

Study on Electrochemical Reduction of Carbon Dioxide for Syngas Production

Abstract

Over the past few years, electrochemical reduction of CO₂ (ERC) has attracted a lot of interest among researchers to convert CO₂ into value added products using renewable energy. Through ERC, CO₂ and water using renewable energy, can be co-electrolyzed to produce many chemicals such as CH₄, C₂H₄, C₂H₆, HCOOH, CH₃OH, and syngas (CO + H₂), which are important industrial chemicals. However, CO₂ is a very stable molecule and thus it is very difficult to reduce it. Therefore, primary focus of research throughout the world has been on developing an electrocatalyst selective to CO₂ reduction. ERC is carried out in presence of water. Thermodynamically, the reduction potentials of ERC and hydrogen reduction potential (HER) are close to each other. Moreover, HER has fast kinetics as compared to ERC. Thus, the electrical charge spent during ERC is used by the facile HER instead of ERC. Thus suppression of HER possess a huge challenge.

ERC can lead to many products i.e., CO, CH₄, C₂H₄, C₂H₆, HCOOH, and CH₃OH etc.; depending upon the electrode potential, electrolyte, electrocatalyst, and reaction conditions. Sixteen different products can be formed using Cu as electrocatalyst. However, it requires high overpotential (~1.0 V), have poor selectivity, and fast deactivation are biggest challenges. The research work in this thesis is focused on selective formation of syngas using Zn and Cu based electrocatalysts. Effect of nature of electrocatalyst layer on the ERC selectivity has been studied. It was found that degree of gas entrapped in different types of layers was different, leading to different selectivity. The role of addition of Cu into the ZnO has also been studied for the synthesis of syngas. On varying the concentration of Cu into the ZnO, it was found that at certain fraction of Cu into the ZnO, charge transfer resistance towards ERC is reduced which ultimately reduces the overpotential requirements. Role of pressure in gas phase ERC was also investigated. It was found that mild increase in pressure leads to shift in Zn/Cu selectivity towards syngas formation. The knowledge gathered by the research work was disseminated through various research papers and presentations in various conferences.

Keywords: Electrochemical reduction of CO₂, Zn/Cu nanocomposite, Gas phase ERC, Elevated pressure.