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Subject: 2200368 Novamet 760 1" Cube Sample and Aluminum 1" In-Vac Spacer Baseline

Background

Hexane swabs from Novamet 760 1" Cube Sample and Aluminum 1" In-Vac Spacer Baseline were submitted for analysis to determine the identity and level of molecular contamination.

Results

PARTS				SAMPLES				RESULTS		
#	Part No.	SN	Description	#	Type	Description	Area (cm^2)	Chemical Functional Group	Total Amount (µg /cm^2)	Pass/Fail
1	N1C	S1	Novamet 1" Cube	1	Surface	~67% of outer surface area	~ 107	AHC, Ester	< 0.02	Pass
2	AIB	S2	Aluminum 1" In-Vac Spacer	2	Surface	~80% of outer surface area	~ 63	AHC, Ester	< 0.02	Pass

Terminology:
AHC: Aliphatic Hydrocarbons, base oil of lubricants, additives
Ester: Common sources include plasticizers and finger prints
µg/cm^2: micrograms per square centime

Instrument Method

Hexane swabs (Soxhlet extracted for 48hrs) were used to extract low volatile residues (LVR) on surfaces of interest. Low volatile residues dissolved into the hexane were analyzed using Diffuse Reflectance Infrared Fourier Transform (DRIFT) spectroscopy. FTIR provides chemical functional group information for qualitative and quantitative determination of materials. The analysis complies with IEST-STD-CC1246E and M2020 requirements (1-2), using a published methodology (3-7), and is sensitive to the stringent levels of molecular contamination (8)

DRIFT- FTIR References and Notes

1. The method conforms to the Institute of Environmental Science and Technology (IEST), Contamination Control Division Document IEST 1246E "Product Cleanliness Levels and Contamination Control Program". The method is intended to conservatively bin the molecular contamination into cleanliness levels. The ACA M2020 limit is "Level R1E-1" (level A/10 of IEST-STD-CC1246E) and this is 0.1 microgram per square centimeter (µg/cm^2) and this corresponds to an average film thickness of 10 angstroms (assuming a density of 1.0).
2. M. S. Anderson, "The Chemical Analysis Plan for M2020 Sample Return Hardware", IOM-3530-2018-043.
3. Fuller, Michael P., and Peter R. Griffiths. "Infrared micro-sampling by diffuse reflectance Fourier transform spectrometry." Applied Spectroscopy 34, no. 5 (1980): 533-539.
4. "Diffuse Reflection spectroscopy" Handbook of Vibrational Spectroscopy, Volume 2, page 1125-1175, J. C. Chalmers and P. R. Griffiths, eds., John Wiley & Sons, Chichester, UK, pp. 2263 (2002).
5. Averett, Lacey A., and Peter R. Griffiths. "Method to improve linearity of diffuse reflection mid-infrared spectroscopy." Analytical chemistry 78, no. 23 (2006): 8165-8167.
6. M. S. Anderson et al "Analysis of Semi-Volatile Residues Using Diffuse Reflectance Infrared Fourier Transform Spectroscopy" in Optical System Contamination: Effects, Measurements, and Control VII; July 2002, edited by Phillip T. C. Chen and O. Manuel Lee; Proceedings of the SPIE, Vol. 4774, pp. 251-261, (2002).
7. Handbook of Vibrational Spectroscopy, Volume 3, J. C. Chalmers and P. R. Griffiths, eds., John Wiley & Sons, Chichester, UK, pp. 2263 (2002).
8. Very clean surfaces, ≤0.02 µg/cm^2, with mono-molecular layers or less are more complex to describe when cleaning or analyzing. Carbon/hydrocarbon based substances are known to rapidly (within ~1 hour) accumulate on most, if not all, freshly exposed surfaces. This "adventitious" carbon is well documented in clean rooms and vacuum systems and compositionally varies by environment. Adventitious carbon is a discontinuous layer of approximately ~0.2 nanometers thick or ~0.02 µg/cm^2 up to 0.1 µg/cm^2 (for $\rho = 1$). The last mono-layer fractions may in some cases be strongly adsorbed to the surface as a "corrosion" layer. Therefore solvent based sampling methods may not remove these fractions, particularly if the surface is porous. When specifying cleanliness level to lower than A/10 IEST-STD-CC1246E (0.1 µg/cm^2) these monolayer effects become more significant. See Anderson M. S., "Chemical Analysis and Mitigation of Adventitious Carbon Contamination", 1/3/2017, Mars 2020 Project, JPL D-97858. See also: H. Piao and N. S. McIntyre, "Adventitious carbon growth on aluminum and gold–aluminum alloy surfaces", *Surface and Interface Analysis*, 2002; 33: 591–594.