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Organic Chemistry at Titan

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The Cassini-Huygens mission has unveiled a world at Titan that geologically resembles Earth in many ways. The 1.5 bar surface pressure coupled with the 93K surface temperature put the surface very near the triple point of methane. Methane outgassed from the interior can form clouds and rain leaving dry riverbeds and lakes over much of the surface in the current season. This methane hydrology operates on a seasonal basis, but on a much longer timescale (tens of millions of years) methane and the dominant atmospheric gas - molecular nitrogen - can be converted into complex organics in the upper atmosphere using the free energy from solar ultraviolet light or energetic particles from Saturn's magnetosphere. These complex hydrocarbons form a high level organic haze that persists throughout the atmosphere. On the surface over time this haze precipitates out forming extensive organic dunes covering wide regions of the surface. Some suggest that elements of this process may reflect an earlier time period on Earth before life led to the rise of oxygen and that the chemistry may tell us something about the formation of organics in interstellar clouds. The intrigue of understanding how the building blocks of life can be produced makes the story of Titan captivating.

The Ion Neutral Mass Spectrometer has collected rich ion and neutral mass spectra from 1 to 100 Daltons 1000 km above the surface. The complexity and interplay of the ion and neutral species indicate that ion-neutral reactions play a major role in the initial formation of aromatics, such as benzene and toluene. When combined with the Ion Beam Spectrometer and the Electron Spectrometer data of the Cassini Plasma Spectrometer investigation we see not only an extension of the positive ion spectra to

over 350 Daltons, but we see indications of the onset of PAH condensation and the apparent formation of large negatively charged organic ions with masses up to 8000 Daltons. We propose that these are the nascent “tholins” from which the organic hazes of Titan are born.

In this talk we present both an overview of the long-term methane cycle and a detailed accounting of the formation of the nascent “tholins” based on mass spectra from the INMS and CAPS data sets.