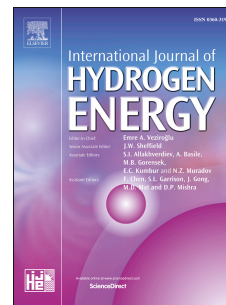


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**THE USE OF ULTRAPURE MOLECULAR HYDROGEN ENRICHED WITH
ATOMIC HYDROGEN IN APPARATUSES OF ARTIFICIAL LUNG VENTILATION
IN THE FIGHT AGAINST VIRUS COVID-19**

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Abstract

COVID-19 is a disease caused by the SARS-CoV virus. It stands for severe acute respiratory syndrome, which affects the lungs

The process of replication and progression of the COVID-19 virus causes the formation of an excessive amount of reactive oxygen species and inflammation.

Many studies have been carried out that have demonstrated that hydrogen has strong anti-inflammatory properties. It reduces hypotension and other symptoms by reducing inflammation and oxidative stress.

Oxygen mixture, enriched with Hydrogen, - helps to reduce the resistance of the respiratory tract and frees up access to the pulmonary alveolus, which improves the penetration of oxygen into the lungs. Since hydrogen is an antioxidant, it helps to reduce the burden on the immune system, helps to maintain the body's health and its ability to quickly recover.

When electrolyzers are used to produce an oxygen-hydrogen mixture, alkaline mist and other impurities can enter the patient's lungs and cause poisoning and chemical burns.

For this reason, the use of atomic hydrogen obtained from metal hydride sources for ventilation of the lungs will be more effective for treating COVID-19 than a molecular hydrogen-oxygen mixture from an electrolyzer.

A functional diagram of a metal hydride source of atomic hydrogen to an artificial lung ventilator is shown. It is possible to create a series of hydrogen storage tanks of various capacities.

Key words: COVID-19, atomic hydrogen, hydrogen, metal hydride sources, functional diagram

1. Introduction

COVID-19 is a disease caused by the SARS-CoV virus. It stands for severe acute respiratory syndrome, which affects the lungs. SARS-Co virus penetrates the lungs and attacks the pulmonary alveoli. Disruption of the environment inside the cells causes an increased level of toxic reactive oxygen particles, such as peroxides and free radicals. The human immune system uses oxidative stress to fight the virus. Reactive oxygen particles - highly oxidizing free radicals

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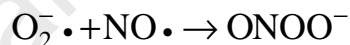
(peroxides $O_2^- \cdot$, $OH^- \cdot$ and $ONOO^-$), are capable of destroying molecules in order to suppress the activity of the virus. They help fight the virus; this is a very important role in the healing **process**. However, when this process is delayed, reactive forms of oxygen begin to accumulate, causing more and more inflammatory processes.

Excessive reactive oxygen species lead to cell destruction and the patient becomes very difficult to breathe. Alveoli begin to die and the body tries to get rid of the accumulated dead cells by coughing. A cough appears in the list of symptoms. The hypothalamus raises body temperature. A temperature appears in the list of symptoms. These processes provoke an increase in inflammation and systemic inflammation caused by the autoimmune process begins.

Superoxide $O_2^- \cdot$ belongs to the active forms of oxygen and plays a huge role in oxidative stress (Oxidative stress is the process of cell damage due to oxidation [1]). The effect of oxidative stress depends on the strength of its severity. Cells can return to their original state with minor abnormalities. However, more pronounced oxidative stress causes cell death. Superoxide kills pathogens and harmful substances. It helps and needs the body, but only in limited quantities. To avoid complications, its amount must be regulated.

Synthases of nitric oxide, NO - synthase (Eng. NO-synthase, NOS) - a group of enzymes that catalyze the formation of nitric oxide ($NO \cdot$) from arginine, oxygen and NADPH. Nitric oxide plays an important role in the body of mammals; it also participates in neurotransmission, regulation of blood circulation, and other aspects of the functioning of various organs and tissues. Nitric oxide is able to inhibit the reproduction of the virus.

The accumulation of radicals ($O_2^- \cdot$ and $NO \cdot$) leads to the formation of peroxynitrite. Peroxynitrite is a strong oxidizing agent. Due to its properties, it is capable of causing damage to a wide range of molecules in the cell, including DNA and proteins. The formation of peroxynitrite in vivo occurs as a result of the interaction of superoxide ion and nitric oxide:



Peroxynitrite produces a harmful, destructive effect that can cause death.

The hydroxyl radical ($\cdot OH$) is also dangerous. The highly reactive and short-lived radical $\cdot OH$, formed by the combination of oxygen and hydrogen atoms. It is usually formed by the interaction of excited oxygen molecules with water. The hydroxyl radical is a reactive form of oxygen and is the most active component during oxidative stress. The half-life time, $t^{1/2}$, of the hydroxyl radical in vivo is very short - about 10^{-9} s, which, combined with its high reactivity, leads to the fact that it is one of the most dangerous agents that form in the body. Unlike superoxide, which can be detoxified by superoxide dismutase, there is no enzyme that eliminates the hydroxyl radical due to its too short lifetime, which is insufficient for its diffusion into the active center of the enzyme. The only defense of the cell against this radical is a high level of low molecular weight antioxidants such as atomic hydrogen, because the hydroxyl radical instantly reacts with any oxidizable molecule in the immediate environment.

All these molecules ($O_2^- \cdot$, $\cdot OH$ and $ONOO^-$) are very dangerous for the human body.

2. USE OF HYDROGEN FOR TREATMENT OF COVID-19

At normal temperature and pressure, hydrogen is a colorless, odorless and tasteless, non-toxic diatomic gas with the chemical formula H_2 . Hydrogen plays a particularly important role in acid-base reactions. Molecular hydrogen is widely used in organic synthesis for the reduction of organic compounds. The presence of an instantaneous electric dipole moment at a hydrogen atom is expressed by a characteristic feature, manifested in its extreme reactivity and propensity for recombination. Hydrogen is able to regulate enzymes and the entire antioxidant system: it

does not react with $O_2^- \bullet$ and $NO \bullet$, but can selectively neutralize $\bullet OH$ and $ONOO^-$. That is, gaseous hydrogen acts as an excellent regulator in the body. This is the smallest molecule, smaller than the oxygen molecule, so it can easily penetrate into the cell and into the nucleus.

Many studies have been carried out that have demonstrated that hydrogen has strong anti-inflammatory properties. It reduces hypotension and other symptoms by reducing inflammation and oxidative stress [2-11].

Thus, the process of replication and progression of the COVID-19 virus causes the formation of an excessive amount of reactive oxygen species and inflammation. The body goes all the way up to cell death, multiple organ failure and death. Hydrogen gas, which is a very simple small molecule, can help the body regulate the state of the cell by selectively lowering the levels of $\bullet OH$ and ONO^- . Hydrogen regulates inflammatory processes by reducing chronic systemic inflammation.

It is important that hydrogen regulates the production of enzymes, and not just reduces or inhibits them. This is important for the human body. This is our immune system, we do not need to oppress it. This is why it is important to develop treatments for COVID-19 and similar diseases using hydrogen.

Oxygen mixture, enriched with Hydrogen, - helps to reduce the resistance of the respiratory tract and frees up access to the pulmonary alveolus, which improves the penetration of oxygen into the lungs. Only hydrogen molecules can penetrate cell membranes and eliminate toxic radicals inside cells. Since hydrogen is an antioxidant, it helps to reduce the burden on the immune system, helps to maintain the body's health and its ability to quickly recover.

3. USE OF ELECTROLYZERS TO OBTAIN OXYGEN MIXTURE ENHANCED WITH HYDROGEN: THE PROBLEM OF SOLUBILITY OF ELECTRODES AND MOLECULAR HYDROGEN

Currently, oxygen-hydrogen mixture for inhalation is prepared by electrolysis. When hydrogen is produced by electrolysis, many of the apparatus proposed use distilled water. Pure distilled water should not be subjected to electrolysis, since its electrical conductivity is very low (about $4 \cdot 10^{-8} \text{ Ohm}^{-1} \cdot \text{Cm}^{-1}$). Therefore, during electrolysis, aqueous solutions of electrolytes are used - acids, alkalis or salts (mainly KOH or NaOH). In the oxygen-hydrogen mixture obtained by electrolysis, there is always a toxic "alkaline fog".

In addition, according to physicochemical parameters, distilled water according to interstate standards (distilled water specifications) must comply with the requirements and norms indicated in the table 1.

Table 1. Physicochemical parameters, distilled water according to interstate standards

Name of indicator	Standard value
1. The mass of the residue after evaporation, mg/dm^3	≤ 5
2. Mass concentration of ammonia and ammonium salts (NH_4), mg/dm^3	$\leq 0,02$
3. Mass concentration of nitrates (NO_3), mg/dm^3	$\leq 0,2$
4. Mass concentration of sulfates (SO_4), mg/dm^3	$\leq 0,5$
5. Mass concentration of chlorides (Cl), mg/dm^3	$\leq 0,02$

6. Mass concentration of aluminum (Al), mg/dm ³	≤ 0,05
7. Mass concentration of iron (Fe), mg/dm ³	≤ 0,05
8. Mass concentration of calcium (Ca), mg/dm ³	≤ 0,8
9. Mass concentration of copper (Cu), mg/dm ³	≤ 0,02
10. Mass concentration of lead (Pb), mg/dm ³	≤ 0,05
11. Mass concentration of zinc (Zn), mg/dm ³	≤ 0,2
12. Mass concentration of substances reducing KMnO ₄ , mg/dm ³	≤ 0,08
13. pH of the water	≤ 5,4-6,6
14. Electrical conductivity at 20 ° C, S/m	≤ 5-10 ⁻⁴

This is a whole spectrum of impurities that, during electrolysis, can interact with hydrogen and oxygen atoms and be present as cations in the vapor phase.

In addition, during electrolysis, the electrodes of the electrolyzer undergo corrosion and cations of the material from which they are made are present in the solution.

Thus, getting into lungs cations can form aggressive compounds. In addition, when using electrolyzers to produce an oxygen-hydrogen mixture, alkaline fog can enter the patient's lungs and cause poisoning and chemical burns.

4. ATOMIC HYDROGEN

Under normal conditions, hydrogen molecules are inactive. The bond strength between atoms in a hydrogen molecule is 2.3 eV. To break this connection, additional energy is needed. The hydrogen coming from the metal hydride storage, leaving the metal lattice, is in an atomic state.

This means that it is already chemically active. In addition, the hydrogen atom has two times smaller geometric dimensions than the molecule. And, accordingly, twice as much penetrating ability.

For this reason, the use of atomic hydrogen obtained from metal hydride sources for ventilation of the lungs will be more effective for treating COVID-19 than a molecular hydrogen-oxygen mixture from an electrolyzer.

5. PRODUCTION OF HIGH PURITY ATOMIC HYDROGEN

For over 50 years, mankind has been trying to use the hydrogen absorption properties of metals and alloys to solve various scientific and technical problems. During this time, many chemical elements, their alloys and compounds were investigated. The features of the thermodynamics of hydrogen sorption and desorption depend on the chemical composition of the solid undergoing the hydrogenation reaction. Metal hydrides have already been found widespread use.

Interest in such compounds is due to their high hydrogen capacity. In a tank filled with metal hydride, you can store 2-3 times more hydrogen than if you would fill the same tank with liquid hydrogen. The method of storing hydrogen in a metal hydride compares favorably with compressed and cryogenic. It is safe and requires lower maintenance costs.

The key advantage of the proposed schema is the purity of hydrogen. Hydrogen during sorption by a metal lattice is subjected to deep purification. Upon desorption of an atomic hydrogen from a metal hydride, it is obtained with a purity of 99.9999%.

6. METAL HYDRIDES AS HYDROGEN STORAGE DEVICES DEVELOPED BY THE AUTHORS OF THIS ARTICLE

We have developed all kinds of modifications for metal hydride hydrogen storage devices with different designs. The intermetallic compounds used in these drives are selected based on the individual requirements for hydrogen temperature and pressure that are presented by the consumer. We usually use alloys like AB, AB₂ AB₅ and others with different impurities [12-19].

Capacities in which metal hydrides are placed are designed for pressure of 15 – 20 MPa with a double safety margin. Hydrogen from storage can be supplied at room temperature under pressure from 0.1 to 5 MPa and when heated to 100 °C - from 4 to 16 MPa. When heated to 300 °C, hydrogen can be obtained under a pressure of 20 MPa. In drives (storages) of this modification we use external and internal heat exchangers[16]. .

The storage capacity varies from tens of liters of hydrogen to several thousand. Each drive is equipped with a pressure gauge and safety valve. [16].

The pictures show desktop and laboratory hydrogen storage tanks of various capacities, of three modifications ("Alsav", "Viachbog" and "Dmisch"), designed for laboratory use complete with laboratory fuel cells. They can also be used for other purposes as sources of hydrogen (Fig. 1-9).

7. DEVELOPING OF A DEVICE WITH SOURCE OF ATOMIC HYDROGEN FOR AN ARTIFICIAL LUNG VENTILATION UNIT USED IN COVID-19 TREATMENT

Fig. 10 shows a schematic diagram of connecting an attachment with a metall hydride source of atomic hydrogen to the artificial lung ventilation apparatus used to treat COVID-19.

In this work, it is planned to use a hydrogen storage alloy made on the basis of commercial low-cost ligatures and metals of technical purity, which will significantly reduce their cost.

It is possible to create a series of hydrogen storage of various capacities [20-23]. Hydrogen accumulators can be charged and recharged both in medical facilities from standard cylinders with compressed hydrogen of technical purity, and at specialized reloading points.

8. Conclusions

Today in the world the demand for such devices exceeds one million units and this value is constantly growing.

In addition to the use inartificial lung ventilation device, metal hydride storages can be used for safe and compact storage of hydrogen, solving energy problems, hydrogen purification , hydrogen evolution from a mixture, separation of isotopes of hydrogen, compression of hydrogen, heat storage.

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Fig. 1. Vessels of modification "Viachbog"



Fig. 2. Hydrogen storage "Viachbog" with a hydrogen capacity of 3, 10, 15 and 75 liters.



Fig. 3. Vessels of "Alsav" modification.



Fig. 4. "Alsav" hydrogen storage tanks with a hydrogen capacity of 3, 10, 15, 75 and 175 liters.



Fig. 5. Vessels of modification "Dmisch".



Fig 6. Hydrogen storage "Dmisch" with a hydrogen capacity of 3, 10, 15, 75 and 175 liters.



Fig. 7. "Dmisch" hydrogen storage devices equipped with heat exchangers powered by 12V DC sources.



Fig. 8. Laboratory storage of high pressure hydrogen with a capacity of 2000 liters of hydrogen.

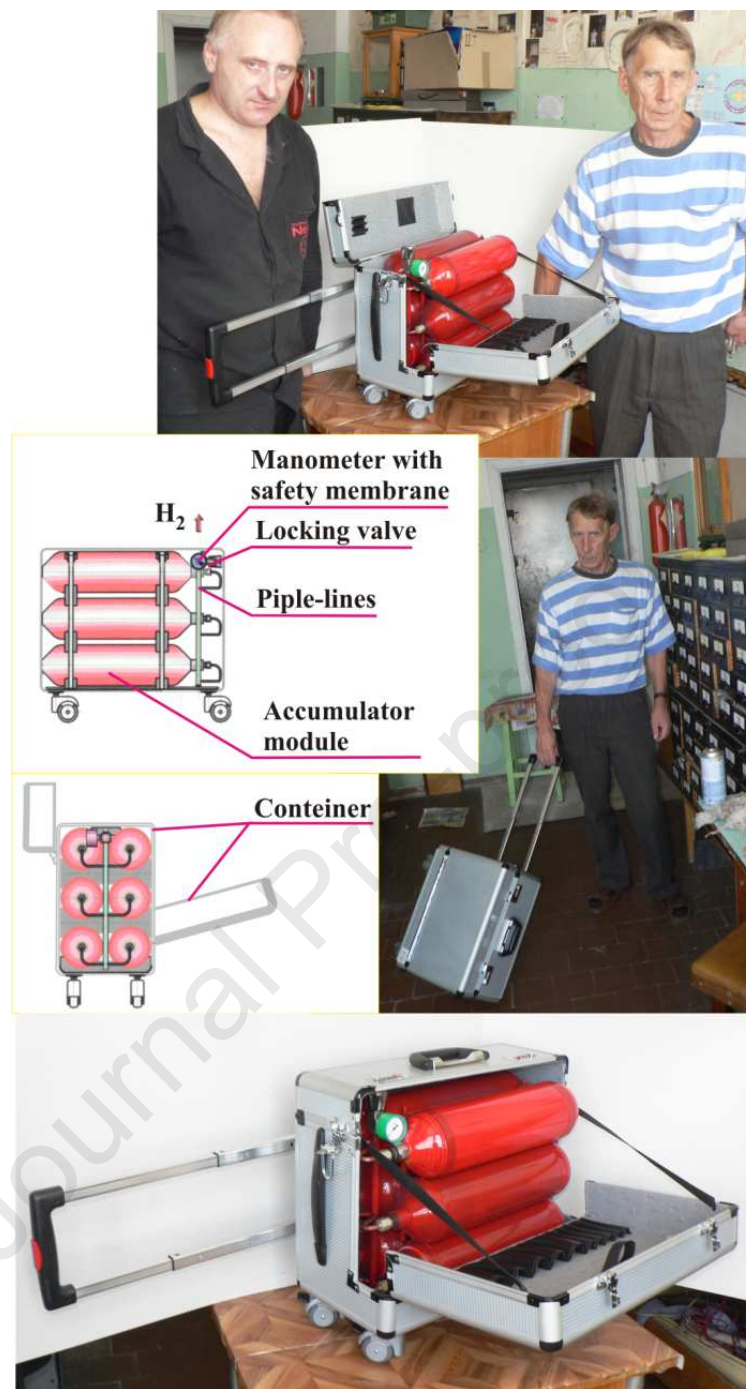


Fig. 9. Laboratory hydrogen storage low pressure with a capacity of 7000 liters of hydrogen.

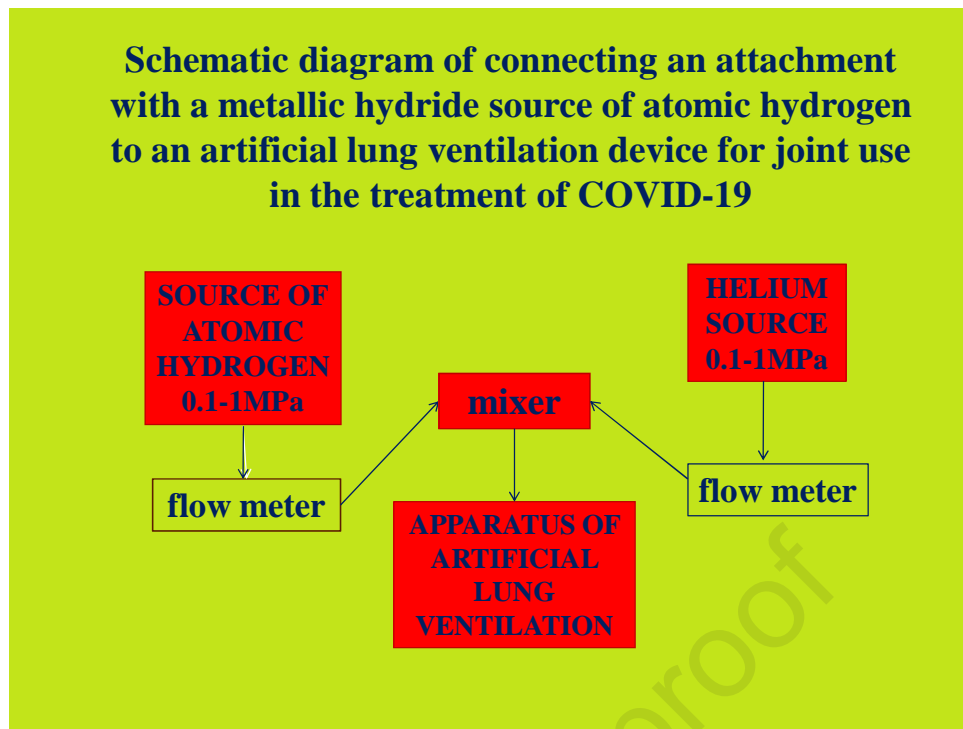


Fig. 10. Schematic diagram of connecting an attachment with a metallic hydride source of atomic hydrogen to an artificial lung ventilation device for joint use in the treatment of COVID-19.

1. COVID-19 is a disease caused by the SARS-CoV virus.
2. Since hydrogen is an antioxidant, it helps to reduce the burden on the immune system.
3. A functional diagram of a metal hydride source of atomic hydrogen is shown.
4. It is possible to create a series of hydrogen storage tanks.

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Declaration of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

No competing interests

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