Supernova mixing models reproducing isotopic ratios of graphite grains from supernovae

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Low density graphite grains are considered to be originating from supernovae. They have excesses of 28Si and small 16O/18O ratios compared with the solar-system composition. Some of them also indicate evidence for the original presence of a short lived isotope 44Ti in their Ca isotopic composition. These isotopic signatures strongly support that these grains are originating from supernovae because 28Si and 44Ti are mainly produced through explosive nucleosynthesis in supernovae and 18O is produced during He-burning stage of massive star evolution. However, quantitative comparison between isotopic ratios of the grains and those evaluated by supernova nucleosynthesis models has not been carried out well. This is because large-scale inhomogeneous mixing in supernova explosions is required to reproduce isotopic ratios of individual single grains and it is difficult to find the mixture compositions reproducing the isotopic ratios. We investigate the mixing ratios and the compositions of the supernova mixtures reproducing isotopic ratios of individual low density graphite grains.

We pick up seven isotopic ratios, 12C/13C, 14N/15N, 16O/17O, 16O/18O, 26Al/27Al, 29Si/28Si, and 30Si/28Si for 26 low density graphite grains. For three of them, we also adopt 44Ti/48Ti. For supernova nucleosynthesis models, we use the composition distributions of the supernova ejecta of 3.3, 4, 6, and 8 solar-mass He star models, corresponding to 13, 15, 20, and 25 solar-mass stars at the zero-age main sequence. We divide the supernova ejecta into seven layers, i.e., the Ni, Si/S, O/Si, O/Ne, C/O, He/C, and He/N layers. Then, we seek the mixing ratios of the mixtures reproducing isotopic ratios of each grain as many as possible.

We reproduce six isotopic ratios by mixtures at most for 20 low density graphite grains. We divide the mixtures reproducing 6 isotopic ratios into three groups on reproduced isotopic ratios; (12C/13C, 14N/15N, 16O/17O, 16O/18O, 29Si/28Si, 30Si/28Si), (12C/13C, 16O/17O, 16O/18O, 26Al/27Al, 29Si/28Si, 30Si/28Si), and (14N/15N, 16O/17O, 16O/18O, 26Al/27Al, 29Si/28Si, 30Si/28Si). We find that the characteristics of the mixing ratios of the mixtures belonging to a same group are similar. In the case of KE3a-322, in which 44Ti/48Ti was measured, the isotopic ratios of (12C/13C, 16O/17O, 16O/18O, 29Si/28Si, 30Si/28Si,44Ti/48Ti) are reproduced. We will discuss the characteristics of mixing ratios and chemical compositions of the mixing ratios and chemical compositions of the mixtures in the three groups.