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MEANS OF SIMULATING TOXIC SUBSTANCES AND THEIR HISTORY OF APPLICATION

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Abstract
This article covers the information on the simulants of toxic substances, their physical and chemical properties and the history of their use.

Keywords: Poison imitators, imitation, organic solution, concentration, amount of mass, chemical weapons, imitation fugases.

Introduction

The former Soviet Union was one of the leading states in the development of chemical weapons and their simulation agents; in particular, comprehensive research was conducted in the field of chemistry, and theoretical and practical work was carried out on the military application of chemical substance imitations. These agents were also utilized to develop and test personal protective equipment for the supply of the armed forces.

During the First and Second World Wars, great attention was paid in many countries to the development of chemical weapons and their practical testing. In particular, the German army used toxic substance simulation agents for training and military activities within its armed forces [1].

Up to the present time, toxic substance simulation agents used have been designed to contaminate areas, weapons, military equipment, and the skin. They consist of a mixture of neutral substances (fillers) and contain compounds with a strong effect on the organism (chloropicrin, chloroacetophenone). These compounds impart an irritating property to the mucous membranes of the eyes and the skin. This ensures the necessity of using personal protective equipment and degassing agents during combat training sessions with personnel. At the same time, such formulations allow the presence of a toxic substance to be simulated exclusively through the irritating properties of the imitation composition.

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As a result of research, a patent was obtained for an iprit (mustard gas) simulant used to train in conducting combat operations under conditions of chemical contamination, possessing characteristics closest to the iprit toxic substance. However, the application of this formulation requires special devices. At the same time, simulants used for training personnel must first of all ensure maximum safety for the personnel and the environment, as well as facilitate their easy detection.

The technical objective of the simulation agents is to create a safe and universal simulant for training personnel in combat operations under conditions of chemical contamination.

This goal is achieved through the application of water-based formulations. As active components, the sodium salt of phenolphthalein, fluorescein sodium salt, 1,2-dialkyldithiaeptane, and carboxymethylcellulose are proposed to be used.

In general, the criteria for selecting the composition of the simulation formulation can be formulated as follows:

the possibility of controlling chemical contamination (daytime and nighttime visual control, organoleptic control);

degassing using standard technical means designed for the degassing of weapons and military equipment;

homogeneity of the composition;

safety of the formulation;

cost characteristics of the composition.

When selecting acceptable compounds for a specific purpose, it is first necessary to take into account the presence of the chemical contamination effect, that is, the possibility of implementing visual and organoleptic control.

For the visual control of chemical contamination during the daytime, it is proposed to use the sodium salt of phenolphthalein. This component is available, adopted in the civil sector, and highly soluble in water. The aqueous solution of the sodium salt of phenolphthalein has a red color, which is clearly visible on protective equipment and machinery. For application, a mass content of 0.3% of the sodium salt of phenolphthalein is considered sufficient. Smaller amounts of this component make the simulation formulation poorly visible against a green background. Larger amounts of the sodium salt of phenolphthalein do not improve the visibility of the simulation formulation and make it more expensive. Treating protective equipment contaminated

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with the simulation formulation with a 1% aqueous solution of DTS GK (two-thirds basic calcium hypochlorite salt) causes the phenolphthalein to become invisible.

For the visual control of chemical contamination during nighttime, it is proposed to use fluorescein sodium salt. This component is available, adopted in the civil sector, and highly soluble in water. During nighttime, when illuminated by ultraviolet rays, the aqueous solution of fluorescein sodium salt is clearly visible on protective equipment and machinery. For application, a mass content of 0.1% of fluorescein sodium salt is considered sufficient. Smaller amounts of this component make the simulation formulation poorly visible against a green background. Larger amounts of fluorescein sodium salt cause the salt to absorb into the treated surface, making its subsequent removal difficult. In this case, protective equipment and machinery cannot be reused for retraining. Treating protective equipment contaminated with the simulation formulation with a 1% aqueous solution of DTS GK leads to the easy removal of fluorescein.

To create the effect of detecting chemical contamination by organoleptic method, it is proposed to use 1,2-dibutyldithianetane. A mass content of 0.01% is sufficient. When larger amounts of 1,2-dibutyldithianetane are used, it becomes insoluble in water, creates a heterophase, and the formulation loses its homogeneity.

To modify the physical properties of the formulation, it is proposed to use carboxymethylcellulose. It is advisable to use a mass content of 0.3% of this compound. A larger amount of the component leads to the inhomogeneity of the formulation. Smaller amounts do not allow the creation of the necessary surface tension and viscosity for the simulation formulation. The studied formulations consisted of mixtures of homogeneous composition.

Toxicological studies of the produced formulation showed that it belongs to the third class of toxicity (intravenous LD_{50} = 909.7 mg/kg; oral more than 5000 mg/kg), which allows its use in training personnel.

The proposed aqueous solution composition of 0.3% phenolphthalein sodium salt, 0.1% fluorescein sodium salt, 0.01% 1,2-dibutyldithianetane, and 0.3% carboxymethylcellulose can be used as a simulation formulation for training in combat operations under conditions of contamination by toxic substances [2].

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Conditional Enemy Toxic Substance Simulation Agents and Training Formulations

To simulate chemical contamination, training formulations simulating toxic substances established in the conditional enemy's table of organization and equipment are used. Training formulations of persistent and non-persistent toxic substances are available in the supply of the troops.

The main means of simulation formulations consist of "IGN" (for simulating non-persistent toxic substances) and "IGS" (for simulating persistent toxic substances) grenades, "IF" type simulation fougasses, training toxic smoke grenades, and training launching devices. In addition, an aerosol generator (AG) can also be used.

Chloropicrin (CCl_3NO_2) — trichloronitromethane, was first obtained in 1848 by the Scottish chemist John Stenhouse using a mixture of 2,4,6-trinitrophenol (picric acid) and chlorinated lime, and was used as a toxic substance during the First World War. In addition to a suffocating effect, it also has a strong tear-gas property. Pure chloropicrin is a colorless liquid with a pungent, unpleasant odor. Freezing point is 69 ^{0}C, boiling point is 113 ^{0}C. It is 5.7 times heavier than air. It is poorly soluble in water and readily soluble in organic solvents. It is well adsorbed on activated charcoal. Chloropicrin does not belong to chemically active substances. Aqueous solutions of acids and alkalis do not react well with chloropicrin. It does not hydrolyze in water, even when boiled. An alcoholic solution of sodium sulfide is used to neutralize chloropicrin. When heated above 300 ^{0}C, it decomposes, forming phosgene and nitrosyl chloride.

The minimum irritating concentration is 0.002 g/m^3. Damage to the respiratory tract occurs at a concentration of 0.1 g/m^3. Breathing chloropicrin at a concentration of 2 g/m^3 in the air for 10 minutes leads to death.

Chloropicrin was used against Russian troops in the summer of 1915. Chloropicrin was also used by the Soviet army in Afghanistan.

The training toxic-smoke grenade is used to simulate the use of the enemy's chemical weapon — large and small-sized munitions filled with non-persistent toxic substances. The training toxic-smoke grenade consists of a cardboard shell inside which two smoke mixture briquettes are placed. The smoke mixture briquette is closed on both sides with cardboard diaphragms and caps. There are openings in the diaphragm for smoke release. In the circular openings of the smoke mixture briquettes, an igniter match with an ignition head is installed together with a paper

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cap-friction igniter. The grenade shell is marked with a light blue ring path on the side of the igniter match. The weight of the grenade is 250-270 g, the weight of the smoke mixture is 190-210 g. The burning time of the match is 20 seconds, and the smoke generation time is 1-3 minutes. Toxic smoke grenades are delivered to the troops filled and are made combat-ready before use. To detonate the grenade, cardboard caps are removed using cords. Taking the friction igniter, the paper cap of the match is removed from the ignition head, rubbed against each other to ignite, and 2-3 seconds later the grenade is thrown to the intended location. If the friction igniter is missing or faulty, the friction surface of a matchbox can be used. The training toxic-smoke grenade is used depending on the wind direction relative to the targets it should affect. Under average meteorological conditions, the toxic smoke cloud spreads along the wind direction up to a distance of 550 m from the ignition line [3].

Persistent Toxic Substance Training Formulations

Persistent toxic substance training formulations (URSOV) are used to indicate the contamination of combat equipment, the surrounding area, and personnel when the enemy uses "VX" and "iprit" types of toxic substances. Persistent toxic substance training formulations are produced in various compositions.

To simulate the "VX" type of toxic substances, the URFOV-2 training formulation is used. This is a light-brown, non-toxic liquid that leaves spots like the "VX" toxic substance on AP-1 film. Clothing and equipment of personnel can be contaminated with this training formulation. The formulation is applied using a training launching device.

To simulate the contamination of combat equipment and the surrounding area with iprit, IV-B and IV-2 training formulations containing chloropicrin and chloroacetophenone are used.

IV-B training formulation is a very dark brown, oily, viscous liquid with a freezing point of 45 ^{0}C; the formulation is non-flammable. Contamination with this formulation is carried out using IGS and IF simulation grenades and fugases.

IV-2 training formulation is a dark brown, viscous liquid with a freezing point of 40 ^{0}C. Contamination with the formulation is carried out using an auto-tanker station or other means. The spread of formulation vapors can reach up to 100 m in the wind direction. Both formulations are delivered to the troops in thick iron-walled barrels

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with capacities of L-100, L-150, L-200, L-250. The formulations have a very unpleasant odor [3].

Non-Persistent Toxic Substance Training Formulations

Non-persistent toxic substance training formulations are designed to simulate air contamination by the enemy with non-persistent toxic substances. Non-persistent toxic substance simulation grenades and training toxic-smoke grenades are filled with these training formulations. In addition, an imitating formulation (IR-1) mixture is used with the help of a smoke-dispersing liquid generator.

Ammonia water can be used to simulate air contamination with VX aerosols. For their application, simulation grenades and fugases, as well as auto-tanker stations (ARS) and degassing kits (DKV) tools, are used with 10 mm diameter rubber hoses and sprayers suspended at a height of 3-4 m (for example, from trees).

Means of Applying Training Formulations

Simulation of an enemy chemical attack is carried out using IGN, IGS simulation grenades, IF simulation fugases, training toxic-smoke grenades, and training launching devices (UMU).

IGN non-persistent simulation grenade is used to simulate the use of small and large-sized munitions filled with non-persistent toxic substances of the enemy's chemical weapon. It consists of two outer and inner cardboard cylinders connected to each other by a circular base, a circle, and a cap. The bottom of the inner cylinder acts as a cup and is designed to accommodate the detonating package. The filled grenade is paraffin-coated and delivered to the troops in this condition. The weight of the filled grenade is approximately 200 g. The weight of the toxic substance training formulation is 100 g.

To detonate the grenade, it is necessary to ignite the ignition head of the detonating package using a match. Once the ignition head ignites, the grenade must be quickly thrown to a pre-designated location. Detonation of the grenade is carried out at a distance of 50 m from personnel and flammable materials.

IGN simulation grenades are always detonated from the windward side of the targets they are intended to affect. A single grenade ensures the contamination of an air volume of 20 m^3 with a non-persistent toxic substance cloud spreading along the wind direction. The effect force is maintained at a distance of 50-100 m from the explosion line.

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IGS simulation grenade is filled with the IV-B training formulation and is used to simulate the enemy's chemical weapon munitions filled with large and small-sized persistent toxic substances. The IGS consists of a cylindrical polyethylene container with a cup in its middle part to accommodate the ignition package. On the upper part of the grenade, there is a stoppered opening where the formulation is poured.

The volume of the training formulation for filling the IGS is 450 cm^3. Filling of the simulation grenades is carried out under the supervision of the RKBM service chief in an open area wearing gas masks and light protective suits or combined-arms protective equipment. To fill the simulation grenades, they are placed in a row on the ground, the stoppers are removed from the containers and placed on the grenade caps. A filling device is installed at the opening of the grenades, through which the formulation is poured. To facilitate filling, a special container with a volume of 450 cm^3 or 500 cm^3 should be used. By detonating a single IGS simulation grenade, an area of up to 25 m^2 can be contaminated.

IF simulation fugase is filled with the IV-B training formulation and is designed to simulate the enemy's minefields installed with chemical fugases and the explosion of large-sized aerial bombs filled with persistent toxic substances. The IF device is similar to the IGS grenade. IF fugases are delivered to the troops unfilled. The volume of the formulation poured into the fugase is 0.9 liters. Filling of the simulation fugases is carried out just like the IGS grenades. IF simulation fugases are installed in specially dug pits and camouflaged (or uncamouflaged). The depth of the pit is equal to the height of the fugase, i.e., 10.5 cm, and the diameter is approximately 12 cm. The pit is dug widening upwards, and its walls should slope outward by approximately 45^0. Detonation of a single IF simulation fugase can contaminate an area equal to 50 m^2. When installing simulation fugases in areas with dry vegetation, fire safety measures must be taken (removing dry vegetation and branches around the fugase) [4].

Toxic Substances Affecting the Mucous Membrane of the Eyes (Tear-gas Agents or Lachrymators)

Chloroacetophenone and bromobenzyl cyanide are examples of the group of tear-gas (lachrymator) toxic substances.

In 1965–1972, the CS substance belonging to this group was widely used during combat operations in South Vietnam. In subsequent years, the CR substance, a

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member of this group, was also synthesized; this substance has a strong irritating property similar to CS.

Bromobenzyl cyanide is a chemically pure, glossy, colorless or yellowish crystalline substance with a characteristic bitter almond odor. Its technical product is a brown or dark-brown oily liquid, sometimes a crystalline substance. The melting point of the pure chemical product is 25,4 ^{0}C, boiling point is 232 ^{0}C, and specific gravity at 20 ^{0}C is 1,52. It is poorly volatile, at 20 ^{0}C, the concentration of bromobenzyl cyanide in 1 m^3 of air is 50 mg. It is completely insoluble in water and cold alcohol, but readily soluble in organic solvents. It does not hydrolyze in cold water, but hydrolyzes gradually when heated. Bromobenzyl cyanide begins to decompose when heated above 150 ^{0}C, and if heating is continued up to 200 ^{0}C, it decomposes completely within 10 minutes [5].

Foreign military specialists recommended using the CS substance as a military chemical weapon in the 1930s due to its strong irritating property [6].

According to foreign data, between 1965 and 1972, 6,800 tons of CS substance were used in South Vietnam. Despite its strong irritating property, it was found to have teratogenic properties; therefore, starting in 1973, the use of this substance by police was not recommended. In its pure form, it is a white crystalline substance melting at 95 ^{0}C, boiling point 315 ^{0}C. It is poorly soluble in water, readily soluble in organic solutions (acetone, benzene, etc.), fats, and lipids, and hydrolyzes well in water. When alkalis are added, the hydrolysis reaction proceeds very rapidly, and the resulting products are considered toxic [7].

Three formulations of the CS substance can be used on battlefields, all of which are used as aerosols. These toxic substances are used through smoke-generating agents. The incapacitating concentration is 0.001–0.005 mg/l, the unbearable concentration is 0.005 mg/l, and the lethal concentration is 25 mg/l.

CR substance. It was first obtained in Switzerland in 1962. They discovered the irritating property of this substance. After it was found that the CS substance has a negative teratogenic effect, specialists from the Port-daun Research Center in Great Britain in 1970 recommended a dibenzoxazepine compound as a toxic substance that could be used by police. In 1973, this compound was adopted under the code CR to equip the British police, and later the US police, as a chemical weapon.

The pure chemical product is a crystalline yellow powder with a melting point of 72 ^{0}C. It is insoluble in water, is a lipidotropic substance, meaning it dissolves well in

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lipids. It does not decompose even when boiled with a 20% aqueous alkali or concentrated hydrochloric acid. On used battlefields, it does not decompose for a long time and persists for a long time. The CR substance is used by the aerosol method. Its irritating property is 8 times higher than that of CS, its skin-damaging property is 20 times higher, and its toxicity is 5 times lower than that of CS.

In conclusion, it should be noted that the historical development of simulation agents plays an important role in military training and protection against chemical weapons in various periods. These agents, in turn, serve as an important tool in ensuring the safety of military personnel and improving the knowledge necessary for military operations.

Toxic substance simulation agents can be complex and hazardous for military personnel because their effects are extremely dangerous and handling them requires caution. Simulation agents can imitate the effects or dispersion of chemical substances, and their effects can be similar to the properties of real harmful substances. Therefore, certain protective measures are necessary to handle them safely and prevent contamination.

References:

1. Imitation formulation for troop training. Access mode: https://patents.google.com. Date of access: 28.02.2025.
2. Simulation formulation of toxic substances. Access mode: https://patents.google.com. Date of access: 28.02.2025.
3. Suyarov Z.Kh. Textbook for Chemical Troops Sergeants. – Tashkent: Talqin Publishing House, 2006. – P. 322-329.
4. Suyarov Z.Kh. Weapons of Mass Destruction and Protection Against Them. – Tashkent: Publishing House of the Ministry of Defense of the Republic of Uzbekistan, 2005. – P. 284-291.
5. A.P. Volkov. Application of Radioactive and Chemical Contamination Simulation Means. Military Publishing House. Moscow – 1989. – P. 3-42.
6. A.D. Moskalyov. Actions of Troops on Contaminated Terrain. Textbook. Moscow – 1989. – P. 88-110.
7. S. Hersh. Chemical and Biological Weapons. America's Secret Arsenal. Textbook. Moscow – 1970. – P. 116-148.