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Deflagration Behavior of HMX-Based Explosives and Effects on the Violence of Thermal Explosions

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XIV ZABABAKHIN SCIENTIFIC TALKS
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Outline

1 Introduction

2 Experiment

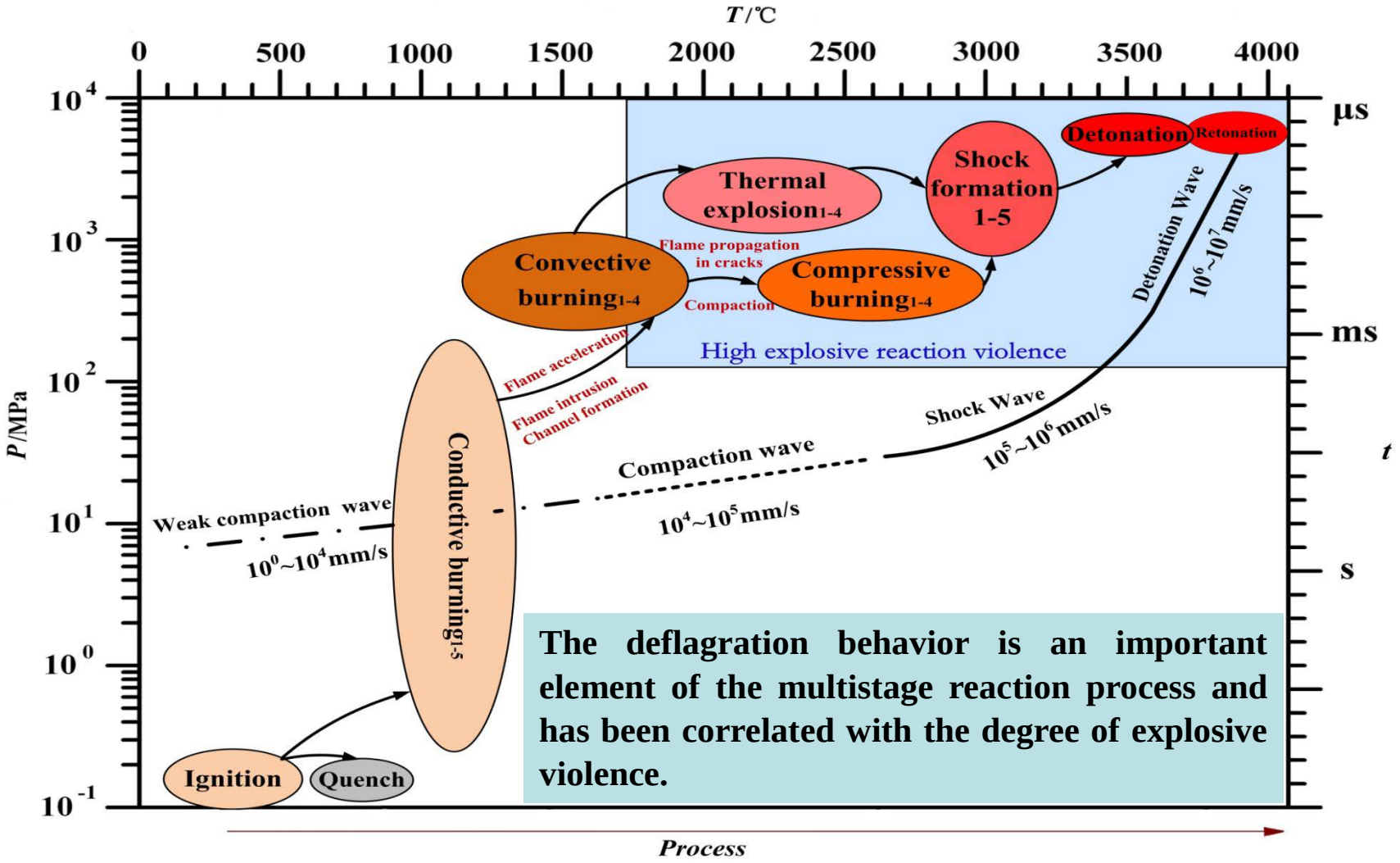
3 Results & Discussion

4 Conclusions

Introduction

Explosives are metastable substance which can occur different violent reaction when subjected to heat, impact, friction, shock, or other suitable initiation stimulus. The safety is basic question that weapon system concerns.

Introduction



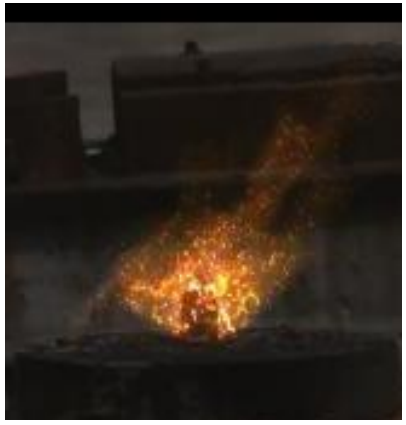
The deflagration behavior is an important element of the multistage reaction process and has been correlated with the degree of explosive violence.

Introduction

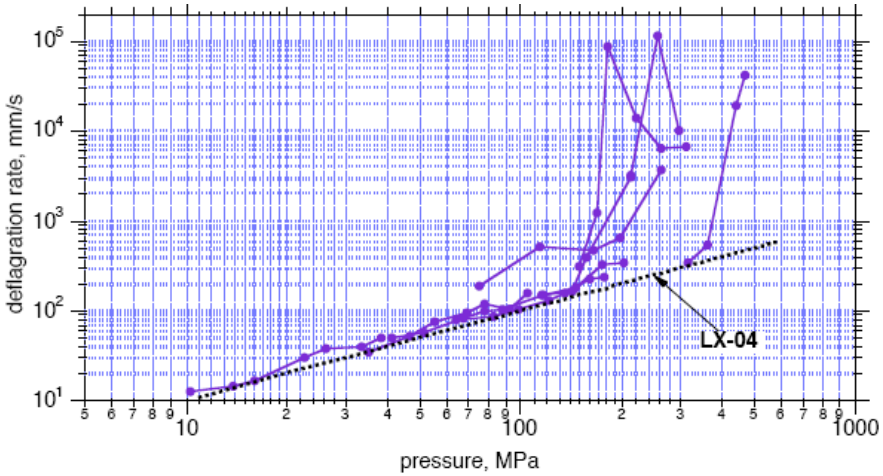
5s

33s

51s



84s



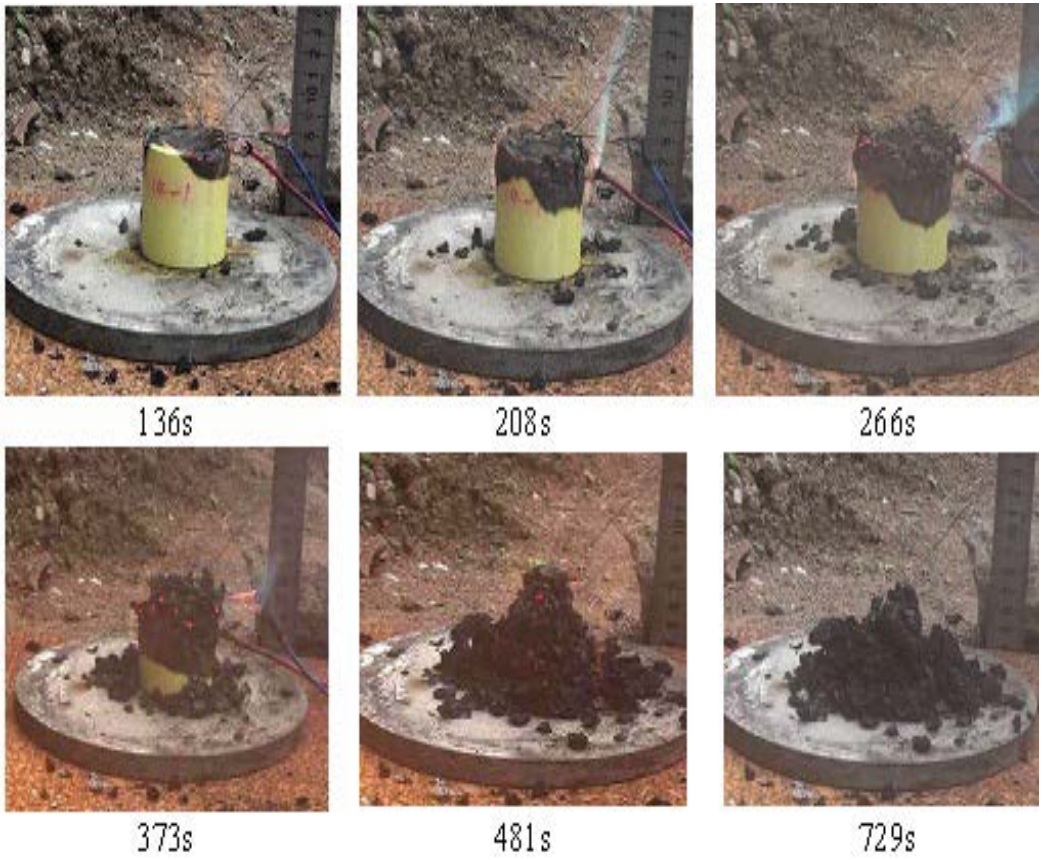
95%HMX/10%Viton A

Jon L. Maienschein, Jeffrey F. Wardell, JANNAF 21st Propulsion Systems Hazards Subcommittee Meeting, 2003

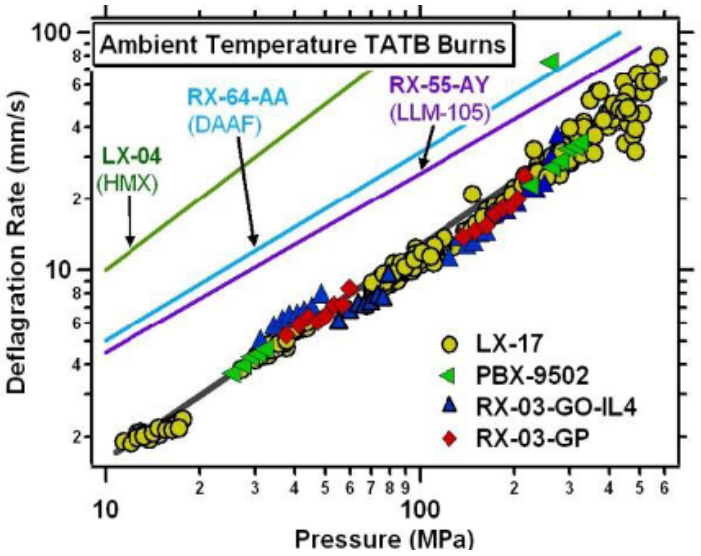
- **A kind of High Explosive**
- **Pressure dependent burn rate is sensitive**
- **deflagrate erratically at high pressure**

HMX-based PBX burns at ambient temperature and pressure

Introduction



TATB-based PBX burns at ambient temperature and pressure



E. A. Glascoe, J. L. Maienschein, K. T. Lorenz, N.Tan, J. G. Koerner, 14th International Detonation Symposium,2010

- **A kind of insensitive High Explosive**
- **Pressure dependent burn rate is insensitive**
- **deflagrate smoothly at high pressure**

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Introduction

Material type	Sensitivity	H50 /cm	E /(kcalmol−1)	D/(ms−1)	PCJ/GPa
HMX	Secondary (CHE)	26	52.7	9010	39
TATB	Secondary (IHE)	>320	59.9	7660	25.9

HMX + TATB → HMX/TATB-based PBX

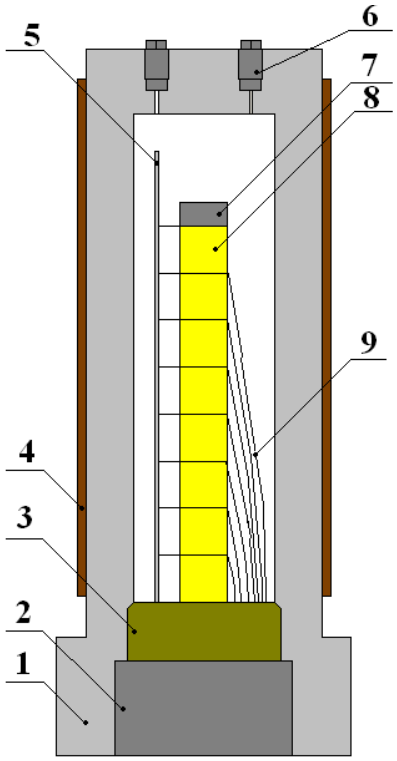
What is the deflagration behavior of HMX/TATB based PBX ?

Is the thermal safety improved?

We measured the burn rate as a function of pressure of HMX-based and HMX/TATB-based PBX with the hybrid strand burner to obtain reaction rate data for prediction of violence of thermal explosions.

Experiment

➢ Apparatus



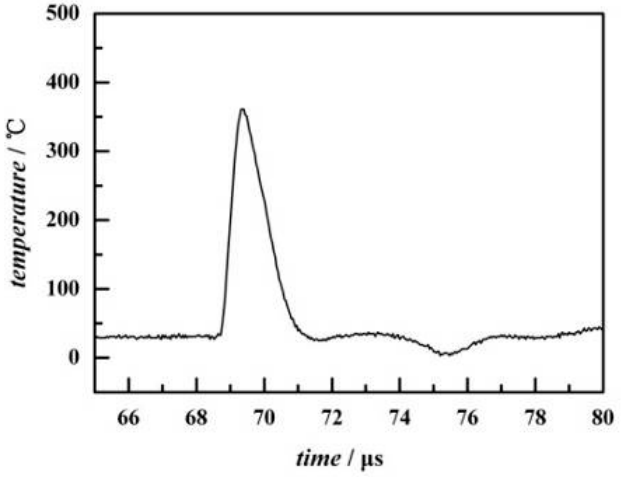
- ✓ Volume 60 cm3
- ✓ Designed pressure 400MPa

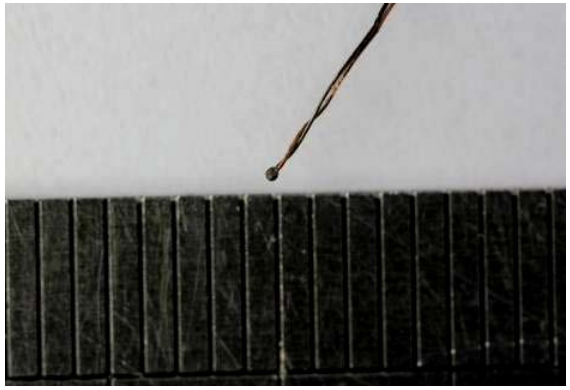
hybrid strand burner

1—vessel ; 2—holder ; 3—connection plug ; 4—heating device ; 5—vertical post ; 6—pressure transducer ; 7—ignitor ; 8—sample ; 9—signal wires

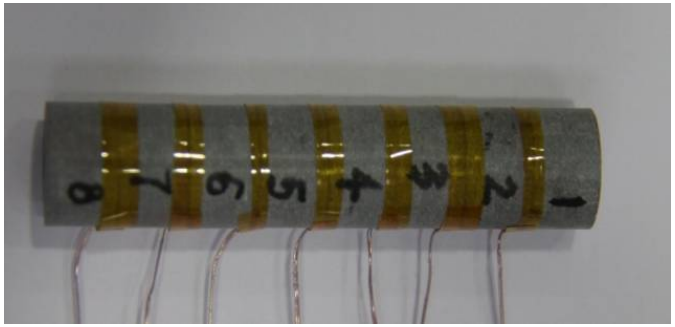
Experiment

➢ Test method





Φ120μm microthermocouple



8 pellets

- ✓ Response time μs
- ✓ Located between each pair of pellets
- ✓ Monitor deflagration front time-of-arrival data
- ✓ Monitor the pressure history with kistler transducer

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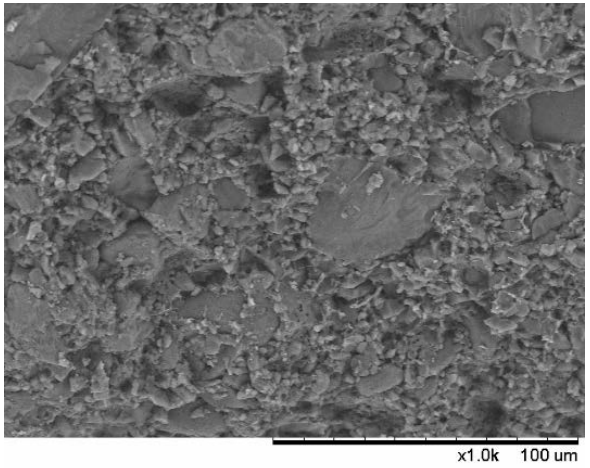
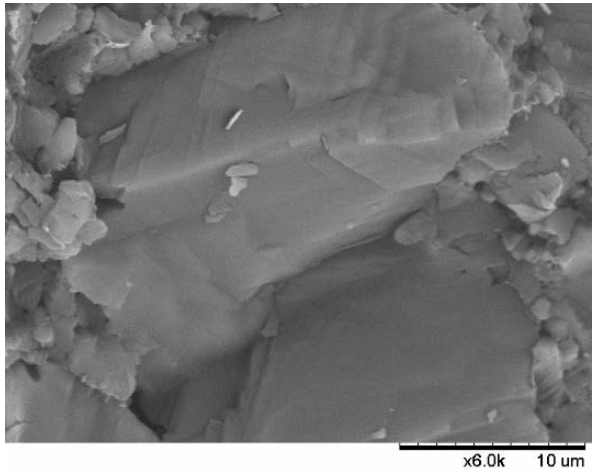
Experiment

➢ Materials

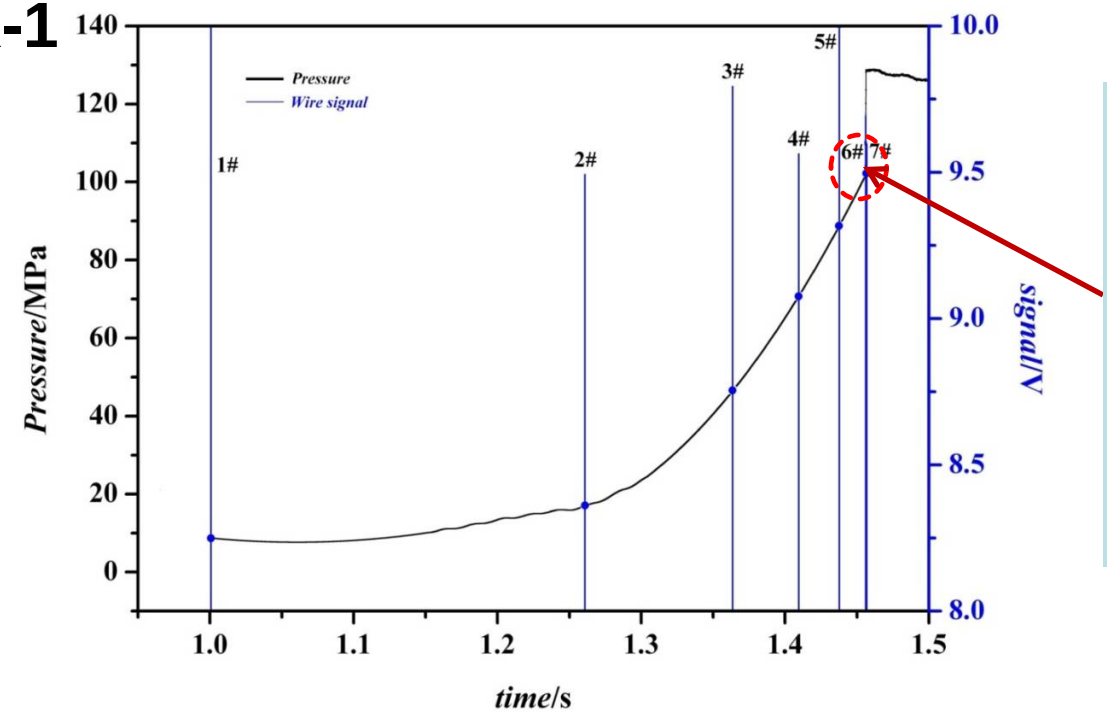
Materials name	Formulation (wt%)	Density (g/cc)	TMD (%)
PBX-1	95 HMX 5 binder	1.863	98.6
PBX-2	87 HMX 7 TATB 6 binder	1.848	98.6





Results & Discussion

➢ **PBX-1**

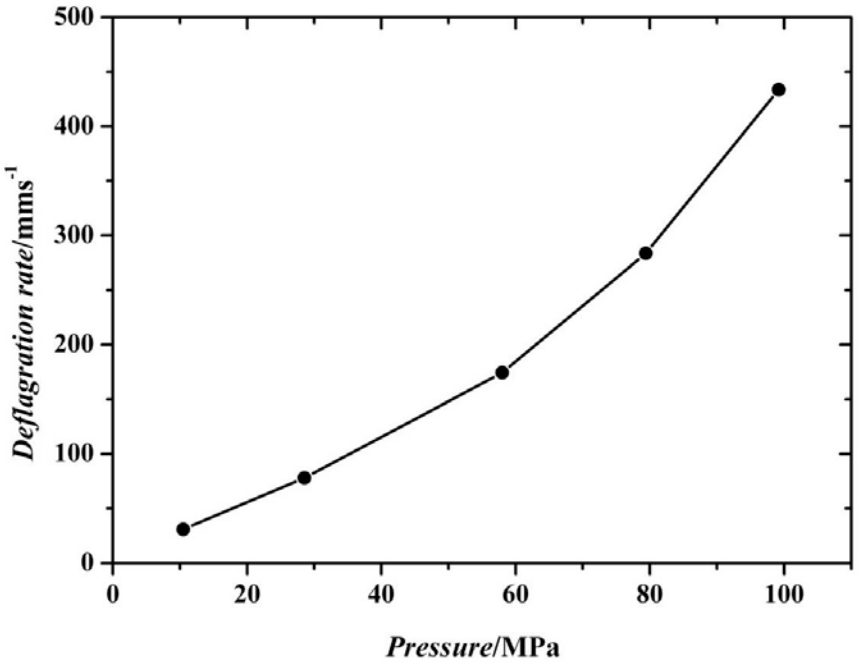


At 100~110MPa the pressure increases rapidly while the burn rate changes from ~10^3 mm/s to ~10^5 mm/s, which shows that PBX-1 occurs deconsolid-ative burning.

Temporal pressure behavior and flame-front time-of-arrival signals

Pellets	2#	3#	4#	5#	6#	7#
Burn time/s	0.25418	0.10269	0.04590	0.02821	0.01845	0.00052
Burn rate/mm·s^{-1}	31.474	77.904	174.192	283.587	433.604	15384.6

Results & Discussion



Pressure/MPa	10.50	28.55	58.00	79.40	99.19
Burn rate/mm·s^{-1}	31.474	77.904	174.192	283.587	433.604

Burn rate as a function of pressure:

$$r_1=(2.16\pm0.55)P^{1.08\pm0.06}$$

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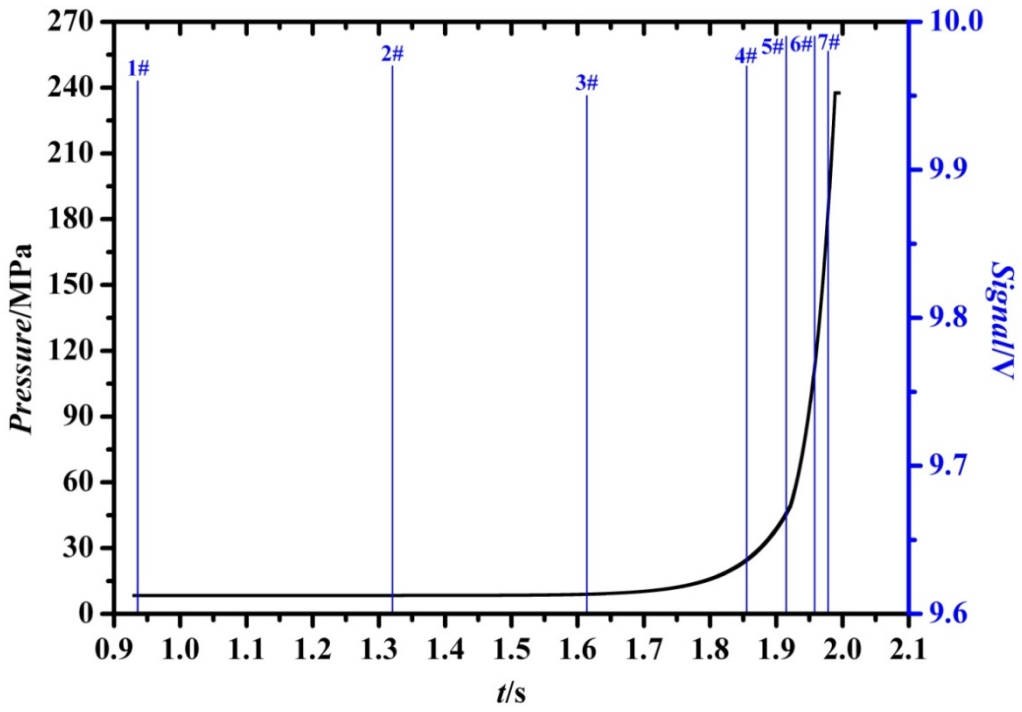
Results & Discussion

➢ **PBX-2**



- Deflagrate smoothly
- No deconsolidative burning

Pellets	2#	3#	4#	5#	6#	7#
Burn time/s	0.3762	0.3017	0.2117	0.0596	0.0428s	0.0205
Burn rate/mm·s^{-1}	21.26	26.52	37.79	134.09	186.92	390.24

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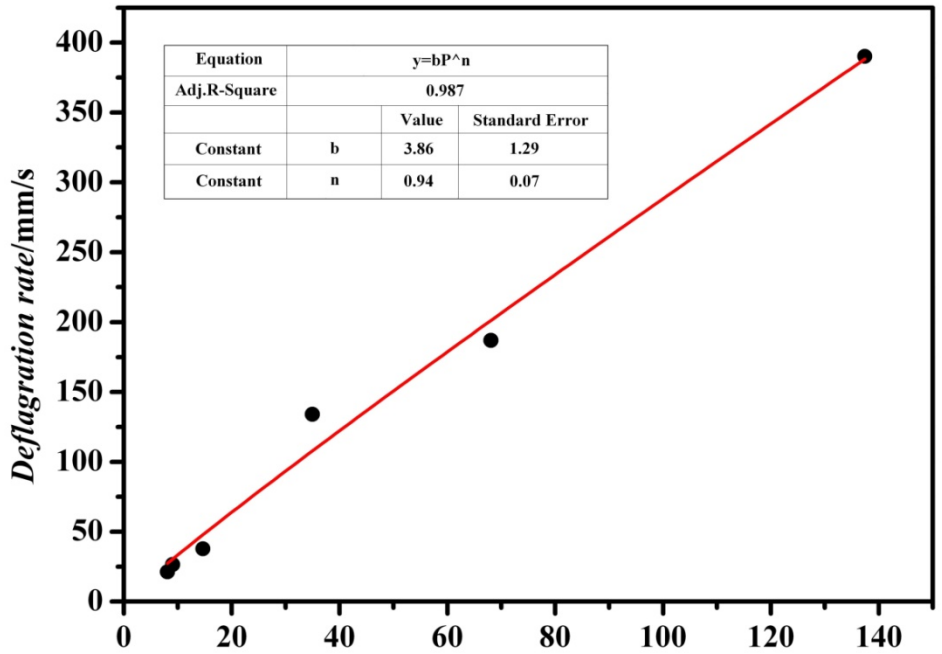
Results & Discussion



Pressure/MPa	8.07	9.05	14.67	34.97	68.09	137.42
Burn rate/mm·s^{-1}	21.26	26.52	37.79	134.09	186.92	390.24

Burn rate as a function of pressure:

$$r_2 = (3.86 \pm 1.29) P^{0.94 \pm 0.07}$$

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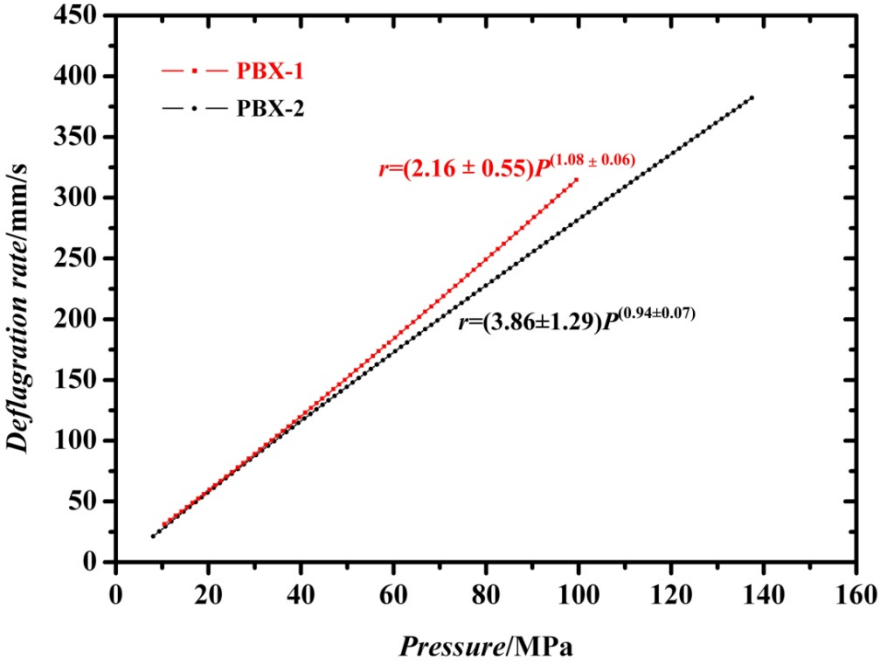
Results & Discussion

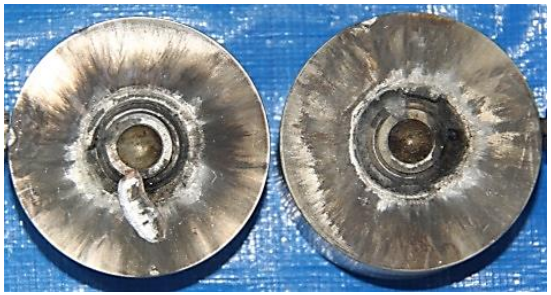
➢ Comparison



- Pressure exponent of PBX-1 $n_1=1.08\pm0.06>1$ and PBX-2 $n_2=0.94\pm0.07<1$, which indicates that the burn rate of PBX-1 is sensitive to pressure than PBX-2.
- PBX-1 occurs high violent reaction easily compared to PBX-2.

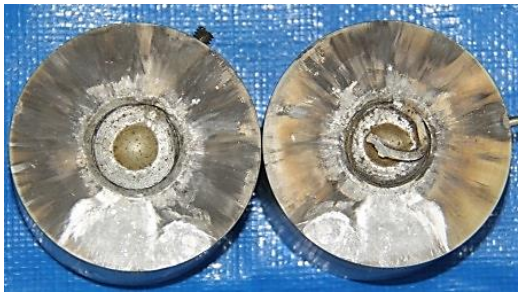
Results & Discussion

➢ **Results of** One Dimensional Time to Explosion（ODTX）



205℃

210℃

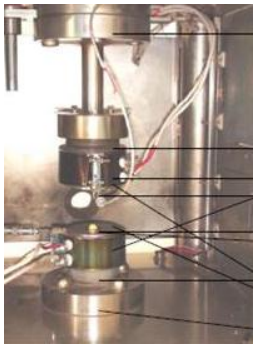


215℃

220℃

230℃

240℃



PBX-1

Anvils confinement 200MPa

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Results & Discussion

210℃

220℃

225℃

230℃

240℃

250℃

PBX-2

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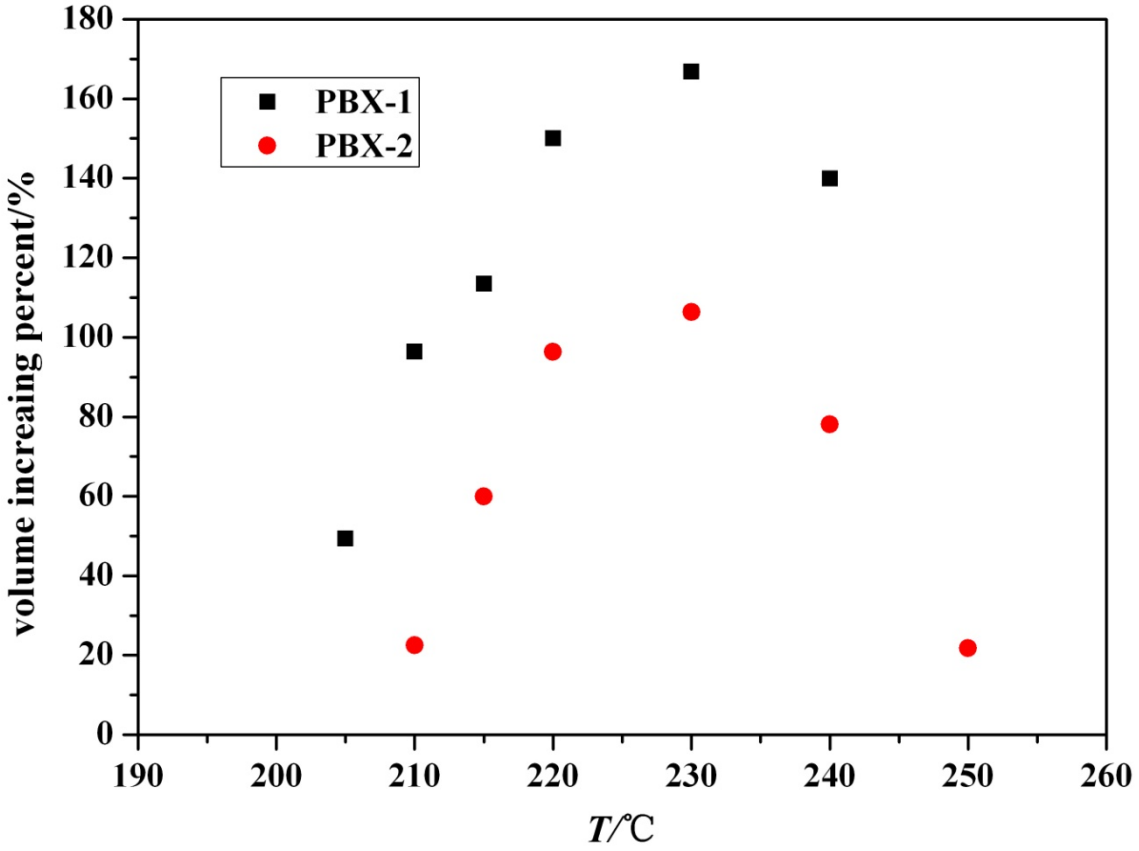
Experiment



The anvils volume increasing percent of ODTX for PBX-1 is bigger than PBX-2 at different temperature, which indicates that the reaction violence of PBX-1 is high than PBX-2.

Conclusions

1、We have characterized the deflagration behavior of HMX-based explosives by measurement in a hybrid strand burner.

2、The deflagration behavior of PBX-2 with TATB changes obviously, which deflagrates smoothly without deconsolidative burning.

3、 The burn rate of PBX-1 is sensitive to pressure than PBX-2, which indicates that PBX-1 could occur higher violent reaction relatively to PBX-2.

4、The characterization of the high-pressure deflagration behavior of explosives can provides insight into prediction of violence of thermal explosions, which are confirmed in ODTX experiment.

Thank you !

Question?