Addressing the stability challenges of Gas Diffusion Electrodes in the presence of ILs-based solutions for the continuous Electrochemical Conversion of CO_2

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In the context of sustainable strategies proposed to convert CO_2 to valuable products, the electrochemical reduction of CO_2 ($ECR\text{-}CO_2$) represents one of the most promising alternatives[1]. Herein, the $ECR\text{-}CO_2$ has been carried out for the first-time employing synthesised core-shell Cu_2O/SnO_2-based nanoparticles within a continuous flow cell and in the presence of ionic liquids (ILs), which have been known to boost CO_2-derived products[2]. The stability issues faced during operations at 10 cm^2 scale, visualized in the darkening of the gas diffusion electrodes and in colour changes of the electrolyte, will be discussed. Raman spectroscopy, Field Emission Scanning Electron Microscopy and Electrochemical Impedance Spectroscopy techniques have been employed for the physicochemical characterization of the electrodes and to assess the evolution of the electrochemical interfaces within the system over time. Interestingly, in aqueous electrolyte, the synthesised material demonstrated a stable syngas production at -20 mA cm^{-2}, with a CO/H_2 ratio of about 10. Furthermore, we observed that the immobilization of ruthenium and rhenium complexes on the catalyst can be crucial to determine its suitability for either the hydroformylation or the carbonylation reaction, making this technology a promising solution for the green transition of the chemical industry in Europe.

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References
1. IEA. *Global Energy Review: CO_2 Emissions in 2021*. (2021).
2. Kunene, T., Atifi, A. & Rosenthal, J. Selective CO_2 Reduction over Rose's Metal in the Presence of an Imidazolium Ionic Liquid Electrolyte. *ACS Appl. Energy Mater.* **3**, 4193–4200 (2020).