Solar Hydrogen Fuel Cell Projects at Brooklyn Tech

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Introduction

Several teams at Brooklyn Technical High School have been working on solar hydrogen powered vehicles using water as fuel. These projects are based on proposals made several years ago and are a continuation of the work of others (Lange, Khan, Zarin, Grey, & Chen, 2008). Our investigations into the pure and applied chemical thermodynamics of hydrogen fuel cells and bio-inspired devices have been consolidated in a new and emerging sub-discipline that we define as solar hydrogen electric bio-mimetic energetics.

We have designed and are developing the following autonomous or remote-controlled/ bio-inspired devices:

- Remote Controlled Hovercraft
- Autonomous Underwater Vehicle
- Air Sampling Craft
- Tranquilizing Dart Projector
- Autonomous Buoyant Micro-power Plant
- Remote Controlled Electric Water Sampling Boat
- Inflatable Electric Kite.

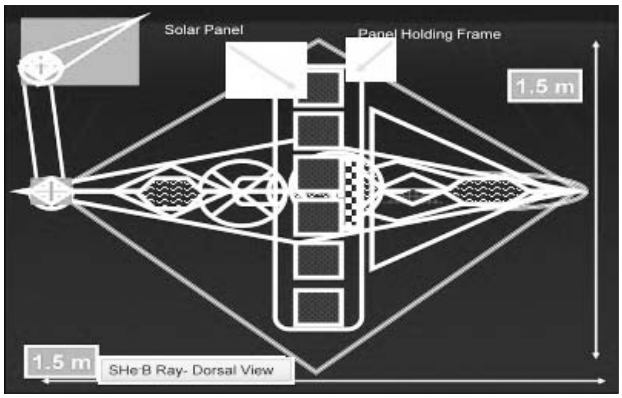
Remote Controlled Hovercraft

The hovercraft was the first remote controlled vehicle developed in our laboratory more than five years ago (Khizner, 2005). Electrochemical thermodynamic and chemical kinetics studies were conducted in standard reactors. The body of the craft is made of honeycomb plastic sheets and the skirt of ultrathin nylon. A pair of 7.2 V solar panels on the dorsal surface of the craft converts light into electrical energy for fuel cells that split water into hydrogen and oxygen. The gases are collected in plastic bottles and used during the voltaic phase to supply energy to the motors of the fans and rudder.

Autonomous Underwater Vehicle

Autonomous underwater vehicles (AUVs) have become a powerful tool for environmental testing. However, energy remains a limitation in AUV development. The purpose of this project was to develop and test an AUV powered by solar-hydrogen electricity technology, to compare the efficiency of solar-hydrogen electricity to other AUV energy sources, and to base the design on the biometrics of a stingray.

The primary components of the AUV are the solar hydrogen fuel cell reactor, the buoyancy apparatus, the rigid framework, and the water-sampling unit. With fuel cells the AUV will be able to operate for prolonged periods of time collecting water samples and other data. Using its onboard camera it can relay images and videos of underwater events.



The buoyancy apparatus of the AUV is designed to mimic the hydrostatics of the swim bladder of teleostean fish (Walcott and Thornton, 2007) using data from in-house hydrostatic studies. By formulating new equations that demonstrate the relationship of Gibbs free energy for hydrogen combustion and the bio-energetic term for fish kinetics, we estimated energy requirements for the AUV. We were also able to use anatomical and fluid dynamics data from the bat ray to design an AUV that mimics elasmobranch motion.

Air Sampling Craft

A similar formulation of equations on the biomechanics of the manta ray has been used in the design and development of the solar hydrogen electric autonomous aeronautical air sampling craft (Roytman, et al., 2008). The craft payload is a

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series of cyclone precipitators that separate micro-particles and convey the remnant air to bags for aerial sampling. Extensive tests on the cyclone precipitator unit and the wind hydrogen electric fuel cell reactor system of the aircraft were conducted.

Tranquilizing Dart Projector

We are developing a remote-controlled tranquilizing dart projector for animals in mountainous regions. Aerodynamic studies have demonstrated that the expiratory volume used for firing a dart from a blowpipe can be mimicked and amplified by means of a safe chemical reaction (Fedotov & Yee, 2005). The design of the dart projector is based on ethno-toxicology studies of blowpipes, especially from the Amazon (Filatova, 2006).

Buoyant Micro-power Plant

The design of the solar hydrogen electric autonomous buoyant micro-power plant utilizes a modular system consisting of a turbine, a membrane electrode assembly (MEA), a solar panel, and the housing, allowing them to be independently fabricated and serviced. The turbine, MEA and housing are built in-house while the solar panel is purchased. The turbine, designed to adapt to unpredictable currents in scientific expeditions as well as seasonal offshore storms, has a vertical axis so that the fins are omni-directional.

Water Sampling Boat

The remote water sampling boat has a roof of six 1.5 V solar panels (Chen and Grey, 2005). In the hull are the fuel cell reactor unit, which consists of plastic bottles for hydrogen and oxygen collection and a series of six 1.5 V fuel cells. Bolted to the inner hull is a winch connected to the robotically controlled probe at the bottom of the hull. The probe can be lowered to specific depths and water samples collected at a variety of depths in test tubes.

Inflatable Electric Kite

Our most recent development is the inflatable solar/wind hydrogen electric kite (Khan and Yam, 2010). We conducted electrochemical, thermodynamic, and chemical kinetics studies on the generation of hydrogen and oxygen in a 3.0 V fuel cell reactor. We determined the energy generated by the wind turbine and studied the aerodynamics of deltoid and aerofoil kites. We then designed and constructed a deltoid-shaped kite with solar panels and a wind turbine.

Future Plans

We will be conducting detailed field tests of our crafts as well as studies in mechanotronics, fluid dynamic investigations, and anatomical studies on aquatic and flying animals. The anatomical investigations include non-invasive studies to develop deeper insights into the connections of structure and fluid dynamic function in living organisms. Teams are currently developing solar hydrogen drone rocket planes for air sampling. Other teams are re-engineering the water sampling boat, the hovercraft, and the AUV.

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