Aeroionizers for Prevention of Viral Diseases

A.S. Abrahamyan, A.H. Mkrtchyan, V.E. Badoyan, R.Yu. Chilingaryan*,
M.A. Hakobyan, H.T. Hovhannisyan, S.A. Mkhitaryan

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Institute of Applied Problems of Physics of the National Academy of Sciences of the Republic of Armenia
25 Hrachya Nersisyan Str., 0014, Yerevan, Republic of Armenia

*E-mail: rychi072@gmail.com

Abstract. The article describes new types of air ionizers designed in the “Acoustophysics” laboratory of the Institute of Applied Problem of Physics of the National Academy of Sciences of the Republic of Armenia. These types of ionizers are created not only for the purpose of cleaning the air in the living and industrial areas from dust, but also fight against different types of viruses, which is especially important during periods of pandemics. The justification of the efficiency of aeroionization is given. The safety of using the developed ionizers has been shown even with continuous operation for a long time. A completely new method for testing the effectiveness of the developed ionizers is also described in detail.

Keywords: ionizer, viral disease, corona discharge

1. Introduction

Viruses are a link that connects living and non–living components of nature, one of the means by which nature controls natural selection. Outside of a biological organism, a virus is an object of inanimate nature and obeys the laws of physics and robotics. In such a dormant state, the virus can exist for a very long time, moving through space and time. When a virus meets a living organism, it attaches itself to it and starts the virus revitalization program, as they say – virus infection.

After infection, the virus is fought with medical means – vaccinations and drugs.

Any biological object always contains a huge number of viruses. And natural selection chooses the most viable biological organism with a set of viruses and bacteria inside it. And these viruses and bacteria are needed by the body and are not pathogenic. But sometimes a virus appears in nature that was not included in the "standard set" (most often it is a virus rejected in the past and we call it a retrovirus). Such a virus would be considered pathogenic.

Consider how you can fight disease–causing viruses before they enter the body.

It is usually advised to wash your hands, disinfect everything around, wear masks, ventilate the system, the rest are physical methods.

The size of viruses is ~ 10^{-9} – 10^{-8} m. The size of air molecules is usually from 10 to 100 times smaller; however, even such particles can seriously damage the virus in collisions, because they have rather high speeds. Therefore, indoors, viruses tend to travel inside dust particles and droplets of liquids and saliva that are in the room and protect them from collisions with molecules.

Masks cannot directly trap the virus itself, but they trap droplets and dust particles, so even simple masks and a scarf can effectively trap viruses. The main thing is that they must be changed frequently; dust particles with viruses accumulate in masks and the concentration of viruses increases.

Aeration of the rooms reduces the number of viruses.

But besides this there is one more method – the creation of negative air ions.

2. Justification of the expediency of aeroionization

In 1918 A.L. Chizhevsky (1897–1964) experimentally established that negative oxygen ions have a positive effect on the human body and suppress the development of pathogens [1–3].

For medical purposes, a 20–minute session of aeroionotherapy is used. The permissible single therapeutic dose is 10^{11} light ions.

Almost any device (displays, heaters, lighting devices) and people themselves create positive ions and destroy negative ones.

To create comfortable conditions, the maximum concentration of negative air ions in a room should be about $5{\cdot}10^4$ ions in 1 cm^3 of air [4].

If a lot of people are in the room, then within 30–60 minutes the number of negative oxygen ions decreases up to 20–50 per cm^3. People feel stuffiness in the room, their health and capacity for work become worse. Artificial ionization of oxygen is required.

What is the prevention of viral diseases?

Indoors, as a rule, dust particles have a positive charge. With each exhalation, a person exhales about 10^6 positively charged microdroplets. As a result, the person himself is charged negatively. Usually we do not notice this, because the charge is very small and flows down to the ground even through large leakage resistances. But a person always has this charge and negative potential. As a result, dust particles with viruses are attracted to a person and viruses from the dust particles move to a person, and infection occurs.

If a large number of negative charges are created in the air in the room, then the dust particles will attract negative charges losing their positive charge, and even charge negatively. The probability that a negatively charged dust particle with a virus will get on a negatively charged person is sharply reduced. Thus, the fight against the virus threat comes down to creating a large number of negative charges in the indoor air. In addition, dust particles can acquire a large negative charge [5]. Negatively charged dust particles and droplets will repel from a person and be attracted to grounded walls and floors. The air will be cleared and the probability of contamination will sharply decrease. Experiments carried out in different countries recently (2017) have shown that for a room with a volume of 50 m^3 for 2 hours of irradiation with ions, the dust content decreased by 100 times [6].

Thus, on the one hand, negative air ions sharply reduce the probability of infection; on the other hand, they have favorably effect on the body and enhance the protective properties of the body. The fight against a viral infection is reduced to the creation in the air of the room of a large number of air ions, preferably those of oxygen.

3. Experiment

For generation air ions, devices called ionizers are used. So far as devices and people themselves create positive ions in a room and destroy negative ones, it is enough to create only negative ions in rooms with the help of ionizers.

The simplest way to obtain negative ions in a room is corona discharge. Oxygen easily attaches the knocked–out electrons and becomes a negative O_2^- ion. Corona discharge is field electron emission. Its efficiency begins to increase noticeably at an electric field strength $> 10^6$ V / m. In order to initiate an electron avalanche, rather than individual electrons, a field of $> 5{\cdot}10^7$ V / m is required. Some of the electrons from the avalanche will combine with oxygen molecules and form negative oxygen ions. Another part of the electron avalanche will knock electrons out of neutral atoms and create positive ions that will bombard the negative electrode, knocking out secondary electrons. To obtain such high values of the electric field strength, electrodes in the form of needles are usually used. The electric field strength on the surface of the tip of such an electrode is $E = U / r$, where E is the field strength, U is the voltage, r is the radius of curvature of the needle electrode. In order to obtain an electric field strength of $5{\cdot}10^7$ V at the corona point at a voltage of 6 kV, it is necessary to have a point with a radius of curvature of the order of 100 μm.

The experiment showed that although the field strength is 50 MV or more, there is no X–ray radiation from the points of the electrodes and from the surrounding air. At a distance of several *cm* from the electrode needles, the increase in X–ray radiation compared to the natural background was no more than 1–4 quanta per second, which is less than the natural background. This is probably due to the too small point volume < 10^{-3} mm^3 and the very low corona discharge current < 10^{-7}A.

Thus, there is no danger of X–ray radiation from the above designs of air ionizers.

Corona discharge is easily obtained by high–voltage multipliers (Fig. 1). Fig. 1 shows diagrams of some such multipliers: an asymmetric Cockcroft–Walton circuit (Fig. 1a), a symmetrical circuit (Fig. 1b), and a symmetrical Halpern cascade generator circuit (Fig. 1c). Symmetrical circuits allow you to get more current. Our experiments have shown that for the purpose of air ionization, the Cockcroft–Walton scheme is sufficient, as it is simpler and cheaper. Such a 16–tree multiplier gave a voltage of 6 kV at the needle electrode at a current of 10^{-5} – 10^{-6} A. At the same time, the electron current into the surrounding space from each electrode point is < 10^{-7} A.

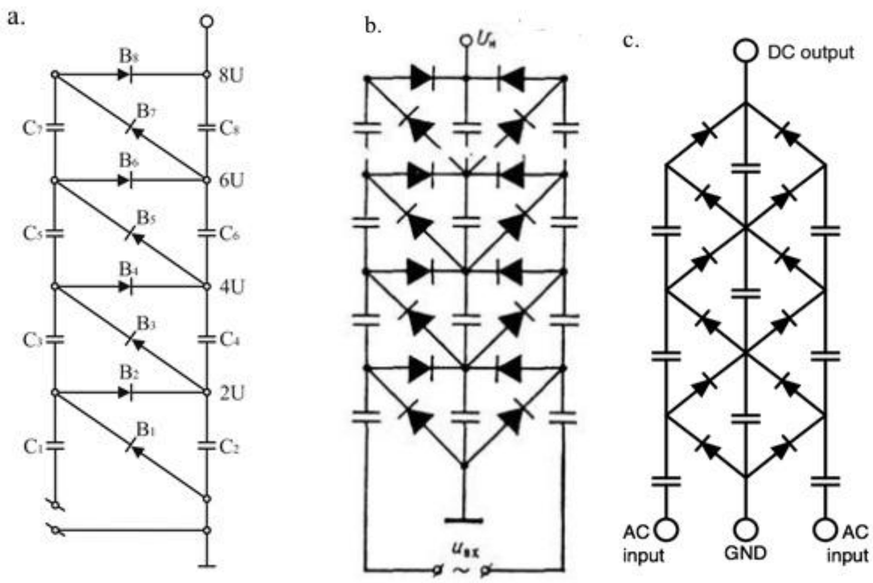

Fig. 1. Multiplier circuits: a – Asymmetrical Cockcroft–Walton scheme; b – Symmetrical circuit; c – Symmetrical Halpern cascade generator circuit.

Very often they are frightened by the appearance of some new chemical compounds in the corona discharge. It can be seen from Fig. 2 that only ozone O_3 can additionally appear in the corona discharge, and in very small quantities. At an electrode voltage of 6 kV, there is practically no ozone. These are not our data, but are taken from a huge review of data over 100 years [6]. Fig. 2 shows on the left the spectrum of particles in a natural environment and in a corona discharge on the right. Fig. 2 was made specifically to show that there is nothing dangerous in the corona discharge.

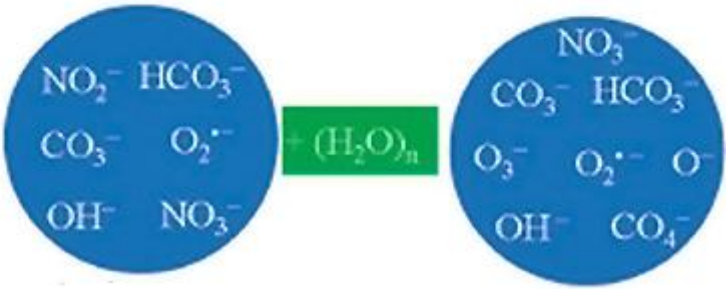

Fig. 2. Spectrum of particles: on the left in the natural environment, on the right in a corona discharge [6].

Fig. 3. Different type of ionizers: a – an ionizer for personal use; b – a cabinet ionizer–recirculator; c – an ionizer without fan with two needles; d – an ionizer with a fan and 12 needles; e – view of the lattice with needles.

Fig. 3 shows the various designs of our manufactured ionizers. On Fig. 3a is shown an ionizer for personal use, which can be switched on continuously. At a distance of 0.3 m, the concentration of negative ions and ozone is several times less than the maximum permissible.

On Fig. 3b is a cabinet–type recirculator ionizer. This is a combined device. It does ozonization, UV cleaning and air ionization at the same time. It can work when a person is in the room. It creates a clean area of approximately 9 m^2 and powered by a 220V network. Ozonization and UV cleaning takes place in a closed recirculator with a DRB–8 bactericidal lamp.

Fig. 3c shows an ionizer made in a small series (20 pcs) without a fan with two electrode needles.

Fig. 3d shows an ionizer made in a small series (40 pcs) with a fan and 12 electrode needles arranged in a lattice.

Fig. 3f shows a lattice with needles.

A feature of these ionizers is that the electrodes of the ionizers are made of tungsten wire with a diameter of 0.1 mm. The length of the needles is about 3 cm. The needles were additionally sharpened to a point with a radius of 50 μm.

4. Results and discussions

To measure the parameters of the ionizers, the designs in Fig. 3c and Fig. 3d were used.

Usually, the discharge current is measured. The concentration of particles is determined by the discharge current divided by their speed. To determine the speed of particles, use the tabular data on the mobility of particles. All these operations increase the error of the measurement. We have developed a method when the amount of charges is directly measured, i.e. the concentration is immediately measured.

By definition, the charge entering the capacitor plates creates a voltage across it. $q = CU$, where q is charge, C is capacity, U is voltage. The change in voltage ΔU can be used to measure the change in charge $\Delta q = C\Delta U$. To determine the voltage, an S–96 kilovoltmeter with a setting of 7.5 kV was used; an ion collector was attached to the high–voltage electrode – a copper disk with an area of 100 cm^2, the intrinsic capacitance of the measuring system was about 2 pF. When the voltage changes by 1 kV, the charge will change by 10^{10} electron charges. The collector was charged positevely to a voltage 6 kV so that all negatively charged particles and ions and electrons were attracted to the collector. The time of decreasing the positive charge on the collector from 4 to 2 kV was recorded, i.e., decrease in the positive charge of the capacitor due to the inflow of negative charge. Thus, it was possible to measure the negative charge entering the collector per unit of time and per area unit. Thus, the total charge coming out of both electrode needles was ~ $(1–2)\cdot 10^{10}$ electrons / sec. Current from both needles was < 0.1 μA.

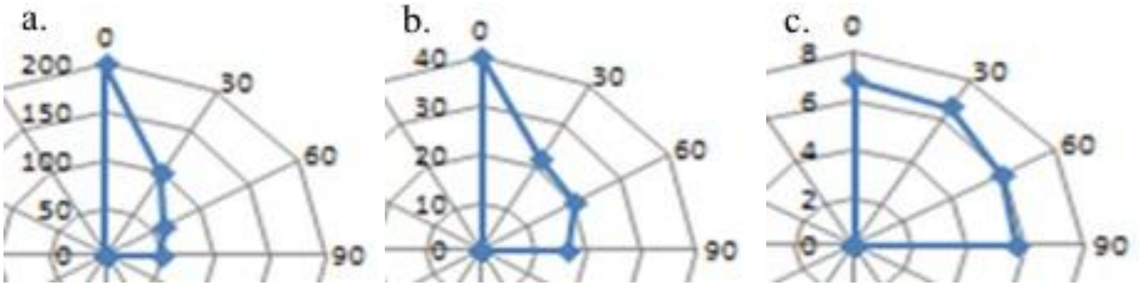

Fig. 4. Change of the directional diagram of negatively charged particles for different distances from the outlet of the ionizer for an ionizer without fan with two needles: a – 0.5m from the outlet of the ionizer, b – 1m, c – 1.5m.

Fig. 4 shows the change in the directional pattern of propagation of negatively charged particles for different distances from the outlet of the ionizer for an ionizer without fan with two needles. We see that at distances greater than 1.5 m, negatively charged particles are distributed evenly at angles from 0 to 90°. To get an approximate idea of the number of particles emitted in a given direction in 1 second, the number shown in the figure must be multiplied by 10^3, i.e. at a distance of 1m from the ionizer in the direction of 60° at an angle to the axis, the number of air ions passing through an area of 1 cm^2 in 1 sec will be about $2\cdot 10^4$.

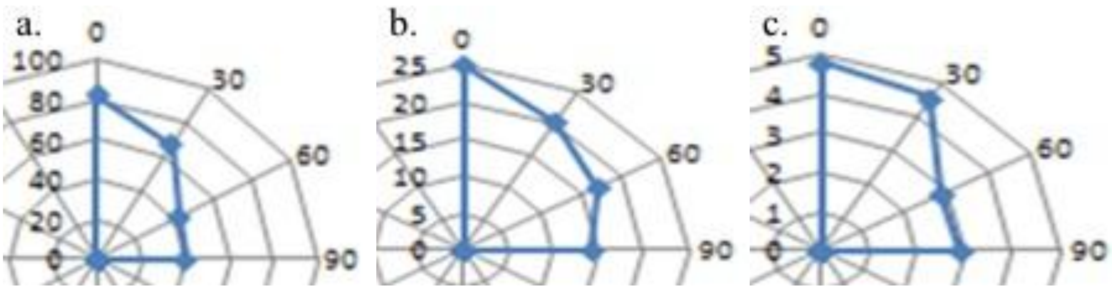

Fig. 5. Directional diagram for ionizer with a fan and 12 needles: a – 0.5m, b – 1m, c – 1.5m.

Fig. 5 shows the directional diagram for an ionizer with a fan and 12 needles. We see that the directivity is preserved even at a distance of > 1.5 m from the output aperture of the ionizer.

Fig. 6 shows the distance dependences of the speed with which ionization propagates in the room (ionization wave). The speed of the ionization wave in the air was determined by the time during which, after the ionizer was turned on, the positive voltage began to drop on the kilovoltmeter for various distances between the ionizer and the ion collector. Blue curve corresponds to an ionizer without fan with two needles, velocity in the direction of the ionizer axis (perpendicular to the exit aperture). Brown curve correspond to an ionizer with 12 needles with fan. We see that the curves differ little, i.e. the use of a fan and a large number of needles is not advantageous. The ionization wave speed does not exceed 0.5 m / s and decreases with the distance from the ionizers according to the logarithmic law (black line in Fig. 6)

$$V = -0.14 \ln(x) + 0.374, \tag{1}$$

where V is the ion speed in m / s, x is the distance from the ionizer in *meters*.

Green curve corresponds to an ionizer with a fan, the axis of the ionizer at 45° to the direction of the collector. We see that the speed of the ionization wave is lower, i.e. the fan plays a small role.

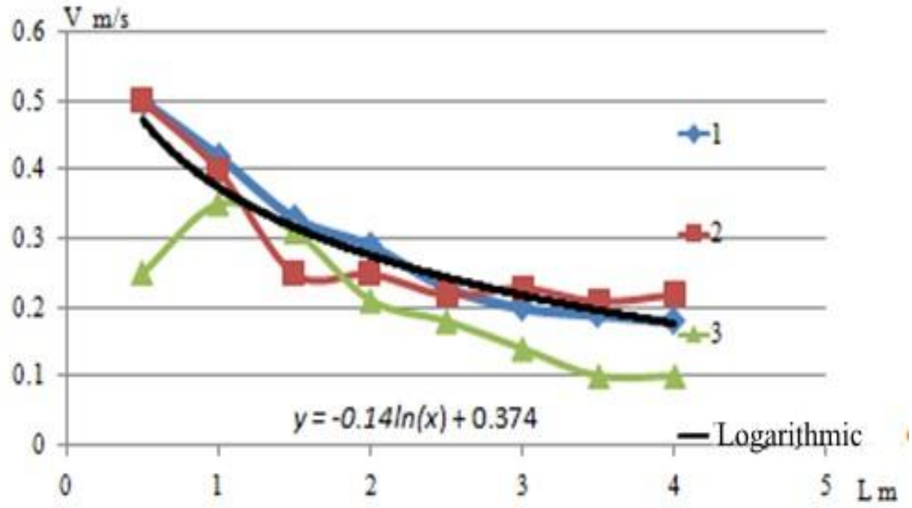

Fig. 6. Ionization wave speed: 1– ionizer with 2 needles without a fan at an angle of 0º to the axis, 2– ionizer with a fan of 12 needles at an angle of 0º to the axis, 3– ionizer with a fan of 12 needles at an angle of 45º to the axis.

We see that the ion ejected from the ionizer will be in 5 seconds at a distance of 4 m along the axis of the ionizer. At an angle of 45° between the axis of the ionizer and the direction of reception at a distance of 4 m, the ion will appear in 10 seconds. Those, we can assume that the entire room will receive negative oxygen ions rather quickly.

5. Conclusions

- Different types of ionizers are produced in different countries. They are designed to improve living conditions. But ionizers can also be used to prevent viral and other infectious diseases. Precisely prevention and not a way of 100% personal protection. In this case, the concentration should be higher, $10^5 – 10^6$ ions / cm^3. Therefore, for the prevention of viral and other infectious diseases, it is advisable to make a specially designed ionizer, specifically for the fight against viruses.

- Corona discharge ionizers are safe. They do not create ozone when the voltage across the needles is no more than 6 kV. Due to the small volume of the tips, they do not generate X–rays.
- Measurements have shown that it is more expedient to use an ionizer without fan with two needles. With the same parameters as other, it is cheaper and simpler.
- At a distance of more than 1.5 m from the ionizer, the directional diagram shows that the ion radiation is uniform within an angle of 180°.
- The speed of the ionization wave – the movement of ions from the emitting aperture does not exceed 0.5m/s and decreases with the distance from the ionizers according to the law $V = -0.14\ln(x) + 0.374$.
- The ionizer gives about 10^{10} electrons / sec. Taking into account the loss of electrons in air, on dust particles, during operation for a long time, etc., we can assume that only 10% of electrons create negative oxygen ions, i.e., the productivity of the manufactured ionizers without fans with two needles is about 10^9 ions / sec. To provide a concentration of 10^4 ions / cm^3 in a room of $50m^3$, $5 \cdot 10^{11}$ ions are required, i.e., about 10 minutes of operation of the ionizer.

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