Supplementary Nanomaterials: Cultivating Fluorescent Flowers with Highly Luminescent Carbon Dots Fabricated by A Double Passivation Method

Shuai Han 1,2, Tao Chang 1, Haiping Zhao 2, Huanhuan Du 1, Shan Liu 1, Baoshuang Wu 1 and Shenjun Qin 2,*

1 College of Materials Science and Engineering, Hebei University of Engineering, Handan 056038, China; hansh04@163.com (S.H.); changt03@sina.com (T.C.); hebei123hh@sina.com (H.D.); ls10280924@sina.com (S.L.); hebeiwbs@163.com (B.W.)

2 Key Laboratory of Resource Exploration Research of Hebei Province, Hebei University of Engineering, Handan 056038, China; hansh04@163.com (S.H.); zhaohaiping609@163.com

* Correspondence: qinsj528@hebeu.edu.cn (S.Q.); Tel.: +86-0310-857-7902
Figure S1. TEM images of ECD (a), Ca-1-CD (b), Ca-2-CD (c).

Table S1. The QY results of the three CD samples in aqueous solution.

<table>
<thead>
<tr>
<th></th>
<th>ECD</th>
<th>Ca-1-CD</th>
<th>Ca-2-CD</th>
</tr>
</thead>
<tbody>
<tr>
<td>QY(%)</td>
<td>73.1</td>
<td>81.3</td>
<td>86.1</td>
</tr>
</tbody>
</table>

Figure S2. The Ca-2-CD aqueous solution under natural light irradiation (0.1 $\mu$g·mg$^{-1}$).

Figure S3. The cyclic voltammogram of the ECD (a), Ca-1-CD (b), Ca-2-CD (c) and 0.1 mol/L KCl aqueous solution (the scan rate: 30 mV/s).
Data notes:

To estimate their HOMO and LUMO energy levels, cyclic voltammetry (CV) was carried out by using a standard three-electrode system, which consisted of glassy carbon electrode as the working electrode, a platinum wire as the counter electrode, and calomel electrode as the reference electrode. CV was recorded in DI-water containing CMCD and 0.1 M KCl as the supporting electrolyte. The HOMO and LUMO energy levels in eV of CMCD were calculated according to the following equations:

\[
E_{\text{HOMO}} = -e(E_{\text{ox}} + 4.4) \text{ (eV)} \tag{1}
\]

\[
E_{\text{LUMO}} = -e(E_{\text{red}} + 4.4) \text{ (eV)} \tag{2}
\]

\[
E_g = -e\Delta E \tag{3}
\]

\[
\Delta E = E_{\text{ox}} - E_{\text{red}} \tag{4}
\]

where \(E_{\text{ox}}\) and \(E_{\text{red}}\) are the onset of oxidation and reduction potential, which are the potentials corresponding to the the maximum forward current and the backward current. \(E_g\) is the energy gap, respectively.\[S5\]

Finally, we could calculate the energy gaps listed as below:

\[E_{\text{ECD}} = 3.57\text{ eV}, \ E_{\text{Ca-1-CD}} = 3.60\text{ eV}, \ E_{\text{Ca-2-CD}} = 3.62\text{ eV}\]

where \(E_{\text{ECD}}, E_{\text{Ca-1-CD}}\) and \(E_{\text{Ca-2-CD}}\) are the energy gaps of ECD, Ca-1-CD and Ca-2-CD, respectively.

![Figure S4. Luminescence decay curve of the three CD samples recorded at room temperature in aqueous solution (a. ECD, b. Ca-1-CD, c.Ca-2-CD).](image)

Data notes:

The emission decay curve was monitored under the excitation wavelength at 360 nm, and two exponents were shown for the three curves (Table S2). The average lifetime \(<\tau>\) is estimated by the following equation:

\[
<\tau> = \frac{\sum A_i \tau_i^2}{\sum A_i \tau_i}
\]

where \(A_i\) is the preexponential factor related to the statistical weights of each exponential and \(\tau_i\) represent the lifetimes of each exponential decay. The lifetimes of the CD samples are shown below:

<table>
<thead>
<tr>
<th></th>
<th>ECD</th>
<th>Ca-1-CD</th>
<th>Ca-2-CD</th>
</tr>
</thead>
<tbody>
<tr>
<td>(E_{\text{ECD}})</td>
<td>3.57 eV</td>
<td>3.60 eV</td>
<td>3.62 eV</td>
</tr>
</tbody>
</table>

Table S2. The lifetimes (\(\tau\)) and the average lifetimes (<\(\tau\>) of the three CD samples.
Figure S5. The results of the longevity-observing tests (left, the longevity of ordinary carnations; right, the longevity of fluorescent carnations).