

**Metropolitan Museum of Art**  
**Gas Chromatography- Mass Spectrometry (GC-MS) Results from Material Analysis**

This document includes (1) a mass spectrum and (2) the volatile organic compounds (VOCs) emitted from samples using GC-MS analysis. The data is not interpreted; however, several classes of chemicals are highlighted because they are potential risks for artwork in an enclosed environment. A basic key, provided below, indicates those classes. The amount of each chemical identified has not been determined; similarly, it is not known how much of each chemical is necessary to do damage to art. Finally, peaks may be present that are the result of the sample adsorbing chemicals from the air and reemitting them during testing rather than being inherent to the sample. Research is ongoing to determine specifically which chemicals and amounts are required to negatively affect artifacts.

**Highlighted data:**

Pink – chemicals currently known to be hazardous to art

Green – amines; can raise the pH, are suspected to react with acids and may form crystals in an enclosed environment

Yellow – chemicals of the following type, which *may* be hazardous to art:

*Acids* – lower the pH, corrosive to metals, degrade organic materials

*Aldehydes* – can convert to acids with heat or exposure to UV light

*Esters* – can hydrolyze into acids with heat and humidity

*Sulfur-containing compounds* – known to tarnish and corrode some metals

*Halogenated compounds* – can become reactive with exposure to heat and UV light

*Nitrogen-containing, not amine* – can react with other off-gassed chemicals

*Alkynes* – can become reactive when exposed to heat or UV light

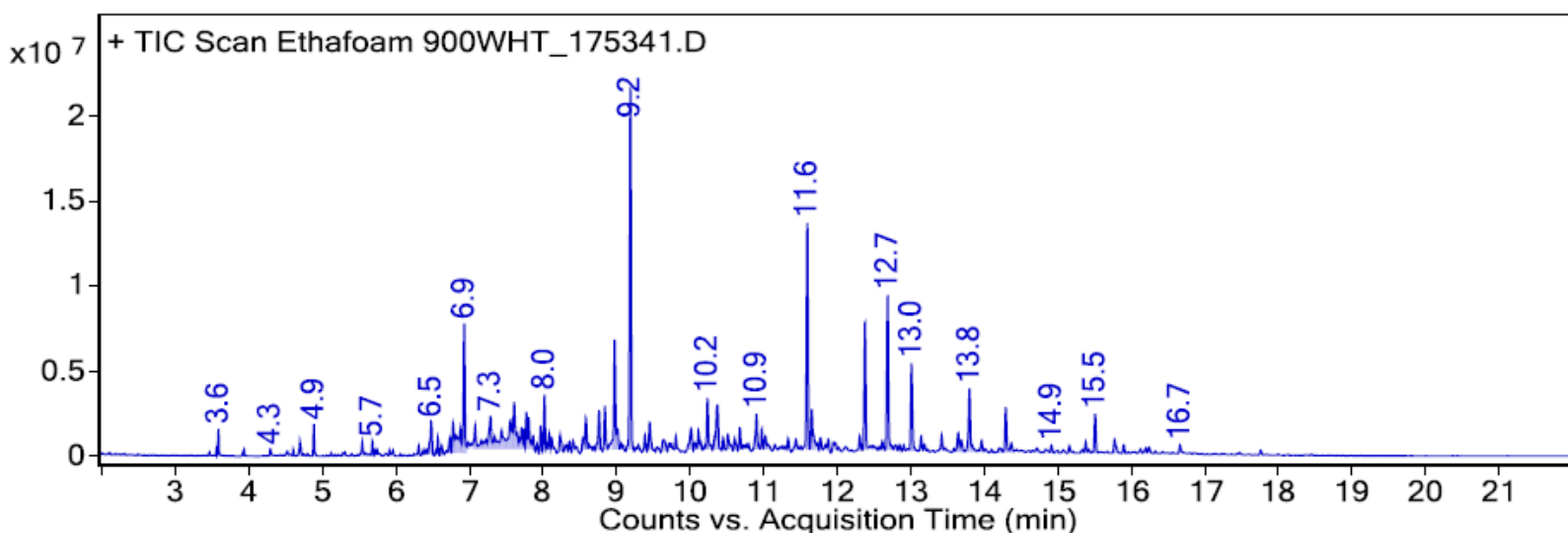
Sample: Ethafoam 900, white

Oddy test result: Permanent

Date GC-MS collected: 3/20/2018

Technique used: SPME Arrow with a PDMS/DVB fiber; Agilent 7890B GC and 5977B MS fitted with a GL Sciences OPTIC-4 multimode inlet and LEAP PAL RTC autosampler; Pre-heated sample at 60°C for 20 minutes; fiber exposure to sample at 60°C for 20 minutes; fiber injected into 220°C inlet and cryotrapped for 2 min at -15°C; GC ramped from 40°C to 225 °C at 10°C/min. Data analyzed in Masshunter Qualitative. Samples > 80% match with a NIST library are reported.

VOCs not highlighted are because they were also observed in blanks: (1) ~12.4 min: 2-methyl-, 2,2-dimethyl-1-(2-hydroxyl-1-methylethyl) propyl ester propanoic acid; (2) ~12.7 min: 2-methyl-, 3-hydroxyl-2,4,4-trimethylpentyl ester propanoic acid



#### Library results

RT	Score	Formula	MW	Area	CAS #	Name
1.500	93.6	C4H10	58.1	21499033	75-28-5	Propane, 2-methyl-
1.700	91.6	C4H10	58.1	1640915	75-28-5	Propane, 2-methyl-
3.600	98.5	C2H4O2	60.0	1546220	64-19-7	Acetic acid
4.700	82.3	C6H12O2	116.1	1294389	1000367-91-1	Formic acid, 2-methylbutyl ester
4.900	97.4	C6H18O3Si3	222.1	1700365	541-05-9	Cyclotrisiloxane, hexamethyl-
5.500	81.1	C6H10O5	162.1	1073551	498-07-7	.beta.-D-Glucopyranose, 1,6-anhydro-
5.700	95.0	C9H20	128.2	792470	1067-20-5	Pentane, 3,3-diethyl-
6.300	87.1	C8H16O	128.1	609907	53907-76-9	Oxirane, (1,1-dimethylbutyl)-
6.500	90.1	C10H20	140.2	3350534	6874-32-4	2-Octene, 3,7-dimethyl-, (Z)-
6.600	92.4	C10H22	142.2	1110839	17302-01-1	3-Ethyl-3-methylheptane
6.600	88.2	C12H22Cl2O2	268.1	788277	1000282-56-6	Dichloroacetic acid, 6-ethyl-3-octyl ester
6.900	94.8	C8H24O4Si4	296.1	10318540	556-67-2	Cyclotetrasiloxane, octamethyl-
7.400	82.3	C3H8O3	92.0	979683	56-81-5	Glycerin
7.700	81.3	C9H20O	144.2	1432806	13254-34-7	2-Heptanol, 2,6-dimethyl-
7.800	94.7	C10H16	136.1	2435351	5989-27-5	Cyclohexene, 1-methyl-4-(1-methylethenyl)-, (R)-
8.000	80.1	C14H30	198.2	1486697	13287-21-3	Tridecane, 6-methyl-
8.000	87.6	C13H28	184.2	3852138	17312-73-1	Undecane, 5,5-dimethyl-

8.100	86.6	C11H24O	172.2	1300239	18675-24-6	1-Decanol, 2-methyl-
8.200	86.1	C15H32	212.3	1735616	3891-98-3	Dodecane, 2,6,10-trimethyl-
8.400	88.1	C12H26O	186.2	796260	3913-02-8	1-Octanol, 2-butyl-
8.500	89.0	C11H24O	172.2	1024445	18675-24-6	1-Decanol, 2-methyl-
8.800	89.5	C16H34	226.3	3829432	544-76-3	Hexadecane
8.800	91.7	C9H18O	142.1	3458164	124-19-6	Nonanal
9.000	87.4	C12H24	168.2	8864947	64723-36-0	Cyclopropane, 1-(2-methylbutyl)-1-(1-methylpropyl)-
9.000	87.7	C12H24	168.2	2182719	64723-36-0	Cyclopropane, 1-(2-methylbutyl)-1-(1-methylpropyl)-
9.100	82.7	C20H40O3	328.3	616370	1000383-15-8	Carbonic acid, decyl nonyl ester
9.200	97.1	C10H30O5Si5	370.1	30263380	541-02-6	Cyclopentasiloxane, decamethyl-
9.500	92.0	C22H42O4	370.3	2582042	1000309-34-6	Oxalic acid, bis(6-ethyloct-3-yl) ester
9.600	85.9	C13H26	182.2	1837219	62199-52-4	Cyclopentane, 1,2-dibutyl-
9.800	84.6	C22H44O3	356.3	935912	1000383-16-0	Carbonic acid, decyl undecyl ester
10.000	82.4	C19H38O2	298.3	2740840	15965-99-8	Oxirane, [(hexadecyloxy)methyl]-
10.100	85.0	C13H28O	200.2	624952	26248-42-0	Tridecanol
10.100	85.6	C15H27Cl3O2	344.1	1491021	74339-51-8	Trichloroacetic acid, tridecyl ester
10.200	93.1	C12H26	170.2	4312945	112-40-3	Dodecane
10.400	85.0	C20H42	282.3	6285880	56862-62-5	10-Methylnonadecane
10.400	85.2	C23H48O	340.4	810813	1000406-37-6	Nonyl tetradecyl ether
10.600	85.8	C13H26	182.2	1069737	2437-56-1	1-Tridecene
10.700	87.2	C12H26O	186.2	1705535	10203-30-2	3-Dodecanol
10.900	87.3	C22H44O3	356.3	3768169	1000383-16-0	Carbonic acid, decyl undecyl ester
11.000	88.6	C16H34O	242.3	1556317	2425-77-6	1-Decanol, 2-hexyl-
11.000	82.6	C13H26	182.2	1406099	25524-42-9	5-Tridecene, (Z)-
11.100	85.5	C16H34O	242.3	675273	2425-77-6	1-Decanol, 2-hexyl-
11.300	84.3	C16H34O	242.3	877227	2425-77-6	1-Decanol, 2-hexyl-
11.400	88.3	C16H34O	242.3	1200046	2425-77-6	1-Decanol, 2-hexyl-
11.600	95.2	C12H36O6Si6	444.1	19247889	540-97-6	Cyclohexasiloxane, dodecamethyl-
11.700	89.4	C15H32	212.3	4711422	31295-56-4	Dodecane, 2,6,11-trimethyl-
11.800	89.0	C23H46O3	370.3	999227	1000383-16-1	Carbonic acid, decyl dodecyl ester
11.900	90.7	C17H34	238.3	865883	6765-39-5	1-Heptadecene
12.000	87.9	C16H34O	242.3	638665	2425-77-6	1-Decanol, 2-hexyl-
12.300	90.3	C24H50S2	402.3	1122487	27458-90-8	Disulfide, di-tert-dodecyl
12.400	91.0	C12H24O3	216.2	11067963	74367-33-2	Propanoic acid, 2-methyl-, 2,2-dimethyl-1-(2-hydroxy-1-methylethyl)propyl ester
12.500	86.6	C16H34O	242.3	706688	2425-77-6	1-Decanol, 2-hexyl-
12.600	86.2	C24H50S2	402.3	728140	27458-90-8	Disulfide, di-tert-dodecyl
12.700	97.1	C12H24O3	216.2	14048519	77-68-9	Propanoic acid, 2-methyl-, 3-hydroxy-2,2,4-trimethylpentyl ester
12.800	87.1	C16H34O	242.3	737252	2425-77-6	1-Decanol, 2-hexyl-
13.000	95.4	C14H30	198.2	8227237	629-59-4	Tetradecane
13.100	89.9	C16H34O	242.3	1010268	2425-77-6	1-Decanol, 2-hexyl-
13.400	83.1	C13H28O	200.2	1173351	1653-37-8	2-Dodecanol, 2-methyl-
13.600	85.4	C17H36	240.3	1957388	14905-56-7	Tetradecane, 2,6,10-trimethyl-
13.700	90.2	C16H34O	242.3	1329492	36653-82-4	1-Hexadecanol
14.000	89.1	C17H36O	256.3	1169685	2490-48-4	1-Hexadecanol, 2-methyl-
14.200	84.1	C17H36O	256.3	676799	2490-48-4	1-Hexadecanol, 2-methyl-
14.300	96.8	C15H32	212.3	3951324	629-62-9	Pentadecane
14.700	83.8	C16H34S	258.2	700813	25360-09-2	tert-Hexadecanethiol
14.900	84.5	C17H36	240.3	626113	14905-56-7	Tetradecane, 2,6,10-trimethyl-
15.500	94.7	C16H34	226.3	3323380	544-76-3	Hexadecane
16.200	83.8	C19H38	266.3	608313	18435-45-5	1-Nonadecene
16.700	90.1	C17H36	240.3	831627	14905-56-7	Tetradecane, 2,6,10-trimethyl-