Repurposing Waste Cu–Sn Bronze for Selective CO_2 Electroreduction into CO

Based on: Stojkovikj et al., *ACS Appl. Mater. Interfaces* 2021, *13(32)*, 38161–38169. https://doi.org/10.1021/acsami.1c05015

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RSC Electrochemistry Group's Electrochem2021 virtual conference 6-7 September 2021

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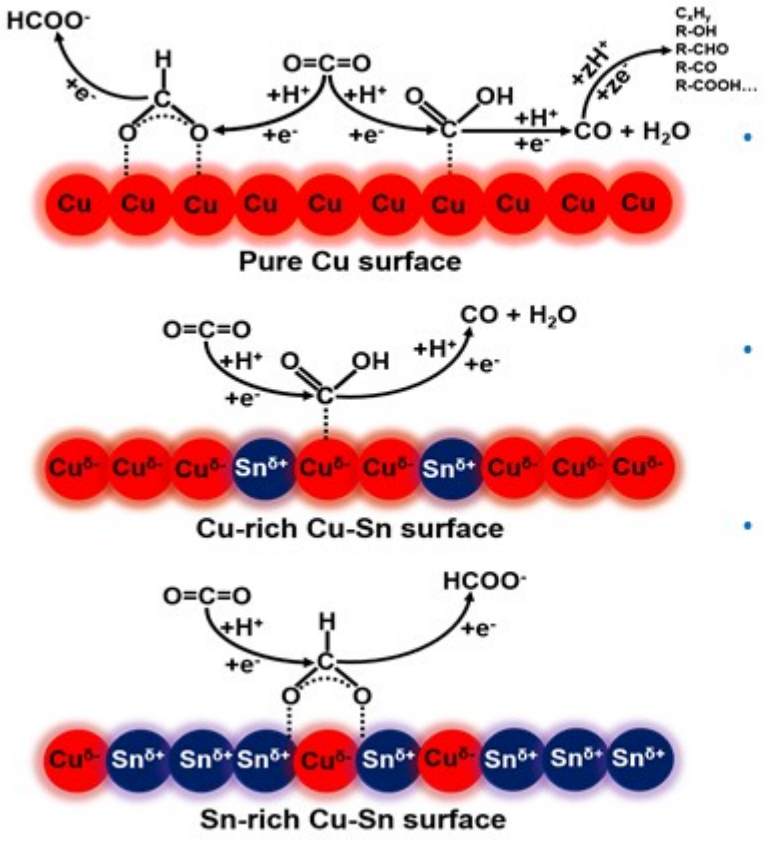
- **The electrochemical reduction of CO_2 (CO_2ER) is a promising strategy for converting this greenhouse gas into valuable products.**
- **Cu is the only electrocatalyst that can significantly reduce CO_2 beyond CO but suffers from selectivity issues (see Scheme bellow).**
- **CO and HCOOH are currently the most techno-economically viable CO_2ER products.**
- **Focusing on CO_2ER to CO, the best electrocatalyst are the noble metals Ag and Au, however Cu-Sn mixtures-based ones emerged as higly active for the same purpose.**



- **The studies of the Cu-Sn Z showed that Cu-rich surfaces provide optimal binding of the *COOH intermediate thus altering the selectivity towards CO production.**
- **On the other hand, Sn-rich surfaces favor the formate pathway via oxophilic binding of the *OCHO* intermediate.**
- **Besides affecting the absorption modes of the CO_2 generated intermediates, Sn weakens the adsorption of the *H intermediate thus suppressing the competitive hydrogen evolution reaction – HER.**

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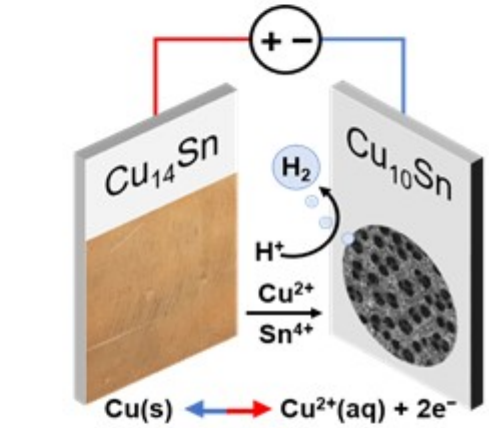
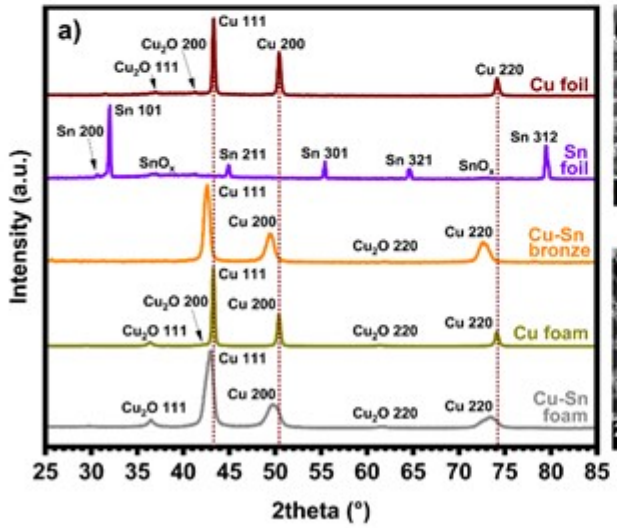
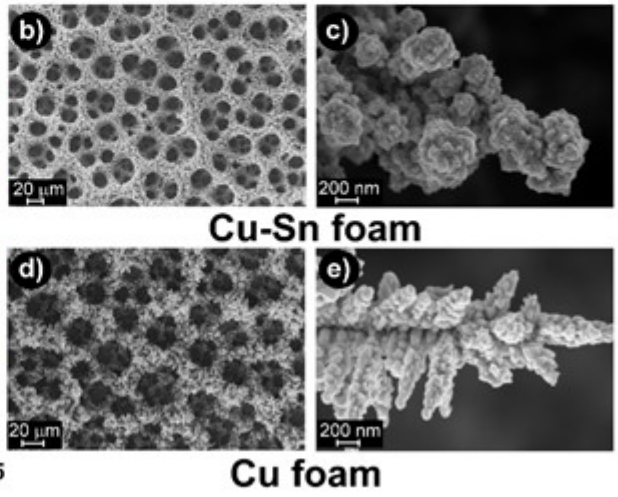
- Even though, Cu and Sn are more abundant than the noble metals Ag and Au, they are listed as endangered elements for risk of future supply.
- Thus, developing alternate strategies based on repurposing and recycling the materials already available for catalysts synthesis is of great importance.
- Therefore, in our study we demonstrate a method for preparation of CO selective CO_2 conversion electrocatalyst via utilization of waste industrial Cu-Sn bronze.
- The method is based on electrochemical transfer of Cu and Sn from the Cu-Sn bronze via anodic dissolution, transport through the solution, and cathodic re-deposition as Cu-Sn foam in acidic medium.
- During the electrodeposition, the simultaneous evolution of H_2 bubbles serves as a template, providing growth of Cu-Sn mesoporous foam like morphology.



- The foam consists of dendrite-like composite microstructures with surface composition of $Cu_{10}Sn$.
- The Cu-Sn dendrites have blunted edges in comparison with pure Cu dendrites that resemble sharper edges.





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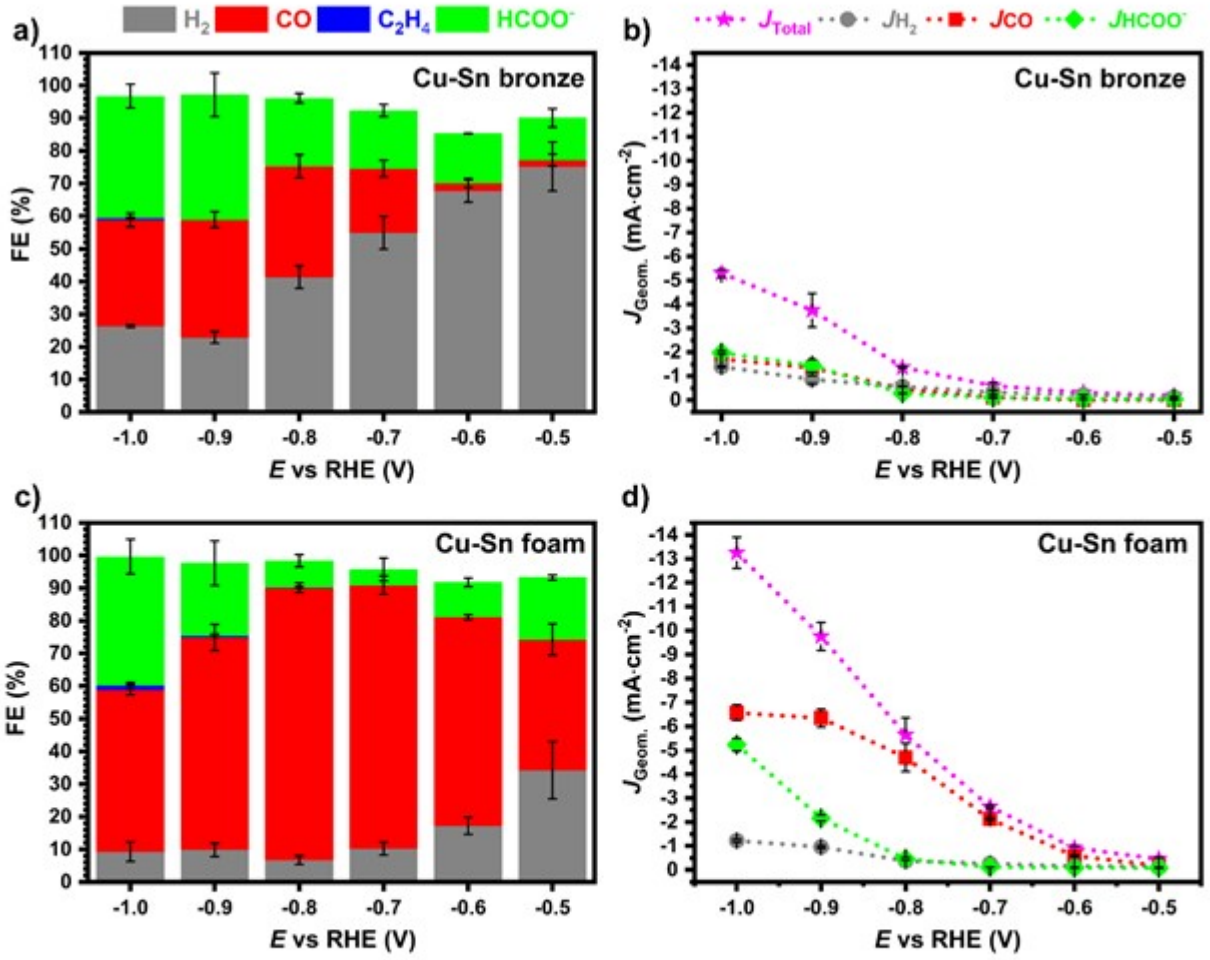
- The CO_2ER activity results show that even though the Cu-Sn bronze has similar surface composition as the Cu-Sn foam, the HER is dominating at potentials less negative than -0.8 V vs RHE.
- On the other hand, the CO_2ER to CO and $HCOO^-$ are dominant processes on the Cu-Sn foam at all applied potentials.
- The highest faradaic efficiency for CO of almost 90% occurs at -0.8 V vs RHE and the highest CO-partial current density at -0.9 and -1.0 V vs RHE.
- The enhanced activity for CO_2 to CO conversion on the Cu-Sn foam in comparison with the pristine bronze with planar surface, most probably occurs due to promoted CO_2 mass transport and thus prevention of local CO_2 depletion near the electrode surface.



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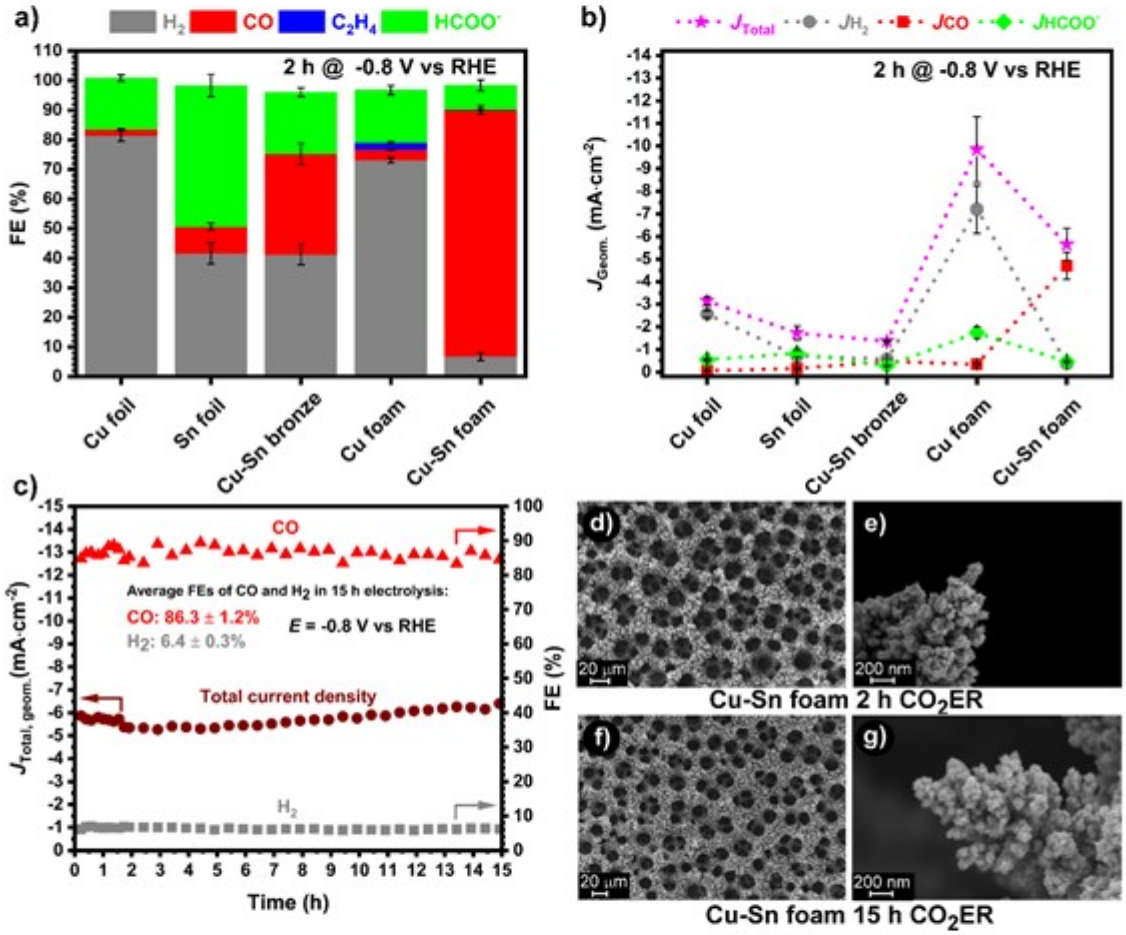
- **The tuning of the selectivity towards CO production on Cu-rich Cu-Sn electrocatalysts is an intrinsic property of these materials since pristine Cu and Sn at -0.8 V vs RHE.**
- **The Cu-Sn foam derived from bronze shows high durability thus maintaining the high activity for CO_2 to CO without any morphological changes under 15 h constinious electrolysis.**



Our study serves as a proof-of-concept that waste materials with technical grade purity can be recycled via simple and cheap methods to prepare electrocatalysts that still show comparable performance as when they are produced via higly-advanced and more expensive methodologies utilizing high grade purity precursors.

More information

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