
Introduction: Presolar grains, which formed in the stars existed before the solar system, have given us valuable information about stellar nucleosynthesis and the origin of the solar system [1]. In these years, presolar silicates have been discovered in interplanetary dust particles (IDPs) and chondrites, which indicates that presolar grains existed more ubiquitously in the early solar nebula than previously considered [2,3]. As reported before, presolar silicates were discovered also in Antarctic micrometeorites (AMMs), using NanoSIMS [4,5]. This discovery tells us that parent bodies of the AMMs preserve a primary feature since their accretions in the early solar nebula. Here we review the discovered presolar silicates and discuss about their stellar origins.

Samples and Methods: Seven AMMs from Cap Prudhomme in West Antarctica (AWU01-3, -9, -11, -14, -16, -24 and -25) and five from Tottuki Point in East Antarctica (T98-G6, -H3, -H5, -NF2 and TT54B397) were used for this study [6-8]. They were analyzed by a scanning electron microscope equipped with energy dispersive X-ray spectrometry (SEM-EDS) and identified as AMMs based on their EDS spectra, which showed chondritic chemical compositions. The former seven AMMs were divided into two pieces; one was used for ion microprobe measurement and the other for noble gas measurement [9,10]. All AMMs except for one (TT54B397) were pressed into Au foils for the ion microprobe and NanoSIMS measurements. For NanoSIMS measurement, ~1nA primary Cs+ ions of Ø100nm in beam size were accelerated with 16kV to raster over the samples. Extracted negative ions were accelerated with 8kV to go through double-focusing mass spectrometer and detected by a multiple collectors system. The mass resolving power was ~6,000. 12C, 13C, 16O, 17O, and 18O (lately 26Si and 24Mg16O instead of 12C and 16O) were simultaneously detected by five electron multipliers. The AMMs were analyzed in isotopic imaging mode with repeated scans over a 20x20µm² area for each analysis.

Results: In total, a ~37000µm² surface area of twelve AMMs was analyzed with NanoSIMS. Six presolar grains were discovered in three AMMs, AWU01-16, T98-H5, and TT54B397, based on their oxygen isotopic anomaly (Fig. 1). Three grains, T98-H5 grain 1-P1, 5-P1 and 15-P1 fall into the composition of Group 1 presolar oxide grains [11]. Although AWU01-16 grain C3-P1 also plot on the Group 1 composition, it cannot be classified as any Group of presolar oxide grains, because its original isotopic composition may be higher than the Group 1 compositions, which is estimated based on the fact that the surrounding area shows gradation in oxygen isotopic ratio and the possibility that the isotopic gradation results from a diffusion of the presolar isotopic oxygen from the grain C3-P1. TT54B397 grain 2-P2 and 2-P2 plot on the region of Group 4 presolar oxide grains. The sizes of these six grains ranges ~1µm to 200nm. All the presolar grains except for T98-H5 grain 15-P1 were also analyzed by the SEM-EDS to be identified as silicates.

Discussion: The three Group 1 presolar silicates are supposed to have formed in the stellar outflow wind from low-mass, high-metallicity red giants or asymptotic giant branch (AGB) stars [11]. For Group 1 presolar oxide grains, their stellar origins have been consistently predicted by theoretical studies, related their oxygen isotopic compositions with masses and metallicities of the RG or AGB stars [11]. As three Group 1 silicates plot on the oxygen three isotope diagram of red giants and AGB stars by theoretical prediction, T98-H5 grain 1-P1, 5-P1 and 15-P1, and TT54B397 grain 2P-1 and 2P-2 were analyzed also for Si isotopes, but no obvious isotopic anomaly out of the range of the solar isotopic composition was observed.

For Group 4 presolar oxide grains, their stellar sources are still under discussion. One possible source is 18O produced in the He burning shell of AGB stars might have been dredged up in the early
thermal pulse [11]. Second possibility is that AGB stars with higher metallicity (subsequently $^{18}$O-enriched) than the sun may have formed Group 4 grains. The third is Type II supernovae (SNII), which could have generated $^{18}$O-rich oxide grains [2]. Each possible source has inconsistency, thus their stellar sources are still unclear. In this study, two Group 4 presolar silicates were also analyzed for Si isotopes, however, no obvious anomaly was detected. In contrast, type X SiC grains that are consistently supposed to originate from SNII show $^{28}$Si enrichments [1]. This may indicate they would not originate from SNII, although SiC and oxide grains should have condensed at different regions in SNII.

Because AWU01-16 grain C3-P1 might originally have much higher $^{17}$O/$^{16}$O and $^{18}$O/$^{16}$O ratios than other Group 1 presolar oxide grains, its plausible stellar source cannot be proposed so far. If all excesses $^{17}$O and $^{18}$O in surrounding regions could have been diffused from the grain, its original $^{17}$O/$^{16}$O and $^{18}$O/$^{16}$O ratios are calculated to be $1.5\times10^{-2}$ and $5.6\times10^{-3}$, respectively. Wolf-Rayet stars, the first dredge-up of very low metallicity AGB stars, and novae could have reached such high $^{17}$O/$^{16}$O ratios, although they should have extreme $^{18}$O depletions [12-14].