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Determination of Sensitivity of Plastic Explosive Containing Insensitve Explosives

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Abstract: In order to obtain low sensitive high explosive formulation. Plastic explosive based on hexogen and octogen were investigated. 3-nitro-1,2,4-triazol-5-one (NTO) was used as an additive. The experimental results show this additive decrease the impact and friction sensitivity without worsening another parameters.

Key words: physical chemistry; low sensitive high explosive; plastic explosive; additive; senstivity

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1 Introduction

Military and civil applications require more and more new insensitive explosives. We investigated low sensitivity plastic explosives because of a profitable technological form and low toxicity of these explosives. For plastic explosive components, the formulation explosion properties are mainly decided by explosive itself. Hexogen (RDX), pentrit (PETN) and octogen (HMX) are used very often. Their energy is high and impact and friction sensitivity are relatively not high. Bullet impact sensitivity is one of the most important parameters. This test standard is described in ONZ transport regulations [1]. It's a shot testing of samples by bullet caliber 12.7 mm of defined energy. The method is presented in reference [2]. We could notice some relations between sensitivity to mechanical stress (to impact, to friction) and sensitivity to bullet shot. Researches show enlarging resistance on shot bullet with desensitized explosive in comparison with RDX, HMX. But shot sensitivity depends on applied measurement methods. The type of tube material and relative bullet energy on area unit (caliber, speed, mass and shape of bullet) affect the results. The results show that samples of traditional high explosives like TNT, RDX-desensitized put in a metal tube are too sensitive and detonation will occur.

In our experiment we used NTO as an additive in order to decrease sensitivity to mechanical stress of the plastic bonded explosive formulations without worsening their detonation parameters.

NTO is a crystalline substance with high density and detonation velocity. The melting point is 260 ℃ (with decomposition) [3,4]. NTO is suitable for a component in insensitive and thermal resistant high explosives. Especially, NTO is low sensitive to mechanical stresses [5]. The critical diameter of NTO is high and depends on grain size characteristic, it is in the range from 13 to 25 mm [6,7].

2 Materials and method

2.1 Characteristics of explosives

The following explosives were used.

RDX: tap bulk density 0.96 $g \cdot cm^{-3}$, grain size analysis is presented in Fig. 1; HMX: tap bulk density 1.04 $g \cdot cm^{-3}$, grain size analysis is presented in Fig. 2; NTO: tap bulk density 0.95 $g \cdot cm^{-3}$, grain size analysis is presented in Fig. 3; crystals of NTO are shown in Fig. 4. RDX was not crystallized from acetone but was received by long stabilizing with water. HMX was crystallized from acetone.

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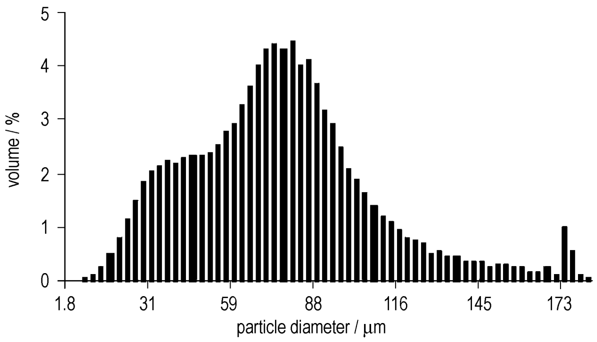

Fig. 1 Particle size distribution of RDX

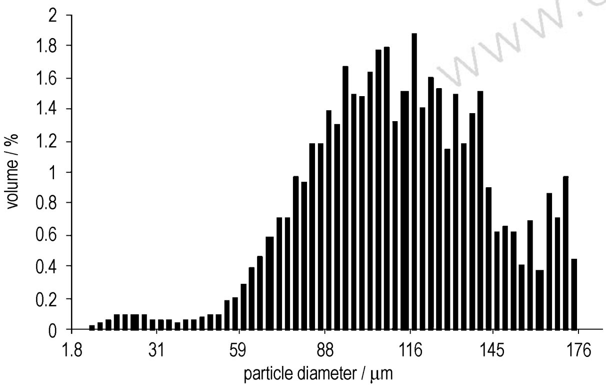

Fig. 2 Particle size distribution of HMX

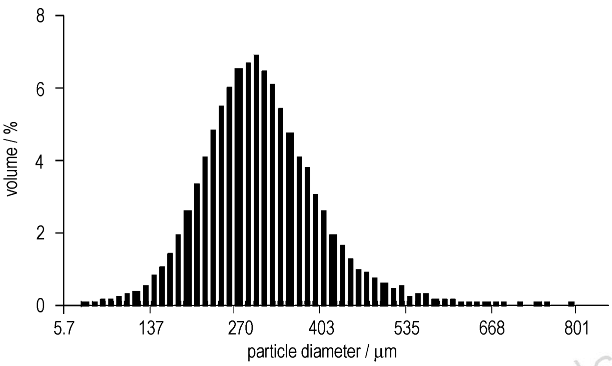

Fig. 3 Particle size distribution of NTO

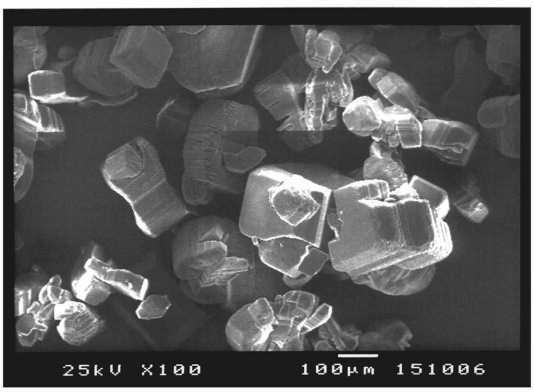

Fig. 4 Crystals of NTO

Binder is butadiene – styrene copolymer containing dioctyl adipate and oil.

We prepared the plastic explosives in the following ways: direct mixing binder with dry explosives; water suspension method to produce molding powder and then drying.

2.2 Methods

Bullet impact tests are expensive so we carried out researches on impact and friction sensitivity of plastic bonded explosive.

The impact sensitivity of explosives was studied using the drop weight apparatus. The friction sensitivity of explosives was studied using the Peters apparatus.

3 Results

3.1 Result for plastic explosives with RDX

Samples contain 84% and 90% explosive. NTO content was changed. Binder content was stable for all series: butadiene-styrene copolymer 30%; dioctyladipate 60%; oil 10%. Result sensitivity tests to impact and friction were shown in Table 1 and Table 2. The lowest sensitivities was obtained for samples content 84% explosives. However density was less then in samples content 90% explosives.

NTO additive reduces sample sensitivity to impact to 34.3 Nm for explosive content 84%, to 29.4 Nm for explosive content 90% (they contain 20% ~ 60% of NTO). A high decrease of sample sensitivity to impact appears for 80% NTO additives.

We also studied samples contained 84% of explosive with adding NGU. The content of NGU was changed. Binder content was stable for all series. Additive NGU reduced impact sensitivity to 34.3 Nm when NGU's relative content was 60%. Results were shown in Table 3.

3.2 Results for plastic explosives with HMX

For HMX, samples contain 90% explosive mixture. NTO content was changed. Binder content was stable for all series. Results were shown in Table 4.

NTO additive reduces sample sensitivity to impact to 29.4 Nm for explosive content 90% (contained 20% ~ 60% of NTO).

Table 1 Test results of sensitivity to impact and friction for plastic explosive containing 84% explosive

84% explosive 16% binder	density/ g·cm^{-3}	impact sensitivity$^{1)}$/Nm	impact sensitivity$^{2)}$/Nm	friction sensitivity$^{1)}$/N	friction sensitivity$^{2)}$/N
0% NTO 100% RDX	–	29.4	24.5	>353	≥353
20% NTO 80% RDX	1.42	34.3	29.4	>353	≥353
40% NTO 60% RDX	1.48	34.3	29.4	>353	≥353
60% NTO 40% RDX	1.50	34.3	29.4	>353	≥353
80% NTO 20% RDX	1.53	>49.0	39.2	>353	≥353

note: 1) min. 1 decomposition at 6 samples; 2) no decomposition at 6 samples.

Table 2 Test results of sensitivity to impact and friction for plastic explosive containing 90% explosive

90% explosive 10% binder	density /g·cm^{-3}	impact sensitivity$^{1)}$/Nm	impact sensitivity$^{2)}$/Nm	friction sensitivity$^{1)}$/N	friction sensitivity$^{2)}$/N
0% NTO 100% RDX	–	24.5	19.6	353	317
20% NTO 80% RDX	1.51	29.4	24.5	>353	≥353
40% NTO 60% RDX	1.56	29.4	24.5	>353	≥353
60% NTO 40% RDX	1.59	29.4	24.5	>353	≥353
80% NTO 20% RDX	1.59	49.1	39.2	>353	≥353

note: 1) min. 1 decomposition at 6 samples; 2) no decomposition at 6 samples.

Table 3 Test results of sensitivity to impact and friction for plastic explosive containing 84% explosive

84% explosive 16% binder	density/ g·cm^{-3}	impact sensitivity$^{1)}$/Nm	impact sensitivity$^{2)}$/Nm	friction sensitivity$^{1)}$/N	friction sensitivity$^{2)}$/N
0% NGU 100% RDX	–	29.4	24.5	>353	≥353
20% NGU 80% RDX	1.3	29.4	24.5	>353	≥353
40% NGU 60% RDX	1.24	29.4	24.5	>353	≥353
60% NGU 40% RDX	1.14	34.3	29.4	>353	≥353
80% NGU 20% RDX	1.08	49.1	39.2	>353	≥353
100% NGU	0.94	>49.1	≥49.1	>352	≥352

note: 1) min. 1 decomposition at 6 samples; 2) no decomposition at 6 samples.

Table 4 Test results of sensitivity to impact and friction for plastic explosive containing 90% explosive

90% explosive 10% binder	density/ g·cm^{-3}	impact sensitivity$^{1)}$/Nm	impact sensitivity$^{2)}$/Nm	friction sensitivity$^{1)}$/N	friction sensitivity$^{2)}$/N
0% NTO 100% HMX	1.56	19.6	14.7	353	317
20% NTO 80% HMX	1.64	29.4	24.5	>353	≥353
40% NTO 60% HMX	1.62	29.4	24.5	>353	≥353
60% NTO 40% HMX	1.58	29.4	24.5	>353	≥353
80% NTO 20% HMX	1.57	39.2	34.3	>353	≥353

note: 1) min. 1 decomposition at 6 samples; 2) no decomposition at 6 samples.

4 Conclusion

Obtained crystalline form and grain size characteristic of NTO enable technological processing and ensure good properties.

Additive NTO decreased the sensitivity to impact of tested samples. The samples containing 84% of explosive had lower sensitivity to impact. For samples, which contained 20% ~ 60% of NTO, sensitivity was the same. The high decrease of sensitivity to impact appeared for 80% of NTO additive. The additive of 20% NTO decreased sensitivity to impact of plastic explosive

The additive NGU (60% ~ 80%) also decreased the sensitivity to impact for tested samples.

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含钝感炸药的塑性炸药配方感度研究

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摘要: 采用低感、钝感炸药 NTO、NGU 作为添加剂,获得了以 RDX、HMX 为基的低感高能炸药配方,研究了 NTO、NUG 对其撞击和摩擦感度的影响。实验表明 NTO 可降低撞击和摩擦感度,并对其他性能产生不大影响。这说明低感或钝感炸药的加入是降低塑性炸药感度的有效方法。

关键词:物理化学; 钝感炸药; 塑性炸药; 添加剂; 感度

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