Supporting Information

Mini 12, Miniature Ambient Mass Analysis System for Clinical and Other Applications – Introduction and Characterization

Linfan Li[1], Tsung-Chi Chen[1], Yue Ren[1], Paul I. Hendricks[2], R. Graham Cooks[2*] and Zheng Ouyang[1,3*]

1. Weldon School of Biomedical Engineering, Purdue University, West Lafayette, IN 47907, USA
2. Department of Chemistry, Purdue University, West Lafayette, IN 47907, USA
3. Center for Analytical Instrumentation Development, Purdue University, West Lafayette, IN 47907, USA

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*Corresponding Authors:

Zheng Ouyang Weldon School of Biomedical Engineering Purdue University, West Lafayette, IN 47907 Email: Ouyang@purdue.edu Phone: 765-494-2214	R. Graham Cooks Department of Chemistry Purdue University West Lafayette, IN 47907 Email: Cooks@purdue.edu Phone: 765-494-5263

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1. User interfaces

Two versions of user interface have been designed and developed in-house: one allows tuning of the instrument, setting up scan functions and data acquisition at any level of complexity, while the other allows simple operation by end-users.

In the expert user interface, shown below, operators have access to and can configure all parameters of the system, including settings of multiplier, dynode, ionization source, PID controller, AD/DA converters, noise filters, etc. Scan functions including the signal sequences of the RF, the AC (including SWIFT and ion excitation for MS/MS), and end-cap potentials are also controllable through the expert user interface. The recorded spectra, shown at the bottom of the screen, can be submitted for storage or further processing.

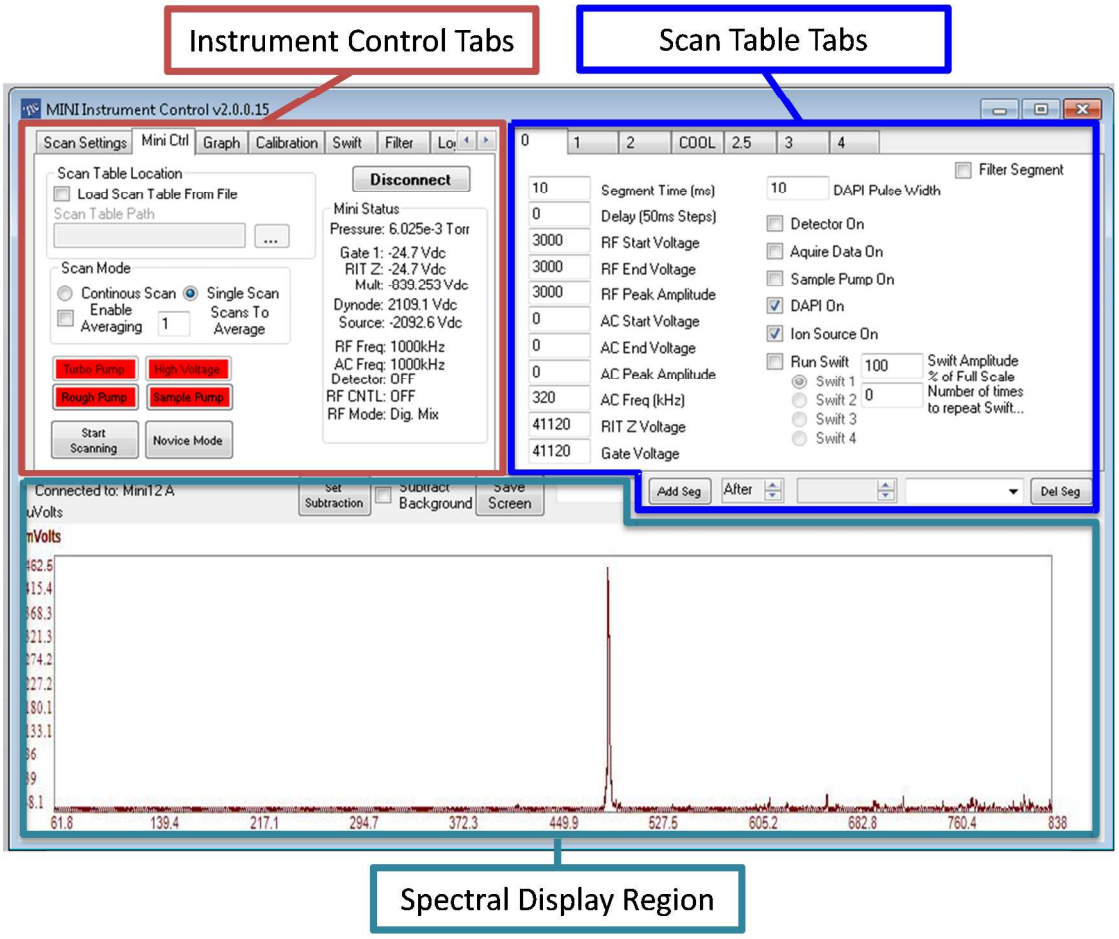


Figure S1. Expert user interface is designed for calibrating and tuning the system and visualizing and storing data.

To use the novice interface, the user does not need a detailed knowledge of the operation of ion traps or any training in interpreting mass spectra or processing MS information. The simplified operational protocol shown below allows a fast, accurate analysis report without the necessity of configuring the mass spectrometer or interpreting the mass spectrum.

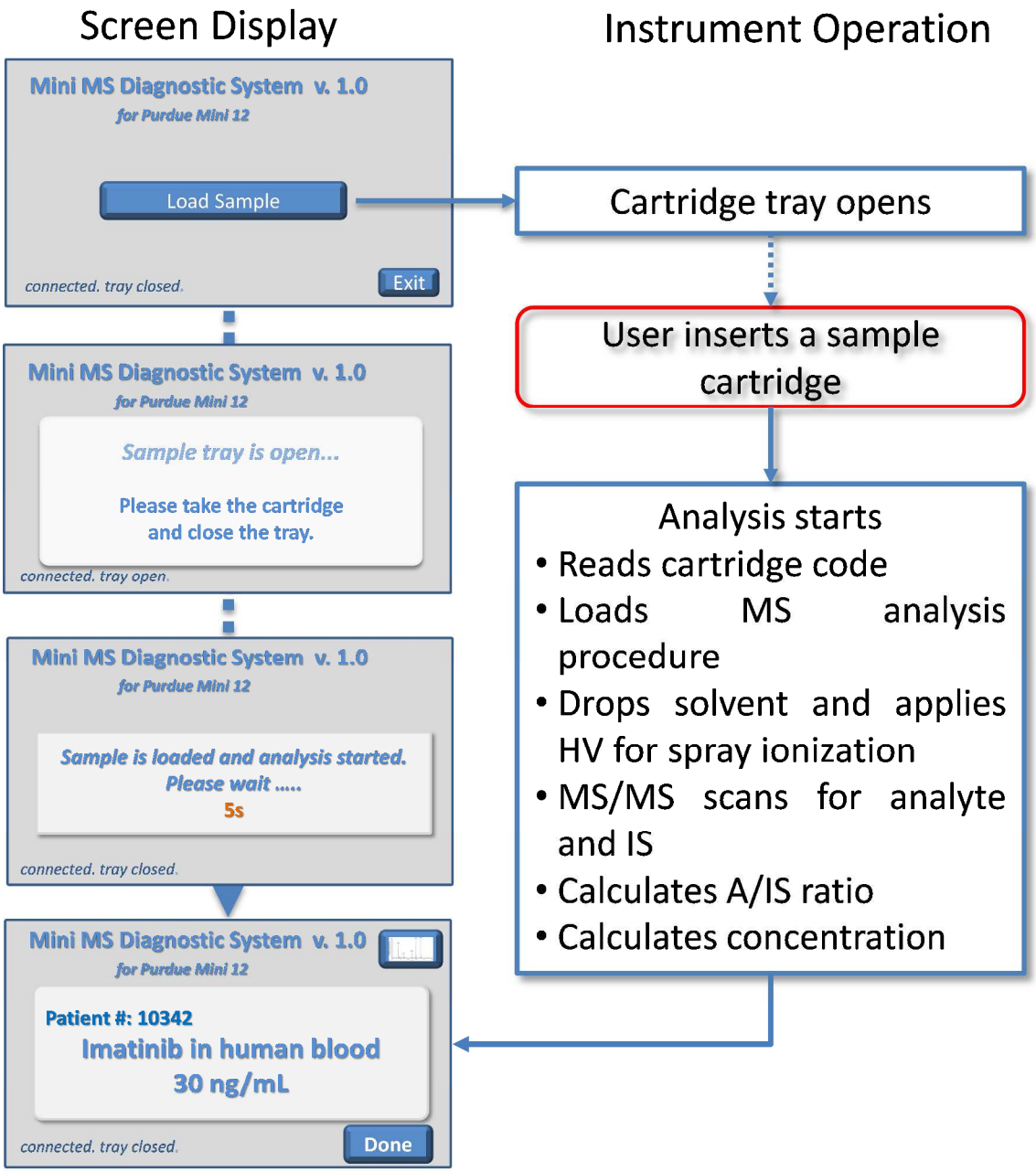


Figure S2. Work flow of novice user interface that is designed for simplified operational control.

2. Paper spray and extraction spray

In paper spray analysis, 2.5 µL of crude sample was deposited onto the paper substrate using an IS coated capillary sampler. After air-drying (for times up to 2 hr, depending on the sample) 40 µL methanol was applied to the paper to elute compounds from the matrix followed by application of a high voltage of 4.3 kV to the paper substrate for ionization.

In extraction spray analysis, 1 µL of sample was applied to a paper strip (Whatman grade 1, length 10 mm, width 0.6 mm), which was inserted into a nanoESI tube made from borosilicate glass in-house. After air drying (for up to 30 min) 5 µL methanol was added into the glass tube and a high voltage of 1.8 kV was applied to the electrode for chemical elution and ionization.

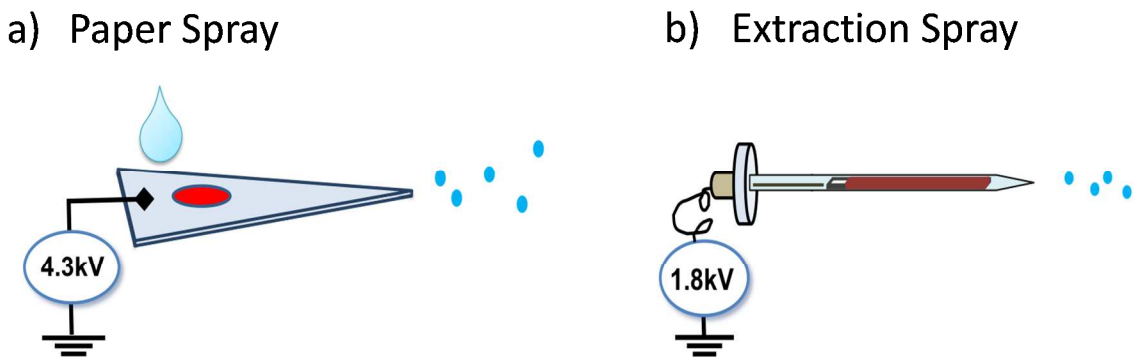


Figure S3. Paper spray and extraction spray showing a) sample on paper substrate with added solvent and the generation of a spray at the paper tip and b) sample on paper to which solvent is added with spray being generated from a conventional emitter tip

3. MS/MS analysis

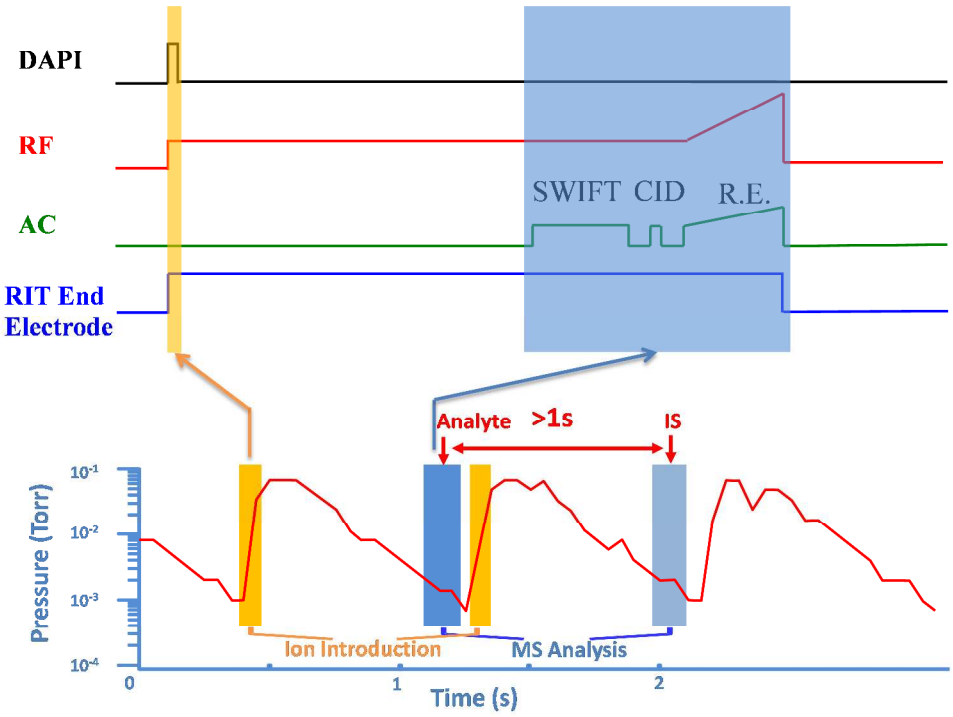


Figure S4. Scan function for MS/MS analysis. RF trapping signal and end electrode potentials were turned on to trap ions during the DAPI opening of about 15 ms, when the pressure in the manifold increased to several hundred millitorr. After the DAPI was closed, the pressure decreased over several hundreds of milliseconds to below 10 mtorr, where MS or MS/MS could be performed. For MS/MS analysis, a SWIFT signal with calculated frequency notch(es) was applied for ion isolation followed by an excitation AC signal for collision induced dissociation (CID). Subsequently, an RF scan with a resonance ejection was performed at ~1mTorr to acquire a mass spectrum of the product ions.

The trapping RF voltage was set to be ~800 Vp-p while the potentials on the end cap electrodes was typically 50 Vdc. A SWIFT isolation was performed in with an amplitude of ~2 Vp-p (varying 30% depending on the m/z values). The dipolar AC excitation for CID was applied for 40 ms with an amplitude in a range of 1.5 Vp-p to 3.5 Vp-p. Resonance ejection was facilitated with a dipolar AC of 350 kHz its amplitude being ramped from 1.5 Vp-p to 5 Vp-p.

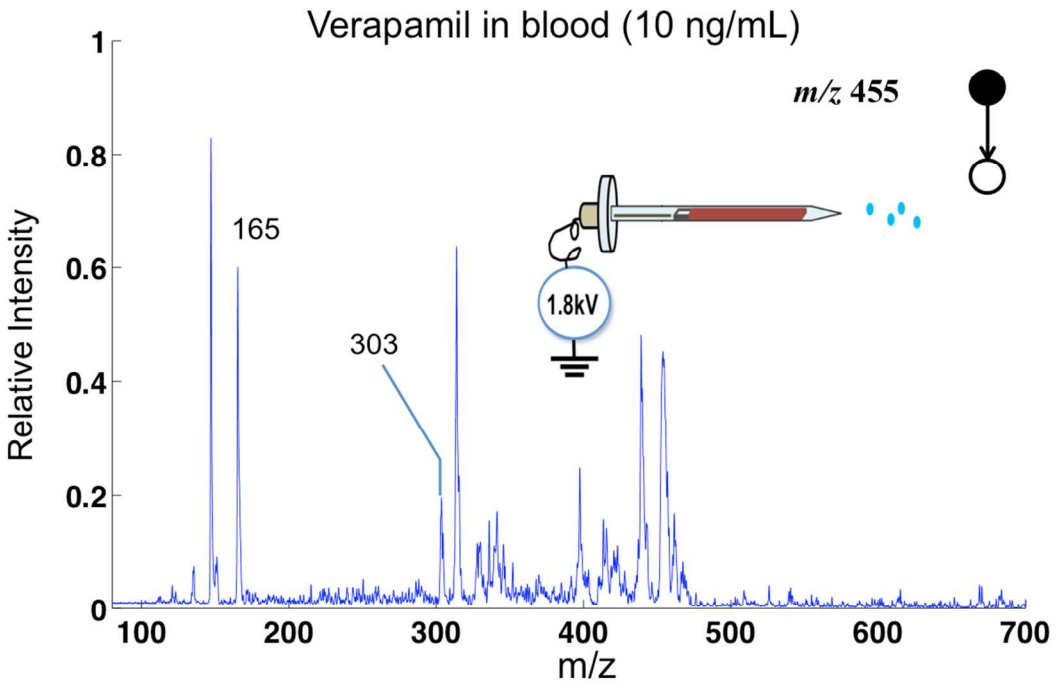


Figure S5. MS/MS spectra of 10 ng/ml verapamil in blood recorded with extraction spray ionization.

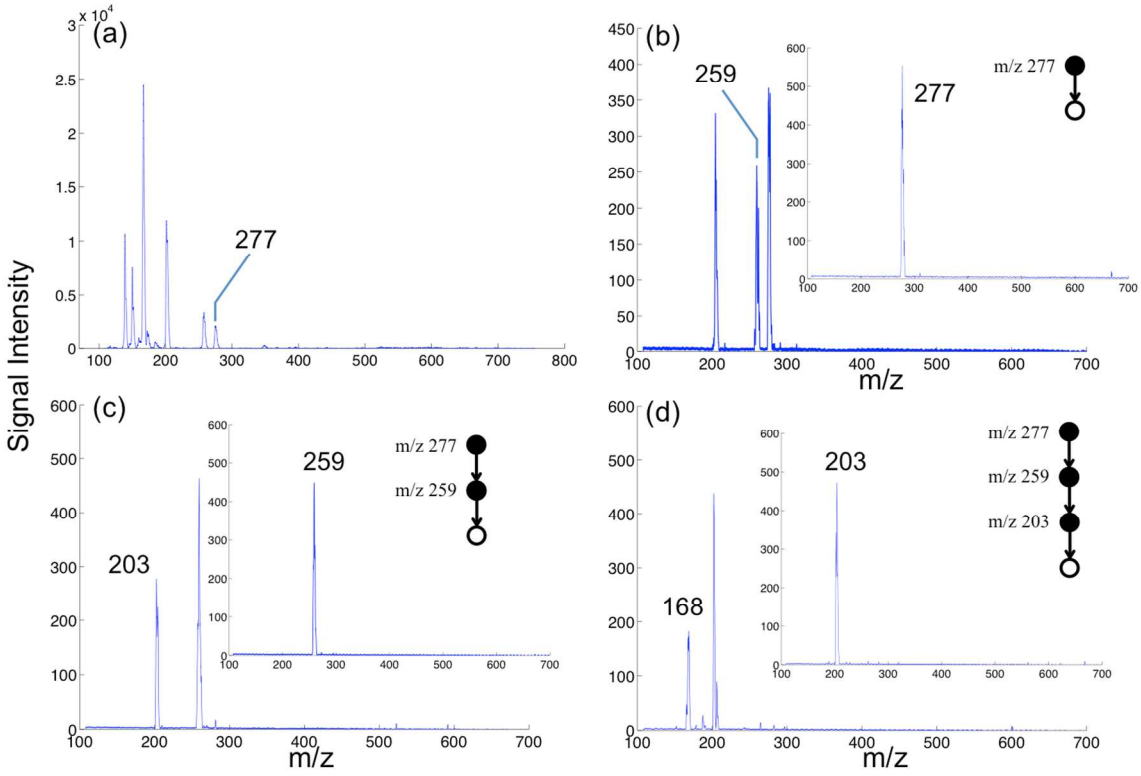


Figure S6. NanoESI/MS^4 study of clenbuterol (20 ppm in MeOH/H_2O) performed using the Mini 12 system. (a) Ions at m/z 277 $[M+H]^+$ were identified, isolated, and submitted for (b) MS^2 . Sequential product ion mass spectra for the subsequent stages (c) MS^3 and (d) MS^4 were each recorded on single ion populations. An average of five scans was combined for the spectra presented here.

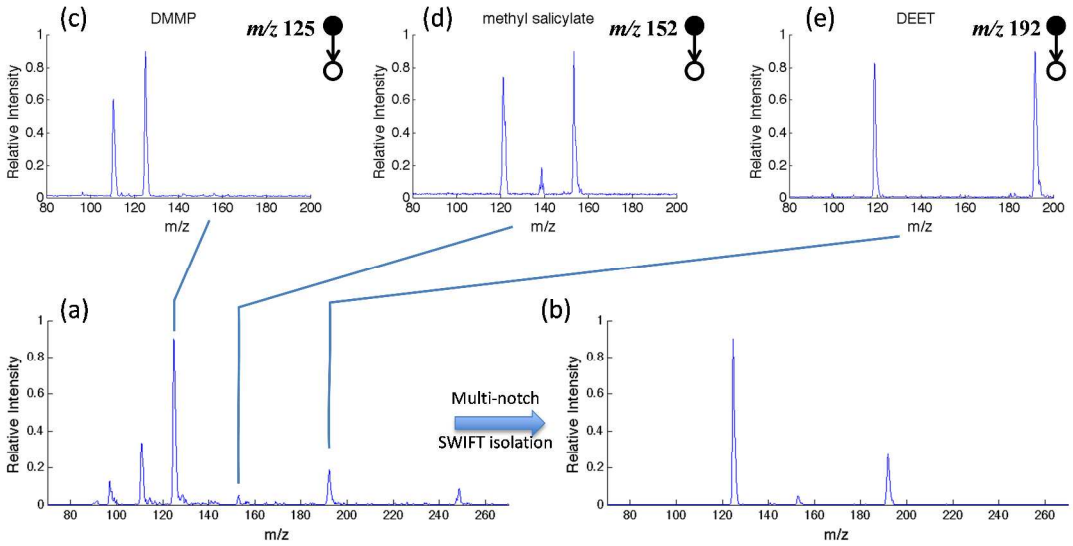


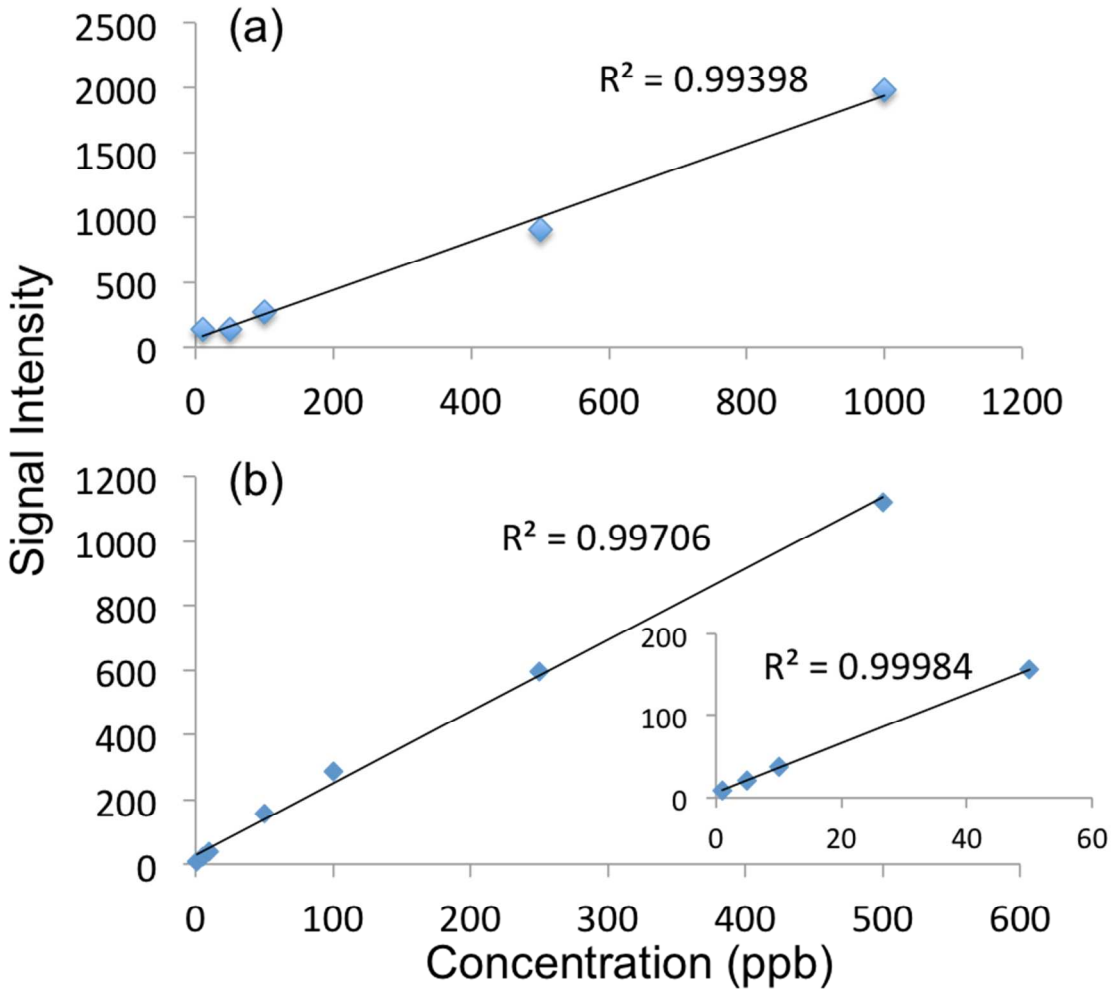
Figure S7. a) Gas sample containing vapors of dimethyl methylphosphonate (DMMP), methyl salicylate, and N,N-diethyl-meta-toluamide (DEET) was ionized by APCI and mass analyzed using Mini 12. b) SWIFT waveform, from 50 kHz to 500 kHz, with three notches at 187 -194 kHz, 150 -157 kHz, and 116 -123 kHz, was applied to isolate the three targeted precursor ions. c-d) Each of these three ions could also be individually isolated and fragmented via CID to produce MS/MS spectra. Dipolar excitation for 40 ms at an amplitude of 1.5 V_{p-p} and frequencies of 190 kHz, 153 kHz, and 119 kHz was applied for CID of DMMP, methyl salicylate, and DEET, respectively.

4. Quantitative analysis

In the process of collecting data for the calibration curve in Fugre 5d, three samples were prepared for each concentration, 50 pairs of scans were recorded for each sample and used to calculate the average ratio of amitriptyline/amitiptyline-d6 shown below.

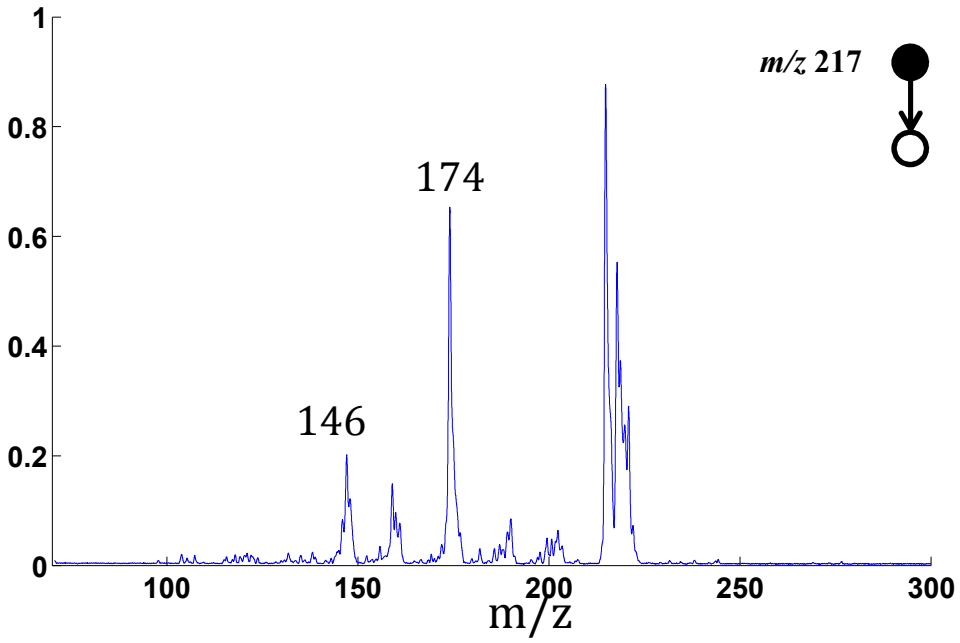
Table 1. Average ratio of amitriptyline/amitriptyline-d6 and the corresponding concentrations in generating calibration curve shown in Figure 5d.

Concentration of Amitriptyline (ng/mL)	7.5	15	60	120	210	510
Average Ratio of Amitriptyline/Amitiptyline-d6	0.367	0.483	0.666	0.952	1.32	2.59



S8. Quantitative analysis (without an internal standard) (a) Pure verapamil ionized using nanoESI and the product ion m/z 165 plotted against amount of analyte. (b) Fungicide thiabendazole in tomato homogenate ionized using paper spray and the product ion m/z 175 plotted against amount of analyte in the mixture.

5. Analysis of environmental and miscellaneous samples



S9 Mass spectrum of 50 ng/ml atrazine in river water recorded with extraction spray ionization and showing the products of ions with m/z 217