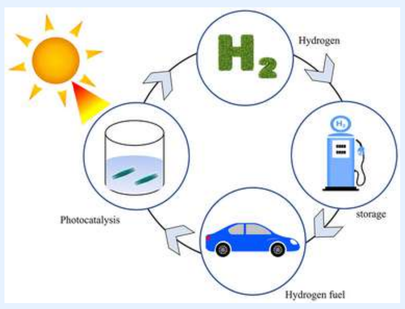
Study of Ag, Au, and Pt Co-catalysis on TiO_2 for Enhancement the Photocatalytic Efficiency

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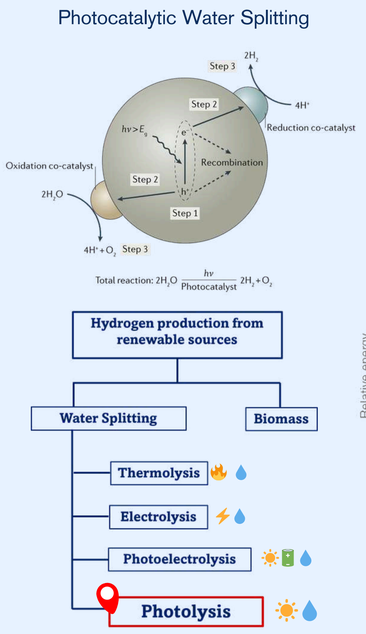
Abstract

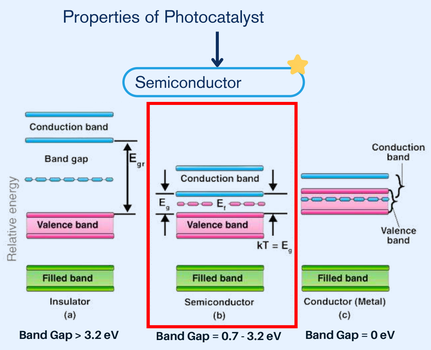
Hydrogen gas (H_2) is considered a highly promising clean energy source due to its environmentally friendly nature, high gravimetric energy density, and the absence of greenhouse gas emissions during combustion. However, current hydrogen production technologies predominantly rely on fossil fuels, which contribute to environmental problems. Therefore, the development of sustainable hydrogen production technologies has become a critical focus in energy research. This study investigates hydrogen production via photocatalytic water splitting using titanium dioxide (TiO_2) as a semiconductor photocatalyst. TiO_2 is widely recognized for its low cost, chemical stability, and environmental benignity. Nevertheless, its relatively wide band gap and high electron–hole recombination rate limit its photocatalytic efficiency. To enhance its performance, noble metal co-catalysts, namely silver (Ag), gold (Au), and platinum (Pt), have been deposited onto the surface of TiO_2 to reduce the charge recombination rate. In this research, the metal deposited on TiO_2 were synthesized using the hydrothermal method at 180°C for 36 h. Structural and morphological characterization confirmed the crystalline nature of the synthesized samples, while compositional analysis verified the successful incorporation of metal species onto the TiO_2 surface. UV-Vis spectroscopy revealed a slight narrowing of the band gap after metal loading. Among the prepared samples, Au-loaded TiO_2 exhibited the narrowest band gap (3.12 eV) compared to pure anatase TiO_2 (3.16 eV). This modification improved the optical properties of the photocatalyst, making it more suitable for photocatalytic hydrogen production. Photocatalytic activity tests were conducted to evaluate hydrogen generation performance. The findings suggest that metal-loaded TiO_2 photocatalysts, particularly Au/ TiO_2, demonstrate enhanced potential for sustainable hydrogen production. This study provides valuable insights into the development of efficient photocatalysts for future clean energy applications.

Introduction



Hydrogen is considered a promising clean energy source, and this study focuses on improving photocatalytic hydrogen production using TiO_2 as a semiconductor photocatalyst.





1.6-3.0 eV → visible light 400 - 700 nm

>3.0 eV → UV light 100 - 400 nm

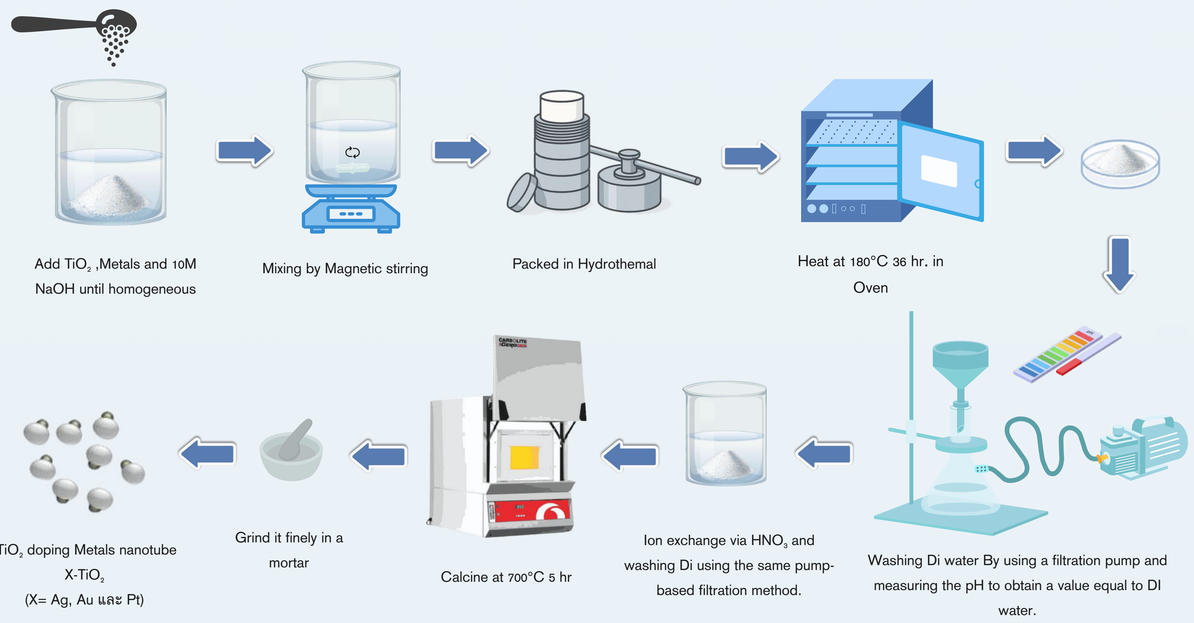
<1.5 eV → Infrared (IR) 700-1400 nm

Objectives

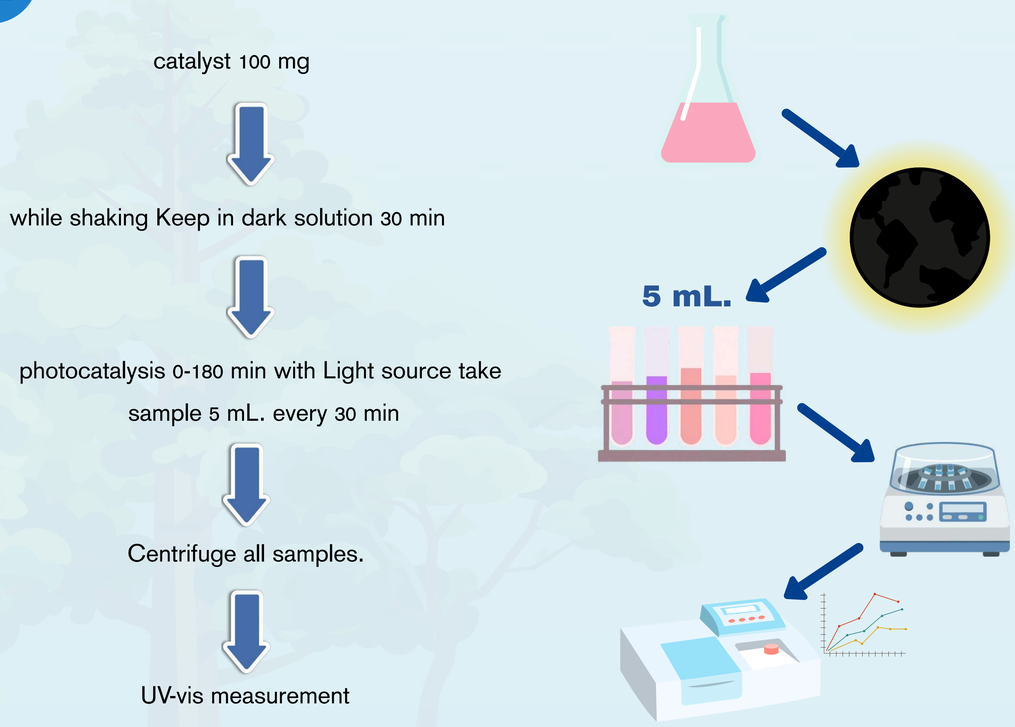
1. To investigate the hydrothermal synthesis of silver (Ag), gold (Au), and platinum (Pt) co-catalysts deposited on titanium dioxide (TiO_2), and to evaluate the effect of metal loading on the improvement of material properties for photocatalytic applications.
2. To evaluate the photocatalytic dye degradation efficiency of Ag, Au, and Pt-loaded TiO_2 and compare their catalytic performance with that of pure TiO_2.

Experiment

1 Synthesis of Ag, Au, and Pt Co-catalysts on TiO_2 Photocatalysts by Hydrothermal Method (HT)

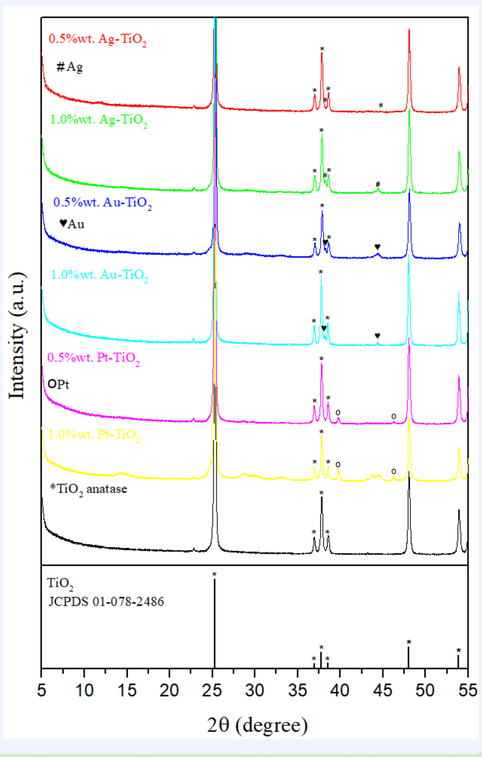


2 Photocatalytic Dye Degradation in 5ppm Rhodamine B 100 mL

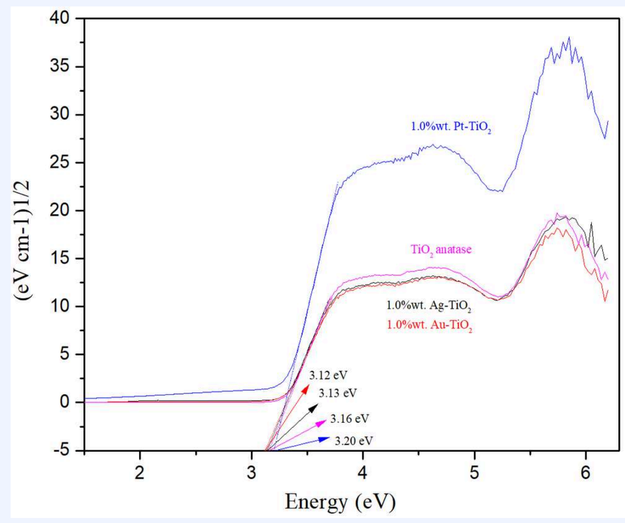


Results & Discussion

XRD

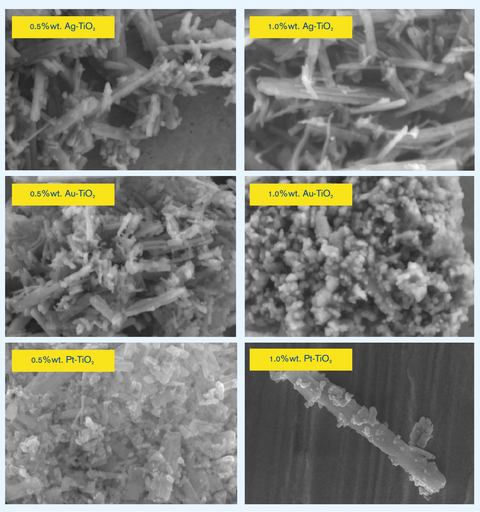


DRS



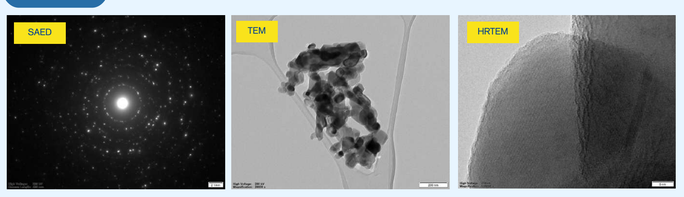
From the DRS analysis, the band gap energy of TiO_2 in the anatase phase was found to be approximately 3.20 eV, which is consistent with values reported in the literature. After the incorporation of noble metals such as Ag, Au, and Pt onto the surface of TiO_2, the band gap slightly decreased to approximately 3.12–3.16 eV. This reduction facilitates improved light absorption and enhances the probability of electron excitation. Consequently, the photocatalytic performance of the material is expected to improve. In particular, Au–TiO_2 and Ag–TiO_2 exhibited lower band gap energies compared with pure TiO_2, indicating their potential for enhanced photocatalytic activity.

SEM



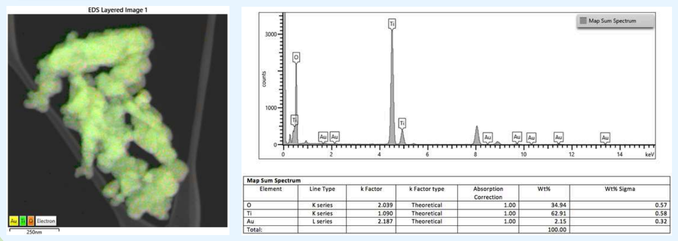
The result of a composite material between TiO_2 and individual metal doping. SEM images reveal nanoparticles of Ag, Au, and Pt coated on TiO_2

TEM

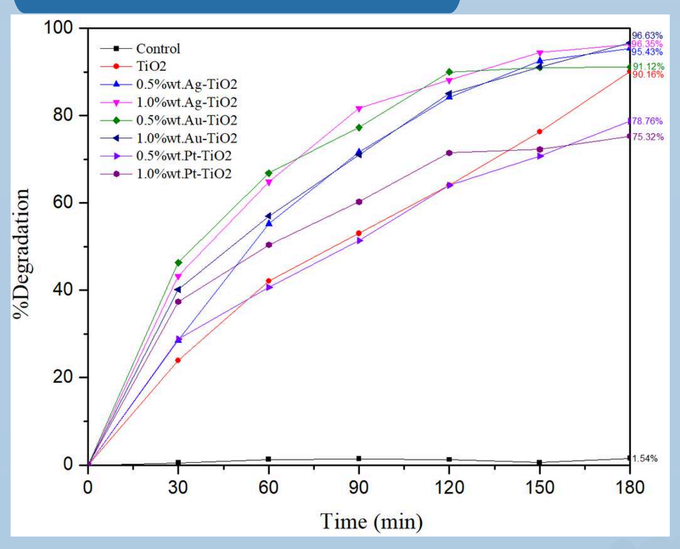


The TEM analysis of the 1.0 wt.% Au–TiO_2 sample revealed that the TiO_2 particles are present as nanoparticles that tend to agglomerate. The material exhibits a well-defined anatase crystalline structure. The SAED and HRTEM images confirm the crystalline nature of the material as well as the presence of Au nanoparticles on the surface of TiO_2

EDS



Photocatalytic efficiency



The dye degradation tests were conducted using 100 mg of the synthesized catalyst to degrade Rhodamine B dye at a concentration of 5 mg/L in 100 mL of dye solution. The photocatalytic reaction was carried out under UV-B irradiation for 300 minutes. The results showed that the degradation efficiency increased progressively with increasing irradiation time. In contrast, the control sample exhibited only minimal degradation of approximately 1.54%, indicating that the degradation of the dye primarily occurred through the photocatalytic process.

1.0%wt. Au-TiO_2 = 96.63%

Conclusion

1.XRD analysis confirmed that TiO_2 exhibited an anatase crystalline phase, while TEM images showed the successful dispersion of noble metal nanoparticles on the TiO_2 surface. DRS results indicated a slight reduction in the band gap after metal loading, which enhanced light absorption and improved the photocatalytic properties of the material.

2.Photocatalytic efficiency tests demonstrated that TiO_2 loaded with Ag, Au, and Pt exhibited higher dye degradation performance than pure TiO_2. The improved activity is attributed to enhanced electron–hole separation and reduced charge recombination.

Acknowledgements

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