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Influence of coating techniques and organic solvents on the quality of granulated PBX based on HMX

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Granulated plastic bonded explosives (PBX) prepared from octogen (HMX) and thermoplastic polymer (Viton A) were obtained using the two solvent-slurry techniques. Four organic solvents were used for dissolving the produced solution of thermoplastic phlegmatizer (acetone, ethyl acetate, methylisobuthyl ketone and methylethyl ketone), and two solvents (ethyl alcohol and n-hexane) for its precipitation from the solvent phlegmatizer and coating crystals of HMX. The phlegmatization results (quality of coating layer on HMX crystals) were realized by microscopic analysis.

Key words: **PBX explosives, granulated explosives, phlegmatization, phlegmatizer, HMX, organic solvent, qualitative analysis.**

Used symbols

HMX – octogen, cyclotetramethylentetranitramin
PBX – Plastic Bonded Explosives
A – mark for coating technique in which adding of solvent cause forming phlegmatizing layer on the explosive crystals (PBX samples A-1 to A-8)
B – mark for coating technique where solvent, in which the phlegmatizer was dissolved, is removed from system and phlegmatizer coated explosives crystals (samples B-I to B-III
OR-1 – organic solvent which dissolve Viton A
OR-2 – organic solvent which not dissolve Viton A
TMD – theoretical maximal density
MEK – methylethyl ketone
MIBK – methylisobutyl ketone
EA – ethyl acetate

Introduction

GRANULATED PBXs are crystalline high explosives coated by plastic phlegmatizers. These explosive compositions are known to have high-performance characteristics, but low friction and impact sensitivity. They can be molded or pressed on high temperatures (hot pressing), applying a pressure in the appropriate range, under vacuum and with longer pressing times. In this way, it is possible to obtain high densities that are very close to TMD of PBX composition. Pressed PBX pellets are compact, without luncers, and they also have excellent mechanical and thermal characteristics.

Pressed PBXs are used as busters and main charge in the state-of-the-art warheads.

This paper analyzes and compares the coating quality of eleven samples of granulated PBX, of same chemical composition, in function of PBX processing technique and kind (type) of organic solvents used.

Experiment

Samples of PBX, marked as A-1 to A-8, are produced by adding a phlegmatizer solution (phlegmatizer lacquer) to aqueous slurry of the crystalline explosive. After that, the organic solvent, in which phlegmatizer is not soluble, was added in to the system to cause precipitation of the phlegmatizer as the coating layer on the particles of the explosive composition (processing technique A) [1].

Second group of PBX samples, consisting of B-I, B-II and B-III, are also produced by adding a phlegmatizer solution to aqueous slurry of the crystalline explosive. However, after this, the organic solvent, in which the explosive was dissolved, is removed by evaporating from the system whereupon the plastic phlegmatizer in its turn is caused to deposit on the surface of explosive crystals and form granules of PBX (processing technique B) [2].

Composition and components of granulated PBX

All the examined samples of explosive molding powder have the same chemical composition: 95 % HMX and 5 % Viton A.

The crystalline HMX, type DYNO class A/C [3] was used as explosive component. Bulk density of the used HMX, determined according to [4], was 1003 g/dm^3. The size range of 80 % HMX crystals was 140 μm - 560 μm.

Viton Fluoroelastomer Type A (*Du Pont Company*) was used as phlegmatizer. Viton A is a copolymer of vinylidene fluoride and hexafluoroprophylene. Their excellent physical, chemical and mechanical characteristics as well as excellent compatibility with high explosives [5] have recommend them for the coating process.

Selection of organic solvents

The selected organic solvent to be used in coating process must satisfy the following requirements:

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– The "phlegmatizer – soluble organic solvent" (marked here as OR-1) should dissolve Viton A very well, but should not dissolve crystalline explosives;
– The boiling temperature of organic solvent OR-1, when processing technique B is used, should be less than 100°C;
– The "phlegmatizer – insoluble organic solvent" (marked here as OR-2) used for the precipitation at Viton A from the lacquer should not dissolve Viton A. By contrast, adding OR-2 into the system should cause depositing of Viton A on the surface of explosive crystals;
– The organic solvent OR-2 should be miscible enough with water and organic solvent OR-1.
– Non-toxity and low flammabitility are favorable characteristics.

PBX processing

The marks of granulated PBX samples are given on Table 1.

Table 1. Marking of granulated PBX samples

	Samples	OR1	OR2	Fig.
Technique A	A-1	acetone	n-hexane	3
	A-2	acetone	ethyl alcohol	4
	A-3	EA	n-hexane	5
	A-4	EA	ethyl alcohol	6
	A-5	MIBK	n-hexane	-
	A-6	MIBK	ethyl alcohol	-
	A-7	MEK	n-hexane	7
	A-8	MEK	ethyl alcohol	8
Tech. B	B-I	acetone	-	9
	B-II	EA	-	10
	B-III	MEK	-	11

The PBX processing technique marked as A is defined in [1]. The PBX processing technique marked as B is described in [2]. Their simplified scheme is presented, in Fig.1.

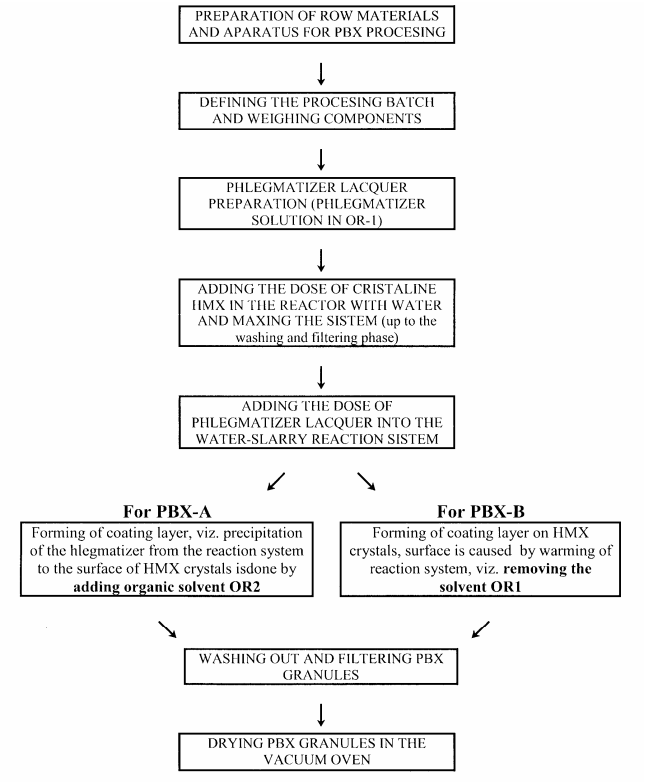

Figure 1. Scheme of PBX processing techniques A and processing techniques B

Results and discussion

The quality of the granulated PBX samples (success of the coating process) is determined by microscopic analysis [6]. All PBX samples and crystals of octogen are photographed by digital camera *Canon Power Shot S40, and* Stereo microscope LEICA. Microscopic photographs of PBX samples are presented in Figures 3 – 11.

Crystals of the used octogen are shown in Fig.2. These crystals are compared with granules of the produced PBX samples.

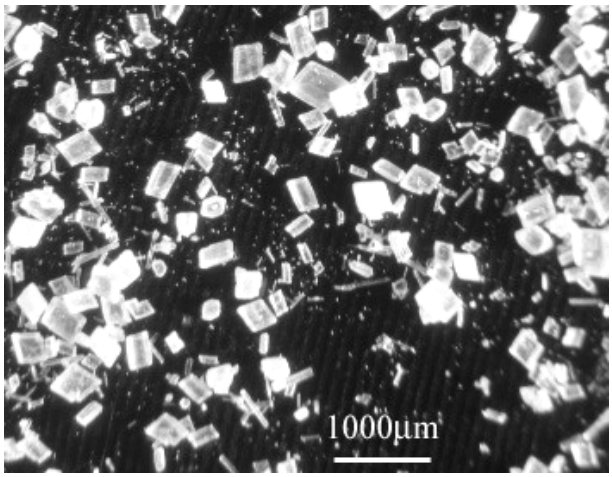

Figure 2. Crystalline of octogen

PBX samples produced by coating technique A are shown in Figures 3–8.

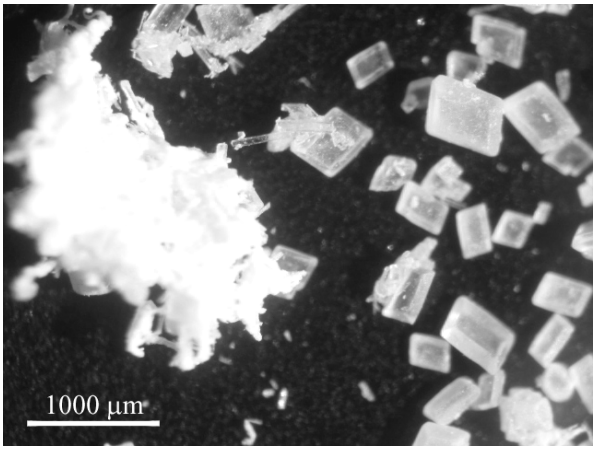

Figure 3. Sample A-1

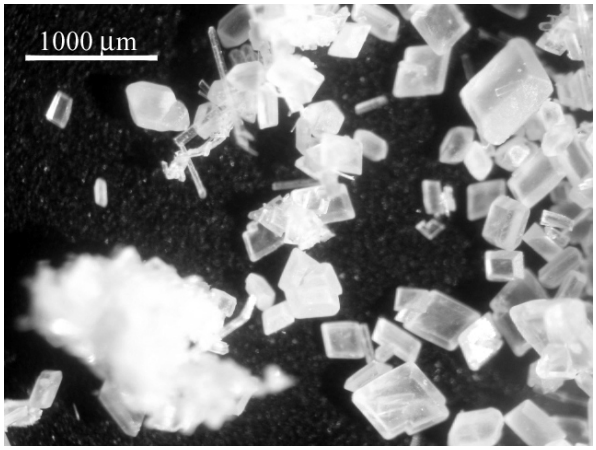

Figure 4. Sample A-2

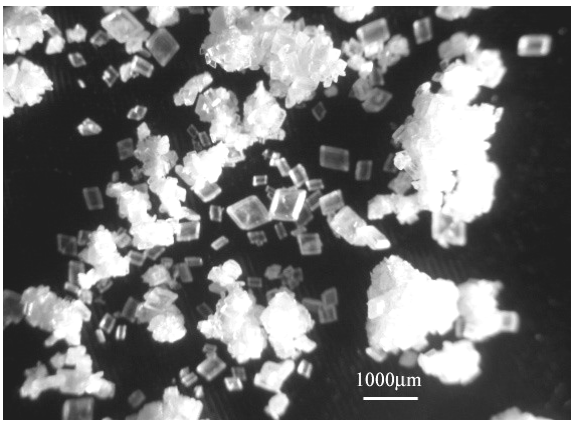

Figure 5. Sample A-3

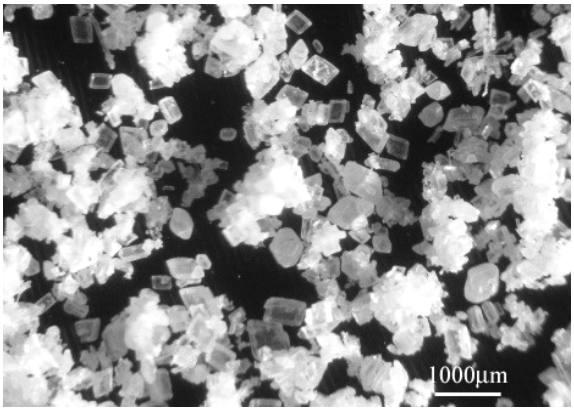

Figure 6. Sample A-4

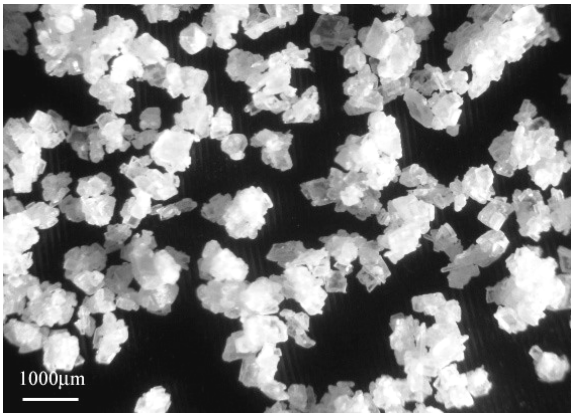

Figure 7. Sample A-7

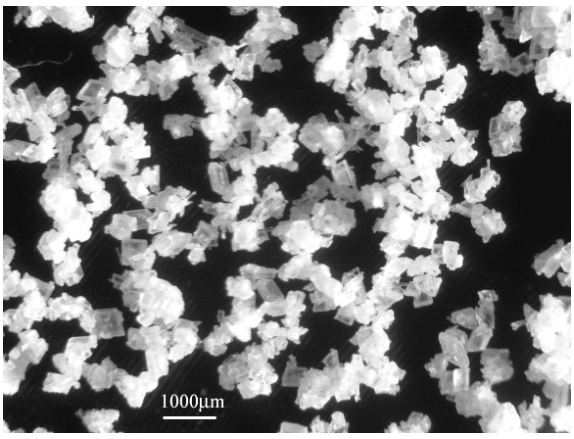

Figure 8. Sample A-8

The sample A-5 had the worst quality. Namely, immediately after adding solvent OR-2 in to the reaction was system dense, stiff, mass was formed. It was not possible to mix the mass by propeller mixer and the process of phlegmatization broken off.

In samples A-1 and A-2 (Figures 3-4) a biger amount of HMX crystals which did not phlegmatize was present. These samples contain a number of big agglomerates consisting of small HMX crystals adhered by the phlegmatizer.

For samples A-3 and A-4 (Figures 5-6) ratio of phlegmatized and unphlegmatized HMX is better than ratio for samples A-1 and A-2 (fifty-fifty).

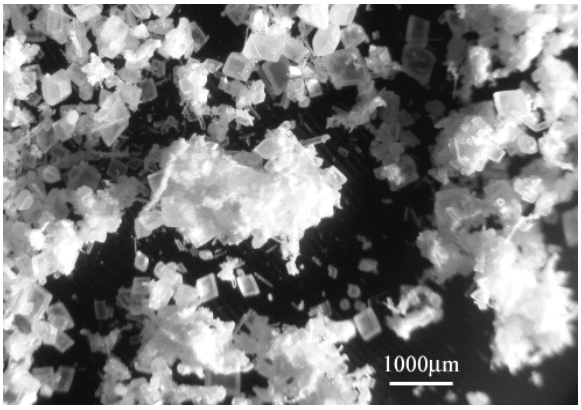

Figure 9. Sample B – I

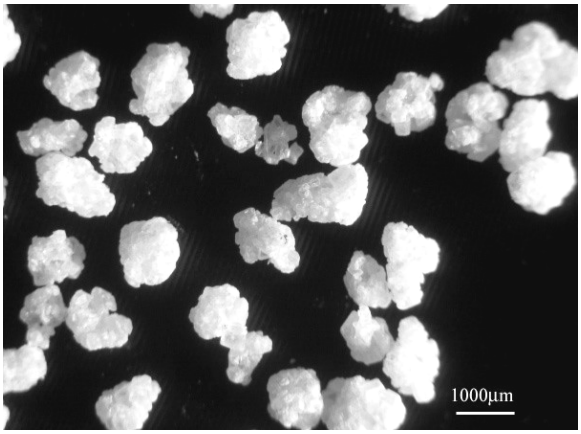

Figure 10. Sample B - II

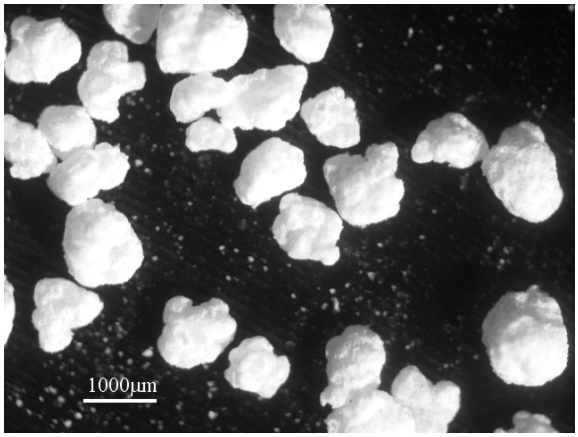

Figure 11. Sample B – III

The best phlegmatized samples obtained by processing technique A were A-7 and A-8. The granules of these

samples are shown in Figures 7-8 MEK was used as solvent OR1 in both phlegmatizations. Precipitation of Viton A was successfully done by adding n-hexane and ethyl-alcohol.

In the group of OR2 solvents, the best coating results were obtained by n-hexane. PBX granules made by n-hexane were well-rounded (without sharp edges), and more uniform in size than granules of sample A-8 (where OR2 was ethyl alcohol).

The agglomerate size of samples A-7 and A-8 was within the range from 500 μm to 1000 μm. Other PBX samples had agglomerates with the size up to 1000 μm.

PBX sample processing by coating technique B are shown in Figures 9–11.

The sample B-I (Fig.9) was prepared by using acetone. Its quality was not satisfactory due to many uncoated HMX crystals within its structure. Phlegmatizer Viton A was not homogenously distributed in the sample. Viton A was concentrated in big agglomerates formed by adhesion of small HMX crystals.

The samples B-II and B-III (Figures 10-11) prepared by using MEK and EA were of very good quality. They have spherical and uniform sized PBX granules. They do not have uncoated, bare crystals of HMX. Bulk mass and granule size satisfy the quality requirements [7].

Analysis of the microscopic results for PBX samples (Figures 3-11) has shown that coating technique B has yielded the best HMX crystals coating, when MEK or EA were used as solvents of Viton A (solvent OR1).

Conclusion

– Acetone and methylisobuthyl ketone are unsuitable for neither processing technique of PBX powder moulding due to a great portion of uncoated HMX crystals in PBX samples.
– Samples marked as A-7 and A-8 have the best quality in the group. The methylethyl ketone in combination with ethyl alcohol and n-hexane, were used for their preparation.
– Samples marked as B-II and B-III are of excellent quality, too. The methylethyl ketone and ethyl acetate were used for their preparation.
– The processing technique in which forming of coating layer on HMX crystals surface is caused by removing of phlegmatizer solvent, given better coated PBX granules than the processing technique in which forming of coating layer is caused by adding other organic solvents.

Received

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Uticaj tehnološkog postupka izrade i korišćenih organskih rastvarača na kvalitet uzoraka granulisanog PBX na bazi HMX

Primenom različitih tehnoloških postupka flegmatizacije dobijene su dve grupe uzoraka granulisanih PBX na bazi oktogena (HMX) i termoplastičnog flegmatozatora (Viton A). Za rastvaranje flegmatizatora korišćena su četiri rastvarača (aceton, etilacetat, metilizobutilketon i metiletilketon), a za njegovu precipitaciju iz rastvora dva (etilalkohol i n-heksan). Na osnovu rezultata mikroskopske analize izvršena je komparacija kvaliteta granula PBX u funkciji postupka izrade i vrste primenjenih rastvarača.

Ključne reči: **PBX eksplozivi, granulisani eksplozivi, flegmatizacija, flegmatizator, HMX, organski rastvarač, kvalitativna analiza.**

Влияние технологического поступка изготовления и пользованных органических растворителей на качество образцов гранулированного ПБЬ на базисе ХМЬ

Применением различных технологических поступков флегматизацие получены две грушы образцов гранулированных ПБЬ на базисе октогена (ХМЬ) и термопластичного флегматизатора (Витон А). Для растворения флегматизатора использованы четыре растворителя (ацетол, этилацетат, метилизобутилкетон и метилэтилкетон), а для его осадок из раствора два растворителя (этиловый спирт и н-метилизобутилкетон). На основании результатов микроскопического анализа сделано сравнение качества гранулей ПБЬ в функции поступка изготовления и типа применяемых растворителей.

Ключевые слова: **ПБЬ взрывчатые вещества, гранулированные взрывчатые вещества, флегматизациы, флегматизатор, ХМЬ октоген, органический растворитель, качественный анализ.**

Influence du procédé technologique et des solvats organiques utilisés sur la qualité des explosifs PBX granulés à la base du HMX

Deux groupes des explosifs PBX granulés, à la base d'octogène (HMX) et des flegmatisans thermoplastiques (Viton A), ont été obtenus par utilisation de deux procédés technologiques de flegmatisation. Pour dissoudre le flegmatisant, on a employé quatre solvants (acétone, éthyle acétate, méthyleisobutyle cétone et méthyle éthyle cétone) et pour sa précipitation de la solution on a utilisé deux solvants (éthyle alcool et N-hexam).En partant des résultats de l'analyse microscopique, on a fait la comparaison de la qualité des granules des PBX, en fonction du procédé de la fabrication et du type des solvants utilisés.

Mots clés: **explosifs PBX, explosifs granulés, flegmatisation, flegmatisant, HMX, solvant organique, analyse qualitative.**