

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

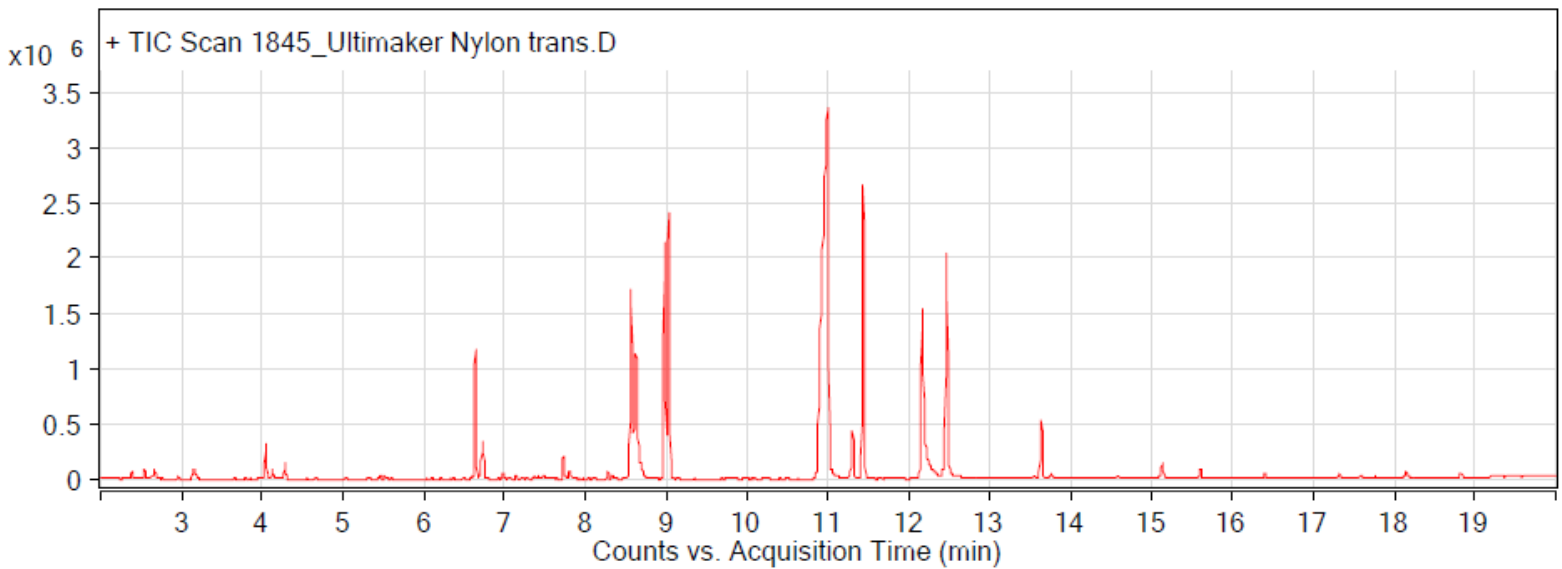
Sample: Ultimaker extruded nylon 3D printed filament with no platform adhesive

Oddy test result: Permanent

Date collected: 10/29/2018

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. 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) 12.2 min: 2-methyl-, 2,2-dimethyl-1-(2-hydroxy-1-methylethyl) propyl ester propanoic acid; (2) 12.5 min: 2-methyl-, 3-hydroxy-2,4,4-trimethylpentyl ester propanoic acid



Retention Time (min)	Abundance (%)	Mass	Compound Name	Formula
4.04	93.88	462797	Cyclopentanone	C5H8O
6.63	95.47	1405064	Cyclotetrasiloxane, octamethyl-	C8H24O4Si4
6.72	95.55	575084	Cyclotetrasiloxane, octamethyl-	C8H24O4Si4
7.72	91.9	319561	2H-Pyran-2-one, tetrahydro-	C5H8O2
8.56	96.66	2834370	Ethanol, 2-(hexyloxy)-	C8H18O2
8.62	96.59	2894345	Ethanol, 2-(hexyloxy)-	C8H18O2
8.98	92.3	2802491	Cyclopentasiloxane, decamethyl-	C10H30O5Si5
9.03	92.29	3425693	Cyclopentasiloxane, decamethyl-	C10H30O5Si5
10.99	94.43	17485288	Caprolactam	C6H11NO
11.3	90.2	694122	[1,1'-Bicyclopentyl]-2-one	C10H16O
11.44	91.58	3801109	Cyclohexasiloxane, dodecamethyl-	C12H36O6Si6
12.16	92.4	4041552	Propanoic acid, 2-methyl-, 2,2-dimethyl-1-(2-hydroxy-1-methylethyl)propyl ester	C12H24O3
12.46	93	3479524	Propanoic acid, 2-methyl-, 3-hydroxy-2,2,4-trimethylpentyl ester	C12H24O3
15.14	92.8	213722	Propanoic acid, 2-methyl-, 1-(1,1-dimethylethyl)-2-methyl-1,3-propanediyl ester	C16H30O4