

**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

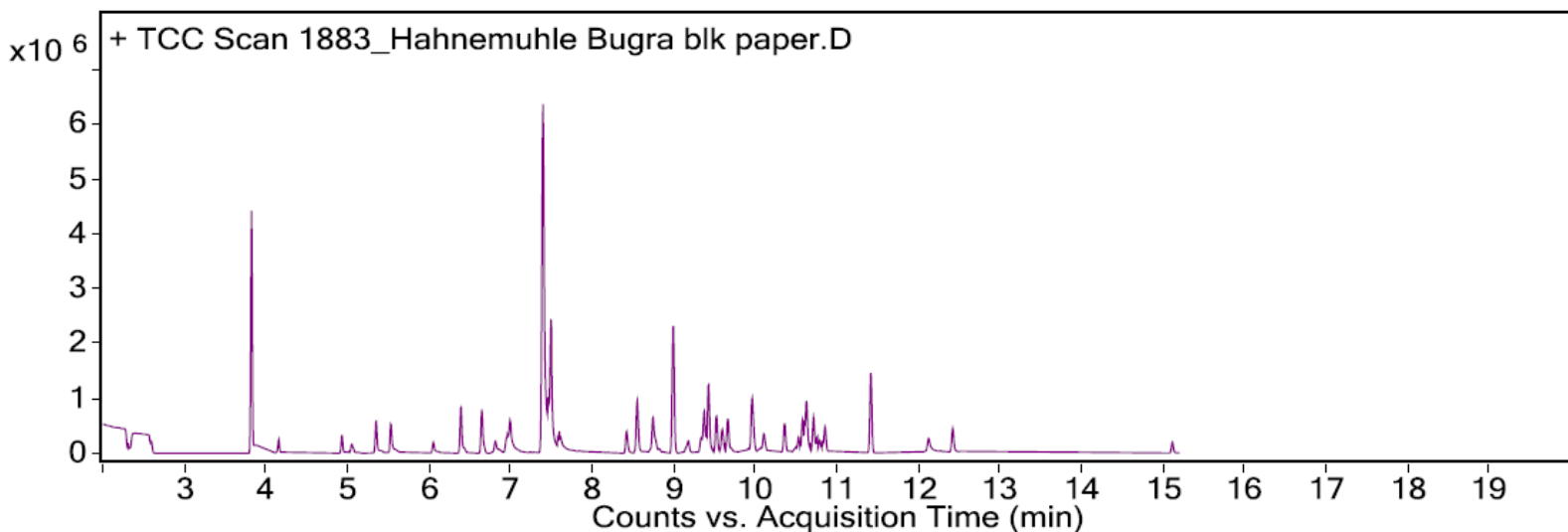
Sample: Talas; Hahnemuhle antique Bugra paper #313; cellulose; black

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
3.821	97.4	C7H8	92.1	5937709	108-88-3	Benzene, methyl-
4.155	97.5	C6H12O	100.1	355484	66-25-1	Hexanal
4.931	99.7	C8H10	106.1	510650	100-41-4	Ethylbenzene
5.051	97.8	C8H10	106.1	394804	95-47-6	o-Xylene
5.349	99.1	C8H8	104.1	1068715	100-42-5	Styrene
5.530	98.2	C6H14O2	118.1	1103769	111-76-2	Ethanol, 2-butoxy-
6.051	97.5	C7H16O2	132.1	389070	5131-66-8	2-Propanol, 1-butoxy-
6.390	98.9	C7H6O	106.0	1532360	100-52-7	Benzaldehyde
6.647	95.4	C8H24O4Si4	296.1	1457344	556-67-2	Cyclotetrasiloxane, octamethyl-
6.812	92.8	C8H18O	130.1	447015	26952-21-6	Isooctanol
6.953	96.6	C7H8O	108.1	1422259	100-51-6	Benzenemethanol
6.994	97.3	C8H16O	128.1	697918	124-13-0	Octanal
7.396	98.2	C8H18O	130.1	13772631	104-76-7	1-Hexanol, 2-ethyl-
7.431	92.9	C10H16	136.1	533641	138-86-3	dl-Limonene
7.495	80.7	C7H8O	108.1	2777487	100-51-6	Benzenemethanol
7.609	96.8	C8H18O	130.1	1124031	7212-53-5	5-Methyl-1-heptanol
8.422	97.0	C8H8O2	136.1	782944	93-58-3	Benzoic acid, methyl ester
8.551	98.7	C9H18O	142.1	1726511	124-19-6	Nonanal
8.745	89.0	C8H18O	130.1	1561763	1653-40-3	1-Heptanol, 6-methyl-
8.994	92.5	C10H30O5Si5	370.1	4314232	541-02-6	Cyclopentasiloxane, decamethyl-
9.178	89.6	C10H20O2	172.1	496384	103-09-3	Acetic acid, 2-ethylhexyl ester
9.372	81.7	C8H16O2	144.1	1584313	35897-13-3	3-Methylpentyl acetate
9.426	86.6	C10H20O2	172.1	2287457	112-14-1	Acetic acid, octyl ester
9.523	87.4	C10H20O2	172.1	1154147	112-14-1	Acetic acid, octyl ester
9.594	84.7	C11H22O2	186.2	820512	1000439-66-5	6-Methyloctyl acetate
9.663	90.5	C10H20O2	172.1	1134103	103-09-3	Acetic acid, 2-ethylhexyl ester
9.962	88.6	C11H20O2	184.1	2122612	2499-59-4	2-Propenoic acid, octyl ester

10.105	87.2	C10H22O	158.2	720518	106-21-8	1-Octanol, 3,7-dimethyl-
10.360	86.5	C11H20O2	184.1	935181	2499-59-4	2-Propenoic acid, octyl ester
10.531	88.2	C11H20O2	184.1	462682	42928-87-0	acrylic acid octyl ester
10.627	90.2	C11H20O2	184.1	1950226	2499-59-4	2-Propenoic acid, octyl ester
10.714	86.6	C11H20O2	184.1	1256582	2499-59-4	2-Propenoic acid, octyl ester
10.856	92.2	C8H18O	130.1	833962	57803-73-3	(S)-(+)-5-Methyl-1-heptanol
11.420	91.2	C12H36O6Si6	444.1	2480109	540-97-6	Cyclohexasiloxane, dodecamethyl-
12.125	90.6	C12H24O3	216.2	743944	74367-33-2	Propanoic acid, 2-methyl-, 2,2-dimethyl-1-(2-hydroxy-1-methylethyl)propyl ester
12.421	93.2	C12H24O3	216.2	821755	77-68-9	Propanoic acid, 2-methyl-, 3-hydroxy-2,2,4-trimethylpentyl ester
15.115	91.5	C16H30O4	286.2	352082	6846-50-0	PENTAN-1,3-DIOLDIISOBUTYRATE, 2,2,4-TRIMETHYL-