Open-source platform for testing and characterizing MFCs

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Microbial fuel cells, or MFCs, use bacteria as a biocatalyst to convert chemical energy in substrate chemicals into electrical energy. This technology may soon offer an efficient and ecological means of power generation for a broad array of applications, from *Gastrobots*, robots which fuel themselves with biomatter from their surroundings, to wastewater treatment strategies [1]. However, the power capabilities of contemporary MFCs remain too low to be useful for most practical applications [1,2]. Over the last ten years, a huge body of research has been generated into understanding the microbial mechanisms of power generation, and into the design of better MFCs [2–4].

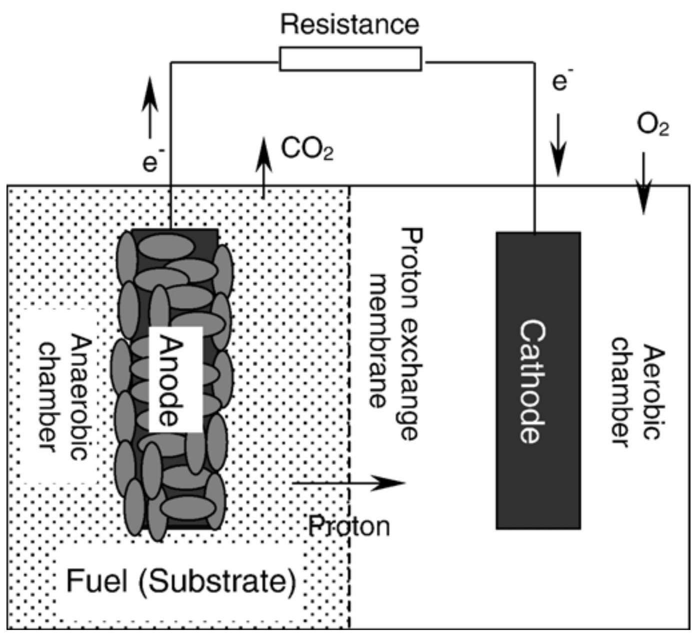

Figure 1: Schematic diagram of a typical two-chamber microbial fuel cell [3]

The key principle on which the MFC operates is the metabolism of organic compounds by bacteria into carbon dioxide, protons, electrons, and chemical byproducts which depend on

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the strain of bacteria, chemical substrate, and mode of operation of the MFC [5]. Similarly to a proton exchange membrane fuel cell, protons diffuse to the cathode where they are reduced to hydrogen gas, and electrons are transferred to the anode; this exchange gives rise to a current (see Figure 1).

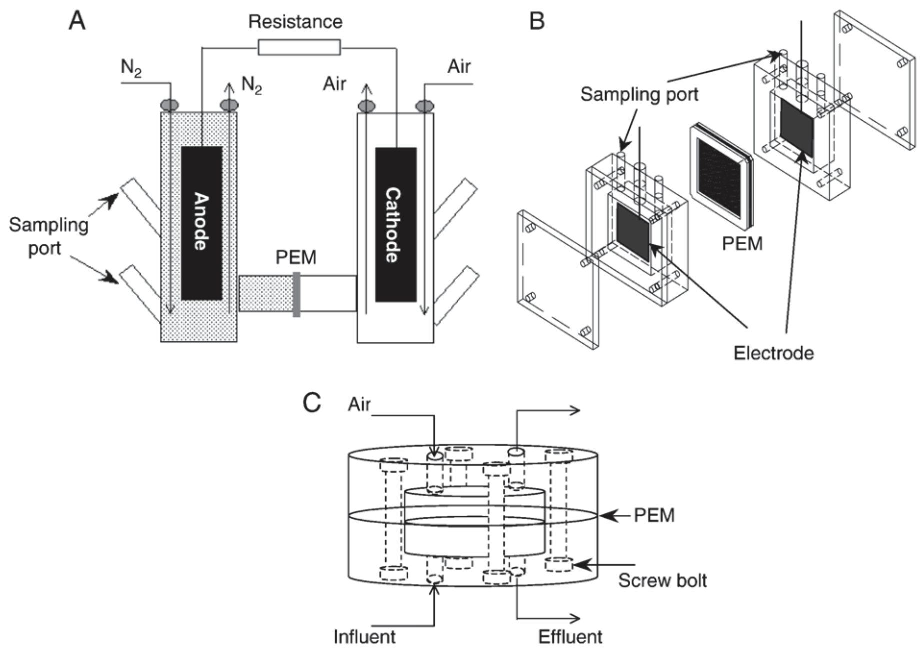

Figure 2: Examples of MFC designs [3]

Many properties of the bacterial mechanisms that give rise to these reactions, however, remain unknown, and better characterization of MFC behavior is necessary [2, 4, 6]. Some researchers are even of the opinion that, given the limited extent of work on characterizing MFCs, further work into applying MFCs at this stage could hurt the field more than help it; the development of MFCs with low power density (most MFCs operate on the order of milliwatts per square meter of electrode [1]) and high material costs may be doing more to steer people away from MFC technology than toward it [2]. Furthermore, with different researchers often focusing on very different types of bacteria, reactions and MFC designs, there remains no standardized method to design, build, operate and research an MFC [1–3]. Figure 2 shows a small collection of the many different MFC designs which have been built.

In this light, we propose to design and build an open-source platform for standardized methods of testing and characterizing MFCs. Given the diversity of MFC designs in the literature, our main aim is to accommodate the largest possible audience. The apparatus will be reusable, with interchangeable parts to allow for use with various bacteria strains, chemical substrates, electrode materials, and modes of operation. We will equip the platform with a measurement electronics board, complete with circuits important for testing and characterizing MFCs, such as a potentiostat [2, 7]. Ideally, the design will be low-cost, compact, aesthetically pleasing, highly functional, and easily replicable. We aim to restrain the dimensions to 5 cm on each side, and to keep the cost of the materials needed in the final product to no more than ten dollars.

We will begin our investigation by experimenting with previously published MFC concepts to learn the benefits and disadvantages of certain designs. During this process, we will develop a procedure for testing and characterizing various MFCs based on published methods. We will then refine our final design to ensure its functionality, low cost and ease of use. Through combined, parallel efforts at understanding MFCs, improving their design, lowering their cost, and improving their availability, MFCs stand the best chance at being a viable energy solution for a wide range of applications.

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