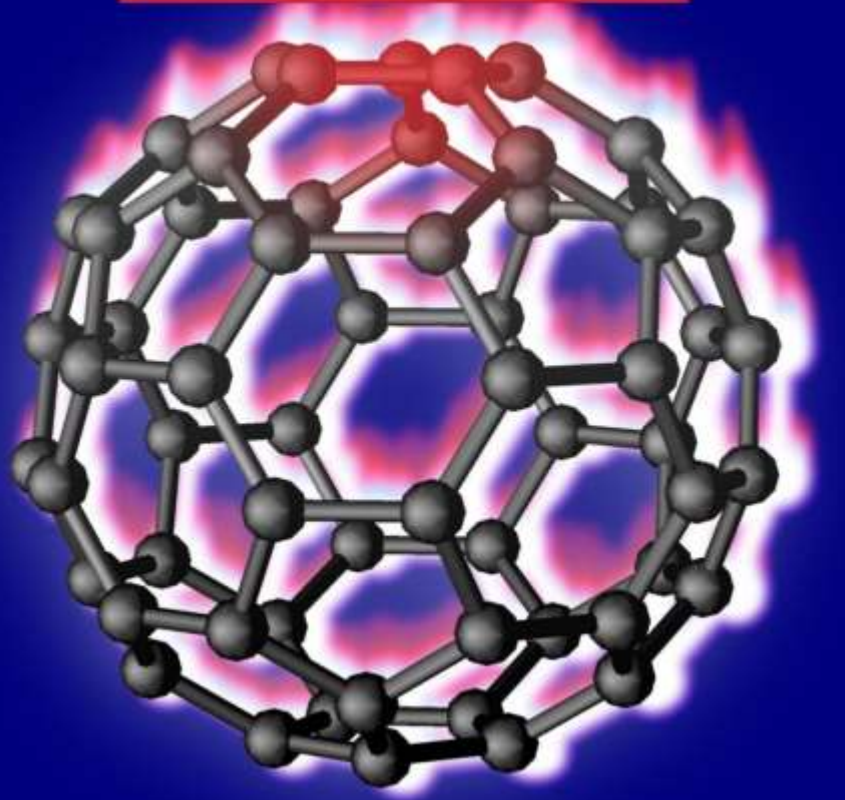
The Ministry of Education & Science of the Republic of Kazakhstan Scientific Committee

Al-Farabi Kazakh National University
International Science and Technology Center
The Institute of Combustion Problems
National Nanotechnology Laboratory of Open Type

X International Symposium

The Physics and Chemistry of Carbon and Nanoenergetic Materials



September 12-14, 2018

ALMATY, KAZAKHSTAN

The Ministry of Education & Science of the Republic of Kazakhstan
Қазақстан Республикасы Білім және Ғылым Министрлігі
Министерство Образования и Науки Республики Казахстан

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Жану Проблемаларының Институты
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National Nanotechnology Laboratory of Open Type
Национальная Лаборатория Открытого Типа
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X International Symposium
«THE PHYSICS AND CHEMISTRY OF CARBON AND NANOENERGETIC MATERIALS»
12-14 september 2018

X халықаралық симпозиумы
«ФИЗИКА ЖӘНЕ ХИМИЯ КӨМІРТЕКТІ ЖӘНЕ НАНОЭНЕРГЕТИКАЛЫҚ МАТЕРИАЛДАР»
12-14 қыркүйек 2018

X Международный Симпозиум
«ФИЗИКА И ХИМИЯ УГЛЕРОДНЫХ И НАНОЭНЕРГЕТИЧЕСКИХ МАТЕРИАЛОВ»
12-14 сентября 2018

Алматы, 2018

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SYNTHESIS OF SOLID HIGH-ENERGY COMPOUNDS

Seisenova A.B.[1,2], Aknazarov S.KH.[1,2], Juan Maria Gonzalez-Leal [3], Golovchenko O.Yu.[1,2], Bairakova O.S.[1,2], Kapizov O.S.[2]

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Abstract

The aim of the work is to obtain solid compounds or a mixture of individual high-energy substances capable of burning in the mode of self-igniting high-temperature synthesis due to the heat of exothermic reactions, with the allocation of a large amount of gaseous working medium with a high temperature.

1. Choice of feedstock and its characteristics

Oxidizers are usually salts of mineral acids rich in oxygen and at this stage of work. In the research under progress ammonium nitrate is chosen as the oxidizing agent. Ammonium nitrate (NH_4NO_3) is a white crystalline substance, the melting point is 169.6 ºC, the density is ρ = 1.725 g/cm^3, it is highly soluble in water and extremely hygroscopic. It decomposes at a temperature of 210 ºC with the release of nitrogen oxides[1].

Pure ammonium nitrate is a very weak explosive, but the addition of combustible substances (organic, inorganic, metallic) to ammonium nitrate dramatically increases its explosive-technical characteristics. Ammonium nitrate is an oxidizer containing in its volume more oxygen than necessary for ionic oxidation of the hydrogen entering into its composition.

Sodium nitrate ($NaNO_3$) or potassium nitrate (KNO_3) is a strong oxidant, an excess of oxygen in the decomposition of 0.47 and 0.40, respectively. The density of $NaNO_3$ 2.257 g / cm^3, melt at a temperature of 308^{0}C, at a temperature above 380^{0}C decomposes, is highly hygroscopic[2].

Potassium nitrate is a white crystal or a powder with a yellowish-gray hue, odorless. Density 2.109 g / cm^3, melting point 334^{0}C, decomposition temperature 400^{0}C.

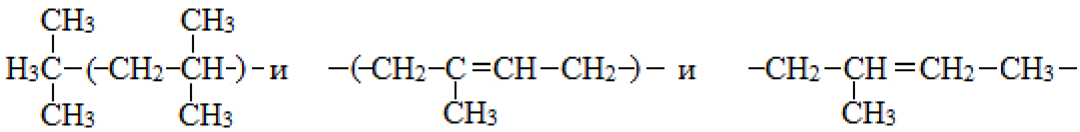
Both nitrates are strong oxidants and react with combustible and reducing agents.

<u>Fuel binder</u>

The fuel-binder is a multicomponent polymer composition of predominantly combustible substances capable of binding powdered components (oxidant, metal fuel, etc.) to a plastic fuel mass and curing to form mechanical and other properties of the fuel charge.

As the main classification characteristics of combustible-binders, it is convenient to use the chemical and phase composition (structure). According to the chemical composition, taking into account the energy characteristics, it is conventionally accepted "inert" and "active" classes of combustible-binders. In the research under progress, butyl rubber BK is chosen as an "inert" fuel binder.

Butyl rubber is a product of copolymerization of isobutylene and a small amount of isoprene (1-5%):



The molecular mass of industrial rubbers is within the range (20-700)×10^3.

The plasticizers provide the necessary physicochemical characteristics to the components of the energy condensed systems.

ASD-6 powder was chosen as the metallic fuel. The characteristics of ASD-6 from TU 48-5-226-87. The content of free metal (activity) is 98%, the moisture content is 0.03-0.08%. The ASD-6 does not have impurities in the form of Fe and Si.

Hardener components of high-energy fuel are added to the system in excess of 100% to give the product to be formed a stable, durable shape. As curing agents, epoxy resin type ED20, isophorone diisocyanate, polybutadiene rubber with carboxyl end groups, di-N-oxide-1,3-dinitrile-2,4,6-triethanol-benzene are used.

TON-2 is chosen as the hardener, which makes it possible to solidify the fuel composition at room temperature (20-35 °C), and also to prevent polyamorphic transitions of ammonium nitrate. Hardener TON-2 crystal powder light cream color, moderately hazardous substance.

2. Analysis

When selecting fuel components, their compatibility in the fuel composition was taken into account. Also a physicochemical study of the materials was carried out to determine the correspondence of these characteristics.

The selected metallic fuel is analyzed for the phase composition by the X-ray phase analysis. The analysis showed that aluminum is the main phase for aluminum ASD-6 and PA-1, and there is an insignificant amount of Al_2O_3 in aluminum ASD-6. Aluminum APSC contains a perceptible amount of oxidized aluminum. Since the X-ray phase analysis is semiquantitative, a chemical analysis using the volumetric method is used to more accurately determine the activity of the reductant used.

The data obtained is to be differentiated from the passport data, especially for aluminum ASD-6.

A phase analysis of the used nitrates was carried out. The substances consist of monophases of the starting materials. A phase analysis of the ammonium nitrate used was carried out. The substance consists of a monophase of the starting material.

Analyzes were also made for aluminum powders in Raman spectroscopy. Raman scattering technology refers to vibrational molecular spectroscopy. Oscillations arise in molecules due to the displacement of nuclei from the equilibrium position. [3] Vibrational spectra are recorded in the form of infrared spectra and Raman spectra (Raman spectra).

The figures below show the spectra of aluminum obtained by Raman spectrometry and also for the ammonium nitrate. The spectra were taken by using a 532 nm wavelength NdYAG laser and 100X objective.

The selected metallic fuel is analyzed on a multimode 3D microscope (Zeta Ltd., model Zeta 300). The Zeta 3D Optical Profiler provides fast, quantitative 3D representations of a surface without contacting or changing the surface, and provides 3D images that really bring the quantitative data to life.[4]

3D profiles were obtained with a three-dimensional image with a high defect resolution.

The experiments were conducted in air, ignition was carried out by a heated metal plate to a temperature of 5700 ° C. The combustion of the samples is uniform. At α = 0.5, significant smoke evolution in the form of CO.

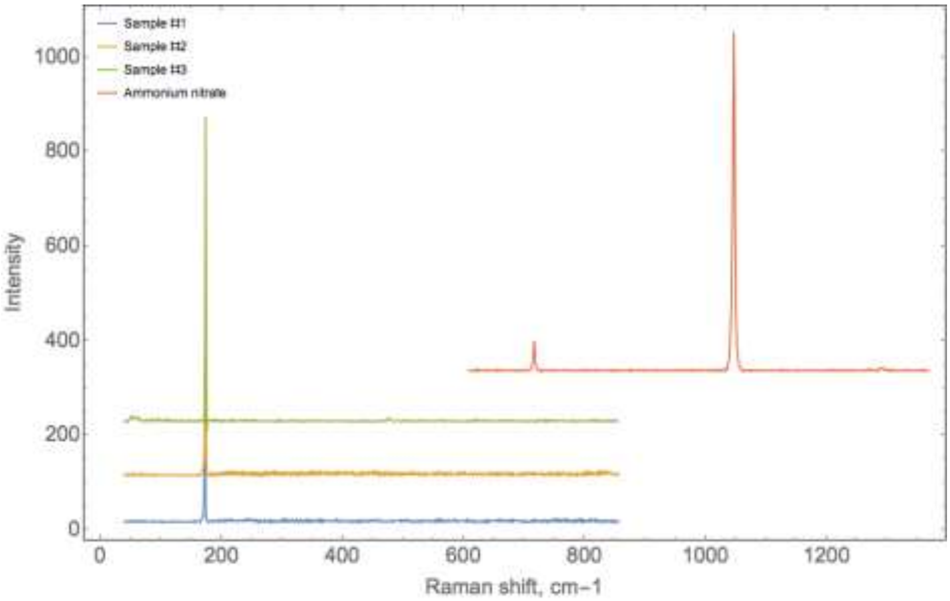


Figure 1 – Ramanoscope spectra of the feedstock. (SAMPLE №1-APSC, SAMPLE №2-PA-1, SAMPLE №3-ASD-6)

A comparative analysis of the combustion of systems containing micro- and high-active aluminum when used without chlorine oxidants and inert fuel has shown that highly active aluminum increases heat release in the condensed phase by intensifying exothermic conversion of exothermic transformation in a narrow reaction layer, the stronger the higher the value of the excess oxidant .

Analysis of fuel samples after combustion using aluminum ASD and highly active showed that when using highly active aluminum in fuel samples, complete combustion of the initial components takes place, both at α = 0.9 and α = 0.5. In the cinder there are only aluminum compounds with calcium present in the rubber.

The advantage of using aluminum powder is a high rate of combustion of fuel, the completeness of combustion of fuel components.

List of literature materials

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