

## Electric Supplementary Information

# Photodeposition of gold nanoparticles on silica nanoparticles using carbon dots as excellent electron donors

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### Experimental section

#### Materials

All chemicals were used as received:  $\text{HAuCl}_4 \cdot 3\text{H}_2\text{O}$  (s, 99.9%), tetraethyl orthosilicate (TEOS, l,  $\geq 99\%$ ), 28-30%  $\text{NH}_4\text{OH}$ (aq), 3-aminopropyl triethoxysilane (APTES, l,  $>98\%$ ), citric acid (s, 99.5%) from Sigma-Aldrich. Isopropyl alcohols (IPA, l) and ethanol(l) were from Dajeong Chemicals, and purified water ( $>15 \text{ M}\Omega \text{ cm}$ ) from an ELGA PURELAB Option-S system was used throughout the experiments.

### **Preparation of SiO<sub>2</sub> nanospheres**

Hard supporters of silica nanospheres were prepared via the sol-gel reaction of TEOS under base catalysis following the Stöber method.<sup>5</sup> 50 mL of ethanol, 3.55 mL of water, 3.1 mL of TEOS, and 3.25 mL of 28-30% NH<sub>4</sub>OH(aq) were mixed and stirred vigorously overnight. The product was centrifuged at 9,000 rpm for 10 min, rinsed three times with water and ethanol, and then dried at 60 °C for 5 h.

### **Synthesis of Cdots-decorated SiO<sub>2</sub> (Cdots-SiO<sub>2</sub>) nanocomposites**

Firstly, the surface modification of SiO<sub>2</sub> nanospheres with APTES was performed to synthesize Cdots directly on surfaces of SiO<sub>2</sub> nanospheres. 100 mg of as-prepared SiO<sub>2</sub> nanospheres was dispersed in 19.5 mL of IPA with sonication. Then, the mixture was added with 0.50 mL of APTES and stirred at 60 °C for 2 h. Then, produced APTES-modified SiO<sub>2</sub> nanospheres were centrifuged at 9,000 rpm for 10 min, washed with IPA several times to remove remaining APTES, and re-dispersed in 20 mL of IPA. Then, 0.10 mmol of citric acid was dissolved in 10 mL of water and added to the above colloidal solution of APTES-modified SiO<sub>2</sub> nanospheres. The resultant mixture was stirred for 10 min, transferred into a Teflon-lined stainless-steel autoclave of 50 ml, and maintained at 180 °C for 3 h. After the reaction, the autoclave was cooled down to room temperature, and the product was centrifuged, rinsed three times with ethanol, and re-dispersed in 5.0 mL of ethanol to produce a 20 g L<sup>-1</sup> Cdots-SiO<sub>2</sub> colloidal solution.

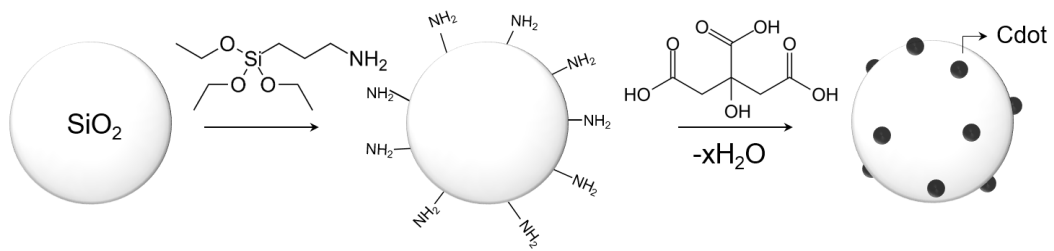
### **Photodeposition of gold nanoparticles on Cdots-SiO<sub>2</sub> nanocomposites**

Au/Cdots-decorated SiO<sub>2</sub> nanocomposites were synthesized by photodepositing gold on surfaces of Cdots-SiO<sub>2</sub> nanocomposites under light irradiation. 15 mL of water and 5.0 mL of ethanol, and 10 μL of the as-prepared Cdots-SiO<sub>2</sub> colloidal solution were mixed. The mixture was transferred into a quartz reactor, stirred for 10 min, placed 30 cm away from a 300 W Schoeffel LPS 255 HR xenon arc lamp with a focusing lens, and irradiated for a few seconds

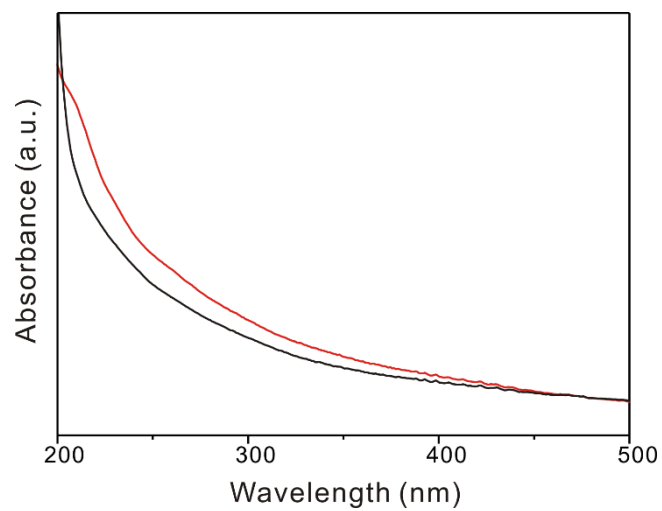
with stirring. The reaction was started by the addition of a specific amount of a  $\text{HAuCl}_4$  stock solution (12.7 mM in ethanol) and stopped by turning off the Xe lamp; the concentration of the gold precursor in 20 mL of the final photodeposition reaction mixture was 6.35  $\mu\text{M}$  and the light intensity at 250 nm was 327 mW. Then, the product was separated by centrifugation at 12,000 rpm for 10 min, washed with ethanol, and re-dispersed in ethanol. Hereafter, the product of Au/Cdots-decorated  $\text{SiO}_2$  nanocomposites will be designated as Au/Cdots- $\text{SiO}_2$  nanocomposites.

### **Characterization**

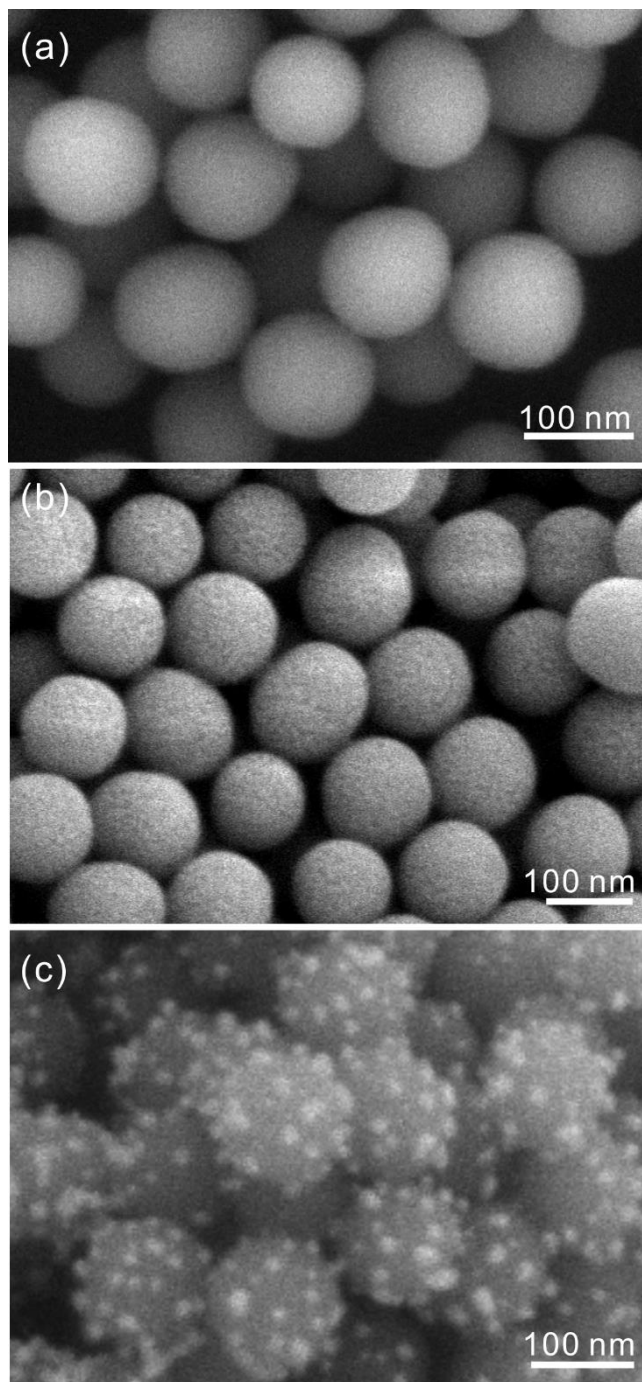
While transmission electron microscopy (TEM) images were measured using a Hitachi H-7600 microscope operating at 100 kV, high-resolution TEM (HRTEM) images and energy-dispersive X-ray (EDX) elemental mappings were measured utilizing a JEOL JEM-2100F microscope. Absorption spectra were measured using a Scinco S3100 UV-vis spectrophotometer, and field-emission scanning electron microscopy (FE-SEM) images were obtained with a ZEISS MERLIN Compact microscope. Light intensities were detected using a Gentec-EO Integra photodetector.



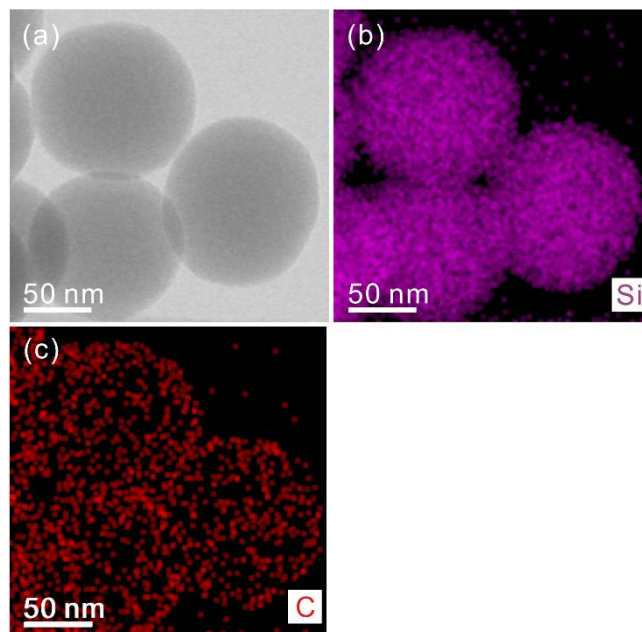
**Fig. S1** Synthetic route of a Cdots-SiO<sub>2</sub> nanocomposite using citric acid and APTES.



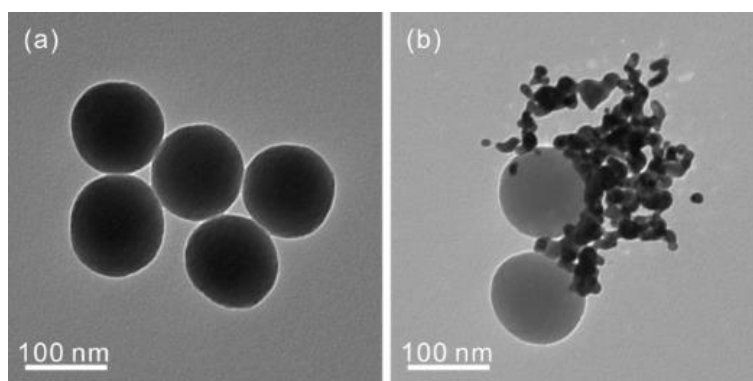
**Fig. S2** Absorption spectra of SiO<sub>2</sub> nanospheres (black) and Cdote-SiO<sub>2</sub> nanocomposites (red).



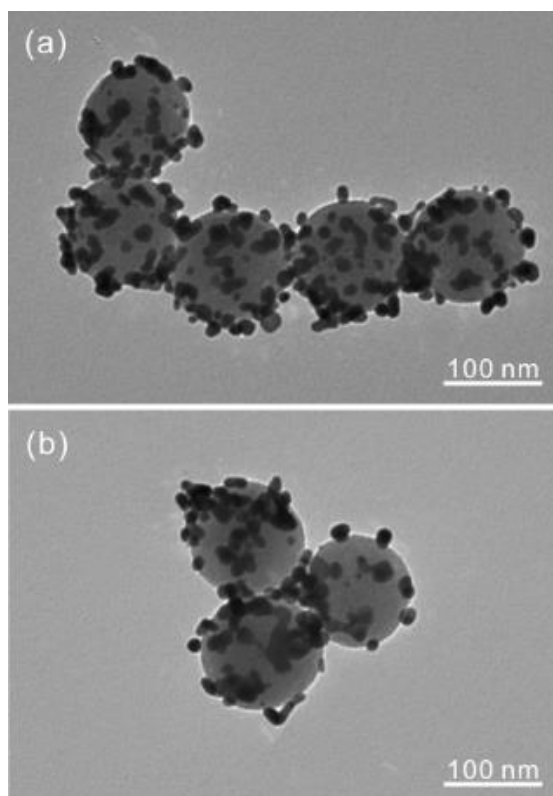
**Fig. S3** FE-SEM images of SiO<sub>2</sub> nanospheres (a), Cdots-SiO<sub>2</sub> nanocomposites (b), and Au/Cdots-SiO<sub>2</sub> nanocomposites (c).



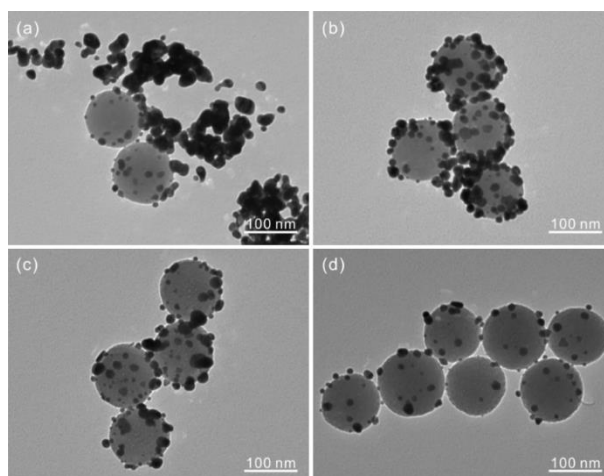
**Fig. S4** HRTEM image (a) and EDX elemental maps (b,c) of Cdots-SiO<sub>2</sub> nanocomposites.



**Fig. S5** TEM images of Au/Cdots-SiO<sub>2</sub> nanocomposites prepared with Cdots-SiO<sub>2</sub> nanospheres under the dark (a) and with Cdots-free SiO<sub>2</sub> nanospheres under light irradiation (b).



**Fig. S6** TEM images of as-prepared Au/Cdots-SiO<sub>2</sub> nanocomposites prepared via photodeposition at light intensities of 111 mW (a) and 57 mW (b).



**Fig. S7** TEM images of as-prepared Au/Cdots-SiO<sub>2</sub> nanocomposites prepared via photodeposition in 20 mL of various ethanol-water solutions:  $V_{\text{ethanol}}/V_{\text{water}}$  values are 0/20 (a), 10/10 (b), 15/5 (c), and 20/0 (d).