



Designation: D6010 – 96(Reapproved 2006)

Standard Practice for Closed Vessel Microwave Solvent Extraction of Organic Compounds from Solid Matrices¹

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1. Scope

1.1 This practice describes the closed vessel microwave extraction of soils, sediments, sludges, and wastes for subsequent determination of solvent extractable semivolatile and nonvolatile organic compounds by such techniques as gas chromatography and gas chromatography-mass spectrometry.

1.1.1 Compounds listed in Tables 1–5 can be extracted from the preceding materials.

1.2 This test method is applicable to samples that will pass through a 10-mesh (approximately 2-mm opening) screen.

1.3 The detection limit and linear concentration range for each compound is dependent on the gas chromatograph or gas chromatograph-mass spectrometer technique employed and may be found in the manual accompanying the instrument used.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. See Section 8 for specific hazard statements.*

2. Referenced Documents

2.1 ASTM Standards:²

[D1193 Specification for Reagent Water](#)

[D3976 Practice for Preparation of Sediment Samples for Chemical Analysis](#)

[D5368 Test Methods for Gravimetric Determination of Total Solvent Extractable Content \(TSEC\) of Solid Waste Samples](#)

¹ This practice is under the jurisdiction of ASTM Committee D34 on Waste Management and is the direct responsibility of Subcommittee D34.01.06 on Analytical Methods.

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² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

2.2 Other Standards:

[United States Environmental Protection Agency \(USEPA\), Test Methods for Evaluating Solid Waste Volume 1A: Laboratory Manual Physical/Chemical Methods³ Title 21, Code of Federal Regulations \(CFR\), Part 1030, and Title 47, Part 18³](#)

3. Summary of Practice

3.1 This procedure ensures intimate contact of the sample matrix with 115°C extraction solvent.

3.2 A1 to 5-g portion of a solid sample is extracted in a sealed microwave transparent extraction vessel with 30 mL of acetone-hexane (1 + 1).

3.3 Up to 12 samples may be extracted simultaneously.

3.4 After extraction the vessels are cooled to room temperature, opened, and the solvent and sample are separated by decanting, filtration, or centrifuging.

3.5 This practice provides a sample suitable for analysis by gas chromatography or gas chromatography-mass spectrometry.

4. Significance and Use

4.1 Extraction of organic pollutants from wastes can provide information on the susceptibility of compounds to leaching, water quality changes, or other site conditions.

4.2 Rapid heating, in combination with temperatures in excess of the atmospheric boiling point of organic solvents, reduces sample extraction times.

4.3 Small amounts of solvents (30 mL) are used resulting in reduced sample preparation cost and time.

5. Interferences

5.1 Method interferences may be caused by contaminants in solvents, labware, and other hardware used in sample processing that lead to discrete artifacts or elevated baselines in gas chromatograms. The analyst must demonstrate, through the

³ Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

analysis of reagent blanks, that the system and the materials are free from interferents.

5.2 The use of high-purity solvents helps to minimize interference problems.

5.3 Matrix interferences are caused by contaminants that are coextracted from the sample. The extent of matrix interferences may vary considerably from sample to sample.

5.4 After cleaning, vessel liners and covers should be stored in a clean environment to prevent accumulation of contaminants.

TABLE 1 Continued

| Analyte | Spike Level, mg/kg | Average Recovery, % ^A | RSD, % |
|---|--------------------|----------------------------------|--------|
| 3-Methylcholanthrene | 5.0 | 117 | 8.6 |
| Methyl methanesulfonate | 5.0 | 48.5 | 28 |
| 2-Methylnaphthalene | 5.0 | 104 | 9.3 |
| 2-Methylphenol | 5.0 | 95.1 | 8.5 |
| 4-Methylphenol | 5.0 | 92.4 | 11 |
| Naphthalene | 5.0 | 95.0 | 12 |
| 1-Naphthylamine | 5.0 | 57.8 | 8.7 |
| 2-Naphthylamine | 5.0 | 73.5 | 9.0 |
| 2-Nitroaniline | 5.0 | 100 | 7.7 |
| 3-Nitroaniline | 5.0 | 96.8 | 8.5 |
| 4-Nitroaniline | 5.0 | 99.0 | 8.5 |
| Nitrobenzene | 5.0 | 88.4 | 19 |
| 2-Nitrophenol | 5.0 | 85.3 | 10 |
| 4-Nitrophenol | 5.0 | 104 | 6.0 |
| <i>N</i> -nitroso- <i>di-n</i> -butylamine | 5.0 | 97.5 | 9.3 |
| <i>N</i> -nitroso- <i>di-n</i> -propylamine | 5.0 | 87.5 | 20 |
| <i>N</i> -nitrosopiperidine | 5.0 | 90.8 | 7.6 |
| Pentachlorobenzene | 5.0 | 101 | 9.1 |
| Pentachloronitrobenzene | 5.0 | 109 | 9.7 |
| Pentachlorophenol | 5.0 | 86.2 | 8.1 |
| Phenacetin | 5.0 | 97.0 | 12 |
| Phenanthrene | 5.0 | 109 | 8.5 |
| Phenol | 5.0 | 97.3 | 9.2 |
| 2-Picoline | 5.0 | 7.7 | 30 |
| Pronamid | 5.0 | 120 | 11 |
| Pyrene | 5.0 | 113 | 8.4 |
| 1,2,4,5-Tetrachlorobenzene | 5.0 | 91.2 | 8.6 |
| 2,3,4,6-Tetrachlorophenol | 5.0 | 104 | 7.3 |
| 1,2,4-Trichlorobenzene | 5.0 | 89.3 | 11 |
| 2,4,5-Trichlorophenol | 5.0 | 95.1 | 12 |
| 2,3,6-Trichlorophenol | 5.0 | 96.4 | 6.7 |
| 2-Fluorobipenyl | 2.5 | 92.9 | 8.0 |
| 2-Fluorophenol | 5.0 | 95.4 | 7.7 |
| Nitrobenzene- <i>d</i> ₅ | 2.5 | 92.2 | 9.8 |
| Phenol- <i>d</i> ₅ | 5.0 | 98.9 | 9.7 |
| Terphenyl- <i>d</i> ₁₄ | 2.5 | 112 | 10 |
| 2,4,6-Tribromophenol | 5.0 | 92.3 | 7.7 |

^A The topsoil was dry when spiked. The number of determinations was three. Determinations were made by gas chromatography-mass spectrometry. All recoveries were corrected for analyte losses incurred during blowdown evaporation of solvent to determine, specifically, recoveries by microwave extraction.

^B Determined as azobenzene.

6. Apparatus

6.1 Microwave Heating System—A laboratory microwave heating system capable of delivering a minimum of 900 W of microwave energy. The system should be capable of 1% power adjustments and 1-s time adjustments. The microwave unit must be capable of measuring and controlling solvent temperature within an extraction vessel. The microwave cavity should be constructed so as to prevent any possible metal to metal arcing from occurring within the cavity. The oven cavity should be equipped with an exhaust ventilation sufficient to provide ten chamber exchanges/min. The ventilation exhaust should contain an air flow sensor and a solvent sensor capable of detecting no air flow and solvent concentrations below their lower explosive limits and shutting the microwave source off. The cavity shall have a 360° oscillating turntable to ensure even sample heating and be capable of removing contained vessel-vented solvents. Safety interlocks to shut off magnetron power output shall be contained in the cavity door opening mechanism. The system shall comply with the Department of Health and Human Services Standards under the CFR, Part 1030.10, Subpart (c)(1), (c)(2), and (c)(3), for microwave leakage. The system should have Federal Communication Commission (FCC) type approval for operations under FCC

TABLE 1 Semivolatile Analyte Recovery from Freshly Spiked Topsoil

| Analyte | Spike Level, mg/kg | Average Recovery, % ^A | RSD, % |
|-------------------------------------|--------------------|----------------------------------|--------|
| Acenaphthene | 5.0 | 97.6 | 9.8 |
| Acenaphthylene | 5.0 | 100 | 10 |
| Acetophenone | 5.0 | 92.2 | 12 |
| 4-Aminobiphenyl | 5.0 | 77.3 | 9.5 |
| Aniline | 5.0 | 68.1 | 7.5 |
| Anthracene | 5.0 | 108 | 9.2 |
| Benzidine | 5.0 | 0 | |
| Benzoic acid | 5.0 | 42.3 | 13 |
| Benzo(a)anthracene | 5.0 | 113 | 9.4 |
| Benzo(b)fluoranthene | 5.0 | | |
| Benzo(k)fluoranthene | 5.0 | 116 | 9.3 |
| Benzo(g,h,i)perylene | 5.0 | 111 | 4.7 |
| Benzo(a)pyrene | 5.0 | 110 | 8.6 |
| Benzyl alcohol | 5.0 | 96.1 | 9.0 |
| <i>Bis</i> (2-chloroethoxy)methane | 5.0 | 92.4 | 9.8 |
| <i>Bis</i> (2-chloroethyl)ether | 5.0 | 96.0 | 11 |
| <i>Bis</i> (2-chloroisopropyl)ether | 5.0 | 95.2 | 12 |
| <i>Bis</i> (2-ethylhexyl)phthalate | 5.0 | 116 | 9.3 |
| 4-Bromophenylphenyl ether | 5.0 | 108 | 9.0 |
| Butyl benzyl phthalate | 5.0 | 116 | 9.8 |
| 4-Chloroaniline | 5.0 | 97.0 | 9.2 |
| 1-Chloronaphthalene | 5.0 | 104 | 12 |
| 2-Chloronaphthalene | 5.0 | 91.8 | 7.3 |
| 4-Chloro-3-methylphenol | 5.0 | 107 | 12 |
| 2-Chlorophenol | 5.0 | 94.5 | 7.8 |
| 4-Chlorophenyl phenyl ether | 5.0 | 106 | 9.7 |
| Chrysene | 5.0 | 111 | 8.8 |
| Dibenz(o,a,j)acridine | 5.0 | 10.6 | 34 |
| Dibenz(o,a,h)anthracene | 5.0 | 110 | 5.9 |
| Dibenzofuran | 5.0 | 98.8 | 9.9 |
| <i>Di-n</i> -butyl phthalate | 5.0 | 113 | 9.4 |
| 1,2-Dichlorobenzene | 5.0 | 89.9 | 12 |
| 1,3-Dichlorobenzene | 5.0 | 87.6 | 13 |
| 1,4-Dichlorobenzene | 5.0 | 87.3 | 13 |
| 3,3-Dichlorobenzidine | 5.0 | 96.8 | 12 |
| 2,4-Dichlorophenol | 5.0 | 97.5 | 8.0 |
| 2,6-Dichlorophenol | 5.0 | 93.1 | 12 |
| Diethyl phthalate | 5.0 | 111 | 8.0 |
| Dimethylaminoazobenzene | 5.0 | 116 | 11 |
| 7,12-Dimethylbenz(a)anthracene | 5.0 | 128 | 7.0 |
| α -Dimethylphenethylamine | 5.0 | 7.0 | 4.1 |
| 2,4-Dimethylphenol | 5.0 | 107 | 9.4 |
| Dimethyl phthalate | 5.0 | 106 | 8.4 |
| 4,6-Dinitro-2-methylphenol | 5.0 | 57.6 | 9.3 |
| 2,4-Dinitrophenol | 5.0 | 17.2 | 39 |
| 2,4-Dinitrotoluene | 5.0 | 98.2 | 6.2 |
| 2,6-Dinitrotoluene | 5.0 | 98.5 | 9.9 |
| 1,2-Diphenylhydrazine ^B | 5.0 | 108 | 11 |
| <i>Di-n</i> -octyl phthalate | 5.0 | 117 | 12 |
| Ethyl methanesulfonate | 5.0 | 77.9 | 10 |
| Fluoranthene | 5.0 | 110 | 8.7 |
| Fluorene | 5.0 | 101 | 10 |
| Hexachlorobenzene | 5.0 | 108 | 8.9 |
| Hexachlorobutadiene | 5.0 | 89.5 | 11 |
| Hexachlorocyclopentadiene | 5.0 | 60.9 | 14 |
| Hexachloroethane | 5.0 | 83.7 | 13 |
| Indeno(1,2,3- <i>cd</i>)pyrene | 5.0 | 99.2 | 6.2 |
| Isophorone | 5.0 | 88.7 | 8.5 |