

**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

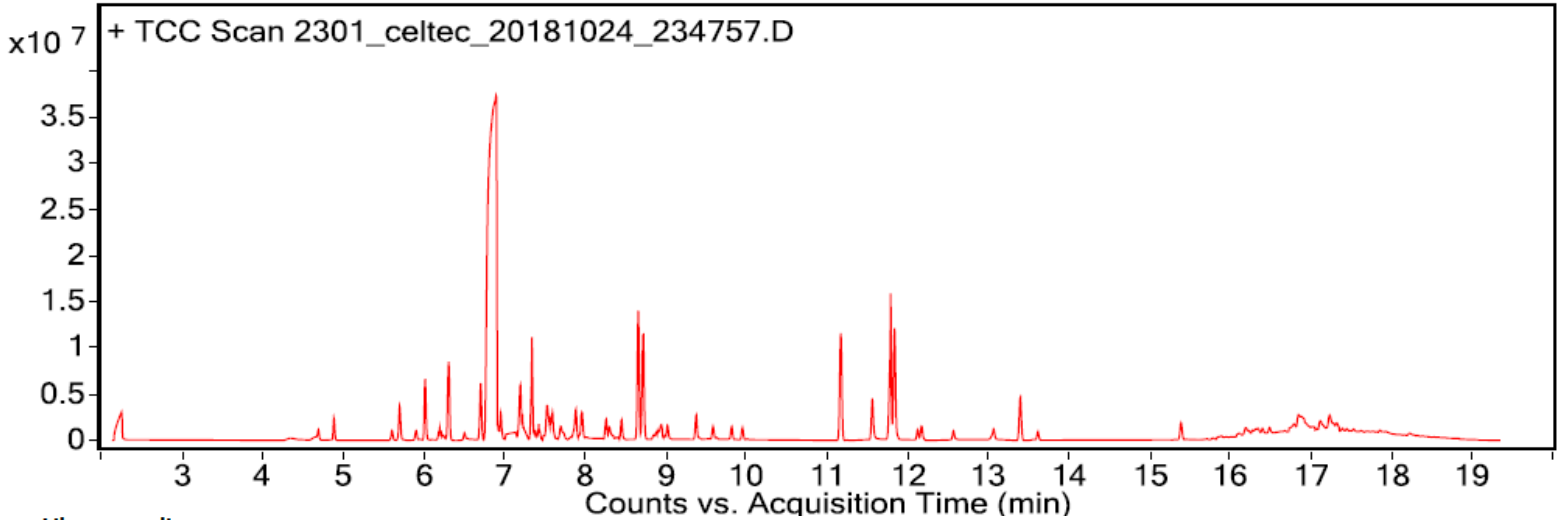
*Alkynes* – can become reactive when exposed to heat or UV light

Sample: Vycom: Celtec expanded PVC board

Date collected: 10/23/2018

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) 11.6 min: 2-methyl-, 2,2-dimethyl-1-(2-hydroxyl-1-methylethyl) propyl ester propanoic acid; (2) 11.8 min: 2-methyl-, 3-hydroxyl-2,4,4-trimethylpentyl ester propanoic acid



Library results

RT	Score	Formula	MW	Area	CAS #	Name
2.250	85.4	C2H4O	44.0	13121073	75-07-0	Acetaldehyde
4.350	84.5	C8H18O	130.1	1634854	999037-39-9	Butyl isobutyl ether
4.690	95.0	C7H12O2	128.1	2992440	141-32-2	2-Propenoic acid, butyl ester
4.890	96.1	C7H14O2	130.1	3169099	590-01-2	Propanoic acid, butyl ester
5.700	92.1	C11H24	156.2	4472197	62016-28-8	Octane, 2,2,6-trimethyl-
5.710	91.8	C7H6O	106.0	1531565	100-52-7	Benzaldehyde
5.900	92.8	C11H24	156.2	1750979	62016-28-8	Octane, 2,2,6-trimethyl-
6.020	93.5	C8H14O2	142.1	9596353	97-88-1	n-Butyl methacrylate
6.190	93.6	C14H30O3S	278.2	1508915	999397-36-5	Sulfurous acid, 2-ethylhexyl hexyl ester
6.310	96.2	C8H24O4Si4	296.1	14287414	556-67-2	Cyclotetrasiloxane, octamethyl-
6.500	91.3	C12H26	170.2	1475423	13475-82-6	Heptane, 2,2,4,6,6-pentamethyl-
6.710	92.6	C12H26	170.2	9512985	13475-82-6	Heptane, 2,2,4,6,6-pentamethyl-
6.870	82.1	C10H17NO3	199.1	13649329	999177-55-2	(S)-4,5-Dihydro-5-pivaloyloxymethyl-2(3H)-pyrrolone
6.900	84.3	C6H14O	102.1	139351375	111-27-3	1-Hexanol
7.200	90.9	C15H32	212.3	10534993	31295-56-4	Dodecane, 2,6,11-trimethyl-
7.230	90.7	C15H32	212.3	2317470	31295-56-4	Dodecane, 2,6,11-trimethyl-
7.340	91.6	C15H32	212.3	9162348	31295-56-4	Dodecane, 2,6,11-trimethyl-
7.430	87.1	C15H32	212.3	1591712	31295-56-4	Dodecane, 2,6,11-trimethyl-
7.600	87.4	C9H18O2	158.1	2530510	1000368-94-7	Formic acid, 2-ethylhexyl ester
7.700	87.5	C9H12O	136.1	2192454	617-94-7	Benzenemethanol, .alpha.,.alpha.-dimethyl-
7.880	93.9	C11H24	156.2	6467654	1120-21-4	Undecane
7.960	97.1	C9H18O	142.1	4597817	124-19-6	Nonanal
8.260	87.9	C13H28	184.2	1696709	62237-97-2	Decane, 2,2,6-trimethyl-
8.300	82.8	C6H15O4P	182.1	1537647	78-40-0	Phosphoric acid, triethyl ester
8.450	97.4	C7H12O4	160.1	3315462	1119-40-0	Pentanedioic acid, dimethyl ester
8.660	96.2	C10H20O2	172.1	21568334	103-09-3	Acetic acid, 2-ethylhexyl ester
8.720	94.6	C10H30O5Si5	370.1	14913042	541-02-6	Cyclopentasiloxane, decamethyl-
8.880	83.6	C17H36O3S	320.2	1761556	999508-28-5	Sulfurous acid, 2-ethylhexyl nonyl ester
8.940	90.6	C12H26	170.2	1841387	1002-43-3	UNDECANE, 3-METHYL-
9.020	98.0	C10H20O	156.2	2426359	15356-70-4	Cyclohexanol, 5-methyl-2-(1-methylethyl)-, (1.alpha.,2.beta.,5.alpha.)-(+/-)-
9.380	93.7	C12H26	170.2	4376978	112-40-3	Dodecane
9.590	88.9	C10H20O	156.2	2383022	21862-63-5	Cyclohexanol, 4-(1,1-dimethylethyl)-, trans-
9.820	95.6	C11H20O2	184.1	2250269	103-11-7	2-Ethylhexyl acrylate
9.950	91.2	C11H22O2	186.2	2025251	999145-46-3	2-Ethyl-1-hexyl propionate
11.170	95.7	C12H36O6Si6	444.1	21637287	540-97-6	Cyclohexasiloxane, dodecamethyl-

11.560	91.6	C12H24O3	216.2	8258179	74367-33-2	Propanoic acid, 2-methyl-, 2,2-dimethyl-1-(2-hydroxy-1-methylethyl)propyl ester
11.790	85.8	C11H22O2	186.2	16950831	142-60-9	Propanoic acid, octyl ester
11.840	92.8	C12H24O3	216.2	12306850	74367-34-3	Propanoic acid, 2-methyl-, 3-hydroxy-2,4,4-trimethylpentyl ester
12.120	95.5	C14H30	198.2	1765818	629-59-4	Tetradecane
12.570	90.2	C10H20O2S	204.1	1793740	7659-86-1	2-Ethylhexyl mercaptoacetate
13.400	80.4	C14H42O7Si7	518.1	8737087	107-50-6	Cycloheptasiloxane, tetradecamethyl-
13.620	96.9	C15H24O	220.2	1486156	128-37-0	Phenol, 2,6-bis(1,1-dimethylethyl)-4-methyl-
15.390	90.6	C16H48O8Si8	592.2	3394170	556-68-3	Cyclooctasiloxane, hexadecamethyl-
17.120	82.9	C18H54O9Si9	666.2	1916966	556-71-8	Cyclononasiloxane, octadecamethyl-