5.2. EFFICIENCY AND SAFETY OF CHEMICALS FOR DISINFECTION, PRE-STERILIZATION CLEANING AND STERILIZATION

The range of antimicrobial agents for disinfection has significantly expanded in recent years. In Russia, more than 400* chemicals for disinfection, pre-sterilization cleaning and sterilization are approved for use. However, evaluating the results of man's struggle with the world of microbes based on scientific publications of the last decade, it is easy to make sure that the “preponderance” is not on the side of man. The number of strains of microorganisms resistant to whole classes of chemical compounds is increasing. Periodic planned replacement of some antimicrobial agents for others in the whole complex of disinfection measures of health care facilities does not solve the problem of nosocomial infections, they only restrain their onslaught and provide a very shaky balance, often disturbed by random factors.

Official policy documents defining a strategy for combating nosocomial infections and ways of developing disinfection are based on the results of analyzing statistical data on the use of certain antimicrobial agents and, in fact, only reflect the proposals of the chemical market, practically without exerting any proactive influence on its formation.

The absence of a unified scientific concept of combating microbes based on the fundamental laws of biology, modern achievements in physics, chemistry, and other sciences leaves no hope for any serious success in the sanitary and epidemiological protection of the population, at least in the present.

A few examples to support what has been said. The concept of prophylaxis of nosocomial infections approved in 1999 by the First Deputy Minister of Health of the Russian Federation [1], postulates that the most promising group of compounds for the disinfection of various types of surfaces in rooms and other objects in health care facilities are cationic surface active substances (CSAS) — quaternary ammonium compounds (QAC) and some other organic compounds. Since these compounds are harmless, it is said that they can be applied at the patient's bedside. For disinfection and pre-sterilization cleaning of medical devices, in addition to CSAS, it is recommended to use also aldehydes and alcohols**.

V. M. Bakhir, V. I. Vtorenko, S. A. Panicheva, V. I. Prilutsky, N. Yu. Shomovskaya. ***Efficiency and safety of chemicals for disinfection, pre-sterilization cleaning and sterilization.*** *Disinfection business, No. 1, 2003, p. 29–36.*

Three years later, the report [2], dedicated to the main directions of increasing the effectiveness of disinfectants, emphasized that the analysis of the practice of using all disinfectants revealed their discrepancy with modern requirements for specific efficiency and hygienic safety. In particular, it is noted that CSAS, possessing stability, good detergent properties, are at the same time inactive or inadequate for resistant species and forms of microorganisms — tuberculosis mycobacteria, fungi, bacilli spores. The unfavorable properties of CSAS are the rapid and frequent formation of resistance of microorganisms to their impact. Liquid concentrates

* *At the beginning of 2014, more than 1000 names of disinfectants were registered.*
** *Despite the outdated links, the essence of the above is still relevant.*

of CSAS with a high content of active ingredients have a pronounced resorptive and irritating effect on the skin and mucous membranes of the eyes, they are often allergens. The same report notes that the presence of high toxicity and sorption capacity of aldehydes does not allow them to be widely recommended for the treatment of surfaces, linen and tableware.

The high toxicity of glutaraldehyde is well known [3]. That is why its use has been legally prohibited in England since May 2002 [4]. However, advertising and sale of drugs based on it continues in Russia.*

The program report [5] dedicated to the methodological problems of modern disinfectology, argues that perfect (and therefore promising) chemical agents for disinfecting medical devices, along with high microbicidal efficiency and some other properties, should have long shelf life and be ready for use without preliminary activation or mixing with other components, and safe to dispose.

Long-term storage of a chemical is feasible with a high chemical stability of the active ingredients; however, the disposal of a stable substance after use requires equivalent costs of other substances or energy. Thus, the combination of stability requirements with ease of disposal is fundamentally impossible.

As for the requirement to exclude pre-activation before using the "perfect" chemical agent, it should be noted that the entire variety of trademarks of antimicrobial chemical agents is based on the use of only a few classes of chemical compounds known for many decades. It is unlikely that a new class of compounds meeting this requirement will emerge. The general trend in the development of chemical disinfectants in recent years is not to create new disinfectants, but to search for ways to activate already known disinfectants, including by chemical additives. For example, while until recently, hydrogen peroxide in the form of a 6% solution was traditionally used for the purposes of sterilization and disinfection of the highest level in the United States, then in order to reduce its corrosive ability while increasing antimicrobial activity, technologies for sterilizing this compound by plasma steam have now been created [6]. Thus, the activation of chemical disinfectants is aimed at the development of regimes providing a high bactericidal effect with minimum concentration of active substances, while the corrosive or destructive activity in relation to the materials of the product, as well as the toxic effect on humans, are minimized.

The treatment time, concentration, temperature and application conditions of active substances are the most important characteristics of medical devices disinfection process and are the main parameters of any practical technique.

As it follows from the above-mentioned report [2], in Russia, one of the main directions of increasing the efficiency of disinfectants is also the addition of activators, synergists to the formulation, the use of additional physical influences, that is, the creation of conditions under which the active substances at the disinfectant application time would be in a metastable state, for example, at the stage of a prolonged chemical reaction with activators.

Let us consider in more detail the processes accompanying the application of a stable organic matter solution for disinfection cleaning of a room using the example of compounds with a membrane attack mechanism for suppressing microorganisms. Such substances include CSAS, phenols, iodophores and a number of others.

Due to the complexity of the structure and multifunctionality of the membrane apparatus of microorganisms, the specific mechanisms of interaction of the above substances with membrane biopolymers have been studied extremely poorly.

The cytoplasmic membrane is an extremely vital structure of any cells, including microbial ones. The organic compounds included in its composition have many reactive groups, which determines the high sensitivity of the membrane to damaging factors of various nature. It is known that membrane-attacking drugs at high concentrations destroy biopolymers included in the membrane. That results in the lysis of the microbial cell. The same drugs in small doses disrupt the functions of the membrane (change osmotic pressure, permeability, transfer processes through the membrane of molecules and ions, inhibit metabolic processes and biological oxidation, cause inhibition of cell division).

Cationic surfactants (quaternary ammonium compounds) concentrate on the membrane and bind to the phosphatide groups of its constituent lipids; anionic surfactants (SAS), which include alkaline soaps, alkyl and aryl sulfones, iodophores, interact with reactive groups of membrane proteins. Phenols and alcohols dissolve the lipid fragments of the membrane.

After the end of disinfection, wet surfaces dry out, organic substances concentrate in the volume of porous materials and on smooth surfaces, turn into the thinnest film invisible to the eye and, with a much lower intensity than when evaporated during wet cleaning, release their molecules into the room air due to the sublimation process.

* Nothing has changed today. Russian patients and hospital staff continue to be exposed to toxic glutaric aldehyde.

The disinfectant aerosol formed in this process is often odorless, which creates 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 the room, as a rule, contains several billion molecules of the substance evaporating naturally, or due to sublimation, even if its concentration is not registered by standard devices and does not exceed hundredths and thousandths of the MPC. In the process of respiration, as well as through the skin and mucous membranes, these molecules enter the body (of patients and staff), and each of them continues to perform its main working function — suppressing the vital activity of cells, but already in the human body. The chemical stability of disinfectants creates the prerequisites for their cumulation in the body, followed by migration along the food chain.

The community of microorganisms, immediately emerging on a dried out organic matter which had recently been active, but lost its microbicidal activity, uses it as a nutrient medium, simultaneously developing resistance to this type of disinfectant. Processes similar to those described in this example have recently become the subject of attention of researchers and are under study [7, 8].

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

This is all the more dangerous due to the fact that targeted and systematic research in this area is extremely rare in health care facilities, therefore, in the overwhelming majority ***of cases, it is not possible to determine during what time after the start of a particular disinfectant, application microorganisms have acquired stability and developed adaptive responses***.

Currently, the effectiveness of a disinfectant is generally understood as the spectrum of its antimicrobial activity. Also, the definition of efficiency includes the treatment time required for the manifestation of the disinfecting effect. However, from the broader perspectives outlined above, ***a disinfectant chemical can only be considered effective if, having a certain spectrum of antimicrobial activity, it does not cause microorganisms to become resistant to it with prolonged use.*** In other words, an effective disinfectant can and should be used for years and decades, ensuring that microorganisms will not be able to develop resistance to it for fundamental reasons.

Various methods and technologies of disinfection corresponding to the above definition of efficiency are known and widely used. Such methods and technologies include exposure to penetrating electromagnetic radiation (X-rays, gamma rays), ultraviolet radiation, ionized plasma treatment, and finally, thermal methods for the destruction of microorganisms. In all these cases, during cold disinfection and sterilization in a liquid medium, the microbicidal activity is due to the metastable state of the dissolved disinfectant.

Consider the mechanism of antibacterial protection, created by nature and functioning in the internal environment of animal organisms — from unicellular to humans, for millions of years without any failures.

Today, it has been undeniably proven [9] that the leading role in the bactericidal action of neutrophils belongs to hypochlorous acid (HClO) produced by phagocytic cells. In a respiratory explosion, up to 28% of the total amount of oxygen consumed by neutrophils is spent on the formation of HClO. In neutrophils HClO is formed from hydrogen peroxide and chloride ions. The catalyst in this reaction is the enzyme myloperoxidase (MPO):

$$H_2O_2 + Cl^- \rightarrow [Cat\ (MPO)\ ] \rightarrow HClO + OH^-\ [9, 10].$$

Hypochlorous acid dissociates in an aqueous medium with the formation of hypochlorite anion and hydrogen ion:

$$HClO \leftrightarrow ClO^- + H^+.$$

At pH values close to neutral, the concentrations of HClO and hypochlorite anions ClO^- are approximately equal. A decrease in pH leads to a shift in the equilibrium of this reaction towards an increase in the concentration of HClO, an increase — towards a higher concentration of hypochlorite anions.

Formation of H_2O_2 and HClO in a short period of time (fractions of a second) in a small volume of an aqueous environment (fractions of a microliter) — that is, in the volume of the active zone of phagocytosis should inevitably be accompanied by reactions of spontaneous decay and interaction of the products of transformations of these compounds with the formation of active particles, similar to those forming during radiolysis or electrolysis.

Spontaneous decomposition of hydrogen peroxide in an aqueous medium is accompanied by the formation of compounds with a very high antimicrobial activity (the corresponding chemical reactions are given in parentheses):

HO_2^- – hydroperoxide anion ($H_2O_2 + OH^- \rightarrow HO_2^- + H_2O$);

O_2^{2-} – peroxide anion ($OH^- + HO_2^- \rightarrow O_2^{2-} + H_2O$);

O_2^- — superoxide anion ($O_2^{2-} + H_2O_2 \rightarrow O_2^- + OH^- + OH^\bullet$);

$HO_2^{\bullet}$ — hydrogen peroxide radical
$(HO^{\bullet} + H_2O_2 \rightarrow H_2O + HO_2^{\bullet})$;
HO_2 — hydrogen superoxide $(O_2^- + H_2O \rightarrow HO_2 + OH^-)$.

At the same time, the formation of an extremely reactive singlet oxygen is possible $^1O_2$:$(ClO^- + H_2O_2 \rightarrow {}^1O_2 + H_2O + Cl^-)$. It was experimentally established [10, 11] that a molecular oxygen radical ion O_2^- participates in phagocytosis reactions, the one described above being a possible way of its formation.

It is known that in an aqueous medium in the presence of HClO and ClO, active free radicals $ClO^{\bullet}$, $Cl^{\bullet}$, $HO^{\bullet}$ may form:

$$(HClO + ClO^- \rightarrow ClO^{\bullet} + Cl^- + HO^{\bullet}).$$

Also very likely from the standpoint of the modern theory of catalytic processes, is the formation of an intermediate activated complex with myeloperoxidase as a catalyst. The decomposition of this complex is accompanied by the formation of $O^{\bullet}$, the return of the catalyst to its original state, and the acidification of the environment:

$$HClO + ClO^- \rightarrow [HClO \Leftrightarrow Cat\ (MPO) \Leftrightarrow ClO^-] \rightarrow \rightarrow 2Cl^- + 2O^{\bullet} + H^+$$

Active hypochlorite radicals $ClO^{\bullet}$ can take part in the reactions of formation of atomic oxygen $(O^{\bullet})$ and hydroxyl radical $(HO^{\bullet})$:

$$ClO^{\bullet} + ClO^- + OH^- \rightarrow Cl^- + 2O^{\bullet} + OH^{\bullet}.$$

Further development of the chain occurs during the formation of atomic chlorine:

$$OH^{\bullet} + Cl^- \rightarrow Cl^{\bullet} + OH^-.$$

The resulting radicals and atomic oxygen take part in the destruction of microorganisms by interacting with biopolymers capable of oxidation, for example, in accordance with the following reactions:

$$RH_2 + OH^{\bullet} \rightarrow RH^{\bullet} + H_2O;$$
$$RH_2 + Cl^{\bullet} \rightarrow RH^{\bullet} + HCl;$$
$$RH_2 + O^{\bullet} \rightarrow RH^{\bullet} + OH^{\bullet}.$$

A metastable mixture of compounds formed in the process of phagocytosis is a very effective means of killing microorganisms, since it has many spontaneously realizing opportunities for changing (irreversible disruption) of the vital functions of biopolymers of microorganisms at the level of electron transfer reactions. Metastable particles with different values of electrochemical potential have a universal spectrum of action, that is, they can have a damaging effect on all large systematic groups of microorganisms (bacteria, mycobacteria, viruses, fungi, spores), without causing harm to human tissue cells and other higher organisms, that is, somatic animal cells as part of a multicellular system.

This is due to fundamental differences in the structure and living conditions of the cells of these life forms. The cells of higher organisms in the process of life, for example, in oxygenase reactions of the functioning of cytochrome P-450, during phagocytosis with adhesion and immobilization of microbial cells, produce and use a number of highly active oxidants. These cells have a powerful chemical antioxidant support network preventing the toxic effects of such substances on vital cellular structures. The antioxidant properties of somatic cells are associated with the presence of a three-layer lipoprotein shell, which contains diene conjugates $(-\overset{|}{C}=\overset{|}{C}-\overset{|}{C}=\overset{|}{C}-)$ and sulfhydryl groups (SH) with electron-donor properties. Microorganisms do not have powerful antioxidant support networks with the participation of these chemical groups.

All somatic cells of animal organisms are heterotrophs: their trophism depends on the presence of nutrients in the extracellular medium: glucose, amino acids, fatty acids. The biological well-being of a somatic cell depends on the place it occupies in the process of distribution of trophic functions of all elements of the multicellular system (one cell supports another).

The trophic functions of animal cells are subject to the law of interchangeability. If the trophism of one individual cell is disturbed, then this disturbance can be corrected by neurotrophic regulation, endocrine regulation, the function of neighboring cells, reparative processes, the nutritional function of the blood, etc.

All microbial cells are autotrophs, and their nutrition depends on their own energetic activity, that is, if enzymatic processes inside a microbial cell are suppressed, this entails its death, since there are no compensatory mechanisms. A microbial cell provides all its trophic functions only through enzymatic reactions. The interaction between microbial cells in their habitat is not compensatory, that is, the vulnerability of a microbial cell is in its autonomy.

The maximum use of the fundamental differences between living things of the micro- and macrobiological world is the ideological basis of electrochemically activated antimicrobial solutions [12].

As a physicochemical process, electrochemical activation is a combination of electrochemical and electrophysical effects on water with ions and molecules of dissolved substances it contains in the space charge region near the electrode surface (either anode or cathode) of the electrochemical system with nonequilibrium charge transfer across the electrode-electrolyte interface by electrons [13, 14].

As a result of electrochemical activation, water transfers to a metastable (activated) state, while exhibiting increased reactivity in various physicochemical processes for several tens of hours. Electrochemical activation makes it possible to purposefully change the composition of dissolved gases, acid-base and redox properties of water within the limits greater than with equivalent chemical regulation, to synthesize chemical reagents (oxidants or reducing agents) in a metastable state from water and dissolved substances. It is used in water purification and disinfection processes, as well as for converting water or dilute electrolyte solutions into environmentally friendly antimicrobial (disinfecting, sterilizing), washing, extracting and other functional solutions.

For the electrochemical conversion of water and dissolved substances contained in it, flow-through diaphragm modular electrochemical cells — FEM elements are used.

Distinctive features of FEM elements are the combination in one element of the properties of a plug-flow reactor and a perfect-mixing reactor, as well as high technical and economic parameters when operating on fresh water and low-mineralized solutions.

There are several types of electrochemically activated anolyte produced in STEL devices, which are designated by abbreviations A, AN, ANK and differ in physicochemical properties and microbicidal activity, which is due to various technological processes of their production. Today, the most advanced of the electrochemically activated solutions in terms of functional and technological properties is Anolyte ANK obtained in STEL devices by treatment in electrochemical reactors made of FEM elements of the starting aqueous salt solution. [Note: at the time of writing the article (2003), STEL-10N-120-01 devices were modern for obtaining Anolyte ANK of the first generation with an oxidant concentration of no more than 500 mg/l with a total mineralization of 3.0–5.0 g/l. In 2012, STEL-ANK-SUPER devices were developed with an almost 100 % degree of salt conversion to obtain low-mineralized anolyte of the third generation Anolyte ANK SUPER with a mineralization of no more than 0.9 g/l and an oxidant concentration of at least 500 mg/l at pH from 5.0 to 6.5]. The technological production process includes at the first stage the cathode treatment of the starting solution, with pH increase and simultaneous saturation with dissolved hydrogen, then gaseous hydrogen and insoluble hydroxides of heavy metals formed during the interaction of metal cations with hydroxyl anions are removed from the catholyte produced, after which anode treatment is performed to saturate the anolyte with hydroperoxide and chlorine-oxygen oxidants. Some of the reactions accompanying the process of obtaining Anolyte ANK are given below.

Reactions of the first stage of Anolyte ANK production:

$2H_2O + 2Na^+ + 2e \rightarrow 2NaOH + H_2$ (sodium hydroxide formation);

$2H_2O + 2e \rightarrow H_2 + 2OH^-$ (the formation of free hydroxyl anions at a current density of more than 500 A/m^2; the reaction rate increases with a decrease in the concentration of sodium chloride);

$O_2 + H_2O + 2e \rightarrow HO_2^- + OH^-$ (peroxide anion formation with the participation of oxygen dissolved in water);

$O_2 + 2H_2 + 2e \rightarrow H_2O_2 + 2OH^-$ (formation of hydrogen peroxide with the participation of oxygen dissolved in water).

Reactions of the last stage of Anolyte ANK production:

$2Cl^- - 2e \rightarrow Cl_2$ (formation of molecular chlorine, which immediately enters into reactions of interaction with the components of the electrode sheath):

$Cl_2 + H_2O \leftrightarrow HClO + HCl$;

$HCl + NaOH \rightarrow NaCl + H_2O$;

$2H_2O - 4e \rightarrow 4H^+ + O_2$ (formation of oxygen and of hydrogen cations);

$OH^- + Cl^- - 2e \rightarrow HClO$ (direct synthesis of hypochlorous acid);

$Cl^- + 2OH^- - 2e \rightarrow ClO^- + H_2O$ (direct synthesis of hypochlorite anion);

$3OH^- - 2e \rightarrow HO_2^- + H_2O$ (peroxide anion formation);

$HO^- - e \rightarrow HO_2$ (hydrogen superoxide formation);

$OH^- - e \rightarrow HO^\bullet$ (hydroxyl radical formation);

$Cl^- + 4\,OH^- - 5\,e \rightarrow ClO_2 + 2H_2O$ (chlorine dioxide formation);

$O_2 + 2OH^- - 3e \rightarrow O_3 + H_2O$ (ozone formation);

$H_2O - 2e \rightarrow 2H^+ + O^\bullet$ (formation of atomic oxygen).

In addition, in the volume of the Anolyte ANK in the relaxation process, there are reactions resulting in the formation of other biocidal compounds, in particular, singlet molecular oxygen ($^1O_2$), ozone molecular anion (O_3^-); hypochlorite radical ($ClO^\bullet$); atomic chlorine ($Cl^\bullet$); chlorite anion (ClO_2^-) and others. ***Comparison of the list of microbicidal compounds involved in the processes of phagocytosis and contained in Anolyte ANK reveals their almost complete identity.***

The environmentally friendly electrochemically activated Anolyte ANK has a “lifetime” required for the disinfection procedure. After use, it spontaneously degrades forming no toxic xenobiotic compounds and not requiring neutralization before being drained into the sewer. Anolyte ANK is activated only during the relaxation period, that is, all the time of a spontaneous change in its physical and chemical parameters, catalytic and biocatalytic activity. The spontaneous change in these parameters indicates the dissipation of excess internal energy due to the known dissipative processes.

A mixture of metastable active substances ensures the absence of adaptation of microorganisms to the microbicidal action of Anolyte ANK, and the low total concentration of active oxygen and chlorine compounds guarantees complete safety for humans and the environment during its long-term use.

The chemical potential of molecules and ions in Anolyte ANK is much higher than in hypochlorite solutions. Low mineralization of Anolyte ANK and its increased hydration capacity, providing an increase in the permeability of cell walls and membranes, create conditions for intensive osmotic and electroosmotic transfer of oxidants into the intracellular environment. Osmotic transfer of oxidants through the membranes of microbial cells is much more intense than through the membranes of somatic cells, due to the significant difference in the osmotic gradient of these types of cells. The accelerated electroosmotic transfer of oxidants into bacterial cells is facilitated by electrically charged cluster structures formed by molecules of gases dissolved in water and electroactive components of the environment, since they create powerful local electric fields with a high degree of heterogeneity in the contact zones with biopolymers.

The activated Anolyte ANK produced in STEL devices destroys pathogens of bacterial, viral and fungal etiology (Staphylococcus aureus, Pseudomonas aeruginosa and E. coli, viruses of hepatitis B, poliomyelitis, HIV, adenoviruses, pathogens of tuberculosis, salmonellosis, dermatomycosis, etc.). Anolyte is much more effective than chloramine, sodium hypochlorite and the vast majority of other disinfectants and sterilization agents.

The sum of active oxygen and chlorine compounds in Anolyte ANK (total concentration of oxidants) ranges from 100 to 500 mg/l, which is tens of times less than in most working solutions of modern disinfectants. Anolyte ANK does not cause coagulation of the protein that protects microorganisms and, due to its loosened structure, easily penetrates the microchannels of living and nonliving matter.

Anolyte ANK is produced from a diluted sodium chloride solution in tap water in STEL-type devices.

The useful properties of Anolyte ANK, the effectiveness, manufacturability, safety and cost-effectiveness of its use are fully confirmed in many medical institutions, in particular, in CCH No. 52 and CCH No. 15 (Moscow), where Anolyte ANK has been practically the only disinfectant solution since 1992. The specific gravity of anolyte in the structure of disinfectants used in these institutions exceeds 97 %, and its annual consumption was about 1000 tons for each of the above hospitals [15, 16].

Before the wide use of Anolyte ANK, those institutions used a variety of drugs, many of which caused corrosion of metals, clouding of glass objects, deterioration of synthetic materials, skin allergic reactions and headaches among medical personnel. To prepare disinfectant solutions, it was necessary in each department to train medical personnel and provide them with protective equipment (a respirator, shoes, goggles, rubber gloves, an apron).

Hospitals used to spend considerable material resources on the purchase of disinfectants, detergents, sterilizing drugs, containers for their storage, special clothing and protective equipment. It was required to periodically repair the sewer pipes that had become unusable as a result of the discharge of aggressive waste solutions. Taking into account the not always sufficient removing effect of many drugs on microorganisms, including nosocomial strains, as well as the possibility of improper preparation of disinfectant solutions, the bacteriological laboratory staff of the hospitals had to carry out initial and repeated bacteriological control of the disinfection and sterilization quality doing up to 500–700 bacteriological washings per month. A large number of special chemicals were consumed to check the concentration of the disinfectant solutions produced.

The functionally useful work of medical personnel in the patient-care workplaces, was complicated due to the need to spend time on studying the rules for preparing solutions and monitoring the knowledge of personnel, as well as on quality control of the prepared solutions.

The use of electrochemically activated Anolyte ANK produced in STEL devices, in addition to eliminating the above negative aspects associated with the use of traditional chemicals, has led to the following positive results: the total bacterial contamination of objects to be treated in the process of sanitary and epidemiological measures, the number of unsatisfactory bacterial washes has decreased by 85–95 %, reducing the number of monthly bacteriological washes to 200–300; in addition, while the incidence rate of viral hepatitis B among those previously treated in hospitals and subsequently sick was 0.45–0.50 % before the use of Anolyte ANK, now, during several years of using anolyte this indicator has constantly been within 0.06–0.08 %, which is an indirect indicator of improving the disinfection quality.

Anolyte ANK is used in the following hospital departments: surgical, purulent surgery, therapeutic, transfusiology, gynecological, proctology, pathological and anatomical, consultative and diagnostic center, reception (over 50 liters per day), trauma, clinical diagnostic laboratory, rehabilitation department, intensive care unit (over 30 liters per day), eye, vascular surgery, cardiac surgery, cardiovascular surgery, neurological, operating, anesthesiology, endoscopic, physiotherapeutic, dental, functional diagnostics, ultrasound diagnostics, radiation diagnostics, as well as in the central sterilization department (City Clinical Hospital No. 15), the maternity hospital (over 50 liters per day), which has departments — obstetric, pregnant women pathology, newborns, operating rooms and maternity wards.

All STEL devices used in hospitals are small in size, easy to operate, environmentally safe, and can be installed in any premises. There is no need for special long-term training of medical personnel to work with STEL devices. Only a medical gown is used as special clothing. The amount of solutions produced corresponds to the actual needs of the departments and can be increased at the request of medical personnel in accordance with the epidemiological situation. It is possible to obtain Anolyte ANK with different concentrations of oxidants according to the modes of Anolyte ANK use for infectious diseases of various etiologies [17]. The concentration of oxidants in the produced Anolyte ANK is checked by express analysis (test strips) or, more precisely, by iodometric titration. neutral Anolyte ANK is easy to use, so it is used with pleasure by the medical staff of hospitals. Unlike other drugs, it simultaneously reliably disinfects, washes and sterilizes.

Conclusions: For the effective implementation of measures for sanitary and epidemiological protection of the population, it is necessary to develop a unified scientific concept of combating microbes based on the fundamental laws of biology, modern achievements ofphysics, chemistry, and other sciences, and including the following fundamental provisions:

1. ***Evaluation 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 creation of new effective chemical antimicrobial agents safe for humans should be based on the use of fundamental differences between micro- and macroorganisms, including by copying or modeling the mechanisms used by the cells of higher organisms.***
3. ***The main principle for assessing the degree of safety of chemical antimicrobial agents should be to determine whether the active substances or components of this agent are xenobiotics. To inform consumers about the degree of danger of the product, the label must contain the inscription: "does not contain xenobiotic substances" or "contains xenobiotic substances".***

REFERENCES

1. *The Concept of Prevention of Nosocomial Infections. V. I. Pokrovsky et al. Ministry of Health of the Russian Federation, 1999. Концепция профилактики внутрибольничных инфекций. В. И. Покровский и др. МЗ РФ, 1999.*
2. *L. S. Fedorova. Principal Directions of Increasing the Efficiency of Disinfectants.//Proceedings of the All-Russian Scientific Conference "Urgent problems of disinfectology in the prevention of infectious and parasitic diseases" dedicated to the birth centenary of V. I. Vashkov — M.: ITAR-TASS, 2002. — p. 26–30. Л. С. Федорова. Основные направления повышения эффективности дезинфицирующих средств.// Материалы Всероссийской научной конференции, посвященной 100-летию со дня рождения В. И. Вашкова «Актуальные проблемы дезинфектологии в профилактике инфекционных и паразитарных заболеваний». — М.: ИТАР-ТАСС, 2002. — с. 26–30.*
3. *Bill Glass. Exposure to Glutaraldehyde Alone or in a Fume Mix: Review of 26 cases. NZMRT Journal. — Volume 40. — № 2, June, 1997. — p. 13–17.*
4. *Jon Richards. Withdrawal of Disinfectant Hit by Safety Fears. BBC News on Line: Health. January 22, 2002.*
5. *M. G. Shandala. Methodological Problems of Modern Disinfectology.//Proceedings of the All-Russian Scientific Conference "Urgent problems of disinfectology in the prevention of infectious and parasitic diseas-*

es" dedicated to the birth centenary of V.I. Vashkov — M.: ITAR-TASS, 2002. — p. 9–16. М.Г. Шандала. Методологические проблемы современной дезинфектологии.//Материалы Всероссийской научной конференции, посвященной 100-летию со дня рождения В.И. Вашкова «Актуальные проблемы дезинфектологии в профилактике инфекционных и паразитарных заболеваний». — М.: ИТАР-ТАСС, 2002. — с. 9–16.

6. *William A. Rutala. Chemical germicides in health care//International symposium, May 1994. Printed in Canada. 1995. — p. 312.*
7. *Patrick R. Murray, Ellen Jo Baron, Michael A. Pfaller, Fred C. Tenover, Robert H. Yolken. Manual of clinical microbiology. Sixth edition. ASM PRESS. Washington, D. C. p. 227–245.*
8. *G. McDonnell, A.D. Russel. Antiseptics and Disinfectants: Activity, Action and Resistance. Clinical Microbiology Reviews 12. p.147–179.*
9. *N.A. Lopatkin, Yu. M. Lopukhin. Efferent Methods in Medicine (Theoretical and Experimental Aspects of Extracorporeal Treatment Methods). — M.: Medicine, 1989. — 352 p. Н.А. Лопаткин, Ю.М. Лопухин. Эфферентные методы в медицине (теоретические и экспериментальные аспекты экстракорпоральных методов лечения). — М.: Медицина, 1989. — 352 с.*
10. *A.I. Archakov, I.I. Karuzina. Oxidation of Foreign Compounds and Problems of Toxicology. Bulletin of the USSR Academy of Medical Sciences, 1988, No. 1, — p. 14–28. А.И. Арчаков, И.И. Карузина. Окисление чужеродных соединений и проблемы токсикологии. Вестник АМН СССР, 1988, №1, — с. 14–28.*
11. *A.I. Archakov. Microsomal Oxidation. — Moscow: Nauka, 1975. — 327 p. А.И. Арчаков. Микросомальное окисление. — М.: Наука, 1975. — 327 с.*
12. *Panicheva S.A. New Technologies for Disinfection and Sterilization of Complex Medical Products. — M.: VNIIMT, 1998. — 122 p; — ill. Паничева С.А. Новые технологии дезинфекции и стерилизации сложных изделий медицинского назначения. — М.: ВНИИИМТ, 1998. — 122 с; — ил.*
13. *Bakhir V.M. Electrochemical Activation. — M.: VNIIMT, 1992. — 2 part — 657 p; — ill. Бахир В.М. Электрохимическая активация. — М.: ВНИИИ мед. техники,1992. — 2 ч. — 657 с; — ил.*
14. *Bakhir V.M., Zadorozhny Yu. G., Leonov B.I., Panicheva S.A., Prilutskiy V.I. Electrochemical Activation: Water Purification and Production of Funktional Solutions. — M.: VNIIMT, 2001. — 176 p.; — ill. Бахир В.М., Задорожний Ю.Г., Леонов Б.И., Паничева С.А., Прилуцкий В.И. Электрохимическая активация: очистка воды и получение полезных растворов. — М.: ВНИИИМТ, 2001. — 176 с.; — ил.*
15. *V.B. Rovinskaya, O.I. Sukhova. Experience in Use of Electrochemically Activated Solutions in a Multidisciplinary Hospital.//Proceedings of the First International Symposium "Electrochemical Activation in Medicine, Agriculture, Industry." — M.: VNIIMT, 1997, — p. 70–72. Ровинская В. Б., Сухова О.И. Опыт применения электрохимически активированных растворов в многопрофильном стационаре.//Труды Первого Международного симпозиума «Электрохимическая активация в медицине, сельском хозяйстве, промышленности». — М.: ВНИИИ мед. техники, 1997, — с. 70–72.*
16. *V.M. Bakhir, V.I. Vtorenko, Yu. G. Zadorozhny, B.I. Leonov, S.A. Panicheva, V.I. Prilutsky. Some Aspects of Producing and Using Electrochemically Activated Anolyte ANK.//Proceedings of the Third International Symposium "Electrochemical Activation in Medicine, Agriculture, Industry." — M.: VNIIMT, 2001, — p. 3–25. Бахир В.М., Вторенко В.И., Задорожний Ю.Г., Леонов Б.И., Паничева С.А., Прилуцкий В.И. Некоторые аспекты получения и применения электрохимически активированного анолита АНК.//Труды Третьего Международного симпозиума «Электрохимическая активация в медицине, сельском хозяйстве, промышленности». — М.: ВНИИИ мед. техники, 2001, — с. 3–25.*
17. *Guidelines for Using Neutral Anolyte ANK Produced by STEL-10N-120-01 Device for the Purposes of Disinfection, Pre-sterilization Cleaning and Sterilization, approved by the Head of the Department of State Sanitary and Epidemiological Supervision of the Ministry of Health of the Russian Federation, No. 11–3/206–09 dated 17.06.2002. Методические указания по применению «Нейтрального анолита АНК», вырабатываемого в установке СТЭЛ-10Н-120-01», для целей дезинфекции, предстерилизационной очистки и стерилизации, утвержденные Руководителем Департамента госсанэпиднадзора МЗ РФ, №11—3/206—09 от 17.06.2002 г.*

УДК 544.6+625.35
ББК 24.57
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.

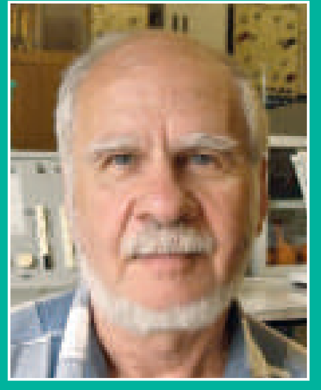
Based on the experience of engineering and practical use of electrochemical systems for production environmentally friendly, safe for humans and animals electrochemically activated detergents, disinfectants and for production of the environmentally friendly sterilizing solutions, the authors predict 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.

ISBN 978-5-6047707-0-2

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.

SVETLANA PANICHEVA — Ph. D., expert in medical electrochemical solutions, experienced in electrochemical medical devices, investigational new drug applications and food safety products development, creation of cGMP manufacturing for stabilized electrochemically activated hypochlorous acid formulations, preparing FDA submissions for topical drug products, validation, and manufacturing. The author of more than 50 international patents and more than 100 publications.



VLADIMIR PRILUTSKY — Ph. D., Scientific Consultant at Electrochemical Systems and Technologies Institute, expert in medical sciences, the author of 20 inventions, 5 monographs and more than 200 scientific articles in the field of electrochemical activation. The author of a number of new concepts on the interaction of electrochemically activated water and solutions with objects of animate and inanimate nature. His ideas have served as a basis for creating fundamentally new technological processes and technical electrochemical systems widely recognized and used in practical medicine.

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.

ISBN 978-5-6047707-0-2

9 785604 770702

ELECTROCHEMICAL ACTIVATION

BAKHIR V. M.
PANICHEVA S. A.
PRILUTSKY V. I.
PANICHEV V. G.

ELECTROCHEMICAL ACTIVATION

INVENTIONS SYSTEMS TECHNOLOGY

Vitold Bakhir Institute