Overcoming the cathodic limitations of the Plant Microbial Fuel Cell for a sustainable source of electricity

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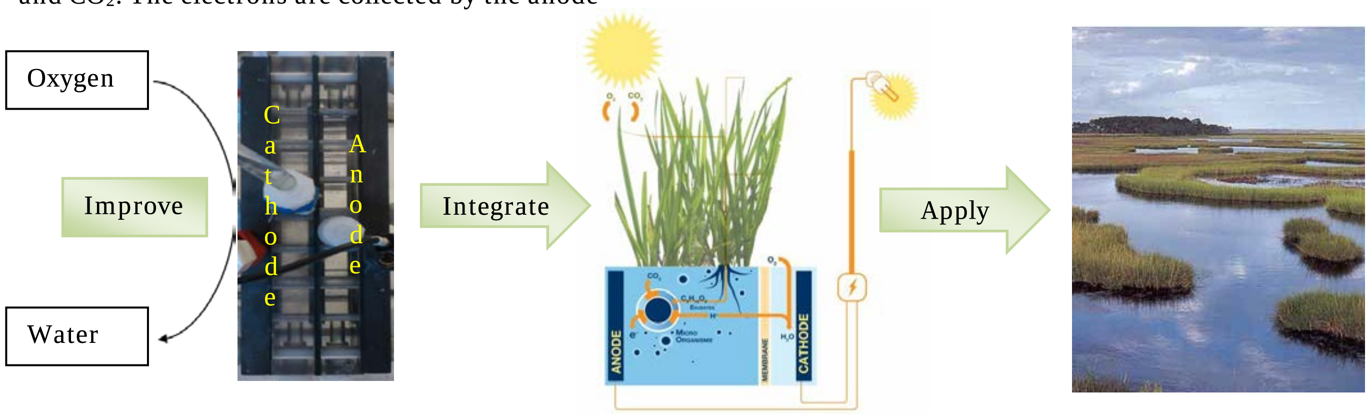
Motivation

The current climate change, the depletion of fossil fuels and the growing energy demand increase the urgency for renewable, sustainable and reliable energy sources. One new source is the plant microbial fuel cell (PMFC), which produces bioelectricity using photosynthesis from solar radiation without harvesting the plants. PMFC requires the anaerobic conditions in for example wetlands (+/-800,000,000 ha worldwide). Wetlands are often unsuitable for crop growth and thus is PMFC not competing for arable land. Even though PMFC is based on photosynthesis, it can deliver electricity 24 hours per day and year-round. This is especially interesting in remote areas without electricity or where electricity is delivered by irregular and unreliable variations in solar energy.

Technological challenge

In a PMFC, plants grow in the anode compartment of the MFC. These plants produce root exudates and provide dead roots to the anode via photosynthesis. Electrochemically active bacteria break down these organic materials and produce protons, electrons and CO_2. The electrons are collected by the anode and transferred to the cathode via an external circuit where the electricity is gained. At the cathode the electrons are collected via the reduction of oxygen.

The theoretical maximum electricity output of a PMFC is 3 W/m^2, currently a long term performance of 0.22 W/m^2 is reached. To reach the theoretical electricity production the internal resistance of the PMFC has to be reduced. Currently the cathode is the main internal resistance. The resistance of the cathode and thus the reduction of oxygen can be improved by the addition of a buffer or catalyzing microorganisms and by changing the design of the cell (i.e. air diffusion biocathode or 3D electrode). The first step in reducing the resistance is to clarify in what way and to what extent each improvement affects the resistances. This is analyzed with several electrochemical measurements. With the results from these analysis a 3D air diffusion biocathode will be developed. The first objective is to develop a biocathode that is able to generated a current density of 5 A/m^2 at 0.1 Ωm^2. Afterwards, the second objective is to integrate the air diffusion biocathode in the PMFC and reach a power output of 3 W/m^2, making PMFC an affordable and sustainable source of electricity.



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