New hybrid catalyst could help decarbonization and make ethylene production more sustainable

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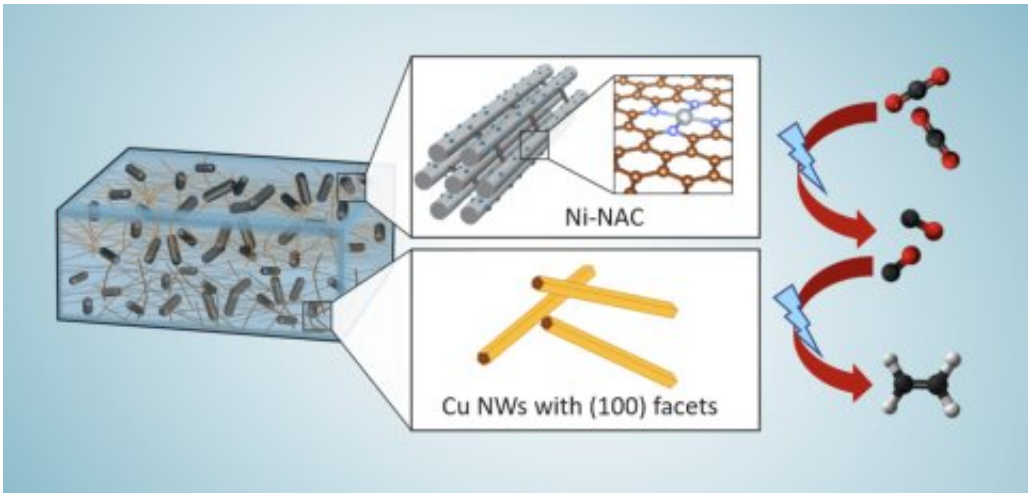

Left: Visual of the composite catalyst. Top Middle: This image shows the porous structure of the Ni-NAC aspect of the composite catalyst. The light blue represents the atomically dispersed Ni, the blue represents the Nitrogen, and the red shows the Carbon in the structure. Bottom Middle: This is a visualization of the copper nanowires. Right: These illustrate the Ni-NAC catalyzed reduction of CO2 into CO atoms by applying an electrical charge, then additional electrical addition causes the reaction of CO to produce ethylene. Credit: *Journal of the American Chemical Society* (2022). DOI: 10.1021/jacs.2c09773

A new hybrid catalyst converts carbon dioxide into ethylene in one pot. The catalyst was developed by scientists from Ames National Laboratory, Iowa State University, University of Virginia, and Columbia

University. This catalyst supports the world net-zero carbon initiative by using carbon dioxide (CO_2) as a feedstock for efficient ethylene production powered by electricity.

Ethylene is a commodity chemical used to manufacture a wide range of products from plastics to antifreeze. The large-scale production of ethylene is energy intensive and relies heavily on fossil resources. Electrocatalytic production of ethylene from CO_2 is emerging as a promising method. This new catalyst consists of only earth-abundant materials, such as nickel and copper, and requires less energy for chemical reaction.

Long Qi, a scientist at Ames Lab, explained how the catalyst works. Atomically dispersed nickel anchored on nitrogen assembly carbon (NAC) works to catalyze CO_2 to CO at low voltage and high current. The catalyst is effective over a wide range of voltages and its effectiveness at higher currents means a higher rate of CO production.

"Since this catalyst remains active over a very wide voltage range, that allows easy coupling with a second catalyst," Qi said. "So we use the second catalyst, which is a copper nanowire, and by combining these two we have a very selective process that has up to 60% efficiency going from CO_2 to ethylene in one pot."

Another important aspect of the catalyst is its structure. Wenyu Huang, an Ames Lab scientist and Iowa State University professor from the team, noted that the catalyst's porous structure enhances its effectiveness. "Our catalyst has an ordered mesoporous structure that is beneficiary for mass transfer," he said. "Because it's highly porous, you have a very high surface area to expose a lot of nickel's active sites, making our catalyst very effective in CO_2 reduction to CO."

For Huang, the most exciting aspect of this research was how the team

combined the two catalysts to streamline the process. "We basically combine the two best catalysts on their own, and they work together so we can connect the CO_2 to CO and the CO to ethylene reactions in one system," he said.

Qi emphasized the importance of using CO_2 as a feedstock for this reaction, because it addresses the global need to reduce the amount of CO_2 released into the atmosphere. He explained that this process can use CO_2 recovered from chemical or industrial processes, or from air capture. "And we can do this without any precious metal, simply the nickel, copper, carbon, and nitrogen, to permit large-scale industrial applications," Qi said. "Also, we potentially eliminate the use of fossil resources to make ethylene."

This research is further discussed in the paper "Hybrid Catalyst Coupling Single-Atom Ni and Nanoscale Cu for Efficient CO_2 Electroreduction to Ethylene," published in the *Journal of the American Chemical Society*.

More information: Zhouyang Yin et al, Hybrid Catalyst Coupling Single-Atom Ni and Nanoscale Cu for Efficient CO2 Electroreduction to Ethylene, *Journal of the American Chemical Society* (2022). DOI: 10.1021/jacs.2c09773

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