Innovative Autothermal Reforming using Hydrogen Peroxide as Oxidant for Portable Fuel Cells

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A compact and highly efficient processor for 200W portable polymer electrolyte membrane fuel cells (PEMFCs) has been developed at the Samsung Digital & Display Interface (SDI) Co. Ltd. Camping and caravanning, yachts and boats have high potential for penetrating the mark with the 200W range portable fuel cell. There is a high demand on the applications for electric power due to electric and electronic device however the sufficient power is getting increasingly difficult. To satisfy this demand, the reformer process should be compact, lightweight, fast start-up and high efficiency.

In order to support sustainable hydrogen economy, it is crucial to produce hydrogen cleanly and renewably. Ethanol is very attractive because of its relatively high hydrogen content, availability, non-toxicity, and storage and handling safety. More importantly, ethanol can be produced renewably by fermentation of biomass sources.

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Ethanol reforming processes for hydrogen production can be generally classified into two groups: (1) steam reforming (SR) and (2) autothermal reforming(ATR). Compared with ATR, the SR process yields the higher hydrogen concentration in the product. However, for practical applications, the ATR processes are more attractive because they can be made more energy-efficient and the hardware can be smaller and lighter.

Air, which is usually used as an oxidant for ATR, contains a large amount of nitrogen, which can cause low the partial pressure of hydrogen, resulting in a decline in PEMFC performance. It is therefore expected that hydrogen peroxide (H_2O_2) is a suitable alternative nitrogen-free oxidant for ATR, providing concentrated hydrogen. In addition, H_2O_2 decomposition is highly exothermic (23.44 kcal/mole) for faster start-up and supplying heat source for ATR. Therefore, the ATR process using H_2O_2 requires no actuator to pre-mix the oxidant with the liquid fuel and no ignitor to start ethanol oxidation, resulting in higher energy density and efficiency reforming process.

For 200W portable fuel cell system, an series tubular type fuel processor consists of an autothermal reformer (ATR) and water–gas shift reactor (WGS), in which the overall integrated volume including insulation is typically small, 307cc (34cc ATR, 188cc WGS, and 85cc insulation). A hydrogen peroxide/ethanol solution (steam/carbon moral ratio = 2.95, carbon/oxygen moral ratio = 0.7) fed into the reactor by a liquid pump with low balance of plant consumed power (total < 2We). It starts instantaneously from room temperatures and reaches equilibrium within 3 minute. It produces hydrogen at 267 l h^{-1} (STP) with high concentrated hydrogen (62.5%) without nitrogen dilution in the process gas (62.5% H_2, 33% CO_2, ~3.5 CH_4, ~1% CO, dry gas base). This fuel processor of power density (~1,000 We l^{-1}), thermal efficiency (Maximum□82%, lower heating value) and specific power (Maximum 537 We kg^{-1}) are exceptionally high. We have operated the reactor for as long as 20 hours on the fuel process with no evidence of deactivation or carbon buildup. In addition, this fuel processor has demonstrated the ability to generate hydrogen from a number of hydrocarbon-based fuels such as ethanol, methanol, propane, sugar and bio diesel with hydrogen peroxide oxidant solution.

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To improve the stability of hydrogen peroxide (H_2O_2) in the mixed solution, a stabilizer has been developed by Hansol chemical Co. Ltd. in Korea. By adding a stabilizer (< 300 ppm), the H_2O_2 can keep over 97.5% stability at 95^{o}C for 1 hour, assigning over 99.9% stability for 1 year at ambient temperatures.