RocketSat IX
CRYME

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Nomenclature

• CRYME: CRYstallization in Microgravity Experiment
• SAT: Sodium Acetate Trihydrate
• SCN: Succinonitrile
RockSat-X Program

- National program in affiliation with NASA enabling universities to launch a payload on an Improved Terrier-Malemute sounding rocket
- Launched from Wallops Flight Facility
- 5 payload bay representing 7 university teams
  - Each payload is provided power and telemetry
  - 30 ± 1 pound weight requirement
  - 11 inch diameter by 11 inch height cylindrical space
  - Approximately 2 minutes in microgravity
Mission Statement

The CRYME payload was built to investigate the validity of microgravity crystalline experiments on sounding rockets for the Air Force Research Laboratory. A supersaturated solution of SAT was used to analyze differences in reaction speed and uniformity between results obtained under Earth and microgravity conditions.
Theory and Background

• Crystallization important in medical and semiconductor industries
• Crystals grow larger and more pure in microgravity
• Lower defect rate
• Could mean more potent and effective drugs for the medical industry
Theory and Background – DECLIC

• Experimentation with SCN on the International Space Station (ISS)
• Cooled over four hours & much more expensive than rocket flight
Concept of Operations

- Launch from Wallops Flight Testing Facility
  - Begin Microgravity and despin
  - Apogee
    - $t \approx 3.3$ min
    - Altitude: $\approx 140$ km
    - Initialize Reaction SAT
  - Power Down
    - $t \approx 5.6$ min
    - Altitude: 44.8 km
  - Chute Deploys
    - $t \approx 7.9$ min
    - Splash Down
  - $t = 0$ min
    - Altitude: 78 km
Expected Results

• Capture and downlink low-res images of the SAT reaction
  – Use shutter function to capture and store several time-stamp images of the reaction
  – Provides data for comparison on ground

• Save high resolution video of the SAT reaction

• Compare the videos of SAT reactions for rate of spread and for uniformity
  – Reaction will travel faster and more uniformly across the solution in microgravity
Design
Sodium Acetate Trihydrate

• Test the effects of microgravity on the spread of crystallization
  – Initiating a homogenous reaction of a supersaturated solution of SAT.
  – Peltier device to heat and cool
• Melting point: 58.4°C
• SAT to water ratio of 4:1
• Approximately 36ml volume
Supersaturated Solution

- Heat water to slightly less than 100°C
- Dissolve SAT in 4:1 ratio
- Allow to cool while covered to protect from contamination
- Crystallization nucleates at point where seed crystal enters solution and spreads until all is crystallized
- Will not crystallize when temperature greater than 50°C
SAT – Reaction Characteristics

• “Fingers” across solution
SAT – Reaction Characteristics

Ideal Temperature: 37°C
SAT – Triggering Crystallization

• Research articles described seed crystals as the only effective triggering method
• Tiny crystals tucked in cracked of materials
  – Reusable hand warmers
  – When flexed, crystals released are enough to initiate
  – Can cause problems with porous materials
• Triggering with other methods was unsuccessful
SAT – Triggering Final Design

• Linear actuators to introduce seed crystal into solution when motor is driven
• Based off syringe design with a plunger

Seed crystals go here

Linear actuator

Crystallization front
SAT – Triggering Final Design

• Two larger wells with linear actuators
  – Redundancy for reaction

• Two small wells completely sealed
  – Control experiment to see if rocket vibration could cause crystallization
Containment of Chemicals

- Compressed by two neoprene rubber gaskets, a polycarbonate sheet and an aluminum top
- Large containers used to have a large crystallization area
- Allowed for the insertion of seed crystals with actuating mechanism

- Compressed by two neoprene rubber gaskets, a polycarbonate sheet and an aluminum top
- Was testing the validity of spontaneous crystallization due to rocket’s vibration during flight
Launch

• Both shells held dry seal throughout flight and recovery
• All of the telemetry data was streamed appropriately
  – 90 pictures were taken throughout (31 after launch)
  – Raw accelerometer data
• No error flags were found on parallel lines
Results

• All wells remained liquid throughout flight
  – Low-resolution images

• Critical mission failure was caused by faulty motor controller
  – Voltage leak drained battery over 6 days
Benefits to the Scientific Community

• Proof that SAT can only be crystallized by a seed crystal
  – Forces of launch did not cause wells to crystallize
  – Crystallization occurs immediately upon introducing seed crystals into solution
Continuing Work

• Supercooling
  – During chemistry research, the team was able to crystallize SAT through supercooling
  – Crystallized around -2°C

• Potential projects on the ISS:
  – Allows for more time to conduct the experiment
  – Allows for greater flexibility in choosing chemicals.
  – Similar to the NASA DECLIC mission
Lesson Learned

• Communication is key
• Test everything!
• Get flight hardware
• Use your resources – find experts
• Make good use of time – there is less than you think
Conclusion

• The vibrations from a rocket launch will not trigger a crystallization reaction of SAT.
• Failure to meet objectives:
  – H-Bridge power leak caused a failure to initiate actuators. Seed crystals were not introduced into the wells. No reaction occurred.
• Our payload was structurally sound.
  – Seals held through re-entry.
  – Low resolution camera and light bar functioned as planned.
• Restoration and Re-Fly
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References


