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Research area: General aims

Energy generation

Key words:

Bioelectric system, microbial electrode, cation exchanger membrane, effluent treatment,

TITLE:

Development of paper-based electrodes for microbial electrochemical effluent treatment

Background/Problem area

Newly developed materials and alternative technological concepts play a central role in the conservation and sustainable use of the resource water. Structures known as bioelectrical systems are an innovative approach in the field of effluent treatment. The degradation of organic constituents in the effluent and the energy produced by microorganisms involved in such degradation are considered to be the ecological and economical solution in the field of effluent treatment. These systems can be operated either as a microbial fuel cell or microbial electrolysis cell. The efficiency of this technology is determined by the efficiency of the individual components. Important elements include the microbial electrode and the cation exchanger membrane. The electrode material should have optimum material and surface properties to guarantee that an electrochemically active biofilm forms whilst at the same time ensuring good electrical conductivity and mechanical stability. A high surface/volume ratio is also required for the necessary system efficiency. A concept for an appropriate electrode material is paper-based materials.

Objectives/Research results

The objective of the research project is to develop paper-based electrodes and hydrocarbon-based cation exchanger membranes to enhance the efficiency of bioelectrochemical systems for use in communal and industrial effluent treatment.

First of all, paper-based conductive surface electrodes and hydrocarbon-based cation exchanger membranes are developed and optimised within the scope of the project. The concept for developing the electrode material is to produce highly filled paper that exhibits high electrical conductivity, is dimensionally stable when used in aqueous media and has been optimised to form electrochemically active biofilms. The microbial electrode is folded to give it a three-dimensional geometry in order to thereby maximise the growth area for microorganisms and at the same time efficiently utilise the reactor volume. The use of the three-dimensional bioelectrode and membrane are to be examined and evaluated by experimental tests and flow simulation. These results are then to be used to design tailored solutions for the operation of a demonstrator in communal and industrial effluent treatment.

In the sub-project on electrode development, a comprehensive laboratory screening was performed to identify a formulation for a suitable paper-based medium, focusing on the contribution of various graphite types to conductivity. High amounts of graphite were bound in the fibre structure and handsheets were formed by means of specific additives, identifying material combinations that lead to high conductivity. First material variations were used to bio-electrochemically characterise the electrodes in a laboratory electrolysis cell. They showed promising characteristics in terms of biofilm growth and energy density.

Application/Economic benefits

Bioelectrical systems (microbial fuel cell / microbial electrolysis cell) present an ecological and economical solution in the field of effluent treatment owing to the degradation of organic constituents in the effluents and the energy produced by the microorganisms that themselves also reproduce. Such a system can replace currently operated, energy-intensive aerobic treatment stages in effluent treatment. This thus pursues a sustainable approach that can make the potentially energy self-sufficient operation of industrial and communal effluent treatment facilities possible.

The materials to be developed will make it possible to provide the required electrodes and membrane surfaces in a cost-efficient manner, thus raising expectations for the economical use of bioelectric systems.

Project period: 01.05.2016 – 30.04.2019

Remarks

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