

## 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

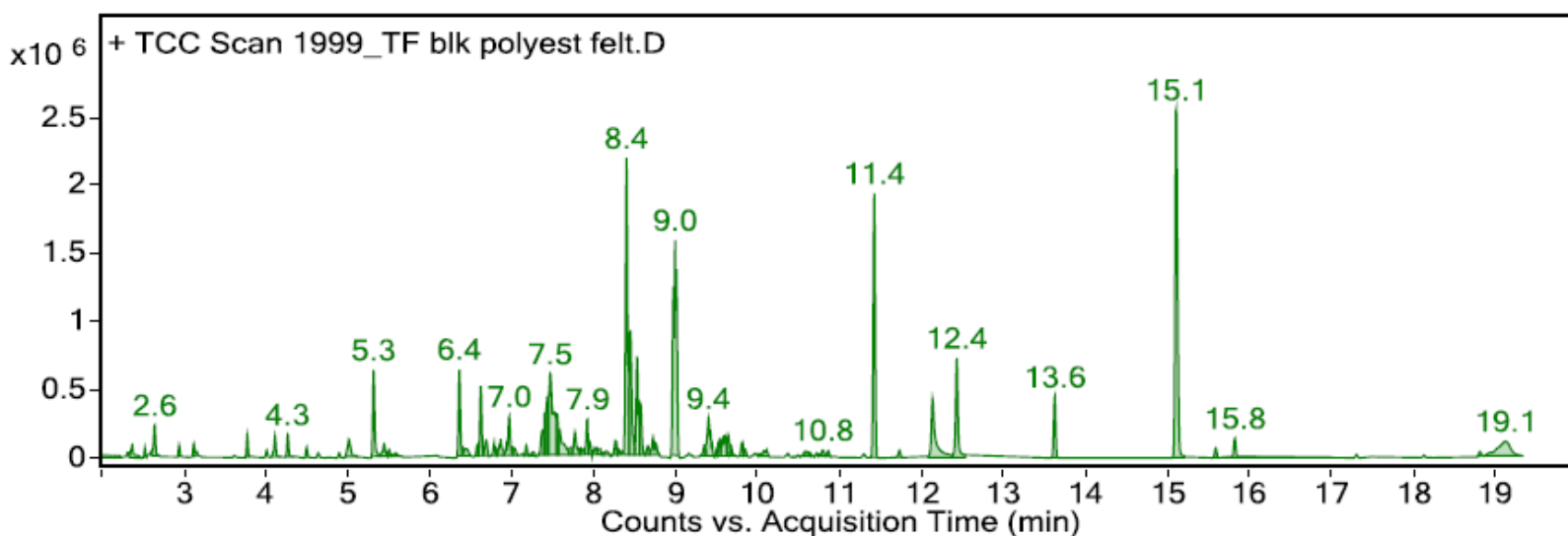
Sample: Test Fabrics; black polyester felt, 11 oz.

Oddy test result: Temporary

Date GC-MS collected: 12/22/2017

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) ~12.1 min: 2-methyl-, 2,2-dimethyl-1-(2-hydroxyl-1-methylethyl) propyl ester propanoic acid; (2) ~12.4 min: 2-methyl-, 3-hydroxyl-2,4,4-trimethylpentyl ester propanoic acid



Library results

RT	Score	Formula	MW	Area	CAS #	Name
2.300	93.0	C2H3DO	45.0	79393	90134-18-2	(O-D)ethenol
2.400	81.8	C5H10O3	118.1	249177	110-49-6	Ethanol, 2-methoxy-, acetate
2.500	95.0	C3H10OSi	90.1	78629	1066-40-6	Silanol, trimethyl-
2.600	95.3	C2H4O2	60.0	277609	64-19-7	Acetic acid
3.100	85.2	C2H8O2Si	92.0	178904	1066-42-8	Silenediol, dimethyl-
3.200	85.4	C5H10O	86.1	39812	110-62-3	Pentanal
3.800	91.1	C7H8	92.1	233484	108-88-3	Benzene, methyl-
4.000	95.9	C8H16	112.1	82496	2511-91-3	Cyclopropane, pentyl-
4.100	94.5	C6H10O	98.1	46521	999009-44-8	4-Ethyl-2,3-dihydrofuran
4.100	92.4	C6H12O	100.1	207117	66-25-1	Hexanal
4.300	91.1	C6H18O3Si3	222.1	266642	541-05-9	Cyclotrisiloxane, hexamethyl-
4.500	91.5	C5H4O2	96.0	118924	98-01-1	2-Furancarboxaldehyde
4.600	93.2	C6H12O2	116.1	63134	123-42-2	2-Pentanone, 4-hydroxy-4-methyl-
4.900	90.8	C8H10	106.1	55735	0-00-0	METHYLLAURATE
5.000	93.3	C6H14O	102.1	120428	111-27-3	1-Hexanol
5.000	97.0	C8H10	106.1	261590	106-42-3	Benzene, 1,4-dimethyl-
5.300	98.6	C8H8	104.1	1002224	100-42-5	Styrene
5.300	90.8	C8H10	106.1	48149	100-41-4	Benzene, ethyl-
5.500	95.7	C6H14O2	118.1	147427	111-76-2	Ethanol, 2-butoxy-
6.400	97.7	C7H6O	106.0	1033399	100-52-7	Benzaldehyde
6.400	95.4	C9H8O2	148.1	332958	999062-75-1	1-Phenyl-1,2-propanedione
6.600	93.6	C6H6O	94.0	142266	108-95-2	Phenol

6.600	95.0	C8H24O4Si4	296.1	811494	556-67-2	Cyclotetrasiloxane, octamethyl-
6.700	93.3	C8H24O4Si4	296.1	309147	556-67-2	Cyclotetrasiloxane, octamethyl-
6.800	93.0	C13H22F4	254.2	152614	108377-18-0	1,1,1,2-tetrafluoro-2-tridecene
7.000	96.3	C8H16O	128.1	307826	124-13-0	Octanal
7.000	92.7	C8H16O	128.1	87771	124-13-0	Octanal
7.200	96.4	C6H4Cl2	146.0	131145	106-46-7	Benzene, 1,4-dichloro-
7.400	83.3	C8H18O	130.1	238608	104-76-7	1-Hexanol, 2-ethyl-
7.400	80.5	C10H18O2	170.1	233121	999108-60-8	methacrylic acid isohexyl ester
7.400	93.5	C10H16	136.1	124884	138-86-3	d-Limonene
7.400	86.0	C8H18O	130.1	327415	104-76-7	1-Hexanol, 2-ethyl-
7.500	93.8	C8H18O	130.1	1243710	111-87-5	1-Octanol
7.600	94.3	C8H18O	130.1	708458	57803-73-3	(S)-(+)-5-Methyl-1-heptanol
7.800	88.5	C10H22	142.2	115895	17302-01-1	3-Ethyl-3-methylheptane
7.900	82.9	C16H33Cl	260.2	53638	4860-03-1	Hexadecane, 1-chloro-
7.900	94.2	C7H12O4	160.1	333617	105-53-3	Propanedioic acid, diethyl ester
8.000	97.2	C8H8O	120.1	184729	98-86-2	Ethanone, 1-phenyl-
8.300	91.3	C9H12O	136.1	162655	617-94-7	Benzenemethanol, .alpha.,.alpha.-dimethyl-
8.300	80.3	C8H8O2	136.1	64497	999043-50-5	methoxycarbonyl-benzene
8.400	94.3	C11H24O	172.2	44368	32357-83-8	Ether, hexyl pentyl
8.400	97.1	C8H8O2	136.1	3381288	93-58-3	Benzoic acid, methyl ester
8.400	96.4	C8H8O2	136.1	2043554	93-58-3	Benzoic acid, methyl ester
8.500	97.5	C9H18O	142.1	1190254	124-19-6	Nonanal
8.600	96.4	C9H18O	142.1	712727	124-19-6	Nonanal
8.700	86.2	C12H24O2	200.2	162743	999180-60-3	DIMETHYL OCTANYL ACETATE
8.800	94.1	C16H32	224.3	124448	35507-09-6	7-Hexadecene, (Z)-
9.000	91.8	C10H30O5Si5	370.1	1975099	541-02-6	Cyclopentasiloxane, decamethyl-
9.000	92.0	C10H30O5Si5	370.1	2330229	541-02-6	Cyclopentasiloxane, decamethyl-
9.200	90.3	C10H20O2	172.1	72808	72218-58-7	3-Methylheptyl acetate
9.400	83.6	C8H18O	130.1	291762	999037-42-1	(S)-3-Ethyl-4-methylpentanol
9.400	89.3	C8H18O	130.1	185352	999037-42-1	(S)-3-Ethyl-4-methylpentanol
9.500	85.4	C9H18O2	158.1	103019	999083-12-4	Octyl ester of formic acid
9.500	82.7	C12H24O2	200.2	148162	112-17-4	Acetic acid, decyl ester
9.600	81.5	C8H16O2	144.1	107563	142-92-7	Acetic acid, hexyl ester
9.600	85.3	C8H17Cl	148.1	91487	628-61-5	Octane, 2-chloro-
9.700	83.9	C8H18O	130.1	162504	57803-73-3	(S)-(+)-5-Methyl-1-heptanol
9.800	95.5	C10H8	128.1	187496	275-51-4	Azulene
9.800	96.0	C10H8	128.1	119737	13633-26-6	Phenylvinylacetylene
10.000	84.6	C16H32	224.3	88469	35507-09-6	7-Hexadecene, (Z)-
10.100	90.6	C10H20O2	172.1	113980	103-09-3	Acetic acid, 2-ethylhexyl ester
10.400	84.4	C16H32	224.3	65342	35507-09-6	7-Hexadecene, (Z)-
10.600	88.9	C11H20O2	184.1	87789	42928-87-0	acrylic acid octyl ester
10.800	81.0	C9H16O2	156.1	41778	2499-95-8	acrylic acid hexyl ester
10.900	86.6	C8H18O	130.1	51230	57803-73-3	(S)-(+)-5-Methyl-1-heptanol
11.300	82.4	C10H14O	150.1	53998	88-18-6	Phenol, 2-(1,1-dimethylethyl)-
11.400	91.5	C12H36O6Si6	444.1	3212253	540-97-6	Cyclohexasiloxane, dodecamethyl-
11.700	96.1	C16H34	226.3	99423	4390-04-9	Nonane, 2,2,4,4,6,8,8-heptamethyl-
12.100	92.5	C12H24O3	216.2	1303885	74367-33-2	Propanoic acid, 2-methyl-, 2,2-dimethyl-1-(2-hydroxy-1-methylethyl)propyl ester
12.400	93.2	C12H24O3	216.2	1363669	77-68-9	Propanoic acid, 2-methyl-, 3-hydroxy-2,2,4-trimethylpentyl ester
15.100	95.9	C12H14O4	222.1	3931297	84-66-2	1,2-Benzenedicarboxylic acid, diethyl ester
15.100	92.3	C16H30O4	286.2	1442652	6846-50-0	PENTAN-1,3-DIOLDIISOBUTYRATE, 2,2,4-TRIMETHYL-
15.600	89.1	C16H48O8Si8	592.2	129451	556-68-3	Cyclooctasiloxane, hexadecamethyl-
15.800	86.5	C15H22	202.2	244212	74708-73-9	1,4-Methanobenzocyclodecene, 1,2,3,4,4a,5,8,9,12,12a-decahydro-
17.300	80.6	C18H54O9Si9	666.2	49038	556-71-8	OCTADECAMETHYLCYCLONONASILOXANE
17.500	90.1	C12H24O2	200.2	41273	25415-84-3	2-Ethylhexyl ester of butanoic acid
18.100	89.5	C20H30O4	334.2	105795	84-78-6	1,2-Benzenedicarboxylic acid, butyl octyl ester
18.800	89.9	C12H10O2S	218.0	66227	127-63-9	Benzene, 1,1'-sulfonylbis-
19.100	95.4	C24H38O4	390.3	1382308	117-81-7	1,2-Benzenedicarboxylic acid, bis(2-ethylhexyl) ester