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Bioelectrochemical Systems for Wastewater Treatment: Agri-food Waste and Byproducts for the Production of Biochar-based Electrodes

Stefania Marzorati, Mirko Magni, Giorgia Ghiara and Stefano Pierpaolo Marcello Trasatti

Department of Environmental Science and Policy, Università degli Studi di Milano, Milan, Italy

Abstract

The potentialities of bioelectrochemical (BES) technologies span over a wide range of practical applications such as micro-electrical power production, organic wastes treatment and electro-fermentation of new valuable products from wastes. Among BES, in microbial fuel cells, mixed cultures of bacteria (already present in wastewater), settle on the electrodes and catalyze the oxidation of biodegradable organics (fuel) dissolved in the anodic compartment. The generated electrons, through an external electric circuit reach the air-exposed cathode, where the hindered oxygen reduction reaction takes place. Micro-electrical power is produced while remediation of wastewater is accomplished (Schievano et al., 2019). Several drawbacks in materials and design have still to be overcome in order to reach competitive performance with respect to other more recognized technologies. Many studies are addressing the development of low-cost and environmentally compatible materials to fabricate large-scale electrodes (Marzorati et al., 2019). In this framework, under the guiding principles of circular economy, this project aimed at developing biochar-based conductive materials to be employed in microbial fuel cells systems as microporous layers acting as catalysts for the cathodic reduction reaction. Biogenic ligno cellulosic materials, after cascade processes for their extraction of added-value products, where employed: i) tomato peels waste; ii) silverskin, the thin layer of coffee beans removed during coffee roasting; iii) pumpkin seeds waste. Biomasses were subjected to a 900°C pyrolysis procedure in order to produce conductive biochar, characterized in terms of electrical and morphological properties. Biochar inks were then formulated and employed to produce microporous layers, finally used as cathodic materials in microbial fuel cells. The cathodic electrodes displayed sufficient conductivity and electrocatalytic activity towards the reduction of oxygen. Despite underperforming compared to other more technological and optimized materials, waste-derived biochar opens new frontiers in design and architectures of new generation bioelectrochemical systems, where not the current production, but mainly wastewater treatment and nutrients recovery can be addressed as the main goals.

Keywords: Wastewater Treatment; Green Energy Production; Bioelectrochemical

Systems; Biochar

References

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