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Titan's Mid-Atmospheric Photochemistry: the chemical composition of the Aerosols and Their Rate of Accumulation on the Surface

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Abstract

As found by the Cassini GC-MS, a plethora of organics are produced in Titan's upper atmosphere by short UV, cosmic rays and Saturn's magnetospheric particles. These energy sources convert the CH_4, and N_2 into mainly C_2H_2, C_2H_4, HCN and HC_3N, which reach a lower altitude at the observed mixing ratios of $3x10^{-6}$, 10^{-7}-10^{-8}, $3x10^{-7}$ and 10^{-9}-10^{-10}, respectively. Reaching down to mid-altitudes, these unsaturated compounds are activated by UV irradiation and form a plethora of hydrocarbons and nitriles, which produced the thick layer of aerosols in Titan's atmosphere.

1. Experimental Results

Photolysis of C_2H_2, C_2H_4 and HCN in the presence of CH_4 by a low pressure Mercury lamp, emitting 38 mW cm^{-2} at 2537 Å and about ten times less at 1849 Å, polymerize these unsaturated compounds to form, by stepwise addition of C_2 and ring closure, polyaromatic hydrocarbons (PAHs). When rings are not closed, polyvinyls, which cross-link form an insoluble 3-dimentional matrix [1]. The main constituents in the gas phase (Figure 1a) is benzene, diacetylene, methane and ethane and up to C_8H_8-styrene. In the solid phase (Figure 1b) the main constituents are biphenyl, naphthalene and phenyl acetylene, up to the condensed 5-ring pyrene.

2. Aerosols' Formation Rate

The rate of aerosol formation (figure 1c) leads to a ~ 42 m thick layer during Titan's life time, 4.6 by. A mere deposition of 10^{-6} cm per year, easily washable by the methane and ethane rains. These aerosols also trap the noble gases Ar, Kr and Xe, which are highly depleted in Titan's atmosphere [2].

3. Figures

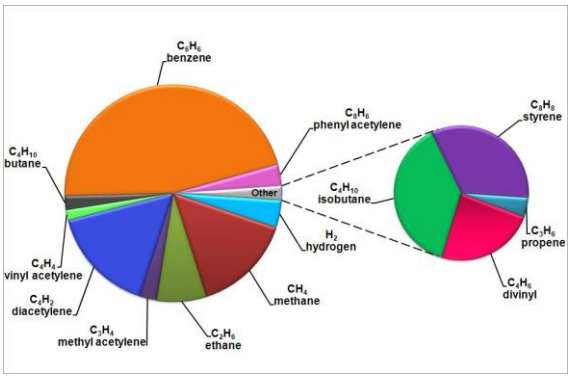

Figure 1a: Gas Phase Products

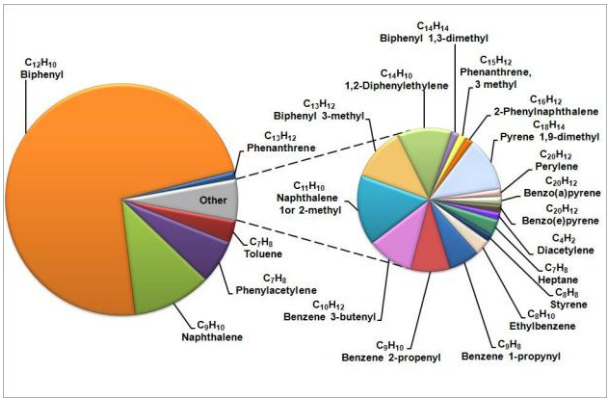

Figure 1b: Solid Phase Products

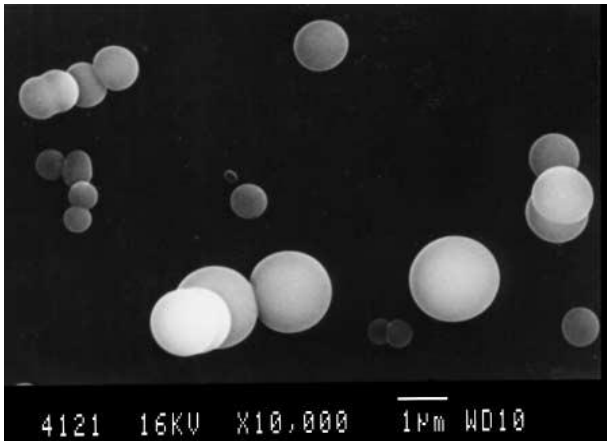

Figure 1c: Electron Microscopy of the aerosols

4. Summary and Conclusions

These measurements are important for better understanding the composition of atmospheric chemistry and Titan's aerosols as well as the composition of the recently discovered lakes on Titan. Another matter could be the composition of water-less Exo-planets.

Acknowledgements

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References

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[2] Jacovi R. and Bar-Nun A. Removal of Titan's noble gases by their trapping in its haze. Icarus, 196, 302-304, 2008.