National Aeronautics and Space Administration

Verifying Venus Aerobot Instruments and Power Components Operate in a Simulated Venus Cloud Environment

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Program: FY22 R&TD Strategic Initiative
Strategic Focus Area: Technologies for Venus Cloud Environments /Venus In-Situ Aerosol Measurement Technologies - Strategic Initiative Leader: James A Cutts

Objectives

This project's objective is to develop an environmental test facility simulating the Venus cloud environment to study the effects of sulfuric acid aerosols on the surfaces of materials, components and instruments that may be used in future missions exploring the Venus cloud layers.

There are two primary applications for this test facility:
(1) Conduct corrosion resistance testing on materials and components to ascertain their robustness in the Venus cloud environment and
(2) Provide a calibrated aerosol source for nephelometers and particle spectrometers which would characterize the physical properties of aerosols in the Venus cloud layers.

Background

Future missions to the Venus cloud layer may operate for several months and be exposed to the harsh corrosive sulfuric acid aerosol environment. Just as spacecraft are tested in thermal vacuum chambers to simulate their operating environment, we have created a test facility that would simulate the Venus cloud environment. This allows testing of hardware in a relevant Venus cloud environment. Here we describe a new test facility, built at Caltech, that has been developed to ensure aerial vehicles and their payloads are robust against the effects of corrosion for missions investigating the Venus cloud layers.

Significance/Benefits to JPL and NASA

This project addresses risks of operating instruments in the corrosive Venus environment by creating a facility that simulates the Venus sulfuric acid aerosols. The facility will be used to perform lifetime or accelerated life testing on key articles to verify they have sufficient corrosion resistance to successfully operate for a proposed mission duration. Venus aerial mission or instrument development proposals carry risk associated with operating for a long duration in the acidic aerosol cloud environment without a corrosion mitigation and operational verification plan. This project will reduce these risks and significantly improve mission assurance in future proposals. Inadequate methods of corrosion assessment, mitigation, and operational verification could be called out as weaknesses for future mission or instrument development proposals to NASA.

Approach and Results

<u>Define relevant sulfuric acid environment specification</u>

We will produce sulfuric acid aerosols from 2 to 10 microns in diameter with an aerosol mass density in CO_2 gas up to 20 mg/m^3 using concentrations ranging from 80 to 95%.

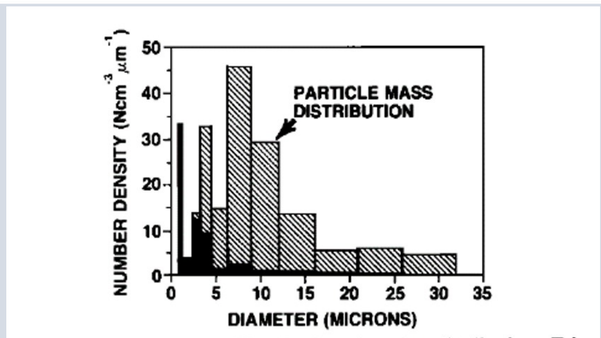
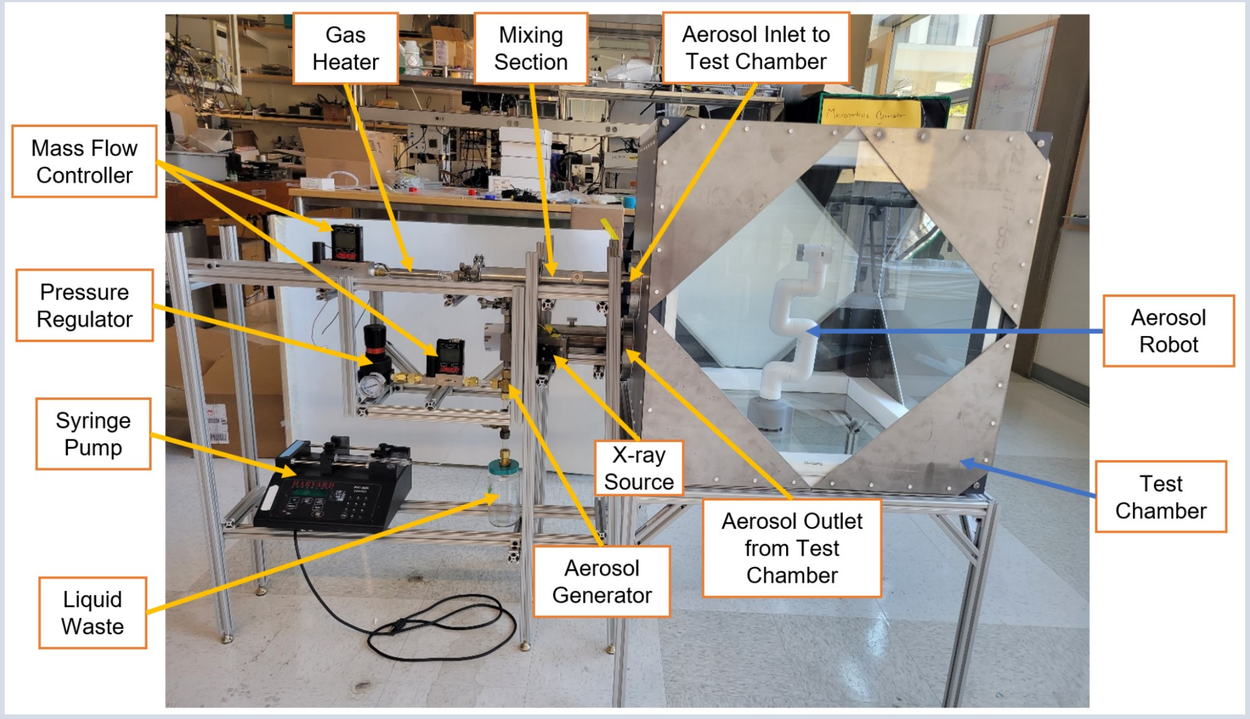


Fig. 6. Average middle cloud region size distribution. Trimodality is apparent in this average size distribution. The mass distribution was computed, using a spherical particle assumption and a density of 2 g cm^{-3}.

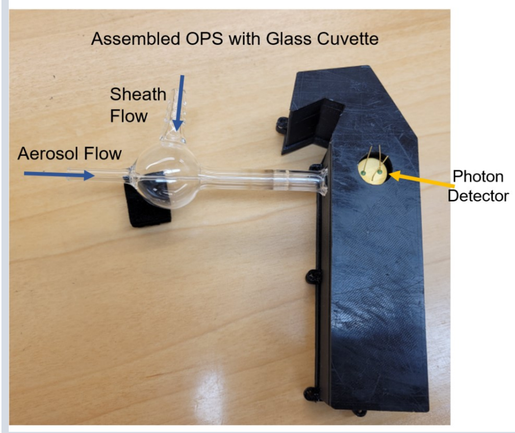
<u>Design and fabrication of the aerosol test facility</u>

The Venus cloud aerosol test facility was developed to provide the following functions: The aerosols are generated in the nebulizer section which contains the inlet pressure regulator, mass flow controller, syringe pump to supply H_2SO_4 and a waste container. The aerosols flow past an x-ray source to neutralize any electrical charge. The heating section supplies additional carrier gas to the aerosol stream to dilute the aerosol mass density to the target value and heat the gas to the desired temperature (up to 100°C). The gas stream enters a mixing section in which an optical particle spectrometer collects a gas sample to analyze the particle size distribution and mass density. The aerosol/gas mixture flows into the 220 liter test volume. Test articles are placed inside this volume for exposure to sulfuric acid aerosols for long durations.



<u>Verification of Venus cloud simulator aerosol properties</u>

We built a custom optical particle spectrometer capable of handling sulfuric acid aerosols by analyzing them within a glass cuvette that flows past a laser which reflects light into a photometer. We installed a small robotic arm inside the test volume with the optical particle spectrometer. The robot will manipulate the instrument around the chamber to measure aerosol properties in a grid pattern to verify the aerosol generator system provides the right properties.



Publications

Pauken, M., Salazar, J., Baines, K., Flagan, R., Gao, P., McGouldrick, K., Cantrell, W., Byrne, P., Akwaboa, S., The Planetary Cloud Aerosol Research Facility, 19th International Planetary Probe Workshop, Santa Clara, CA, 2022.

Acknowledgements

We acknowledge the advice, counsel and support from Len Dorsky, Jim Cutts, Jeff Hall, Pat Beauchamp and Satish Khanna during monthly management reviews and providing valuable feedback on the progress and direction of this project. We also acknowledge support from the manufacturing engineering team members, machinists at JPL and Caltech, and glass blower for making it possible for this facility come together.

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Clearance Number: CL#
Poster Number: RPC# 22-019