Observation of Enstatite Whiskers in Fine-grained Rims in the Carbonaceous Chondrite ALH A77307

*Yasuhisa Shirota[1], Masahiro YASUTAKE[1], Satomi Enju[1], Akira Tsuchiyama[1]

1. Division of Earth and Planet, Science, Kyoto University

Introduction Chondritic porous -interplanetary dust particles (CP-IDPs) are material that are suggested to be originated from comets and to be one of the most primitive materials in the solar system (Bradley et al., 1983). CP-IDPs include enstatite ($MgSiO_3$) whiskers. They are thought to be formed by condensation in the solar nebula (Bradley et al., 1983).

Primitive carbonaceous chondrites are affected by little aqueous alteration. Recent studies have discovered enstatite whiskers in matrices in primitive carbonaceous chondrites (Vaccaro et al., 2017; Matsumoto et al., 2018). If such crystals have similar formation processes to those of enstatite whiskers in CP-IDPs, it will constrain the formation processes of not only asteroids but also CP-IDPs. However, only a few enstatite whiskers are observed in carbonaceous chondrites. Therefore, it is not certain whether or not enstatite whiskers are common in carbonaceous chondrites and have same formation processes in CP-IDP.

We conducted a detail petrological observation of matrix in ALH A77307 (CO3.0) to understand distribution of whisker-like enstatite crystals using a scanning electron microscopy (SEM) and to constrain the formation process using a transmission electron microscopy (TEM).

Sample and Methods We observed one of the most primitive CO chondrites ALH A77307. Vaccaro et al. (2017) reported whisker-like enstatite crystals in ALH A77307. SEM/EDS analysis was carried out with an FE-SEM (JEOL JSM-7001F, Kyoto University, Hitachi HT SU6600, ISAS, JAXA) operating at 100 pA probe current and 8 kV accelerating voltage. A TEM thin section including one whisker was extracted using focus ion beam (FIB) (FEI, Helios NanoLab 3G, Kyoto University). TEM analysis was carried out with a (S)TEM/EDS (JEOL JEM-2100T, Kyoto University) operating at 200 kV accelerating voltage.

Result and Discussion We observed fine-grained rims around three chondrules. These rims consist mainly of amorphous silicate, olivine, pyroxene, and Fe,Ni metal, and similar to primitive matrix. The whisker-like enstatite crystals occur in all regions observed and the total number of whiskers found are 12. The maximum size of the whisker is 11.91 μm in length and 0.27 μm in width. We classified whiskers based on criterion the aspect ratio, p, by Bradley et al. (1983). The whiskers are classified as 4 Rods (p>20) and 8 Ribbons (p<20). The abundance of whiskers is >40 mm^{-2}, suggesting that whisker-like enstatite is common in chondrule rims in primitive carbonaceous chondrites although the abundance in CP-IDPs is higher. The aspect ratios are similar to those of enstatite whisker in CP-IDPs. In contrast to enstatite whiskers in CP-IDPs, some whiskers are curved and/or broken. It may be the result of deformation during accumulation on the parent body.

We have observed one ribbon crystal (length 1.21 μm, width 0.16 μm) using TEM. The ribbon crystal was orthoenstatite elongated along [001] axis based on electron diffraction patterns. Three dimensionally, this crystal is thought to be a columnar crystal elongated along [001] or a plate crystal with flattened (010) plane. From this results, this crystal is thought to be a platelet crystal formed by condensation in the solar nebula like enstatite whiskers in CP-IDPs (Bradley et al., 1983) or crystal formed by annealing of

amorphous silicate (Brearley, 1993). To constrain more detail formation process of the whisker-like material in carbonaceous chondrites, mineralogical investigation of whisker-like material, especially rod crystals is needed.

[1] Vaccaro E. (2017) PhD thesis. The Open University. [2] Bradley J. P. et al. (1983) Nature. 301, 473-477. [3] Matsumoto M. et al. (2018) 81st Annual Meeting of the Meteoritical Society [4] Brearley. (1993) Geochim. Cosmochim. Acta 57, 1521-1550

Keywords: Enstatite whisker, Primitive Carbonaceous Chondrite

