Martian Mulch
Symposium Presentation

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Life on Mars

Astronaut Requirements:

Food and energy

Waste produced:

Inedible biomass

Human waste

Is there a way to recycle wastes into energy?
Approaches to Producing Ethanol

The stages to produce ethanol using a biological approach are:

1. A "pretreatment" phase, to make the lignocellulosic material such as wood or straw amenable to hydrolysis
2. Cellulose hydrolysis (cellulolysis), to break down the molecules into sugars
3. Separation of the sugar solution from the residual materials, notably lignin
4. Microbial fermentation of the sugar solution
5. Distillation to produce roughly 95% pure alcohol
6. Dehydration by molecular sieves to bring the ethanol concentration to over 99.5%
What is Pretreatment of Lignin Cellulose?
Methods of Pretreatment

- Steam Explosion
  - Effective method yet energy intensive.

- Acid Hydrolysis
  - Effective yet requires chemical transport.

- Microbial Breakdown
  - Experimental, GMO’s specific to crops.

- Radiation
  - Gamma, levels must be extremely high.
  - UV?
What about UV?

- High amounts of UV radiation present on Mars.
- Will UV work alone?
  - Our original thinking.
- Research
  - Patent 3,352,773

**3,352,773**

**METHOD OF DEGRADING POLYSACCHARIDES USING LIGHT RADIATION AND A WATER-SOLUBLE METAL OR NITROGEN BASE SALT OF NITRIOUS OR HYPOCHLORIC ACID**

*United States Patent Office*

*Patented Nov. 14, 1967*
Photoreactive substrate

\[ \text{UV} \rightarrow \text{NaNO}_2 \rightarrow \text{Radical} \rightarrow \text{Cellulose} \rightarrow \text{Glucose} \]
Conversion Cycle

Human Waste → N₂, NH₃, NaNO₂ → Cellulosic breakdown → UV

Plant Waste → Lignin cellulose

Fermentation/Distillation → Glucose → Biofuel
Mission Predictions and Expectations

• Prediction
  – high UV present at higher altitudes will break lignin cellulose down into glucose.

• Expectation
  – payload to survive the flight.

• Prediction
  – Find measureable amounts of glucose in our flight sample.
Experiment Overview

• Replicate patent experiment.
  – Create hand made paper impregnated with NaNO2
  – Use proportions of cellulose to NaNO2 described in patent with highest degree of polymerization
  – Fly payload atop satellite for maximum UV exposure
  – Isolate and test for glucose production
  – Isolate and test for NaNO2 consumption
Pre-flight Procedures

• Paper creation
  – Combine 100% cotton paper, water in blender
  – Combine NaNO2 to pulp in beaker
  – Distribute pulp into retention tray
Pre-Flight Procedures

• Payload Design
  – External sample flight deck
  – Heated
    • photoreactions
  – Removable
Post-flight Procedures
Paper analysis

• Sample Preparation For IR Spectrometry
  – Breakdown paper in water
  – Filter out pulp
  – Separate NaNO2 and possible Glucose into aqueous solution
  – Evaporate solution
    • H2O will show up in IR
Post-flight Procedures

Paper analysis

• Sample Analysis
  – Combine evaporated mixture with KBr (potassium bromide)
  – Pack into purpose built nut
Testing Methods

• IR Spectrometer
• Baselines
  – Glucose
  – NaNO₂
• Samples
  – Flight
  – Control
IR Spec of NaNO$_2$ Baseline
IR Spec of Glucose Baseline
IR Spec of Glucose and NaNO$_2$

Baseline
Control and NaNO$_2$ Baseline
Flight Sample IR Spec
Flight Sample 1, 2 and Control Overlay
Further Tests

• NaNO₂ Concentration Test
  – Determines amount of NaNO₂ consumed in reaction if any
    – If NaNO₂ was consumed and glucose found then we might conclude
Conclusion

• No measurable amounts of glucose were found in flown sample.
• What does this tell us?
  – Glucose was too small to be found
  – No Cellulose breakdown through UV NaNO2 reaction
  – Exposure time insufficient
  – Cellulose type (paper) was incompatible
Lessons Learned

• Flight length
  – Was UV exposure time insufficient for breakdown cellulose to Glucose?

• Paper making
  – It’s a lot harder than you think
  – Heterogeneous mixture
Things to do differently…

- Use plant waste material and not cotton paper
- Variations of biomass
- Ground testing under UV lamps
Martian Mulch

The End
Inside of Payload
IR Spec of Glucose and NaNO$_2$
Baseline
Structural Drawings and Pictures

There will be a flexible heating pad under the floor, held down by clothesline wire.

Dimension: 13.4 cm x 22 cm
Height: 10.4 cm
Heater Circuit
Subsystem Overview

Power

Power subsystem shall provide 9V to the Data and Thermal subsystems at all times.

Data

The Data subsystem shall record external temperature and pressure information at all times during the flight and store that information on a micro SD card.

Thermal

The Thermal subsystem shall keep the interior of the box and the paper warm during the duration of the flight.

Subsystems:

Power

- 3 9V LiPo Batteries

Data

- External Temperature Sensor
- Pressure Sensor
- SD Shield
- Micro SD Card

Thermal

- 3 4Ω Resistors
- 1 5x15cm Flexible Heating Pad

Materials

- 1 5x15cm Piece of Cotton and Sodium Nitrite paper.

Testing

- Mass Spectrometer
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<th>Product name</th>
<th>Part number (sparkfun)</th>
<th>Amount</th>
<th>Price</th>
<th>Weight</th>
<th>Dimensions</th>
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<td>CCA</td>
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<tr>
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<td>Flexible Heating Pad</td>
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<td>$50.28</td>
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Sodium Nitrite (NaNO2)

- **Potential Acute Health Effects:**
  - Very hazardous in case of eye contact (irritant), of ingestion, of inhalation. Hazardous in case of skin contact (irritant). Slightly hazardous in case of skin contact (permeator). Prolonged exposure may result in skin burns and ulcerations. Overexposure by inhalation may cause respiratory irritation. Severe over-exposure can result in death. Inflammation of the eye is characterized by redness, watering, and itching.

- **Special Remarks on Explosion Hazards:**
  - Explodes when heated over 1000 F (538 C). Sodium Nitrite + thiocyanate explodes on heating. A mixture of sodium nitrite and various cyanides explodes on contact. Mixture of sodium nitrite and phthalic acid or anhydride explode violently on heating. Fusion of urea with sodium nitrite Interaction of nitrites when heated with metal amidosulfates (sulfamates) may become explosively violent owing to liberation of nitrogen and steam mixed with ammonium sulfamate form. Violent explosion occurs if an ammonium salt is is melted with nitrite salt. Shock may explode nitrites. must be carried out exactly as described to avoid risk of explosion.

- **Physical state and appearance:** Solid. (Powdered solid.)
- **Odor:** Odorless.
- **Taste:** Saline. (Slight.)
- **Molecular Weight:** 69 g/mole
- **Color:** White to slightly yellowish.
- **pH (1% soln/water):** 9 [Basic.]
- **Boiling Point:** 320°C (608°F)
- **Melting Point:** 271°C (519.8°F)
- **Critical Temperature:** Not available.
- **Specific Gravity:** 2.2 (Water = 1)
- **Vapor Pressure:** Not applicable.
- **Vapor Density:** Not available.

All information (MSDS) was gathered from ScienceLab.com: [http://www.sciencelab.com/msds.php?msdsId=9927272](http://www.sciencelab.com/msds.php?msdsId=9927272)
Dwighth: Team Leader
Project Engineer
Heater circuit, Payload Design, Research

Gaberiel: Programmer
Project Engineer

Erick: Box Design, Construction of Box
Project Engineer

Viri: Budget Control, Heater Circuit, Documenter
Project Engineer
Concerns

- Our main concern continues to be a working plan for UV exposure of sodium nitrite cotton paper
- Viability of Experiment