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Nitrogen-doped carbon dots for detection and degradation of antibiotics

以氮掺雜碳量子點奈米材料進行抗生素之檢測與降解研究

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Abstract

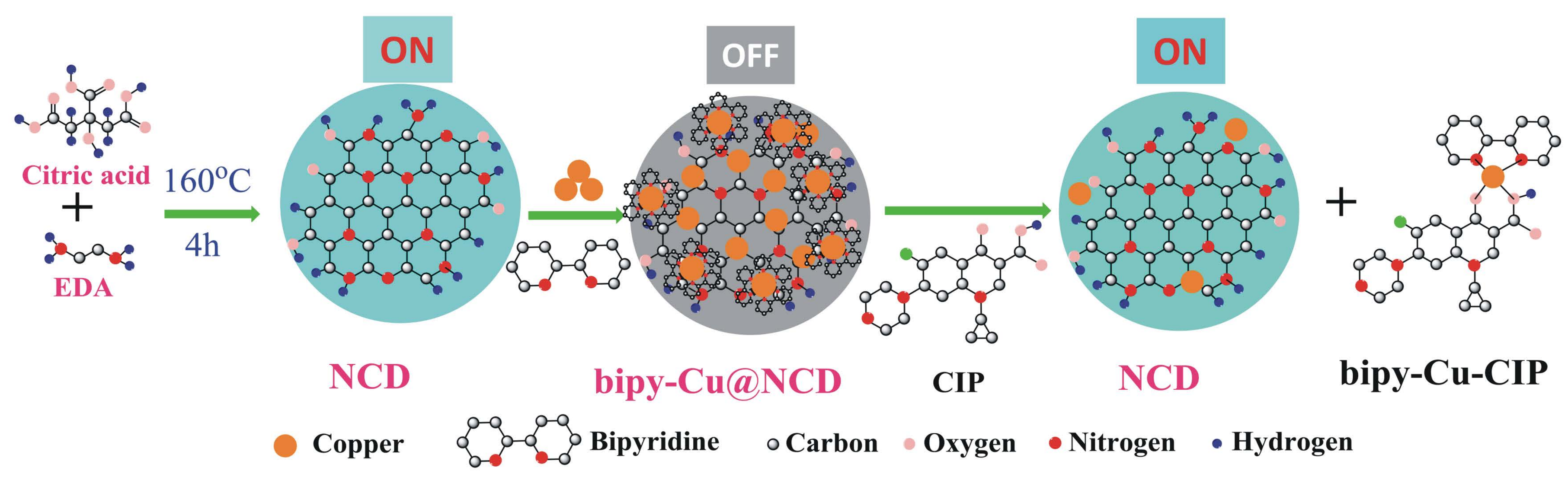
The research aims to utilize carbon-based nanomaterial for rapid detection devices and treatment systems of antibiotics in water. The carbon-based nanomaterial is a platform for the development of cost-effective and robust sensing probes for the detection of antibiotics. The material also proved its capability to combine with other semiconductors to enhance the photodegradation of pharmaceuticals, which could be further explored to synthesize a greatly productive photocatalyst for the practical treatment of pharmaceutical-contaminated water.

INTRODUCTION

- The N-doped carbon dots (NCD) was prepared by a one-step hydrothermal method using citric acid and ethylenediamine (EDA) as precursors.
- The fluorescence of NCD is quenched by Cu^{2+}, and recovered by the addition of CIP in presence of bipyridine because of the binding of CIP and bipy-Cu complex.
- The deposition of NCD onto the surface of semiconductor complex Bi_2MoO_6/g-C_3N_4 enhances the photodegradation of CIP, with removal efficiency of 99% in 30 minutes.

EXPERIMENTS

NCD as a sensing probe to detect CIP



RESULTS

Characterization of Cu-bipy@NCD

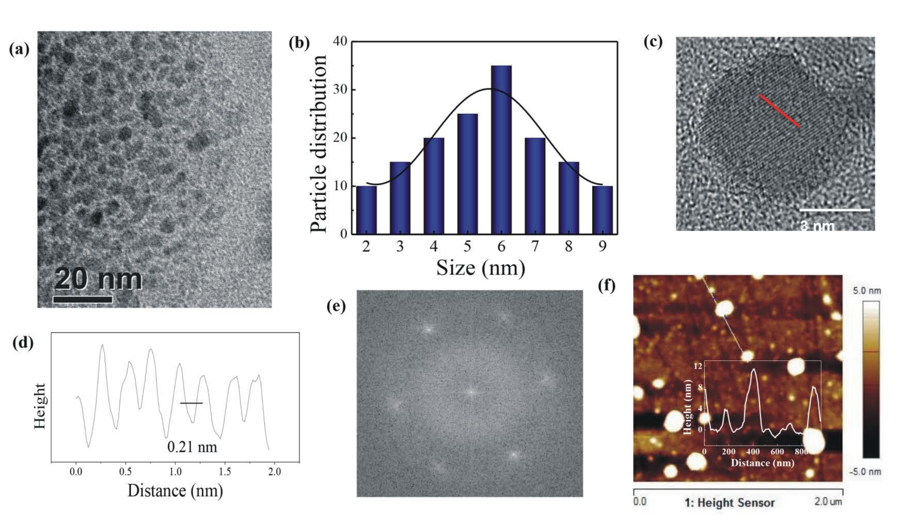


Fig. 1. (a) TEM image, (b) particle size distribution, (c) HRTEM image, (d) lattice spacing, (e) Fast Fourier Transform pattern, and (f) AFM image of the as-prepared NCD.

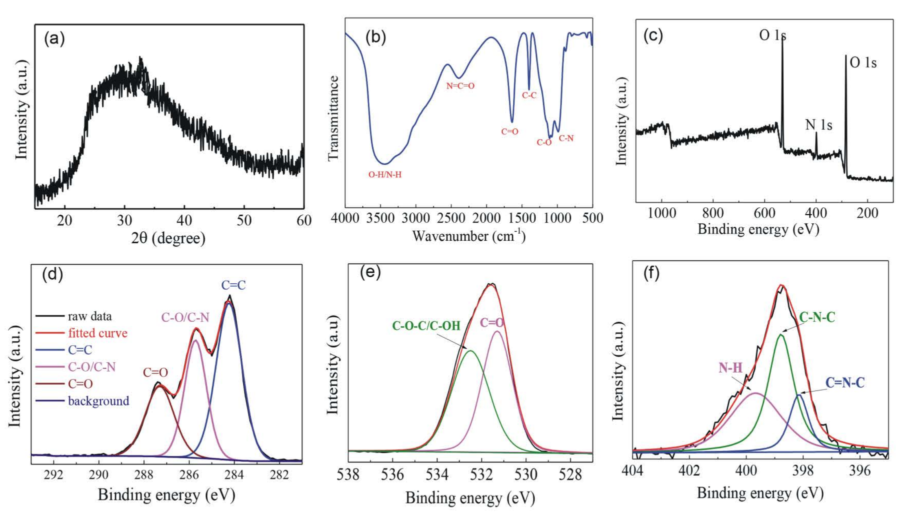


Fig. 2. (a) XRD pattern, (b) FTIR spectra, (c) Full XPS survey spectra of NCD, (d) C 1s peaks, (e) O 1s peaks, and (f) N 1s peaks of NCD.

CIP detection by Cu-bipy@NCD

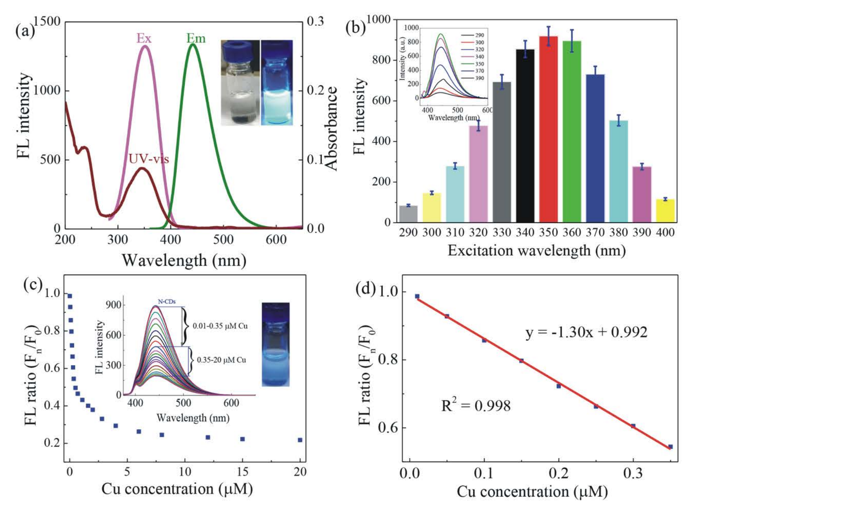


Fig. 3. (a) UV-visible and FL spectra, (b) FL intensity at various excitation WL, (c) FL quenching by 0.01 – 20 μM Cu^{2+}, (d) linearity when adding 0.01 to 0.35 μM Cu^{2+}.

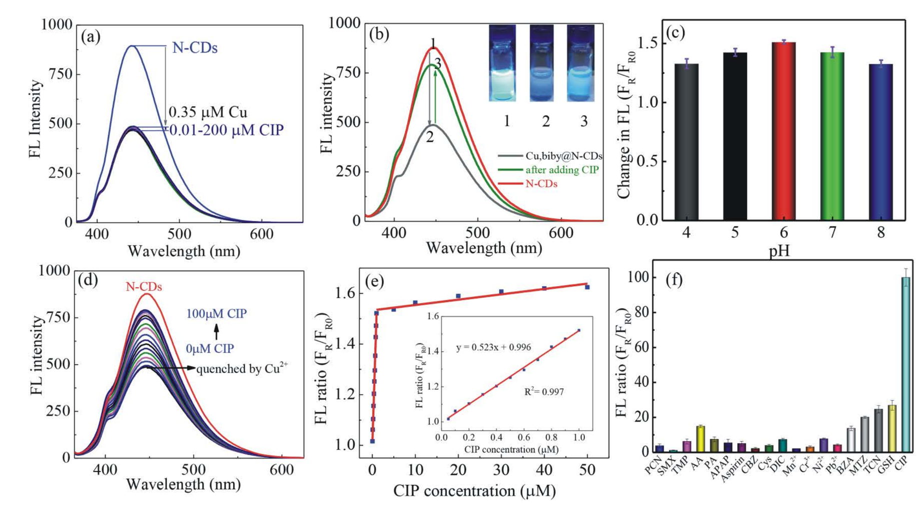
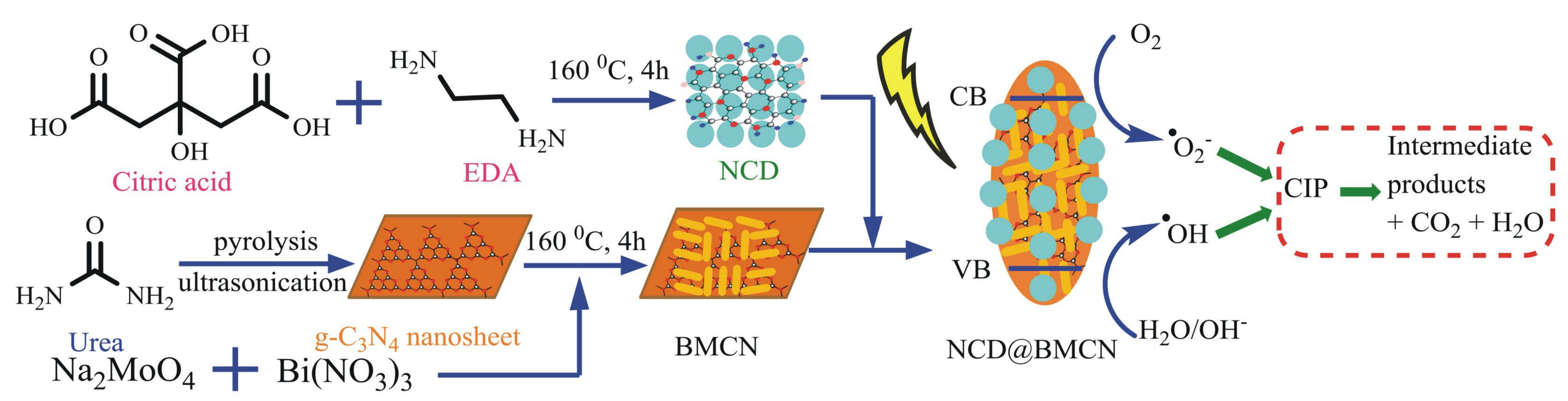


Fig. 4. FL intensity (a) with and (b) without bipy, (c) effect of pH, (d) FL spectra after addition of 0 – 100 μM CIP, (e) FL intensity when adding 0 to 50 μM CIP, and (f) selectivity of CIP over others.

Combination of NCD and semiconductors



Characterization of NCD@Bi_2MoO_6/g-C_3N_4

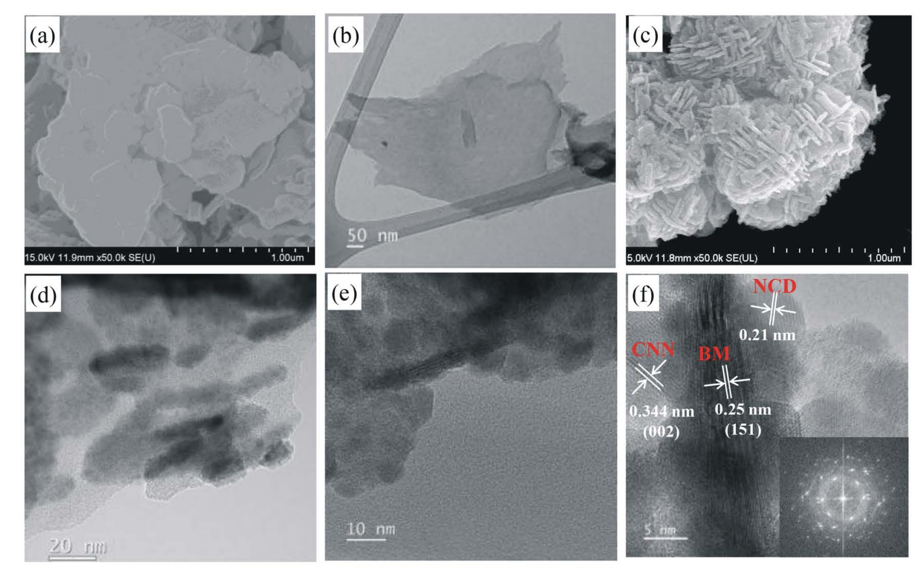


Fig. 5. SEM and TEM of CN (a, b), BMCN (c, d), TEM and (f) HRTEM of NCD@BMCN (e, f). Inset: FFT pattern of NCD@BMCN.

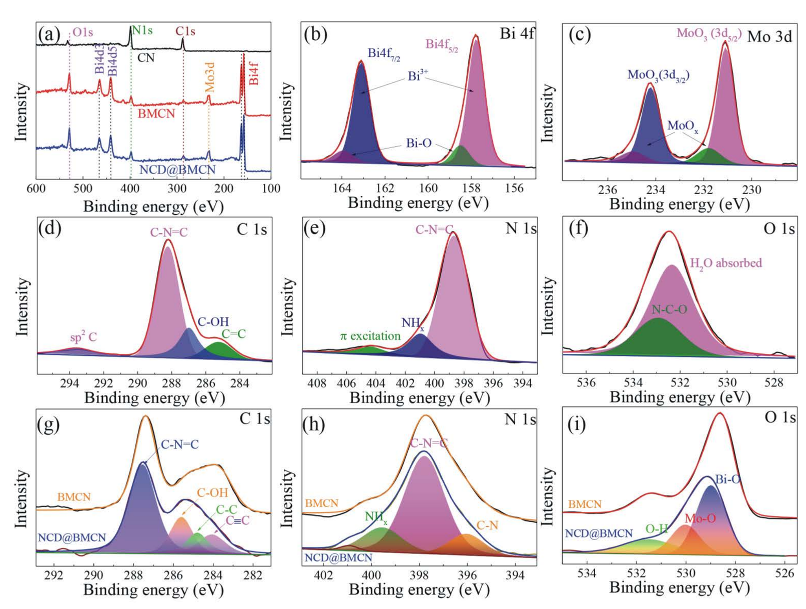


Fig. 6. XPS survey (a), deconvolution of (b) Bi 4f and (c) Mo 3d, (d, g) C 1s, (e, h) N 1s, and (f, i) O 1s of CN, BMCN and NCD@BMCN.

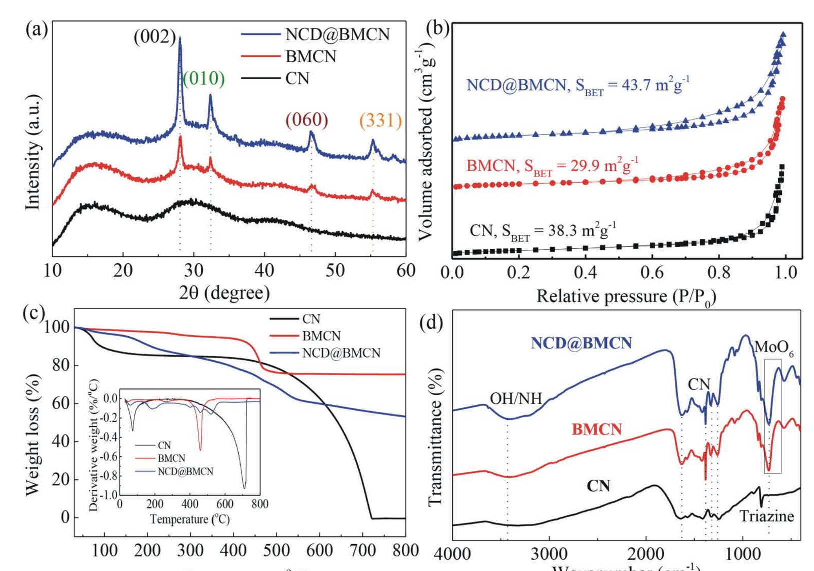


Fig. 7. (a) XRD patterns, (b) N_2 adsorption-desorption curves, (c) TGA, and (d) FTIR spectra.

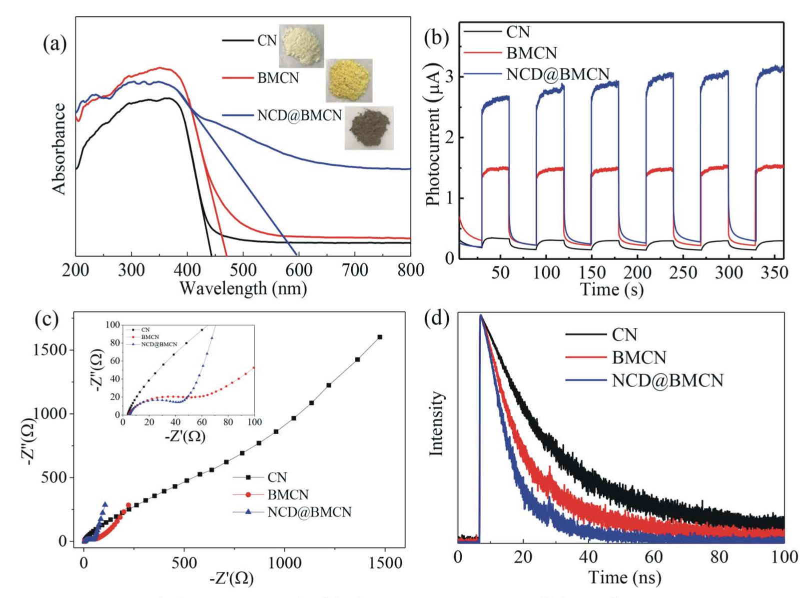


Fig. 8. (a) UV-visible spectra, (b) photocurrent spectra, (c) Nyquist plot, and (d) FL life-time.

CIP degradation by NCD@Bi_2MoO_6/g-C_3N_4

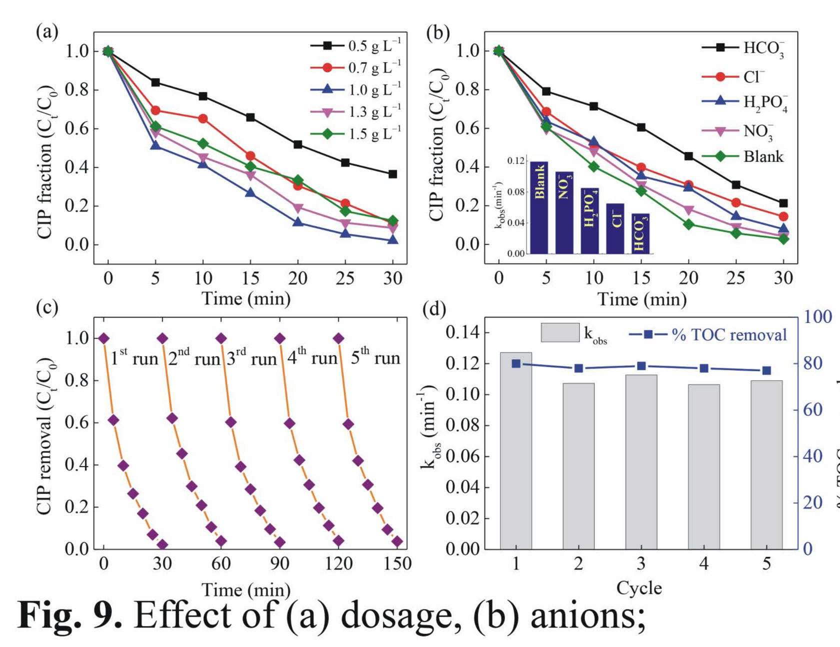


Fig. 9. Effect of (a) dosage, (b) anions; (c) recyclability, (d) k_{obs} and TOC

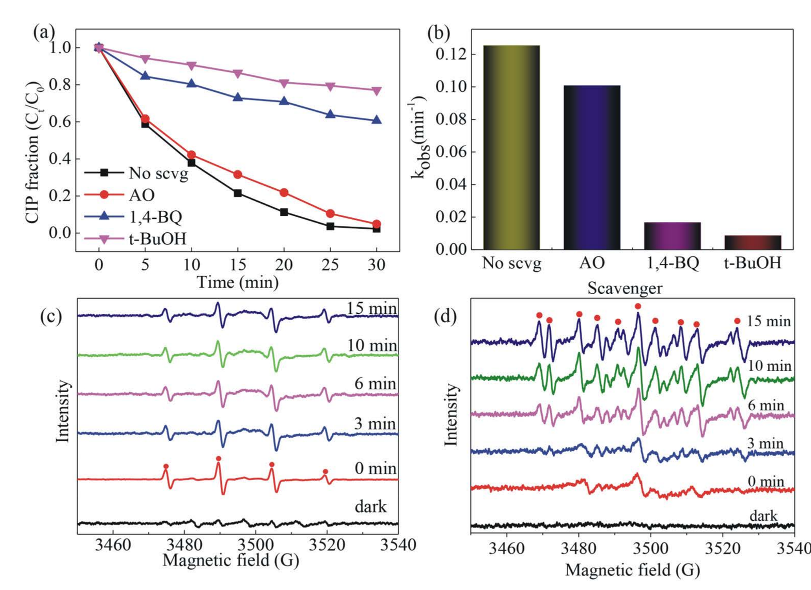


Fig. 10. scavengers effect (a, b); EPR spectra of (c) DMPO–•OH, and (d) DMPO–•O_2^- adducts

CONCLUSION

- NCD serves as a fluorescence turn "off-on" sensing probe for detection of Cu^{2+} ions first and then CIP in the presence of bipyridine.
- Indirect Z-scheme NCD@$BiMoO_6$/g-C_3N_4 photocatalyst has been successfully synthesized using facile strategies to degrade CIP with excellent performance.

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