Contamination monitoring of the OSIRIS-REx ISO5 asteroid sample cleanroom

K. Righter[1], N.G. Lunning[1], K. Allums[2], M. Calaway[2], M. Rodriguez[2], R. Funk[2], L. Yan[2], T. Cala[2], J. McQuillan[2], A. Regberg[1], R. Davis[2], E.L. Berger[1,2], A. Burton[1], A. DeCuba[2], J. Ponce[2]
[1]*Astromaterials Curation, NASA Johnson Space Center, 2101 NASA Pkwy, Houston, TX 77058 USA*
[2]*Jacobs/JETS, Astromaterials Curation, NASA Johnson Space Center, 2101 NASA Pkwy, Houston, TX 77058 USA*

The OSIRIS-REx mission to asteroid Bennu successfully collected hundreds of grams of asteroid regolith in October 2020 [1]. The spacecraft departed Bennu in May 2021 for Earth return and will release the sample canister to be recovered in Utah in September 2023 [2]. Samples will be transported to the curation facility at NASA Johnson Space Center, where an ISO5 equivalent cleanroom has been designed in 2017 and completed in 2021. Aspects of the design and material selection for the cleanroom and its supporting facilities (air handling system, cleanroom floors and walls, filters, paints, etc.) were optimized to minimize effects of organic and inorganic contaminants and offgassing [3]. Since its completion, the lab has been carefully monitored to understand and establish a baseline with respect to multiple environmental aspects – measurement of particle counts, deploying Si wafer witness plates for organic and inorganic contaminants, deploying aluminum foils for a focus on organics with JSC in-house expertise, gas samples, and regular microbial and fungal measurements on selected surfaces and air samples in the cleanroom. This contribution will report on nearly one year of monitoring and highlight several specific aspects that have led to a better understanding of the new cleanroom environment.

<u>Particle counts:</u> particle counts are taken weekly in 6 different locations in the cleanroom, in high traffic and low traffic areas and distributed representatively throughout the lab. The particle counts have remained well within the ISO5 rating of the cleanroom and have only exhibited higher counts (but still well within the ISO5 limits) in cases where there has been unusual activity. One such example is the repair of fan filter units (FFUs) in September 2022. Careful coordination of particle count measurements during servicing of the FFUs led to a better understanding of how the counts are affected when ceiling tiles were removed and FFUs were adjusted, as well as providing baseline information on how quickly the cleanroom environment is restored to background levels after the cease of repair activities. Monitoring of such off nominal events will be done in the future as opportunities arise.

<u>Si wafer witness plates (Balazs, Inc):</u> Large area Si witness plates have been deployed several times over this period, with the goal of detecting possible organic and inorganic contaminants. For inorganic and organics, 8-inch polished semiconductor silicon witness wafers were exposed to the laboratory air for 24 hours each. After exposure, the witness plate for organics was sent to Balazs for Thermal Desorption Gas Chromatography Mass Spectroscopy (TD-GC-MS), yielding results for organic compounds from C6 to C28 (with limit of 0.1 ng/cm^2). The wafer for inorganics was analyzed by vapor phase decomposition inductively coupled plasma mass spectrometry (VPD-ICP-MS) which yielded data for 35 elements of interest (Al, As, B, Ba, Be, Ca, Cd, Ce, Co, Cr, Cu, Fe, Ga, Ge, Hf, In, K, La, Li, Mg, Mn, Mo, Na, Ni, Pb, Sb, Sn, Sr, Ta, Ti, W, V, Y, Zn, and Zr). Analyses for organics have yielded very low concentrations in general – lower than similar monitoring of the ISO4 equivalent Genesis lab, for example across a decade of monitoring. The few and very low species detected in early testing included TXIB (a plasticizer used in urethane elastomers and PVC piping), triacetin (a common plasticizer and solvent, 2-(2-butoxyethoxy) ethanol and texanol (used as a solvent for and in paints). These species have not been detected in measurementsts made in late 2022. Analyses for inorganics that were above detection limits included Al (from wall and ceiling struts), B (from the borosilicate glass in the Fan Filter Unit (FFU) ULPA filters), Cu, Sn, and Zn (could be from electrical or electrical conduit), and Fe (could be from stainless steel or electrical conduit). Continued monitoring of these elements will allow identification of problematic sources, but the levels detected are lower than other NASA curation labs, which is a testament to the careful selection of materials during the design and construction phase.

<u>Gas sampling (Balazs and JSC):</u> Cleanroom air samples were analyzed using two different approaches. Volatile organics in air were sampled with an adsorbent tube connected to a pump (100 mL/min.) for 6 hours. After exposure, the adsorbent tube was sent to Balazs for TD-GC-MS analyses for a wide range of hydrocarbons and volatile organic compounds (limit of 0.1 ng/L). A NASA-JSC based collection of 450 ml gas samples was followed by GC-MS. Both approaches have demonstrated very low levels of organics in general, with most species either (a) below detection limits, or (b) expected but present at very low levels (e.g., isopropanol, toluene, and xylene).

Al foils deployment: In addition to the Si wafers deployed for analysis by Balazs, the curation staff has also deployed monthly sets of aluminum foil witnesses that are being archived. These will also be analyzed using JSC in-house analytical techniques for amino acids. Results are not yet available at the time of writing of this abstract.

Microbial and fungal monitoring: Terrestrial contamination of asteroid or meteorite samples can lead to biological degradation, something we wish to avoid during short- and long-term curation. Swabs and sampling for microbial and fungal analysis have been collected regularly on various surfaces within the OSIRIS-REx cleanroom (as well as many other JSC cleanrooms [4]). Microbiological air samples were also collected by passing air through an electret filter at 200 L/min. Results of these analyses show very low levels in general, and decrease with time in any given area. When rates become more elevated, special cleaning procedures involving hydrogen peroxide have been developed to lower the fungal and microbial recovery rates.

Having the cleanroom completed more than a year in advance of sample return has allowed many important kinds of monitoring to be undertaken, lab environments characterized, and baseline established for any expected or unexpected contaminants. Future emphasis will be on maintaining the monitoring during outfitting of the lab (see details in [5]), as well as the presence of human processors in the lab for longer durations.

References

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