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The application of anion and cation exchange membranes in microbial electrochemical systems

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Microbial fuel cells (MFC) are considered an important area of investigation in the field of renewable energy and efficient wastewater treatment. They combine the production of power with the treatment of various waste streams, and several researchers have reported functionalizing them further [1]. The standard membrane used in the MFC setup is a cation-exchange membrane (CEM), usually Nafion. Alternatives have been studied, including the use of anion exchange membranes [2]. Power generation is greater and more stable when these membranes are used, and there is evidence that they suffer less fouling [3]. There are major factors that affect a membranes performance in the cell, such as conductivity, stability under various conditions and oxygen permeability.

Anion-exchange membranes (AEMs) have been extensively researched for application in low temperature chemical fuel cells at Surrey [4], but they also have the potential for use in microbial fuel cells. These membranes potentially possess characteristics desirable in a microbial fuel cell setup such as low oxygen permeability and low ionic resistance. This presentation will detail the testing (both *in situ* and *ex* situ) of the Surrey-made radiation-grafted (RG) AEMs compared to RG-Surrey CEMs and Nafion.

Ex-situ stability testing has been carried out on RG-AEMs and CEMs ex-situ to determine whether the various components of the solutions and suspensions used in the MFCs have any measurable effect on their performance. Tests include ion exchange capacity (IEC), conductivity and gravimetric water uptake (WU) measurements along with FT-Raman and FT-IR spectroscopy. Low analyte volume MFCs were operated with the use of both CEMs and AEMs as the separator - to see which produces the higher power density.

Results to date indicate that the performance of the membranes is less stable in bacterial suspensions, and that the MFC compartments suffer from a more pronounced pH change over the course of several days, probably due to the production of acidic metabolites by the bacteria. The changes in conductivity, gravimetric water uptake and ion exchange capacity show that the degradation of the AEMs is considerably less than that of the industry standard Nafion and the RG-CEM (out of the two CEMs the RG-CEM suffered significantly less degradation) [Figure 1]. This may be due to the high sodium content of media used in most MFCs. According to the manufacturer (DuPont) alkali metals, sodium in particular, can directly affect the performance of Nafion under normal conditions of temperature and pressure.

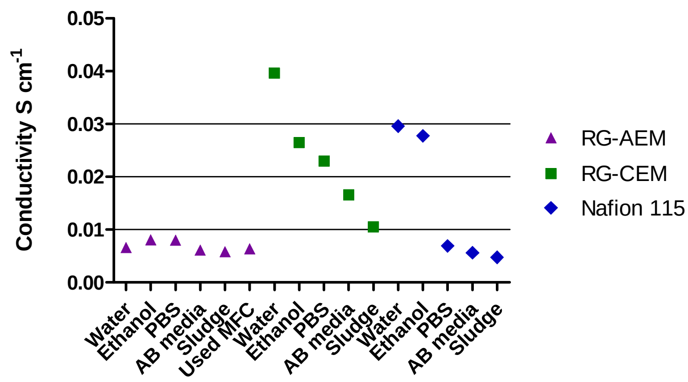

Fig. 1 – Conductivity of membranes after exposure to various solutions/suspensions

The oxygen permeability of the membranes is also under investigation to assess whether oxygen has a detrimental effect on the performance of the anaerobic bacteria in the anode chamber of the MFCs.

The results obtained from the *in-situ* testing compared with *ex situ* shows the same level of degradation between membranes that were operated in the MFC and membranes that were tested *ex-situ* (in the presence of bacteria and media). These tests have only been conducted over a period of several weeks. The results of a long term experiment will help to assess any different fouling of the membrane.

References

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