

Stepwise Electric Power Generation for Prolonging Lifetime of Miniaturized Biofuel Cell

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The Lifetime of an enzymatic biofuel cell is usually determined by enzyme stability. In recent days, some researchers suggested that the immobilized enzymes within a microstructure, such as a meso-porous carbon matrix [1] or Nafion membrane [2], showed higher stability. Here we report, a new power generation system for prolonging total lifetime of miniature biofuel cells.

As shown in Fig. 1, micro-biofuel cells, which are protected with different kinds of degradable films, are connected in parallel. Each of the cells is designed to be activated at different time intervals after exposure to the fuel solution. This can be controlled by the properties of the degradable films: the material used, the molecular mass, the composition, or the thickness. Therefore, the total power output can be expected to be stable.

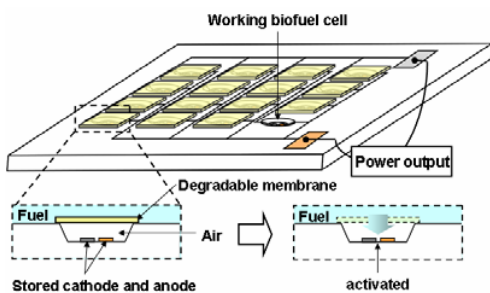


Figure 1. Schematic illustration of an array of miniature biofuel cells protected with degradable films that can be stepwisely degraded.

We designed and tested a degradable device to investigate the feasibility of achieving multi-pulse electrode activation without requiring any external trigger. Fig. 2 shows the experimental system in this study. Three biofuel cells which are composed of a Pt cathode and a bienzyme-modified glucose anode respectively [3, 4], were connected in parallel. Two of the three cells were separated from solution by biodegradable poly(lactic-co-glycolic acid) (PLGA) thin films whose degradation rates are different from each other.

The results presented in Fig. 3 shows the time course of the output current from the prototype device shown in Fig. 2. The observed current of 3.8 μA at early stage (0 to 7 min) was generated by the non-covered cell. The current suddenly increases to 4.6 μA at 7 min due to the tearing of the PLGA film of low molecular mass, exposing of a new set of electrodes to the fuel solution (the activation of another fuel cell). Similarly, the current increasing at 27 min was caused by the tearing of the PLGA film of high molecular mass.

We demonstrated that the provisional protection of subsets of biofuel cells is effective in prolonging the total lifetime of the fuel cell system. In order to miniaturize and integrate the cells, we are now studying the suitable device structure and its fabrication method.

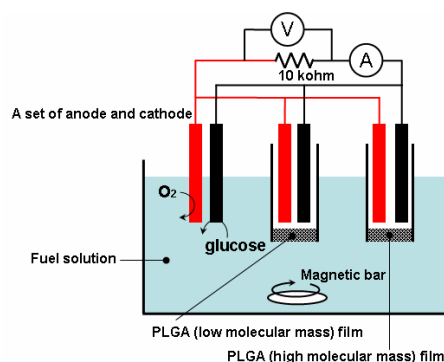


Figure 2. Prototype of miniature biofuel cells covered with different types of PLGA films.

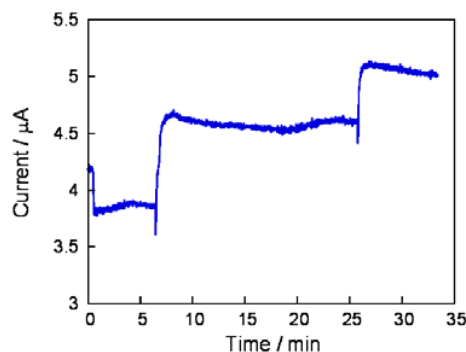


Figure 3. Output current of the biofuel cell system shown in Fig. 2 over time. The measurements were conducted in an air-saturated phosphate buffer (pH 7, 37°C) containing 30 mM glucose and 1 mM NAD^+ .

Acknowledgments:

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References:

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