Chapter 7

Harvesting Energy from Microbial Fuel Cells: Powering Wireless Sensor Networks Operating in Wastewater Treatment Plants

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ABSTRACT

Microbial Fuel Cells (MFC) are the main topic of this chapter. Different types of electrochemical devices are presented and their typical power output is compared with other energy sources, providing a framework for the uses and applications of MFC technology. Following an historical approach of how this technology came to be, a more detailed description of some aspects of a typical microbial fuel cell is then brought forward. The energy harvesting concept, its use on low power wireless systems and maximum power point tracking (MPPT) techniques are presented and described. Wastewater treatment plants are a kind of infrastructure where this technology could be applied with a major success to power wireless sensing networks. An experimental setup, develop to improve the use of MFC in waste water treatment plants is presented. This chapter also provides a review on research trends for microbial fuel cells and maximum power point tracking algorithms, therefore, pointing current researches on this technology.

INTRODUCTION

Wastewater treatment processes for agglomerates with less than 2000 population equivalents, especially the ones located on the countryside and in areas with a low population density, have used low cost solutions based on filtration systems (e.g. constructed wetlands and sand filtration beds). Low power wireless sensors networks are becoming a very interesting solution for monitoring the operation of wastewater treatment plants. Their biggest limitation is related with power: the batteries usually applied

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have a short lifetime, soon needing replacement. This increases operation and maintenance costs and decreases product’s appeal gained with the wireless feature. Some bibliographic records point to 74% of all the consumed power of a sensor node being directed at the transceiver module (Huang, et al., 2012). Given this, one of three challenges can be tackled: to decrease the power consumption of this module; to increase the effective rate of transmitted data, decreasing the time for which the module has to be turned on; or to come up with sustainable energy alternatives that can account for all the power needs of these circuits (Nordic Semiconductor, 2012). Energy harvesting, power harvesting or even energy scavenging, is a suitable solution for powering remote devices where no conventional power source is available. For most common remote sensors, power in the range of milliwatts is enough (Raju, 2008).

This chapter aims to provide an overview description of a self-sustaining energy harvesting Microbial Fuel Cell (MFC), a promising solution to this challenge where organic substrates are available.

Firstly, the energy harvesting concept, its use on low power wireless systems and maximum power point tracking (MPPT) techniques will be explored and briefly described. After that, different types of electrochemical devices are presented and their typical power output is compared with other energy sources, providing a framework for the uses and applications of the MFC technology. Following an historical approach of this technology, a description of some aspects of a typical microbial fuel cell is discussed. The chapter closes with the report of an experimental setup and the retrieved data for its operation, while pointing to current and future research trends for microbial fuel cells.

**BACKGROUND**

*Harvesting Energy for Energetically Independent Devices*

Throughout history, mankind seems to get more inventive, focused and productive as it gets more limited, be it on tools, food, money, time or space. Currently, particularly due to critical budget constraints, the scientific community is as committed to making brand new discoveries as it is with perfecting already existing processes, materials and methods. Therefore, process monitoring is of the greatest importance. The field of instrumentation and measuring devices, as others, is experiencing an exciting growth (De-wan, Ay, Karim, & Beyenal, 2014). Several very different knowledge domains are getting together and confronting needs and answers. Instrumentation devices are useful in sports - evaluating performances, achievements and material conditions -, in cooking, to improve comfort at home, in medicine, in media devices – like cellphones, tablets or smart watches -, or in industry. Instrumentation devices allow us to keep track of changes and analyze data. As with any other electric device, instrumentation modules require power. And power availability ultimately limits their usefulness: a sensor is no good if it needs to be connected to the main power grid or if it’s powered by a battery, running only for a couple of hours. Versatility and reliability are the main keywords for any electrical devices, instrumentation included, irrespective of their application area.

Instrumentation devices can be powered by connecting them to the main power grid, with a suitable power transformer, or by using batteries. The connection to the main power grid severely hinders the versatility of the devices, namely their ability to be used at different locations. Even though wires are the most reliable, faster and safest way to power anything of electrical nature, the connectors are a weak point, susceptible to moisture and dust and the wiring always limits the portability of the device (Li Huang et al., 2010; Smith, 2011; “Ultra low power wireless connectivity technology backgrounder,”