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

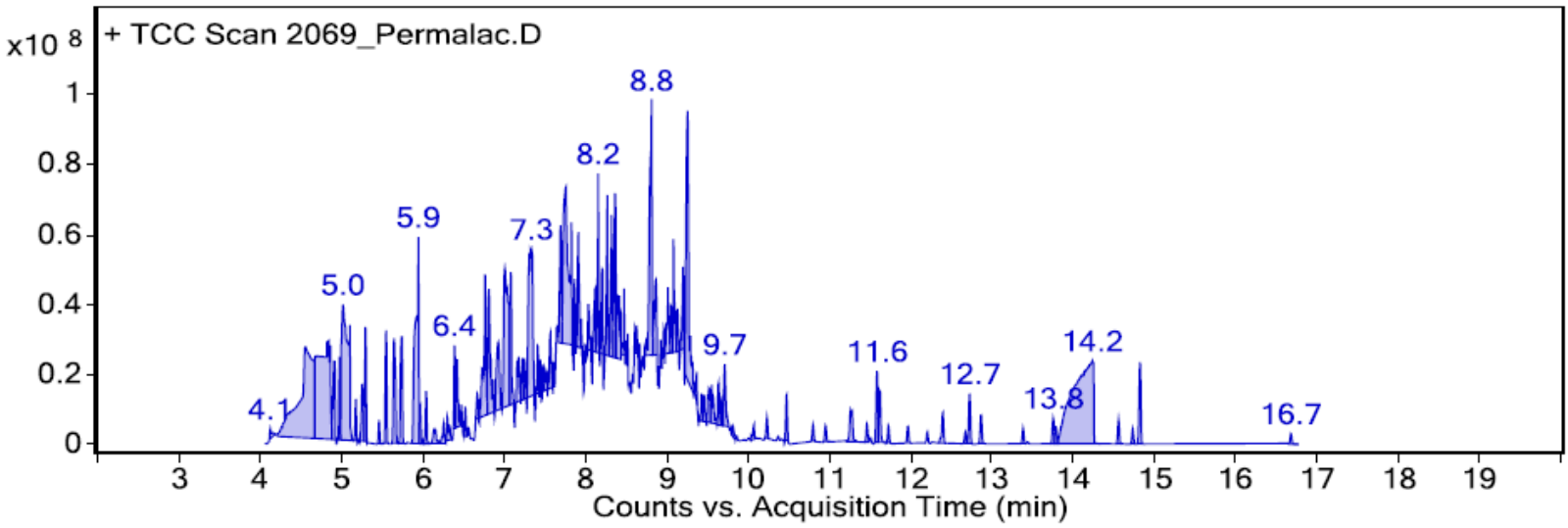
Alkynes – can become reactive when exposed to heat or UV light

Sample: Permalac matte, three coats on mylar, dried

Oddy test result: Temporary

Date GC-MS collected: 3/19/2018

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. VOC not highlighted because it was also observed in blanks: 12.7 min: 2-methyl-, 3-hydroxyl-2,4,4-trimethylpentyl ester propanoic acid



Library results

RT	Score	Formula	MW	Area	CAS #	Name
4.100	88.7	C5H8O2	100.1	10411265	80-62-6	Methyl methacrylate
4.500	93.3	C12H14	158.1	373059139	76024-05-0	Tricyclo[4.4.1.1(2,5)]dodeca-3,7,9-triene
4.900	86.4	C8H16	112.1	9735647	638-04-0	Cyclohexane, 1,3-dimethyl-, cis-
4.900	83.5	C8H16	112.1	25350132	2207-01-4	Cyclohexane, 1,2-dimethyl-, cis-
4.900	90.8	C8H18	114.1	11061152	111-65-9	Octane
5.000	93.8	C8H16	112.1	10925610	6876-23-9	Cyclohexane, 1,2-dimethyl-, trans-
5.000	82.6	C4H4O4	116.0	8870638	4480-83-5	1,4-Dioxane-2,6-dione
5.200	93.2	C8H16	112.1	13434613	930-89-2	Cyclopentane, 1-ethyl-2-methyl-, cis-
5.300	84.9	C8H16	112.1	20791411	2040-96-2	Cyclopentane, propyl-
5.300	81.4	C8H16	112.1	9258787	107-40-4	2-Pentene, 2,4,4-trimethyl-
5.300	95.5	C8H16	112.1	26262139	1678-91-7	Cyclohexane, ethyl-
5.500	94.0	C7H4ClF3	180.0	6950549	98-56-6	Benzene, 1-chloro-4-(trifluoromethyl)-
5.500	95.2	C8H10	106.1	39177987	108-38-3	Benzene, 1,3-dimethyl-
5.600	97.3	C8H10	106.1	55916259	106-42-3	Benzene, 1,4-dimethyl-
5.900	82.7	C6H11NO	113.1	37180930	999019-06-3	2-(N-Methyl)imino-3-pentanone
6.000	94.1	C9H20	128.2	7060803	111-84-2	Nonane
6.000	94.9	C7H14O2	130.1	13869903	590-01-2	Propanoic acid, butyl ester
6.100	83.9	C9H18	126.1	5358380	4926-78-7	Cyclohexane, 1-ethyl-4-methyl-, cis-
6.200	90.1	C8H18	114.1	4511647	111-65-9	Octane
6.300	93.1	C10H22	142.2	7823264	17301-94-9	Nonane, 4-methyl-
6.300	81.7	C10H22	142.2	5131123	15869-93-9	Octane, 3,5-dimethyl-
6.400	93.8	C10H22	142.2	22315328	15869-94-0	Octane, 3,6-dimethyl-
6.400	85.0	C8H14O	126.1	24110756	5441-51-0	Cyclohexanone, 4-ethyl-
6.500	92.7	C10H22	142.2	16592400	7146-60-3	Octane, 2,3-dimethyl-
6.500	88.6	C10H20	140.2	15160584	7058-05-1	Cyclohexane, 1-ethyl-2,3-dimethyl-
6.600	84.0	C10H20	140.2	5188610	19899-28-6	1,2,3,5-tetramethylcyclohexane (1r,2t,3c,5t)
6.700	86.6	C13H28	184.2	23931599	17615-91-7	Undecane, 5,6-dimethyl-
6.700	97.7	C9H12	120.1	9713488	0-00-0	unidentified C3-benzene

6.800	91.8	C10H22	142.2	36407904	17301-94-9	Nonane, 4-methyl-
6.900	93.8	C10H22	142.2	38786309	5911-04-6	Nonane, 3-methyl-
6.900	95.5	C9H12	120.1	43641023	0-00-0	unidentified C3-benzene
7.000	94.4	C8H24O4Si4	296.1	16773113	556-67-2	Cyclotetrasiloxane, octamethyl-
7.000	86.9	C7H10N2O2	154.1	103977065	999073-76-9	Cyclopentyl diazoacetate
7.000	80.5	C4H10O	74.1	45418805	999002-61-5	BUTYLALCOHOL-N
7.200	86.9	C10H20	140.2	45401834	13837-67-7	m-Menthane, (1S,3S)-(+)-
7.200	81.0	C6H5NO3	139.0	6158110	999048-38-9	(E)-Basidalin
7.200	80.1	C4H5DN2	83.1	10424943	999003-53-7	2-Deuterario-N-methylimidazole
7.200	86.6	C10H20	140.2	20864883	13837-67-7	m-Menthane, (1S,3S)-(+)-
7.200	84.3	C8H16O2	144.1	10686506	109-21-7	Butanoic acid, butyl ester
7.300	85.5	C10H20	140.2	18271670	7058-05-1	Cyclohexane, 1-ethyl-2,3-dimethyl-
7.300	93.1	C10H22	142.2	83152150	124-18-5	Decane
7.400	84.7	C10H20	140.2	20310354	4291-79-6	Cyclohexane, 1-methyl-2-propyl-
7.400	90.5	C10H20	140.2	8339829	13990-93-7	Trans-1,4-diethylcyclohexane
7.500	80.7	C18H38	254.3	10733028	593-45-3	Octadecane
7.600	84.1	C9H20	128.2	32014492	2216-32-2	Heptane, 4-ethyl-
7.600	85.0	C11H24	156.2	82018075	2847-72-5	Decane, 4-methyl-
7.700	89.5	C9H12	120.1	39382244	526-73-8	Benzene, 1,2,3-trimethyl-
7.700	86.0	C10H20	140.2	27629862	4291-80-9	Cyclohexane, 1-methyl-3-propyl-
7.700	91.4	C9H5NO	143.0	42941269	999055-47-0	p-Cyanoyl-o-ethynylphenol
7.800	84.3	C2H5NO	59.0	43654943	123-39-7	Formamide, N-methyl-
7.800	94.6	C8H18	114.1	97854327	594-82-1	Butane, 2,2,3,3-tetramethyl-
7.900	84.1	C15H32	212.3	26455359	31295-56-4	Dodecane, 2,6,11-trimethyl-
8.000	81.8	C15H28O2	240.2	41971840	103677-78-7	Cyclopropanecarboxylic acid, undecyl ester
8.200	83.2	C11H24	156.2	70367893	13151-35-4	Decane, 5-methyl-
8.300	90.8	C11H24	156.2	63116483	6975-98-0	Decane, 2-methyl-
8.300	84.0	C10H18	138.1	35214454	493-01-6	Naphthalene, decahydro-, cis-
8.400	89.3	C13H28	184.2	64883882	62185-53-9	Nonane, 5-(2-methylpropyl)-
8.400	82.4	C12H24	168.2	35035254	2030-84-4	4-DODECENE, CIS/TRANS
8.500	85.0	C10H14	134.1	15710818	488-23-3	Benzene, 1,2,3,4-tetramethyl-
8.500	84.2	C14H30O	214.2	50437084	112-72-1	1-Tetradecanol
8.500	89.5	C10H14	134.1	10540493	488-23-3	Benzene, 1,2,3,4-tetramethyl-
8.700	84.2	C11H22	154.2	62207993	62238-33-9	Cyclohexane, 1-ethyl-2-propyl-
8.800	81.0	C9H19F	146.1	14953540	52708-15-3	3-Fluoroheptane
8.800	92.4	C11H24	156.2	98023466	1120-21-4	Undecane
9.200	89.8	C5H4FN	97.0	7415727	372-48-5	2-fluoropyridine
9.200	95.6	C10H30O5Si5	370.1	42872999	541-02-6	Cyclopentasiloxane, decamethyl-
9.300	84.8	C12H24	168.2	44701463	55499-02-0	3-Decene, 2,2-dimethyl-, (E)-
9.400	81.9	C11H20	152.2	7208205	2547-27-5	trans-4a-Methyl-decahydronaphthalene
9.400	82.6	C11H22	154.2	17784067	4292-92-6	Cyclohexane, pentyl-
9.400	80.6	C8H14O	126.1	5919423	4643-27-0	2-Octen-4-one
9.500	87.6	C12H24	168.2	15616470	55499-02-0	3-Decene, 2,2-dimethyl-, (E)-
9.600	81.0	C12H26	170.2	8303079	17312-44-6	2,3-Dimethyldecane
9.700	87.1	C12H26	170.2	8948022	1002-17-1	Decane, 2,9-dimethyl-
9.800	81.1	C12H24	168.2	7037640	999104-97-4	Hexamethylcyclohexane
9.800	84.2	C18H38	254.3	9074204	26741-18-4	9-methylheptadecane
9.900	80.5	C9H16O4	188.1	4234913	2121-68-8	Pentanedioic acid, 2,4-dimethyl-, dimethyl ester
10.200	90.1	C12H26	170.2	12108258	112-40-3	Dodecane
10.500	96.0	C12H36O4Si5	384.1	19285506	141-63-9	Pentasiloxane, dodecamethyl-
10.800	80.1	C11H20O3	200.1	7878654	1000382-54-1	Carbonic acid, heptyl prop-1-en-2-yl ester
11.600	96.3	C12H36O6Si6	444.1	26314463	540-97-6	Cyclohexasiloxane, dodecamethyl-
11.700	81.8	C18H40O3Si	332.3	7061402	18536-91-9	Silane, dodecyltriethoxy-
12.000	84.5	C10H16O4	200.1	6834702	4513-62-6	Hexanedioic acid, 2-methyl-5-methylene-, dimethyl ester
12.700	94.6	C12H24O3	216.2	4796926	74367-34-3	Propanoic acid, 2-methyl-, 3-hydroxy-2,4,4-trimethylpentyl ester
12.700	95.3	C14H42O5Si6	458.2	16617063	107-52-8	Hexasiloxane, tetradecamethyl-
12.900	83.3	C14H22	190.2	12213783	2189-60-8	Benzene, octyl-
13.800	80.5	C14H42O7Si7	518.1	6905681	107-50-6	Cycloheptasiloxane, tetradecamethyl-
14.200	94.9	C6H5N3	119.0	411327528	95-14-7	1H-Benzotriazole
14.600	95.3	C14H28O2	228.2	9326649	1000360-29-5	Butyl 4-ethyloctanoate
14.700	88.8	C16H48O6Si7	532.2	6045210	541-01-5	Heptasiloxane, hexadecamethyl-