# Development of a Glucose-Air Biofuel Cell

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Research in our laboratory has been focused on gas-diffusion laccase- and Bilirubin oxidase-catalyzed cathodes, operating under "air-breathing" conditions, which can utilize oxygen directly from atmospheric air. In this paper, we report on the integration of such gas-diffusion enzyme-catalyzed cathode with a glucose electrooxidizing, nickelocene-mediated glucose oxidase anode. Biofuel cell characteristics, such as, power density, cell voltage, cell design parameters will be discussed. Development of the designs allowing for direct utilization of various fuels harvested from biological sources will be addressed. This will include employment of coupled enzymatic reactions between glucose oxidase and invertase, for example, to provide for the possible use of sucrose as a fuel.

One of such basic anode design concepts relies on mediated enzymatic oxidation of glucose. Being the first enzyme to be used in glucose biosensors, Glucose oxidase (Gox) has been the most commonly used for glucose electrooxidation at the anode of enzymatic biofuel cells. Among the numerous mediators and redox polymers that have been used for the electrical communication between the Gox enzyme and the electrode, we have exploited nickelocene, which has a more favorable quasi-redox potential of around –100mV vs. Ag/AgCl, compared to ferrocene derivatives, and other commonly used redox mediators. The composite electrode was prepared using a mixture of teflonized carbon and carbon black, with the mediator and Gox immobilized by physical adsorption following a previously reported procedure [4] and was designed to serve as anode of the biofuel cell. This electrode demonstrates high activity in glucose conversion and can provide current output exceeding 3 $mA/cm^2$ at 0.0 V vs. Ag/AgCl electrode.

Bilirubin oxidase (BOD) from *Myrothecium verrucaria* was used for bio-electroreduction of oxygen based on direct electron transfer (DET). Carbon composite electrode made from a mixture of teflonized carbon and untreated carbon black was used to immobilize BOD by physical adsorption. Cyclic voltammetric experiments revealed an on-set potential for electroreduction of oxygen at +0.6 V vs. Ag/AgCl with a decrease in the overpotential by 0.8 V compared to the blank electrode without the enzyme. Polarization curve was measured using BOD-catalyzed gas-diffusion electrode in the galvanostatic mode, with an open circuit voltage (OCV) of 0.65 V vs. Ag/AgCl at zero current density, at pH 7. Here we report on the characteristics of the BOD-catalyzed oxygen reduction, and discuss its possible application as a cathode in an enzymatic biofuel cell in the future.

In this work BOD was immobilized at the air gas-diffusion cathode. The electrolyte used was 0.1 M phosphate buffer at pH 7, which was found to be optimal for both enzyme electrodes. This paper will discuss the integration of BOD-catalyzed cathode with a glucose-oxidizing anode into a miniature biofuel cell prototype with a footprint of 1 $cm^2$.

The resulting polarization performance of the biofuel cell in air-breathing mode and the associated power performance curve are presented in Figure 1 and 2. Issues associated with further miniaturization of the cell and its integration with sensing devices will be discussed.

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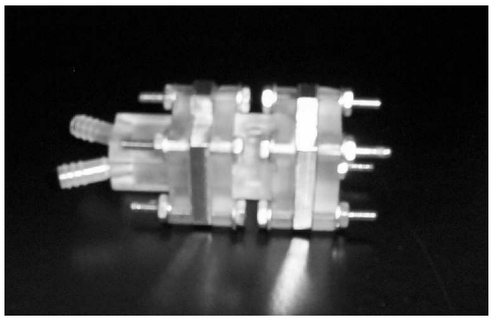

Fig. 1: Photograph of the glucose/air biofuel cell prototype.

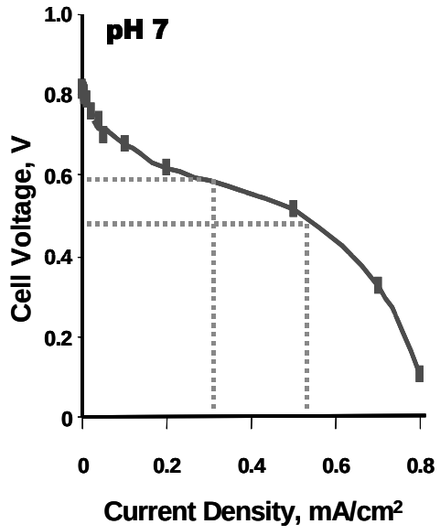


Fig. 2: Polarization curves of the biofuel cell gas-diffusion air cathode with BOD as oxygen reduction electrocatalyst and glucose oxidation anode based on mediated nickellocene/glucose oxidase electrode.

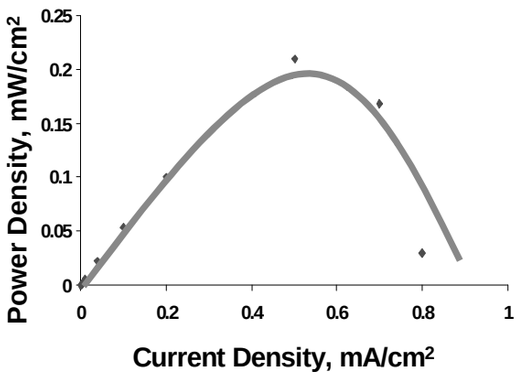


Fig. 3: Dependence of the power derived from the glucose-air biofuel cell on the current density.