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Quantum efficiency of visible-light photochemical water splitting for hydrogen production by photocatalysis

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: Hydrogen has been labeled as the cleanest energy carrier, which can be used for fuel cells. However, the use of clean and renewable energy has been largely hindered by the low efficiency of photocatalysts. An efficient and cheap photocatalyst is required to produce energy from hydrogen in large quantities to meet the ever-increasing demand. Water splitting photocatalysts have attracted a lot of interest because of the environmental friendliness of the technique, however, most of these use only 4 % (UV-region) of the solar energy. In this study CdS, nanoparticles for photocatalytic water splitting were synthesized by using a chemical precipitation method. One of the aims of this investigation was to see to what degree bandgap engineering over a large spectral range could be conducted through particle size manipulation. It is well known that the capping agent, as well as the surfactant concentration, largely contribute to the final nanoparticle size. As such, in this study, we investigated to what degree thioglycerol (TG) could be used as a capping agent (to this end). Structural and morphological properties of the synthesized material were conducted with transmission electron microscopy (TEM), scanning electron microscopy (SEM) as well as Scherrer analysis of the x-ray diffraction patterns (XRD). We showed that the particle sizes and band gap energy could be successfully controlled with the TG capping agent and particle sizes were varied between 6.8 ±1 nm and 1.8 ±1 nm. The quantum-confinement effect was also visually observed in a change in the color of the CdS NP's from dark yellow to light green with increasing TG concentration was noted. Small sized particles have a high surface-to-volume ratio, this shortens the distance the electrons travel during separation, leading to a large number of electrons reaching the surface without recombination. An increase in the bandgap from 2.5 eV (500 nm) to 3.2 eV (384 nm) was observed with UV-vis spectroscopy. Furthermore, annealing studies revealed that an enhancement in the crystallinity of the material may lead to a reduction in the recombination rates of the electron-hole pair during photocatalytic water splitting. Photoluminescence (PL) studies show a change in luminescence centers with increasing annealing temperature and crystallinity.

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