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Photoelectro- and Photothermal-catalytic Removal of Environmental Pollutants by using 2D and 3D Graphene Oxide Materials

Jing Shang*, Yuhan Liu, Kuang Yu, Mei Yu
SKL-ESPC & SEPKL-AERM, College of Environmental Sciences and Engineering, Center for Environment and Health, Peking University, Beijing, 100871, P. R. China
shangjing@pku.edu.cn

Extended Abstract

Photoelectro-catalysis and photothermal-catalysis are the two main auxiliary methods in photocatalytic technology. Graphene oxide (GO), a new and promising material, has been widely used as a co-catalyst in photocatalytic studies. However, there is a scarcity of information regarding the intrinsic photocatalytic reduction capability of GO as a sole photocatalyst. In this study, we prepared two-dimensional (2D) and three-dimensional (3D) GO samples and utilized them as photocatalysts for photocatalytic reduction of carbon dioxide (CO_2) and chromium (VI)[1-6]. Our study successfully demonstrated the photoelectro- and photothermal-catalytic reduction abilities of GO materials, providing valuable theoretical insights and technical references for the design of GO photocatalysts, and offering a new idea for the treatment of environmental pollutants.

We applied GO onto etched ITO, creating a solid-state planar photoelectrocatalytic device, denoted as ITO/GO/ITO [1]. This device was employed for the gas-solid photoelectrocatalytic reduction of CO_2. The planar configuration of the device facilitated the formation of a horizontal electric field via biasing, thereby promoting the separation of photogenerated electron-hole pairs and effectively improving the efficiency of photocatalytic reduction. Furthermore, given GO's excellent infrared absorption capability for photothermal conversion, it holds promise for photothermal catalytic reduction of CO_2. We combined thermally-reduced GO with carbon nitride nanosheets and photo-reduced GO with covalent organic frameworks, obtaining two S-scheme heterojunction nanocomposites [2, 3]. In the absence of external heat input and under visible and infrared light irradiation only, both non-metallic composites demonstrated excellent efficiency in CO_2 reduction.

2D graphene oxide was subjected to either photoreduction (e.g., simulated sunlight or UV irradiation) or thermal reduction (e.g., heat treatment) to obtain reduced GO (rGO). It was observed that photoreduced GO enhanced the photocatalytic conversion of CO_2 and Cr(VI) due to increased defect density and enhanced electron generation efficiency. Similarly, thermal reduction obviously boosted the catalytic activity of GO [4, 5]. In the investigation of 3D graphene oxide aerogels (GOA), hydrothermal reduction of GO led to the generation of more defects on the basal surface [6]. Additionally, the incorporation of a cross-linking agent or heteroatom doping was found to augment interlayer spacing, resulting in a larger specific surface area and a richer porous structure for GOA. Combining adsorption and photocatalytic technologies, 3D GOA samples exhibited excellent adsorption capacity and photocatalytic removal efficiency for both CO_2 and Cr(VI).

References

[1] Y. H. Liu, J. Shang, T. Zhu, "Gas-solid photoelectrocatalytic CO_2 reduction using solid planar photoelectrocatalytic device ITO/RGO/ITO", *Appl. Surf. Sci.* vol. 639, an. 158196, 2023.

[2] Y. H. Liu, J. Shang, T. Zhu, "Enhanced thermal-assisted photocatalytic CO_2 reduction by RGO/H-CN two-dimensional heterojunction", *J. Mater. Sci. Technol.*, vol. 176, pp. 36-47, 2023.

[3] Y. H. Liu, Y. Wang, J. Shang, J. Peng, T. Zhu, "Construction of a novel metal-free heterostructure photocatalyst PRGO/TP-COF for enhanced photocatalytic CO_2 reduction", *Appl. Catal. B-Environ.* vol. 350, an. 123937, 2024.

[4] M. Yu, J. Shang, Y. Kuang, "Efficient photocatalytic reduction of chromium (VI) using photoreduced graphene oxide as photocatalyst under visible light irradiation", *J. Mater. Sci. Technol*., vol. 91, pp. 17-27, 2021.

[5] Y. Kuang, J. Shang, T. Zhu, "Photoactivated Graphene Oxide to Enhance Photocatalytic Reduction of CO_2", *ACS Appl. Mater. Interfaces*, vol. 12, pp. 3580-3591, 2020.

[6] M. S. Sheng, M. Yu, J. Shang, T. Zhu, "High efficient adsorption and photocatalytic removal of hexavalent chromium over three-dimensional graphene oxide aerogel under visible light", *Chin. Sci. Bull.-Chin.,* vol. 67, pp. 447-458, 2022.