Instantaneous Detection of Particles Liberated by Open Detonation Treatments

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The Idea:

This project supports DAC’s effort to increase efficiency of operations.

Open burn and detonation treatments release aerosol particles:
- Characterize the particles generated
- Track these particles in the environment
  - On range
  - Fencelines
  - Residential areas
**SPAMS Data**

1. **B. atrophaeus spore size distribution**
   - Effectively monodisperse.
   - Ultimate detection limit is a single particle

2. **UV-LIF B. atrophaeus**
   - 266nm excitation
   - “threat region”

3. **Mass spectrum of single B. atrophaeus (B. globigii) spore**
   - Dipicolinic Acid
   - Intensity (Arbitrary Units)
   - Mass spectrum showing peaks at m/z values like +23, +39, +40, +74
Proving the Concept

LLNL Site 300, Bunker 850
Site 300 Background/Post Shot

[Graph showing various ions and molecules such as Na+, K+, NO3-, NO2-, NH3-, NH2-, Na3SO4+, Na2NO3+, Fe+, W+, and WO3+, WO4+ with their corresponding masses and envelopes marked.

- Na+
- NO3-
- NO2-
- NH3-
- NH2-
- Na3SO4+
- Na2NO3+
- WO3+
- WO4+
- Fe+
- W+]

[Reference: 8/3-Shot5-1056]
The BAMS at HEAF

150 g TNT and LX-17 charges.
Comp B, 0.9 mJ/Pulse

“Lucky Shot”

[TNT-NO$_2$-CH$_4$]$^-$

HPO$_2^-$ CNO$^-$

-187

-103 -59 NH$_2^-$ -19 Na$^+$

+56

[RDX-O]$^+$

Na$^+$

N$^{++}$
LX-17, Decreasing Laser Power

Average, 0.8 mJ/pulse

9/16-Shot1-Average0:155

[TATB-H]^-
[TATB-NH_3]^-
[TATB-NH_3-O]^-
[TATB-NH_3-O-H_2O]^-

50 100 150 200 250

C_2H_3^+
+43
+70

Na^+
C^+
CN^-
HCNO^-

Average, 0.22 mJ/pulse

9/16-Shot1-Average270:320

[TATB-H]^-
[TATB-NH_3]^-
[TATB-NH_3-O]^-
[TATB-NH_3-O-H_2O]^-

50 100 150 200

C_2H_3^+
+43
+70

Na^+
C^+
CN^-
HCNO^-

Average, 0.11 mJ/pulse

9/16-Shot1-Average421:470

[TATB-H]^-
[TATB-NH_3]^-
[TATB-NH_3-O]^-
[TATB-NH_3-O-H_2O]^-

-300 -200 -100 0 100 200 300

C_2H_3^+
+43
+70

Na^+
C^+
CN^-
HCNO^-
Expanding the Library: Explosives

TNT  Nitro Guanidine (NQ)  HMX  PETN

[Images of chemical structures]

Ion Signal vs. Mass-to-Charge Ratio

- TNT
- [TNT-H]-
- [TNT-NO]−
- NO₂⁻
- CN−
- CNO⁻
- NO⁺
- Na⁺
- K⁺
Field Testing

• ONLY QUALITATIVE DATA
• TEAD
• 800 lbs NEW
• Comp B/TNT
• 3 distances
  – 70 M
  – ~200 M
  – Fenceline
Plumes
Identified Soil Particles

Before Shot
- Nearfield: 12% Soil, 88% Other
- Midfield: 8% Soil, 92% Other
- Fenceline: 5% Soil, 95% Other

After Shot
- Nearfield: 30% Soil, 70% Other
- Midfield: 18% Soil, 82% Other
- Fenceline: 10% Soil, 90% Other

Legend:
- Blue: Soil
- Red: Other
Near Field Data: 70 Meters

- Background: 1456 Spectra over 21 minutes
- Shot Spectra: 1365 Spectra over ~2 hours
  - Different sampling inlet
- Major Clusters Present:
  - Soil, Soot, Ammonium Nitrate with Salts
Soot

Diagram showing various carbon compounds and ions, such as C6-, C5-C4-C3-C2-, C13, C12, C11, and C10-.
Other Background Particle Classes

Mass-to-charge ratio

Intensity (arbitrary units)

-150  -100  -50   0    50   100   150   200

NO_2^-  NO^-  NH_3^-  Na^+  KOH^+  NO^-  K^+  KOH^+

-150  -100  -50   0    50   100   150   200

NO_2^-  NO^-  NH_3^-  Na^+  KOH^+  NO^-  K^+  KOH^+

-150  -100  -50   0    50   100   150   200

NO_2^-  NO^-  NH_3^-  Na^+  KOH^+  NO^-  K^+  KOH^+
Near Shot Data: Before and After

Background Ambient
- Soot: 0%
- Soil: 27%
- Sodium/Potassium: 27%
- Potassium Nitrate: 12%
- Sodium Nitrate: 32%
- Other: 0%

Shot Spectra
- Soot: 6%
- Soil: 55%
- Sodium/Potassium: 3%
- Potassium Nitrate: 4%
- Sodium Nitrate: 6%
- Other: 3%
PAMS/BAMS/SPAMS 2.0 (!)
SPAMS 2.0 Design Changes

• Particle Focusing
• Two stages of fluorescence preselection
• Advanced Mass Spectrometer
• Improved Software
  – XML File Format
• Reduced footprint and weight!
The Aerosol Beam Can Be Aimed

- X
- Y
- θ

Tracking/sizing 150 μm beam

Pre-selection 150 μm beam

Laser direction

DI 400 μm beam
Preselection Increases Sensitivity
The Mass Spectrometer is 4x smaller

Vacuum chamber

Acceleration & steering
Drift
Reflectron
MCP Detector
SPAMS 1.5
B. Atrophaeus
1000 Spectra

SPAMS 2.0
B. Atrophaeus
1000 Spectra
The Files are Now in XML

- Self-documenting.
- User can decide what data to save.
- Extensible if instrument is improved in the future.
- Openable in most web browsers.

**Performances:**

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<th>Size</th>
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Conclusions/Future Research

• The concept of SPAMS for demil impact monitoring works.
• SPAMS 2.0 is at least comparable to SPAMS 1.X in all respects and better in most.

• Next Stop: Spartan Rocket Motor Demil Operation!
• We are seeking other applications for this technology. See me after the seminar!
Acknowledgements

• The BAMS Group at LLNL
• Tooele Army Depot
  – Keith Siniscalchi
  – Dave Ayala
  – Spencer Chamberlain
• The funding agencies:
  – DoD Office Of Munitions TCG-IX
  – Defense Ammunition Center
  – DARPA
  – TSWG
  – LLNL LDRD
  – DHS

This work was performed under the auspices of the U. S. Department of Energy by the University of California, Lawrence Livermore National Laboratory under Contract No. W-7405-Eng-48.