Green Catalytic Transformation of CO_2 to Syngas Using Aerogels

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The recycling of CO_2 into value-added products has become a central focus in the pursuit of renewable fuels and a sustainable energy paradigm. In this context, the development of efficient, eco-friendly catalytic systems for CO_2 conversion is essential to reduce dependence on fossil resources and to enable circular carbon utilization. Motivated by this challenge, the present study aims to contribute to the design of green catalytic platforms for the electrochemical reduction of CO_2 into syngas, a key intermediate for synthetic fuels and chemicals. To achieve this goal, we explored the use of alginate-based aerogels as catalytic supports due to their intrinsic properties—such as high porosity, tunable structure, and environmental compatibility. Abundant and low-cost, these materials improve active phase dispersion and mass transport through promising surface properties[1]. Alginate, a natural polysaccharide extracted from brown algae, stands out for its biodegradability, low toxicity, and chemical stability, making it a promising candidate aligned with green chemistry principles[2]. In this study, alginate aerogels were synthesized using a sol–gel method, followed by impregnation with metallic zinc particles and copper nanowires[3]. The resulting materials were tested as cathodes in the co-electrolysis of CO_2 and water for CO production[4]. Furthermore, a strategy to tailor the pore size of the electrodes using different crosslinking agents was developed, aiming to optimize catalytic performance. Computational modeling complemented the experiments by providing insight into structure–property correlations and catalytic performance. Key findings reveal how crosslinker type, surface area, and morphology influence productivity and faradaic efficiency. Overall, this work offers a sustainable electrochemical platform for CO_2 recycling, combining renewable materials and structural tuning—supported by computational insights—to advance renewable fuel production in a circular carbon economy.

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