

# CHEMICAL, BIOLOGICAL, AND EXPLOSIVE SENSORS FOR FIELD MEASUREMENTS

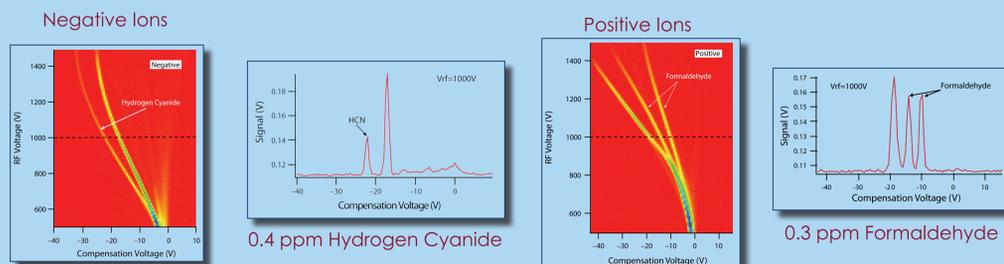
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Special Technologies Laboratory (Operated by National Security Technologies, LLC, for the U.S. Department of Energy)



## CHEMICAL DETECTION: TICs

DMS-TIC Concept: Differential mobility spectrometry (DMS) provides greater selectivity for the detection of trace (ppb level) gas-phase chemical species. Toxic industrial compounds (TICs) require smart-sampling approaches integrated into situational operations-management software for First Responder applications. Using microchip, ion mobility-based “ADS” sensor motes in mesh networks for real-time alarms, followed by complete verification analyses within 15–300 seconds by fGC/DMS, minimizes false positives and false negatives.



TIC	IDLH (ppm)	TLV (ppm)
Hydrogen cyanide	50	4.7
Cyanogen chloride	20	0.3
Chlorine	10	0.5
Ammonia	300	25
Ethylene oxide	800	1
Aniline	3	0.005
Formaldehyde	25	0.3
Acrolein	2	0.1
Acrylonitrile	85	2
Phosgene	2	0.1
Sulfur dioxide	100	2
Hydrochloric acid	50	5
Bromomethane	250	1

45 Component Analysis by fGC/DMS

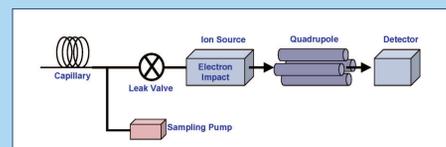
### NOTES FOR TICs, EXPLOSIVES, AND CWA

Enabling CBE Sensor Technology

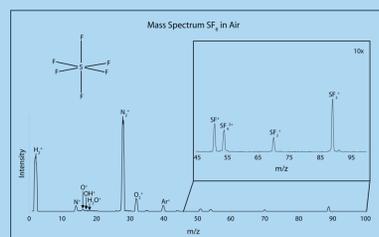
- Sensor mote networks for remote monitoring
- Monitoring/verification analysis concept



## DMS/MASS SPECTROMETRY

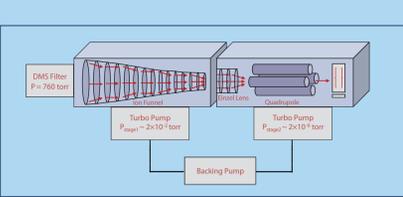


Direct Air Sampling MS

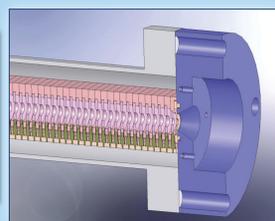


Monitoring With Direct Air Sampling MS

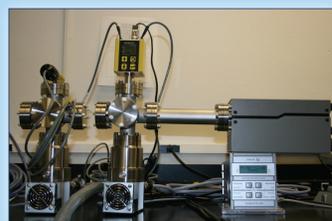
Field DMS/MS Concept: Coupling a DMS, as an ion filter, to an MS generates a powerful tool for enhancing the overall MS performance. Target compounds are separated from complicated mixtures in milliseconds. Modern fast GC columns still require times of 10–300 seconds. Additionally, sweeping the DMS “filtration voltage” allows “real-time” separation, or components enter the MS at different times, generating individual, time-separated mass spectra for identifying multiple analytes. DMS provides direct atmospheric sampling, vastly simplifies the mass spectra, and provides chemical information based on ion shape.



DMS/MS Schematic



Ion Funnel



Prototype DMS/MS

### SPECIAL TECHNOLOGIES LABORATORY INSTRUMENTAL DEVELOPMENT GOALS

- Handheld, field-portable MS
- Real-time analysis
- High selectivity
- Trace detection
- Direct-air smart sampling

## GROUND TRUTH DIAGNOSTICS FOR TEST AND EVALUATION

Spiral Development of R & D



Plume Modeling



Recent Chem/Bio Events at NTS



Autonomous Cueing



Systems Integration



Event Scenarios



Open Air Bio-aerosol Releases for Instrument T&E and Training Exercises

### OPEN AIR BIO-AEROSOL T&E

Open air bio-aerosol releases for instrument T&E and training exercises  
Application: Aerosol releases for field testing of new biodetection equipment, training exercises, and decontamination procedure testing

- Dry and wet aerosol releases of Biosafety Level 1 organisms
- Ground truth field diagnostics for real-time plume monitoring
- Air sampling and microbiology facilities for post-test release analysis

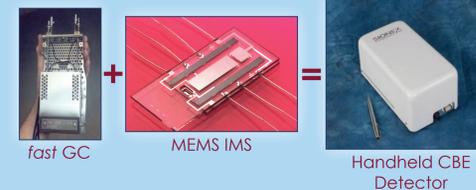
## EXPLOSIVES DETECTION

HAVES Concept: Handheld alert/verify explosives systems (HAVES) are required for noninvasive, situational-awareness monitoring for IEDs. An earlier project successfully utilized fast gas chromatography (fGC) + DMS to rapidly separate and detect triacetone triperoxide (TATP), implicated in the Shoe Bomber and Heathrow Airport events. Continuous monitoring with DMS plus verification analysis using fGC/DMS can be integrated into smart sampling systems with receiver operator characteristic (ROC) curve data analyses for field programmable operations in a variety of remote monitoring and networked sensing scenarios.

PROBLEM: IEDs, SPECIFICALLY TATP\*

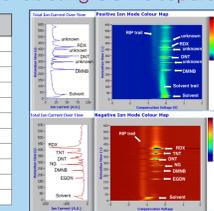
APPROACH: SMART FIELD MONITORING AND CBE VERIFICATION SYSTEM

SOLUTION: ENABLING TECHNOLOGIES



EXPLOSIVE/MARKER	~ SATURATED HEADSPACE CONC
TATP	1000 ppm
HMTO	500 ppm
EGDN	200 ppm
2-MNT (TNT marker)	130 ppm (100 ppb)
DMNB (Semtex marker)	2 ppm (40 ppb)
NG	340 ppb
2,4-DNT (TNT marker)	500 ppb (10 ppb)
TNT	~ 1 ppb
PIETN	~ 10 ppb
BDX	~ 10 ppb
HMX	< 1 ppb

Identifies and Detects TATP Used in IEDs at Trace Levels Using GC Pre-separation



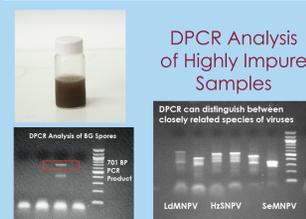
\*Sponsor: DOE IN-1 Applied Technology Program; Monitor: DHS Office for Bombing Prevention

## DIRECT POLYMERASE CHAIN REACTION (DPCR)

Direct PCR analysis of highly contaminated samples without sample purification  
Application: PCR analysis of airborne particles  
Viral and bacterial analysis

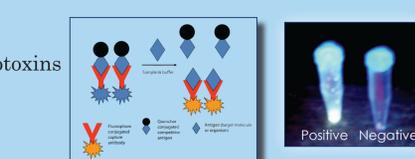
- PCR performed on samples collected “as is”
- No requirement for lengthy purification steps
- Amenable to real-time PCR analysis

## BIO THREAT DETECTION



DPCR Analysis of Highly Impure Samples

DPCR can distinguish between closely related species of viruses



DPCR Analysis of BG Spores

LdMNPV HtzSNPV SeMNPV

## ONE-STEP IMMUNOFLUORESCENT ASSAY

One-step immunoassay requiring no sampling washing steps  
Application: Rapid response immunoassay for bacteria and biotoxins

- Simplified field use
- No additional reagents required
- Just add buffered solution of sample and let develop

### SPECIAL TECHNOLOGIES LABORATORY BIOSENSOR R&D GOALS

- Provide technical solutions to nontechnical users
- Simplify bioassay/collection procedures to one-step processes
- Minimize liquids and reagents