Finding more efficient catalysts for sunlight-powered hydrogen production

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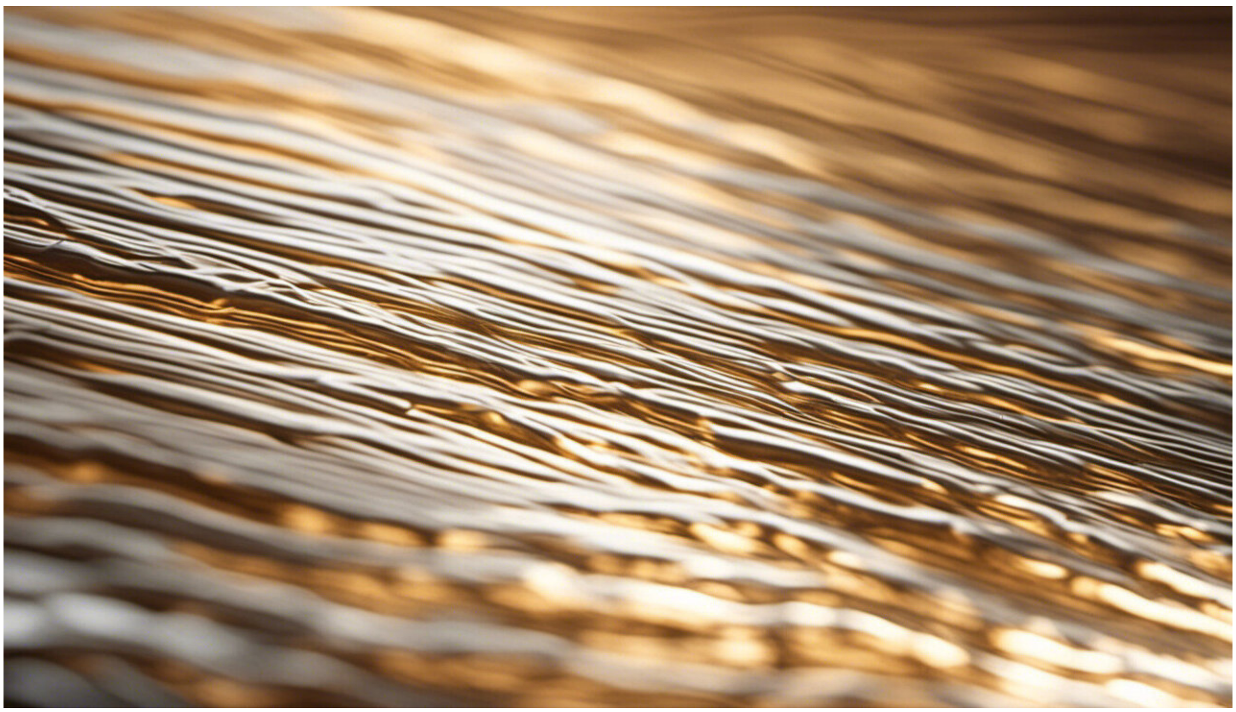

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Hydrogen is crucial for the oil-refining industry and the production of essential chemicals such as the ammonia used in fertilizers. Since producing hydrogen is costly, scientists have long searched for alternative, energy-efficient methods to separate hydrogen atoms from abundant sources such as water.

Nanometer-scale structures consisting of cheap metal and oxide spheres were recently demonstrated as an excellent catalyst for a hydrogen-production reaction powered only by sunlight. The study was completed by Ming-Yong Han and his colleagues of the A*STAR Institute of Materials Research and Engineering, Singapore, working in collaboration with a team of researchers from Singapore and France.

Han and his team mixed 50-nanometer diameter spheres of gold into a titanium dioxide precursor such that a sphere of titanium dioxide formed on the side of each gold nanoparticle. Structures with this two-sphere arrangement are known as Janus particles, named after the two-headed god from Roman mythology. While the Janus particles were suspended in a mixture of water and isopropyl alcohol, Han and co-workers shone visible light on them and measured hydrogen production, which proceeded at a rate as fast as 2 milliliters per minute.

The researchers then used theoretical models to show that this production rate was caused by so-called plasmonics effects: that is, the electrons on the surface of the gold nanoparticle at the junction with the titanium dioxide coupled to the incoming light and formed light–matter hybrid particles called plasmon polaritons. The energy absorbed by these particles then passed into the surrounding liquid, and this drove the hydrogen-releasing chemical reaction.

"Our work provides insight into mechanisms that will be useful for the future development of high-performance photocatalysts," says Han. Indeed, Han and his co-workers were able to improve the efficiency of the hydrogen production even further: they increased the area of the metal–oxide interface by using larger gold nanoparticles.

The Janus particles were 100 times more efficient as a catalyst for hydrogen production than bare gold nanoparticles. Moreover, they were over one-and-a-half times better than another common type of plasmonic nanoparticle, core–shell particles, in which the oxide material forms a coating around the metal nanoparticle.

"We next hope to develop a better understanding of the processes that occur at the metal–titanium-dioxide interface using a combination of experimental observations and theoretical simulations," says Han. "This will get us closer to our ultimate goal of using solar illumination as an abundant source of renewable energy."

More information: Seh, Z. W., Liu, S., Low, M., Zhang, S.-Y., Liu, Z., et al. Janus Au-TiO2 photocatalysts with strong localization of plasmonic near-fields for efficient visible-light hydrogen generation. *Advanced Materials* 24, 2310–2314 (2012). onlinelibrary.wiley.com/doi/10 … a.201104241/abstract

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