Effect of Nano Combustion Modifier on Combustion Properties of DB and CMDB-propellant

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Abstract. In order to investigate the effects of several nano combustion modifiers (nm-DPT, nm-CB and nm-Al) on the combustion properties of DB/Al-CMDB/RDX-CMDB propellants, the propellant samples were prepared through a solventless extrusion technique. The burning rates of propellants were measured by the strand burner method. The results showed that the nm-DPT enabled a plateau burning effect to appear for the Al-CMDB propellant in the pressure range of 8~22MPa, and the burning rate at 10MPa to exceed 29mm/s. The additional nm-CB powder increased the burning rates of the propellant, and the propellant burning rate at 10MPa exceeded 35mm/s. The nm-DPT enabled a plateau burning effect to appear for the RDX-CMDB propellant in the pressure range of 8~22MPa and a mesa effect in the pressure range of 12~22MPa, and the burning rate at 10MPa to exceeded 28mm/s. The additional nm-CB increased the burning rate of the propellant, the burning rate at 10MPa exceeded 30mm/s and the pressure exponent in the pressure of 16~22MPa was -0.10.

Introduction

As a new kind of functional material, much attention has been paid to nanomaterials. The preparation of nano metal powder, nano metal oxide; nano metal composites and nano carbon materials were investigated. The applications of many kinds of nano materials including nano oxides in DB-propellant were reported in many literatures. And the influence of nano materials on thermal decomposition of some compositions of propellant was studied much [1-13]. But the nanometer materials enhancing the burning rate of propellant was not so much.

High burning rate propellants have great potential applications in high velocity kinetic energy missle and aerial defence missle, antitank missle and new individual weapon for soldiers .However, it is hard to exceed 30mm/s for the burning rate of DB/CMDB propellants. Aiming at the need of high burning rate DB/CMDB propellants, this paper studied the influences of some nano materials on the burning properties of DB/CMDB propellants. And it turned out that the burning rate of Al-CMDB propellant reached 35mm/s (10MPa).The author wished this paper could provide

technology auspice for the application of this kind of nanometer materials in DB/CMDB propellants.

Experiment

Materials

Nitrocellulose (NC, industrial pure), Nitroglycerine (NG, industrial pure), Cyclotrimethylenetrinitramine (RDX, industrial pure), the burning catalysts adopted here included Pb-Cu-CB composite and nano DPT with a diameter of 50nm. Moreover, nano Al (80nm) and nano carbon black (nm-CB, 50nm) were used in the experiments. Nm-DPT was shown in Fig.1 tested by SEM (Scanning electronic microscopy).

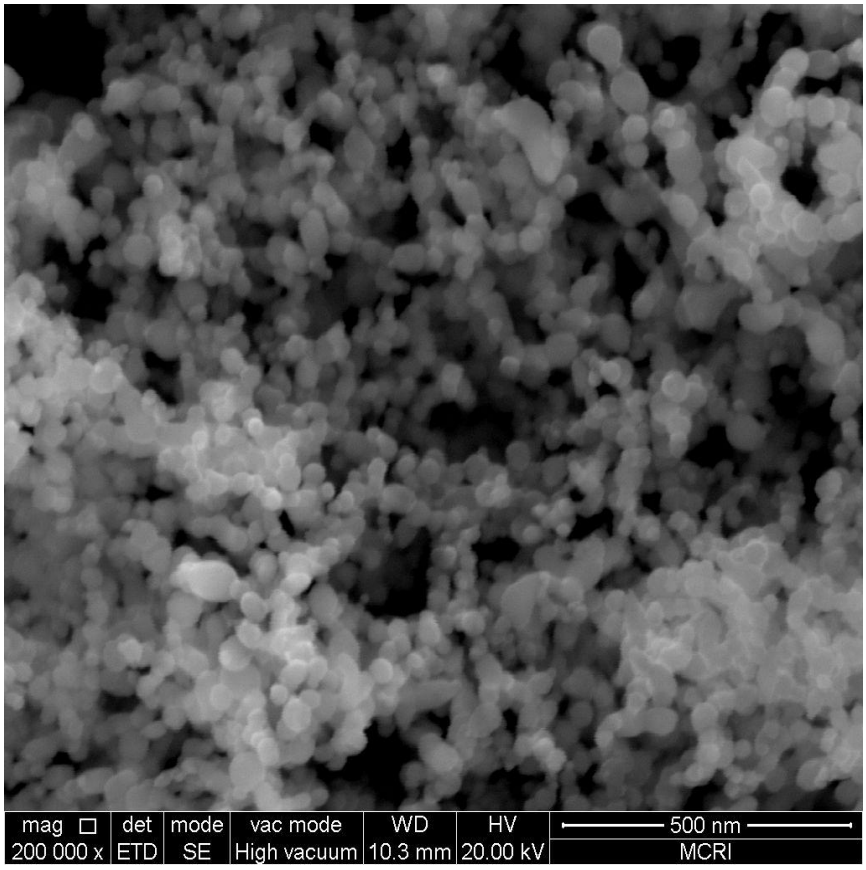

Fig.1 SEM Photograph of nm-DPT

Burning Rate Test

The burning rates were tested following the method of GJB770B-2005 706.1 “the burning rate strand burner method”. The samples for test were φ5mm×160mm strand covered with polyvinyl alcohol ,the burning rates were tested in azotes and the pressure exponent were calculated according to the relation of u=apn, where u was the burning rate, p was pressure, a was constant.

Formulation Designation and Sample Preparation

The DB/Al-CMDB/RDX-CMDB propellant formulations with or without catalysts were designed as exhibited in Table 1.

The propellant samples were prepared by solventless extrusion technology including absorbing, dehydrating, extrusion and cutting.

Tab.1 The Formulation of Propellants

No.	ω/%									
	NC+NG	RDX	Al	Pb salt	Cu Salt	CB	nm-DPT	nm-CB	nm-Al	others
1	82.9			3.5	1.0	0.75				11.85
2	82.9			3.5	1.0	0.75	0.7			11.15
3	82.9			3.5	1.0	0.75	0.7	0.3		10.85
4	80			2.5	2.5	0.3			0	14.7
5	80			2.5	2.5	0.3			2	12.7
6	80			2.5	2.5	0.3			5	9.7
7	80			2.5	2.5	0.3			10	4.7
8	82.5			3.0	0.5	0.75		0		13.25
9	82.5			3.0	0.5	0.75		0.3		12.95
10	82.5			3.0	0.5	0.75		0.5		12.75
11	82.9		5.5							11.6
12	82.9		5.5				1.0			10.5
13	82.9		5.5	3.5	1.0	0.75				5.25
14	82.9		5.5	3.5	1.0	0.75	0.7			4.55
15	82.9		5.5	3.5	1.0	0.75	0.7	0.3		4.25
16	63.4	24		3.5	0.7	0.65				7.75
17	63.4	24		3.5	0.7	0.65	0.7			7.05
18	63.4	24		3.5	0.7	0.65	0.7	0.3		6.75
19	63.4	24								12.6
20	63.4	24					0.7			11.9
21	63.4	24					0.7	0.3		11.06

Results and Discussion

Effect of nm-DPT, nm-CB and Common Catalyst on the Burning Properties of DB Propellants

The DB propellants were widely adopted in many missiles. This paper dealt with the effect of nm-DPT, nm-CB and common catalyst on the burning properties of DB propellant. The results are shown in Fig.2.

As shown in Fig.2, adding nm-DPT to the DB propellant could increase the burning rate (the burning rate at 10MPa could be enhanced by 30%) and reduce the pressure exponent in middle and high pressure zone (the pressure exponent in 8~22MPa could be reduced to -0.13).Adding nm-DPT to the DB propellant could result in high burning rate and low pressure exponent, which are very favorable for applications of DB propellants.

Nm-CB could increase the burning rate under the high pressure (12~22MPa) on the basis of adding nm-DPT. For example, the burning rate reached 40mm/s under 14MPa, and exceeded 44mm/s when the pressure increased to 22MPa.Meanwhile, the pressure exponent between 8~22MPa increased to 0.35 because the burning rates at high pressure zone were enhanced.

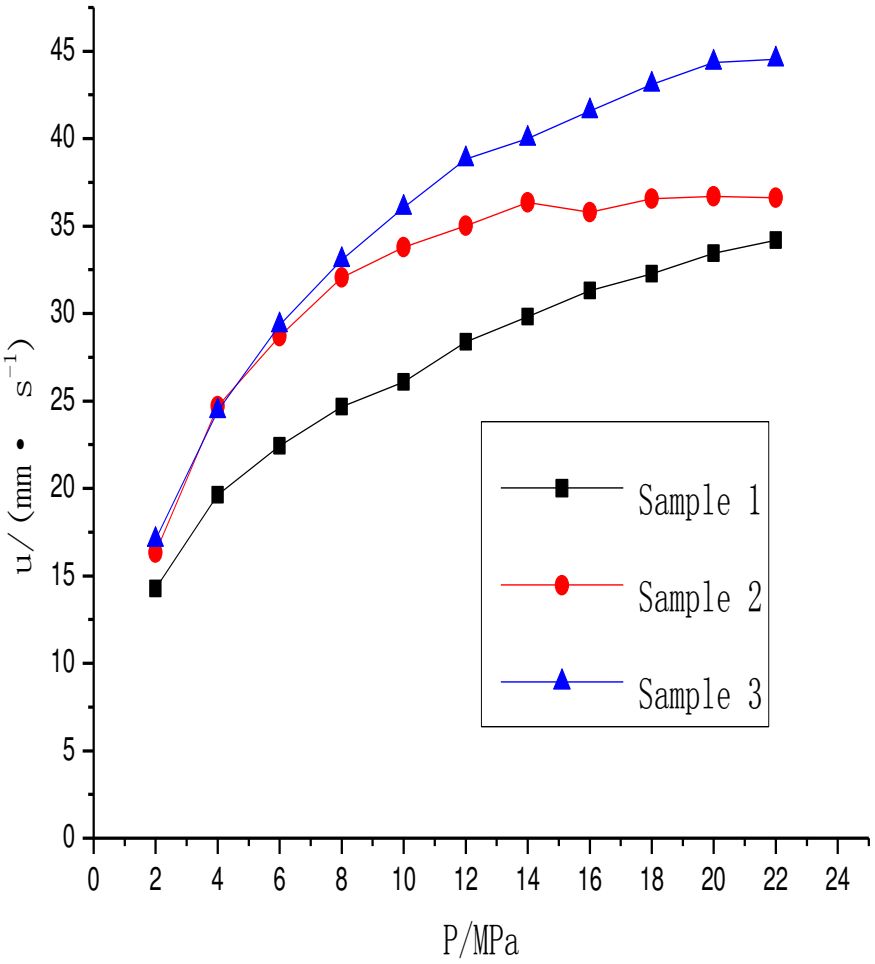

Fig.2 Effect of nm-DPT, nm-CB and Common Catalyst on Combustion Properties of DB Propellant

Nm-DPT could increase the burning rate and reduce the pressure exponent at high pressures remarkably even when other catalyst were also added to the propellants which resulted a low content of nm-DPT of lower than 1%.Obviously,nm-DPT is a promising assistant catalyst.

Effect of nm-Al and nm-CB to the Combustion Properties on DB Propellants

There are many reports on application of nm-Al in propellants[14-16], but only a few job dealt with the effect of nm-Al on the combustion property of DB propellant, especially the effects of the content of nm-Al on combustion property. Similarly, there was only a few works on the application of nm-CB in DB propellants. In this work, the effects of nm-Al and nm-CB on propellant's combustion properties were as shown in Fig.3.

As shown in Fig.3, adding nm-Al could reduce the burning rates of propellant much in middle or low pressure zone, but results in only a little change for burning rates in high pressure zone, so the pressure exponent was enhanced significantly. With the increase in content of nm-Al, the burning rate reduced markedly but the pressure exponent increased gradually. The burning rate of DB propellant containing common catalyst would increase a little and the pressure exponent would not change evidently for adding nm-CB into the propellant. With the increase in content of nm-CB, the burning rate increased a little but the pressure exponent did not change.

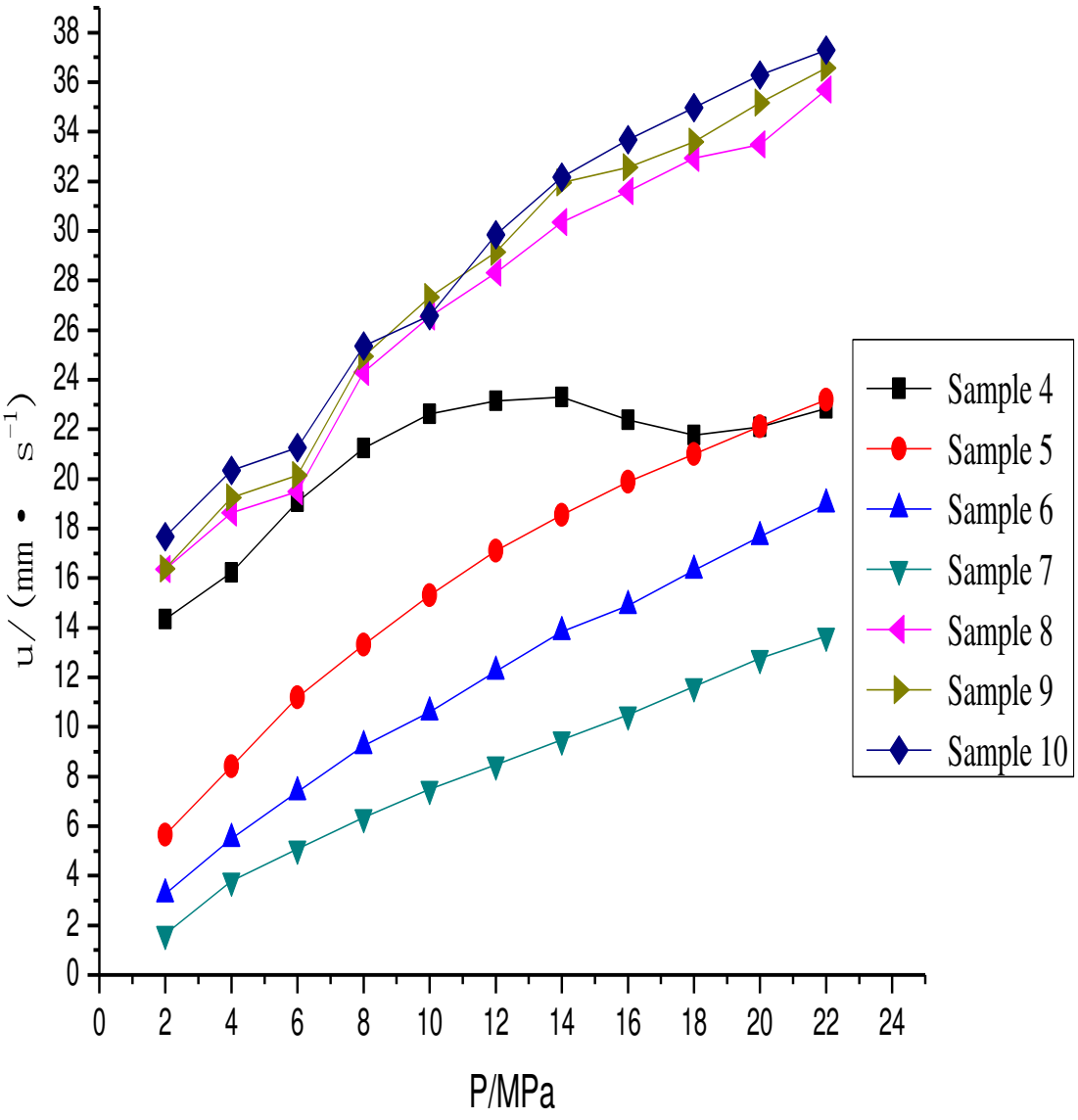

Fig.3 Effects of nm-Al and nm-CB with Different Contents on Combustion Properties of DB Propellant

Effect of nm-DPT, nm-CB and Common Catalyst on Combustion Properties of Al-CMDB Propellant

Al-CMDB propellant has many advantages such as higher power than DB propellant, good quality consistency, adjustable burning rate and pressure exponent, so Al-CMDB propellants were applied in engine of tactical missile widely. But the burning rate of Al-CMDB propellant was not high enough so the application was limited. In this work, the effects of nm-DPT, nm-CB and common catalyst on propellant′s combustion properties were investigated. The results were shown in Fig.4.

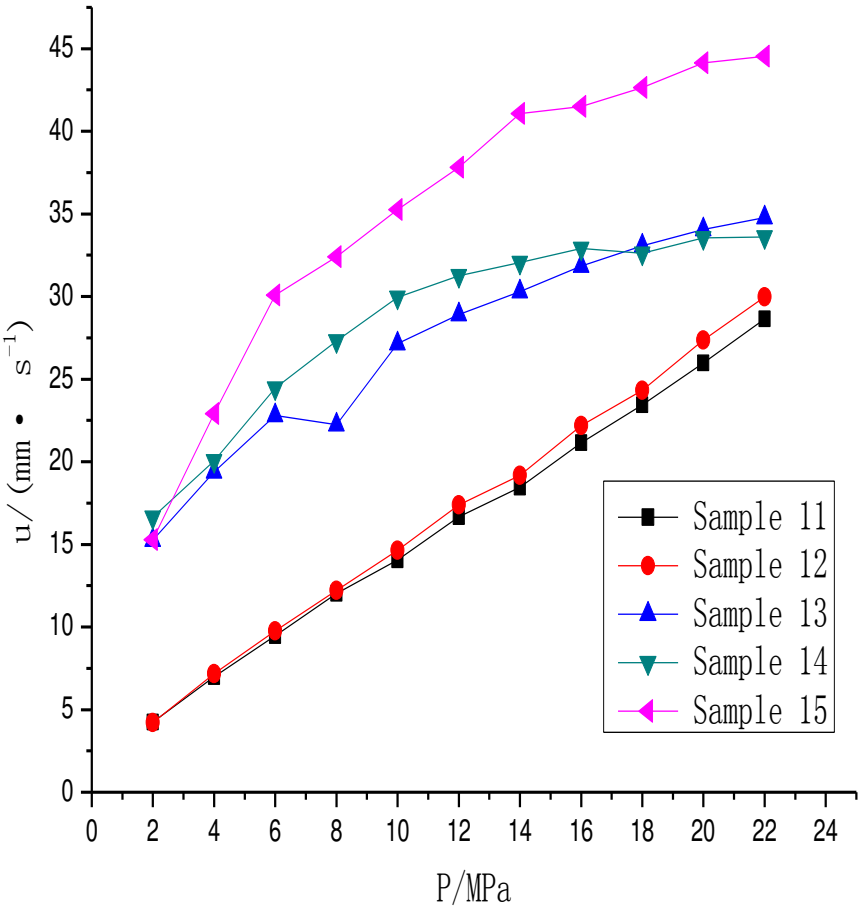

Fig.4 Effects of nm-DPT, nm-CB and Common Catalyst on Combustion Properties of Al-CMDB Propellants

As shown in Fig4, adding 1.0% nm-DPT could increase the burning rate of Al-CMDB propellant without common catalyst in the zone of 4~22MPa by 0.2~1.0mm/s, and increase the pressure exponent in the zone of 2~22MPa from 0.79 to 0.81.This showed that the effects of nm-DPT on combustion properties of propellants without common catalyst were little.

Adding 0.7% nm-DPT could increase the burning rate of Al-CMDB propellant with common catalyst in the zone of 2~16MPa and reduce the burning rate in the zone of 18~22MPa, so the pressure exponent between 8~22MPa reduced evidently from 0.37 to 0.19, showing a wide plateau zone. Adding more 0.3% nm-CB could increase the burning rate in the zone of 6~22MPa by 6~11mm/s.

Comparing formulation 11, 12, 13 with 14, we could find the nm-DPT has little effects on Al-CMDB propellant without common catalyst, but has great effects on Al-CMDB propellant with common Pb-Cu-C catalyst including increasing the burning rate at the low pressures and reducing the pressure exponents.

Comparing formulation 14 with 15, we could see adding nm-CB or nm-DPT can increase the burning rate of Al-CMDB propellant with common Pb-Cu-C catalyst and nm-DPT greatly.

Effects of nm-DPT, nm-CB and Common Catalyst on Combustion Properties of RDX-CMDB Propellant

RDX-CMDB propellant has many advantages such as good quality consistency,low signature and adjustable burning rate and pressure exponent so RDX-CMDB propellant was applied in many

model weapons. But their burning rates need to be increased. This paper studied the effect on nm-DPT, nm-CB and common catalyst on RDX-CMDB propellant combustion properties. The results were shown in Fig.5.

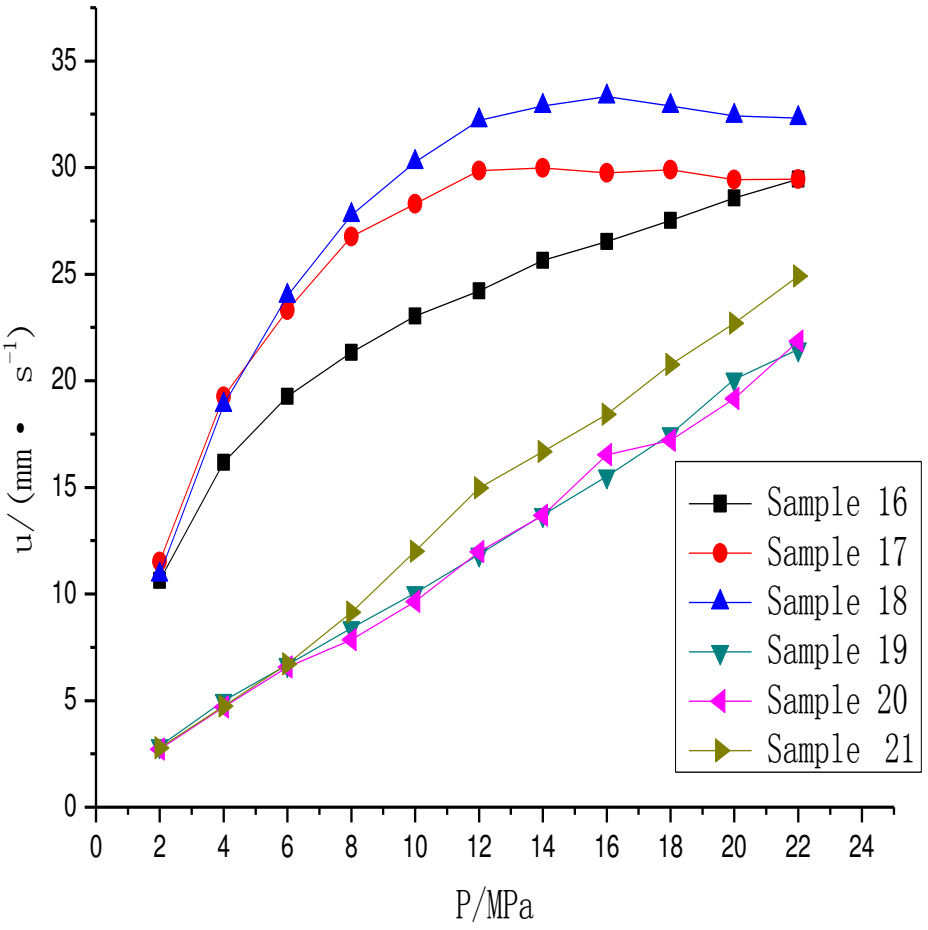

Fig.5 Effects of nm-DPT, nm-CB and Common Catalyst on Combustion Properties of RDX-CMDB Propellant

As shown in Fig.5,the burning rate of RDX-CMDB propellant containing common catalyst would be increased by about 3.1~5.6mm/s at 4~16MPa and about 0~2.4mm/s at 18~22MPa ,so that the pressure exponent reduce to 0 or much little, showing mesa-burning behavior by adding nm-DPT.

Adding nm-CB to the propellant containing common catalyst and nm-DPT would increase the burning rate by 0.6~3.6mm/s at 6~22MPa and more at 14~16MPa, so the pressure exponent increased to 0.14 at 8~22MPa, but reduced to -0.10 in the high pressures of 16~22MPa.

Adding nm-DPT and nm-CB to the propellant without common catalyst leads to a stepwise increase of the pressure exponent. The burning rate changed a little and the pressure exponent increased a little if adding nm-DPT into propellant. Adding nm-CB to the propellant with nm-DPT would enable the burning rate in the low pressure zone to rise a little but much bigger in the high pressure zone, so the pressure exponent increased (from 0.87 to 0.95).

It was concluded that nm-DPT and nm-CB were useful burning catalysts; they could enhance the burning rates and reduce the exponents of propellant with other catalysts. If just adding nm-DPT or nm-CB only into propellant without other catalyst, the effects was little. So adding nm-DPT, nm-CB and other catalyst together was a valuable way to enhance the burning properties of DB or

CMDB propellants.

Conclusions

(1) The burning rates of DB propellants would reduce and the pressure exponent would increase by adding nm-Al. The burning rates of DB propellants would increase a little and the pressure exponent would not change by adding nm-CB to DB propellant. The burning rate of DB propellant would increase to 40mm/s at 14MPa and exceed 44mm/s at 20MPa.

(2) Adding nm-DPT made the Al-CMDB propellant including 5.5% Al powder result in plateau-burning effect at 8~22MPa, and the burning rate at 10MPa exceed 29mm/s. If adding nm-DPT and nm-CB to propellant, the burning rate would increase obviously, exceed 35mm/s at 10MPa and 40mm/s at 14MPa.

(3) Adding nm-DPT made the RDX-CMDB propellant with 24% RDX result in mesa-burning effect at 12~22MPa,and the burning rate at 10MPa would exceed 28mm/s. Addition of nm-CB to the propellant with nm-DPT would lead to the ulteriorly increased burning rate ,exceed 30mm/s at 10Mpa and the pressure exponent would be -0.10.

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