

Jet Propulsion Laboratory
California Institute of Technology

Materials Characterization for Contamination Mitigation on SHERLOC

Presented by Qian Nataly Chen, Materials and Processes Engineer
Jet Propulsion Laboratory, California Institute of Technology
July 18, 2017



Scanning Habitable Environments with Raman and Luminescence for Organics & Chemicals



SHERLOC
A New Paradigm in Organic Detection

Contributors

Margarite Sylvia

Contamination Control

Rohit Bhartia

SHERLOC Deputy Principal
Investigator

Ivria Doloboff

Planetary Chemistry and
Astrobiology

Nicholas Heinz

Analytical Chemistry

Mark Anderson

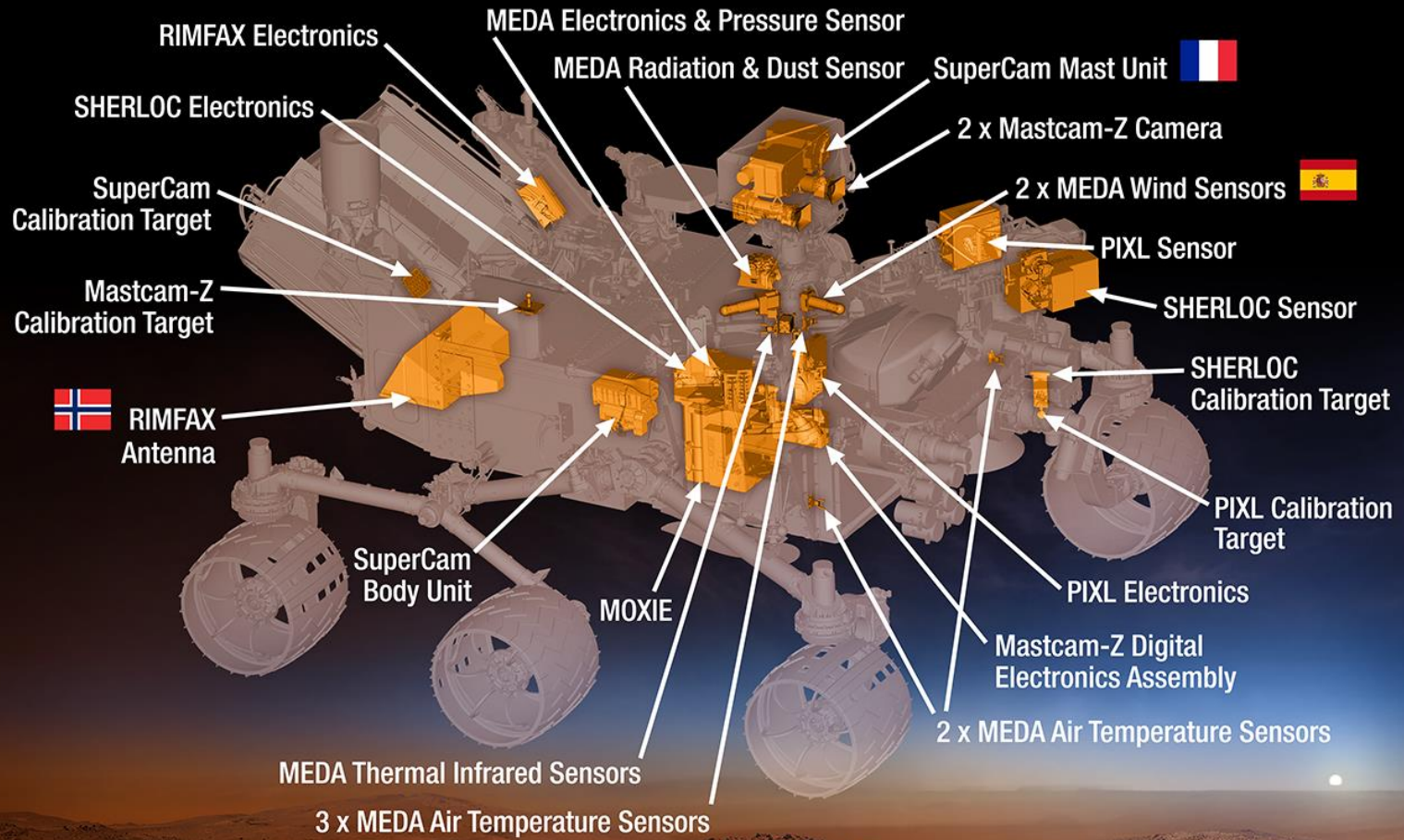
Analytical Chemistry

Lauren DeFlores

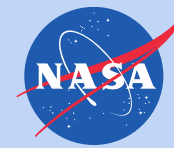
SHERLOC Instrument Systems
Engineer

All from Jet Propulsion Laboratory,
California Institute of Technology

Mars 2020 Rover



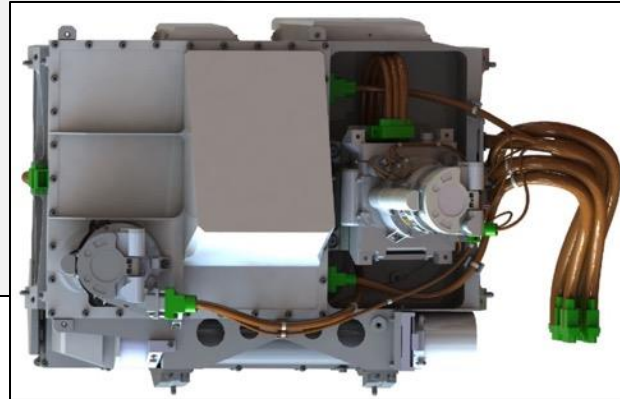
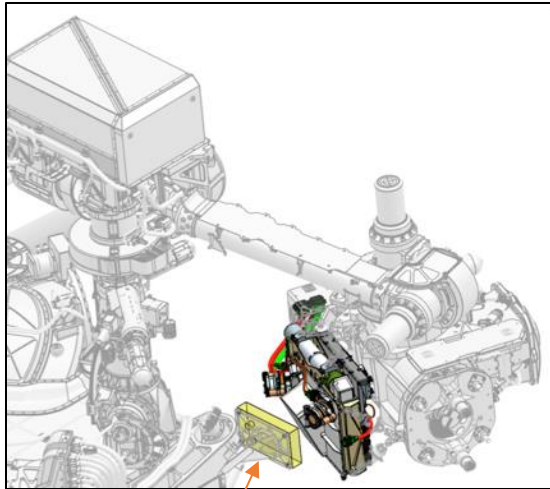
SHERLOC Location on Rover



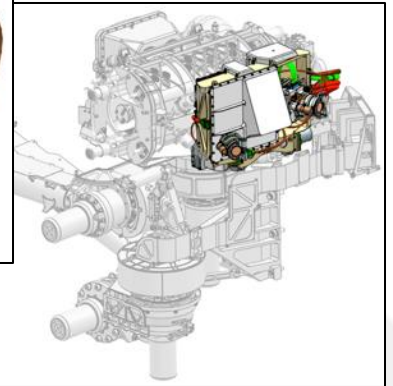
SHERLOC

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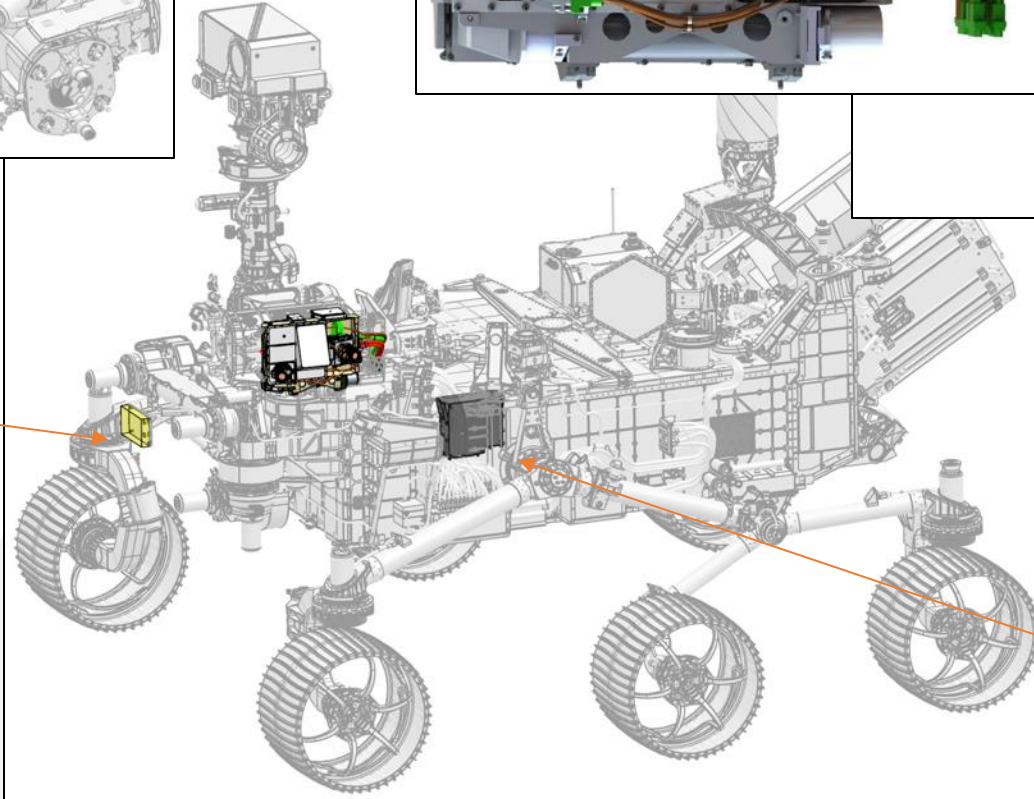
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SHERLOC Turret Assembly (STA)



SHERLOC Calibration Target (SCT)



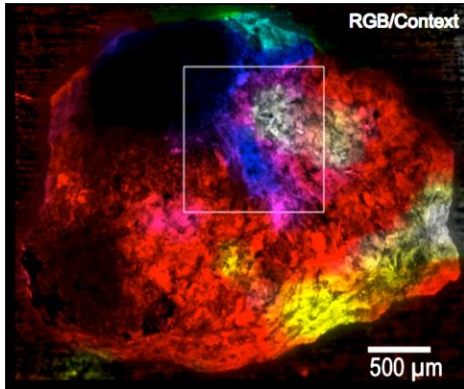
**SHERLOC Body Assembly (SBA)
(Inside Rover Chassis)**



Scanning Habitable Environments with Raman & Luminescence for Organics and Chemicals

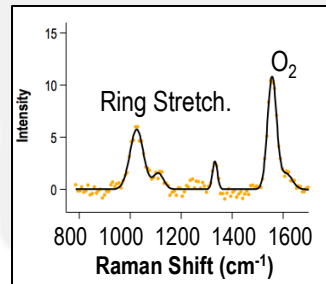
Correlation of Composition and Texture

Spectral Maps and Visible Imager

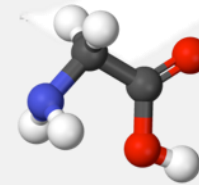


Detect and Classify Potential Biosignatures

Raman and Fluorescence Spectroscopy



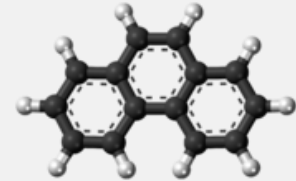
Aliphatics



Astrobiologically Relevant Minerals

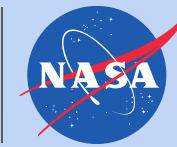


Aromatics



- *Detects* and *classifies* organics and astrobiologically relevant minerals on the surface and near subsurface of Mars.
- Organic sensitivity of 10^{-5} w/w over the observed area
- Organic sensitivity of 10^{-3} w/w spatially resolved at $<100\mu\text{m}$
- Astrobiologically relevant mineral detection and classification to $<100\mu\text{m}$

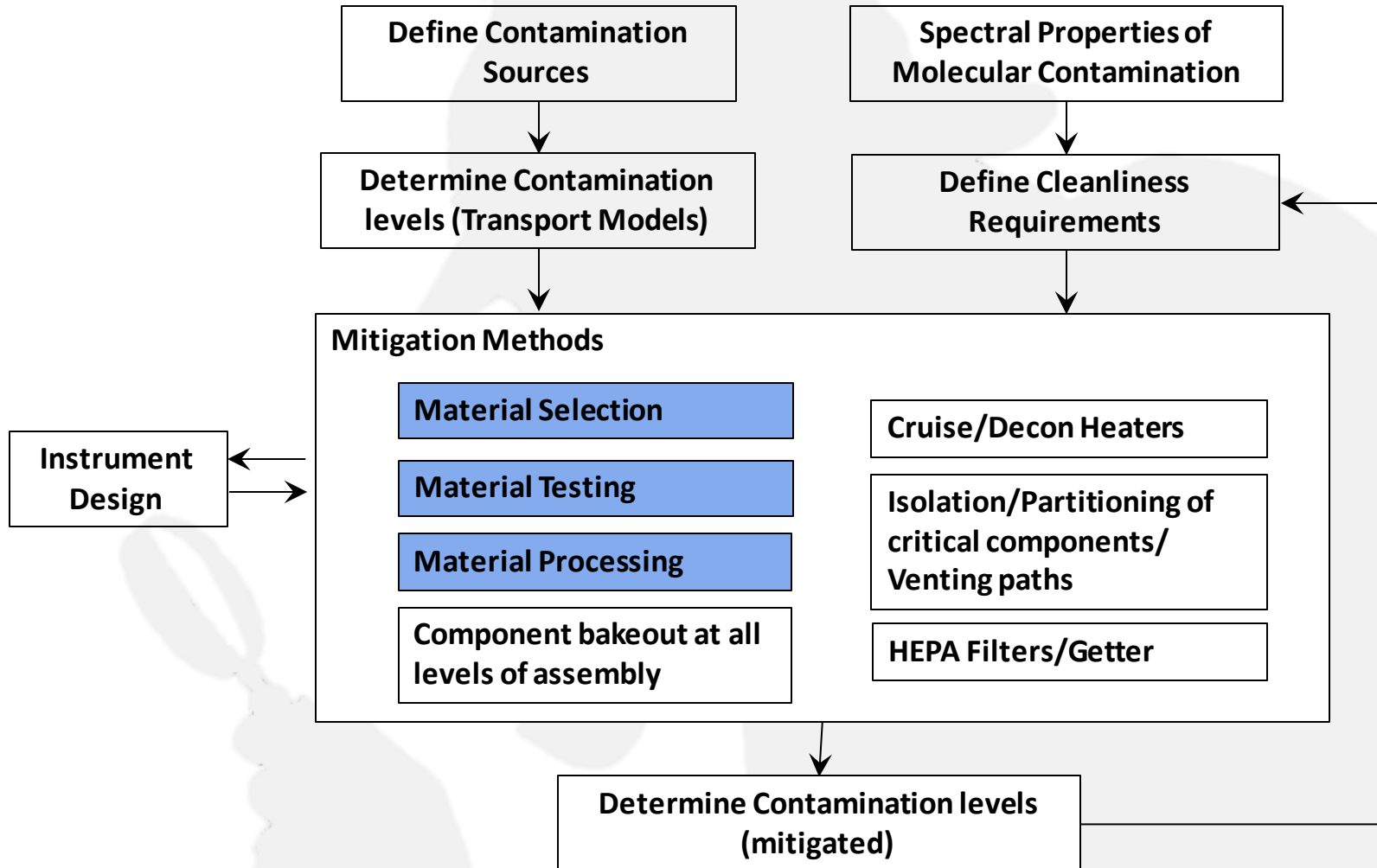
Contamination Control Plan

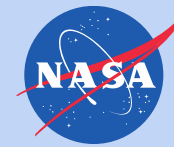


SHERLOC

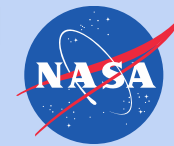
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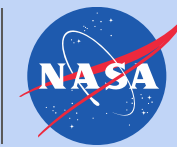


1. Identify materials within optical bench
 - a) Select highest impact materials for increased testing
2. Obtain and prepare material samples, matching flight mix and cure conditions.
3. Test bulk materials, as feasible
 - Outgassing rate measurements via ASTM E1559 on high impact materials
 - Outgassing measurement via ASTM E595
 - DART-MS
 - FTIR
 - UV fluorescence
4. Outgas bulk samples onto cold collectors
 - Custom deposition onto optic
 - Modification of micro-VCM instrument operation
5. Characterization of outgassed contaminants
6. Evaluation and Material Selection




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Materials Identification and Preparation






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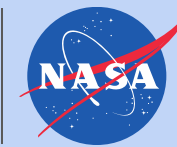
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Item #	Material	IR Number (Mix)	IR Numbers (Material)	Lot/Batch Information	Manufacturer & Location	Date of Manufacture	Mix	Cure Requirement	Expiration Date	Sample Prep Notes	Physical Description	Picture
							Performed by Jim Denman in Silicone Lab	Group 1 Room temperature, 24 hours, followed by 2		Slabs of 2585 cured on metal mold. Material for UV Fluorescence placed in plastic petri dish, along with aluminum blank for		

Item #	Material	IR Number (Mix)	IR Numbers (Material)	Lot/Batch Information	Manufacturer & Location	Date of Manufacture
4	Stycast 2850FT w/ Cat 24LV	1204942	1103933 (Stycast 2850FT) 1201892 (Catalyst 24)	OX5B000358 (Stycast) OX5G001576 (Catalyst 24)	Henkel	2/11/2015 (Stycast) 8/3/2015 (Catalyst 24)
5	EA 9394 A/B Gray	1203675	1203755	JH5HAE3815	Hysol	9/14/2015

10	Z-306 Paint	IBAT 615225	1203462 (Aeroglaze 9929, Aeroglaze 9953) 1203503 (Aeroglaze Z306)	(9929 A) 0011553642 (9929 B) 0011567452 0011557422	Lord Corporation	12/3/15 (9929 A) 10/29/15 (9929 B) 12/14/15 (9953) 11/21/2015 (Z306)	Primer: 190.8 g 9929A; 34.7 g 9929B; 26.0 g 9953	Room temperature, 40-80% RH, 3 days	1/1/17 (for 9953) 2/1/17 (for 9929, Z306)	Primer applied 6/28, Paint applied 6/29 Blank for fluorescence placed in paint booth for 1 week alongside painted sample	Light yellow primer, black paint	
11	Parylene C	N/A	N/A	N/A	Unknown	Unknown	N/A	N/A	Unknown	Sample obtained from Jong-ook Suh, for fluorescence measurement only	Clear film	
12	Black Anodized Aluminum "Sealed"	N/A	N/A	003722 000 997000 (Anodization)	Danco	~ 6/1/16	N/A	N/A	N/A	Provided by MSSS	Black Anodized Al Alloy 7075-T7351 block	

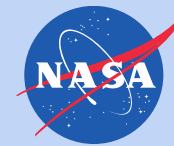
Materials Identification and Preparation



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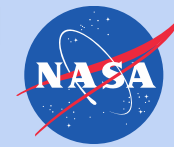
Mix	Cure Requirement	Expiration Date	Sample Prep Notes	Physical Description	Picture
400 g Stycast 2850FT; 28 g Catalyst 24	Room temperature, 8-16 hours	8/12/2016 (for frozen pre-mix)	Deposited from frozen pre-mix on 5/26/2016	Black, very liquidy	
200 g 9394A; 17 g 9394B	Room temperature, 5 days	2/16/2017 (for frozen pre-mix)	Deposited from frozen pre-mix on 5/26/2016	Gray	

10	Z-306 Paint	IBAT 615225	1203462 (Aeroglaze 9929, Aeroglaze 9953) 1203503 (Aeroglaze Z306)	(9929 B) 0011567452 (9953) 0011557422	Lord Corporation	12/3/15 (9929 A) 10/29/15 (9929 B) 12/14/15 (9953) 11/21/2015 (Z306)	Primer: 190.8 g 9929A; 34.7 g 9929B; 26.0 g 9953	Room temperature, 40-80% RH, 3 days	1/1/17 (for 9953) 2/1/17 (for 9929, Z306)	Blank for fluorescence placed in paint booth for 1 week alongside painted sample	Light yellow primer, black paint	
11	Parylene C	N/A	N/A	N/A	Unknown	Unknown	N/A	N/A	Unknown	Sample obtained from Jong-ook Suh, for fluorescence measurement only	Clear film	
12	Black Anodized Aluminum "Sealed"	N/A	N/A	003722 000 997000 (Anodization)	Danco	~ 6/1/16	N/A	N/A	N/A	Provided by MSSS	Black Anodized Al Alloy 7075-T7351 block	



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Material Selection for ASTM E1559



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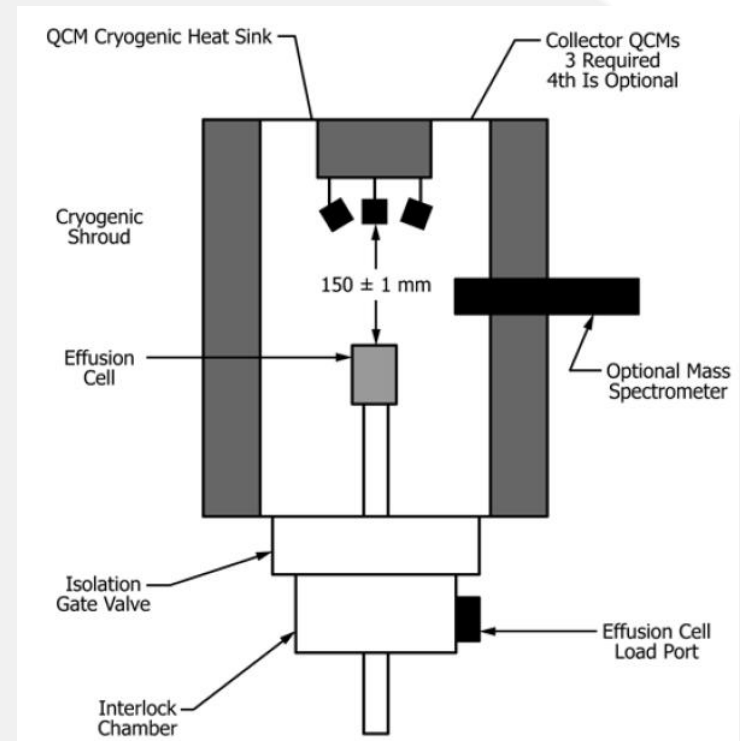
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- SCV-2585 for bonding optics to optical mounts
 - Evaluated and qualified specifically for SHERLOC applications
- Aeroglaze Z306 black paint with Aeroglaze 9929 primer
- Loctite/Hysol EA 9394 Epoxy
- 3M Scotch-Weld 2216 Epoxy

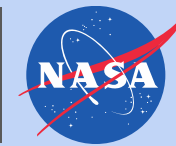
All materials are first thermal vacuum baked at flight-relevant temperatures and durations, then tested per ASTM E1559 to obtain outgassing rates.

- Rates used for contamination modeling
- Guides material selection

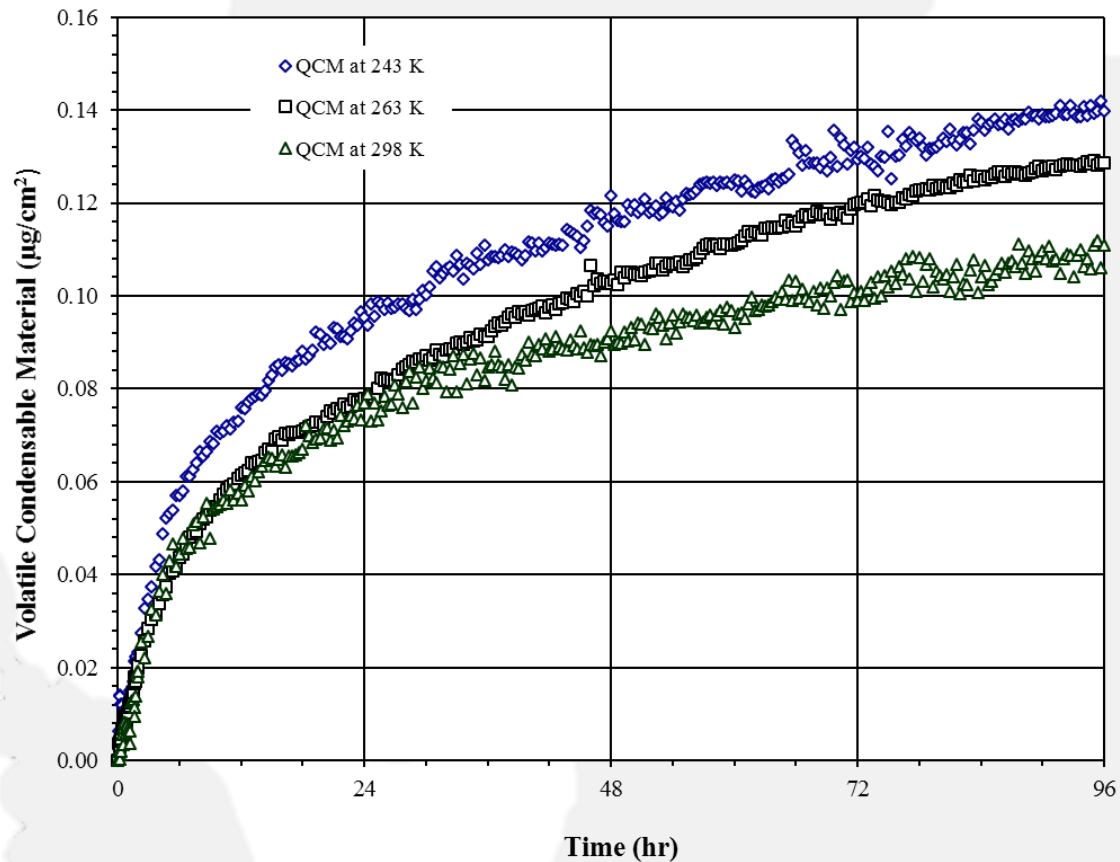


ASTM E1559-09

ASTM E1559 Material Testing Results

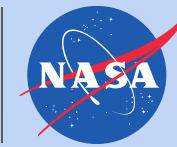


NuSil SCV-2585 RTV Adhesive at 40°C.



Post thermal vacuum bakeout at 60°C for 96 hours

ASTM E1559 Material Testing Results

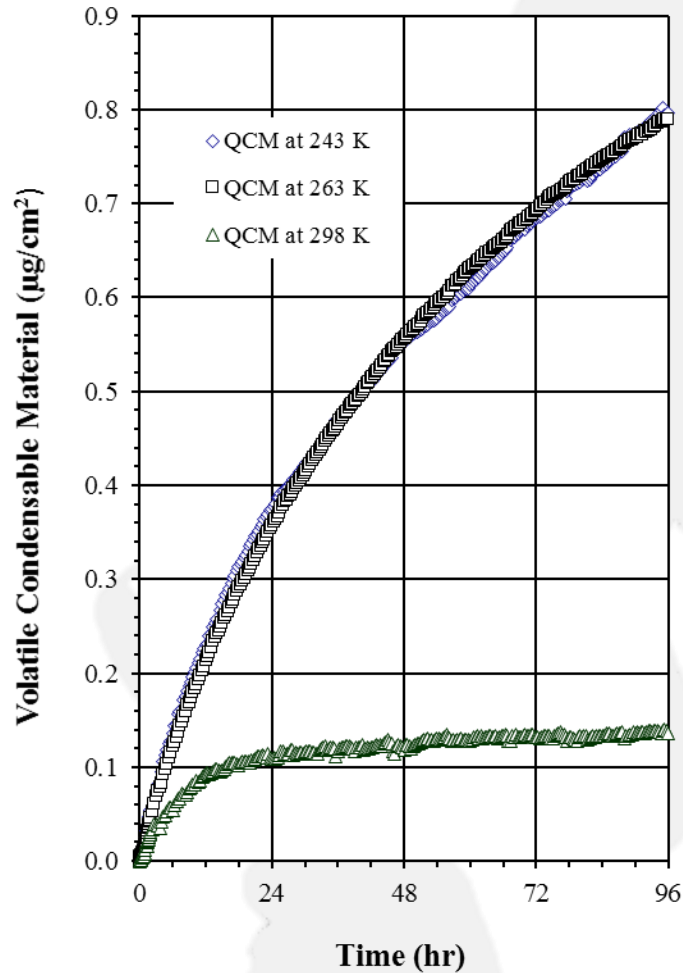


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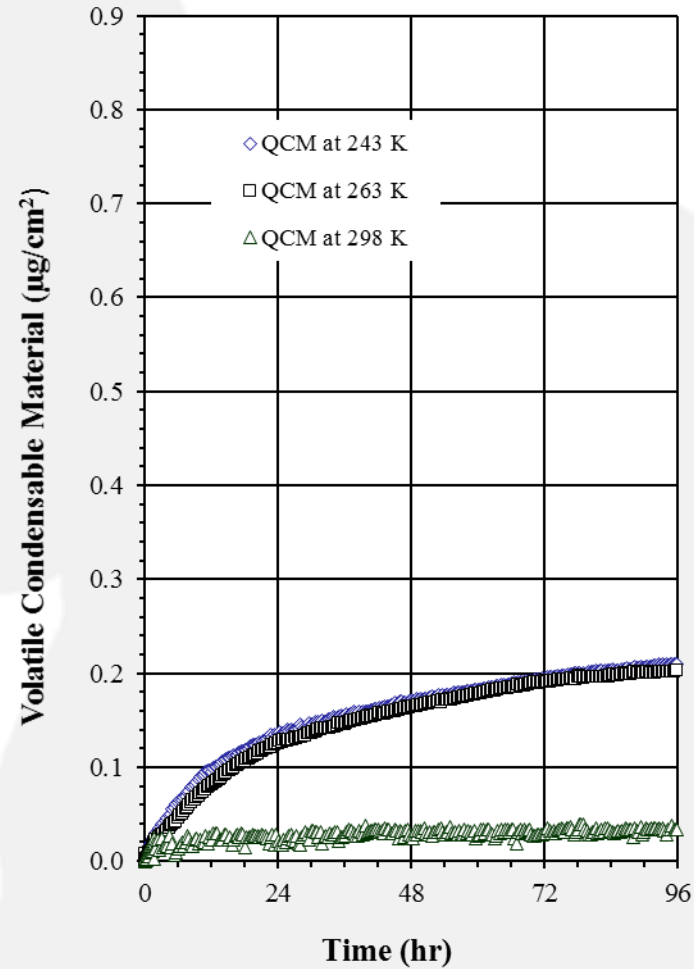
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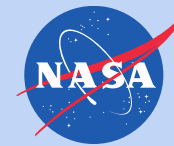
ScotchWeld 2216 Epoxy at 40°C.



Hysol EA 9394 Epoxy at 40°C.

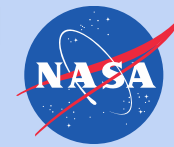


Post thermal vacuum bakeout at 60°C for 96 hours



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Material Testing: ASTM E595



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All bulk organic materials tested in flight-like mix and cured conditions.

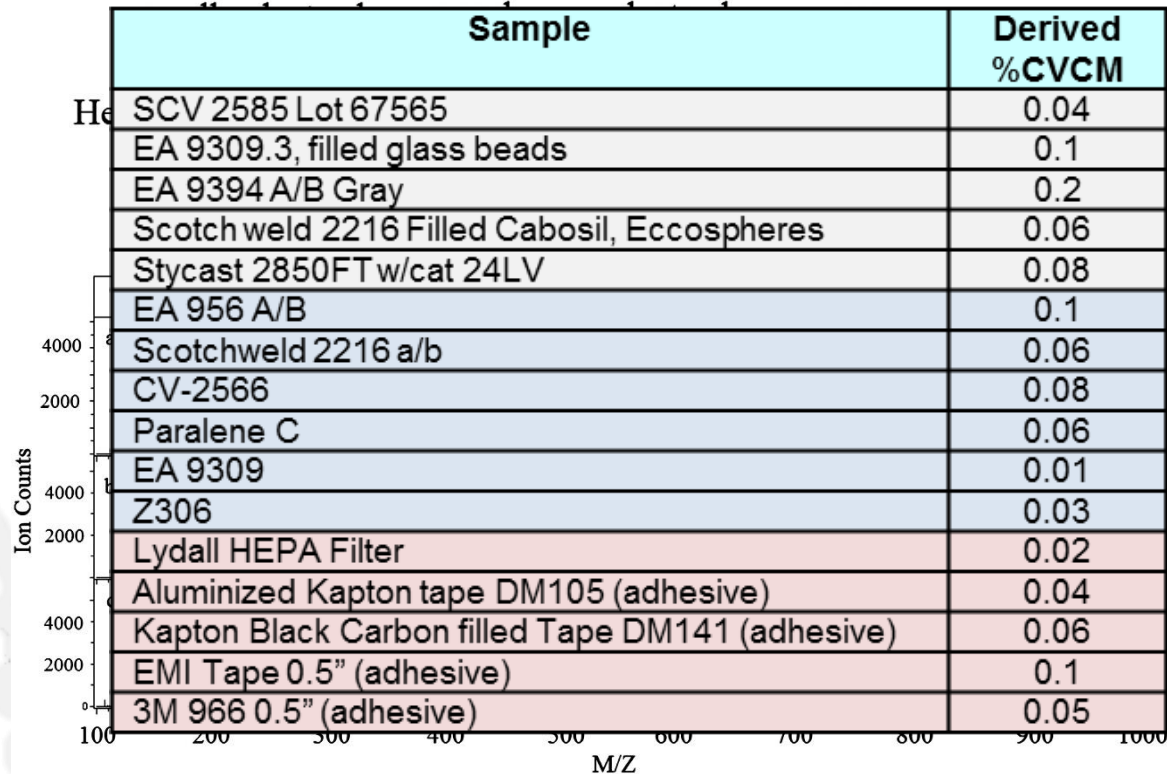
- Majority of materials in MAPTIS, but not necessarily current and with exact mix/cure condition



Material	Lot #	IR #	Test Num	%TML	%WVR	%CVCM
CV1-2566	64042	N/A	160525	0.94	0.07	0.09
SCV-2585	67565	N/A	160525	0.03	0.03	0.00
SCV-2590	67299	N/A	160525	0.02	0.01	0.00
TFLEX	Unknown	N/A	160525	0.45	0.01	0.13
CV1-2566	64042	N/A	160615	0.95	0.08	0.10
EA 9309.3 NA	JH5FAA3305	1203414	160615	1.94	0.82	0.00
EA 9394 gray	JH5HAE3815	1203675	160615	1.72	0.78	0.00
Scotchweld 2216 filled	5068AR/5069AA	1204645	160615	1.14	0.60	0.00
Stycast 2850FT w/ CAT24LV	OX5B000358/OX5G001576	1204942	160615	0.73	0.21	0.00

All organic materials tested via DART Mass Spectrometry

- Standard against which flight lots can be screened



Anderson, Mark S., *Mass Spectrometry of Spacecraft Contamination Using Direct Analysis in Real-Time Ion Source*, Journal of Spacecraft and Rockets, Vol. 51, No. 1, 2014.



All materials characterized via Fourier Transform Infrared (FTIR) Spectrometry

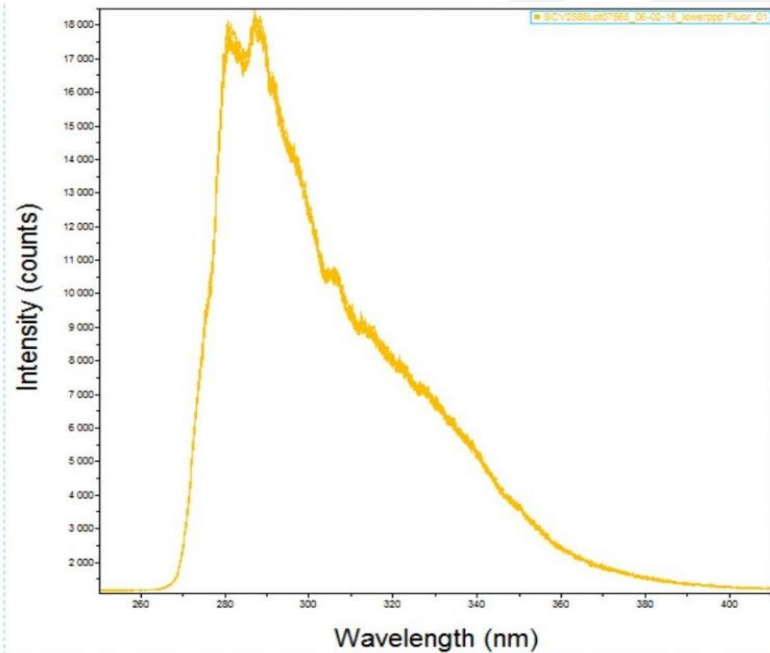
- With attenuated total reflectance (ATR) microscope attachment
- Chemical functional group information for material identification
- Data available for quantitative analysis as necessary

Sample	FTIR Functional Groups
SCV 2585 Lot 67565	Silicone, polydimethylsiloxane
EA 9309.3, filled glass beads	Epoxy
EA 9394 A/B Gray	Epoxy
Scotch weld 2216 Filled Cabosil, Eccospheres	Epoxy
Stycast 2850FT w/cat 24LV	Epoxy
EA 956 A/B	Epoxy
Scotchweld 2216 a/b	Epoxy
CV-2566	Silicone, polydimethylsiloxane
Paralene C	Paralene, poly(p-xylylene)
EA 9309	Epoxy
Z306	Epoxy
Lydall HEPA Filter	Polyester, polyethylene terephthalate
Aluminized Kapton tape DM105 (adhesive)	Acrylic
Kapton Black Carbon filled Tape DM141 (adhesive)	Kapton, Polyimide
EMI Tape 0.5" (adhesive)	Acrylic
3M 966 0.5" (adhesive)	Acrylic

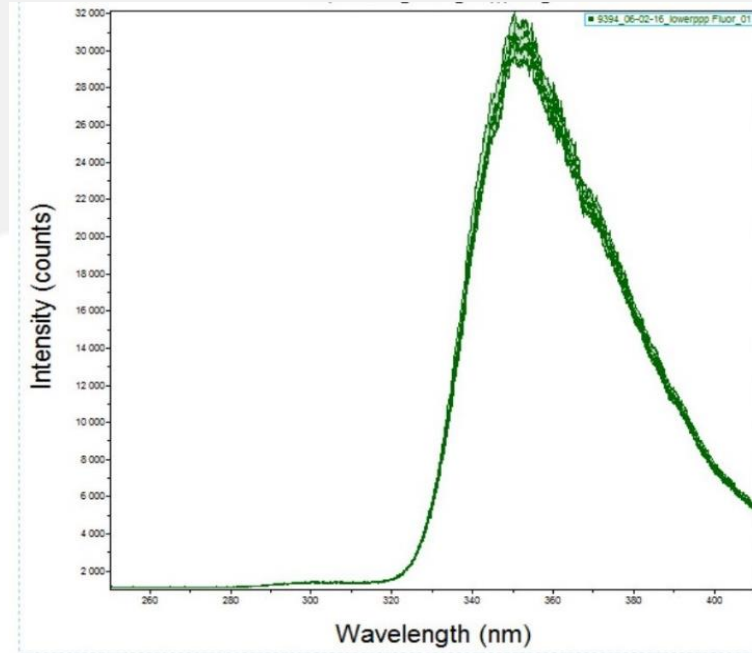
Fluorescence of bulk material tested with Deep UV Raman/Fluorescence Spectrometer

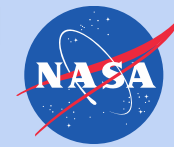
- SHERLOC-like bench top instrument
- Samples illuminated with deep UV laser (248.6 nm)
 - Incident photons absorbed and re-emitted at longer wavelength
- Primarily identification tool for organic materials used within optical bench

SCV-2585



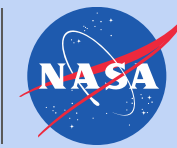
EA 9394





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Vacuum Deposition onto Optic



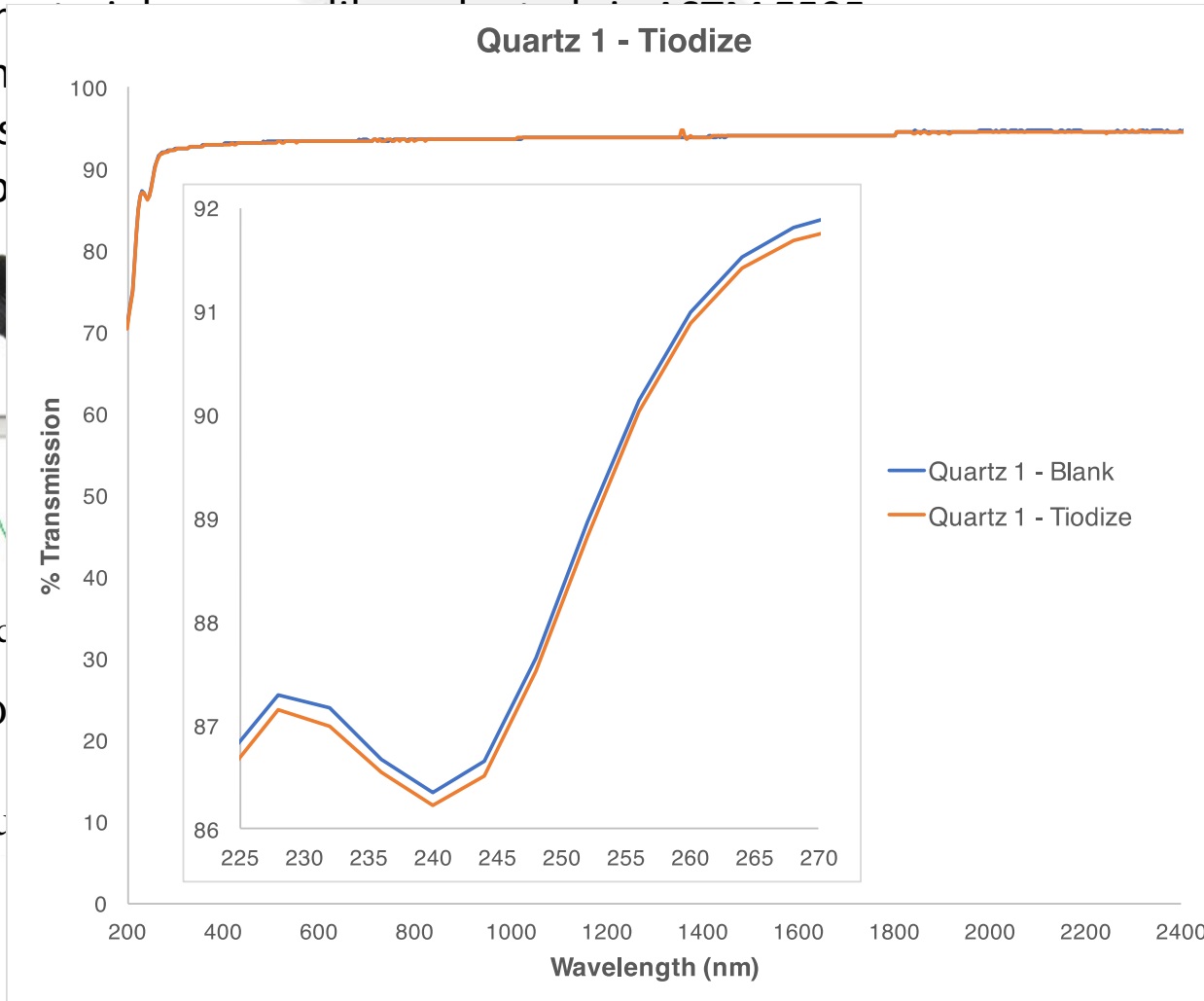
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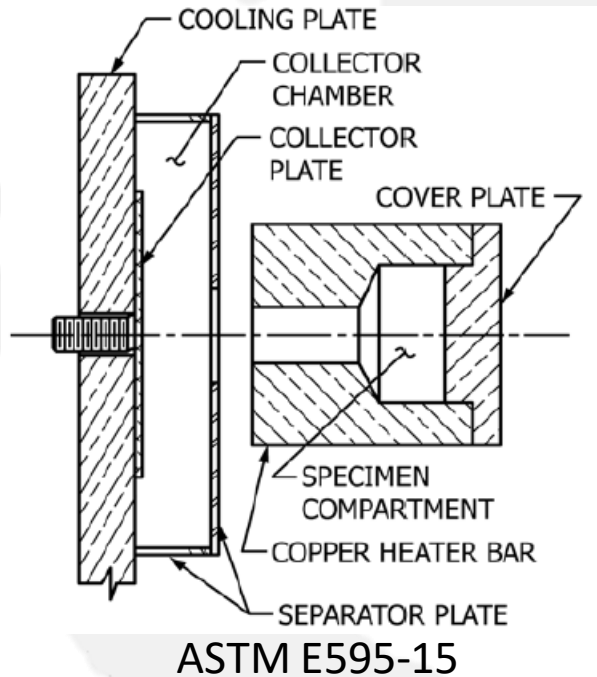
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- Not all r
- Vacuum
- Samples
- UV-vis p

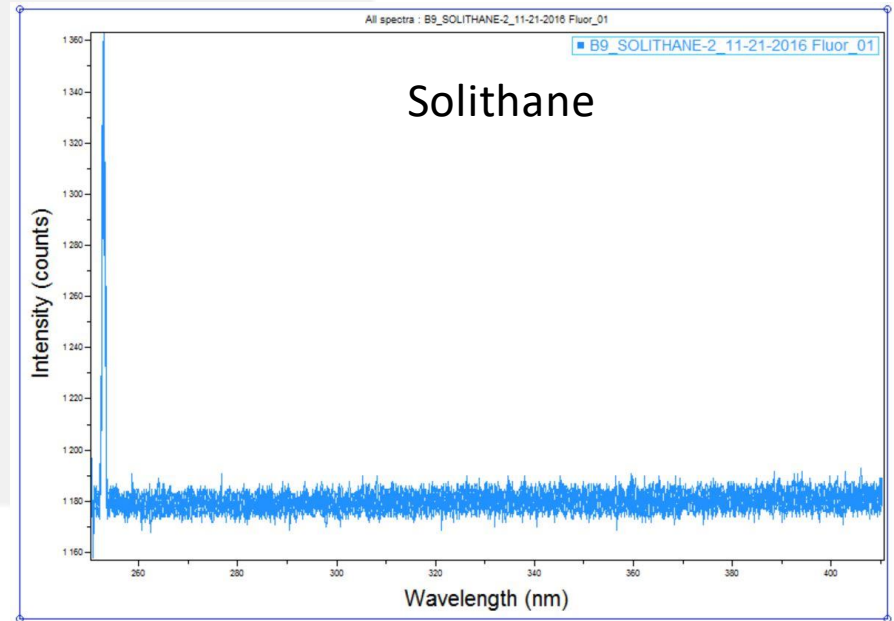
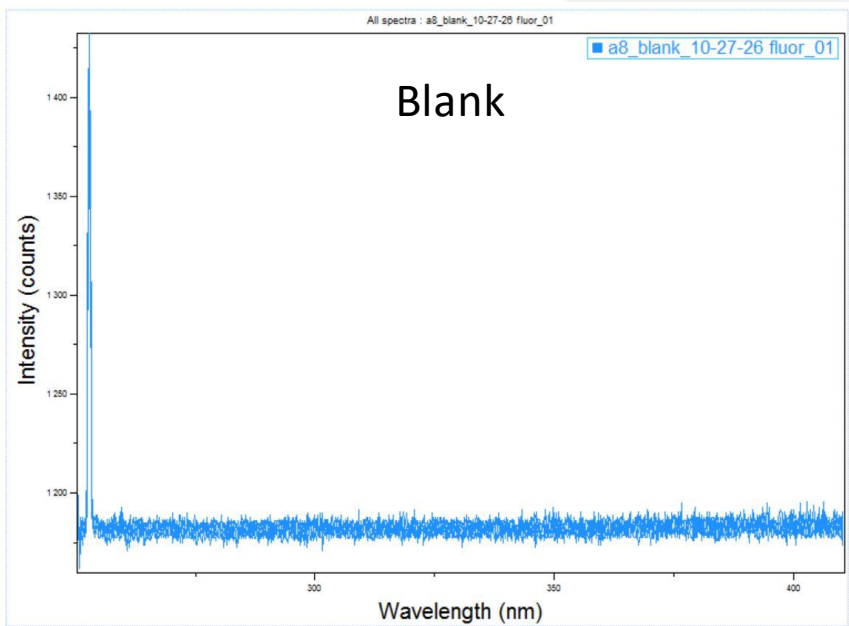
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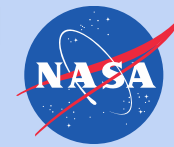
- UV Fluorescence measurement of bulk organic materials of limited utility
 - Characterization of outgassed condensate crucial for material screening
- Utilized Micro-VCM test chamber to outgas organic materials directly onto chromium-plated aluminum collector disc
 - Heated samples to 70°C, cooled targets to 10°C
 - Ran blank samples in between each material



Samples tested without thermal vacuum bake (“worst-case” scenario)



UV Fluorescence Characterization

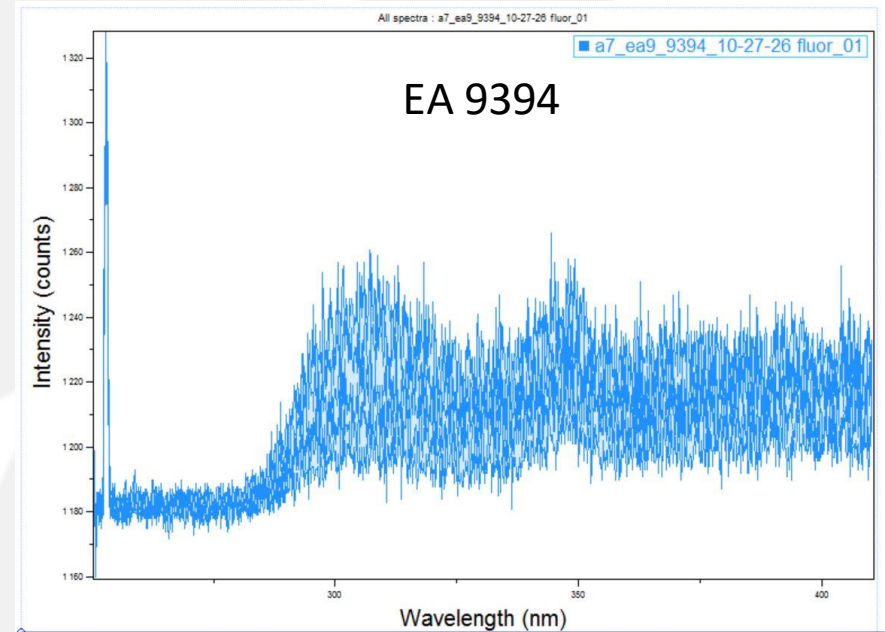
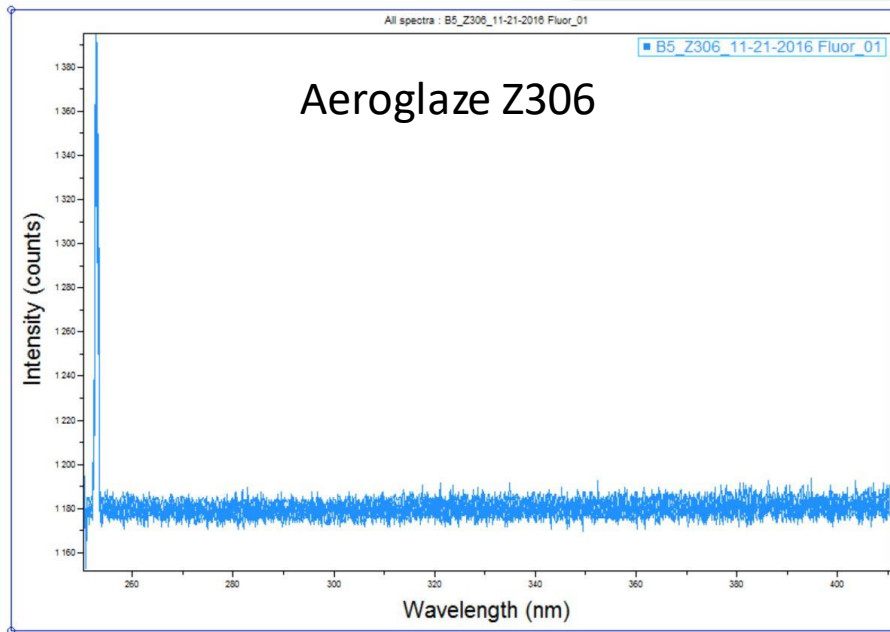


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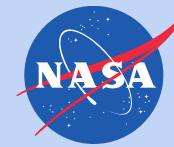
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UV Fluorescence Characterization



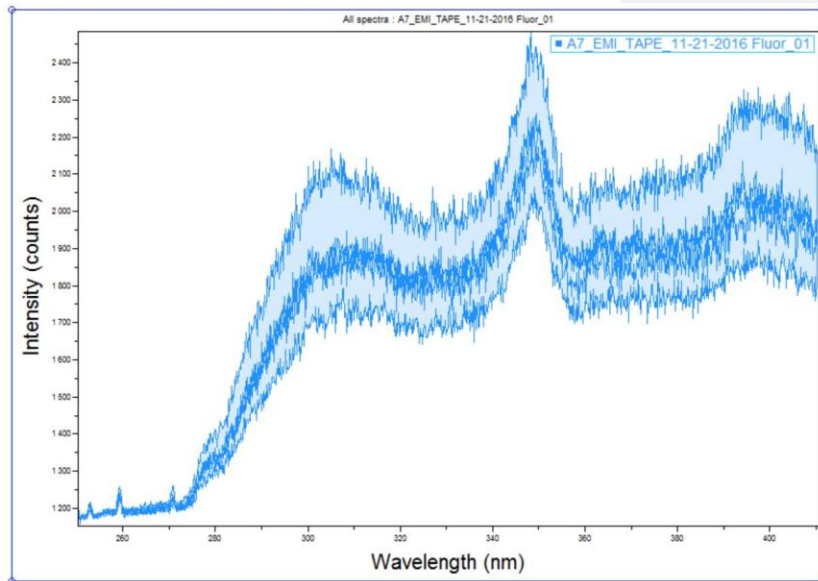
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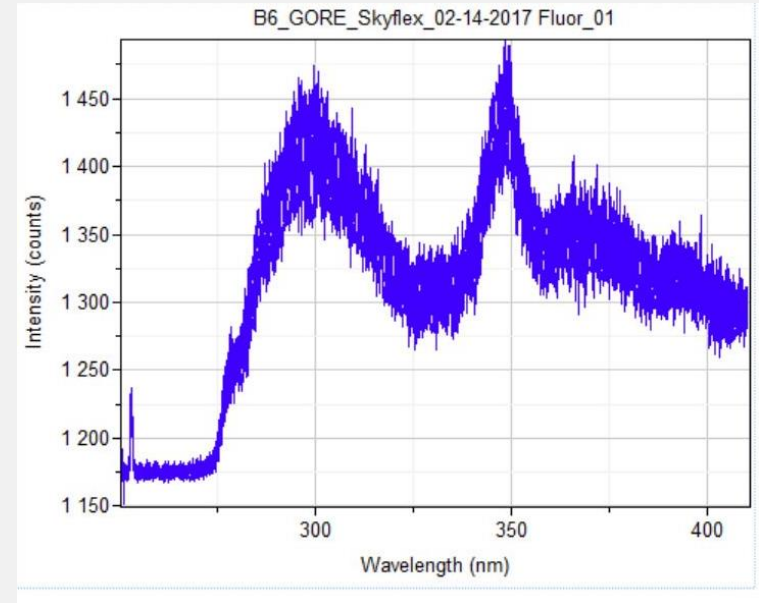
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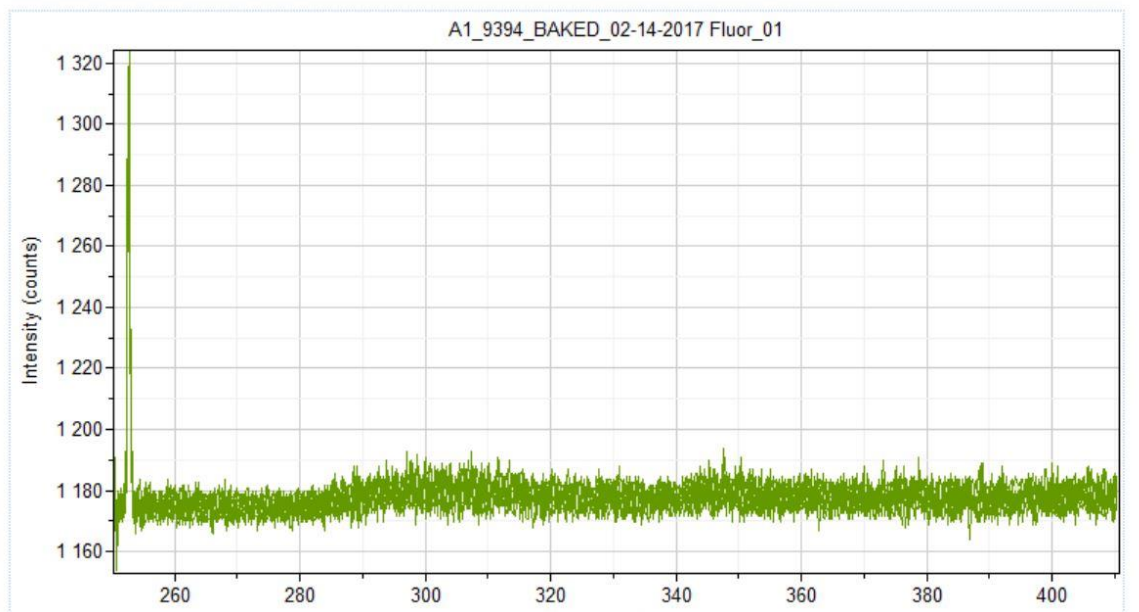
Lairdtech EMI Tape

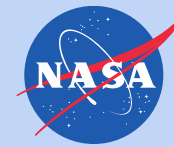


Gore Skyflex Gasket Tape



- High outgassing materials, particularly those that outgas fluorescent condensates, banned from optical bench
- Questionable materials re-evaluated post-bakeout





- Completed evaluation of organic materials within optical bench
- Results guided material selection
- Ongoing work: continued evaluation of materials
 - ASTM E1559 of anodized coating
 - Post-bakeout evaluation of cabling materials previously banned
- Ongoing work: collection of samples of flight material
 - Future comparison against test data as needed



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