**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

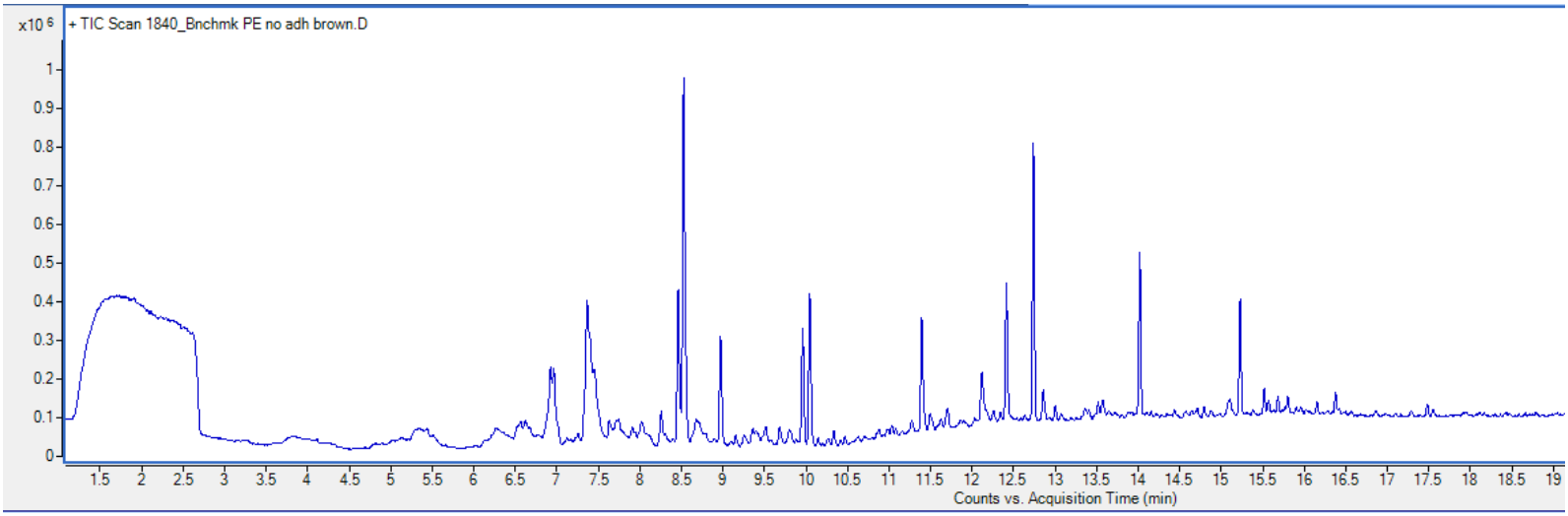
Sample: Benchmark 35-111 sueded polyethylene fabric; brown; no adhesive backing

Oddy test result: Temporary

Date collected: 12/04/2017

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 > 80% match with a NIST library are reported.

VOCs not highlighted are because they were also observed in blanks: (1) 12.1 min: 2-methyl-, 2,2-dimethyl-1-(2-hydroxy-1-methylethyl) propyl ester propanoic acid; (2) 12.4 min: 2-methyl-, 3-hydroxy-2,2,4-trimethylpentyl ester propanoic acid




**Library results**

| RT | Score | Formula | MW | Area | CAS # | Name |
|---|---|---|---|---|---|---|
| 4.267 | 85.8 | C14H11NO | 209.1 | 80128 | 999205-14-4 | (3R)-3-Phenyl-2,3-dihydro-1H-isoindol-1-one |
| 4.820 | 83.1 | C10H14O2 | 166.1 | 98009 | 68332-20-7 | 2-Ethenylcyclohex-2-enyl ethanoate |
| 5.662 | 85.2 | C10H8MoO4 | 289.9 | 42197 | 999429-12-4 | Tricarbonyl(.eta.6-anisole)molybdenum |
| 6.357 | 93.2 | C7H6O | 106.0 | 213008 | 100-52-7 | Benzaldehyde |
| 6.570 | 92.3 | C6H6O | 94.0 | 203725 | 108-95-2 | Phenol |
| 6.618 | 90.3 | C8H24O4Si4 | 296.1 | 69884 | 556-67-2 | Cyclotetrasiloxane, octamethyl- |
| 6.846 | 96.8 | C9H12 | 120.1 | 98481 | 25551-13-7 | x - ethyl - x - methyl - benzene |
| 6.921 | 93.1 | C10H22 | 142.2 | 467436 | 124-18-5 | Decane |
| 6.963 | 94.6 | C8H16O | 128.1 | 594771 | 124-13-0 | Octanal |
| 7.123 | 80.9 | C9H22Si | 158.1 | 45154 | 56310-20-4 | DI-TERT-BUTYLMETHYLSILANE |
| 7.361 | 97.8 | C8H18O | 130.1 | 1506683 | 104-76-7 | 1-Hexanol, 2-ethyl- |
| 7.400 | 83.9 | C10H16 | 136.1 | 330264 | 138-86-3 | dl-Limonene |
| 7.456 | 92.0 | C7H8O | 108.1 | 540683 | 100-51-6 | Benzyl alcohol |
| 7.632 | 95.8 | C5H9NO | 99.1 | 192531 | 872-50-4 | 2-Pyrrolidinone, 1-methyl- |
| 7.906 | 87.2 | C10H22 | 142.2 | 85687 | 2051-30-1 | Octane, 2,6-dimethyl- |
| 7.949 | 92.1 | C8H8O | 120.1 | 64219 | 999025-65-3 | benzophenone |
| 8.125 | 85.4 | C10H19ClO | 190.1 | 45122 | 999153-61-7 | 2-t-Butyl-2-chloro-3,3-dimethylbutanal |
| 8.259 | 88.2 | C9H12O | 136.1 | 183443 | 617-94-7 | Benzenemethanol, .alpha.,.alpha.-dimethyl- |
| 8.459 | 97.7 | C11H24 | 156.2 | 760505 | 1120-21-4 | Undecane |
| 8.526 | 98.6 | C9H18O | 142.1 | 1893594 | 124-19-6 | Nonanal |
| 8.969 | 91.2 | C10H30O5Si5 | 370.1 | 453463 | 541-02-6 | Cyclopentasiloxane, decamethyl- |
| 9.155 | 91.2 | C10H20O2 | 172.1 | 40231 | 72218-58-7 | 3-Methylheptyl acetate |
| 9.356 | 80.3 | C10H18O | 154.1 | 71630 | 491-07-6 | Cyclohexanone, 5-methyl-2-(1-methylethyl)-, cis- |
| 9.682 | 93.7 | C10H20O | 156.2 | 111681 | 999080-23-2 | isoneomenthol |
| 9.803 | 87.4 | C10H8 | 128.1 | 66791 | 91-20-3 | Naphthalene |
| 9.959 | 96.6 | C12H26 | 170.2 | 552283 | 112-40-3 | Dodecane |
| 10.045 | 98.1 | C10H20O | 156.2 | 733980 | 112-31-2 | Decanal |
| 10.336 | 93.9 | C11H20O2 | 184.1 | 59153 | 103-11-7 | 2-Propenoic acid, 2-ethylhexyl ester |
| 10.877 | 81.2 | C14H30 | 198.2 | 40802 | 629-59-4 | Tetradecane |

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|---|---|---|---|---|---|---|
| 11.035 | 90.6 | C12H26S | 202.2 | 39550 | 999185-34-2 | dihexylsulfide |
| 11.389 | 95.3 | C13H28 | 184.2 | 449246 | 629-50-5 | Tridecane |
| 11.400 | 86.2 | C12H36O6Si6 | 444.1 | 78287 | 540-97-6 | Cyclohexasiloxane, dodecamethyl- |
| 11.493 | 83.2 | C11H22O | 170.2 | 68743 | 112-44-7 | Undecanal |
| 11.709 | 86.3 | C13H28 | 184.2 | 91628 | 17301-23-4 | Undecane, 2,6-dimethyl- |
| 12.117 | 92.9 | C12H24O3 | 216.2 | 380420 | 74367-33-2 | Propanoic acid, 2-methyl-, 2,2-dimethyl-1-(2-hydroxy-1-methylethyl)propyl ester |
| 12.259 | 93.2 | C35H72 | 492.6 | 47894 | 630-07-9 | Pentatriacontane |
| 12.343 | 82.5 | C18H38 | 254.3 | 37327 | 21164-95-4 | Hexadecane, 7,9-dimethyl- |
| 12.410 | 93.2 | C12H24O3 | 216.2 | 637358 | 77-68-9 | Propanoic acid, 2-methyl-, 3-hydroxy-2,2,4-trimethylpentyl ester |
| 12.740 | 96.0 | C14H30 | 198.2 | 1123192 | 629-59-4 | Tetradecane |
| 12.861 | 95.2 | C12H24O | 184.2 | 138245 | 112-54-9 | Dodecanal |
| 13.000 | 94.6 | C15H24 | 204.2 | 50935 | 475-20-7 | Junipene |
| 14.018 | 95.6 | C15H32 | 212.3 | 679847 | 629-62-9 | pentadecane |
| 15.082 | 94.9 | C12H14O4 | 222.1 | 48158 | 84-66-2 | 1,2-Benzenedicarboxylic acid, diethyl ester |
| 15.106 | 94.6 | C16H30O4 | 286.2 | 55869 | 6846-50-0 | PENTAN-1,3-DIOLDIISOBUTYRATE, 2,2,4-TRIMETHYL- |
| 15.228 | 95.3 | C16H34 | 226.3 | 481030 | 544-76-3 | Hexadecane |
| 15.516 | 86.2 | C17H26O2 | 262.2 | 95249 | 14035-34-8 | 2,6-Bis(1,1-dimethylethyl)-4-(1-oxopropyl)phenol |
| 15.569 | 81.0 | C16H48O8Si8 | 592.2 | 47233 | 556-68-3 | Cyclooctasiloxane, hexadecamethyl- |
| 16.379 | 94.8 | C35H72 | 492.6 | 113897 | 630-07-9 | Pentatriacontane |
| 17.480 | 94.2 | C35H72 | 492.6 | 47171 | 630-07-9 | Pentatriacontane |
| 21.413 | 86.8 | C24H38O4 | 390.3 | 284465 | 6422-86-2 | 1,4-Benzenedicarboxylic acid, bis(2-ethylhexyl) ester |