INV-08

Session 8) Biogeochemical Cycle uncovered by PSIA and Clumped

^{13}C-^{13}C Fingerprinting in Ethane

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Ethane (C_2H_6) is the second most abundant low-molecular-weight hydrocarbons in natural gas after methane (CH_4). Understanding ethane's origins can help estimate global methane emissions and the deep microbial communities utilizing ethane as a potent energy and carbon source. Ethane is believed to be derived from two sources on Earth: thermogenic or abiotic, yet differentiation between sources remains challenging. While carbon ($^{13}C/^{12}C$) and hydrogen (D/H) isotope ratios can provide insight into the origin of hydrocarbons, the abundance of the clumped isotopologue $^{13}C_2H_6$, may provide additional information regarding the origin of C-C bonds in hydrocarbons. Two analytical techniques have been developed to quantify $^{13}C_2H_6$ abundances in ethane precisely by high-resolution mass spectrometers [Clog et al., 2018] or the fluorination method with standard isotope ratio mass spectrometers [Taguchi et al., 2020; 2021]. Results from both techniques have demonstrated new constraints on the origins of ethane that can be inferred from clumped isotopologues of ethane. In particular, ethane synthesized abiotically from methane through methyl radicals showed significantly low $^{13}C_2H_6$ abundance compared to stochastic distribution [Taguchi et al., 2022]. Remarkably, natural ethane samples putatively from abiotic sources showed a similar $^{13}C_2H_6$ abundance to ethane synthesized abiotically. In contrast, ethane from sites suggesting thermogenesis and laboratory organic matter pyrolysis demonstrated none or only a slight $^{13}C_2H_6$ enrichment compared to the stochastic distribution. We will discuss $^{13}C_2H_6$ systematics for identifying the origin of ethane in the natural environment. The developed ^{13}C-^{13}C fingerprint may apply to any molecules containing C-C bonds and thus could be a promising (a)biomarker on Earth and in extra-terrestrial environments.

References

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