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TEX——A LOVA Explosive

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Abstract: The author briefly analyses the problems of setting new explosives and explosive compositions with classification of low vulnerable ammunition (LOVA) explosives. Further a brief analysis of known characteristics of explosives is realised. 4,10-dinitro-4,10-diaza-2,6,8,12-tetraoxatetracyclo[5.5.0.$0^{5,9}$.$0^{3,11}$]dodecane(TEX) is taken to be a low vulnerable explosive. But has not been reported in any references about its utilization in wide scale. The analysis in this article is a try to find a possible explication of current situation and further development.

Key words: TEX; LOVA explosive; sensitivity

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1 Introduction

One of the most expressive trend during the last decade in the field of explosives for military application is first of all qualitative change of claims layed on their vulnerability, i. e. predisposition to endanger the surrounding in case of extreme (accident) exposition in stocking, transportation or practical use. At present the modern military explosives (or explosive composition) are usually designed and realised because of the references of low vulnerability, but possibilities of classical (sensitive) explosives, which consist in their desensitisation, are foreclosed in this respect. Then we turn our attention to new energetic structures, which are able to comply with those high requirements.

2 Tests for classification of LOVA explosives

Tests for classification of LOVA explosives are practised according to a methodology for EIDS, Extremely Insensitive Detonation Substances (UN specifications, registration to a transport class 1.6)[1]. Munition objects are tested mostly according to common military standards by modeling a pos-sible accident of the exposure explosive in the ammunition[2].

Sensitivity of explosives in this context is evaluated according to drops, to a friction, to thermal stimulations (heating-up, thermal stability), to initiation by a shock wave (by a detonator), to an impact-small calibre projectile, a fragment or a cumulative jet.

3 Factors influencing the selection of LOVA explosives

The requirements on the insensitive explosives are so strict that the selection of individual explosives, which are able to satisfy these requirements, is very limited. Factors, which determine the utilization of possible structures, can be classified approximately into three categories such as fundamental, technological, economical.

1) Utilization of the explosive is in principle determined by properties of power and sensitivity. However these characteristics are antagonistic. High power of explosives is always connected with a high sensitivity. A possibility to realize a structure, which has high enough power and at the same time is really little sensitive to outer stimulations, is very limited and the possible assortment is drastically reduced by this basic condition. In substance a definite compromise is necessary, and for achievement the acceptable parameters of sensitivity demand to reduce the requirements on power to suitable extent. This selection is often realized by evaluating possible structures in theoretic aspect. Verification in practice is proceeded only in the most interesting cases.

2) Beside the basic condition, such as the practicability of prime synthesis, there exist a number of further aspects,

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which can make this substance out of possible practical use even it could be very promising. For example, its toxicity, chemical and physical stability, tolerance to various substances, solubility (or insolubility), crystallography those can be included in main aspects if the given substance is suitable. It is possible to treat individually a large part of possible problematic properties. In case of accumulation of other factors the situation complicates and solving process are difficult because of economic factor.

3) Economical difficulty of setting LOVA explosives is generally higher than that of expolsives at the same sensitive equivalent. The higher production is, the lower cost is, but it seems to be impossible to reach a break progression in economical area, because general technically-technological difficulty of preparation and application of the explosives, which are suitable for conditions LOVA, is always higher than that of commonly extended and used "sensitive" explosives. However there is a necessity of searching the compromise between the possible and the real. Economical possibilities of every setting are limited and a mass application of LOVA explosives must be in contradiction with this.

4 Individual LOVA explosives

At present there exist only two individual explosives for mass setting, which are generally suitable for requirements of LOVA. They are:

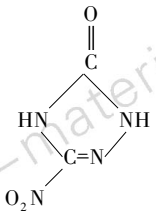
NTO[3]

$\rho_{TMD} = 1.91\ g \cdot cm^{-3}$

$T_m = 270\ ℃$

$\Delta H_f = -544.7\ kJ \cdot mol^{-1}$

$\Delta H_c = 954.7\ kJ \cdot mol^{-1}$



TEX[3]

$\rho_{TMD} = 1.99\ g \cdot cm^{-3}$

$T_m = 299\ ℃$

$\Delta H_f = 2\ 271.7\ kJ \cdot mol^{-1}$

$\Delta H_c = 2\ 782.7\ kJ \cdot mol^{-1}$

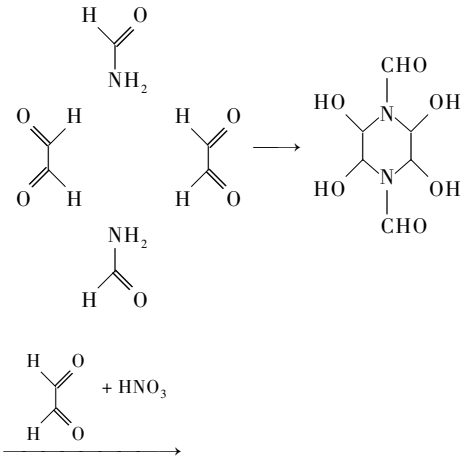
While most of the properties of NTO are known and commonly published, only a few publication about TEX-based explosive properties can be found[4~6].

5 Present situation of TEX explosives

An analysis of some of the known properties of TEX is presented in next part of the article, which focuses on the possible reason why there is no wide practical use. In this analysis, samples of explosives are made by proving technology in Research Institute of Industrial Chemistry (VUCH) Synthesia Semtín, and are phlegmated by a 3% wax ISCOBLEND.

5.1 Preparation

Generally, TEX is prepared by a two-stage method as following:



5.2 Performance

Table 1 contains some detonation parameters calculated according to known Kamlet's relations. Calculated data are approximate, but they are sufficient for rough comparison.

Table 1 Some detonation parameters of NTO and TEX calculated according to Kamlet's equations and derived relations [7~9]

explosive	ρ_{TMD} /g · cm^{-3}	ϕ	$D^{1)}$/km · s^{-1}	$p^{2)}_{C\text{-}J}$/GPa	γ	$u^{3)}$/km · s^{-1}
NTO	1.93	5.07	7.98	29.42	3.18	2.60
TEX	1.99	5.09	8.17	31.40	3.23	2.64

Notice: 1) D—detonation velocity; 2) $p_{C\text{-}J}$—detonation pressure; 3) u—Gurney velocity.

5.3 Sensitivity

When a sensitivity of TEX ($\rho_0 = 1.78\ g \cdot cm^{-3}$, phleg. 3.5% wax Svit 3RV) to compression wave by a

small Gap test (21 mm in diameter) with minimum barrier was tested, a dispersion of the samples occured. Therefore there exists a serious apprehension that TEX has a very high critical diameter. By the tests author (during working on another project) find that TEX (ρ_0 = 1.87 g · cm^{-3}, phleg. 3% wax ISCOBLEND of diameter 25 mm and total height 50 mm inserted into copper tube with thickness of the wall 2.5 mm) detonates without any problems by using powerful booster.

At present there are some experiments in order to determinate further upper and critical diameter of phlegmated TEX and other detonation parameters.

5.4 Thermostability

Generally LOVA explosives must have a high thermal stability. However it isn't given only by a melting point (or a boiling point) and a temperature, by which a pyrolysis of explosives begins, but also by a character of this decomposition. In this connection there occurs the only important problem resulting from the innate chemical principle of TEX. TEX contains two pairs of ether-bonded atoms of oxygen. This arrangement together with an isowurtzitane structure gives this substance the expectations of high thermal stability, but on the other side the reason is a very sharp destruction of a molecule at overreaching the limiting thermal values. This effect is evident from the DTA curves (see Fig. 1 and Fig. 2).

This could be a reason of a problematic behaviour of the explosive enclosed in a massive case, which is represented by ammunition objects. Deep-going problems with fulfilment of required criteria could occur at the tests of thermal straining by a fast or slow heating (EIDS Fast/Slow/Cook-Off Test). It is obviously only a theory. To enounce particular results a determination of a rate constant of thermal decomposition would be needed at least, for example with the help of a vacuum stability test (STABIL[10]) at higher temperatures.

5.5 Crystallography

TEX crystals have a form of a flat plate, which is an absolutely unsuitable form for achievement the near organisation of crystals with minimizing the free intercrystalline spaces. However it is possible to solve this problem by a controlled crystallisation.

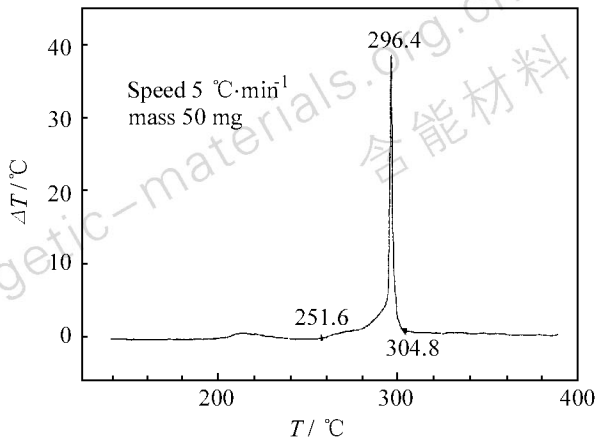


Fig. 1 DTA curve of phlegmated TEX

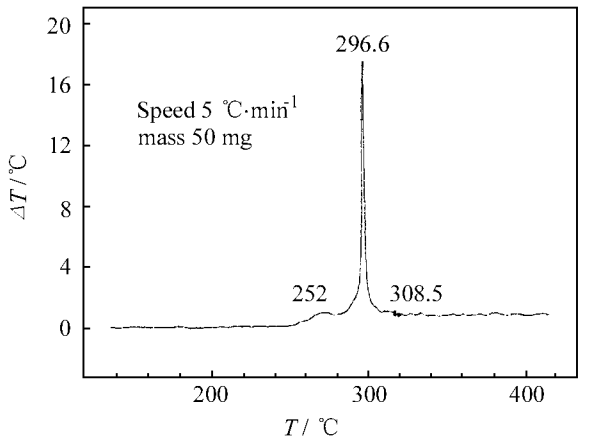


Fig. 2 DTA curve of pure TEX

5.6 Solubility

TEX is low soluble in most common solvents in contrast to NTO.

5.7 Pressing

As it was mentioned, TEX phlegmatized by 3% wax was in a charge of a diameter 25 mm pressed to density ρ_0 = 1.87 g. cm^{-3}, which agree roughly with 97% TMD. The fact that TEX is very insensitive allowed a high pressing pressure, which obviously led to large crunching the crystals and their very near organization.

From the mentioned facts, the pressability of nonmodified phlegmatized TEX is very good.

5.8 Availability

Generally the preparation of TEX is not extremely difficult (see part of preparation). Obtaining a pure

product in satisfactory profits naturally requires relative knowledge. This technology is already available in our conditions.

5.9 Economics

Financial demands of the production and establishment of the TEX in wider scale would be surely considerable. TEX has many incomparable characters and problems of establishing the low vulnerable explosives and ammunition will be actual in future. We can suppose that a shift meaning of economic views in this areas will arise. Special device and experts should have top priority. It will not be able to expose them to the risks resulting from presence of the danger factor, which is sensitive ammunition.

In addition, TEX (similarly to NTO) mass setting would reduce the production deeply. If that the horizon cost (in case of high enough production) for existing synthesis implies is approximate to cost of the HMX, it would be an acceptable.

6 Conclusion

From the hitherto known facts, there is not any evident objective inconvenience for setting TEX as a LOVA explo-sive. An exception makes the problematic character of thermal decomposition of TEX, to which we should pay attention and other detailed analysis later.

Fact that there are not published any works, which would imply any intention to take advantage of TEX for LOVA, does not mean, that expansion in this areas would not in occur future, because most of its characters are for LOVA. In addition, the establishment of pure explosives with characters of LOVA usually realizes for optimizing the performance and sensitiveness parameters in form of explosive compositions of PBX in combination with currently applied high explosives like RDX and HMX, and they are suitable plastic binders (for example it may be French mixture on base of NTO-B 2 214, B 2 248[11,12]). In this form, a number of problems connected with fill (and of course demilitarization) of the explosives is then eliminated. It would also definitely need the TEX, because its distinctly low sensitivity would enable to take advantage of more distinct rate the sensitive component with maintenance the values of criteria for EIDS, which could favourably express itself on costs or, in case of maintenance of the proportions, it would come to increase the safety of IM essentially.

The above-mentioned fact shows TEX is really a highly perspective explosive for LOVA in wide field.

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TEX——一种低易损炸药

摘要: 根据低易损弹药(LOVA)的分类就合成新炸药和复合炸药的问题进行了扼要分析,并对一些已知的炸药特性进行了讨论。认为 4,10-二硝基-4,10-二氮杂-2,6,8,12-四氧四环[5.5.0.0^{5,9}.0^{3,11}]十二烷(TEX)是一种 LOVA 炸药,但是至今未见其广泛应用的报道,本文试图对炸药的现状及未来的发展寻找一种可能的解释。

关键词: TEX; 低易损弹药; 炸药感度