Supporting Information

Glucose-fueled Micromotors with Highly Efficient Visible Light Photocatalytic Propulsion

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Video S1： The speed of Cu_2O@N-CNTs micromotors significantly increased after adding 20 mM glucose under 55300 Lux green light

Video S2： N-CNTs particles in different conditions

Video S3: Motion direction of Cu_2O@N-CNTs micromotors controlled by green light

Video S4: Vetical motion of Cu_2O@N-CNTs micromotors under blue light

Video S5: Cu_2O@N-CNTs micromotor's on/off motion

Video S6: The Cu_2O@N-CNTs micromotors with different N-CNTs content move in 10 mM glucose under 55300 Lux green light

Video S7: The Cu_2O@N-CNTs micromotors with 1.35% N-CNTs move in different glucose concentration under 55300 Lux green light

Video S8: The Cu_2O@N-CNTs micromotors with 1.35% N-CNTs move in 10 mM glucose concentration under different light intensity

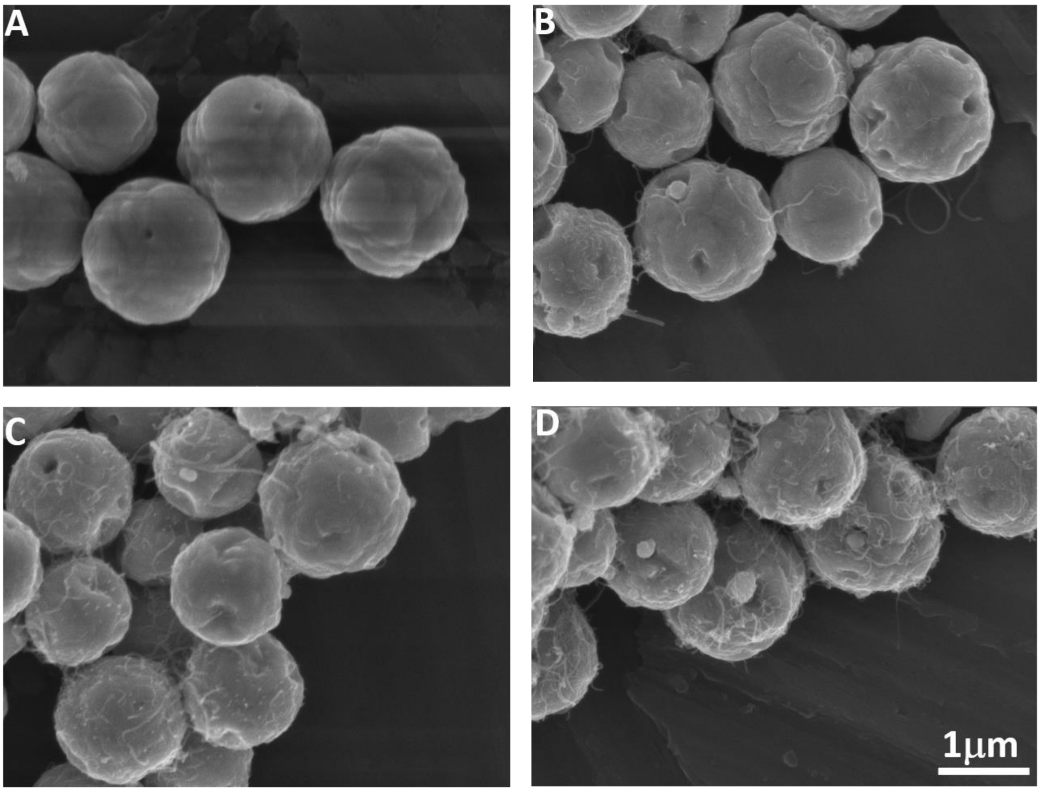

Figure S1. (A-D) SEM of Cu_2O@N-CNTs micromotor with 0%, 0.91%, 1.72%, and 2.35% N-CNTs content respectively.

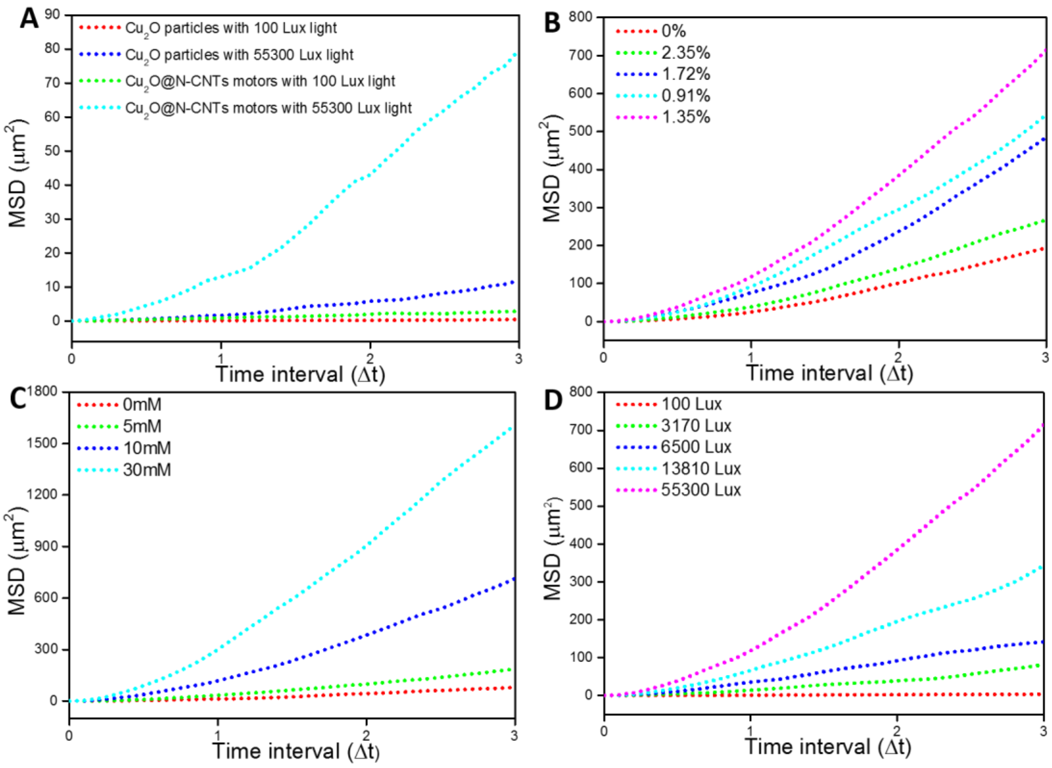

Figure S2. (A) Average MSD of Cu_2O particles and Cu_2O@N-CNTs micromotors with 1.35% N-CNTs content under different green light intensities in pure water vs time interval (Δt). (B) Average MSD of Cu_2O@N-CNTs micromotors with different N-CNTs content under 55300 Lux light in 10mM glucose solution vs time interval (Δt). (C) Average MSD of Cu_2O@N-CNTs micromotors with 1.35% N-CNTs content under 55300 Lux light in different concentrations glucose solution vs time interval (Δt). (D) Average MSD of Cu_2O@N-CNTs micromotors under different green light intensities in 10mM glucose solution vs time interval (Δt).

Supporting Figure S2A shows that, under 100 Lux light, the random motion of Cu_2O particles is Brownian motion with negligible displacements, while the Cu_2O@N-CNTs micromotor exhibits enhanced Brownian motion in pure water. when the light intensity increases to 55300 Lux, the motion of Cu_2O particles has a certain directionality, and Cu_2O@N-CNTs micromotor has a significantly larger displacement than Cu_2O particles. The results show that the Cu_2O@N-CNTs micromotor has significantly enhanced photocatalytic activity compared to the pure Cu_2O particle. Supporting Figure S2B further confirms that when the N-CNTs content is 1.35%, the motor has the highest photocatalytic activity, corresponding to faster speed and maximum displacement. Uuder 55300 Lux light, the displacement of the Cu_2O@N-CNTs micromotor increases as the glucose concentration increases. When in 30 mM glucose, the motor speed is the fastest, corresponding to the largest displacement (Supporting Figure S2C). The motion of micromotors changes from Brownian motion to directional motion with increasing luminous flux (Supporting Figure S2D). Increasing the flux of photons of a certain wavelength of light will lead to an enhanced charge separation in Cu_2O. It is clear from Supporting Figure S2D that as the light intensity increases from 100 to 55300 Lux, the displacement of the motor increases and exhibits enhanced directional motion.

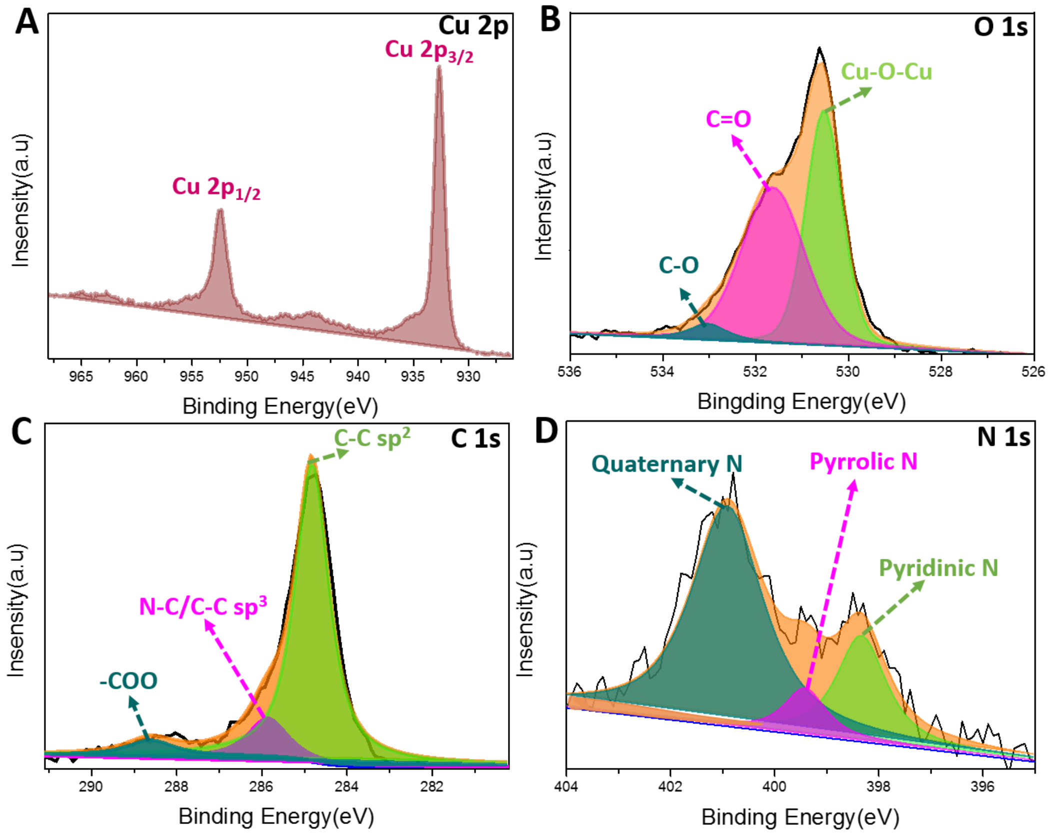

Figure S3. High-resolution X-ray photoelectron spectroscopy (XPS) spectra of Cu_2O@N-CNTs sample. (A) Cu 2p, (B) O 1s, (C) C 1s and (D) N 1S

X-ray photoelectron spectroscopy (XPS) survey spectrum which is used to further confirm the chemical states of Cu_2O@N-CNTs particles. The XPS of Cu_2O@N-CNTs shows the main peaks of Cu 2p, O 1s, C 1s, and N 1s. Peaks at 932.7 and 952.6 eV (Figure S3A) are respectively identified as the characteristic Cu $2p_{3/2}$ and Cu $2p_{1/2}$ peaks which agrees with the Cu (I) oxidation state. In Cu (I) oxide, a very weak satellite at ~945eV was observed due to remaining Cu(II) oxide. Oxygen-containing functionalities such as C-O (531.6 eV), C=O (533.0 eV) were found in the deconvoluted

O1s XPS spectrum of N-CNTs (Figure S3B), and the peak at 530.5 eV belong to Cu_2O. In addition, due to the extremely low CuO content, we cannot separate its peak. The deconvoluted C 1s spectrum (Figure S3C) shows peaks corresponding to C-C (sp^2), C-N/C-C (sp^3), and -COO components at 284.9, 285.8, and 288.7 eV, respectively. The high-resolution XPS N 1s peak (Figure S3D) reveals the presence of pyridnic N (398.2 eV), pyrrolic N（399.3 eV），quaternary N（401.1 eV）.

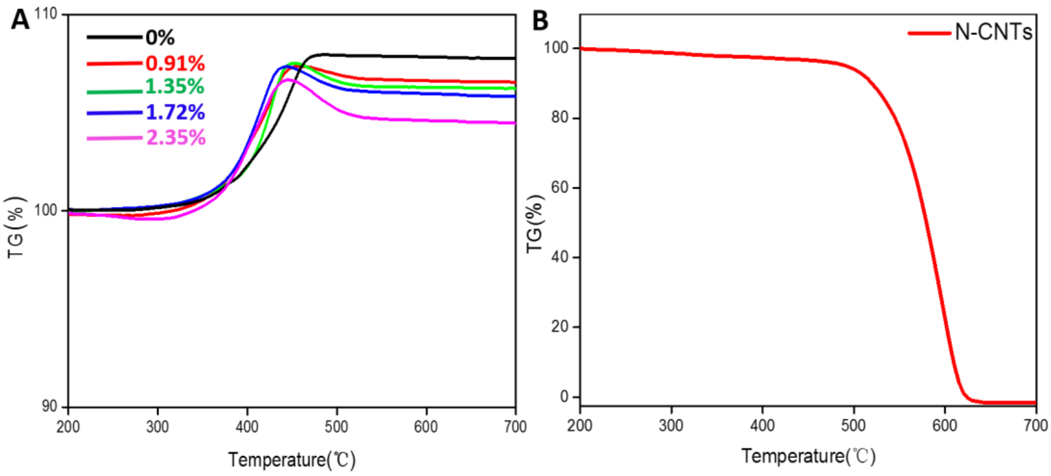

Figure S4. (A) Thermal gravimetric analysis of different Cu2O@N-CNTs micromotors in oxygen atmosphere. (B) Thermal gravimetric analysis of pure N-CNTs.

The precise N-CNTs content of the micromotor can be clearly reflected by Figure S4A, in which 0%, 0.91%, 1.35%, 1.72%, and 2.35% are the final N-CNTs content of motors corresponding to 0 mg, 0.3 mg, 0.5 mg, 0.7 mg, and 0.9 mg initial N-CNTs mass for preparing motors, respectively. In addition, the analysis of TG was carried out under an oxygen atmosphere, due to the decomposition temperature of Cu_2O and N-CNTs is higher than 900 ℃ under nitrogen atmosphere, and thermogravimetric instrument cannot meet the experimental requirements. In our system, when the weight loss temperature is less than 700 ℃, it is clear from Supporting Figure S4B, the decomposition temperature of N-CNTs is about 500 °C. As a result, Cu_2O can maintain thermal stability and the weight loss is purely due to N-CNTs, meaning that the percentage of weight loss is the final content of N-CNTs. In addition, since the N-CNTs and Cu_2O are in a composite state, the temperature of thermal weight loss is slightly lower than that pure N-CNTs, that is, the pure N-CNTs is more thermally stable.