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Evaluation of microbial fuel cells with graphite/MnO_2 composite oxygen reduction cathode catalyst and their power generation performances in real waste water

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Introduction:

In recent years, research on microbial fuel cells (MFC) has increased since MFC have the ability to clean waste water and to produce electricity simultaneously [1]. MFC technologies has not reached industrial application, higher power and long time stability of the electrodes must be improved. [1]. The cathode is the main limiting factor for to reach high power density, especially in real wastewater. Graphite and MnO_2 are widely available and low cost materials. MnO_2 can be used as catalyst on the cathode in order to improve its performance. The application of the MnO_2 was done as a paint, made conductive by graphite.

Mechanisms of MFC:

Electricity generation during organic degradation represents a process of directly converting chemical energy within organic matters to electrical energy, which gives rise to a potential for MFC to produce electricity from organic wastewater along with wastewater treatment. The construction of an MFC and its chemical reaction on the electrodes is shown in Fig.1. It can be seen in Fig.1 that the organic reactant is oxidized to CO_2 at the anode, while the oxygen reacts in the cathode. A membrane is located between anode and cathode for proton exchange.

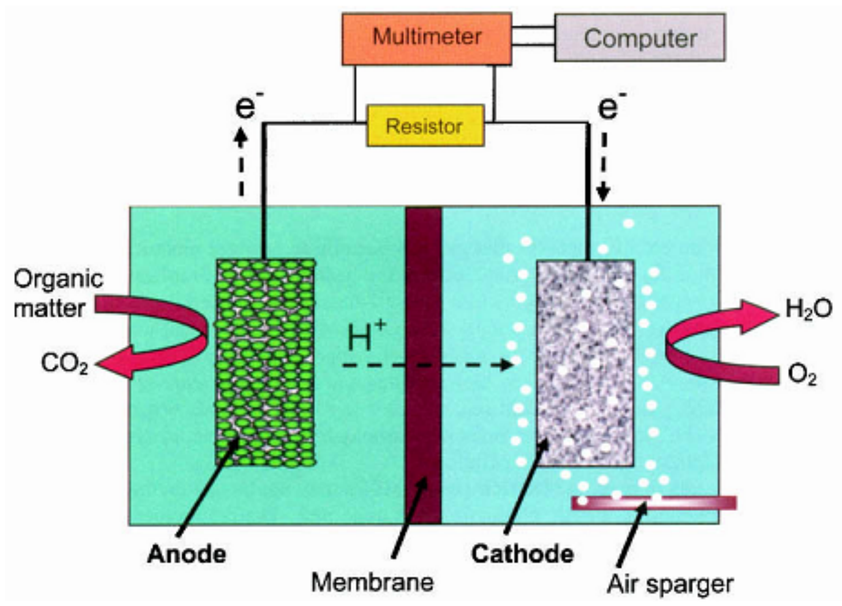

Fig. 1: Schematic of a typical two-chamber microbial fuel cell and its reactions

Methods:

In this work a catalytic graphite/MnO_2 composite was prepared by dispersion of MnO_2 and graphite in a solution of celluloid as a binder in acetone. Then the prepared graphite/MnO_2 composite was coated on the surface of a cathode carrier material (stainless steel mesh) with the mass ratio of graphite and MnO_2 10:1. Four MFCs were connected in series with the wastewater supply and their individual output power densities with time were evaluated.

The stainless steel mesh with graphite/MnO_2 composite coating and the MFCs are shown in Fig.2.

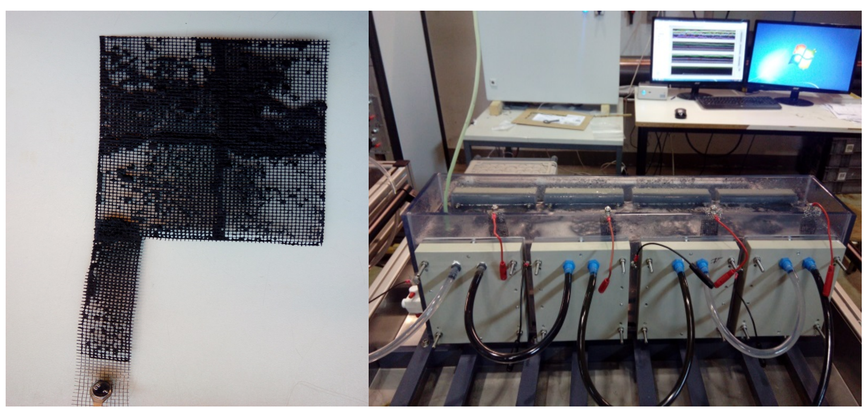

Fig. 2: Stainless steel mesh with graphite/MnO2 (left) and four in series connected MFCs (right)

Results and Discussions:

The individual output power densities with time are shown in Fig.3. It can be seen that the power densities increased slightly with time within 9 days. However, the power densities increased rapidly and reached relatively high values (for cell No.12 110mW/m^2, for cell No.9,10 and 11 150 mW/m^2) at the 10^{th} day and then tended to fluctuate around a value of 100 mW/m^2, which is a good value for real wastewater. A cathode without a catalyst for the oxygen reduction reaction reached only a power density of about 40 mW/m^2. The power density could be improved by more than 50 mW/m^2 (Fig.4), this is an increase of a factor of more than two. This demonstrates that a low cost MnO_2 catalyst can play an important role on improving the power density generation of MFCs by ir

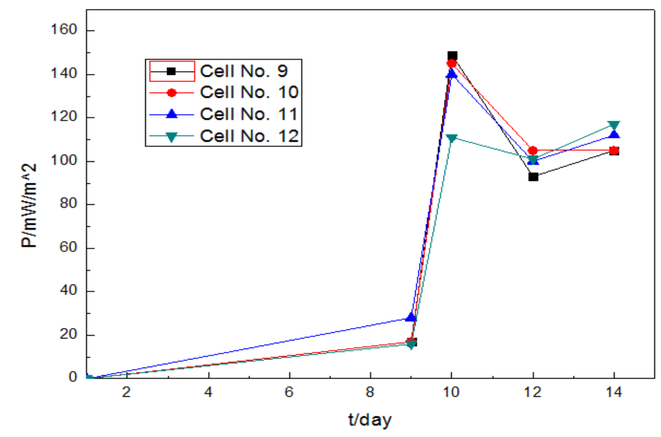

Fig. 3: Power density development over time

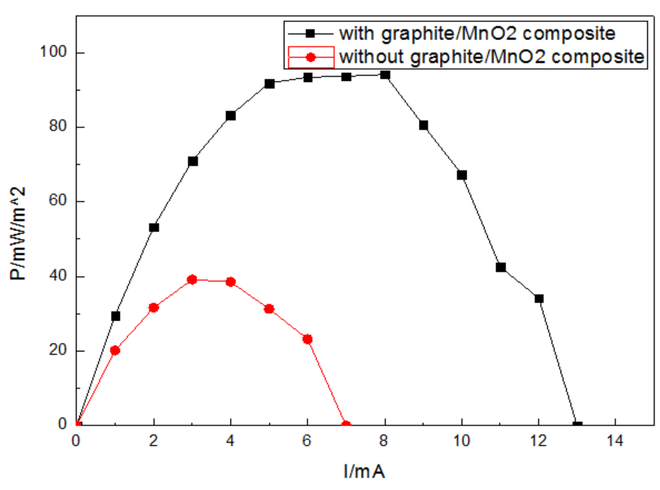

Fig. 4: Power densities of MFCs after 2 weeks with graphite/MnO_2 composite cathode catalyst

Conclusions:

- MnO_2 is a catalyst well suited for the cathode of a MFC. The power densities of the MFCs increased rapidly and reached relatively high values
- Long time power densities of around a value of 100 mW/m^2, which is a good value for real wastewater, were reached.
- A cathode without a catalyst for the oxygen reduction reaction reached only a power density of about 40 mW/m^2.
- The power density could be improved by more than 50 mW/m^2 , this is an increase of a factor of more than two.
- This work confirms that the cathode is the power limiting electrode in a microbial fuel cell.
- Future work should focus on better cathode catalyst which are cheap and non poisoning for water organism.

Acknowledgement:

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References

[1] Lin C. W., Wu C. H., Huang W. T., Tsai S. L.; Evaluation of different cell-immobilization strategies for simultaneous distillery wastewater treatment and electricity generation in microbial fuel cells; Fuel, 144, (2015), 1-8.