Department of Materials Science and Engineering Seminar Series 2024

TUNING ELECTRONIC STRUCTURES AND MICROENVIRONMENT OF CATALYSTS TO BOOST ELECTROCHEMICAL CARBON DIOXIDE REDUCTION REACTION

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Date and time: 22 Nov 2024, 1-3 pm

Venue: EA-06-04

Abstract

Electrochemical CO_2 reduction (CO_2RR) has been considered a powerful approach to closing the carbon cycle. Numerous catalysts for CO_2RR have been developed to facilitate efficient CO_2 conversion. Among these strategies, electronic structure tuning and microenvironment modulation are two important design principles. In this thesis, we explored these two strategies. In this thesis, we first demonstrated the effect of electronic structure on CO_2RR performance using the composites of the Ag-$Ti_3C_2T_X$ system. We reported that $Ti_3C_2T_X$'s electronic structure could be tuned by the Ag^+ loading method via redox interactions, tuning the reaction selectivity towards CO and activity for CO_2RR. To further enhance the CO selectivity, we developed a facile method to dope the Cu species into the ZnO matrix to enhance the CO_2RR performance. Compared to the pristine

ZnO, the Cu-doped ZnO demonstrated high performance with a Faradaic efficiency (FE) of 97% and current density of -25.6 mA cm^{-2}. The catalyst was further integrated into a membrane electrode assembly (MEA) electrolyzer. The device can achieve a high selectivity of a FE over 90% within a wide range of current densities from 100 mA cm^{-2} to 400 mA cm^{-2}. Finally, we focused on tuning the microenvironment of CO_2RR to enhance the selectivity towards C_{2+} products. We designed our experiments using a simple variable: the thickness of the catalyst layer. It was found that the C_{2+} product selectivity decreased with a thicker catalyst layer, while the CO selectivity was higher. Further explorations showed that the availability of local K^+ is the main reason for C_{2+} selectivity change.

Biography

Sun Guangxin received his bachelor's degree and master's degree from Beihang University in 2017 and 2020, respectively. He is currently a Ph.D. candidate under the supervision of Assistant Prof. Andrew Barnabas Wong and Prof. He Chunnian. His research focuses on new catalysts development for the electrochemical CO_2 reduction reaction.

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