

The Electrolyte Effects on Carbon Dioxide Electro-catalysis

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DESCRIPTION

The electrochemical reduction of carbon dioxide to fuels or commodity chemicals may be a reaction of high interest for closing the anthropogenic carbon cycle. The role of the electrolyte is of certain interest, as the interaction between the electrocatalytic surface and the electrolyte plays a very important role in deciding the result of the carbon dioxide reduction reaction. Therefore, insights into electrolyte effects on the electrochemical reduction of carbon dioxide are crucial in designing electrochemical devices that are able to efficiently and selectively convert carbon dioxide into a valuable product.

The electrochemical reduction of carbon dioxide to fuels or goods chemicals, driven by renewable energy, provides a unique chance to utilize carbon dioxide and store renewable energy in chemical bonds [1]. Though the electrochemical reduction of carbon dioxide into a valuable product is promising since it is often performed at room temperature and air pressure victimization of earth electrocatalytic materials, major problems need to be resolved before the method becomes feasible. Several of those problems are associated with the high overpotentials required for product formation, poor product selectivity, low conversion rates, and poor stability of the catalytic system.

Until now, most analysis has focused on the development of novel electrocatalysts for carbon dioxide reduction, since the determined overpotentials and poor product selectivity stem from the suboptimal binding of key intermediates on the catalytic surface [2]. Clearly, these novel electrocatalysts can solely perform optimally below optimized method conditions. One of the vital factors deciding the result of carbon dioxide reduction is the interaction between the electrocatalytic surface and the electrolyte. Therefore, an in-depth understanding of the electrolyte effects on carbon dioxide electrocatalysis is crucial in designing efficient systems for the reduction of carbon dioxide to the desired product. This analysis aims to produce an outline of recently obtained insights relating to electrolyte effects on the electrochemical carbon dioxide reduction reaction (CO₂RR) associated to present an outlook on how these insights are often used as design parameters to lower over potentials for carbon dioxide reduction and boost product selectivity.

The overall solubility of carbon dioxide in water is low, close to 35 mm under standard conditions. The addition of salts to make the liquid electrolyte will induce a salting out result, any lowering carbon dioxide solubility in the electrolyte. Thus, if carbon dioxide is entirely present as dissolved carbon dioxide in an electrolyte, this restricted solubility can induce mass transfer limitations during operation at higher current densities. Gas diffusion-based setups and membrane electrode assembly reactors with a gas phase can provide the solution to this problem, as these setups produce a triple-phase boundary where gaseous carbon dioxide is involved with an electrolyte on the point of the electrocatalytic surface. This allows for fast diffusion of carbon dioxide towards the electro catalytic surface. Thereby, this system is able to sustain considerably higher current densities than systems where carbon dioxide is dissolved within the bulk electrolyte, e. g. a traditional H-cell.

A general concern is the purity of the electrolyte, as trace metal impurities will deposit on the electrocatalytic surface altering the efficiency and selectivity of the method over time. To mitigate this result, the electrolyte is often be purified by using a pre-electrolysis methodology [3]. By using this method, any residual metal ions within the electrolyte are deposited on an electrode before the electrolyte is used for carbon dioxide reduction experiments.

In liquid electrolytes, a pH gradient between the local pH at the surface and the bulk pH of the electrolyte affects the electrochemical reduction of carbon dioxide and the hydrogen evolution reaction leaving the management of product distribution and product selectivity by tuning the local pH at the surface. This principle has been exploited in alkaline electrolyzers for carbon dioxide reduction that produce C₂ products, like ethylene and ethyl alcohol, with high Faradaic efficiencies at high current densities and low over potentials [4]. The addition of specific anions and cations provides a different way to tune the property of electrochemical carbon dioxide reduction. Though the precise mechanism by which cations and anions alter the carbon dioxide reduction reaction continues to be debated, there's a significant effect on each products selectivity and electrode stability.

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Non-aqueous electrolytes usually have the next carbon dioxide solubility, creating them attractive alternatives to liquid systems. Though usually stable, it's vital to check the electrolyte stability and to measure if the carbon atoms in the measured product are coming back from carbon dioxide or from the electrolyte. The addition of water to non-aqueous electrolytes, or electrolyte combining, includes an important result in the determined product distribution and product stability.

Overall, the electrolytes are often used as a design parameter to change the selective reduction of carbon dioxide to the desired product. By controlling the processes going down at the interface of the electrocatalyst and the electrolyte, a higher electrocatalytic system is often obtained. Although most work has been performed in aqueous electrolytes, non-aqueous electrolytes offer extra possibilities to suppress the unwanted hydrogen evolution reaction and boost carbon dioxide reduction due to their higher carbon dioxide solubility [5]. By mixing, electrolytes can be engineered to tune the obtained product distribution and merchandise selectivity.

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