Implementation of DART and DESI Ionization on a Fieldable Mass Spectrometer

Mitch Wells, Mike Roth, Garth Patterson

Griffin Analytical Technologies, LLC
West Lafayette, IN

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NEW THREATS. NEW THINKING.
Griffin - Overview

Timeline:
- Founded in 2001
- Partnered with ICx Technologies in 2006

Griffin’s Location:
- Purdue Research Park
  West Lafayette, IN USA

Size:
- 10,800 Square Feet
- 41 full time plus 6 part time
- 2/3 staff is technical (scientists and engineers)

Technology:
- Fieldable Mass Spectrometers
- Flexible Inlet Technologies
- Sophisticated Software
Griffin Analytical makes fieldable mass spectrometers for the accurate identification of known and unknown chemical threats.

How can the products be used?

- Force protection
- DoD operations
- Hot zone deployment
- Terrorism threats
- Urban air monitoring
- Environmental monitoring and analysis
- Mobile laboratories
- Site assessments and remediation
- Real-time monitoring
- Emergency response
- Petrochemical troubleshooting
- Quality assurance
- Application and method development
- Research & teaching tool
Griffin Sample Inlet Technology

Ambient Sample – solid, liquid, or vapor at atmospheric pressure (760 Torr)

New Developments: Atmospheric Pressure Ionization

Low Thermal Mass GC

Direct SPME

Direct Leak

MS Vacuum Environment – $1 \times 10^{-4}$ Torr
Griffin R&D projects

- External Ionization – Atmospheric Pressure Ionization
- Alternative to GC for sample introduction to the MS
- Direct sampling and ionization of components in liquids, on surfaces, etc.
- Explosives detection applications
- Premium class on-site bioanalytical applications
- Requires an API interface for the MS

*Electrospray ionization (ESI)*

*DESI*

*DART*
Griffin API Interface

Three stage vacuum system

First Vacuum Region

Second Vacuum Region

Third Vacuum Region

Ion focusing lenses

octapole

capillary

skimmer

~8 cm

~20 cm
Griffin API Interface

Three stage vacuum system

Atmosphere
~150 mL/min

First vacuum region
~700 mTorr

Second vacuum region
~10 mTorr

Mass spectrometer high vacuum
2 x 10^{-4} Torr (He)

Alcatel MDP5011 drag pump

Main port

Pfeiffer TMH071

Auxiliary port

KNF 813.4

KNF N920

~8 cm

~20 cm
Griffin API Interface

First vacuum region

Ion sampling capillary
Tubular focusing lens
Ion sampling orifice

[Diagram of the Griffin API Interface with labeled components: lens, sampling orifice]
Griffin API Interface

Second vacuum region

Octapole ion guide with Ardara RF supply
**Griffin API Interface**

**Third vacuum region**

![Diagram of the third vacuum region showing lens 1 stopping curve and experiment vs. SIMION injected count.](image)

**Lens 1 Stopping Curve**

Experiment vs. SIMION Injected Count

- **m/z 186 Arb Peak Height**
  - Experiment
  - SIMION 6eV, Injected

![Graph showing lens 1 voltage against m/z 186 injected count.](image)
Griffin API Interface

Third vacuum region - RIT simulations
Griffin API Prototype Instrument

Mass $\approx 45$ kg
Electrospray of drug mixture standard

- Methamphetamine (M+H)^+
- Cocaine (M+H)^+
- Heroin (M+H)^+
Griffin ESI - Myoglobin
Electrospray of dimethyl methylphosphonate (DMMP)
Calibration Curve for DMMP

Griffin ESI - CW Simulants

LOD ~ 20 ppb

DMMP concentration (ppb)

abundance (arb. units)
Griffin and DART

Direct Analysis in Real Time (DART)

TNT detected from fingerprints

Nitroglycerine detected on a necktie
Griffin and DART

IonSense DART source on the Griffin API prototype
Griffin and DART

DART MS of Altoid Mints

- Cinnamon
- Spearmint
- Peppermint
- Wintergreen
Griffin and DART

Ibuprofen Tablet

- Negative Ion Mode
- Positive Ion Mode

207 Da
205 Da

100 120 140 160 180 200 220 240 260 280 300

m/z
Methyl Salicylate Vapors

- **Negative Ion Mode**
- **Positive Ion Mode**

![Graph showing mass spectra for Methyl Salicylate Vapors with peaks at 151 Da and 153 Da.](image)

$m/z$ range: 75 to 215
DNT Film on Glass Rod

- Negative Ion Mode
- Positive Ion Mode

181 Da
183 Da

m/z
Griffin and DART

Detection of TNT on Paper
Desorption Electrospray Ionization (DESI)

RDX detected on a suitcase handle
Griffin and DESI - Drugs of Abuse

DESI of methamphetamine spotted onto a glass slide

Prosolia OmniSpray® Source on Griffin API prototype

methamphetamine (M+H)^+
Griffin API future directions

**Next prototype**
- Installed in a 400 case
- Improved pumping
- Improved ion transmission and trapping
Griffin API future directions

Miniaturized DART gun and controller

- smaller form factor gun
- 24 V operation
- Optimized for nitrogen
- single PCB controller
- Includes Gas/Ion Separator
Conclusions

- Griffin has field portable GC/MS/MS and direct-sampling MS/MS systems for homeland security applications
- Development of atmospheric pressure sampling systems are underway to leverage novel new ionization sources
- A mobile API-equipped instrument has been constructed
- Preliminary data with ESI, DART, and DESI have been acquired for a variety of compound classes
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