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Electric Spark Sensitivity of Nitramines. Part II. A Problem of "Hot Spots"*)

Svatopluk ZEMAN, Vojtěch PELIKÁN, Jiří MAJZLÍK

Institute of Energetic Materials, University of Pardubice
CZ-532 10 Pardubice, Czech Republic
E-mail:svatopluk.zeman@upce.cz

Jiří KOČÍ

Austin Detonator, Ltd., CZ-755 01 Vsetín, Czech Republic

Abstract: Attention was focused on the influence of grain size upon the electric spark sensitivity of 1,3,5-trinitro-1,3,5-triazinane (hexogen) and 1,3,5,7-tetranitro-1,3,5,7-tetrazocane (octogen). Also the dependence of this sensitivity is monitored upon the addition of hard and fine admixtures (crushed glass or diamond dust) to these compounds and sample of ε−HNIW. It was found that this artificial introduction of the said admixtures decreases the electric spark sensitivity of corresponding mixtures because the number of intergrain contact points of the nitramines grains in the volume unit is decreased by implementation of the foreign particles. It was also suggested that dislocations in the crystals should play some role here. It is stated that an impact component absents in relevant electric discharge.

Keywords: electric spark, grain size, hexogen, octogen, "hot spots", sensitivity

Introduction

Some molecular structural aspects of the spark sensitivity of nitramines were dealt with in the first part [1] of this series. An assumption was pronounced that significant influence of shape [2] and size [2-5] of crystals on the electric

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spark sensitivity might connect with dislocations in these crystals [1]. The said factors influence a mechanism of energy transfer of the primary impulse into the reaction centre of the given molecule. At present there is no unified model of the said mechanism [6].

A probable influence of the above-mentioned dislocations might have been also connected with impact component of the electric discharge. However, Stengach confirmed [7] the absence of this component in his experiment with electric spark sensitivity of lead(II) azide. This paper deals with an examination of the presence or absence of the impact effect in the electric spark sensitivity measurements. Hexogen (RDX, 1,3,5-trinitro-1,3,5-triazinane), octogen (HMX, 1,3,5,7-tetranitro-1,3,5,7-tetrazocane) and 2,4,6,8,10,12-hexanitro-2,4,6,8,10,12-hexaazaisowurtzitane (HNIW) are used as the studied samples in which "hot spots" are artificially introduced. Attention is paid also to the influence of the crystal size of RDX and HNX on their electric spark sensitivity.

Experimental

Apparatus

Corresponding measurements were made with the instrument [1, 8-10] which we developed with a financial support from Czech Ministry of Industry and Commerce [11]. Its code designation is ESZ KTTV [1, 9, 10]. Function of the instrument is described in the first part of this series [1]. Electric spark sensitivity is expressed as the energy of the electric spark, E_{ES}, required for 50% initiation probability.

Nitramines

The following samples were tested: hexogen; produced by Chemko Strážske in seven granulometric qualities according to MIL standard R-398C (1977) and octogen of foreign provenance in five granulometric qualities according to MIL standard H-45444B (1978). The individual classes of these nitamines are characterized in Table 1 by their average grain size (the mean value of limit magnitudes in the given class). This Table also presents the results of measurements. Also samples were used of Dyno Nobel's hexogen RDX-RS (grain sizes from 50 up to 630 μm), another kind of octogen (with grain sizes from 50 up to 630 μm) and ε–modification of 2,4,6,8,10,12-hexanitro-2,4,6,8,10,12-hexaazaisowurtzitane (HNIW with grain sizes from 20 up to 100 μm) produced by Institute of Industrial Chemistry, Explosia, Ltd., Pardubice.

Table 1. Electric spark sensitivity of hexogen and octogen versus averaged values of their grain size (see also Figure 1)

RDX		HMX	
Mean value of grain size [μm]	E_{ES} [mJ]	Mean value of grain size [μm]	E_{ES} [mJ]
600	1170	1000	875
450	1060	400	495
350	900	150	242
250	535	40	152
150	215	27	88
75	137		
30	55		

"Hot spots"

In the nature of the "hot spots" are meaning fine and hard particles, here crushed glass (with grain size below 20 μm) and synthetic diamond's dust of Russian provenance [12]. For evaluation of the influence of the crushed glass on the electric spark sensitivity, the lowest-grain Chemko's hexogen (see Table 1), HMX (another kind), RDX-RS and HNIW were mixed with this additive. Analogue influence of diamond's dust, whose particle size (its agglomerates) does not exceed 5 μm, was evaluated. Mixtures containing various amounts of these hard particles were then measured. Results are presented in Figures 3 and 4.

Discussion

Effect of granulometry on E_{ES} values

The relationship between octogen's granulometry and its sensitivity to electric spark has been dealt with recently by Roux *et al.* [2, 4]. Our results obtained by measurement with the ESZ KTTV instrument are given in Figure 1. In contrast to the results obtained by Roux *et al.* [2, 4], our dependences have opposite trend. The difference between our and Roux *et al.* finding might be due to mutual different construction of the apparatus' circuits and spark gaps in their and our cases. However, we suppose that our finding confirms the statement by Auzanneau *et al.* [4]: "hot spots" develop at the thinnest part of the solid, i.e. at intergrain points. The number of these points in volume unit decreases with the increasing grain size, and that increases the corresponding E_{ES} values. However, on the basis of relationships between the E_{ES} values and heats of fusion of nitramines [1] we should suppose that also dislocations in the crystals have some effect on the initiation of these compounds by spark.

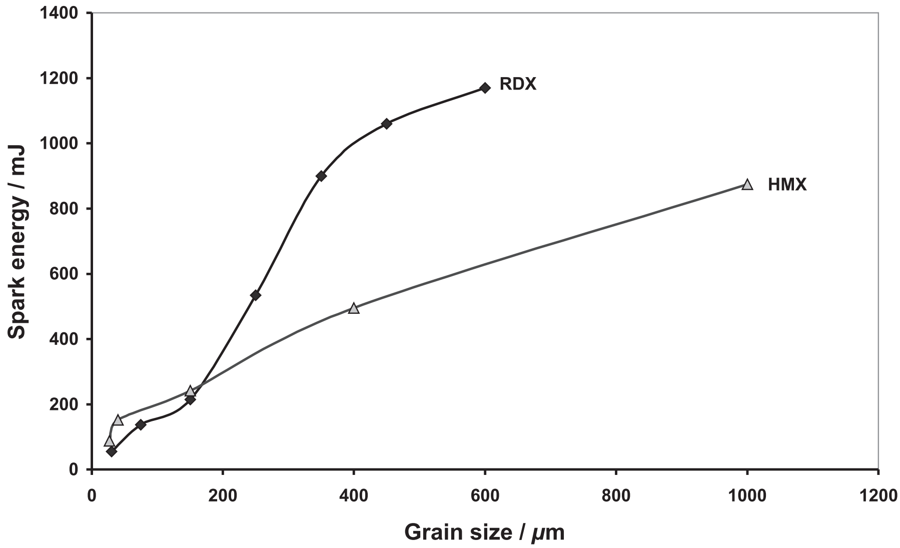

Figure 1. Relationship between the grain size and electric spark sensitivity of hexogen (RDX) and octogen (HMX).

Effect of artificially introduced "hot spots" on electric spark sensitivity

Stengach studied the electric spark sensitivity of lead(II) azide and found out that an addition of the hard inert admixtures to this azide (up to 10% by wt.) has practically no effect on its electric spark sensitivity [7] (while the impact sensitivity is increased). We have chosen a similar strategy in the measurements. The samples measured were Chemko's hexogen of mean grain size equal to 30 μm, hexogen RDX-RS, HMX and HNIW, all substances with an admixture of crushed glass (see Figure 2) and the last three nitramines with admixture of diamond's dust (see Figure 3). The results, given in the Figures 2 and 3, are in accordance with those given by Stengach [7], stating the absence of effect of impact component in the electric discharge used. It can be stated that the relationships in the both Figures depend on the chemical entity and quantity of nitramine, and on the entity and quantity of admixture in the final mixture. The trend shown in these Figures can be interpreted by the introduced glass or diamond particles separating the nitramines from each other. Thereby the number of the intergrain contact points of these nitramines grains in volume unit is decreased, and hence the electric spark sensitivity of the respective mixture decreases, too.

This statement again stands in accordance with the above-mentioned view by Auzanneau *et al.* [4].

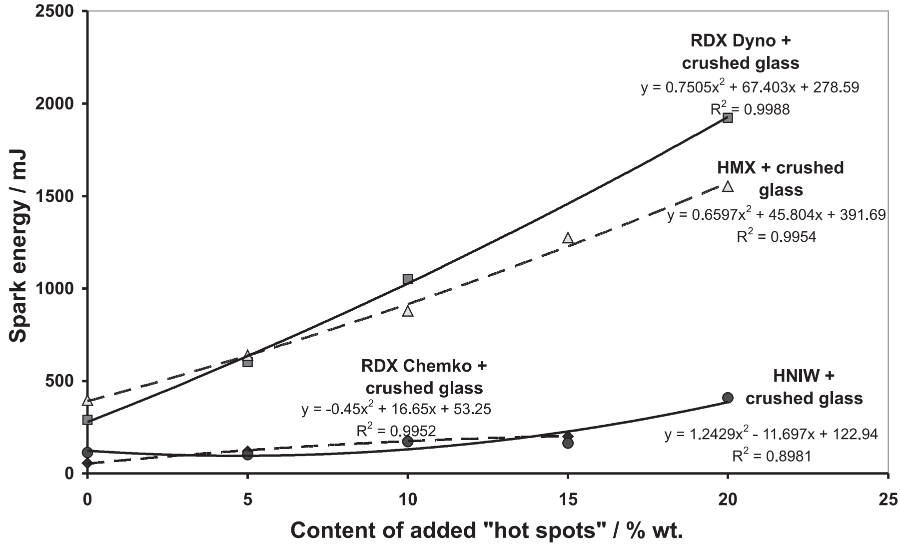

Figure 2. Electric spark sensitivity of mixtures of the hexogen, octogen (another kind) and HNIW with crushed glass.

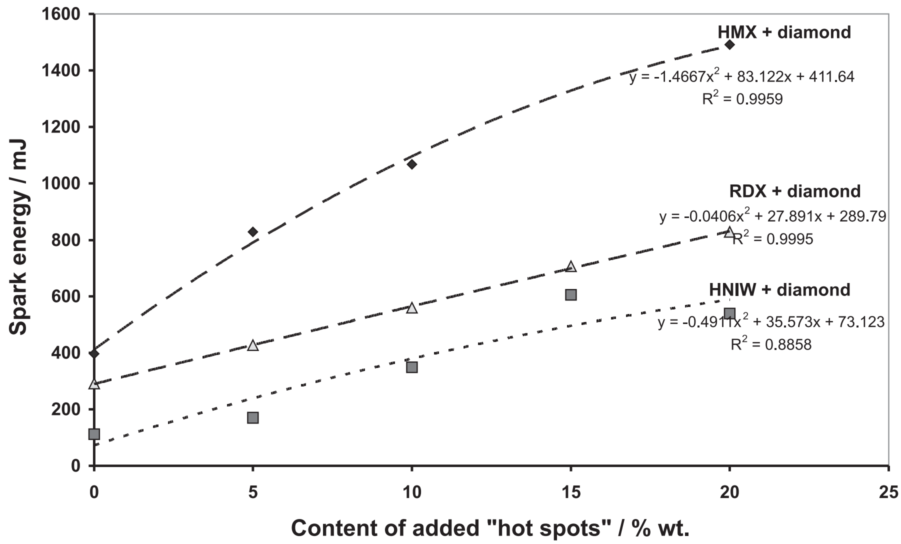

Figure 3. Electric spark sensitivity of mixtures of the hexogen, octogen (another kind) and HNIW with diamond dust.

Conclusion

Decreasing the electric spark sensitivity (i.e. increasing the E_{ES} values), when grains size of nitramines' crystals increase, confirms the idea by Auzanneau *et al.* [4] about the mechanism of spark energy transfer into the powdered reactive solid, i. e. in this case to decrease the number of intergrain points in volume unit. However, also dislocations in the crystals should have some effect on this type of energetic materials initiation [1].

Artificially introduced fine and hard particles into the crystalline nitramines decrease the electric spark sensitivity of the resulting mixtures, i.e. the particles behave as flegmatizing additive, here the number of intergrain contact points of the nitramines grains is decreased by implementation of the foreign particles. This fact also agrees with the idea by Auzanneau *et al.* [4] and confirms the Stengach's statement [7] about the absence of the effect of the impact component in the given electric discharge.

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