Association reactions in Titan's ionosphere

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On October 15, 1997 the Cassini spacecraft was launched on a 7 year voyage to Saturn. After orbital insertion in July 2004, the orbiter will undertake a four year "tour of duty" of the Saturnian system including its largest satellite, Titan, which is, in fact, a prime target of the mission. Titan is the largest of any satellite in the Solar system and in many respects is an enigmatic body having a dense nitrogen-based atmosphere. Along with Earth, these two bodies are the only ones in the Solar system to have substantial amounts of nitrogen in their atmospheres. In addition to nitrogen, Titan has an exotic mix of hydrocarbons which leads to a fascinating number of possible ion-molecule reactions that can occur in Titan's ionosphere.

The purpose of this investigation is to examine the types of processes that might occur on Titan and to get some understanding of what the mass spectrometer on board the spacecraft will be expected to find when the orbiter flies through Titan's ionosphere. An important class of ion-molecule reactions is that of association in which the ion and neutral moities combine to form a new entity. There are three features in the Titan atmosphere that cause association reactions to be much more important than they are on Earth: the low temperatures, the pressure and the presence of hydrocarbons. On Earth the association reactions that occur in the D region of the ionosphere produce products that usually are weakly-bound electrostatic cluster species.

$$NO^+ + N_2 + M \rightarrow NO^+.N_2 + M$$

On Titan these more weakly-bound clusters are replaced by association ions that are new covalently-bound chemical species and it is possible to build quite complex molecules in comparatively few collisions.

Laboratory work undertaken for this study employed two quite different experimental techniques; ion cyclotron resonance (ICR) mass spectrometry and flowing afterglow-selected ion flow tube (FA-SIFT) studies. In the ICR cell, the pressure was varied between $1x10^{-6}$ Torr to $1x10^{-2}$ Torr. The FA-SIFT studies used a pressure of around 0.5 Torr. A new technique was used in this work to unravel the ion chemistry and evaluate the termolecular association processes which often occur in competition with bimolecular processes. In previous studies it was usual to examine the reaction of an ion where that ion is the major ion and sometimes the only ion in the cell. In many of the systems examined here, many ions were present and the rate coefficients and branching rations obtained were the result of numerical modeling of the chemistry. As a start-off point to the modeling, data from the literature was used and any differences that were seen due to association processes showed up as a divergence from the model. The much higher pressures of the FA-SIFT instrument emphasized termolecular association and therefore the importance of association reactions when they occurred. Pure hydrocarbons or mixtures of two hydrocarbons were admitted to the ICR cell and all the ions present were then monitored at all pressures. In this poster the reactions occurring in pure **propyne** will be presented and discussed.