Isotopic measurements of the Wild2 cometary dust.

Motoo Ito[1]; Scott Messenger[1]

[1] NASA JSC, ARES

Introduction: Extraterrestrial materials available for cosmochemical studies have come from the inner solar system, such as meteorites and the lunar samples. The STARDUST mission has, for the first time, returned cometary materials from Wild2 for analyses in terrestrial laboratories. Launched in 1999, the Stardust spacecraft encountered comet P81/Wild 2 in January 2004, passing through the dust cloud surrounding the cometary nucleus. These were successfully returned to Earth in January 2006. In this study, we have measured isotopic ratios of H, C, N and O in several cometary dust grains. These isotopic signatures vary widely in different primitive solar system materials and their compositions often can be linked to distinct astrophysical environments and/or processes.

Experimental: The STARDUST samples are relatively small, typically was less than few microns. The NanoSIMS is the most favorable tool for a detailed isotopic measurement for samples having an isotopically heterogeneity on a sub-micron scale level (e.g. Messenger et al., 2005). The C, N and O isotopic compositions of the several cometary dust samples were determined with the Johnson Space Center NanoSIMS 50L ion microprobe following the non-destructive analyses, i.e. TEM, XANES and SEM. An 8 keV Cs+ primary ion beam with a diameter of about 100 nm was used. The primary beam current was 1.0 pA. The measured area ranged from 8 x 8 to 15 x 15 micrometer by rastering. Secondary ion images of 12C-, 13C-, 12C14N-, 12C15N-, 16O-, 17O-, and 18O- were acquired simultaneously in multi-detection system with EM detectors at a high mass resolution of 9500 that is sufficient to separate interfering 16OH to 17O. A normal-incident electron gun was utilized for charge compensation of the analysis area. Nearby grains of 1-hydroxybenzotriazole hydrate, USGS24 graphite, and San Carlos olivine with known selective isotopic ratios were measured as N, C, and O isotopic standards, respectively.

Results: From the isotopic measurements of H, C, N and O by the Preliminary Examination (PE) isotope team, we found several important issues as follows (McKeegan et al., 2006). (1) Most of the samples have H, C, N, and O isotopic compositions similar to solar system average. (2) A refractory mineral assemblage, named Inti, was found to have CAI-like mineralogy together with an 16O-rich isotopic composition. The degree of 16O-enrichment was similar to that of the CAIs minerals from carbonaceous chondrites. The O isotopic data suggest the comet contains materials formed at high temperatures near the Sun, suggesting massive recycling and long scale transport of material in the early solar system. (3) Only one presolar grain was identified during PE, marked by a highly elevated 17O/16O ratio. (4) We identified submicrometer carbon-rich regions with 15N-enrichments, showing that cometary organic matter was collected and that these materials origins could be traced to low temperature chemical reactions.

References: McKeegan K. D. et al. (2006) Science 314, 1724. Messenger S. et al. (2005) Nature 309, 737.