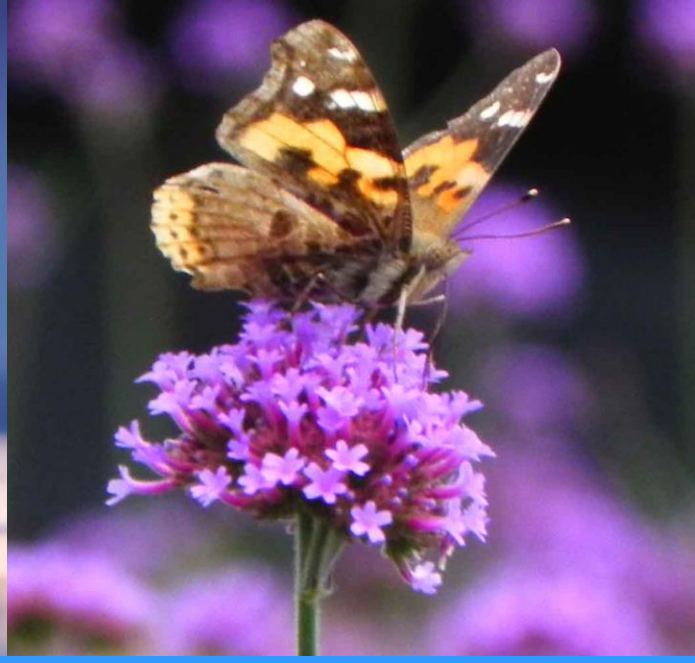




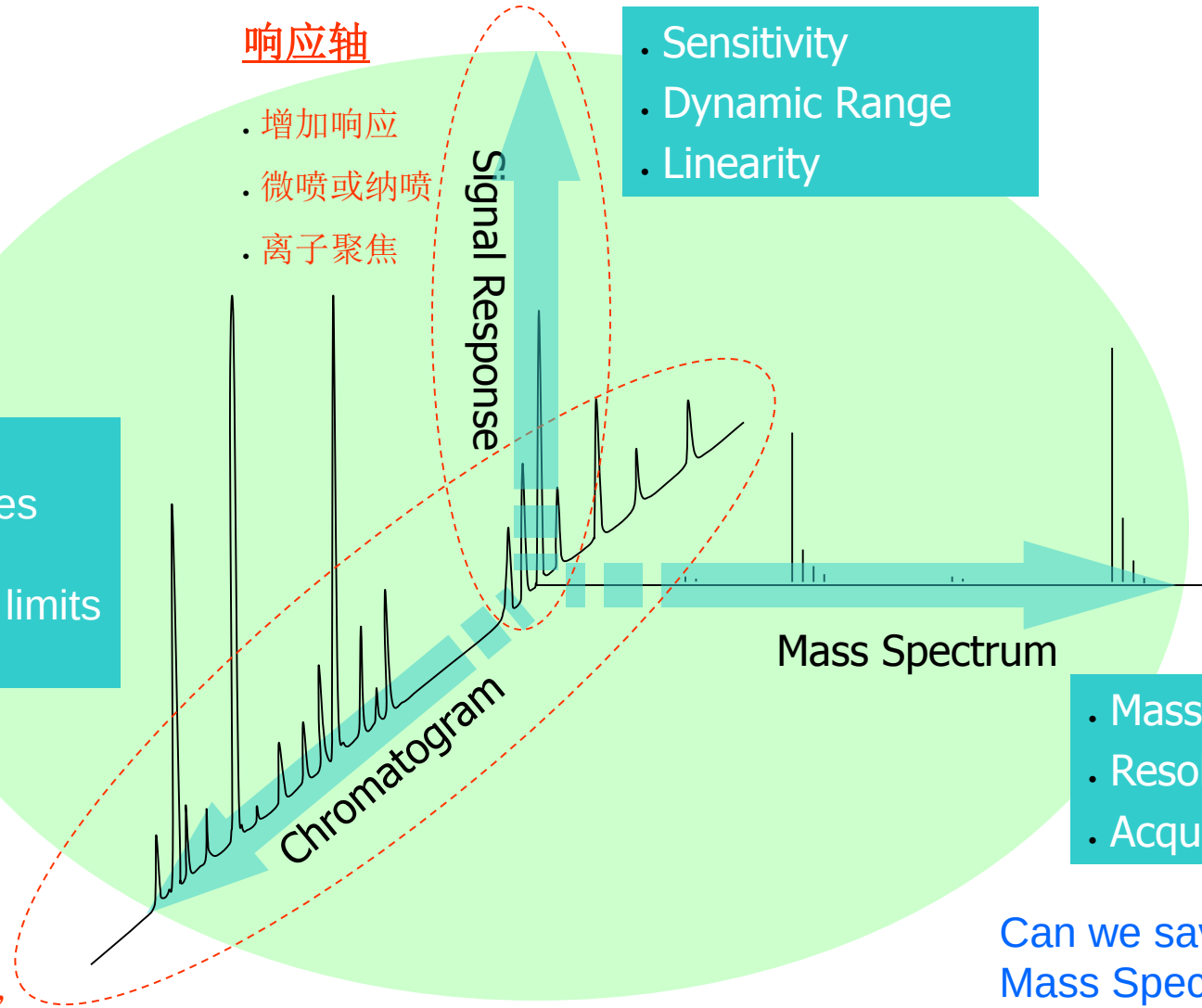
Advances of Quantitative DART®-MS for Direct and Sensitive Analysis in Real-Time

定量 DART® 最新进展

Charles C Liu, Ph.D. 刘春胜 博士

ASPEC Technologies 华质泰科生物技术（北京）有限公司

MS-based Technique 质谱相关技术



响应轴

- 增加响应
- 微喷或纳喷
- 离子聚焦

- Sensitivity
- Dynamic Range
- Linearity

GC and LC
10 – 40 minutes per sample
Time demand limits productivity

时间轴

- 缩短时间
- 直接进样
- 实时直接分析（DART，MALDI，DESI，LDTD）

- 离子聚焦技术
- 分析器升级
- Orbi，TOF，FT

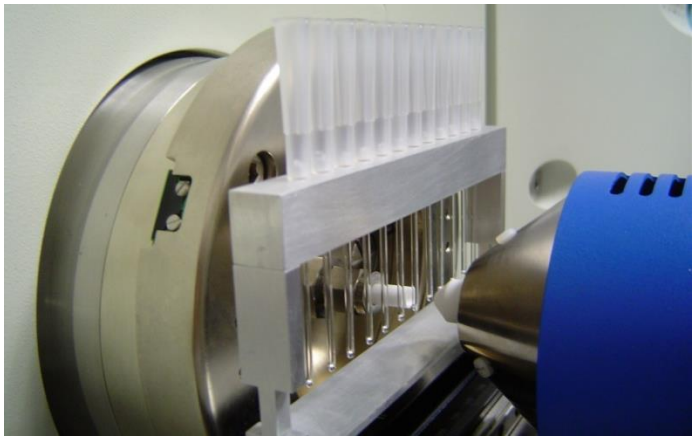
- Mass Accuracy
- Resolving Power
- Acquisition Rate

Can we save time using Mass Spectrometers?

Operational and Safety 可操作性及安全性不同

DART

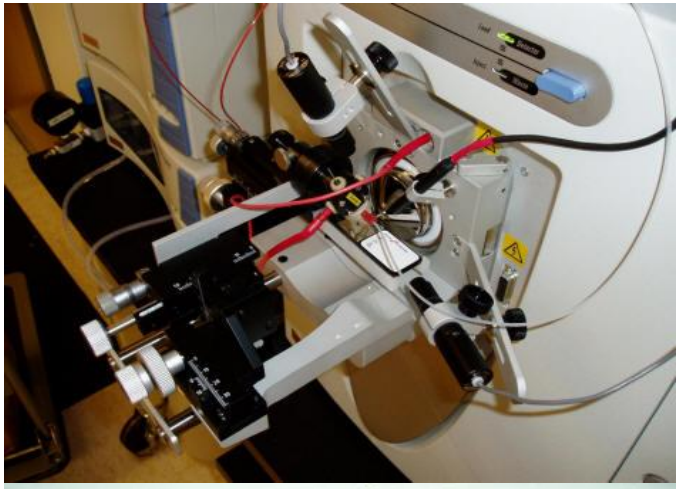
安全



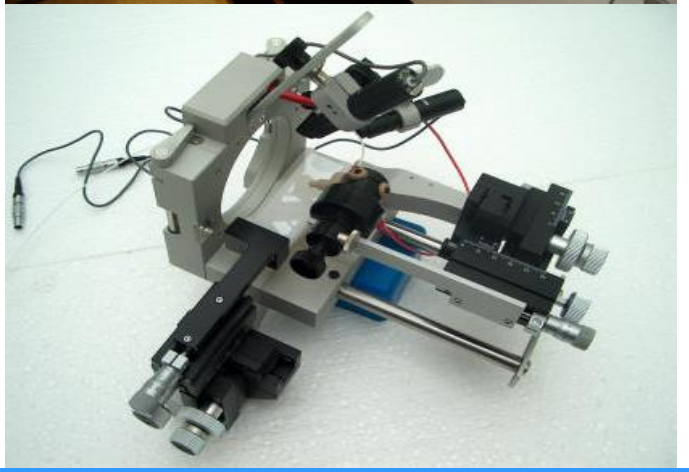
自动

DESI & Similar

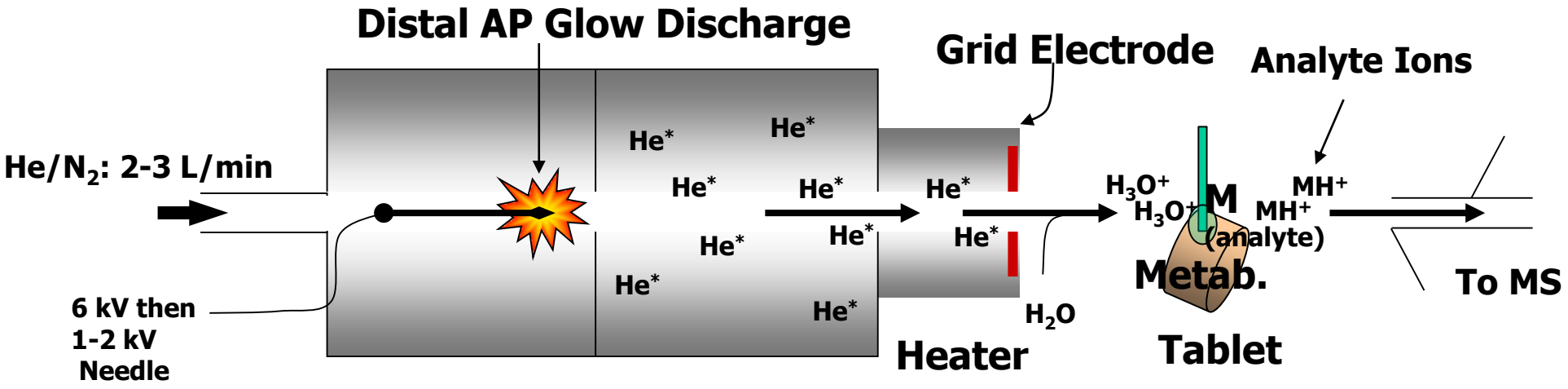
暴露



手动



DART® 原理图



Positive Mode:

$$He^{*} + H_2O \rightarrow H_2O^{+\bullet} + He + e^{-}$$

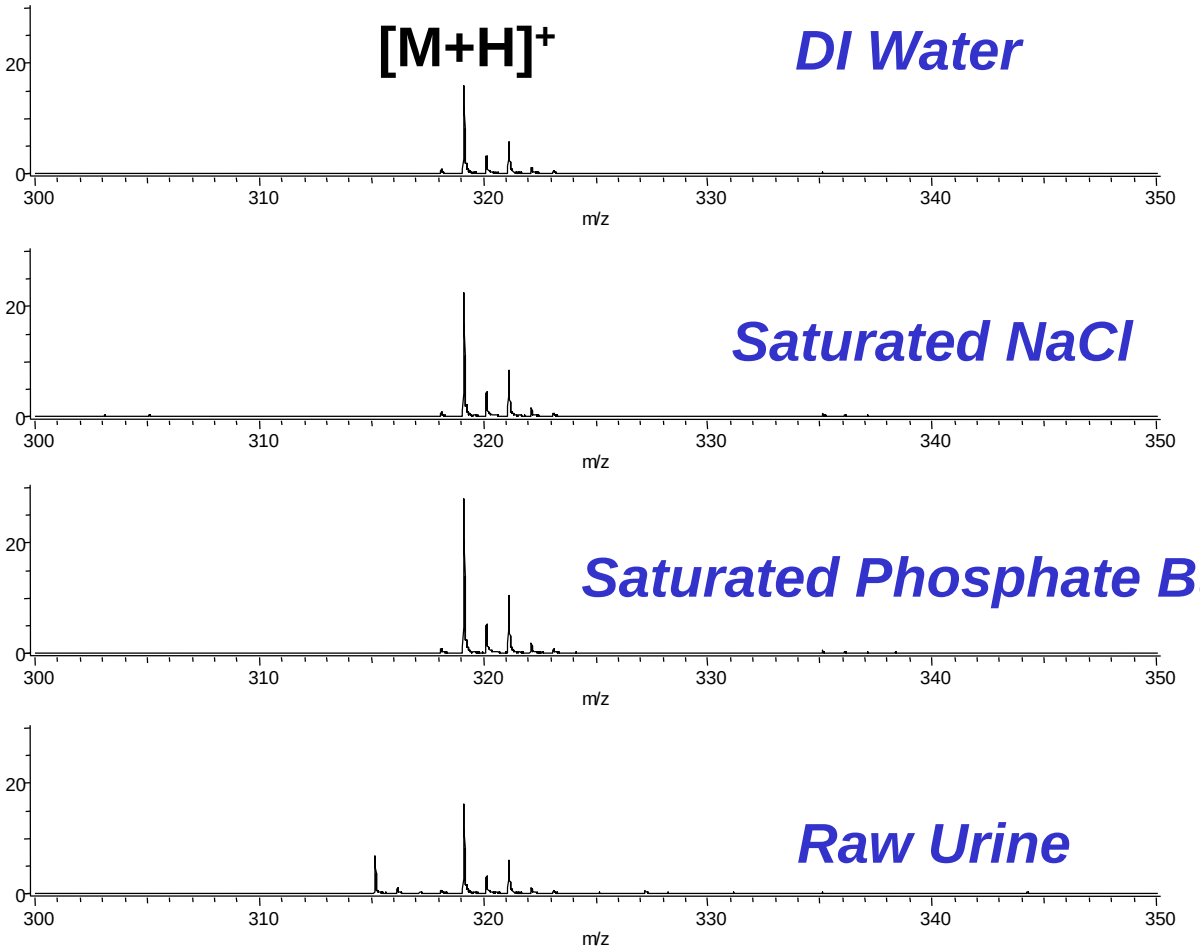
$$H_2O^{+\bullet} + H_2O \rightarrow H_3O^{+} + OH^{\bullet}$$

$$H_3O^{+} + (n-1)H_2O \rightarrow [(H_2O)_nH]^{+}$$

$$[(H_2O)_nH]^{+} + M \rightarrow MH^{+} + nH_2O$$

Cody, R., et al., *Anal. Chem.*, **2005**, 77, 2297.

Contamination Resistance 无离子抑制



谱图简单

Chlorpromazine [M+H]+

无加合离子

No alkali metal cation adducts

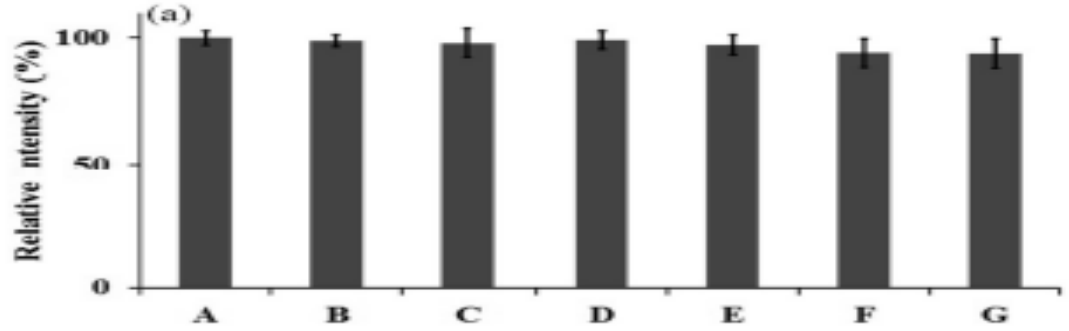
无多电荷产生

No multiple charging

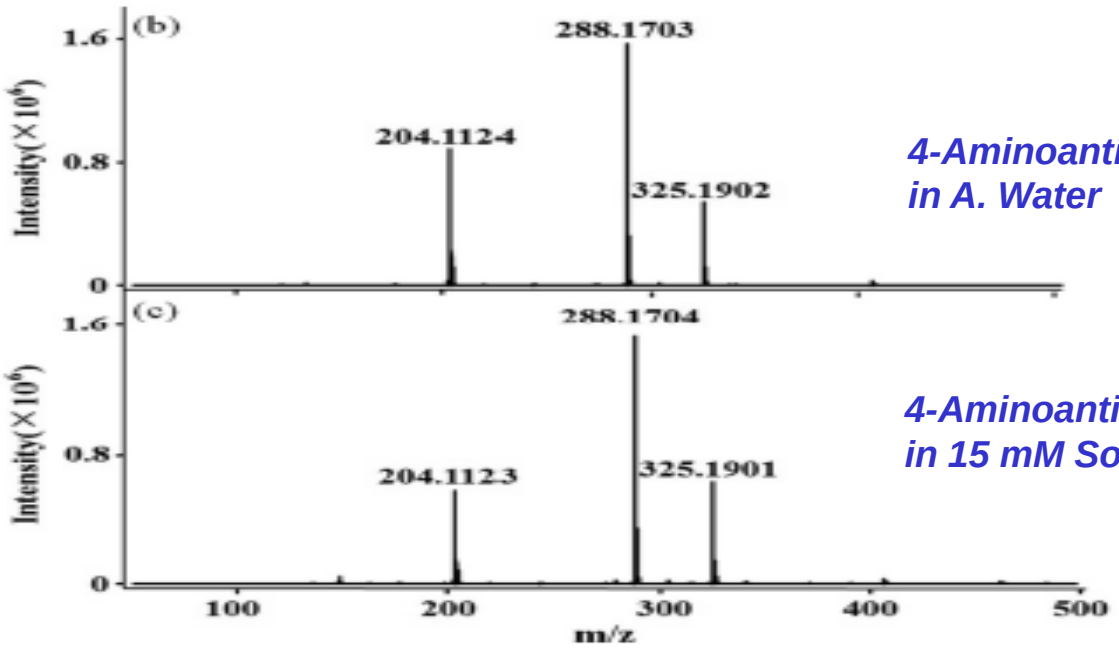
无明显离子抑制

No apparent suppression

Contamination Resistance 无离子抑制



A. Water
B. 15 mM Sodium Borate
C. 30 mM Sodium Borate
D. 50 mM Sodium Borate
E. 100 mM Sodium Borate
F. 15 mM SDS in 15 mM Sodium Borate
G. 30 mM SDS in 30 mM Sodium Borate

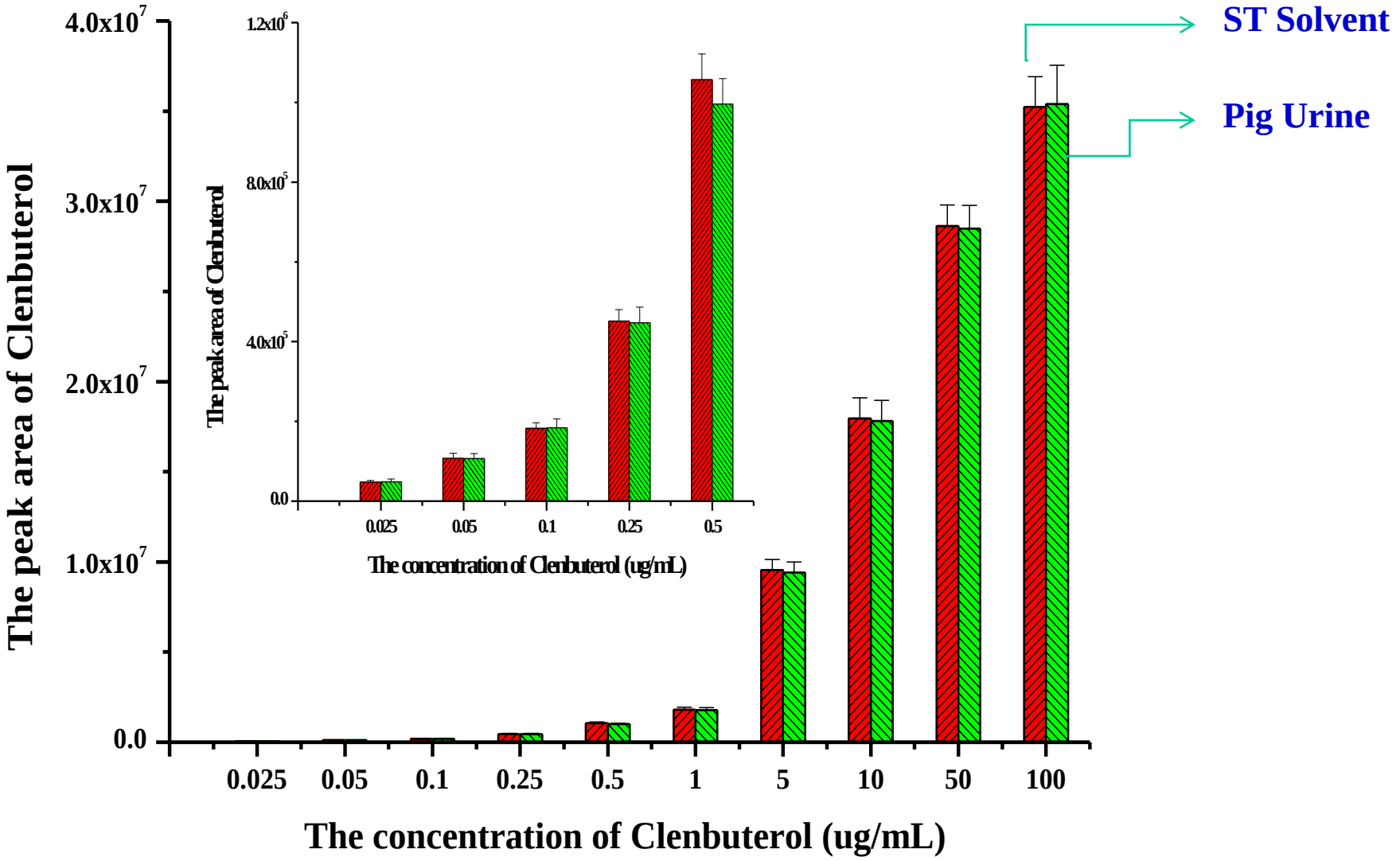


4-Aminoantipyrine 4-氨基安替吡啉 100ppm in A. Water

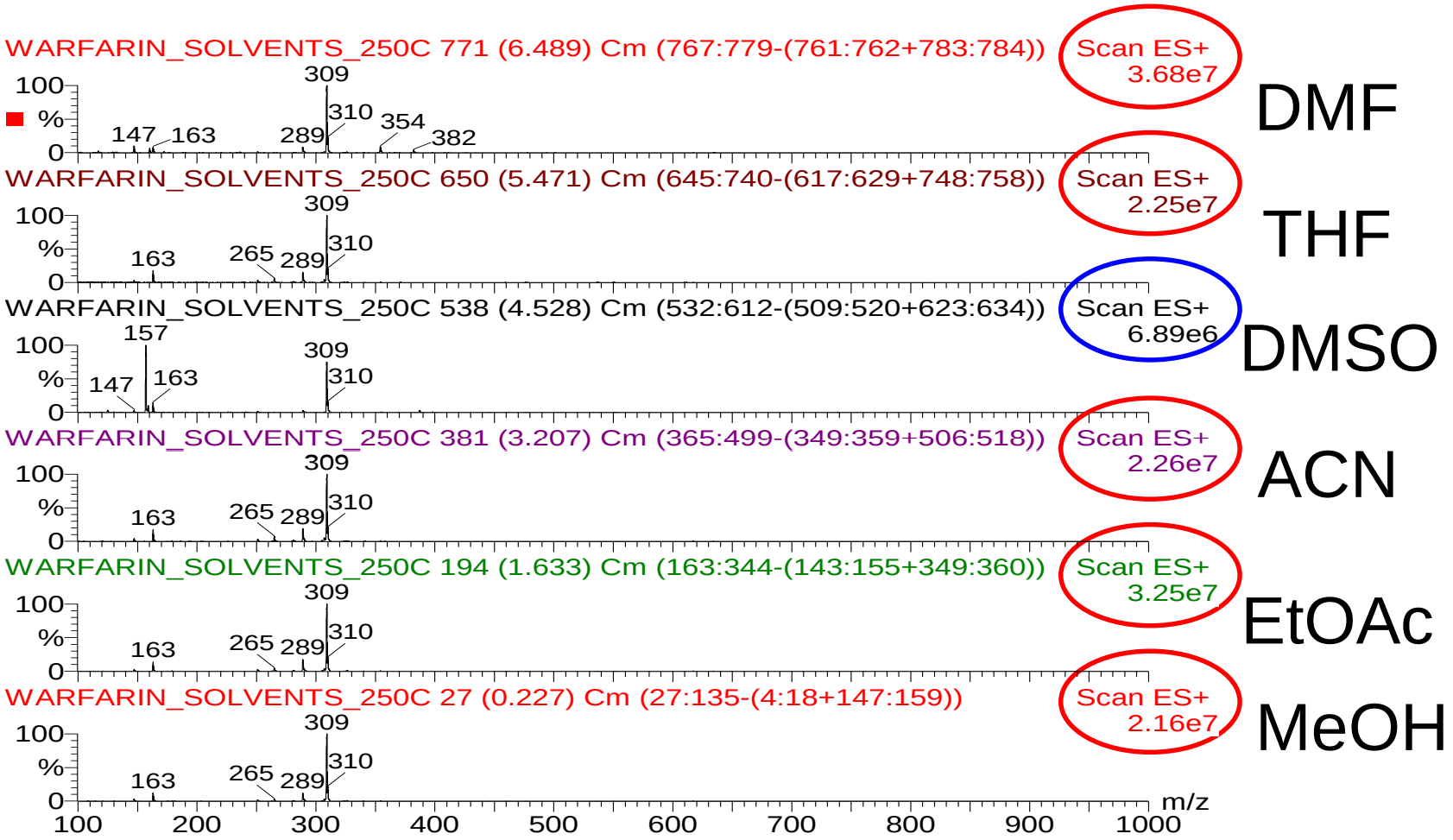
4-Aminoantipyrine 100ppm in F. 15 mM SDS in 15 mM Sodium Borate

Anal. Chem. 2013, 85, 170−176

No Matrix effect 无基质效应



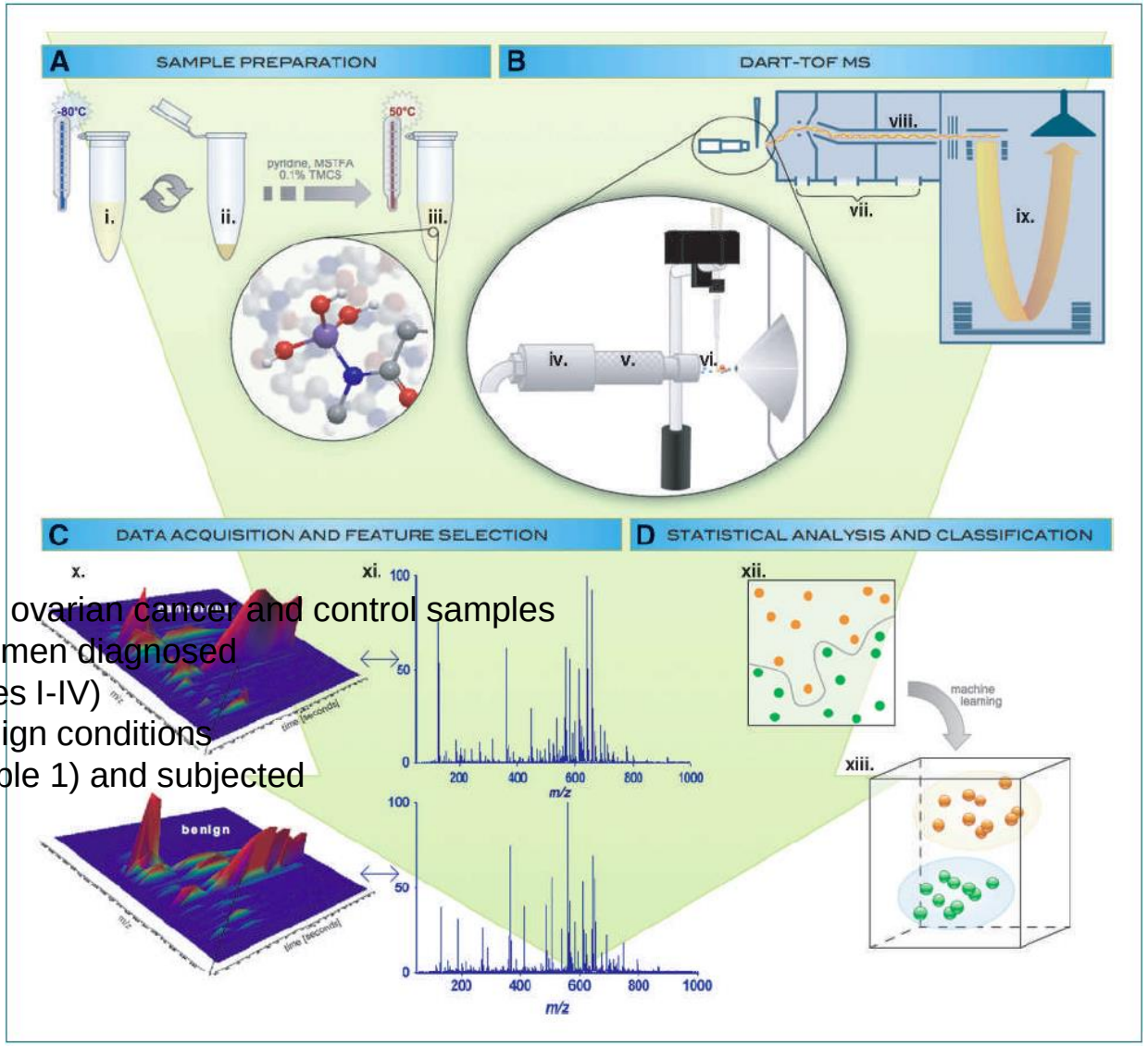
Solvents Friendly 无溶剂效应



Regardless of solvent type, DART yields protonated molecules

DART 准确检测卵巢癌患者血清代谢谱

- Cancer and Control Groups
- 99% to 100% accuracy
  - 100% sensitivity
  - 98-100% specificity
- Two different data evaluation approaches

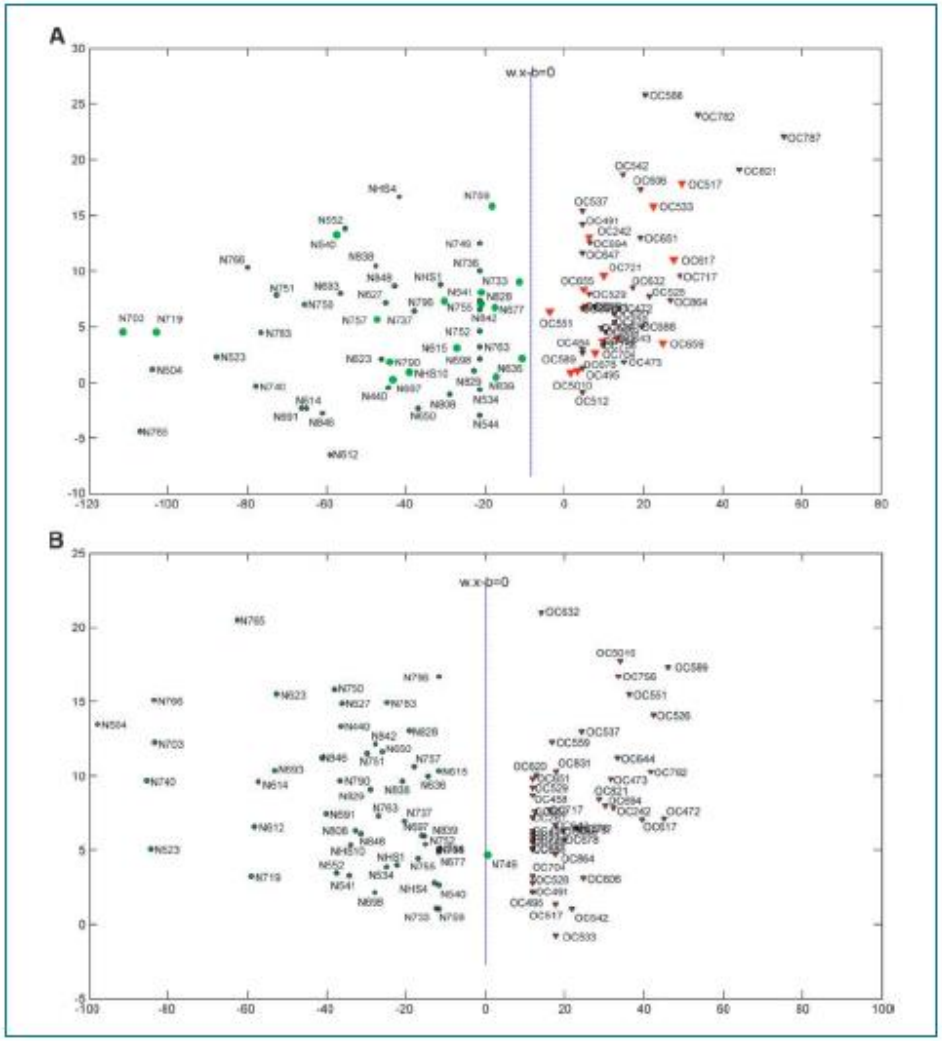


Metabolic profiles can distinguish between ovarian cancer and control samples
Serum samples were obtained from 44 women diagnosed with serous papillary ovarian cancer (stages I-IV) and 50 healthy women or women with benign conditions (e.g., serous, simple, or follicular cysts; Table 1) and subjected in triplicate to DART MS profiling.

Zhou, Fernández, et al.
Ovarian Cancer Institute, Georgia Tech., etc.
Cancer Epidemiology, Biomarkers & Prevention，*2010*

DART 准确检测卵巢癌患者血清代谢谱

- **Metabolic profiles can distinguish between ovarian cancer and control**
- **44 women diagnosed with serous papillary ovarian cancer (stages I-IV)**
- **50 healthy women or women with benign conditions**
- **Subjected in triplicate to DART MS profiling.**



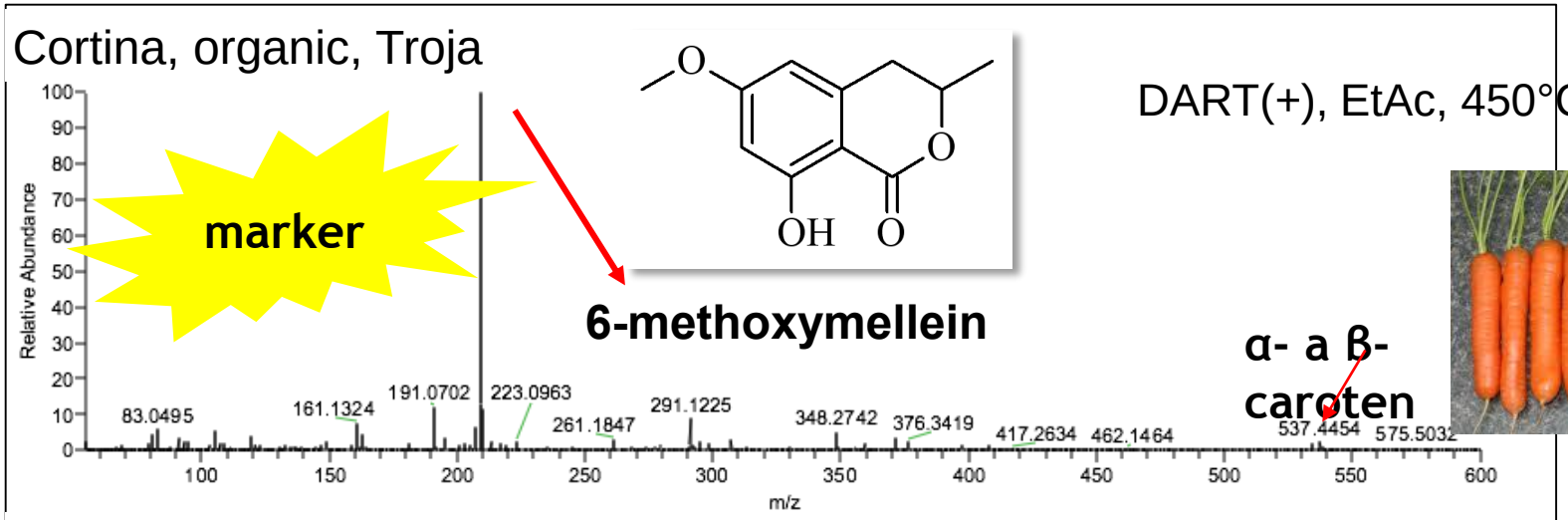
Zhou, Fernández, et al.
Ovarian Cancer Institute, Georgia Tech., etc.
Cancer Epidemiology, Biomarkers & Prevention，2010

DART 有机食品认证

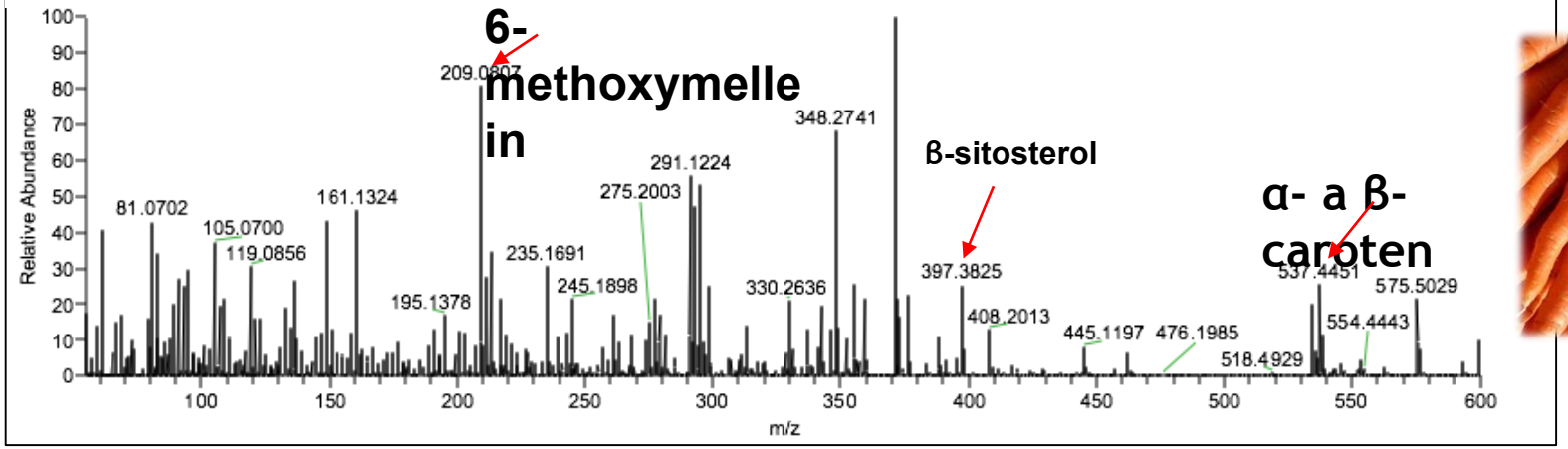
Metabolomics based non-target screening

Methods for Organic Food Authentication, BioFach 2013

Cortina, organic, Troja



Cortina, conventional, Suchdol



Locality Troja – no treatment (Ortiva) against *Alternaria Dauci*
→ induction of phytoalexine **6-methoxymellein**

ICT PRAGUE

DATA ANALYSIS: way of farming

DART 有机食品认证

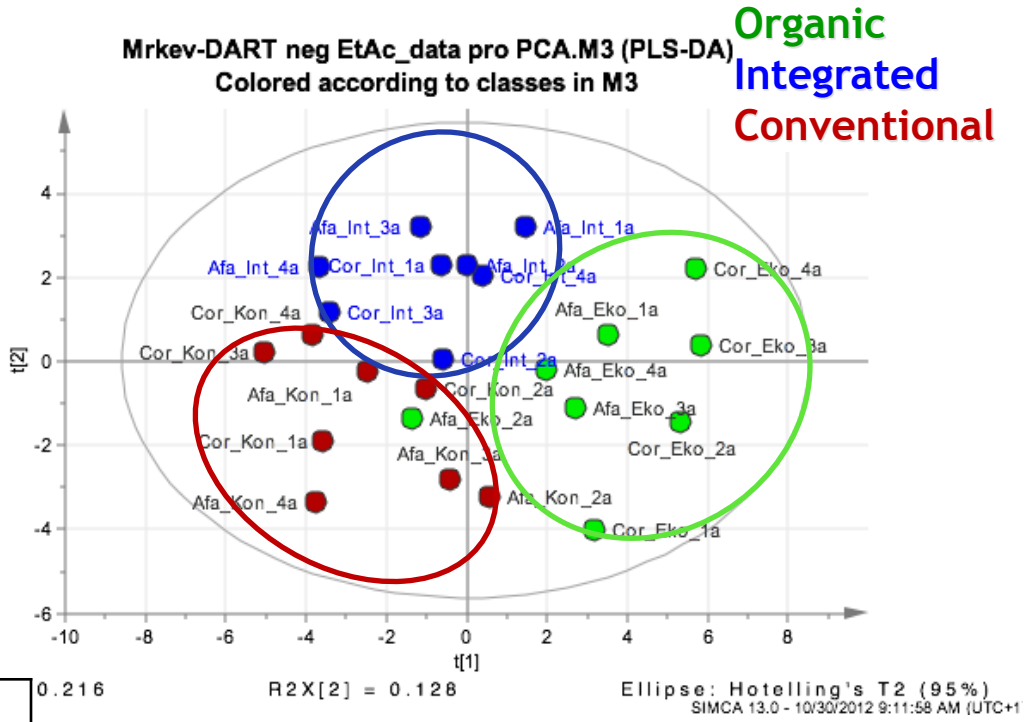
Data processing:

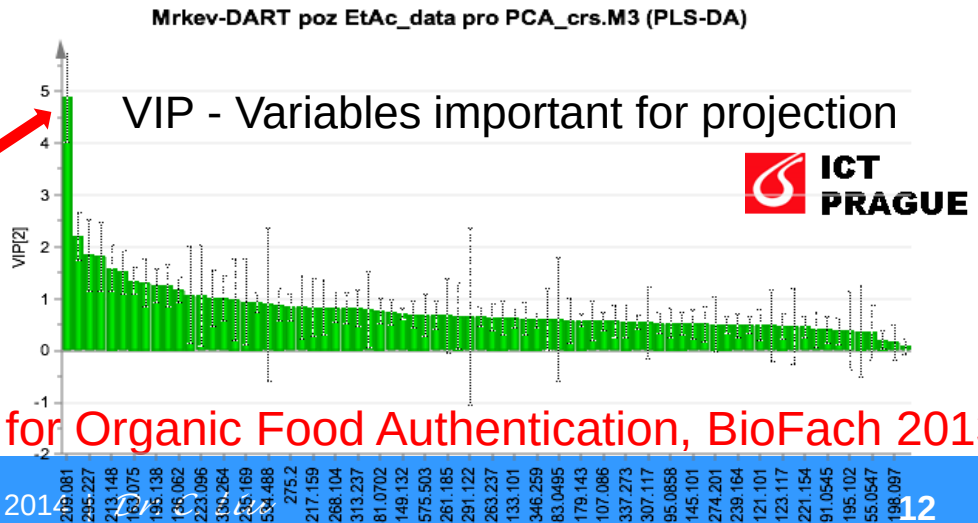
- Principal Component Analysis (PCA)
- Partial Lest Squares Discriminant Analysis, PLS-DA

Prediction and recognition abilities between **organic**, **integrated** and **conventional** crops, obtained by PLS-DA model

Variables	Recognition ability	Prediction ability
24	91.7 %	62.5 %

6-methoxymellein *discrimination between organic, integrated and conventional farming*





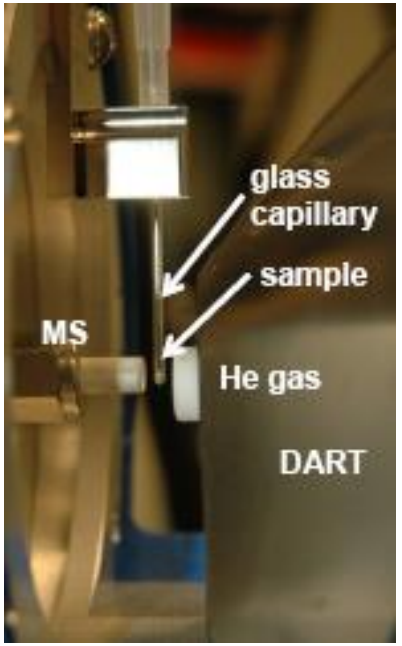
ICT PRAGUE

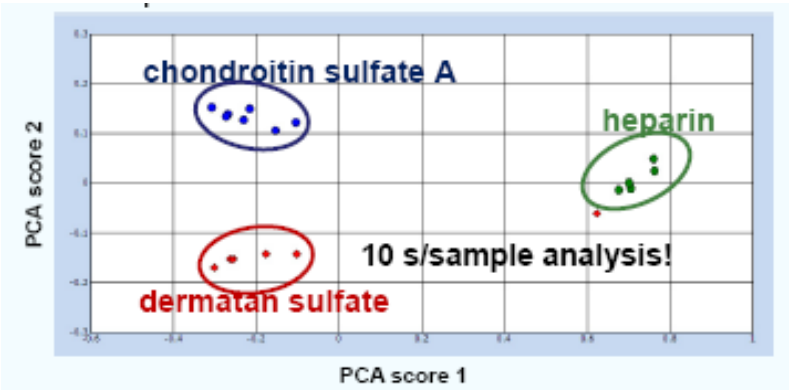
Methods for Organic Food Authentication, BioFach 2013

DART 快速识别肝素及多硫酸软骨素污染

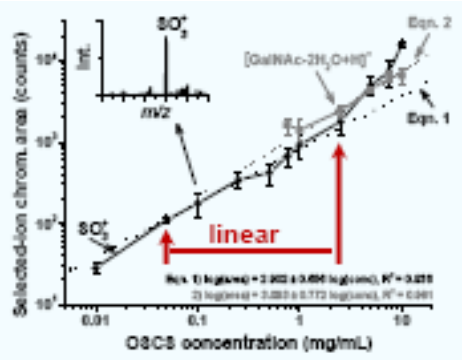
- GAGs degrade at elevated temperatures in DART MS
- Studied: chondroitin sulfate, dermatan sulfate, OSCSs, and heparin
- Degradation products help to screen for contaminants
- Conjoin *real time* multivariate data analysis to discriminate samples
- Limit matrix interference on quantitation
- Measure OSCS-contaminated samples from industry
- Combine with portable MS to mobilize screening to sites of need

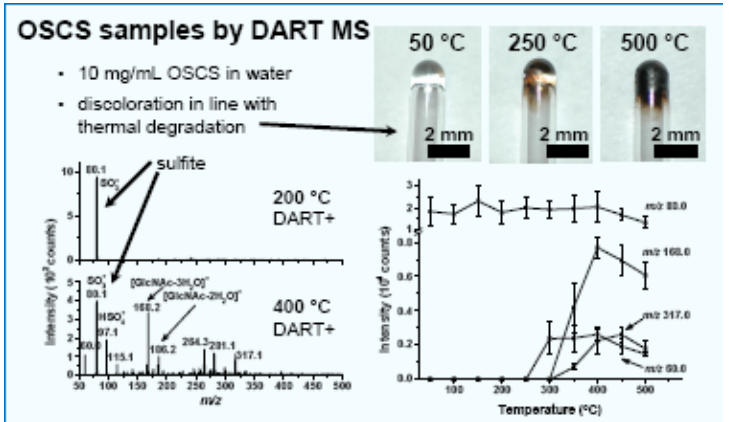
Peter Nemes and Dinesh V. Patwardhan
FDA OSEL/CDRH/Division of Chemistry and Materials Science, Silver Spring, MD, USA
ASMS 2012





→ Thermal degradation in DART with PCA of the data capable of differentiating major GAG types in high throughput.

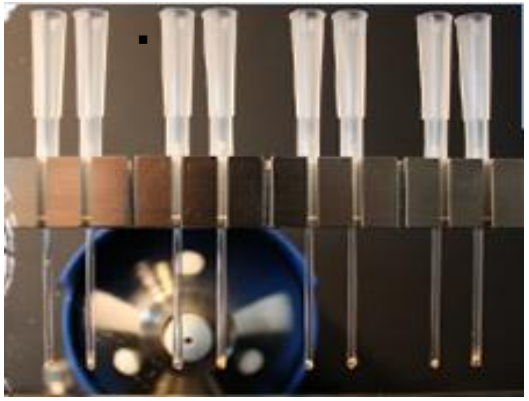




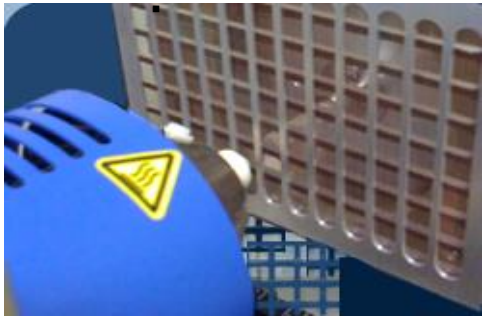
In DART MS, OSCSs
→decompose in a temperature-dependent manner,
→yield fragments different from those of heparin, and
→show feasibility for diagnosing contamination.

DART Modules 进样方式多样化

1 *中通量液体进样*

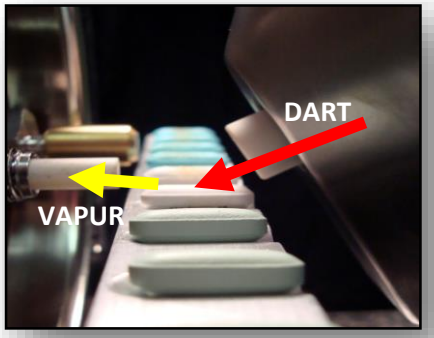


2 *高通量液体进样*

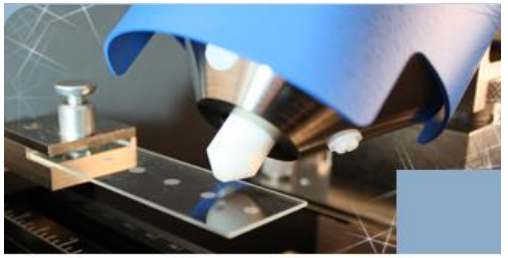


6 *手动单一样品进样*

5 *药片自动进样模块*

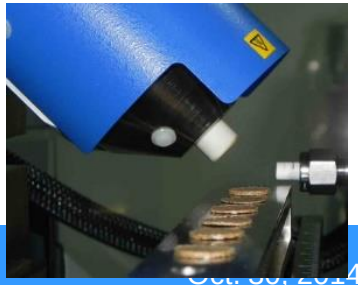


3 *薄层板进样*

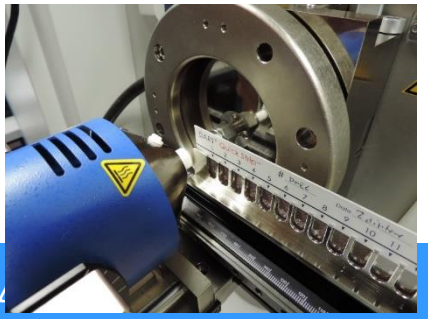


4 *连续自动进样*

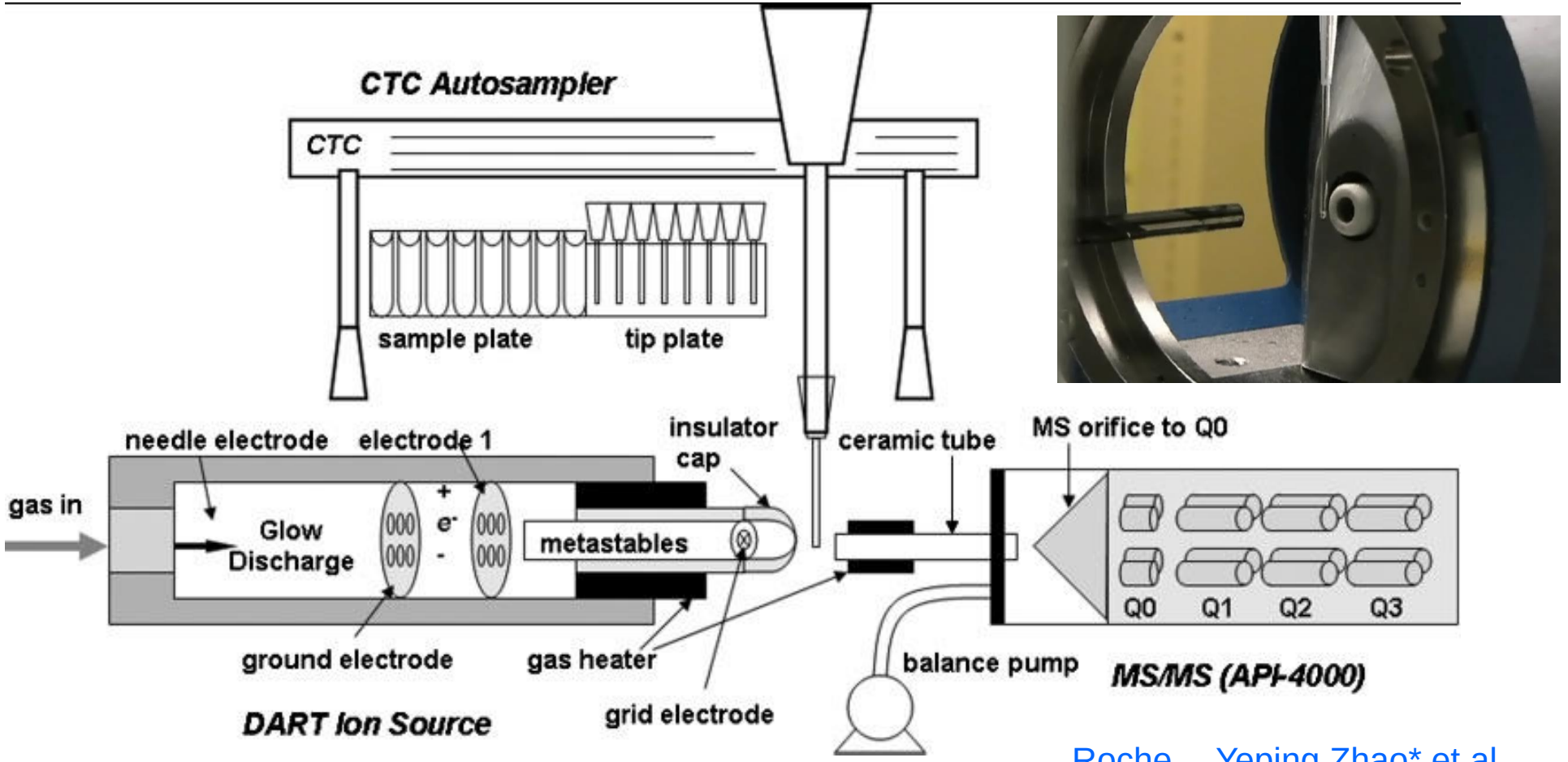
7 *压片自动进样模块*



8 *QS 中通量自动进样模块*



DART in ADME 药代及药分：定量

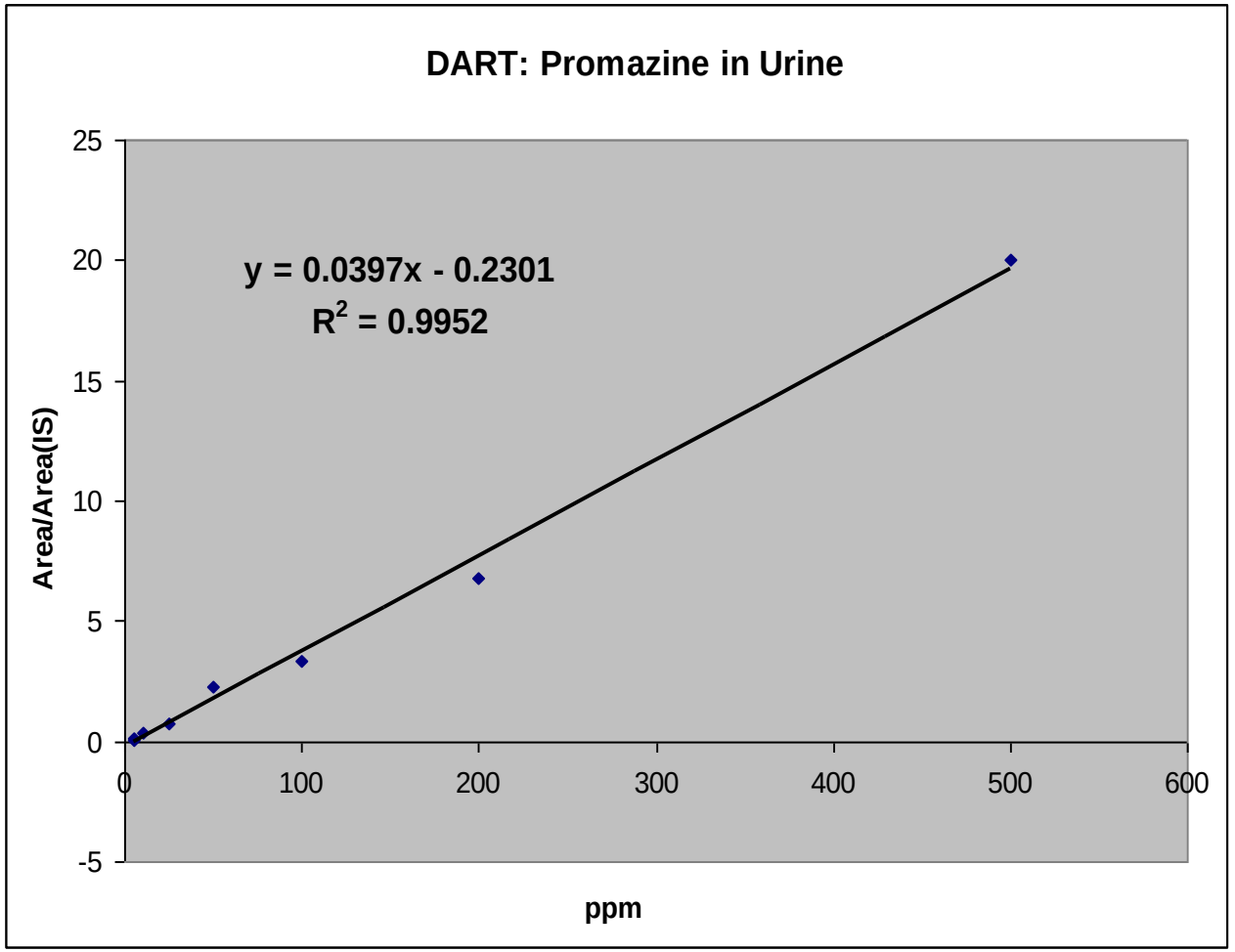


Roche， Yeping Zhao* et al

Rapid Commun. Mass Spectrom. 2008; 22: 3217–3224

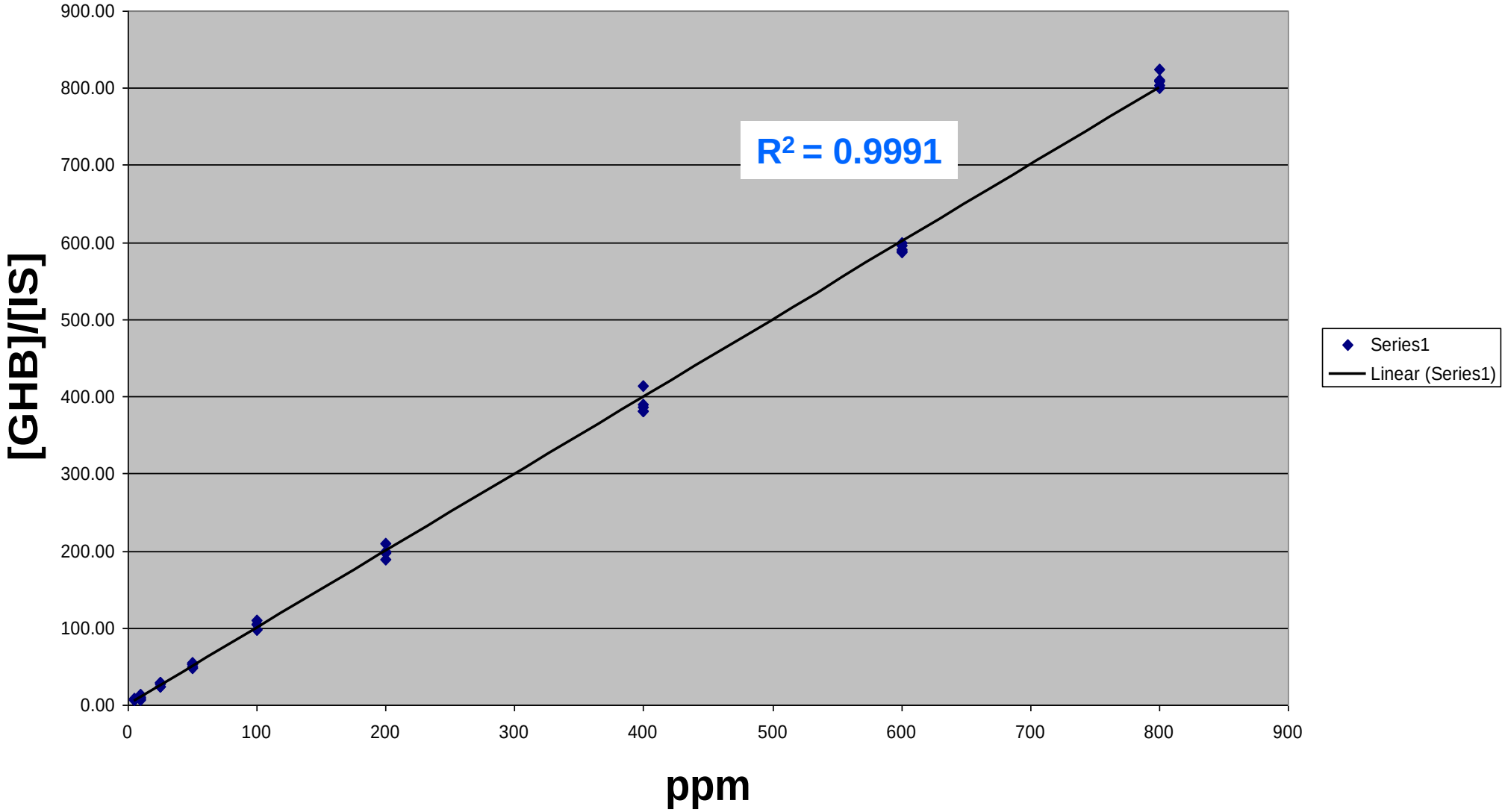
Promazine in Urine 内标定量

Chlorpromazine internal standard

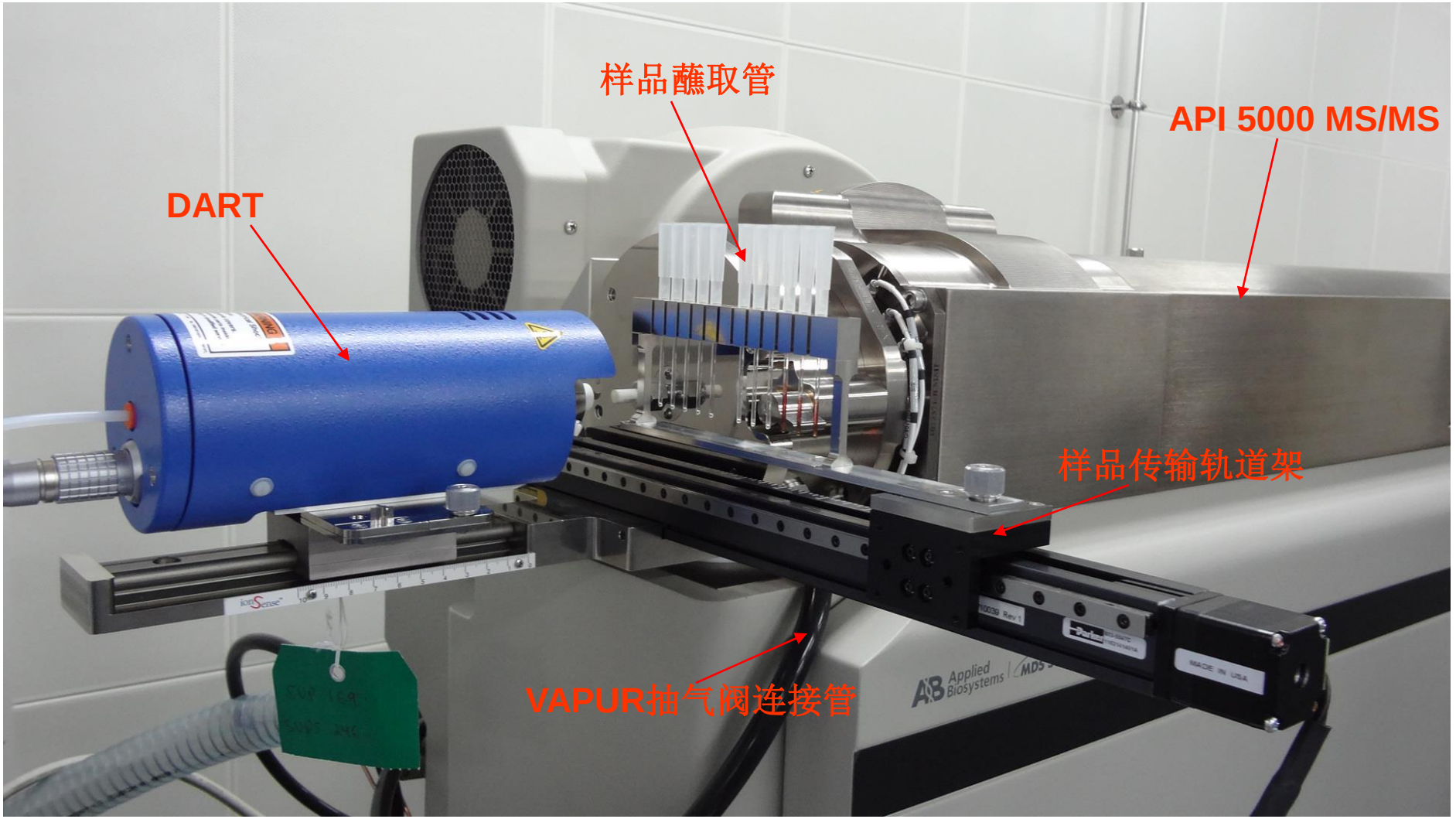


Typical LLOD
0.25 – 5 ng/mL
in plasma
22 compounds

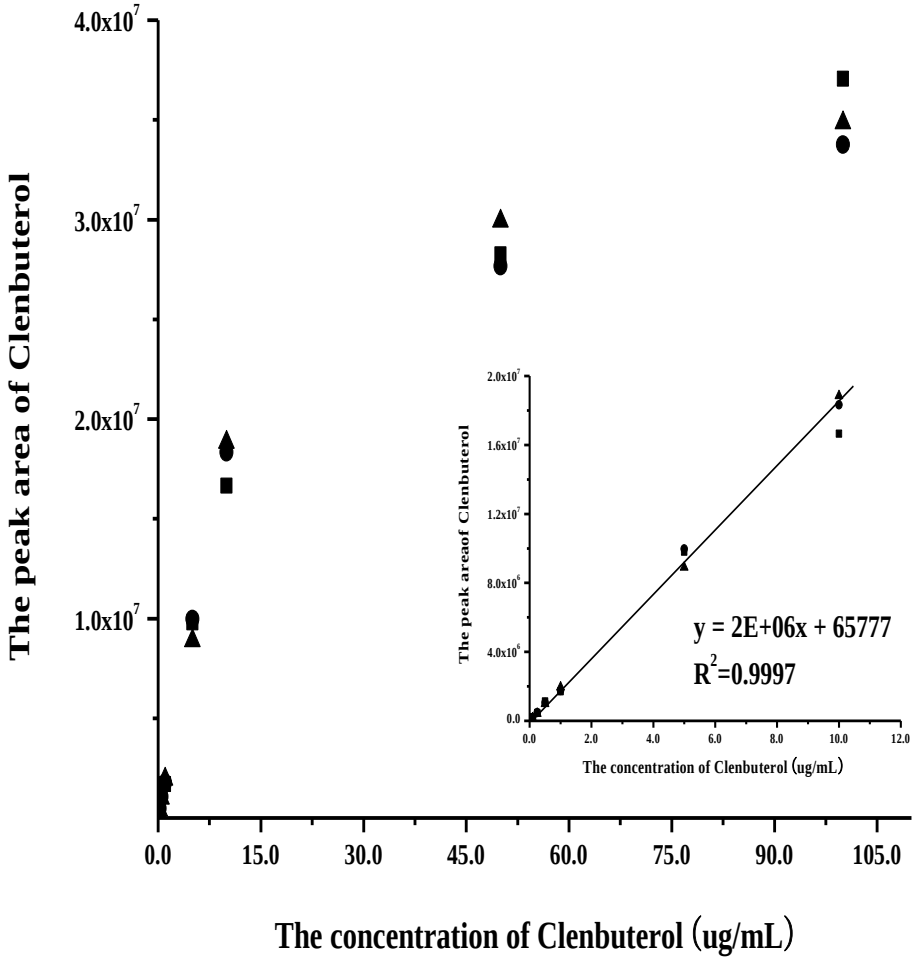
GHB in Urine 氘代内标定量 (Deuterated I.S.)



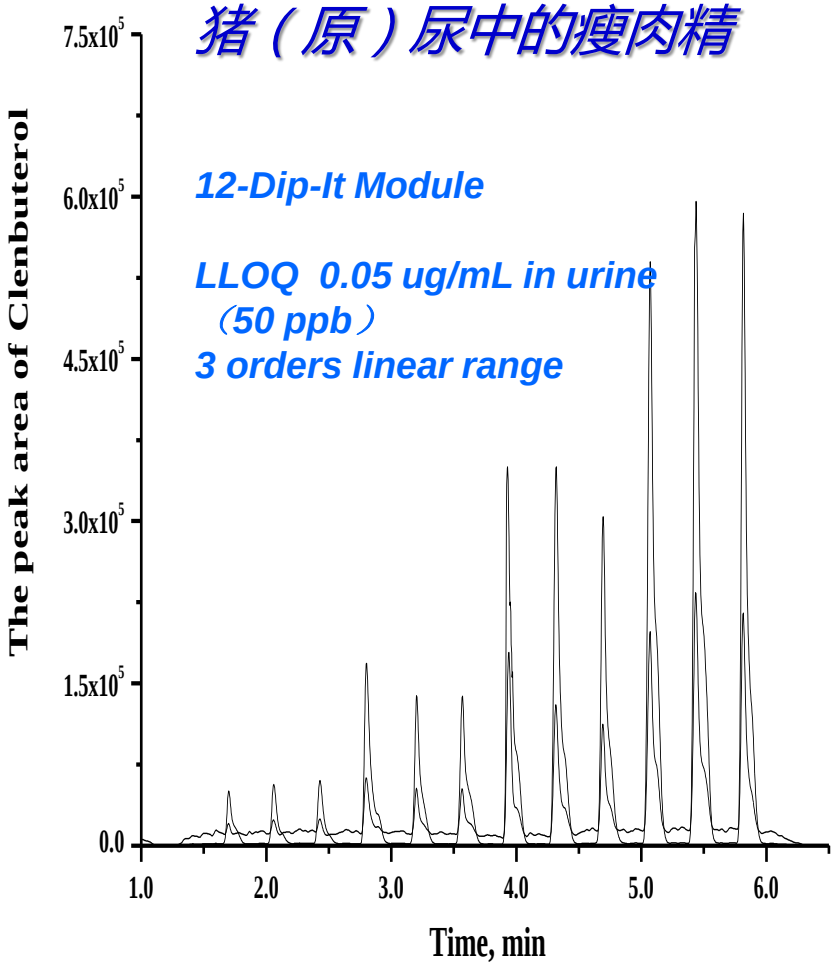
DART - API 5000 MS/MS 质谱系统



DART - 5000 MS/MS MRM 定量



猪（原）尿中的瘦肉精

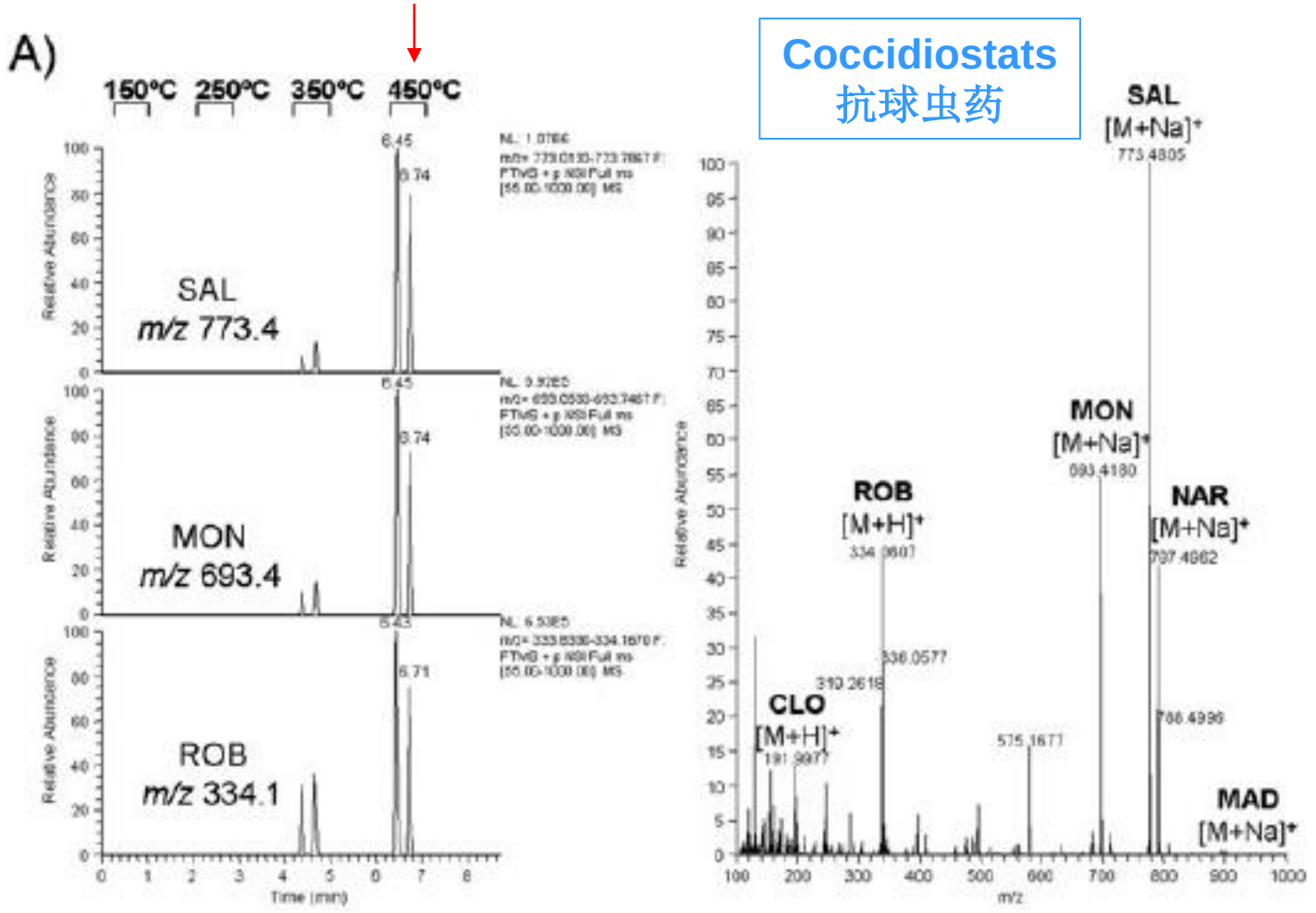


12-Dip-It Module

LLOQ 0.05 ug/mL in urine（50 ppb）

3 orders linear range

DART 快检饲料食品中的抗寄生虫兽药

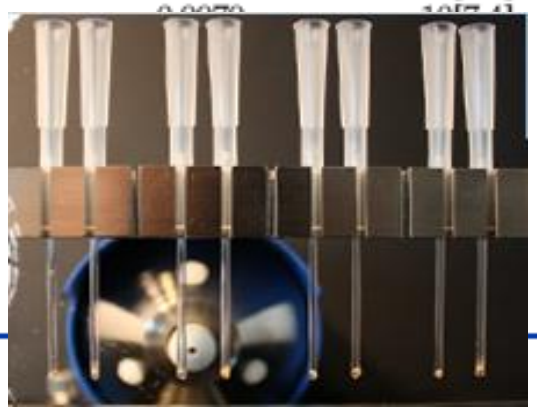


Rapid Commun Mass Spectrom. 2013 Feb 15;27(3):467-75.

DART 快检饲料食品中的抗寄生虫兽药

Table 2. Quality parameters of the method for the determination of benzimidazoles in milk and authorized MRLs in milk

Compound	LCL ($\mu g\ kg^{-1}$)	Recovery (% RSD)	Linearity (r)		Run-to-run (% RSD) [Accuracy (rel. error %)]		MRL ($\mu g\ kg^{-1}$)
			External calibration	Internal standard calibration	Low level (10 $\mu g\ kg^{-1}$)	Medium level (100 $\mu g\ kg^{-1}$)	
ABZ	1	92 (5.1)	0.9968	0.9993	19 [2.5]	11[2.0]	100
ABZ-SO_2	5	87 (3.4)	0.9949	0.9986	25[8.3]	22[5.4]	100
ABZ-SO	1	86 (6.3)	0.9911	0.9991	21[8.5]	13[6.1]	100
NH_2-ABZ-SO_2	5	82 (5.7)	0.9920	0.9994	25[7.9]	18[6.3]	100
TBZ	1	95 (2.4)	0.9937	0.9960	17[5.3]	14[3.3]	100
TBZ-OH	1	89 (4.8)	0.9969	0.9997	15[6.2]	13[4.2]	100
FBZ	1	82 (6.2)	0.9960	0.9978	13[5.4]	9[4.2]	10
FBZ-SO_2	5	84 (5.7)	0.9942	0.9970	20[9.3]	15[6.8]	10
MBZ	1	88 (4.3)	0.9991	0.9990	18[6.2]	16[5.3]	-
NH_2-MBZ	5	85 (6.7)	0.9937	0.9985	25[9.2]	20[7.6]	-
MBZ-OH	1	84 (5.4)	0.9968	0.9984	22[6.8]	5[4.2]	-
FLU	1	79 (3.4)	0.9953			6[3.7]	-
NH_2-FLU	10	77 (7.2)	0.9957			18[5.3]	-
OFZ	5	89 (5.6)	0.9952			17[6.4]	10
OXI	1	87 (6.1)	0.9981			13[5.2]	-
CBZ	1	90 (3.4)	0.9994			11[5.3]	-
TCZ	1	76 (7.2)	0.9994			12[6.4]	-
KETO-TCZ	1	65 (8.6)	0.9977			14[7.5]	-
FEB	1	92 (3.5)	0.9968			14[3.8]	10
LEV	1	94 (2.2)	0.9979			16[5.4]	-



Rapid Commun Mass Spectrom. 2013 Feb 15;27(3):467-75.

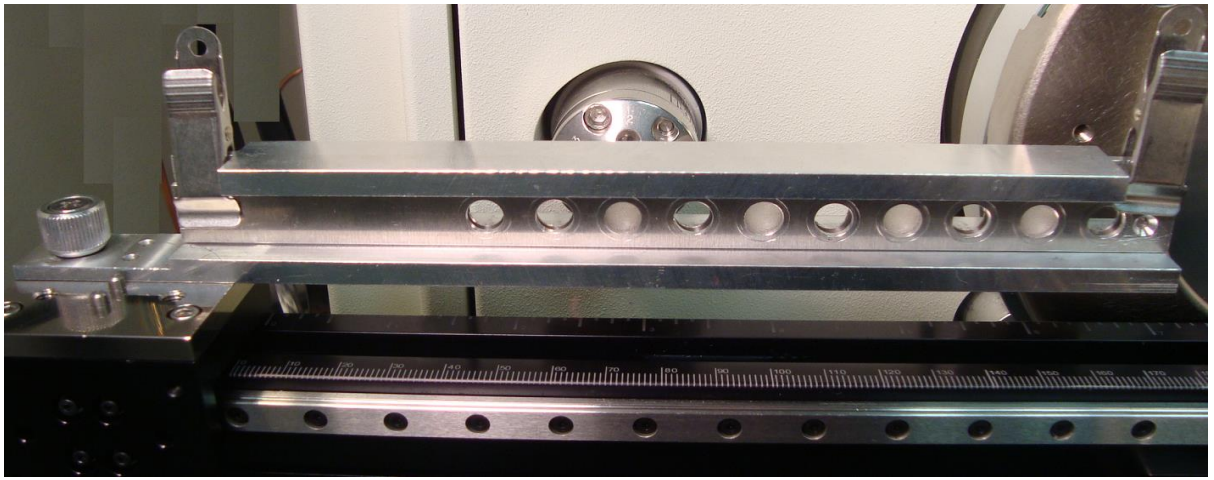
Transmission Module 透过式 DART

Rapid Screening for Pesticides

DART and High Resolution

FDA Forensic Center Results

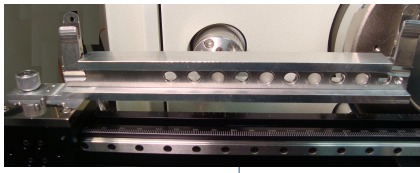
April 2010

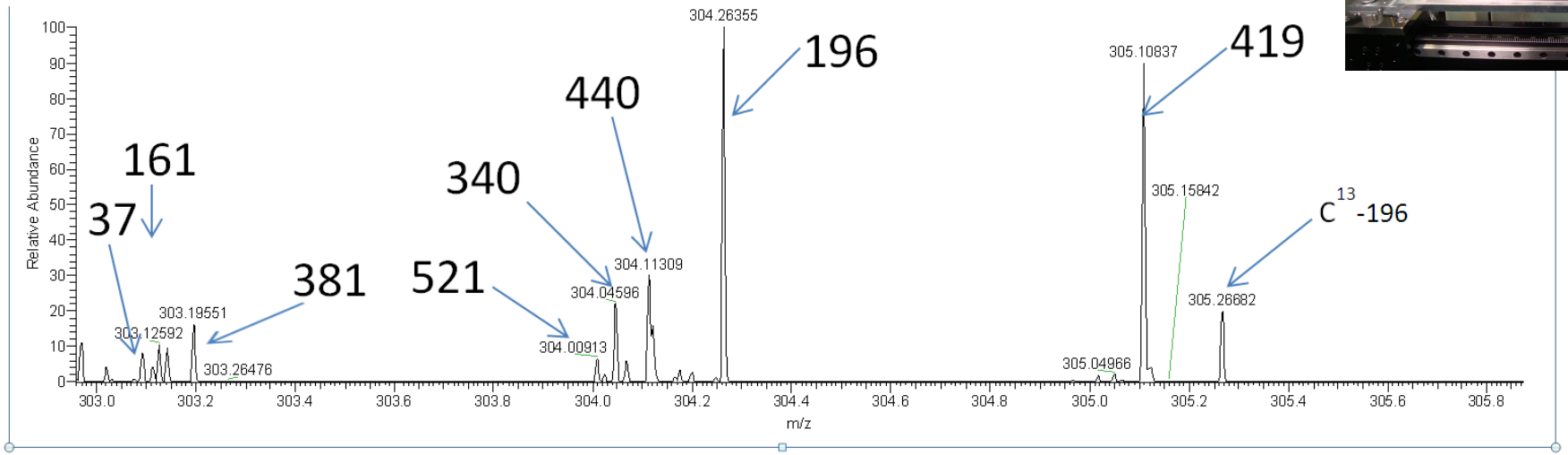


Transmission Module穿透式DART

1.8 min Screening for 529 Pesticides

Simultaneous Detection of 8 Pesticides in 3 dalton mass range

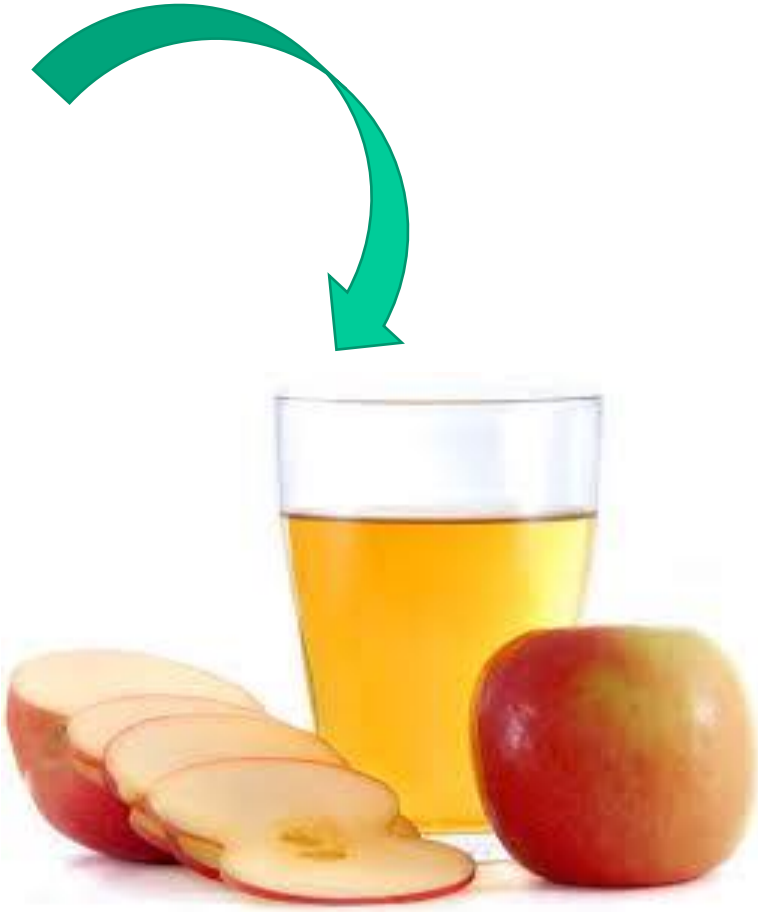




Partial Mass Spectrum - 303 – 306 dalton mass range

Clofentezine	#37	Cumyluron	#161	Allethrin	#381	Tri-allate	#521
Norflurazon	#340	Fenamiphos	#440	Diazinon	#419	Fenpropimorph	#196

DART Apple Juice: DART 苹果汁

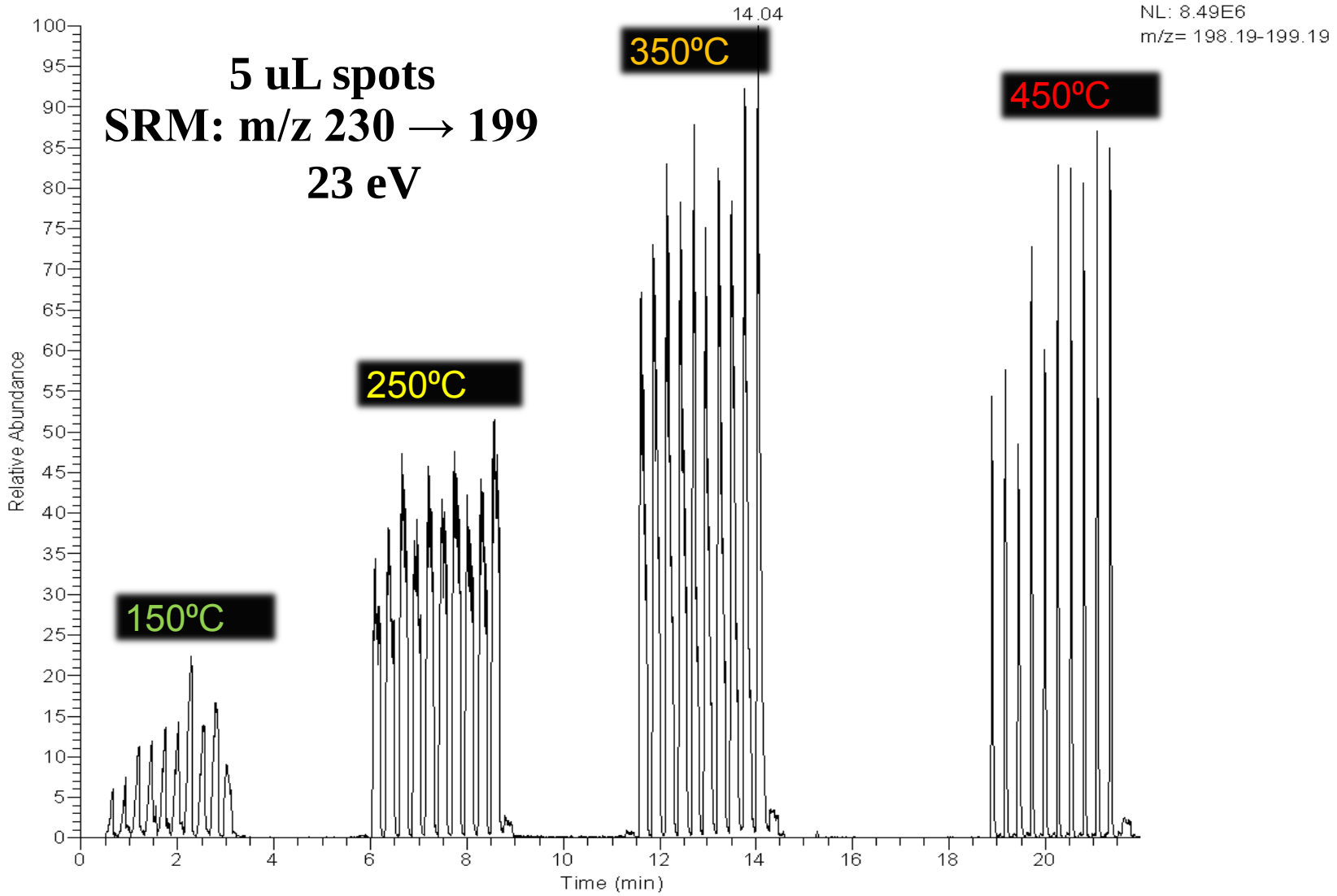


Dimethoate Spiked at:

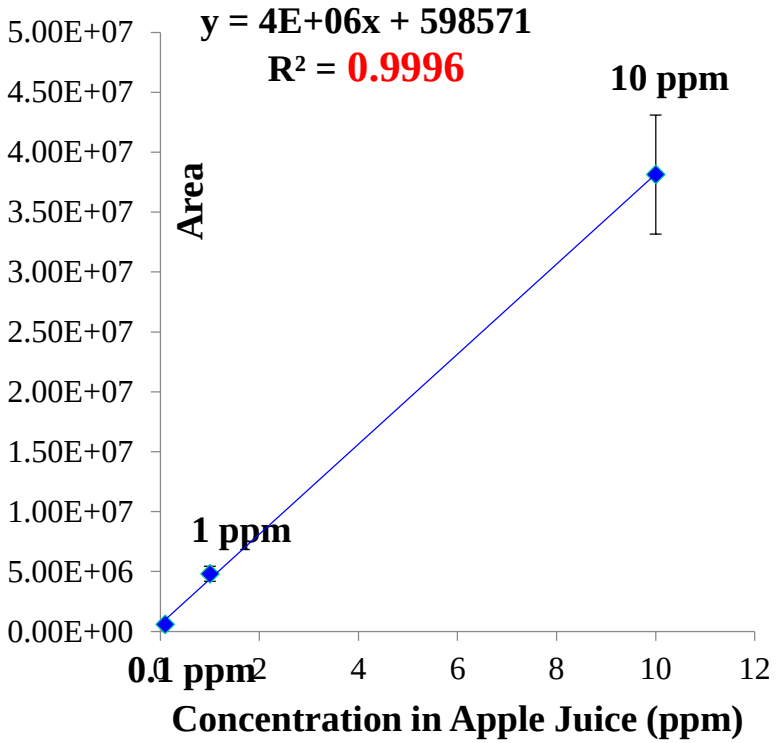
- **100 ppb**
- **1 ppm**
- **100 ppm**

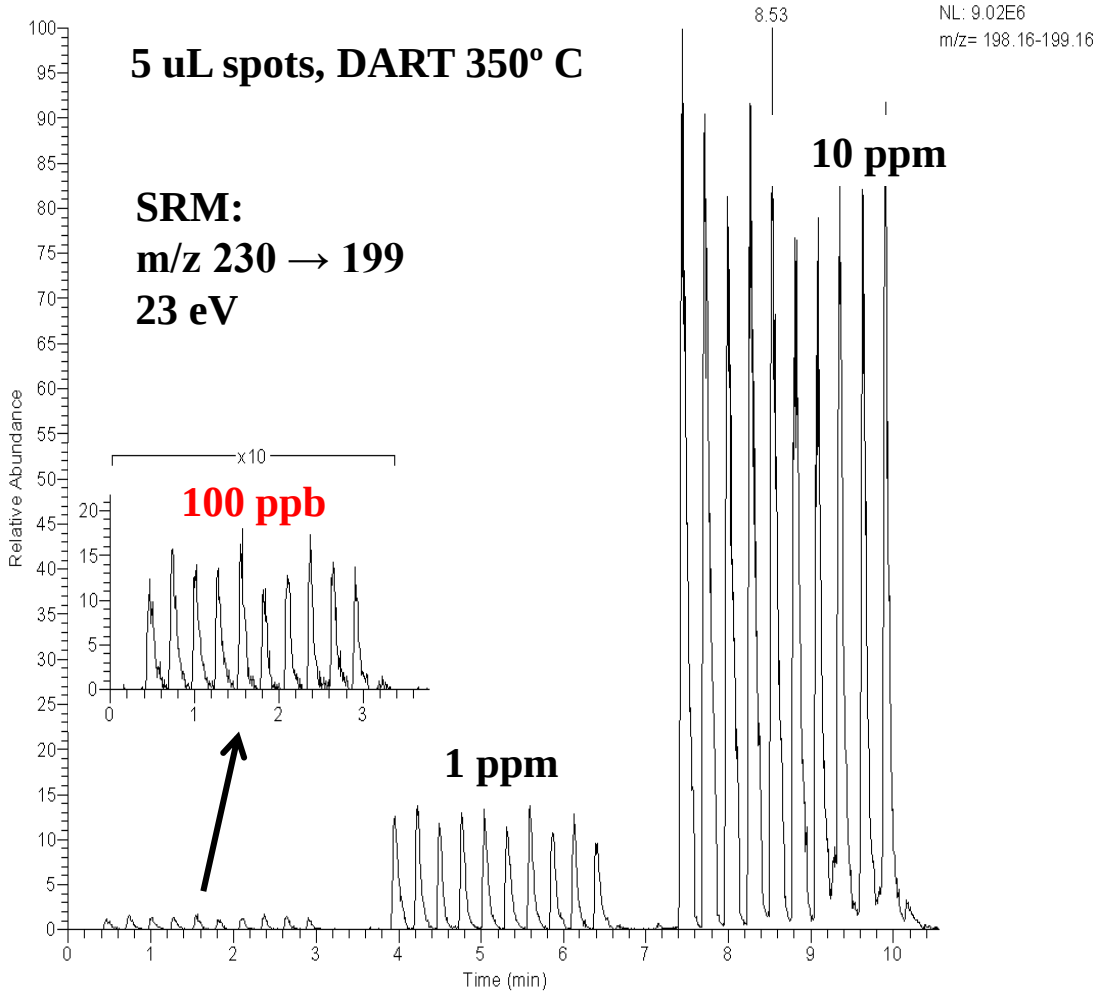
Temp Ramp 3+D: Dimethoate in Apple Juice

10 ppm

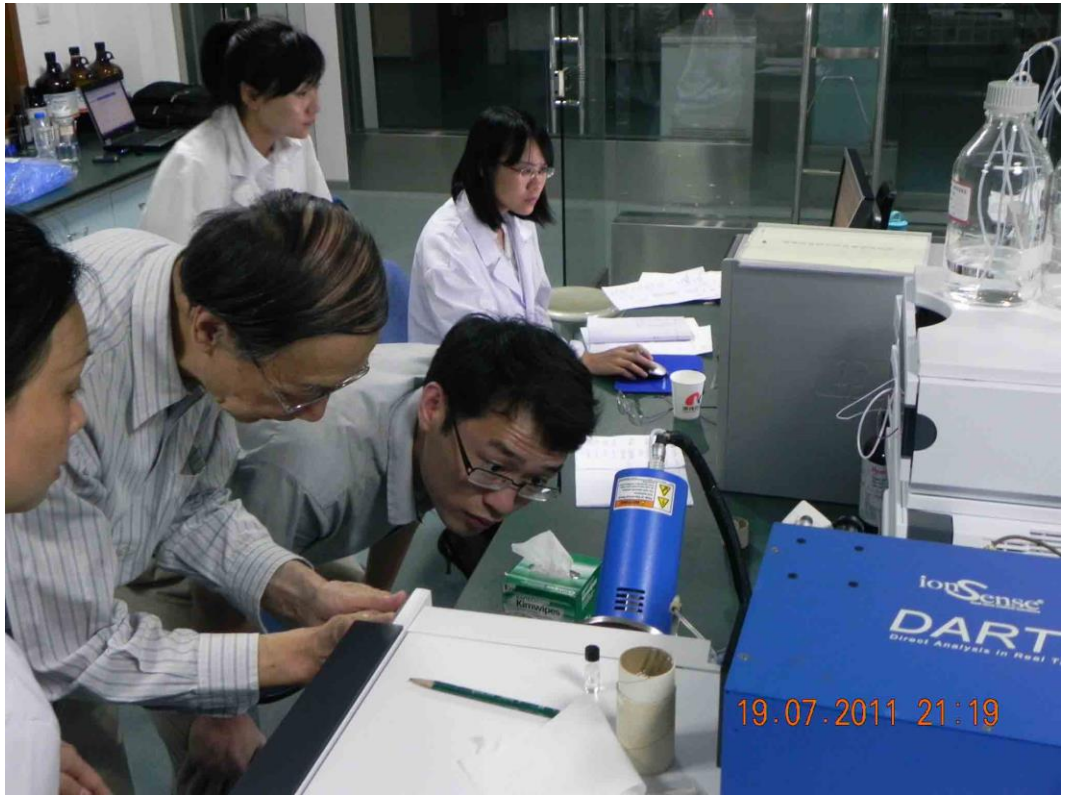


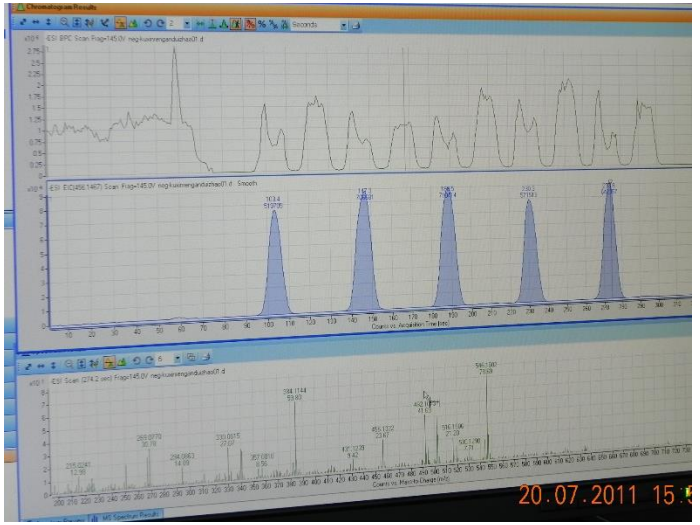
Dimethoate in Apple Juice 苹果汁中乐果

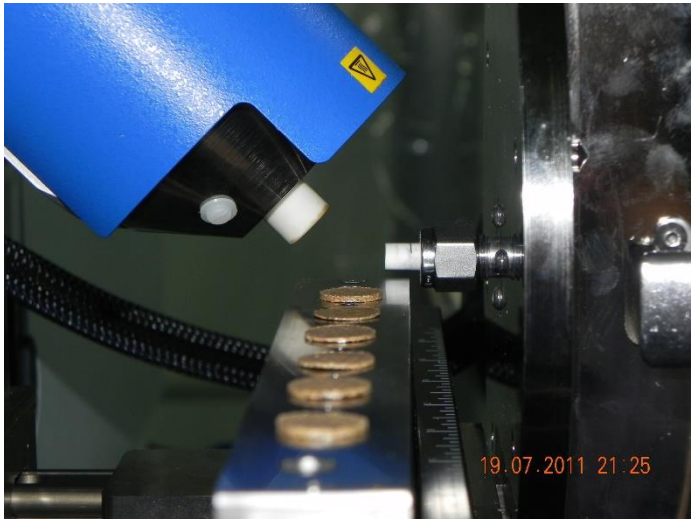




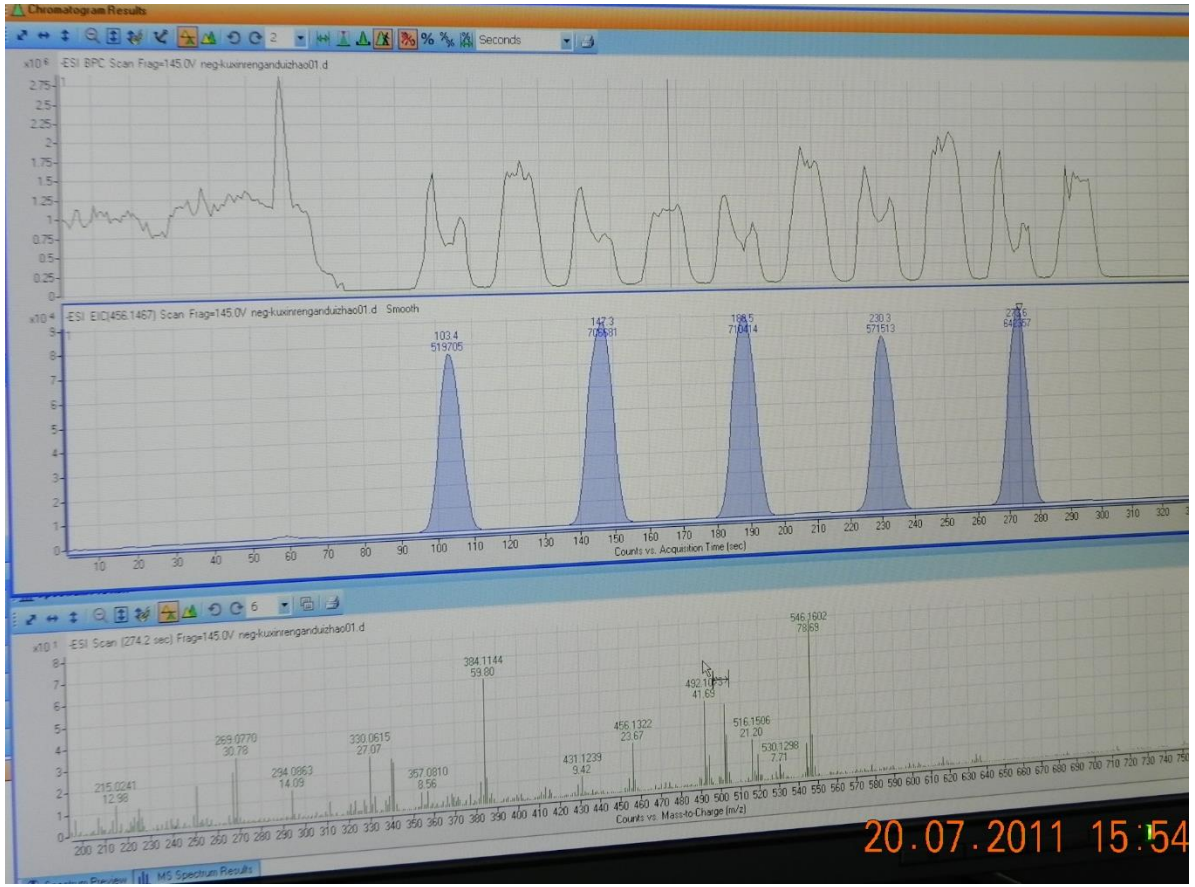
DART - TOF 中药制剂分析

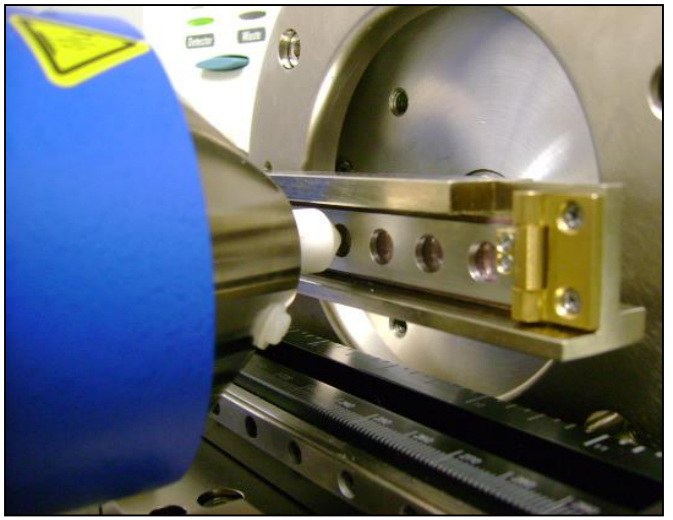






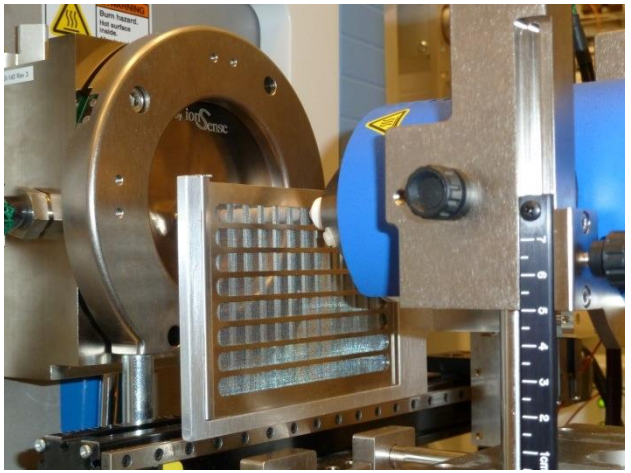
Transmission DART：透过式

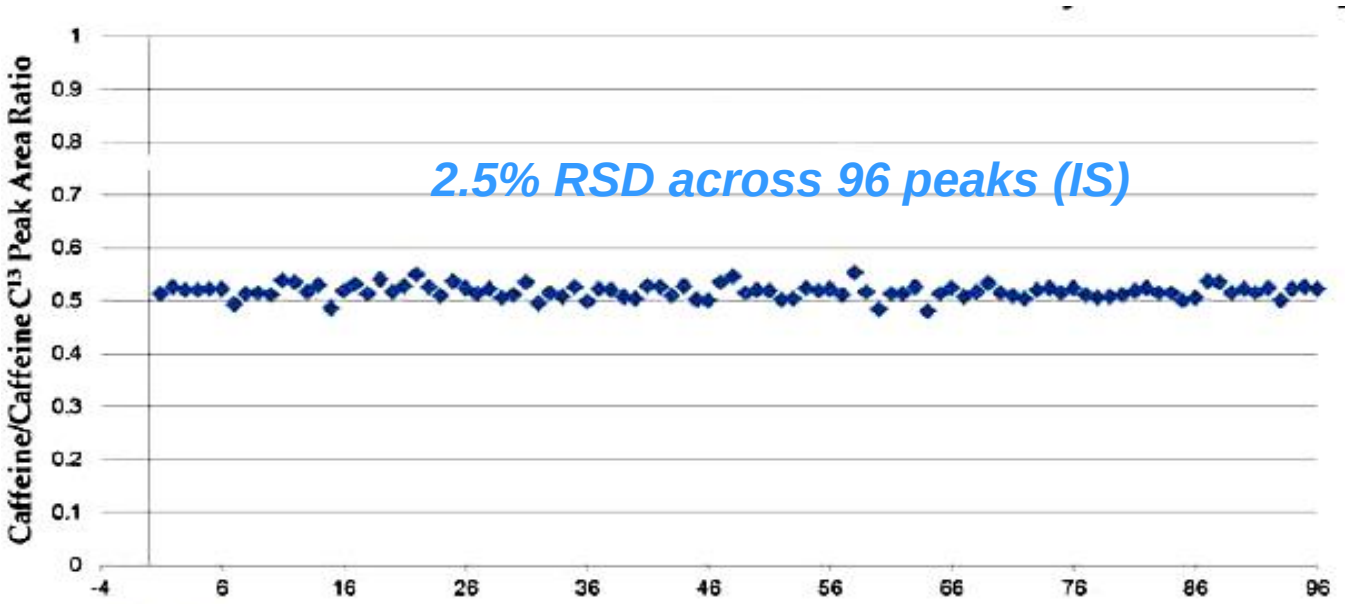


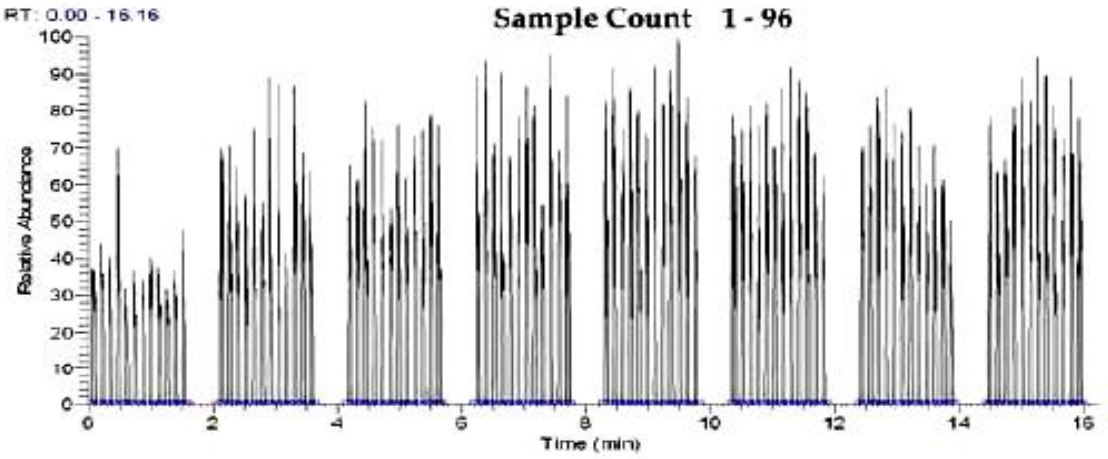


X-Z Transmission：透过式

- XZ Scanner
- 96 samples in 16 minutes
- Caffeine standards







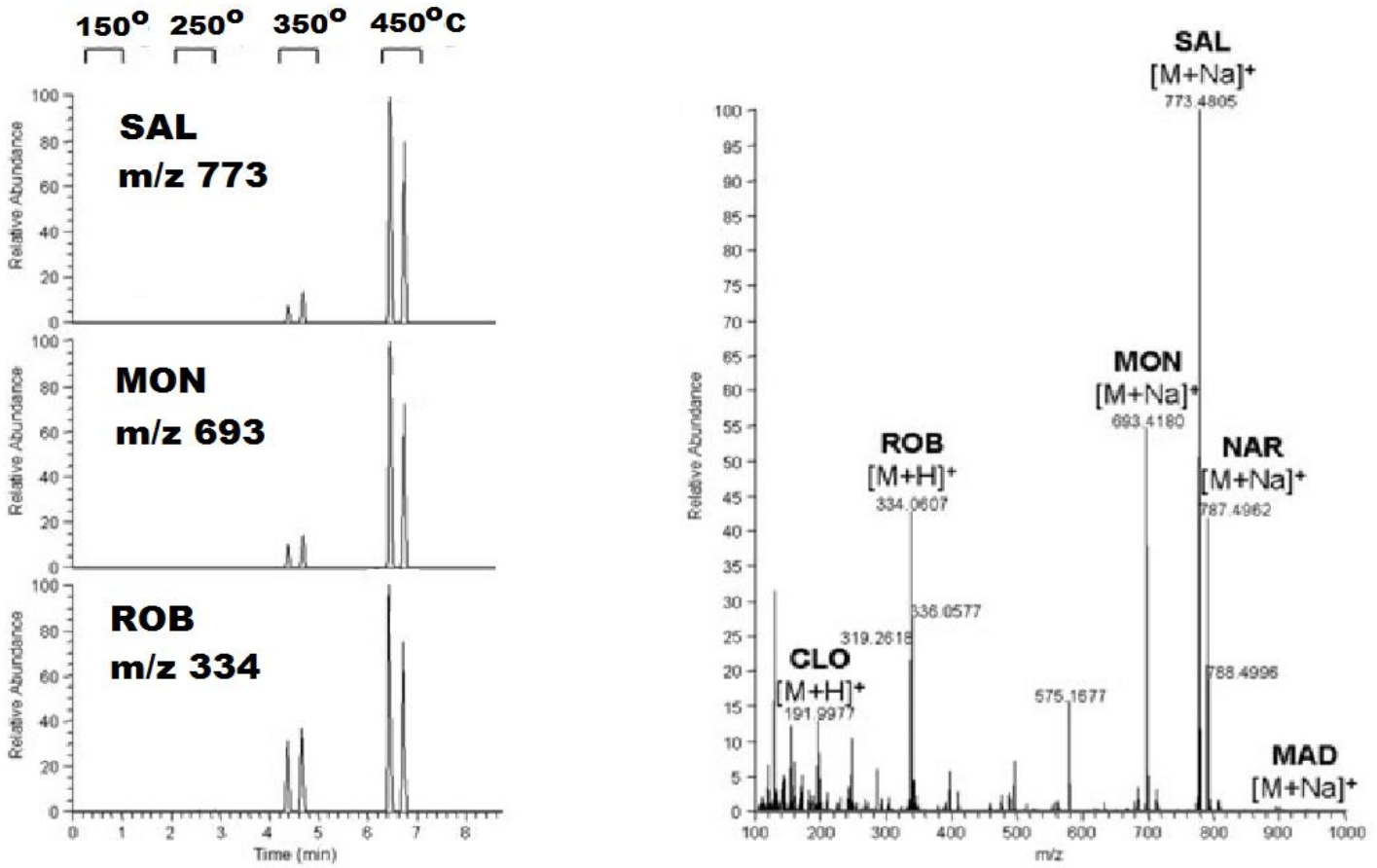
Antiparasitic Veterinary Drugs in Feed and Food DART-MS Analysis with **QuEChERs**

- Utilize commercially available QuEChERs kit
- Good for complex food matrices, bulk food and those containing high fat content
- Enhances transfer of small polar molecules into the organic solvent phase of the extraction

- Antibiotics in milk example:
- Milk 15 gm
- Add 0.1% Formic acid to create more acidic solution for acidic antibiotics
- Add Dispersive Sorbents
  - 50mg PSA and 50 mg C18
  - 1ml Acetonitrile
- Add Mg salt and mix
- Analyze organic phase by DART-MS

Hajsolva, J., et al. Institute Chemical Tech., Prague, CZ. Rapid Comm. Mass Spectrom. 2013, 27, 467

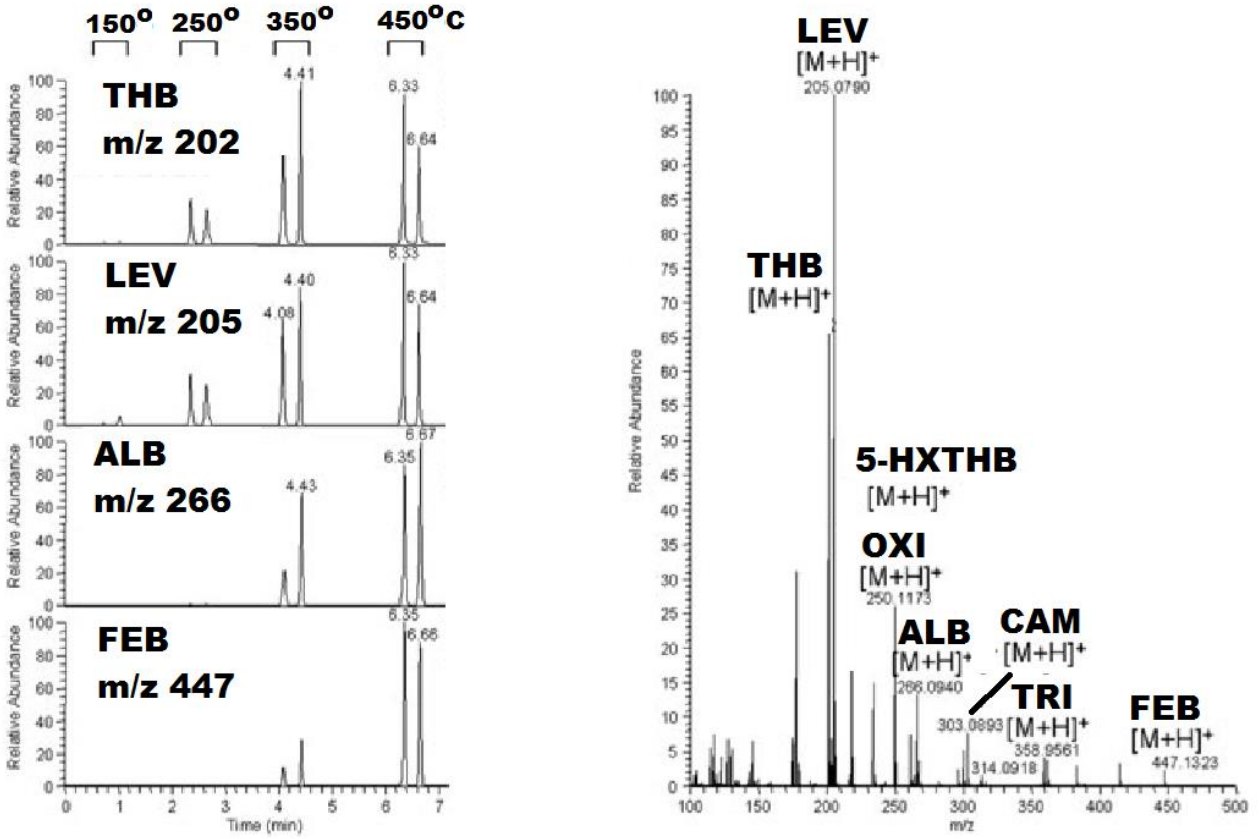
Analysis of QuEChERs extracts of milk for antibiotics



Effect of gas temperature on DART-HRMS sensitivity for coccidiostats

Hajsolva, J., et al. Institute Chemical Tech., Prague, CZ. Rapid Comm. Mass Spectrom. 2013, 27, 467

Analysis of QuEChERs extracts of milk for antibiotics



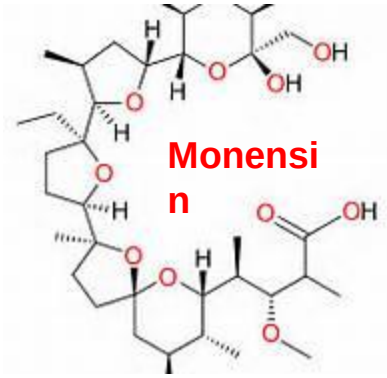
Effect of gas temperature on DART-HRMS sensitivity for benzimidazoles.

Hajsolva, J., et al. Institute Chemical Tech., Prague, CZ. Rapid Comm. Mass Spectrom. 2013, 27, 467

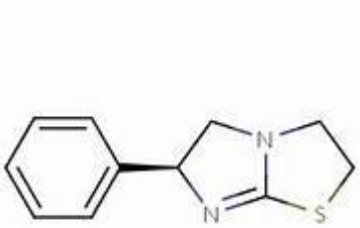
Rare occurrence of [M+Na]+ produced by DART

Compounds	Detected ions Ion assignment	Exact mass (Da)
ABZ	$[M+H]^+$	266.0958
ABZ-SO_2	$[M+H]^+$	298.0857
ABZ-SO	$[M+H]^+$	282.0907
NH_2-ABZ-SO_2	$[M+H]^+$	240.0802
TBZ	$[M+H]^+$	202.0434
TBZ-OH	$[M+H]^+$	218.0383
FBZ	$[M+H]^+$	300.0802
FBZ-SO_2	$[M+H]^+$	332.0700
MBZ	$[M+H]^+$	296.1030
NH_2-MBZ	$[M+H]^+$	238.0975
MBZ-OH	$[M+H]^+$	298.1187
FLU	$[M+H]^+$	314.0936
NH_2-FLU	$[M+H]^+$	256.0881
OFZ	$[M+H]^+$	316.0751
OXI	$[M+H]^+$	250.1187
CBZ	$[M+H]^+$	303.0911
TCZ	$[M-H]^-$	356.9428
KETO-TCZ	$[M-H]^-$	326.9500
FEB	$[M+H]^+$	447.1333
LEV	$[M+H]^+$	205.0794
MON	$[M+Na]^+$	693.4185
NAR	$[M+Na]^+$	787.4967
SAL	$[M+Na]^+$	773.4811
LAS	$[M+Na]^+$	613.3711
MAD	$[M+Na]^+$	939.5288
AMP	n.d.	
ROB	$[M+H]^+$	334.0621
CLO	$[M+H]^+$	191.9978
ETH	$[M+H]^+$	238.1074
DIC	$[M-H]^-$	404.9718
DNC	$[M-H]^-$	301.0578
TOL	$[M-H]^-$	424.0584
TOL-SO_2	$[M-H]^-$	440.3737
TOL-SO	$[M-H]^-$	456.3731

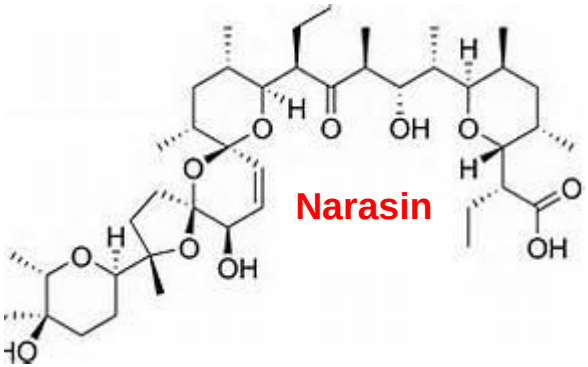
Rapid Commun. Mass Spectrom. **2013**, *27*, 467–475



Monensin



Levamidisole



Narasin

Structures with significant hydrogen bonding facilitate capture of the cation

Solid Phase Extraction (ITSP SPE)

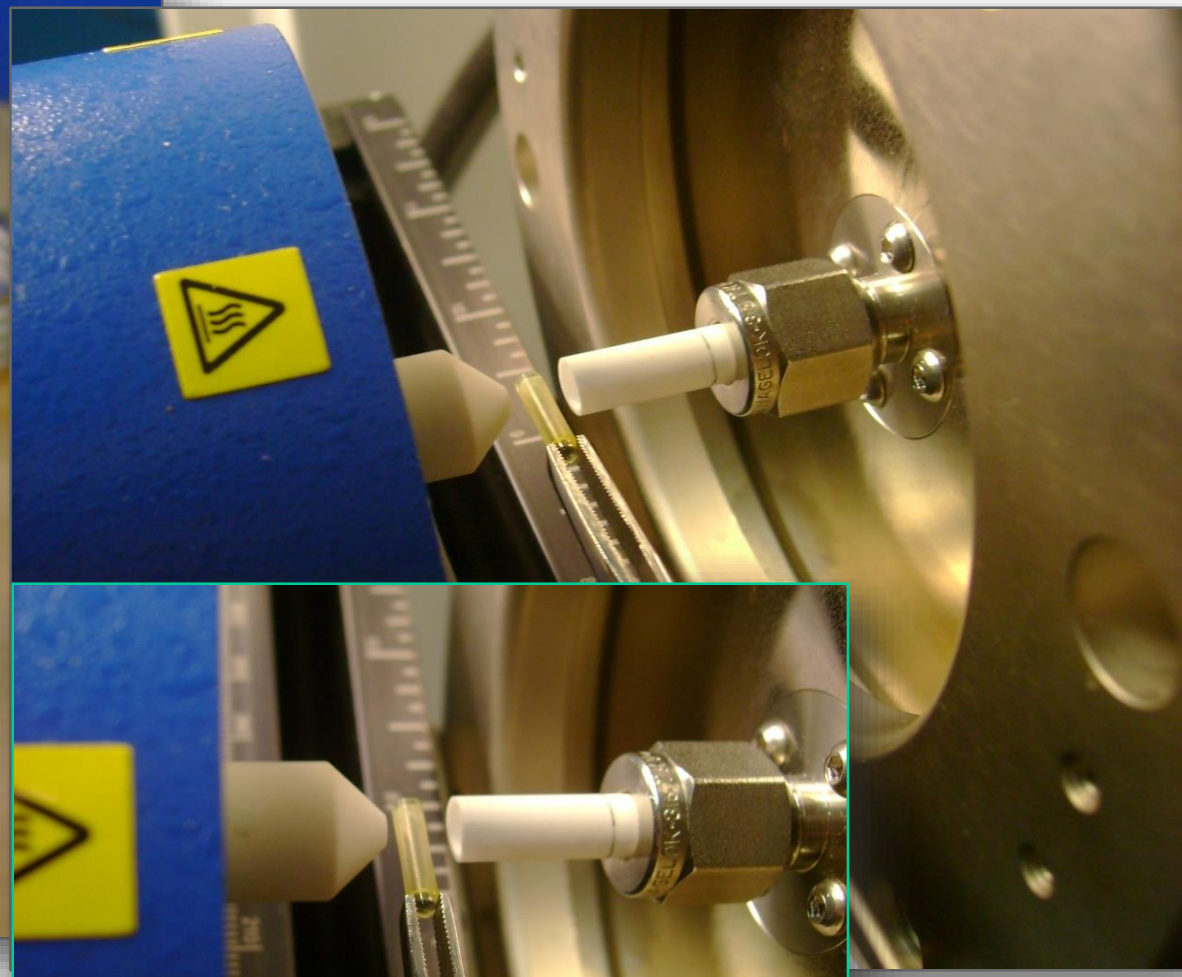
Instrument top sample prep (ITSP) solid phase extraction is a procedure that utilizes a small cartridge with C-18 sorbent.

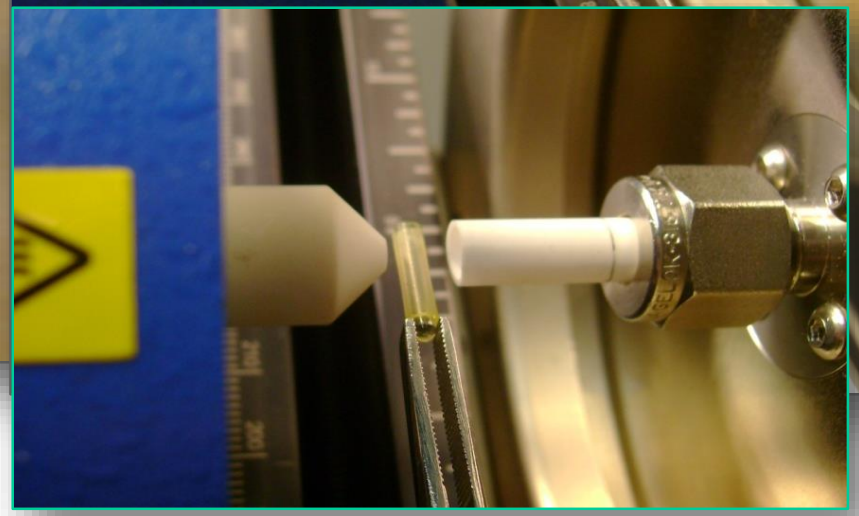
Procedure

- The initial sample preparation was done by extracting 200 mg of sample in 5 ml of water at 90° C for 5 minutes.
- The cartridge was first conditioned with methanol and water.
- 100µl of sample was applied to the column.
- A 100µl portion of water was used to elute interfering molecules.
- A 100µl portion of methanol was used for the elution of more polar compounds.
- The sample and two elutions were collected in separate vials for analysis.

info@itspsolutions.com

Gerstel Twister Spin Bar: Sample Concentration

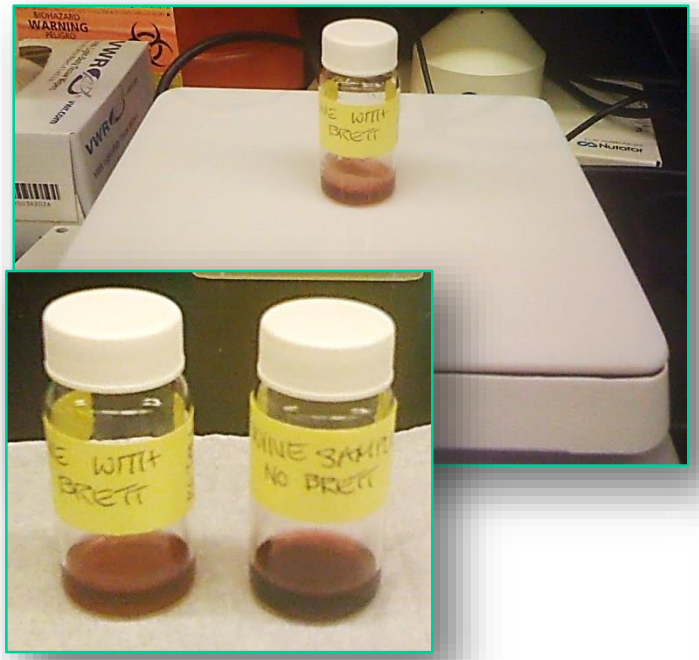




Twister was **spun overnight** in **orange juice** with **50 ppb** level of **10 pesticides**

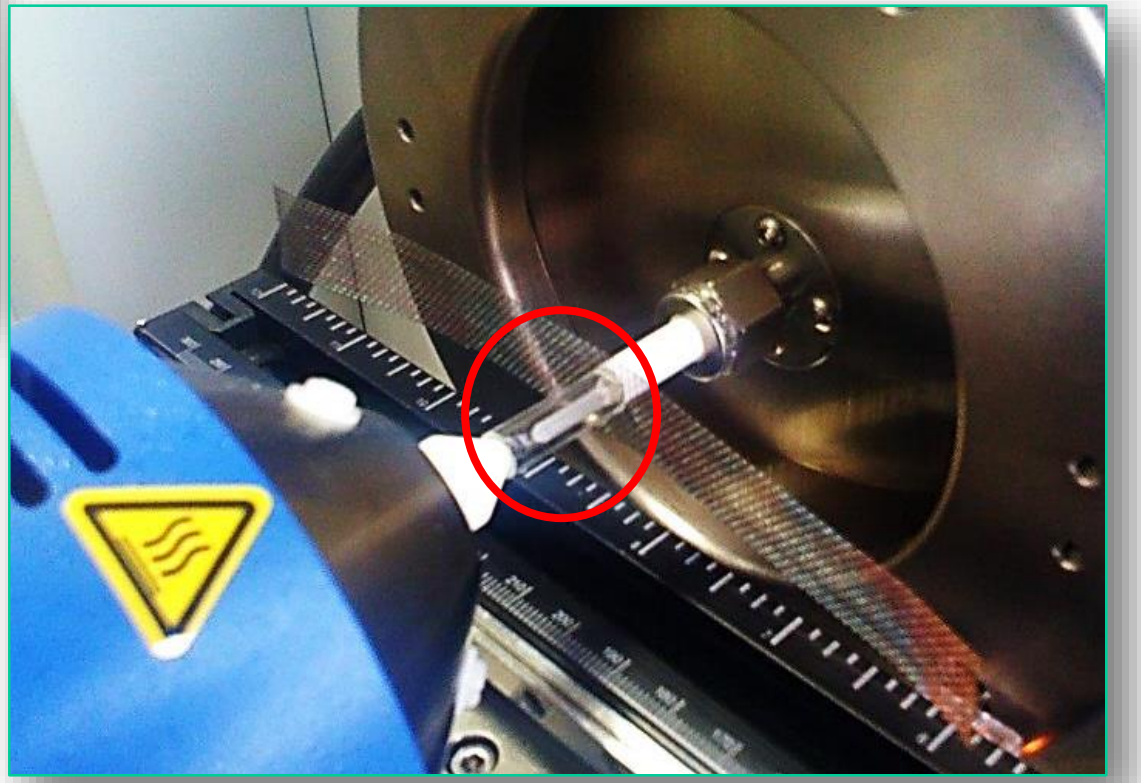
Wine Sampled with PDMS Twister

Minimum 30 minutes unattended stirring



Twister stir bar (PDMS, 0.5 mm thickness) introduced into 2 mL wine

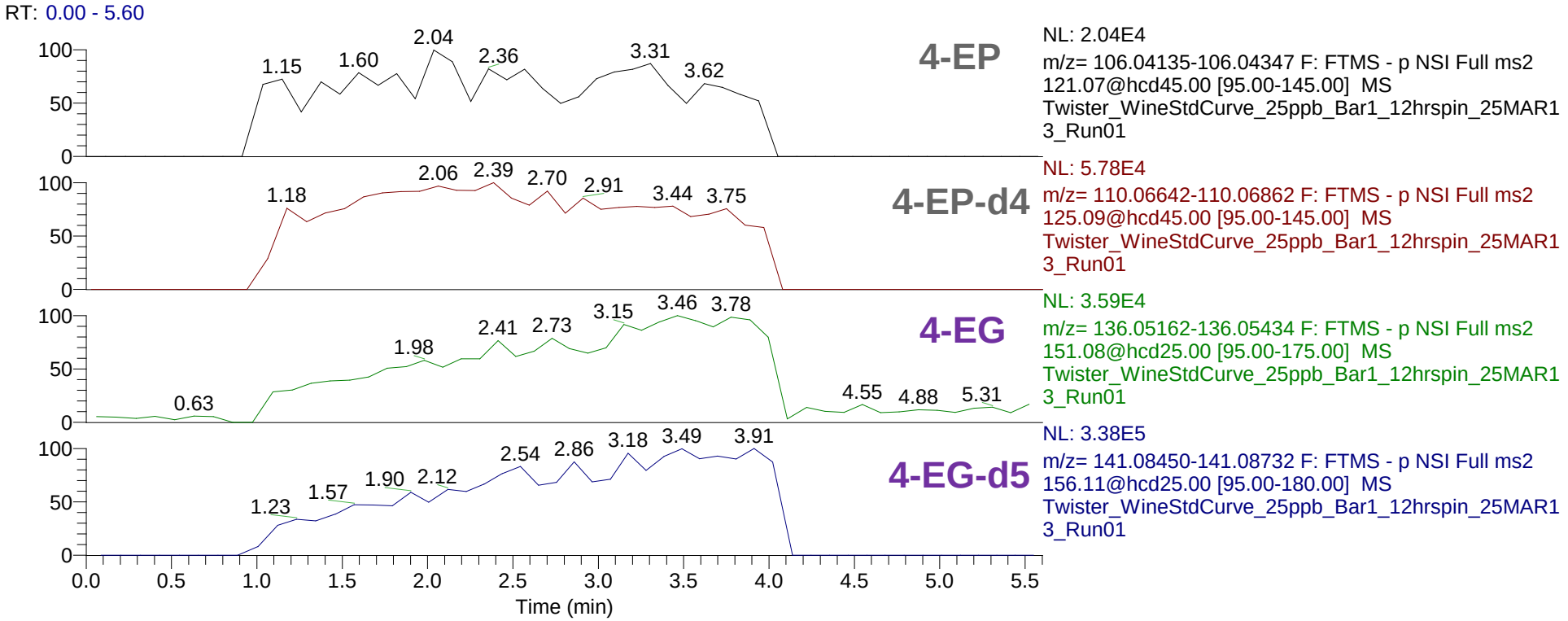
Twister placed in glass chamber = COMPLETE desorption



Typical DART-MS Chronogram from Stir Bar

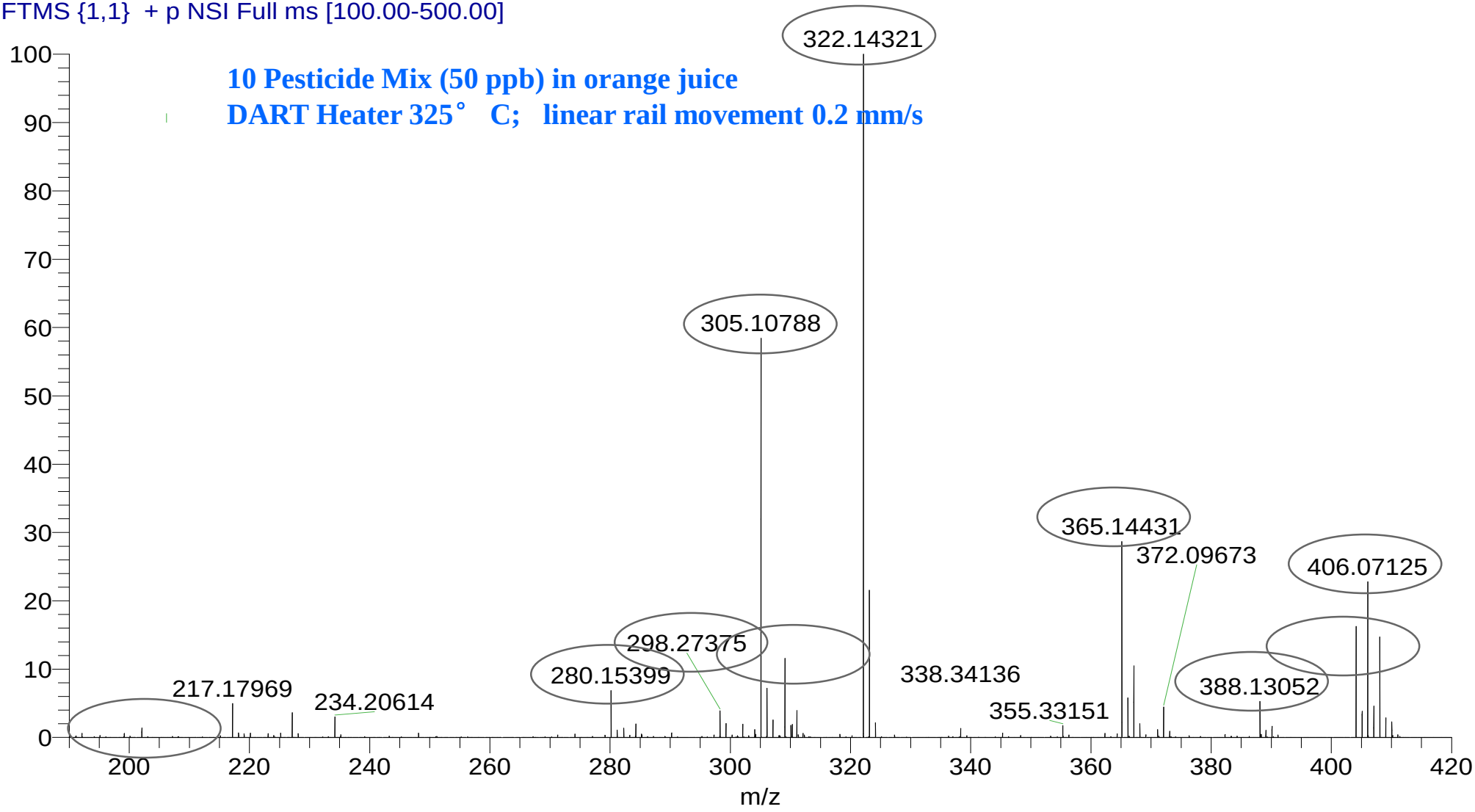
Glass Chamber: Much Improved Reproducibility

25 ppb Spiking Level of Phenolics



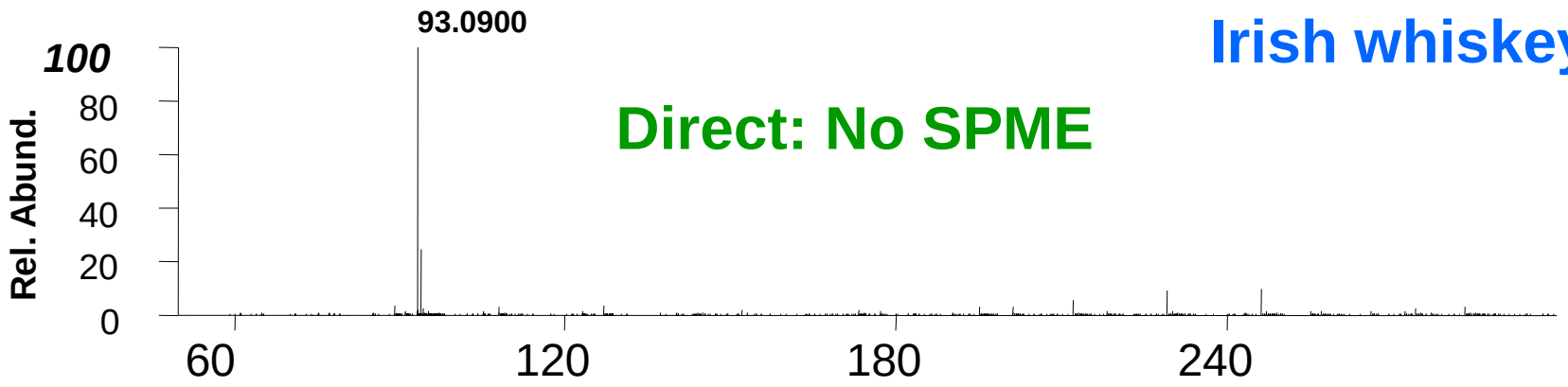
Direct Twister DART-MS Analysis

120424-01_Twister19&20_OSCranLt_Blank&50ppbSpin #598-654 RT: 4.99-5.41 AV: 57 SB: 116 0.46-1.46 NL: 1.34E6
T: FTMS {1,1} + p NSI Full ms [100.00-500.00]



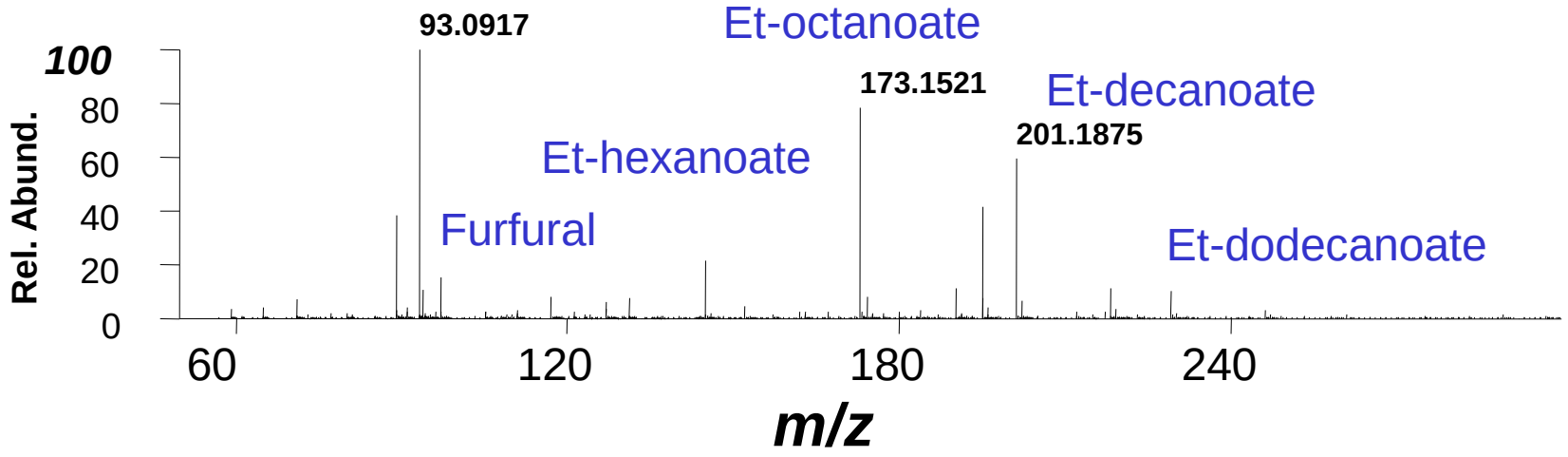
SPME/DART

Irish whiskey



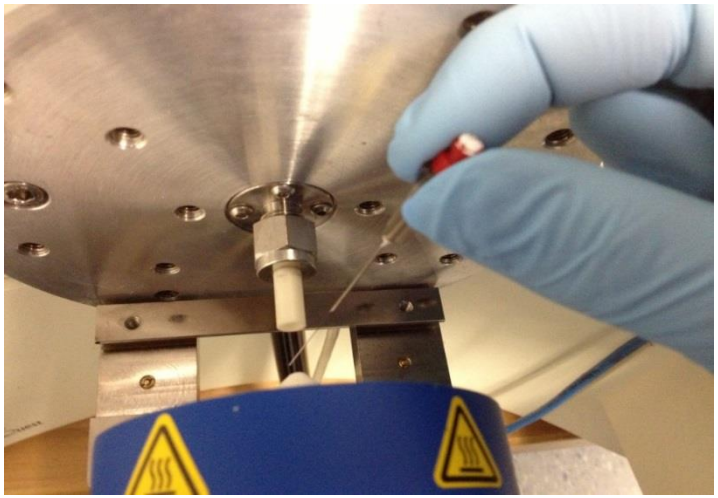
Direct: No SPME

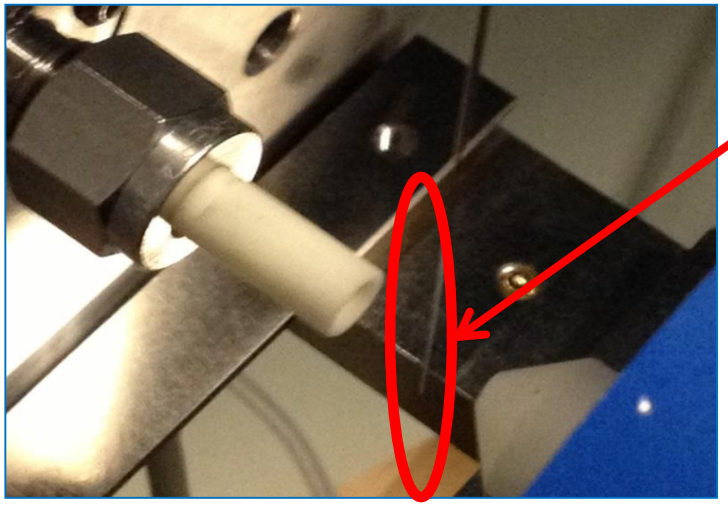
Carboxen/DVB/PDMS SPME Fiber



New Technology Solid Phase Micro Extraction (SPME) Probes

- Supelco LC-Probes are 45 micron SPE coated fibers
- Designed to collect samples for LC/MS analysis
- DART-MS probe to urine for rapid 15 minute extraction
- C-18 coating retains drugs and small molecules
- Remove probe, rinse with water to remove solubles like creatinine
- Position between DART source and MS inlet with results in seconds
- Also works with foods and forensic samples

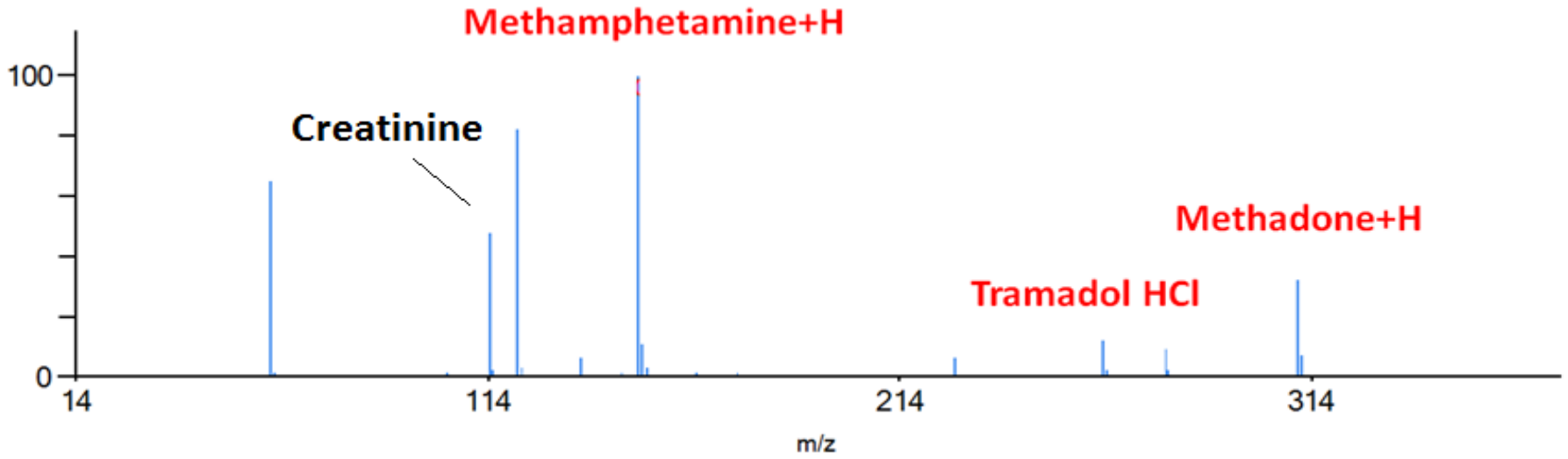




Sorbent coated portion of the probe

LC-Probe (SPME) Analysis of Urine (HR-MS)

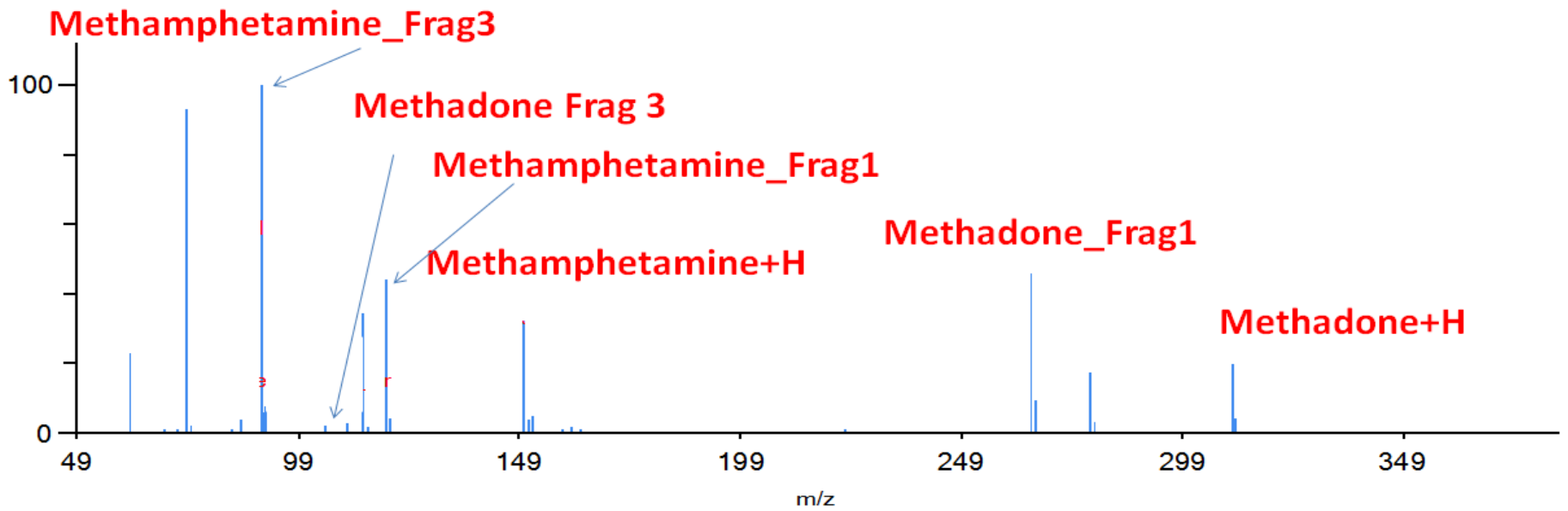
Drugs concentrate on the fiber reducing effect of creatinine which normally causes matrix interference



Name	Composition	Adduct	Measured	Calculated	mmu	Abund.
Tramadol HCl	C16H25NO2		263.186	263.188	1.83	12
± Methadone	C21H27NO	+H	310.215	310.217	1.48	32
Methamphetamine	C10H15N	+H	150.128	150.128	-0.22	100

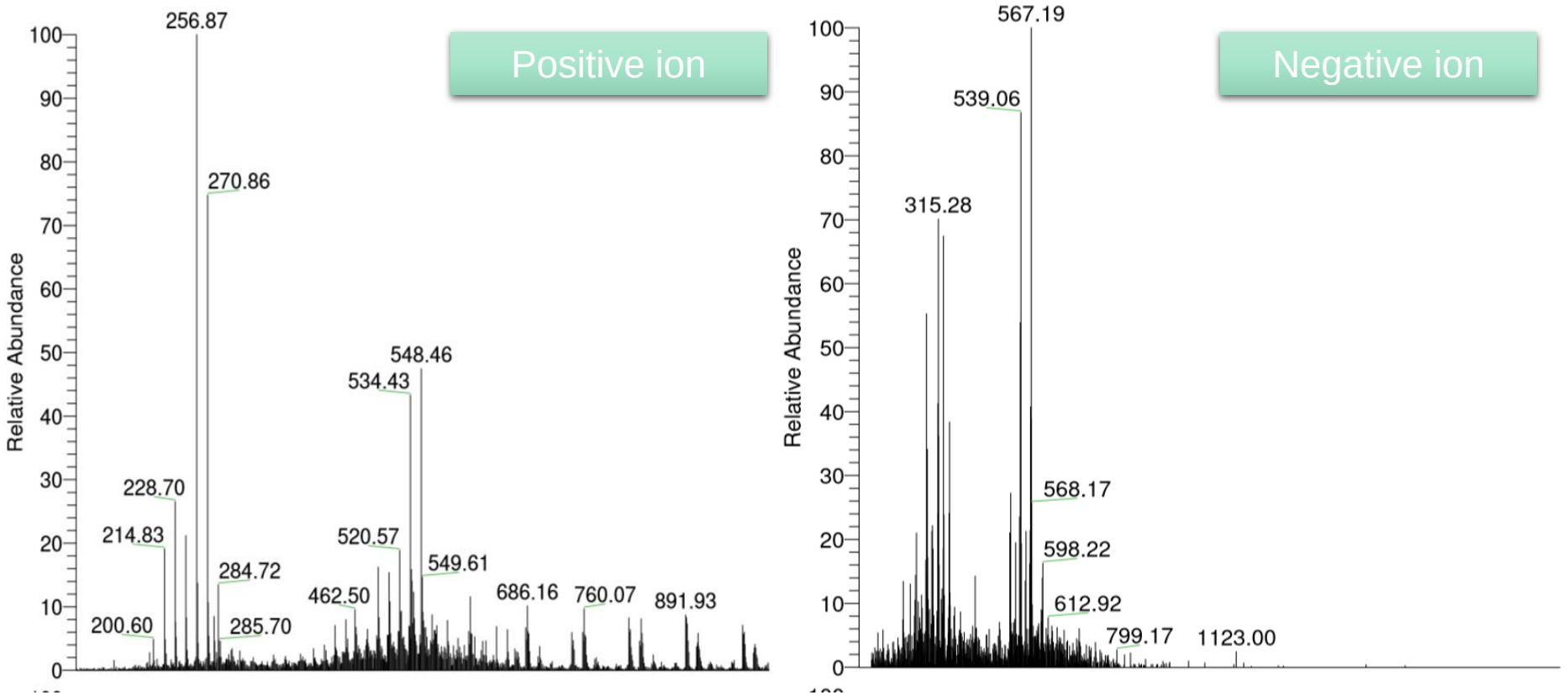
LC-Probe (SPME) Analysis of Urine (HR-MS)

Drug confirmed with in-source fragmentation



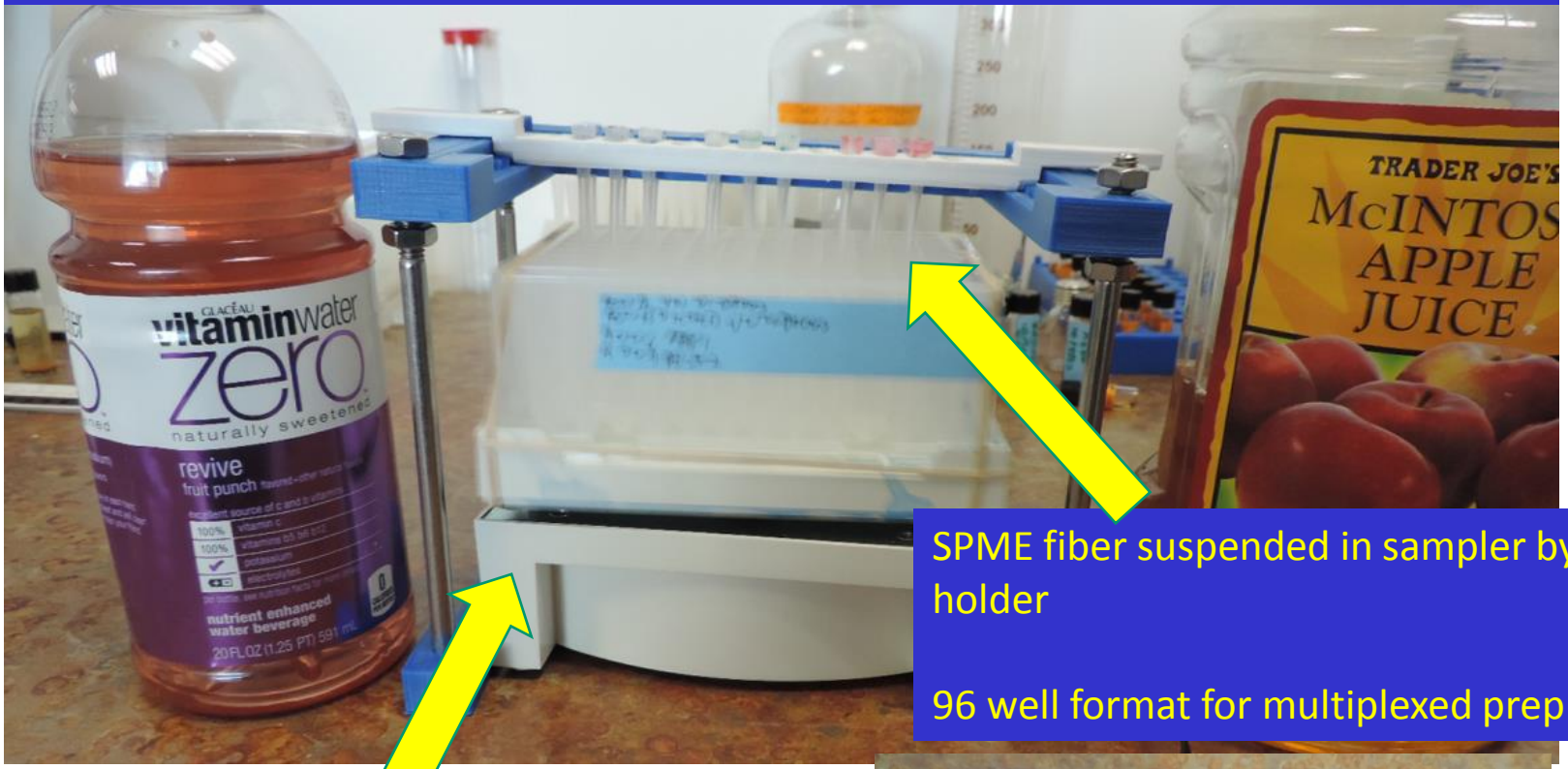
Name	Composition	Adduct	Measured	Calculated	mmu	Abund.
± Methadone	C21H27NO	+H	310.217	310.217	-0.11	19
± Methadone_Frag1	C19H21O		265.159	265.159	-0.55	45
± Methadone_Frag3	C7H5O		105.033	105.034	0.44	2
Methamphetamine	C10H15N	+H	150.127	150.128	1.08	36
Methamphetamine_Frag1	C9H11		119.083	119.086	2.57	45
Methamphetamine_Frag2	C7H7		91.054	91.054	0.77	100

SPME DART of Green Tea



SPME extraction with PDMS DVA showing positive ion mass spectrum and same sample extracted with SCX fiber (right). Most likely different chemical entities are collected by the different fibers as evidenced by many different mass values

Sample Apparatus

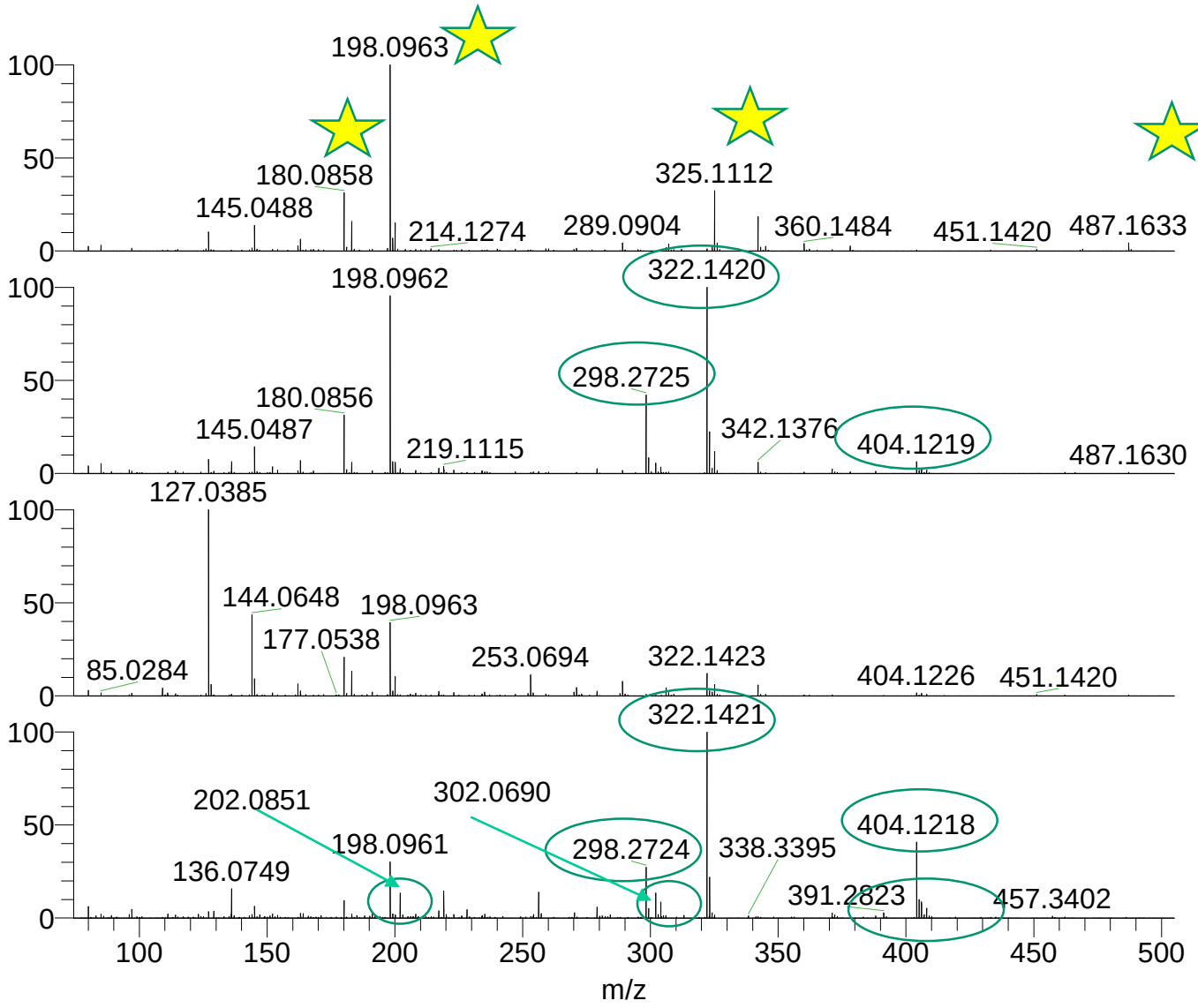


SPME fiber suspended in sampler by holder

96 well format for multiplexed prep

Plate shaker used for sustained sample agitation while SPME fiber is immersed in liquid sample

Apple Juice with 6 Pesticide Mix



NL: 3.84E8

Glass Capillary

Carbohydrates dominate signal

NL: 3.51E8

C18 SPME Fiber

NL: 5.62E8

SCX SPME Fiber

NL: 1.69E8

PDMS/DVB SPME Fiber

Pesticides and m/z of [M+H]+
Carbaryl 202,
Spiroxamine 298,
Pyriproxyfen 322
Fenhexamid 302,
Azoxystrobin 404
Difenoconazole 406,

analytical chemistry

Article

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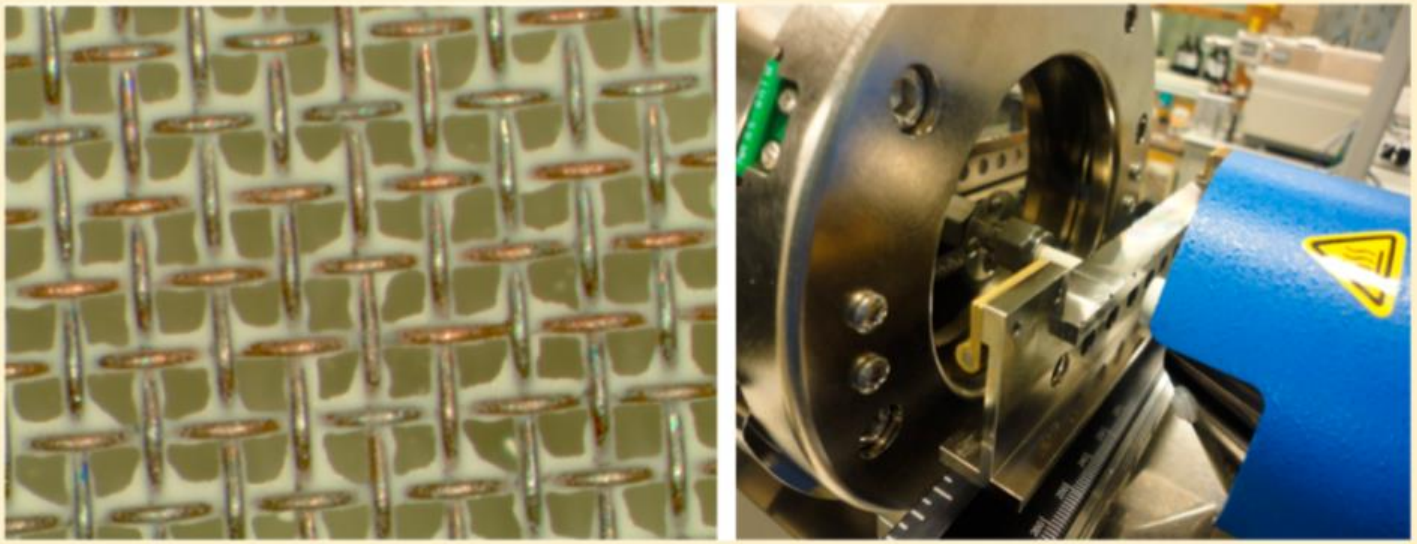
Reusable Solid-Phase Microextraction Coating for Direct Immersion Whole-Blood Analysis and Extracted Blood Spot Sampling Coupled with Liquid Chromatography–Tandem Mass Spectrometry and Direct Analysis in Real Time–Tandem Mass Spectrometry

Fatemeh S. Mirnaghi and Janusz Pawliszyn*

Department of Chemistry, University of Waterloo, 200 University Avenue West, Waterloo, Ontario, N2L 3G1, Canada



C18 PAN coated screen (left) mounts in Transmission Module

SPME-TM-DART 高灵敏度DART定量

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COMMUNICATION

Solid phase microextraction (SPME)-transmission mode (TM) pushes down detection limits in direct analysis in real time (DART)†

Germán Augusto Gómez-Ríos and Janusz Pawliszyn

/Cite this: DOI: 10.1039/x0xx00000x

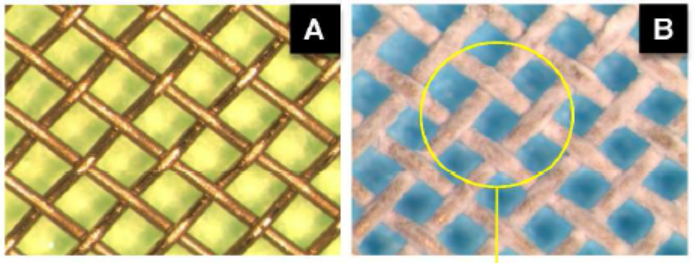
Received 00t **2014**
Accepted 00t

DOI: 10.1039/x0xx00000x

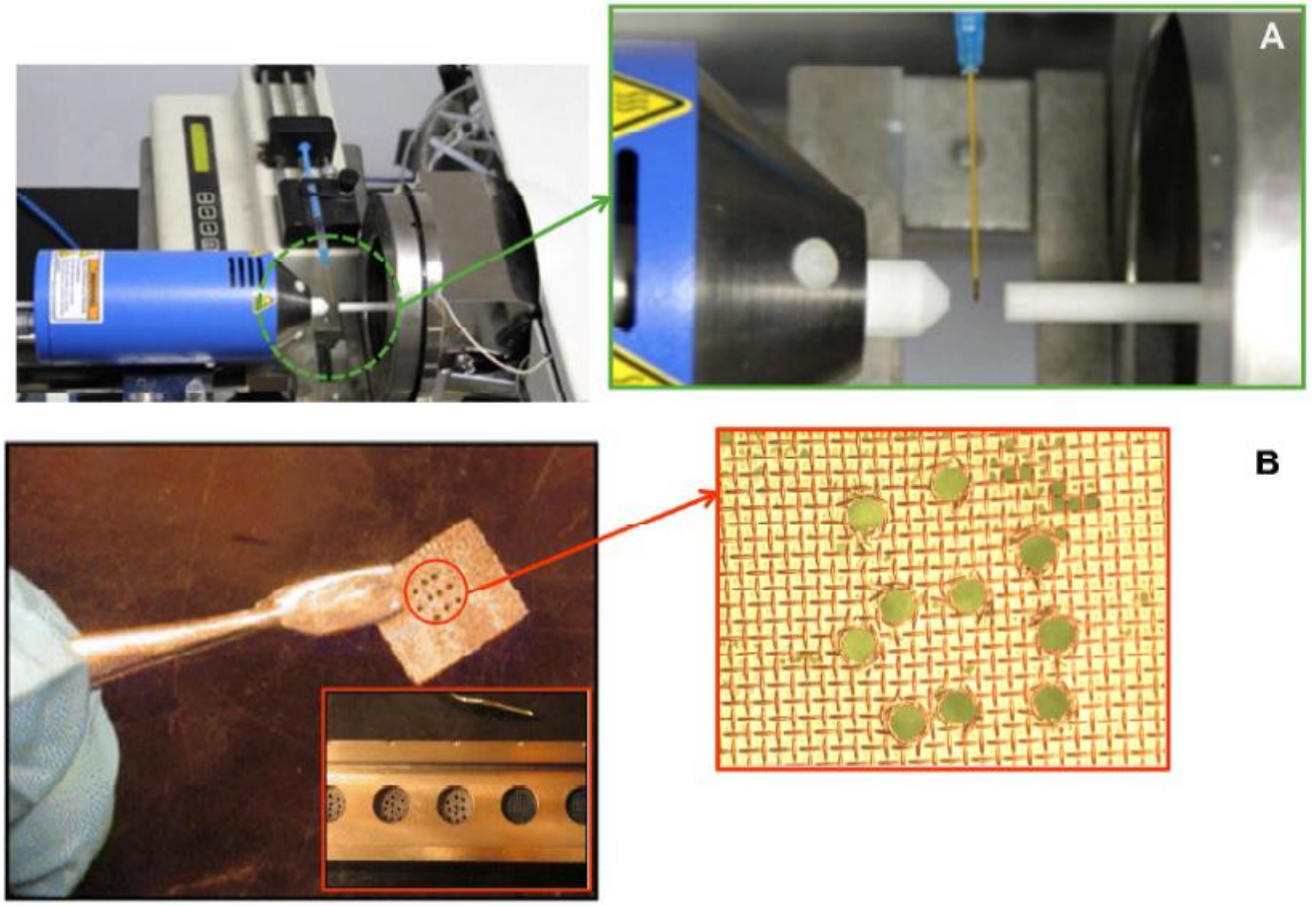
www.rsc.org/

RSD < 5%
LLOD ~ 10 - 100 ppt
3 min per sample

A new SPME device was developed and applied for quick solventless extraction/enrichment of small molecules from complex matrices. Subsequently, the device was coupled as a transmission mode substrate to DART resulting in limits of detection in the low pg/mL level in less than 3 minutes with reproducibility below 5% RSD.



SPME-TM-DART 高灵敏度DART定量



X. Wang, X. Li, Z. Li, Y. Zhang, Y. Bai, H. Liu, *Anal. Chem. 2014, **86**, 4739-4747.*

A. Rodriguez-Lafuente, F. S. Mirnaghi, J. Pawliszyn, *Anal. Bioanal. Chem.* 2013, ***405***, 9723-9727.

Figure S2A. In-Tube Solid-Phase Microextraction with Direct Analysis in Real Time Mass Spectrometry; image was adapted from the original source published by Wang and collaborators [2]. B. Thin-film solid-phase microextraction and direct analysis in real time; image was adapted from the original source published by Rodriguez-Lafuente and collaborators [3].

SPME-TM-DART 高灵敏度DART定量

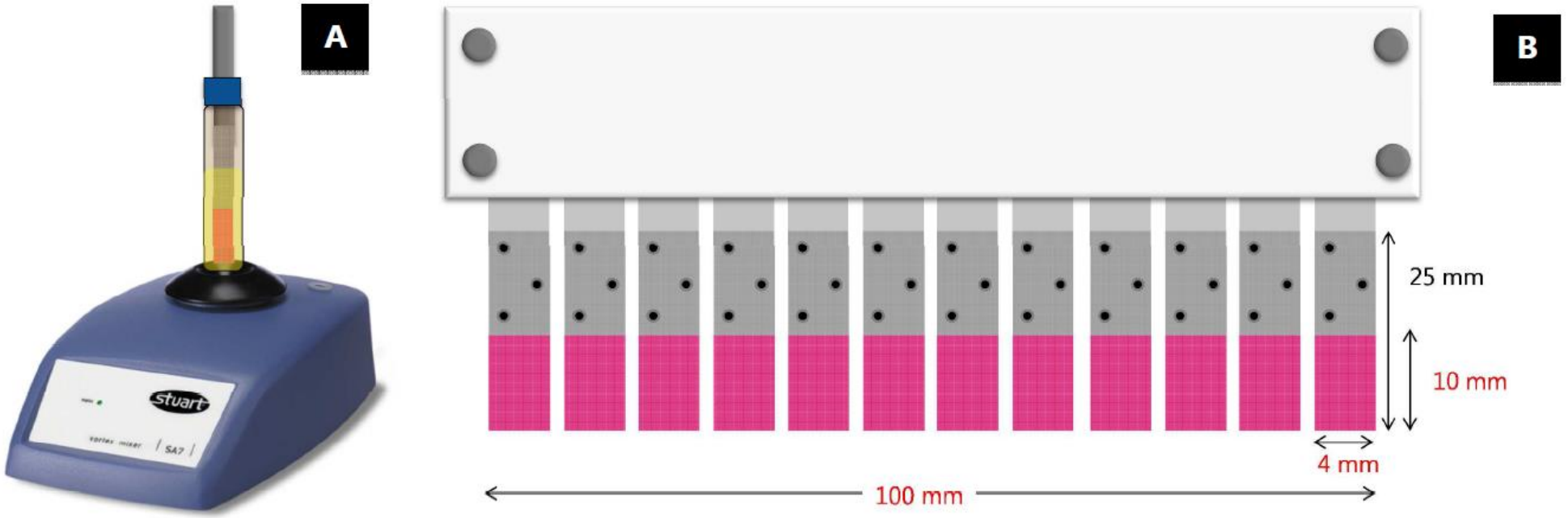
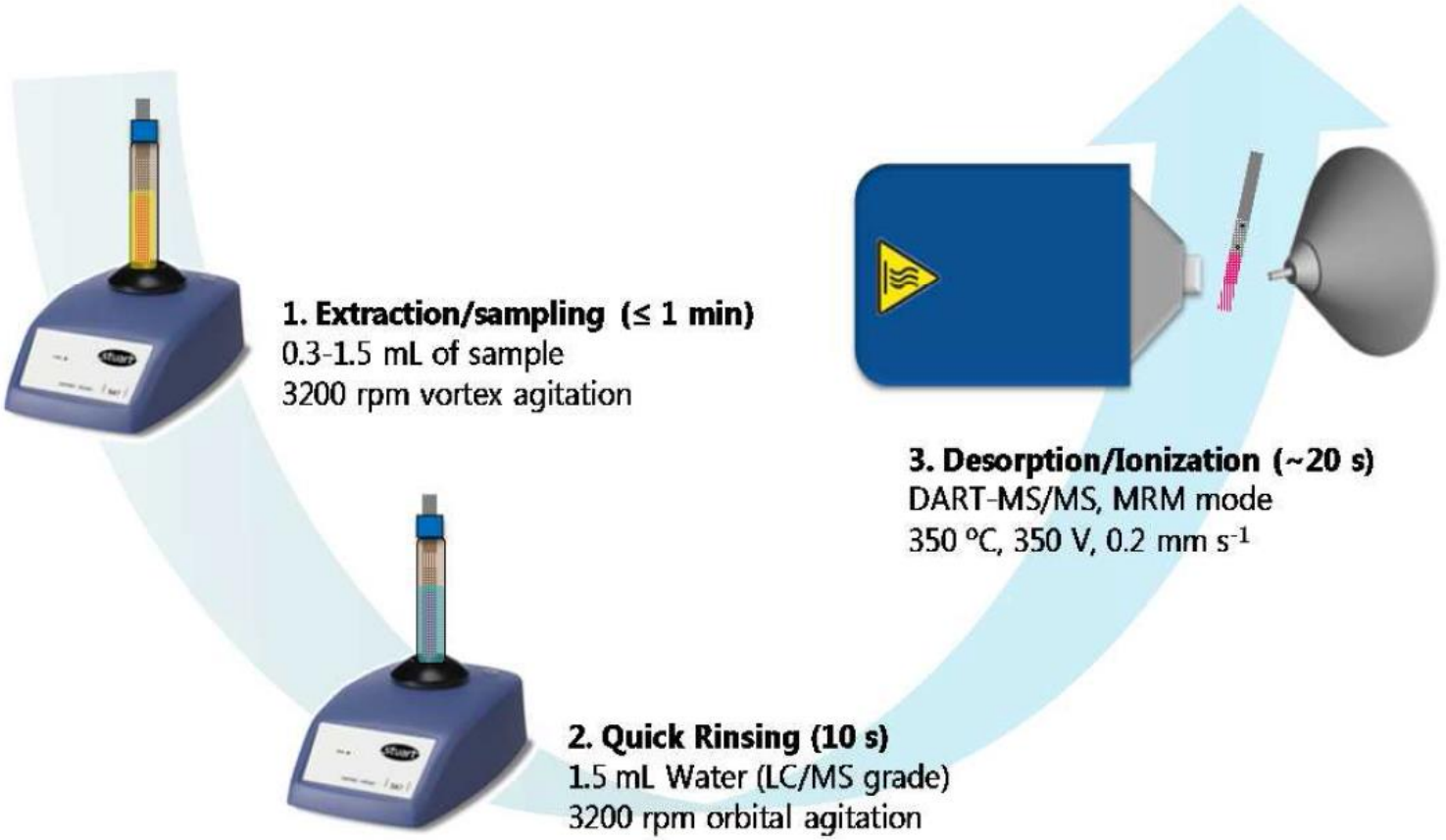


Figure S10 A. SPME-TM configuration for individual extractions and **B.** SPME-TM 12-strips configuration for high-throughput analysis using 96-Concept autosampler (PAS Technologies) [1].

*Germán Augusto Gómez-Ríos and Janusz Pawliszyn**
ChemComm 2014

SPME-TM-DART 高灵敏度DART定量



Scheme 1 Experimental set up for SPME-TM extraction from complex matrices and desorption/ionization using DART-MS/MS.

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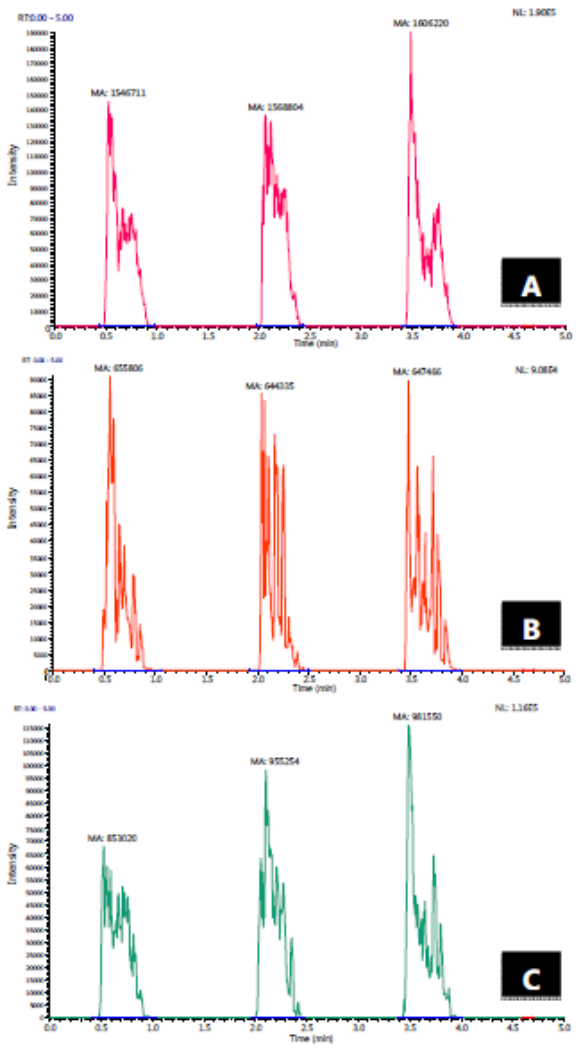
SPME-TM-DART 高灵敏度DART定量



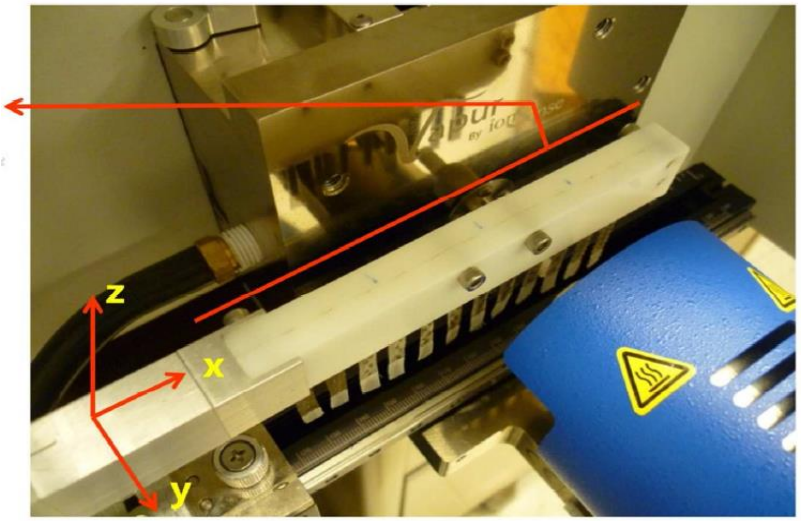


Figure S9 Ion chronograms of three controlled substances: heroin (**A**),propranolol (**B**), and stanozolol (**C**). 1 min extractions were performed using vortex agitator set-up at maximum speed (3200 rpm). Simultaneous extraction from 1.5 mL of PBS spiked with20 ng mL-1of 21 substances described on **Table S2**. Analyses were performed using a Thermo TSQ on MRM mode.

*Germán Augusto Gómez-Ríos and Janusz Pawliszyn**
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SPME-TM-DART 高灵敏度DART定量

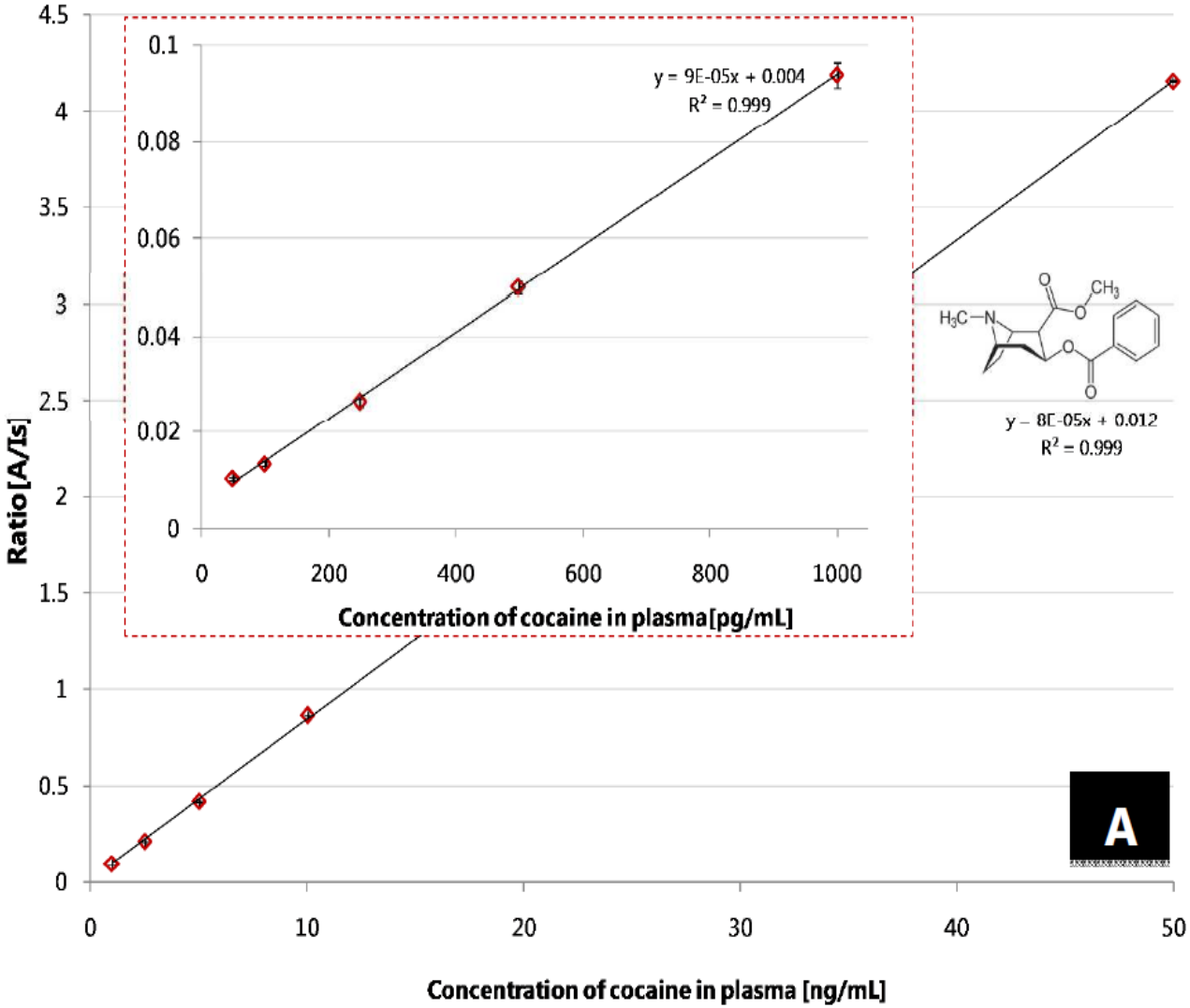

Figure S7-1 A. Quantitative analysis of plasma spiked with cocaine (50 pg mL-1 to 50 ng mL-1) and its isotopomer [D3] cocaine (12 ng mL-1). **B.** Quantitative analysis of urine spiked with cocaine (50 pg mL-1 to 50 ng mL-1) and its isotopomer [D3] cocaine (12 ng mL-1).

*Germán Augusto Gómez-Ríos and Janusz Pawliszyn**
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#	Compound name	Log P	Parent ion (m/z)	Product ion (m/z)	S-lenses	Collision energy	Polarity	LOD* (ppt)
1	Amphetamine	1.76	136.099	91.114	17	36	+	112
2	Methamphetamine	2.07	150.112	91.120	19	45	+	20
3	Nikethamide	0.33	179.100	108.102	18	76	+	17
4	Salbutamol	0.64	240.143	148.103	18	59	+	1474
5	Propranolol	3.48	260.123	116.138	17	89	+	31
6	Metoprolol	1.60	268.140	116.146	18	94	+	108
7	Trenbolone	2.27	271.133	165.106	56	97	+	31
8	Clenbuterol	2.61	277.068	203.049	15	70	+	13
9	Testosterone	3.32	289.157	97.123	21	91	+	10
10	Exemestane	3.70	297.173	121.118	19	72	+	17
11	Codeine	1.20	300.105	152.092	64	104	+	46
12	Cocaine	2.30	304.142	182.173	18	87	+	2
13	Bisoprolol	2.14	326.160	116.135	17	102	+	45
14	6-acetylmorphine	0.42	328.126	165.092	37	122	+	21
15	Stanozolol	5.53	329.229	81.108	44	130	+	22
16	Strychnine	1.93	335.155	184.129	36	136	+	33
17	6-acetylcodeine	2.08	342.124	165.092	45	165	+	7
18	Formoterol	2.20	345.133	121.090	32	85	+	831
19	Heroin	1.52	370.133	165.097	48	119	+	13
20	Toremifene	6.80	406.210	72.167	24	108	+	42
21	GW501516	6.29	454.091	257.068	29	108	+	352

Table S3MS/MS parameters used for the analysis of 21 WADA controlled substances in positive mode, as well as instrumental response of C18-PAN SPME-TM tandem mass spectrometry analysis. Integrated peak area obtained for a 20 ng mL-1 solution in PBS. Average peak area (n=3). LOD*, limit of detection estimated.

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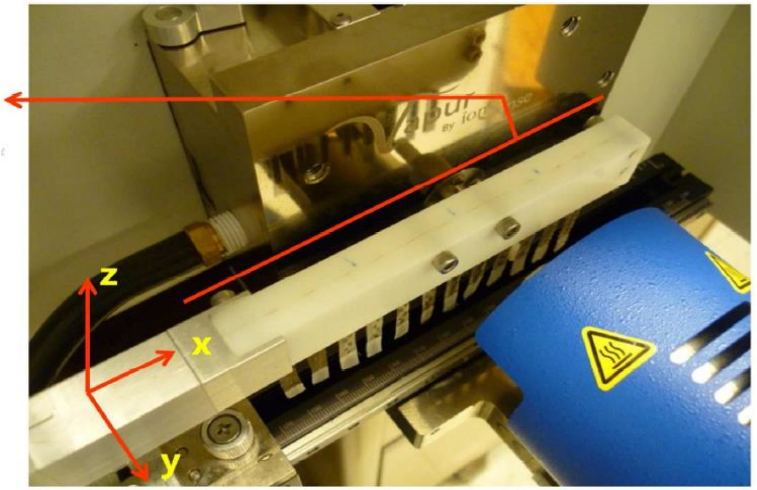
Summary 总结



Direct Analysis in Real Time
DART 原位电离与实时直接分析

- **2-3 sec analyses time** 几秒钟定性定量
- **Fully automated** 自动、高通量
- **No sample prep** 无需样品制备
- **Nondestructive** 非接触、无损分析
- **Solvents friendly** 无溶剂效应
- **Salts compatible** 耐盐、无基质效应
- **Universal Ionization** 广谱、中能量电离

Sensitive and Quantitative DART-MS
高灵敏度的 SPME 结合 DART 定量分析

- **3 min per sample** 几分钟定量
- **<5% RSD** 高通量、高精度
- **10-100 ppt LLOD** 检出下限在 ppt 级别
- **3-5 Orders Linearity** 线性范围宽
- **Compatible with all MS** 兼容
- **Comprehensive** 应用范围广谱
- **Simple and Fast** 实施简便、分析快速