Understanding the enhanced photocatalytic activity in CdS/Ta_3N_5 heterostructure nanocomposites for water splitting and H_2 evolution

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Abstract: Energy and environment is the biggest concern of the modern world. The energy resources are shrinking very fast due to the growing population and industrialization. At the same time, the accumulation of CO_2 in the atmosphere is also increasing alarmingly high. In view of the above concerns, the scientists are looking for renewable and green energy alternatives. In this perspective, H_2 evolution from photocatalytic water splitting is seldom a bad idea. A lot of research has been done in this direction and a variety of photocatalysts have been so far reported.

Here, in this study, we have explored the photocatalytic H_2 evolution by CdS/Ta_3N_5 heterostructure nanocomposites. The synthesized photocatalysts were characterized by XRD, SEM, TEM, EDX and XPS study. The XRD study shows that the pure crystalline phase nanocomposite samples have been synthesized. SEM and TEM indicated that small rod shaped Ta_3N_5 nanoparticles are surrounded by CdS nanoparticles leading to the formation of the nanocomposite heterostructures. Elemental analysis was done by EDX and the oxidation states of the constituent elements were confirmed by the XPS study. The Optical study was done by UV-Vis-DRS and the band gap was determined using Kubelka-Munk formulation and Tauc plots. The electrochemical study viz; Mott Schottky was employed to determine the band gap positions of these semiconductor nanocomposites whereas Electrochemical Impedance Spectroscopy was done to determine the charge transfer properties of the nanocomposite samples.

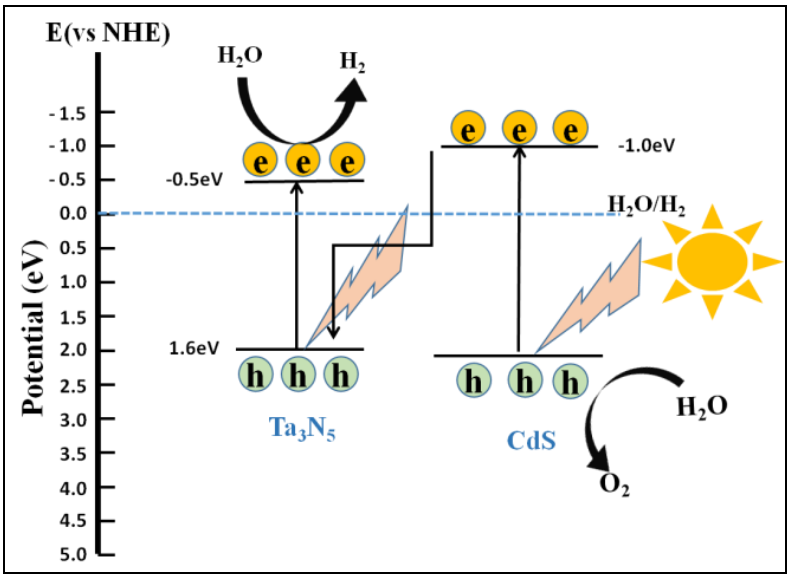

Figure 1: Plausible Z-Scheme mechanism for the H_2 production by Ta_3N_5/CdS heterostructure nanocomposites.

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The photocatalytic experiment was performed in a closed reaction vessel containing the aqueous mixture of the photocatalyst and the sacrificial reductants. The reaction vessel was purged with N_2 gas prior to the reaction so as to remove the residual H_2 and other gases. 400 W xenon lamp with a 400 nm cut-on filter was used to irradiate the reaction mixture. The gas samples were taken out by syringe through the septum so as to analyze by the GC instrument.

It was found that 10 % CdS/Ta_3N_5 nanocomposite photocatalyst exhibited the best activity for H_2 evolution. The enhancement in the activity can be attributed to the enhanced light absorption, improved charge transfer and decreased charge carrier recombination owing to the heterostructure formation

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