The Titan Haze Simulation experiment on COSmIC: investigating Titan’s atmospheric chemistry at low temperature

SPECIAL SEMINAR
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Abstract: Titan is the largest satellite of Saturn and is the only object in the outer solar system with a dense (1.5 bar at the surface) atmosphere. In Titan’s atmosphere, mainly composed of nitrogen (N₂ – 95-98%) and methane (CH₄ – 2-5%), a complex organic chemistry is induced by solar UV radiation and electron bombardment from Saturn’s magnetosphere. This chemistry occurs at low temperature (<200 K) and forms an array of species (anions, cations, radicals and neutrals) that continue to react, ultimately forming macromolecules that agglomerate into solid aerosols, producing the orange haze surrounding Titan. The Titan Haze Simulation (THS) experiment was developed at the Ames COSmIC facility to study the chemical pathways that link the molecules resulting from the first steps of the N₂-CH₄ chemistry to benzene, and to PAHs as precursors to solid aerosols. In the THS, the chemistry is simulated at Titan-like temperature (150-200 K) by a plasma generated in the stream of a supersonic expansion. Because the gas is accelerated to supersonic speed in the PDN expansion, the residence time of the gas in the active region of the pulsed plasma discharge is on the order of 3 µs, allowing us to control how far the chain of chemical reactions progresses, depending on the precursors present in the initial gas mixture. This way, we can probe the first and intermediate steps of the chemistry as well as specific chemical pathways by injecting different N₂-CH₄-based gas mixtures in the plasma, with or without the addition of heavier precursors present as trace elements on Titan (C₂H₂, C₂H₄, C₃H₆, C₆H₆, PAHs…). We will discuss the results of two complementary studies of the gas- (mass spectrometry) and solid (SEM, XANES, IR) phases and show the potential of THS for the study of Titan’s atmospheric chemistry.