Current Status of Martian Moons eXploration (MMX) Contamination Control and Curation Activity

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Martian Moons eXploration (MMX) is a sample return mission from the Martian moon Phobos. The MMX spacecraft is scheduled to launch in 2026 and return to Earth in 2031. The main science goals of MMX are “to reveal the origin of the Martian moons and make progress in the understanding of planetary system formation and material transport in the solar system, and to observe processes that impact the circumplanetary and surface environments of Mars” [1]. MMX has two sampling systems: coring (C)-sampler and pneumatic (P)-sampler and plans to bring back >10 g of Phobos sample. The retuned sample in the sample capsule will be transferred to the curation facility in ISAS/JAXA for sample curation and subsequent sample analysis [2, 3].

Contamination control of the sample return mission requires special care to prevent terrestrial contamination to the spacecraft, which would ruin the scientific value of the returned sample. Retaining the pristineness of the retuned sample is an important task of the MMX Curation and Sampler Science teams. The basis of the contamination control is (1) to minimize and understand the nature and amount of contaminants, (2) to perform contamination assessment and evaluate the effect of contaminants in the spacecraft on the retuned sample, (3) to employ a contamination knowledge (CK) material coupon in the spacecraft to identify the contaminants in the returned samples. In the MMX contamination control plan, the allowable contamination level for each contaminant is carefully defined. They are mostly set to be 1/1000 of the expected amount of each material in the returned sample and are divided into two main categories: organic and inorganic. The allowable atmospheric leakage rate to the sample container is also defined. The allowable contamination level of the organic materials is based on the composition of carbonaceous chondrites. The target contaminants are amino acids, aliphatic and aromatic hydrocarbons, carboxylic acids, etc. In case of the inorganic materials, the target contaminants are important elements to permit distinguishing the origin of the Martian moon by nucleosynthetic isotope anomalies (Cr, Ti, and Mo) and to reveal the evolution of the Martian moon by chronology (Hf, W, U, Pb, Rb, Sr, Sm, and Nd).

The key instrument of contamination control in the sample return mission is the sampler system. The C-sampler has been developed by JAXA and the P-sampler was provided by Honeybee/NASA. In MMX, materials used in the two samplers (C- and P- sampler) were carefully selected to avoid potential contamination from the design stage of the system. The individual parts of the C-sampler FM (Flight Model) were thoroughly cleaned at the curation facility in ISAS/JAXA by the full-course cleaning procedure, which is an ultrasonic cleaning with organic solvents and ultrapure water in several steps [4, 5]. The equivalent level of cleaning was also carried out on the P-Samper FM as well by Honeybee Robotics in the USA. Now, MMX is in the critical phase for contamination control called ATLO: Assembly, Test, and Launch Operations. During the ATLO phase, sampler FM is constantly purged with nitrogen gas and maintained at positive pressure to prevent environmental contamination. The surrounding environments of the sampler FM are also simultaneously monitored using the CK Monitoring Coupon Set, which consists of several witness materials such as a glass petri dish, sapphire glass disk, and carbon adhesive tape (Figure 1) [6, 7]. The detailed environmental assessment of each clean room used for the assembly and test of the sampler FM has also been conducted. This assessment includes microbial analysis, which was performed for OSIRIS-REx [8, 9].

Regarding the sample recovery and sample curation, we have started the designing of Sample Container Disassembling Instrument for the sample recovery from the sample container and the MMX curation chamber for sample curation. The curation protocol for the Phobos returned sample has also been discussed by the MMX Sample Analysis Working Team (SAWT). The MMX curation protocol consists of three phases: (1) quick analysis, (2) pre-basic characterization, and (3) basic characterization. (1) is extraction of the sample gas from the sample container and analysis by mass spectrometry, (2) is observation in bulk level, and (3) is observation in grain level and allocation of the sample aliquots [3]. In parallel with the curation protocol, the returned sample undergoes preliminary examination for scientific investigations to achieve science goals [2]. In addition, the CK witness plates made of sapphire glass are on board the sampler system. The CK witness plates will be recovered from the sampler system and analyzed by SAWT for the assessment of in-flight contamination.

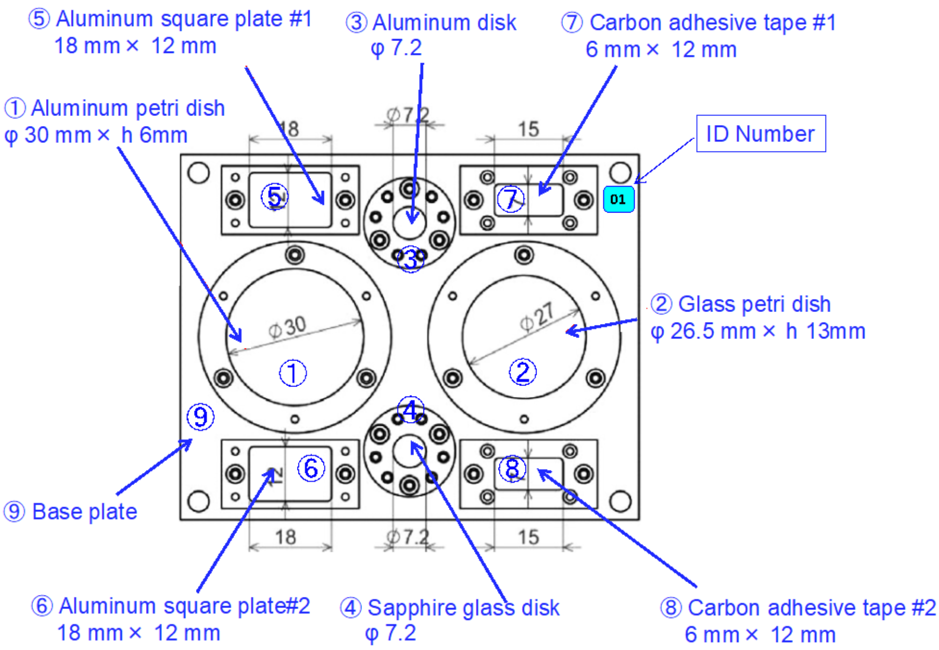

Figure 1. CK Monitoring Coupon Set for environmental monitoring. (Modified from Sawada et al., 2017 [6])

References

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