PARAMETERS WITH IMPACT ON SENSITIVITY OF FOX CRYSTALS AND FORMULATIONS

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Outline

• Introduction
  – FOX-7
  – FOX-12
• Results
  – 4 case-studies
• Conclusions
• Acknowledgements
Introduction

FOX-7
• The relationship between particle size and sensitivity
• The impact on press density of solvent used in the flegmatization process
• The impact of sample capsule on DSC behavior

FOX-12 (GUDN)
• Impact on sensitivity of fragmented FOX-12/TNT melt cast formulations
## Results - Particle size vs sensitivity

### FOX-7 Particles

<table>
<thead>
<tr>
<th>FOX-7 type</th>
<th>Particle size [μm]</th>
<th>Bulk density [g/cm³]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class I</td>
<td>20-40</td>
<td>&lt; 0.60</td>
</tr>
<tr>
<td>Class II</td>
<td>50-100</td>
<td>0.70</td>
</tr>
<tr>
<td>Class III</td>
<td>100-200</td>
<td>0.85</td>
</tr>
<tr>
<td>Class IV</td>
<td>250-350</td>
<td>&gt; 0.95</td>
</tr>
</tbody>
</table>

- FOX-7 Class 1 (NSF110)
- FOX-7 Class 2 (NSF 120)
- FOX-7 Class 3 (NSF 130)
- FOX-7 Class 4 (NSF 140)
# Results - Particle size vs. sensitivity

<table>
<thead>
<tr>
<th>Median particle size [μm]</th>
<th>Drop hammer [J]</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;300</td>
<td>29.4</td>
</tr>
<tr>
<td>100-300</td>
<td>24.5</td>
</tr>
<tr>
<td>50-100</td>
<td>19.6</td>
</tr>
<tr>
<td>&lt;50</td>
<td>14.7</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Median particle size [μm]</th>
<th>SSGT [mm]</th>
<th>Pressure [kbar]</th>
</tr>
</thead>
<tbody>
<tr>
<td>250-350</td>
<td>2.8</td>
<td>140.4</td>
</tr>
<tr>
<td>20-40</td>
<td>14.0</td>
<td>117.4</td>
</tr>
</tbody>
</table>
## Results - Solvent impact on press density

<table>
<thead>
<tr>
<th>Solvent</th>
<th>Water solubility [% w/w]</th>
<th>Azeotropic ratio [% w/w]</th>
<th>Viscosity [cP]</th>
<th>Pressed Density [kg/dm³]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>30 bar</td>
</tr>
<tr>
<td><strong>A</strong></td>
<td>10</td>
<td>90</td>
<td>0.46</td>
<td>1.80</td>
</tr>
<tr>
<td><strong>B</strong></td>
<td>25</td>
<td>90</td>
<td>0.41</td>
<td>1.78</td>
</tr>
<tr>
<td><strong>C</strong></td>
<td>100</td>
<td>-</td>
<td>0.33</td>
<td>1.74</td>
</tr>
</tbody>
</table>

Solvent A

Solvent B

Solvent C
Results - Impact of sample capsule on DSC behavior

Method: 25-400 10 c/min
dt 1.00 s
25.0-400.0°C 10.00°C/min
Synchronization enabled

FOX 7 falls Pt: 0806030, 24.03.2019 14:16:17
FOX 7 falls Pt: 0806030, 0.5000 mg

Integral normalized: 189.89 mJ
Onset: 225.35 °C
Peak: 237.86 °C

Integral normalized: 144.47 mJ
Onset: 296.26 °C
Peak: 297.88 °C
Results - Impact of sample capsule on DSC behavior
Results - Impact of sample capsule on DSC behavior

Method: 25-400 10 c/min
dt 1.00 s
25.0-400.0°C 10.00°C/min
Synchronization enabled

Integral normalized
Onset 1968.77 mJ
Peak 3937.54 Jg^-1
254.60 °C
258.01 °C
Results - Impact of sample capsule on DSC behavior
Results – Sensitivity of fragmented FOX-12/TNT

GUNTOL

- 50/50 of FOX-12/TNT
- IM material
- Micro cavities
- Hot Spots
- Increased sensitivity
- Solid melt-cast or fragmented?
Results – Sensitivity of fragmented FOX-12/TNT

NOL Large Scale Gap Test

- Acceptor
- Attenuator (PMMA disks)
- Detonator
- Detonator holder
- LS GT tube
- Donor (Hexogen/wax)
- Attenuator (PMMA disks)
- Long cardboard tube
- Witness plate
- Distances (air gap)
- Bottom distances
## Results – Sensitivity of fragmented FOX-12/TNT

<table>
<thead>
<tr>
<th>FOI cards / mm / US-cards</th>
<th>Result (+/-)</th>
<th>FOI cards / mm / US-cards</th>
<th>Results (+/-)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 / 18 / 72</td>
<td>+</td>
<td>13 / 19.5 / 78</td>
<td>+</td>
</tr>
<tr>
<td>13 / 19.5 / 78</td>
<td>+</td>
<td>14 / 21 / 84</td>
<td>+</td>
</tr>
<tr>
<td>14 / 21 / 84</td>
<td>+</td>
<td>15 / 22.5 / 90</td>
<td>+</td>
</tr>
<tr>
<td>15 / 22.5 / 90</td>
<td>+</td>
<td>16 / 24 / 96</td>
<td>-</td>
</tr>
<tr>
<td>16 / 24 / 96</td>
<td>-</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The sensitivity of GUNTOL:
- 78-90 US cards crushed material
- 84-90 US cards cast material
<table>
<thead>
<tr>
<th>Explosive composition</th>
<th>Number of US-cards in the NOL LSGT</th>
</tr>
</thead>
<tbody>
<tr>
<td>GUNTOL 50:50</td>
<td>78-96</td>
</tr>
<tr>
<td>TNT cast</td>
<td>133</td>
</tr>
<tr>
<td>TNT pressed</td>
<td>175</td>
</tr>
<tr>
<td>RDX</td>
<td>323</td>
</tr>
<tr>
<td>TATB</td>
<td>78</td>
</tr>
<tr>
<td>Composition B (cast)</td>
<td>201</td>
</tr>
<tr>
<td>Composition B (pressed)</td>
<td>238</td>
</tr>
<tr>
<td>C-4</td>
<td>192</td>
</tr>
<tr>
<td>PBXN-110 (Bofors)</td>
<td>158</td>
</tr>
</tbody>
</table>
Conclusions

• FOX-7
  – Larger particles are less sensitive than smaller ones
  – Type of solvent has direct impact both on coating efficiency and pressed density
  – The DSC behavior depends on the type of sample pan used
    • Open pans → two exothermal peaks,
    • Semi-open pans → one double peak
    • Sealed high pressure pans → one single peak
  – For risk analysis sealed high pressure pans should be used

• FOX-12
  – GUNTOL is just as insensitive when crushed as it is when intact
  – Further studies of this subject will be carried out
Acknowledgements

Eurenco Bofors AB

• Carina Bergvall-Laitala
• Karolina Mazurek
• Michal Mazurek
• Fredrik Persson
• Helen Stenmark

Swedish Defence Research Agency (FOI)

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