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

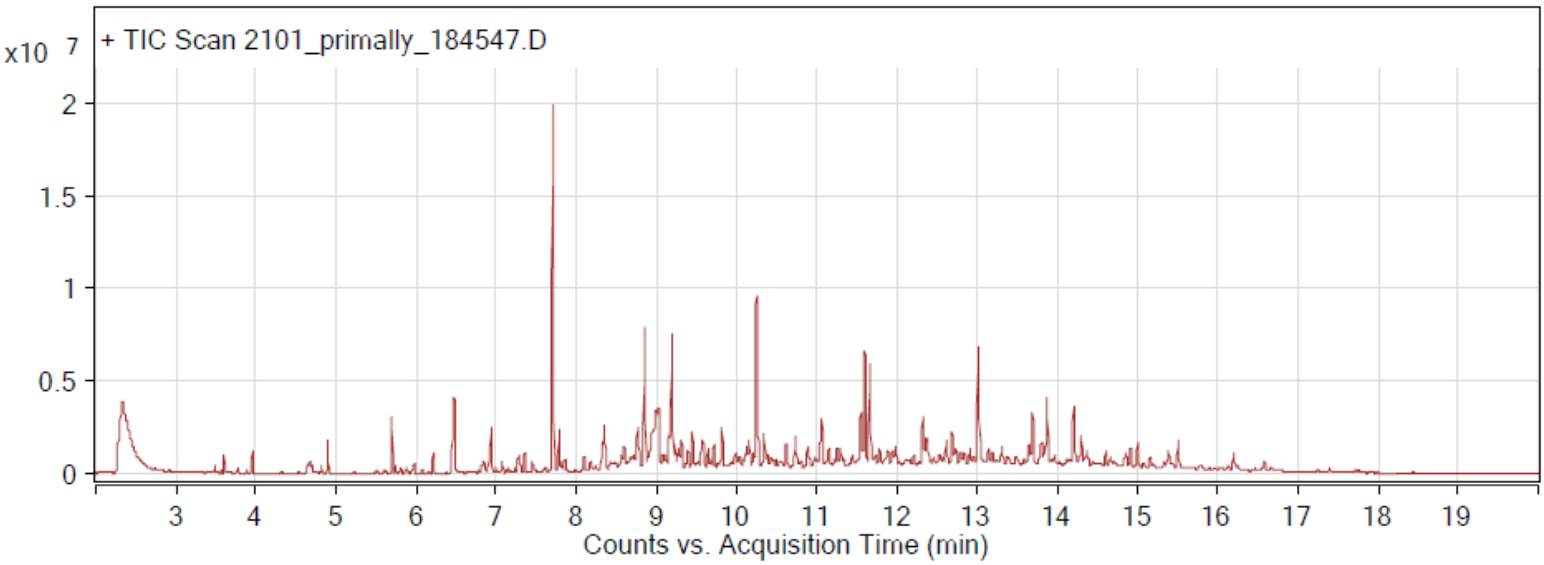
Sample: Verbatim 3D printed Primalloy 99026 filament

Oddy test result: Temporary

Date collected: 04/18/2018

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) 12.7 min: 2-methyl-, 3-hydroxyl-2,2,4-trimethylpentyl ester propanoic acid



Compound Table

RT	Score (Lib)	Area	Name	Formula
2.33	96.3	37022326	Furan, tetrahydro-	C4H8O
2.73	93.66	513417	Furan, tetrahydro-	C4H8O
3.6	97.95	731818	Acetic acid	C2H4O2
3.95	95.08	815506	Silanediol, dimethyl-	C2H8O2Si
4.82	93.31	457114	Hexanal	C6H12O
4.9	92.48	1363573	Cyclotrisiloxane, hexamethyl-	C6H18O3Si3
5.69	90.4	2727069	Butyl isobutyl ether	C8H18O
5.97	91.19	585283	Ethanol, 2-butoxy-	C6H14O2
6.47	93.93	7382604	1,4-Butanediol	C4H10O2
6.82	97.74	514917	Benzaldehyde	C7H6O
6.84	90.68	565084	1-Heptanol	C7H16O
6.94	96.39	1784061	Cyclotetrasiloxane, octamethyl-	C8H24O4Si4
7.08	97.95	566099	.alpha.-Methylstyrene	C9H10
7.28	85.59	962429	Ethanol, 2-(2-ethoxyethoxy)-	C6H14O3
7.35	97	1117209	Octanal	C8H16O
7.45	95.35	664442	dipropylene glycol monomethyl ether isomer, STRUCTURE UNKNOWN	C7H16O3
7.7	96.2	26028781	1-Hexanol, 2-ethyl-	C8H18O
7.78	97.67	2741288	dl-Limonene	C10H16
7.82	93.64	598854	Benzyl Alcohol	C7H8O
8.09	91.43	1072275	2,6-Dimethyldecane	C12H26
8.35	85.49	784125	DIHYDROMYRCENOL	C10H20O
8.68	94.13	416864	Benzene, 1-methyl-3-(1-methylethenyl)-	C10H12
8.69	85.25	758953	dihexylsulfide	C12H26S
8.71	85.22	513686	BENZENE, (1,1-DIMETHYLPROPYL)-	C11H16
8.85	95.5	9736163	Nonanal	C9H18O
8.99	88.33	5217398	Decane, 2,6,6-trimethyl-	C13H28
9.16	85.48	3331751	1-Hexanol, 5-methyl-2-(1-methylethyl)-	C10H22O

9.19	94.34	7513916	Cyclopentasiloxane, decamethyl-	C10H30O5Si5
9.23	91	1505197	1-Nonanol	C9H20O
9.27	86.22	1481706	Undecane, 4,7-dimethyl-	C13H28
9.31	92.73	1892459	1-Butanol, 4-butoxy-	C8H18O2
9.39	89.04	1089681	(S)-(+)-6-Methyl-1-octanol	C9H20O
9.44	92.58	2528332	Acetic acid, 2-ethylhexyl ester	C10H20O2
9.64	89.9	1123360	2,3-Dimethyldecane	C12H26
9.81	94.13	2499031	Undecane, 2,3-dimethyl-	C13H28
9.98	89.43	1194792	Cyclohexanol, 5-methyl-2-(1-methylethyl)-, (1.alpha.,2.beta.,5.alpha.)-(.+/-.)-	C10H20O
10.12	89.96	1537653	1-Dodecene	C12H24
10.15	89.03	1770331	Naphthalene	C10H8
10.2	94.04	731549	Methyl salicylate	C8H8O3
10.27	89.91	1700667	TRANS-ANETHOLE	C10H12O
10.34	96.44	2310004	Decanal	C10H20O
10.48	87.24	381374	Pentasiloxane, dodecamethyl-	C12H36O4Si5
10.61	93.25	1541601	2-Ethylhexyl acrylate	C11H20O2
10.74	91	1848555	2-Ethyl-1-hexyl propionate	C11H22O2
10.89	85.32	1450987	Cyclopentane, pentyl-	C10H20
11.06	93.97	4734185	Caprolactam	C6H11NO
11.15	87.66	1237239	Dodecane, 2-methyl-	C13H28
11.29	88.34	1056640	Undecane, 3,8-dimethyl-	C13H28
11.54	94.05	3867391	1-Tridecene	C13H26
11.6	95.5	7559193	Cyclohexasiloxane, dodecamethyl-	C12H36O6Si6
11.66	95.18	7556265	Tridecane	C13H28
11.78	91	1336737	Carbonic acid, decyl undecyl ester	C22H44O3
11.88	85.1	1373040	1-Decanol, 2-methyl-	C11H24O
11.98	93.49	1240215	Nonane, 2,2,4,4,6,8,8-heptamethyl-	C16H34
12.21	85.02	555536	Benzene, 3-cyclohexen-1-yl-	C12H14
12.32	88.71	3042634	Heptylcyclohexane	C13H26
12.62	89.85	1802449	Heptadecane, 7-methyl-	C18H38
12.69	89.54	2427946	Propanoic acid, 2-methyl-, 3-hydroxy-2,2,4-trimethylpentyl ester	C12H24O3
12.84	87.18	744879	Longicyclene	C15H24
12.91	91.93	1029234	Cyclotetradecane	C14H28
13.01	95.24	9678828	Tetradecane	C14H30
13.14	89.81	1411247	1-Octadecanol	C18H38O
13.31	93.97	1411044	Longifolene	C15H24
13.65	87.54	1520588	5,5-Dibutylnonane	C17H36
13.69	94.93	4345701	Cyclopentane, nonyl-	C14H28
13.84	86.33	1331159	Tetradecane, 4-methyl-	C15H32
13.87	94.46	4678562	2,5-Cyclohexadiene-1,4-dione, 2,6-bis(1,1-dimethylethyl)-	C14H20O2
13.97	87.73	868525	1-Dodecanol	C12H26O
14.2	95.53	4546955	1-Pentadecene	C15H30
14.29	91.74	2340972	pentadecane	C15H32
14.6	91.57	1117528	.delta.-Cadinene	C15H24
14.66	89.63	527456	Calamenene	C15H22
15	94.52	1855309	n-Nonylcyclohexane	C15H30
15.16	91.9	770503	Pentadecane, 3-methyl-	C16H34
15.38	86.91	1361156	Propanoic acid, 2-methyl-, 1-(1,1-dimethylethyl)-2-methyl-1,3-propanediyl ester	C16H30O4
15.51	88.08	2061930	5,5-Diethyltridecane	C17H36
16.2	92.71	1425718	Cyclohexadecane	C16H32
16.58	86.33	984809	1-Heptadecene	C17H34
16.66	87.2	371669	Heptadecane	C17H36