Adsorption of ammonia onto grain surface as a potential mechanism for nitrogen isotopic discrimination

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Solar system objects show great variation in the nitrogen isotopic composition, which ranges from -400‰ of the Sun [1] and Jupiter [2] to +1500‰ of comets and chondrites (in bulk) [3] and further extends to +5000‰ of nanometer scale organic materials in carbonaceous chondrites [e.g., 4, 5]. The large ^{15}N-enrichments in the pristine solar system materials are possibly originated in cold molecular clouds and/or in the outer solar nebula [e.g., 6], but the likely scenario has still not been well understood.

In the study, we propose adsorption of ammonia onto grain surface as an alternative scenario to produce ^{15}N-enrichment. Ammonia is a primitive and abundant molecule in the molecular clouds, as well as in the solar system. It is a highly reactive chemical, thus its adsorption onto grain surface would be a beginning of grain surface chemistry to form more complex nitrogen-containing organic molecules.

In order to examine the nitrogen isotopic fractionation by adsorption of ammonia onto grain surface, we conducted simple adsorption-desorption experiments using ammonia gas and several clay minerals (e.g., montmorillonite). The each clay mineral was put into the vacuumed glass vial, and ammonia gas was introduced. Then, the nitrogen isotopic composition of the adsorbed ammonia was determined by nano-EA/IRMS technique [7]. Next, the vial was vacuumed and the remaining adsorbed ammonia was analyzed again.

The adsorbed ammonia showed a large ^{15}N-enrichment than the initial ammonia gas as the highest Δ^{15}N value was +44.4‰. The vacuumed samples were generally more enriched in ^{15}N and the Δ^{15}N value reached was +64.1‰. These results suggest that adsorption-desorption process of ammonia causes significant nitrogen isotopic fractionation and could be a potential mechanism for the protosolar ^{15}N- enrichment.

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