

**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

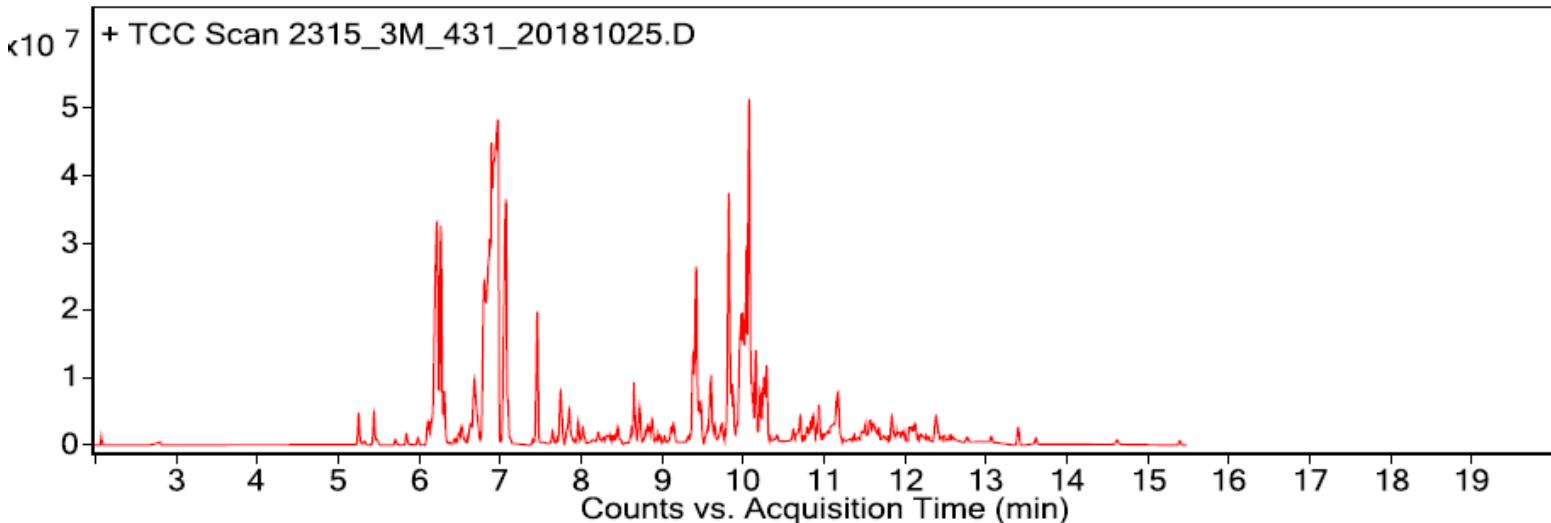
*Alkynes* – can become reactive when exposed to heat or UV light

Sample: Talas; single sided tape with potato starch gumming

Date collected: 10/25/2018

Technique used: SPME with a PDMS/DVB fiber; Agilent 7890B GC and 5977B MS fitted with a GL Sciences OPTIC-4 multimode inlet and LEAP PAL RTC auto-sampler; Pre-heated at 60°C for 20 minutes; fiber exposure at 60°C for 20 minutes; sample 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 using the Masshunter Qualitative program. Samples > 80% match with a NIST 17.0 library are reported.

VOCs not highlighted are because they were also observed in blanks: (1) 11.8 min: 2-methyl-, 3-hydroxyl-2,4,4-trimethylpentyl ester propanoic acid



Library results

RT	Score	Formula	MW	Area	CAS #	Name
1.490	97.8	C2H4O2	60.0	1295631	64-19-7	Acetic acid
2.080	93.7	C2H8O2Si	92.0	1207023	1066-42-8	Silanediol, dimethyl-
2.810	94.1	C4H8O2	88.1	1881872	999006-02-9	2-Methylpropanoic acid
5.250	91.7	C7H16O	116.1	6911958	6570-87-2	1-Pentanol, 3,4-dimethyl-
5.330	84.4	C9H16O2	156.1	1189903	7336-27-8	Isoamyl methacrylate
5.440	95.4	C7H16O	116.1	7967315	1767-46-0	1-Hexanol, 4-methyl-, (S)-
5.710	97.9	C7H6O	106.0	1463659	100-52-7	Benzaldehyde
5.840	88.9	C7H16O	116.1	2771816	111-70-6	1-Heptanol
5.990	89.2	C8H18O	130.1	1643783	123-44-4	1-Pentanol, 2,2,4-trimethyl-
6.110	90.9	C8H18O	130.1	5707906	106-67-2	1-Pentanol, 2-ethyl-4-methyl-
6.130	89.5	C6H6O	94.0	1069846	108-95-2	Phenol
6.220	93.2	C8H18O	130.1	95454192	1653-40-3	1-Heptanol, 6-methyl-
6.270	88.7	C8H18O	130.1	27197622	0-00-0	Isooctanols
6.440	86.0	C8H18O	130.1	1615902	0-00-0	Isooctanols
6.490	86.5	C8H18O	130.1	1116466	6570-88-3	2,3,4-trimethyl-1-pentanol
6.520	92.6	C8H18O	130.1	4657583	6570-88-3	2,3,4-trimethyl-1-pentanol
6.680	96.2	C8H18O	130.1	33710254	1000144-07-1	(S)-3-Ethyl-4-methylpentanol
6.850	83.9	C7H11NO2	141.1	42033004	999051-84-7	O-Propenylcarbonyl-N-isopropylidene oxime
6.920	85.3	C7H13NO	127.1	65911434	88362-46-3	4,5-dihydro-2-methyl-4-(1-methylethyl)oxazole
6.960	83.0	C5H12O	88.1	60240783	71-41-0	1-Pentanol
7.050	87.9	C5H9NO	99.1	1989592	872-50-4	2-Pyrrolidinone, 1-methyl-
7.070	96.0	C8H18O	130.1	76797218	57803-73-3	(S)-(+)-5-Methyl-1-heptanol
7.090	86.0	C5H9NO	99.1	1315661	872-50-4	2-Pyrrolidinone, 1-methyl-
7.410	95.4	C8H8O	120.1	1102064	98-86-2	Ethanone, 1-phenyl-
7.460	97.2	C8H18O	130.1	31847088	111-87-5	1-Octanol
7.650	91.4	C9H20O	144.2	3086640	143-08-8	1-Nonanol
7.750	85.1	C9H20O	144.2	12943914	3452-97-9	1-Hexanol, 3,5,5-trimethyl-
7.850	89.1	C10H20	140.2	13614045	62238-07-7	Cyclopropane, 1-methyl-2-(3-methylpentyl)-
7.970	97.3	C9H18O	142.1	5080322	124-19-6	Nonanal
8.210	88.6	C8H18O	130.1	3927125	1653-40-3	1-Heptanol, 6-methyl-
8.400	89.5	C13H22ClF3	270.1	1809605	108400-10-8	2-chloro-1,1,1-trifluoro-2-tridecene
8.450	95.2	C7H12O4	160.1	2682647	1119-40-0	Pentanedioic acid, dimethyl ester
8.620	86.1	C8H18O	130.1	2196250	999037-42-1	(S)-3-Ethyl-4-methylpentanol
8.660	96.3	C10H20O2	172.1	8599584	103-09-3	Acetic acid, 2-ethylhexyl ester

8.880	81.9	C8H18O	130.1	5958209	100431-87-6	(s)-3-ethyl-4-methylpentanol-1
8.970	84.1	C10H20O2	172.1	2616845	103-09-3	Acetic acid, 2-ethylhexyl ester
9.150	87.7	C11H20O2	184.1	4242035	103-11-7	2-Propenoic acid, 2-ethylhexyl ester
9.380	81.3	C12H26	170.2	9138138	112-40-3	Dodecane
9.420	88.9	C11H20O2	184.1	47354695	2499-59-4	2-Propenoic acid, octyl ester
9.600	90.4	C10H20O	156.2	7544934	21862-63-5	Cyclohexanol, 4-(1,1-dimethylethyl)-, trans-
9.650	85.0	C11H20O2	184.1	3168347	42928-87-0	acrylic acid octyl ester
9.820	87.3	C8H18O	130.1	32792684	1070-32-2	1-Heptanol, 3-methyl-
9.880	91.1	C8H14N2O	154.1	17084722	84213-57-0	N-(1-Cyano-1-methylethyl)isobutyramide
9.990	83.8	C8H16	112.1	17153919	7145-23-5	3-Hexene, 2,3-dimethyl-
10.070	86.8	C11H20O2	184.1	47748292	2499-59-4	2-Propenoic acid, octyl ester
10.160	86.1	C11H20O2	184.1	21011852	2499-59-4	2-Propenoic acid, octyl ester
10.210	91.5	C15H28O2	240.2	13109524	2156-97-0	acrylic acid dodecanyl ester
10.260	80.6	C13H24O2	212.2	6595319	1330-61-6	2-PROPENOIC ACID, ISODECYL ESTER
10.290	90.2	C8H18O	130.1	18147969	57803-73-3	(S)-(+)-5-Methyl-1-heptanol
10.420	84.7	C18H38O	270.3	1954860	1000406-38-3	Decyl octyl ether
10.620	88.3	C11H24O	172.2	3322962	112-42-5	1-Undecanol
10.710	91.7	C11H20O2	184.1	3295619	42928-87-0	acrylic acid octyl ester
10.790	82.7	C13H28	184.2	3997253	629-50-5	Tridecane
10.820	81.7	C10H17F3O2	226.1	1818117	0-00-0	1,1,1-trifluorooctan-2-ol
10.870	87.5	C9H20O	144.2	8660617	143-08-8	1-Nonanol
11.170	95.5	C12H36O6Si6	444.1	12019442	540-97-6	Cyclohexasiloxane, dodecamethyl-
11.510	82.2	C13H28	184.2	1686404	17312-68-4	Undecane, 4,4-dimethyl-
11.560	83.8	C12H24O3	216.2	4585456	74367-33-2	2,2-Dimethyl-1-(2-hydroxy-1-isopropyl)propyl ester of isobutanoic acid
11.610	81.9	C16H32	224.3	4248952	41977-40-6	Cyclopropane, 1-methyl-1-(1-methylethyl)-2-nonyl-
11.740	81.9	C20H42O	298.3	2312920	1000406-38-4	Dodecyl octyl ether
11.840	94.3	C12H24O3	216.2	6488281	74367-34-3	Propanoic acid, 2-methyl-, 3-hydroxy-2,4,4-trimethylpentyl ester
12.120	89.8	C14H30	198.2	5059235	629-59-4	Tetradecane
12.380	81.9	C12H24	168.2	1932945	74630-41-4	1-Undecene, 9-methyl-
12.440	84.5	C18H36	252.3	1721279	41977-42-8	Cyclopropane, 1-(1,2-dimethylpropyl)-1-methyl-2-nonyl-
12.590	83.9	C16H32	224.3	1692871	41977-40-6	Cyclopropane, 1-methyl-1-(1-methylethyl)-2-nonyl-
12.770	82.5	C19H38	266.3	1521530	13151-91-2	Tridecane, 6-cyclohexyl-
13.060	88.8	C14H20O2	220.1	1579380	719-22-2	2,5-Cyclohexadiene-1,4-dione, 2,6-bis(1,1-dimethylethyl)-
13.400	80.4	C14H42O7Si7	518.1	4779468	107-50-6	Cycloheptasiloxane, tetradecamethyl-
13.620	95.3	C15H24O	220.2	1483034	128-37-0	Phenol, 2,6-bis(1,1-dimethylethyl)-4-methyl-
15.390	88.9	C16H48O8Si8	592.2	1210326	556-68-3	Cyclooctasiloxane, hexadecamethyl-