ENGINEERING SCIENCES

THE USE OF PHOTOCATALYTIC TECHNOLOGY FOR THE DISINTEGRATION OF HAZARDOUS CHEMICAL SUBSTANCES

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Introduction. The experience of recent years shows that in modern world the threat of using nuclear, biological and chemical weapons as well as high-precision weapons remains, as a result of which potentially hazardous facilities can be destroyed. There are more than 1,5 thousands chemically dangerous objects on the territory of Ukraine, whose activity is related to the production, use, storage and transportation of hazardous chemicals, and more than 22 million people live in the areas of their location. The danger of functioning of these objects of economic activity (chemically dangerous objects) is related to the probability of accidental emissions (spillages) of a large number of hazardous chemical substances (hereinafter referred to as «HCHS») outside the objects, because many of them retain 3-15 daily supplies of chemicals.

Since the effectiveness of the assigned tasks depends of the degree of protection of personnel, it is necessary to look for approaches to address this problem. Filter-ventilator units, both stationary and on armored vehicles, and filter systems that were created in Soviet times, do not protect personnel from hazardous chemical substances, as chlorine, ammonia, sulfur trioxide etc.

Priority direction of improving the efficiency of the filtering systems from HCHS to protect armored vehicles and stationary structures is the additional installation of the mesh with a coated layer of catalytic material in the absorber filter. Neutralization of toxins of different nature due to photocatalytic gas purification [1], in which titanium dioxide is used as a photocatalyst, is a promising development direction in the defense sphere of the state.

Exposition of basic research material. Photocatalytic properties of titanium (IV) oxide [2] depend on its morphology, crystalline form, particle size, specific surface. The most famous forms are anatase, rutile, brookite and a new modification – eta TiO_2 (η-TiO_2). Titanium oxide, when absorbing a quantum of light with an energy greater than 3.2 eV (light with a wavelength less than 390 nm – ultraviolet), generates free charge carriers – negative (electrons) and positive vacancies (holes). Electrons

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and holes, coming to the surface of TiO_2 enter into redox reactions with oxygen and vapors of water from the air or water, as a result of which strong oxidizers (O_2, OH and radicals) are formed, which directly interact with various organic pollutants. The formation of such kinds of particles makes the surface of TiO_2 a very strong oxidizing agent, which allows decomposing harmful substances through their photocatalytic oxidation to harmless H_2O and CO_2.

Valence band, conduction band, organic pollutant, active oxidizers, oxidation products

In practice, a photocatalytic air purifier includes a porous carrier coated with TiO_2, which is irradiated with UV rays, and through which air is pumped.

Currently, LED lamps are widely used, but their use for photocatalysis was limited to a rather narrow emission spectrum, which made it possible to generate these products. Numerous experiments have proven that the most effective for photocatalysts based on titanium dioxide is ultraviolet radiation of the A and B sub-ranges (wavelength from 280 to 400 nm) – with the extreme degree of air purification achieved at a wavelength of 320 nm [3].

In [4], it was proposed to use LED strip in the so-known «tubular photocatalytic air purifier». In this design, titanium (IV) oxide is applied to the inner surface of the tube equally along its entire length, and the most technologically advanced is a section in the form of a circle (Figure 1). When using a gas-discharge lamp as a source of ultraviolet rays, a lamp (a tube of quartz glass) is placed along the axis of the air purifier, therefore it uniformly irradiates the entire inner surface with a deposited TiO_2 layer. When placed on the strip of separate LEDs at a certain distance from each other, there were so-called «dead zones», that is, areas of the inner surface of the tubular air purifier, which receive a relatively small stream of UV rays. The issue can be solved by placing LEDs at a shorter distance or by replacing them with incandescent lamps that are directional and emit light without additional focusing and shielding.

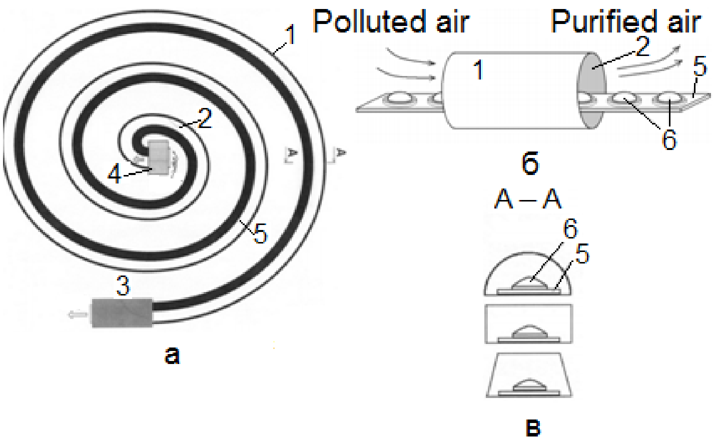

Figure 1. Photocatalytic air purifier a – top view; b – placement of the LED strip in the housing; c – forms of housing sections; 1 – spiral housing; 2 – photocatalyst layer; 3 – pump fan; 4 – dust filter; 5 – LED strip; 6 – UV LEDs

In [5], we studied the catalytic properties of coatings with mixed oxides in the oxidation reaction of carbon monoxide. The catalytic activity of mixed oxide systems was tested in the oxidation of carbon (II) oxide to carbon (IV) oxide on a laboratory bench in a tubular flow reactor made of silica glass with a coaxially wound heating coil.

Exposition of basic material. According to the results of the analysis of the above material, it was established that there are no such types of filters that protect against all HCHS. Therefore, it is necessary to formulate requirements for collective protection systems both on armored vehicles and stationary ones, which will protect against HCHS.

In works [6], it is indicated that in collective protection system it is possible to improve the performance characteristics without significant structural changes and significant material costs due to the additional installation of a cleaning system (Figure 2) in filter-ventilator installations (units) on armored vehicles and stationary structures.

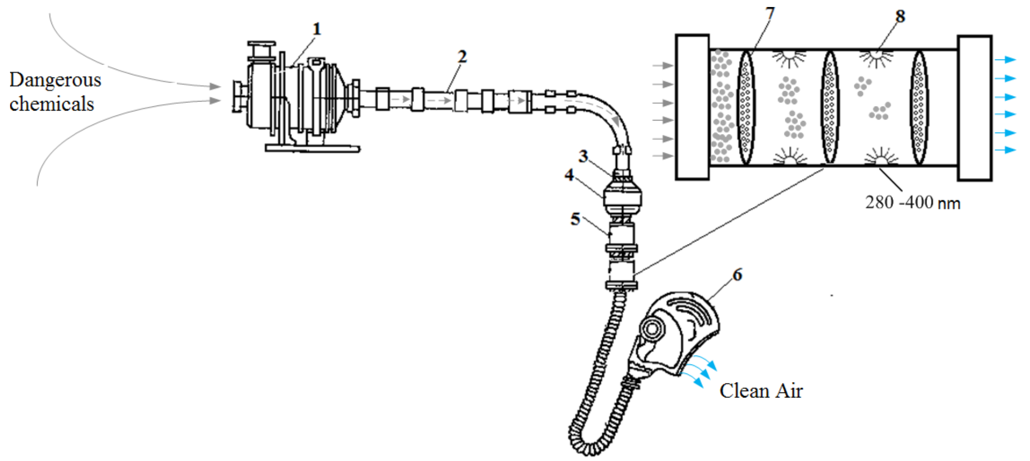

Figure 2. Scheme of improvement of the filter-ventilator unit FVU-3,5:
1 – filter-ventilator unit assembly FVA-3,5; 2 – hose; 3 – valve; 4 – canister;
5 – electric radiator; 6 – facepiece; 7 – titanium alloy mesh; 8 – LED

This will enable to neutralize (decompose) toxins of various nature at high efficiency performance in a wide range of temperatures and corrosion resistance. In the purification system, the polluted air passes through the meshes of titanium (IV) oxide coated with a layer of catalytic material, which receives ultraviolet rays from the LEDs installed in the system. This makes TiO_2 a very strong oxidizing agent, which allows the decomposition of harmful substances through their photocatalytic oxidation to safe H_2O and CO_2.

Conclusion and prospects for further development of this direction. According to the results of the analysis, it was established that photocatalytic purification from hazardous chemical substances is a very important issue for the protection of personnel. To improve the existing collective protection systems, they need to be equipped with a system of UV irradiation of the mesh surface with a layer of titanium (IV) oxide for photocatalytic destruction of toxicants. One of the following research tasks is to define the system requirements:

– determine the type of source of UV radiation that will provide uninterrupted emission of radiation under conditions of vibration, different acceleration and impact;

– optimize the placement of the UV radiation source to reduce the size and number of «dead zones» in which the radiation does not fall, and determine the radiation power that will ensure the energy-efficient disintegration of toxicants, depending on their composition and content in air mixtures.

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APPROACH TO CHOOSING A DRIVING ROUTE WHEN ORGANIZING A CAR DRIVING PRACTICE

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While organizing the process of learning practical driving, a considerable role is played by the choice of the venue, namely the choice of playground or a fully-fledged route in the city. Typically, in primary classes, such training takes place at separate sites of specialized racetracks. As the practical skills are consolidated, the combination of skillful application of theoretical knowledge of learning becomes a

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