Supporting Information

Parameters Affecting Synthesis of Carbon Dots for Quantitation of Copper Ions

Yu-Syuan Lin,†+ Yaling Lin,†+ Arun Prakash Periasamy,† Jinshun Cang ‡ and Huan-Tsung Chang*,†,§

†Department of Chemistry, National Taiwan University, Taipei 10617, Taiwan
‡ Department of Chemical Engineering, Yancheng Institute of Industry Technology, Yancheng, Jiangsu 224005, China
§Department of Chemistry, Chung Yuan Christian University, Taoyuan City 32023, Taiwan
+These authors contributed equally to this work

Corresponding Author: Professor Huan-Tsung Chang, Department of Chemistry, National Taiwan University, 1, Section 4, Roosevelt Road, Taipei 10617, Taiwan. Tel and fax: 011-886-2-33661171. E-mail: changht@ntu.edu.tw

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Table S1. Elemental compositions (%) of four types of C dots before and after reaction with Cu²⁺ ions.

| Elements | C dots | Cl-C dots | Br-C dots | I-C dots | I-C dots + Cu²⁺ |
|----------|--------|-----------|-----------|----------|-----------------|
| C        | 68.79  | 66.40     | 57.00     | 59.70    | 44.84           |
| N        | 14.52  | 15.35     | 17.73     | 15.30    | 6.50            |
| O        | 16.33  | 17.61     | 23.96     | 23.33    | 47.15           |
| I        | - a    | -         | -         | 1.46     | 0.55            |
| Br       | -      | -         | 0.95      | -        | -               |
| Cl       | 0.37   | 0.64      | 0.23      | 0.21     | 0.22            |

a not detected
Table S2. Quantitation of Cu$^{2+}$ ions using different nanomaterial probes.

| Probe                  | Linear range (μM) | LOD (μM) | Ref. |
|------------------------|-------------------|----------|------|
| $^a$CdSe@C-TPEA        | 1-100             | 1        | 1    |
| $^b$ZnS QDs            | 26-260            | 7.1      | 2    |
| $^c$Probe L            | 4-12              | 1.8      | 3    |
| $^d$B, N-C dots        | 1-25              | 0.3      | 4    |
| Cys-CdS QDs            | 2-10              | 1.5      | 5    |
| C dots                 | 5.16-20           | 1.72     | 6    |
| Petroleum coke C dots  | 0.25-10           | 0.029    | 7    |
| N-C dots               | 0.6-30            | 0.19     | 8    |
| I-C dots               | 0.3-3             | 0.22     | This study |

$^a$TPEA: N-(2-aminomethyl)-N,N,N’tris(pyridin-2-ylmethyl)ethane-1,2-diamine.
$^b$QDs: quantum dots.
$^c$Probe L prepared from 4-bromo-1,8 naphthalene anhydride and 2-thiophene formaldehyde.
$^d$B, N-C dots prepared from aminophenylboronic acid.
$^e$CQD: carbon quant
Fig. S1. TEM images of (A) C dots, (B) Cl-C dots, (C) Br-C dots, and (D) I-C dots. Insets: HRTEM images of the corresponding C dots.
**Fig. S2.** FTIR spectra of (a) histidine, (b) C dots, (c) Cl-C dots, (d) Br-C dots, (e) I-C dots, and (f) I-C dots after reaction with 100 µM Cu\(^{2+}\) ions.
Fig. S3. Deconvoluted (A) C1s and (B) N1s core level XPS spectra of (a) C dots, (b) Cl-C dots, (c) Br-C dots, and (d) I-C dots. (C) Deconvoluted Cu$_{2p3/2}$ core level spectra of I-C dots after reaction with 100 µM Cu$^{2+}$ ions.
Fig. S4. Raman spectra of (A) C dots, (B) Cl-C dots, (C) Br-C dots, and (D) I-C dots.
Fig. S5. Effects of (A) pH (3.0–11.0) and (B) NaCl concentration (0–3.0 M) on the stability of (a) C dots, (b) Cl-C dots, (c) Br-C dots, and (d) I-C dots. C dots: 0.01X; phosphate solutions: 20 mM; excitation and emission wavelengths: 420 and 505 nm, respectively.
Fig. S6. Selectivity of (a) C dots, (b) Cl-C dots, (c) Br-C dots, and (d) I-C dots toward the detection of Cu$^{2+}$ ions (100 µM) over the other metal ions (100 µM) in phosphate buffer (20 mM, pH 3.0). The concentrations of the four C dots used are all 0.01X. Other conditions are the same as in Fig. 2.
Fig. S7. (A) CV curves and (B) EIS spectra of bare GCE recorded in phosphate buffer (20 mM, pH 3.0) under different conditions. (A) I-C dots were dispersed in phosphate buffer (20 mM, pH 3.0) solution (a) without and (b-f) with containing Cu$^{2+}$ and Fe$^{3+}$ (200 µM). Cu$^{2+}$ ion concentrations (µM) used are (b) 100, (c) 200, (d) 300, (e) 400, and (f) 500. Fe$^{3+}$ was added as a control. Scan rate for CV curves is 50 mV s$^{-1}$. (B) EIS spectra were recorded over the frequency range from 0.01 to 10000 Hz at an amplitude of 5 mV in N$_2$ saturated phosphate buffer (a) without I-C dots, (b) with I-C dots, and (c) with I-C dots and 100 µM Cu$^{2+}$ ions. Inset in (B): Magnified view of high frequency region of EIS spectra.
Fig. S8. Linearity of relative PL intensity at 505 nm of I-C dots (0.001X) toward the quantitation of Cu$^{2+}$ ions in (A) tap water, (B) lake water, and (C) seawater. Samples were mixed with phosphate buffer (20 mM, pH 3.0), and standard Cu$^{2+}$ solutions. Other conditions are the same as in Fig. 2.
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