Solar energy-driven H_2O_2 photosynthesis from water and oxygen using Ba-implanted ordered carbon nitride

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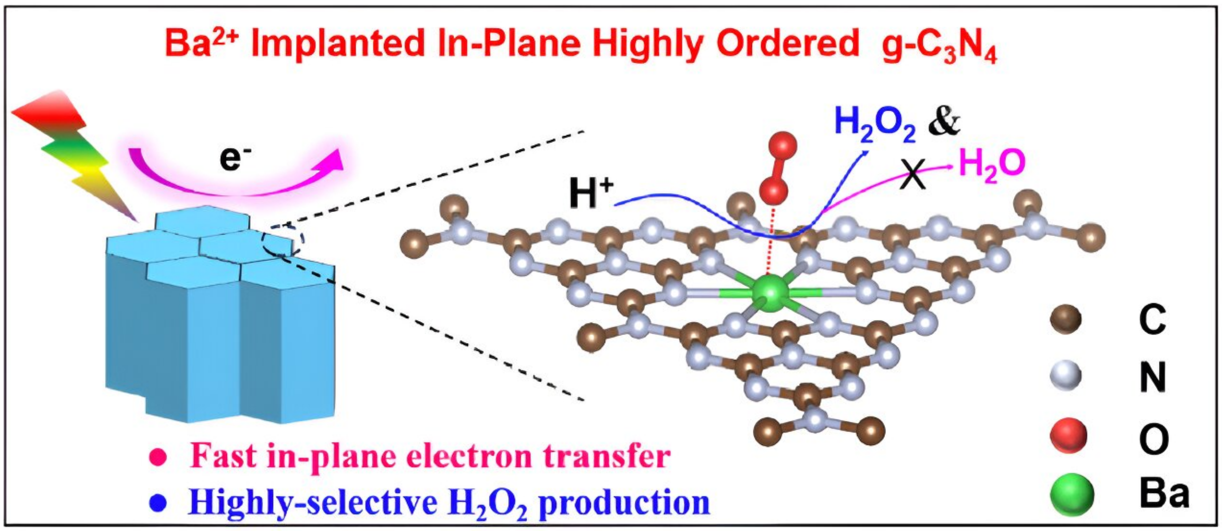

Photocatalytic H_2O_2 production by using only water and oxygen as ingredients is an attractive and sustainable strategy to replace traditional anthraquinone process. Using a $BaCl_2$-mediated in-plane polymerization strategy, researchers synthesized a novel Ba-implanted graphitic carbon nitride photocatalyst with unique highly ordered nanorod structures, which demonstrated a boosted photocatalytic H_2O_2-evolution rate. This innovation paves the way for greener and more efficient H_2O_2 production process. Credit: *Chinese Journal of Catalysis*

H_2O_2, a green oxidant and clean fuel, is in high demand across chemical industries, environmental treatments, and even aerospace. However, traditional production methods rely on energy-intensive processes that are not environmentally friendly. Scientists have been seeking a greener alternative, and semiconductor photocatalysis using solar energy to drive chemical reactions has emerged as a promising solution.

To date, various photocatalysts, such as TiO_2, $BiVO_4$, metal-organic complexes and organic polymers, have been explored for H_2O_2 photosynthesis. Cost-effective graphitic carbon nitride (g-C_3N_4) has caught widespread attention in H_2O_2 photosynthesis due to its elemental abundance, high structure stability and appropriate band structure.

However, the H_2O_2 production efficiency of traditional g-C_3N_4 is severely limited due to poor crystallinity and selectivity in two-electron oxygen reduction reaction ($2e^-$-ORR). Therefore, improving the in-plane crystallinity of bulk g-C_3N_4 is greatly requisite to sufficiently trigger oxygen reduction reaction for efficient photocatalytic H_2O_2 production.

Recently, a research team led by Prof. Yaorong Su from Shenzhen Technology University, China, ingeniously overcomes these obstacles. They developed a new type of photocatalyst, in-plane highly ordered g-C_3N_4 nanorods with barium (Ba) atoms implanted. This innovation not only enhances the in-plane crystallinity but also induces a highly selective $2e^-$-ORR, which is the key to efficient H_2O_2 production.

The Ba-implanted nanorods work their magic by altering the way oxygen molecules (O_2) interact with the photocatalyst. Instead of the typical side-on binding that favors water production, the Ba atoms encourage a more favorable end-on binding. This change significantly reduces the possibility of O-O bond breaking, effectively suppressing the competing four-electron reaction and boosting the production of H_2O_2.

An outstanding 6.1 times increase in H_2O_2 production rate compared to the original g-C_3N_4 was achieved. This breakthrough not only optimizes the photocatalytic process of solar energy-driven H_2O_2 photosynthesis but also opens up new possibilities for designing efficient catalysts for solar-to-fuel conversion, bringing us closer to a sustainable future.

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More information: Aiyun Meng et al, Towards highly-selective H_2O_2 photosynthesis: In-plane highly ordered carbon nitride nanorods with Ba atoms implantation, *Chinese Journal of Catalysis* (2024). DOI: 10.1016/S1872-2067(24)60008-2

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