EPSC Abstracts
Vol. 14, EPSC2020-380, 2020, updated on 21 May 2022
https://doi.org/10.5194/epsc2020-380
Europlanet Science Congress 2020

Detection of Cyclopropenylidene on Titan

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Titan, Saturn's largest moon, has long been known to harbor a thick atmosphere [1] that evolves a complex array of organic molecules through atmospheric photochemistry [2, 3]. Especially from the 1970s onwards, successive waves of investigation with ground-based telescopes, spacecraft including Voyager 1 and Cassini-Huygens, and space telescopes have revealed the molecular inventory of its atmosphere through remote sensing at UV to radio wavelengths, and in situ mass spectroscopy [4, 5]. Since coming online in 2012, the ALMA (Atacama Large Millimeter/submillimeter Array) telescope has added importantly to our knowledge of Titan's atmospheric composition, especially through first detections of propionitrile (ethyl cyanide, C_2H_5CN) and acrylonitrile (vinyl cyanide, C_2H_3CN) in the neutral atmosphere [6, 7]. Such new measurements are of vital importance for constraining photochemical models [8-10] and helping us unravel the steps to building even larger molecules and haze particles [11], with important repercussions for astrobiology [12].

In recent years we have continued the search for new molecules in Titan's atmosphere, acquiring high-sensitivity observations with ALMA to search for larger hydrocarbons, nitriles and other species. In 2016 we acquired 129 mins of integration on Titan in ALMA Band 6 that exhibited many lines of C_2H_5CN (ethyl cyanide) and other known species. In addition we found several weak lines that we identified as c-C_3H_2 (cyclopropenylidene), a small cyclic molecule frequently seen in the interstellar medium [13, 14], but not previously seen in a planetary atmosphere. The spectrum was modeled using the NEMESIS radiative transfer and inversion computer model [15] yielding a best-fit mixing column abundance of 5.29×10^{12} molecule cm^{-2}, somewhat greater than predicted by recent photochemical models (1.41×10^{12} [8]; 7.71×10^{11} [16]).

Cyclopropenylidene is now only the second cyclic molecule to be detected in a planetary atmosphere after benzene. Its measurement will provide vital constraints on the chemistry of important intermediate-size radicals such as C_3H_3 (propargyl and its isomers) whose chemistry may lead to either c-C_3H_2 (by hydrogen loss) or to benzene (e.g. by self-reaction). Ultimately, a better understanding of cyclic molecule chemistry will lead to a better understanding of haze formation, and Titan's potential for astrobiology.

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