Martian Mulch

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Abstract

. In a Martian environment there are several unique conditions that aid the production of biofuels from waste plant cellulose; Cellulose needs to be "pretreated" to release glucose from ethanolization. A photochemical process exists for pretreating cellulose with a combination of UV radiation and sodium nitrite; procurable from urine. Satellite Martian Mulch will exploit Martian like conditions found at high altitudes in Earth's atmosphere. A sheet of specialty handmade paper made from raw cotton paper and sodium nitrite will be flown on top of our satellite for maximum light exposure. Flight sample will then be tested for sodium Nitrite consumption and possible glucose production. Through this experiment we hope to determine if high UV radiation levels breakdown cellulose to its base component glucose. The breakdown of glucose (pretreatment) allows for the next step in ethanol production to take course for the overall production of biofuels.

1. Introduction

Our interest for this experiment began with the idea that Astronaut's on Mars will have several basic requirements Two being the capacity for food production and the need for energy production. It is foreseeable that Astronaut's will grow their own food in greenhouses which will produce plant waste as byproduct of cultivation. This plant waste is mainly lignocellulose. Lingnocellulose, or dry plant matter (biomass), can be processed into ethanol by using the following simplified procedure:

- 1. Pretreatment
- 2. Cellulose Hydrolysis: to break down complex molecules into sugars
- 3. Separation of sugars from their original residue
- 4. Microbial fermentation of the sugar solution
- Dehydration by molecular sieves

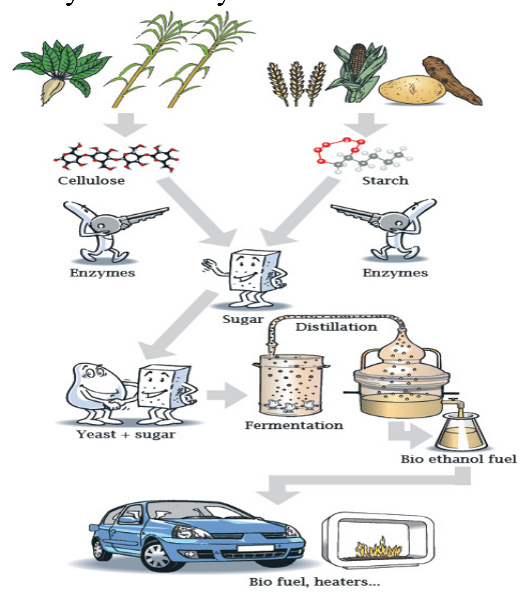


Figure1. Biological Ethanol Production

Of interest to our mission is the "pre-treatment" phase. Pretreatment means to separate lignocellulose into lignin cellulose and glucose. Through our research we came across multiple methods to conduct pretreatment. [1] The most successful and efficient way to conduct this procedure is through physical and chemical methods. Yet on Mars large amounts of energy, equipment and complex chemicals would be impractical. However chemically reactive UV radiation is abundant. The Stratosphere/Troposphere mimics similar conditions found on Mars. At an altitude of approximately 100,000 ft. the payload will encounter high levels of UV radiation. UV radiation with the addition of Sodium Nitrite further creates powerful free radicals capable of breaking the long polymer bonds of lignin cellulose. Thus producing a photochemical pretreatment method. Sodium nitrite could be produced by two possible methods on Mars. The first being from biologically processed astronaut urine; the second being some possible yet unknown method of converting sodium nitrate, found in abundance on mars, into sodium nitrite.

[1] Pretreatment will be tested through a photochemical process that will consist of homemade 100% cotton paper impregnated with sodium nitrite. The sample will be flown to high altitudes to expose it to high levels of UV radiation. After flight, the payload will be recovered and tested for sodium nitrite consumption due to UV exposure. IR Spectroscopy will also be used to detect the existence of Glucose produced by the breakdown of lignin cellulose. The goal of the experiment is to correlate sodium nitrite consumption (UV reactant) with Glucose production.

2.1 Design

Exterior

The box is made up of a thin sheet of construction cardboard, which is sealed at the corners with heavy duty clothe woven foil tape (used for HVAC in industrial settings). The box will carry a modified lid made out of foam core designed to carry the handmade paper for maximum UV exposure. The lid will carry a 15x5cm heater pad designed to keep one of two samples of cotton paper at warmer temperatures. (Consumption of sodium nitrite and breakdown of cellulose is more efficient when exposed to higher temperatures in combination with UV radiation.) One of the two pieces of sample paper will be mounted on top of the heater pad while the other will be mounted without a heater. Both will be protected by a clear layering to protect the overall integrity. The heater pad will be powered by 3 9V batteries to ensure maximum capacity of the heater pad resulting in better results for our overall payload experiment.

The payload's four bottom corners are protected with foam pads to ensure the payload survives once the flight is complete. Each piece of foam is attached using silicone based glue to guarantees high resistance. The entire exterior of our satellite is surrounded by the heavy duty HVCA tape (consisting of multiple layers of thin wire, paper and cloth). Three LED rocker switches are located on one side of the satellite that will control power to the internal heater circuit, Arduino and heater pad. On the front surface of the payload, two LED lights will ensure that the Arduino is functioning properly. A white LED will indicate power while a blue LED will indicate that the Arduino is writing sensor data to the micro SD card. On the posterior of the payload, a temperature sensor is attached and connected to Arduino Uno.

Interior

The interior part of the payload was designed to tightly and securely enclose all components to minimize weight. The interior houses the Arduino Uno, six 9V batteries, a digital camera, heater circuit, pressure sensor and paddings to secure each interior component.

The camera overlooks the exterior environment through a small hole specifically measured to fit the lens of the camera. It is tightly secured inside of the box by thick foam padding locking it into place with little to no movement expected during flight.

The six 9V batteries are centered in the middle of the payload on either side of the flight string. The batteries are secured into the foam padding which tightly encloses them; to provide extra security, Velcro surrounds the entire battery compartment.

The Arduino will be secured into the box by installing heavy duty Velcro as well as a handmade foam shielding designed to strictly enclose it in its designed slot. The Arduino is placed on the left side of the battery holder to easily power the Arduino using one of the six batteries.

The internal heater circuit is mounted in the lid of the payload and securely attached with silicone glue and zip ties. The heater circuit is used to maintain a warm temperature inside the payload for proper function of interior electronics. The heater circuit will run off of 2 9V batteries from the beginning of the flight until the end.

Sodium Nitrite Cotton Paper

[1] An essential part of our experiment is to accurately prepare our homemade paper for success of "pretreatment." The paper will be created using water, pure cotton, and sodium Nitrite. To protect the integrity of the paper and minimize risk factors that can potentially harm the overall results of the experiment; precise measurements of each component will be measured.

For a surface area of 75cm^2 we need $\frac{1\ gram\ cellulose}{4\ grams\ water}$ and we need $\frac{1\ gram\ sodium\ nitrite}{20\ grams\ cellulose}$

1. Water and cotton will be blended together to create a thick pulp. The water and cotton will be weighed to the dot to retrieve accurate data for cellulose concentration in paper.
2. A measured amount of sodium nitrite will be added to the thick pulp to blend all three components to create the final result: paper.
3. Once properly blended the pulp will evenly spread on a 15x5cm mesh to drain the retained water as well as to allow for retained water to evaporate.

The measurements for these procedures are crucial for the overall success of pretreatment.

Top Lid

Mounted on the top part of the payload will be a separate lid weighing approximately 100g that will carry both samples of homemade sodium nitrite cotton paper with the heating pad underneath one of the samples.

Arduino Uno

The program data writing program that the Arduino Uno will use is based off of the program provided by the CU Boulder workshop. The Arduino Uno will write the data from the exterior temperature sensor and the data from the internal pressure sensor to the micro SD card in order to determine the external temperature and the external pressure while payload ascends to the stratosphere.

2.2 Pre Flight Testing

2.2a Structural Integrity Testing

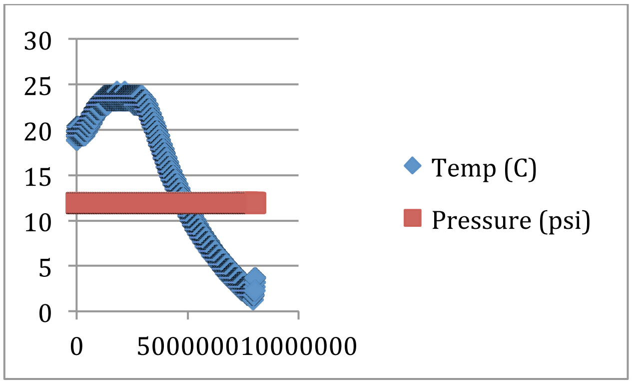
Throughout the course of building our experiment we have conducted several tests to insure the overall integrity of our pay load.

Drop Test: The drop test is used to simulate the impact of the payload falling from a height of approximately 100,000ft. These tests will ensure the durability and safety of the payload.

Whip Test: The whip test simulates the "g" forces acting on the box during the uncontrolled descent, ensuring that the payload will stay in one piece while descending.

2.2b Flight Condition Simulation

Freeze Test: Considering the extreme temperatures found in the Stratosphere, a freeze test was conducted to simulate the extreme temperatures present at high altitudes. The payload was placed in a cooler along with several chunks of dry ice for two hours. This was the done with all electrical systems (Arduino, heater circuits and camera) powered and operating. Data taken from the trial was then used to determine functionality of the payload and to make improvements to the payload. The approximate temperature of all payload components was determined using a hand held IR thermometer.



Graph 1. Freeze Test Data

2.2c Chemical Testing

Prior to flight we conducted several tests using a Sodium Nitrite Kit (can be found at local pet stores; often used for fish tank water testing) to calculate the levels of nitrite in a given solution. The purpose of this was to practice the procedures we will use to test for the diluted solution we will create after the recovery of the flight sample of handmade paper to test for sodium nitrite consumption due to UV radiation. We simulated the test by adding 5mL of water into a clear glass container, added the given reagent (8 drops), filled a clear syringe with 1000ppm (parts per million) of nitrite and carefully inserted nitrite through a small hole in the container until the solution turned a light blue. We conducted this procedure 5 times. Through this trial we familiarized ourselves with the procedures and safety measures needed to accurately and safely conduct our sodium nitrite consumption test.

2.3 Flight/Recovery

Flight is scheduled to be April 12, 2014. Our payload must be recovered in fair conditions to successfully complete Part II of our "Pretreatment" experiment. Upon recovery we will ensure the mounted lid is in good conditions for proper development of our experimental sample.

3.0 Post Flight Testing

Sodium Nitrite Consumption

After our flight we will dissolve our two paper samples in two beakers containing a known amount of water. After the two paper samples have dissolved we will use the method described in section **2.2c** to analyze how much nitrite (and thus cellulosic material) has been reacted.

Cellulose Degradation Testing (IR)

We will then use IR Spectroscopy to determine how much of the reacted cellulosic material has been broken down into its natural components, mainly glucose.

4.0 Results

Upon returning to CCA several testing procedures and data retrieval will take place. The SD card retrieved form Arduino Uno will be analyzed for temperature and pressure readings recorded while in flight. The handmade sodium nitrite cotton paper will be manipulated into an aqueous solution for Nitrite consumption testing due to high energy radiation (UV). As mentioned in our Post testing techniques and procedures we will mount the test and conclude our results when payload is recovered. The test for nitrite consumption will be conducted immediately after returning to CCA Engineering lab to protect the culture (Martian like environment) of our handmade paper.

5.0 Benefits to NASA

Retrieving ways to conduct energy is an ongoing innovating research. Mars encloses major opportunities for fuel production via waste products. A cheaper and efficient way to produce fuel is taking a biological approach that will enhance the production of fuel using waste products from Astronauts and future plant like environments such as greenhouses. Cellulose can be found in many plant like and non-plant like objects (leafs, clothing, food, bark, etc.) that can later be retrieved for ethanol as discussed in our experiment. In Mars, sodium nitrite can be procured from Urine (Astronauts, future inhabitants) to derive the nitrite consumption that correlates to the breakdown of cellulose into its natural sugar glucose. Experimenting practical, inexpensive ways to retrieve energy for future life on Mars will enhance our overall understanding of the steps needed to inhibit such planet. Using common resources we will expand our understanding of Mars and its potential to provide life.

6.0 Conclusion

Our hypothesis is that due to UV radiation the cellulosic material (in conjunction with nitrite consumption) in our handmade paper will be broken into smaller molecules such as glucose which can then be used to create biofuels. This will prove that high intensity UV radiation (present on Mars) is a viable pretreatment stage for the production of biofuels. [1] The nitrite will used as a controlling quantity in the reaction to degrade cellulose to its base components.

7.0 Diagrams

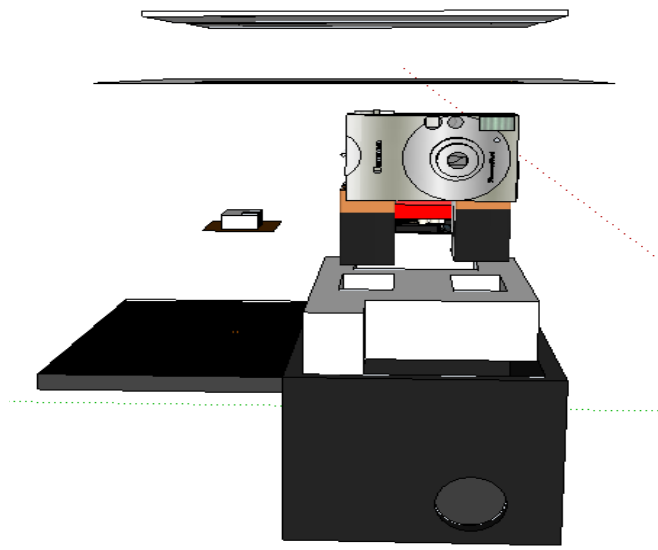


Diagram 2. Payload Design

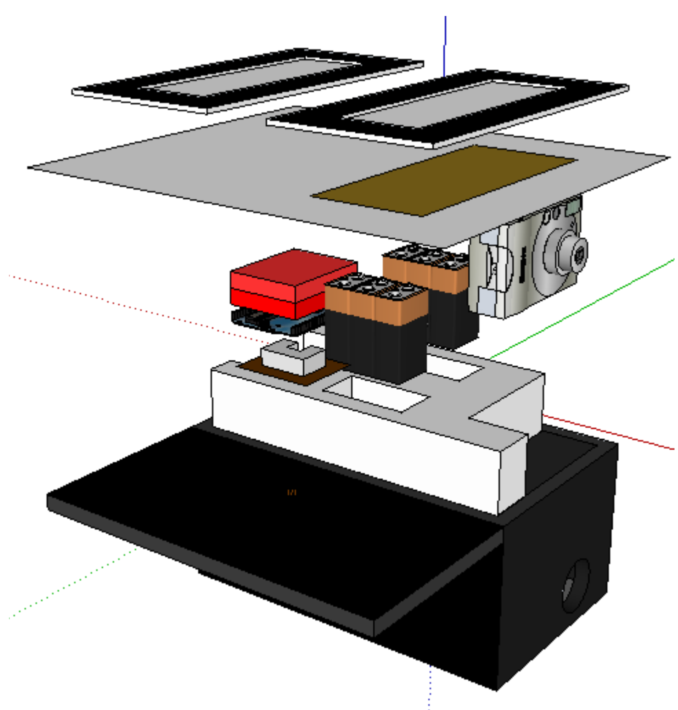


Diagram 3. Payload Design Alternate Angle

8.0 References

[1] Schwartz. M. Anthony., Radar. A. Charles., "Methof of Degrading Polysaccharides Using Light Radiation and a Wter Soluble Metal or Nitrogen Base Salt of Nitrous or Hyponitric Acid", *United Sates Patent Office,* Washington, D.C., Sept. 16, 1964.

[2] Shuler. L. Michael., "Utilization and Recycle of Agricultural Wastes and Residues." CRC Press, 1980.