SMALL SCALE EVALUATION OF ENERGETIC MATERIALS: SHOCK SENSITIVITY CHARACTERISATION AT THE EARLY STAGE OF SYNTHESIS

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1. Context of this study

2. Small GAP test setup

3. Database construction

01
CONTEXT OF THIS STUDY

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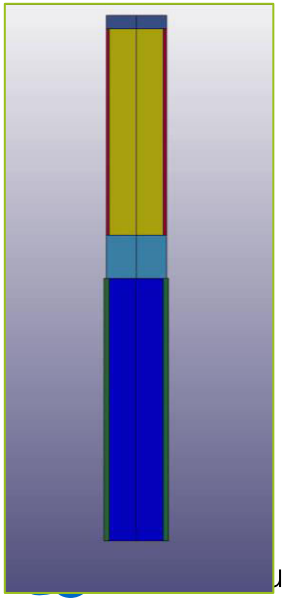
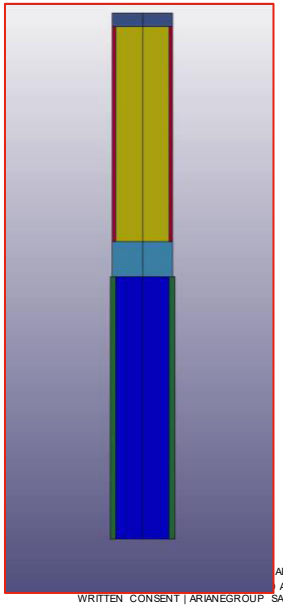
Question : How determine the relative sensitivity of EM?

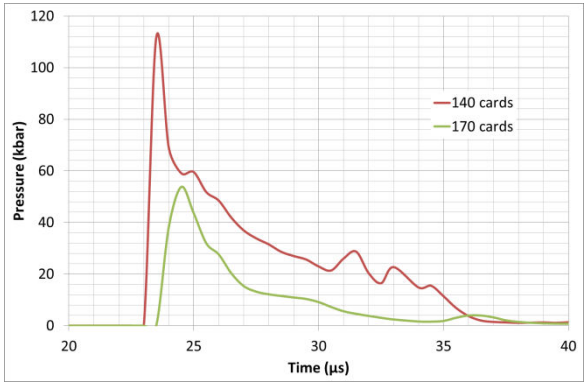
Shock to Detonation Transition

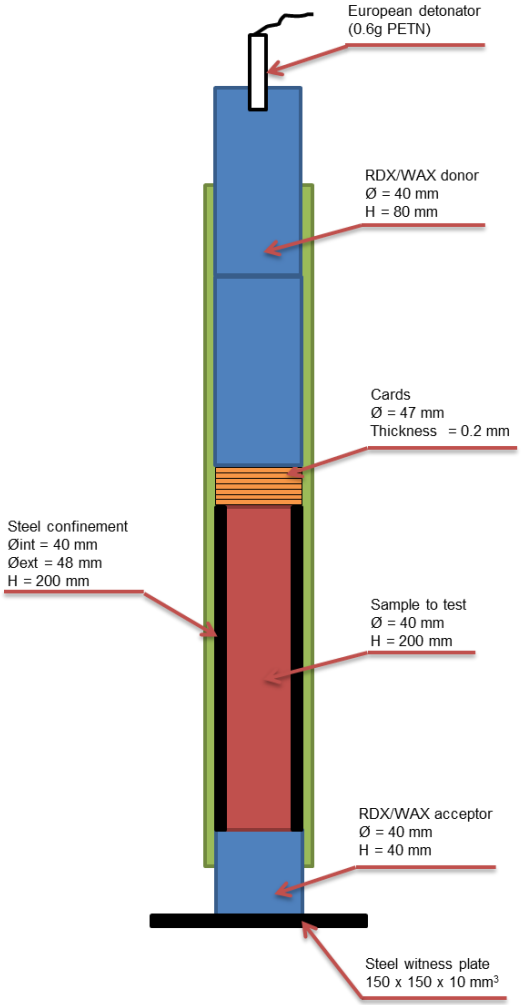
Critical pressure vs. time

Answer : Gap test









CONTEXT OF THIS STUDY

Properties of new molecules since the early stages of synthesis is usually difficult to determine:

Some performances (detonation velocity…) can be worked out with thermochemical codes (e.g. Cheetah 2.0)

Some characteristics, like sensitivity, are characterized after many years of studies

Scale	Quantity	Delay	Product	Granular product characterization	Formulations characterization
1	500 mg - 1 g	T0	Granular product	safety (ISI, ISF, ESD), chemical structure, thermal analysis	None
2	10 - 20 g	2 years	20 g of granular product	Compatibilities, formation enthalpy, density, micro calorimetry	density, safety, micro calorimetry
3	100 g - 2 kg	4 years	Formulations with 100 g of product	Gap test and mini gap test, detonation velocity, critical diameter…	Gap test and mini gap test, detonation velocity, critical diameter…

CONTEXT OF THIS STUDY

The constraints are the following ones:

Only few grams of new charges are available

Test configuration has to be representative of a future application

Results obtainable with our methodology have to be comparable with known results

Answer :

A reduced gap test

A reference matrix to reduce the quantity of product

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SMALL GAP TEST METHODOLOGY

SMALL GAP TEST METHODOLOGY

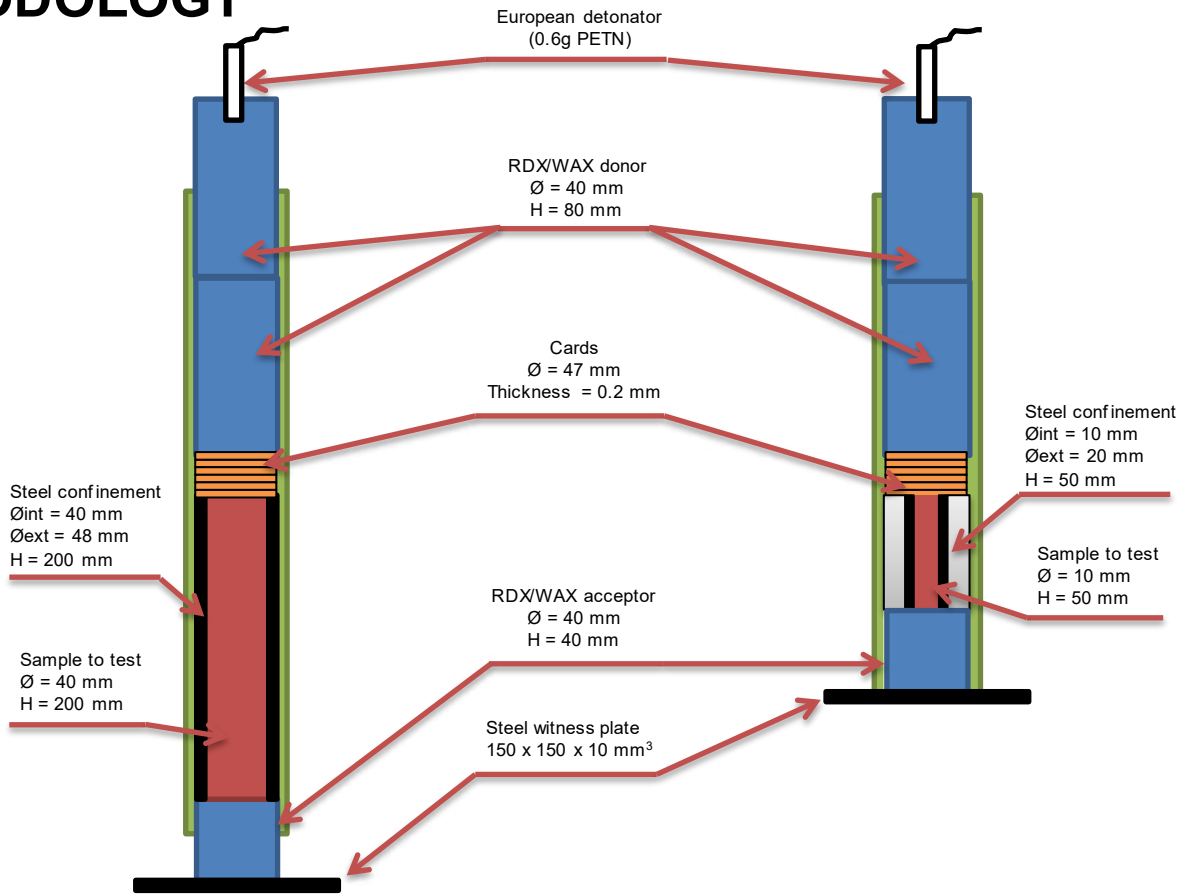
Test setup

RDX/Wax donor and acceptor are the same than Card Gap Test (Ø40 mm) in order to obtain a correlation

Use of sample confinement to access composition detonability even with a failure diameter > 10 mm (e.g. : PBXN109, Øc = 14 mm)

Ø10 mm H50 mm samples, between 6 and 7 g of product (70 g for the full test)

- Use of an energetic matrix to reduce the needed quantity od product
- Formulation with matrix is representative of future applications

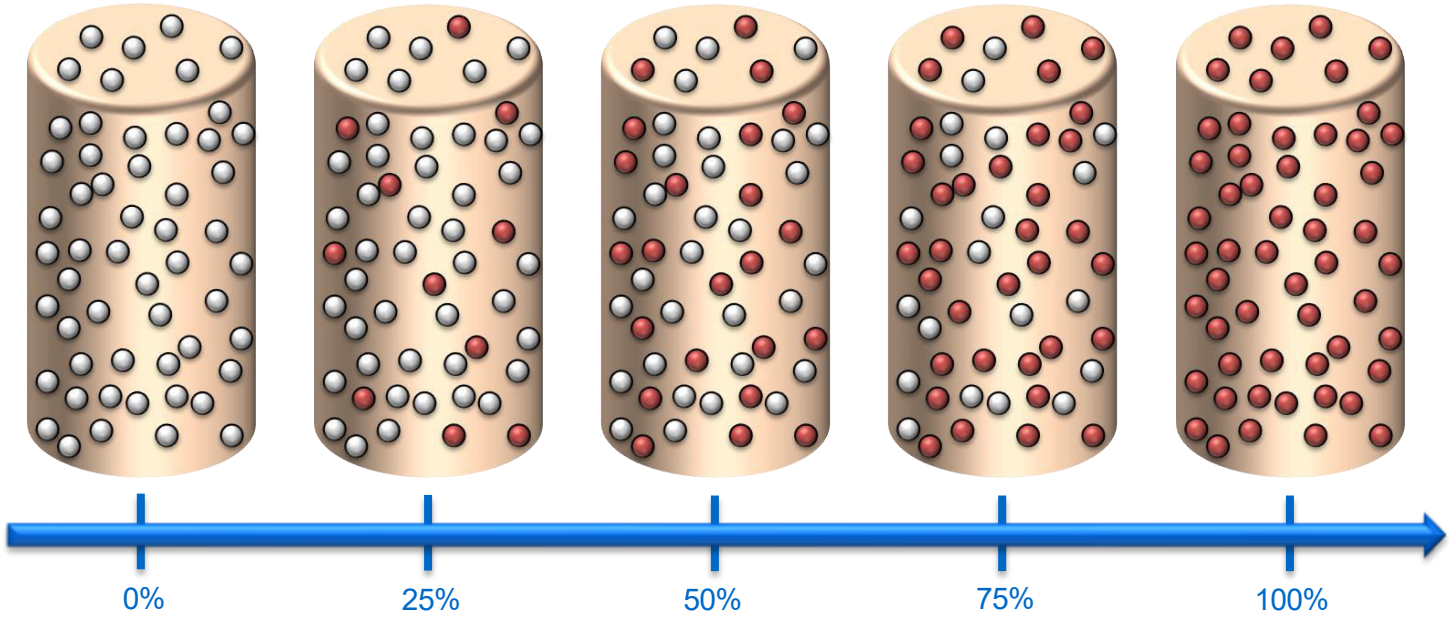


SMALL GAP TEST METHODOLOGY

Inert binder / RDX reference composition research

Based on inert binder/RDX explosive

- Replacement of a part of RDX by new charge we want to characterize



SMALL GAP TEST METHODOLOGY

Inert binder / RDX reference composition research

Based on inert binder/RDX explosive

- Variation of RDX filling rate, RDX particle size, RDX quality
  - **Reference composition : HTPB/RDX 0-200 B 30/70 (180 cards)**
    - high rate of RDX + large particle size of fillers to avoid charge settling in the binder
    - Can detonate in 10 mm diameter steel tube

Ref.	Weight composition (%)							Cards number
	Neutral binder	HTPB binder	RDX M3C CH	RDX M3C B	RDX 0-200 B	RDX 0-100 B	RDX 75-300 CH	
1	30	-	70	-	-	-	-	140
2	45	-	55	-	-	-	-	135
3	60	-	40	-	-	-	-	130
4	30	-	-	-	70	-	-	175
5	45	-	-	-	55	-	-	150
6	60	-	-	-	40	-	-	155
7	30	-	-	70	-	-	-	155
8	30	-	-	-	-	70	-	165
9	30	-	-	-	-	-	70	185
10	-	30	70	-	-	-	-	140
11	-	45	55	-	-	-	-	130
12	-	60	40	-	-	-	-	125
13	-	30	-	-	70	-	-	180
14	-	30	-	-	-	-	70	170

- Testing of different binder : well known HTBP, other neutral binder to face up with some compatibilities
  - **Evaluation of paraffin wax in comparison of HTPB as binder**
  - **Specific attention about sample homogeneity**
  - **Similar results with correct reproductibility**

Binder	RDX 0-200 B	Cards (mini GT Ø10H50)
PBHT	70%w.	175
PBHT		190
paraffin wax Tf=65°C		175
paraffin wax Tf=65°C		>180

SMALL GAP TEST METHODOLOGY

Scope of explored sensitivity level

Based on inert binder/RDX explosive

- Reference composition : **HTPB/RDX 0-200 B 30/70 (180 cards)**

- Replacement of a part of RDX by NTO (lower limit):

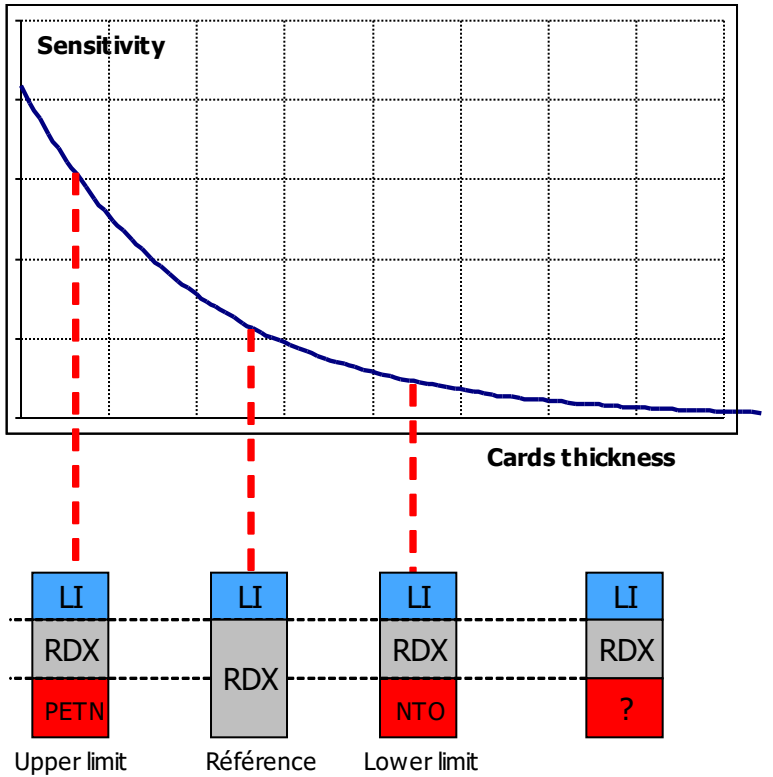
  - 3 RDX/NTO compositions (75/25, 50/50, 25/75)

  - Detonability & Sensitivity ➔ 130 cards (59 kbar)

- Replacement of a part of RDX by PETN (upper limit):

  - 2 RDX/PETN compositions (50/50, 25/75)

  - Detonability & Sensitivity ➔235 cards (22 kbar)



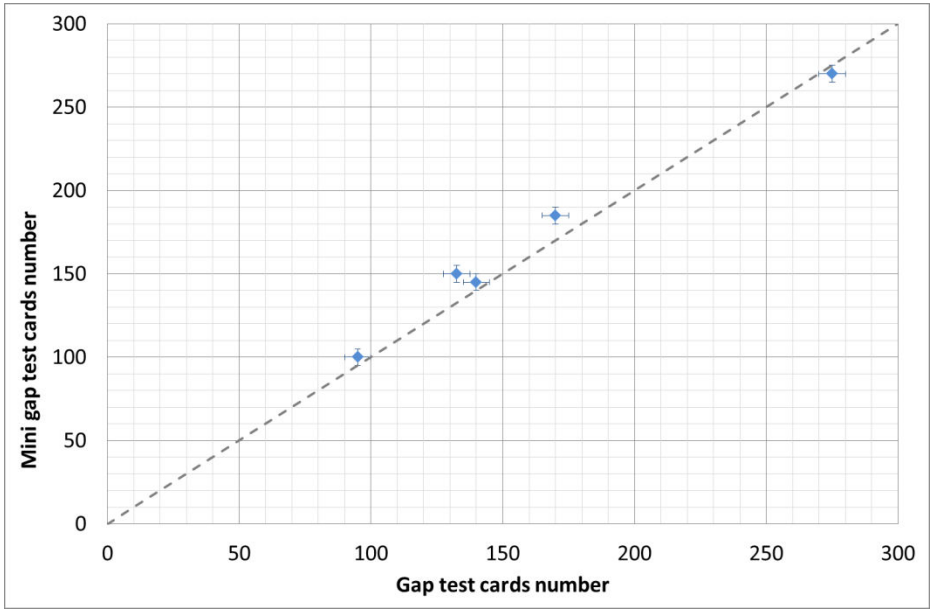
SMALL GAP TEST METHODOLOGY

Test representativeness

Gap test comparison on different materials

- Function of failure diameter
- Transposition factor between Gap Test and mini-gap test [130; 220 cards]

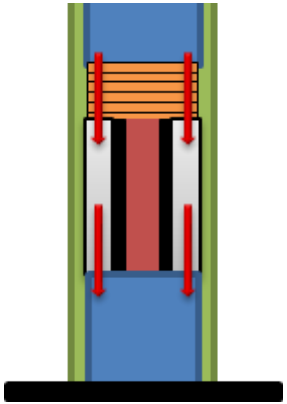
	RDX/Wax	70% RDX 0-200B	PBXN109	B2258B	17,5/52,5% RDX/NTO	70% NTO
Øc (mm)	<2	~5	14	16/18	> 40	Test limit
IAD	275	170	140	130/135	90 < N ≤ 100	
Mini-IAD	260 <N ≤ 270	180/190	145	150	100	
f	0,98	1,07	1,04	1,1	1,00	



Number of cards similar for both test

SMALL GAP TEST METHODOLOGY

Test limitation

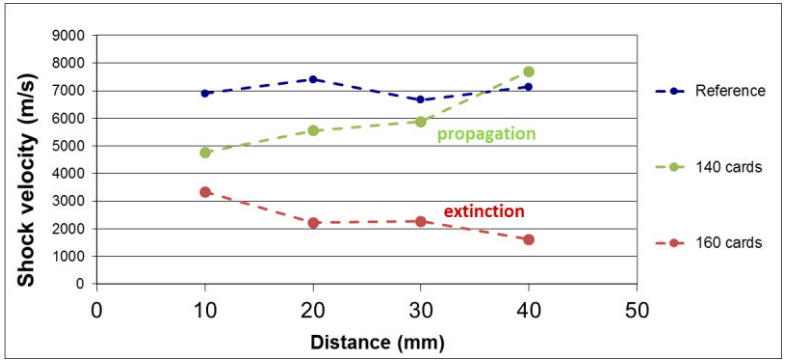


Special focus on very insensitive compositions

- Reference composition : **HTPB/RDX 0-200 B 30/70 (180 cards)**

  - Under 100 card, a shock wave transmitted through steel confinement causes the detonation of the RDX/Wax acceptor.

  - In order to detect these “false positive”, we have improve the test setup with contact pin among the confinement



- We can extend test domain to less sensitive charge

03
DATABASE CONSTRUCTION

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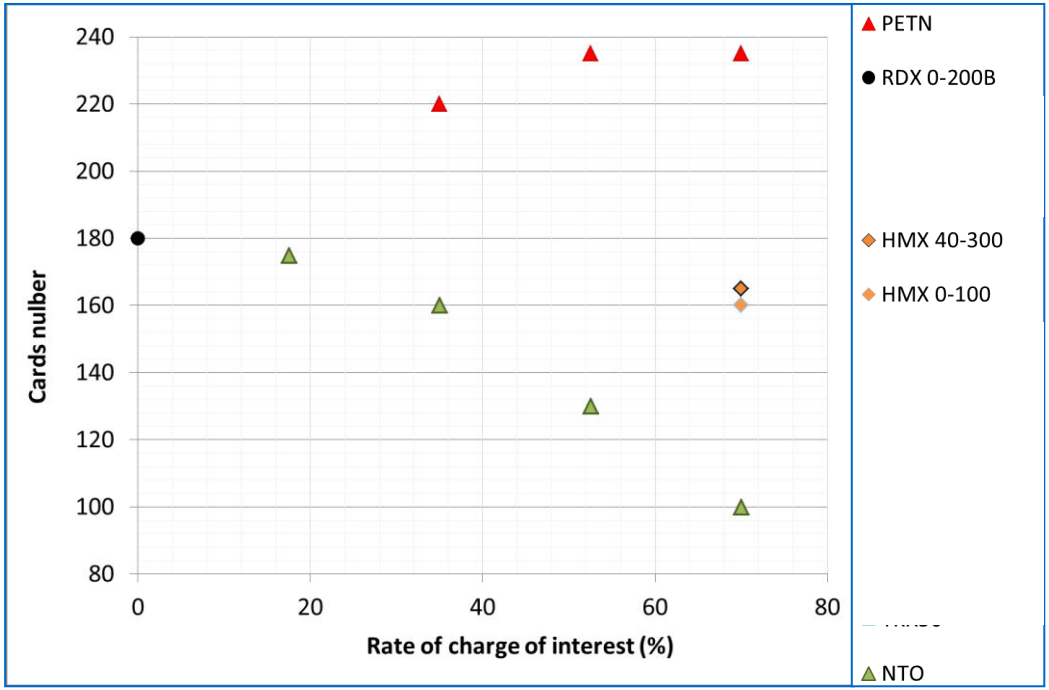
Reference compositions characterization

Sensitivity scale border

- Replacement of RDX by PETN increases the sensibility
- Replacement of RDX by NTO decreases the sensibility
- Compositions with HMX seem to have a light reduced sensibility in comparison with compositions based on RDX

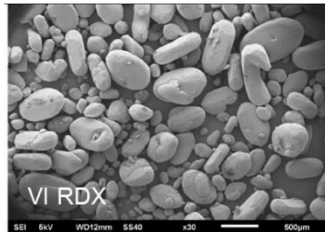
Weight composition (%)				
RDX	HMX			Mini-GT (cards)
0-200 B	40-300	0-100	M3C	
70				180
	70			165
		70		160
	35		35	155

➔ in agreement with the state-of-the art



DATABASE CONSTRUCTION

Reference compositions characterization



Introduction of well-known molecules

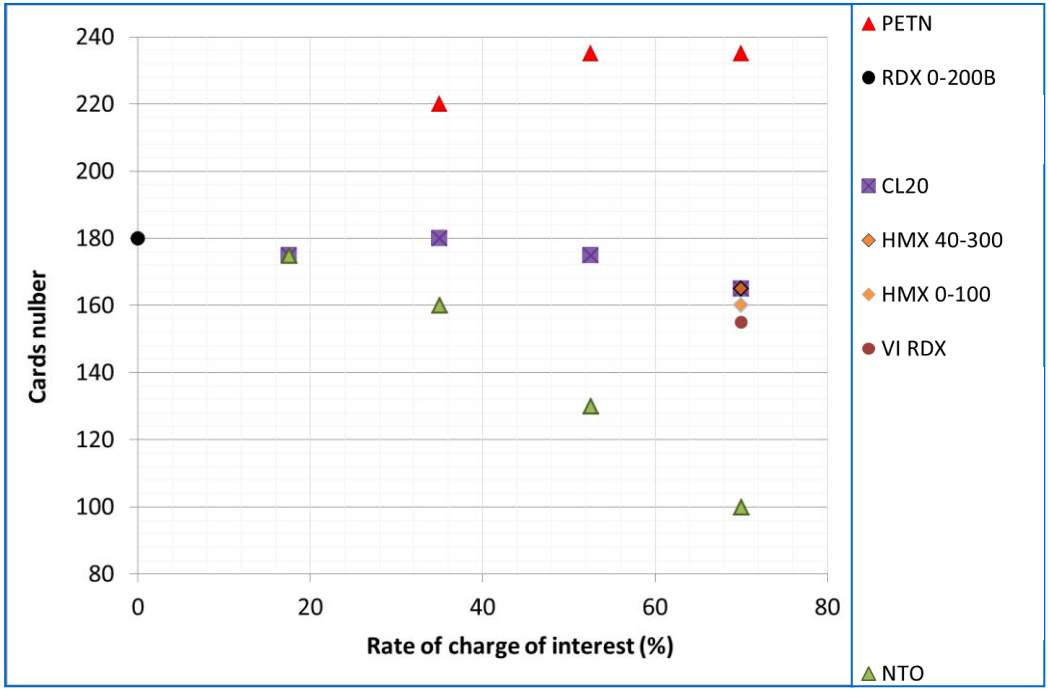
- **V**ery **I**nsensitive **RDX**

  - Less sensitive than RDX or HMX @ same size

70% weight composition		
RDX	**Mini-gap test**	**HMX**
0-200 B	175-190	
75-300 CH	170-185	
0-100 B	165	40-300
	160	0-100
VI	150<N≤160	
M3C B	155	
M3C CH	140	

- CL20

  - Less sensitive than RDX in composition @ ≠ size



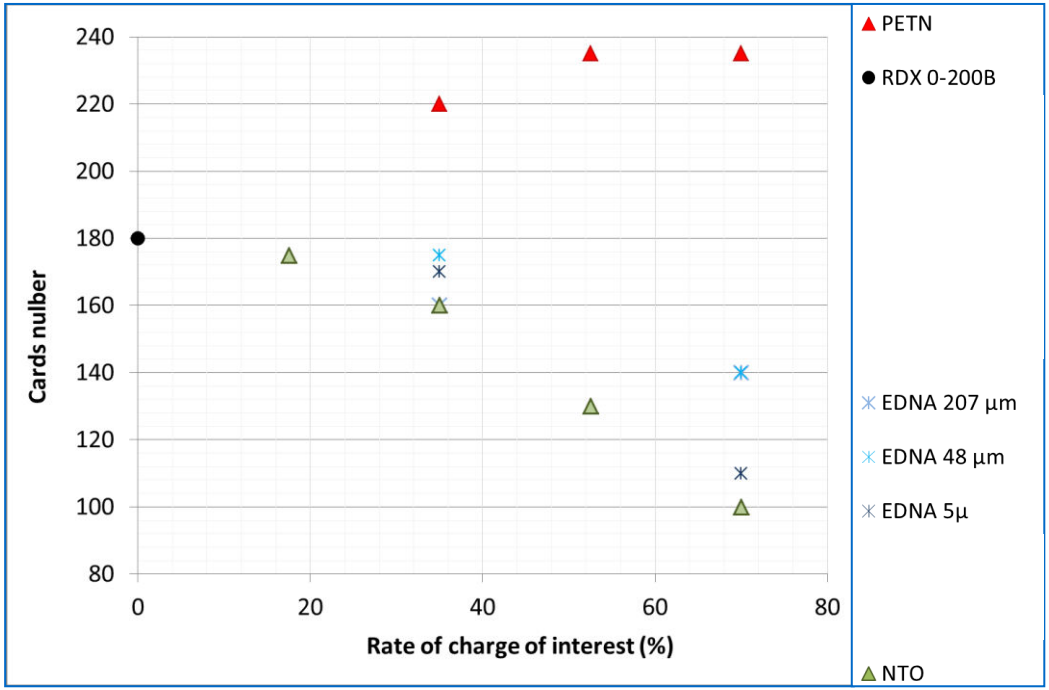
DATABASE CONSTRUCTION

On-going molecules characterization

EDNA-based compositions characterization

- Less sensitive than RDX
- No effect of the grain size between coarse and middle-sized particle
- Fine particles have a decreasing effect on the shock sensitivity of the composition

Weight composition (%)					
Binder	EDNA			RDX	Card numbers
	Coarse	Middle-sized particle	Fine	0-200B	
Paraffin wax	-	-	-	70	180
	35			35	160
	70			-	140
	-	35		35	175
	-	70		-	140
		-	35	35	170
		-	70	-	110



DATABASE CONSTRUCTION

On-going molecules characterization

Testing of partners molecule

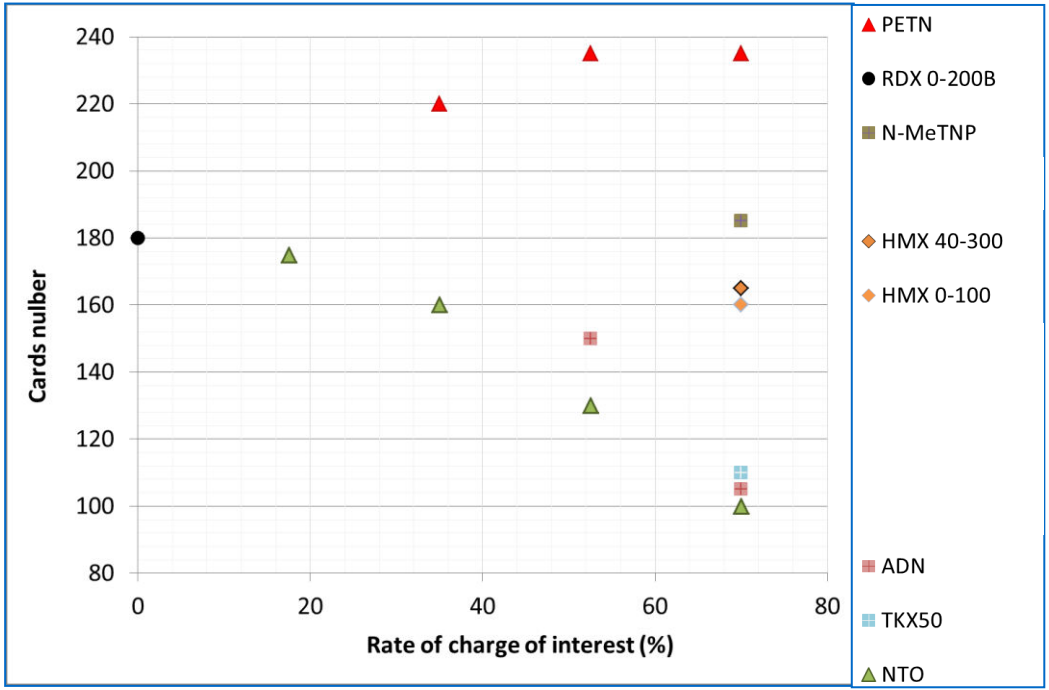
- **ADN** form EURENCO Bofors

Weight composition (%)			
Binder	**ADN Ø111µm**	**RDX 0-200B**	**Cards number**
PBHT		70	180
	35	35	150
	70		105

- **TKX50**, form EURENCO

  - Less sensitive than NTO ?

- **N-Me TNP**, trinitropyrazole in paraffin binder, from Arianegroup



04
CONCLUSIONS

CONCLUSION/PERSPECTIVES

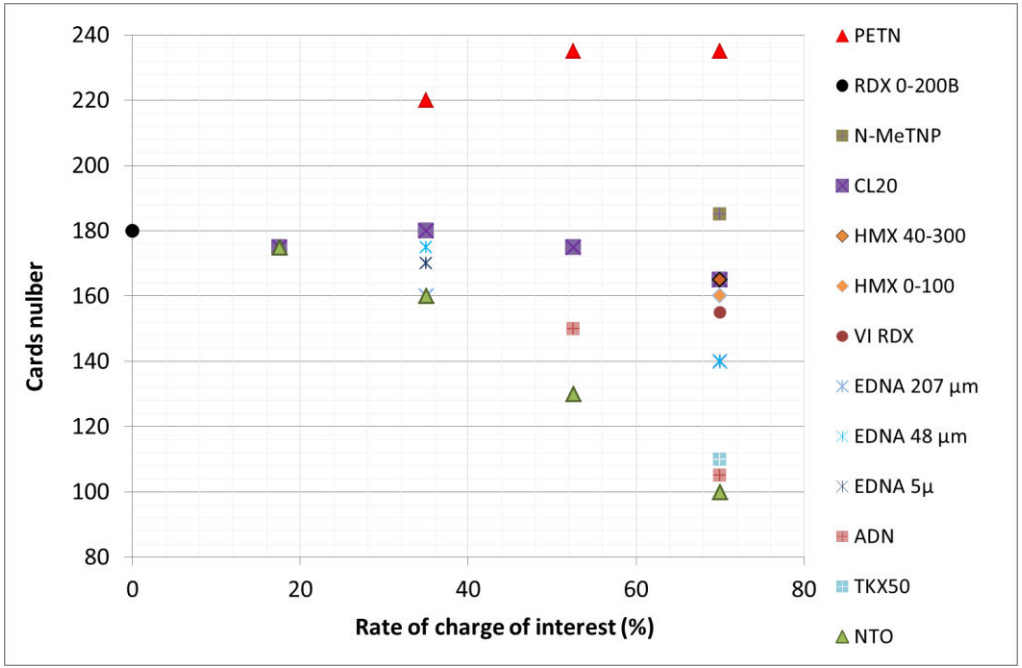
Small scale evaluation methodology

A new method has been developed to test new molecule sensitivity in composition :

- Using a Small Scale Card Gap test (mini Gap test)
- Able to class molecules in a range from PETN to NTO
- Using 50 g of new molecule
- Comparable with usual Gap Test results
- Test domain extended to low sensitive charge

New molecules test still in progress

Database useful to study the impact of ingredient (molecule, particle size, filling rate..) on sensitivity



THANKS TO CONTRIBUTORS