Mass Independent Fractionation of Titanium Isotopes

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Some of the isotopic anomalies in meteorite components are interpreted as due to nuclear processes, i.e. ascribed to the survival in the protoplanetary disk (PPD) of grains originating from the envelope of dying stars(1). Others could be due to mass-independent reactions taking place in the disk, as suggested by the synthesis of ozone which yields a mass independent fractionation (MIF) of oxygen isotopes mimicking the slope 1 in the 3 O isotope plot for Solar system objects(2). The origin of this physical effect in ozone is still debated(3,4) and its possible extension to the PPD remains an open question. Self-shielding of UV light by CO gas has also been proposed. We show experimentally that large MIF effects for Ti isotopes can be produced in the lab. These MIF are similar to those found in meteoritic CAIs(5), and likely result from the same effect than for O isotopes in O_3(6).

Organic matter was deposited in a plasma consisting of a gaseous mixture of $TiCl_4$ and hydrocarbons transferred by continuous N_2 flow in the RF discharge chamber(7). Large MIF effects (up to 1000‰) are observed for all $^{m}Ti/^{48}Ti$ isotope ratios (m standing for masses 46, 47, 49 and 50) in organic deposits. The effect is attributed to the stabilization of metastable molecules formed during the $Ti/TiCl_x$ isotope exchange at the surface of micron-sized grains condensed form the gas(3). Calculation of MIF effects on Ti isotopes, also proposed to account for the O isotope anomaly in O_3(8), reproduces the experimental Ti isotope pattern defined by the $^{46,47,49,50}Ti/^{48}Ti$ ratios. This effect could tentatively be extended to high temperature gases where Ti/TiO_x isotope exchanges take place along with the formation of oxide grains.

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