

Electronic Supplementary Material

Sustainable nitrogen-doped carbon dots from biomass for ultrasensitive and selective fluorescent detection of isoliquiritigenin

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Fluorescence quantum yield measurements of NCDs

Quantum yields (Φ_X) were determined relative to quinine sulfate standard (QY = 54% in H_2SO_4 at 310 nm) under identical instrumental settings. To avoid inner-filter effects, sample and reference absorbance values were kept below 0.05 at 310 nm. Emission spectra were integrated over the full fluorescence band (corrected for instrument response), and the following relation was applied:

$$\phi_X = \phi_s \times \frac{F_{NCDs}}{F_S} \times \frac{A_S}{A_{NCDs}} \times \frac{\eta_{NCDs}}{\eta_S}$$

Φ_X represents the quantum yield of NCDs, ϕ_s represents the quantum yield of quinine sulfate, F_X is the fluorescence intensity of NCDs, F_S is the fluorescence intensity of standard (S, quinine sulfate), A refers to the absorbance value and η refers to the refractive index of the solvent (H_2SO_4). The synthesized NCDs were dissolved in distilled water ($\eta = 1.33$) and S was dissolved in H_2SO_4 ($\eta = 1.33$).

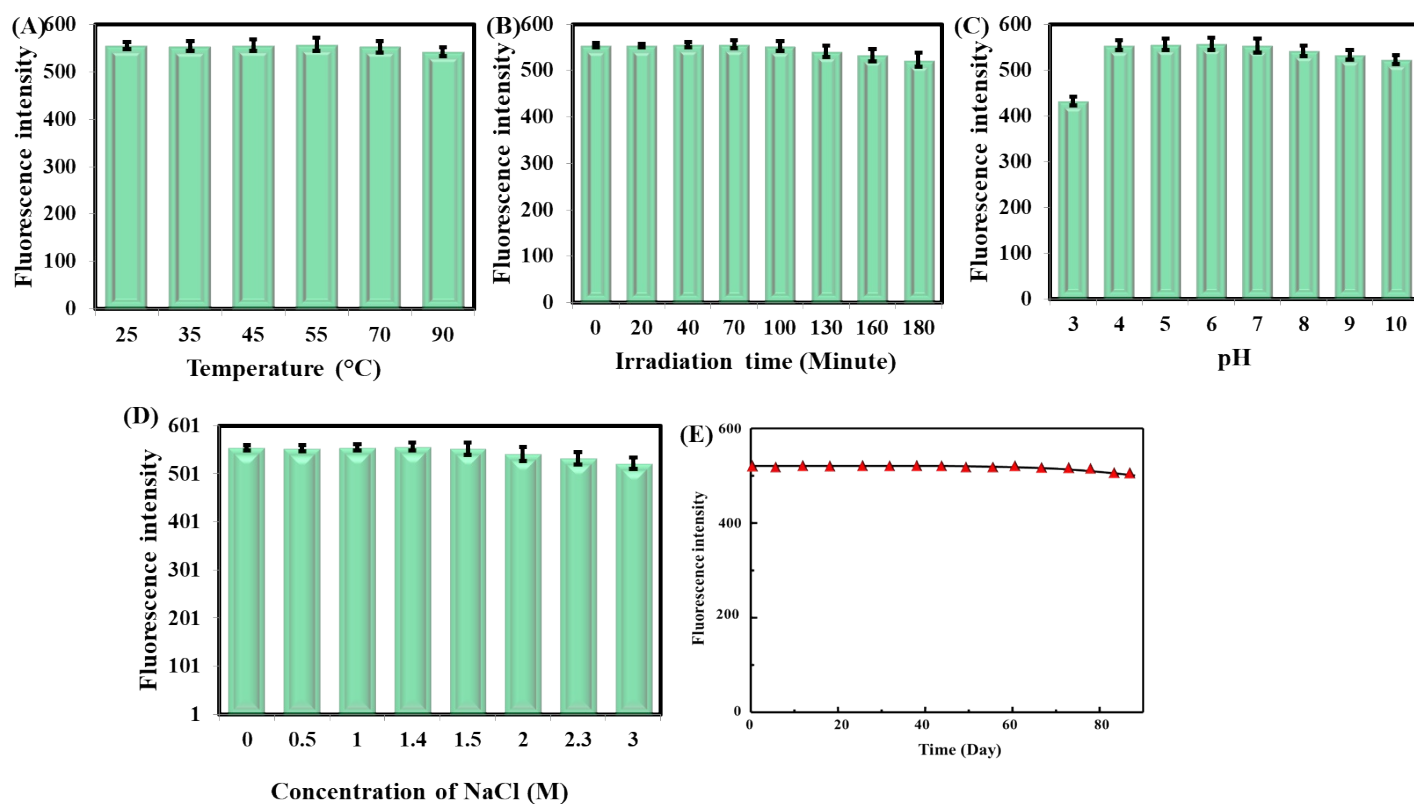


Fig. S1 Stability of biowaste-derived NCDs after exposure to different conditions: (A) temperature, (B) irradiation time, (C) pH, (D) ionic strength, and (E) storage time. Each data point represents the mean \pm SD of three independent measurements (n = 3).

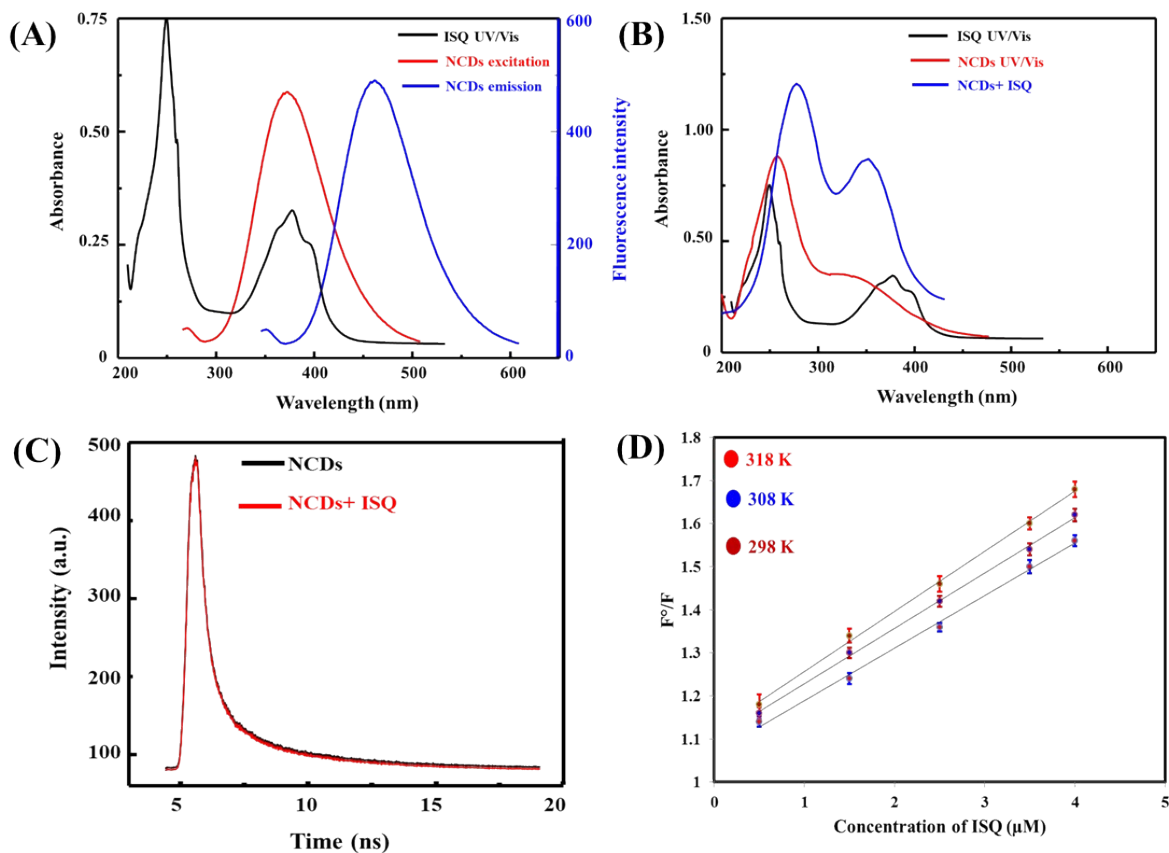


Fig. S2 (A) UV-Vis absorption spectrum of ISQ and excitation/fluorescence emission spectra of NCDs; (B) UV-Vis absorption spectra of ISQ, NCDs, and NCDs + ISQ; (C) Fluorescence lifetime decay curves of NCDs before and after ISQ addition; (D) Stern-Volmer plots for NCDs with increasing ISQ concentrations at different temperatures.

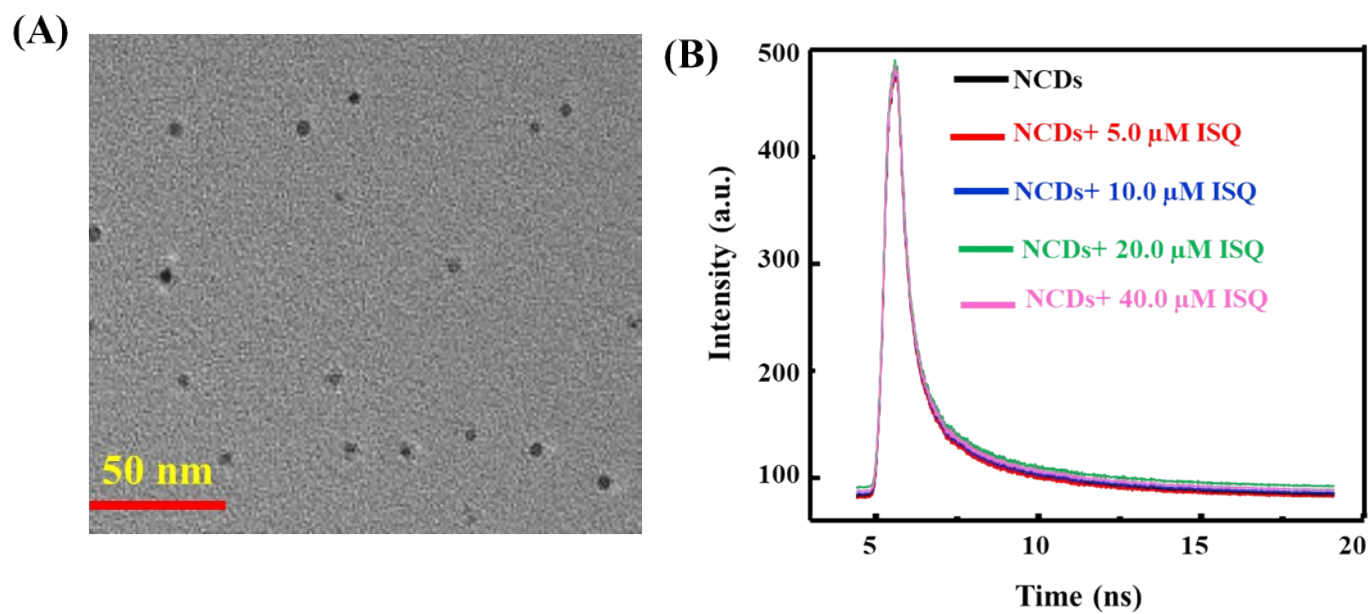


Fig. S3 (A) TEM image of NCDs after interaction with 50 μM ISQ and (B) Fluorescence lifetimes of NCDs before and after addition different amounts of ISQ.

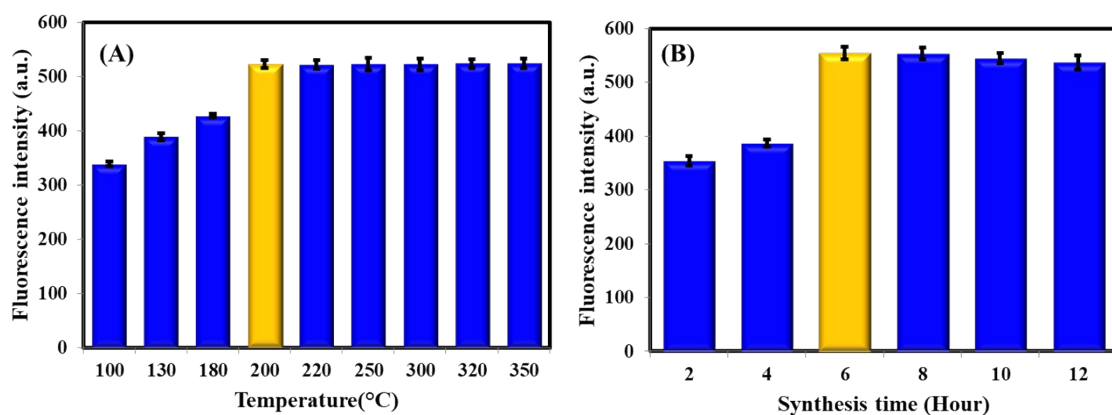


Fig. S4 Influence of synthesis temperature (A) and time (B) on the fluorescence emission of biowaste-derived NCDs. Each data point represents the mean \pm SD of three independent measurements ($n = 3$).

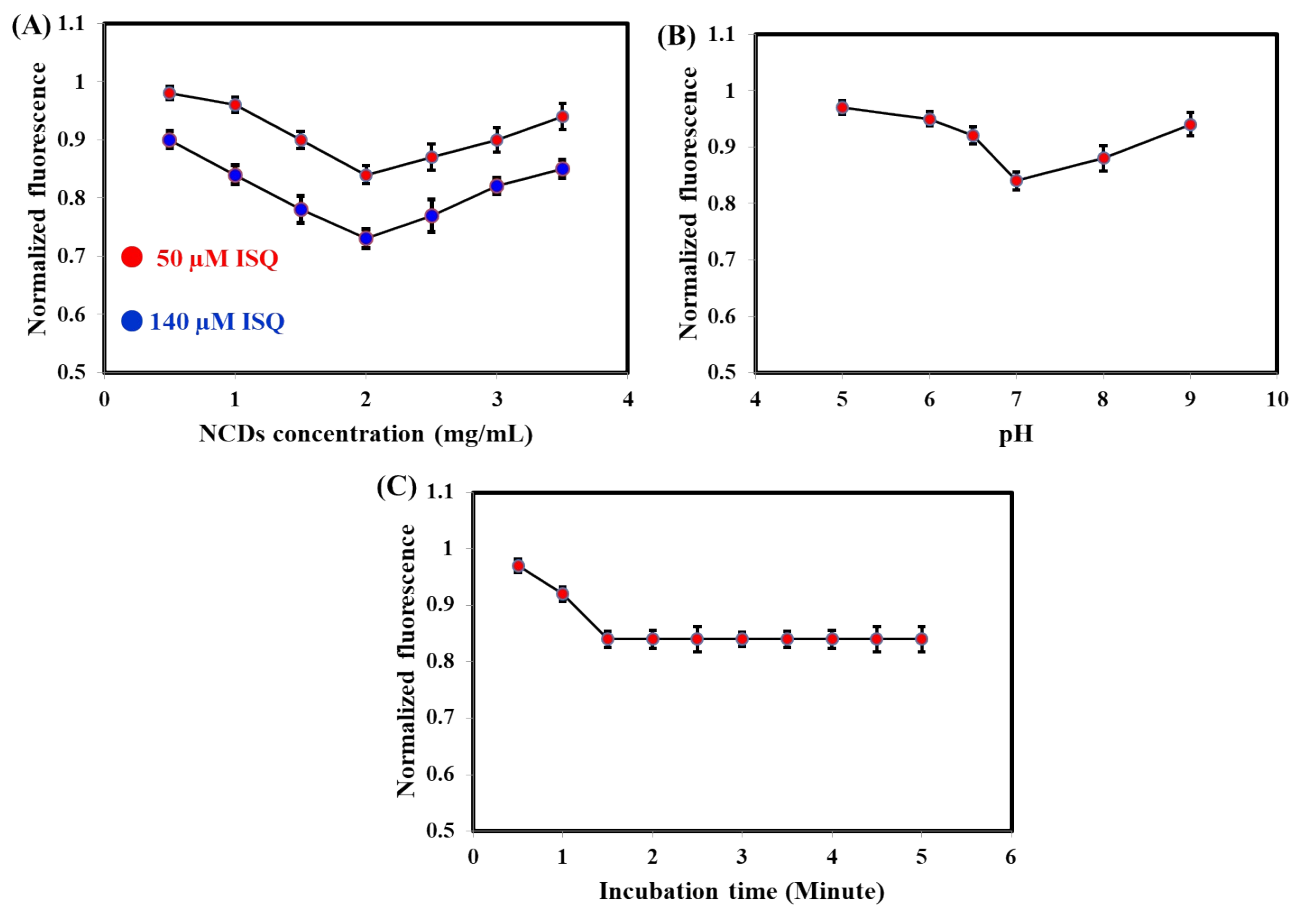


Fig. S5 Influence of NCDs concentration (A) on the detection of 50 and 140 μ M ISQ, pH (B), and incubation time (C) on the detection of 50 μ M ISQ. Each data point represents the mean \pm SD of three independent measurements ($n = 3$).

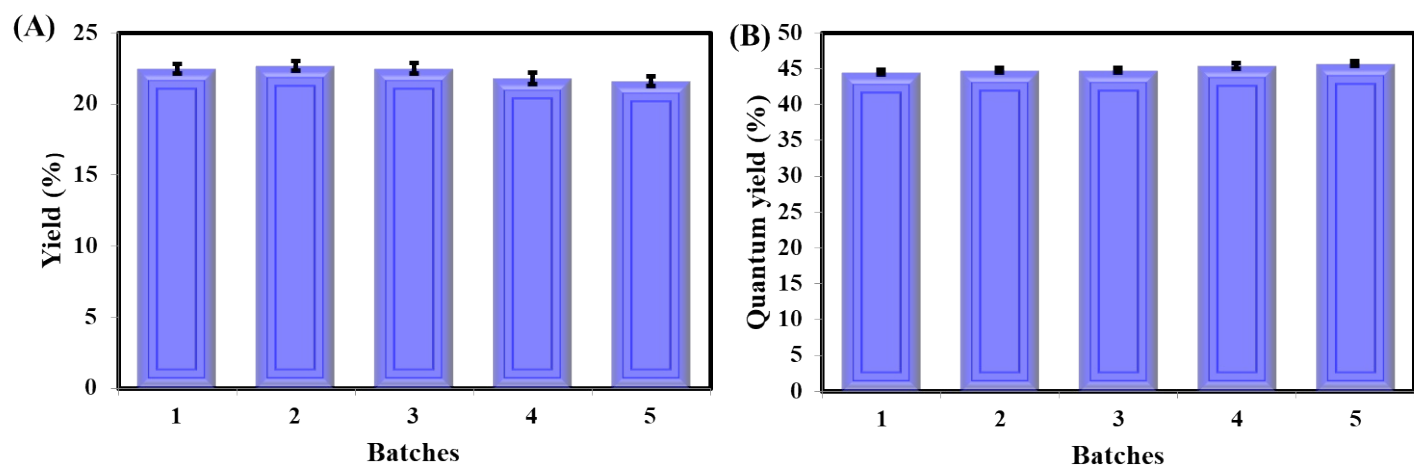


Fig. S6 Batch-to-batch reproducibility and scalability of the as-prepared NCDs. Each data point represents the mean \pm SD of three independent measurements ($n = 3$).

Table S1 Batch-to-batch reproducibility and scalability of the as-prepared NCDs (n=3).

Batch No.	Yield (%)	Quantum yield (%)	Emission peak (nm)	Purity	Zeta potential (mV)
1	22.5± 0.14	44.2± 0.13	465± 0.08	High	-22.4± 0.14
2	21.8± 0.11	44.6± 0.15	466± 0.07		-22.1±0.15
3	22.3± 0.15	44.8± 0.15	465± 0.08		-22.5± 0.14
4	21.9± 0.12	44.5± 0.13	465± 0.09		-22.3± 0.13
5	22.1± 0.13	44.7± 0.12	465± 0.08		-22.6± 0.14

All batches synthesized under identical conditions (220 °C, 4 h, 5 g biomass, dialysis at 1000 Da, 30 mL water).

Table S2 Comparative green metrics between NCDs and other techniques/sensors.

Metric	HPLC	CE	NCDs (this work)	Other CDs
Energy per batch	~1.8– 2.5 kWh/run	~1.5 kWh/run	~1.0 kWh (220 °C, 4 h)	Varies (pyrolysis ~2–5 kWh)
Solvent use	High (methanol, acetonitrile)	Moderate	None (aqueous)	Some require organic solvents (solvothermal)
Hazardous waste	Organic waste	Capillary effluent	None	Depends on feedstock
Biowaste valorized	None	None	Potato peel (food waste)	Varies
Heavy metal/leaching risk	Not applicable	Not applicable	None detected	Risk if doped with metals
Green chemistry rating	Low	Medium	High	Variable