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A Comparative Study to Enhance the Photocatalytic Activity of 2D g-C_3N_4 for Pollutant Remediation and CO_2 Reduction : Doping versus Heterojunction

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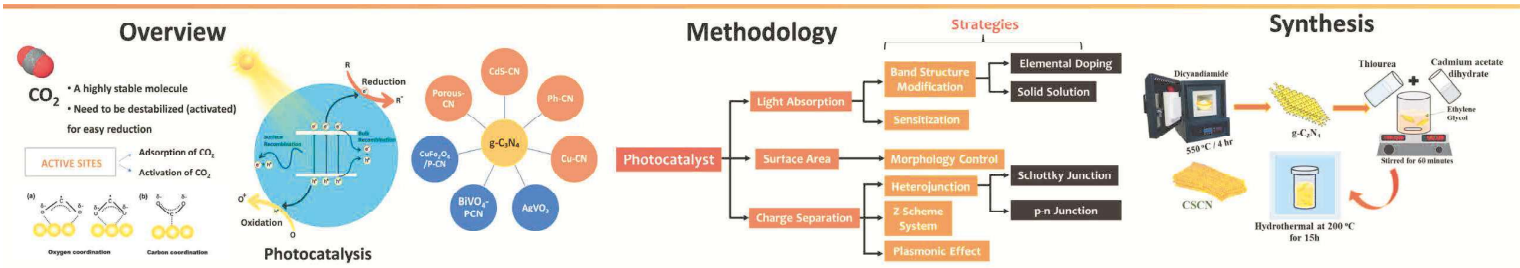
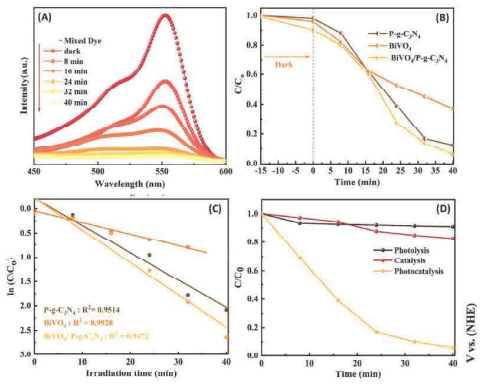
ABSTRACT

Pollutant degradation and CO_2 reduction are pressing challenges for environmental sustainability. Photocatalysis provides a green solution by leveraging solar energy to degrade pollutants and convert CO_2 into valuable products.

Graphitic carbon nitride (g-C_3N_4) stands out for its visible light activity and cost-effectiveness but suffers from low light absorption and charge recombination. Strategies like doping and forming heterojunctions (e.g., CdS-CN, Cu-CN, $BiVO_4$/P-CN) can significantly enhance its photocatalytic efficiency.



POLLUTANTS DEGRADATION



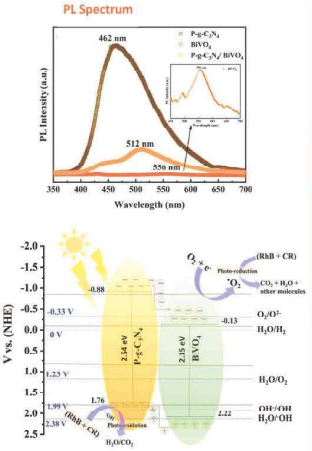
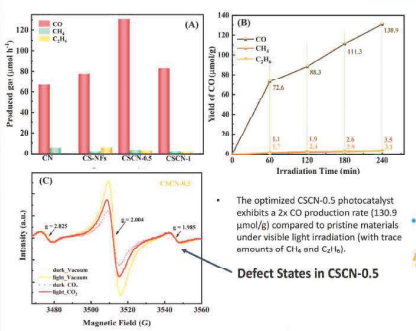


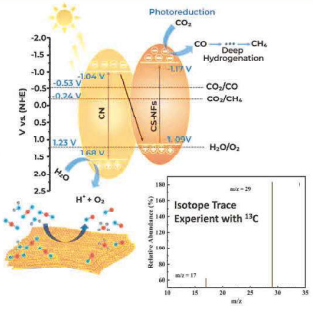
Fig.1 (A) UV-vis absorption spectra for the photodegradation of RhB and CR combined, (B) C/Co vs time for the different photocatalysts, (C) First order kinetics plot for the photodegradation of the dye mentioned above, and (D) C/Co vs time for the dye under light and BiVO4/P-g-C3N4 composite under dark and light.

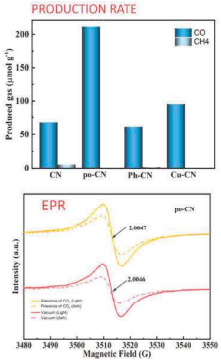
Fig.2 Schematic illustration of the formation of $BiVO_4$/P-g-C_3N_4 heterojunction for the photodegradation of RhB and CR dye under visible-light irradiation

VISIBLE LIGHT CO_2 REDUCTION



The optimized CSCN-0.5 photocatalyst exhibits a 2x CO production rate (130.9 μmol/g) compared to pristine materials under visible light irradiation (with trace amounts of CH_4 and C_2H_6).





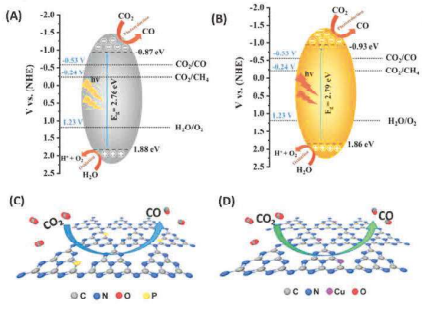


Fig.3 Schematic representation of photocatalytic reaction mechanism for (A) CN, (B) po-CN, (C) Ph-CN, and (D) Cu-CN

SUMMARY

- Provided insights into underlying mechanisms of enhanced performance.
- Optimal degradation rate for Congo Red and RhB (6.66×10^{-2} min^{-1}), pristine $BiVO_4$ (2.39×10^{-2} min^{-1}) by 2.78 times, P-g-C_3N_4 (5.61×10^{-2} min^{-1}) by 1.18 times.
- Developed CSCN heterostructure photocatalyst with a 2x CO production rate (130.9 μmol/g) compared to pristine materials (with trace amounts of CH_4 and C_2H_6).
- po-CN has more efficient charge separation and transfer rate with CO_2 reduction ability of 3.5x higher than pure CN, Ph-CN, and 2x higher than Cu-CN.

Selected Publications

- Chowdhury, A., Yang, T. C. K., & Lee, L. W. C. (2024). Synergistic Enhancement of CO_2 photoreduction through sulfur defects in (3D/2D) CdS-nanoflowers/CN Binary heterojunction photocatalyst under visible light. *Journal of Environmental Management*, *365*, 121602.
- Chowdhury, A., Balu, S., Lan, K. W., Wei-Chih Lee, L., & Yang, T. C. K. (2023). Synergistic Effect of $BiVO_4$/Pg-C_3N_4 Heterojunction with Enhanced Optoelectronic Properties on Synthetic Colorants under Visible Light. *Colorants*, *2*(2), 426-442.
- Chowdhury, A., Balu, S., Venkatesvaran, H., Chen, S. W., & Yang, T. C. K. (2022). Facile construction of $CuFe_2O_4$/pg-C_3N_4 p-n heterojunction with boosted photocatalytic activity and sustainability for organic degradation reactions under visible-light. *Surfaces and Interfaces*, *34*, 102329.

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