

Photoelectrochemical hydrogen production using CdS nanoparticles photodeposited onto Li-ion-inserted titania nanotube arrays

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This study reports the synthesis of cadmium sulfide (CdS) nanoparticles on Li⁺-inserted TiO₂ nanotube array (Li-TNA) to fabricate Li-TNA/CdS heterojunction electrodes for photoelectrochemical (PEC) hydrogen production under air mass (AM) 1.5 light and solar visible light ($\lambda > 420$ nm). For fabrication of the heterojunction, Li ions are rapidly inserted into TNA pre-grown on Ti foil, and CdS is then photodeposited onto the Li-TNA electrodes for varying deposition times. Surface analyses reveal that sub-100-nm polycrystalline CdS particles partly cover the Li-TNA (length: ~ 800 nm, pore diameter: ~ 100 nm), enabling the heterojunction to utilize AM 1.5 light as well as visible light. In aqueous solutions of sulfide and sulfite, the Li-TNA/CdS exhibits an incident photon-to-current efficiency (IPCE) of $\sim 20\%$ ($\lambda = 420$ nm) while generating H₂ at a Faradaic efficiency of $\sim 100\%$. This PEC performance is superior to that of TNA/CdS, which is attributed to the Li⁺-enhanced charge transfer at the TNA/CdS interface. Electrochemical impedance analysis shows that the charge-transfer resistance of the TNA is reduced by $\sim 60\%$ by Li⁺ insertion. Time-resolved photoluminescence decay profiles further reveal that the charge transfer in Li-TNA is completed within 0.8 ns, which is $\sim 33\%$ faster than that in TNA. The sample surface is analyzed using scanning electron microscopy, X-ray diffraction, energy-dispersive X-ray spectroscopy, X-ray photoelectron spectroscopy, and ultraviolet-visible

spectroscopy, and the PEC behavior of the samples is discussed in detail.

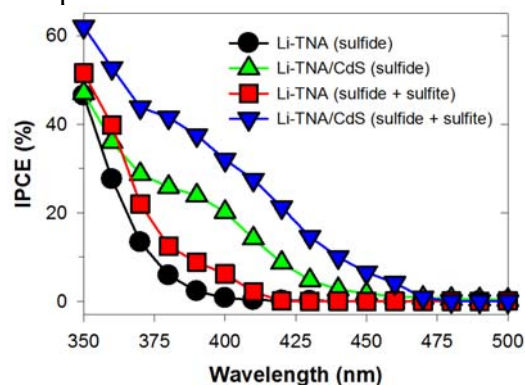


Fig.1 IPCE profiles of sample electrodes at 0 V in aqueous sulfide (1 M) or sulfide/sulfite (each 0.5 M) solutions.

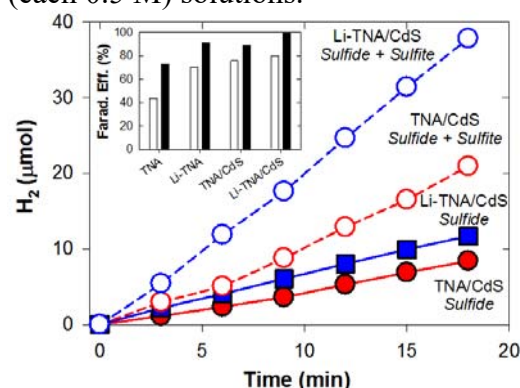


Fig. 2. PEC performance of sample electrodes held at -0.5 V in aqueous sulfide (1 M) or sulfide/sulfite (each 0.5 M) solutions under AM 1.5 light. Time-profiled H₂ evolution. The faradaic efficiencies for H₂ are compared in the inset of figure.

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