Investigating L-Amino Acid Enantiomeric Excess in CM and CR Carbonaceous Chondrites

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Meteorites are known to contain a wide array of soluble organic compounds, including amino acids. These organics provide clues about parent body processes and chemical reactions that may have been responsible for the production of extraterrestrial biomolecules. Non-protein amino acids, such as isovaline (Iva), are of particular interest because these species are less likely to be terrestrial contaminants and therefore can be good indicators of extraterrestrial synthesis. Furthermore, the enantiomeric compositions of meteoritic amino acids with chiral centers can provide insights into the origin of homochirality on Earth, or elsewhere, and correlate with the degree of aqueous alteration experienced on the meteorite parent body.

Previous explorations of the least aqueously altered type 2/3 CR meteorites have shown significant L-Iva excesses are not observed [1]. However, analyses of aqueously altered type 1 CI, CM, and CR meteorites, and some aqueously altered CM2 meteorites, have revealed significant L- isovaline excesses of up to ~15% [2]. These findings support the hypothesis that parent body aqueous alteration was required for amplification of small, initial L-excess of Iva [3] in these meteorites.

While CM2 meteorites, such as Yamato-791198 (Y-791198), have been analyzed for amino acids [4], a detailed analysis of amino acid enantiomeric excesses in Y-791198 has yet to be reported. Such an investigation is necessary to determine if the aforementioned hypothesis holds true for other carbonaceous chondrite groups.

In this work, we are studying 5 different Antarctic meteorites: Y-791198 (CM2), EET 96029 (CM2), MIL 090657 (CR2), LAP 02342 (CR2), and GRA 95229 (CR2). These meteorites will be analyzed for a broad range of amino acids, and the analyses will be compared to that of two different samples of the non-Antarctic Murchison meteorite (the most abundant and well-studied CM2): 1) Murchison USNM 54512, and 2) Murchison from the Chicago Field Museum of Natural History. A primary interest of the analyses is Iva enantiomeric abundances.

Meteorites were prepared for analysis by hot-water extraction, acid-vapor hydrolysis, desalting, and pre-column derivatization with *o*-pthaldialdehyde/N-acetyl-L-cysteine (OPA/NAC) [2]. OPA/NAC is a chiral tagging agent that enhances analytical specificity for primary amino groups and provides chromatographic separation of primary amines with chiral centers. Samples will be analyzed for amino acids using ultraperformance liquid chromatography with fluorescence detection, and time-of-flight mass spectrometry. Aliquots of the bulk powders have been analyzed for their H-C-N abundances and isotopes to determine their relative degree of alteration [5].

The experiments performed here will evaluate the inference that aqueous alteration is required for the amplification of small, initial L-excesses of amino acids, namely Iva, in carbonaceous chondrites. The results will provide new insights into the formation of L-excesses of chiral amino acids in CM and CR meteorites that have experienced limited aqueous alteration. This research could have implications regarding L-amino acid excesses that might exist in pristine sample material returned from the asteroids Ryugu (JAXA's Hayabusa2 mission) and Bennu (NASA's OSIRIS-REx mission).

References

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