Bioengineering Aquatic Environments - Day 1 - Session 2
4.1.2.02

Systematic comparison of anode materials for microbial fuel cells

Kipf E.[1], Koch J.[2], Kerzenmacher S.[1]
(1) University of Freiburg - IMTEK, Department of Microsystems Engineering, Laboratory for MEMS Applications, Freiburg, Germany

Summary:
We present a systematic comparison of anode materials for microbial fuel cells (MFCs). Therein the anodes are assembled as half-cells and galvanostatic polarization curves are recorded against a reference electrode. This approach led to the identification of activated carbon cloth (ACC) as superior anode material compared to graphite felt (GF), which at present is predominantly used in microbial fuel cells.

Introduction:
MFCs bear great potential as an alternative electricity source combined with simultaneous waste water treatment. Nevertheless, applications are still limited because of their low power densities. Consequently a number of researchers focus on the identification and development of cost-effective high performance materials. However, often only the performance of complete fuel cells is reported, which renders the systematic evaluation and comparison of different anode and cathode materials difficult.
Here we present the first results of a systematic anode material screening by recording half-cell polarization curves against a reference electrode. This approach not only ensures a high degree of comparability but is also time and cost effective since no complete fuel cell assembly is necessary.

Experimental setup:
The anode material screening for MFCs was carried out in an aseptic chemical reactor [2] filled with 1 L Shewanella oneidensis MR-1 cell suspension (OD600=0.066 at the beginning of the experiment). Two different anode materials, GF (Sigratherm GFD 2, SGL carbon group) and ACC (C-Tex 13, MAST Carbon), each as triplicates with a size of 2.25 cm², were assembled inside the reactor as half-cells. Anode polarization curves of the half-cells against a reference electrode (SCE) were recorded applying a galvanostatic technique with step-wise increase in load current (50 µA every 48h) [2]. This approach helps to prevent performance overestimation by a too fast current sweep rate. During all experiments the cell suspension in the vessel was purged with nitrogen.

Results:
At an anode potential of 0 V vs. SCE the ACC showed a current density of 72 ± 2 µA/cm² (normalized to the projected electrode area), whereas the GF reaches this potential already at a current density of only about 24 µA/cm². Taking into account the different thickness of the materials (ACC: 0.54 mm, GF: 2 mm) also current densities normalized to the total volume of the electrode can be calculated. At 0 V vs. SCE ACC shows 1331 ± 34 µA/cm³ (per electrode volume), whereas the GF reaches this potential already at the lower current density of about 118 µA/cm³ (per electrode volume).

Conclusion:
We show the systematic comparison of potential anode materials for MFCs applying a half-cell electrode setup. With this approach ACC was identified as superior anode material compared to GF, commonly used as anode material. At 0 V vs. SCE the current density of ACC exceeds the GF not only normalized to the projected anode area, but also normalized to the electrode volume. Here ACC shows an about 11 times higher volumetric current density compared to GF.

For a better comparison to the state of the art a theoretical power density for ACC can be calculated taking into account the polarization data of a benchmark platinum air cathode from literature [3]. This gives a maximum power density for ACC of 23 ± 1 µW/cm², which is comparable to the results of Watson et al. [4]. They achieved a maximum power density of 33 ± 2 µW/cm², normalized to the projected cathode area. However, at the same cathode area their graphite brush anode has a 500 times larger volume than the ACC electrode. Thus ACC would allow for the construction of a fuel cell with increased volumetric power density.

Investing in your future
European Regional
Development Fund
Bremerhaven
Bremen