Ballistic Stability and Influence of the Firing Temperature of Two Deterred Propellants

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OUTLINE

- Introduction
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  - ✓ Nitrocellulose spherical propellant
  - ✓ Deterrent diffusion
- Aim
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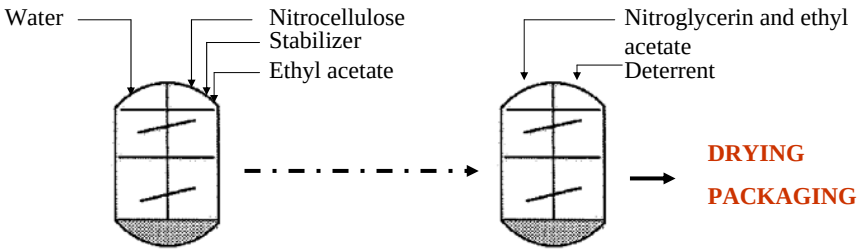
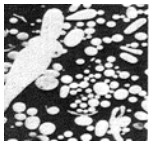
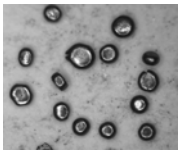
  - ✓ Deterrent diffusion during ageing
    - Infra-red microscopy
    - Closed vessel test
  - ✓ Temperature sensitivity
    - Closed vessel test
    - Ballistic firing
- Conclusions and way ahead

Introduction

Manufacture of Nitrocellulose spherical propellant

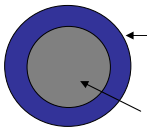






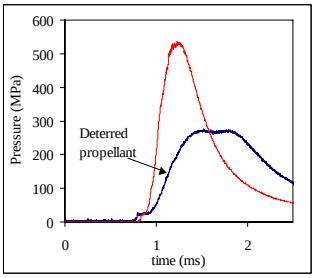
Introduction

Nitrocellulose spherical propellant



NC/ Ngl Deterrent ⟹ Low combustion rate

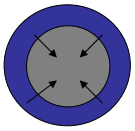
NC / Ngl ⟹ High combustion rate



The deterrent permits to have a lower maximal pressure in the cartridge for a same bullet velocity

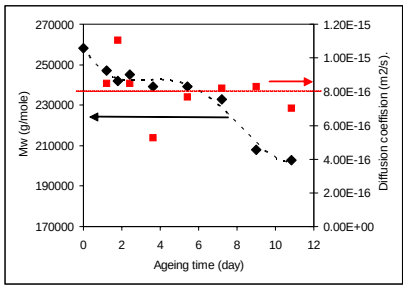
Introduction

Deterrent diffusion



Deterrent diffuses during ageing

For DBP at 80°C



No relation between the deterrent diffusion coefficient and a moderate molecular weight decrease

Aim

- EEC REACH regulation
  - ⇒ Need of new combustion moderator
  - ⇒ Investigation of the ballistic stability of two new deterrents (A and B)
- Importance of the temperature sensitivity at the firing temperature
  - ⇒ First screening of the temperature sensitivity

Operating procedure

Deterrent diffusion during ageing

- Ageing of propellants containing deterrent A or B

80°C

Ageing (day)	1.8	3.0	4.1	7.1	9.0	10.8	13.0	18.0	25.0	39.0	49.0	56.0

71°C

Ageing (day)	12.6	30.0	37.0	48.0	62.5	70.0	98.0	126.0	154.0

- Measurement of the deterrent concentration profile (IR microscopy)
- Measurement of the combustion rate of the different aged propellants (closed vessel tests)

Operating procedure

Temperature sensitivity

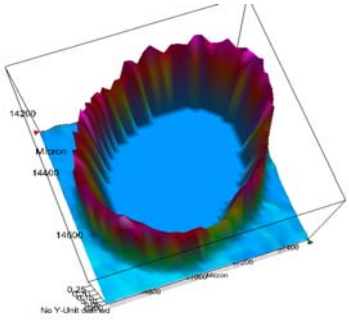
- Measurement of the combustion rate by closed vessel tests at -40°C, 25°C and 71°C of the unaged and some selected aged propellants

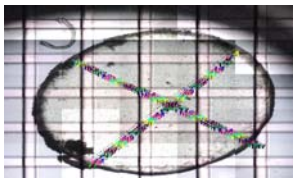
- Ballistic firing at -54°C, 21°C and 71°C of unaged propellants and propellants aged 30 days at 71°C.

Results

Deterrent diffusion during ageing

Infra red microscopy





Section: thickness 7µm

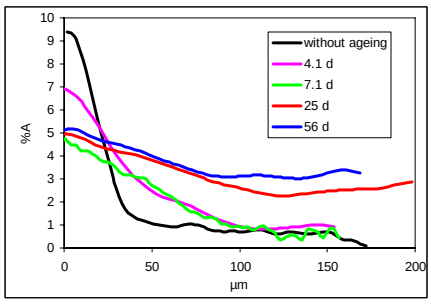
Measurement at different locations to get the deterrent concentration profile

Results

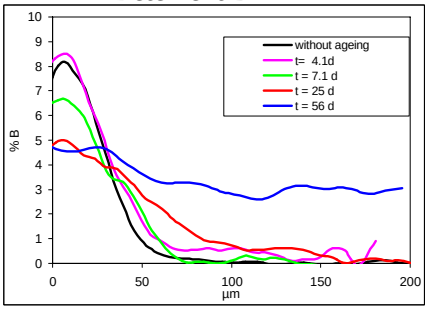
Deterrent diffusion during ageing

Infra-red microscopy (ageing at 80°C)

Deterrent A



Deterrent B



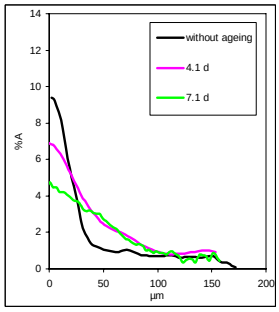
Same type of diffusion for propellant A and B

Results

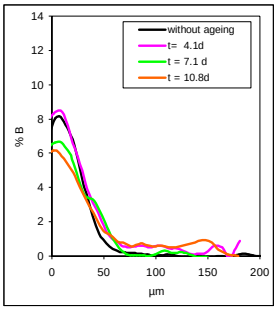
Deterrent diffusion during ageing

Infra-red microscopy (ageing at 80°C)

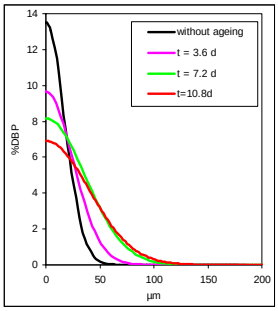
Deterrent A



Deterrent B



DBP



Diffusion of DBP greater than for deterrent A between 0 and 4d.

Afterwards same type of diffusion for the 3 deterrents

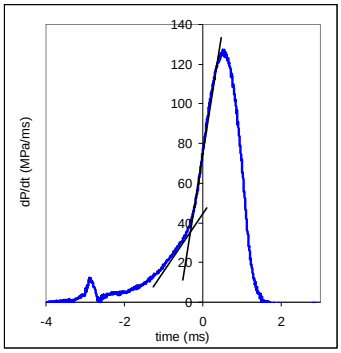
Results

Deterrent diffusion during ageing

Closed vessel test

Gaseous ignition ($1CH_4$-$1.4O_2$)

⇒ permit to observe the combustion of the deterred part and of the centre part

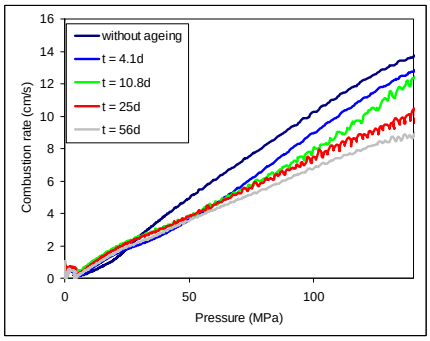


Results

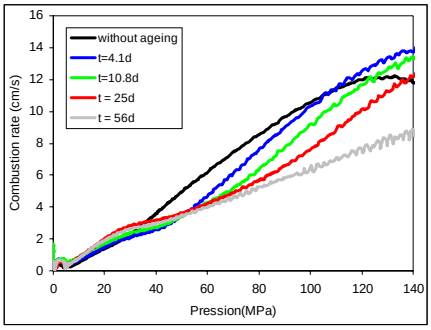
Deterrent diffusion during ageing

Closed vessel test (ageing at 80°C)

Deterrent A



Deterrent B

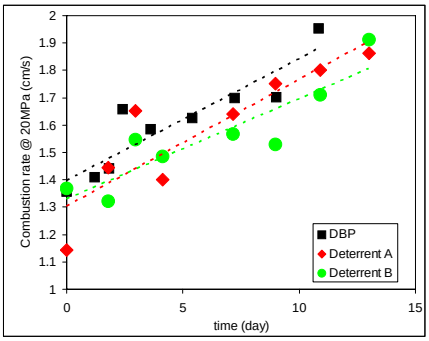


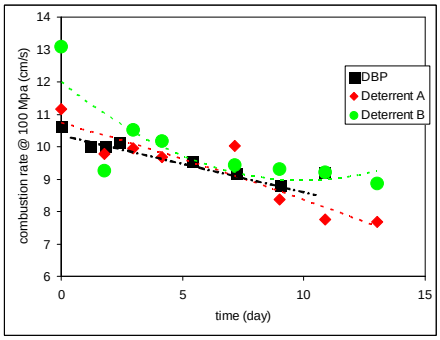
Similar variation for the two propellants

Results

Deterrent diffusion during ageing

Closed vessel test





Similar variation for the 3 deterrents

Temperature Sensitivity

- Arrhenius equation: the combustion rate increases with the temperature

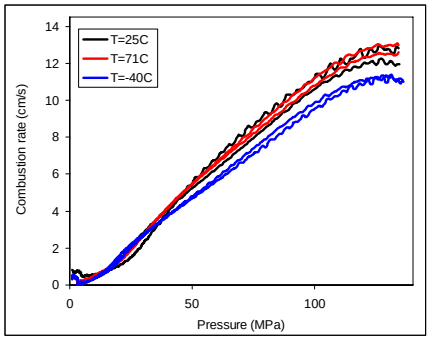
- Different factors can influence the temperature sensitivity:
  - ✓ At low temperature, depending on the nitrocellulose propellant structure, propellant can break more or less easily inducing a change in the combustion surface
  - ✓ At high temperature, propellant grain can agglomerate inducing a change in the combustion surface
  - ✓ These factors are not only related to intrinsic properties of the propellant, they depend also on other parameters like ignition system, cartridge size, …

Results

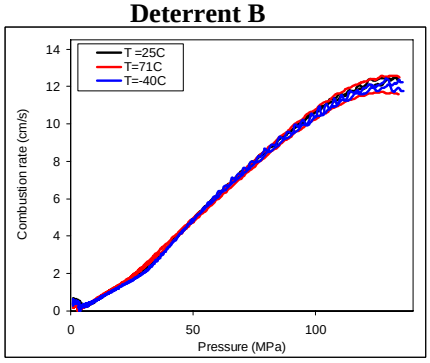
Temperature sensitivity

Closed vessel test

Deterrent A



Deterrent B



The temperature sensitivity is lower for propellant B

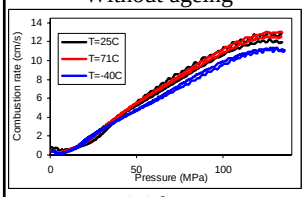
Results

Temperature sensitivity

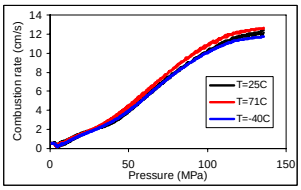
Closed vessel test

Deterrent A- Ageing @ 80°C

Without ageing



t=1.99d



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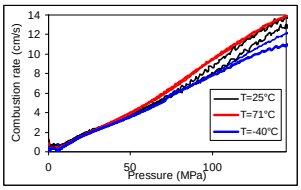

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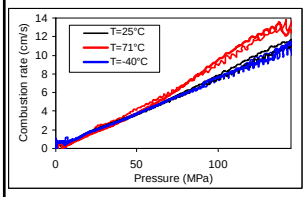

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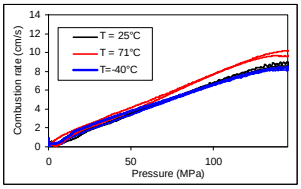


First: decrease of the temperature sensitivity

Secondly: increase of the temperature sensitivity between 25°C and 71°C

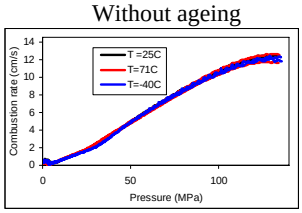
Results

Temperature sensitivity

Closed vessel test

Deterrent B- Ageing @ 80°C

Without ageing



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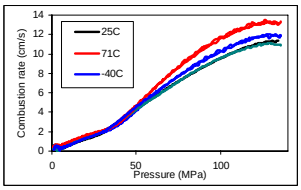

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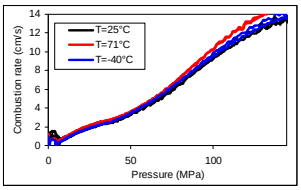

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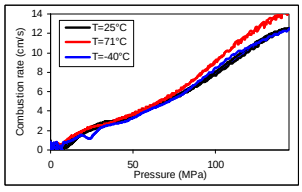

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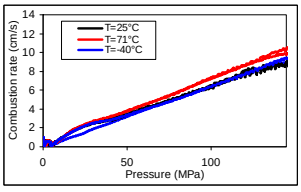
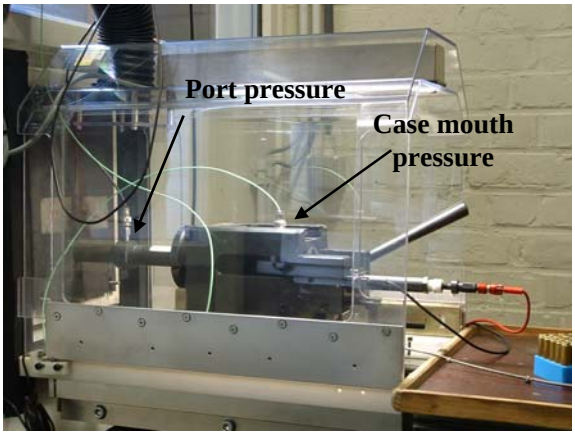


Increase of the temperature sensitivity with ageing

Results

Temperature sensitivity

Ballistic firing

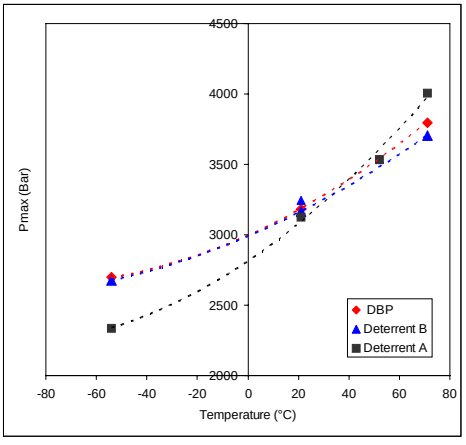


Pressure measurement at the case mouth

Results

Temperature sensitivity

Ballistic firing



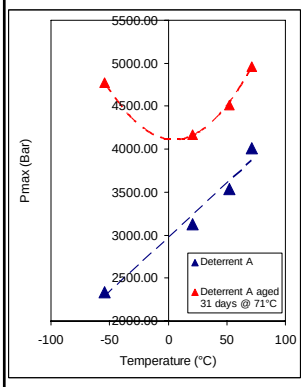
Deterrent A has a greater temperature sensitivity (similar to the closed vessel test)

Results

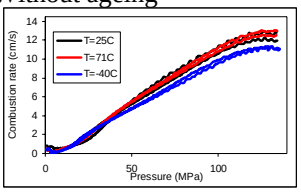
Temperature sensitivity

Ballistic firing and closed vessel test

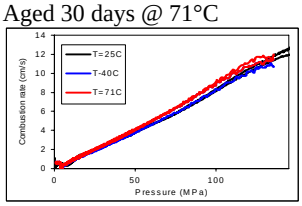
Deterrent A



Without ageing



Aged 30 days @ 71°C



Same temperature sensitivity for aged and unaged propellant for the ballistic firing between 21°C and 71°C

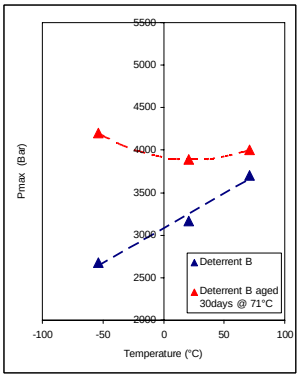
Between -54°C and 21°C, increase of the maximum pressure for the aged propellant. This could be due to cracks in the aged propellant

Results

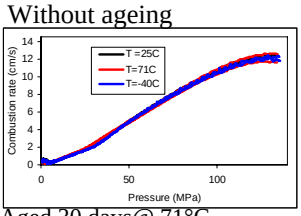
Temperature sensitivity

Ballistic firing and closed vessel test

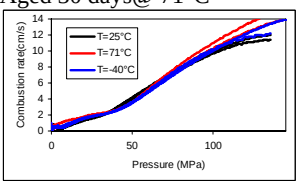
Deterrent B



Without ageing



Aged 30 days@ 71°C



Decrease of the temperature sensitivity with ageing for the ballistic firings

Conclusion and Future work

Conclusion

- Deterrents A and B show a similar diffusion process during ageing than DBP
- The temperature sensitivity test enable to exhibit the difference in sensitivity of both tested propellants
- Ageing influences the temperature sensitivity especially at low temperature

Future work

- Investigation of the influence of the ignition system on the temperature sensitivity
- Ballistic firing at different ageing times