wetsus
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for sustainable water technology

Capacitive bio-anodes for electricity production in Microbial Fuel Cells

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Motivation

Wastewater treatment is an essential part of the contemporary society and will remain so in the future. The organic material in wastewater can be recovered as electricity with Microbial Fuel Cells (MFCs), while the wastewater is treated simultaneously[1]. The dissolved organic material in wastewater is directly converted to electricity via oxidation by electroactive bacteria growing on the anode: a bioanode (Figure 2, top left). Industrial application of the technology is hampered by clogging, pH gradients and slow, expensive cathodes compared to the anode, limiting scale up and power densities. A new development: the capacitive MFC can in principle solve these challenges[2]. Bacteria grow on the surface of a porous structure and oxidize the organic material. Electrons from the oxidation are stored in the porous structure. A highly porous structure has high internal surface area, which allows for a high capacitance. The combination forms a capacitive bioanode, shown in Figure 1 as a porous activated carbon granule. The electricity is produced by discharging the capacitance.

Technological challenge

The capacitance allows decoupling of the wastewater treatment and the electricity production, which allows both steps to be optimized separately. In the larger anode volume, the bioanode granules, which provide high capacitance and growth surface per volume of reactor, are charged. The charged granules move to a smaller discharge cell, where the electricity is produced, which reduces the costs per volume. See Figure 1 for a schematic representation.

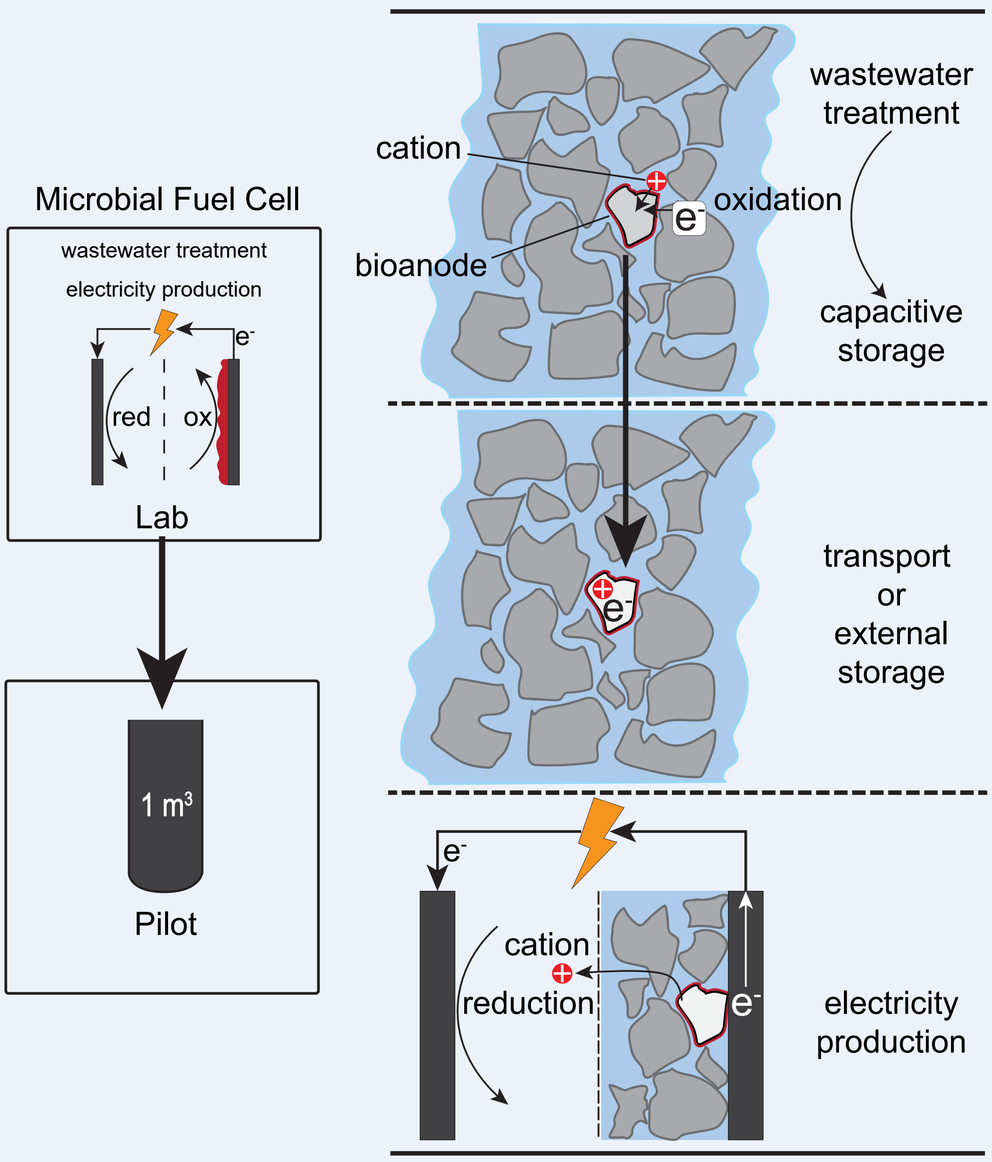

Fig 2. Graphical abstract, showing the goal to pilot scale (left) and the capacitive bio-anode process (right).

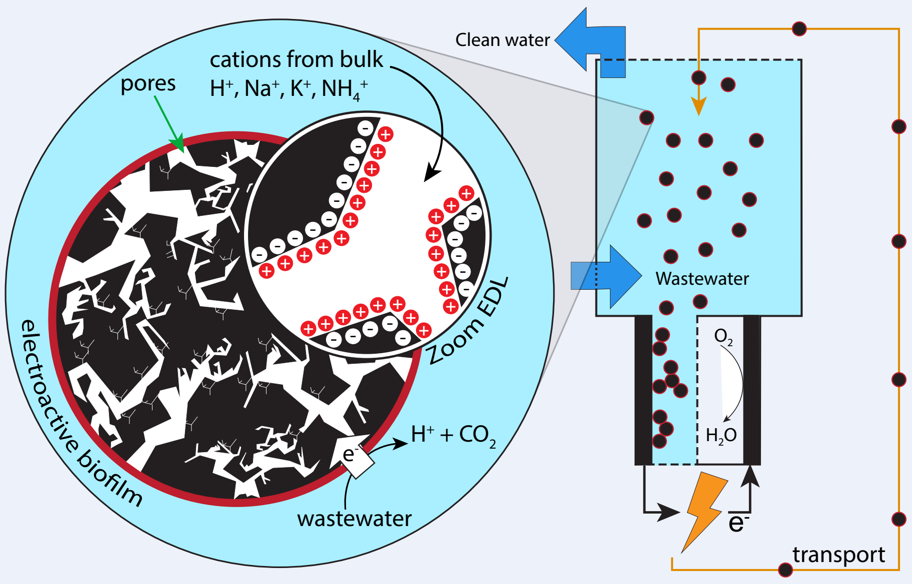

Fig 1. Schematic overview of a capacitive granule MFC, where the wastewater treatment and electricity production steps are separated. The zoom to the granule shows the capacitive charging process via oxidation on the bioanode electroactive bacteria and charge storage at the pore surface in the electric double layer.

Research goals

The aim this research project is to develop the capacitive bioanode Microbial Fuel Cell concept towards application, by:

- Studying optimization of the discharge characteristics of granular (bio)anodes (discharge cell, capacitive materials and interaction of biofilm with material)
- Designing a moving bed reactor
- Optimization of operational parameters
- Pilot scale application with real wastewater.

[1] Logan, Environ Sci Technol (2006) 5181-5192.
[2] Deeke, Environ Sci Technol (2015) 1929-1935.

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