HETEROGENEOUS CHEMISTRY AND THE MASS INDEPENDENT DISTRIBUTION OF OXYGEN ISOTOPES IN THE PARENT MOLECULAR CLOUD AND SOLAR SYSTEM

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Introduction: The distribution of oxygen isotopes in the Solar System is unusual, with the Sun and CAIs being relatively ^{16}O enriched compared to the terrestrial planets (Earth and Mars), and asteroids. This distribution of oxygen isotopes in the Solar System cannot be explained via conventional mass-dependent processes [1].

Photochemical mechanisms such as the self-shielding of CO by VUV radiation [2] offer a plausible mechanism for generating mass-independent oxygen isotopic reservoirs in the early-solar system [3] or in the parent molecular cloud [4]. However, laboratory tests of self-shielding of CO have not confirmed the general constraint that the mechanism responsible for the anomalous distribution of oxygen in the Solar System produce a slope~1[5]. Recently, it was proposed that the isotopic composition of presolar silicate dust, which can constitute up to 30% of all oxygen in the solar system, was ^{16}O depleted compared to the gas phase oxygen [6].

Certain photochemical processes that occur in Earth's atmosphere are well-known to produce mass-independently fractionated reservoirs, with the formation of ozone ($O+O_2+M \rightarrow O_3$, $\Delta^{17}O$~25-35‰) being the archetype. Furthermore, the isotopic anomaly associated with O_3 is transferred to other compounds such as nitrate (NO_3) and sulfate (SO_4) via chemical reactions that occur on aerosol particles (heterogeneous chemistry) [7].

Astrochemical models of H_2O formation in dense molecular clouds (DMCs) suggest that H_2O is produced on the surfaces of interstellar dust grains and that this water may carry a significant fraction (up to 60%) of the oxygen reservoir in these environments. Furthermore, it is widely believed that H_2O formation on the surface of cold interstellar dust grains occurs via a linear combination of O_3 and/or HO_2 precursors on the surface of interstellar dust grains [8].

I recently proposed that the H_2O-ice mantles of interstellar dust grains in DMC environments may be isotopically anomalous ($\Delta^{17}O \neq 0$) with respect to the gas-phase oxygen reservoir due to their formation from isotopically anomalous O_3 and/or HO_2 precursors on the surface of interstellar dust grains. If true, then this implies that H_2O present in the parent molecular cloud had at least two mass-independently fractionated reservoirs [9].

A major assumption of this model of the oxygen isotopic composition of the Solar System is whether O_3 and/or HO_2 formed on the surface of dust grains is mass-independently fractionated. I will describe an experiment to study the isotopic composition of surface formed O_3 at 10K that is currently underway.

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