SPME/GC for Forensic Applications: Explosives, Fire Debris, and Drugs of Abuse

Solid phase microextraction is a fast, solventless alternative to conventional sample extraction techniques. In SPME, analytes establish equilibria among the sample matrix, the headspace above the sample, and a polymer-coated fused silica fiber, then are desorbed from the fiber to a chromatography column. Because analytes are concentrated on the fiber, and are rapidly delivered to the column, minimum detection limits are improved and resolution is maintained. In monitoring explosives, arson samples, and drugs of abuse, SPME is simpler and faster, and produces cleaner extracts, than liquid-liquid or solid phase extraction. This bulletin summarizes a few of the procedures that have been reported in the literature.

Key Words:
ι forensics ι explosives ι arson ι fire debris
ι drugs of abuse ι solid phase microextraction ι SPME

In forensic analyses, sample preparation usually involves removing and concentrating the analytes of interest through liquid-liquid extraction, solid phase extraction, or other techniques. These methods have various drawbacks, including excessive preparation time and extravagant use of organic solvents. Solid phase microextraction (SPME)* eliminates most of these drawbacks. SPME is fast, requires no solvents or complicated apparatus, and provides linear results over wide concentrations of analytes (typically to parts per million/parts per billion levels). The technique can be used to monitor analytes in liquid samples or headspace, and can be used with any GC, GC-mass spectrometer, or HPLC system.

In SPME, equilibria are established among the concentrations of an analyte in a sample, in the headspace above the sample, and in the polymer coating on a fused silica fiber. The amount of analyte adsorbed by the fiber depends on the thickness of the stationary phase coating on the fiber and the distribution constant for the analyte, which generally increases with increasing molecular weight and boiling point of the analyte. Extraction time is determined by the time required to obtain precise extractions for the analyte with the largest distribution constant. Volatile compounds require a thick polymer coat; a thin coat is most effective for adsorbing/desorbing semivolatile analytes. Analyte recovery also is improved, or selectivity altered in favor of more volatile or less volatile compounds, by agitating or adding salt to the sample, changing the pH or temperature, or sampling the headspace rather than the sample – or *vice versa* (see *Optimizing SPME: Parameters to Control to Ensure Consistent Results* on page 5 of this bulletin).

Explosives

With SPME, it is possible to extract inorganic compounds from an aqueous sample, and then extract organic components, such as explosives, from the same sample. Investigators at the Metro-Dade Police Crime Laboratory in Miami, FL, USA and at the Department of Chemistry at Florida International University (Miami) used SPME for the analysis of high explosives from solid debris and aqueous samples (1). They placed their soil and solid samples in distilled water and agitated prior to extraction. To sample an aqueous mixture of standard explosives, they used an SPME fiber coated with 65µm polydimethylsiloxane/divinylbenzene (PDMS/DVB). Direct immersion of the SPME fiber was found to be more effective than exposing the fiber to the sample headspace. Equilibrium time was under 30 minutes for the

Figure A. Explosives Sampled Without Solvent

Sample:	50ng/mL of each explosive in water
SPME Fiber:	**65µm polydimethylsiloxane/divinylbenzene**
Cat. No.:	**57310-U**
Sampling:	30 min, immersion
Desorption:	5 min
GC Column:	cyanopropyl silicone, 30m x 0.25mm ID, 0.25µm film
Equivalent:	SPB™-1701 (Cat. No. 24113)
Oven:	95°C (3 min) to 182°C at 8°C/min (4 min) to 250°C at 8°C/min (6 min)
Carrier:	nitrogen, 60mL/min
Det.:	ECD, 250°C
Inj.:	split/splitless, 180°C

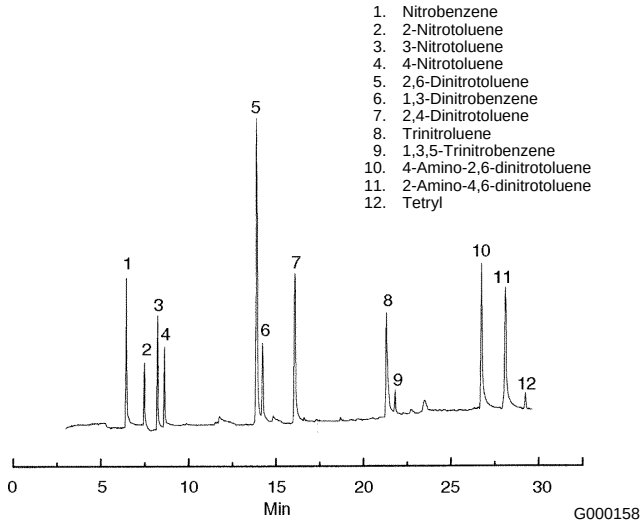


Figure courtesy of José Almirall, Crime Laboratory Bureau, Metro-Dade Police Department, Miami, FL, USA, and Grace Bi and Kenneth Furton, Department of Chemistry, Florida International University, Miami.

* Technology licensed exclusively to Supelco. US patent pending; European patent #0523092.

more volatile explosives (peaks 1-4 in Figure A), and longer for the less volatile explosives. After one-step extraction by SPME, the compounds in Figure A were detected at concentrations less than 50 parts per billion (ppb).

Analysis by GC proved to be more rapid, sensitive, and reliable than by HPLC. HMX and RDX explosives, however, must be analyzed by HPLC (1).

Arson

Furton *et al.* developed what they described as a simple, inexpensive, rapid, and sensitive method for analyzing gasoline in fire debris, using SPME for headspace sampling (2). According to the investigators, current methods for sampling flammable or combustible liquid residues from fire debris include static headspace sampling (capable of detecting ~10µL of petroleum product residue) and concentration methods including solvent extraction, dynamic headspace concentration, and passive headspace concentration (capable of detecting ~0.1µL of petroleum product residue). All of the concentration methods are cumbersome and time-consuming, and require the analyst to use carbon disulfide, a toxic and highly flammable solvent. In a direct comparison of headspace SPME and passive headspace concentration on activated charcoal strips, SPME was faster, simpler, and more economical, and offered greater sensitivity. SPME also eliminated the need to expose the technician to carbon disulfide.

Figure B. Headspace Sampling of 0.1µL Gasoline

Sample:	0.1µL gasoline/1 gallon can, heated 30 min at 40°C
SPME Fiber:	**100µm polydimethylsiloxane**
Cat. No.:	**57300-U**
Sampling:	20 min, headspace
Desorption:	10 sec (splitless mode)
Column:	polydimethylsiloxane phase, 30m x 0.25mm ID, 0.25µm film
Oven:	35°C (2 min) to 220°C at 10°C/min, hold 2 min, to 300°C at 30°C/min, hold 5 min
Carrier:	helium, 1mL/min (split 50:1)
Det.:	FID, 300°C
Inj.:	splitless (closed 3 min), 220°C (2mm ID injector liner)

1. Toluene
2. Ethylbenzene
3. m-Xylene, p-Xylene
4. o-Xylene
5. 1,2,4-Trimethylbenzene
6. 1,2,3-Trimethylbenzene
7. n-Butylbenzene
8. Naphthalene
9. 2-Methylnaphthalene
10. 1-Methylnaphthalene

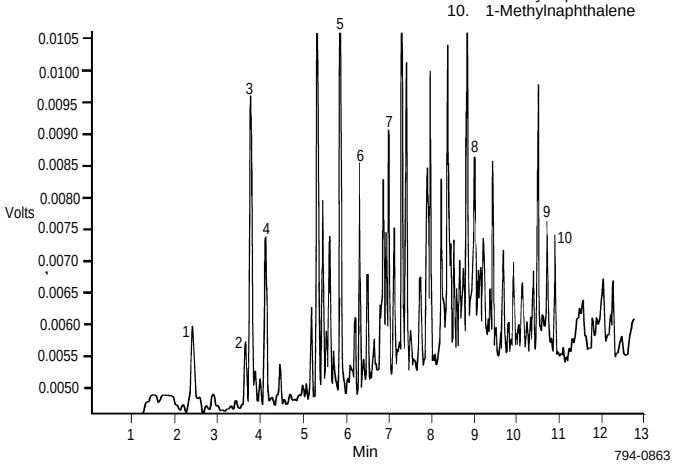


Figure courtesy of José Almirall, Crime Laboratory Bureau, Metro-Dade Police Department, Miami, FL, USA, and Kenneth Furton and Juan Bruna, Department of Chemistry, Florida International University, Miami.

Table 1. Detector Responses for Selected Hydrocarbons in Gasoline

	Gasoline Quantity (µL)	FID Response (volts) SPME	Passive	Response Ratio SPME/Passive
Ethylbenzene				
	5	0.07	0.12	0.6
	1	0.015	0.010	1.5
	0.1	0.0057	0.0060	1.0 $\underline{x}$ = 1.0
n-Butylbenzene				
	5	0.26	0.078	3.3
	1	0.042	0.0065	6.5
	0.1	0.0090	0.0062	1.5 $\underline{x}$ = 3.8
2-Methylnaphthalene				
	5	0.28	0.02	14
	1	0.042	0.0023	18.3
	0.1	0.0076	0.0055	1.4 $\underline{x}$ = 11.2

Data from reference 2.

After heating various fixed volumes of gasoline at 40°C for 30 minutes, the investigators exposed a 100µm polydimethylsiloxane-coated SPME fiber to the headspace above the sample for 20 minutes, then desorbed and analyzed the analytes under conditions listed with Figure B. They used a Hamilton® heated syringe cleaner (120VAC; Supelco Cat. No. 20770-U) to clean the fiber assembly between samples. Although relatively small amounts of analytes were recovered under these conditions, the SPME technique eliminated sample transfer/sample handling losses (the entire extract was introduced onto the GC column) and yielded high sensitivity. The investigators calculated that headspace SPME offered, on average, a 1.0-, 3.8-, and 11.2-fold increase in response, relative to passive concentration, for three measured components of the gasoline samples (Table 1). SPME produced acceptable, identifiable chromatograms from as little as 0.04µL gasoline, a significantly smaller volume than the normal limit for passive headspace sampling, 0.1µL. The forensics experts also were impressed with the savings in time and cost per sample offered by SPME (20 minutes or less, versus 16 hours; less than half the cost of passive sampling). These analysts now are applying their headspace SPME technique to analyses of other samples, including alcohols and diesel fuel.

Because liquid (immersion) and headspace sampling methods differ in kinetics, the two approaches can be considered complementary. For a given sampling time, other analysts found immersion SPME was more sensitive than headspace SPME for analytes predominantly present in the liquid (3). The reverse was true for analytes that were primarily in the headspace. These generalizations can be used to advantage to selectively adsorb more volatile or less volatile compounds, as a situation warrants. For higher sensitivity from headspace SPME, the sample headspace should be as small as is practical. A detailed theoretical discussion of headspace SPME is presented in reference 4.

The presence of water in a fire debris sample enhances the concentration of accelerants in the headspace, making extraction by SPME easier than by other methods. Using traditional extraction methods, accelerants are not easily extracted from fire debris samples that contain large quantities of water, both because of the solubility of some polar accelerants and because water vapor interferes with the adsorption of the accelerant onto the carbon.

Almirall *et al.* used an SPME fiber coated with 65µm PDMS/DVB for a fire debris sample containing water (5). Equilibrium time was less than 25 minutes for low molecular weight accelerants. High

molecular weight accelerants were found at higher concentration on the fiber when the fiber was exposed for a longer time (up to an hour). The investigators found that analysis of accelerants by GC was simpler, faster, and more highly sensitive using SPME, as opposed to the conventional carbon strip extraction method. Using SPME/GC/FID, they identified 30 potential accelerants used for arson fires.

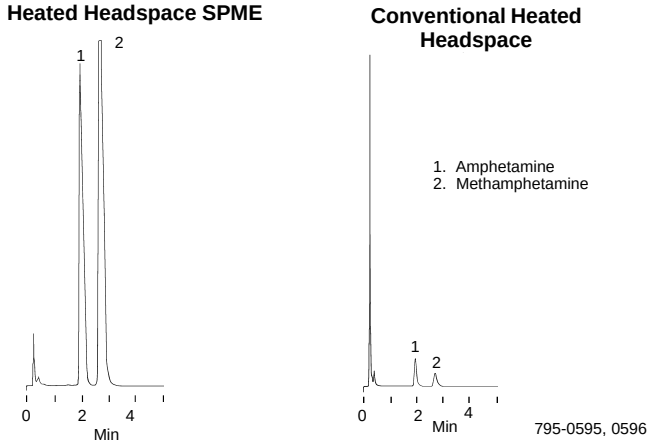
Drugs of Abuse

Amphetamines in Urine

Staff members of the Department of Legal Medicine, Hiroshima University School of Medicine and the Department of Legal Medicine, Fukuoka University School of Medicine have developed an accurate, simple, and rapid method for analyzing urine for methamphetamine and its principal metabolite, amphetamine, using heated headspace SPME and capillary GC (6). The investigators seal a 1mL urine sample in a 12mL vial, add internal standard (5µg pentadeuterated methamphetamine, prepared according to reference 7) and 0.7g potassium carbonate, and heat the sample at 80°C for 20 minutes on a block heater. They then expose an SPME fiber coated with 100µm of PDMS to the headspace above the sample for 5 minutes, then introduce the fiber into the injection port of the chromatograph. In a system equipped with mass spectrometry/chemical ionization selected ion monitoring (GC-MS/CI-SIM), this analysis was 20 times as sensitive as a method incorporating conventional headspace extraction (Figure C). Correlation coefficients for methamphetamine and amphetamine, based on d_5-methamphetamine, were 0.9999 for concentrations of 0.2–10mg/liter and 0.9970 for concentrations of 5–100mg/liter (Figure D). Coefficients of variation for amphetamine and methamphetamine at 5mg/liter in urine were 7.0% and 5.1%, respectively.

Figure C. Methamphetamine and Amphetamine in Urine

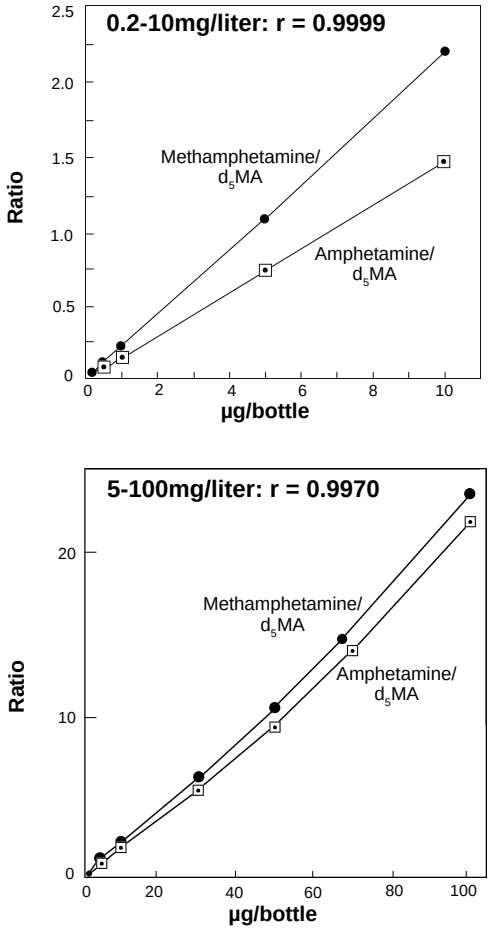
Sample:	1mL urine (100µg each analyte, 5µg d_5-methamphetamine, 0.7g K_2CO_3) in 12mL vial
SPME Fiber:	**100µm polydimethylsiloxane**
Cat. No.:	**57300-U** (manual sampling)
Extraction:	headspace, 80°C, 5 min (sample incubated 20 min)
Desorption:	3 min, 250°C
Column:	polydimethylsiloxane, 15m x 0.53mm ID, 2.0µm film
Oven:	110°C
Carrier:	nitrogen, 25mL/min
Det.:	FID, 250°C
Inj.:	splitless, 250°C



795-0595, 0596

Figure D. Linear Extraction of Methamphetamine and Amphetamine

Sample:	1mL urine (100µg each analyte, 5µg d_5-methamphetamine, 0.7g K_2CO_3) in 12mL vial
SPME Fiber:	**100µm polydimethylsiloxane**
Cat. No.:	**57300-U** (manual sampling)
Extraction:	headspace, 80°C, 5 min (sample incubated 20 min)
Desorption:	3 min, 250°C
Column:	polydimethylsiloxane, 15m x 0.53mm ID, 2.0µm film
Oven:	110°C
Carrier:	nitrogen, 25mL/min
Det.:	FID, 250°C
Inj.:	splitless, 250°C



995-0597, 0598

Figures C and D provided by M. Yashiki, T. Kojima, T. Miyazaki, N. Nagasawa, and Y. Iwasaki, Dept. Legal Medicine, Hiroshima University School of Medicine, Hiroshima, Japan and K. Hara, Dept. Legal Medicine, Fukuoka University School of Medicine, Fukuoka, Japan.

Subsequently, these authors developed a similar procedure for monitoring amphetamines in blood (N. Nagasawa, M. Yashiki, Y. Iwasaki, K. Hara, and T. Kojima, *Rapid Analysis of Amphetamines in Blood Using Head Space-Solid Phase Microextraction and Selected Ion Monitoring* in *Forensic Science International* 78 (2), 1996). In place of potassium carbonate, 0.5mL 1N sodium hydroxide is used to drive the analytes into the headspace (see *Optimizing SPME: Parameters to Control to Ensure Consistent Results).*

In analyzing urine samples for suspected drugs, the New Jersey State Police Forensic Laboratory used headspace SPME, followed by headspace derivatization and GC/MS, with positive identification of amphetamines (8). Headspace sampling was found to be more effective than direct fiber immersion, due to potential interferences. The equilibrium time for the compounds was less than 30 minutes. The analysts used an SPME fiber coated with 65µm PDMS/DVB.

Cocaine in Urine

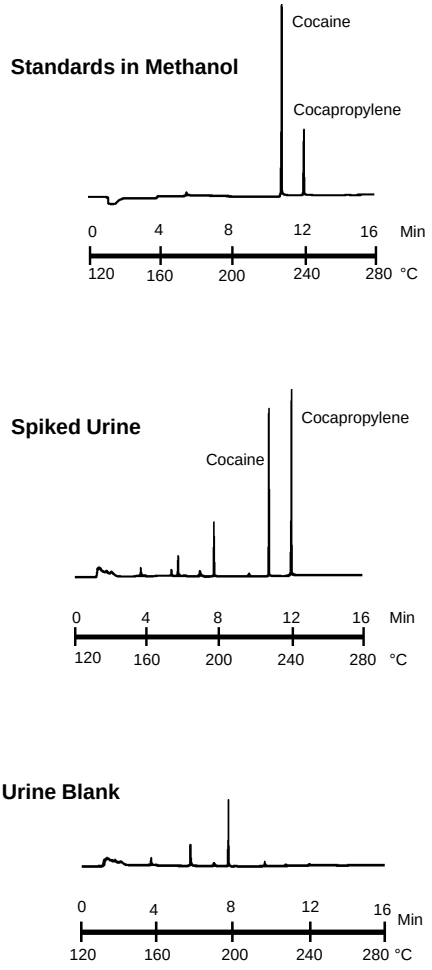
Investigators in the Department of Legal Medicine, Showa University School of Medicine and the Department of Legal Medicine, Hamamatsu University School of Medicine developed a method for detecting cocaine in urine, by combining SPME with capillary GC on a polydimethylsiloxane column (30m x 0.32mm ID, 0.25µm film) and a nitrogen-phosphorus detector (9). Because headspace extraction gives poor recovery values for cocaine, the analysts immerse a 100µm PDMS SPME fiber into the samples.

To demonstrate their technique, the analysts add 0.5mL urine plus 250ng cocaine and 250ng internal standard (cocapropylene, prepared according to reference 10) to a 1mL vial containing 20µL of 2.5% sodium fluoride solution and a small magnetic stirring bar. They insert the needle on the SPME device through the septum sealing the vial, immerse the SPME fiber in the sample for 30 minutes, then expose the fiber in the heated injection port for 3 minutes to ensure complete desorption of the extracted analyte.

Figure E shows chromatograms for cocaine and the internal standard in methanol (direct injection, 20ng each on-column), the drug and internal standard as extracted from spiked urine, and an extract from a urine blank. The extracts are very clean – urine background does not interfere with the analysis. Recovery values for cocaine and the internal standard, determined by comparing peak areas for the extracts to those for the methanol solution, were 20% and 30%, respectively. Extractions were linear from 30ng–250ng/0.5mL urine; the detection limit for cocaine was approximately 6ng/0.5mL urine.

Figure E. Cocaine in Urine

Sample:	0.5mL urine (250ng each analyte, 20µL 2.5% NaF) in 1mL vial
SPME Fiber:	**100µm polydimethylsiloxane**
Cat. No.:	**57300-U** (manual sampling)
Extraction:	immersion, 30 min
Desorption:	3 min, 240°C
Column:	polydimethylsiloxane, 30m x 0.32mm ID, 0.25µm film
Oven:	120°C to 280°C at 10°C/min
Carrier:	helium, 3mL/min
Det.:	NPD, 280°C
Inj.:	splitless (splitter opened after 1 min), 240°C



796-0151, 0156, 0157

Figure provided by T. Kumazawa and K. Sato, Dept. Legal Medicine, Showa University School of Medicine, Tokyo, Japan and K. Watanabe, H. Seno, A. Ishii, and O. Suzuki, Dept. Legal Medicine, Hamamatsu University School of Medicine, Hamamatsu, Japan.

Used with permission of Japanese Journal of Forensic Toxicology.

Optimizing SPME: Parameters to Control to Ensure Consistent Results

As these examples indicate, analysts using solid phase microextraction routinely obtain consistent results and reliable detection of low concentrations of analytes. The polarity and thickness of the coating on the fiber, sample agitation, the sampling method (fiber immersion or headspace sampling), the pH, salt content, and volume of the sample, and other factors affect results from SPME. It is important to remember that in SPME neither complete extraction of analytes nor full equilibrium are necessary, but consistent sampling time, temperature, fiber immersion depth, and headspace volume are crucial to reproducibility.

Fiber Polarity Because the SPME fiber is only 1cm long, the coating on the fiber must be either nonpolar or strongly polar in nature. In chromatography, small changes in the chemical nature of the stationary phase are useful (a 5% diphenylsiloxane/95% dimethylsiloxane phase versus a 100% dimethylsiloxane phase, for example), but such small differences will not produce appreciable selectivity differences in SPME. What *is* beneficial, however, is the incorporation of an adsorbent material in the coating. The potential value of including various adsorbents, carbons, and silica in SPME coatings is under review at Supelco.

Fiber Coating Thickness Diffusion of an analyte from the sample matrix or headspace into the coating on the fiber is proportional to the thickness of the coating. A thicker film retains volatile compounds and transfers them to the GC injection port without loss. For higher boiling compounds, a thin film ensures fast diffusion and release of the analyte during thermal desorption. A thick film will effectively remove high boiling compounds from the sample matrix, but the desorption rate will be prolonged, and analytes could be carried over to the next extraction.

Sample Agitation Sample agitation enhances extraction and reduces extraction time, especially for higher molecular weight analytes with high diffusion coefficients. Inconsistent stirring causes poor precision and is worse than no stirring. Sonication promotes analyte adsorption, but can heat the sample. This might be detrimental to some heat-sensitive analytes or, alternatively, could be useful for vaporizing analytes for headspace extraction.

Immersion versus Headspace Sampling; Effects of Salt and pH Analytes that exhibit a vapor pressure can be extracted by immersing the fiber into the sample, or by sampling the headspace above the sample. Analytes that exhibit no vapor pressure must be extracted by immersion. Adding salt to the sample or changing the pH prior to extraction can increase the ionic strength of the solution and, in turn, reduce the solubility of some analytes. Conversely, salt can increase the solubility of other analytes. Consequently, the effects of adding salt to a sample should be evaluated for each specific combination of analytes and sample matrix. Changing the pH can minimize solubility; acidic and basic compounds are more effectively extracted at acidic and basic pH, respectively. A combination of salt and pH modification often enhances the extraction of analytes from the headspace. Equilibration is faster in headspace sampling, because in immersion sampling the analyte molecules must penetrate a static layer of water molecules surrounding the fiber. For higher sensitivity from headspace SPME, the sample headspace should be as small as is practical. A detailed theoretical discussion of headspace SPME is presented in reference 4.

Other Factors Less subject to control, but influencing the extraction, is analyte concentration. At low concentrations, changes in sample volume do not affect response, because equilibrium is concentration-dependent. At higher concentrations, changes in sample volume become significant. With a large sample (>5mL) containing a high concentration of analyte, the amount of analyte removed from the sample is not sufficient to change the concentration. Therefore, response throughout the calibration curve is exponential, not linear, especially for compounds with high distribution constants. Responses may be linear for low concentrations. Because analyte concentration often is not known, it is best to keep sample volumes between 1mL and 5mL, and always use the same volume for samples and calibration standards. If you anticipate extracting the analytes by using an immersion sampling technique, minimize the headspace in the sample vial.

Finally, the desorption parameters – injection port temperature, depth of fiber insertion in the injection port, desorption time – also must be optimized for the analytes involved. Once established, these values should be used consistently. Desorption of an analyte from the SPME fiber depends on the boiling point of the analyte, the thickness of the coating on the fiber, and the temperature of the injection port. Some analytes can take up to 30 seconds to desorb, and cryogenic cooling might be required to focus these compounds at the inlet of a capillary GC column. Use of an inlet liner with a narrow internal diameter (e.g., 0.75-1mm) generally provides sharp peaks and can eliminate the need for cooling. As with any other extraction/concentration technique, it is best to use multiple internal standards in SPME methods, and to treat the standards and the analytes identically.

References

1. Almirall, J.R., G. Bi and K.G. Furton, *The Analysis of High Explosives Residues by Solid-Phase Microextraction Followed by HPLC, GC/ECD and GC/MS.* Paper presented at Academy of Forensic Science, 2/13/98.
2. Furton, K.G., J.R. Armirall, and J.C. Bruna, J. Forensic Sci., **41**: 12-22 (1996).
3. Yang, X. and T. Peppard, J. Agric. Food Chem., **42**: 1925-1930 (1994).
4. Zhang, X. and J. Pawliszyn, Anal. Chem. **65**: 1843-1852 (1993).
5. Furton, K.G., J. Bruna, and J. Almirall, J. High Resol. Chromatogr., **18**: 625-629 (1995).
6. Yashiki, M., T. Kojima, T. Miyazaki, N. Nagasawa, Y. Iwasaki, and K. Hara, *Forensic Science International* **76**: 169-177 (1995).
7. Hara, K., T. Nagata, and K. Kimura, *Z. Rechtsmed.*, **96**: 93-104 (1986).
8. Brettell, T., M. Sinibaldi, E. McLaughlin, and M. Kennedy, *Rapid Identification of Amphetamines in Urine Using Headspace Derivatization by Solid-Phase Microextraction and Gas Chromatography/Mass Spectrometry.* Paper presented at Eastern Analytical Symposium, Nov. 16-18, 1997.
9. Kumazawa, T., K. Watanabe, K. Sato, H. Seno, A. Ishii, and O. Suzuki, *Japan. J. Forensic Toxicol.*, **13**: 207-210 (1995).
10. Roy, I.M., T.M. Jefferies, M.D. Threadgill, and G.H. Dewar, *J. Pharm. Biomed. Anal.*, **10**: 943-948 (1992).

References not available from Supelco.

Ordering Information:

Description	Cat. No.
SPME Fiber Holder	
Initially you must order both holder and fiber assembly. Holder is reusable indefinitely.	
For manual sampling	**57330-U**
For Varian 8100/8200 autosampler (requires Varian SPME upgrade kit)	**57331**
SPME Fiber Assemblies (pk. of 3)	
100µm polydimethylsiloxane coating (best for volatile analytes)	
For manual sampling	**57300-U**
For Varian 8100/8200 autosampler	**57301**
65µm polydimethylsiloxane/divinylbenzene coating	
For manual sampling	**57310-U**
For Varian 8100/8200 autosampler	**57311**
75µm polydimethylsiloxane/Carboxen™ coating (for nonpolar–intermediate polarity semivolatiles)	
For manual sampling	**57318**
For Varian 8100/8200 autosampler	**57319**
SPME Fiber Assembly Kit	
One fiber assembly each: 100µm polydimethylsiloxane, 65µm polydimethylsiloxane/divinylbenzene, 75µm polydimethylsiloxane/Carboxen	
For manual sampling	**57324-U**
For Varian 8100/8200 autosampler	**57325-U**

SPME Portable Field Sampler

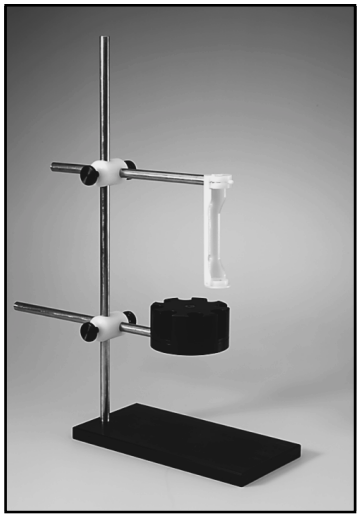
This manual-type holder stores the fiber after sampling by sealing it with an internal septum. It is ideal for field work and comes with a PDMS/Carboxen fiber for trace-level volatile analysis, or a PDMS fiber for concentrating polar analytes.

997-0046

Description	Cat. No.
SPME Portable Field Samplers, pk. of 2	
75µm PDMS/Carboxen	**504831**
100µm PDMS	**504823**
Replacement Septa, pk. of 10	**20638**
SPME Septum Removing Tool	**504858**

SPME Sampling Stand

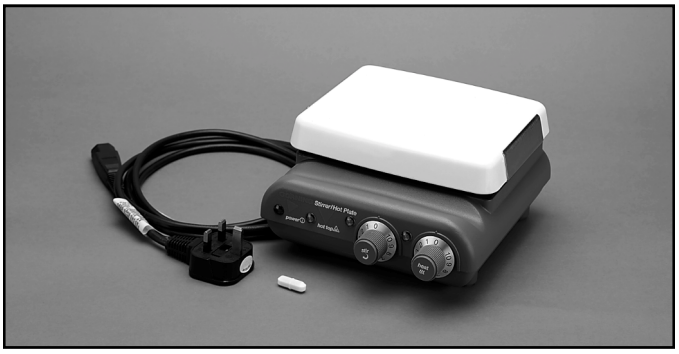
Holds eight vials while supporting the SPME syringe for consistent fiber immersion. Accommodates 4mL vials only.



9950254

Description	Cat. No.
SPME Sampling Stand	**57333-U**

Heat/Stir Plate



997-0102

Heat or stir samples when using the SPME sampling stand. The plate fits compactly on the base of the stand. Heating range is 40-550°C. Stirring range is 60-1200rpm.

Description	Cat. No.
Corning Heat/Stir Plate, 120VAC	**Z26,212-9**
Corning Heat/Stir Plate, 240VAC [n]	**Z26,2137-1EA**

Magnetic Stirring Bars

Fit 4mL vials. 10 x 3mm, pk. of 3.

Magnetic Stirring Bars	**Z11,8877-3EA**

Thermometer

For monitoring the temperature of samples when using the SPME sampling stand and the heat/stir plate. 5" long.

Thermometer	**57332**

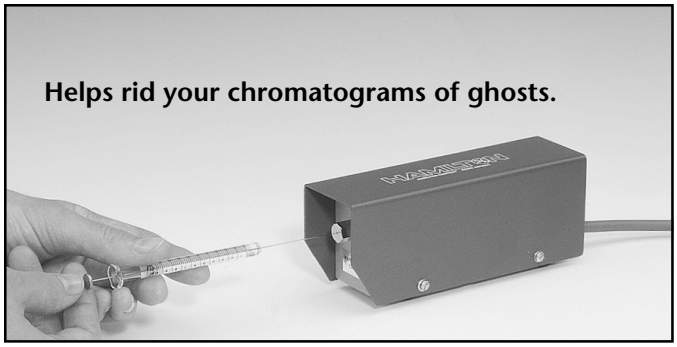
[n]CE approved.

Vials and Closures

9940420

Description	Qty.	Cat. No.
Screw Top Vials for Varian 8100/8200 AutoSampler, 12mm OD x 32mm length		
Clear, 2mL	100	**27124-U**
Amber, 2mL	100	**27005**
Headspace Vials, 15mm OD x 45mm length		
Clear, 4mL	10	**26901**
	100	**27136**
Amber, 4mL	10	**26930**
	100	**27006**

Syringe Cleaner



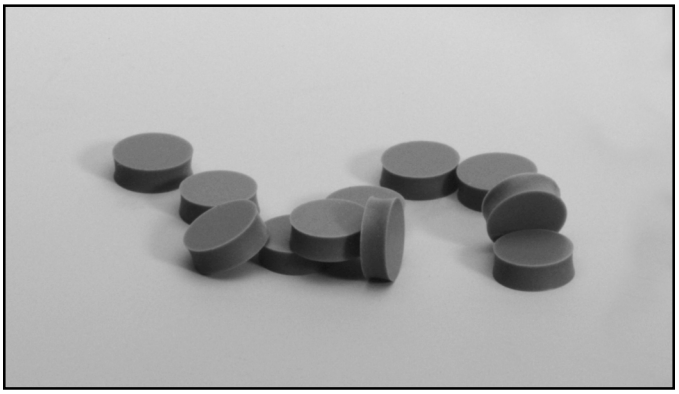
9100191

Cleans Hamilton syringes and other syringes with needles up to 18 gauge (0.049" OD). Just connect the unit to your water aspirator or other vacuum source, insert the needle through the septum, and in 10-30 seconds, you're ready for a new sample. A combination of heat (250°C) and vacuum vaporizes and removes contaminating volatiles in a single operation.

Description	Qty.	Cat. No.
Hamilton Syringe Cleaner		
120V	1	**20770-U**
Replacement Septa		
5mm	100	**20712**

[s] Does not have a CE mark.

Pre-Drilled Septa for SPME



897-0032

- Easier needle penetration and high puncture tolerance
- Reduces septum coring that can cause extraneous peaks
- Conditioned, ready-to-use
- Extremely low bleed over a wide range of inlet temperatures — from 100°C to 250°C
- Rubber formulation exclusive to Supelco

Description	Qty.	Cat. No.
Thermogreen™ LB-2 Septa, Pre-Drilled		
11mm	pk. of 25	**23167**
11mm	pk. of 50	**23168**
9.5mm	pk. of 25	**23161**
9.5mm	pk. of 50	**23162-U**

SPME Inlet Liners

Achieve Sharper Peaks with SPME/GC

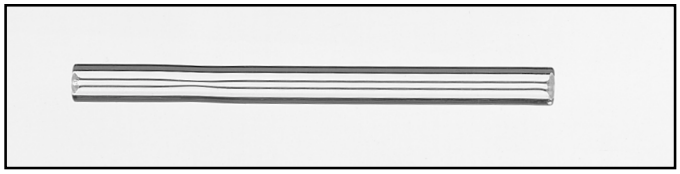
997-0137

Using a 0.75mm ID inlet liner in the GC injection port increases linear velocity through the liner, compared to a larger volume 2mm ID liner, and rapidly introduces analytes onto the column in a narrow band. Our proprietary, high-temperature technique thoroughly deactivates these liners to minimize adsorption of active sample components.

Inlet Liners for SPME

Description	Cat. No.
Hewlett-Packard® (5880, 5890 series, 6890)	
Each	**26375,01**
pk. of 5	**26375,05**
pk. of 25	**26375,25**
Varian	
1075/1077 Injectors	
Each	**26358,01**
pk. of 5	**26358,05**
pk. of 25	**26358,25**
1093/1094 SPI Injectors	
Each	**26364,01**
pk. of 5	**26364,05**
pk. of 25	**26364,25**
Perkin-Elmer® (Auto System Split/Splitless Injector)	
Each	**26312,01**
pk. of 5	**26312,05**
pk. of 25	**26312,25**
Shimadzu®	
GC Models 9A/15A/16 (SPL-G9/15 Injector)	
Each	**26329,01**
pk. of 5	**26329,05**
pk. of 25	**26329,25**
GC Models 14/15A/16 (SPL-14 Injector)	
Each	**26335,01**
pk. of 5	**26335,05**
pk. of 25	**26335,25**
GC Models 17A (SPL-17 Injector)	
Each	**26339,01**
pk. of 5	**26339,05**
pk. of 25	**26339,25**

SPME Inserts



913-0249

Description	Cat. No.
Flash On-Column Inserts for Varian SPME Injector pk. of 5	**26364,05**

Acknowledgments

The procedure for detecting explosives was developed by José Almirall, Metro-Dade Police Crime Laboratory, 9105 NW 25 St., Miami, FL 33172 USA; and Grace Bi and Kenneth G. Furton, Department of Chemistry, Florida International University, Miami, FL 33199 USA.

The procedure for detecting gasoline in fire debris was developed by José Almirall, Metro-Dade Police Crime Laboratory, 9105 NW 25 St., Miami, FL 33172 USA; and Kenneth G. Furton and Juan Bruna, Department of Chemistry, Florida International University, Miami, FL 33199 USA.

The procedure for detecting amphetamines in urine was developed by Mikio Yashiki, Tohru Kojima, Tetsuji Miyazaki, Nobuyuki Nagasawa, and Yasumasa Iwasaki, Department of Legal Medicine, Hiroshima University School of Medicine, 1-2-3 Kasumi, Minami-ku, Hiroshima 734, Japan and Kenji Hara, Department of Legal Medicine, Fukuoka University School of Medicine, 7-45-1 Nanakuma, Jonan-ku, Fukuoka 814-01, Japan.

The procedure for detecting cocaine in urine was developed by Takeshi Kumazawa and Keizo Sato, Department of Legal Medicine, Showa University School of Medicine, 1-5-8 Hatanodai, Shinagawa-ku, Tokyo 142, Japan and Kanako Watanabe, Hiroshi Seno, Akira Ishii, and Osamu Suzuki, Department of Legal Medicine, Hamamatsu University School of Medicine, 3600 Handa-cho, Hamamatsu 431-31, Japan.