Mesoporous Architectures of Spinel Chalcogenide Nanoparticles Coupled with Transition Metal Phosphides for Photochemical Water Splitting and Hydrogen Production

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The photochemical water splitting for hydrogen production has been proven as an attractive solution to the rising problem caused by the excessive fossil fuel consumption. This photochemical process of producing solar fuels, such as hydrogen, has a positive impact on the environment due to the zero emission of harmful byproducts. Hydrogen is a promising future energy source thanks to its high gravimetric energy density and efficient conversion to electricity with zero carbon emission. However, until now over 95% of hydrogen is produced from fossil fuels with significant amount of greenhouse gas evolution. To this end, there has been a strong effort from the research community to devise new photocatalytic materials that combine high solar-to-chemical conversion efficiency, low cost of production and high chemical stability. Our research group and others have already projected the potential of mesoporous assemblies of metal chalcogenide nanoparticles as outstanding photocatalysts for hydrogen evolution from water.[1] Recently, we found that the co-existence of two types of materials, the spinel chalcogenides and transition metal phosphides, in the same structure can be considered as an ideal candidate for the photochemical water splitting and hydrogen generation. Herein, we report for the first time a low temperature synthesis of $CdIn_2S_4$ nanocrystals of size 5-10 nm and their conversion to mesoporous architectures with large internal surface area (>135 m^2g^{-1}) and outstanding photocatalytic activity for hydrogen evolution (100 μmol h^{-1}). Furthermore, when Ni_2P nanosheets recombine on the $CdIn_2S_4$ mesoporous surface to produce $Ni_2P/CdIn_2S_4$ heterostructures the photocatalytic H_2 evolution rate rises to 400 μmol h^{-1}, affording an apparent quantum yield over 50% at 420 nm for water splitting, which is the highest ever reported activity for thiospinel-based systems.

References

[1] I.Vamvasakis et al, *Adv. Fun. Mat.* **26**, 2016, 8062-8071; *ACS Catal.* **8**, 2018, 8726-8738.

[2] The authors acknowledge support from the Hellenic Foundation for Research and Innovation (H.F.R.I.) under the "1st Call for H.F.R.I. Research Projects to support Faculty Members & Researchers and the Procurement of High-cost research equipment grant" (Project Number: 400).

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