

## 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

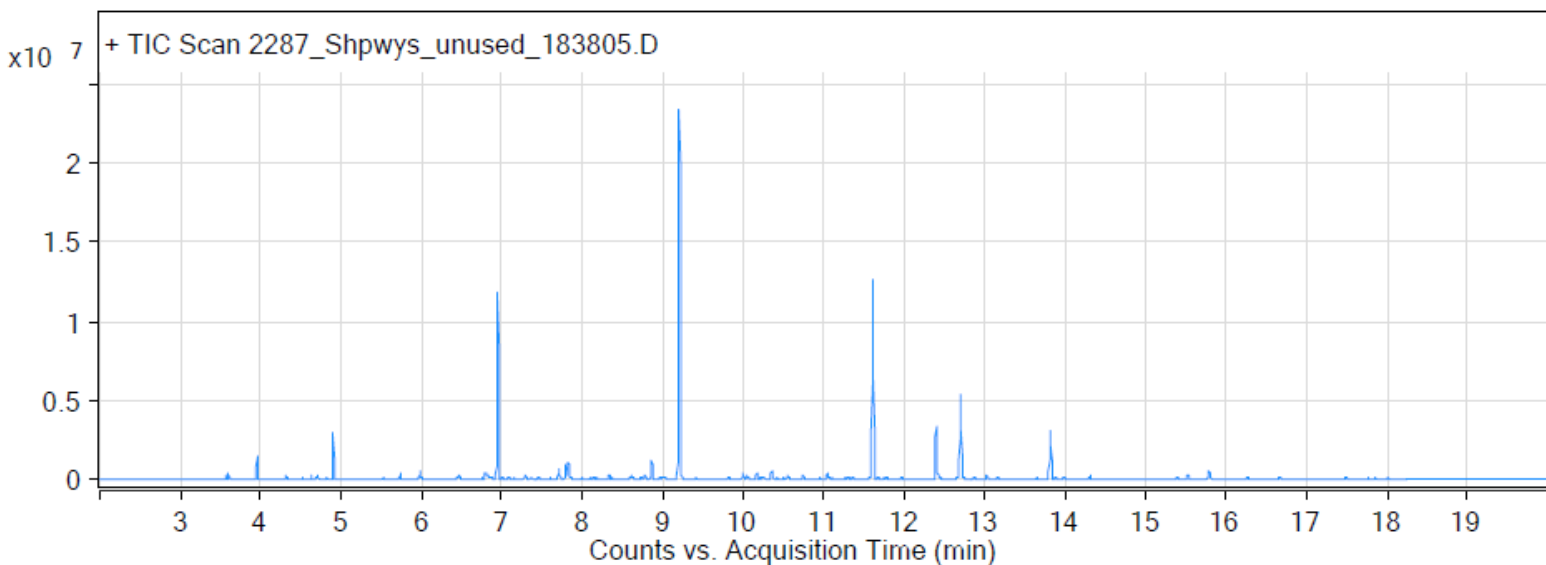
Sample: 3D printed Shapeways Nylon

Oddy test result: Temporary

Date collected: 04/16/2018

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 crotrapped for 2 min at -15°C; GC ramped from 40°C to 225 °C at 10°C/min. Data analyzed in Masshunter Qualitative Analysis. Samples > 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) 5.7 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-2,2,4-trimethylpentyl ester propanoic acid



Compound Table

RT	Score (Lib)	Area	Name	Formula
3.6	97.85	291044	Acetic acid	C2H4O2
3.95	93.69	919500	Silanediol, dimethyl-	C2H8O2Si
4.31	94.63	299681	1,2-Propanediol	C3H8O2
4.71	93	322375	Propanoic acid, 2,2-dimethyl-	C5H10O2
4.9	92.48	2329315	Cyclotrisiloxane, hexamethyl-	C6H18O3Si3
5.74	85.48	338083	Oxime-, methoxy-phenyl-	C8H9NO2
5.98	96.54	646153	Ethanol, 2-butoxy-	C6H14O2
6.93	87.15	418363	Phenol	C6H6O
6.95	96.48	11014653	Cyclotetrasiloxane, octamethyl-	C8H24O4Si4
7.7	96.54	868865	1-Hexanol, 2-ethyl-	C8H18O
7.79	96.05	1022985	d-Limonene	C10H16
7.82	96.12	1309749	Benzyl Alcohol	C7H8O
8.78	87.76	295685	Undecane	C11H24
8.86	96.47	1448224	Nonanal	C9H18O
9.21	95.64	26628478	Cyclopentasiloxane, decamethyl-	C10H30O5Si5
9.99	97.59	468517	Menthol	C10H20O
10.04	92.81	267092	Ethanol, 2-(2-butoxyethoxy)-	C8H18O3
10.16	96.15	443714	Azulene	C10H8
10.35	90.54	632592	Decanal	C10H20O
11.04	93.36	542004	Caprolactam	C6H11NO
11.61	95.9	15473357	Cyclohexasiloxane, dodecamethyl-	C12H36O6Si6
12.39	90.53	4385478	Propanoic acid, 2-methyl-, 2,2-dimethyl-1-(2-hydroxy-1-methylethyl)propyl ester	C12H24O3
12.7	93.37	7326196	Propanoic acid, 2-methyl-, 3-hydroxy-2,2,4-trimethylpentyl ester	C12H24O3
13.03	94.92	337602	Tetradecane	C14H30
15.52	93.97	268335	Hexadecane	C16H34
15.79	89.97	612035	Cyclooctasiloxane, hexadecamethyl-	C16H48O8Si8