Nitrogen isotopic fractionation of ammonia by adsorption on grain surface: An experimental approach to understand ^{15}N-enriched organic matters in extraterrestrial materials

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Nitrogen isotopic composition of the solar system objects show a variation in the range of minus hundreds to plus thousands permil in δ^{15}N value (‰, normalized as vs. Air). The bulk δ^{15}N values of the solar system, which are inferred from the analysis of the solar wind samples returned by Genesis mission, exhibit around −400‰ and those of the protosolar nebula are considered as similar values [1]. The bulk δ^{15}N values of Jupiter atmosphere are also similar to those of the solar wind [2]. Conversely, the terrestrial planets (Venus, Earth, and Mars) show much more positive values ranging from −40 to +350‰ [3, 4]. Primitive solar system materials, such as chondrites, comets, and interplanetary dust particles (IDPs) also show various degrees of ^{15}N-enrichment up to +1500‰ in the bulk δ^{15}N value [5, 6]. Furthermore, anomalously high ^{15}N-enrichments, as called hot spots, are frequently found within a single material and their highest δ^{15}N values reach as high as +5000‰ [7]. However, only a few models can explain the considerable δ^{15}N diversity in the interstellar medium (ISM) [e.g., 8] and likely isotopic discrimination processes have never been well understood.

In the study, we shed light on an adsorption of ammonia on grain surface as a potential mechanism for ^{15}N-discrimination in ISM. Adsorption is an interaction between gaseous molecules and grain surface and may be a first step for grain surface chemistry to form more complicated organic matter. We focused on ammonia in this study, because it is one of major carrier forms of nitrogen in ISM and also a high-active chemical as a precursor for nitrogen-involving organic matters. As a potential model for the ^{15}N-discrimination through adsorption process on grain surface, we enclosed ammonia gas into vacuumed glass vials together with several absorbent materials. We determined the difference in δ^{15}N value between the initial ammonia gas and the absorbed one.

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