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Red and Green-emitting Biocompatible Carbon Quantum Dots for Efficient Tandem Luminescent Solar Concentrators

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Simulation:

The external optical efficiency of the LSCs can be expressed as:[1]

$$\eta_{opt} = \eta_{Abs} \cdot \eta_{internal} \tag{1}$$

η_{Abs} can be calculated as:[1]

$$\eta_{Abs} = (1 - R)\frac{\int_0^{\infty} I_{in}(\lambda)(1 - e^{-\alpha(\lambda)d})d\lambda}{\int_0^{\infty} I_{in}(\lambda)d\lambda} \tag{2}$$

In which α is the absorption coefficient [calculated as $\alpha = \ln(10)\frac{A}{d}$, where *d* is the effective length and *A* the absorption of the LSC], I_{in} is the Sun irradiance.

R can be calculated as follows:[1]

$$R = \frac{(n_{glass} - n)^2}{(n_{glass} + n)^2} \tag{3}$$

R at the interface of glass and air is 4% as the n_{glass} is 1.50 and n_{air} is 1. R at the interface of glass and the mixture of the glass and the C-dots/PVP film is in the range of 0.36-0.44%, depending on the refractive index of the mixture.

A spectrally averaged internal efficiency ($\eta_{internal}$) over the PL of the C-dots was calculated as:[1]

$$\eta_{internal} = \frac{\int_0^{\infty} \frac{\eta_{QY} P_{TIR}}{1 + \beta\alpha(\lambda)L_{lsc}(1 - \eta_{QY} P_{TIR})} S_{PL}(\lambda)d\lambda}{\int_0^{\infty} S_{PL}(\lambda)d\lambda} \tag{4}$$

in which $S_{PL}(\lambda)$ is the PL spectrum; β is a numerical value fixed to 1.4 and L_{lsc} is the length of the LSC. η_{QY} is the quantum yield of the C-dots/PVP film.

Assuming an isotropic emission, P_{TIR} is defined by the escape cone identified by the critical angle θ of the solution/glass interface:[1]

$$P_{TIR} = \sqrt{1 - \left(\frac{n_{air}}{n}\right)^2} \tag{5}$$

Figures

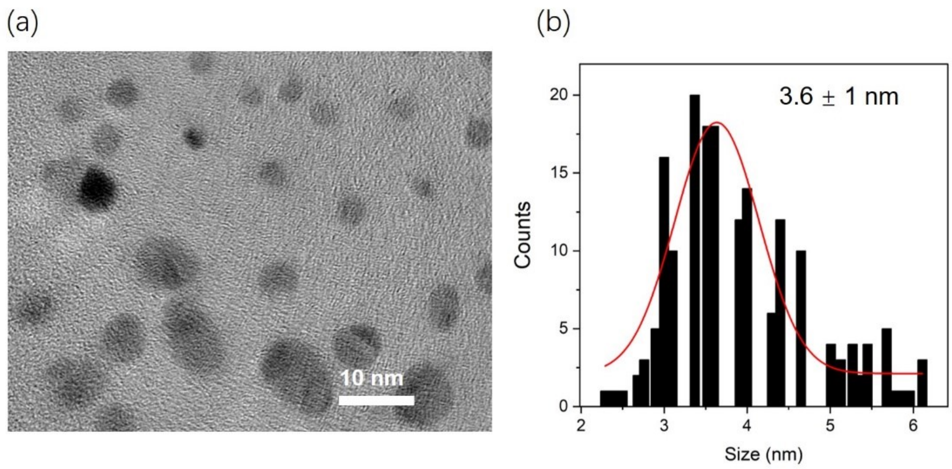

Figure 1. TEM image (a) and size distribution (b) of C-dots synthesized at 160 °C using CA/urea as precursors and DMF as solvent.

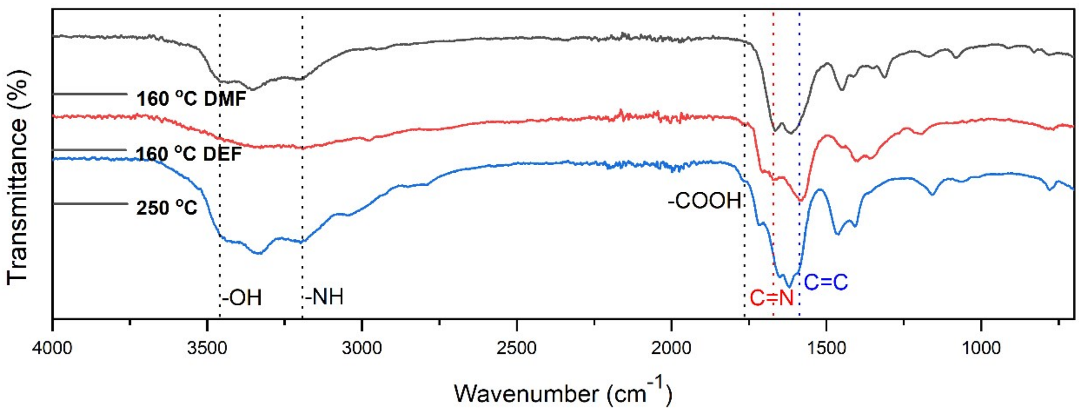

Figure S2. FI-IR spectra of the synthesized C-dots.

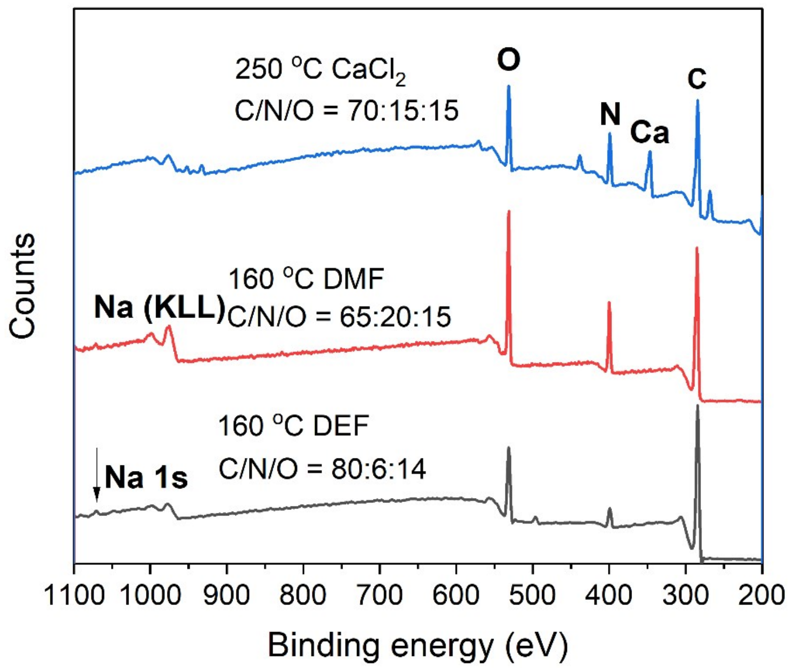

Figure S3. XPS spectra of the synthesized C-dots.

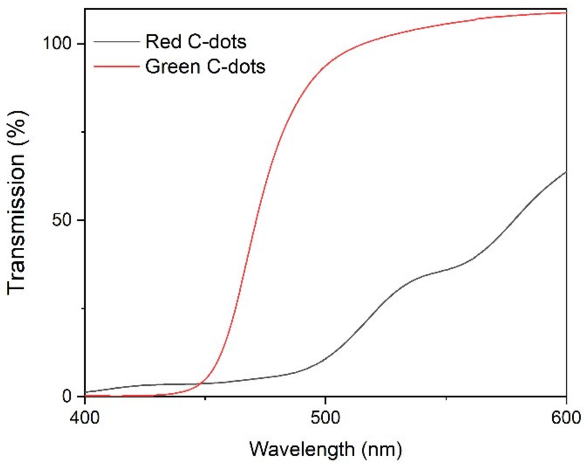

Figure S4. Transmission of the C-dots based LSCs in the wavelength range of 400-600 nm.

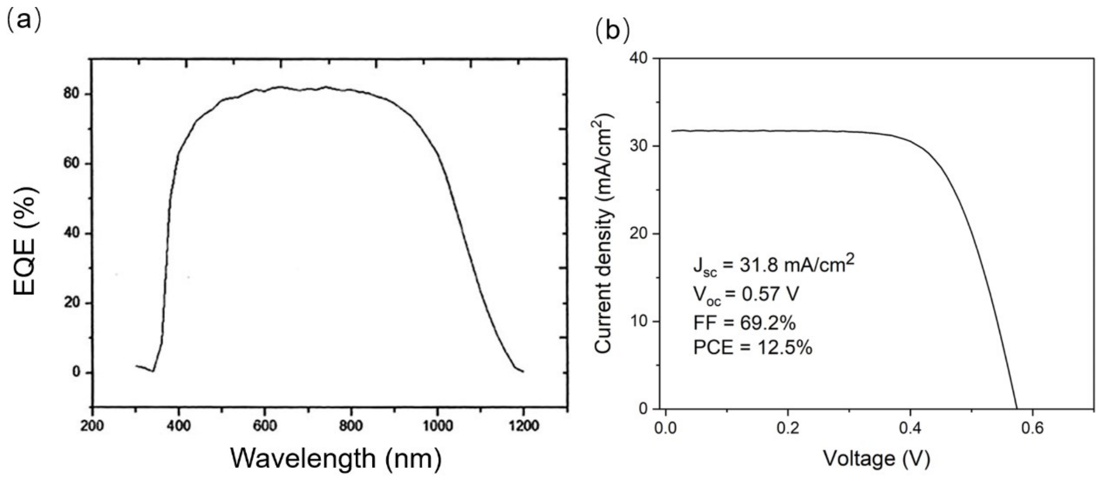

Figure S5. (a) External quantum efficiency (EQE) and (b) J-V response of the commercial solar cell used in this work upon simulated sunlight (100 mW/cm^2).

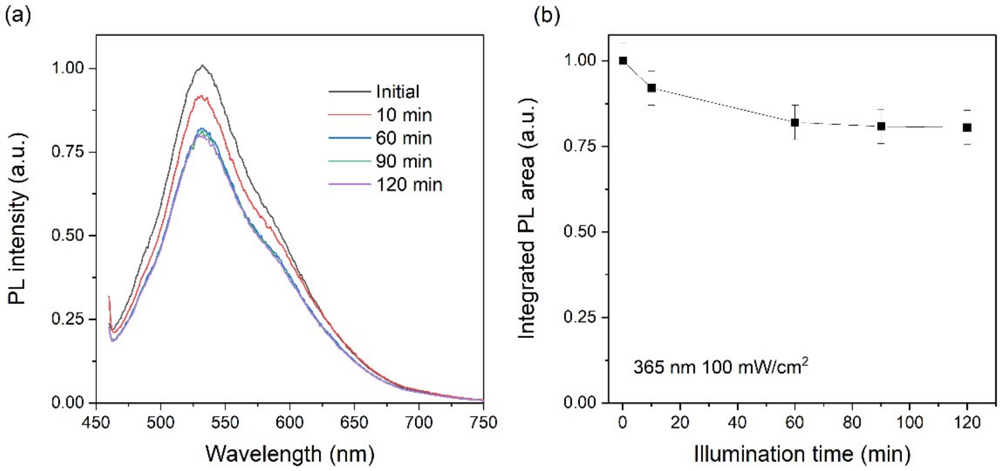

Figure S6. (a) PL intensity and (b) integrated PL area of the LSC based on red C-dots (0.5 mg/cm³) as a function of illumination time. The excitation wavelength is 430 nm. The LSC was upon 365 UV lamp (100 mW/cm²).

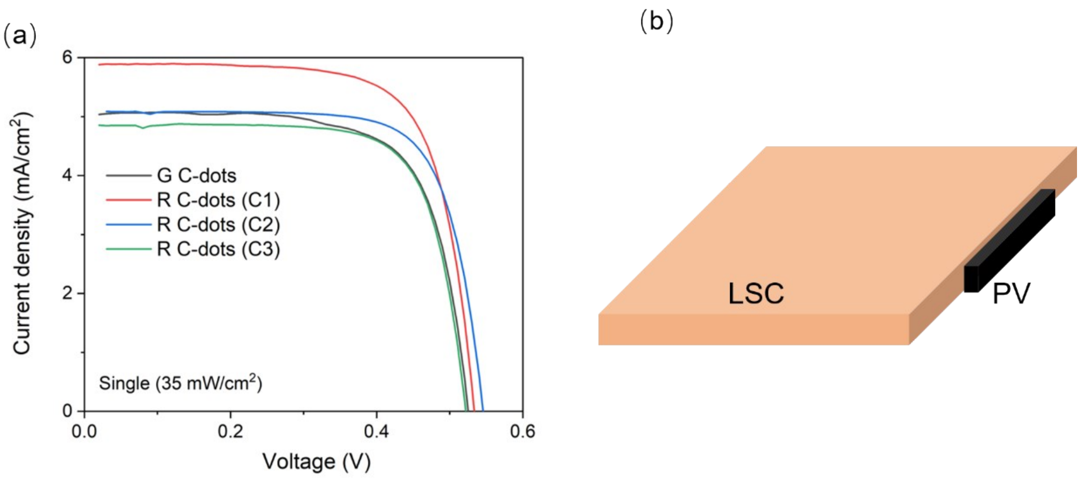

Figure S7. (a) J-V response of silicon PV attached on one edge of the LSC (as shown in Fig. S7b) under the natural sunlight (35 mW/cm²). (d) tandem LSC (70 mW/cm²).

Reference

1. V. I. Klimov, T. A. Baker, J. Lim, K. A. Velizhanin and H. McDaniel, *ACS Photonics*, 2016, **3**, 1138.