried overnight.

**Preparation Pt as a CE**

The platinum counter electrode (CE) was prepared by thermal decomposition of hexachloroplatinic acid hexahydrate (drop-casting 4 mM of H2Pt(Cl)6. 6H2O in 2-propanol solution onto a pre-cleaned FTO glass plate) at 450 °C for 30 min- and cooled down to room temperature. These Pt electrodes were used as the CE in this work.

**Preparation of Dye sensitized FTO/TiO2 plates**

The dye-sensitization was performed by dipping photoanodes (FTO/TiO2) at 70 °C in 5 mM N3 dye dissolved in a 1:1 acetonitrile – tert-butanol solvent for 24 hrs under dark conditions. Then, the dye-coated TiO2 films were taken out from the dye solution, and the plates were rinsed with ethanol to remove the excess dye. The excess portion of the dye-coated TiO2 film was scrapped to fix the cell active area (0.25 cm2).

**Fabrication of DSSCs**

Now, both dyes adsorbed TiO2 electrode and counter electrodes were sandwiched with the help of two crocodile clips. Parafilm was used to separate the electrodes from contacting each other to avoid the short circuit between two conductive surfaces of the electrodes. Finally, the liquid electrolyte (an iodide/triiodide (I-/I3-) solution) consisting of LiI/I2 (0.05 M/0.01 M), and LiClO4 (0.5 M) dissolved in 3-methoxy-propionitrile was injected in between the two electrodes.