Isotopically anomalous organic grains in meteorites and comets

SCOTT MESSENGER[1], KEIKO NAKAMURA-MESSENGER[1,2], and LINDSAY P. KELLER[1]

[1]*Robert M. Walker Laboratory for Space Science, ARES, NASA JSC, 2101 NASA parkway, Houston TX. scott.r.messenger@nasa.gov*

[2]*ESCG/JACOBS Engineering, Houston TX 77058*

Organic matter in primitive meteorites and interplanetary dust particles (IDPs) is often enriched in D/H and $^{15}N/^{14}N$ relative to terrestrial values [1-3] due to preservation of interstellar cold molecular cloud material [1]. Some meteorites and IDPs contain µm-size inclusions with extreme H and N isotopic anomalies [2-4], possibly due to preserved primordial organic grains. In the Tagish Lake meteorite the main carriers of these anomalies are sub-µm, hollow organic globules [5]. Similar objects have been observed in extracts of other chondritic meteorites, but little is known about their N and H isotopic compositions [6-8].

We have measured the isotopic compositions of organic globules in the Bells CM2 carbonaceous chondrite meteorite, NASA Stardust (comet Wild-2) mission samples, and in ‘cometary’ IDPs. High-resolution TEM imaging and EELS show that the globules consist of structurally amorphous carbon lacking long range order or development of graphite-like domains. In almost all cases the organic globules have strong enrichments in D/H and $^{15}N/^{14}N$. These isotopic anomalies likely resulted from low temperature (~10 K) chemical reactions in a cold molecular cloud or at the outer regions of the protosolar nebula. These results show that microscopic organic grains were widespread constituents of the protoplanetary disk. However, few of the organic globules contain internal mineral grains as predicted by some models of interstellar dust. We propose that these organic globules formed by condensation of isotopically anomalous organic molecules onto preexisting ice grains that were subsequently photochemically processed by UV radiation.

Keywords: organic matter, comets, interstellar dust, interplanetary dust

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