Fuel Cell

The fuel and oxidant selected for this system was a sodium borohydride fuel and hydrogen peroxide oxidant. All relevant reactions are as follows:

Anode: (-1.24 V)

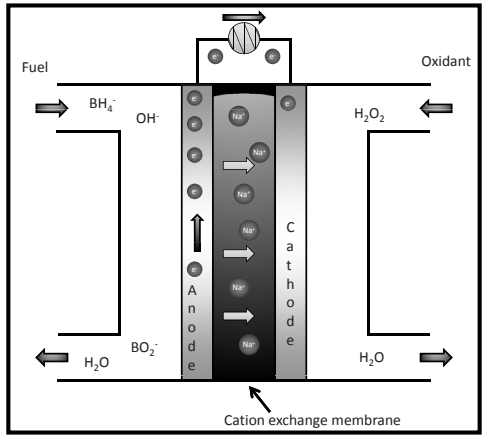
$BH_4^- + 8\ OH^- \longrightarrow BO_2^- + 6\ H_2O + 8\ e^-$

Cathode: (1.77 V)

$H_2O_2 + 2\ H^+ + 2\ e^- \longrightarrow 2\ H_2O$

Overall: (3.01 V)

$BH_4^- + 8\ OH^- + 4\ H_2O_2 + 8\ H^+ \longrightarrow BO_2^- + 14\ H_2O$

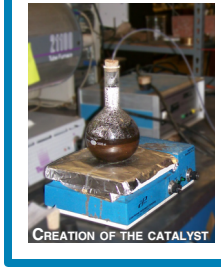


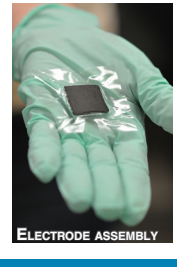
Exact system specified using:

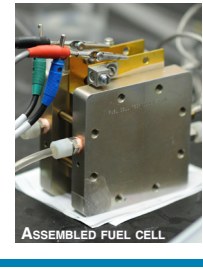
- Chemical reaction produces no gases
- Minimal environmental impact
- Power requirements estimated by propulsion group (2 kW)
- Polarization data from literature

Experiments

Creation of a fuel cell with a 97% Au/3% Pt on carbon catalyst.


Creation of the catalyst

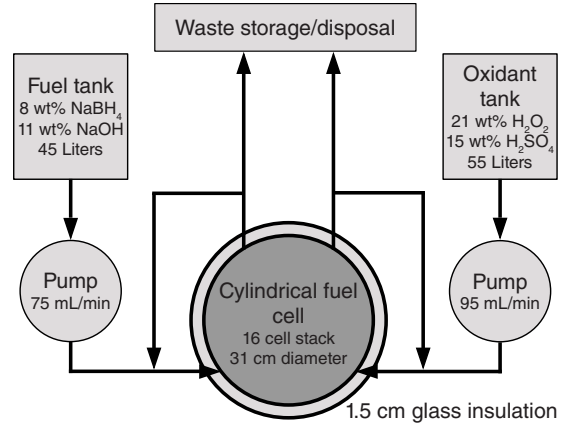

Electrode assembly


Assembled fuel cell

Literature Design Overview

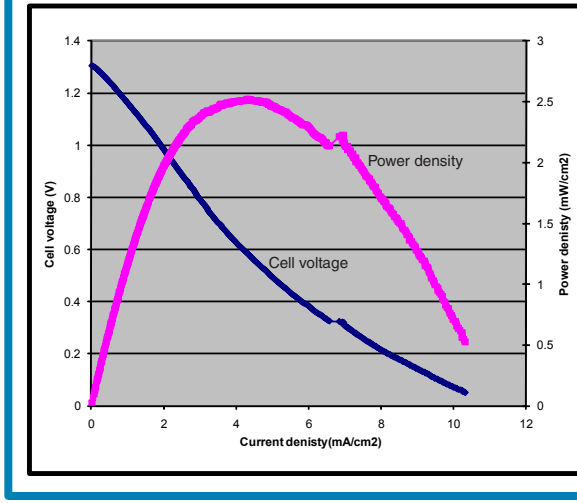
Fuel Cell Design Results

Number of cells	16
Cell operating voltage	1.5 V
Fuel cell length	29 cm
Fuel cell volume	23 L
Cell power output	2 kW
Cell voltage	24 V
Energy	~40 kWh



Experiments & Results

Performance of second fuel cell using Nafion 117 with higher flow rates. Outperformed thinner Nafion 112, which was more suited for gas reactions.

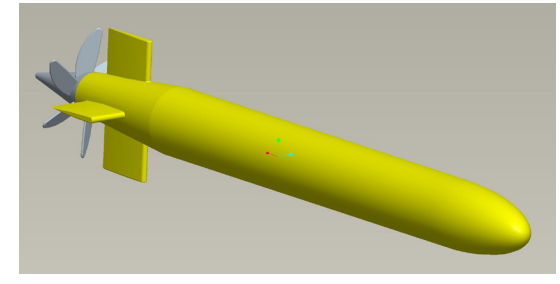


Propulsion Model

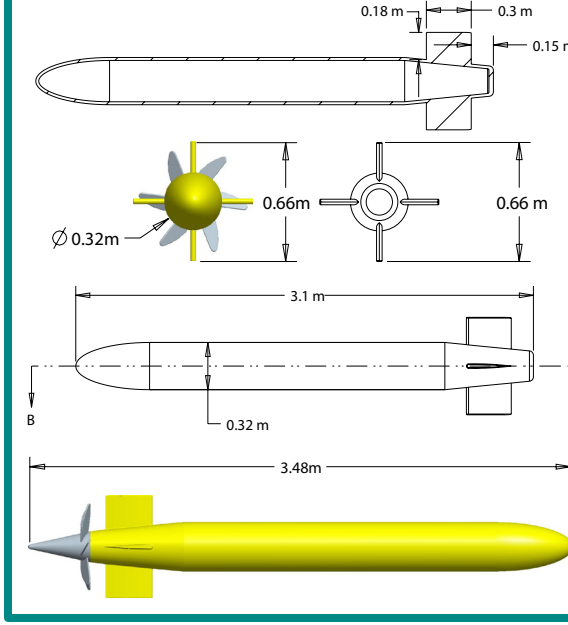
- Design based off of US Navy's Mk. 48 Mod. 7 torpedo currently in active duty with all US Navy nuclear attack submarines (SSNs) and nuclear balistic missile submarines (SSBNs).

UUV Designed Specifications

Designed operating depth	1 km
Cruise speed	1 m/s
Max speed	~3 m/s
Dry weight	~225 kg
Range (round trip)	70 km



Hull Drawings



IPRO Goals

- Investigate potential use of fuel cell to power unmanned underwater vehicle (UUV)
  - o Replace the use of conventional battery power
  - o Research and design fuel cell power system
    - > Design centered on a sodium borohydride ($NaBH_4$) fuel cell
    - > Hydrogen peroxide oxidant (H_2O_2)
- Design a complete submersible package including:
  - o Dimensions
  - o Control surfaces
  - o Material requirements

Fuel Cell Background

- Unmanned Underwater Vehicles (UUV) operate in conditions impossible for manned submarines
  - o Naval applications for UUV's include reconnaissance and sabotage
- Current fuel cell technology
  - o Hydrogen polymer electrolyte membrane fuel cells most common
  - o Research for UUV applications focus on $NaBH_4$ fuel cell
  - o Two to three times more efficient than internal combustion engines
- $NaBH_4$ fuel cell technology
  - o Relatively low environmental impact
  - o Liquid reactions produce no gases in cell

Propulsion Background

- Survey of current technology
- Design a vessel around the propulsion system
  - > Theoretical design
  - > Practical design
- Fully specify and model a practical UUV
  - > Modeled in Pro/E

IPRO 349 - The 349er's

*Back row: Chris Chock, **Dr. Vijay Ramani**, Kevin Abankwa, Kamaldeen Olorunoje, Ethan Baughey, Nic Sansone, Ray Ballard, Brian Olson*
Middle row: El Kenig, Dan Miladinovich, Jaya Singh, Sahar Ashrafi, Matt Chaffee, Moses Cho, Jainam Shah, Yukiya Takada
Front row: Chris Wolcott, Suk Hwan Yun, Jenn Guilfoyle, Matt Hagopain, Trang Nguyen, Cheryl Mukai, Marcus Choy

CHE 296

Kevin Abankwa
Ethan Baughey
Matthew Chaffee
Moses Cho
Matthew Hagopain
Kamaldeen Olorunoje
Brian Olson
Olakunle Olorunoje
Nic Sansone
Jaya Singh
Yukiya Takada

CHE 496

Sahar Ashrafi
Ray Ballard
Chris Chock
Jennifer Guilfoyle
Cheryl Mukai
Chris Wolcott
Suk Hwan Yun

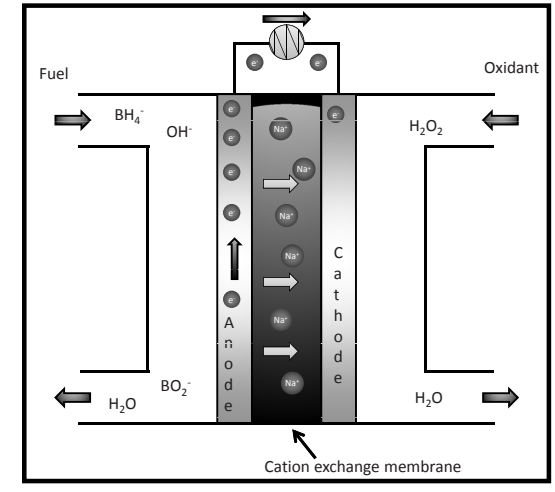
IPRO 349

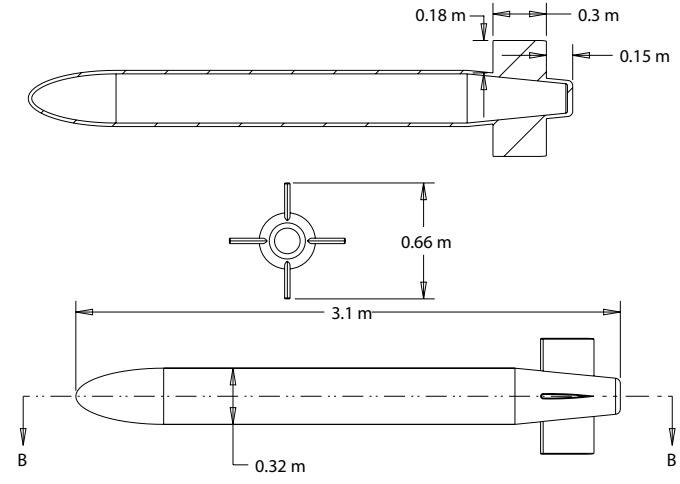
Marcus Choy
Elezar Kenig
Chieh Luo
Daniel Miladinovich
Trang Nguyen
Jainam Shah

IPRO 349: Fuel Cells for Unmanned Underwater Vehicles (UUVs) cooperated with CHE296/496 to create a fuel cell poweplant and complete UUV design intended for US Naval applications.

IPRO 349

Fuel Cells for Unmanned Underwater Vehicles





Spring 2010

Dr. Vijay Ramani, IIT ChBE

http://mypages.iit.edu/~ipro349s10