High Performance Aluminized Gap-based Propellants
IM Results

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Agenda

- Aluminized GAP-based solid propellant
- Vulnerability requirements and results
- Conclusions

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- Aluminized GAP-based solid propellant
  - Formulation
  - Azalane® characteristics (performance, mechanics, safety)
- Vulnerability requirements and results
- Conclusions

Propulsion Needs for Defense Applications

- **Global performance**
  - Performance (Isp, IFT)
  - Energy management

SNPE answer :
Alumized GAP-based propellants

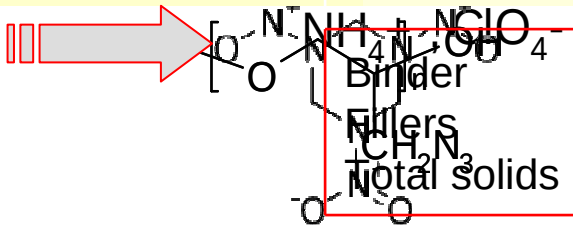
- **Operation**
  - Safety, IM
  - Reliability
  - Control of functional properties (combustion, structural behavior, ageing, …)

- **Requirements**
  - Costs
  - Environmental issues

Formulation

- Formulation studies, with energetic molecules / mature ingredients
  ➔ Aluminized GAP-based compositions

BALANCED FILLERS	OXIDIZERS	PLASTICIZED BINDERS
RDX	AP	GAP



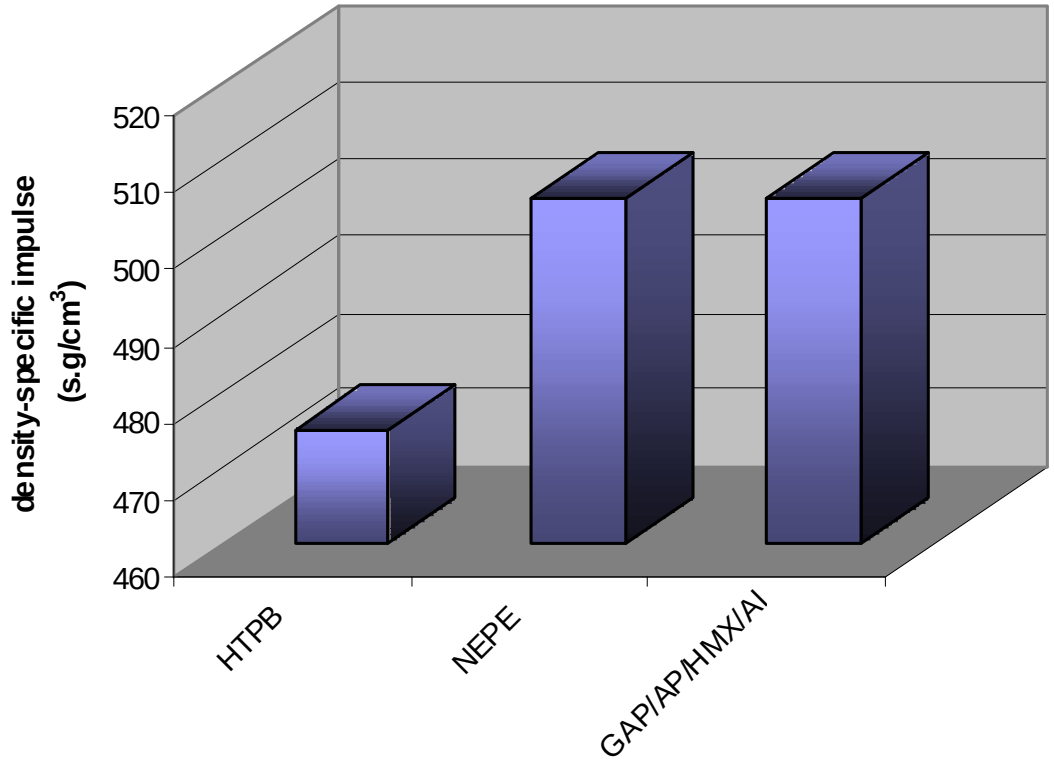
Azalane®

Binder
Fillers
Total solids

ΔH_f = + 701 kJ/mol
ρ = 1,95 g/cm^3
73%
ρ = 1,82 g/cm^3

Azalane® characteristics

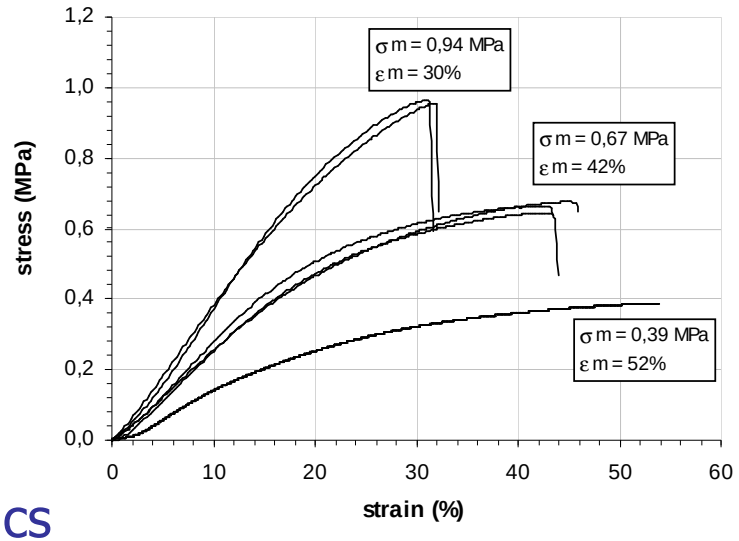
- Performances
  - Similar performance compared to NEPE based compositions
  - Increased performance compared to HTPB based compositions



Azalane® characteristics

❑ Mechanical properties

- Adjustment and optimization of Azalane® mechanical properties is possible



❑ Pyrotechnic safety characteristics

- No particular sensitivity is induced by GAP

Tests	Results
Friction sensitivity UN 3b)i)	76 N
Impact sensitivity UN 3a)ii)	22 J
Self ignition STANAG 4491 annex B2	172°C

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- Aluminized GAP-based solid propellant
- Vulnerability requirements and results
  - Safety characteristics in detonics
  - Slow heating
  - ES sensitivity
  - Bullet impact tests
- Conclusions

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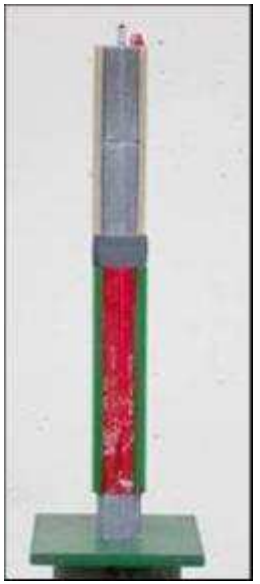
Safety characteristics in Detonics

- Azalane® contains energetic binder, plasticizer and nitramine, thus further studies are needed to ensure safety
- Large Scale Gap Test (LSGT), according to STANAG 4488 annex B

- Similar sensitivity compared "good" insensitive explosives (I-PBXN109)
- Reduced sensitivity compared NEPE based compositions

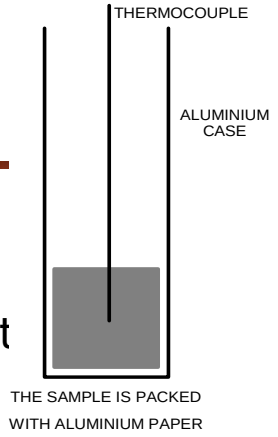
	Azalane®
Simplified composition	GAP/BTTN/TMETN AP HMX Aluminum
LSGT Result (Nb of acetate cards)	150
Pressure in acetate (kbar)	48

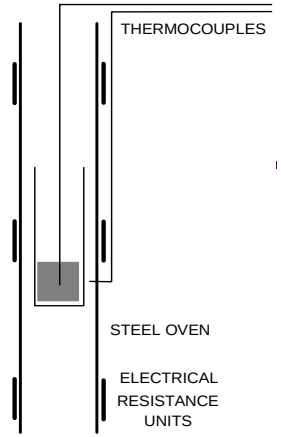


Hazard classification 1.3c
(manufacturing and storage)

Response to slow Heating

- Thermal threat studied through :
  - unconfined thermo-ignition critical temperature test
  - small scale slow heating tests
  - ∅ 50 mm & length 50 mm samples





- Azalane® propellant behavior
  - Moderate reaction is observed

- Classical HTPB propellant behavior
  - Violent reaction is observed (oven / vessel explosion)

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Response to slow Heating / ES sensitivity

ES characteristics

- Many studies related to ES phenomena during the 80's & 90's, applied to HTPB based propellants
- Azalane® behavior ≠ HTPB based propellant behavior when submitted to ES discharges

Test	HTPB / AP / Al based propellant *	AZALANE® propellant
Volumic electrostatic resistivity (Ω.m)	10^{+10}	10^{+05}
Intrinsic characteristic	**insulating**	**conductive**
Large scale test STANAG 4490 annex B	**sensitive to ES discharges**	**no-sensitive to ES discharges**

ES accident can not occur with Azalane®

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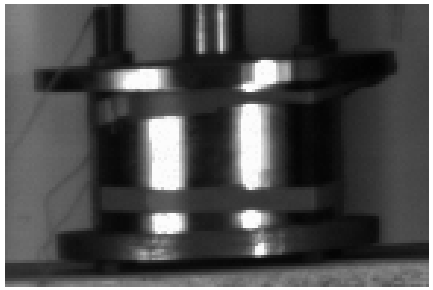
Bullet Impact Demonstration

Experiment description

- SNPE mock up
  - Length 100 mm
  - Propellant diameter ∅152 mm
  - Cylindrical central bore ∅50 mm
- 0.5" armour-piercing bullet 12.7 mm bullet, velocity = 850 m/s
- Monitoring techniques (high speed camera, overpressure measurement)

Bullet impact test #1, in closed vessel, fired @ 850m/s



- Propellant combustion followed by mock-up pneumatic explosion
- Case and unburnt residual propellant is recovered
- No metallic fragment is generated
- No blast overpressure is measured

Type V reaction,
according to STANAG 4439 / AOP39

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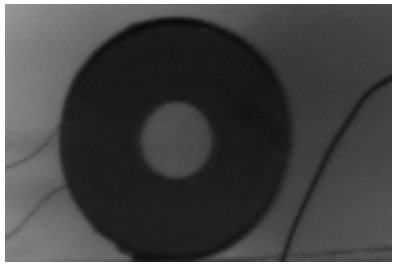
GROUPE SNPE

Bullet Impact Demonstration

❑ Experiment description

- SNPE mock up
  - Length 100 mm
  - Propellant diameter 152 mm
  - Cylindrical central bore ∅50 mm
- 0.5" armour-piercing bullet 12.7 mm bullet, velocity = 850 m/s
- Monitoring techniques (high speed camera, overpressure measurement)

❑ Bullet impact test #2, in opened vessel, fired @ 850m/s



- Propellant combustion
- Precision on ignition scenario : friction of the bullet on the propellant
- No metallic fragment is generated
- No blast overpressure is measured

Azalane® exhibits a satisfactory behaviour to BI tests, improved w.r. to NEPE and comparable with that of HTPB

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Conclusions

- High energetic performance and IM behavior are not intrinsically incompatible,
- Azalane® solid propellant exhibits very satisfactory behavior to safety and vulnerability test at small scale assessment (Slow heating threats, ES phenomena, Bullet impact, Mechanical shocks),
- Compared to HTPB propellants, Azalane® IM characteristics are equivalent or even better,
- New rocket rocket propellants are ready for coming applications : motors filled with Azalane® propellant with attractive IM signature can be expected, in the future.

Acknowledgements

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Thank you for your attention

Any questions are welcome