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Radiation-induced near-surface atmospheres of Europa and Titan

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Abstract

We will discuss and compare photochemical processes on Europa and Titan, focusing on the near-surface and lower-atmospheric organic composition on both of these moons. Europa's surface receives high doses of radiation that can easily oxidize organics in the presence of water-ice. Titan's atmosphere is depleted of oxygen, but enriched with organic molecules, including condensed aerosols.

In this contribution we will focus on photochemistry caused by longer wavelength UV-VIS photons (>250 nm) photons that can pass through Titan's atmosphere to the haze region (~100 km) and onto the surface of Titan [1, 2] and electron-induced processes of organics on Europa's surface, leading to the formation of Europa's tenuous atmosphere [3-6]. We then compare the role of organics on both of these astrobiologically-important icy bodies in our solar system.

1. Introduction

The Cassini-Huygens mission revealed that the nitrogen- and methane-dominated Titan atmosphere of Titan is complex and more active than previously thought [7, 8]. Until recently it has been assumed that photochemistry is only confined to the upper atmosphere, where high-energy UV photons, electrons, Saturn's magnetospheric particles, and solar wind can penetrate. At lower altitudes, due to the lack of high-energy radiation sources (other than cosmic rays), it is expected that no further photochemistry could occur. Recent studies in our laboratory clearly demonstrated that ices and aerosols in Titan's atmosphere could further undergo photochemical transformations that result in the formation of larger organics [9-11] in Titan's haze region in its lower atmosphere (<100 km). These covalently-bonded organic aerosols containing predominantly C, H, and N elements finally rain down onto Titan's surface [12, 13].

Unlike Titan (with close to a 1.5 bar atmosphere), Europa does not have an atmosphere. Sputtering through radiation, ion, and micrometeoroid bombardment results in the formation of only a tenuous atmosphere on Europa. The survival of organic matter on Europa's surface under these conditions is not well understood. Our work on radiation-processed organics in ice sheds more light on the fate of organics on Europa and what kinds of ions and neutrals are generated near the surface that could form the tenuous atmosphere of Europa.

2. Laboratory Experimental Studies

Most of this work has been conducted at the *Ice Spectroscopy Lab (ISL)* and at the *Titan's Organic Aerosol Spectroscopy and chemisTry (TOAST)* lab of Gudipati at JPL.

This talk focuses on photochemical processes of volatile condensates on pre-formed Titan organic aerosols, simulating the lower-atmospheric and surface processes on Titan. We carried out laser irradiation studies using 532 nm, 355 nm, and 266 nm (Nd-YAG laser 2nd, 3rd, and 4th harmonics). IR and UV spectra were monitored simultaneously to follow the reaction kinetics and reaction products.

In Europa simulations, we irradiated organics such as polycyclic aromatic hydrocarbons (PAHs) and subjected them to electron and photon bombardment. We conducted UV, IR, and mass-spectrometric analysis on these ices.

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