6.4. EXPERIENCE IN COMBATING COVID-19 IN CITY CLINICAL HOSPITAL NO. 52 IN MOSCOW

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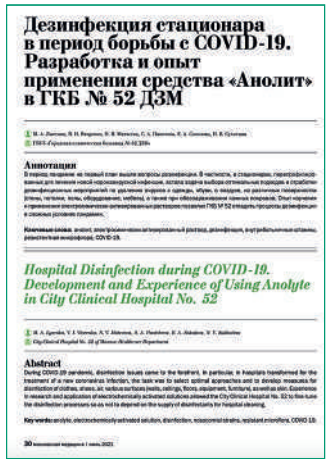
Дезинфекция стационара в период борьбы с COVID-19. Разработка и опыт применения средства «Анолит» в ГКБ № 52 ДЗМ

Аннотация

Hospital Disinfection during COVID-19. Development and Experience of Using Anolyte in City Clinical Hospital No. 52

Abstract
During COVID-19 pandemic, disinfection issues came to the forefront. In particular, in hospitals transformed for the treatment of a new coronavirus infection, the task was to select optimal approaches and to develop measures for disinfection of clothes, shoes, air, various surfaces (walls, ceilings, floors, equipment, furniture), as well as skin. Experience in research and application of electrochemically activated solutions allowed the City Clinical Hospital No. 52 to fine-tune the disinfection processes so as not to depend on the supply of disinfectants for hospital cleaning.

Key words: anolyte, electrochemically activated solution, disinfection, nosocomial strains, resistant microflora, COVID-19

City Clinical Hospital No. 52, opened in 1955 in four departments, today represents one of the largest multidisciplinary hospitals in the capital.

The hospital bed fund is 1070 therapeutic, surgical, nephrological and obstetric beds, including 72 beds in resuscitation and intensive care units.

In accordance with the Order of the Department of Health of the city of Moscow, late in February 2020, the therapeutic building of the SBHI (State Budgetary Healthcare Institution) *CCH No. 52 of MCHD* was redesigned to receive patients with community-acquired pneumonia and coronavirus infection.

Since 04/11/2020, four buildings in the hospital have been redesigned for the reception and treatment of patients with coronavirus infection, which provided 845 therapeutic beds and 98 resuscitation beds.

At the end of February 2020, in connection with the expansion of the spread of the SARS-CoV2 virus, the hospital strengthened measures to prevent and improve the quality of treatment for community-acquired pneumonia. In particular, additional places were allocated for patients with this disease. The choice of the 52nd hospital as one of the leading medical institutions for combating the viral pandemic is due to the presence of an extracorporeal membrane oxygenation (ECMO) center in the hospital, which can be used to treat patients with severe community-acquired pneumonia. Also, multidisciplinary teams were formed, including an infectious disease doctor, a pulmonologist, an epidemiologist, an anesthesiologist, a resuscitator, and emergency doctors.

At the same time, the hospital management began planning and immediate implementation of measures for the general preventive disinfection of premises and decontamination of the hospital territory, including the air in crowded places (at the entrance to the hospital, at the entrances to medical buildings, office buildings and premises, in the corridors, elevators, stairwells and landings). Primary attention was paid to the development and implementation of new rules for the rational and safe movement of people and goods around the hospital in order to prevent the spread of infection, to ensure the protection of people. The issues of choosing the most rational methods (technologies) and means for combating infection in all areas of work of the hospital staff were urgently resolved. It was necessary to choose the optimal approaches and work out disinfection measures to remove viruses from clothes, shoes, in the air, on various surfaces (walls, ceilings, floors, equipment, furniture), including the skin disinfection.

The necessity of an extensive, massive use of various disinfection measures has caused the need for a more thorough study of the disinfectants themselves and the methods of their use.

The instructions for carrying out disinfection measures for the prevention of diseases caused by coronaviruses (annex to the letter of Rospotrebnadzor dated January 23, 2020 No. 02/770-2020–32), as well as the documents of Rospotrebnadzor published over the next three months [1], offer the following means from different chemical groups: chloractive (sodium salt of dichloroisocyanuric acid — in the concentration of active chlorine in the working solution not less than 0.06 %, chloramine B — in the concentration of active chlorine in the working solution not less than 3.0 %), oxygen-active (hydrogen peroxide in the concentration not less than 3.0 %), cationic surface active agents (CSAA) — quaternary ammonium compounds (in a concentration in the working solution not less than 0.5 %), tertiary amines (in a concentration in the working solution not less than 0.05 %), polymeric derivatives of guanidine (at a concentration in the working solution of at least 0.2 %), alcohols (as skin antiseptics and disinfectants for the treatment of small surface areas — isopropyl alcohol at a concentration of at least 70 % by weight, ethyl alcohol at a concentration of at least 75 % by weight). In the documents of Rospotrebnadzor concerning disinfection, the list of recommended disinfectants has remained unchanged from March to May.

Rospotrebnadzor in its instructions recommends using the least toxic agents for disinfection. In this regard, we have analyzed the possibilities of using the disinfectants specified in the Rospotrebnadzor documents considering their composition and properties specified in the disinfectants State Registers of and instructions for use. A summary of the analysis is shown below.

1. **Dichloroisocyanuric acid sodium salt, State Registration Certificate** RU.77.99.32.008**. E.**000454.01.11**.** According to the parameters of acute toxicity in case of intragastric intake, the product is classified as moderately hazardous (hazard class 3); for cutaneous — to low-hazard substances (hazard class 4). Causes severe irritation of the skin and mucous membranes, eye damage. The development of skin sensitization is possible with repeated contact in highly sensitive individuals. It has a moderate cumulative capacity. The most affected organs and systems: the central nervous and respiratory systems, liver, kidneys, gastrointestinal tract, blood, skin, eyes. Can penetrate intact skin, causing general toxic effects.

Disinfectant «Javel Absolute» (77.99.1.2.U.9450.10.09). Active ingredients: sodium salt of dichloroisocyanuric acid 84 %, auxiliary components (adipic acid, carbonate, sodium bicarbonate, etc.). Fragments from the advertising description: «Javel ABSOLUT» belongs to the group of chlorine-containing preparations, which include adipic acid and sodium carbonates. They promote rapid drug dissolution and reduce **toxicity***. The principle of reducing **toxicity** is that the active ingredient is hypochlorous acid.

2. From the instructions for use for the **CHLORAMIN B agent (RU.77.99.88.002. E.002575.06.16)**: «Working solutions of more than 1 % cause dry skin, in aerosol form they irritate the respiratory organs and mucous membranes of the eyes».
3. Quaternary ammonium compounds (QAC): **«Alaminol» (RU.77.99.27.002.E.053021.12.11)**. Active ingredients: 5 % alkyldimethylbenzylammonium chloride and 8 % glyoxal, as well as a surfactant, dye and water; According to the parameters of acute toxicity according to GOST 12.1.007–76, it belongs to the 3rd class of moderately hazardous substances when administered into the stomach and to the 4th class of low-hazard substances when applied to the skin. It has a pronounced local irritant effect on the skin and mucous membranes of the eyes, inhalation is low-hazard in the form of vapors. Working solutions show a weak local irritant effect, do not possess sensitizing properties. **«Alaminol plus» (RU.77.99.27.002.E.053018.12.11)**: alkyldimethylbenzylammonium chloride (QAC), 30.0 %; glutaraldehyde, 0.6 %; glyoxal, 6.0 %. Maximum residue limit (MRL) for alkyldimethylbenzylammonium chloride in the air of the working area 1.0 mg/m^3 (aerosol, marked «Skin and eye protection required»); MRL of glutaraldehyde in the air of the working area 5.0 mg/m^3 (vapor, marked «Allergen»); Maximum concentration limit of glyoxal in the air of the working area is 2.0 mg/m^3 (marked «Skin and eye protection is required»). The hazard class of the «Alaminol Plus» agent according to the degree of impact on the body of warm-blooded animals in accordance with GOST 12.1.007–76 when applied to the skin is 4 (low-hazard substances), according to the degree of exposure when introduced into the stomach — 3 (moderately hazardous substances).

Based on reports of health problems with health care personnel in the UK, who carried out disinfection activities using the disinfectants with glutaraldehyde as the main active ingredient, the UK Occupational Health and Safety Executive (HSE) raised questions about the use of the product. Studies carried out by UK toxicologists have identified the negative effects of glutaraldehyde on the skin, eyes and respiratory tract of health care personnel. As a result, the use of glutaraldehyde was legally prohibited in the UK since May 2002 [2–4]. It should be noted that the Tentative Safe Exposure Level (TSEL) for glutaric aldehyde in the atmospheric air is 0.03 mg/m^3, that is, approximately 160 times less than the MRL in the working area.

Fragments from the safety data sheet for glutaraldehyde of the manufacturer company — BASF CZ00156-E (D/D). Potential danger to humans and the environment: Toxic by inhalation and if swallowed. Causes poisoning. Personal precautions: do not inhale, avoid contact with skin, eyes, clothing. Environmental precautions: avoid spillage into water and ground.

4. Tertiary amines: **Mistral (77.99.1.2.U.9852.11.08), Triacid-N (77.99.1.2.U.5621.7.08), Desolon (77.99.1.2.U.8676.7.05).** They belong to the third class of moderately hazardous substances when injected into the stomach, to the 4th class of low-hazard substances when applied to the skin. At the same time, solutions of Mistral in the form of an aerosol are highly hazard-

* *It becomes clear that people interested in sales know about the toxicity of dichloroisocyanurates, know about the non-toxicity of hypochlorous acid, but the instructions for use do not contain the above information on the toxicity of the agent, although in fact the toxicity is determined by the presence of dichloroisocyanurates in the solution.*

ous. Working solutions of Mistral and Desolon are characterized by a pronounced local irritant effect on the skin and mucous membranes of the eyes. However, according to the official data, Triacid-N is devoid of all these shortcomings, which is surprising if we compare the chemical composition of these agents.

5. Guanidines: **Almadez (77.99.1.2.U.11004.12.09).** Contains N, N-bis-(3-aminopropyl) dodecylamine 0.5 %, alkyldimethylbenzylammonium chloride 6 %, polyhexamethylene guanidine hydrochloride 2.3 % and poly- (1-hexamethylene) biguanidine hydrochloride 0.1 % as active ingredients as well as a detergent, perfume and water. According to the parameters of acute toxicity, the product belongs to the 3rd class of moderately hazardous substances when administered into the stomach, to the 4th class of low-hazard substances when applied to the skin and in the form of vapors when inhaled. The concentrate of the product has a moderate irritant effect during contact with the skin and a pronounced irritant effect on the mucous membranes of the eyes. In the form of an aerosol, working solutions of the agent have an irritating effect on the mucous membranes of the eyes and respiratory tract.

Based on fundamental scientific concepts, it should be recognized that the above, as well as the overwhelming majority of agents used for disinfection, pre-sterilization cleaning, sterilization of medical devices, as well as for disinfection of premises and air are xenobiotic substances.

Xenobiotics (from the Greek ξένος — alien and βίος — life) is a conditional category for designating chemicals alien to living organisms, naturally not involved in the biotic cycle. These include synthetic surfactants, dyes, quaternary ammonium compounds, tertiary amines, aldehydes, guanidines, heavy metal salts, organochlorine compounds, in particular, organic chloramines, trihalomethanes, chloroisocyanurates, inorganic chloramines and a number of others. Many other substances can also be classified as xenobiotics if they are found in the environment in unnaturally high concentrations.

Once in the body of humans or animals, in the natural environment, xenobiotic substances can cause an increase in the frequency of allergic reactions, the death of organisms, change hereditary characteristics, reduce immunity, disrupt metabolism, disrupt the course of processes in natural ecosystems up to the level of the biosphere as a whole. This information is publicly available and reflects the results of many years of observations and fundamental research by hundreds and thousands of scientists and specialists around the world [5].

Let us consider the processes occurring during the usual disinfection cleaning of the premises using a stable organic chemical preparation, which has, for example, a membrane-attacking mechanism for suppressing microorganisms (cationic surface active agents, phenols, iodophores and a number of others).

It is known that agents of this type destroy biopolymers that make up the cell membrane. As a result, the lysis of the microbial cell occurs. The same agents in small doses disrupt the functions of the membrane (change osmotic pressure, permeability, rate of transfer of molecules and ions through the membrane, inhibit metabolic processes and biological oxidation, cause inhibition of cell division).

After the end of disinfection, wet surfaces dry out, organic substances are concentrated in the volume of porous materials and on smooth surfaces, turning into the thinnest film invisible to the eye. The community of microorganisms, immediately emerging on the dried organic matter with lost antimicrobial activity, uses it as a habitat and a nutrient medium, simultaneously developing resistance to this type of disinfectant.

However, the disinfectant molecules continue to enter the room air due to the sublimation process. The invisible «fog» of disinfectant molecules forming in this case has practically no smell, which can create the illusion of its harmlessness. However, it should be borne in mind that in accordance with the well-known laws of physics, each liter of air in a room, as a rule, contains several billion molecules of a substance that evaporates naturally or due to sublimation, even if its concentration is not fixed by control devices and does not exceed hundredths and thousandths of the MRL. In the process of breathing, as well as through the skin and mucous membranes, these molecules enter the human body (patients, staff) and each of them continues to perform its main function — suppressing the vital activity of cells, but now in the human body. The chemical stability of disinfectants creates the prerequisites for their accumulation in the body, followed by migration through the food chains.

It is quite obvious that *by developing more and more new chemical agents to fight microbes, to which they adapt after a while, a person creates conditions for improving the mechanism of microbial variability, initiating by his actions the emergence of new strains of microorganisms resistant to disinfectants.*

Often, as a positive property of agents based on stable, i. e. organic compounds that are difficult to transform under the influence of environmental factors, the absence of odor is indicated (as opposed to chlorine-containing preparations) or, on the contrary, the presence of a pleasant smell of flavoring substances. In fact, these «benefits» should be treated with great caution. Most organic compounds used as disinfectants, or products of their transformations during natural or artificial decay processes, are no less and often much more toxic than, for example, gaseous chlorine at the same concentrations. For example [6], preparations based on orthophthalic aldehyde (Sidex OPA, Ofal), according to the applicants, are less volatile and less toxic than preparations based on glutaraldehyde. However, according to studies published by the Metrex Research Corporation (USA) [7], the toxicity of orthophthalic aldehyde is three times higher than that of glutaraldehyde. Moreover, the higher toxicity of orthophthalic aldehyde is combined with a weak odor of the substance, which is a significant risk factor for personnel. In fact, glutaraldehyde has a specific smell and by its appearance it can be judged that the concentration of the substance in the air is exceeded, while even a significant concentration of vapors of orthophthalic aldehyde is insensible to humans and can be dangerous.

The smell for most multicellular complex organisms in the usual conditions of the environment is a source of information. The absence of a smell, signaling a danger, does not allow a person to evade harmful effects, which results in functional and organic disorders in the body. These violations are usually observed after a more or less long time since direct contact with a harmful substance, so their causes can very rarely be adequately identified.

In the journal Education in Chemistry 2002, no. 1, on p. 14 the following problem for schoolchildren is published: the mass of all atmospheric air is 5.2 x 1015 tons. The Roman dictator and writer Julius Caesar drew his last breath with the words «Et tu, Brute (you too, Brutus)!» on March 15, 44 BC. Question: is the saying right that in every our current breath there is a molecule that flew out of the mouth of the dying Caesar? We give the answer to the problem without accompanying calculations: every time we inhale 2.5 × 1022 molecules, so about 6 of them belonged to Caesar!

If we calculate how many molecules of active substances (AS) from a disinfectant that has already dried up and has lost the ability to suppress the microflora enters our lungs with each breath after the treatment of the room, it turns out that this number is measured in many billions. The internal environment of the human body is literally saturated with xenobiotic substances. Hence, among other reasons, the emergence of persistent nosocomial strains, taking time and effort to combat it, while losing the health of both staff and patients.

In addition to the above analysis data, we have conducted an extensive review of the latest disinfection means and methods accumulated in the world and in Russia.

Early in April 2020, the information center for monitoring the situation with coronavirus of the Federal State Budgetary Institution NMRC PPI (National Medical Research Center of Phthisiopulmonology and Infectious Deseases) of the Ministry of Health of the Russian Federation published guidance materials in the form of recommendations for chief physicians: *The Experience of Moscow for Preventing the COVID-19 Epidemic in the Regions of the Russian Federation* — on the experience of Moscow hospitals in treatment of coronavirus patients. The above document indicates anolytes with hypochlorous acid as the main active ingredient among disinfectants.

Anolytes are metastable electrochemically activated disinfecting, washing and sterilizing solutions of a wide spectrum of action, environmentally safe, synthesized in STEL-type devices from drinking water and table salt, entered into the disinfectants State Registers (certificates of state registration Nos. 77.99.1.2. U. 12139.12. 09 dated 30.12.2009; 77.99.1.2. U. 5720.6.09 dated 09.06.2009; 77.99.28.U. 5222.5.05 dated 17.05.2005; RU.77.99.88.002.E. 002867.08.19 dated 09.08.2019; RU.77.99.88.002.E. 011094.12.15 dated 28.12.2015; RU.77.99.88.002.E. 010872.12.15 dated 17.12.2015; RU.77.99.88.010.E. 008641.10.14 dated 03.10.2014; RU. 77.99.01.002.E. 031063.08.11 dated 08.08.2011) and are approved for use by all known methods, including the processing of objects with Anolyte aerosol [8–11]. The main AS of Anolytes are hypochlorous acid and hydrogen peroxide at a concentration of 500 mg/l, measured in total as active chlorine. Ballast substances are represented by sodium chloride in a concentration of 1 to 5 g/l for Anolyte ANK and from 0.2 to 1.0 g/l for Anolyte ANK SUPER, the total salinity of which corresponds to fresh water, and therefore the degradation product of Anolyte ANK SUPER is fresh water [8]. It was these solutions that were widely used by hospital staff during the period of intensive preparation and treatment of coronavirus patients. It should be noted that the search for information on the use of anolytes has shown that in many European countries, in the USA, Mexico, Canada, electrochemically activated solutions and various products based on them are officially registered as means for deep disinfection, pre-sterilization cleaning, and also as pharmaceuticals for the treatment of humans and as veterinary drugs for the treatment of animals [12–14]. Suffice it to say that the number of Internet links to the Russian words «*Electrochemical activation*» is 300–400 thousand, while for the same words in English it is more than 25 million. The technology of electrochemical activation, which has produced, among other things, STEL devices and Anolytes, comes from the Soviet Union [15]. This technology received significant development in application for medicine in the system of the Ministry of Health of the USSR, and then the Ministry of Health of the Russian Federation [16].

City Clinical Hospital No. 52 has more than twenty years of experience in using Anolyte ANK (Anolyte Neu-

Fig.6.4.1. *STEL-10N-120-01 device (model 80) with a capacity of 80 l/h for anolyte ANK. City Clinical Hospital No. 52, 1999.*

tral ANK, Anolyte ANK SUPER) as a disinfectant, which is produced in STEL devices (STEL-10N-120–01, STEL-ANK-PRO, STEL- ANK-SUPER), developed by a group of scientists and specialists under the leadership of V. M. Bakhir [16].

The hospital has STEL devices of all the indicated types, which makes it possible to meet about 85% of the need for disinfectants. Currently, there are 14 STEL devices of various capacities in the hospital usage. Most of the STEL devices that produce Anolyte ANK are over 20 years old. In total, more than 200,000 liters of Anolyte ANK are produced per month (about 3,000 tons per year).

A recently published article [17] considers the economic indicators and functional properties of Anolyte ANK, practically tested in the 4th Main Directorate of the USSR Ministry of Health in the period 1995–1998.

Below are selected fragments of this article, since its author, Doctor of Medicine, professor S. M. Savenko worked in close cooperation with specialists and researchers of CCH 52 and a group of developers of STEL devices in the field of research and practical use of electrochemically activated solutions. The article also provides data on the consumption of disinfectants in Russia. According to data for 2016, this amount was 1.28 million tons, which in monetary terms is equivalent to many billions of rubles. According to S. M. Savenko, disinfectants, often of dubious quality, surging to Russia, do not eliminate, but contribute to the possibility of infection of patients and medical personnel in hospitals with various pathogens of nosocomial infections.

Fig. 6.4.2. *STEL-ANK-SUPER-100 devices with Anolyte ANK SUPER capacity of 100 l/h, with automatic systems for maintaining the Anolyte level in the storage tank and cleaning the reactor. City Clinical Hospital No. 52, 2016*

«Disinfection deadlock» — this is how he briefly described the situation with disinfectants, which is taking place today due to the dominance in medical practice of chemicals officially registered and continuing to be registered by Rospotrebnadzor with overestimated efficiency and scope of application [17].

Professor S. M. Savenko, one of the first enthusiasts among professionals in the epidemiological service, in 1992 began to apply STEL devices in practice and study the functional properties of electrochemically activated solutions (ECA solutions). In December last year, Stanislav Maksimovich passed away. However, the fragments of his article given below completely coincide with the experience and ideas of the authors.

«The cost of Anolytes of all types obtained in STEL devices is no more than 0.2 ruble per 1 liter, while the cost of ready-made purchased working disinfectant solutions ranges from 50 to 200 rubles per 1 liter.

The solutions were tested at the central sterile services department (CSSD) of the Fourth Main Directorate under the USSR Ministry of Health (S. M. Savenko worked there for many years), for disinfecting ability, effectiveness, quality of pre-sterilization cleaning of instruments, and for harmfulness (the term from the original article).

The study of ECA solutions showed them to be as follows:

1. Inactivating for microorganisms of all types and forms (bacteria, mycobacteria, viruses, fungi and spores).
2. ECA solutions are superior in bactericidal properties to almost all stable chemical disinfectants.
3. The cost of ECA solutions is many times cheaper than the cost of purchased chemicals.
4. Environmentally friendly. After being used as directed, they decompose and turn into slightly mineralized water. They can freely drain into the sewer without disturbing the ecology of the environment. The harmlessness of electrochemically activated solutions lies in the fact that anolytes are based on hypochlorous acid, produced in the human body by special cells of the immune system — phagocytes, which kill infectious particles that have entered the body.
5. Do not require rotation of disinfectants, since microorganisms are not able to develop strains resistant to metastable solutions.

Table 6.4.1

Below are the comparative economic indicators of standard hospital disinfection measures carried out using various disinfectants

Disinfectant	Cost of 1000 liters of working solution, USD	Cost of processing 1000 square meters, USD	Disinfectant costs per year, USD*
Chloramine B	12.5	2.5	25 000
Javeleon	10.7	1.1	11 111
Alaminol	27.5	4.2	41 667
Deseffect	43.1	6.4	63 889
Septabic	16.7	1.7	16 667
Bianol	7.4	1.1	11 111
Septodor Forte	27.8	2.8	27 778
Hydrogen peroxide (3%)	41.7	8.3	83 333
Anolyte ANK	2.8	0.3	**2 500**

* *Disinfectant costs per year are calculated for a 1000-bed hospital with an operational area of 10 million square meters.*

Operational area ($S_{oper.}$) is the total area of objects subjected to regular wet cleaning and disinfection throughout the year:

$$S_{oper.} = (S1 + S2 + S3) \times k,$$

where S1 is the floor area of the premises; S2 — the area of the walls when they are processed to a height of up to 3 meters; S3 — the area of equipment and furniture to be processed (taken as 50% of the floor area); k is the number of treatments per year. Consumption of disinfectants: 100–120 ml/m^2.»

Paper [18] published in the journal Disinfection Business in 2003 with the participation of the authors of this article, showed for the first time in the world the identity of the active substances of Anolyte ANK and a mixture of oxidants produced by phagocytic cells of the body immune system [19].

Thus, in 2003, it was shown that the effectiveness of metastable electrochemically activated solutions, including their ability to prevent the emergence of resistant microflora, is due to fundamental differences between representatives of the micro- and macrobiological world. It became clear that the use of chemically stable disinfectants to combat representatives of the microworld was a bridge to nowhere. One can endlessly compose new, increasingly expensive combinations of reagents of the same classes of stable xenobiotic chemicals that persist in warehouses and do not deteriorate during transport, but it should be understood that THE DEAD WILL NEVER BEAT THE LIVING. *The rate of chemical interconversions of active particles in inorganic metastable systems is orders of magnitude higher than the rate of any, including adaptive, biochemical reactions in microorganisms. This is the reason for the absence of microflora resistant to metastable anolytes.*

Since the appearance of the article, the number of scientific papers confirming and developing this concept [20–23] has been growing exponentially.

Based on experimental and practical research of Anolyte ANK, in cooperation with the main developers of electrochemical systems and technologies, in 2004 we formulated the basic requirements for an ideal disinfectant [9, 16, 18]:

- the disinfectant must have a broad spectrum of action, i.e. effectively destroy bacteria, mycobacteria, viruses, fungi and spores, regardless of the duration and frequency of use, which implies the presence of properties that prevent microorganisms from developing resistance;
- the disinfectant must be safe for humans and animals both during its preparation and use, and after the end of its intended use, that is, during the period of degradation and destructive changes under the influence of environmental factors or as a result of biodegradation processes in the human body, i.e., in other words, the antimicrobial agent and products of its natural or artificial degradation should not contain xenobiotic substances;
- the disinfectant must have a versatility of action, that is, have not only antimicrobial and antiviral properties, but also have a detergent ability with minimal damaging and corrosive activity in relation to various materials, do not leave deposits after drying on smooth surfaces, and also be maximum easy to use yet relatively inexpensive.

These requirements are fundamentally different from their traditional counterparts, formulated in various regulatory documents [24–27]. The traditional approach is focused on the established practice of using concentrated liquid or solid preparations, which are a combination of substances from a small amount of the main classes of biocides: halogens, alcohols, peroxides, phenols, quaternary ammonium compounds, aldehydes, tertiary amines, acids. It is convenient to store and transport such agents in canisters or packages, the chemical composition of the agents must remain constant during the entire storage period, and working solutions can in some cases be used several times.

The active ingredients in Anolyte ANK and a more perfect solution — Anolyte ANK SUPER [16] are hypochlorous acid and hydrogen peroxide (basic), ozone and singlet oxygen. The peculiarity of Anolyte ANK and Anolyte ANK SUPER is the long-term coexistence of antagonistic substances in solution: hypochlorous acid and hydroperoxide compounds. It is impossible to obtain such a mixture chemically, since when mixing the initial components, their mutual neutralization is inevitable. One of the authors of the article, in collaboration with specialists and scientists of the Battelle Memorial Institute (USA), participated in a comparative study of the effectiveness of Anolyte ANK and an acidified hypochlorite solution (Fig. 6.4.3). The results showed a multiple excess of the antimicrobial ability of Anolyte ANK in comparison with hypochlorite solutions, reduced to the same parameters for the content of active chlorine and pH. This made it possible to conclude that the product obtained by electrochemical treatment according to the original technology, including the removal of heavy metal ions from the water-salt solution, saturation of the solution with free hydroxyl groups and hydrogen, followed by the introduction of anodic oxidation products, is fundamentally different in physical and chemical and biological properties from a chemical model in the form of an acidified sodium hypochlorite solution with the same pH value.

In the anolyte ANK obtained in STEL-10N-120–01 devices, the total salinity varies from 2 to 5 g/l, the entire AS complex with a concentration of 0.2–0.5 g/l (0.02–0.05 %) lasts no more than 5 days. The sporicidal activity of such Anolyte ANK in this regard also does not exceed 5 days. In Anolyte ANK, obtained in STEL-ANK-PRO devices, the total salinity is in the range of 1.0 to 1.2 g/l at the AS concentration of 0.05 % (500 mg/l). The lifetime of the active mixture of AS and, accordingly, the sporicidal activity of such Anolyte ANK when stored in canisters is 3 months. The life time of Anolyte ANK SUPER with the total salinity not exceeding 0.9 g/l (0.09 %) at the AS concentration of 0.05 % (500 mg/l), is 6 months.

The useful properties of anolyte ANK, like efficiency, manufacturability, safety and cost-effectiveness of its use are fully confirmed in many medical institutions, in particular, in City Clinical Hospital No. 52, where anolyte ANK has been the dominant disinfectant solution for many years. The share of anolyte in the structure of disinfectants used in these institutions exceeds 85 %, and its annual consumption is about 3000 tons.

Before the wide use of anolyte ANK, a variety of agents were applied in the hospital, many of them causing corrosion of metals, clouding of glass products, damage of synthetic materials, skin allergic reactions and headaches among medical personnel.

The hospital spent significant funds on the purchase of disinfectants, detergents, sterilizing agents.

Currently, anolyte ANK is used at all departments of the hospital: the operating unit, surgical, gynecological, urological, ophthalmological, otorhinolaryngological, endoscopic, and pathological departments, at the hospital emergency room, at nephrological and other therapeutic profile departments, in 6 resuscitation care and intensive therapy departments, at clinical diagnostic laboratory, con-

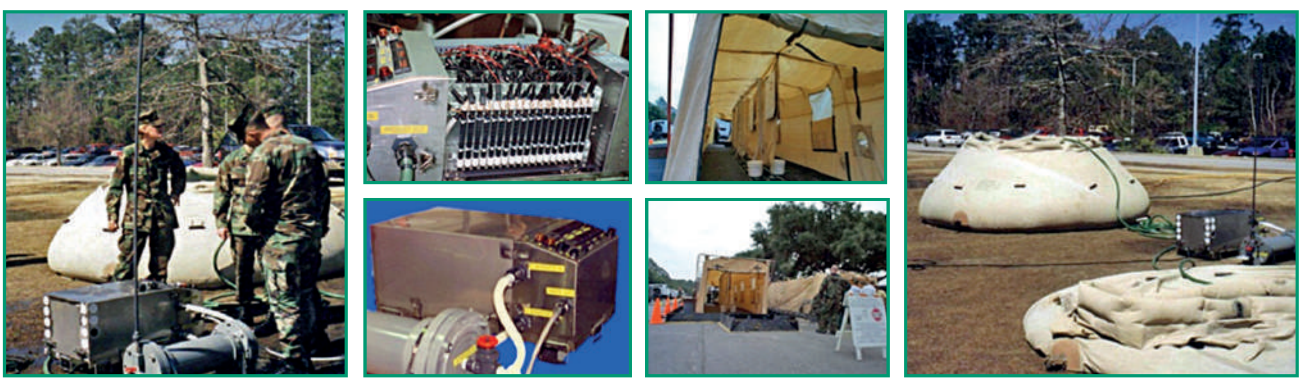

Fig. 6.4.3. *Anolyte ANK treatment of servicemen who have left the zones of microbiological or chemical damage, as well as all their equipment and clothing. Marine Corps Base Camp Lejeune, USA. Specialists of the Battelle Memorial Institute (USA) found that anthrax spores die in 0.5 % sodium hypochlorite solution in 30 minutes, while in 0.035 % Anolyte ANK (15 times less AS concentration) in a few seconds.*
Anolyte ANK, which is produced by STEL-10N-120–01 and STEL-ANK-60–03 devices (about 60,000 such devices were produced in Russia during the period from 1995 to 2010) has been used in the US Army since 2000.

sultative and diagnostic center, as well as at the central sterilization department.

STEL devices used in the hospital are small in size, easy to operate, environmentally friendly, and can be installed in any premises. No special long-term training of medical personnel is required to work with STEL devices. Only a medical gown is used as special clothing. The number of prepared solutions corresponds to the actual needs of the departments and can be increased at the request of medical personnel in accordance with the epidemiological situation and the technical characteristics of the equipment. It is possible to obtain anolyte ANK with different concentrations of oxidants according to the modes of using anolyte ANK for infectious diseases of various etiologies. The concentration of oxidants in the prepared anolyte ANK is checked by express analysis (test strips) or, more precisely, by the method of iodometric titration. Neutral anolyte ANK is easy to use and is used with pleasure by the hospital's medical staff. Unlike other preparations, it simultaneously reliably disinfects, washes and sterilizes. The ability to process objects in the presence of patients, as well as the absence of allergic reactions among medical personnel, are also a positive point for choosing anolyte. In addition, Anolyte is a ready-made working solution, the concentration of the active substance in it can be controlled by test strips both at the outlet of the apparatus and in containers for disinfection. Electrochemical activation is not a monotechnology in the field of disinfectology, since it allows a wide variation in the properties of anolytes, including anolyte ANK, and does not exclude their combined use with other disinfectants. As good as one particular disinfectant is, hospital staff should always have a possibility of «antimicrobial maneuver». The safety of anolyte ANK is confirmed by the fact that it can be used for therapeutic purposes (application therapy, washing the abdominal cavity).

Fig. 6.4.4. *STEL-ANK-SUPER-100 device. Electrochemical Systems and Technologies Institute, Moscow, 2019.*

In combination with anolyte in 2019 and 2020, the institution also used other agents: peroxide-containing Tori-hydroxy (contains 45 % of perborate), 3-component agents containing quaternary ammonium compounds (QAC), amines and guanidines (Megabac, Hort).

During the coronavirus pandemic, the demand for disinfectants and skin antiseptics has increased. Obtaining the anolyte agent directly at the institution has made it possible to provide departments with a disinfectant and not be tied to the problems of supplying other agents.

During the period of the spread of the new coronavirus infection, the effectiveness of the use of anolyte for both routine and general cleanings has been proven in practice, which is confirmed by laboratory studies as part of production control.

At present, the stock of STEL devices producing Anolyte ANK with a salinity of 2 to 5 g/l is morally and physically obsolete and does not correspond to modern developments in this area. STEL-ANK-SUPER devices currently produced in Russia since 2016, are fully automated and do not require attendance of personnel, since their mode of operation, including the quality of the produced Anolyte ANK SUPER, is ensured through remote control by both the consumer and the manufacturing company. The devise can work around the clock according to a preset scheme, synthesizing Anolyte ANK SUPER with a concentration of oxidants from 200 to 500 milligrams or more in one liter. Salt consumption per 1000 liters of Anolyte ANK SUPER is no more than 900 grams, electricity consumption is no more than 400 Watt-h per 1000 liters of Anolyte ANK SUPER. Anolyte ANK SUPER in all respects is a more perfect solution in comparison with Anolyte ANK. It possesses properties as close to ideal as possible. The content of sodium chloride ballast ions in Anolyte ANK SUPER does not exceed the mineralization of tap drinking water. This circumstance gives Anolyte ANK SUPER a number of new properties. The difference in the corrosive activity of anolytes depending on the mineralization is clearly shown in Fig. 6.4.5.

Anolyte ANK SUPER has a good cleaning ability, a very weak smell of chlorine-oxygen oxidants, reacts with ethyl alcohol, converting it into peracetic acid, leaves no residue on a smooth surface after drying, when spraying, the smell of chlorine is completely absent, foreign odors disappear almost instantly, the air feels fresh, like after rain.

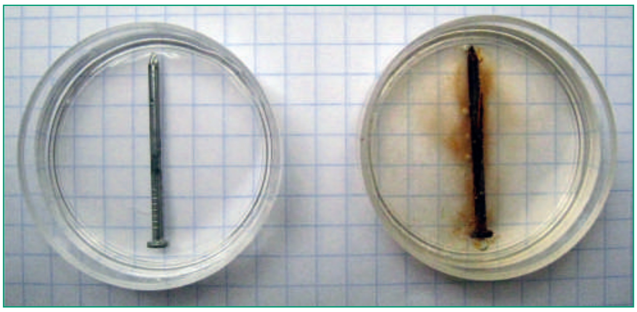

Fig. 6.4.5. Comparison of the corrosiveness of anolyte ANK produced in a STEL-10N-120–01 device with an oxidant concentration of 500 mg/l and a total salinity of 5 g/l (photo on the right) and anolyte ANK produced in a STEL-ANK-PRO device with an oxidant concentration 500 mg/l and total salinity 1.2 g/l (left photo) 25 hours after the start of the experiment.

Figuratively speaking, ANOLYTE ANK SUPER is a «cold flame of water». The metastable system of antagonist oxidants is constantly ready, upon contact with organic matter, to instantly transform into a multitude of active particles, almost exactly repeating the substance produced by phagocytes and allowing them to help cope with infection even in the case when some types of «smart» microorganisms disable the phagocytic system protection. Such protective reactions of microorganisms, allowing them to neutralize the attack of a phagocyte, are known and described in scientific articles.

Active substances (AS) of Anolyte ANK SUPER are represented by oxychloric and hydroperoxide oxidants: hypochlorous acid, hydrogen peroxide, ozone, and singlet oxygen. Anolyte ANK SUPER does not leave traces when drying on smooth surfaces, does not cause corrosion of metals, is practically odorless.

Long-term (more than 25 years) use of Anolyte ANK, the predecessor of Anolyte ANK SUPER, in medical institutions without replacing with other means, has demonstrated the complete absence of addiction of microorganisms to this agent, which is due to its metastability.

Studies of Anolyte ANK SUPER abroad during the coronavirus pandemic have shown its high efficiency against any types of RNA-containing viruses, including SARS-CoV-2 [28–39].

It is quite easy to verify the authenticity of Anolyte ANK SUPER-500 with an oxidant concentration of 500 mg/l.

1. First of all, you need to measure the concentration of dissolved substances using the simplest device — a conductometer or TDS meter (from the English *Total Dissolved Solids*). If the concentration of dissolved electrolyte substances is more than 0.9 g/l, then this solution is not Anolyte ANK SUPER.

If the concentration of solutes is equal no more than 0.9 g/l, then the concentration of oxidants should be measured.

2. The exact method for measuring the concentration of oxidants is the iodometric titration method, which requires special laboratory equipment and chemical reagents. However, for a rough estimate, it is sufficient to use test strips (for example made by HACH Company) to measure the concentration of oxidants in terms of active chlorine from 0 to 800 mg/l. You can also estimate the concentration of oxidants using a simple reagent — potassium iodide. A small amount of potassium iodide powder at the tip of a spatula is introduced into a glass with 100–150 ml of the solution under test. The behavior of the powder granules is observed through the walls of the glass. If after some time they settle and form a colored dark brown layer at the bottom of the glass, then the concentration of oxidants is no less than 500 mg/l. If the entire volume of liquid in the glass acquires a less intense color, then the concentration of oxidants in the solution is less than 500 mg/l.

If it turns out that the concentration of oxidants is below 500 mg/l, then this solution is not Anolyte ANK SUPER.

If the concentration of oxidants in the solution is equal to or greater than 500 mg/l, then another test should be performed: measuring the pH of the solution.

3. You can measure the activity index of hydrogen ions pH using a portable or laboratory pH meter.

If the pH of the solution is below 5.0 or above 6.5, you can be sure that this solution does not contain a mixture of chlorine-oxygen and hydroperoxide oxidants and contains AS represented only by chlorine-oxygen compounds, which does not allow it to be considered Anolyte ANK SUPER. It should be borne in mind that with an increase in pH above 6.5, the concentration of the least active form of chlorine-oxygen compounds, represented by sodium hypochlorite, proportionally increases in the solution.

Conclusions:

1. *For the effective implementation of measures for sanitary and epidemiological protection of the population, an assessment of the effectiveness of an antimicrobial chemical agent should include not only the spectrum of its antimicrobial activity and the time of the disinfection process, but also information on the ability of microorganisms to develop resistance to this agent.*
2. *The main principle for assessing the degree of safety of chemical antimicrobial agents should be determining whether the active substances or components of the agent, as well as their degradation products, are xenobiotics. To inform consumers about the hazard level of the product, the label should have the inscription: «does not contain xenobiotic substances» or «con-*

tains xenobiotic substances». The choice of antimicrobial agents should be carried out in accordance with the proposed criteria.

3. *The most effective in terms of functional properties with a simultaneous low toxicity or its complete absence are metastable low-salinity antimicrobial solutions with chlorine-oxygen and hydroperoxide AS (electrochemically activated solutions), which have no alternative, while life on Earth is represented by various forms of existence of protein bodies in an electrolyte of aqueous solutions of ions, mainly of sodium and chlorine.*

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Э45

Bakhir V. M., Panicheva S. A., Prilutsky V. I., Panichev V. G.

Э45 ELECTROCHEMICAL ACTIVATION:
INVENTIONS, SYSTEMS, TECHNOLOGY

The book considers theoretical concepts and hypotheses about the nature of the phenomenon of electrochemical activation of substances discovered by Vitold M. Bakhir in the seventies of the last century. It provides information on the most significant inventions in the field of electrochemical activation and the results of the practical implementation of inventions in various fields of science, engineering and technology. It describes various electrochemical systems for producing liquids with an abnormally high activity in oxidation-reduction, catalytic and biocatalytic processes.

Based on the experience of engineering and practical use of electrochemical systems for production environmentally friendly, safe for humans and animals electrochemically activated detergents, disinfectants and for production of the environmentally friendly sterilizing solutions, the authors predict further development of electrochemical activation technology. Various examples show that the role of electrochemical activation in the near future will steadily increase not only in the field of drinking water disinfection and purification, wastewater and swimming pool water treatment, food industry and agriculture, but also in chemical, petrochemical and mining industries to save raw materials, time and energy, while improving environmental safety and efficiency of the processes.

The book is intended for a wide range of specialists and students interested in the application of electrochemical technologies in various fields of human activity.

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ELECTROCHEMICAL ACTIVATION

INVENTIONS
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Vitold Bakhir Institute

ELECTROCHEMICAL ACTIVATION

VITOLD BAKHIR — the creator of new scientific and technical field — electrochemical activation (ECA). Doctor of Technical Sciences, Professor, Scientific Director at Electrochemical Systems and Technologies Institute. The author of more than 400 inventions with copyright certificates of the USSR and patents of the Russian Federation, USA, Canada, Great Britain, Germany, Switzerland, Italy, Japan, China, South Korea. The above-mentioned inventions are implemented in several hundred thousand various electrochemical devices in many countries. The author of 7 monographs and more than 300 scientific articles.

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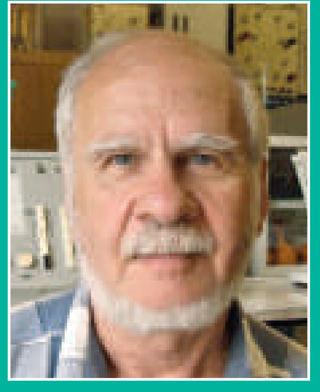

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VADIM PANICHEV — expert in Electrochemical Technology Applications for Regulated Industries (Pharma, Medical Devices, Biotech, etc.), working over the past 25 years in Electrochemical Equipment Design and Development, Product Development and process validation for DOD, Agricultural, Medical Devices and Pharma Industries. The author of international patents for methods of manufacturing and application of electrochemically activated solutions and stabilized hypochlorous acid formulations.

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