# OZONE THERAPY TECHNIQUE. BIOCHEMICAL ASPECTS OF OZONE THERAPY. INDIVIDUAL SELECTION OF OZONE AND ANTIOXIDANT DOSES. OZONE THERAPY TECHNOLOGIES IN THE ACTIVE TREATMENT SYSTEM OF SERIOUS BURNS.

**STATE UNIVERSITY OF MEDICINE AND PHARMACY "NICOLAE TESTEMITANU"**

**DEPARTMENT OF INTERNAL MEDICINE**

**THE DISCIPLINE OF GERIATRICS AND OCCUPATIONAL MEDICINE**

**OPTIONAL COURSE: OZONE THERAPY**

# Subjects:

- Biochemical aspects of ozone therapy.
- Individual selection of ozone and antioxidant doses.
- Ozone therapy technologies in the active treatment system of serious burns.

# SHORT HISTORICAL DATA

Ozone was first discovered in 1785 by the Dutch physicist M. Van Marun due to its characteristic smell and the special oxidizing properties that air acquires after an electric spark passes through it. However, Van Marun did not describe the new substance. Van Marun believed that a special "electrical matter" was formed.

The properties of ozone are described in detail by Professor Shonbeyt in the book Obtaining Ozone by chemical methods (1832). The scientist also gave the name of this gas. Schonbeyt also discovered, for the first time, the ability of ozone to combine with organic substances at the site of double bonds in them.

For the first time as an antiseptic, ozone was used by the German physician A. Wolff since 1915, during World War I, for the treatment of purulent wounds, fistulas and burns. Particularly good results have been obtained in the treatment of extremity gangrene and anaerobic phlegm. The author noted an improvement in the clinical course of diseases, a wound healing and a pronounced disinfecting effect of ozone.

In 40-50 of the 19th century, numerous studies were carried out that made it possible to determine the chemical structure of ozone, its properties and possible uses.

Interest in ozone in various branches of science was growing.

In 1873, the English researcher C.. Fox wrote, “to a philosopher, physician, meteorologist, and chemist, there is no subject more attractive than ozone.” Even then, he showed the possibility of using ozone in communal hygiene and medicine: "Ozone is the most powerful deodorizing and cleaning agent. It should be used in infectious wards, sick rooms, places with high concentrations of poor.”

In 1852, studies of the Königsber Medical Union proved the effectiveness of using ozone to stop inflammatory processes in the upper respiratory tract.

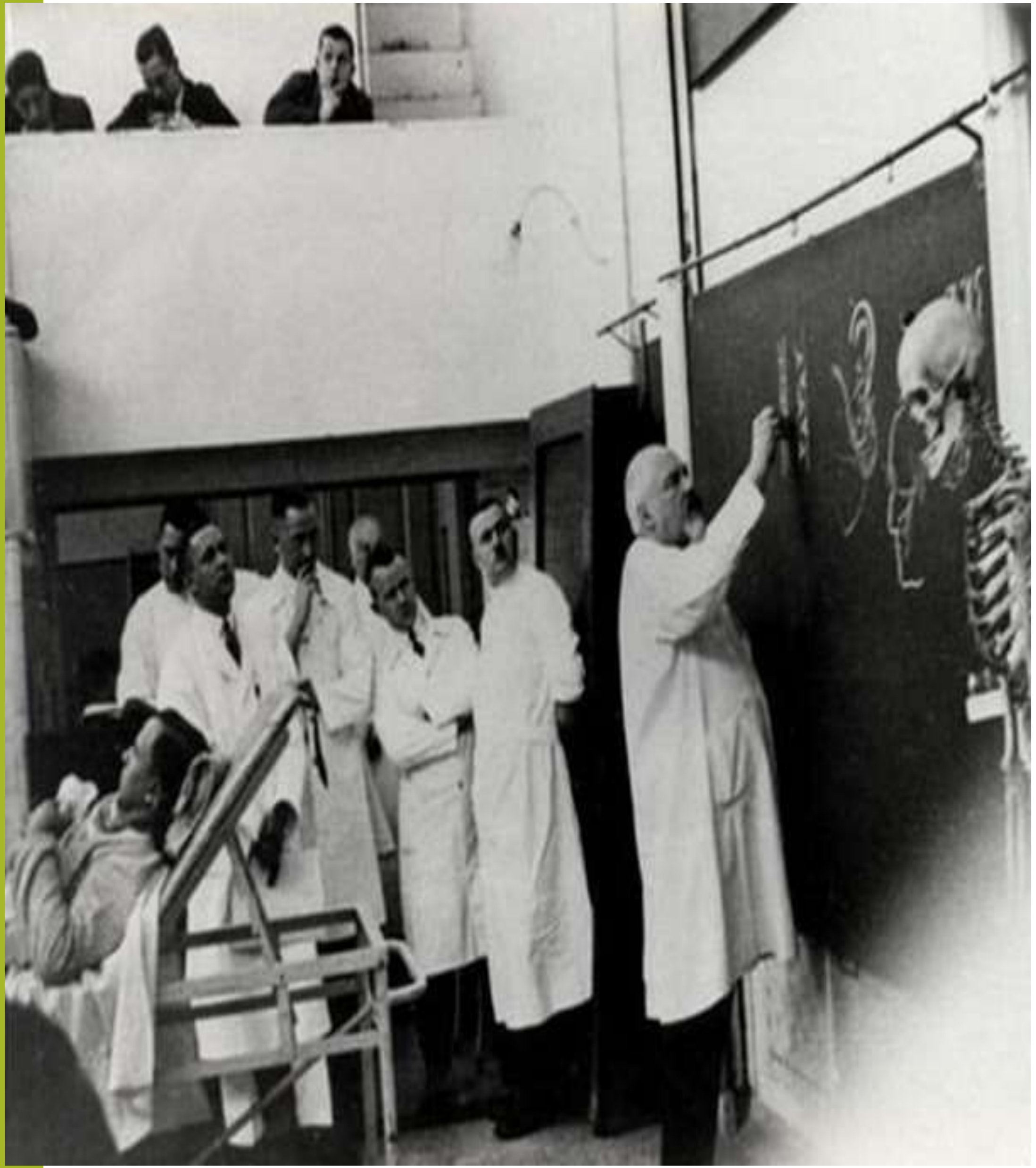
In 1895, the Institute of oxygen Therapy was opened in Germany, where parenteral ozone was administered to animals for the first time in history. 15 years later, the American and German Osotherapists, who joined their efforts, formed the Ozone Therapy Association of East America

Since the end of the 19th century, ways to successfully use ozone for medical purposes have been sought. However, it was possible to approach the real solution of this problem only in 80-90 of the 20th century.

An important prerequisite for the use of ozone in medicine was the discovery of its powerful antimicrobial action, which was used in the purification of drinking water.

The first ozone generators, which by their technical characteristics could be used in medicine, appeared in the early 20th century in the USA.

However, it was more than 50 years before I. Hansler developed the first ozone therapy device in 1957, which allows accurate dosing and safe application of medical ozone, opening wide opportunities for the development of the given treatment method.



In the era before the discovery of antibiotics, the use of ozone, despite the imperfection of technology and equipment, was a very effective and promising method for the treatment of severe inflammatory processes.

After completing the ozone therapy experience of that time, Prof. E.. Payr wrote: “The successes achieved in ozone therapy are good, although the number of observations is not so impressive, they have led to a therapeutic effect so pronounced that the method could be called very valuable and promising.”

Historical fact: The introduction of ozone therapy in general surgery was based on the achievements of dentistry. E. Payr began conducting research on ozone only after he himself as a patient became familiar with this method in the clinic of dentist and maxillofacial surgeon E.A. Fisch.

The latter has gained considerable practical experience in using ozonized water as a local antiseptic in dental practice.

E.Fisch 1899-1966
Dentist

In Russia, the use of ozone-oxygen therapy began in 1979 in cardiac surgery prof. Boyarinov G.A. However, this was preceded by a series of experimental studies on the effect of ozone on the metabolism of various organs under normal and pathological conditions. The Russian school has developed a fundamentally new method of ozone therapy - intravascular administration of ozone-saturated solutions.

Today Moscow and Nizhny Novgorod became centers of ozone therapy. Leading medical institutions in Russia successfully use ozone in thousands of patients. The Russian scientific and practical center for ozone therapy was established in Moscow, thus demonstrating social and medical interest in ozone therapy.

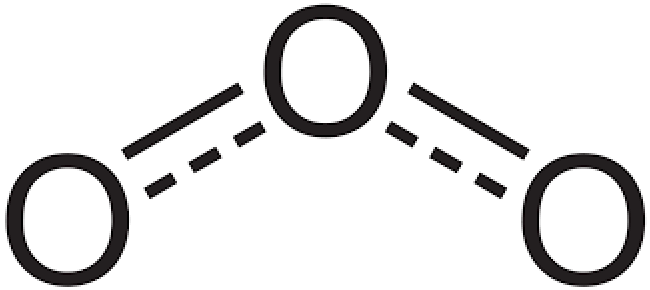
As far as I have noticed in the evolution of ozone use, there has been a curiosity about its properties.

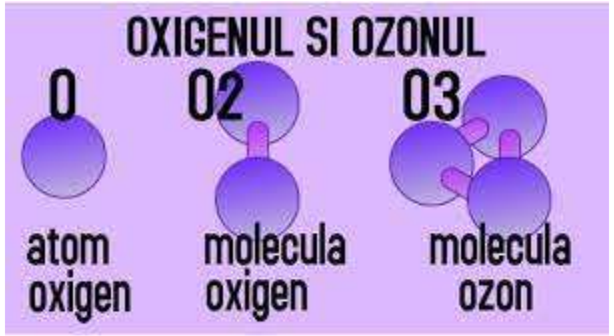
To understand how ozone performs its specific tasks, it is necessary to know the physical, chemical and biochemical properties that it has.

# GENERAL PHYSICAL AND CHEMICAL ASPECTS OF OZONE

Oxygen forms two allotropic changes - oxygen and ozone, which differ in molecular composition and have different properties.

Alotropia is the property of chemical elements to exhibit two or more crystalline forms, when atoms are placed differently according to the constituent chemical bonds. Alotropia refers only to the different forms of an element in the same state of aggregation.

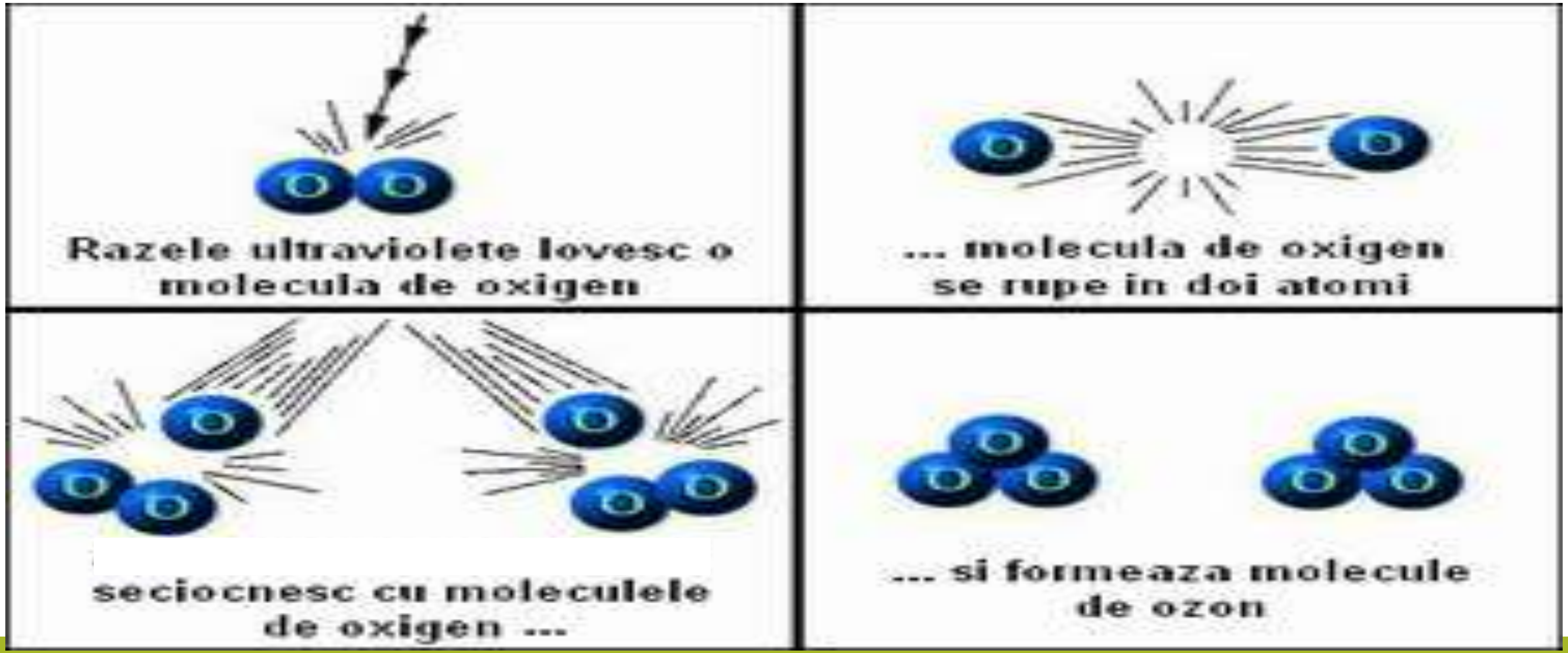


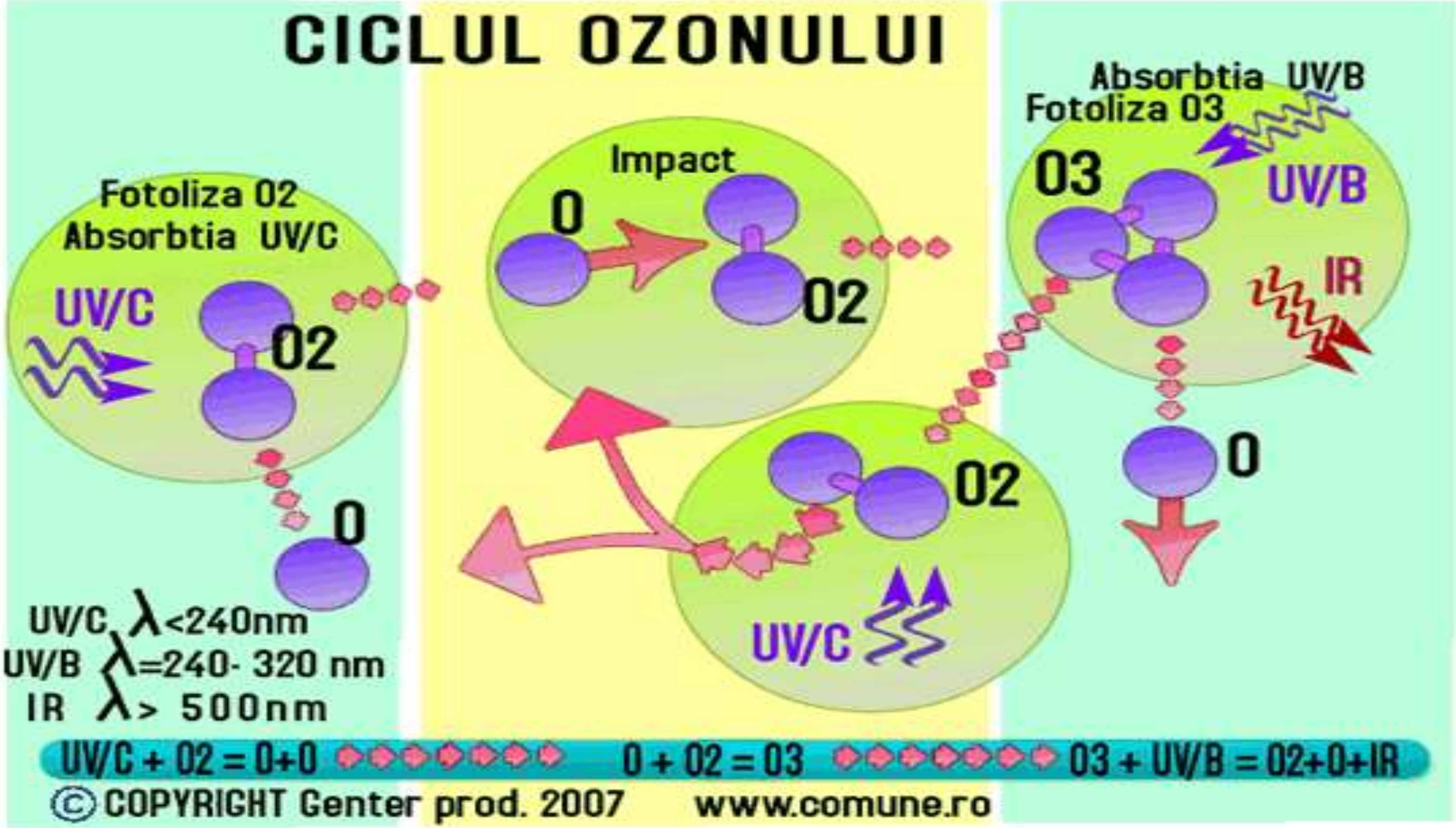




Ozone ($O_3$) is a blue gas with a characteristic odor. Translated from the Greek, ozone means “smelly.”

Ozone is found in the upper atmosphere and protects the Earth from the sun’s ultraviolet radiation.

Ozone is formed in the atmosphere during lightning discharges, which explains the specific smell of freshness after a storm, as well as during the operation of high-voltage transformers.

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IR
0
UV/C λ<240nm
UV/B λ=240- 320 nm
IR λ> 500nm
UV/C + 02 = 0+0
0 + 02 = 03
03 + UV/B = 02+0+IR
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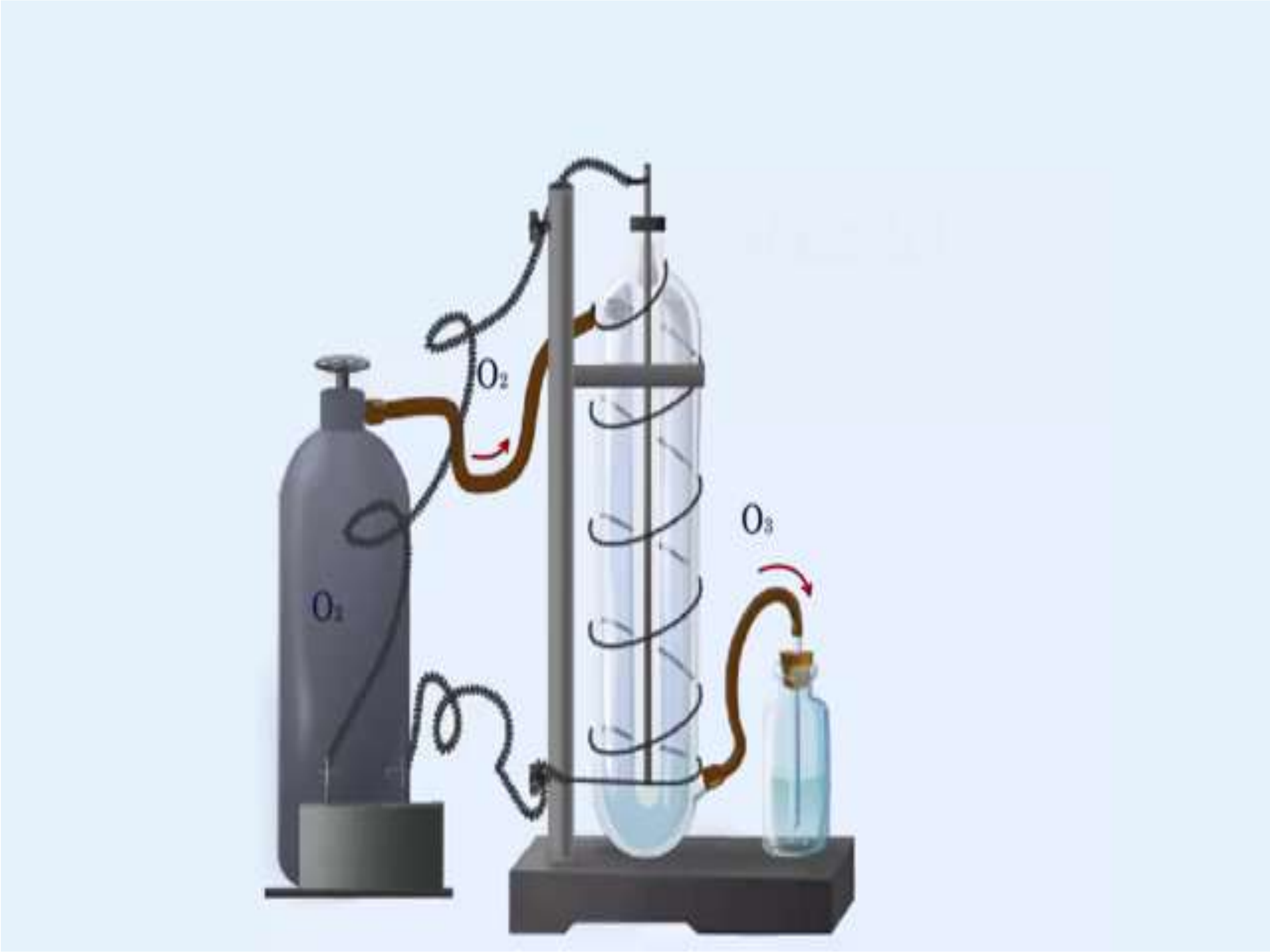
Ozone is obtained from atmospheric oxygen in electric discharge ozone. The ozone formation reaction is reversible, endothermic (endothermic reactions are chemical reactions that result with the release of light or heat):

$3O \leftrightarrow O_3 - 284\ kJ$

In the laboratory, ozone can be obtained by the action of cooled concentrated sulfuric acid when interacting with barium peroxide:

$3H_2SO_4+3BaO_2=3BaSO_4+O_3+3H_2O$

Under normal conditions, ozone has a blue color, when liquefied it turns into an indigo liquid, and in the solid state it is present in the form of dark blue crystals, almost black.


O₂
O₂
O₃

Ozone is an oxidizing agent more powerful than oxygen. Unlike oxygen, ozone reacts with a solution of potassium iodide to release iodine:

$2KI+O_3+H_2O = I_2+2KOH+O_2$

This reaction is used as a qualitative one for detecting ozone or ions: Starch is added to the solution, which gives a characteristic blue color due to the formation of a complex with iodine. Ions and ozone do not oxidize.

Ozone oxidizes almost all metals except gold, platinum and iridium, as well as many nonmetals, turning into oxygen:

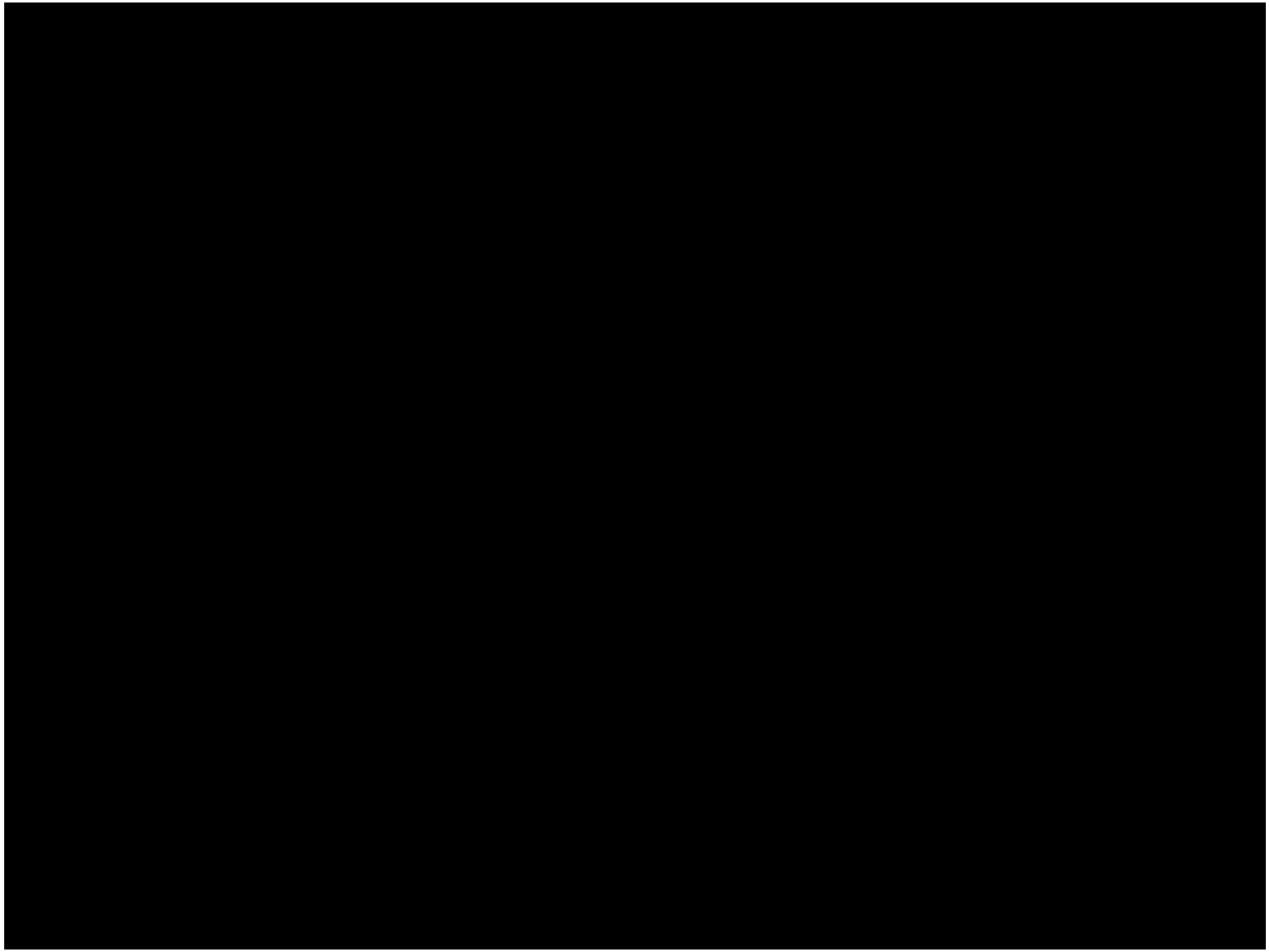
$2Ag+O_3 = Ag_2O+O_2$

Ozone is unstable and easily converts to oxygen : $2O_3 = 3O_2$

The use of ozone is due to its strong oxidation properties. Ozone is used for:

- purification and disinfection of water and air;
- sterilization of medical instruments;
- paper whitening;
- purification of oil;
- disinfection of premises and clothing;
- destruction of mold, bacteria and viruses;
- production of many organic and inorganic substances.

When ozone is used as an agent for the purification of water and air, no harmful and toxic substances are formed (as opposed to the use of chlorine compounds).

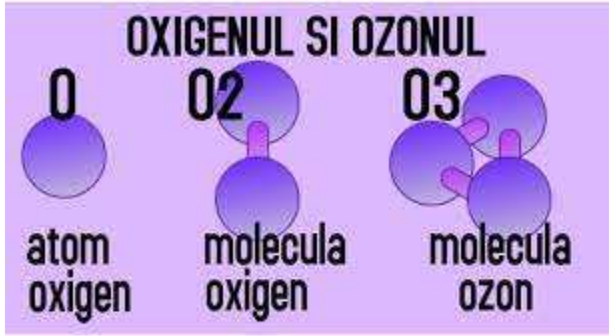


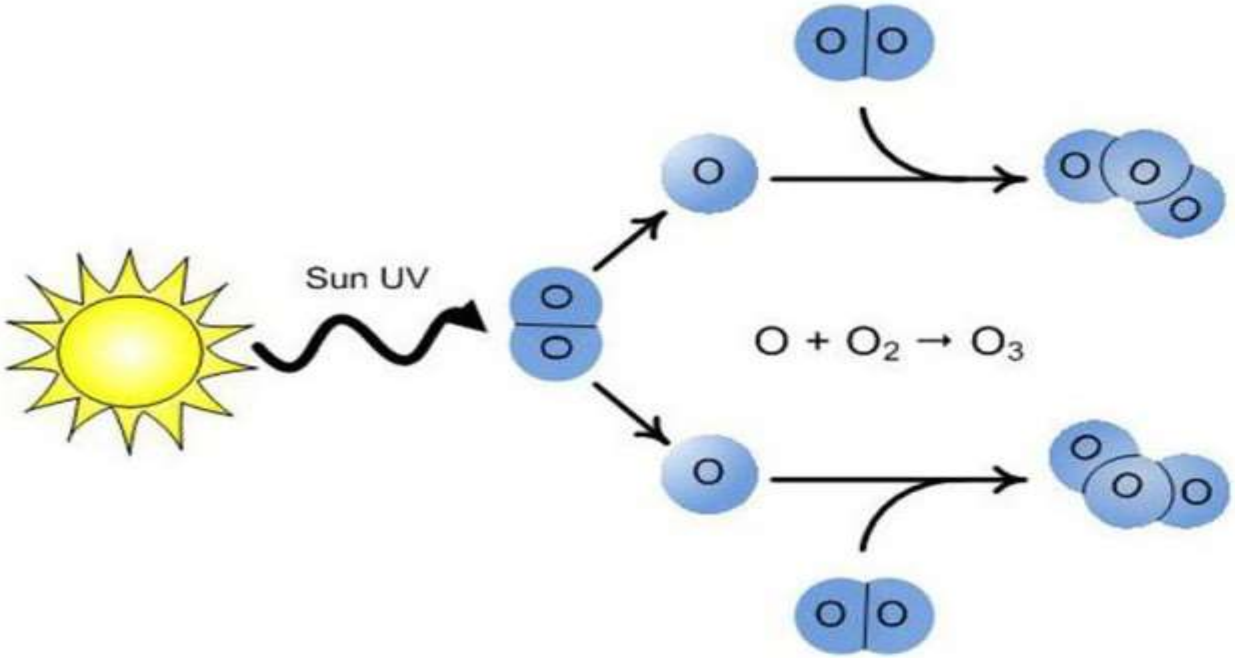
Ozone is an allotrope change in oxygen.

The properties of ozone are different from those of oxygen.

Ozone is a much more powerful oxidizing agent than oxygen.

The use of ozone is due to its strong oxidation power.



# THE PHYSICAL PROPERTIES OF OZONE

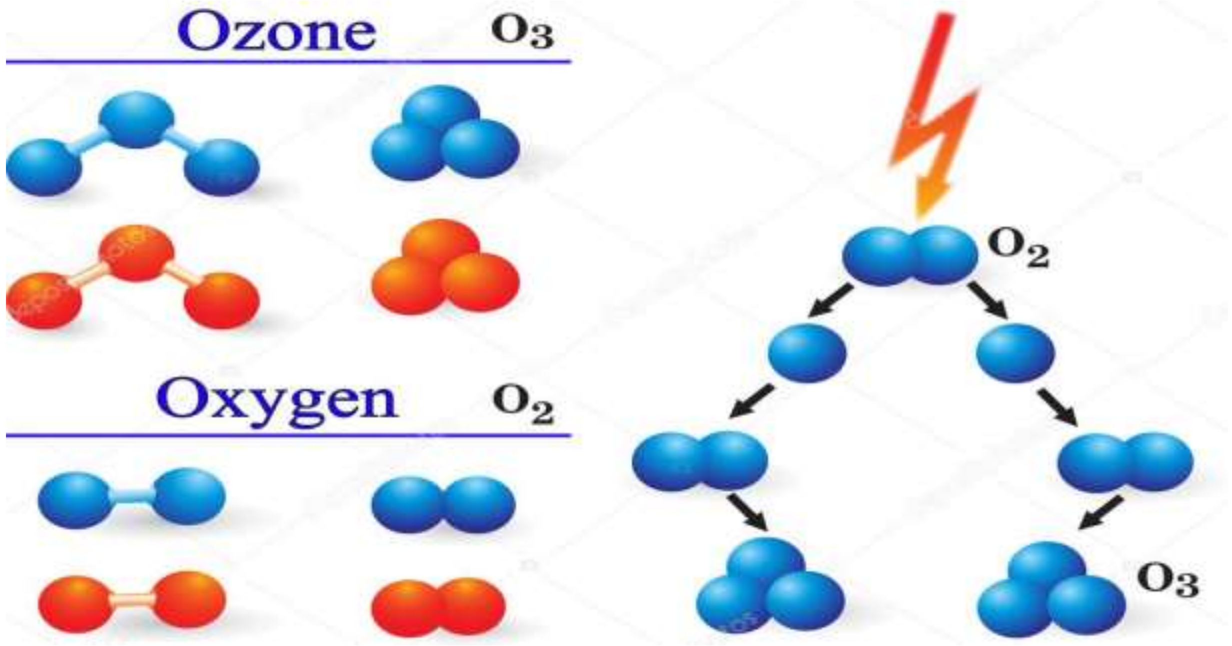
Pure ozone is obtained from its mixture with oxygen, turning it into a liquid state when cooled with liquid air. Because the ozone molecule has a high polarity, ozone has a higher boiling point (-111.9°C) than oxygen. This also explains the greater intensity of the ozone color and its better solubility in water.

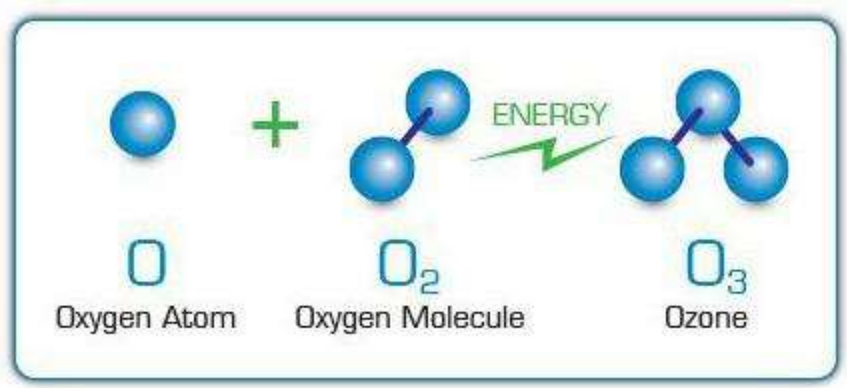
The gas density under normal conditions is 2.14 kg/m3. Relative gas density for oxygen 1.5. Liquid density at -183°C = 1.71 kg/m3. In the gaseous state, ozone has a bluish color with a sharp odor and is toxic. At t = -112°C, ozone gas is converted into liquid ozone - a dark blue liquid, solid ozone - dark purple crystals (Tmelt = -197.2ºC).

Ozone is 1.62 times heavier than air. Its solubility in water is 15 times that of oxygen. In the gaseous state, ozone is diamagnetic; in the liquid state, it is weakly paramagnetic. The smell is sharp, specifically "metallic" (after D.. I. Mendeleev, the smell of cancer. Liquid ozone and its concentrated mixtures (70% - O3) are explosive. At high concentrations, it resembles the smell of chlorine. The smell is noticeable even at a dilution of 1:100 000. Ozone is toxic even in low concentrations.

It is necessary to note another property of ozone, because the ozone molecule is unstable, it turns again into oxygen.

Due to this property, some of the ultraviolet radiation from the Sun hitting the Earth is converted into thermal energy.



# CHEMICAL PROPERTIES OF OZONE

Ozone is an endothermic and therefore reactive compound. Its oxidizing properties are more pronounced than those of oxygen. A more precise comparative feature of the oxidizing properties of the ozone molecule is the value of the red-ox potential corresponding to the electron addition reaction, for example:

$O2 + 2\bar{e} + 2H+ \rightarrow O2 + H2O$ corresponds to the potential $E = + 2.07$ V.

$4\bar{e} + 4H+ + O\rightarrow 2H2O$ is smaller: $E = +0.815$ V, because ozone "pulls" electrons much more strongly.

With high oxidative activity, ozone oxidizes almost all metals (except gold, platinum and iridium) to the highest oxidation states.

The reaction product as a result is mainly oxygen.

$8Ag + 2O_3 \rightarrow 4Ag_2O + 2O_2$

$HG + O_3 \rightarrow HgO + O_2$

3) Ozone increases the oxidation state of oxides

$NO + O_3 \rightarrow NO_2 + O_2$.

4) nitrogen dioxide can be oxidized in nitrogen trioxide: $NO_2 + O_3 \rightarrow NO_3 + O_2$ to form nitrogen anhydride $NO_2 + NO_3 \rightarrow N_2O_5$

5) Ozone reacts with carbon to form carbon dioxide: $C + 2O_3 \rightarrow CO_2 + 2O_2$

6) Ozone does not react with ammonium compounds, but reacts with ammonia: $2NH_3 + 4O_3 \rightarrow NH_4NO_3 + 4\ O_2 + H_2O$

7) Ozone reacts with sulfates forming sulfates: $PBS + 4O_3 = PbSO_4 + 4O_2$

8) using ozone, sulfuric acid can be obtained from both elemental sulfur and sulfur dioxide: $S + H_2O + O_3 \rightarrow H_2SO_4$ $3SO_2 + 3H_2O + O_3 \rightarrow 3H_2SO_4$

9) with hydrogen peroxide, ozone acts as a reducing agent: $H_2O_2 + O_3 = 2O_2 + 2H_2O$

10) with alkali metal hydroxides, ozone forms so-called ozone, formed by positively charged ions and negatively charged ions

$O_3$ - $K + O_3 \rightarrow KO_3$

Potassium ozone can be obtained in another way from potassium hydroxide: $2KOH + 5O_3 \rightarrow 2KO_3 + 5O_2 + H_2O$

The reaction determines paramagnetism and the presence of color in the ozone. They are usually red.

11) for the detection and quantification of ozone, the reaction of its interaction with potassium iodide shall be used:

$O3 + 2KI + H2 \rightarrow I2 + 2KOH + O2$

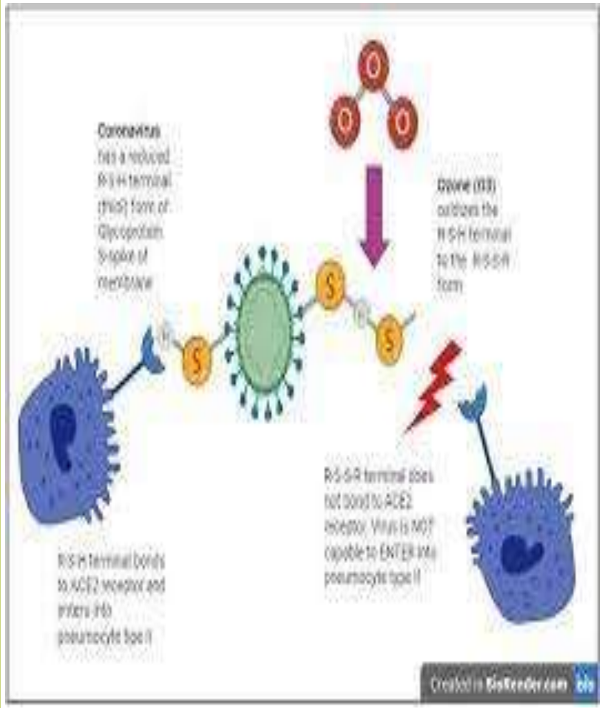
Free iodine is released from a solution of potassium iodide, which gives a blue color with starch

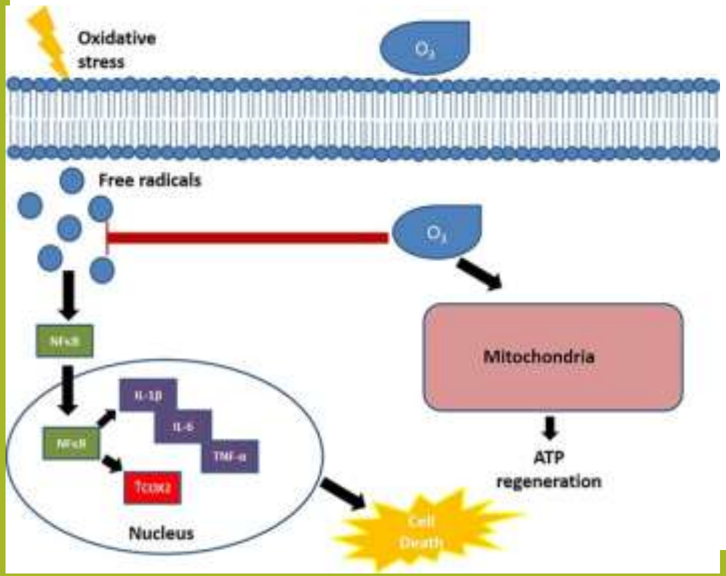
12) Ozone can be used to remove manganese from water with the formation of a precipitate that can be removed by filtration:

$2Mn2 + 2O3 + 4\ H2O \rightarrow 2MnO\ (Oh)\ 2 + 2O2 + 4H\ +$

# BIOCHEMICAL PROPERTIES OF OZONE

Ozone has a high redox potential and high reaction rates with organic molecules. The systematic study of these reactions to isolate the finished products and the course of the reaction presented the generally recognized mechanism of ozonolysis of polyunsaturated fatty acids formulated by R. Criegee in 1949.



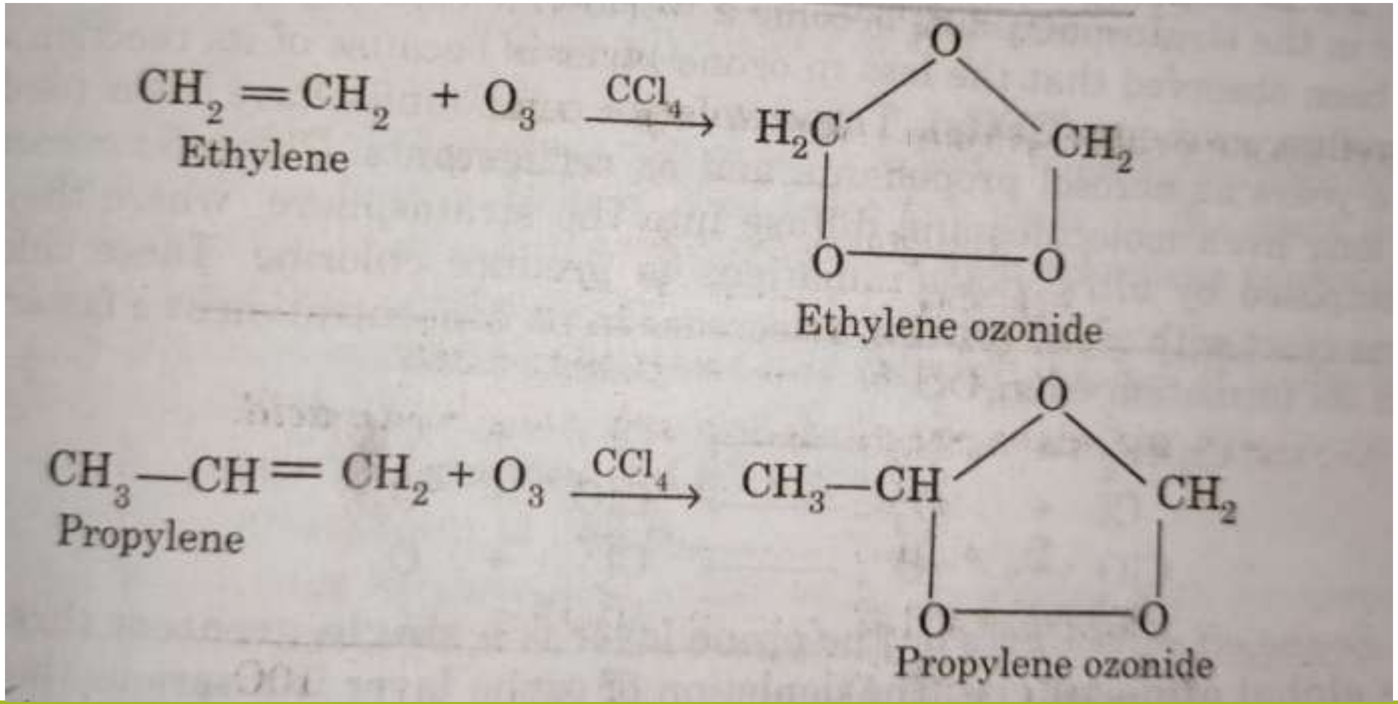




In medical practice, it is of great interest the interaction of organic substances dissolved at body temperature with 5% ozone in oxygen or an ozonized solution.

Ozone is a powerful oxidizing agent that is able to react with almost all organic substances, causing their oxidation, and with an excess of ozone, their oxidative decomposition - ozonolysis. Ozone reacts directly with hydrocarbon compounds, S=S and S-H bonds, trivalent phosphorus, double and triple carbon bonds, and C=N bonds

The reaction of ozone with a CH bond occurs slowly with the formation of unstable hydrotrioxide, which spontaneously decomposes with the release of molecular oxygen and hydroxylated products.

Irreversible oxidation reactions along the C-H bond, especially ether alcohols, occur only at high temperatures and with an excess of ozone.



The reaction of ozone with sulfur-containing organic compounds occurs in two phases: Rapid, sulfoxid formation, followed by a relatively slow reaction with sulfone formation.

The destruction of S=S double bonds by ozone leads to the rapid degradation of a number of polymer materials, especially rubber, which makes it impossible to use them in ozone therapy procedures.

Ozone is also able to interact with organic phosphorus as well as aromatic compounds containing nitrogen. Reactions with an aromatic ring depend on the structure of the molecule, so benzene is very resistant to ozone, but the reaction speed is significantly accelerated if radicals are added to the benzene ring, which increase the density of electrons inside the ring.

Amino acids and amines react intensively with ozone, but reaction speeds depend on pH, they decrease in acidic environment, and in a strong acid reaction practically does not occur interaction.

All of these reactions are carried out at different speeds, therefore in vivo conditions, when low concentrations of ozone (a significant excess of organic substrate with lack of ozone) are used, only direct oxidation reactions occur faster.

Ozone has been shown to react extremely selectively and not selectively, as we would expect from such a powerful oxidizing agent.

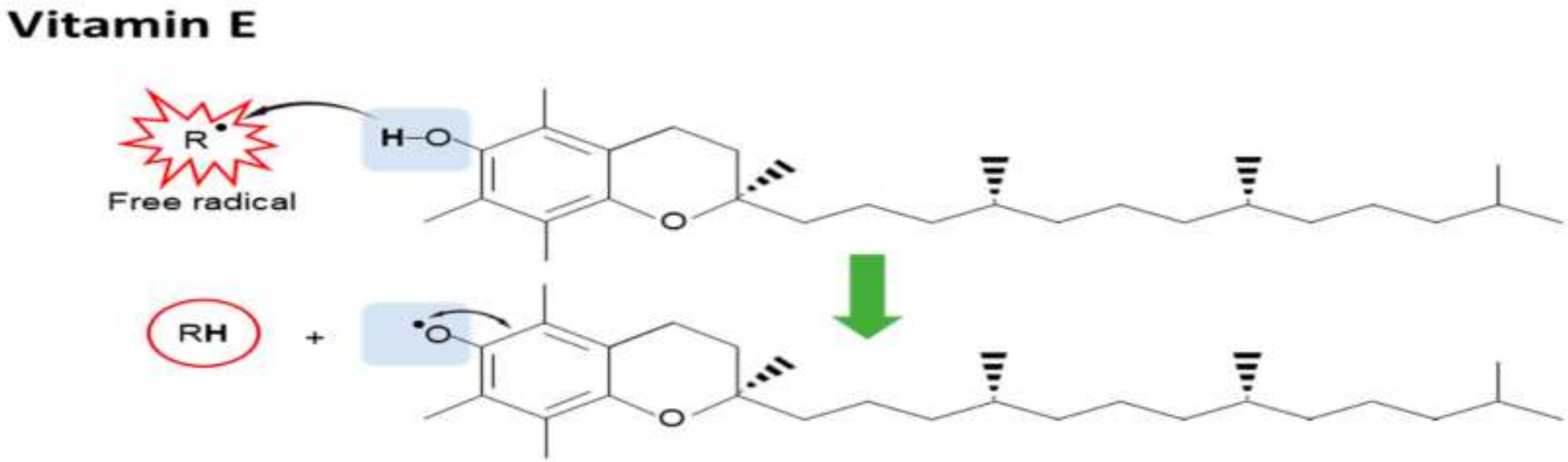
Ozone oxidizes free phenols and amines in seconds, alcohols within a few hours and reacts instantly with compounds containing a double bond C=C.

The reason for this is the polar structure of ozone molecules. High biochemical selectivity compared to compounds containing a double bond C=C, and this is primarily polyunsaturated fatty acids, which are part of the phospholipids of cell membranes, this reaction underlies the mechanisms of its biological action.

The speed of the ozone reaction to double bonds is often higher than the speed of reactions with other groups of organic molecules, therefore, under in vivo conditions, ozone almost completely interacts with polyunsaturated fatty acids.

In the presence of Oh- at pH>8, the number of free radical reactions increases with the occurrence of a chain reaction. However, under physiological conditions at pH less than or equal to 7.4, i.e. in the presence of free polyunsaturated fatty acids, the reaction proceeds predominantly according to the ion mechanism and begins with dipolar addition to bonds 1.3.

Studies confirm that vitamin E, which is a less selective antioxidant and can be easily oxidized by both ionic and free radical mechanisms, actively interacts with ozone in blood plasma. This is another confirmation of the fact that the physiological pH values predominate the ionic mechanism.



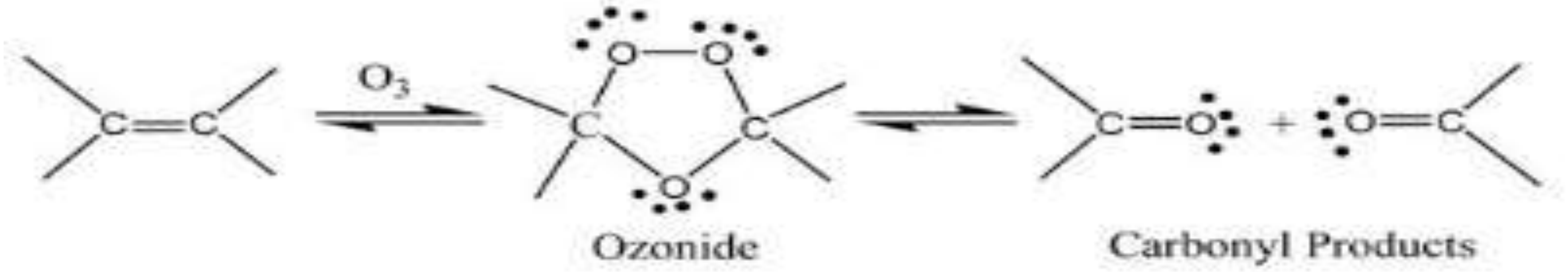
Thus, unlike most other reactive oxygen species, ozone reactions with phospholipids of cell membranes do not occur through a mechanism of free radicals, but with the formation of specific compounds - ozone.

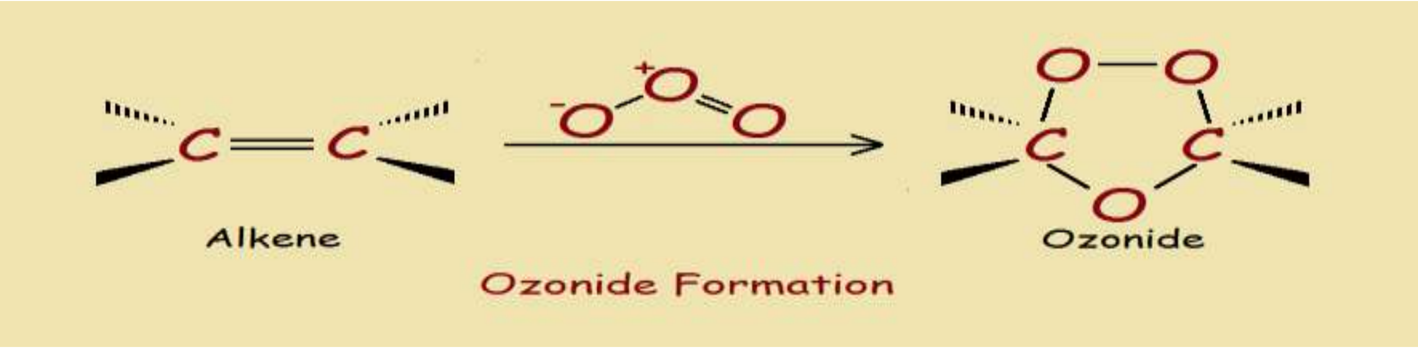
According to a number of authors, these compounds mediate most of the area of biological effect. The assumption that in order to achieve the biological effects of ozone, it is necessary to achieve a threshold concentration of ozonolizal lipid products in the cell, made it possible to explain the nature of its effect on erythrocytes and leukocytes.

It follows that excessively low doses of ozone will be ineffective, while excessively high doses will have a cytotoxic effect.

Ozone and other peroxides formed under the action of ozone are a completely different type of compounds compared to substances formed during the oxidation of free radicals.

Unlike free radicals, which are unable to penetrate the cell and react on the surface of the membrane, ozone is water soluble and penetrates slightly deep into the cell.



Unlike ozone, whose life span in the body is negligible, ozone is more stable substances. Ozonides, as secondary oxidants, have a systemic metabolic effect and have a non-specific bactericidal effect.

An important problem is the reactions of ozone with a protein molecule. Potentially, ozone is able to oxidize a protein molecule along many links, causing its oxidative degradation or a significant change in its structure and properties.

With the introduction of therapeutic ozone concentrations, there is no complete oxidation of the protein molecule, only some very active groups react with ozone.

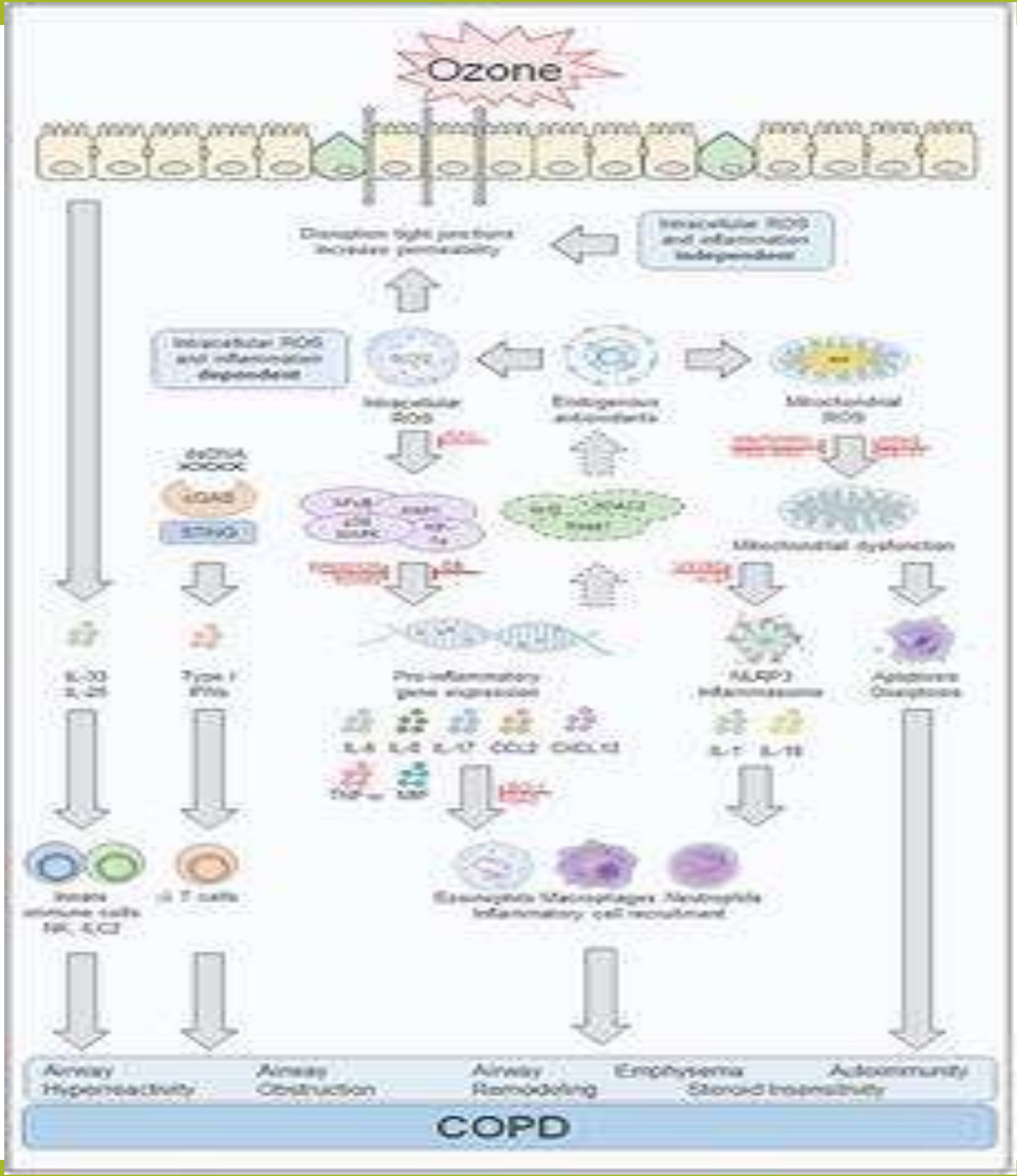
Laboratory studies on the oxidation of amino acids in a protein molecule under the action of ozone have shown that their interaction with ozone depends on the reciprocal arrangement in the tertiary or quaternary structure of the protein molecule, as well as its position in the cell membrane. It has been shown that transmembrane proteins are practically not oxidized by ozone (it is possible to actively react with phospholipids of cell membranes). Studies show that the cell wall and proteins of microorganisms interact differently with ozone compared to human cells and proteins.

Ozone oxidizes The S-H groups of methionine in the cytochrome C molecule and apparently interacts similarly to antioxidant enzymes. Plasma proteins, primarily albumin, are oxidized by ozone, but this does not lead to a significant change in their structure and properties.

With regard to the effect of ozone on enzymes, the data are contradictory, as it is determined by the non-specific effect of ozone on the protein molecule: Ozone oxidizes the available active groups in the tertiary structure of the protein and leads to the modification of the protein structure, thus altering the parameters of the enzyme's activity. These changes depend on many factors, including the dose of ozone.

Ozone mainly interacts with the active center of the enzyme, but can alter the structure of the terminal chains. The effect of ozone on proteolytic enzymes, which are activated by splitting part of the molecule, is of a different nature. In vitro, high doses of ozone can activate these enzymes by oxidative degradation of the protein molecule. This mechanism makes it possible to simulate the toxic effect of ozone and suggest methods of monitoring ozone therapy procedures. Thus, the toxic effect can be manifested by hypercoagulability and activation of proteolytic enzymes in the pancreatic tissue (however, it requires high doses of ozone, much higher than therapeutic ones).

The reaction rate of ozone with phospholipids is so high that it practically excludes its interaction with the polysaccharides of the cell membrane, ozone does not penetrate into the cell, cytoplasm and nucleus, binding completely on the surface of the membrane.



All of the above concerns the reactions of the ozone molecule itself. However, when ozone is introduced into the body, we are dealing with the simultaneous effect of ozone, molecular and atomic oxygen, as well as the intermediate products of their reactions - ozone, peroxides, free radicals, etc.

The properties of some intermediate reaction products have not yet been studied, given their instability and high chemical activity.

# SOLUBILITY AND STABILITY OF OZONE IN LIQUID MEDIA

The data on the solubility of gases in liquids is of great theoretical and practical interest.

In modeling processes involving the dissolution (absorption) of gases into liquids, these data are of primary importance.

In general, the solubility of a gas in liquids is a special case of phase balance between gaseous and liquid phases where the gaseous component is either above its critical temperature or has a vapor pressure above 1.013 bar at system temperature.

The other component will exist as a liquid and is called a solvent.

# THE SOLUBILITY OF OZONE IN LIQUID MEDIA

Solubility is the property of a solid, liquid, or gaseous chemical (called a solvent) to dissolve in a solid, liquid, or gaseous solvent. Usually we hear of oxygen or dissolved O2. It means that O2 is soluble in water. Ozone gas (O 3) is 13 times more soluble in water than O2.

Ozone is soluble in many substances, forming either stable or metastable solutions.under water-friendly conditions, ozone is more soluble than oxygen, but forms a metastable solution.

The solubility of gases in liquid media is described by Henry's law (Henry's law states that the solubility of a gas in a liquid is proportional to the pressure of the gas over the liquid). As Henry said, this law can only be applied to gases that do not change chemically in water during transfer.

Conditions that will affect the solubility of a gas in water:

Water temperature.

- Water pressure: The higher the pressure, the greater the solubility.
- Gas pressure: Pressurized gas, that is, gas that is at high pressure, being applied to water, also improves efficiency (increased pressure, will increase solubility).
- Concentration: If the gas you put in the water is in an increased concentration, this will allow for additional solubility.

The efficiency of the diffuser, the purpose of which is the transfer of ozone into water.

It is more complicated to predict the solubility of ozone than other gases, because the solubility of ozone is influenced by several factors.

The degree of solubility of ozone gas depends on the concentration of gas and therefore depends on the partial pressure.

Besides the partial pressure, other important factors influencing the solubility of ozone are temperature, PH and ion concentration in the solution.

**The solubility of ozone in water can be increased by:**

- Increase the ozone concentration in the supply gas;
- Increased air pressure;
- Decrease in water temperature;
- Decrease in the amount of dissolved substances;
- Lowering the pH.

**The table below shows the solubility of 100% ozone in pure water for the range 0°C to 60°C, these values were divided into 40, 20 and 10, respectively, to achieve solubility for ozone concentrations of 2.5%, 5% and 10%.**

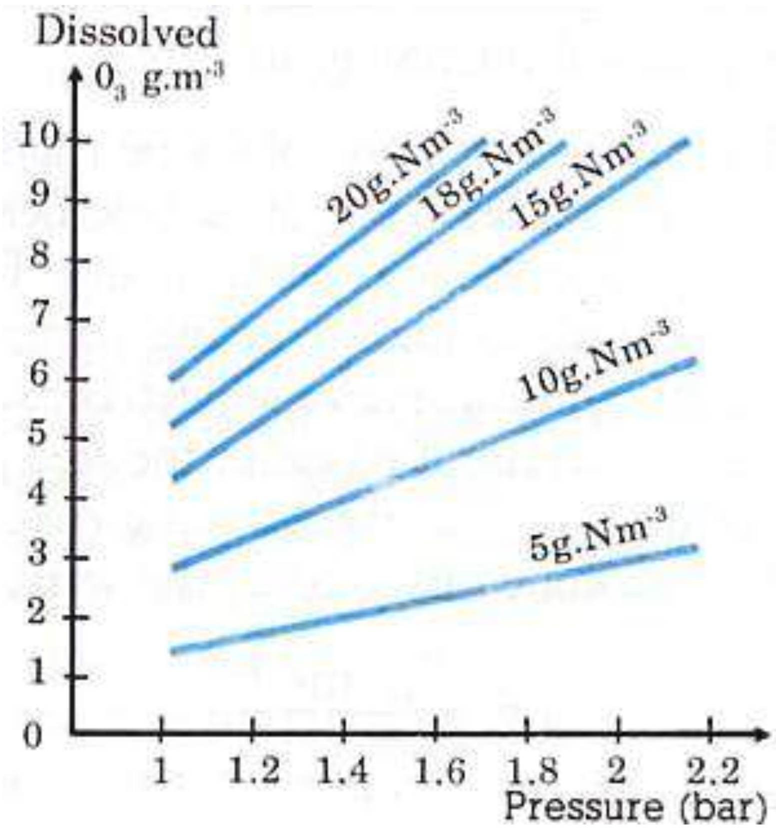
| TEMPERATURA (ºC) | MG/L 100% | MG/L (2,5% ÎN GREUTATE $O_3$) | MG/L (5% ÎN GREUTATE $O_3$) | MG/L (10% ÎN GREUTATE $O_3$) |
|---|---|---|---|---|
| **0** | 10900 | 27.25 | 54,5 | 1090 |
| **10** | 780 | 19.5 | 39,0 | 78 |
| **20** | 570 | 14.25 | 28.5 | 57 |
| **30** | 400 | 10 | 20,0 | 40 |
| **40** | 270 | 6,75 | 13.5 | 27 |
| **50** | 190 | 4,75 | 9.5 | 19 |
| **60** | 140 | 3.5 | 7.0 | 14 |

The different temperature and ozone concentration play a role in the solubility of ozone in water.this shows that a small change in water temperature can create a large difference in the ozone potential dissolved in water.also, changes in ozone concentration will dramatically change the solubility of ozone.

The table below shows the difference that water pressure causes on ozone solubility for a 6% ozone concentration and a 15°C water temperature.

| PRESIUNE A APEI | (MG/L) 6% $O_3$ LA 15ºC |
|---|---|
| **0 PSIG** (1 atm) | 26.598 |
| **5 PSIG** (1,34 atm) | 35,64132 |
| **10 PSIG** (1,68 atm) | 44,68464 |
| **15 PSIG** (2 atm) | 53.196 |
| **20 PSIG** (2,36 atm) | 62,77128 |
| **25 PSIG** (2,7 atm) | 71,8146 |
| **30 PSIG** (3 atm) | 79.794 |

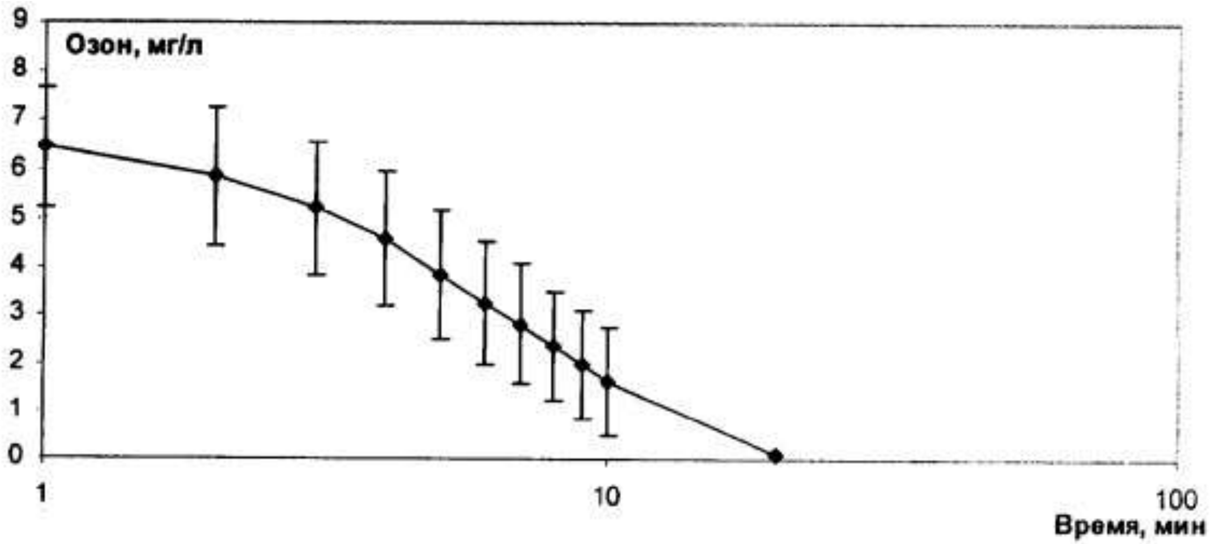
Thus, the higher the water pressure, the greater the solubility of ozone and the greater the mass transfer of ozone into water. water pressure can cause differences in gas transfer to a pure effect and faster decomposition of ozone gas.



# STABILITY OF OZONE IN LIQUID ENVIRONMENTS

Once incorporated into the liquid, ozone must remain in that liquid for some time to achieve its oxidation effect. The half-life of dissolved ozone is generally higher than this requirement. The decomposition of ozone in water (given the absence of contaminants) is produced by recombination with itself and converts ozone back into oxygen. This decomposition will be in function of: Temperature, pH and the presence of UV rays. In neutral water and at temperatures around 18ºC the stability will have an average of 20 minutes.

# Stability of ozone in liquid medium for 15 minutes at 20°C



# THE OZONE VALIDITY AND THE HALF-LIFE

One of the biggest benefits of using ozone is that there are no residues or by-products that could need to be removed. Ozone decomposes in an absolutely natural way in air or water, forming ordinary oxygen, water, carbon oxides and superior oxides of other elements.

Ozone molecules are extremely unstable, and O3 quickly converts to O2 oxygen. At the same time, in low concentrations and without impurities, it decomposes quite calmly. The higher the ozone concentration, the longer it takes to break down into oxygen.

After tests as early as the 18th century, it was revealed that in the presence of ozone, mercury loses its brightness and sticks to the glass. As a result of passing O3 through an aqueous solution of potassium iodide, iodine gas will be released.

Of course, enthusiasts tried to do the same experiments with ordinary oxygen, but nothing came out. Gradually, scientists have begun to discover the unique properties of ozone, which are only now being adopted very actively.

As it turned out, pure ozone is an excellent antiseptic that simply does its job and is spontaneously removed without harming the environment and the formation of carcinogens. This is what distinguishes ozone as a disinfectant from the same chlorine, which is often used to disinfect surfaces and drinking water.

Those experiments were an important step, the invention of the first ozonizers, which allow the disinfection of air and all surfaces in any enclosure. Since then, many devices have been created, and the possibilities of using them are continuously revealed.

After learning about the healing and disinfecting properties of ozone, many rushed to buy household ozonators, which, in addition, can be found not so expensive. It should be noted that low-power ozonizers are not suitable for disinfection, as low concentrations of ozone will begin to decompose without having time to affect harmful microorganisms. For disinfection purposes, only certified industrial ozonators are required. Their performance is hundreds of times higher than that of domestic ones.

What happens in a room where a high-quality industrial ozonator has just disinfected the air or killed harmful microorganisms?

Ozone begins to dissipate rapidly in the air, especially if ventilation is provided to accelerate natural decomposition reactions.

It turned out that after ten minutes, the ozone content in the air will decrease by about half; in water, in about half an hour O3 will decompose by half.

Концентрация озона
15
10
5
0
5
10
15
Время

Most ozone breaks down in the first few minutes. And as the concentration decreases, the rate of decomposition of ozone into oxygen also decreases.

If you return after an hour, the air in the room will be clean and saturated with oxygen, which will only benefit health and have a positive effect on performance. Only a faint smell of ozone will remain in the room. Doctors call it the “smell of health” because the room is absolutely safe, and the presence of ozone in a low concentration stimulates the human immune system.

However, it is worth considering the results of studies, according to which ozone decomposes at different speeds, depending on the finish of the room.

For example, O3 comes more in contact with rubber fabrics, carpets and surfaces, which means it doesn’t stay in the air for long. Ozone destroys itself to oxygen when it comes to a solid surface. But if plastic and ceramics are present in the finish, a high concentration will last a little longer.

Ozone in the air is much more stable than aqueous ozone solutions.

The half-life of ozone in air depends mainly on the air temperature:

| Temperature, °C | Half-life |
|---|---|
| -50 | 3 months |
| -35 | 18 days |
| -25 | 8 days |
| +20 | 3 days |
| +120 | 1.5 hours |
| +250 | 1.5 seconds |

# The half-life of ozone in the liquid medium at pH = 7:

| The half-life | The temperature of the liquid **°C** |
|---|---|
| 30 minute | 15 |
| 20 minute | 20 |
| 15 minute | 25 |
| 12 minute | 30 |
| 8 minute | 35 |

These values are based on the thermal composition. The actual half-life of ozone will be significantly shorter when it comes to organic loads, pressure, humidity and other factors. These values provide a good indication of how quickly ozone breaks down, as well as how the high temperature of the factor affects the half-life of ozone.

The temperature can have both a positive and a negative effect on the use of ozone. When the temperature is very low, the half-life of ozone is very long, however, ozone is much more stable and may not react as we suppose. Conversely, when temperatures are very high, the ozone half-life may be so short that ozone does not have time to exist, or the ozone reaction rate may not be sufficiently accelerated to create the desired reaction in a shorter time.

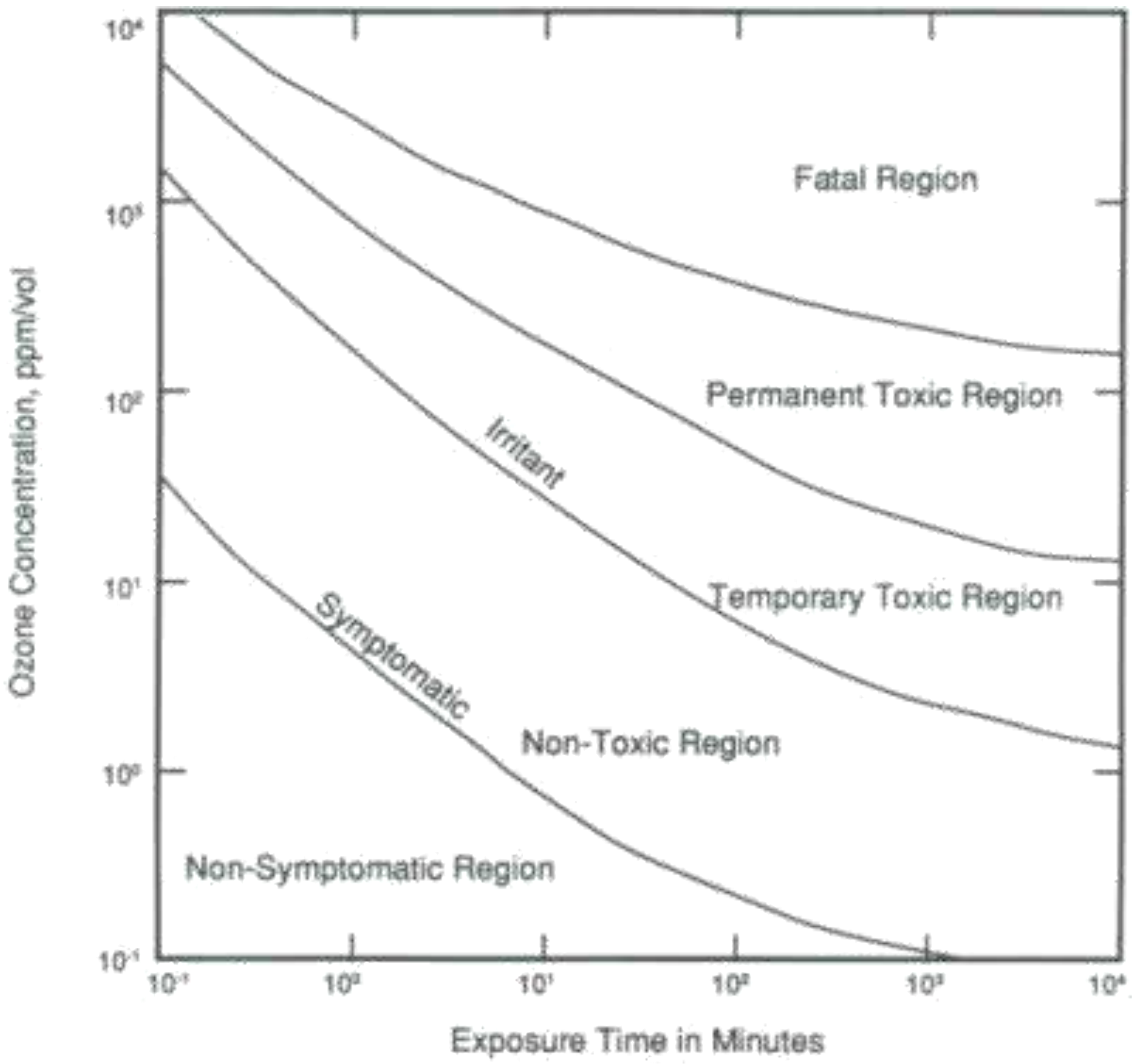
# Ozone dosing and dose selection individually

Internationally there is discussion on the topic of optimal dose in ozone therapy. Scientists are looking for an ideal formula to select the ozone dose individually for each patient.

At the moment, there is a widely recognized method for determining the individual ozone concentration.

Lymphocytes, the main components of the immune system, were chosen as the object of assessing the condition of the patient’s homeostasis.

The method for determining the level of lymphocytotoxicity was taken as the basis for the method for determining the ozone concentration effective for the body.



Fatal Region
Permanent Toxic Region
Irritant
Temporary Toxic Region
Symptomatic
Non-Toxic Region
Non-Symptomatic Region
Ozone Concentration, ppm/vol
Exposure Time in Minutes

Cytotoxicity is known to depend on the functional activity of lymphocyte receptors, the presence of the necessary amount of antibodies and lymphocyte itself.

To achieve a cytotoxic effect on lymphocytes, direct contact of antigen-specific membrane receptors with antibodies is required.

The cytotoxicity of lymphocytes is closely related to the products of oxygen-dependent metabolism.

These products primarily include a complex of free radicals - superoxide anion, hydrogen peroxide, as well as reactive oxygen species that can induce the formation of these radicals.

Because free radicals and hydrogen peroxide cause lipid peroxidation and protein denaturation, conditions are created for the lysis of cell membranes - the initial stage of the cytotoxic effect.

On the other hand, the activation of antigen-specific receptors is associated with depolarization of the plasma membranes of lymphocytes.

In this case, lipids play the role of a matrix of membrane receptors, creating the necessary conditions for their functioning. The inclusion of unsaturated fatty acids in cell membranes leads to an increase in the cytolytic capacity of cells, and saturated fatty acids to its decrease.

With the introduction of ozone into the human body, the main point of its influence are the cell membranes, in which, under the influence of ozone, the saturated fatty acid index increases, the viscosity of the membranes and the activity of the antioxidant system changes, so it has a strong effect on the reduction of cytotoxicity.

The essence of the method for determining the level of lymphocyotoxicity is that the isolated lymphocytes were treated with serum containing antibodies, then with complement, from which the antibodies were combined with membrane receptors of lymphocytes, which resulted in lymphocyte lysis.

The determination of the individual ozone dose is based on the identification of the level of lymphocytotoxicity in a given patient before and after the treatment of its lymphocytes with different ozone concentrations. When choosing an individual dose of ozone, preference is given to that, after the "treatment" of which the level of lymphocyotoxicity was minimal.

The maximum daily dose of ozone should not exceed 3.0 mg per day.

The maximum permissible ozone concentration in parenteral solutions should not exceed 20.0 mg/l.

Research has shown that at higher concentrations of ozone, destruction of tissues, blood vessels and nerve endings can occur.

Of course, dose selection depends on a very wide range of factors, some of them have been mentioned in the physical, chemical and biochemical aspects of ozone. The patient's clinic is of particular importance in the selection of the ozone dose, so the selection of the ozone dose requires a multilateral and individual approach.

# OZONE THERAPY TECHNOLOGIES IN THE ACTIVE TREATMENT SYSTEM OF SERIOUS BURNS.

High-tech healthcare for patients with severe burns has been actively based on surgical procedures including early necrotomy, accelerated preparation of lagrefa wounds, self-dermoplasty, early repair plastic surgery, skin cell grafting, Infusion-transfusion intensive therapy, efferent therapy, multicomponent drug therapy, surgical and conservative methods of post-burn treatment.

Local and systemic ozone therapy methods can be used in most of the components described as integrative treatment in patients with heavy burns.

# LOCAL OZONE THERAPY FOR THERMAL INJURIES

The primary areas of local ozone therapy in the treatment of thermal lesions are: Control of inflammation, elimination of infection and reduction of wound healing time.

Ozone can also be used due to the bactericidal, virucidal, fungicidal effect, due to the ability to stimulate tissue repair and regenerative processes.

In addition, ozone can improve the microcirculation of the wound, so it provides oxygen-rich blood flow. Full local treatment of ozone wounds ensures that necrotic tissues are removed within 5 days without necrotomy.

These procedures completely guarantee the cleansing of deep wounds of grade 3-4 after necrotomy, without enzymatic treatment. In addition, trophism of tissues improves and the viability of tissues grows, as a result, a faster reduction of the wound area is achieved.

# TREATMENT OF WOUNDS WITH AN OZON OXYGEN MIXTURE IN A PLASTIC BAG

Such a method is applicable in case of injury to the limbs.

The method consists of: A bandage moistened with saline solution or distilled water is applied to the affected area of the skin. A plastic bag (chamber) is placed on an extremity and in it is carried out irrigation of the wound with ozone.

Treatment of non-ozone-infected superficial burns aims to maintain low levels of bacteria and reduce wound contamination to facilitate self-healing. For this purpose it is sufficient to perform daily ozone treatment at 1.5-2.0 mg/L at gas flow rate of 0.5-1,0L/min and exposure time 25-30 min.

The procedures will be performed two or three times a day. The crust on the wound should not be thicker than 2 layers of gauze and should not be removed unless necessary. The general requirements will be as follows: Pre-drying the crust with preheated air.

**In the treatment of deep burns using ozone, the following three main problems are present:**

**I.wound healing.**

**II. Getting better results with self-dermoplasty.**

**III. Prevention and treatment of wounds that are difficult to heal.**

# Subcutaneous injections

Subcutaneous injections are administered with the mixture $O_3/O_2$ at a concentration of 1 mg/L to 5mg/L, are used for each injection site.

The affected area is injected in a circumferential direction at a distance of 0.5-2.0 cm from the limit of hyperemia.

Medical ozone can be injected daily or once every two days.

The duration of treatment depends on the clinic and the evolution of the pathological process.

# Intramuscular injection

Most often the application of this method to patients with burns is used when a non-clostrid or anaerobic infection is present in a wound.

When an infectious process is revealed, after wide debridement of the skin and fascia incisions, the wounds are irrigated with ozonized saline solution at an ozone concentration of 4–5 mg/L or administered using oxygen-ozone tissue microirrigators (at a concentration of 10-20 mg/L, volume of 10-20 ml).

The gas mixture is injected slowly to avoid painful reactions.

# Thank you!