

## Performances of copper-tin nanoalloy catalysts in electrochemical CO<sub>2</sub> reduction

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Increase of energy consumption in the world has led to steady increase in atmospheric CO<sub>2</sub> concentration over several decades. Electrochemical conversion of CO<sub>2</sub> into small organic molecules is regarded as one of the promising strategies to decrease CO<sub>2</sub> emission and to form valuable products such as methane and ethanol. Copper and tin have been applied as an electrocatalyst for CO<sub>2</sub> reduction. Both elements exhibit particular catalytic performances of CO<sub>2</sub> reduction, i.e., preferential formation of C<sub>2</sub> products such as ethylene and ethanol on Cu and formic acid on Sn. We are interested in the catalytic activities of the alloy constituted of Cu and Sn for CO<sub>2</sub> reduction and expect significant improvement of catalytic performances by alloying. Here, we synthesized novel Cu-Sn nanoalloys (NAs), single Cu and Sn nanoparticles (NPs), and applied to electrochemical CO<sub>2</sub> reduction as electrocatalysts using a flow reactor.

We synthesized the NPs and NAs by liquid reduction method and obtained two types of Cu-Sn NAs, i.e., Cu<sub>3</sub>Sn and Cu<sub>41</sub>Sn<sub>11</sub>. From transmission electron microscopic (TEM) observation, rod-like and spherical morphology were observed for the Cu<sub>3</sub>Sn and Cu<sub>41</sub>Sn<sub>11</sub> samples (Fig. 1), respectively. We investigated the catalytic performances of the prepared catalysts for the electrochemical CO<sub>2</sub> reduction using the flow reactor. The Cu and Sn catalysts showed the highest and lowest current density for CO<sub>2</sub> reduction, respectively, and the Cu-Sn nanoalloys showed the medium current densities between those on the Cu and Sn catalysts. The Cu NP showed high activities for productions of CO, ethylene and ethanol and low activity for production of formic acid from CO<sub>2</sub> while the Sn NP showed high activity for production of formic acid and low or no activities for productions of CO, ethylene and ethanol. The Cu-Sn NAs showed relatively high activities for formation of the products, suggesting that the Cu-Sn NAs have the both catalytic properties of Cu and Sn. Interestingly, the NAs showed the lower Faradaic efficiency (FE) of reduction of protons to H<sub>2</sub>, which leads to higher FE for reduction of CO<sub>2</sub>, than those on Cu and Sn NPs.

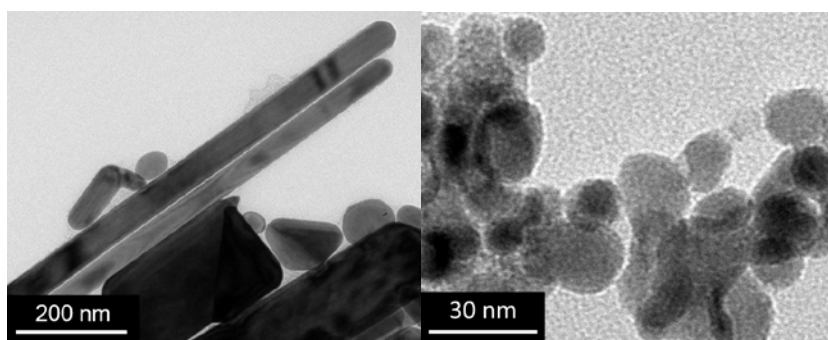


Fig. 1 TEM images of the prepared Cu-Sn NAs (left: Cu<sub>3</sub>Sn, right: Cu<sub>41</sub>Sn<sub>11</sub>)

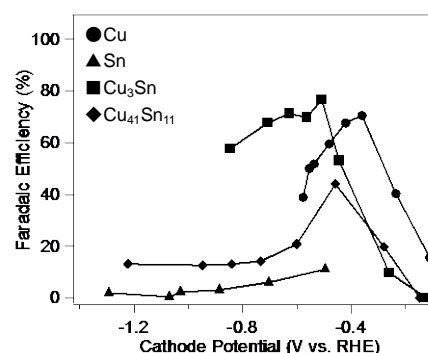


Fig. 2 FE for reduction of CO<sub>2</sub> to CO on NPs and NAs