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Enhancing photosensitivity of C_{60} nanorod visible photodetectors by coupling with Cu_2O nanocubes

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1, TEM images of the as-prepared Cu_2O nanocubes

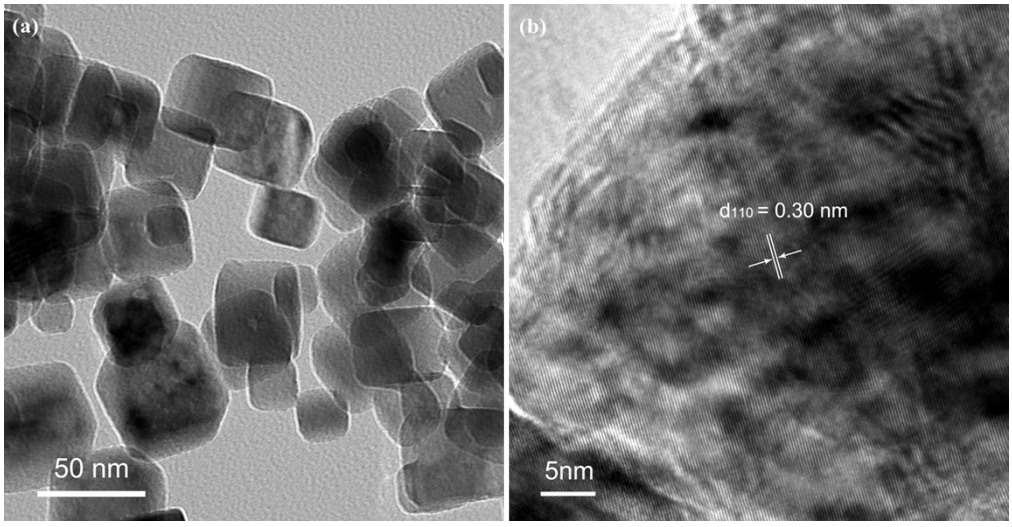

Figure S1 (a) TEM and HRTEM images of the as-synthesized Cu_2O NCs.

2, The absorption spectra of Cu_2O nanocubes

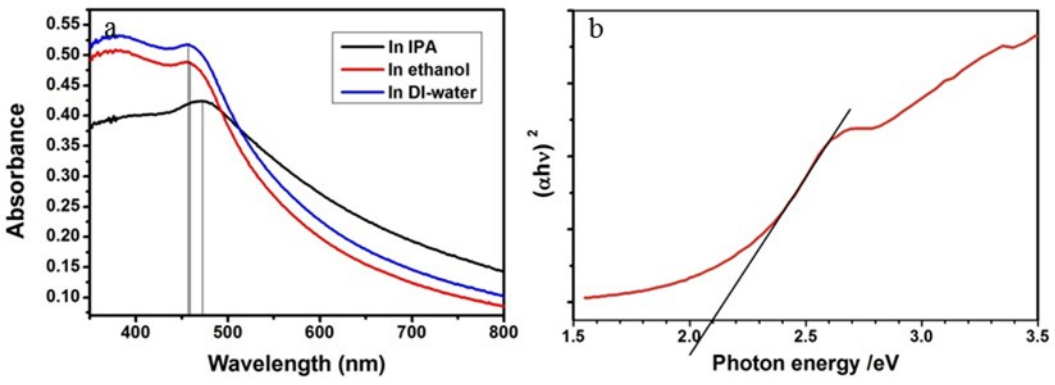

Figure S2 (a) Absorption spectra of Cu_2O nanocubes in different solvents and (b)

plotted curve of $(\alpha hv)^2$ against (hv).

As shown in Figure S2(a), the absorption spectra of Cu_2O nanocubes are different in different solvents. In most relevant works, ethanol is chose as the solvent of absorption spectrum measurement of Cu_2O nanocubes, especially involved in calculation of bandgap. So, in this work, the $(\alpha hv)^2$ - hv curve of Cu_2O nanocubes (shown in Figure S2(b)) was converted from the absorption spectrum of Cu_2O nanocubes in ethanol.

3, The $(\alpha hv)^2$ - hv curve of pure C_{60} nanorods

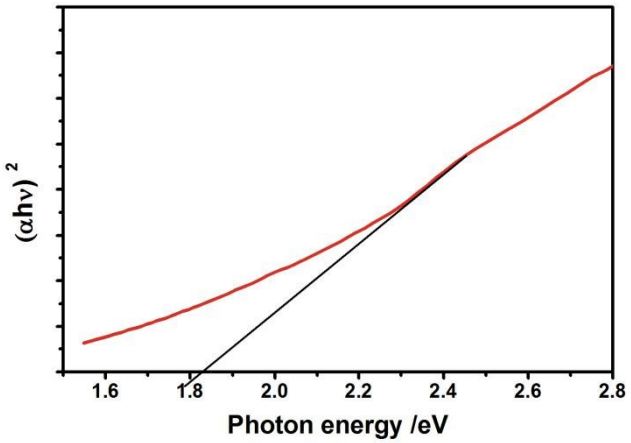

Figure S3 $(\alpha hv)^2$ - hv curve of C_{60} nanorods.

4, LUMO/HOMO measurements

The LUMO and HOMO energy levels of C_{60} NRs and Cu_2O 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:

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

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_2O 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_2O 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_2O 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.

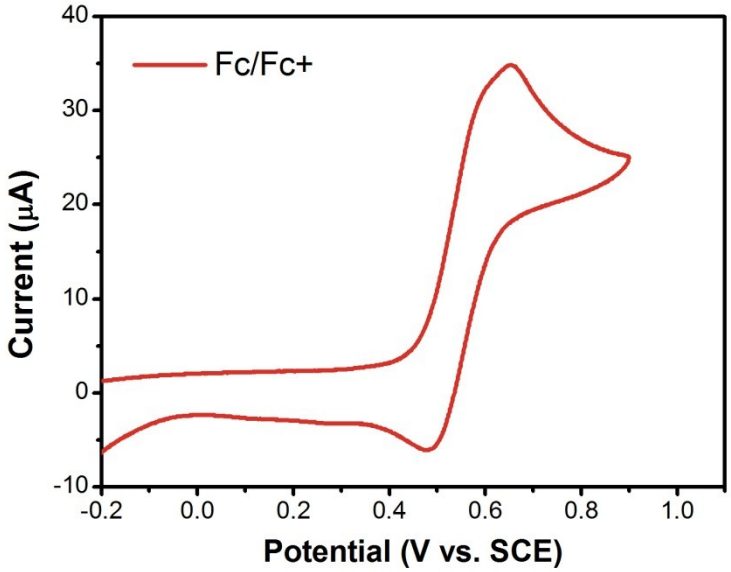

Figure S4. Fc/Fc^+ is internal reference for the measurements. $E_{1/2}$ is 0.566V for Fc/Fc^+ vs SCE.

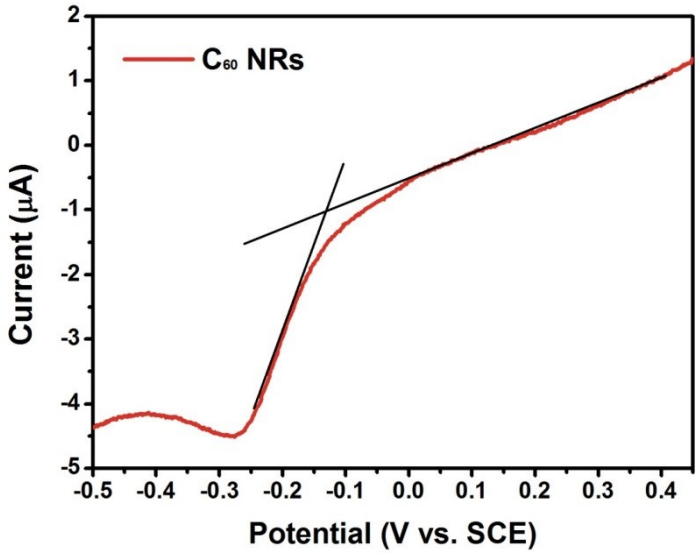

Figure S5. CV curve of C_{60} NRs on glassy carbon electrode.

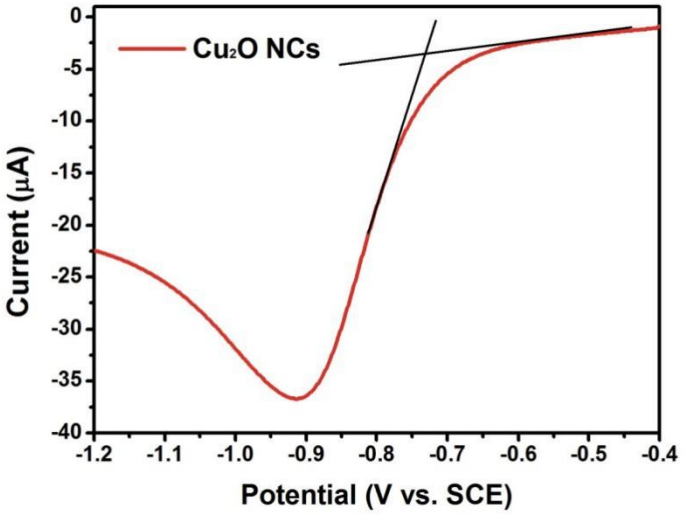

Figure S6. CV curve of Cu_2O NCs on glassy carbon electrode.

5, Performance comparison of the photodetectors

Table S1. Comparison on the performance of the related photodetectors

Active Material	Wavelength	Sensitivity (folds)	t_{rise}	t_{fall}	Year/Ref.
C_{60}-ribbon	UV/Visible	250	500ms	500ms	2013[1]
Cu_2O/ZnO	UV/Visible	25	<100ms	<100ms	2014[2]
P3HT/CdSe NCs/ PbS NCs /C_{60} NR	UV/Visible	400	7.5ms	-	2014[3]
C_{60} NR/Cu_2O NC	Visible	72.5	50ms	10ms	This work

References:

[1] L. Wei, J. Yao and H. Fu, ACS Nano, 2013, 7, 7573-7582.

[2] X. Liu, H. Du, P. Wang, T. T. Lim and X. W. Sun, J. Mater. Chem. C, 2014, 2, 9536-9542.

[3] R. Saran, V. Stolojan and R. J. Curry, *Sci. Rep.*, 2014, **4**, 5041.

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_2O/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_2O NC composite is suitable for detecting visible light signals.