Selective Electrochemical Conversion of Carbon Dioxide to Ethanol

**Achievement:** A nanostructured catalyst electrochemically converts dissolved carbon dioxide to ethanol under ambient conditions with 63% yield.

**Significance and Impact:** This catalyst achieves unprecedented selectivity for a complex reaction and demonstrates that nanoscale texture can be used to control reaction outcomes.

**Research Details:**
- Nanoscale spikes made of carbon and nitrogen are deposited as a film. Copper nanoparticles are imbedded within the spikes.
- When placed in a solution of potassium bicarbonate and biased to -1.2 V, ethanol is the main product.
- The 12-electron reaction proceeds by at least two types of reaction sites on the nanoparticles and the spikes.

**Sponsor/Facility:** This research was conducted at the Center for Nanophase Materials Sciences, which is a Department of Energy (DOE) Office of Science User Facility.

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**Overview:**
This work highlights an electrochemical process based on tiny spikes of a carbon/nitrogen nanocomposite and copper nanoparticles to turn electricity and carbon dioxide, a greenhouse gas, into ethanol. By arranging common materials that avoid traditional catalysis such as expensive or rare metals, into highly nanotextured structure, unwanted chemical side reactions are limited, providing a high yield (63%) of the desired product (84%), ethanol. Electrochemical analysis and density functional theory calculations suggest that a preliminary mechanism driving the direct reduction process involves active sites on the Cu nanoparticles and the carbon nanospikes working in tandem to control the electrochemical reduction of the carbon monoxide dimer to alcohol.