Copper-based porous surfaces for electrocatalytic CO_2 reduction

Maria José Lima[a, b], José David Castro[c], Sandra Carvalho[c]

[a] Physics Centre of Minho and Porto Universities (CF-UM-UP), University of Minho, 4710-057, Portugal

[b] LaPMET - Laboratory of Physics for Materials and Emergent Technologies, University of Minho, 4710-057, Portugal

[c] CEMMPRE Mechanical Engineering Department, University of Coimbra, Coimbra, 3030-788, Portugal

The United Nations (UN) has identified carbon dioxide (CO_2) as a greenhouse gas (GHG) that is present in the atmosphere as an environmental issue in Goal 13 for climate action.

Decreased CO_2 emissions and participation in a circular economy are crucial to achieving these goals. To include CO_2 in a circular economy, capture and electroreduction of CO_2 into long-chain hydrocarbons or alcohols (C2+) can be the solution. From a material perspective, copper-based catalysts are active and selective cathodes capable of producing hydrocarbons, increasing the Faradaic efficiency of the CO_2RR to C2+ molecules.

Enhancing electrochemical active sites can be an additional strategy to improve CO_2RR. Different strategies can produce porous electrodes, thus increasing the electrochemical active surface area (ESCA) and the CO_2-catalyst interaction. One technique that produces porous materials is the anodization process, an electrochemical process capable of producing a thin oxide layer at the metallic surface.

In this work, we systematically optimized the anodization parameters of metallic copper (Cu) to develop Cu_xO_y porous electrodes. Different anodization parameters were studied, such as voltage, time, electrolyte concentration, and distance between the anode and the cathode.

Materials characterization was made by SEM, EDS, and XRD, where it was possible to observe higher porosity and Cu_2O crystalline phase obtained using 0.1 M of K_2CO_3 and applying 25 V for 15 min (Fig. 1). In fact, lower applied potentials shown a compact surface with cracks. Increasing the potential to 25 V favors the formation of hollow tubes, whereas a further increase to 50 V results in structure compaction.

Electrochemical analyses, such as linear sweep voltammetry and cyclic voltammetry, will be shown to discuss the involved redox reactions of organic and inorganic species. ESCA calculation of each electrode material will permit understanding of how it correlates with morphology.

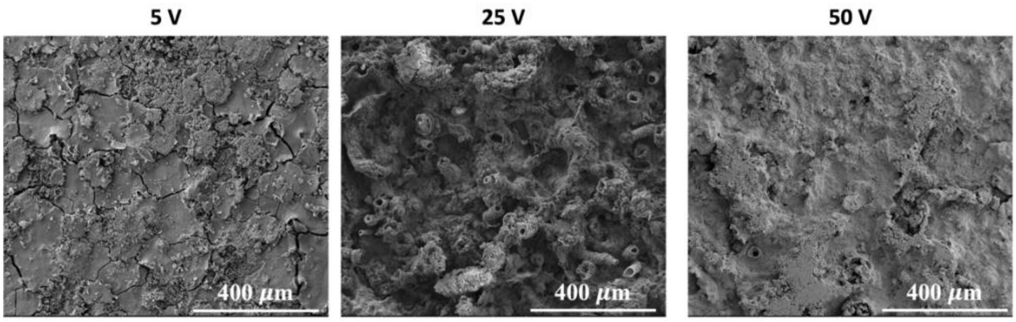

Fig. 1: SEM micrographs of Cu-based electrodes obtained using 5 V, 25V and 50 V of applied potential during anodization process.