

## Effects of Stabilizer Concentration on the Electrochemical Performance of Au-Pt Anode Catalysts for Direct Glucose Fuel Cell

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### Abstract

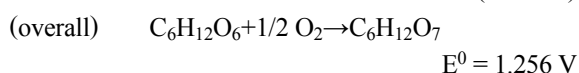
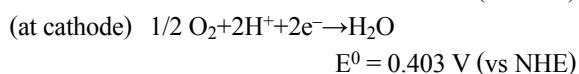
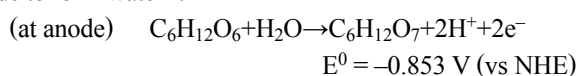
Effects of stabilizer (poly(*N*-vinyl-2-pyrrolidone), PVP) concentration on the electrochemical performance of Au-Pt bimetallic (Au<sub>4</sub>Pt) anode catalysts for direct glucose fuel cell (DGFC) have been investigated. In the cyclic voltammetry, the maximum current density was recorded at [PVP] / [metal] = 1 in molar ratio for the carbon supported metal nanoparticle catalysts at 5 wt% metal loading. At lower PVP concentrations, the current density decreased due to aggregation of metal nanoparticles, while at higher PVP concentrations, the current density also decreased, presumably due to loss of active surface area of the metal catalyst by passivating with the stabilizer. Also for the full cell systems, the maximum power density was recorded at [PVP] / [metal] = 1. When the optimal stabilizer condition was applied to the full cell system, the maximum power density of 12.7 mW cm<sup>-2</sup> at 0.38 V vs Ag | AgCl and the open circuit voltage of 0.85 V were recorded. Furthermore, a set of 10 stacked cells was able to light 6 LED lamps of total 1 W for over 60 h without flowing the glucose fuel. These results demonstrate that the present DGFC system can be applied as a power supply for LED illuminating systems.

**Key-words:** Glucose fuel cell, Au-Pt catalyst, PVP, Cyclic voltammetry, LED lighting

### 1. Introduction

There is an urgent demand in the world for constructing sustainable energy systems for reducing global warming caused by emitted greenhouse effect gases (CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, etc.) from the consumption of fossil fuels<sup>1,2</sup>. Glucose has attracted increasing attention as a clean sustainable energy source. It is abundantly available not only from fruits and starch-containing vegetables but also from exhausted cellulose by biological or chemical degradation processes<sup>3-5</sup>.

Direct glucose fuel cells (DGFCs) work by oxidizing glucose at the anode and reducing oxygen at the cathode. Glucose molecules are oxidized at the anode to yield gluconolactone or its hydrolyzed product, gluconic acid, by releasing two protons and two electrons. These protons are diffused to the cathode by passing an ion-permeating membrane, while the electrons are transported through the external electric circuit. These protons and electrons are recombined with oxygen molecules at the cathode to form water<sup>6</sup>:



There are two categories for the DFGC systems, i.e., biotic and abiotic ones. The biotic DFGC systems utilize enzymes or microorganisms to oxidize glucose<sup>7-10</sup>. They are superior to the abiotic counterparts in the low cross over of the fuel between the cathode and the anode, owing to their specificity for glucose substrate. Therefore, it is possible to construct the biotic DFGCs without separator between the two electrodes, which enables a simple cell structure. Moreover, owing to the high specificity between the enzyme and substrate, they are hardly subject to poisoning by intermediate or final products, leading to the long durability of a durable and steady electric power. However, in order to exploit such a high catalytic performance, it is crucial to maintain the pH and temperature at an optimal condition, which confines the environment that the biotic DFGCs are applied, i.e., in living body<sup>11</sup>. Besides, in biotic DFGC systems, an appropriate mediator is often required to transfer an electron to the electrode since the electrocatalytically active site of the enzyme is often located inside the molecule, which may reduce the electric current<sup>7,12,13</sup>.

By contrast, in abiotic DFGC systems, oxidation of glucose molecules is performed with metal nanoparticle catalysts deposited on a conductive support, i.e. carbon<sup>14,15</sup>. Although they can work in harsh conditions (pH and temperature), they do not have a high specificity for a certain substrate