

SULFUR AND HYDROGEN ISOTOPE ANOMALIES IN ORGANIC COMPOUNDS FROM THE MURCHISON METEORITE

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Isotopic measurements have been made on organic sulfur and phosphorus compounds recently discovered in the Murchison meteorite. Carbon, hydrogen and sulfur measurements were performed on individual members of the organic sulfur compounds, alkyl sulfonates; and carbon and hydrogen measurements were made on bulk alkyl phosphonates. Cooper and Chang (1995) reported the first carbon isotopic measurements of Murchison organic sulfonates, providing insight into the potential synthetic mechanisms of these and, possibly, other organic species. Hydrogen isotopic measurements of the sulfonates now reveal deuterium excesses ranging from +660 to +2730 ‰. The deuterium enrichments indicate formation of the hydrocarbon portion of these compounds in a low temperature astrophysical environment consistent with that of dense molecular clouds. Measurements of the sulfur isotopes provide further constraints on the origin and mechanism of formation of these organic molecules.

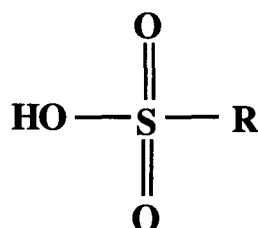
Recently, there has been growing documentation of sulfur isotopic anomalies in meteoritic material. Thiemens and Jackson (1995) have shown that some bulk ureilites possess excess ³³S and Thiemens et al. (1994) have reported excess ³³S in an oldhamite separate from the Norton County meteorite. Rees and Thode (1977) reported a large ³³S excess in an Allende acid residue, however, attempts to verify this measurements have been unsuccessful, possibly due to the heterogeneous nature of the carrier phase. With the recognition that sulfur isotopes may reflect chemistry in the protosolar nebula or the precursor molecular cloud, identification of potential carriers is of considerable interest.

In the present study, the stable isotopes of sulfur were measured in methane sulfonic acid extracted from the Murchison meteorite. The isotopic composition was found to be: $\delta^{33}\text{S} = 2.48 \text{ ‰}$, $\delta^{34}\text{S} = 2.49 \text{ ‰}$ and $\delta^{36}\text{S} = 6.76 \text{ ‰}$. Based upon analysis of more than 60 meteoritic and numerous terrestrial samples, the mass fractionation lines are defined by $^{33}\Delta = \delta^{33}\text{S} - 0.50 \delta^{34}\text{S}$ and $^{36}\Delta = \delta^{36}\text{S} - 1.97 \delta^{34}\text{S}$. From these relationships a $^{33}\Delta = 1.24 \text{ ‰}$ and a $^{36}\Delta = 0.89 \text{ ‰}$ are observed. These anomalies, particularly the $^{33}\Delta$, lie well outside the range of analytical uncertainty. They are the largest observed in any meteoritic component and the first found in an organosulfur compound.

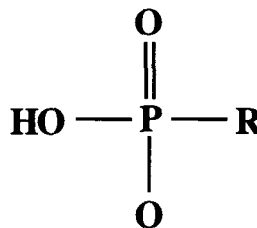
As discussed by Thiemens and Jackson (1995), due to it's position on the

periodic chart, sulfur undergoes chemically induced mass independent isotopic fractionations as does oxygen. Experiments by Mauersberger et al. (1993) show that in such processes, the magnitude of fractionation for the different isotopically substituted species varies with mass and angular momentum; thus, anomalies are expected for both ^{33}S and ^{36}S , but not necessarily of the same magnitude. Laboratory experiments have also confirmed that chemically produced, mass independent fractionations are mediated by molecular symmetry factors (Bains-Sahota and Thiemens, 1989). A chemical source of fractionation requires that the sulfur isotopic anomaly was established in the gas phase, probably in reactions involving symmetric CS_2 . The discovery of an anomalous sulfur isotopic composition in a specific molecule containing excess deuterium is an important advance in the understanding of the cosmochemistry of sulfur. This evidence suggests that methanesulfonic acid was synthesized by interstellar processes. Further measurements and details of possible synthesis and fractionation mechanisms will be presented.

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sulfonates



phosponates

