Conversion of CO_2 into Valuable Chemicals by Utilization of Synergetic $Zn_{(x)}Cu_{(100-x)}$ as well as $ZnO_{(x)}CuO_{(100-x)}$ Catalysts in Aqueous-Fed Systems

Edwin U. Onoh [1, 2], Ilias Stamatelos [2] , Joachim Pasel [2] , Girum Ayalneh Tiruye [1].
[1]*Materials Science Program/Department of Chemistry College of Natural and Computational Sciences, Addis Ababa University, Addis Ababa, Ethiopia;*
[2]*IEK14-Electrochemical Process Engineering Forschungszentrum Jülich GmbH, Jülich, Germany*

Abstract

To combat climate change stemming from CO_2 emissions, various methods have been proposed to convert CO_2 into valuable chemicals. Among different strategies, electrochemical CO_2 reduction (ECR) is a promising method to convert CO_2 into useful fuels and chemicals. Transition metal catalysts, notably copper (Cu), exhibit potential for ECR; however, they frequently prioritize hydrogen evolution. Bimetallic and bimetallic-oxide catalysts offer a promising avenue to augment ECR selectivity. Incorporating zinc (Zn) into Cu is particularly appealing as Zn can alter Cu's electronic properties, enhancing selectivity for desired products. This study explores the synergistic potential of $Zn_{(x)}Cu_{(100-x)}$ as well as $ZnO_{(x)}CuO_{(100-x)}$ catalysts in aqueous bicarbonate-fed systems, by optimizing the Zn/ZnO content for promoting methane or formic acid production and evaluating the influence of catalyst surface morphology on ECR activity and selectivity. Furthermore, our investigation reveals the impact of different electrolytes on catalyst performance, with $KHCO_3$ exhibiting superior results compared to $NaHCO_3$. Ultimately, the objective is to develop highly efficient and selective ECR catalysts for converting CO_2 to valuable chemicals and fuels, paving the way for a more sustainable future. SEM analyses reveal complex catalyst structures with potential benefits for CO_2 reduction, with XRD suggesting mixed phases influenced by Zn/Cu ratio. EDS and XPS confirmed successful Zn incorporation and the presence of Cu and Zn in their expected oxidation states, with compositions reflecting the initial precursor ratio. The catalytic performance of $Zn_{20}Cu_{80}$, $Zn_{70}Cu_{30}$, $ZnO_{70}CuO_{30}$, and $ZnO_{50}CuO_{50}$ showcased promise for CH_4/HCOOH production at moderate current densities, with $ZnO_{70}CuO_{30}$ excelling in CH_4 production (84.3% FE), while $ZnO_{50}CuO_{50}$ favored HCOOH production (81.8% FE). In conclusion, the ratio of bimetallic and bimetallic oxides tailors active sites on the catalysts, promoting selective CO_2 reduction and suppressing H_2 evolution.