Needs Assessment

Hydrogen from Microalgae and the Collection and Sensing Systems

Team 9

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TABLE OF CONTENTS

Abstract

Although it may not be readily apparent, energy directly correlates with the quality of life and technological resources that are available to people. As societies grow and become more advanced, the consumption and need for more energy increases. The augmented demand can put a strain on available resources which is why there has been a heightened interest in alternative energy. This project will focus on hydrogen as an alternative energy source. A photobioreactor has been developed which uses the hydrogen gases produced by microalgae to create energy. This project seeks to improve microalgae cultivation and develop a sensor to accurately measure the amount of hydrogen produced.

Introduction

Hydrogen gas has become an ideal fuel source for the future since it burns clean and generates a large amount of energy per unit mass allowing it to be more fuel efficient than other resources[1]. Using hydrogen in renewable energy processes has become of greater interest due to the depletion of natural oil reserves. However, because of low concentrations at its pure form, hydrogen is not cost efficient for everyday use, making the study of biohydrogen one of great interest[2]. This calls for the exploration of hydrogen generation as a waste product of anaerobic respiration of green and blue algae from a photo bioreactor. When a controlled environment enables and regulates the proper anaerobic conditions necessary for the cultivation of algae, a photobioreactor is constructed to allow larger amounts of bio hydrogen to be produced and utilized as clean energy[3]. This occurs through biophytolysis of water by algae. The presence of light irradiation catalyzes the event and water is broken down into its hydrogen and oxygen components[4]. The phenomenon in which hydrogen is created as a waste product during the photosynthesis of algae must be promoted in a way that overcomes various issues[5]. These issues include creating a system that enables steady and continuous microalgae growth that is cost effective. The evolution of hydrogen results in an amount of fuel that is useable in commercial applications. The scope of this project will be directed toward the design and development of microalgae and measuring and collecting the hydrogen produced.

Project Definition

Background Research

In today's world, the need for renewable and sustainable energy has never been greater. Coal, petroleum, and other types of non-renewable sources provide much of the energy used today. As the demand and usage of energy is rapidly increasing, there is a greater interest in discovering alternative energy sources. Hydrogen is at the top of the list of biofuels that can solve the energy crisis that future generations face. Hydrogen is the most basic element known to man and it is usually combined with other elements when found in nature. For example, hydrogen combines with oxygen to form H_2O, the most abundant resource on our planet[6]. However, it has proven difficult and expensive to split hydrogen from water to use as an energy source[7]. The most common form of this element is found as hydrocarbons, a product of organic compounds, which make up gasoline, methanol, and propane. A process known as reforming allows hydrogen to be extracted from hydrocarbons through the application of heat[6]. The downside of reforming is the byproduct CO2, which contributes to the greenhouse effect.

One alternative for hydrogen comes from algae cultivation. Using sunlight as its primary energy source, under the right conditions, algae can give off hydrogen as a byproduct of biochemical reactions within the cells. Research is currently being performed on this method of hydrogen production in regards to two species of algae: Scenedesmus sp. and Chlamydomonas reinhardti, *figures 1a* and 1b, respectively.

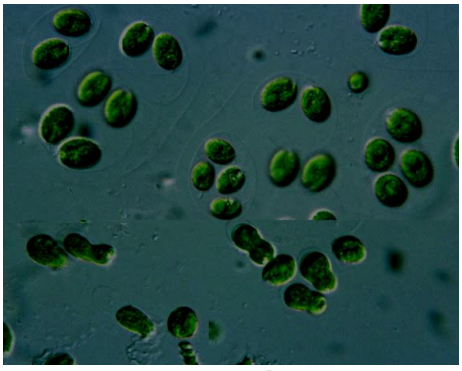


Figure 1a: Scenedesmus sp

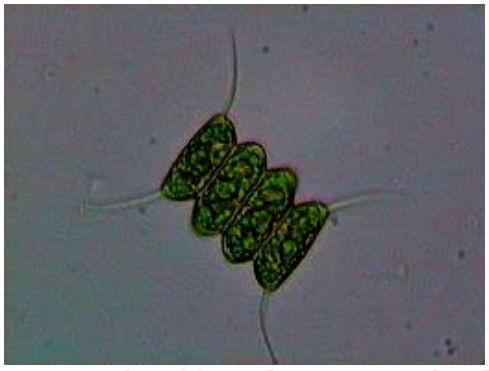


Figure 1b: Chlamydomonas reinhardti

These types of algae are favored due to their high degree of adaptability and fast reproductive cycle[8]. Our sponsor has given us the primary tasks of designing and developing a hydrogen gas (H_2) producing photo bioreactor and an electronic H_2 mass measuring sensor to test such a system.

In order to produce H_2 from algae, the algae must be cultivated in a controlled manner. There are two ways to cultivate algae: open ponds and photobioreactors. Photobioreactors (PBRs) are closed systems that provide a controlled environment where algae productivity can be regulated. PBRs are used to better control the CO2 supply, water supply, temperature, etc[9]. *Figure 2* shows a basic schematic of a PBR. The main components of such a system include a light source, hot plate, thermocouple, container, and a gas collection apparatus. If the appropriate balance of parameters is carried out regarding algae cultivation along with a gas collection apparatus, hydrogen from microalgae could serve as a reasonable alternative tour dependence on non-renewable energy sources.

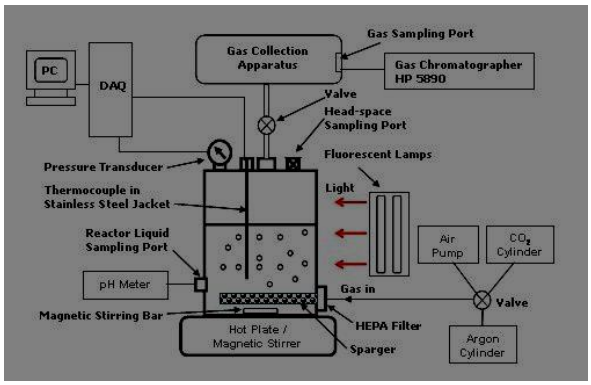


Figure 2: Photobioreactor Schematic

Need Statement

There is need for a scalable and sustainable process for producing hydrogen from microalgae cultures such as Scenedesmus sp. and Chlamydomonas reinhardtii to demonstrate the feasibility of photo bioreactors in the field of alternative energy. Additionally, an automated sensing system will be needed to monitor the hydrogen content of the resulting PBR system.

Goal Statement

The goal of this project is to help the development of alternative energy, with the use of a sustainable process for producing hydrogen from microalgae. To consider this project as successfully completed, there are several goals that need to be met. Below are the main objectives that must be accomplished:

- Design and construct operational H_2 producing units
- Design and construct an electronic H_2 mass measuring sensor
- Provide enough experimental data to test the operation of the H_2 producing designed units
- Provide mechanical drawings of the entire system and sensor for future product scale up

- Write an invention disclosure (FSU team) to be submitted to the USPTO by the OTT/FSU, and a patent request (Brazilian team) to be submitted to the Brazilian INPI, for the H_2 producing photo bioreactor system developed

Constraints

Time is a major constraint for this project. It can take up to two months to grow enough algae in order to produce substantial amounts of hydrogen. The slow hydrogen production rate is too low for commercial application. There is also the issue of maintaining healthy, hydrogen producing algae. The Brazil team began growing microalgae the last week of August but had to restart the growth process because the algae had died. Continuous long term production of hydrogen from the microalgae can cause some concern. The processing of biomass feed stock is also very expensive. If this it to become a widespread energy source in the future, the cost of production must be reduced. There are also many engineering issues such as appropriate bioreactor designs and scaling-up the system, preventing interspecies hydrogen transfer to non-sterile conditions, and the purification and separation of hydrogen. Many of the students working on this project have little background in the growth processes of microalgae and microorganisms in general. This insufficient knowledge could lead to a lack of understanding on how to integrate hydrogen production with other processes.

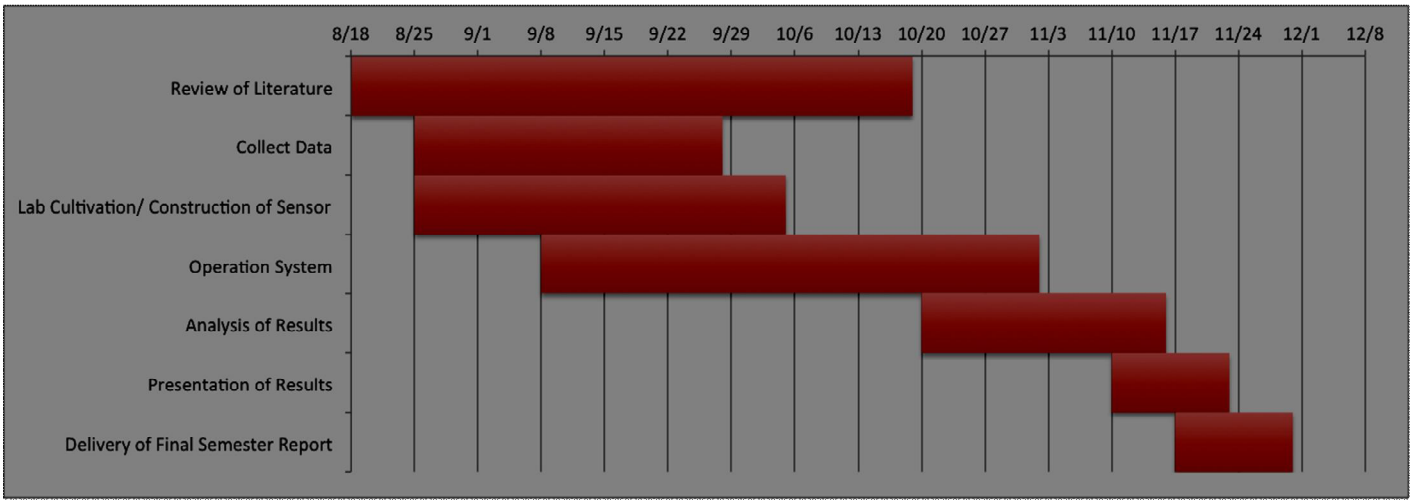
Methodology

Creating a set schedule and organization of tasks is essential to ensuring a successful project. The first tasks include researching microalgae. It is important to understand how to grow and maintain healthy algae so that enough hydrogen will be produced. Without a substantial amount of hydrogen, testing will be inadequate. Data will be collected periodically in order to determine how well the system is working. Team members will also work on designing and constructing a sensor which will aid in determining the amount of hydrogen being produced. The collected results will be analyzed and used to determine how the current system can be improved. The final results and suggestions for improvement will be presented during the final presentation.

Schedule

The team's schedule for the semester is shown in the following table:

Table 1: Team 9 tentative working schedule fall 2014



Conclusion

The continuous development of renewable energy sources like that of hydrogen can make a positive impact on society. Decreasing society's dependency on fossil fuels will not only create a cleaner atmosphere by reducing greenhouse gas emission, but it is also an economically viable energy option. This design project is focused on developing a more efficient way of cultivating microalgae as well as maximizing the amount of hydrogen that is produced and extracted in order to develop an effective energy alternative.

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