Carbon and hydrogen isotopic fractionations of organic compounds during UV degradation

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It is well-known that carbonaceous chondrites contain various classes of organic compounds such as amino acids, carboxylic acids, and hydrocarbons. These organic compounds may have played an important role in chemical evolution and origins of life on Earth. Meteoritic organic compounds are enriched in ^{13}C and deuterium (D) relative to terrestrial compounds, suggesting their interstellar origin.

In interstellar environments, ultraviolet (UV) is one of the ubiquious energy sources which promote production and degradation of organic compounds. Therefore it is important to understand the isotopic behavior of interstellar organic molecules by UV degradation in order to clarify their ^{13}C- and D-condensed passway. This approch is consequently expected to reveal the origin, and ^{13}C- and D-condensed signatures of meteoritic organic compounds.

In this study, carbon and hydrogen isotopic fractionations of five organic compounds (acetic and propionic acids, acetnitrile, benzene, and methanol) during UV degradation were measured using gas chromatograph-combustion and pyrolysis-isotope ratio mass spectrometer. UV was emitted from a high-pressure mercury lump.

Results and Discussion

Carbon and hydrogen isotopic ratio of five organic compounds became higher with increasing UV exposure times. Carbon isotopic fractionation factor of five organic molecules ranges from 0.9968 (methanol) to 0.9875 (benzene). Hydrogen isotopic fractionation factor of five organic molecules ranges from 0.9910 (acetic acid) to 0.9543 (methanol).

In addition to the molecular isotopic fractionation pattern described above, the intra-molecular carbon isotopic fractionation of acetic acid gave a different isotopic behavior between the methyl and carboxyl carbon. The carboxyl carbon in acetic acid became enriched in ^{13}C relative to the methyl carbon with increasing UV exposure times. Carbon isotopic fractionation factor of the methyl and carboxyl carbon in acetic acid is 0.9961 and 0.9823, respectively.

A different degree of the isotopic fractionation by UV degradation among different organic compounds and within a molecule may be useful to understand the isotopic variation in meteoritic organic compounds.