

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 <u>energy conversion</u> for <u>artificial photosynthesis</u>, 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, <u>photosynthetic</u> organelles harness <u>solar radiation</u> 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 <u>energy crisis</u> and reduce <u>carbon emissions</u>.

Benefiting from the existence of intermolecular hydrogen bonds, the spherical nanomicelles assembled from amphiphilic tri-block porphyrinbased 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 <u>carbon</u> <u>monoxide</u> 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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