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MEPS - Micro Extraction by Packed Sorbent

Online SPE for GC and LC sample preparation - extraction to injection in a single process

Save Hours in Sample Preparation

- Reduce the time to prepare and inject samples from hours to minutes
- Eliminate all extra steps between sample preparation and sample injection
- Reduce buffer and solvent volume from Milliliters to Microliters
- Reduce the sample volume needed to as little as 3.6 µL

PATENT PENDING

SGE Analytical Science

What is MEPS?

MEPS is Micro Extraction by Packed Sorbent and is a new development in the fields of sample preparation and sample handling. MEPS is the miniaturization of conventional SPE packed bed devices from milliliter bed volumes to microliter volumes.

The MEPS approach to sample preparation is suitable for reversed phases, normal phases, mixed mode or ion exchange chemistries. MEPS is available in a variety of common SPE phases.

The MEPS **B**arrel **I**nsert and **N**eedle Assembly (BIN), (Patent Pending) contains the stationary phase, and is built into the syringe needle (Figure 1).

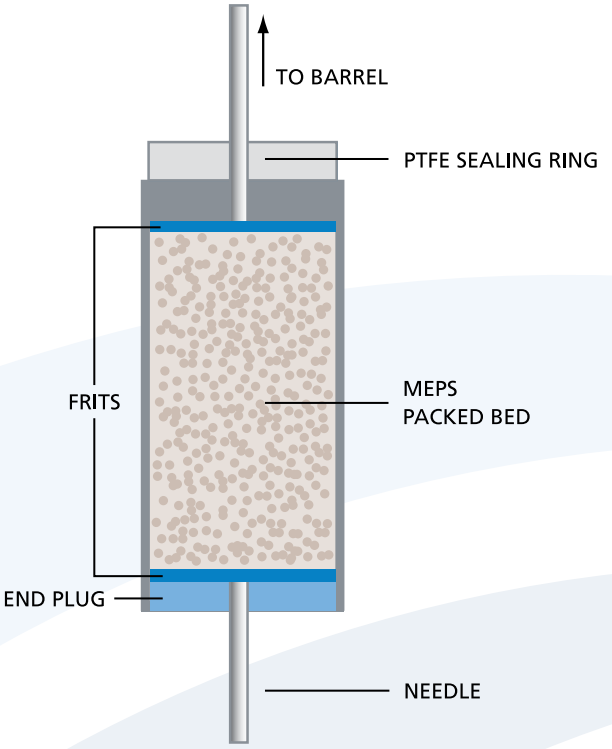
Why use MEPS?

Historically, many sample preparation methods used liquid-liquid extraction (LLE) which required large volumes of sample, solvents and time. The advantages of SPE over LLE are that SPE takes much less time, can be developed into a fully automated technique, requires much less solvent and offers selectivity.

MEPS performs the same functions as SPE – the removal of interfering matrix components and the selective isolation and concentration of analytes. MEPS increases the advantages of conventional SPE in the following ways:

- Significantly reduces the time needed to prepare and inject samples
- Can be combined with LC or GC automation - the extraction step and injection step are performed on-line using the same syringe.
- Significantly reduces the volume of solvents needed
- Ability to work with samples as small as 3.6 µL versus several hundred mL for SPE

FIGURE 1
Schematic of the MEPS BIN in the syringe needle.



Sample Size and Sensitivity

Sample volumes may be as little as 10 µL, or by taking multiple aliquots of 100 µL or 250 µL, samples of 1 mL or larger may be concentrated.

Automation

The capability to extract samples and make injections on-line using a single device reduces both sample processing times and the need for operator intervention.

Sorbent Life

Typical BIN life for extraction of whole plasma sample is conservatively about 40 to 100 samples. This significantly increases for cleaner samples.

Carry Over

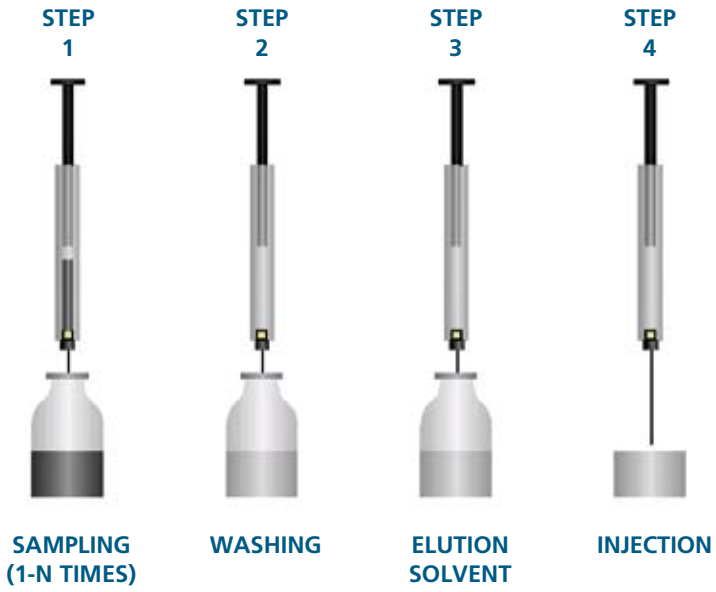
The small quantity of phase in the MEPS BIN can be easily and effectively washed between samples to reduce the possibility of carryover. This washing process is simply not practical with off-line SPE devices. With automation of MEPS washing can occur while the previous sample is running.

Flexible and easy to use

The dimensions of the sorbent bed ensure that the performance remains identical to conventional SPE devices when used for extraction of similar samples. MEPS BINS can be used for sample volumes as small as 3.6 µL making them particularly well suited to on-line use with LC-MS analysis of volume limited samples.

How to use MEPS

- **Step 1:** Pump the sample through the MEPS BIN (one or more volumes may be taken)
- **Step 2:** Wash the MEPS BIN once by pumping 20 µL to 50 µL of wash solution through the BIN to remove interferences
- **Step 3:** Elute the analyte by drawing solvent through the BIN into the syringe barrel
- **Step 4:** Inject the analyte directly into the injector
- Pump 50 µL solvent followed by 50 µL wash solution to prepare BIN for the next sample



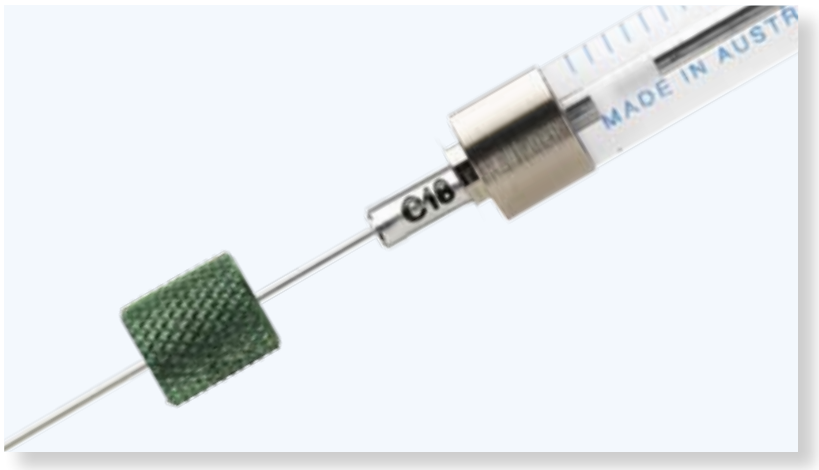


FIGURE 2
When the sorbent is exhausted, or another phase is required, the BIN is easily exchanged by simply unscrewing the locking nut and removing / replacing the BIN.

The MEPS BIN is easily installed into the syringe housing and then secured by the locking nut. Individual labeling of each BIN insures the use of the correct stationary phase for each extraction.

How Does MEPS Perform?

Sample preparation for complex biological samples is readily adapted to MEPS and reduces the volumes of sample and reagents required for extraction when compared with conventional SPE and other "micro extraction procedures". The extraction of xanthine metabolites from raw human urine using a MEPS BIN packed with C18, prior to GC-MS analysis, is shown in Figure 3 and the extraction of anesthetics from rat plasma using a MEPS BIN packed with C2, prior to LC-MS analysis is shown in Figure 4.

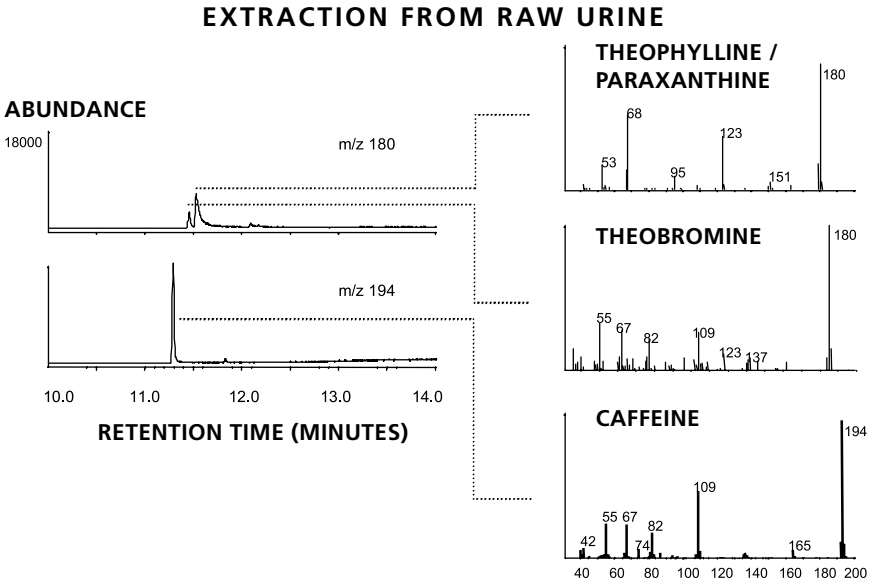


FIGURE 3
Difficult matrices such as human urine are easily processed using MEPS. In this example 100 µL of human urine was aspirated through a C18 MEPS BIN (conditioned with methanol and water, water wash). Bound xanthines were eluted with 30 µL methanol, 2 µL injected on a BPX5 column for GC-MS analysis.

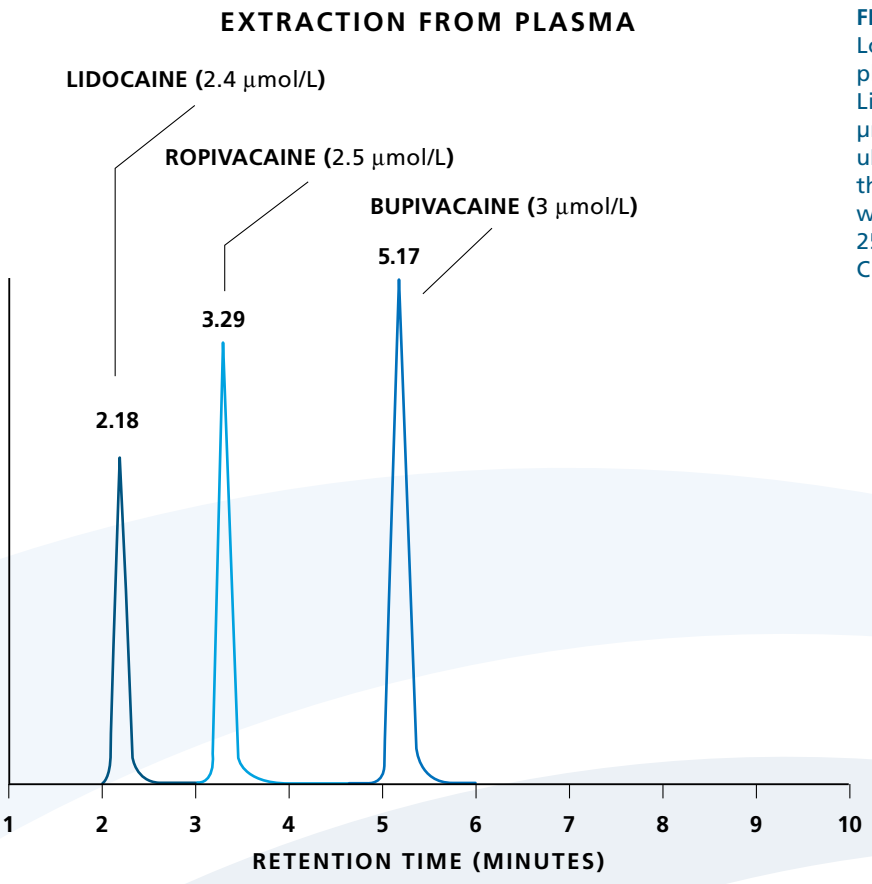


FIGURE 4
Local anesthetics were spiked into rat plasma samples - final concentrations: Lidocaine 2.4 µmol/L, Ropivacaine 2.5 µmol/L and Bupivacaine 3.0 µmol/L. 50 uL of the spiked plasma was aspirated through a C2 MEPS BIN, washed with water and eluted using 0.1% HCOOH in 25% Acetonitrile + 75% water onto a C18, 100 X 2.1 mm column.

How Does MEPS compare?

Accuracy and Precision

Table 1 summarizes the precision and accuracy results obtained analyzing Ropivacaine by four sample preparation methods: MEPS, Liquid-Liquid Extraction (LLE), conventional SPE and Solid Phase Microextraction (SPME). Compared to SPME, also a µSPE technique, MEPS demonstrated better precision and accuracy while taking significantly less time to process each sample.

TABLE 1 : Comparison of accuracy and precision between MEPS and other methods for ropivacaine (local anesthetics)

Method	Ropivacaine LOD (nM)	Accuracy (%)	Precision (RSD%) (Inter-assay)	Handling time
[1] MEPS / GC-MS	2	105	5.0	1 min
[2] LLE / GC-MS	2	101	3.8	20 min
[3] SPE / LC-UV	100	101	3.0	20 min
[4] SPME / GC-MS	5	110	6.3	40 min

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Table 2 compares the accuracy, precision, limits of detection and extraction time of MEPS with two other µSPE techniques, SPME and SBSE (Stirring Bar Sorbent Extraction) for 5 different PAH's extracted from water. The results from the MEPS and SBSE techniques are significantly better than SPME but MEPS processes each sample 100 times faster than SBSE.

TABLE 2 : Comparison of accuracy and precision of MEPS, SPME and SBSE for the analysis of PAH's in water.

Compound	Accuracy (%)			Precision RSD (%)			Limit of detection (ng/L)			Extraction time (min)		
	MEPS	SPME	SBSE	MEPS	SPME	SBSE	MEPS	SPME	SBSE	MEPS	SPME	SBSE
Anthracene	84	81	99	12	3	6	5	100	1.2	2	30	200
Chrysene	107	81	100	1	4	5	5	90	0.2	2	30	200
Fluoranthene	100	84	100	9	4	4	5	100	1.2	2	30	200
Fluorene	103	96	97	5	5	4	1	40	0.7	2	30	200
Pyrene	115	86	100	7	3	3	1	40	0.7	2	30	200

M. Abdel-Rehim / J. Chromatog. A 1114 (2006) 234-238

Is there significant carry over using MEPS?

Devices used for SPE are traditionally considered to be single use. The precision engineering used in the design and manufacture of MEPS allows for simple wash steps and consequently the re-use of the device. To demonstrate this we extracted phenols from waste water and measured the carry over between experiments.

Figure 5 shows the chromatograms for the three 10 µL extractions. The first is labeled "phenols 25 ppb," the second is "extraction 2," and the third "extraction 3". Clearly all of the phenols were eluted in the first 10 µL of Methanol used.

One of the most often stated reasons for the use of disposable SPE BINS is the issue of carry over. Results from 5 studies are summarized in Table 3. Utilizing a series of washes using eluent and then wash solution the carry over was virtually eliminated. With a cycle time measured in seconds for MEPS this washing takes less than 5 minutes. To accomplish the same for conventional SPE takes an hour or more and uses significant amounts of solvents.

Summary

Table 4 summarizes the comparison of MEPS, SPME and conventional SPE. MEPS requires much less time than either SPE or SPME, and shows much better recovery and sensitivity than SPME. MEPS also eliminates any intermediate steps between the sample preparation steps and the injection into a GC or LC system.

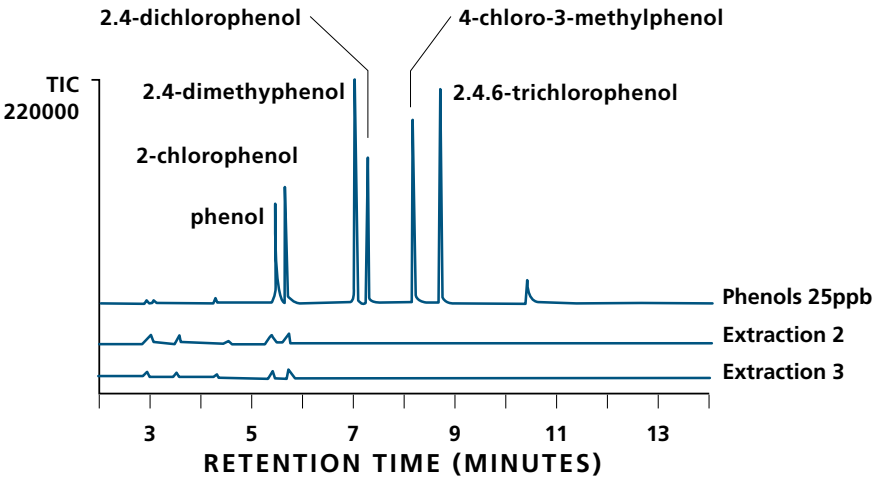

FIGURE 5
Phenols at 25 ppb in alkane contaminated water. 10 x 100 µL cycles on C18 MEPS BIN (conditioned with methanol and water). Sample was eluted with methanol 10 µL, 2 µL injected onto a BPX5 column and analyzed by GC-MS.

TABLE 3 : Comparison of carryover and wash regime.

	Wash volume (uL)	# of washes and wash solution	Carry-over	Source
PAH's in water	50 µL	4X methanol, 5X water	0.2% - 1%	M. Abdel-Rehim / J. Chromatog. A 1114 (2006) 234-238
Anesthetics in Human Serum	50 µL	4X methanol, 4X water	~ 0.2% (I.S.)	M. Abdel-Rehim / J. of Chromatography B, 801 (2004) 317-321
Roscovitine in plasma and urine	50 µL	5X methanol/water (95:5, v/v), 5X water/methanol (90:10, v/v)	<0.1%	M. Abdel-Rehim / J. of Chromatography B, 817 (2005) 303-307\
Roscovitine in Human plasma	50 µL	4X methanol, 4X water	<0.01%	M. Abdel-Rehim / J. Mass Spectrom. 204;39:1488-1493
Olomoucine in Human plasma	50 µL	5X methanol/water (95:5, v/v), 5X water/methanol (90:10, v/v)	<0.1%	M. Abdel-Rehim et al. / Analytica Chimica Acta 2005

TABLE 4 : Comparison of MEPS BINs, SPME and conventional SPE.

Factor	MEPS BIN	SPE	SPME
Amount sorbent	0.5-2 mg	50-2000 mg	thickness 150 mm
Sample prep. time	1-2 min	10-15 min	10-40 min
BIN use	40 to 100 extractions	once	50-70 extractions
Recoveries	good	good	low
Sensitivity	good	good	low

M. Abdel-Rehim / J. of Chromatography B, 801 (2004) 317-321

MEPS SYRINGE OPTIONS
All syringes may be used manually as well as with the listed autosamplers

Part No.	Description	Items per package
005291	100µL Removable needle MEPS syringe for CTC Analytics, HTA 300A Plus & Varian 8400 systems	1
031826	Replacement plunger assembly for 005291	1
006291	250µL Removable needle MEPS syringe for CTC Analytics, HTA 300A Plus & Varian 8400 systems	1
031831	Replacement plunger assembly for 006291	1
006292	250µL Removable needle MEPS syringe for CTC Analytics systems	1
031831	Replacement plunger assembly for 006292	1

MEPS BARREL INSERT AND NEEDLE ASSEMBLY OPTIONS

FOR GC APPLICATIONS, needle is 23 gauge, 0.63mm OD, Cone point style

Phase	Description	For use with MEPS Syringe, P/N	# per Pack	Part Number
C18	MEPS BIN for CTC Analytics, HTA 300A Plus & Varian 8400 systems	005291 and 006291	5	2900101
Silica	MEPS BIN for CTC Analytics, HTA 300A Plus & Varian 8400 systems	005291 and 006291	5	2900102
C8+SCX*	MEPS BIN for CTC Analytics, HTA 300A Plus & Varian 8400 systems	005291 and 006291	5	2900103
C2	MEPS BIN for CTC Analytics, HTA 300A Plus & Varian 8400 systems	005291 and 006291	5	2900104
C8	MEPS BIN for CTC Analytics, HTA 300A Plus & Varian 8400 systems	005291 and 006291	5	2900106
MEPS Development kit for CTC Analytics, HTA 300A Plus & Varian 8400 systems (contains 1 each of C18, C8, C2, SILICA and C8+SCX)		005291 and 006291	5	2900105
C18	MEPS BIN for CTC Analytics systems using 250µL syringes	006292	5	2900301
Silica	MEPS BIN for CTC Analytics systems using 250µL syringes	006292	5	2900302
C8+SCX*	MEPS BIN for CTC Analytics systems using 250µL syringes	006292	5	2900303
C2	MEPS BIN for CTC Analytics systems using 250µL syringes	006292	5	2900304
C8	MEPS BIN for CTC Analytics systems using 250µL syringes	006292	5	2900306
	MEPS Development kit for CTC Analytics systems using 250µL syringes (contains 1 each of C18, C8, C2, SILICA and C8+SCX)	006292	5	2900305

FOR LC APPLICATIONS, needle is 22 gauge, 0.72mm OD

C18	MEPS BIN for CTC Analytics, HTA 300A Plus & Varian 8400 systems	005291 and 006291	5	2900401
Silica	MEPS BIN for CTC Analytics, HTA 300A Plus & Varian 8400 systems	005291 and 006291	5	2900402
C8+SCX*	MEPS BIN for CTC Analytics, HTA 300A Plus & Varian 8400 systems	005291 and 006291	5	2900403
C2	MEPS BIN for CTC Analytics, HTA 300A Plus & Varian 8400 systems	005291 and 006291	5	2900404
C8	MEPS BIN for CTC Analytics, HTA 300A Plus & Varian 8400 systems	005291 and 006291	5	2900406
SCX	MEPS BIN for CTC Analytics, HTA 300A Plus & Varian 8400 systems	005291 and 006291	5	2900408
SAX	MEPS BIN for CTC Analytics, HTA 300A Plus & Varian 8400 systems	005291 and 006291	5	2900409
MEPS Development kit for CTC Analytics, HTA 300A Plus & Varian 8400 systems (contains 1 each of C18, C8, C2, SILICA and C8+SCX)		005291 and 006291	5	2900405
C18	MEPS BIN for CTC Analytics systems using 250uL syringe	006292	5	2900501
Silica	MEPS BIN for CTC Analytics systems using 250uL syringe	006292	5	2900502
C8+SCX*	MEPS BIN for CTC Analytics systems using 250uL syringe	006292	5	2900503
C2	MEPS BIN for CTC Analytics systems using 250uL syringe	006292	5	2900504
C8	MEPS BIN for and CTC Analytics systems	006292	5	2900506
SCX	MEPS BIN for and CTC Analytics systems	006292	5	2900508
SAX	MEPS BIN for and CTC Analytics systems	006292	5	2900509
	MEPS Development kit for CTC Analytics systems using 250µL syringes (contains 1 each of C18, C8, C2, SILICA and C8+SCX)	006292	5	2900505

Base material is silica with mean particle size of 45µm and pore size of 60Å.

*C8+SCX BINS are labelled as M1.

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