^{15}N fractionation in star-forming regions and Solar System objects

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Abstract
A central issue for understanding the formation and evolution of matter in the early Solar System is the relationship between the chemical composition of star-forming interstellar clouds and that of primitive Solar System materials. The pristine molecular content of comets, interplanetary dust particles and carbonaceous chondrites show significant bulk nitrogen isotopic fractionation relative to the solar value, $^{14}N/^{15}N \sim 440$. In addition, high spatial resolution measurements in primitive materials locally show even more extreme enhancements of $^{14}N/^{15}N < 100$.

The coherent 15N enrichment in comets originating in different formation zones suggests that these isotopic enhancements are remnants of the interstellar chemistry occurring in the natal molecular cloud core and the outer protosolar nebula. Indeed, early chemical models of gas-phase ion-molecule nitrogen fractionation showed that HCN and HNC (nitriles) can hold significant ^{15}N enrichments in cold dark clouds where CO is depleted onto dust grains. In addition, ^{15}N fractionation in nitriles and amines (NH_2, NH_3) follow different chemical pathways. More recently we have shown that once the spin-state dependence in rates of reactions with H_2 is included in the models, amines can either be enhanced or depleted in ^{15}N, depending on the core's evolutionary stage. The observed ^{15}N fractionation in amines and nitriles therefore cannot be expected to be the same, instead their ratio is a potential chemical clock.

Observations of molecular isotope ratios in dark cores are challenging. Limited published results in general show higher $^{15}N/^{14}N$ ratios in HCN and HNC than ammonia, but more measurements are necessary to confirm these trends. We will present recent results from our ongoing observing campaign of $^{14}N/^{15}N$ isotopic ratios in HCN, HNC and NH_3 in dense cores and protostars which seem consistent with significant fractionation in nitriles as compared to other molecules in each object. The few $^{14}N/^{15}N$ ratios observed in N_2H^+ are similar to those in NH_3, contrary to our model results which predict a significant ^{15}N enhancement in N_2 and N_2H^+. Model upgrades which may adress this discrepancy will be presented and discussed.