Harvesting Energy from Microbial Fuel Cells and their Impedance Analysis

Abstract

At present, the world in a dire need of green, renewable and sustainable energy sources. There are many reasons for this, for example, the ever-growing problem of pollution caused by fossil-fuel based energy sources, the depletion of fossil-fuel resources and the world's growing population. The main aim of my work is to investigate an upcoming source of sustainable energy – Microbial Fuel Cells (MFCs). MFCs are bio-electrochemical devices which are based on electro-active bacteria. These bacteria produce electrons in their metabolic process. The electrons produced by these bacteria can be collected on the electrode and later stored into a battery/super capacitor through a power management system.

This thesis is an in-depth explanation of the work I performed on MFCs. Initially, I worked on investigating the internal processes occurring on the anodes of MFCs, related to diffusion of substrates and the bacteria's charge transfer mechanisms. The main tool used for this study was Electrochemical Impedance Spectroscopy (EIS). EIS is a non-invasive technique used to study a variety of systems. It is performed by exciting the system under study using a small alternating voltage at different frequencies. The resulting current responses are used to calculate the impedance of the system at each frequency point. During this part of my work, we analyzed a biofilm formed by mixed community bacteria and inferred conclusions about the different processes detected by EIS.

The next part of my work was dedicated to energy harvesting from MFCs. More specifically, the work was related to a special kind of MFCs known as floating-MFCs (fMFCs). fMFCs are mostly used in aquatic/marine environments to harvest energy using seawater as the source of organic matter. An integral part of this work was to propose a setup of fMFCs which requires minimal cost and effort to start functioning as an energy harvesting device. Mostly, the MFCs used

are setup in the laboratory and a considerable amount of time and effort is required in the initial acclimation period. Furthermore, different chemical compounds are also required in this phase which add to the overall cost of the device. Therefore, these methods of MFC startup impose limitations on their use. To ensure the widespread use of MFCs as devices producing sustainable energy, it is important to devise cost-effective and simple ways of setting them up. The later part of my work focused on developing an fMFC with an in-situ biofilm formation. Not only does it help reduce the cost of the fMFC's setup, but also makes its use more feasible for different applications in the marine environment.

It is important that we shift our focus towards the use of renewable and sustainable energy sources. Not only is it essential for the deteriorating environment but it also enables us to rely less on the limited fossil fuel resources. MFCs are a step in this direction. Even though, the amount of extractable energy from MFCs is low, they are still very useful in providing a continuous source of energy for low power applications based in remote environments.