Enhancing photosensitivity of $C_{60}$ nanorod visible photodetectors by coupling with Cu$_2$O nanocubes

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1. TEM images of the as-prepared Cu$_2$O nanocubes

Figure S1 (a) TEM and HRTEM images of the as-synthesized Cu$_2$O NCs.

2. The absorption spectra of Cu$_2$O nanocubes

Figure S2 (a) Absorption spectra of Cu$_2$O nanocubes in different solvents and (b)
plotted curve of \((ahv)^2\) against \((hv)\).

As shown in Figure S2(a), the absorption spectra of Cu$_2$O nanocubes are different in different solvents. In most relevant works, ethanol is chose as the solvent of absorption spectrum measurement of Cu$_2$O nanocubes, especially involved in calculation of bandgap. So, in this work, the \((ahv)^2 - hv\) curve of Cu$_2$O nanocubes (shown in Figure S2(b)) was converted from the absorption spectrum of Cu$_2$O nanocubes in ethanol.

3, The \((ahv)^2 - hv\) curve of pure C$_{60}$ nanorods

![Figure S3 (ahv)$^2$ - hv curve of C$_{60}$ nanorods.](image)

4, LUMO/HOMO measurements

The LUMO and HOMO energy levels of C$_{60}$ NRs and Cu$_2$O NCs were measured via cyclic voltammetry (CV). A standard three-electrode system was adopted, including a SCE as the reference electrode, a platinum mesh as the counter electrode, and a glassy carbon as the working electrode. The supporting electrolyte is DMF containing 0.1 M tetrabutylammonium hexafluorophosphate (TBAPF$_6$). The
LUMO energy level has been determined using following equation:

\[
E_{LUMO} (eV) = -4.8 - (E_{onset}^{red} (vs \ SCE) - E_{Fc/Fc^+} (vs \ SCE))
\]

\[
E_{Fc/Fc^+: E_{1/2}} vs \ SCE.
\]

Herein, \(E_{1/2}\) is 0.566 V (shown in Figure S3).

The onset reduction potentials of C_{60} NRs and Cu_{2}O NCs are -0.14V and -0.74V, respectively (shown in Figure S4 and Figure S5). Accordingly, the LUMO energy level of C_{60} NRs and Cu_{2}O NCs are -4.05 eV and -3.45 eV, respectively.

The HOMO energy level was calculated as follows:

\[
E_{HOMO} (eV) = E_{LUMO} - E_g
\]

The energy of bandgap (\(E_g\)) was obtained from absorption spectra. For C_{60} NRs and Cu_{2}O NCs, \(E_{HOMO}\) are -5.89 eV (\(E_g=1.84\) eV ,shown in Figure S2) and -5.55 eV (\(E_g=2.1\) eV ,shown in Figure S1(b)), respectively.

**Figure S4.** \(Fc/Fc^+\) is internal reference for the measurements. \(E_{1/2}\) is 0.566V for \(Fc/Fc^+\) vs SCE.
Figure S5. CV curve of C$_{60}$ NRs on glassy carbon electrode.

Figure S6. CV curve of Cu$_2$O NCs on glassy carbon electrode.

5. Performance comparison of the photodetectors

<table>
<thead>
<tr>
<th>Active Material</th>
<th>Wavelength</th>
<th>Sensitivity (folds)</th>
<th>$t_{\text{rise}}$</th>
<th>$t_{\text{fall}}$</th>
<th>Year/Ref.</th>
</tr>
</thead>
<tbody>
<tr>
<td>C$_{60}$-ribbon</td>
<td>UV/Visible</td>
<td>25</td>
<td>500ms</td>
<td>500ms</td>
<td>2013$^1$</td>
</tr>
<tr>
<td>Cu$_2$O/ZnO</td>
<td>UV/Visible</td>
<td>25</td>
<td>&lt;100ms</td>
<td>&lt;100ms</td>
<td>2014$^2$</td>
</tr>
<tr>
<td>P3HT/CdSe NCs/ PbS NCs /C$_{60}$ NR</td>
<td>UV/Visible</td>
<td>400</td>
<td>7.5ms</td>
<td>-</td>
<td>2014$^3$</td>
</tr>
<tr>
<td>C$_{60}$ NR/Cu$_2$O NC</td>
<td>Visible</td>
<td>72.5</td>
<td>50ms</td>
<td>10ms</td>
<td>This work</td>
</tr>
</tbody>
</table>

Table S1. Comparison on the performance of the related photodetectors
To compare the performance of fullerene-based and metal oxides-based photodetectors, some related researches are listed in Table S1. The sensitivity of the C_{60}-ribbon photodetector is outstanding, and the response time may be improved by coupling with photodopants. For the Cu_{2}O/ZnO photodetector, both sensitivity and response time have potential to be optimized. P3HT/CdSe NC/PbS NC/C_{60} NR photodetector exhibits ultrahigh photoelectric performance due to the contribution of various photodopants (P3HT, CdSe NCs and PbS NCs) in the C_{60} NR-based system. Our photodetector has achieved photosensitivity of ~ 72.5 folds under 405 nm light illumination and moderately fast response. Therefore, the C_{60} NR/Cu_{2}O NC composite is suitable for detecting visible light signals.