Artificial spherical chromatophore nanomicelles for selective CO2 reduction in water

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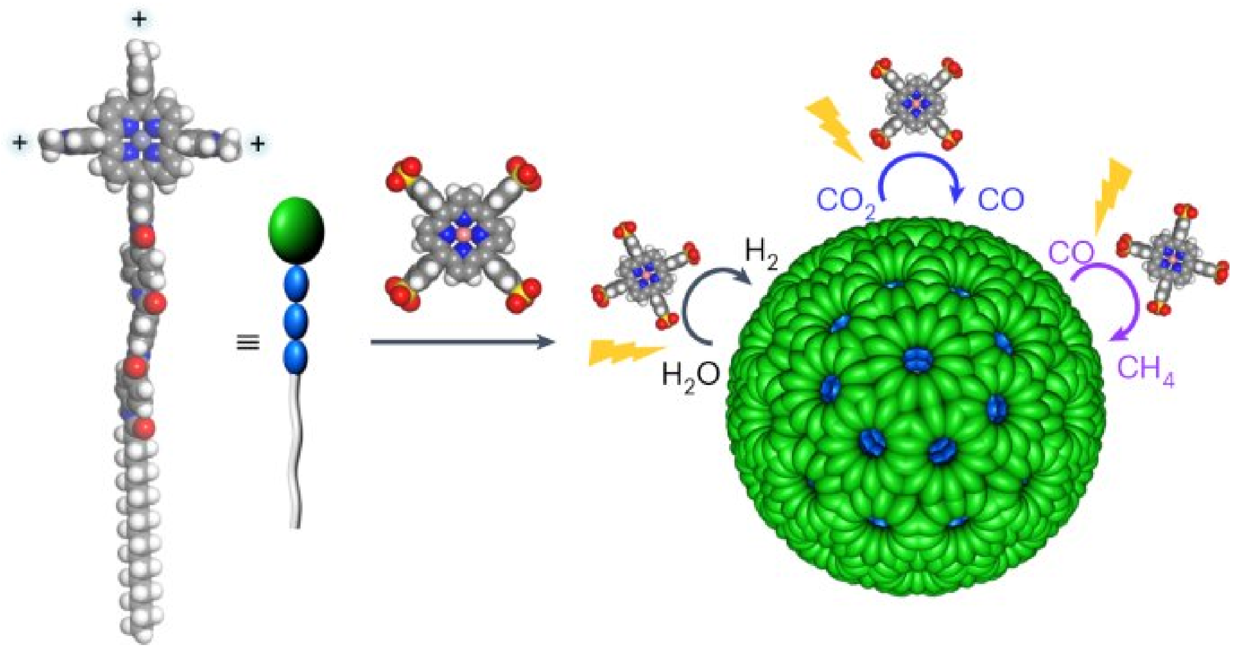

Graphical abstract. Credit: *Nature Catalysis* (2023). DOI: 10.1038/s41929-023-00962-z

Researchers led by Prof. Tian Jia from the Shanghai Institute of Organic Chemistry of the Chinese Academy of Sciences have developed a new strategy for visible-light-induced selective carbon dioxide (CO_2) conversion by mimicking the key elements and assembly structures of natural photosynthetic purple bacterial chromatophores through supramolecular self-assembly.

This work, which offers new insights for accurately simulating the biological structures and functions of supramolecular assemblies and energy conversion for artificial photosynthesis, was published in *Nature Catalysis* on May 18.

Photosynthesis is the ultimate source of energy and organic matter for nearly all living organisms. In nature, photosynthetic organelles harness solar radiation to produce energy-rich compounds from water and atmospheric CO_2 via exquisite supramolecular assemblies.

Although artificial photocatalytic cycles have been shown to operate with higher intrinsic efficiencies, the low selectivity and stability in water for multi-electron CO_2 reduction hampers their practical applications. The creation of water-compatible artificial photocatalytic systems mimicking the natural photosynthetic apparatus for selective and efficient solar fuel production represents a major challenge.

In this study, the researchers used a supramolecular assembly approach to create an artificial photosynthetic chromatophore nanomicelle system based on the structure of natural photosynthetic purple bacteria. The system was applied to selective CO_2 catalytic conversion in water under visible light irradiation and showed excellent stability and efficiency.

The team proposed a promising solution for energy conversion and storage through "zero-carbon cycle" pathways, which is an effective way to alleviate energy crisis and reduce carbon emissions.

Benefiting from the existence of intermolecular hydrogen bonds, the spherical nanomicelles assembled from amphiphilic tri-block porphyrin-based supramolecules are extremely stable in aqueous phase. As a chromatophore, the nanomicelles exhibited obvious light-harvesting antenna effect and strong resistance to photobleaching.

Moreover, electropositive ring-like porphyrin arrays of 4.2 nm in diameter were observed on their surface, and each sub-structure consists of ca. 12 porphyrin by calculation.

For the purpose of efficient electron injection, an electronegative carbon monoxide catalyst was chosen as the ideal catalyst because the space distance between the catalyst and the ring-like porphyrin array was drawn closer by electrostatic force. Under the irradiation of visible light, the artificial photocatalytic system achieved the conversion of CO_2 to methane with high efficiency and selectivity.

In addition, the researchers proposed a two-stage mechanism in which carbon monoxide was regarded as intermediate species, which was further proved by isotope labeling experiment, steady-state and transient absorption spectra and density functional theory calculations.

More information: Junlai Yu et al, Artificial spherical chromatophore nanomicelles for selective CO2 reduction in water, *Nature Catalysis* (2023). DOI: 10.1038/s41929-023-00962-z

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