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Cellulose-based ionogels as novel membrane materials for microbial fuel cell applications

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Microbial fuel cells (MFC) are renewable-based energy producing electrochemical platforms. They exploit the so-called exoelectrogenic metabolism of specific bacteria. These electro-active bacteria conduct the transfer of substrate oxidation-based electrons to a conductive surface extracellularly. Such feature makes them able to be applied as waste-based energy recovery techniques. Although MFC technology has highly advantageous features in the context of renewable electricity and circular economy, the main challenges mitigating its scaled-up implementation are the cost and – more importantly – the incompatibility of the available membrane and electrode materials.

In this work, we present a novel membrane alternative based on green building blocks. Cellulose ionogels (CIg) are made by dissolving cellulose in specific ionic liquids (IL), and by a simple sol-gel transition after heat treatment. The reconstructed cellulose, thus, immobilizes IL within the formed gel phase, resulting in good ionic conductivity. CIg exhibit unique mass transport properties compared to widely used membrane materials (e.g. Nafion). To test these alternative materials as separators, experiments in MFC were conducted parallel to Nafion-MFC control. The biofilm formation stage was affected by mass transfer between the anode and cathode chambers, and the CIg membranes seemed to shorten acclimation. Comparable current density production at optimal external load was achieved, 11.9±1.9 and 9.4±1.3 A m^{-3} for Nafion-MFC and Cig-MFC, respectively. Meanwhile, internal resistance of MFCs were remarkably low (102.7±24.1 Ω and 147.2±33.7 Ω for Nafion-MFC and Cig-MFC). In summary, it turned out that CIg membranes offer a cost-effective alternative for polymeric ion exchange membrane for efficient current generation in MFC. Future research should focus on stability and manufacturing optimization of the existing and new ionogel types.

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