Visible-Light-Active N-Doped TiO_2 coupled with Bi_2WO_6 Z-Scheme Heterojunctions for Indoor VOC and CO_2 Abatement

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Highlights

- N-doped TiO_2 and Bi_2WO_6/N-TiO_2 Z-scheme heterojunctions enabled visible-light activation for VOC/CO_2 abatement
- Solution combustion and sol-gel doping strategies yield tailored decreasing bandgap and charge separation.
- Hydrothermally synthesized Bi_2WO_6 coupling enhances stability and visible-light utilization in defective nanostructures
- Synthesis parameters directly control crystallinity, surface area, and optical properties for indoor pollution remediation

1. Introduction

Indoor air pollution from volatile organic compounds (VOCs) like ethylene and CO_2 threatens human health, deteriorating respiratory issues and contributing to the global warming [1]. Photocatalytic degradation under visible light offers a sustainable, low-energy solution, with TiO_2 standing out for its stability and oxidizing power but limited by its wide bandgap and UV dependence [2]. This study develops visible-light-active TiO_2-based photocatalysts via non-metal doping and Z-scheme heterojunctions, targeting efficient VOC degradation and CO_2 reduction under realistic indoor conditions. Nitrogen (N) doping narrows the bandgap through valence band modulation, while bismuth tungstate (Bi_2WO_6) coupling promotes charge separation and photocorrosion resistance, addressing key limitations for practical deployment [3].

2. Methods

Undoped and N-doped TiO_2 were synthesized via hydrothermal (HYD), solution combustion (SCS), and sol-gel (SG) synthesis, with N: Ti molar ratios from 3:1 to 1:1 using urea and ammonium hydroxide as N sources. Bi_2WO_6, Bi_2WO_6/TiO_2, and Bi_2WO_6/N-TiO_2 composites were prepared using hydrothermal synthesis to form Z-scheme heterostructures. Materials were characterized by XRD (crystallinity, phase, crystallite size), N_2 physisorption (BET surface area, pore volume), and DR-UV-Vis (bandgap, visible-light absorption). Photocatalytic oxidation of ethylene (100ppm in air) was evaluated with a continuous-flow gas-phase reactor under Xe arc lamp irradiation, with GC analysis for performance screening to be presented.

3. Results and discussion

XRD confirmed crystalline anatase TiO_2 phases across samples, with minor FWHM shifts indicating preserved structure post-doping and coupling where Bi_2WO_6 also maintained its orthorhombic phase. UV-Vis revealed bandgap narrowing in N-TiO_2 (enhanced visible absorption) and further reduction in Bi_2WO_6/N-TiO_2, enabling efficient photoexcitation. BET showed TiO_2_HYD with the highest surface area, decreasing in N-TiO_2_SG and Bi_2WO_6 composites due to heterojunction formation—balancing adsorption capacity with charge dynamics. These traits position Bi_2WO_6/N-TiO_2 as optimal for visible-light VOC/CO_2 conversion, with synthesis variations (e.g., SCS for bulk efficiency) offering tunable defect-rich sites for superior electron-hole separation versus pristine TiO_2. Ethylene conversion for synthesized samples with respect to pristine TiO_2, correlating to optimized bandgap and defects; full conversion and mineralization (CO_2 yield) will be presented.

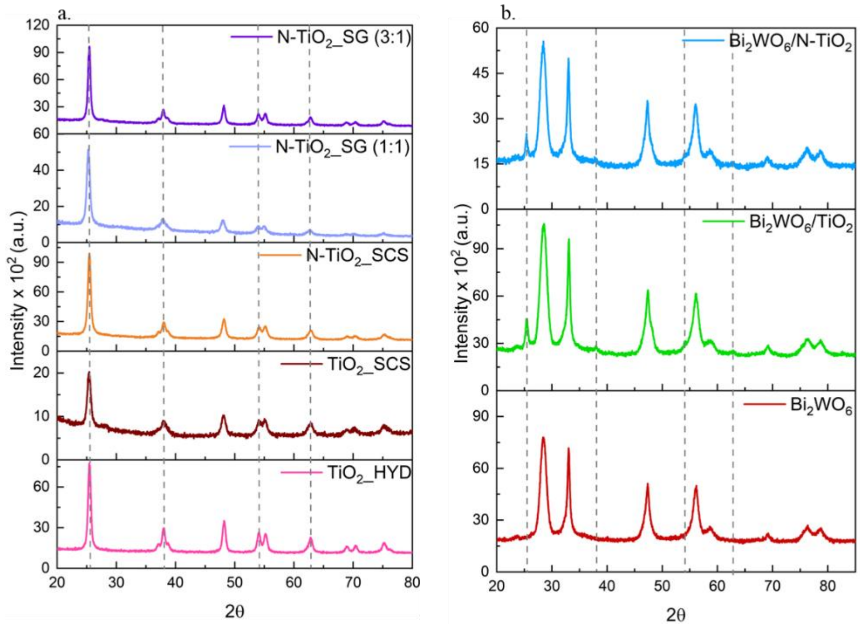

Figure 1.a. XRD of TiO_2_HYD, TiO_2_SCS, N-TiO_2, SCS, N-TiO_2_SG, b. XRD of Bi_2WO_6, Bi_2WO_6/TiO_2 and Bi_2WO_6/N-TiO_2

4. Conclusions

N-doping and Bi_2WO_6 Z-scheme engineering transformed TiO_2 into a versatile visible-light photocatalyst, where the synthesis routes shaped the critical optical and textural properties for indoor air purification. Ongoing reactor screening will quantify ethylene conversion, CO_2 mineralization, and stability, promising breakthroughs in sustainable indoor air pollution control.

References

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Keywords

Indoor air pollution; visible-light photocatalysis; N-doped TiO_2; Bi_2WO_6 coupled TiO_2; Z-scheme heterojunction; VOC oxidation; CO_2 reduction

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