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

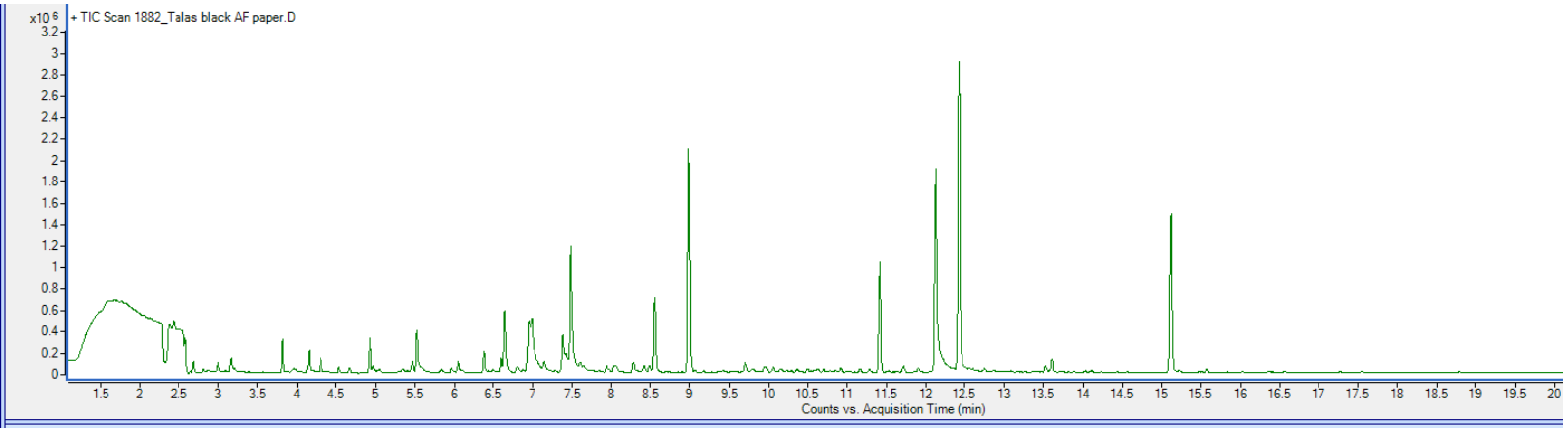
Sample: Talas; Antique endleaf paper; acid free and lignin free with 2% alkaline reserve; black

Oddy test result: Permanent

Date collected: 12/11/2017

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 autosampler; Pre-heated at 60°C for 20 minutes; fiber exposure at 60°C for 20 minutes; sample injected into 220°C inlet and crotrapped 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-hydroxy-1-methylethyl) propyl ester propanoic acid; (2) 12.4 min: 2-methyl-, 3-hydroxy-2,2,4-trimethylpentyl ester propanoic acid



Library results

RT	Score	Formula	MW	Area	CAS #	Name
2.432	85.3	C4H8O2	88.1	113190	5878-19-3	2-Propanone, 1-methoxy-
2.584	90.2	C3H10OSi	90.1	77125	1066-40-6	Silanol, trimethyl-
2.687	98.4	C2H4O2	60.0	152191	64-19-7	Acetic acid
2.998	92.3	C4H10O	74.1	114725	71-36-3	1-Butanol
3.159	93.6	C2H8O2Si	92.0	211795	1066-42-8	Silanediol, dimethyl-
3.820	96.9	C7H8	92.1	358315	108-88-3	Benzene, methyl-
3.958	88.2	C6H12O2	116.1	88383	142-62-1	Hexanoic acid
4.153	94.3	C6H12O	100.1	348774	66-25-1	Hexanal
4.305	93.4	C6H18O3Si3	222.1	183701	541-05-9	Cyclotrisiloxane, hexamethyl-
4.536	96.7	C5H4O2	96.0	82843	98-01-1	2-Furancarboxaldehyde
4.670	95.5	C6H12O2	116.1	78156	123-42-2	2-Pentanone, 4-hydroxy-4-methyl-
4.929	99.7	C8H10	106.1	474560	100-41-4	Ethylbenzene
4.969	93.1	C6H12O3	132.1	60644	108-65-6	1-Methoxy-2-propyl ester of acetic acid
5.346	93.1	C8H8	104.1	125765	100-42-5	Styrene
5.365	91.4	C9H12O	136.1	63869	999044-39-0	.alpha.-Methoxy-3-methylbenzyl
5.528	98.0	C6H14O2	118.1	761661	111-76-2	Ethanol, 2-butoxy-
5.964	89.8	C5H12O2	104.1	66743	126-30-7	Neopentyl glycol
6.048	97.1	C7H16O2	132.1	205841	5131-66-8	2-Propanol, 1-butoxy-
6.387	98.8	C7H6O	106.0	324481	100-52-7	Benzaldehyde
6.599	98.5	C6H6O	94.0	235615	108-95-2	Phenol
6.644	95.4	C8H24O4Si4	296.1	868939	556-67-2	Cyclotetrasiloxane, octamethyl-
6.954	97.1	C7H8O	108.1	2144788	100-51-6	Benzenemethanol
6.991	96.6	C8H16O	128.1	494959	124-13-0	Octanal
7.149	94.4	C7H16O3	148.1	166996	0-00-0	dipropylene glycol monomethyl ether isomer, STRUCTURE UNKNOWN
7.384	93.6	C8H18O	130.1	852911	104-76-7	1-Hexanol, 2-ethyl-
7.427	96.2	C10H16	136.1	163828	138-86-3	dl-Limonene
7.484	97.7	C7H8O	108.1	2087960	100-51-6	Benzenemethanol
7.495	93.2	C9H18O2	158.1	383107	999083-12-4	Octyl ester of formic acid
7.603	90.7	C8H18O	130.1	181584	57803-73-3	(S)-(+)-5-Methyl-1-heptanol
7.941	92.9	C7H12O4	160.1	89756	105-53-3	Diethyl malonate

8.036	93.9	C8H18O	130.1	172794	111-87-5	1-Octanol
8.284	92.5	C9H12O	136.1	156159	617-94-7	Benzenemethanol, .alpha.,.alpha.-dimethyl-
8.418	92.1	C8H8O2	136.1	108909	93-58-3	Benzoic acid, methyl ester
8.548	98.7	C9H18O	142.1	1277121	124-19-6	Nonanal
8.989	91.9	C10H30O5Si5	370.1	3133327	541-02-6	Cyclopentasiloxane, decamethyl-
9.699	94.9	C10H20O	156.2	169728	1490-04-6	Cyclohexanol, 5-methyl-2-(1-methylethyl)-
10.061	95.4	C10H20O	156.2	80790	112-31-2	Decanal
11.415	91.5	C12H36O6Si6	444.1	1448468	540-97-6	Cyclohexasiloxane, dodecamethyl-
11.721	93.8	C16H34	226.3	102270	4390-04-9	Nonane, 2,2,4,4,6,8,8-heptamethyl-
11.908	93.9	C7H12O5	176.1	67489	102-62-5	Glycerol 1,2-diacetate
12.125	92.4	C12H24O3	216.2	4285933	74367-33-2	Propanoic acid, 2-methyl-, 2,2-dimethyl-1-(2-hydroxy-1-methylethyl)propyl ester
12.423	93.5	C12H24O3	216.2	5035572	77-68-9	Propanoic acid, 2-methyl-, 3-hydroxy-2,2,4-trimethylpentyl ester
12.750	99.6	C26H54	366.4	69335	630-01-3	Hexacosane
15.093	95.9	C12H14O4	222.1	116199	84-66-2	1,2-Benzenedicarboxylic acid, diethyl ester
15.116	92.6	C16H30O4	286.2	2281353	6846-50-0	PENTAN-1,3-DIOLDIISOBUTYRATE, 2,2,4-TRIMETHYL-