

Development of Liquid Fuel Reformer Using Low Energy Pulse (LEP) Discharge at Room Temperature

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Introduction: Polymer Electrolyte Membrane Fuel Cell (PEMFC) is one of the promising technologies. It is operated lower temperature than that of other fuel cells, and it has high performance in energy efficiency. But recent considerable Hydrogen production and transportation processes have many problems with the present technology (for example, The transportation and storage of Hydrogen), so it is need to research innovative technological methods to produce Hydrogen. So, we applied low energy pulse (LEP) discharge for this purpose. If LEP discharge used for reforming, reactions can be achieved at room temperature and atmospheric pressure. On the other hand, ethanol has a potential for being an alternative fuel replacing fossil fuels because ethanol can be produced from various renewable sources. So we tried to unify a supply and storage system with using liquid fuel (ethanol and water solution) and LEP discharge. And it was also attempted to design much smaller reformer, and improve energy efficiency.

Experimental: Figure 1-(a) shows our previous fuel delivery system. No catalyst was used, and argon was used as carrier gas. Gap distance of electrodes was fixed at 2.1 mm. Our previous reformer was flow type reactor, and the mixture of ethanol and water was supplied by chemical pump, and evaporated at 413 K. The reaction temperature was set at 393 K to prevent condensation into liquid.

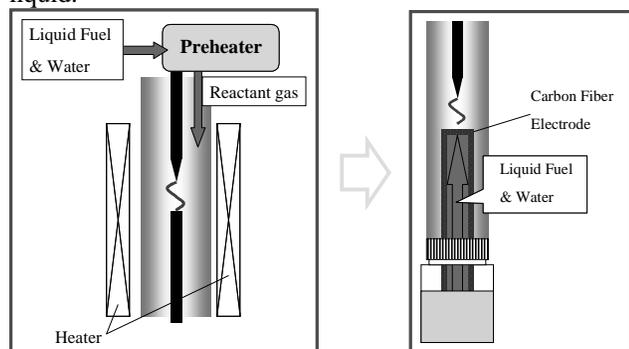


Figure 1 Schematic diagram for our reaction systems (a:left figure; conventional one, b:right figure; novel one)

On the other hand, Figure 1-(b) shows our novel system. Lower end of carbon fiber bundle was soaked into ethanol solution contained in a small tank. This reformer used carbon fiber bundle as electrode and as pump for supplying fuel by capillary action. The solution was pumped up to the top of the carbon fiber bundle and supplied into discharge region. And, liquid fuel was evaporated by Joule heat which generate from internal resistance of electrode. The supplied fuel amount was controlled by the length and number of carbon fibers, and the amount became larger in proportion to its length and number. And the supplying fuel amount into the discharge region was about 30 cc min⁻¹, when the length was 7 cm and the number of carbon fiber was 84,000.

A DC power supply (Matsusada precision inc. HARb-40R30) was used to produce the non-equilibrium pulsed discharge. All products were analyzed using a gas

chromatography equipped with FID and TCD (Shimadzu GC14-B). The current and voltage waveforms were observed by a digital signal oscilloscope (DSO):(Lecroy 9314C).

Results and Discussion: At first, we investigated the effect of input power on ethanol consumption rate and carbon selectivity. As a result, ethanol consumption rate was in proportion to the input power, and carbon selectivity was almost stable under any conditions.

So we investigated effect of concentration of ethanol and water. H₂ and O₂ were not generated when H₂O concentration was 100 %. So the reaction of water electrolysis did not go on. Next, at the decomposition reaction of ethanol 100 %, small amount of carbon deposition were gradually formed, and it caused destabilization to stop the discharge. So the discharge couldn't be kept stable for a long time. On the other hand, when the reaction was handled in the case of steam reforming (this means 0 < ethanol concentration < 100), the discharge could be stabilized for a long time and could be continued in steam reforming without stopping the reaction.

Figure 2 shows the results. The larger ethanol concentration is, the more produced H₂. And higher ethanol concentration field, C2 selectivity was rather high (it was about 30 %), compared to that of lower ethanol concentration field. So it seems to say that the reaction of which ethanol concentration is from 20 to 50 mol% is the highest efficiency at a present stage. Because C2 selectivity was not high, and carbon deposition was not observed.

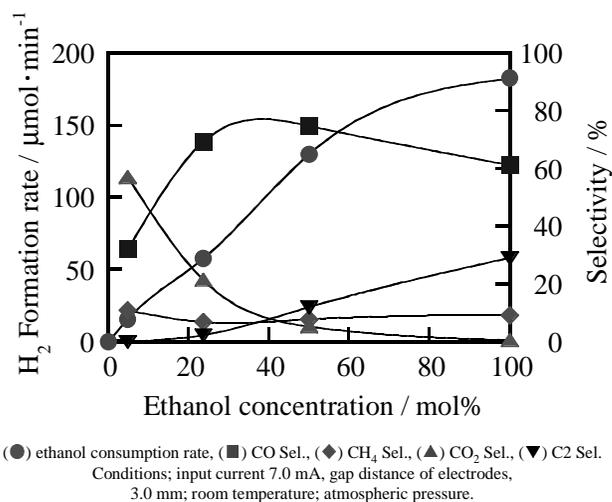


Figure 2 Effect of ethanol concentration on H₂ formation rate and on Carbon selectivity.

From these results, we succeeded in improving the energy efficiency because the liquid phase reactor does not require a heater which is needed to vaporize the mixture of water and ethanol. Moreover any pump supplying the liquid into the reactor was not required. So the liquid phase reactor made the process scale reduced, and also made the device size compact without spoiling its function. Therefore, if the controlling Voltage and Current system makes more progress, we consider that this process would be very useful for room temperature hydrogen formation system.

References

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