

**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

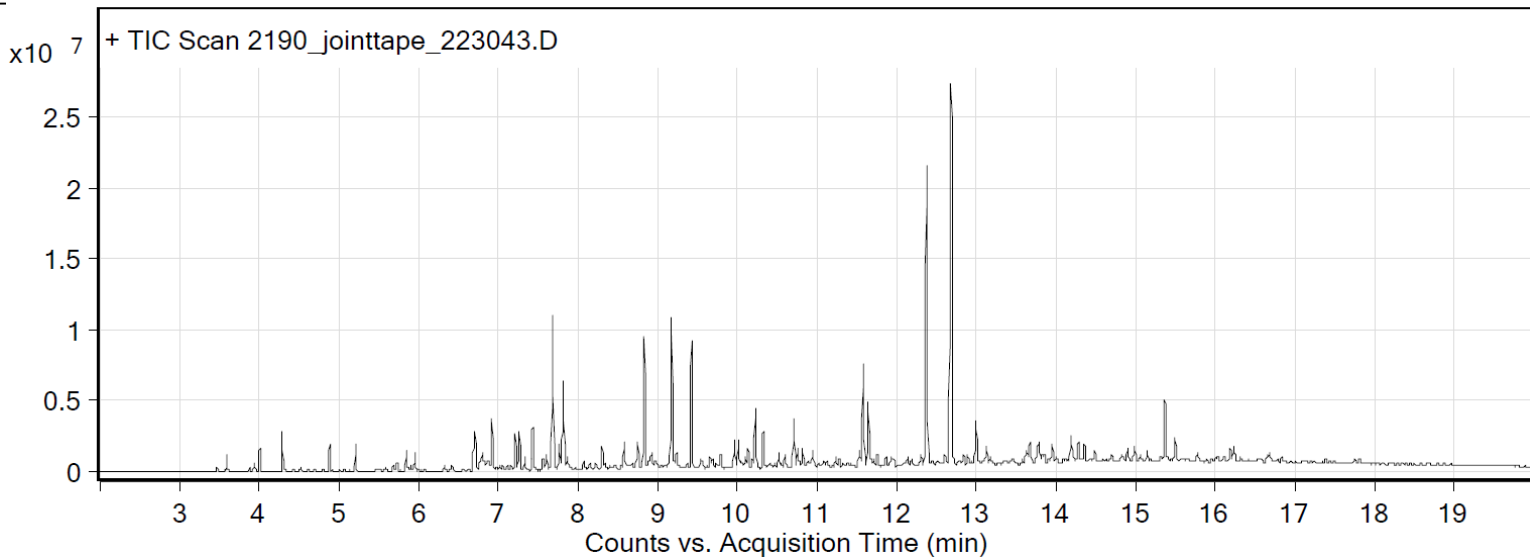
Sample: Joint tape

Oddy test result: Unsuitable

Date collected: 6/29/2018

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 autosampler; Pre-heated at 60°C for 20 minutes; fiber exposure at 60°C for 20 minutes; sample injected into 220°C inlet and cryo-trapped for 2 min at -15°C; GC ramped from 35°C to 250 °C at 10°C/min. Data analyzed in Masshunter Qualitative Analysis. Deconvoluted data with > 85% match with a NIST 17.0 or Wiley 9 library are reported.

VOCs not highlighted are because they were also observed in blanks: (1) 4.8 min: methoxyphenyl 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



Compound Table

RT	Score (Lib)	Area	Name	Formula
3.59	97.96	856755	Acetic acid	C2H4O2
4	95.79	1150844	Triethylamine	C6H15N
4.28	94.5	2406932	1,2-Propanediol	C3H8O2
4.88	92.47	1436108	Cyclotrisiloxane, hexamethyl-	C6H18O3Si3
5.21	94.56	1650028	2-Pentanone, 4-hydroxy-4-methyl-	C6H12O2
5.73	85.77	724467	Oxime-, methoxy-phenyl_	C8H9NO2
5.84	94.51	1281400	2-Propenoic acid, butyl ester	C7H12O2
5.95	93.46	1273685	Ethanol, 2-butoxy-	C6H14O2
6.32	88.26	449381	Ethanol, 2-(2-methoxyethoxy)-	C5H12O3
6.7	97.03	5001453	Ethanol, 2,2'-oxybis-	C4H10O3
6.92	85.51	3732980	Cyclotetrasiloxane, octamethyl-	C8H24O4Si4
7.21	85.58	2890593	dipropylene glycol monomethyl ether isomer, STRUCTURE UNKNOWN	C7H16O3
7.25	93.41	477512	unidentified C3-benzene	C9H12
7.26	94.2	3072436	dipropylene glycol monomethyl ether isomer, STRUCTURE UNKNOWN	C7H16O3
7.28	92.33	886261	Decane	C10H22
7.33	97.61	1087948	Octanal	C8H16O
7.43	97.92	3719067	dipropylene glycol monomethyl ether isomer, STRUCTURE UNKNOWN	C7H16O3
7.56	94.74	1378819	2-Propanol, 1,1'-oxybis-	C6H14O3
7.61	88.22	1229026	4-Cyanocyclohexene	C7H9N
7.68	97.28	13226327	1-Hexanol, 2-ethyl-	C8H18O
7.76	96.66	2184164	dl-Limonene	C10H16
7.86	93.48	1115734	2-Propanol, 1,1'-oxybis-	C6H14O3
8.22	90.95	541599	Dodecane, 2,6,11-trimethyl-	C15H32
8.34	87.56	604572	2-Octanol, 2-methyl-6-methylene-	C10H20O
8.68	85.29	815179	dihexylsulfide	C12H26S
8.75	93.81	2864521	Undecane	C11H24
8.83	96.56	11955089	Nonanal	C9H18O
8.92	92.33	2472283	Hexanoic acid, 2-ethyl-	C8H16O2

9.17	95.29	12164102	Cyclopentasiloxane, decamethyl-	C10H30O5Si5
9.24	95.24	1408754	Pentanedioic acid, dimethyl ester	C7H12O4
9.42	96.47	10841359	Acetic acid, 2-ethylhexyl ester	C10H20O2
9.54	88.53	1007214	1,3-Pentanediol, 2,2,4-trimethyl-	C8H18O2
9.79	91.15	1331165	Decyl heptyl ether	C17H36O
9.96	97.67	2678193	Cyclohexanol, 5-methyl-2-(1-methylethyl)-	C10H20O
10.01	95.44	2660687	Ethanol, 2-(2-butoxyethoxy)-	C8H18O3
10.13	92.56	1630600	Azulene	C10H8
10.18	96.94	923504	Methyl salicylate	C8H8O3
10.22	92.15	5368409	Dodecane	C12H26
10.32	94.41	3441604	Decanal	C10H20O
10.52	92.06	1312866	Ethanol, 2-phenoxy-	C8H10O2
10.59	90.19	1226978	2-Ethylhexyl acrylate	C11H20O2
10.71	89.2	4273005	Benzothiazole	C7H5NS
10.76	88.52	1566500	2-Propanol, 1,1'-oxybis-	C6H14O3
10.82	88.1	1713888	2-Propanol, 1-(2-butoxy-1-methylethoxy)-	C10H22O3
10.89	87	632259	1-Phenoxypropan-2-ol	C9H12O2
10.95	93.55	1496816	Hexanoic acid, 2-ethyl-, 2-methylpropyl ester	C12H24O2
11.09	88.42	668332	Nonanoic acid	C9H18O2
11.24	94.33	1075180	1-Decanol	C10H22O
11.28	88.55	739466	Hexadecane	C16H34
11.37	90.26	456918	Benzaldehyde, 4-propyl-	C10H12O
11.53	86.29	1511352	pentadecene	C15H30
11.58	95.74	9055580	Cyclohexasiloxane, dodecamethyl-	C12H36O6Si6
11.64	94.34	6012412	Tridecane	C13H28
11.71	91	681510	Naphthalene, 2-methyl-	C11H10
11.76	93.16	1205435	Tetradecanal	C14H28O
12.19	85.59	589092	5,6,7,8,9,10-Hexahydrobenzocyclooctene	C12H16
12.37	88.31	30629679	Propanoic acid, 2-methyl-, 2,2-dimethyl-1-(2-hydroxy-1-methylethyl)propyl ester	C12H24O3
12.68	93.54	42365234	Propanoic acid, 2-methyl-, 3-hydroxy-2,4,4-trimethylpentyl ester	C12H24O3
12.89	95.74	974887	1-Tetradecene	C14H28
13	95.63	4748859	Tetradecane	C14H30
13.13	91.6	1819809	Tetradecanal	C14H28O
13.63	85.19	1348247	5,5-Dibutylnonane	C17H36
13.67	92.1	2506719	Cyclopentane, nonyl-	C14H28
13.82	87.88	1067431	Tetracosane	C24H50
13.85	86.62	742273	2,5-Cyclohexadiene-1,4-dione, 2,6-bis(1,1-dimethylethyl)-	C14H20O2
13.95	95.61	2000358	1-Dodecanol	C12H26O
14.18	93.61	2885459	1-Pentadecene	C15H30
14.28	92.94	2141065	pentadecane	C15H32
14.35	93.05	1436638	Phenol, 2,6-bis(1,1-dimethylethyl)-4-methyl-	C15H24O
14.48	89.49	1257934	Tetradecane, 2,2-dimethyl-	C16H34
14.9	87.59	1396345	Sulfurous acid, hexyl tetradecyl ester	C20H42O3S
14.99	93.66	1622257	n-Nonylcyclohexane	C15H30
15.06	88.87	770608	Tetradecane, 3-methyl-	C15H32
15.14	86	1068448	Pentadecane, 3-methyl-	C16H34
15.49	88.55	2450911	Dodecane, 2,6,10-trimethyl-	C15H32
16.03	86.86	963828	Tridecane, 5-propyl-	C16H34
16.11	86.01	602371	3,3-Diethyltridecane	C17H36
16.18	90.82	1450706	Cyclopentane, undecyl-	C16H32
16.23	91.57	1589331	Methyl octyl ether	C9H20O
16.68	85.38	1400541	Pentadecane, 2,6,10,14-tetramethyl-	C19H40
16.83	86.31	531460	Heptane, 2,2,4,6,6-pentamethyl-	C12H26
17.81	89.06	635256	Hexadecane, 2,6,10,14-tetramethyl-	C20H42