Nanostructuring increases efficiency of metal-free photocatalysts by factor 11

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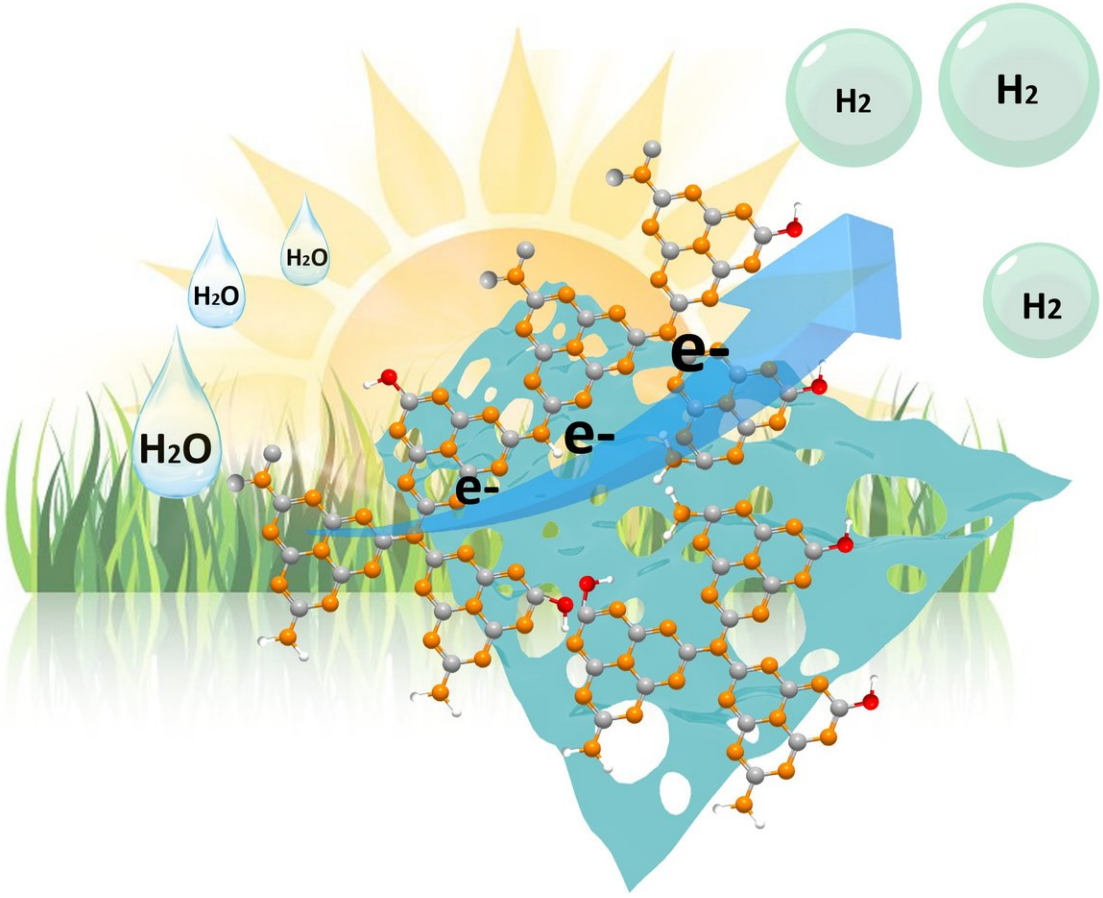


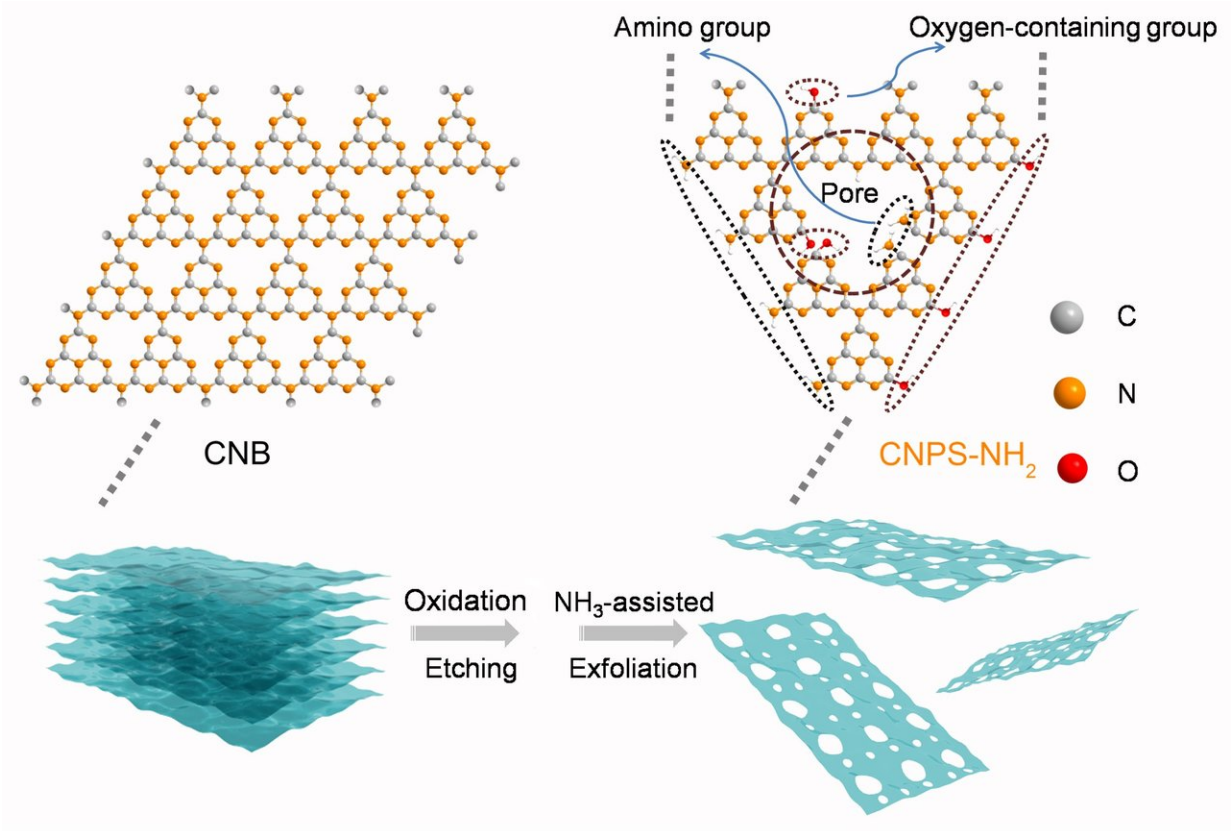
PCN nanolayers under sunlight can split water. Credit: Nannan Meng /Tianjin University

One of the major challenges of the renewable energy transition is to

supply energy even in the absence of sunlight. Hydrogen production by splitting water with the help of sunlight could offer a solution. Hydrogen is a good energy storage medium, and can be used in many ways. However, catalysts are needed to split water. Platinum is often used, but it is rare and expensive. Researchers therefore seek more economical alternatives. Now, a team headed by Dr. Tristan Petit from the HZB, together with colleagues led by Prof. Bin Zhang from Tianjin University, Tianjin, China, has made important progress using a well-known class of metal-free photocatalysts.

Bin Zhang and his team specialise in the synthesis of polymeric carbon nitrides (PCN) as a catalyst for hydrogen production. The PCN molecules form a structure that can be compared to thin layers of filo pastry dough—tightly packed sheets of this material are packed together. The Chinese chemists have now succeeded in separating the individual sheets from each other by means of a relatively simple two-step heat treatment—the same way that puff pastry separates into individual crispy layers in the oven. The heat treatment produced samples consisting of individual nanolayers with large pores containing different amino groups with specific functionalities.

Petit and his team investigated a series of these PCN samples at BESSY II. "We were able to determine which amino and oxygenated groups had been deposited in the pores," says Ph.D. student Jian Ren, co-first author of the publication. The researchers analysed how specific amino groups pull electrons to themselves, a particularly favourable property for splitting water, and how new oxygen-based defects were formed.



heat treatment produced samples consisting of individual nanolayers with large pores containing different amino groups with specific functionalities. Credit: Nannan Meng /Tianjin University

When combined with nickel as a co-catalyst, those samples of nanostructured PCN actually exhibited record-breaking efficiency, 11 times that of normal PCN under visible light irradiation.

"This demonstrates that PCN is an interesting potential catalyst for solar-to-hydrogen production, approaching the efficiency of inorganic catalysts," says Petit, who is a Volkswagen Foundation Freigeist Fellow. "Furthermore, this work also shows that soft X-ray spectroscopies are

essential tools to unravel possible catalytically active sites on photocatalysts."

More information: Nannan Meng et al, Engineering oxygen-containing and amino groups into two-dimensional atomically-thin porous polymeric carbon nitrogen for enhanced photocatalytic hydrogen production, *Energy & Environmental Science* (2018). DOI: 10.1039/C7EE03592F

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