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Energy harvesting from microbial fuel cells – wastewater to electricity

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Microbial fuel cells (MFCs) have the potential to revolutionise wastewater treatment from being an energy-consuming process to an energy-producing one. One of the major challenges in the use of MFCs for wastewater treatment is energy harvesting and system maintenance. In this study, we describe work ongoing in our laboratory involving a cassette-based MFC system, attached to an energy harvesting system, enabling energy storage for use in self-monitoring and downstream processes.

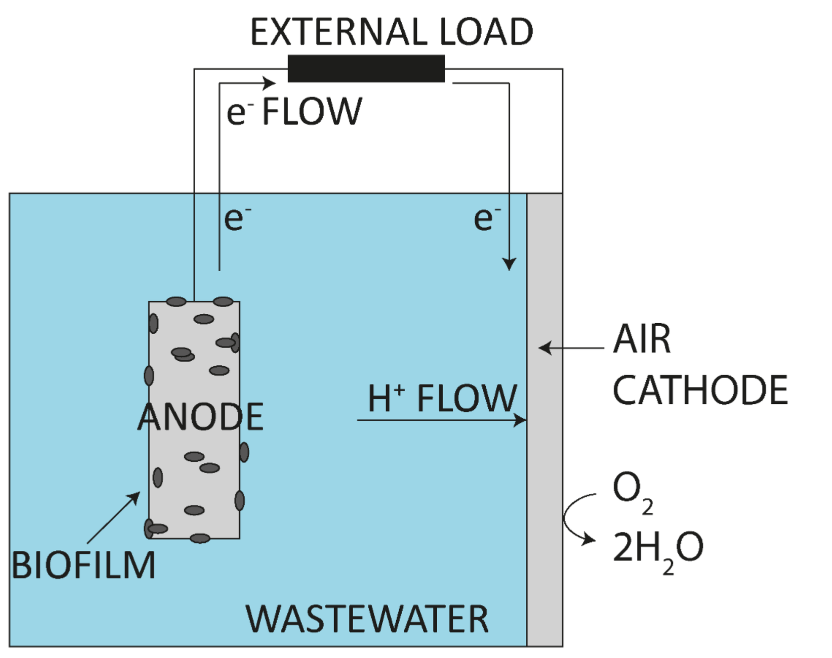

Figure 1: Side-view schematic of one anode and one cathode of the MFC system. Exoelectrogenic microorganisms form a biofilm donating electrons to the anode, whilst protons are accepted by the cathode, generating electricity.

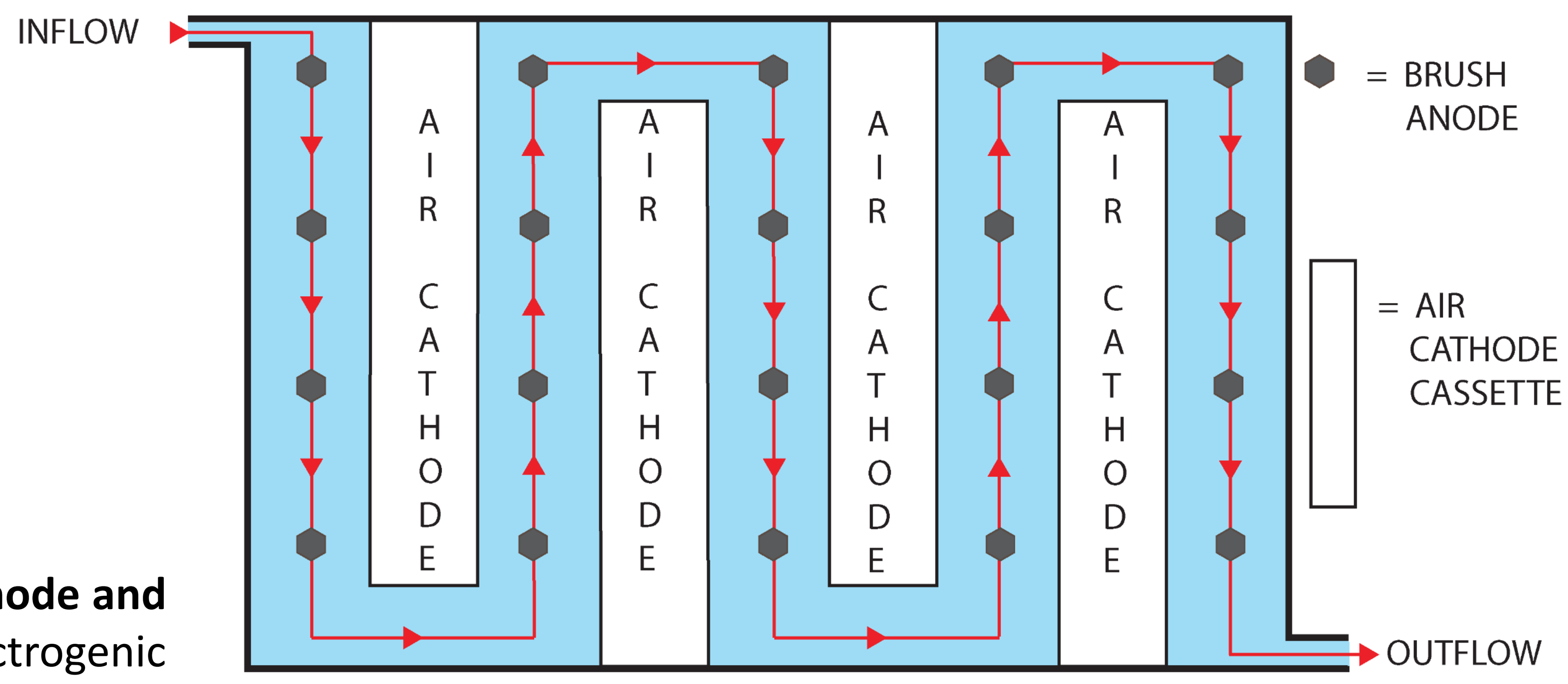

Figure 2: Top down view schematic of MFC system. This includes positions of anodes and air-cathode cassettes, as well as wastewater flow direction.

Figure 3: Steel mesh cathode coated with PVDF, activated carbon and carbon black.

Figure 4: A carbon fibre brush anode.

Wastewater moves through the system in a serpentine manner, maximising interaction with anodes and cathodes (Figs. 1, 2, 3 and 4). As many cassettes as are required for the given application can be used in this model, presenting a potential rapid route to scale-up (Fig. 5).

Synthetic wastewater was made up to 20 L, consisting of minimal salts media (MSM), supplemented with organic carbon, along with 1 % (v/v) trace minerals and 1% (v/v) vitamin mix. 10 % (v/v) *Shewanella oneidensis* MR-1, a known exoelectrogen was used to inoculate the system. Voltage was recorded at two-minute intervals using a PicoLog ADC-24 Data Logger. From this current was inferred (Fig. 6).

The designed circuit board incorporates a highly efficient energy harvesting circuit, a battery/super capacitor charging circuit and a power converter to power-up electronics with various power requirements through the stored energy. These blocks are supervised by a low-power microcontroller (MCU) to ensure optimum system performance. Furthermore, the MCU also facilitates the real time management of operating conditions including flow-rate and temperature regulation in response to changing conditions. The circuit's goal is to ensure sufficiency of the system for optimal wastewater treatment (Fig. 7).

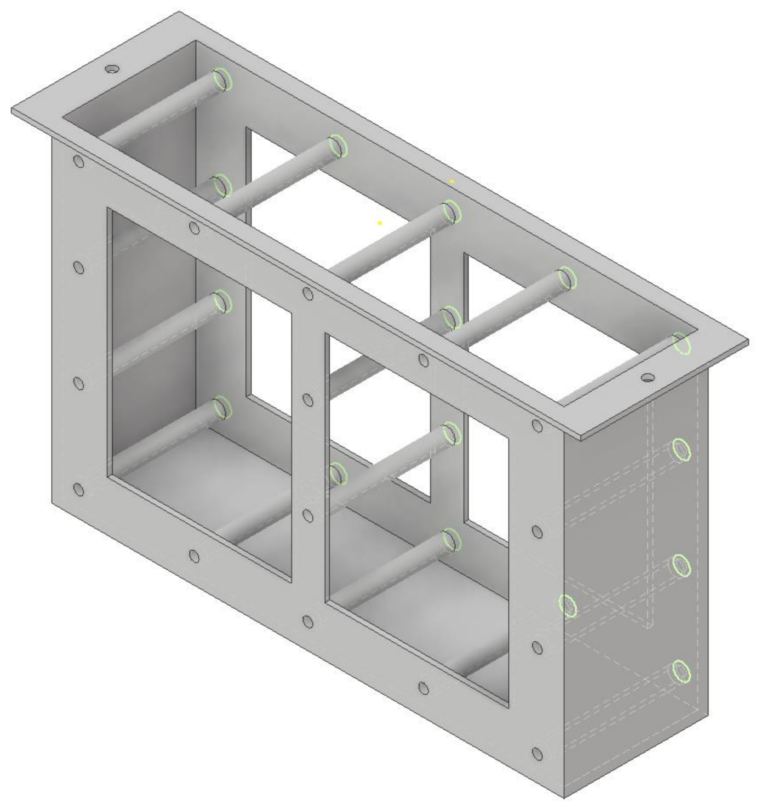

Figure 5: The skeleton of an air-cathode cassette. Cathodes are attached to the large square windows.

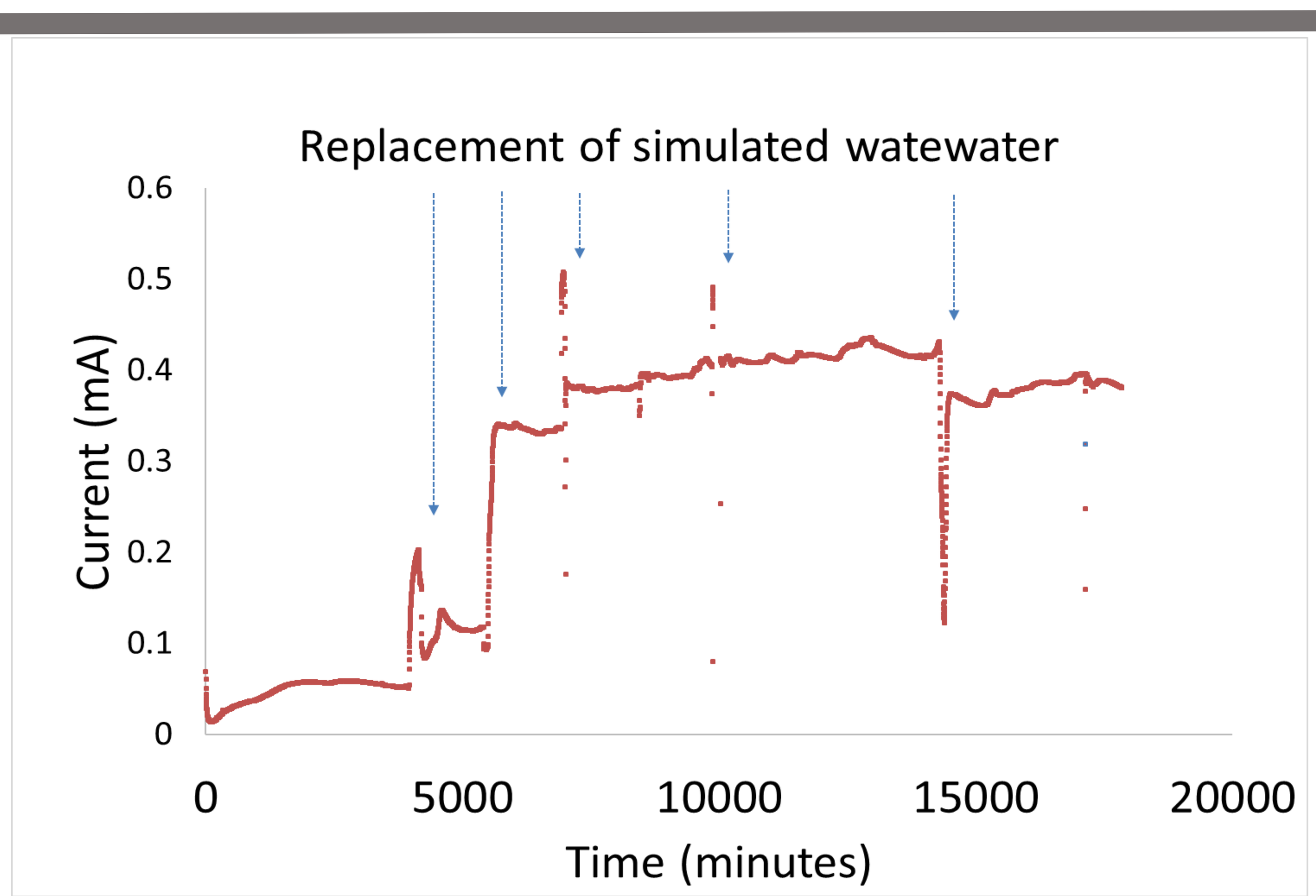

Figure 6: Current/time trace during 'start-up' of a recirculating batch mode 20 L version of the described system. After the 3rd replacement of media, current stabilises relative to subsequent media replacements. This indicates the 'start-up' is complete after 4 days and operating current is ~0.4 mA.

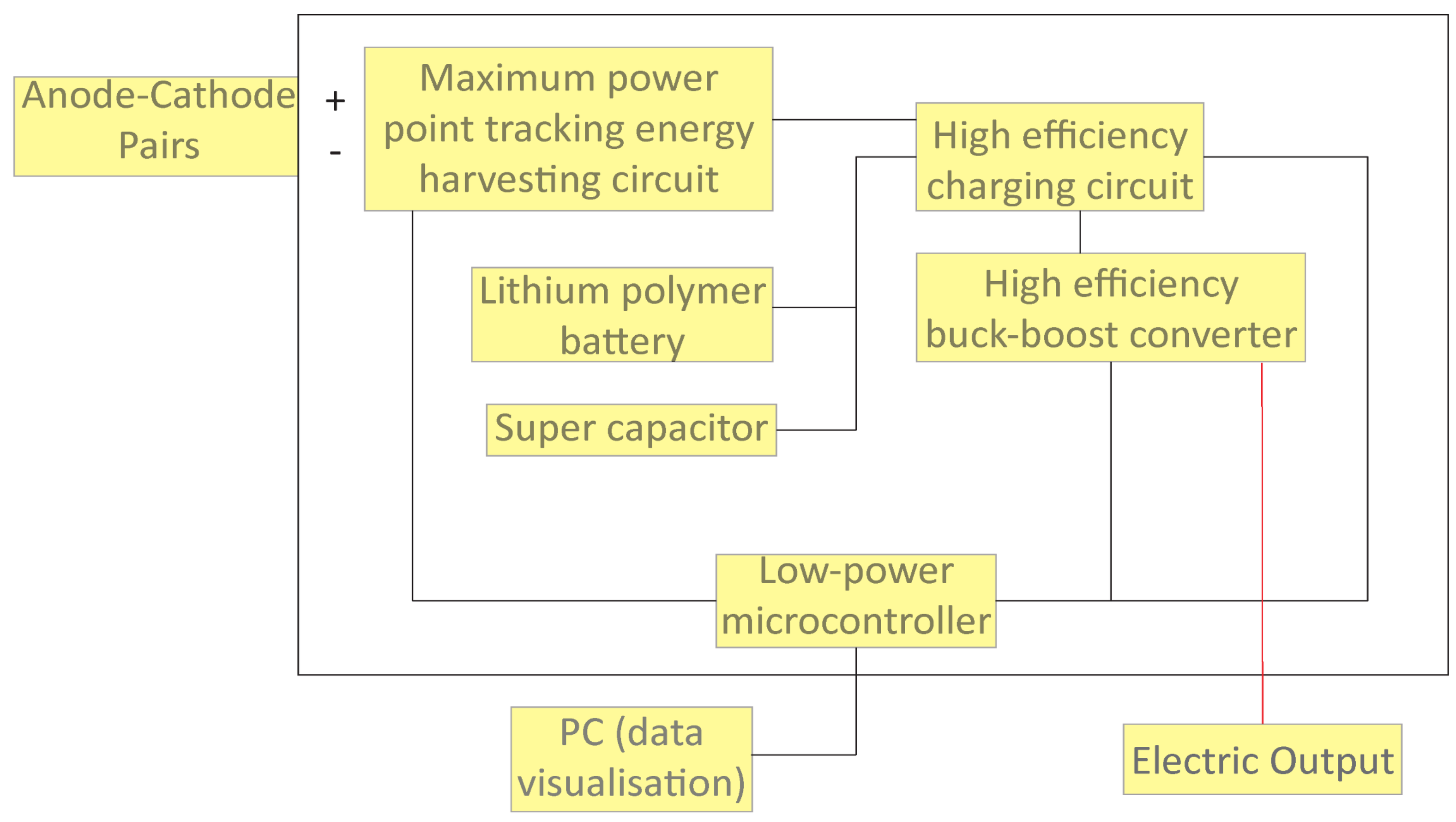

Figure 7: A schematic of the energy harvesting and management system

A 20 L cassette-based MFC reactor was designed and its performance, including energy harvesting is currently being investigated.

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