Fuel Cell System as Longer Lived Battery Replacement

Center for Applied NanoBioscience of the Biodesign Institute at Arizona State University

1 Overview

Power-hungry next-generation portable electronics applications require power sources with more energy density than batteries. As much as 10 times greater energy can be made available by replacing a battery-pack with a fuel-cell power-pack of the same size and weight provided a suitable supply of hydrogen is available. This supply is being provided by a new compact microreactor, which converts alkaline borohydride solution to H_2. The entire system is orientation independent and operates at room temperature and pressure. New materials, microfabrication and microfluidics technology enable this new power-source technology. A complete power-source prototype is being developed for wireless and hand-carried electronics. The prototype consists of an energy-rich borohydride fuel cartridge, a micropump, a catalytic hydrogen generator, a fuel-cell, a small battery and electronics for battery recharging, system controlling and power conditioning .

2 Fuels and Relative Energy Density

$NaBH_4$ … LOW COST per Watt-hour:

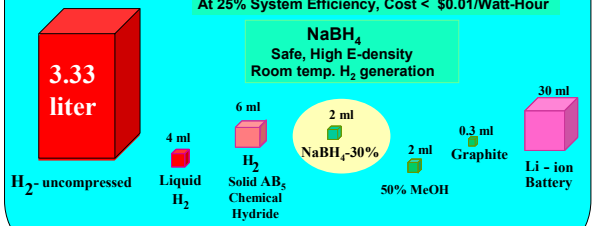
For 30% $NaBH_4$ in water = ~ $10/gallon

At 25% System Efficiency, Cost < $0.01/Watt-Hour

$NaBH_4$

Safe, High E-density

Room temp. H_2 generation



Volumes of different Fuels equivalent to ~10 Watt-hours of Electrical Energy at 100% Chemical to Electrical Conversion Efficiency.

3 Preparation of Ru Catalyst for H_2 Generation

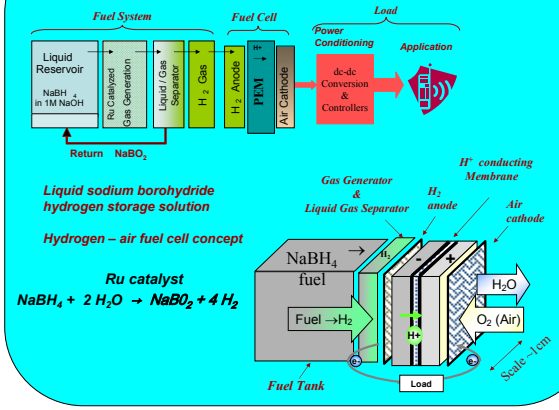
2wt.% and 5wt.% $RuCl_3$ solutions in DI water

High surface area gamma alumina pellets for catalyst support

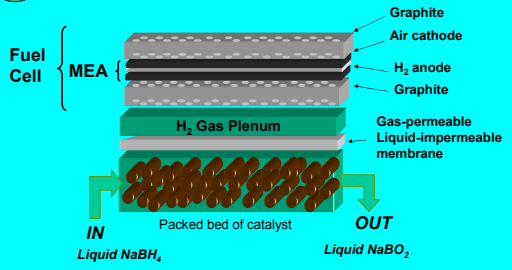
Alumina pellets soaked in the Ru Cl_3 solutions.

Solution soaked $RuCl_3$ on alumina pellets, decanted, air dried.
Samples were heated under 5% hydrogen, balance helium.
Heated at 100°C/hr to 150°C or 700°C, no dwell or 6 hour dwell

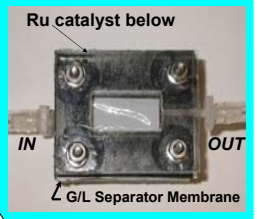
4 Diagrams of fuel/fuel-cell sub-system



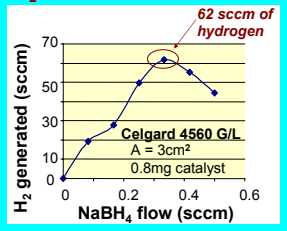
5 H_2 Generator integrated to Fuel Cell



Actual H_2 Generator



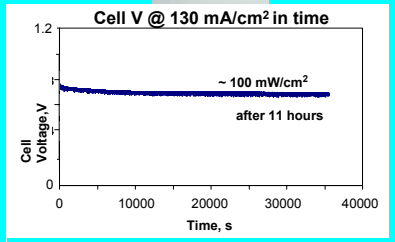
H_2 Gen thru G/L Membrane



6 Fuel Cell Performance

Membrane Electrode Assembly →

Moldable Graphite
- current collector
- gas flow field



Cell voltage at constant load (130 mA/cm²) in time for MEA with 4.5 mg Nafion in 50 mg E-TEK electrode H_2 and O_2 . Loading = 0.5 mg Pt/cm² .

7 Implications of technology

- Extended life for Wireless applications from energy dense alkaline borohydride H_2 storage (2500 Wh/liter or kilogram) and compact H_2 generator with the reliable efficient H_2 - air fuel cell.
- H_2 storage solution is safe: nontoxic, nonflammable.
- Virtually no free hydrogen during power generation.
- Fuel cell system is cost competitive with batteries.
- Ambient temperature and pressure operation is compatible with hand-carried portable applications.
- Liquid would leak slowly and safely from a punctured liquid alkaline borohydride storage-solution cartridge, whereas a ruptured pressurized tank of H_2 is hazardous and H_2 would be lost nearly instantaneously.
- With electronics for system control and power conditioning makes a complete fuel cell power pack with 3 to 10x more life than a battery pack of comparable size and weight.

8 Prototype Timeline

pplied NanoBioscience Center

THE biodesign INSTITUTE at Arizona State University

ASU Arizona State University