Small scale ceramic MFCs for efficient energy harvesting from wastewater and full system development

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Observing continuously increasing demand in the world for water and energy, alternative sources are needed to meet the requirement of a growing population. Microbial Fuel Cell (MFC) represents one sustainable technology that directly converts organic biomass in wastewater into electric current, thus it can be a potential alternative source for energy and water clean-up. Microbial Fuel Cells generate electric current as a direct result of microbial metabolism, where the anodic biofilm is the engine of the process cleaning wastewater and converting chemical energy to electrical energy. MFC technology development into commercial applications has been limited by high cost of materials and low efficiency of energy recovered. Therefore, the successful scale-up process should involve material and design optimisation. With this approach in mind, recent advancements bring the technology closer to the real life implementation thanks to using ceramic for MFC architecture [1] and improved design of multiple units in the system [2]. In addition, it results in electrochemically treated waste and usable electricity levels, for example to power indoor lighting [3].

The main aim of this work was to increase the efficiency of the ceramic based MFCs by compacting the design and exploring the ceramic support as the building block for small scale modular multi-unit systems. The improved energy density would then allow to utilise the energy locked in the feedstock (waste) more efficiently, make MFCs more applicable in industrial and municipal wastewater treatment facilities, and scale-up-ready for real world application.

Materials and Methods

MFCs were made out of small scale terracotta cylinders (70 mm long, 15 mm diameter) tested in triplicate groups assembled with carbon veil fibre used as anode electrodes. The cathode electrode was made of activated carbon and placed against the ceramic separator inside the hollow cathode chamber. The MFCs were compared against large tubular MFCs (100 mm long, 42 mm diameter) with the same anode to cathode ratio (27:1) and operated in laboratory conditions.

Results and Discussion

Results showed that the small scale MFCs shown improved power density performance in comparison to the large tubular MFCs.

The maximum performance achieved during polarization experiment showed that volumetric density of the small scale MFCs was 21 W/m^3 while large MFCs only 8.5 w/m^3 which is suggests 2.5 improvement of small MFCs. This supports the smaller MFC devices can take advantage of high surface to volume ratio which in this case was calculated as 2.6 for small MFCs and 1 for large MFCs. During electrochemical MFC operation, the production of catholyte on the surface of the cathode electrode was also observed and driven by generated current. The simplicity of the design is allowing to configure any number of units in parallel configuration and use them in any wastewater tank as ”dip and go” system. This includes MFC use in urinal tanks to power devices in remote locations or in large wastewater treatment plants to lower energy cost. This might also help to solve the electricity and sanitation problem in the Developing World. Efficient utilisation and scale-up allows the technology to come out of the laboratory to field trails to become useful to societies and to the environment.

Conclusions

This approach leads to more efficient utilization of organic compounds in wastewater including urine and the development of the off-the-grid electrochemical system that allows net generation of usable power and wastewater decontamination.

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