

**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

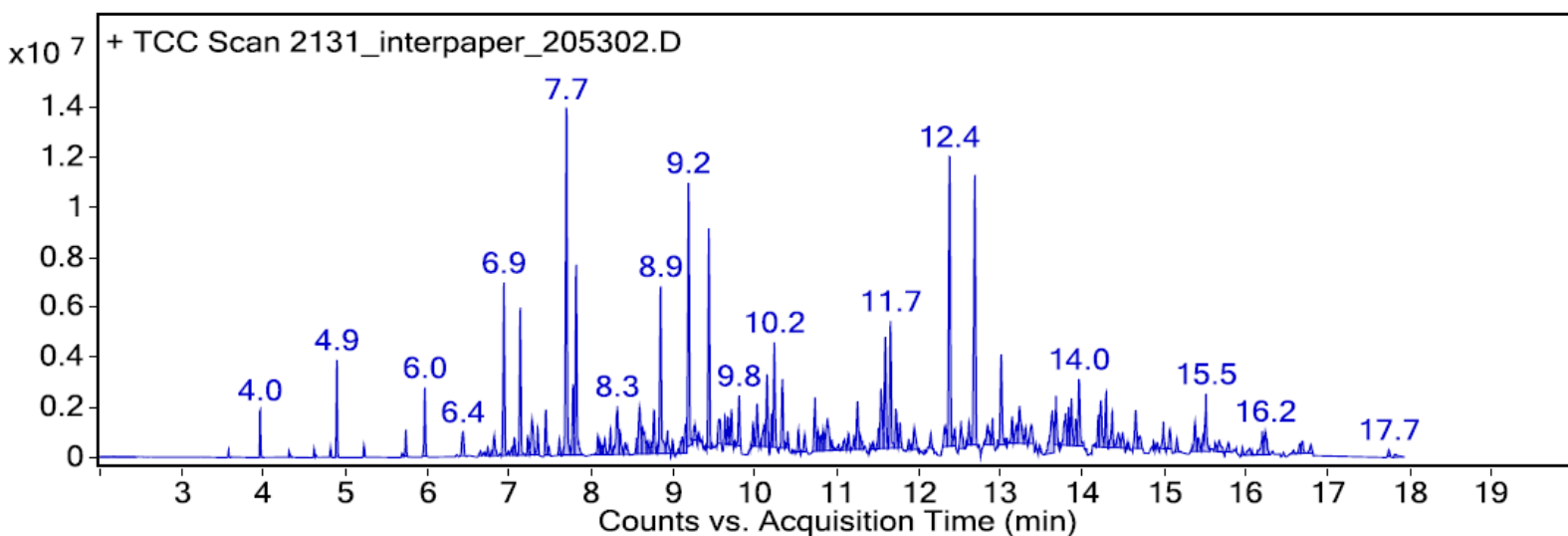
Sample: Talas; Green's Unbuffered neutral pH tissue made from abaca fibers; 10 gsm

Oddy test result: Permanent

Date GC-MS collected: 4/18/2018

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) 5.7 min: methoxy-phenyl oxime; (2) ~12.4 min: 2-methyl-, 2,2-dimethyl-1-(2-hydroxyl-1-methylethyl) propyl ester propanoic acid; (3) ~12.7 min: 2-methyl-, 3-hydroxyl-2,4,4-trimethylpentyl ester propanoic acid



#### Library results

RT	Score	Formula	MW	Area	CAS #	Name
3.600	92.7	C3H10OSi	90.1	207842	1066-40-6	Silanol, trimethyl-
4.000	93.7	C2H8O2Si	92.0	1527244	1066-42-8	Silanediol, dimethyl-
4.300	94.5	C3H8O2	76.1	315904	57-55-6	1,2-Propanediol
4.800	97.4	C6H12O	100.1	352396	66-25-1	Hexanal
4.900	92.4	C6H18O3Si3	222.1	3515529	541-05-9	Cydotrisiloxane, hexamethyl-
5.200	95.6	C6H12O2	116.1	519931	123-42-2	2-Pentanone, 4-hydroxy-4-methyl-
5.700	89.5	C8H18O	130.1	200540	142-96-1	Butane, 1,1'-oxybis-
5.700	85.7	C8H9NO2	151.1	1064984	1000222-86-6	Oxime-, methoxy-phenyl-
6.000	96.9	C6H14O2	118.1	3188793	111-76-2	Ethanol, 2-butoxy-
6.400	94.9	C7H16O2	132.1	905418	5131-66-8	2-Propanol, 1-butoxy-
6.800	96.0	C7H6O	106.0	956137	100-52-7	Benzaldehyde
6.800	85.9	C7H16O	116.1	291775	111-70-6	1-Heptanol
6.900	90.3	C6H6O	94.0	1254012	108-95-2	Phenol
6.900	94.6	C8H24O4Si4	296.1	7411363	556-67-2	Cydotetrasiloxane, octamethyl-
7.100	80.2	C10H18O	154.1	595120	78-70-6	Linalool
7.100	98.8	C6H10O4	146.1	3892905	111-55-7	1,2-Ethanediol, diacetate
7.200	97.6	C7H16O3	148.1	842582	0-00-0	di(propylene glycol monomethyl ether isomer, STRUCTURE UNKNOWN
7.300	93.2	C9H12	120.1	491923	0-00-0	unidentified C3-benzene
7.300	85.8	C6H14O3	134.1	1643065	111-90-0	Ethanol, 2-(2-ethoxyethoxy)-
7.300	86.1	C10H22	142.2	914366	124-18-5	Decane
7.300	97.7	C8H16O	128.1	1051207	124-13-0	Octanal
7.400	97.9	C7H16O3	148.1	2418992	0-00-0	di(propylene glycol monomethyl ether isomer, STRUCTURE UNKNOWN

7.600	93.5	C10H22	142.2	832846	15869-94-0	Octane, 3,6-dimethyl-
7.700	90.7	C9H12	120.1	360544	0-00-0	unidentified C3-benzene
7.700	96.4	C8H18O	130.1	18393168	104-76-7	1-Hexanol, 2-ethyl-
7.800	97.9	C10H16	136.1	3154661	138-86-3	d-Limonene
7.800	96.0	C7H8O	108.1	4859840	100-51-6	Benzyl Alcohol
8.100	88.6	C6H18O3S3	222.1	286191	541-05-9	Cyclotrisiloxane, hexamethyl-
8.200	91.1	C15H32	212.3	654140	31295-56-4	Dodecane, 2,6,11-trimethyl-
8.300	80.9	C10H18	138.1	216102	91-17-8	Naphthalene, decahydro-
8.400	80.5	C10H20O	156.2	672919	53219-21-9	DIHYDRO-MYRCENOL
8.600	80.8	C12H26	170.2	652141	2801-84-5	Decane, 2,4-dimethyl-
8.700	84.7	C12H26O	186.2	712092	3913-02-8	1-Octanol, 2-butyl-
8.800	89.9	C11H24	156.2	2632949	1120-21-4	Undecane
8.800	97.0	C9H18O	142.1	8704939	124-19-6	Nonanal
9.000	95.1	C8H10O	122.1	950679	60-12-8	Benzeneethanol
9.200	95.5	C10H30O5S5	370.1	13565533	541-02-6	Cyclopentasiloxane, decamethyl-
9.200	88.4	C16H11NO2S	281.1	195452	70453-75-7	2-methoxy[1]benzothieno[2,3-c]quinolin-6(5H)-one
9.300	93.7	C7H12O4	160.1	972870	1119-40-0	Pentanedioic acid, dimethyl ester
9.300	80.1	C13H28	184.2	749543	629-50-5	Tridecane
9.400	96.7	C10H20O2	172.1	6258832	103-09-3	Acetic acid, 2-ethylhexyl ester
9.600	90.7	C12H26	170.2	558754	2980-69-0	Undecane, 4-methyl-
9.700	80.5	C10H18O	154.1	655561	491-07-6	Cyclohexanone, 5-methyl-2-(1-methylethyl)-, ds-
9.800	92.6	C17H36O	256.3	1670134	1000406-39-1	Decyl heptyl ether
9.900	82.9	C10H18O	154.1	358537	464-45-9	Bicyclo[2.2.1]heptan-2-ol, 1,7,7-trimethyl-, (1S-endo)-
10.000	97.3	C10H20O	156.2	1681413	15356-70-4	Cyclohexanol, 5-methyl-2-(1-methylethyl)-, (1.alpha.,2.beta.,5.alpha.)-(+/-)-
10.000	94.2	C8H18O3	162.1	1452006	112-34-5	Ethanol, 2-(2-butoxyethoxy)-
10.100	95.2	C10H8	128.1	3492671	91-20-3	Naphthalene
10.200	95.2	C8H8O3	152.0	1318340	119-36-8	Methyl salicylate
10.300	97.5	C10H20O	156.2	3915951	112-31-2	Decanal
10.500	92.9	C8H10O2	138.1	1496342	122-99-6	Ethanol, 2-phenoxy-
10.600	84.1	C11H20O2	184.1	1158385	54774-91-3	2-Propenoic acid, 6-methylheptyl ester
10.800	87.8	C10H22O3	190.2	810117	29911-28-2	2-Propanol, 1-(2-butoxy-1-methylethoxy)-
10.900	83.6	C12H24	168.2	1023529	294-62-2	Cyclododecane
10.900	88.1	C9H12O2	152.1	678030	770-35-4	1-Phenoxypropan-2-ol
10.900	81.4	C10H14O	150.1	561948	99-49-0	2-Cyclohexen-1-one, 2-methyl-5-(1-methylethenyl)-
11.100	86.9	C8H8O2	136.1	302969	123-11-5	Benzaldehyde, 4-methoxy-
11.100	81.4	C10H18O	154.1	1032744	3913-81-3	2-Decenal, (E)-
11.300	94.2	C18H38O	270.3	1752622	1000406-38-3	Decyl octyl ether
11.300	96.4	C9H8O	132.1	399260	104-55-2	2-Propenal, 3-phenyl-
11.500	88.1	C10H14O	150.1	495566	89-83-8	Phenol, 5-methyl-2-(1-methylethyl)-
11.500	93.2	C13H28O	200.2	1601906	112-70-9	1-Tridecanol
11.600	96.1	C12H36O6S6	444.1	6226441	540-97-6	Cyclohexasiloxane, dodecamethyl-
11.700	94.9	C13H28	184.2	7333309	629-50-5	Tridecane
11.700	94.5	C11H10	142.1	1976437	91-57-6	Naphthalene, 2-methyl-
11.800	96.0	C11H22O	170.2	1418972	112-44-7	Undecanal
11.900	85.7	C17H36O	256.3	792229	1000406-39-1	Decyl heptyl ether
11.900	93.3	C11H10	142.1	1276781	91-57-6	Naphthalene, 2-methyl-
12.100	93.9	C9H14O6	218.1	888741	102-76-1	Triacetin
12.400	89.8	C12H24O3	216.2	11585300	74367-33-2	Propanoic acid, 2-methyl-, 2,2-dimethyl-1-(2-hydroxy-1-methylethyl)propyl ester
12.600	85.4	C14H30	198.2	1247888	6418-41-3	Tridecane, 3-methyl-
12.700	93.8	C12H24O3	216.2	16786858	74367-34-3	Propanoic acid, 2-methyl-, 3-hydroxy-2,4,4-trimethylpentyl ester
12.800	88.5	C15H24	204.2	768734	1137-12-8	Longicyclene
12.800	92.9	C12H10	154.1	812050	92-52-4	1,1'-Biphenyl

12.900	93.7	C14H28	196.2	1059537	1120-36-1	1-Tetradecene
13.000	95.8	C14H30	198.2	5948918	629-59-4	Tetradecane
13.100	87.4	C12H12	156.1	411025	939-27-5	Naphthalene, 2-ethyl-
13.100	80.8	C15H24	204.2	229102	475-20-7	Junipene
13.100	90.4	C12H10O	170.1	245945	101-84-8	Benzene, 1,1'-oxybis-
13.100	97.5	C12H24O	184.2	2172096	112-54-9	Dodecanal
13.300	94.6	C15H24	204.2	1558731	475-20-7	Longifolene
13.400	88.6	C12H12	156.1	881013	575-37-1	Naphthalene, 1,7-dimethyl-
13.400	91.3	C12H12	156.1	466146	575-37-1	Naphthalene, 1,7-dimethyl-
13.700	90.2	C14H28	196.2	2302859	2882-98-6	Cyclopentane, nonyl-
13.900	89.5	C14H20O2	220.1	2059868	719-22-2	2,5-Cyclohexadiene-1,4-dione, 2,6-bis(1,1-dimethylethyl)-
14.000	95.1	C12H26O	186.2	2700242	112-53-8	1-Dodecanol
14.200	93.0	C15H30	210.2	1883163	13360-61-7	1-Pentadecene
14.200	85.5	C13H12	168.1	720077	101-81-5	BENZENE, 1,1'-METHYLENEBIS-
14.200	96.3	C12H10	154.1	2664031	83-32-9	Acenaphthylene, 1,2-dihydro-
14.300	92.6	C13H28	184.2	2832104	31081-17-1	Nonane, 2-methyl-5-propyl-
14.300	92.9	C13H12	168.1	346975	643-58-3	1,1'-Biphenyl, 2-methyl-
14.400	92.6	C14H22O	206.2	2386410	96-76-4	Phenol, 2,4-bis(1,1-dimethylethyl)-
14.400	84.4	C13H26O	198.2	574248	10486-19-8	Tridecanal
14.700	90.9	C12H8O	168.1	1675545	132-64-9	Dibenzofuran
15.000	87.4	C15H30	210.2	1083302	2883-02-5	n-Nonylcyclohexane
15.100	86.7	C20H42	282.3	615464	638-36-8	Hexadecane, 2,6,10,14-tetramethyl-
15.200	90.1	C16H34	226.3	811001	2882-96-4	Pentadecane, 3-methyl-
15.300	81.9	C12H24	168.2	271350	74630-67-4	5-Undecene, 3-methyl-, (E)-
15.500	96.4	C13H10	166.1	587665	86-73-7	9H-Fluorene
15.500	92.8	C16H34	226.3	1882450	544-76-3	Hexadecane
15.800	87.6	C16H40O8S8	592.2	277666	556-68-3	Cydoctasiloxane, hexadecamethyl-
16.000	98.1	C13H10O	182.1	408860	119-61-9	Methanone, diphenyl-
16.000	81.2	C16H34	226.3	703048	55045-11-9	Tridecane, 5-propyl-
16.200	87.7	C16H32	224.3	622465	6785-23-5	Cyclopentane, undecyl-
16.200	87.4	C18H38O	270.3	681531	1000406-38-3	Decyl octyl ether
16.700	82.7	C19H40	268.3	841056	1921-70-6	Pentadecane, 2,6,10,14-tetramethyl-
17.700	95.8	C14H10	178.1	481248	120-12-7	Anthracene