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

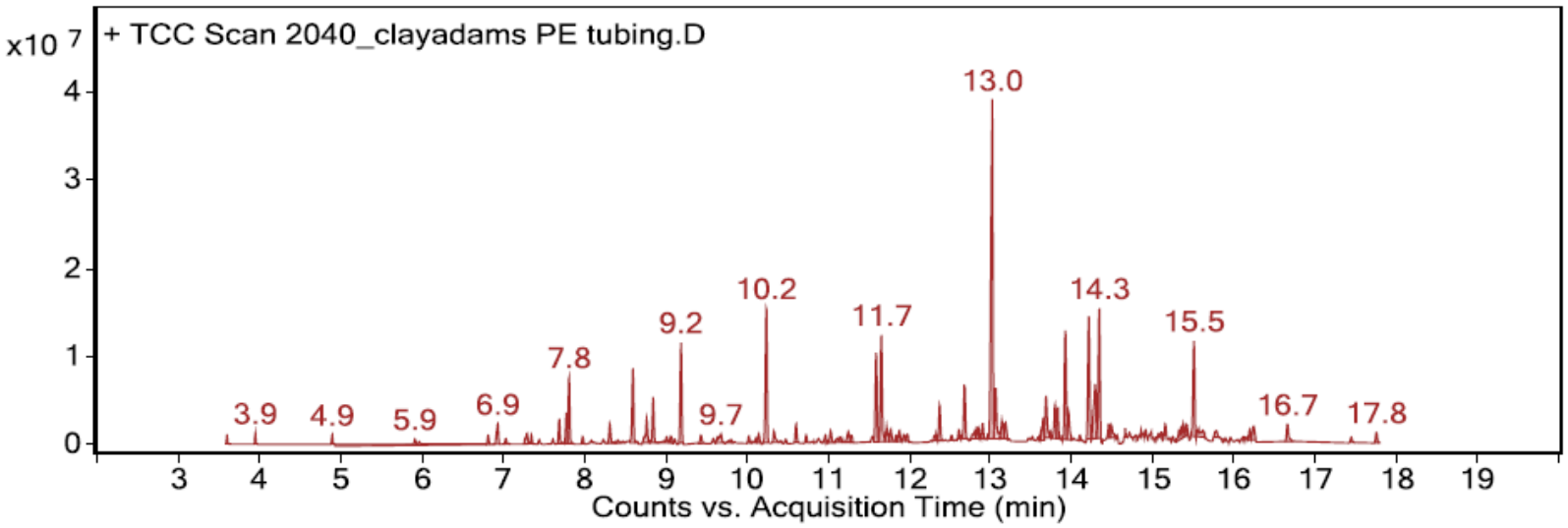
Sample: Clay Adams Intramedic non-radiopaque PE tubing 427411

Oddy test result: Permanent

Date GC-MS collected: 03/09/2018

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) 12.4 min: 2-methyl-, 2,2-dimethyl-1-(2-hydroxyl-1-methylethyl) propyl ester propanoic acid; (2) 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	98.0	C2H4O2	60.0	870107	64-19-7	Acetic acid
3.900	95.1	C2H8O2Si	92.0	983855	1066-42-8	Silanediol, dimethyl-
4.900	92.5	C6H18O3Si3	222.1	969549	541-05-9	Cyclotrisiloxane, hexamethyl-
5.900	90.8	C6H10O	98.1	649138	108-94-1	Cyclohexanone
6.800	97.8	C7H6O	106.0	1248093	100-52-7	Benzaldehyde
6.900	89.5	C6H6O	94.0	1236134	108-95-2	Phenol
6.900	94.2	C8H24O4Si4	296.1	2457558	556-67-2	Cyclotetrasiloxane, octamethyl-
7.000	87.0	C7H14O3	146.1	762537	763-69-9	Propanoic acid, 3-ethoxy-, ethyl ester
7.300	92.3	C6H14O3	134.1	801726	111-90-0	Ethanol, 2-(2-ethoxyethoxy)-
7.300	94.2	C10H22	142.2	1404497	124-18-5	Decane
7.300	96.5	C8H16O	128.1	963780	124-13-0	Octanal
7.400	93.3	C7H16O3	148.1	697431	0-00-0	dipropylene glycol monomethyl ether isomer, STRUCTURE UNKNOWN
7.600	82.2	C12H26	170.2	630208	13475-82-6	Heptane, 2,2,4,6,6-pentamethyl-
7.700	97.4	C8H18O	130.1	3520180	104-76-7	1-Hexanol, 2-ethyl-
7.800	97.0	C10H16	136.1	4384328	138-86-3	dl-Limonene
7.800	96.5	C7H8O	108.1	5538337	100-51-6	Benzyl Alcohol
8.000	92.8	C10H30O3Si4	310.1	1071414	141-62-8	Tetrasiloxane, decamethyl-
8.200	89.4	C15H32	212.3	739880	31295-56-4	Dodecane, 2,6,11-trimethyl-
8.300	84.0	C8H8O	120.1	2249044	98-86-2	Ethanone, 1-phenyl-
8.400	85.1	C15H32O3S	292.2	719171	999435-65-5	Sulfurous acid, decyl 2-pentyl ester
8.600	91.9	C9H12O	136.1	8249522	617-94-7	Benzenemethanol, .alpha.,.alpha.-dimethyl-
8.700	96.5	C8H8O2	136.1	876146	93-58-3	Benzoic acid, methyl ester
8.800	95.5	C11H24	156.2	3872015	1120-21-4	Undecane
8.800	97.7	C9H18O	142.1	6550795	124-19-6	Nonanal
9.000	81.7	C12H24O2	200.2	1235362	20780-49-8	3,7-Dimethyloctyl acetate
9.100	96.4	C10H14	134.1	668506	488-23-3	Benzene, 1,2,3,4-tetramethyl-
9.200	95.2	C10H30O5Si5	370.1	14928124	541-02-6	Cyclopentasiloxane, decamethyl-
9.700	94.4	C12H36O4Si5	384.1	937484	141-63-9	Pentasiloxane, dodecamethyl-

9.800	84.8	C20H42O	298.3	674762	2456-28-2	Decane, 1,1'-oxybis-
10.000	94.3	C8H18O3	162.1	1089674	112-34-5	Ethanol, 2-(2-butoxyethoxy)-
10.100	86.5	C16H32	224.3	776199	629-73-2	1-Hexadecene
10.100	89.3	C10H8	128.1	1425434	91-20-3	Naphthalene
10.200	87.1	C11H16	148.1	1062516	98-51-1	Benzene, 1-(1,1-dimethylethyl)-4-methyl-
10.200	95.4	C12H26	170.2	20425105	112-40-3	Dodecane
10.300	96.6	C10H20O	156.2	2286012	112-31-2	Decanal
10.500	96.2	C12H36O4Si5	384.1	737921	141-63-9	Pentasiloxane, dodecamethyl-
10.600	87.7	C11H20O2	184.1	2758077	42928-87-0	4-(Prop-2-enoyloxy)octane
10.700	91.4	C11H22O2	186.2	1122429	999145-46-3	2-Ethyl-1-hexyl propionate
10.900	80.5	C10H20	140.2	1011229	3741-00-2	Cyclopentane, pentyl-
11.000	93.4	C6H11NO	113.1	2628877	105-60-2	Caprolactam
11.100	88.8	C13H28	184.2	1029899	17312-77-5	Undecane, 2,3-dimethyl-
11.200	86.3	C30H58O4	482.4	1091009	2432-89-5	Decanedioic acid, didecyl ester
11.600	96.0	C12H36O6Si6	444.1	13864372	540-97-6	Cyclohexasiloxane, dodecamethyl-
11.700	94.9	C13H28	184.2	17507792	629-50-5	Tridecane
11.700	92.9	C11H10	142.1	1112412	90-12-0	Naphthalene, 1-methyl-
11.800	88.9	C14H28O	212.2	1574279	124-25-4	Tetradecanal
11.900	84.1	C11H10	142.1	871016	90-12-0	Naphthalene, 1-methyl-
12.000	82.8	C16H34	226.3	892648	4390-04-9	Nonane, 2,2,4,4,6,8,8-heptamethyl-
12.300	84.1	C20H42O	298.3	1430108	1000406-38-4	Dodecyl octyl ether
12.400	90.1	C12H24O3	216.2	6216878	74367-33-2	Propanoic acid, 2-methyl-, 2,2-dimethyl-1-(2-hydroxy-1-methylethyl)propyl ester
12.500	88.7	C13H28	184.2	1552813	17312-58-2	Undecane, 3-ethyl-
12.600	90.3	C14H30	198.2	2124978	6418-41-3	Tridecane, 3-methyl-
12.700	93.3	C12H24O3	216.2	10048217	74367-34-3	Propanoic acid, 2-methyl-, 3-hydroxy-2,4,4-trimethylpentyl ester
12.800	89.4	C14H28	196.2	1726259	19780-34-8	1-Dodecene, 2-ethyl-
12.800	85.2	C12H10	154.1	1475746	92-52-4	Biphenyl
12.900	95.6	C14H28	196.2	3113102	295-17-0	Cyclotetradecane
13.000	95.8	C14H30	198.2	58799645	629-59-4	Tetradecane
13.100	95.4	C13H12	168.1	7488862	643-58-3	1,1'-Biphenyl, 2-methyl-
13.100	89.8	C18H38O	270.3	2345416	112-92-5	1-Octadecanol
13.200	80.8	C20H40O3	328.3	1282472	1000383-13-8	Carbonic acid, 2-ethylhexyl undecyl ester
13.500	93.9	C13H12	168.1	590543	101-81-5	Diphenylmethane
13.600	88.7	C17H36	240.3	2487326	6008-17-9	5,5-Dibutylnonane
13.700	95.7	C14H28	196.2	4531134	2882-98-6	Cyclopentane, nonyl-
13.800	81.4	C16H34	226.3	1599260	3891-99-4	2,6,10-Trimethyltridecane
13.800	80.3	C14H42O7Si7	518.1	4720957	107-50-6	Cycloheptasiloxane, tetradecamethyl-
13.800	90.9	C24H50	338.4	2774417	646-31-1	Tetracosane
13.900	93.4	C14H22O2	222.2	12846307	7534-94-3	iso-Bornyl methacrylate
14.000	95.6	C12H26O	186.2	2145539	112-53-8	1-Dodecanol
14.100	86.7	C10H18O	154.1	993366	56606-79-2	1-decen-3-one
14.200	95.5	C13H12	168.1	21283861	644-08-6	1,1'-Biphenyl, 4-methyl-
14.300	93.6	C14H14	182.1	4127518	611-43-8	1,1'-Biphenyl, 2,3'-dimethyl-
14.300	94.7	C15H32	212.3	9449287	629-62-9	pentadecane
14.300	95.0	C13H12	168.1	10558233	101-81-5	Diphenylmethane
14.500	94.4	C14H14	182.1	1905575	611-43-8	1,1'-Biphenyl, 2,3'-dimethyl-
14.500	88.5	C16H34	226.3	1970840	59222-86-5	Tetradecane, 2,2-dimethyl-
14.600	92.4	C12H10O	170.1	899412	90-43-7	[1,1'-Biphenyl]-2-ol
14.700	83.5	C14H14	182.1	1171337	103-29-7	Benzene, 1,1'-(1,2-ethanediyl)bis-
14.900	86.8	C20H42O3S	362.3	2079815	1000309-13-6	Sulfurous acid, hexyl tetradecyl ester
15.100	89.7	C16H34	226.3	1286395	1560-93-6	Pentadecane, 2-methyl-
15.100	85.4	C13H16O3	220.1	1116475	999233-92-8	1-METHYL-2-(PROPENYLOXY)-ETHYL ESTER OF BENZOIC ACID
15.200	93.6	C16H34	226.3	2468334	2882-96-4	Pentadecane, 3-methyl-
15.200	80.4	C13H16O3	220.1	851725	999233-92-8	1-METHYL-2-(PROPENYLOXY)-ETHYL ESTER OF BENZOIC ACID
15.300	81.5	C10H18O	154.1	1347345	56606-79-2	1-Decen-3-one
15.400	92.9	C16H34O	242.3	1191985	36653-82-4	1-Hexadecanol
15.500	86.7	C14H14	182.1	1104945	7383-90-6	1,1'-Biphenyl, 3,4'-dimethyl-
15.500	92.6	C16H34	226.3	16084952	544-76-3	Hexadecane
15.600	88.7	C14H30O	214.2	897889	112-72-1	1-Tetradecanol
15.600	94.3	C14H14	182.1	908991	612-75-9	3,3'-Dimethylbiphenyl
15.600	82.3	C20H42O	298.3	603736	645-72-7	1-Hexadecanol, 3,7,11,15-tetramethyl-
15.800	89.5	C16H48O8Si8	592.2	975085	556-68-3	Cyclooctasiloxane, hexadecamethyl-
15.800	88.1	C15H30O2	242.2	945259	10233-13-3	Dodecanoic acid, 1-methylethyl ester
16.000	96.6	C12H12N2	184.1	1054839	92-87-5	[1,1'-Biphenyl]-4,4'-diamine
16.000	85.4	C18H38	254.3	852516	3892-00-0	Pentadecane, 2,6,10-trimethyl-
16.100	91.2	C17H36	240.3	997735	1000360-41-2	3,3-Diethyltridecane
16.200	92.1	C16H32	224.3	2184507	295-65-8	Cyclohexadecane
16.200	88.5	C20H42	282.3	1206886	638-36-8	Hexadecane, 2,6,10,14-tetramethyl-
16.700	90.2	C17H36	240.3	3752680	629-78-7	Heptadecane
17.400	85.4	C19H40	268.3	951642	1560-88-9	Octadecane, 2-methyl-