Hydrophobicity, porosity and functionalization of nanoporous activated carbon/carbon paper electrodes and their performance of CO_2 electroreduction

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The electrochemical reduction of CO_2 (CO2ER) is an alternative to mitigate the environmental impact generated by massive CO_2 emissions, in addition to forming value-added products. In this sense, numerous investigations are focused on the search for electrocatalytic materials other than those based on noble metals, e.g. nanoporous carbon materials [1]. Their electrocatalytic activity in CO2ER is studied by electrolysis in electrochemical cells, where the cathode is the nanoporous carbon material deposited on a conductive inert support [2], where Toray carbon paper (TCP) is one of the most widely used. In order to control its hydrophobicity and mechanical resistance, it is common to find PCT with different Teflon (PTFE) coatings between 0 and 30 %. In this work, the effect of the percentage of PTFE coating of the PCT support on carbon-based electrodes for CO2ER has been firstly evaluated. For this purpose, three PCT supports with PTFE coatings of 0, 5 and 20%, respectively, were selected for the fabrication of the electrodes. A nanoporous activated carbon deposited on PCT by aerography (Dye: 75/25 %wt carbon/Nafion in ethanol,) was used as electrocatalyst. CO2ER was performed at constant potential for 6 h in an undivided three-electrode cell using 0.5 M $KHCO_3$ as a CO_2-saturated catholyte. Analysis of the obtained gaseous products, CO and H_2, showed a correlation between the percentage of PTFE and the selectivity to CO, being higher for PCTs with PTFE. These results show how the hydrophobicity of the PCT/electrode especially influences H_2 production, being higher for the PCT with lower hydrophobicity. Secondly, the role of porosity has been less addressed [1], consequently, this work also explores the electrocatalytic activity in CO2ER of a series of carbon materials with different porosity and control of the type and amount of oxygen containing functionalization, which were synthesized by physical overactivation processes of a commercial microporous carbon material with CO_2 (775 ºC for 4, 8 and 16 h), thus obtaining four materials with different surface area and pore size distribution while maintaining their chemical composition. Again all the electrosynthesis corresponding to CO2ER were performed at controlled potential using an H-type split cell, setting a constant CO_2 flow through the catholyte. The results reveal an effect of the porosity of the carbon material on the selectivity and faradaic efficiencies of the CO2ER products, whose electrochemical indicators may be associated with the interaction and nano-confinement of CO_2 molecules and reaction intermediates present in the nanoporosity of the electrode.

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