BiSX and BiSX/g-C_3N_4 (X = Cl, Br, I): Synthesis, Characterization, Photocatalysis of Carbon Dioxide, and Crystal Violet Dye

科學教育與應用學系 四年級 曾智暄

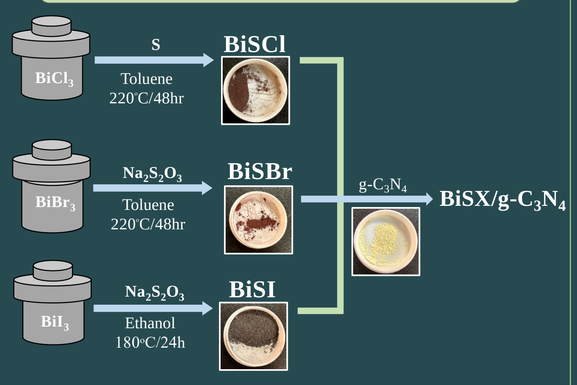
指導教授 黃旭村 教授兼系主任,陳錦章 卓越講座教授兼理學院院長

Abstract

Using a simple hydrothermal method, we successfully synthesized a series of BiSX compounds, belonging to the group of V–VI–VII compounds, which includes BiSCl, BiSBr, and BiSI. These compounds have been under investigation since the last century due to their potential for optoelectronic applications.The binary composite photocatalysts BiSX/g-C_3N_4 were prepared by mixing varying weights of g-C_3N_4 and heating the mixture at 100°C for 4 hours. The resulting products underwent characterization using XRD, FE-TEM, FT-IR, SEM-EDS, DR-UV, BET, PL, EPR, and HR-XPS techniques. Discussion on the photocatalytic efficiency of BiSX and BiSX/g-C_3N_4 demonstrates significant effects, as these catalysts were utilized for converting CO_2 into hydrocarbons and for the photocatalytic degradation of the organic pollutant, crystal violet (CV), suggesting their promising potential in mitigating environmental pollution.

Results and Discussion

Catalysts Preparation



XRD

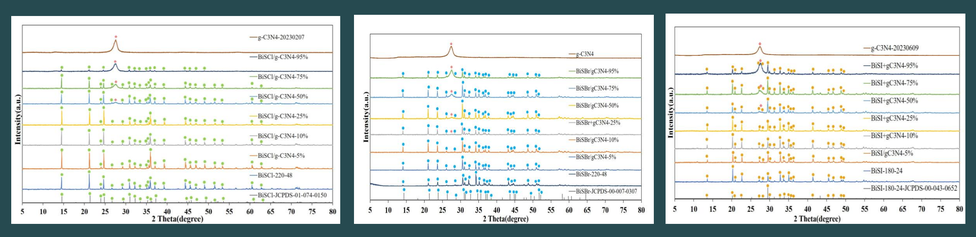


Fig.1 XRD patterns of BiSX (X = Cl, Br, I) and BiSX/g-C_3N_4.

FE-SEM-EDS

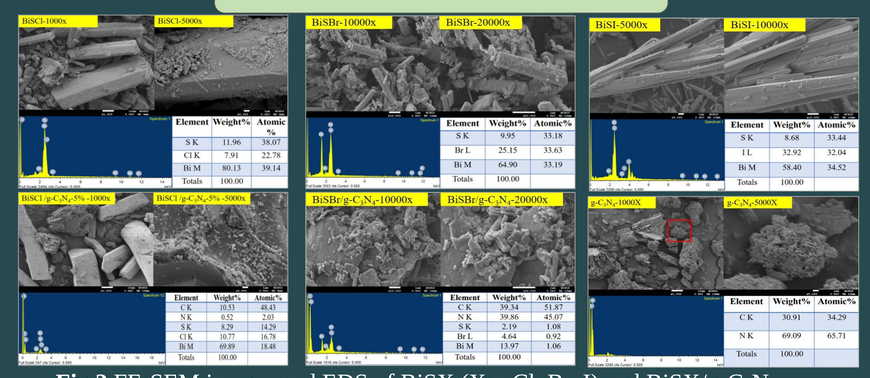


Fig.2 FE-SEM images and EDS of BiSX (X = Cl, Br, I) and BiSX/g-C_3N_4.

FE-TEM-EDS

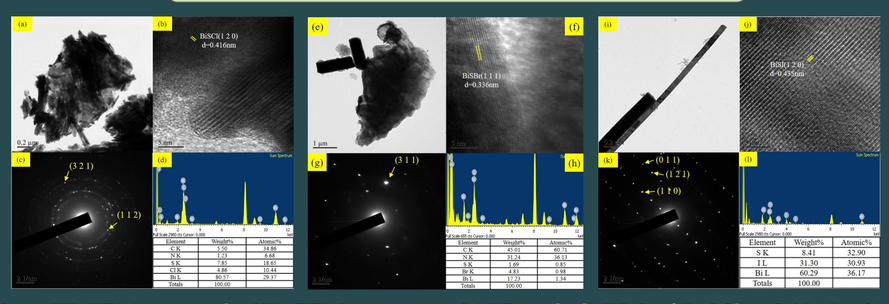


Fig.3 (a) FE-TEM image, (b) HR-TEM image, (c) SAED and (d) EDS of BiSCl/g-C_3N_4-5wt% sample, (e) FE-TEM image, (f) HR-TEM image, (g) SAED and (h) EDS of BiSBr/g-C_3N_4-95wt% sample, (i) FE-TEM image, (j) HR-TEM image, (k) SAED and (l) EDS of BiSI sample.

Photocatalytic Degradation of CV

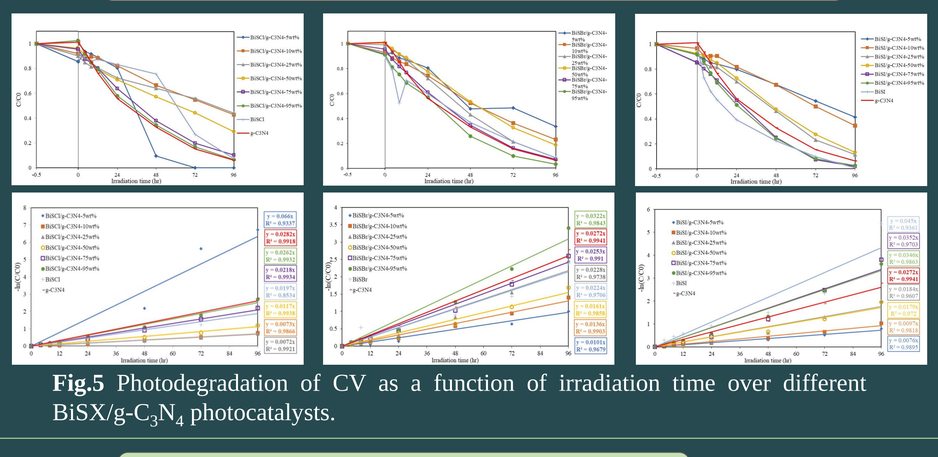


Fig.5 Photodegradation of CV as a function of irradiation time over different BiSX/g-C_3N_4 photocatalysts.

HR-XPS

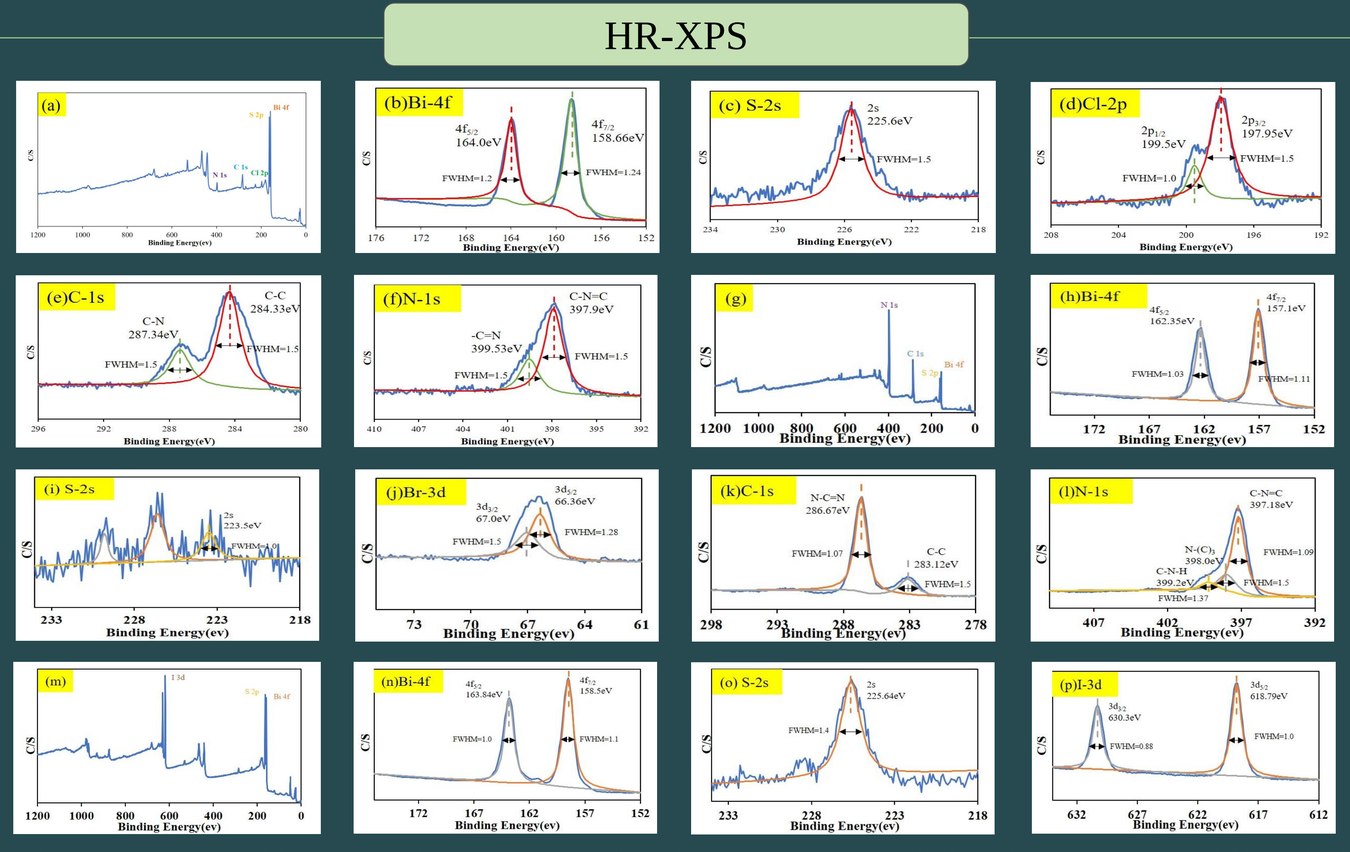


Figure 4. XPS spectra of the as-prepared BiSX/g-C_3N_4 samples: (a) survey XPS spectrum; high-resolution XPS spectra of (b) Bi 4f, (c) S 2s, (d) Cl 2p, (e) C 1s and (f) N 1s of the BiSCl/g-C_3N_4-5wt%; (g) survey XPS spectrum; high-resolution XPS spectra of (h) Bi 4f, (i) S 2s, (j) Br 3d, (k) C 1s and (l) N 1s of the BiSBr-gC_3N_4-95wt%; (m) survey XPS spectrum; high-resolution XPS spectra of (n) Bi 4f, (o) S 2s , (p) I 3d of the BiSI.

Photoreduction of CO_2

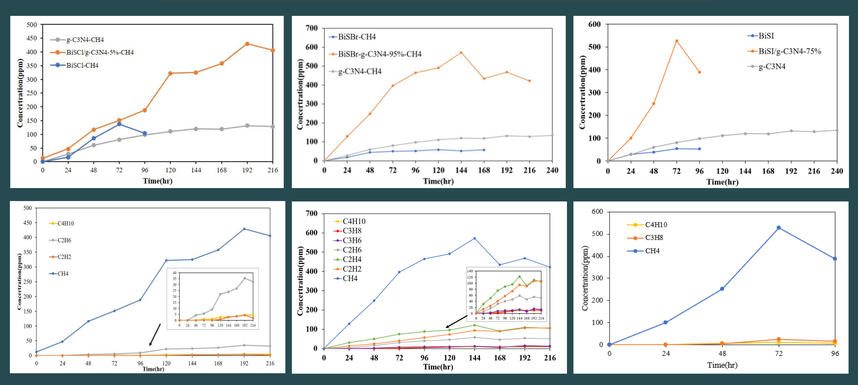


Fig.6 Photocatalytic reduction of CO_2 by BiSX/g-C_3N_4.

BET

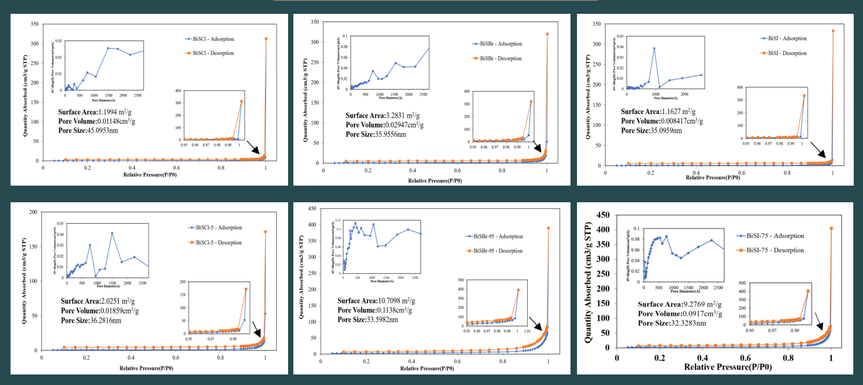


Fig.7 N_2 adsorption isotherm and pore size distribution of BiSX, BiSX/g-C_3N_4.

Mechanism

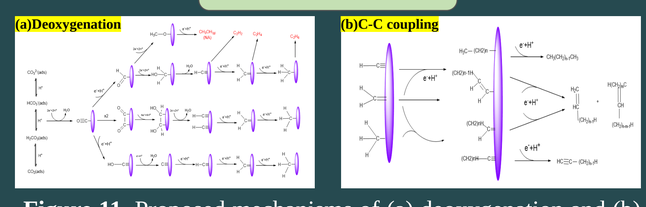


Figure 11. Proposed mechanisms of (a) deoxygenation and (b) C-C coupling on photoreduction CO_2 with BiSX/g-C_3N_4 photocatalysts.

Scheme

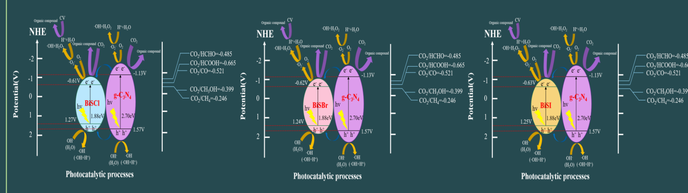


Fig.12 Band structure diagram and possible charge separation processes of BiSX/g-C_3N_4 for the photoreduction of CO_2.

UV-Vis-NIR

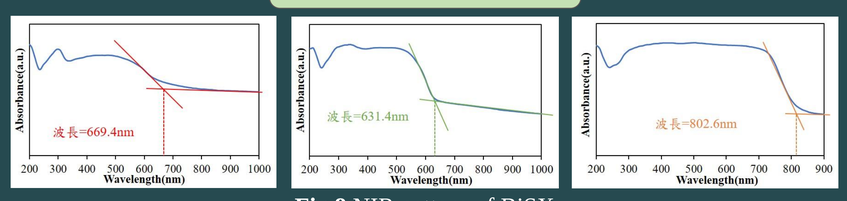


Fig.8 NIR pattern of BiSX.

EPR

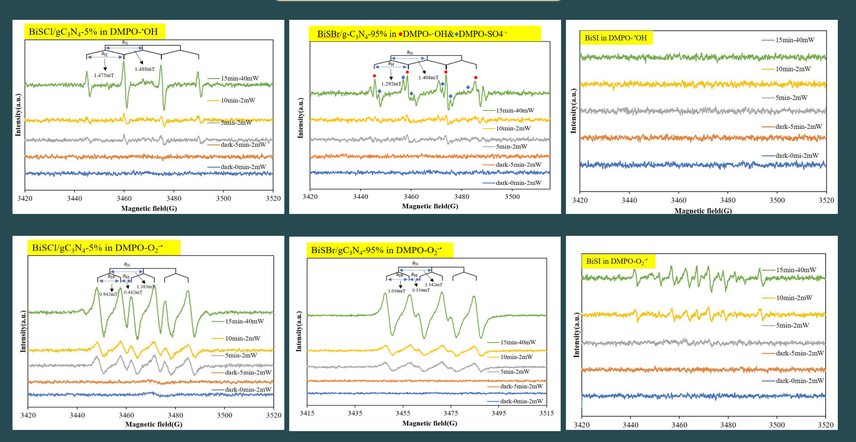


Fig.10 EPR pattern of BiSCl/g-C_3N_4-5wt%, BiSBr/g-C_3N_4-95wt% and BiSI.

PL

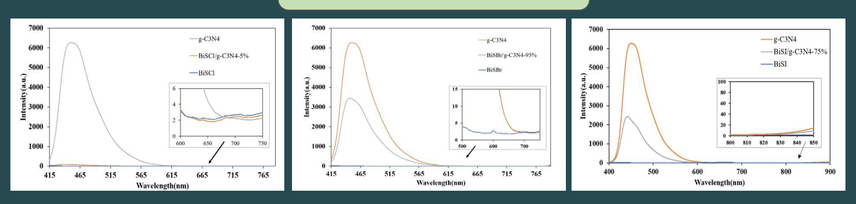


Fig.9 PL pattern of BiSX, BiSX/g-C_3N_4 and g-C_3N_4.

Summary

The utilization of BiSX and BiSX/g-C_3N_4 for CO_2 reduction and photocatalytic degradation of organic pollutants, such as crystal violet (CV), demonstrates significant effects, indicating their promising potential for reducing environmental pollution.