Abstract of Doctoral Dissertation

Title: Development of practical Microbial Fuel Cells for electrical generation and biosensing applications

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Microbial Fuel Cells (MFCs) are emerging technologies and are described as the newest approach using microbial metabolism to generate electricity by converting chemical energy directly from organic substrates. The main limitations of MFCs come from the low electricity production and complicated setup in practical applications. This thesis presents a series of lab-scale experiments with a variety of innovative, cost-effective, and convenient MFC designs to produce electricity on demand and can be used as a sensor for water sensing, which will be helpful in agriculture management.

First of all, a new baker yeast-powered MFC was proposed by hybridizing the MFC and EFC (enzymatic fuel cells) technologies to enhance power performance. By adding the commercial alcohol and aldehyde dehydrogenase enzymes (ADHE), the maximum power density (MPD) was improved when compared with the MFC without using ADHE. Furthermore, the anaerobic culture condition is more suitable for MFC operation than the aerobic condition.

Next, three different compact, easy-to-use, and cost-effective Soil MFC configurations were proposed to improve electricity generation.

The first portable plugged-type double-chambered SMFC was fabricated using low-cost materials with LB dipped-anode to facilitate the biofilm formation by simply plugging in the natural wet soil.

The second compact, membrane-less SMFC was used to investigate the electricity generation ability from household rice washing wastewater (RWW) in different soil types. The results imply that RWW is a rich carbon source for SMFC operation, and the proposed SMFC can operate in various types of soil and effectively generate bioelectricity from RWW.

The third portable membrane-less SMFC used to harvest electricity is made of modified electrodes using multi-walled carbon nanotube paper (MCNTP) with high conductivity, flexibility, and durability. The SMFC was designed with three anodes in series, and a floating air cathode could be activated on-demand by simply stabbing in the wet soil. The SMFC generated electricity rapidly and was also used as the electrical source to power a fully functioning clock.

Finally, biosensing is another application of SMFC. A new design of low-cost SMFC was used as a

biosensor for sensing soil water content. In the range of 60-80% soil water holding capacity (SWHC), the sensitivity of SMFC was the highest, whereas humidity less than 60% cannot activate and maintain the SMFC operation. Therefore, with the SWHC of 60 - 80% corresponding to 24 - 36% soil moisture suitable for many plants, the proposed SMFC can be potentially used as a sensor for agriculture applications.