Fine Particles and their origin in the Hayabusa2 clean chamber of the Extraterrestrial Sample Curation Center at JAXA

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Introduction: The samples returned from C-type asteroid 162173 Ryugu are stored and handled in a pure nitrogen gas environment in the clean chamber (CC) in the Extraterrestrial Sample Curation Center (ESCuC) in Sagamihara to prevent alteration and contamination by Earth's atmosphere and surrounding materials [1]. The cleanliness of the samples in the CC has been controlled by restricting the use of materials of tools used in the CC, developing cleaning methods for them, and monitoring the environment. For example, humidity, oxygen, carbon dioxide, and methane levels are constantly monitored by Atmospheric pressure ionization-mass spectrometry (API-MS), which is directly connected to the CCs. Sampling the surface contaminants by placing quartz glass petri dishes in CC and following organic and inorganic mass spectrometry are also conducted several times a year (e.g. [2]). On the other hand, environmental monitoring focusing on the fine particles themselves, which are several tens to several hundred micrometers in size, has not been conducted systematically. In this study, we investigate fine particles in the CC where the samples returned from asteroid Ryugu are stored.

Methods: We collected particles attached to several Facility to Facility Transfer Containers (FFTCs) from CC4-1, which is utilized to store Ryugu samples. Samples to be allocated for other research institutes are packed in FFTCs and they are stored inside the CC until the timing of allocation. In this process, FFTCs are touched by gloves and other tools equipped with the CCs. The FFTCs used in this study are the ones stored in the CC for about half a year. We put the carbon tape to the outer wall surface of the FFTC at the clean room immediately after it was taken out from the CC, and the sticking particles were sampled. This method allows us to indirectly identify the particle present in the CC without contaminating the CC. The collected particles were observed by FE-SEM (SU6600: Hitachi High-Tech) equipped with an EDS detector. Some of them were mineralogically identified by Raman spectrophotometers (NRS-5100: JASCO). In addition, Ryugu samples (A0308 and C0054) were also observed to investigate the contamination on Ryugu particles. These samples were selected for publicity activities, and before loaning them to various institutions for display, basic data have been obtained by non-destructive analysis to explain the samples.

Results and Discussions: Most of the recovered particles from the surface of the FFTCs were several tens of micrometers in size, which were identified by analysis as aluminum alloy, SUS304, and silicates. Aluminum alloy and SUS304 are the main components of the CC and the handling tools used within CC. These results suggest that dust particles generated by friction between CC components (and tools) are deposited on the surface of the CC and stick to the gloves due to static electricity. Most of the silicates in recovered particles were identified as talc, chlorite, and wollastonite, and those materials are known as additives to Viton rubber in the manufacturing process. Fine particles originating from Viton gloves are also possibly generated by friction between gloves and between a glove and metallic tools.

SEM observations of Ryugu samples revealed that tiny fragments (tens of micrometers) of sapphire glass and SUS304 are attached to the sample surface. Sapphire glasses were observed on both samples (A0308 and C0054), and SUS304 fragments were observed only on C0054. Sapphire glasses were not observed as particles in the CC in this study. However, it is a material of the sample container and potentially exists as fine particles in the CC. C0054 was in contact with the CC floor during the initial description (classified as Class 2). Therefore, it is possible that the SUS304 particles, which were present on the CC floor, sticking to Ryugu samples.

Our result shows that even Class 2 Ryugu samples did not show a record of significant contamination. In addition, there is no previous study reporting these kinds of fine particles on the Ryugu samples except for this study. This is because the following measures were taken to reduce the possibility of contamination during sample handling: (1) Ryugu particles are kept in a covered container except during handling and analysis, (2) only the sample container (sapphire glass) and sample handling tools (vacuum tweezers, spatulas) are used to touch the Ryugu particles, and (3) The glove does not pass over the top surface of the sample during handling. We will establish a protocol for monitoring these particles on the CC surface and investigate better ways to reduce the frequency of particle generation. As the fine particles observed in this study are potential contaminants to the sample, it is important especially for samples classified as Class2 which are experienced to touch the surface of the CC and/or tools in the CC to investigate the influence on the sample analysis.

References

[1] Yada et al. Earth, Planets and Space (2023). [2] Hitomi et al. JAXA Special Publication (2023).