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Experimental Investigations of Precipitation of Crystalline Compounds from Titan's Lakes

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Abstract

We report preliminary results of laboratory experiments designed to investigate the formation of crystalline compounds from solutions of methane and ethane. These experiments are intended to simulate processes of concentration and precipitation that may occur on Titan during evaporation of lakes or pools of liquid hydrocarbons. Precipitates are formed from saturated of solutions of benzene, acetylene, acetonitrile and ammonia in methane and ethane which are slowly allowed to evaporate under a stream of nitrogen at 94 K. The precipitates are analyzed with a combination of Raman microscopy, Cryogenic Scanning Electron Microscopy, and cryogenic optical microscopy. We discuss the implications of these experiments on the surface chemistry of Titan, and how the presence of precipitates can inform interpretation of Cassini radar and VIMS data.

1. Introduction

The Cassini/Huygens mission has dramatically improved our understanding of the surface of Titan. Widespread lakes were discovered on Titan by the Cassini mission in 2006 [1]. Radar images of the north pole of Titan show a number of sharp-edged, dark features, presumed to lakes of liquid hydrocarbons [1]. At Titan surface pressures and temperatures a mixture of liquid methane and photochemically produced ethane is the most likely liquid. This solution will serve as a solvent for the complex mixture of photochemical products formed in the upper atmosphere of Titan, which eventually fall to the surface. The presence of liquid hydrocarbons on the surface of Titan naturally motivates questions about the solubility of surface materials in the liquid, and their fate during possible changes in lake composition and level. Two classes of materials are relevant: the putative bedrock material of Titan (water ice, ammonia) and photochemically produced organics that precipitate from the atmosphere (acetylene, benzene, HCN).

Modeling of lake composition [2] suggests that some species may be present in the lakes at saturation or near saturation (Table 1). Therefore, changes in lake composition due to evaporation or other processes are likely to induce precipitation of some of the dissolved organics. These organic "evaporites" may play an important role in Titan's surface chemistry, and might be identifiable in Cassini VIMS or radar data.

1.1 Experimental Details

Organic evaporates are produced in a custom built cryostat (Figure 1). Approximately 5mL of liquid ethane or methane saturated with the solute or solutes of interest is held at 94 K while a stream of nitrogen is blown across the surface to hasten evaporation. Evaporation rates can be controlled by varying the temperature and/or nitrogen flow rate.

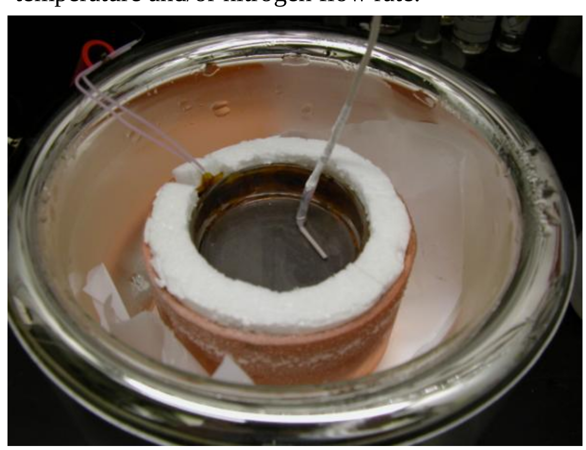

Figure 1: Liquid cryostat for precipitate preparation.

The chemical composition of the precipitates is determined by Raman spectroscopy with a Horiba Jobin Yvon LabRam HR confocal Raman spectrometer, coupled to a microscope equipped with a Linkam LTS 350 liquid nitrogen-cooled cryostage. Precipitate morphology is determined by Cryogenic Scanning Electron Microscopy with an FEI XL30 SEM equipped with a LN_2 cooled Polaron stage.

2. Results

We will report on preliminary results of experiments on acetylene, benzene, acetonitrile and ammonia, and mixtures thereof. Particle size as a function of evaporation rate and composition will be reported. We will also explore the possible formation of co-crystalline compounds with acetylene [3].

We will discuss the implications of our results in relation to Cassini VIMS and radar data.

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