Laboratory experiments on chemical reactions in Titan's atmosphere

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BRIEF SUMMARY: Titan's atmosphere is rich in complex hydrocarbon and nitrile species, that were detected, during the Cassini mission, as charged particles at ionospheric altitudes. Recent laboratory experiments using guided ion beam methods will be presented to shed lights on the feasibility of ion-neutral reactions in the build up of large organic species.

EXTENDED ABSTRACT:
Titan, the largest among Saturn satellites, has one of the densest and most chemically complex atmospheres of the solar system [1]. The Cassini spacecraft, which reached Saturn in 2004, has completely changed the former view on the atmospheric chemistry in Titan, where neutral-neutral reactions were regarded as the major players in the formation of the organic aerosols at stratospheric altitudes, and the ionosphere was believed to consist only of few low-mass ions. Measurements from the Ion and Neutral Mass Spectrometer (INMS), the Cassini Plasma Spectrometer (CAPS) and the Radio and Plasma Wave Science (RPWS) Langmuir Probe (LP) revealed an extraordinary complex ionosphere, populated by heavy positive ions (up to 350 amu/q) most likely having structures of unsaturated hydrocarbons and nitriles [2] as well as anions (up to 13.800 amu/q) [3]. Hence, a new paradigm for chemical evolution has been proposed, in which molecular growth starts at ionospheric level where ion-molecule reactions followed by recombination processes with electrons and anions leads to the formation of neutrals which can ultimately condensate and precipitate to lower altitudes [4]. To validate such models it is necessary to investigate formation (as well as destruction) pathways for large ions. Ion-neutral reactions using light and medium sized hydrocarbons as building blocks can be invoked for the production of complex species [4] since such type of processes have the advantage – over alternative mechanisms requiring sequential additions of small species - of attaining substantial growth in molecular size within a single reactive encounter.
Our contribution is in the laboratory measurements of kinetic parameters (i.e. reactive cross sections and branching ratios as a function of the collision energy) for the reaction of charged molecules with neutrals, using tandem mass spectrometric techniques and RF octupolar trapping of charged species.
In the contribution, we will review our studies on the reactions of hydrocarbon and cyano cations with saturated and unsaturated hydrocarbons present in Titan's atmosphere, with special reference to the reactivity of CH_3^+ and CH_2CN^+ [5] cations, as well as isomer-selective reactivity of $CH_3CN^{+\bullet}$/ $CH_2CNH^{+\bullet}$ radical cations [6].

References

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