Biofuel cells with cellulose nano-particles

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The production and consumption of fossil fuels raised great environmental concerns for last few decades. Besides, the burning of fossil fuels produced around 21.3 billion tones of carbon dioxide per year globally, but it was estimated that natural processes can only absorb about half of that amount. Therefore, a global movement toward the generation of renewable energy is under way to meet increased energy demands.

Using a vast unused renewable alternative energy sources, such as, lignocellulosic biomass can be an alternative energy source to restrain the global warming and construction of material-based sustainable society. It has been known that lignocellulosic materials represent the largest repertoire of potential carbohydrate on the earth. Because, approximately 1,500 billion tons of cellulose that is the main component of lignocellulosic biomass is produced.

For effective and efficient utilization of lignocellulosic biomass as a fuel, saccharification process is required to produce soluble sugars such as glucose. But we developed in this study, a novel way of direct electricity generation using cellulose nano-particles, without any saccharification process.

Fuel cell system that has been employed in cellulose energy conversion system is showed in Fig. 1. This fuel cell consisted of two equal volume chambers for anode and cathode separated by glass filter. The gold electrode and platinum electrode were used as a working and counter electrodes respectively, while Ag/AgCl electrode used as a reference electrode. Saturated KCl chamber connected to anode chamber by using salt bridge (saturated KCl) was prepared for reference electrode.

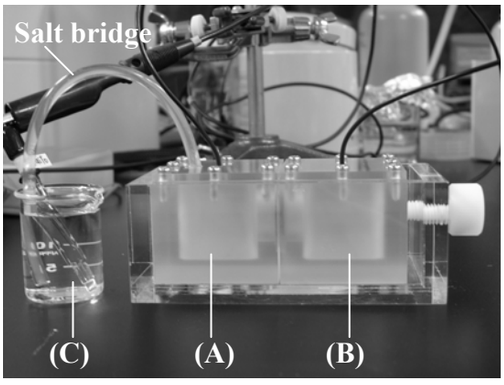

Fig. 1. Fuel cell system
(A) Anode chamber, (B) Cathode chamber, (C) KCl saturated chamber

Electrochemical studies were performed in a conjunction with cyclic voltammogram using an Autolab PGSTAT 12 electrochemical analysis system, connected to General Purpose Electrochemical System (GPES) software. Experiment was carried out at ambient temperature.

The electrochemical characteristics of oxidation reaction between cellulose nano-particles and gold electrode surface were measured using fuel cell system constructed in this study. Before supplying substrate to the anode chamber of the fuel cell, cellulose was treated with nano-mechanical process using ball mill (Fritsch Japan Co.,Ltd) in order to obtain cellulose nano-particles. Then, the cellulose nano-particles were dissolved in alkaline solution by using thiourea. The electrochemical characteristics of cellulose oxidation reaction on gold electrode surface were observed using cyclic voltammetry. Fig. 2 shows cyclic voltammogram of cellulose oxidation on gold electrode sulfate.

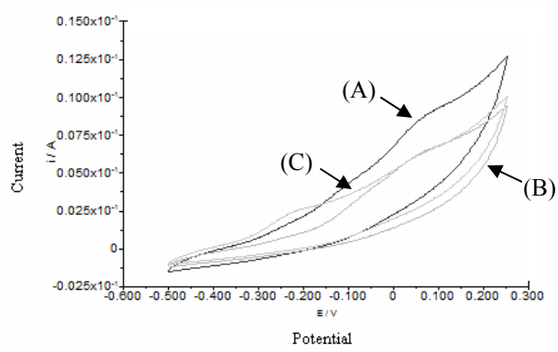

Fig. 2. Cyclic voltammogram of cellulose oxidation on gold electrode surface
(A) Cellulose nano-partices and thiourea in alkaline solution, (B) Commercialized crystalline cellulose and thiourea in alkaline solution, (C) Thiourea in alkaline solution

It was observed that there was an oxidation peak at about +0.05 V potential only in the presence of cellulose nano-particles and commercialized crystalline cellulose (Fig. 2 A and B) compared without cellulose (Fig. 2 C). The increase in the oxidation peak current value of cellulose nano-particles is 1.3 times higher than that of commercialized crystalline cellulose. The increase in the current value of cellulose nano-particles is probably due to its nano order size. Hence, we are currently investigating different size of cellulose with nano-order for efficient and effective electricity generation biofuel system.

In this research, we constructed fuel cell system that can measure the electricity generation from cellulose. This result indicates that there was electron transfer to the electrode from cellulose nano-particles. There is possibility to construct the fuel cell using unused lignocellulosic biomass.

References

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