Laboratory investigation of Venus aerosol analogs

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Abstract:
The Venusian cloud deck is a 20-km-thick global layer of micron-scale sulfuric acid droplets with other trace components. This cloud layer absorbs fully half the incident solar radiation and is important for understanding the thermal balance, composition, and chemistry of the Venusian atmosphere [1,2]. Absorption of solar radiation in the cloud deck creates mesoscale convective cells near the subsolar point [3], drives overturning circulation [4], and maintains the global atmospheric superrotation [4,5]. A complex sulfur cycle sustains the extensive cloud layer, which includes particles of sulfuric acid, elemental sulfur, and an unidentified ultraviolet absorbing species [3]. A basic knowledge of the composition and morphology of Venusian aerosol has existed since the 1970s. Nevertheless, several major questions persist: what is the nature of UV-absorptive species at the cloud tops? Do large particles exist in the clouds? What is the composition of the non-sulfuric-acid component of the clouds? What are the properties of the (non-cloud) haze layers and how do they form?

To date, no laboratory investigations of Venusian aerosol formation have been performed, even with these longstanding questions. We have designed a series of experiments to investigate these questions. We expose simulated Venusian atmospheres composed of CO_2 and SO_2 (with SO_2 mixing ratios ranging from parts-per-million to several percent) to an energy source to initiate photochemical reactions in the laboratory. These new experiments are based on a large body of work regarding the production of organic haze particles in the atmosphere of Titan (see [6] for review). Laboratory experiments of sulfate aerosol formation have been performed with Earth-like atmospheres [7,8], but similar investigations have not yet been performed for strongly oxidized Venus-like atmospheres.

Preliminary experiments performed with Venus-like gas mixtures of SO_2 and CO_2 exposed to plasma discharge or UV radiation generate micron to millimeter size particles. We plan to analyze these particles by mass spectrometry, scanning and transmission electron microscopy, and infrared (FTIR) spectroscopy to determine composition. FTIR and UV-VIS spectroscopy (0.175 – 29 μm) will be used to determine how the particles interact with light and will allow for comparisons to recent spacecraft observations, e.g. [9–11].

References:
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