Gold Nanoparticle Synthesis on a Microfluidic Chip in Microgravity Condition

Columbia Space Initiative Rocket Payload Team

Project Proposal for Spaceport America Cup SDL Payload Challenge

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Technical Objective

Gold nanoparticles have myriad applications as catalysts, sensory probes, drug delivery agents, and radiation shielding materials, among others. Typically synthesized in batches, one of the biggest challenges to their utility is the wide distribution of particle sizes, which significantly reduces their potential applications. Microgravity further exacerbates this problem by increasing agglomeration. On Earth, a synthesis method that has shown promise in reducing the particle size distribution of nanoparticles is the usage of microfluidic chips.

Our objective is to test a rapid gold nanoparticle synthesis method using a microfluidic chip design during the time from motor burnout to coast to apogee when the rocket is in a reduced gravity environment.

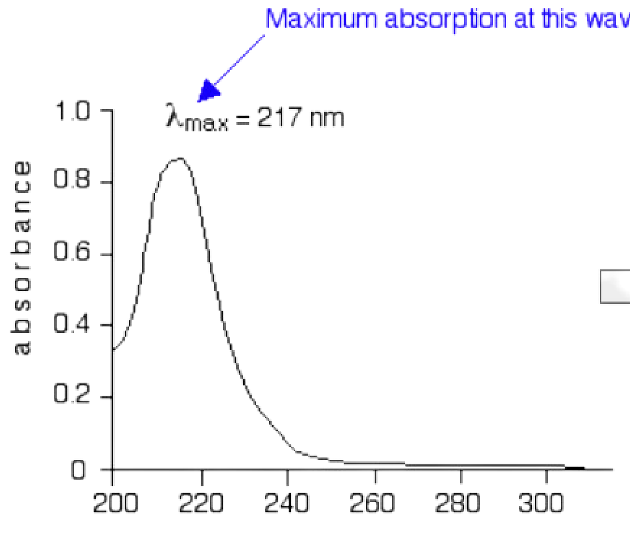
We aim to generate nanoparticles in the size range of 50 to 60 nm, which is the optimal size for overcoming the blood-brain barrier and allowing drugs to enter the brain. If microfluidic chips can be used to synthesize usable gold nanoparticles in microgravity, it has the potential to revolutionize drug manufacturing and delivery, particularly in remote settings like outer space, as well as various other in-space manufacturing applications due to their point-of-use and portable nature.

Methods

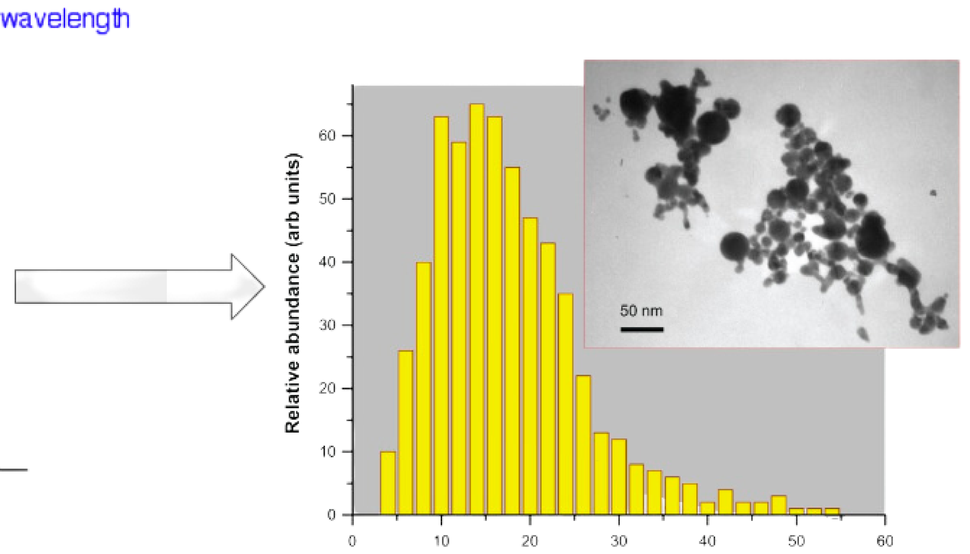
The chemicals used to generate the gold nanoparticles will be maintained in a 20 °C fridge throughout transportation and the duration of the competition (except for during launch, when it will be placed into the payload frame when it is time to prepare the payload for launch). To keep the payload and experiment functional after hours of launch preparation, wait time, heat exposure, and travel time, we have implemented heat-resistant materials, a shake-tested structure, and a two-cylinder frame filled with mineral wool in between walls for insulation purposes.

Data Analysis

Post-recovery the gold nanoparticles in the control chamber and microfluidic chip will be collected and placed in a UV-Vis spectrophotometer. Data of absorbance of the solution at different wavelengths used to produce a distribution of gold nanoparticle size. This data will confirm the size of the nanoparticles as well as their relative abundances.



UV-Vis Spectroscopy



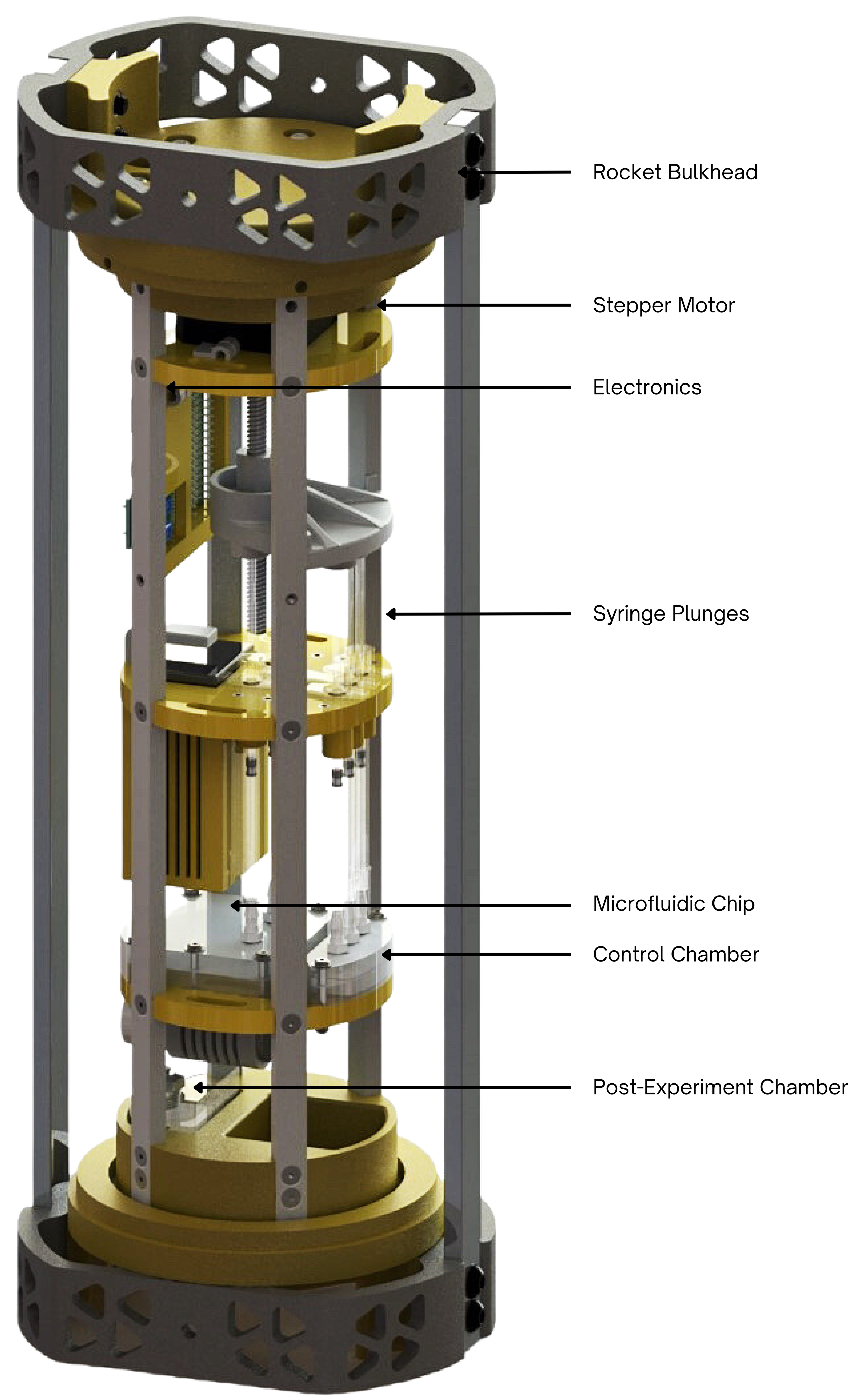
Gold nanoparticle size distribution

Payload Design

Components		
Solenoid on/off valve	Soft PVC clear tubing	Acrylic control chamber
Stepper motor	Barber luer adapters	Microfluidic diagnostic tape
Arduino	Insulin syringes	Mineral wool
Battery	Acrylic microfluidic chip	Frame

The chemicals used to generate the gold nanoparticles are:

- N-2-hydroxyethylpiperazine-N-2-ethanesulphonic acid (HEPES)
- Chloroauric acid
- Phosphate



Electronics

- Once the payload Arduino receives signal from the flight computer, the stepper motor is set to move at approximately 0.72 mm/s for a chemical flow rate of 0.1 mL per 10 seconds.
- After all the plunges are at their final position, the pinch valve will close the pipe to secure the chemicals post-experiment.
- The module is powered using an 11.1 V 1500 mAh Lipo battery.
- The entire experiment will take about 75 seconds to be completed.

Potential Failure Modes and Hazards

- A microfluidic diagnostic tape with acrylic adhesive is utilized to seal all chemicals flowing through the chip in the reduced gravity environment, preventing leakage or outflow.
- To ensure stability during the experiment, all syringes are firmly attached to the main frame of the payload using 3D printed adapters.
- The payload undergoes shake testing, replicating the conditions experienced during a rocket launch, to verify the robustness of all components.
- To contain any spilled chemicals in the event of a rocket crash, the payload is securely housed within its own container, which can be easily clicked into place in the payload bay of the main rocket before launch.
- The payload chamber consists of an outer compartment and an inner compartment that nests the experiment. The space between the outer and inner chamber is coated with mineral wool, providing passive insulation. This insulation has been tested to maintain the internal chamber, housing the experiment, close to room temperature despite the rocket being exposed to extremely high desert temperatures for several hours, spanning from launch preparation to recovery.

References

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