Innovation ... Delivered.

Development Toward the Large Scale Synthesis of TEX

Dr. Sarah A. Headrick
• Development of novel Insensitive Munitions (IM) is a top priority for the US government
  – IM materials respond only when specifically initiated
• IM materials are targeted to replace legacy materials such as RDX
  – RDX is not IM
  – RDX is environmentally unfriendly
• Novel IM material is TEX
  – Low solubility = environmentally friendly
  – Easily synthesized from inexpensive starting materials
    - Simple, two step process provides high producibility and low cost
  – Energy resultant mainly from caged chemical structure
    - High energy with low sensitivity

TEX is inexpensive, producible IM material of the future
A premier aerospace and defense company

### Performance Comparison

<table>
<thead>
<tr>
<th>Property</th>
<th>RDX</th>
<th>NTO</th>
<th>TEX</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density (g/cc)</td>
<td>1.82</td>
<td>1.91</td>
<td>1.99</td>
</tr>
<tr>
<td>VOD (ms/animation)</td>
<td>9045</td>
<td>8328</td>
<td>8683 (calc)*</td>
</tr>
<tr>
<td>Impact (ABL, cm)</td>
<td>3.5</td>
<td>N/A</td>
<td>33</td>
</tr>
<tr>
<td>Friction (lb/animation)</td>
<td>324</td>
<td>N/A</td>
<td>800</td>
</tr>
<tr>
<td>ESD (Joules)</td>
<td>0.22</td>
<td>0.91</td>
<td>0.43</td>
</tr>
<tr>
<td>Onset (°C)</td>
<td>234</td>
<td>270</td>
<td>300</td>
</tr>
</tbody>
</table>

*Calculated using Cheetah 3.0

**Excellent IM improvement over RDX**
Synthesis of TEX

Two step synthesis from glyoxal

- Completed on 2 and 10 g scale at AES
- Material hazards tested and characterized via DSC

<table>
<thead>
<tr>
<th>Hazards Test</th>
<th>TEX</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impact</td>
<td>51 cm</td>
</tr>
<tr>
<td>ABL Friction</td>
<td>210 lbs @ 8 ft/sec</td>
</tr>
<tr>
<td>ESD</td>
<td>0.025 J</td>
</tr>
</tbody>
</table>

TEX from facile, two step process
Clean, sharp exotherm peak indicates purity
TEX IR Spectrum

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High quality TEX

C-H

C-O-C

NO₂
- TEX compatibility tested with NTO, GuDN, NC, NG, RDX and NQ
  - Compatible with all materials

TEX has exceptional compatibility
Pilot Scale THDFP Flow Diagram

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Predictable, inert reaction
Pilot Scale TEX Flow Diagram

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Easy, fast nitration
Future Pilot Scale Synthesis

- TEX to be synthesized in AES’s new pilot plant
  - Built in 2008
  - Designed for manufacture of specialty materials
    - Explosive and inert
  - Air permitted
  - Sited for 10,000 lbs of explosive
  - 2 L to 100 gallon capacity reactors
    - Flexible configuration
  - Support buildings for additional storage
  - Conductive flooring throughout

Pilot Plant open and ready for business
Pilot Plant Safety Features

Separate control room allows for remote capability

- State of the art PLC system including 7 cameras
- Remote control of pumps, stirrers, heating, cooling, dump valves and two electrical outlets

- Loading dock for transporting materials
  - Provides minimal movement for sensitive materials
  - Eliminates need for heavy lifting
Flexible Facility

Small scale reactors move in and out

- Medium scale (10 and 20 L) on rolling stands

- Multiple heating, cooling, steam, vacuum, compressed air and ventilation connections

- Easily changes configuration

- Permitted for all kinds of processes

Flexible to fulfill customer needs
Support Utilities

• Large capacity storage
  – Acid storage tank
  – Vacuum receiver tank
  – Acid neutralization tank

• Glycol heating and cooling system

• Drown tank available for exotherms

All necessary utilities provided
Technical Results

TEX has been synthesized on small scale

- Quick, two step process
- Material characterized by DSC
- Material DSC compatibility tested with several materials
  - Compatible with those tested

• Future work to complete pilot scale synthesis of TEX
  - To be performed in AES new pilot plant
    - Construction completed in 2008
    - Fully equipped for energetic and non-energetic reactions (TEX and THDFP)

AES has manufacturing capability for excellent IM material
TEX is a novel IM material

- Inexpensive to produce
- Simple chemistry yields high producibility
- Quick reaction times yields fast manufacturing of production quantities

• AES Energetics Pilot Plant

- Fully constructed
- Exceeds all necessary industry safety standards
- Fully flexible for various operations
- All necessary utility support included