The role of heterogeneous reactions in the origin and evolution of Titan's atmosphere

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Titan, the largest moon of Saturn, has a thick atmosphere composed primary of nitrogen and methane. More than 10 organic molecules and dense haze layers also have been detected in Titan's atmosphere [1]. The goal of this study is to understand why Titan's atmospheric composition is the current one and how the atmosphere has evolved during the age of solar system. In this study, we focused on the heterogeneous reactions on the surface of organic aerosol, which forms haze layers in Titan's atmosphere. We experimentally investigated the heterogeneous reactions of atomic deuterium with Titan tholin (laboratory analog of Titan's aerosol) in a laboratory and determined the reaction probabilities of the heterogeneous reactions quantitatively [2]. By incorporating the reaction probabilities into a photochemical model of Titan's atmosphere, we evaluated the role of organic haze both in the chemical composition of the atmosphere and the hydrogen budget on Titan [3].

Our results suggest that the heterogeneous reactions significantly reduce the concentrations of atomic hydrogen in the stratosphere and mesosphere. Low concentration of atomic hydrogen enhances the concentrations of unsaturated complex organics and reduces the concentrations of saturated hydrocarbons. These results show that Titan's aerosols act as an efficient sink of atomic hydrogen (Figure 1). Such behavior of aerosol may keep the chemical composition of the Titan's atmosphere to the current one, which is suitable for synthesis of complex organic molecules. Furthermore, our results also suggest that the increase in haze production induces further increase in the haze production in the atmosphere. By taking into account this positive feedback in Titan's atmosphere, we will discuss the role of the heterogeneous reactions in the evolution of the atmosphere-surface system on Titan.

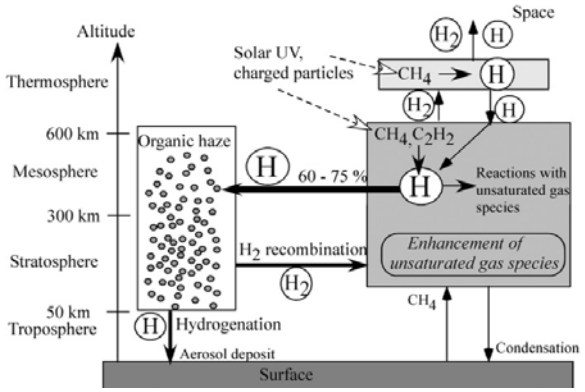

Figure 1: Schematic diagram of the fate of atomic hydrogen in Titan's atmosphere. The organic aerosol acts as a catalyst not only to remove highly reactive atomic hydrogen from the atmosphere but also to enhance the efficient production of higher molecular-weight hydrocarbons in the atmosphere.

References

[1] F. M. Flaser, et al., 2005, Science 308, 975
[2] Y. Sekine et al., 2008, Icarus 194, 186
[3] Y. Sekine et al., 2008, Icarus 194, 201