Geophysical Research Abstracts
Vol. 18, EGU2016-4071, 2016
EGU General Assembly 2016

Adsorption of Acetylene and Formation of Benzene on Cosmic Dust in Titan's Atmosphere

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The formation of the haze layers and tholins in Titan's atmosphere is unclear. One potential mechanism is that small precursors, such as acetylene (C_2H_2), adsorb onto un-ablated cosmic dust particles as they sediment through Titan's atmosphere. The uptake coefficient of C_2H_2 onto cosmic dust analogues was measured using low temperature dual flow tube apparatus. Synthesized olivines analogues ($Mg_{2-2n}Fe_{2n}SiO_4$ where $1 \geq n \geq 0$) were used to represent the cosmic dust particles based on investigations of cometary dust. The results indicated that the adsorption of C_2H_2 was independent of the Mg:Fe ratio in the dust analogue with the mean uptake coefficient (at 181 K) as 1.7 $\times 10^{-4}$. In some cases, the uptake experiments were left until the surface had become saturated with C_2H_2. Here, a small benzene (C_6H_6) mass trace was detected indicating that cyclotrimerzation of C_2H_2 into C_6H_6 was occurring on the surface. Further experiments using ultrahigh vacuum apparatus were used to confirm this observation.

The rate of C_6H_6 (formed through C_2H_2 cyclotrimerization) desorbing from un-ablated cosmic dust particles sedimenting through Titan's atmosphere was explored using a 1D model. The results revealed that this heterogeneous formation and desorption route was competitive with gaseous C_6H_6 formation rates suggesting that the dust could be acting as a seed for the formation of complex organic molecules (such as PAHs) and tholins and, through this, the formation of the haze layers.