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FROM: *R 2/21/17*  
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SUBJECT: Analytical Results of 4 OSIRIS-REx TAGSAM Gas Samples

## INTRODUCTION

At the request of the NASA JSC Astromaterials Research Office, the Toxicology and Environmental Chemistry Laboratory (TEC) analyzed 4 air samples collected by Lockheed Martin (LM) personnel in November 2016 and January 2017 at the OSIRIS-REx (Origins-Spectral Interpretation-Resource Identification-Security-Regolith Explorer) Assembly, Test and Launch Operations (ATLO) facility in Littleton, Colorado. Samples were collected from the flight unit of the Touch-and-Go Sample Acquisition Mechanism (TAGSAM) of the OSIRIS-REx spacecraft. These samples are the fifth and final set of samples received from the processing of the vehicle.

The grab samples were collected in verified-clean (proofed), evacuated, passivated stainless steel canisters. Three of the 4 samples were collected in 500mL size canisters and one (#AQ170014) was collected in a 6L size canister, all supplied by the TEC Laboratory. The samples were received into the TEC-Air Quality Laboratory on January 25, 2017. Sample log information is provided in the table below:

Sample Tracking #	Canister SN#	TAGSAM Sample Description	Sample Date	Date Received	Date Analyses Completed
AQ170015	21191	Flight unit: sample taken through flight loading system	11/14/16	1/25/17	1/30/17
AQ170016	22379	Flight unit: sample taken through flight loading system & Qual Bottle heated for 24 hrs prior to transfer	11/22/16	1/25/17	1/30/17
AQ170014	16193	Flight unit: sample taken through pyrovalve during firing	1/18/17	1/25/17	1/30/17
AQ170017	23687	Flight unit: GN <sub>2</sub> /GHe from source K-bottle	1/19/17	1/25/17	1/30/17

## **METHODS**

Analyses were accomplished using both gas chromatography (GC) and gas chromatography/ mass spectrometry (GC/MS). The samples were analyzed for volatile organic compounds (VOCs) by GC/MS according to WI-TEC-210, "Measurement of Volatile Organic Compounds in Air by Gas Chromatography/Mass Spectrometry Using Grab Sample Containers." Additionally, the samples were analyzed for VOCs using the GC method according to WI-TOX-004, "GC Analysis of Volatile Organic Compounds, Carbon Monoxide, Methane, Carbon Dioxide and Hydrogen in Air Samples." This GC-flame ionization detector (FID) method is used for reporting high levels of methanol, ethanol, isopropanol, 2-butanone and acetone if the concentration is above 0.15 parts per million (ppm). Additional compounds may be quantified using this method if their levels are sufficiently high.

## **RESULTS**

The analytical results for the 4 gas samples are reported in Table 1. Table 2 provides the results of duplicate analyses on sample AQ170014. Concentrations of identified compounds are reported as mg/M<sup>3</sup> at 14.7 psia and 25°C. Quantitative measurements of listed Target Compounds (TO-15) were calculated using a weighted quadratic regression model from the multi-point standardization as described in EPA method TO-15 and WI-TEC-210 for GC/MS measurements. One compound, hexamethylcyclotrisiloxane (HMCTS) in the Special Interest Compounds (SICs) group, was quantified using an average response factor from an internal study performed by TEC-Air Quality. However, the results for HMCTS are estimates due to the variations observed in the response factors at different concentrations. The quantitative measurements of the remaining compounds in the SIC group were based upon estimates of "B" response factors available in the literature ("Compilation of Mass Spectral Data" by A. Cornu and R. Massot). There were no non-target compounds found in the 4 samples having peak areas greater than 10% of the fluorobenzene standard peak.

Compound concentrations listed as "< the laboratory reporting limit" indicate that these compounds were analyzed for, but not detected in the sample. The laboratory reporting limit for most compounds was 0.025 mg/M<sup>3</sup>.

## **QUALITY REVIEW**

Review of the gas sample measurement data was performed as described in WI-TOX-021 "Flight Sample Quality Assurance Review."

The raw data were reviewed from the instrument data systems and printouts for response integration, compound identification and operating parameters.

The GC/MS instrument used to generate report data was determined to be stable and calibrated during measurements of the samples. The instrument stability was demonstrated to meet specifications by daily bromofluorobenzene tune verification and daily calibration verification by analysis of a mid-range standard. The reported concentrations were quantified using 3 different methods: 1) multiple-point calibrations for the Target compounds, 2) a response factor generated from an internal study for one compound in the SIC group, and 3) "B" response factors obtained from the reference previously mentioned.

The GC-FID (high VOCs) instrument was also demonstrated to be linear over a wide range of concentrations and stable as shown by daily calibration verifications using standard mixtures. The reported concentrations were quantified using a minimum of 4-point calibration curves.

As part of the routine preparation, surrogate compounds (3) were added to the sample canisters prior to delivery to the ATLO processing facility. Laboratory surrogate control canisters were set up at the same time. Upon sample analysis, the recoveries of the surrogate compounds provide useful quality assurance information regarding the entire sampling and analysis process. The recoveries for all 3 compounds for the TAGSAM samples were extremely low, ranging from 0 – 7.8%, whereas, the laboratory control recoveries were excellent (97 – 103%). However, as confirmed by the OSIRIS-REx representative, the 6L container was purged prior to sample acquisition, resulting in the loss of the surrogate compounds. It is presumed that the same or similar sample acquisition process occurred for the other samples. For this reason, a surrogate recovery table is not provided in this report.

Upon receipt of the samples into the laboratory, the pressures were initially measured and also measured during subsequent steps of the sample processing to ensure sample integrity.

Instrument calibration and check standard data for each instrument were reviewed along with the results from all sample analyses. All procedures and hardware were monitored for any errors or anomalies and no unusual trends impacting data quality were observed.

  
Internal Quality Reviewer

TABLE 1  
ANALYTICAL RESULTS OF OSIRIS-REX TAGSAM GRAB AIR SAMPLES

CHEMICAL CONTAMINANT	CONCENTRATION (mg/M3)			
	AQ170015 S/N 21191	AQ170016 S/N 22379	AQ170014 S/N 16193	AQ170017 S/N 23687
	Flight unit: sample taken through flight loading system  11/14/16	Flight unit: sample taken through flight loading system & Qual Bottle heated for 24 hrs. prior to transfer  11/22/16	Flight unit: sample taken through pyrovalve during firing  01/18/17	Flight unit: GN2/GHe from source bottle  01/19/17
<b>TARGET COMPOUNDS (TO-15) **</b>				
Octafluoropropane (Perfluoropropane)	<0.10	<0.10	<0.10	<0.10
Perfluoro(2-methylpentane)	<0.050	<0.050	<0.050	<0.050
Propene	<0.025	<0.025	<0.025	<0.025
Propane	<0.025	<0.025	<0.025	<0.025
Carbonyl sulfide (Carbon oxide sulfide)	<0.025	<0.025	<0.025	<0.025
Freon 12 (Dichlorodifluoromethane)	<0.025	<0.025	<0.025	<0.025
Chloromethane	<0.025	<0.025	<0.025	<0.025
Freon 114 (1,2-Dichloro-1,1,2,2-tetrafluoroethane)	<0.025	<0.025	<0.025	<0.025
Isobutane	<0.025	<0.025	<0.025	<0.025
Vinyl chloride	<0.025	<0.025	<0.025	<0.025
Methanol	<0.025	<0.025	<0.025	<0.025
Acetaldehyde	<0.025	<0.025	TRACE	<0.025
2-Methyl-1-propene	<0.025	<0.025	<0.025	<0.025
Butane	<0.025	<0.025	<0.025	<0.025
1,3-Butadiene	<0.025	<0.025	<0.025	<0.025
Bromomethane	<0.025	<0.025	<0.025	<0.025
Chloroethane	<0.025	<0.025	<0.025	<0.025
Ethanol	<0.025	<0.025	<0.025	<0.025
Freon 11 (Trichlorofluoromethane)	<0.025	<0.025	<0.025	<0.025
Propenal (Acrolein)	<0.025	<0.025	<0.025	<0.025
Acetonitrile	<0.025	<0.025	<0.025	<0.025
Acetone	0.042	0.027	0.15	<0.025
Propanal (Propionaldehyde)	<0.025	<0.025	<0.025	<0.025
Furan	<0.025	<0.025	<0.025	<0.025
Pentane	<0.025	<0.025	<0.025	<0.025
2-Propanol (Isopropanol) *	1.5	2.8	8.0	<0.025
Isoprene (2-Methyl-1,3-butadiene)	<0.025	<0.025	<0.025	<0.025
1,1-Dichloroethene	<0.025	<0.025	<0.025	<0.025
Dimethyl sulfide	<0.025	<0.025	<0.025	<0.025
Acrylonitrile	<0.025	<0.025	<0.025	<0.025
Freon 113 (1,1,2-Trichloro-1,2,2-trifluoroethane)	<0.025	<0.025	<0.025	<0.025
2-Methyl-2-propanol	<0.025	<0.025	<0.025	<0.025
Methyl acetate	<0.025	<0.025	<0.025	<0.025
3-Chloropropene (Allyl chloride)	<0.025	<0.025	<0.025	<0.025
Methylene chloride (Dichloromethane)	<0.025	<0.025	<0.025	<0.025
Carbon disulfide	<0.025	<0.025	<0.025	<0.025
1-Propanol	<0.025	<0.025	<0.025	<0.025
Trimethylsilanol	<0.025	<0.025	<0.025	<0.025
1,1-Dichloroethane	<0.025	<0.025	<0.025	<0.025
Butanal (Butyraldehyde)	<0.025	<0.025	<0.025	<0.025
2-Butanone (Methyl ethyl ketone)	<0.025	<0.025	<0.025	<0.025
Hexane	<0.025	<0.025	<0.025	<0.025
2-Methylfuran	<0.025	<0.025	<0.025	<0.025
cis-1,2-Dichloroethene	<0.025	<0.025	<0.025	<0.025
trans-1,2-Dichloroethene	<0.025	<0.025	<0.025	<0.025
Ethyl acetate	<0.025	<0.025	<0.025	<0.025
Chloroform	<0.025	<0.025	<0.025	<0.025
1,1,1-Trichloroethane	<0.025	<0.025	<0.025	<0.025
2-Butenal	<0.025	<0.025	<0.025	<0.025
1,2-Dichloroethane	<0.025	<0.025	<0.025	<0.025
Benzene	<0.025	<0.025	<0.025	<0.025
Carbon tetrachloride	<0.025	<0.025	<0.025	<0.025
1-Butanol	<0.025	<0.025	<0.025	<0.025
2-Methylhexane	<0.025	<0.025	<0.025	<0.025
2,3-Dimethylpentane	<0.025	<0.025	<0.025	<0.025
3-Methylhexane	<0.025	<0.025	<0.025	<0.025
2-Pentanone	<0.025	<0.025	<0.025	<0.025
Pentanal	<0.025	<0.025	<0.025	<0.025
n-Heptane	<0.025	<0.025	<0.025	<0.025
Trichloroethene	<0.025	<0.025	<0.025	<0.025
1,2-Dichloropropane	<0.025	<0.025	<0.025	<0.025
2,5-Dimethylfuran	<0.025	<0.025	<0.025	<0.025
1,4-Dioxane	<0.025	<0.025	<0.025	<0.025
4-Methyl-2-pentanone (MIBK)	<0.025	<0.025	<0.025	<0.025
cis-1,3-Dichloropropene	<0.025	<0.025	<0.025	<0.025
2-Pentenal	<0.025	<0.025	<0.025	<0.025
trans-1,3-Dichloropropene	<0.025	<0.025	<0.025	<0.025
Toluene	<0.025	<0.025	<0.025	<0.025
1,1,2-Trichloroethane	<0.025	<0.025	<0.025	<0.025
Mesityl oxide (4-Methyl-3-penten-2-one)	<0.025	<0.025	<0.025	<0.025
Octane	<0.025	<0.025	<0.025	<0.025
Hexanal	<0.025	<0.025	<0.025	<0.025
Butyl acetate	<0.025	<0.025	<0.025	<0.025
Tetrachloroethene (Perchloroethene)	<0.025	<0.025	<0.025	<0.025

TABLE 1  
ANALYTICAL RESULTS OF OSIRIS-REX TAGSAM GRAB AIR SAMPLES

CHEMICAL CONTAMINANT	CONCENTRATION (mg/M3)			
	AQ170015 S/N 21191	AQ170016 S/N 22379	AQ170014 S/N 16193	AQ170017 S/N 23687
	Flight unit: sample taken through flight loading system  11/14/16	Flight unit: sample taken through flight loading system & Qual Bottle heated for 24 hrs. prior to transfer  11/22/16	Flight unit: sample taken through pyrovalve during firing  01/18/17	Flight unit: GN2/GHe from source bottle  01/19/17
1,2-Dibromoethane (EDB)	<0.025	<0.025	<0.025	<0.025
Chlorobenzene	<0.025	<0.025	<0.025	<0.025
Ethylbenzene	<0.025	<0.025	<0.025	<0.025
m & p-Xylene	<0.025	<0.025	<0.025	<0.025
2-Heptanone	<0.025	<0.025	<0.025	<0.025
Nonane	<0.025	<0.025	<0.025	<0.025
Styrene (Ethenylbenzene)	<0.025	<0.025	<0.025	<0.025
Heptanal	<0.025	<0.025	<0.025	<0.025
o-Xylene	<0.025	<0.025	<0.025	<0.025
Cyclohexanone	<0.025	<0.025	<0.025	<0.025
1,1,2,2-Tetrachloroethane	<0.025	<0.025	<0.025	<0.025
Octamethylcyclotetrasiloxane	<0.075	<0.075	<0.075	<0.075
1,3,5-Trimethylbenzene	<0.025	<0.025	<0.025	<0.025
1,2,4-Trimethylbenzene	<0.025	<0.025	<0.025	<0.025
1,3-Dichlorobenzene	<0.025	<0.025	<0.025	<0.025
1,4-Dichlorobenzene	<0.025	<0.025	<0.025	<0.025
1,2-Dichlorobenzene	<0.025	<0.025	<0.025	<0.025
Decamethylcyclopentasiloxane	<0.10	<0.10	<0.10	<0.10
1,2,4-Trichlorobenzene	<0.050	<0.050	<0.050	<0.050
Hexachlorobutadiene	<0.050	<0.050	<0.050	<0.050
<b>SPECIAL INTEREST COMPOUNDS ***</b>				
Ethylene oxide	<0.050	<0.050	<0.050	<0.050
2-Methyl-2-propenal	<0.050	<0.050	<0.050	<0.050
3-Butene-2-one	<0.050	<0.050	<0.050	<0.050
2-Ethoxyethanol	<0.050	<0.050	<0.050	<0.050
Dimethyl disulfide	<0.050	<0.050	<0.050	<0.050
Hexamethylcyclotrisiloxane #	<0.10	<0.10	<0.10	<0.10
<b>NON-TARGET COMPOUNDS</b>				
No non-target compounds found				
<b>TOTAL CONCENTRATION (NON-METHANE HYDROCARBONS)</b>	<b>1.5</b>	<b>2.8</b>	<b>8.2</b>	<b>0.0</b>

\* GC/FID data results are in bold

\*\* Quantified using a multi-point calibration

\*\*\* Quantified using "B" response factor except where noted; concentrations are estimates only.

# Response factor generated from an internal study

< : Value is less than the laboratory reporting limit.

TRACE: Amount detected is sufficient for compound identification only. One-half of the reporting limit was used in the Total Concentration summation.

TABLE 2  
ANALYTICAL RESULTS OF  
OSIRIS-REx TAGSAM DUPLICATE GRAB AIR SAMPLE ANALYSIS

CHEMICAL CONTAMINANT	CONCENTRATION (mg/M <sup>3</sup> )	
	AQ170014 S/N 16193 Flight unit: sample taken through pyrovalve during firing 01/18/17	AQ170014-DUP S/N 16193 Flight unit: sample taken through pyrovalve during firing 01/18/17
	<b>TARGET COMPOUNDS (TO-15) **</b>	
Octafluoropropane (Perfluoropropane)	<0.10	<0.10
Perfluoro(2-methylpentane)	<0.050	<0.050
Propene	<0.025	<0.025
Propane	<0.025	<0.025
Carbonyl sulfide (Carbon oxide sulfide)	<0.025	<0.025
Freon 12 (Dichlorodifluoromethane)	<0.025	<0.025
Chloromethane	<0.025	<0.025
Freon 114 (1,2-Dichloro-1,1,2,2-tetrafluoroethane)	<0.025	<0.025
Isobutane	<0.025	<0.025
Vinyl chloride	<0.025	<0.025
Methanol	<0.025	<0.025
Acetaldehyde	TRACE	TRACE
2-Methyl-1-propene	<0.025	<0.025
Butane	<0.025	<0.025
1,3-Butadiene	<0.025	<0.025
Bromomethane	<0.025	<0.025
Chloroethane	<0.025	<0.025
Ethanol	<0.025	<0.025
Freon 11 (Trichlorofluoromethane)	<0.025	<0.025
Propenal (Acrolein)	<0.025	<0.025
Acetonitrile	<0.025	<0.025
Acetone	0.15	0.16
Propanal (Propionaldehyde)	<0.025	<0.025
Furan	<0.025	<0.025
Pentane	<0.025	<0.025
2-Propanol (Isopropanol) *	<b>8.0</b>	<b>8.0</b>
Isoprene (2-Methyl-1,3-butadiene)	<0.025	<0.025
1,1-Dichloroethene	<0.025	<0.025
Dimethyl sulfide	<0.025	<0.025
Acrylonitrile	<0.025	<0.025
Freon 113 (1,1,2-Trichloro-1,2,2-trifluoroethane)	<0.025	<0.025
2-Methyl-2-propanol	<0.025	<0.025
Methyl acetate	<0.025	<0.025
3-Chloropropene (Allyl chloride)	<0.025	<0.025
Methylene chloride (Dichloromethane)	<0.025	<0.025
Carbon disulfide	<0.025	<0.025
1-Propanol	<0.025	<0.025
Trimethylsilanol	<0.025	<0.025
1,1-Dichloroethane	<0.025	<0.025
Butanal (Butyraldehyde)	<0.025	<0.025
2-Butanone (Methyl ethyl ketone)	<0.025	<0.025
Hexane	<0.025	<0.025
2-Methylfuran	<0.025	<0.025
cis-1,2-Dichloroethene	<0.025	<0.025
trans-1,2-Dichloroethene	<0.025	<0.025
Ethyl acetate	<0.025	<0.025
Chloroform	<0.025	<0.025
1,1,1-Trichloroethane	<0.025	<0.025
2-Butenal	<0.025	<0.025
1,2-Dichloroethane	<0.025	<0.025
Benzene	<0.025	<0.025
Carbon tetrachloride	<0.025	<0.025
1-Butanol	<0.025	<0.025
2-Methylhexane	<0.025	<0.025
2,3-Dimethylpentane	<0.025	<0.025
3-Methylhexane	<0.025	<0.025
2-Pentanone	<0.025	<0.025
Pentanal	<0.025	<0.025
n-Heptane	<0.025	<0.025
Trichloroethene	<0.025	<0.025
1,2-Dichloropropane	<0.025	<0.025
2,5-Dimethylfuran	<0.025	<0.025
1,4-Dioxane	<0.025	<0.025
4-Methyl-2-pentanone (MIBK)	<0.025	<0.025
cis-1,3-Dichloropropene	<0.025	<0.025
2-Pentenal	<0.025	<0.025
trans-1,3-Dichloropropene	<0.025	<0.025
Toluene	<0.025	<0.025
1,1,2-Trichloroethane	<0.025	<0.025
Mesityl oxide (4-Methyl-3-penten-2-one)	<0.025	<0.025
Octane	<0.025	<0.025
Hexanal	<0.025	<0.025
Butyl acetate	<0.025	<0.025
Tetrachloroethene (Perchloroethene)	<0.025	<0.025

**TABLE 2**  
**ANALYTICAL RESULTS OF**  
**OSIRIS-REx TAGSAM DUPLICATE GRAB AIR SAMPLE ANALYSIS**

CHEMICAL CONTAMINANT	CONCENTRATION (mg/M <sup>3</sup> )	
	AQ170014 S/N 16193	AQ170014-DUP S/N 16193
	Flight unit: sample taken through pyrovalve during firing 01/18/17	Flight unit: sample taken through pyrovalve during firing 01/18/17
1,2-Dibromoethane (EDB)	<0.025	<0.025
Chlorobenzene	<0.025	<0.025
Ethylbenzene	<0.025	<0.025
m & p-Xylene	<0.025	<0.025
2-Heptanone	<0.025	<0.025
Nonane	<0.025	<0.025
Styrene (Ethenylbenzene)	<0.025	<0.025
Heptanal	<0.025	<0.025
o-Xylene	<0.025	<0.025
Cyclohexanone	<0.025	<0.025
1,1,2,2-Tetrachloroethane	<0.025	<0.025
Octamethylcyclotetrasiloxane	<0.075	<0.075
1,3,5-Trimethylbenzene	<0.025	<0.025
1,2,4-Trimethylbenzene	<0.025	<0.025
1,3-Dichlorobenzene	<0.025	<0.025
1,4-Dichlorobenzene	<0.025	<0.025
1,2-Dichlorobenzene	<0.025	<0.025
Decamethylcyclopentasiloxane	<0.10	<0.10
1,2,4-Trichlorobenzene	<0.050	<0.050
Hexachlorobutadiene	<0.050	<0.050
<b>SPECIAL INTEREST COMPOUNDS ***</b>		
Ethylene Oxide	<0.050	<0.050
2-Methyl-2-propenal	<0.050	<0.050
3-Butene-2-one	<0.050	<0.050
2-Ethoxyethanol	<0.050	<0.050
Dimethyl disulfide	<0.050	<0.050
Hexamethylcyclotrisiloxane #	<0.10	<0.10
<b>NON-TARGET COMPOUNDS</b>		
No non-target compounds were found		
<b>TOTAL CONCENTRATION (NON-METHANE HYDROCARBONS)</b>	<b>8.2</b>	<b>8.2</b>

\* GC/FID data results are in bold

\*\* Quantified using a multi-point calibration

\*\*\* Quantified using "B" response factor except where noted; concentrations are estimates only.

# Response factor generated from an internal study

< : Value is less than the laboratory reporting limit.

TRACE: Amount detected is sufficient for compound identification only.

One-half of the reporting limit was used in the Total Concentration summation.