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ACS TRACE GAS DETECTION ATTEMPTS

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Introduction: The ACS instrument onboard ExoMars TGO has been developed to meet a variety of science goals, in particular, the sensitive search for trace species in the Martian atmosphere [1]. Regular soundings in solar occultation mode started in March 2018. For methane ACS reported stringent 20 ppt upper limits all over the planet [2,3], which are not correlated with surface measurements by the MSL rover [4]. With the methane lifetime of ~300 years, conventional chemistry cannot explain the disagreement. ACS continues regular measurements to gain statistics and in hope for possible methane spikes reported previously [5]. The presence of methane derivatives like ethane C2H6 is very unlikely, yet ACS sets an improved upper limit of 50 ppt.

Recently discovered by ACS [6], hydrogen chloride (HCl) may be involved in many atmospheric processes, so we looked for chloromethane (CH3Cl) features in the data. The Viking landers detected chloromethane during the search for organic compounds in Martian soils [7]; MSL again noted CH3Cl during the pyrolysis of soil [8], still these detections are believed to have a contamination source. The ACS upper limit for CH3Cl in the atmosphere is better than 1 ppb, which is several times better than previous knowledge [9], and extends over seasons.

Sulfur species were searched as an indicator of any volcanic outgassing from the surface of Mars. For the most optimal sensitivity conditions, we determine upper limits of SO2 at 20 ppbv, H2S at 15 ppbv, and OCS at 0.4 ppbv [10]; the last value is lower than any previous upper limits imposed on OCS in the literature.

Nitrogen is known to be present in the Martian atmosphere, forming the oxidation products derived from ionospheric dissociation of N2. The first species to searched for with ACS is NO2. It has comparable model predicted abundances with NO in the lower atmosphere. ACS is sensitive to NO2 with an accuracy of 200 pptv matching model predicted concentrations [11]. Without a confident detection, the median abundance over the entire ACS dataset agrees with this value. In 2021 we started a dedicated search campaign for NH3 and HCN. Preliminary derived upper limits are 11 ppb and 1 ppb accordingly.

References

[1] Korablev, O. et al. The Atmospheric Chemistry Suite (ACS) of three spectrometers for the ExoMars 2016 Trace Gas Orbiter. Space Sci. Rev. 214, 7 (2018).

[2] Korablev, O. et al. No detection of methane on Mars from early ExoMars Trace Gas Orbiter observations. Nature 568, 517–520 (2019).

[3] Montmessin, F. et al. A more stringent upper limit of methane on Mars and strong constraints on methane dispersion outside Gale crater. Astron. Astrophys. 650, A140 (2021).

[4] Webster, C. et al. Background levels of methane in Mars' atmosphere show strong seasonal variations. Science 360, 6393, 1093-1096 (2018).

[5] Giuranna, M. et al. Independent confirmation of a methane spike on Mars and a source region east of Gale Crater. Nature Geoscience 12, 326–332 (2019).

[6] Korablev, O. et al. Transient HCl in the atmosphere of Mars. Sci. Adv. 7, eabe4386 (2021).

[7] Biemann, K et al. The search for organic substances and inorganic volatile compounds in the surface of Mars. J. Geophys. Res., 82, 4641-4658 (1977).

[8] Glavin, D. et al. Evidence for perchlorates and the origin of chlorinated hydrocarbons detected by SAM at the Rocknest aeolian deposit in Gale Crater. JGR Planets 118, 10 (2013).

[9] Villanueva, G. et al. A sensitive search for organics (CH4, CH3OH, H2CO, C2H6, C2H2, C2H4), hydroperoxyl (HO2), nitrogen compounds (N2O, NH3, HCN) and chlorine species (HCl, CH3Cl) on Mars using ground-based high-resolution infrared spectroscopy. Icarus 223(1), 11-27 (2013).

[10] Braude, A. S. et al. No detection of SO2, H2S, or OCS in the atmosphere of Mars from the first two Martian years of observations from TGO/ACS. Astron. Astrophys. 658, A86 (2022).

[11] Moudden, Y., McConnell, J.C. Three-dimensional on-line chemical modeling in a Mars general circulation model. Icarus 188(1), 18-34 (2007).