Supporting Information

Calligraphic Solar Cells: Acknowledging Paper and Pencil

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Photo-to-electron conversion efficiency calculation of a photovoltaic (PV) cell.

$$\eta_{max} = \frac{P_{max}}{I_{rf} * A_c} * 100\% \qquad \text{Equation 1S}$$

P_{max} is the maximum power output, A_c is area of the device, I_{rf} is incident radiation flux.

The incident radiation flux is the amount of sunlight that hits the earth's surface in W/m^2.

I_{rf} = 200 watts /m^2

Area of the photo-detector is 0.0000785 m^2

Incident photon power is 0.0157 Watts

P_{max} = 200 watts/m^2

A_c = 0.0005006316 m^2

$$\eta_{max} = \frac{0.0017682 Watts}{200 \frac{watts}{m2} * 0.0005006316 m2} * 100 \qquad \text{Equation 2S}$$

= 1.766%

I_{SC} and V_{OC} represent maximum current and voltage obtained from a pen-pencil PV device fabricated in our lab. The fill factor "*FF*" [Eq. 3S] of 0.4 represents the maximum electrical output power from a PV device.

$$\text{Fill Factor} = \frac{I_{mp} * V_{mp}}{I_{sc} * V_{oc}} \qquad \text{Equation 3S}$$

$$= 0.4$$

where V_{mp} is the maximum voltage and I_{mp} is the maximum current that we obtained from the I-V curve.

Control Experiments.

Quenching of QD-PTCDA by MuLG: Fluorescence spectrum in Figure S1(A) shows the electron transfer between CdSe-PTCDA by MuLG in solution. For each experiment 100 µl of MuLG was added to a 2 ml of PTCDA-QD (0.054 µM). These experiments are designed to probe the decrease in intensity which results from electron transfer from QD-PTCDA to MuLG. After the first addition of MuLG to QD-PTCDA the solution mixture is excited at 400nm with the band pass of 5nm and scanning speed of 500 nm/min. The K_{sv} was obtained to be 0.87 L mg^{-1}.

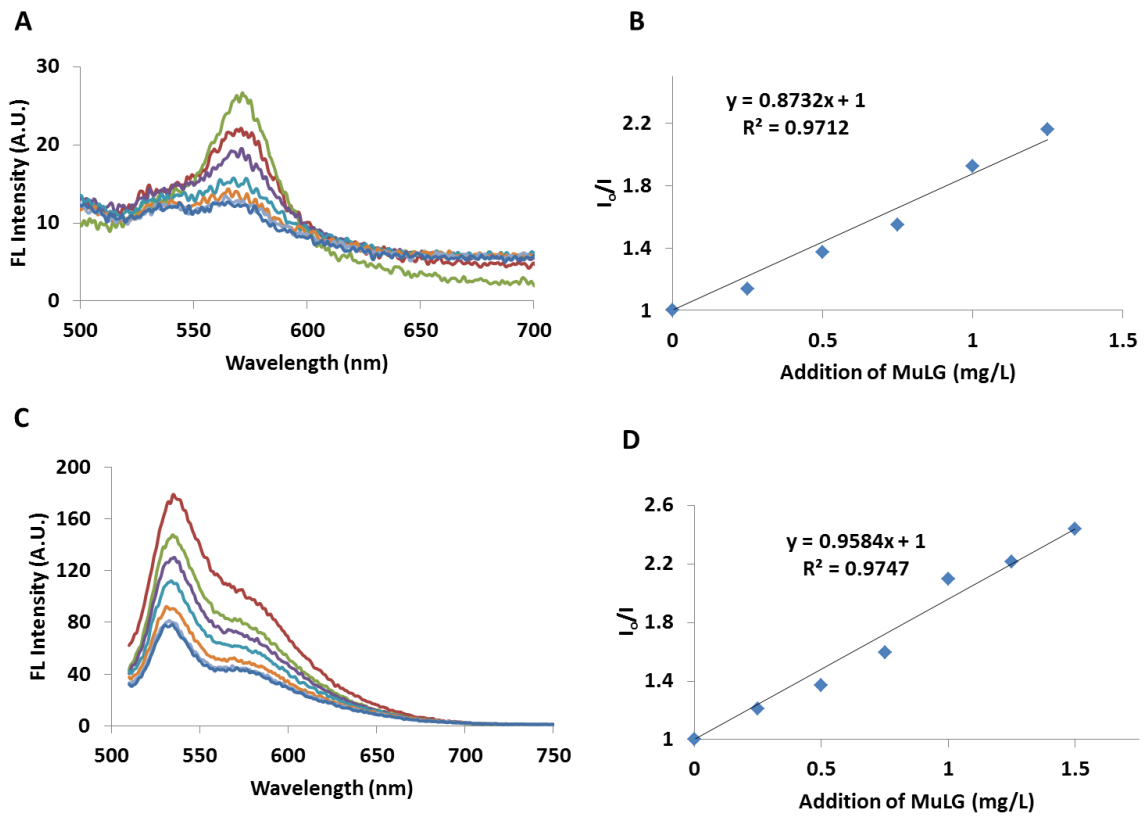

Figure S1. (A) The fluorescence quenching of QD-PTCDA by MuLG. The QD-PTCDA acts as donor and MuLG is an acceptor. B) The Stern–Volmer plot gives the quenching constant (K_{sv}) ~ 0.87 L mg^{-1} for QD-PTCDA/MuLG (C) The fluorescence quenching of PTCDA (donor) by MuLG (acceptor). (D) The Stern–Volmer plot yielded a quenching constant (K_{sv}) of 0.96 L mg^{-1} for PTCDA/MuLG pair.

PTCDA UV-Visible and fluorescence emission spectra.

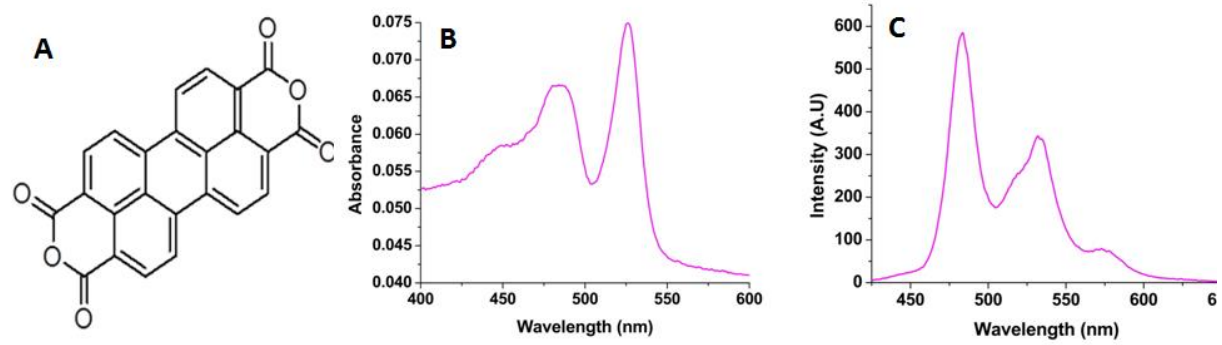

Figure S2. A) Chemical structure of PTCDA bridging molecule used between CdSe QD and MuLG. (B) and (C) are the UV-Visible and emission spectra of PTCDA respectively.

PIC-time response for PEDOT: PSS control experiment.

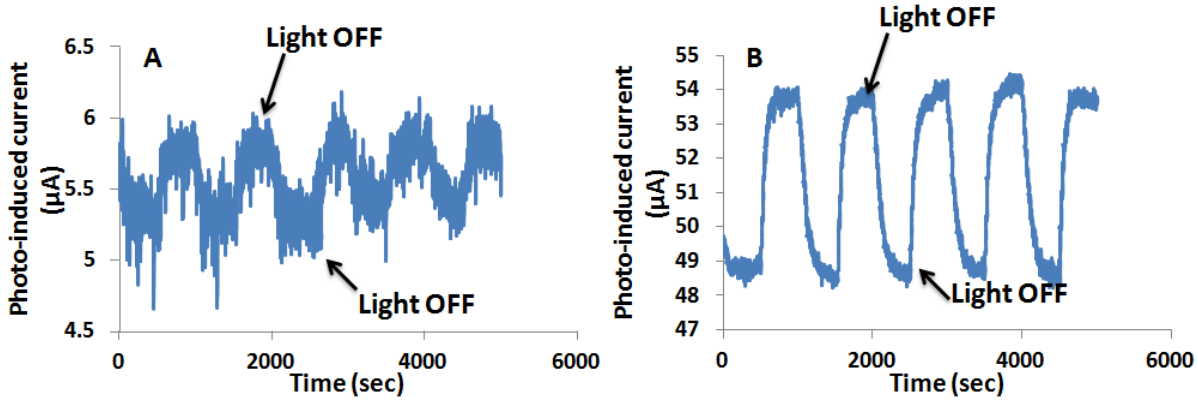

Figure S3. Control experiment of PEDOT: PSS electron blocking layer. The experiments were performed in the presence (B) and in the absence (A) of PEDOT: PSS. The devices with PEDOT: PSS yielded ~ 10 times more PIC than a typical device fabricated without PEDOT: PSS coating. All the measurements were made at an applied voltage of 5V.

Hyperspectral imaging of QDs-PTCDA layer.

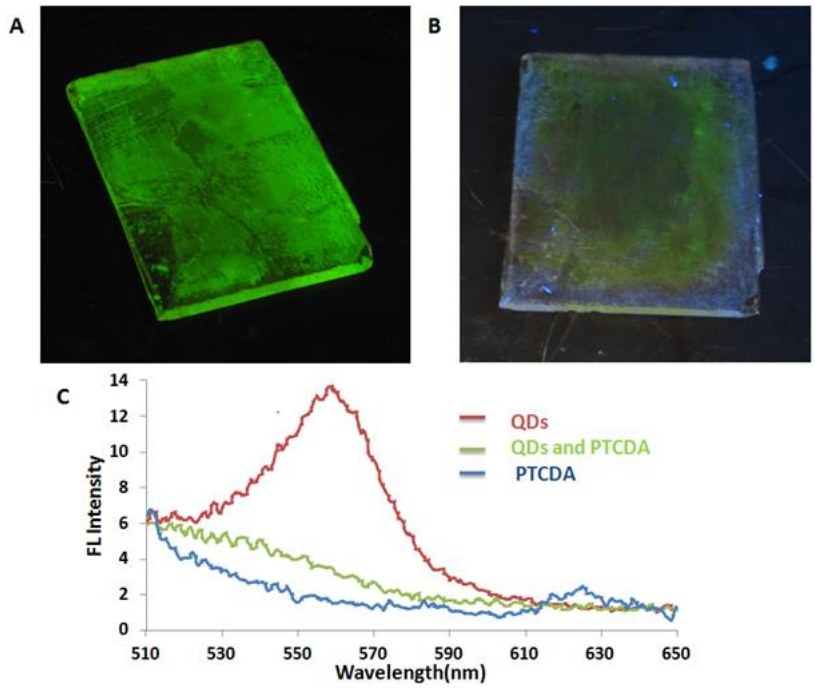

Figure S4. Hyperspectral imaging of active materials. (A) Fluorescence micrograph of QD-only layer excited using a green filter. (B) Fluorescence micrograph of a QD-PTCDA layer deposit on ITO showing significantly lowered emission. (C) The fluorescence spectra of the coatings containing QDs, PTCDA, and QD-PTCDA.

FTIR spectrum of QD-PTCDA.

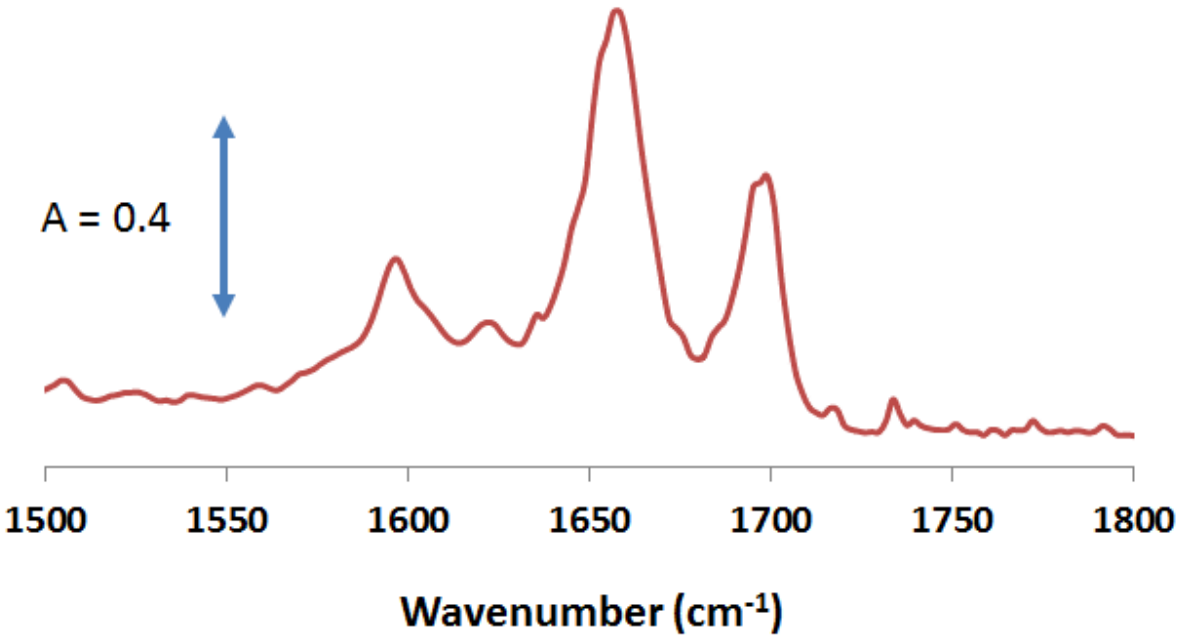

Figure S5. FTIR spectrum of QD-PTCDA in 1500-1800 cm^{-1} region exhibiting C=O stretching peaks from amide and possibly carbonyl stretching in five member ring.

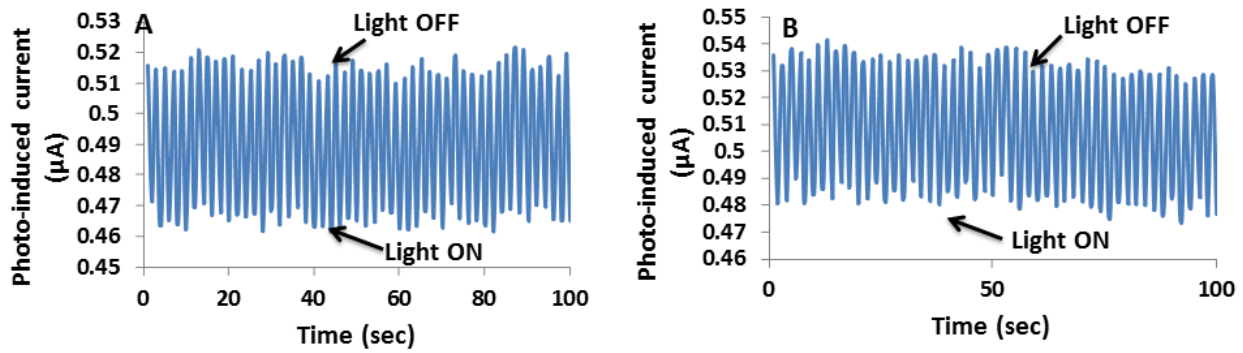

Figure S6. Photosensitivity of the device was tested with applied voltage 5V, ON and OFF are the points the device was exposed to light and turned off for every 0.5 s. (A) The PIC switching rate between photo "ON" and "OFF" exhibiting photocurrent elevation of ~13% in the "ON" state compared to "OFF" state on an ITO electrode device. (B) A similar device as shown in (A) showing a temporal response of a device fabricated on MuLG electrode. The comparison between ITO and MuLG shows that MuLG is a good electrode for electronic and opto-electrical devices.

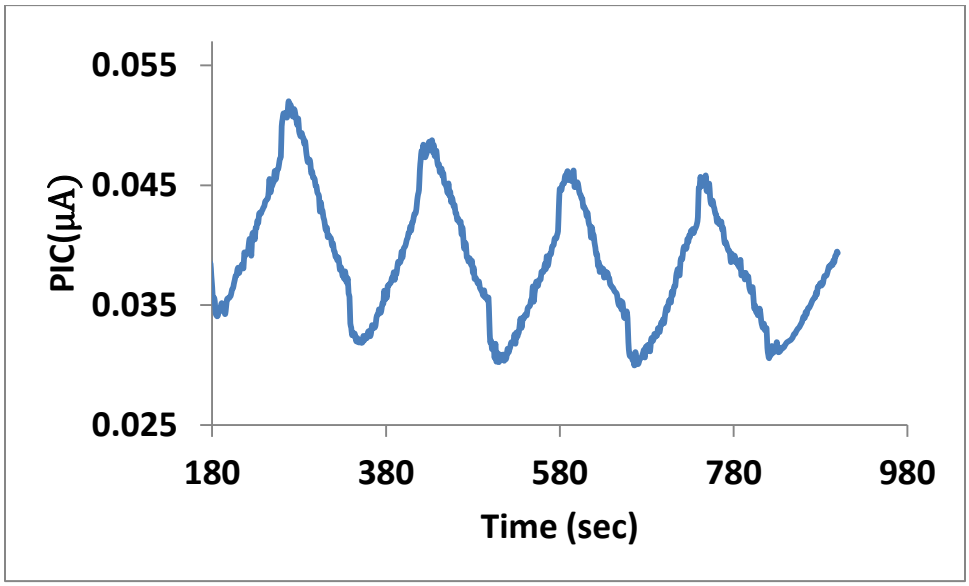

Figure 7S. PIC-time curve for a two-electrode device fabricated using PTCDA only. The PIC for PTCDA device was about two orders of magnitude smaller than that for QD-PTCDA device.

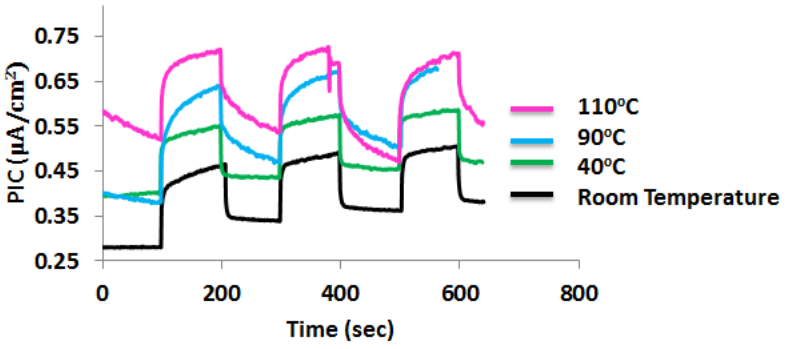

Figure 8S. PIC-time dependence at four different temperatures. These studies clearly demonstrated that our paper-based photodetector devices are stable at higher temperature for >5 minutes.