Characterization of Voids in an Insensitive RDX-based Nanocomposite Explosive

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Hongwei Qiu, Tsengming Chou, and Woo Y. Lee
Department of Chemical Engineering and Materials Science
Stevens Institute of Technology

Victor Stepanov, Ashok Surapaneni, and Anthony R. Di Stasio
Energetics, Warheads, and Environmental Technology
U.S. Army - Picatinny Arsenal

Shuang Zhang, Visualization Sciences Group
One-Step Manufacturing of Energetic Nanocomposite Granules

RDX/PVAc Nanocomposite Granule

Co-precipitation Confined within Shrinking Droplet

Droplet (High Explosive & other Dissolved in Solvent)

Spray Dryer
Granule Size and Size Distribution

20 μm

Histogram showing the size distribution of granules with diameter ranges from 0-5, 5-10, 10-15, 15-20, 20-25, 25-30, 30-35, 35-40, and >40 μm.
RDX Nanocrystals

200 nm

2 μm
Internal RDX Crystals
Uniform Distribution of Polymeric Binder
### Shock Insensitivity Improvement

- **RDX/PVAc or VMCC**
  - HE: 83%
  - Avg. size: ~15 μm

- **Pressing conditions:**
  - 32 ksi
  - Room temperature

- **Mechanism**
  - Elimination of large pores due to existence of nano RDX as well as intimate nanoscale mixing between RDX and polymer

#### Small Scale Gap Test
- Electric detonator
- Donor charge
- PMMA
- Acceptor charge (1.5g, Φ=5mm, L=5cm)
- Al Witness Plate

<table>
<thead>
<tr>
<th>Composition</th>
<th>Shock Sensitivity (GPa)</th>
<th>Density (g/cm³)</th>
<th>% TMD</th>
<th>Binder wt.%</th>
<th>HMX wt.%</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDX/PVAc (Spray Dried)</td>
<td>4.0</td>
<td>1.58</td>
<td>91.9</td>
<td>17</td>
<td>4</td>
</tr>
<tr>
<td>RDX/VMCC (Spray Dried)</td>
<td>3.3</td>
<td>1.62</td>
<td>92.5</td>
<td>17</td>
<td>9</td>
</tr>
<tr>
<td>4-μm RDX/VMCC (Slurry coated)</td>
<td>2.5</td>
<td>1.64</td>
<td>93.7</td>
<td>17</td>
<td>9</td>
</tr>
</tbody>
</table>
Focused Ion Beam (FIB)-SEM Characterization of Voids

3-D Model of Voids

FIB

Voids
Voids in Pressed Formulations
FIB Milled at -135° C

@ 20 nm Z-slice
Voids Reconstruction

Voids <0.001 μm³ were filtered out
Cross-sectional images collected by FIB-SEM at -135°C
Pressed Formulation of Nanocomposite Eliminates Large Voids

- RDX crystals are small (sub-micron)
  - Small internal voids
  - Small external spacing

- RDX crystals have a size distribution which can enhance particle packing during pressing

- Uniform mixing between RDX crystal and binder improves the filling of empty spaces during pressing
Conclusions

• A one-step process was developed for manufacturing RDX nanocomposite granules. Pressed formulation of the granules demonstrated significantly reduced sensitivity in SSGT test.

• The voids inside the pressed formulation were characterized using FIB nanotomography. The voids have an average size of ~250 nm. Volume, shape, and spatial distribution of the voids were also obtained.

• The superior shock insensitivity is attributed to the elimination of large voids, due to small RDX crystals and uniform mixing of binder and RDX in the nanocomposite granules.
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