ISSN 2286-4822
www.euacademic.org

EUROPEAN ACADEMIC RESEARCH
Vol. VIII, Issue 9/ December 2020

Impact Factor: 3.4546 (UIF)
DRJI Value: 5.9 (B+)

Determination Physical and Explosion Properties for Lead Azide and Dextrin Lead Azide

MOHAMMED ALMUNTAGA AHMED
College of Graduate Studies and Scientific Research
Karary University, Khartoum, Sudan
MOHAMMED H. M. ABUUZNIEN
Associate Professor, Karary University, Khartoum, Sudan
ADIL A. MOHAMMED
Assistant Professor, Chemical Engineering Department
Karary University, Khartoum, Sudan

Abstract

The aim of this work is to study the physical and explosion properties of lead azide and dextrin lead azide primary explosives. Three experimental samples were prepared for two substances according to DOD military standards. The physical properties like moisture content, density, particle size and explosion properties like heat of explosion, ignition temperature and impact sensitivity of two materials were measure and compared with references values. All results of experiments show good agreement with reference values. The moisture content and particle size of LA is less than DLA while the bulk density of LA is higher than DLA. Hheat of explosion and impact sensitivity of LA is better than DLA. Results also show that lead azide is more suitable for using in impact detonators while dextrin lead azide is the best for electric detonators.

Keywords: lead azide, dextrin lead azide, explosion properties, primary explosive.

1- INTRODUCTION:

Initiating substances (primaries) are chemical compounds/mixtures used in igniters or detonators to bring about burning or detonation of energetic material. In general, igniters (containing a priming composition) are used to provide flame, while detonators (containing the primary explosive) are designed to create a shock wave which starts the detonation reaction in a secondary explosive. The successful initiation of explosives begins with a small external stimulus called the simple initiating impulse (SII) The SII is a nonexplosive type of impulse such as flame, heat, impact, stab, friction, electric spark, etc. The choice depends on the type of material to be initiated and on the desired output effect.[1]

Azides are substances containing the N_3 group. They exist as inorganic salts, organic compounds, organo-metals, or complexes. The discovery of lead azide (LA) is attributed to Curtius who first prepared this substance and characterized its explosive properties in 1891. In 1893, some experiments with lead, silver, and mercury were carried out in Spandau in Prussia. However, an unexpected explosion occurred during testing of azides with fatal results, which caused termination of further experiments. They were not re-started until 1907 when Wohler drew attention to azides once again as he saw it as a possible substitute for expensive MF[2]. The real era of LA started in 1908 after Hyronimus patented its use as “a primer for mines and fire-arms consisting of charge of trinitride of lead”.

Lead azide is insoluble in water, is resistant to heat and moisture, and is not too hygroscopic. It is prepared by reacting aqueous solutions of sodium azide and lead nitrate with each other. During the preparation, the formation of large crystals must be avoided, since the breakup of the crystalline needles may produce an explosion. Accordingly, technical grade product is mostly manufactured which contains 92–96% $Pb(N_3)_2$, and is precipitated in the presence of dextrin, polyvinyl alcohol, or other substances which interfere with crystal growth. Lead azide is employed as an initiating explosive in blasting caps. When used as a primary charge, it is effective in smaller quantities than mercury fulminate, has a higher triggering rate, and, unlike mercury fulminate, cannot be dead-pressed by even relatively low pressures. In order to improve its flammability, an easily flammable additive, such as lead trinitroresorcinate, is added. Lead azide is decomposed by atmospheric CO_2, with evolution of hydrazoic acid [3]. Lead azide detonators for use in coal mining have copper capsules; for all other blastings, aluminum caps are used. Dextrinated lead azide (DLA): An amorphous form of LA was made in the USA in

1930 and was found to be safe during manufacture and handling. It was prepared by slowly adding a slightly alkaline solution of sodium azide to a solution of lead nitrate and dextrine. It is hygroscopic and has poor cohesive properties. Dextrine prevents the formation of large sensitive crystals of LA and regulates their shape [4].

Transportation and handling of dangerous materials such as primary explosives through any route of transport requires a lot of precautionary and safety measures. The use of detonators for civil explosives in mining areas in Sudan increased last years. The proper method of transportation of these hazardous materials which ensure safety and precaution is very complicated and costly so this leads to look for producing these dangerous materials locally in Sudan. The objective of this work is to prepare lead azide and dextin lead azide at lab scale, determine their physical and explosion properties for suitable efficiency and safety using detonators.

2- EXPERIMENTAL WORK:

2.1 Samples

Two primary explosives, lead azide and dextrin lead azide, used in this study. Three samples of pure lead azide and dextrin lead azide (20% dextrin and 3% dextrin). The samples were prepared according to the DOD Military standard [5].

2.1.1 Pure lead azide (LA) samples:

Two grams from Sodium azide NaN_3,(Mwt 65 g/mol), three grams from lead nitrate $Pb(NO_3)_2$ (Mwt 331.2 g/mol) were weighted, all reactants were dissolved in 100 ml of distilled water separately. The solution of sodium azide were poured into the solution of lead nitrate gradually with continues stirred, while the lead nitrate was contained, after that the product solution was filtered by filter paper to produce crystals of lead azide and sodium nitrate dissolve in water solution. The chemical equation below explains the chemical reaction of lead nitrate and sodium azide which reacts to produce lead azide the reaction as follows:

$$Pb(NO_3)_2 + NaN_3 \rightarrow Pb(N_3)_2 + 2\ NaNO_3 \qquad (1)$$

2.1.2 Dextrin lead azide (DLA) samples:

Two grams from Sodium azide NaN_3, three g from lead nitrate $Pb(NO_3)_2$ and (1) g from dextrin ($(C_6H_{10}O_5)nx.H_2O$) were weighted. All reactants were dissolved in 100 ml of distilled water separately. Sodium azide were poured into the solution of lead nitrate gradually with continuous stirred, while the lead nitrate was contained, after that the product solution was filtered by filter paper to produce crystals of dextrin lead azide. about 20 % from solution

2.2 The physical and explosion Tests:

The physical and explosion properties were measured for lead azide and dextrin lead azide according to the NATO standard [6]. These properties include Bulk density, Moisture content, Particle size, Heat of explosion, Ignition temperature, Impact sensitivity and Detonation velocity.

2.2.1 Bulk density determination

Density device were prepared; the beaker was filled with auxiliary liquid known density, the universal holder for solids were suspended from the bracket. The samples of lead azide were weighed in air firstly and in liquid secondly, the densities were estimated and the results were registered. The tests were done by (Density Kit ME-DNY-4).

2.2.2 Moisture content determination

Karl Fischer solution were preparation, water reacts with iodine and sulfur dioxide quantitatively in the presence of base and alcohol the chemical equation below explains the dehydration reactions

$$H_2O + I_2 + SO_2 + CH_3OH + 3RN \rightarrow [RNH]SO_4CH_3 + 2[RNH]I$$

Dehydrated solvent was put in the titration cell and the dehydrated state were achieved by titration using Karl Fischer reagent, the samples were added separately into the titration cell. Titration proceeds by controlling the titration speed while detecting the polarization of the electric potential of the detection electrode and the weight samples were entered into the device, water content was determined by using Karl Fischer reagent of which the factor (mgH_2O/mL) is pre-determined with the water-methanol standard and the results were registered from screen device of micro moisture tester. The test was done by (SF101 Micro moisture Tester)

2.2.3 Particle size determination

The samples of LA and DLA were prepared separately and dispersed to the correct concentration by n-butyl acetate then were delivered to the optical bench. The prepared samples were measured by captured of the scattering pattern by optical bench after the measurements were completed analyses were done by the Malvern software (Master Size 2000).

2.2.4 Heat of explosion determination

In a calorimeter device, combustion processes take place under precisely defined conditions. For this purpose, the decomposition vessel is charged with a weighed in fuel sample, one gram from each sample substances lead azide and dextrin lead azide were weighed in cup test, tungsten wire was prepared to make ignition, cup test was charged in bomb test (decomposition vessel), the bomb test was closed and vacuumed from air then charged into the calorimeter system. The calorimeter systems were worked until its stable, the fuel samples were ignited, and the increase in temperature in the calorimeter system were measured. The specific gross calorific value of the sample was calculated from: the weight of the fuel sample the heat capacity (C value) of the calorimeter system the increase in temperature of the water in the inner vessel of the measurement cell (IKA, Calorimeter System C5003)

2.2.5 Ignition temperature determination.

The three samples of each LA & DLA were prepared; then charged into its place, ignition temperature systems were turned, the temperature degree were raised gradually until ignition happened and the results were registered.

2.2.6 Impact sensitivity determination

The samples were prepared; 20mg from each substance LA and DLA were weighted and charged into sample, the samples were put into a hammer impact sensitivity device separately every once time then the safety cupboard were closed. The hammer mass of 1 kg were chosen and the height distance (m) were set, free fallen down by gravity, the experiments were repeated three times for any height, finally the impact sensitivity force (N.m) were determined at height which the substance were exploded by : mass (Kg) X height (m) X earth gravity (m/s^2).

3- RESULTS:

Table 1 shows the results values of physical and explosion properties for LA compared with reference values.

Table1: Physical and explosion Properties results for lead azide LA

No	Test	Results	Values from reference
1	Density (g/cm^3)	4.696	4.8 for pure LA
2	Particle size (μm)	6.93	-
3	Moisture content (%) (μg H_2O)	0.04(31.5)	0.3 %
4	Heat of explosion (KJ/Kg)	1601	1637
5	Ignition temp (°C)	334	320 - 360
6	Impact sensitivity (N.m) do by mass 1 Kg	2.9 (at height 0.3m)	2.5 - 4

Table 2 shows the results values of physical and explosion properties for DLA compared with reference values.

Table 2: Physical and explosion properties results for Dextrin lead azide DLA

No	Test	Results	Values from reference
1	Density (g/cm^3)	2.467	2-3 for pure DLA
2	Particle size (μm)	29.41	-
3	Moisture content (%) (μg H_2O)	0.774(410.5)	0.5 %
4	Heat of explosion (KJ/Kg)	1356	1637
5	Ignition temp (°C)	335	320 - 360
6	Impact sensitivity (N.m) do by mass 5 Kg	No result	2.5 - 4

Particle size of LA results picture took from screen of Malvern device shown that in figure 1 below consist from table and graph.

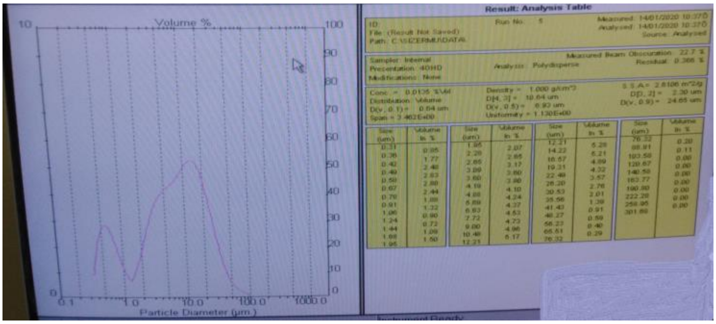

Figure 1: Particles size result Malvern analysis for pure LA

Particle size of DLA results picture took from screen of Malvern device shown that in figure 2 below consist from table and graph.

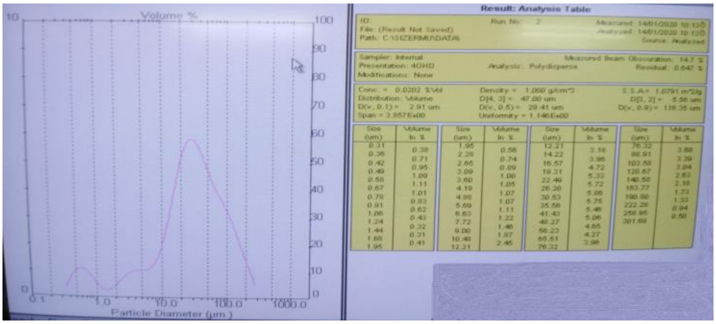

Figure 2: Particles size result Malvern analysis for 20% DLA

4-DISCUSSION:

Results show that all prepared samples are in agreement with references values for both lead azide and dextrin lead azide.

Results show that the LA appearance is white; while the appearance of DLA is snow white. LA density is (4.696 g/cm^3) and DLA density is (2.467g/cm3) its reasonable value due to the effect of dextrin. The LA is insoluble in water, so, the value of moisture content for LA is very low (0.04%). The moisture content value for DLA is (0.774%) which is higher than LA. This means that DLA relatively less sensitive than LA and safer in processing, handling and storage relatively.

Also, the value of particle size for LA is (6.93 µm) and for is DLA (29.41µm). The particle size of LA is smaller than DLA, this refers to that dextrin material which make collide particles of DLA the sensitivity and amount of heat of explosion that depend on the surface area of particle.

As expected, the heat of explosion value for LA is (1601 KJ/Kg), which is higher than for DLA is (1356 KJ/Kg), these values are reasonable, because, lead azide and dextrin used as detonator for civil explosives.

The ignition temperature of LA and DLA is almost the same, (333 °C) and (334 °C) respectively. Impact sensitivity for LA is (2.9 N.m) which in agreement with the reference value (2.5-4 N.m). This value makes LA used in impact detonator. Impact sensitivity of DLA (20% dextrin) no result value until 40 N.m, this mean that the DLA becomes very poor sensitive material because of the high percentage of dextrin 20%.

5- CONCLUSION

The primary explosive lead azide and dextrin lead azide are prepared at laboratory scale according to the DOD Military standard. The physical properties (bulk density, moisture content, particle size) and explosion properties (heat of explosion, ignition temperature and impact sensitivity) for the two materials are determined for using in detonators. The results of experiments show good agreement with reference values, so we can use these substances in detonators. The physical properties of LA is less than DLA for moisture content and particle size while the bulk density of LA is higher than DLA. The explosion properties, such as, heat of explosion and impact sensitivity of LA is higher than DLA. Also, the results show that lead azide is better to be used in impact detonators than (20%) dextrin lead azide but dextrin lead azide will be the best for electric detonators.

Acknowledgments

The authors are grateful to College of Graduate Studies and Scientific Research, Karary University and Defense Industries System MASAD for their help and support.

REFERENCES:

[1] R. Matyáš and J. Pachman, *Primary explosives*, vol. 9783642284. 2012.
[2] S. Iyer and N. Slagg, *Energetic Materials*, vol. 2, no. 4. 1990.
[3] R. M. J. K. A. Homburg, *Explosive*, vol. 91, no. 5. 2012.
[4] J. P. A. High, *High Energy Matreials*, vol. 44, no. 8. 2011.
[5] D. S. A, "Military Standard Propellants, Solid : Sampling, Examination and Testing," no. October, 2010.
[6] North Atlantic Treaty Organization, "Manual of Data Requirements and Tests for the Qualification of Explosive Materials for Military Use Aop-7," vol. 7, no. June, pp. 1–547, 2003, [Online]. Available: https://www.difesa.it/Amministrazionetrasparente/segredifesa/terrarm/Documents/aop_07_2.pdf.
[7] E. B. F. Galante, A. Haddad, D. Boer, and D. Bonifácio, "Life cycle inventory for lead azide manufacture," *J. Aerosp. Technol. Manag.*, vol. 6, no. 1, pp. 53–60, 2014, doi: 10.5028/jatm.v6i1.289.