Decreasing Shock Sensitivity by containing Nitramin

Particles with FOX-7 or FOX-12

Peter Gerber*, Thomas Heintz, Horst Krause
Fraunhofer Institut für Chemische Technologie

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* Contact: Peter.Gerber@ict.fraunhofer.de
Outline

- Motivation / Goals
- Fluidized Bed technology
- Particle Characterization
- Formulation of cast able explosives
- Gap – Test results
- Conclusion
- Future work
Particle-Coating: Fluidized bed technology

- Fluidized bed equipment:
  - Type Mycrolab (Hüttlin GmbH) ➔ Lab-scale
  - Type HKC 5 (Hüttlin GmbH) ➔ Field-scale
- Processing conception:
  - Modification suitable for processing oxidizers and explosives
Creation of composite particles consisting of HMX/Fox7 or HMX/Fox12

- Intention: Cost effective standard materials (e.g. HMX) as core (90%) + special and high pricing materials (e.g. Fox7 or Fox12) at the surface (10%).

- Production method: Fluidized bed technology

- Particles with core/shell- or mixed structure

Possible new applications:
- Production of insensitive Nitramines, e.g. for high explosives.
- Adding burn rate modifying substances to composite particles
Creation of composite particles consisting of HMX/Fox7 or HMX/Fox12

Requirement for fluidized bed technology: Coating material must be liquid resp. dissolved

Solubility of Fox 12 in several solvents

Temperature [°C]

Solubility [g Fox12 / g solvent]

dimethylformamide
water
acetone
ethanol
isopropanol
1-propanol
tetrahydrofuran
ethyl acetate
decane
Composite particles consisting of HMX/Fox12

HMX original:
Typ B Class 1
DDP04D0049E

HMX with 5 % Fox12

HMX with 10 % Fox12
Composite particles consisting of HMX/Fox7 and GAP

HMX original: Typ B

HMX with Fox7 / GAP

Light microscopy

SEM

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### Characterization of composite particles (overview)

<table>
<thead>
<tr>
<th>Sample</th>
<th>Mean particle size [µm]</th>
<th>Impact sensitivity [Nm]</th>
<th>Friction sensitivity [N]</th>
<th>Particle crushing strength [N/mm²]</th>
</tr>
</thead>
<tbody>
<tr>
<td>HMX core material: Typ B Class 1 DDP04D0049E</td>
<td>197</td>
<td>10</td>
<td>128</td>
<td>4,2</td>
</tr>
<tr>
<td>Fox 12</td>
<td>-</td>
<td>40</td>
<td>&gt; 360</td>
<td>-</td>
</tr>
<tr>
<td>Fox 7</td>
<td>-</td>
<td>15</td>
<td>252</td>
<td>-</td>
</tr>
<tr>
<td>HMX + 10 % Fox 12</td>
<td>75 (abrasion)</td>
<td>7,5</td>
<td>160</td>
<td>not measurable</td>
</tr>
<tr>
<td>HMX + 10 % Fox 7</td>
<td>33 (abrasion)</td>
<td>15</td>
<td>324</td>
<td>not measurable</td>
</tr>
<tr>
<td>HMX pure, after 3 h fluidized bed process</td>
<td>56 (abrasion)</td>
<td>15</td>
<td>120</td>
<td>not measurable</td>
</tr>
<tr>
<td>HMX + 10 % Fox 7 + 5 % GAP</td>
<td>179</td>
<td>10</td>
<td>240</td>
<td>8,3</td>
</tr>
</tbody>
</table>
Particle crushing strength test (GFP) – example: HMX/Fox7/GAP composite

![Graph showing force in N vs. deformation in mm for a particle crushing test example. The graph displays a sharp peak followed by a gradual decrease.]

![Image of a yellow particle under a load.]
Characterization of composite particles (HMX/Fox7+GAP) with IR-spectroscopy (FTIR-Imaging)
Formulation work

PBX N – 109
84 % Filler Content
  20 % Aluminium
  64 % Hexogen
16 % HTPB Binder

PBX N – 109 analogue formulation
84 % Filler Content
  20 % Aluminium
  64 % Nitramin
16 % HTPB Binder

64 % Nitramin => 10 % Coating
  90 % Nitramin
### Studied Formulation

<table>
<thead>
<tr>
<th>HXA</th>
<th>Energetic Filler</th>
<th>Coating</th>
</tr>
</thead>
<tbody>
<tr>
<td>259</td>
<td>HMX, Type B</td>
<td>-</td>
</tr>
<tr>
<td>257</td>
<td>HMX, Type B</td>
<td>FOX-12</td>
</tr>
<tr>
<td>258</td>
<td>HMX, Type B</td>
<td>FOX-7</td>
</tr>
<tr>
<td>261</td>
<td>HMX, Type B</td>
<td>FOX-12 / GAP</td>
</tr>
<tr>
<td>262</td>
<td>HMX, Type B</td>
<td>FOX-7 / GAP</td>
</tr>
<tr>
<td>260</td>
<td>HMX, Type B</td>
<td>FOX-12 / GAP + CNT</td>
</tr>
</tbody>
</table>

Peter Gerber, October 2011, Folie 12
# Impact and Friction Sensitivity

<table>
<thead>
<tr>
<th>Formulation</th>
<th>Friction</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>HXA</td>
<td>N</td>
<td>Nm</td>
</tr>
<tr>
<td>259</td>
<td>360</td>
<td>20</td>
</tr>
<tr>
<td>257</td>
<td>360</td>
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<td>20</td>
</tr>
<tr>
<td>260</td>
<td>360</td>
<td>20</td>
</tr>
</tbody>
</table>
Gap – Test  Ø 21 mm

detonator

donator (HWC)

PMMA

tube (PMMA)

acceptor

Witness plate

Gap – Test  Ø 21 mm

40mm

42mm

X mm

21mm
21 mm PMMA - Gap Test results

Initiation pressure / GPa

Energetic Filler / Aluminium / HTPB - 64% / 20% / 16%

Go

HMX

HMX/FOX-7

HMX/FOX-7/GAP

No - Go

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21 mm PMMA - Gap Test results

![Graph showing Gap Test results for HMX, HMX/FOX-12, and HMX/FOX-12/GAP. The graph displays the initiation pressure in GPa for different mixtures of energetic filler, aluminium, and HTPB at 64%, 20%, and 16% respectively. The results indicate that HMX/FOX-12/GAP has a No-Go result at the initiation pressure level shown.]
21 mm PMMA - Gap Test results

Energetic Filler / Aluminium / HTPB - 64 % / 20 % / 16 %

Initiation pressure / GPa

Go
No - Go

HMX
HMX/FOX-12
HMX/FOX-7

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Conclusion

• Fluidised bed technology is useful to produce coated energetic particle

• FOX-7 and FOX-12 are suitable coating materials to reduce the shock sensitivity
Future Work

• Gap Test with 50 mm, based on coated Octogen

• Transfer the results to Hexogen
Acknowledgement

- Ballistic lab
  A. Kessler, T. Fischer, W. Merz., W. Erhardt, …

- Formulation of EBX
  A. Happ, F. Berge, A. Kretschmer

- WTD 91, Meppen
  T. Eich (Projektbetreuung)
Thank You For Your Attention!