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

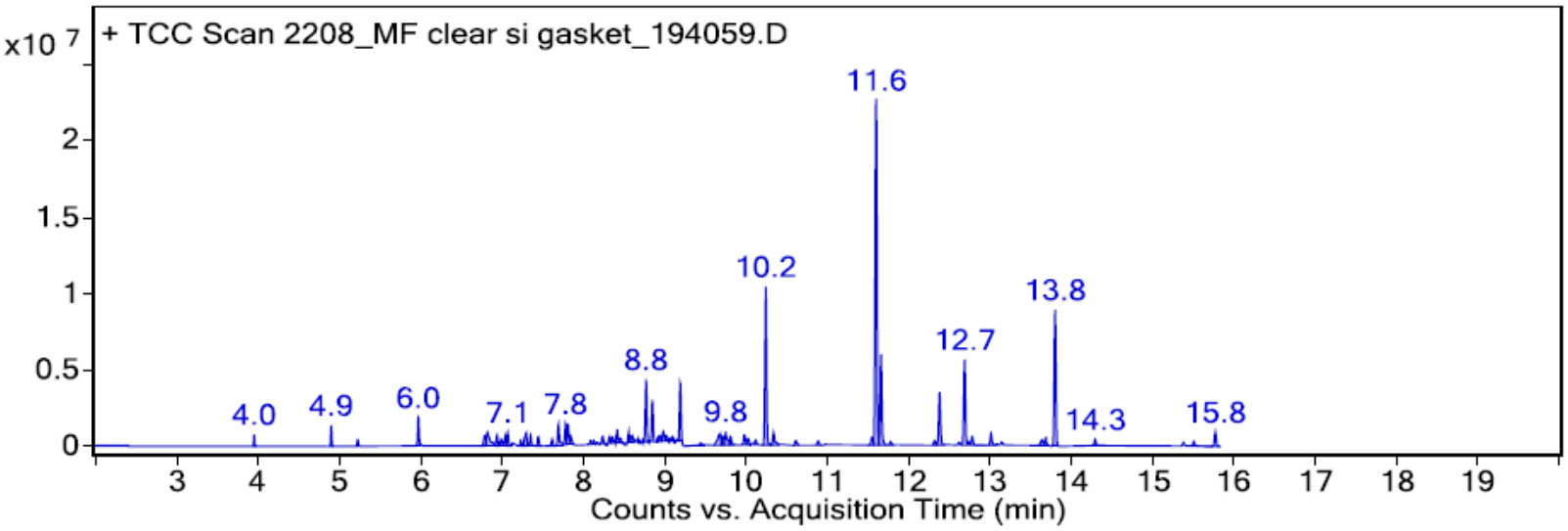
Sample: Manfred Frank MF-S1 Compression Seal

Oddy test result: Temporary

Date GC-MS collected: 6/20/2018

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
2.300	80.2	C8H6O2	134.0	657526	101672-23-5	3-acetoxy-1,2,4-trioxolane
4.000	95.1	C2H8O2Si	92.0	550892	1066-42-8	Silanediol, dimethyl-
4.900	92.5	C6H18O3Si3	222.1	1198274	541-05-9	Cyclotrisiloxane, hexamethyl-
5.200	95.2	C6H12O2	116.1	443689	123-42-2	2-Pentanone, 4-hydroxy-4-methyl-
6.000	96.9	C6H14O2	118.1	2200706	111-76-2	Ethanol, 2-butoxy-
6.800	87.3	C7H6O	106.0	1232182	100-52-7	Benzaldehyde
6.900	93.1	C8H24O4Si4	296.1	689603	556-67-2	Cyclotetrasiloxane, octamethyl-
7.100	93.4	C8H14O	126.1	519878	110-93-0	6-Methyl-5-hepten-2-one
7.200	96.7	C7H16O3	148.1	435532	0-00-0	dipropylene glycol monomethyl ether isomer, STRUCTURE UNKNOWN
7.300	86.6	C7H16O3	148.1	631754	0-00-0	dipropylene glycol monomethyl ether isomer, STRUCTURE UNKNOWN
7.300	95.7	C10H22	142.2	977605	124-18-5	Decane
7.400	97.3	C8H16O	128.1	659697	124-13-0	Octanal
7.400	99.4	C7H16O3	148.1	877096	0-00-0	dipropylene glycol monomethyl ether isomer, STRUCTURE UNKNOWN
7.600	87.8	C12H26	170.2	517420	62199-06-8	Heptane, 5-ethyl-2,2,3-trimethyl-
7.700	96.8	C8H18O	130.1	2035069	104-76-7	1-Hexanol, 2-ethyl-
7.800	96.8	C10H16	136.1	1509074	138-86-3	dl-Limonene
7.800	83.4	C10H18O	154.1	498227	470-82-6	1,8-Cineole

8.100	81.8	C10H22	142.2	584454	15869-94-0	Octane, 3,6-dimethyl-
8.200	93.2	C15H32	212.3	899327	31295-56-4	Dodecane, 2,6,11-trimethyl-
8.500	83.7	C15H32	212.3	756361	31295-56-4	Dodecane, 2,6,11-trimethyl-
8.600	85.1	C8H16O3	160.1	1320293	112-07-2	2-Butoxyethyl acetate
8.600	83.8	C12H26	170.2	570288	62183-55-5	Octane, 3-ethyl-2,7-dimethyl-
8.700	87.3	C14H30	198.2	560066	13287-21-3	Tridecane, 6-methyl-
8.800	97.0	C11H24	156.2	6024191	1120-21-4	Undecane
8.800	96.6	C9H18O	142.1	4208017	124-19-6	Nonanal
8.900	89.7	C12H26	170.2	651512	1632-70-8	Undecane, 5-methyl-
9.000	84.4	C10H22	142.2	1225055	7146-60-3	Octane, 2,3-dimethyl-
9.200	94.3	C10H30O5Si5	370.1	5550439	541-02-6	Cyclopentasiloxane, decamethyl-
9.700	97.3	C12H36O4Si5	384.1	594454	141-63-9	Pentasiloxane, dodecamethyl-
9.700	82.3	C20H40O3	328.3	990796	1000383-13-8	Carbonic acid, 2-ethylhexyl undecyl ester
9.800	82.7	C9H20	128.2	421296	3522-94-9	Hexane, 2,2,5-trimethyl-
9.800	90.3	C18H38	254.3	884447	26741-18-4	9-methylheptadecane
10.000	97.3	C10H20O	156.2	1117018	1490-04-6	Cyclohexanol, 5-methyl-2-(1-methylethyl)-
10.100	91.9	C12H24	168.2	560118	112-41-4	1-Dodecene
10.200	95.5	C12H26	170.2	14020677	112-40-3	Dodecane
10.300	96.6	C10H20O	156.2	1253283	112-31-2	Decanal
10.600	84.5	C11H20O2	184.1	512237	103-11-7	2-Ethylhexyl acrylate
10.900	83.4	C10H20	140.2	501886	3741-00-2	Cyclopentane, pentyl-
11.500	89.7	C13H26	182.2	878099	2437-56-1	1-Tridecene
11.600	96.5	C12H36O6Si6	444.1	33228387	540-97-6	Cyclohexasiloxane, dodecamethyl-
11.700	95.3	C13H28	184.2	8711295	629-50-5	Tridecane
11.800	90.3	C14H28O	212.2	377782	124-25-4	Tetradecanal
12.300	85.5	C13H26	182.2	510692	5617-41-4	Heptylcyclohexane
12.400	90.4	C12H24O3	216.2	5242733	74367-33-2	Propanoic acid, 2-methyl-, 2,2-dimethyl-1-(2-hydroxy-1-methylethyl)propyl ester
12.600	81.7	C14H30	198.2	341976	6418-41-3	Tridecane, 3-methyl-
12.700	94.4	C12H24O3	216.2	8387622	74367-34-3	Propanoic acid, 2-methyl-, 3-hydroxy-2,4,4-trimethylpentyl ester
12.800	95.0	C13H20O2	208.1	950513	5888-33-5	2-Propenoic acid, 1,7,7-trimethylbicyclo[2.2.1]hept-2-yl ester, exo-
13.000	95.6	C14H30	198.2	1242718	629-59-4	Tetradecane
13.100	95.4	C12H24O	184.2	366606	112-54-9	Dodecanal
13.700	90.8	C14H28	196.2	429392	2882-98-6	Cyclopentane, nonyl-
13.800	81.1	C14H42O7Si7	518.1	12843610	107-50-6	Cycloheptasiloxane, tetradecamethyl-
14.300	94.2	C15H32	212.3	571037	629-62-9	pentadecane
15.500	93.1	C16H34	226.3	425895	544-76-3	Hexadecane
15.800	90.7	C16H48O8Si8	592.2	1378537	556-68-3	Cyclooctasiloxane, hexadecamethyl-