

## 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

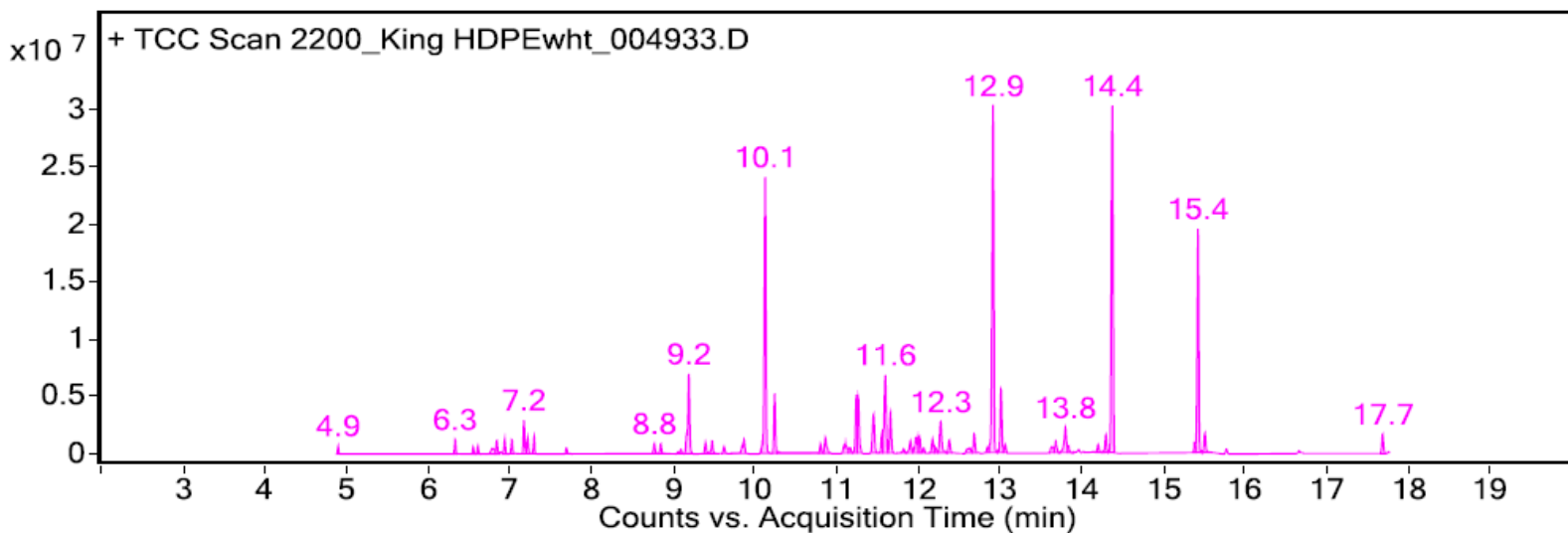
Sample: King Plastic Corporation; King HDPE sheet, white, from McMaster-Carr; 8609K441

Oddy test result: TBA

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) 8.8 min: nonanal; (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
4.900	92.5	C6H18O3Si3	222.1	666015	541-05-9	Cyclotrisiloxane, hexamethyl-
6.300	89.1	C9H20O	144.2	1381889	143-08-8	1-Nonanol
6.600	91.2	C10H22	142.2	656040	52896-87-4	Heptane, 4-(1-methylethyl)-
6.600	91.6	C9H20O	144.2	786740	143-08-8	1-Nonanol
6.800	91.0	C10H20	140.2	713609	62960-76-3	4-Octene, 2,6-dimethyl-, [S-(E)]-
6.900	94.1	C8H24O4Si4	296.1	1421587	556-67-2	Cyclotetrasiloxane, octamethyl-
7.000	92.8	C10H20	140.2	1495206	62960-76-3	4-Octene, 2,6-dimethyl-, [S-(E)]-
7.200	96.1	C10H20	140.2	3464717	872-05-9	1-Decene
7.200	97.6	C10H20	140.2	1925607	19689-19-1	5-Decene
7.300	96.6	C10H22	142.2	888852	124-18-5	Decane

7.700	96.6	C8H18O	130.1	667669	104-76-7	1-Hexanol, 2-ethyl-
8.800	96.5	C11H24	156.2	1261625	1120-21-4	Undecane
8.800	96.6	C9H18O	142.1	1138760	124-19-6	Nonanal
9.100	81.2	C10H22O	158.2	692823	112-30-1	1-Decanol
9.200	90.0	C12H24	168.2	2435272	74663-85-7	Cyclopropane, nonyl-
9.200	94.5	C10H30O5Si5	370.1	9448063	541-02-6	Cyclopentasiloxane, decamethyl-
9.400	91.8	C12H26	170.2	1264233	17312-44-6	2,3-Dimethyldecane
9.500	95.4	C12H24	168.2	1549848	74630-38-9	1-Undecene, 5-methyl-
9.600	93.7	C12H24	168.2	944114	20634-43-9	4-Undecene, 5-methyl-
9.800	86.6	C12H24	168.2	957357	31613-73-7	5-Undecene, 5-methyl-
9.900	86.4	C12H24	168.2	917112	20634-43-9	4-Undecene, 5-methyl-
10.100	87.9	C12H24	168.2	698255	294-62-2	Cyclododecane
10.100	96.7	C12H24	168.2	33477333	112-41-4	1-Dodecene
10.200	96.0	C12H26	170.2	6880460	112-40-3	Dodecane
10.800	87.0	C12H24	168.2	1196391	64723-36-0	Cyclopropane, 1-(2-methylbutyl)-1-(1-methylpropyl)-
10.900	87.1	C11H22	154.2	2615442	19780-74-6	5-Ethyl-1-nonene
11.100	83.5	C15H32O3S	292.2	1661011	999435-65-6	Sulfurous acid, butyl undecyl ester
11.200	85.6	C19H38	266.3	988720	18435-45-5	1-Nonadecene
11.200	82.0	C12H24	168.2	3704316	74630-41-4	1-Undecene, 9-methyl-
11.300	87.1	C12H24	168.2	4283133	64723-36-0	Cyclopropane, 1-(2-methylbutyl)-1-(1-methylpropyl)-
11.400	82.1	C14H28	196.2	2957632	41446-60-0	7-Tetradecene, (Z)-
11.500	87.9	C16H34	226.3	3322949	56292-69-4	Tetradecane, 2,5-dimethyl-
11.600	88.8	C12H24	168.2	2626479	64723-36-0	Cyclopropane, 1-(2-methylbutyl)-1-(1-methylpropyl)-
11.600	86.7	C12H24	168.2	2135026	64723-36-0	Cyclopropane, 1-(2-methylbutyl)-1-(1-methylpropyl)-
11.600	95.3	C12H36O6Si6	444.1	9236756	540-97-6	Cyclohexasiloxane, dodecamethyl-
11.700	91.0	C13H28	184.2	5617618	629-50-5	Tridecane
11.800	82.2	C11H24	156.2	856317	61868-42-6	Heptane, 2,2,3,5-tetramethyl-
11.900	84.2	C14H28	196.2	1928001	24949-42-6	6-Tridecene, 7-methyl-
12.000	85.4	C14H30O	214.2	2952584	103-20-8	4-Undecanol, 7-ethyl-2-methyl-
12.100	87.0	C14H28	196.2	800452	1120-36-1	1-Tetradecene
12.200	91.4	C14H28	196.2	929118	51655-65-3	2-Butyl-1-decene
12.200	93.0	C20H42	282.3	782189	56862-62-5	10-Methylnonadecane
12.300	93.4	C14H28	196.2	5108680	51655-65-3	2-Butyl-1-decene
12.400	90.6	C12H24O3	216.2	1983737	74367-33-2	Propanoic acid, 2-methyl-, 2,2-dimethyl-1-(2-hydroxy-1-methylethyl)propyl ester
12.700	93.6	C12H24O3	216.2	2582980	74367-34-3	Propanoic acid, 2-methyl-, 3-hydroxy-2,4,4-trimethylpentyl ester
12.800	81.7	C14H28	196.2	775316	19780-34-8	1-Dodecene, 2-ethyl-
12.900	95.9	C14H30O	214.2	47201290	112-72-1	1-Tetradecanol
13.000	95.1	C14H30	198.2	8207824	629-59-4	Tetradecane
13.100	89.3	C14H28	196.2	503216	19780-34-8	1-Dodecene, 2-ethyl-
13.600	82.9	C17H36O3S	320.2	603360	999508-28-4	Sulfurous acid, butyl tridecyl ester
13.700	93.8	C14H28	196.2	1243212	2882-98-6	Cyclopentane, nonyl-
13.800	80.1	C14H42O7Si7	518.1	2944190	107-50-6	Cycloheptasiloxane, tetradecamethyl-
13.800	87.9	C12H26O	186.2	821298	3913-02-8	1-Octanol, 2-butyl-
14.000	93.7	C12H26O	186.2	615620	112-53-8	1-Dodecanol
14.200	95.1	C15H30	210.2	1308953	13360-61-7	1-Pentadecene
14.300	95.2	C15H32	212.3	2276875	629-62-9	pentadecane
14.400	84.9	C15H24O	220.2	49145879	128-37-0	Phenol, 2,6-bis(1,1-dimethylethyl)-4-methyl-
15.400	95.8	C16H34O	242.3	19332818	36653-82-4	1-Hexadecanol
15.500	93.7	C16H34	226.3	2801778	544-76-3	Hexadecane
15.800	89.6	C16H48O8Si8	592.2	665617	556-68-3	Cyclooctasiloxane, hexadecamethyl-
16.700	94.0	C17H36	240.3	518860	629-78-7	Heptadecane
17.700	96.0	C18H36	252.3	2449598	7206-19-1	3-Octadecene, (E)-