A catalyst for converting carbon dioxide, the main cause of global warming, into ethylene using vitamin C

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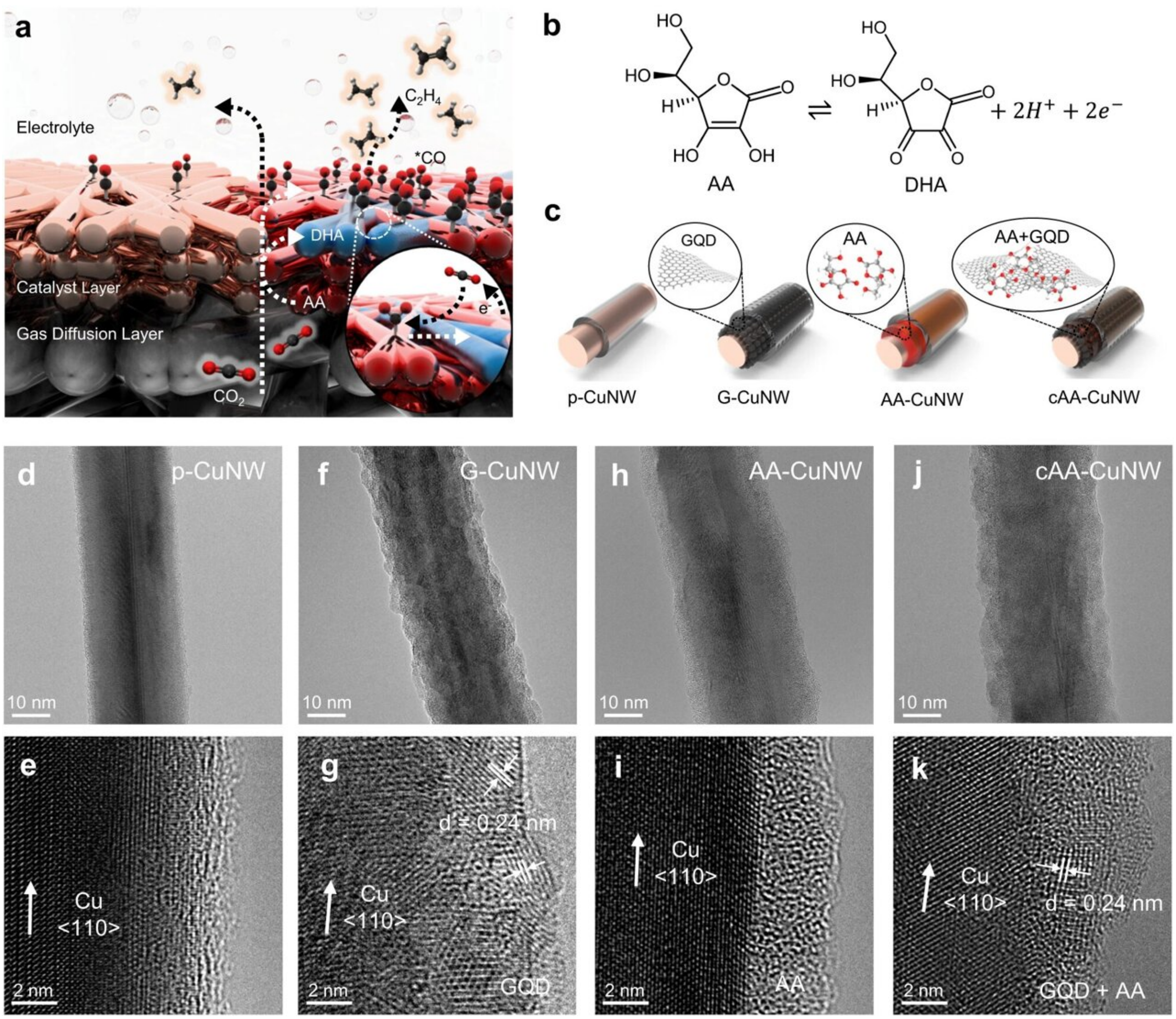

CO_2 capture strategy and surface structures of AA-augmented CuNWs. **a**

Schematic of enhanced CO_2-to-*CO conversion and *CO dimerization in cAA-CuNW for high-rate C_2H_4 production. **b** Redox of AA and DHA for CO_2 capture. **c** Schematic illustration of surface modification of CuNWs with GQD, AA, and nanoconfined AA on GQDs. An ionomer is coated on the outer surface of CuNWs during the fabrication of the GDE. TEM (top) and HR-TEM (bottom) images of (**d, e**) p-CuNW, (**f, g**) G-CuNW, (**h, i**) AA-CuNW, and (**j, k**) cAA-CuNW. Credit: *Nature Communications* (2024). DOI: 10.1038/s41467-023-44586-0

A joint research team has developed a new electrochemical catalyst that promotes the conversion from carbon dioxide (CO_2) to ethylene (C_2H_4).

Through joint efforts led by Professors Dae-hyun Nam and Youn-gu Lee from the Department of Energy Science and Engineering at DGIST and Professor Seo-in Back from the Department of Chemical and Biomolecular Engineering at Sogang University, the research team has devised a technology to substantially enhance ethylene production by incorporating vitamin C into a carbon dioxide reduction catalyst of a heterogeneous system.

This is based on the observation that the presence of carbon dioxide in the air impacts the vitamin C levels in fruits.

The electrochemical reduction of carbon dioxide is gaining recognition as a fundamental technology for "eco-friendly energy." This process aims to decrease the concentration of carbon dioxide in the atmosphere while generating cleaner sources of future energy. However, existing electrochemical catalysts face challenges in achieving consistent catalytic performance under high current density conditions.

This limitation hampers the formation of the essential intermediate product, carbon monoxide, which plays a critical role in ethylene conversion. Instead, these catalysts tend to induce the reaction for hydrogen generation rather than the carbon dioxide reduction reaction.

Therefore, for seamless reduction of carbon dioxide, achieving stable formation of the intermediate product of carbon monoxide at high current density through an electrochemical catalyst and promoting dimerization where two carbon monoxide intermediate products are combined is significant.

Thus, the research team led by Professor Nam at DGIST devised a method to integrate the oxidation-reduction reaction of vitamin C into the electrochemical reduction of carbon dioxide based on the phenomenon where the vitamin C content in fruits decreases in an environment with a high concentration of carbon dioxide.

The research team synthesized vitamin C with graphene quantum dots and fabricated a "vitamin C boosting copper nanowire" by combining the synthesized material with copper. This approach helped stabilize vitamin C through the nano-confinement effects of graphene quantum dots and enabled the reversibility of oxidation-reduction.

Additionally, the oxidation-reduction reaction of vitamin C consistently supplied electrons and protons to carbon dioxide, promoting the dimerization process and creating the carbon monoxide intermediate product. Consequently, the newly developed catalyst exhibited a 2.9-fold enhancement in ethylene production compared to conventional copper nanowire catalysts.

Furthermore, the research team identified that the vitamin C confined in graphene optimizes the integration of carbon monoxide intermediate product and copper catalyst through real-time Raman spectroscopic analysis and computer simulation. The research team also identified the working principle of the catalyst by verifying that electrons and protons can be delivered, which facilitates the reduction reaction of carbon dioxide based on a strong hydrogen bond.

Professor Nam at DGIST stated, "This research created an electrochemical catalyst capable of large-scale ethylene production through the reduction of carbon dioxide and revealed a novel reaction mechanism. This technology is expected to play a key role in achieving carbon neutrality by transforming carbon dioxide—a major contributor to global warming—into a high-value compound."

The work is published in the journal *Nature Communications*.

More information: Jongyoun Kim et al, Vitamin C-induced CO_2 capture enables high-rate ethylene production in CO_2 electroreduction, *Nature Communications* (2024). DOI: 10.1038/s41467-023-44586-0

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