

One-step hydrothermal synthesis of chiral carbon dots and their effects on mung bean plant growth

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1. Detail experiments and procedures

1.1 TEM image: Transmission electron microscopy (TEM) images were acquired using a FEI/Philips Tecnai G2 F20 transmission electron microscope at an acceleration voltage of 200 kV. The L- or D-CDs (1 mg/mL) were dropt onto copper grid and dried under 25 °C.

1.2 XPS analysis: The X-ray photoelectron spectroscopy (XPS) was measured using an Axis Ultra DLD X-ray photoelectron spectroscope. The L- or D-CDs (1 mg/mL) were dropped onto cleaved mica surface and dried under 25 °C.

1.3 FTIR analysis: Fourier Transform Infrared (FT-IR) spectra of chiral CDs were obtained with a Perkin Elmer FT-IR spectrometer. The L- or D-CDs (1 mg/mL) were added into potassium bromide powder and the mixture was adequately grinded by mortar. Then the fine powder of CDs-KBr was dried in infrared lamp and tableted by a tablet pressing machine.

1.4 Optical property of chiral CDs

1.4.1 UV-Vis spectroscopy: The ultraviolet-visible (UV-Vis) absorption spectra were obtained with a Perkin Elmer UV-Vis spectrophotometer (Lambda 750) at 25 °C using a quartz cuvette with a 1 cm path-length.

1.4.2 CD spectra: The circular dichroism (CD) spectra were recorded on a JASCO J-815 spectropolarimeter at 25 °C using a quartz cuvette with a 1 mm path-length.

1.4.3 Photoluminescent spectroscopy: The steady state fluorescence spectra of chiral CDs was carried out with Fluoromax-4 (France Jobin Yvon Company) at 25 °C using a quartz cuvette with a 1 cm path-length.

Fluorescence quantum yield (QY) was measured in accordance with the method previous reported. Quinine sulfate in 0.10 mol/L H₂SO₄ (QY = 54%) was used as standard. The absorbance was kept below 0.15 to minimize the reabsorption effects. The QY values of chiral CDs were calculated according to the following equation:

$$Q = \frac{Q_R \cdot m \cdot n^2}{m_R \cdot n_R}$$

Here, Q and Q_R are quantum yields of chiral CDs and quinine sulfate. m and m_R are the slopes of the fluorescence intensity versus corresponding UV-Vis absorbance values of chiral CDs and quinine sulfate. n and n_R are the refractive index of chiral CDs and quinine sulfate.

The time resolved fluorescence decay experiments were carried out with a time-correlated single-photon counting (FL-TCSPC) spectrometer (HORIBA Jobin Yvon Company) at 25 °C using a quartz cuvette with a 1 cm path-length.

2. Supplementary figures

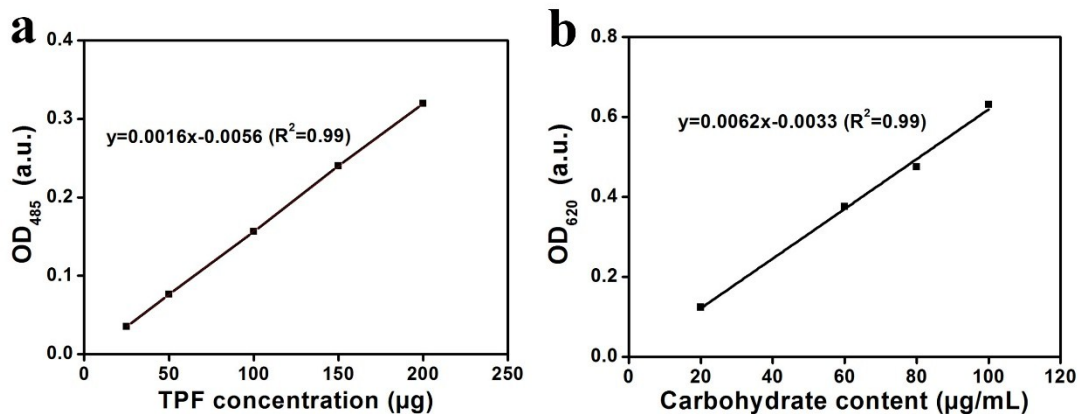


Fig. S1 standard curves of (a) root vigor and (b) carbohydrate content.

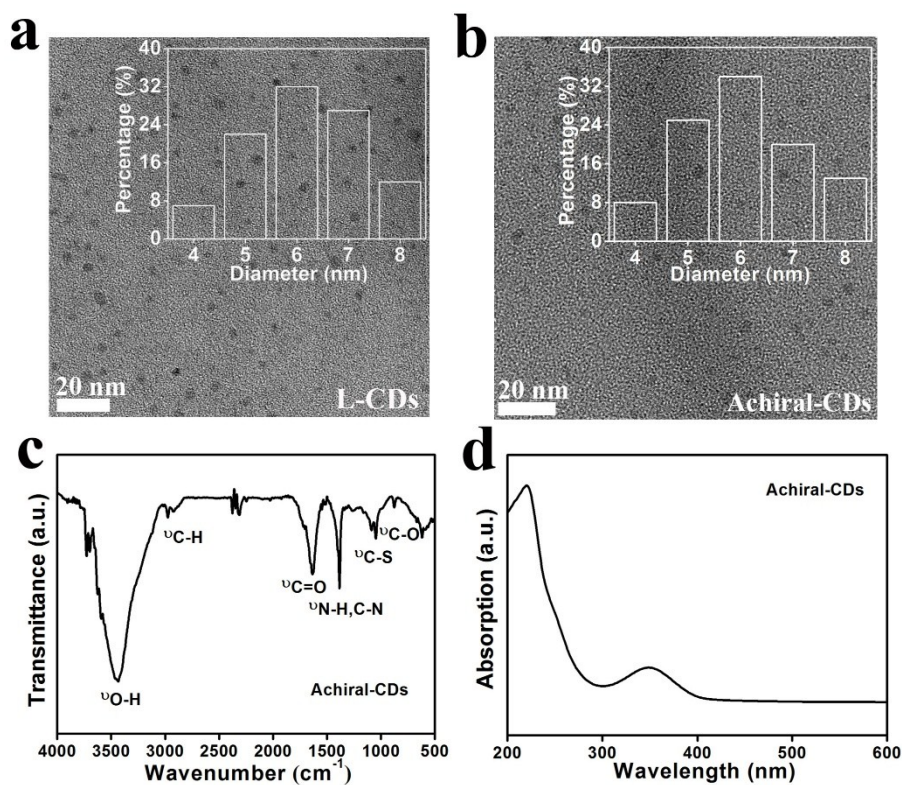


Fig. S2 TEM images of L-CDs (a) and achiral CDs (b); FTIR spectra (c) and UV-Vis absorption spectra (d) of achiral CDs.

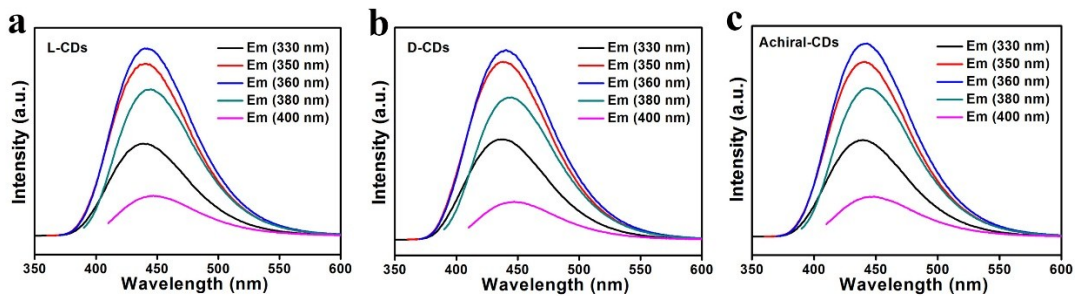


Fig. S3 PL spectra of L-CDs (a), D-CDs (b) and achiral CDs (c) with different excitation wavelength from 330 nm to 400 nm.

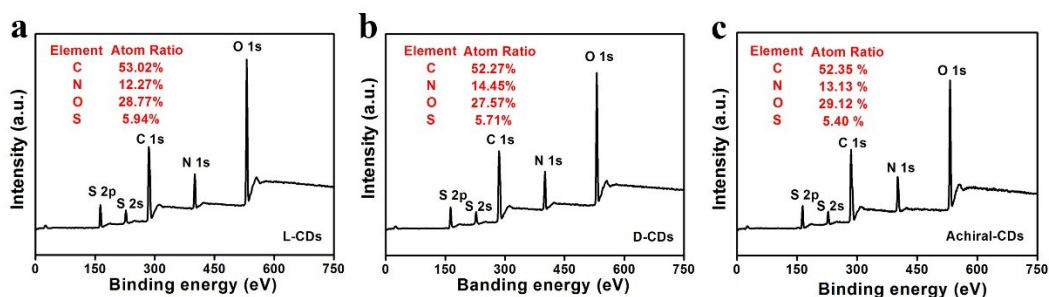


Fig. S4 Full scan XPS spectra of L-CDs (a), D-CDs (b) and achiral CDs (c).

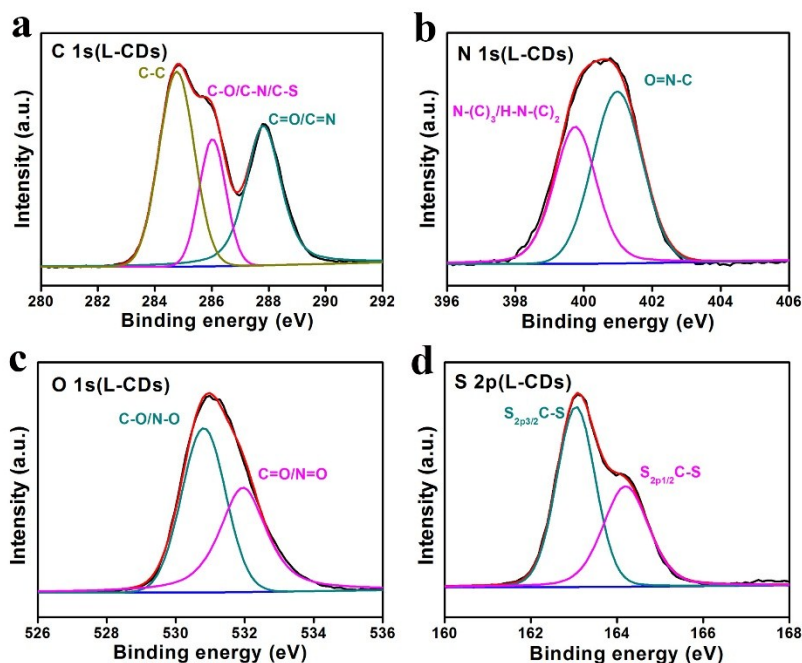


Fig. S5 High-resolution XPS spectra of (a) C 1s, (b) O 1s, (c) N 1s and (d) S 2p of L-CDs.

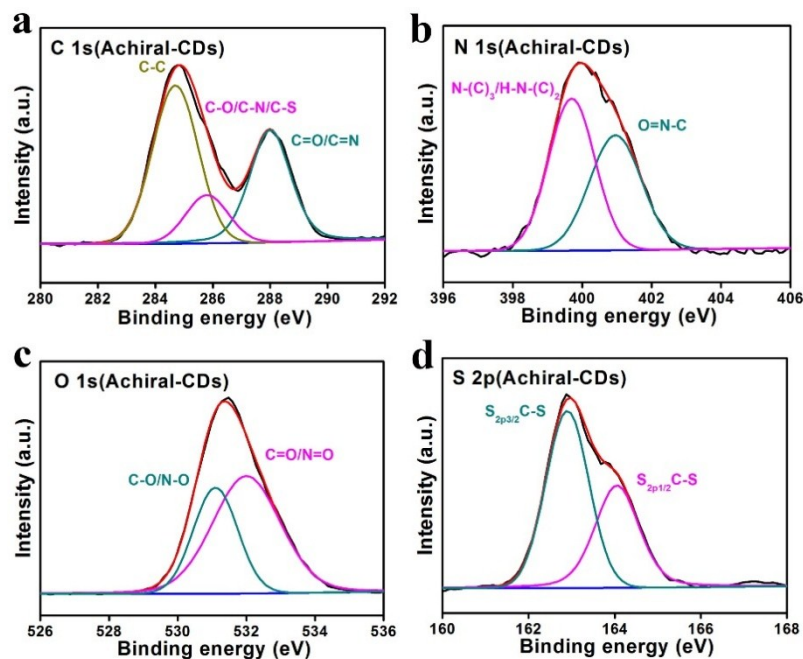


Fig. S6 High-resolution XPS spectra of (a) C 1s, (b) O 1s, (c) N 1s and (d) S 2p of achiral CDs.

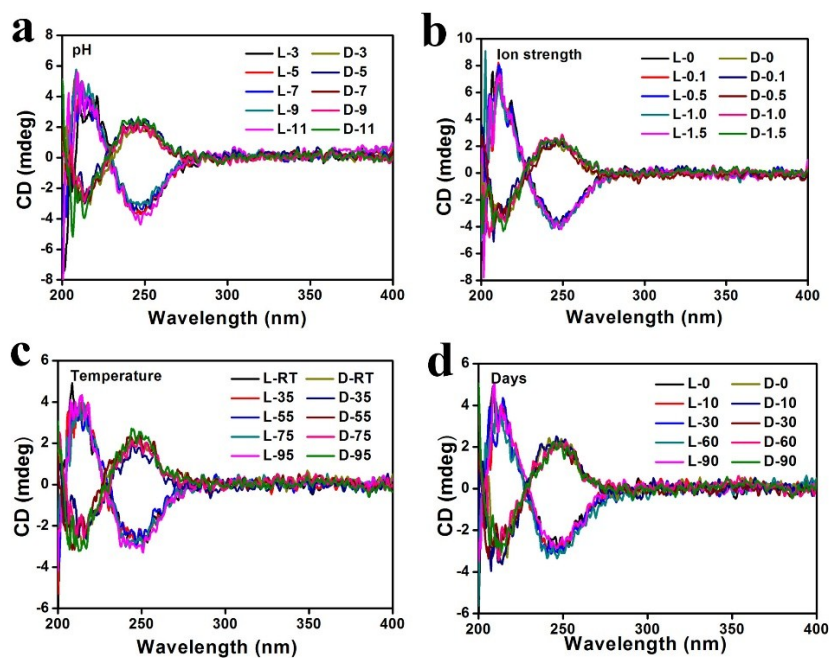


Fig. S7 CD spectra of L-CDs and D-CDs in different pH value (a, from 3.0 to 11.0); in different ionic strength (b, from 0 to 1.5 mol/L NaCl); in different temperature (c, from 20 to 100 °C); in different days (d, from 0 to 90 days).

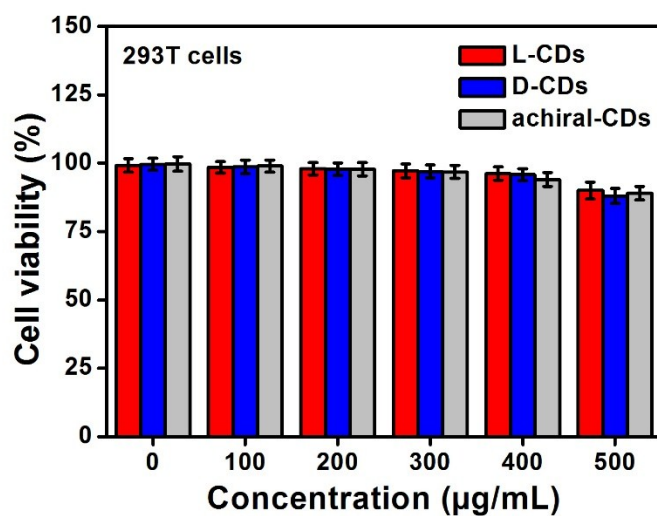


Fig. S8 Viability of 293T cells after 48 h of incubation with different concentrations of L-CDs (red trace), D-CDs (blue trace) and achiral CDs (gray trace).

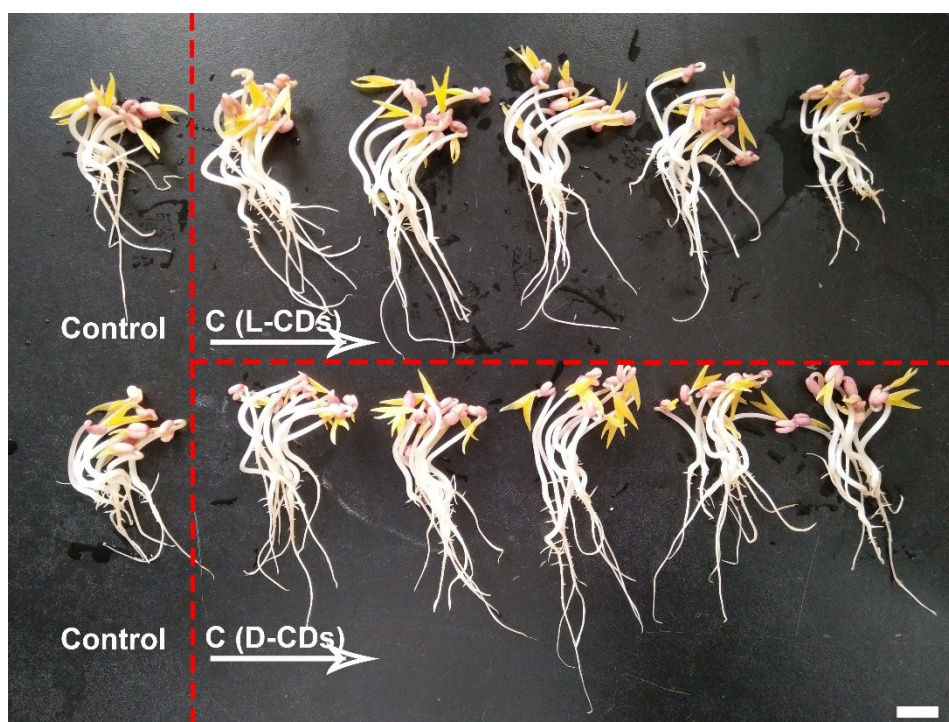


Fig. S9 Digital photo of mung bean plants after incubation for 5 days keep in dark place. Mung beans were grown in water (control), different chiral CDs solution with 0, 10, 50, 100, 500, 1000 µg/mL, respectively (from left to right). Scale bar: 1 cm.

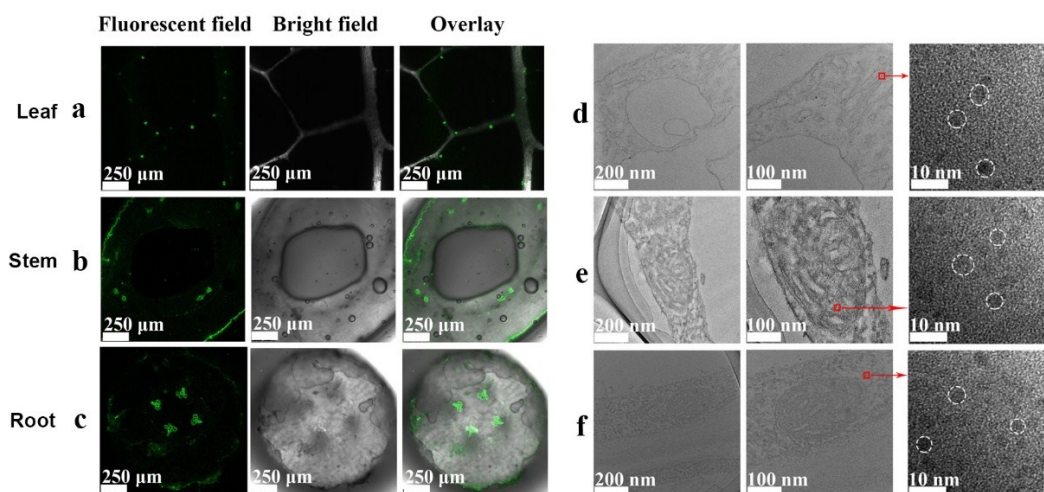


Fig. S10 TEM and LSM images of root, stem and leaf section of mung bean sprouts. Cultured with L-CDs solution (100 $\mu\text{g}/\text{mL}$) for 5 days. All mung beans were collected under same exposure conditions. The LSM images was under 405 nm laser excitation.

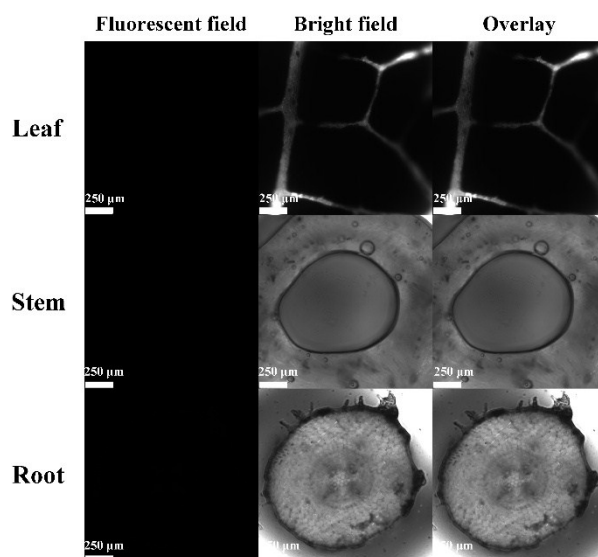


Fig. S11 LSM images of root, stem and leaf section of mung bean sprouts cultivated by pure water for 5 days. All mung beans were collected under same exposure conditions. The LSM images was under 405 nm laser excitation.

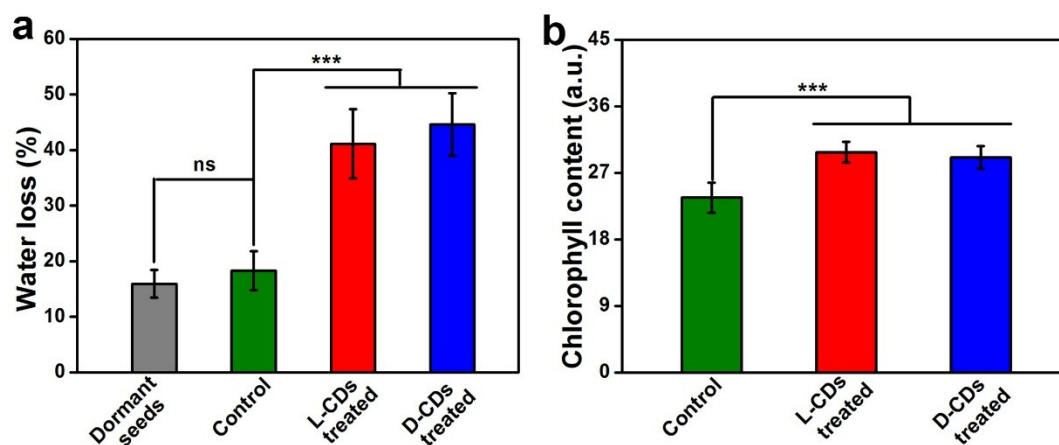


Fig. S12 (a) Water loss of dormant tomato seeds (gray trace), tomato seeds incubated with pure water (olive trace), 100 $\mu\text{g}/\text{mL}$ L-CDs (red trace) and 100 $\mu\text{g}/\text{mL}$ D-CDs (blue trace) in 25 $^{\circ}\text{C}$ for 4 h; (b) Chlorophyll content of mung bean sprouts cultured with pure water (olive trace), 100 $\mu\text{g}/\text{mL}$ L-CDs (red trace) and 100 $\mu\text{g}/\text{mL}$ D-CDs (blue trace) for 8 days. Ns (no significant differences) and*** ($P < 0.001$) indicate significant differences (* is the significance level, P is the P-value.).