An "on-off-on" selective fluorescent probe based on nitrogen and sulfur co-doped carbon dots for detecting Cu$^{2+}$ and GSH in living cells

Shanshan Wei,$^{a,b}$ Tinghua Li,$^{a,b}$ Xingyu Zhang,$^{a,b}$ Hongyuan Zhang,$^{a,b}$ Chunzhu Jiang,$^{a,*}$ and Guoying Sun$^{a,b,*}$

$^a$School of Chemistry and Life Science, Changchun University of Technology, 2055 Yanan Street, Changchun 130012, P. R. China

$^b$Advanced Institute of Materials Science, Changchun University of Technology, 2055 Yanan Street, Changchun 130012, P. R. China. E-mail: sunguoying@ccut.edu.cn
Figure. S1 (a) The TEM images of N, S-CDs/Cu²⁺. (b) The TEM images of N, S-CDs/Cu²⁺/GSH. (c) The XRD pattern of the N, S-CDs. (d) Raman spectroscopy of N, S-CDs.

Figure. S2 (a) The reaction temperature (140-160 °C), (b) reaction time (1-5h) of N, S-CDs.
**Figure. S3** (a) Relationship between reaction time (0-60 min) of N, S-CDs/Cu$^{2+}$. (b) Reaction time (0-60 min) of N, S-CDs/Cu$^{2+}$/GSH. (c) Fluorescence spectra of N, S-CDs treated with different concentrations of NaCl solutions. (d) Fluorescence spectra of N, S-CDs (red) and N, S-CDs$^+$ H$_2$O$_2$ (black) (e) Fluorescence spectra of N, S-CDs irradiation for 3 hours under UV light.

**Figure. S4** The N, S-CDs is irradiated at a wavelength of 365 nm with an ultraviolet lamp, a is the N, S-CDs, b is the N, S-CDs/Cu$^{2+}$ and c is the N, S-CDs/Cu$^{2+}$/GSH.
**Figure. S5** UV-vis absorption spectra of N, S-CDs and N, S-CDs/Cu^{2+}.

**Figure. S6** Zeta potential of N, S-CDs, N, S-CDs/Cu^{2+} and N, S-CDs/Cu^{2+}/GSH,
Figure. S7 UV-vis absorption spectra of N, S-CDs (red), N, S-CDs/Cu$^{2+}$ (blue), and N, S-CDs/Cu$^{2+}$/GSH (black).

Table S1 Optical parameters of pH, reaction time and used amount for the detection of Cu$^{2+}$ and GSH

<table>
<thead>
<tr>
<th>Analyte</th>
<th>pH</th>
<th>Time (min)</th>
<th>Amount (μL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cu$^{2+}$</td>
<td>7</td>
<td>10</td>
<td>50</td>
</tr>
<tr>
<td>GSH</td>
<td>7</td>
<td>10</td>
<td>100</td>
</tr>
</tbody>
</table>