Photocatalytic reduction of dense phase CO2

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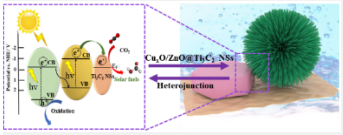

Photocatalysis offers a viable method for mitigating carbon emissions directly at their source by facilitating the conversion of CO_2 into various forms of renewable energy fuels. Currently, most research is on reducing CO_2, employing UV light for irradiation, and conducting experiments at ambient temperature and pressure. The study of photocatalytic reduction of dense phase CO_2, including its liquids or supercritical states, has seldom been explored. This research introduces an innovative method for applying visible light in photocatalytic CO_2 conversion, focusing on the utilization of CO_2 in its dense phase and addressing the issue of catalyst agglomeration. Hence, the 2D/3D heterojunction, combined MXene nanosheets with ZnO/Cu_xO nanoparticles, is synthesized for the photocatalytic reduction of condensed phase CO_2, driven by visible light.

Introduction

Fossil fuels (*e.g.*, coal, oil, and gas) constitute the primary sources of energy for industries and transportation, releasing significant amounts of greenhouse gases, mainly carbon dioxide, into the environment[1,2]. It is predicted that the concentration of CO_2 is anticipated to reach 750 ppm by 2040, which surpasses the pre-industrial level of 400 ppm (0.04%) significantly[3].

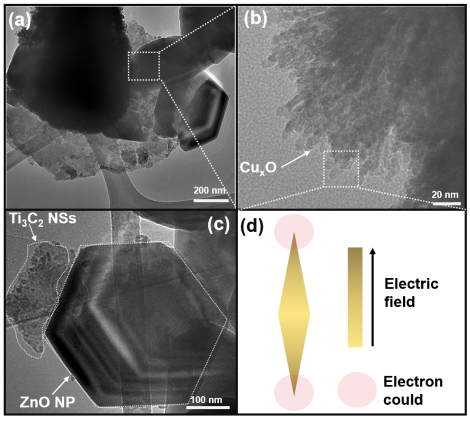

Figure 1. (a-c) TEM images of $ZnO/Cu_xO@Ti_3C_2$ NSs. (d) Electron cloud distribution at the tip of copper oxide particles.

This will lead to a global temperature increase by more than 4 ℃. As a sustainable alternative, carbon dioxide can be converted back into valuable fuels, serving industrial demand while simultaneously reducing the atmospheric CO_2 content. However, CO_2 is an inert gas with a highly stable C=O bond at a corresponding binding energy of 750 KJ/mol, which mandates the use of catalysts. Considering the case of photocatalysis, an external photosensitizer can facilitate the process in combination with a CO_2 activation co-catalyst to break the arch in this area over recent decades, the photocatalytic reduction of CO_2 remains inefficient. C=O double bond and initiate the conversion of CO_2. It is an effective measure for increasing the concentration of CO_2 and enhancing the CO_2 reduction selectivity. Ideally, supercritical fluid CO_2 and liquid CO_2 could potentially be used as the medium. A fluid is deemed supercritical when its temperature and pressure surpass the critical thresholds. Near their critical point, fluids demonstrate a significant reliance on temperature and pressure for fluid density, leading to marked shifts in their solvent properties. To date, there has been limited research attention given to the photocatalytic reduction of condensed-phase CO_2, whether in liquid or supercritical states.

Material and Methods

The synthesis and evaluation of the $Cu_xO/ZnO@Ti_3C_2NSs$ catalyst are among the major accomplishments of the research undertake thus far. Instruments used to characterize these materials comprise X-ray Diffraction (XRD), Raman Spectroscopy, Photoluminescence (PL) Spectroscopy, Ultraviolet-visible Diffuse Reflectance Spectroscopy (UV-vis DRS), Four-transform Infrared Spectroscopy (FT-IR), Transmission Electro Microscopy (TEM), and Scanning Transmission Electron Microscopy Energy Dispersive X-ray Spectroscopy (STEM-EDS). In addition, photocatalytic experiments to test the catalytic activity of the prepared photocatalysts will

be conducted later.

Results and Discussion

Furthermore, Due to the wide bandgap (3.3 eV) of ZnO nanoparticles, the absorption ability for UV light is strong. To achieve full spectrum absorption (UV light and visible light). Copper is incorporated into the catalyst system, which results in the formation of cuprous oxide and a semiconductor with a narrow bandgap (2.0 eV). Improving the ability of the system to absorb and convert visible light. MXene nanosheets enhance photogenerated electron transfer. Their high specific surface area increases CO_2 adsorption and edge defects provide catalytic sites.

It is the first time to utilize solar photocatalytic reduction for dense phase CO_2 (liquid or supercritical state). In addition, Cu_xO catalysts, with narrow bandgaps (CuO, Eg=1.35 to 1.7 eV; Cu_2O, Eg=1.9 to 2.2 eV), exhibit p-type semiconductor properties for visible light absorption. Hybridizing with ZnO creates p-n junctions, enhancing charge separation and photocatalytic CO_2 reduction) MXene (Ti_3C_2) nanosheets with high surface area enhance CO_2 capture, preventing photogenerated carrier recombination, and improving photocatalytic efficiency. Incorporating amine-functionalized ionic liquid can increase the solubility of CO_2 in water, lower the overpotential, and increase the rate of reaction conversion.

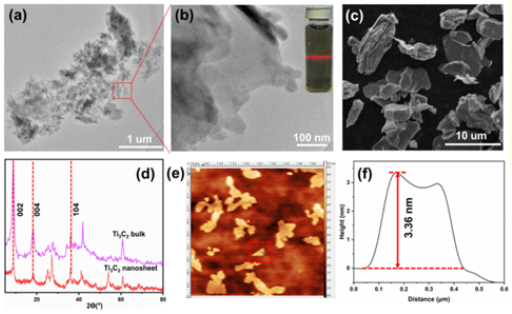

Figure 2. (a-b) TEM images of MXene nanosheets; (c) TEM images of MXene block; (d) MXene nanosheet and MXene block XRD results; (e) AFM images of MXene nanosheets. (f) The thickness of MXene nanosheets.

Conclusions

In this research, we synthesized Cu_xO/ZnO nanoparticles by employing solar-driven MXene nanosheets as co-catalysts to enhance the effectiveness of photocatalytic reduction of dense phase CO_2.

Acknowledgments

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References

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