

PAL SYSTEM
Ingenious sample handling

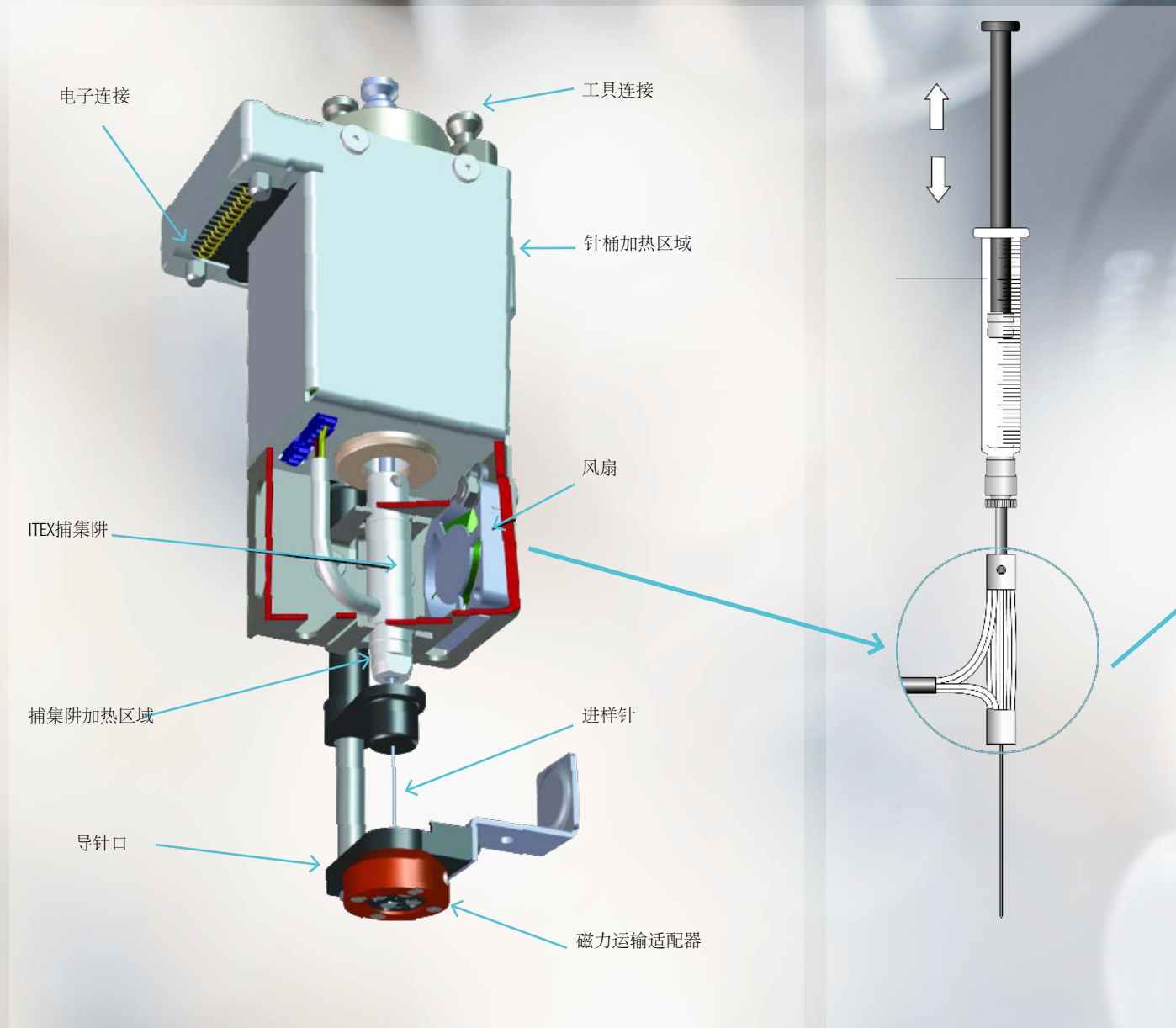


ITEX动态顶空 强大的GC样品富集技术



ITEX (冷阱捕集顶空萃取) 动态顶空模块

快速从固态、液态、气态样品中高效富集挥发性、半挥发性化合物



ITEX动态顶空萃取流程

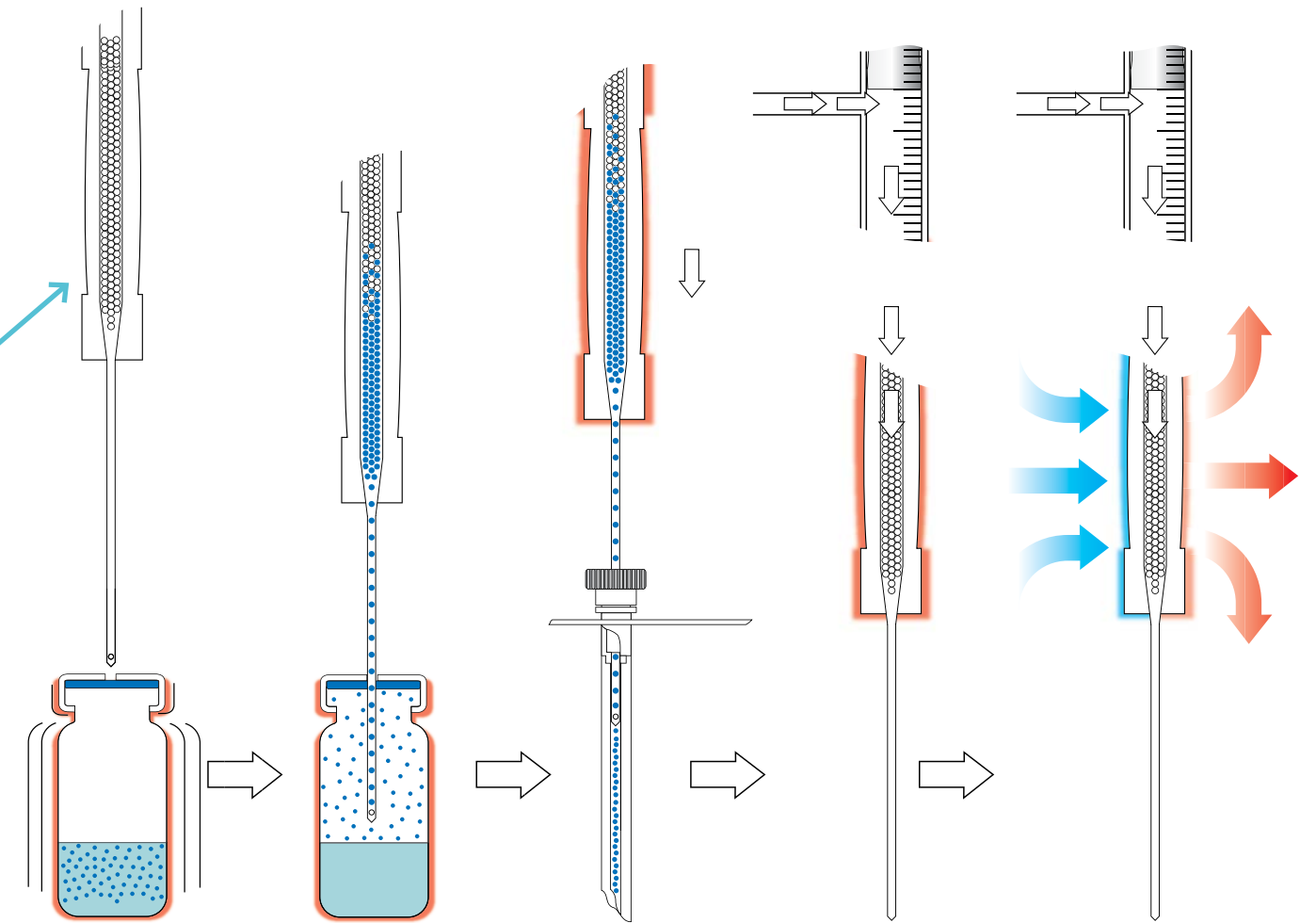
样品在密封的样品瓶中加热和/或振荡

ITEX针刺穿密封的顶空瓶，预加热的针筒如针泵原理将瓶内顶空相样品富集在冷的捕集阱中。此时可增加捕集阱除水步骤

ITEX捕集阱可快速加热到350°C，并将被分析物引入GC进样口中解析。

热解吸后使用惰性气体清洗ITEX捕集阱。

主动降温功能确样品前处理循环时间缩短。



样品孵化

萃取

解吸

清洗捕集阱

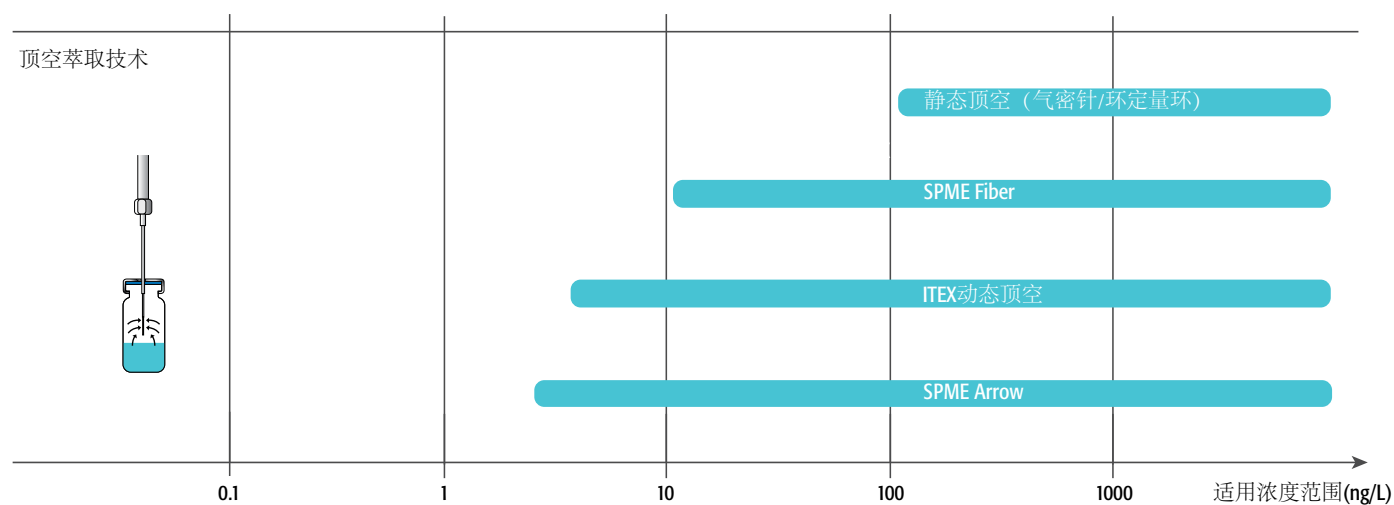
主动降温

- 冷阱捕集顶空萃取与解吸采用工业标准吸附剂；
- 针筒设计：无定量环，传输线，切换阀的残留隐患；
- 不同应用可选择不同捕集阱固定相；
- 主动降温功能加速样品制备、缩短进样品周期；
- 无需改造GC进样口；
- PAL RTC平台可实现顶空，SPME，ITEX在同一个序列、同一台仪器上自动进样切换。

浏览更多信息请点击[ITEX DHS](#)



灵敏度



ITEX动态顶空与吹扫捕集灵敏度比较

ITEX与Purge & Trap灵敏度比较

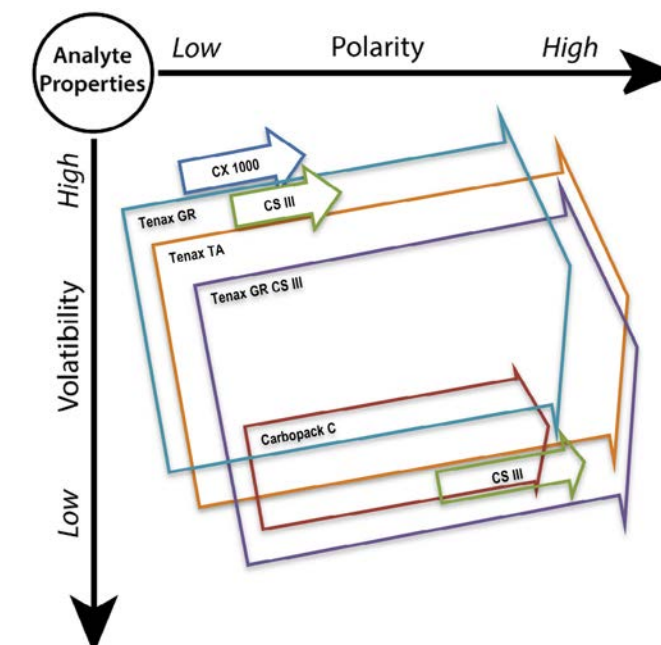
化合物	ITEX 动态顶空				吹扫捕集		
	方法检出限 [$\mu\text{g L}^{-1}$]	线性范围 [$\mu\text{g L}^{-1}$]	R ²	RSD [%]	回收率 [%]	方法检出限 [$\mu\text{g L}^{-1}$]	RSD [%]
Vinylchloride	0.008	0.02-2.0	0.999	5.3 (n=63)	103	0.008	
Dichloromethane	0.01	0.03-2.7	0.999	5.5 (n=63)	97		
MTBE	0.004	0.01-1.5	0.999	6.1 (n=63)	88	0.001	4.7
ETBE	0.001	0.004-1.5	0.998	6.6 (n=77)	94	0.009	5.1
Chloroform	0.004	0.007-2.9	0.999	5.4 (n=77)	99	0.008	
Benzene	0.001	0.002-1.8	0.999	5.4 (n=84)	89	0.002	5
TAME	0.001	0.004-1.5	0.999	5.8 (n=77)	95	0.01	3
1,2-dichloroethane	0.002	0.006-2.5	0.999	5.3 (n=77)	97		
Trichloroethylene	0.001	0.007-2.9	0.999	5.2 (n=77)	95	0.003	5.3
Bromodichloromethane	0.001	0.002-4.0	0.999	6.1 (n=91)	97	0.007	5.2
1,4-Dioxane	0.07	0.1-2.1	0.998	8.9 (n=49)	59		
Toluene	0.005	0.009-1.7	0.998	7.3 (n=70)	96	0.001	4.5
Tetrachloroethylene	0.001	0.003-3.2	0.999	5.7 (n=84)	97	0.004	7.3
Dibromochloromethane	0.005	0.02-4.9	0.999	5.8 (n=70)	98	0.001	4.1
Ethylbenzene	0.002	0.009-1.7	0.999	8.7 (n=70)	93	0.001	5.5
p-Xylene	0.004	0.009-1.7	0.999	8.9 (n=70)	117	0.001	4.9
o-Xylene	0.005	0.02-1.7	0.999	6.9 (n=63)	90	0.002	4.7
Bromoform	0.002	0.006-5.8	0.999	5.7 (n=84)	94		
2-Methylisoborneol	0.03	0.1-2.0	0.999	5.5 (n=49)	94	0.001	5.6
Geosmin	0.06	0.1-2.0	0.999	5.1 (n=49)	88	0.002	6.1

Ref: Laaks J, Jochmann MA, Schilling B, Schmidt TC ; Anal. Chem. 2010, 82, 7641-7648

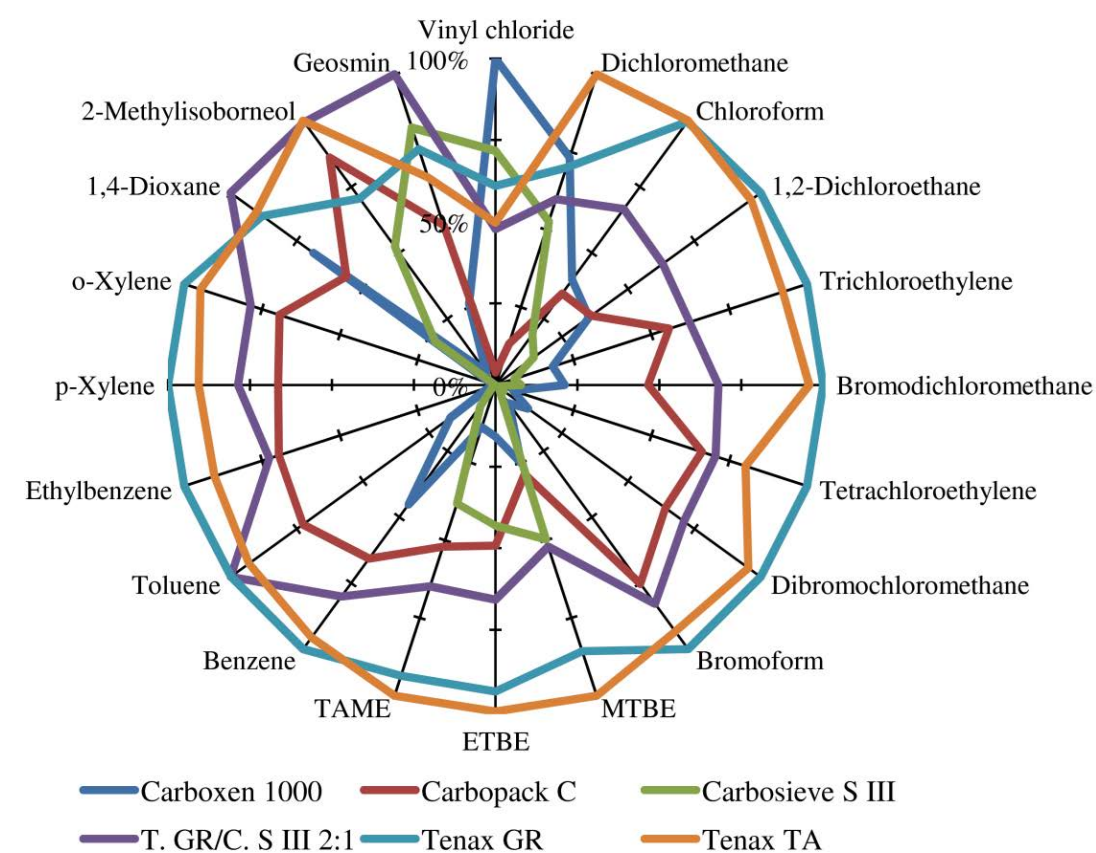
ITEX捕集阱

PAL3-ITEX-Trap-Carb-S3	PAL3 ITEX trap Carboxieve SIII -60/ 80 mesh
PAL3-ITEX-Trap-Carb1000	PAL3 ITEX trap Carboxen 1000 -60 / 80 mesh
PAL3-ITEX-Trap-CarbC	PAL3 ITEX trap Carbopack - C 80 /100 mesh
PAL3-ITEX-Trap-TxGR	PAL3 ITEX trap Tenax GR - 80 /100 mesh
PAL3-ITEX-Trap-TXTA100	PAL3 ITEX trap Tenax TA 80 /100 mesh
PAL3-ITEX-Trap-Mix-1	PAL3 ITEX trap Mix1 Tenax TA : Carboxen1000 (Bottom: Top - 1: 1)
PAL3-ITEX-Trap-Mix-2	PAL3 ITEX trap Mix2 Carbopack C : Carboxieve SIII (Bottom: Top - 2: 1)
PAL3-ITEX-Trap-Mix-3	PAL3 ITEX trap Mix3 Tenax GR : Carboxieve SIII (Bottom: Top - 1: 1)

ITEX捕集阱适用范围

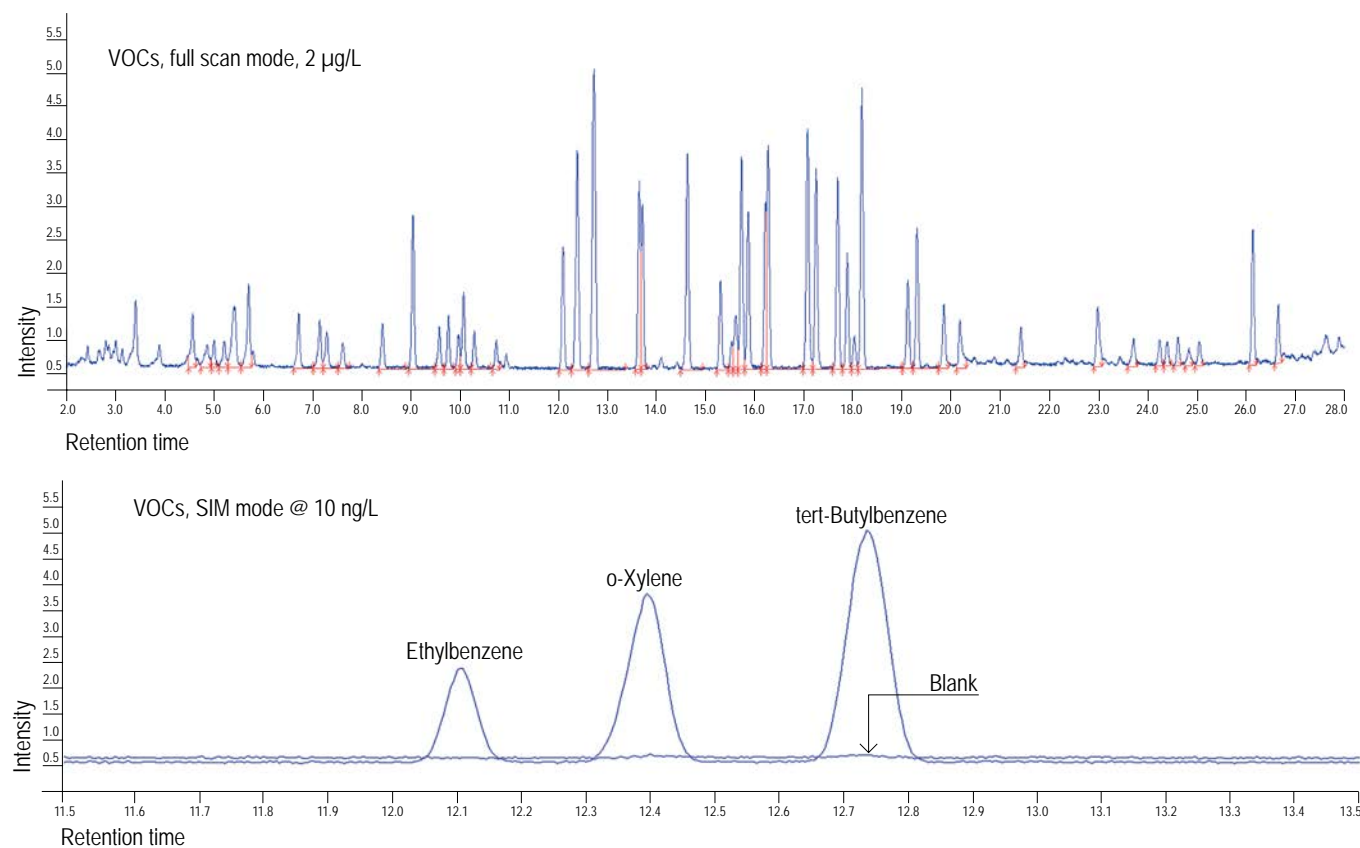


挥发性化合物在不同ITEX固定相萃取比较



J. Laaks, M. Jochmann, B. Schilling, T. Schmidt; Optimization strategies of ITEX methods - Analytical and bioanalytical chemistry 407/2015

环境方面应用 水中痕量VOCs, BTEX分析, EPA 502.2



样品前处理:

Full scan data: 2 µg/L MegaMix® Standard, 524.2 73 components), Restek PN 30601

SIM scan data: 10 ng/L MegaMix® Standard, 502.2 (54 components), Restek PN 30432

10mL water + 标准品, 放入20 mL 顶空瓶中, + 3g NaCl

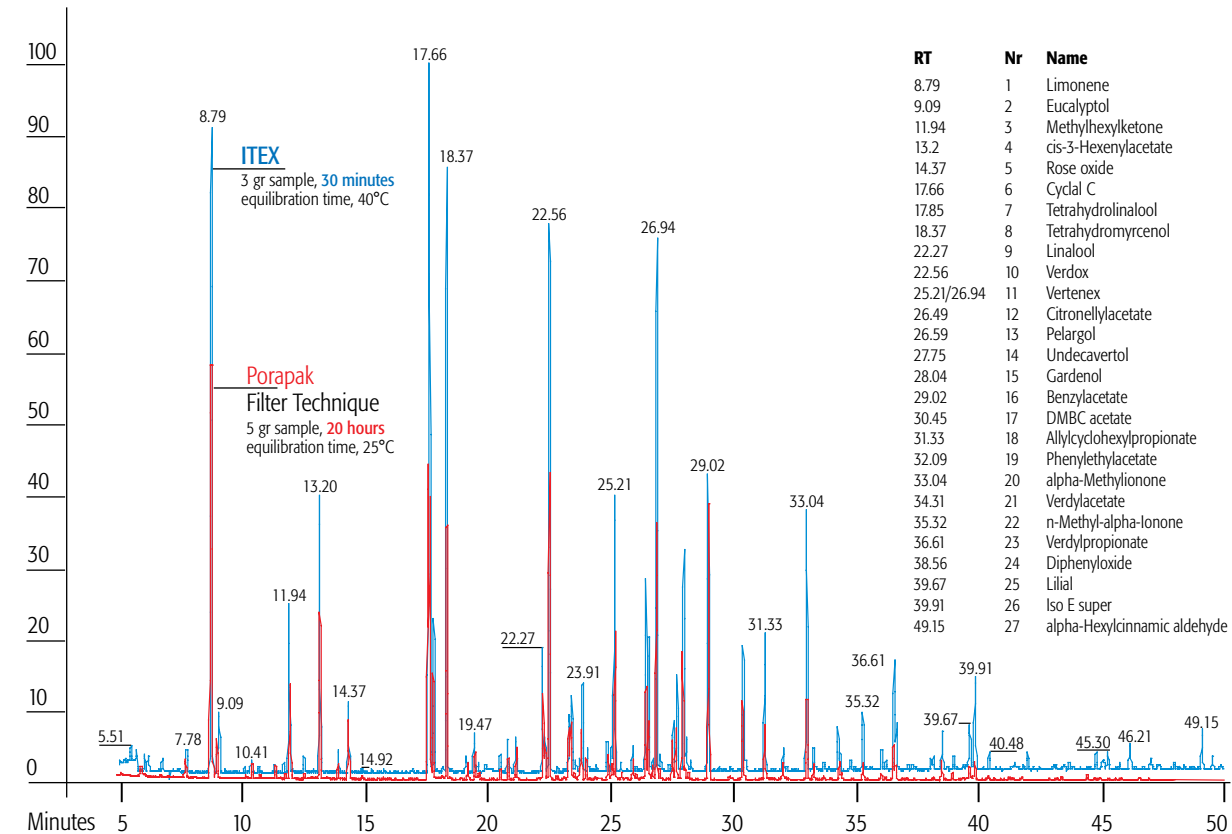
色谱条件 (Shimadzu GC-2010 Plus):

Column	Rxi® 624 Sil MS, 30 m x 0.32mm, 1.8 µm df
Carrier gas	helium, 93.2 kPa
Temperature program	40°C for 1 min, 5°C/min to 250°C, 2 min hold
Injector	split/split less at 225°C
Liner	Restek catalog # 23321.1, 3.5 mm Splittless Single Tpr Gsnk
GC	Shimadzu GC-2010 Plus
Detector	Shimadzu GCMS-W2010E

ITEX动态顶空萃取及进样参数

Incubation temperature	40°C
Incubation time	3 min
Syringe temperature	50°C
Extraction strokes	3 x 1 mL at 40°C (12 min)
Extraction speed	100 µL/s
Desorption temperature	200°C with 1 mL headspace
ITEX trap material	Tenax TA

食品方面应用 香料/柔顺剂分析结果比较 ITEX动态顶空vs. Poropak过滤器



色谱条件 (Thermo TraceGC):

Column	Stabilwax 30 m x 0.25 mm, ID x 0.25 mm film thickness
Oven	35°C - 0.5 min 15°C/min 50°C - 0 min 5°C/min 220°C/1 min
SSL	splitless with surge, surge pressure 20 kPa/0.4 min (0.5 mL), split flow 100 mL/0.3 min
Carrier	He, 1 mL/min constant flow with vacuum compensation

质谱参数 (Thermo Trace MS system)

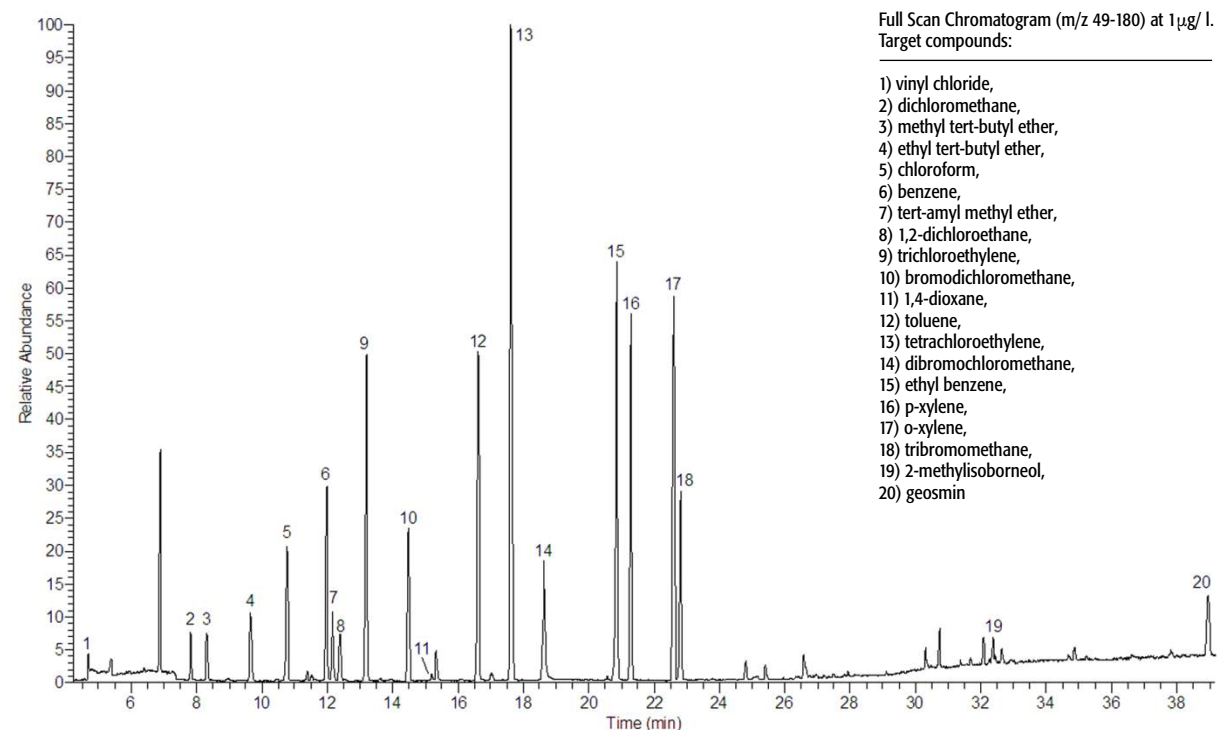
Ionisation mode	El+
Source temperature	230°C
Interface	220°C
Mass	20 - 350 amu

ITEX动态顶空萃取及进样参数

Incubation temperature	40°C
Incubation time	30 min
Syringe temperature	45°C
Extraction volume	1000 µL/stroke
Extraction strokes	10
Extraction speed	100 µL/s
Desorption temperature	200°C
Desorption speed	100 µL/s
Flush time	5 min

Courtesy of: Givaudan Research Company, CH-8600 Dübendorf, Zürich, Switzerland, H. Koch

环境方面应用 GC/MS测定水中挥发性有机物, EPA 524.2



ITEX分析挥发、半挥发有机物, 灵敏度可达ppt级

仪器条件

GC	Thermo Trace GC Ultra	40°C for 1 min, 4°C/min to 130°C, 10°C/min to 200°C for 10 min
MS	Thermo DSQII	El 70evm Scan mode m/z 49-180
Injector	AtasGL Optic 3 with cryofocusing unit	280°C Crytrap - 165°C for 30 s, 30°C/s to 250°C
GC Column	Restek VMS 60 m x 0.32 mm i.d., 1.8 µm film	1.5 mL/min constant flow
Autosampler	PAL RTC with ITEX Dynamic Headspace, Tenax GC/ Carbosieve S3 trap	10 mL sample in 20 mL headspace vial

参数

ITEX动态顶空参数

Sample storage in tray cooler	25°C	Extraction volume	1000 µL
Tray temperature	40°C	Extraction flow rate	100 µL/s
Syringe temperature	60°C	Desorption volume	500 µL
Incubation time	5 min	Desorption flow rate	10 µL/s
Agitator speed	500 rpm	Desorption temperature	300°C
Extraction temperature	60°C	Trap cleaning temperature	350°C
Extraction stroke	60	Trap cleaning time	5 min

更多应用示例

环境

In-Tube Extraction of Volatile Organic Compounds from Aqueous Samples: An Economical Alternative to Purge and Trap Enrichment

Jens Laaks,† Maik A. Jochmann*,†
Beat Schilling, and Torsten C. Schmidt†
Anal. Chem. 2010, 82, 7641–7648

Multi-walled carbon nanotubes as sorptive material for solventless in-tube microextraction (ITEX2)—a factorial design study

Thorsten Hüffer & Xochitli L. Osorio & Maik A. Jochmann & Beat Schilling & Torsten C. Schmidt
Instrumental Analytical Chemistry, University of Duisburg-Essen, Universitätsstrasse 5, 45141 Essen, Germany; BGB Analytik GmbH, Rohrmattstrasse 1, 4461 Boeckten, Switzerland
Anal Bioanal Chem (2013) 405:8387–8395

Microwave-assisted nonionic surfactant extraction of aliphatic hydrocarbons from petroleum source rock

A. Akinlua, M.A. Jochmann, J. Laaks, A. Ewert, T.C. Schmidt
a Fossil Fuels and Environmental Geochemistry Group, Department of Chemistry, Obafemi Awolowo University, Ile-Ife, Nigeria
b Instrumental Analytical Chemistry, University Duisburg-Essen, Universitätsstr, 5, 45141 Essen, Germany

Predominance of Biotic over Abiotic Formation of Halogenated Hydrocarbons in Hypersaline Sediments in Western Australia

A. Ruecker,† P. Weigold,† S. Behrens,† M. Jochmann,† J. Laaks,† and A. Kappler*,†
†Geomicrobiology, Center for Applied Geosciences, University of Tübingen, Tübingen 72074, Germany
‡Instrumental Analytical Chemistry, Faculty of Chemistry, University of Duisburg-Essen, Essen 45141, Germany

Sub-ppt determination of butyltins, methylmercury and inorganic mercury in natural waters by dynamic headspace in-tube extraction and GC-ICPMS detection†

Jing Hu,ab Enea Pagliano,b Xiandeng Hou, a Chengbin Zheng,a Lu Yang *b and Zoltan Mesterb

化工

Microwave-assisted nonionic surfactant extraction of aliphatic hydrocarbons from petroleum source rock

A. Akinlua*, M.A. Jochmann^b, J. Laaks^b, A. Ewert^b,
T.C. Schmidt^b - Analytica Chimica Acta 691 (2011) 48–55

Optimization strategies of in-tube extraction (ITEX) methods

Jens Laaks¹ & Maik A. Jochmann¹ & Beat Schilling² & Torsten C. Schmidt¹

Unbiased profiling of volatile organic compounds in the headspace of Allium plants using an in-tube extraction device

Miyako Kusano^{1,2*}, Makoto Kobayashi², Yumiko Iizuka^{2,3}, Atsushi Fukushima² and Kazuki Saito^{2,4}

Multi-walled carbon nanotubes as sorptive material for solventless in-tube microextraction (ITEX2)—a factorial design study

Thorsten Hüffer & Xochitli L. Osorio & Maik A. Jochmann & Beat Schilling & Torsten C. Schmidt

食品

In-tube Extraction and GC–MS Analysis of Volatile Components from Wild and Cultivated sea buckthorn (Hippophae rhamnoides L. ssp. Carpatica) Berry Varieties and Juice

Sonia A. Socaci,^a Carmen Socaci,^{a*} Maria Tofan,^a Ioan V. Ratib and Adela Pintea - Phytochem. Anal. 2013, 24, 319–328

Automated and quantitative headspace in-tube extraction for the accurate determination of highly volatile compounds from wines and beers

Julián Zapata, Laura Mateo-Vivaracho, Ricardo Lopez, Vicente Ferreira*
J. Chromatography A, 1230 (2012) 1–7

In-Tube Extraction-GC/MS as High Capacity Enrichment Technique for the Analysis of Alcoholic Beverages.

Laaks J., Jochmann M.A., Schilling B., Molt K., Schmidt T.C.
†Instrumental Analytical Chemistry, University Duisburg-Essen, Universitätsstrasse 5, D-45141 Essen, Germany;
§BGB Analytik AG, Lettenstrasse 97, CH-8134 Adliswil, Switzerland
J. Agric. Food Chem. 2014, [Epub ahead of print]

Determination of Wine Aroma Compounds by Head Space “In tube extraction” Technique and Gas Chromatography (HS-ITEX-GC/MS)

Luminita VÂRVA¹, Sonia SOCACI¹, Anca FARCAS¹, Liana SALANTA¹, Ana-Viorica POP (CUCEU)¹, Elena MUDURA² and Maria TOFANA^{1*}

临床/生命科学

Headspace In-Tube Extraction Gas Chromatography–Mass Spectrometry for the Analysis of Hydroxylic Methyl-Derivatized and Volatile Organic Compounds in Blood and Urine

Ilpo Rasanen, Jenni Viinamäki, Erkki Vuori, and Ilkka Ojanperä*
J Analytical Toxicology, 34, 2010, 113-121

Metabolic Profiling of Oxidized Lipid-Derived Volatiles in Blood by Gas Chromatography/Mass Spectrometry with In-Tube Extraction (ITEX)

Shoji Kakuta,¹ Yasuhiko Bando,² Shin Nishiumi,³ Masaru Yoshida,^{3,4,5} Eiichiro Fukusaki,¹ and Takeshi Bamba*,¹

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4 e Integrated Center for Mass Spectrometry, Kobe University Graduate School of Medicine, 7–5–1 Kusunoki-cho, Chu-o-ku, Kobe, Hyogo 650–0017, Japan
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Medicine, 7–5–1 Kusunoki-cho, Chu-oku, Kobe, Hyogo 650–0017, Japan
Mass Spectrometry 2013, 2, A0018

Metabolomic signature of brain cancer†


Renu Pandey¹, Laura Caffisch², Alessia Lodi¹, Andrew J. Brenner^{2,3}, Stefano Tiziani^{1,4}

ITEX动态顶空指标

捕集阱温度范围	40°C - 350°C
针温度范围	40°C - 120°C
萃取速率	10 µL/s - 1000 µL/s
萃取次数 (次/样品)	0 - 1000
萃取体积	0 µL - 1300 µL
孵化时间	最多600 min.
标准吸附填料	Tenax TA 80/100 mesh, 其他产品请见第五页
除水步骤中捕集阱温度	40°C - 150°C
缩短进样周期的捕集阱降温功能	迅速捕集阱降温 < 2分钟



ITEX动态顶空所需工具及模块

ITEX Kit		PAL3 ITEX tool, including: 1 pc Smart ITEX syringe 1.3 mL (SITEX-1300-T) 2 pcs ITEX trap TENAX TA 80/100 mesh (PAL3-ITEX-Trap-TXTA100) compatible with all PAL RTC/PAL RSI models from firmware version 2.3. or higher requires firmware version 3.n or higher and PAL RTC/PAL RSI Series II for Smart functionality
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必需模块

顶空孵化炉模块		F用于加热和震荡样品 • 可放置6个20 mL顶空瓶 • 温度范围40 - 200 °C • 震荡速度250 - 750 rpm • 可选2 mL 或 10 mL 样品瓶适配器
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其他可选的顶空进样工具及模块

顶空工具		顶空进样组成: - 1000, 2500 和5000 µL 样品针可选 - 支持惰性气体针吹扫, 避免残留 - 支持2 mL, 10 mL, 20 mL 样品瓶磁力运输
智能SPME Fiber 套件		智能SPME 套件, 组成: 1 pc SPME tool 1 pc SPME Fiber assortment kit (SFIB-SEL5-S2) 1 pc SPME performance evaluation mix
智能SPME Arrow 套件		智能SPME Arrow 套件不包含 GC进样口适配器的组成: 1 pc SPME Arrow tool 1 pc Smart SPME Arrow assortment kit (SARR1115-SEL5-S2) 1 pc SPME performance evaluation mix 需要GC具体进样口的适配器套件
磁力搅拌模块		强大的加热和混合模块, 用于样品前处理和SPME Arrow • 温度范围 40° - 150 °C • 磁力搅拌速度可达 1600 rpm (无需磁子) • 可用于20 mL 样品瓶(10 mL 样品瓶需要适配器)
涡旋混合模块		用于有效的混合(dilution / extraction) • 标准样品瓶类型: 2 mL / 10 mL / 20 mL • 1 个额外的位置支持自定义的样品瓶 • 提供有效的样品混合, 混合速度可达2000 rpm



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