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REVIEW

of M.Sc., Ing. Ahmed Hussein's PhD Thesis titled

"Study of Energetic Compositions Based on Explosives Mixtures and Cocrystals"

done at Faculty of Chemical Technology, University of Pardubice

BCHMX is a nitramine explosive with high detonation parameters and relatively high sensitivity. Thus, the possibility of using BCHMX as a component of high-energy explosive formulations is constantly being studied. Usually, sensitivity, thermal properties and detonation performance of explosives based on BCHMX are determined and compared with proper characteristics of existing explosive formulations. The second problem examined in the doctoral dissertation regarding the possibility of producing explosive co-crystals is also currently under study and is very perspective. Therefore the studies undertook by Mr Ahmed Hussein are fully justified.

Submitted dissertation consists of 7 main chapters and a list of references. Main part of the work is preceded by a summary, the aim of the studies, a list of figures, a list of tables, a nomenclature and a list of Mr Ahmed Hussein's publications. The aim of the study is to use BCHMX as an ingredient in complex insensitive compositions and in plastic bonded explosives (PBXs), and to compare the properties of new formulations with plastic explosives based on different pure nitramines.

In Chapter 1 the theoretical part of the dissertation is presented. It contains a description of selected molecular explosives with their division into traditional, modern explosives and low-sensitive explosives. Explosive mixtures and PBX-type explosives are also specified. In the case of the latter, examples of inert and energy binders and techniques used in their manufacturing are described. Examples of PBXs based on nitramines and nitroaromatic compounds were shown. At the end of the chapter explosives produced by co-crystal technique were defined and their examples were given.

The first part of Chapter 2 comprises detailed description of all the explosive ingredients used for preparation of tested formulations and the method used for preparation of melt-cast composition, plastic bounded explosives with different binders and co-crystal explosives. Extraction and pressing techniques were applied to obtain the charges for tests. The methods used to characterise some properties of the explosives are described in the

second part of the chapter. The elemental analyser, X-ray difractometer, Raman spectrometer, thermochemical code and bomb calorimeter were used. Methods for measuring impact and friction sensitivity, detonation velocity, and explosive strength were presented. In the end, the instruments used for determination of thermal characteristics of tested formulations and the methods applied to determine kinetic parameters are presented.

Chapter 3 is devoted to the insensitive compositions containing NTO, FOX-7 or TNT in addition to BCHMX as explosive components. Polydimethylsiloxane (PDMS) was used as a binder. The results of the sensitivity testing of BCHMX/Fox7-Sil and BCHMX/NTO-Sil formulations on impact and friction confirmed that they are potentially insensitive compositions. However, this conclusion should be confirmed by performing large-scale sensitivity tests (gap test, cook-off test, for example). Moreover, it is undesirable to lower the stability of these compositions due to the addition of NTO and FOX-7. The sensitivity parameters of BCHMC/TNT mean that it can not be treated as an insensitive composition.

The results of the research on manufactured PBXs that contained BCHMX are presented in Chapter 4. The compositions contained also RDX and HMX in different quantities, and 5 types of binders (PDMS, SBR, HTPD, GAP and Viton). The author analyzed the particle size distribution of pure explosives used. The empirical formula, internal energy of combustion and enthalpy of formation determined for all the tested PBXs are presented in tables. The measured detonation velocities were compared with those calculated by using Explo5 program. The author of the PhD Thesis discussed the results obtained. However, the accuracy of the given values of the detonation velocity requires explanation. The author states on page 46 that three measurements were made for each sample and the mean value was calculated. The average values had an uncertainty of ±125 m/s. Meanwhile, all the results of the detonation velocity measurement were given with accuracy to 1 m/s.

Mr Hussein also proved that there is a linear relation between loading density and detonation velocity for chosen types of PBXs. The results of ballistic mortar measurements are also presented. The author discussed the results of the sensitivity to impact and friction. The results of DTA tests were the basis for determining the kinetic parameters of PBXs tested. From the thermal stability measurements the conclusions were drawn regarding the effect of the binder or matrix on the decomposition temperatures of the explosives.

In Chapter 5, the author attempted to obtain energetic EDNA/DAT co-crystals. Their preparation was confirmed by XRD technique. The heat of formation and kinetic parameters of the new explosive were determined experimentally. The detonation parameters were

calculated in a theoretical manner. Chapter 6 describes some of the properties of nitraminic energetic materials, and Chapter 7 summarizes the results of the work.

Mr Ahmed Hussein carried out a study that undoubtedly increased the knowledge concerning the sensitivity and detonation characteristics of insensitive compositions based on BCHMX, PBX formulations based on nitramine mixtures and energetic co-crystals. A lot of attention the author devoted to characterise the explosives with regard to their sensitivity, stability and detonation properties. The results of this study are important from the practical point of view. But in terms of scientific value, the attempts to establish relationships between the physical properties and the detonation performance of explosives are interesting. Thanks to this, Mr Hussein's PhD Thesis exemplifies original scientific output. It convincingly shows that the author knows the experimental and theoretical methods applied in investigation of explosives. It also indicates that the author is able to write a scientific report with clearly defined objective and a range of investigations.

Mr Hussein is a co-author of ten papers in scientific journal and five contributions at scientific conferences. Topics of these publications are compatible with topic of his dissertation.

Bearing in mind quality of the Mr Hussein's PhD Thesis and his publication activity I recommend his dissertation for defence.

Warsaw, September 10, 2018

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