ELECTRIC SPARK SENSITIVITY OF POLYNITRO COMPOUNDS: A COMPARISON OF SOME AUTHORS' RESULTS

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ABSTRACT The electric spark sensitivties of 15 polynitro compounds were measured and compared with the results reported by other authors. The electric energy, E_{ES}, required for 50% initiation probability of the same sample is different from each other obtained by different author, which must be caused by the different test specification of the electrode energy used by different authors. But the authors of this report have found a linear relationship between their own experimental data with some other authors'.

KEYWORDS 50% initiation probability, electric spark sensitivities, polynitro compounds.

1 INTRODUCTION

Recent papers[1~12] published in the field of studies of sensitivity of energetic materials to electric spark have shown that this sensitivity depends not only on the chemical entity of the material given[1,4,6,8,10,11], its granulometry[1,2,10] and grain shape[3], its mechanical properties[6], temperature[1,12] and its moisture content[1,2,4,10] but also on the configuration of electrodes and structure of the circuit[2,4]. Consequently, it has not yet been possible to propose an international standard test specifying this stability. Irrespective of the above-mentioned spectrum of effects influencing the said sensitivity, however, Zeman et al.[8] preliminarily confirmed the presumption of Matsuzawa et al.[9] that it is possible to find a relationship between the test results obtained with various apparatuses. The above-mentioned preliminary results[8] have now been reexamined and extended by further measurements and are given in the present paper.

2 EXPERIMENTAL

The apparatus for measurements is constructed in the R&D department of Zbrojovka Indet,

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Inc., Vsetín. Figure 1 presents the scheme of the apparatus circuit: U stands for the generator of high d-c voltage, P is a spherical switch, V is an electrostatic voltmeter, C is a tubular capacitor, and J is the spark gap. All the elements of the apparatus are interconnected by multiple bunched conductors (as short as possible) with large cross section and with double insulation. The spark gap is schematically represented in Figure 2. The bottom is a steel base with an attached screw, which is used as a leak electrode. Attached to this screw is a plastic cylinder with a cut for fastening a piece of flexible tube of 5mm height and 5mm diameter serving as a container of the sample tested. The top electrode is a steel cylinder of conical shape with attached resistance wire protected by a plastic distance stop which presses the foil lid to the flexible tube. The capacity of the capacitor is chosen so as to allow measurements in the voltage interval from 8kV to 14kV. If the initiation is successful, the next measurement is carried out with a voltage lowered by 0.2kV, if it is unsuccessful, the voltage is increased by the same value (Up and Down Method). We consider an initiation to be successful if the sample disappears or the flexible tube is torn. Altogether 25 measurements are carried out with each substance and the results are treated statistically. The spark energy E_{ES} for 50 percent probability of initiation is then calculated from the well-known relation $E_{ES} = 0.5CU^2$, and the resulted values are presented in Table 1 for the compounds tested. The E_{ES} values published by Larson et al.[1], Amari et al.[4], Roux et al.[10] and Hosoya et al.[12] are also included as comparison.

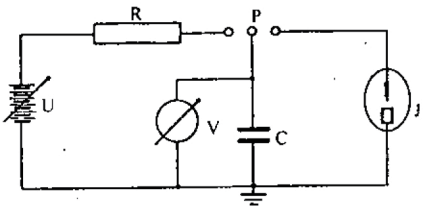

Fig. 1　Scheme of the apparatus circuit

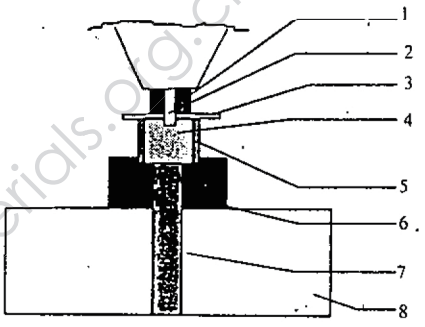

Fig. 2　Spark gap
1——Insulation, 2——Wire, 3——Foil lid, 4——Sample, 5——Tube, 6——Plastic, 7——Electrode, 8——Steel base.

3　RESULTS AND DISCUSSION

Studying the interrelation of our E_{ES} values and those published by Larson et al.[1] and Amari et al.[4], we can find a relationship as below.

$$E_{our} = A \times E_{pub} + B \qquad (1)$$

Where, E_{our}, the E_{ES} values of ours, E_{pub}, the E_{ES} values of ref. [1,4].

The values of A, B and the correlation coefficient R are listed in Table 2.

Table 1 E_{FS} required for 50% initiation probability of various polynitro compounds

Substance	Code design	E_{FS}/J						
		this paper	ref.[1] a	ref.[1] b	ref.[4]	ref.[10]	ref.[12] c	ref.[12] d
1-Methyl-2,4,6-trinitrobenzene	TNT	4.1	0.46	3.75	22.38	1.26	8.57	5.47
1-(Methylnitramino)-2, 4, 6-trinitrobenzene	Tetryl	5.49	0.54	3.79	29.51			
1-Hydroxy-2, 4, 6-trinitrobenzene	PA	8.98				1.22		
1-Methyl-3-hydroxy-2, 4, 6-trinitrobenzene	TNCr	5.21				1.54		
1, 3-Diamino-2, 4, 6-trinitrobenzene	DATB	10.97	1.48	10.79			29.84	17.14
1, 3, 5-Triamino-2, 4, 6-trinitrobenzene	TATB	17.8	4.25	18.14			11.88	13.52
2, 2′, 4, 4′, 6, 6′-Hexanitrobiphenyl	HNB	5.03				0.82		
2, 2′, 4, 4′, 6, 6′-Hexanitrobiphenylamine	DPA	5.02				0.96		
2,2′,4,4′,6,6′-Hexanitrostilbene	HNS	5.32			18.19		7.04	5.94
2, 2′, 4, 4′, 6, 6′-Hexanitrobibenzyl	DPE	3.89				1.17		
2,6-Bis(2, 4, 6-trinitrophenylamino)-3,5-dinitropyridine	PYX	9.03	1.18	9.00				
1,3,5-Trinitro-1,3,5-triazacyclohexane	RDX	2.49	0.21	0.96	3.23			
1,3,5,7-Tetranitro-1,3,5,7-tetraazacyclooctane	HMX	2.92	0.23	1.42	8.13			
Pentaerythritol tetranitrate	PETN	1.74	0.19	0.75	2.6			
3-Nitro-1,2,4-triazol-5-one	NTO	8.98	0.91[e]	3.40[e]				

Notes: a) The values obtained from the measurements with samples covered with Pb foils of 3-mils(0.076mm).

b) The values obtained from the measurements with samples covered with Pb foils of 10-mils(0.254mm).

c) The values obtained from the measurements at 293K.

d) The values obtained from the measurements at 333K.

e) The values taken from ref.[13].

Table 2 Values of A, B and R

Resource of E_{pub}	A	B	R
Larson et al.[1] for 0.076mm	3.821	3.045	0.8925
Larson et al.[1] for 0.254mm	0.894	1.387	0.9936
Amari et al.[4]	0.128	1.885	0.8368

Note: a) The published E_{FS} value of NTO (i.e. 3.40J)[13] does not correlate in the sense of Eqn.(1).

No relationship is found between our E_{ES} values and those by Roux et al.[10] and Hosoya et al.[12], the latter are measured at 293 K. However, a quadratic relationship is intimated in the case of results obtained at 333K by Hosoya et al.[12].

The existence of Eqn. (1) indicates a possibility to compare the sensitivity results obtained from various apparatuses and thus confirming the presumption of Matsuzawa et al.[9]. The possibility might connect with some resemblance in electrodes configuration of these apparatuses. The difference between absolute values of E_{ES} found by the individual authors mainly resulted from different energy specification of spark itself. In our opinion, this is the decisive problem faced in the attempts at standardization of electrostatic spark sensitivity test specification.

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REFERENCES

1 Larson T E, Dimas P and Hannaford C E. Electrostatic Sensitivity Testing of Explosives at Los Alamos. Inst. Phys. Conf. Ser. No.118: Section 2 (Electrostatics '91), IOP Publishing Ltd., 1991. 107 ~ 117

2 Roux M, Auzanneau M and Brassy C. Electric Spark and ESD Sensitivity of Reactive Solids, Part Ⅰ: Experimental Results and Reflection Factors for Sensitivity Test Optimization. Prop., Explos., Pyrotech., 1993, 18: 317 ~ 324

3 Auzanneau M, Roux M. Electric Spark and ESD Sensitivity of Reactive Solids, Part Ⅱ: Energy Transfer Mechanism and Comprehensive Study on E_{50}. Prop., Explos., Pyrotech., 1995, 20: 96 ~ 101

4 Amari S, Hosoya F, Mizushima Y and Yoshida T. Electrostatic Spark Ignitability of Energetic Materials. Proc. of the 21st Int. Pyrotech. Seminar, Moscow, Sept. 1995.

5 Rat R, Roux M and Chaumat J P. Etudes Theoriques Sur Les Phenomenes D'initiation des Matierse Explosibles. In: Roux M, Ed. Recueil des communications "Journees d'etudes sur la sensibilité des composants et des substances énergét. ál'electricite statique". Aussois, Mai 1996. 147 ~ 168

6 Chaumat J P. L'initiation est elle "thermique"?. In: Roux M, Ed. Recueil des communications "Journee d'etudes sur la sensibilité des composants et des substances énergét. ál'electricite statique". Aussois, Mai 1996. 173 ~ 179

7 Hasegawa T, Kawashima E, Satoh K and Yoshida T. Correlations between Screening Test Results of Energetic Materials. Proc. of the 22nd Int. Pyrotech. Seminar, Fort Collins, Colorado, July 1996. 195 ~ 207

8 Zeman S, Kamenský Z, Valenta P and Jakubko J. On the Electrostatic Spark Sensitivity of Some Organic Polynitro Compounds. In: Roux M, Ed. Recueil des communications "Journees d'etudes sur la sensibilité des composants et des substances énergétiques ál'electricite statique". Aussois, Mai, 1996. 197 ~ 206

9 Matsuzawa T, Itoh M, Arai M, Hatanaka S, Miyahara A and Tamura M. Electric Spark Sensitivity for Materials and Compositions of Fireworks. Kayaku Gakkaishi 1994, 55: 39 ~ 45, Chem. Abstr. 121, 13270e.

10 Roux M, Trevino A, Auzanneau M and Brassy C. Sensibilite des substances explosives: Etude de la sensibilite electro-statique d'explosifs polynitres aromatiques. Proc. of the 16th Annual Conf. ICT. Karlsruhe

1985.

11 Zeman S, Zeman V and Kamenský Z. Relationship between the Electric Spark Sensitivity and the NMR Chemical Shifts of Some Organic Polynitro Compounds. Proc. of the 28th Annual Conf. ICT. Karlsruhe, June 1997.

12 Hosoya E, Shiino K and Itabashi K. Electric-Spark Sensitivity of Heat-Resistant Polynitroaromatic Compounds. Propellants, Explos., Pyrotech., 1991, 16: 119 ~ 122

13 Kien-Yin Lee and Coburn M D. 3-Nitro-1,2,4-triazol-5-one, a Less Sensitive Explosive. Report LA-10302-MS, Los Alamos Natl. Lab., February 1985.

多硝基化合物的静电火花感度及其与文献值的对比

摘要 测定了15种多硝基化合物的静电火花感度并与文献值进行了对比。对同一样品来说不同作者得到的50%发火概率的 E_{ES} 值不尽相同，其主要原因是不同作者所采用的静电火花试验规范不同。但是本实验值与文献值存在着线性关系。

关键词 50%发火概率 多硝基化合物 静电火花感度

中图法分类号 TQ56