Ultrasonic spray coated nanostructured layer to enhance anodic performance in Bio-Electrochemical Systems

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In the ever-growing context of hydrogen production, Microbial Electrolysis Cells (MEC) are currently emerging as a promising solution. MECs belong to the family of Bio-Electrochemical Systems (BES), which share the ability to convert wastewater-derived chemical energy into hydrogen, electricity, or other chemical products. The crucial feature of all BES lies in the anode electrode, where an electroactive microbial biofilm acts as biocatalyst for the oxidation reaction of the chemical energy source. Leveraging the microbial activity at the anode, MECs can achieve the Hydrogen Evolution Reaction at the cathode while sensibly reducing the energy cost when compared to standard electrolysers. It is therefore essential to develop anode electrodes able to sustain MEC operation, by enhancing electrodes' surface properties that are crucial for microbial proliferation and activity. Indeed, overall MEC performances can improve by enhancing hydrophilicity, surface porosity and electrical conductivity of commercially available carbon-based electrodes. To this end, we propose the nanostructured deposition on commercial carbon paper electrodes of a thin layer of intrinsically conductive polymer (poly(3,4-ethylene-dioxy-thiophene):poly(styrene-sulfonate), PEDOT:PSS). The deposition is performed by Ultrasonic Spray Coating, a technique based on the dispersion of a spraying ink via high-frequency vibrations, which can deliver nanocoatings with high spatial uniformity even on large areas and on complex morphologies. Through a range of physical chemical characterizations, as well as the validation in lab-scale BES experiment, we demonstrate the positive impact of the PEDOT:PSS nanostructured layer on anodic microbial activity. Among the deposition conditions investigated, we identify the most suitable solution that could prove crucial for the development of future MEC devices.

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