

ABSTRACT - POSTER

Impact of Cu particle size and loading on the catalytic performance of Cu/(Al:)ZnO in the light-powered conversion of CO₂ to CO

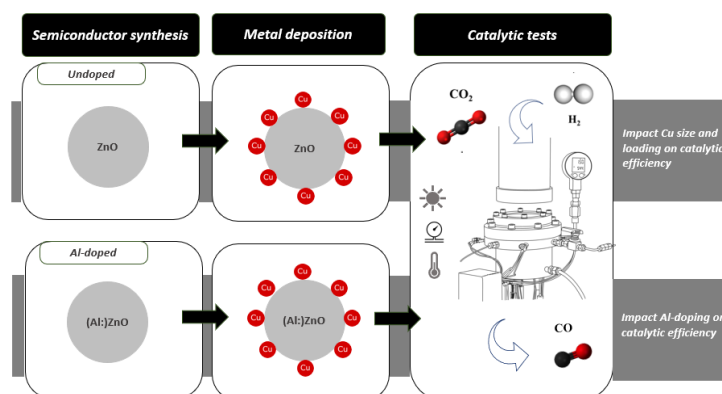
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Achieving climate neutrality in the chemical industry requires a transition from fossil resources to renewable feedstocks and sustainable energy sources. The reverse water-gas shift (rWGS) reaction converts carbon dioxide (CO₂) and hydrogen (H₂) into carbon monoxide (CO) and water (H₂O), providing CO for syngas production and the synthesis of value-added chemicals, thereby supporting carbon recycling.¹ Copper-based catalysts, particularly Cu/ZnO/Al₂O₃ (CZA), are widely used in industrial CO₂ conversion and have also demonstrated activity in the rWGS reaction.^{1,2} However, conventional thermocatalytic processes require elevated temperatures and, depending on the process, high pressures, often relying on fossil-derived energy. Therefore, the solar-driven CO₂-to-CO conversion offers a potential alternative by harnessing sunlight to drive the reaction.¹⁻⁵

Zinc oxide (ZnO) is a promising n-type semiconductor for photocatalysis owing to its chemical stability, low toxicity, and ease of synthesis.³ However, its limited visible-light absorption and rapid charge-carrier recombination can restrict photocatalytic efficiency. Al doping can modify the electronic and structural properties of ZnO, potentially influencing charge-carrier transport and recombination, and thereby affecting photocatalytic performance. Decorating ZnO with plasmonic Cu nanoparticles (NPs) induces localized surface plasmon resonance (LSPR), which may enhance light harvesting and promote photothermal heating, hot-carrier generation, and near-field enhancement.^{4,5} The extent to which these effects depend on Cu NP size and loading remains to be systematically established.

In this work, Cu/ZnO and Cu/Al:ZnO (2 at% Al) catalysts are investigated to study the impact of Al-doping on the catalytic performance in solar-driven CO₂-to-CO conversion. The effects of Cu loading (1.25 - 4.90 - 11.27 wt% Cu) on both catalyst systems and the associated variations in Cu nanoparticle (NP) size (from ≤5 nm to ≥20 nm) are systematically examined. By comparing doped and undoped catalysts and correlating their structural and optical properties with CO production, this study aims to establish structure-property-performance relationships. These insights will support the rational design of efficient plasmonic photocatalysts for sustainable CO₂ utilization.



References

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