

PROBING THE INTERSTELLAR HERITAGE OF THE SOLAR SYSTEM WITH THE NITROGEN ISOTOPIC RATIO. P. Hily-Blant^{*1}, V. S. Magalhaes¹, F. Daniel¹, A. Faure¹, ¹Institut de Planétologie et d'Astrophysique de Grenoble, Domaine Universitaire BP 53 F-38041 Grenoble Cedex 09 (France)
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The extent to which the chemical reservoirs in interstellar molecular clouds are preserved during the formation of stars and planetary systems is a central question with implications from astrophysical, chemical, and biological perspectives. However, the degree to which the original cloud composition may be altered or even reset during the star and planet formation process is unknown. Isotopic ratios are powerful tools to trace the chemical heritage of the solar system, and planetary systems more generally¹. In the case of nitrogen, the ¹⁴N/¹⁵N isotopic ratio indicates that comets have preserved, to some extent, the Sun's original interstellar chemical reservoir². However, the mean cometary isotopic ratio of 150 is in sharp disagreement with the protosun value of 441³. The reasons are not clear. In this talk, we will address various scenarios that may explain this disagreement, based on observations and chemical models of prestellar precursors of protosolar nebula analogs.

In particular, one scenario may be that the N-carriers observed in comets (such as NH₂, CN, HNC) derive from a single nitrogen reservoir which was not representative of the bulk nitrogen in the protosolar nebula. This would indicate a so-far unidentified reservoir of nitrogen in comets, perhaps in their deep interiors. Such a reservoir could be atomic nitrogen. Alternatively, using the IRAM/NOEMA and IRAM/30m instruments, we observationally explore the possibility that chemical fractionation taking place in interstellar ices could be at work since the prestellar phase or during the lifetime of the comets. Finally, we will open the discussion towards protoplanetary disks based on recent measurements of the double isotopic ratio in H₁₃CN/HC₁₅N in the MWC480 disk⁴ which leads to a ratio consistent with Solar System comets. This work also puts the chemical history of the Solar system in perspective with the chemical evolution of interstellar matter as a result of the star formation history, and questions the birthplace of the Solar system in the Milky Way.

- [1] Cleaves et al, *Nature* 345, 6204 (2014)
- [2] Hily-Blant et al, *Icarus* 223, 582 (2013)
- [3] Füri and Marty, *Nature Geoscience* 8 (2015)
- [4] Guzman et al, *The Astrophysical Journal* 814 53 (2015)

NITROGEN ISOTOPIC FRACTIONATION OF AMMONIA BY ADSORPTION ON MINERAL SURFACE.

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Stable nitrogen isotopic composition ($\delta^{15}\text{N}$, relative to terrestrial air) in the solar system objects shows various degrees of ¹⁵N-enrichment compared to that in the Sun ($-407\pm 7\%$) [1] and Jupiter ($-390\pm 70\%$) [2]. Especially, pristine solar system materials, such as comets and carbonaceous chondrites are highly enriched in ¹⁵N by up to +1500‰ as bulk samples [3,4]. Furthermore, they also have extremely ¹⁵N-enriched microscale domains, which are frequently called as hot spots, within a single material. The highest $\delta^{15}\text{N}$ value reaches as high as +5000‰ [5]. These ¹⁵N-enrichments may have inherited from the enrichments in cold interstellar environments or the outer protosolar nebula. Although several potential models have been proposed to explain the formation of extreme ¹⁵N-enrichments in molecular clouds (e.g., [6]), their nitrogen isotopic fractionation processes have not been fully understood.

In this study, we propose the isotopic fractionation between ammonia and their adsorption on mineral surface as another potential process to cause the ¹⁵N-enrichment in the interstellar or protosolar environments. Ammonia is a primitive nitrogen-containing molecule and distribute in abundance in molecular clouds and the protosolar nebula. Since Ammonia is highly reactive molecule, it is considered to be a precursor for other nitrogen-involving organic molecules. Adsorption of ammonia on mineral surface will be the first step in the grain surface chemistry to form more complex molecules.

To understand the isotopic fractionation of nitrogen associated with the adsorption of ammonia on mineral surface, we conducted simple adsorption experiments using ammonia gas and adsorbent materials. We chose typical clay minerals (montmorillonite, saponite, dickite, kaolinite, pyrophyllite, and halloysite) as the adsorbents. The each clay mineral was enclosed into a glass vial and vacuumed to remove air. Then 1 atm of ammonia gas (27‰) was introduced and set at room temperature for a couple of days to adsorb. The nitrogen isotopic composition of the adsorbed ammonia was determined by nano-EA/IRMS [7]. The results showed that the adsorbed ammonia is generally enriched in ¹⁵N relative to initial ammonia gas. Moreover, there was a negative correlation between $\delta^{15}\text{N}$ value and adsorption ratio. This correlation may be explained by Rayleigh fractionation or two end-member mixing model, which were related to different adsorption processes (adsorption as ammonium ion, ionized by water or adsorption as ammonia molecule in interlayer of clay minerals). Our findings suggest the adsorption of ammonia on mineral surface as a potential mechanism for the extreme ¹⁵N-enrichment in the interstellar or protosolar environments.

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