Abstract of Sergey Yuryevich Panfilov on the topic:

Development of Technology for Production of Industrial Emulsion Explosives using Reclaimed Primary Components

Urgency of the research. Pursuant to the data of Federal Environmental, Industrial and Nuclear Supervision Service of Russia as of 2024 2.4 million tons of industrial explosives were used while mining in the Russian Federation, of which 87% (2.1 million tons) were produced from non-explosive components at the sites. Of these, 73% (1.6 million tons) were the safest industrial emulsion explosives (IEE), which are produced during charging of blastholes using MMUs based on an emulsion matrix produced under production conditions and which is a second-type emulsion (inverted emulsion - "water-in-oil"), where ammonium nitrate in water (dispersed phase) is dispersed in mixtures of petroleum products and emulsifiers. The emulsion matrix is a metastable system and despite the use of surfactants and various stability-enhancing additives, it always undergoes the decomposition - coalescence and flocculation, which with time leads to the complete destruction of the emulsion. Usually, the destruction time exceeds the time required for its intended use. However, under certain conditions these processes significantly accelerate and a completely or partially broken emulsion is formed.

Thus, when an emulsion matrix is produced, an off-spec emulsion, i.e. an emulsion that does not comply with the standards, regulations and specifications, may be formed.

It can be formed due to errors in the production process, the use of low-quality raw materials and due to the properties of the emulsion system. Approximately the volume of such industrial waste can reach 5%, which is more than 70 thousand tons per year.

The RF Legislation defines such waste in the order of Rosprirodnadzor No. 242 dd. 22.05.2017 as "Waste of emulsion dispersion of ammonia and sodium nitrate solution in industrial oil" and also as the subject to the disposal.

The Russian Federation Legislation sets forth only the disposal of already sensitized emulsions, which are industrial emulsion explosives.

The disposal of the emulsion matrix is not specified and is carried out by the Manufacturer pursuant to the accepted internal regulations.

So far, such waste is mainly destructed or burnt due to the lack of requirements and industrial ways of recycling.

Thus, the issues of regeneration of off-spec industrial explosives into primary components for their reuse are of not only a research, development, and engineering interest, but also of a great economic and environmental importance.

The topic status. Water-in-oil industrial emulsion explosives have been known since 1969, when the first US patent was published, but so far, the researches on perfecting the formulations, production processes and properties are conducted very actively by both scientists and Manufacturers of industrial emulsion explosives. Quite a lot of scientific reports and regulations, standards and specifications deal with the disposal of off-spec products and waste of emulsion explosives in various countries. There are foreign patents and various engineering solutions for the destruction and disposal of emulsion waste.

However, the issues on the efficient disposal, regeneration of off-spec emulsion matrices and extraction of primary components from them for their subsequent use are new for the industrial chemistry; thus, there are no scientific reports on the study of these processes in the indigenous scientific and technical literature and there are no such operating procedures used in Russia.

The purpose of the scientific report is to recycle waste, obtain industrial emulsion explosives based on them and reduce harmful emissions into the environment during their production.

Scientific report goals:

1. Development of a procedure for demulsification of "water-in-oil" emulsion matrices, which are the basis for production of industrial emulsion explosives;

2. Processing of off-spec emulsion matrix to obtain reclaimed products of oxidizer and oil phase;

3. Development and engineering of a laboratory plant for production of reclaimed products from off-spec emulsion matrices;

4. Studying of the properties and confirmation of the compliance with the specifications of emulsion matrices and industrial emulsion explosives obtained using reclaimed products;

5. Development of the industrial process for recycling off-spec emulsion matrices and production of industrial emulsion explosives using reclaimed primary components.

Novelty.

The possibility of obtaining reclaimed products of the oxidizer and the oil phase from water-in-oil emulsion matrices, which are the basis of industrial emulsion explosives, has been experimentally confirmed.

An empirical dependence of the required concentration of the demulsifier solution has been obtained for the effective process of complete destruction of the emulsion matrix depending on its state, determined by the viscosity and crystallineness.

It was newly study of physicochemical and operational properties of emulsion matrices and industrial emulsion explosives obtained with the partial and complete replacement of the primary components with their reclaimed products extracted from off-spec semi-products.

The dependence of viscosity on temperature of initial emulsion matrices and those obtained with the application of reclaimed primary components has been determined.

It was the newly study of the detonation parameters of industrial emulsion explosives based on the reclaimed primary components conducted using the electromagnetic approach. Detonation velocity values, mass velocity profiles and explosion pressure have been obtained.

Impact sensitivity characteristics of off-spec emulsion, newly produced emulsion acidified with acetic acid and industrial emulsion explosives obtained from primary components and reclaimed from off-spec semi-finished products have been obtained for the first time depending on the storage time after the gasification.

Theoretical and practical significance.

The chemical method of destruction, separation and extraction of reclaimed products from "water-in-oil" emulsion matrix of industrial emulsion explosives base has been developed.

A laboratory plant for the separation and extraction of reclaimed products from off-spec emulsion matrices of industrial emulsion explosives has been developed and engineered.

Emulsion matrices and industrial emulsion explosives with the partial and complete replacement of primary components with reclaimed oxidizers and oil phase have been obtained.

The compliance of physicochemical and operational properties and also safety requirements with the standards, regulations and specifications of the emulsion matrix and industrial emulsion explosives obtained using reclaimed primary components has been confirmed.

A mobile off-spec emulsion matrix recycling plant has been engineered; It can be used for the existing industrial emulsion explosives production plants without extra changes of process parameters. The Production Procedure for processing off-spec emulsion matrices into reclaimed primary components has been worked out.

A patent has been obtained for the approach of destruction and disposal of off-spec emulsion semi-finished products of industrial emulsion explosives (No. 2848106 dated 16.10.2025).

Practical Procedure and research methods. The scientific report employes approaches for determining a density, viscosity, electrical capacity, electron microscopy, water resistance to study the physicochemical properties of emulsion matrices; gravimetrical, gas analysis and high-efficiency liquid chromatography to determine the content of the obtained reclaimed products; an electromagnetic detonation testing method for checking the explosive characteristics of industrial emulsion explosives; an impact sensitivity has been determined pursuant to GOST 4545-88 and also the critical pressure method.

The Provisions submitted for defense:

1. The Chemical Approach of Breaking Water-in-Oil Emulsions Used for Production of industrial emulsion explosives;

2. Engineering of a laboratory plant and pilot production of reclaimed products from off-spec emulsion matrices of industrial emulsion explosives for the subsequent use;

3. Preparation and properties of samples of emulsion matrices and industrial emulsion explosives using reclaimed primary components;

4. The Procedure of industrial processing of off-spec emulsion matrices

Degree of reliability of outcomes. The reliability of the outcomes is ensured by using standard testing methods, battle-tested research methods and also up-to-date methods for analyzing and processing the obtained outcomes.

Peer-reviewed evaluation of the research outcomes. The main provisions and outcomes of the academic dissertation are presented and discussed at the conferences: VIII International Scientific and Technical Conference "Industrial Explosives: Status, Development and Application Prospects" (Dzerzhinsk, 2023), XIX, XX, XXI International Congress of Young Scientists in Chemistry and Chemical Technology (Moscow, 2023, 2024, 2025), International Academic Symposium "Miner's Week" (Moscow, 2024, 2025), VI International Scientific and Practical Conference of Young Scientists on Technosphere Safety Issues (Moscow, 2024), XI

International Scientific and Practical Conference "Innovative Directions when it comes to Engineering of Mining Plants. Safe and efficient development of mineral deposits" (St. Petersburg, 2024), All-Russian scientific and technical conference "Successes in special chemistry and chemical technology" (Moscow, 2025).

Contributions. 12 scientific reports have been published on the topic of the academic dissertation, including 6 articles in publications classified in Scopus and ChemAbs international databases. The outcomes of the scientific research have been confirmed by the participation in scientific events of the all-Russian and international level: 5 scientific reports have been published using documents from all-Russian and international conferences and symposiua.

1 patent of the Russian Federation has been obtained.

Personal contribution of the author. He actively participated in obtaining the above outcomes - from setting tasks, planning and conducting key experiments to discussing and execution of publications. Some of the pilot outcomes have been obtained by the staff of the Technosphere Safety Department. They have obtained sensitivity parameters and explosive characteristics.

In this case the applicant's contribution: setting tasks, discussing and interpreting the outcomes and writing articles.