LOW-TEMPERATURE OZONE STERILIZER BASED ON REACTOR WITH ELECTROLITYC CELL

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Low-temperature ozone sterilizer based on reactor with electrolytic cell for processing small-sized surgical and dental instruments has been developed. The maximal ozone concentration in water comprised 7.5 mg/l during 10 min of operation. It was revealed that the highest ozone concentration was achieved in 400 ml water volume. When increasing the volume to 600 ml, the ozone concentration in water was minimal. The method of neutralizing of alkaline solution from the surface of medical instruments was investigated. Samples for elimination of alkaline solution were processed in 1 % alcohol solution of phenolphthalein. It has been monitored that the time required to remove alkaline solution from the surface of medical instruments is not less than 20 min. The carried out experiments on removal of organic residues (blood) from medical instruments showed that the traces of blood were not presented on the surface after 10-min treatment (the "Delatest" test system was used to determine the number of blood traces).

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INTRODUCTION

Ozone has long been recognized as a useful chemical product, valuable, in particular, for its outstanding oxidative activity, bactericidal and antimicrobial properties. Due to this activity, it finds wide application in the processes of disinfection and sterilization. In fact, it kills bacteria faster than chlorine decomposing organic molecules. Ozonation can remove cyanides, phenols, iron, manganese and detergents and can destroy various viruses.

With the help of ozone sterilization, an effective control against pathogenic flora is provided, including the causative agents of especially dangerous infections: Pseudomonas Aeruginosa, Staphylococcus, Influenza virus, Hepatitis B, Tuberculosis, Klebsiella, etc. [1].

Ozone sterilization is quick and effective and in some cases, the exposure time can be measured in seconds. If the ozone concentration is insufficient, the exposure time increases up to 1…2 hours without affecting the quality of sterilization.

In terms of sterilization quality and technical characteristics, the ozone sterilizer is superior to ultraviolet sterilizers and steam autoclaves, liquid and gas sterilization. The bactericidal ozone effect within 3 to 5 min is analogous to the effect of quartz irradiation for an hour.

Sterilization with ozone is characterized by low temperature (room temperature) during the sterilization cycle, low energy consumption, it does not require chemicals to be recycled, does not require product washing or aeration after the sterilization cycle. Ozone is converted into oxygen, after the end of the sterilization cycle.

The modern method of obtaining ozone is carried out by means of a dielectric barrier discharge with the use of dry air or dry oxygen as initial gas. Ozone produced by these generators is perfectly suited for wastewater treatment, drinking water purification, etc., but has limitations when working with disinfection and sterilization systems [2-5].

The innovative and efficient way to produce ozone presented in this paper is to use an electrolytic ozone generator that divides water into basic elements and then converts some of the released oxygen into ozone.

1. EXPERIMENTAL SETUP

Ozone sterilizer with a capacity of 1 l is designed for low-temperature ozone sterilization of medical instruments (surgical, dental, plastic products, silicone, and glass). The sterilization vessel is made of stainless steel. The chamber is sealed with a lid (10 mm thick acrylic glass), which has an ozone resistant isolation. The general view of the device is shown in Fig. 1.

Fig. 1. General view of the sterilizer with electrolytic cell

As an ozone generator, an electrolytic ozone generator type as PEM-800 is used. This electrolytic system is a fundamentally different method of water dissociation because a solid polymer membrane is used as an electrolyte instead of a liquid – this feature,

combined with an appropriate controlled intermediate anode reaction, makes it particularly suitable for disinfection and sterilization of water. Ozone dissolves in water as soon as it forms – this leads to sterilization with a minimum amount of equipment.

The membrane, which functions as an electrolyte and a separator between the anode and the cathode, contacts on both sides with activated porous electrodes. As a result of the action of direct current, the water supplied to the anode side of the cell dissociates at the interface between the anode and the membrane [3].

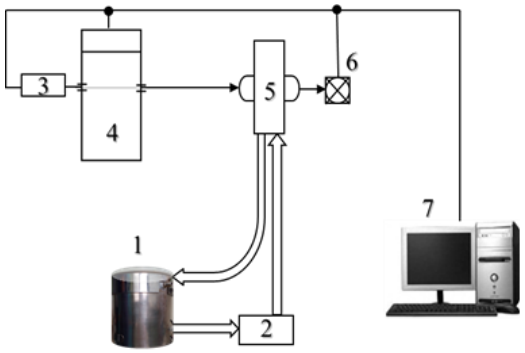

Fig. 2. Block diagram of measurement of ozone concentration in the sterilizer: 1 – sterilization chamber; 2 – water pump for circulation through the monochromator system; 3 – PMT; 4 – MDR-2; 5 – optical system with two quartz cells; 6 – UV source mercury lamp; 7 – PC

The compressor, which is part of the sterilizer, is necessary to neutralize ozone in the sterilization vessel after the sterilization process is completed. Excess portions of ozone pass into the destructor, where they decompose to oxygen and exit into the atmosphere. The concentration of ozone in the sterilization vessel was determined on an automated stand using the MDR-2 monochromator (LOMO, Russia) and the photoelectric multiplier (PMT). The scheme for measuring the ozone concentration in the sterilizer is shown in Fig. 2.

2. RESULTS AND DISCUSSION

The experiments carried out have shown that the highest ozone concentration in water in the sterilization bath was achieved in a water volume of 400 ml. When increasing the volume to 600 ml, the ozone concentration in water had a minimum value (Fig. 3). For 300 ml water volume, the ozone concentration at the initial moment increases faster, and then the ozone concentration rate tends to decrease. We speculate that this is due to the heating of water in the sterilization volume, which impairs the ozone solubility. The dependence of the water heating temperature on the water volume is shown in Fig. 4.

The rate of ozone decomposition in water was estimated using the half-life term, i.e. the time during which the ozone concentration is halved. After reaching the operating mode, in which the ozone concentration reached a maximum value and was constant, the power of the electrolytic cell was turned off (Fig. 5).

The method of neutralizing an alkaline solution on the surface of medical instruments was investigated [4]. Samples for elimination of alkaline solution were carried out with a 1 % alcohol solution of phenolphthalein.

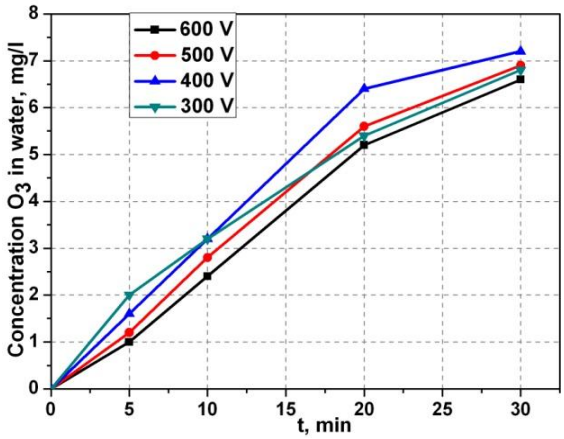

Fig. 3. Dependence of ozone concentration in water on time at different water volumes

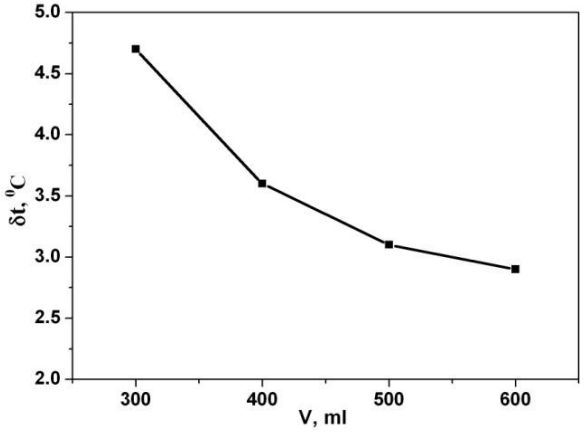

Fig. 4. Dependence of the water temperature in the sterilization bath on the volume

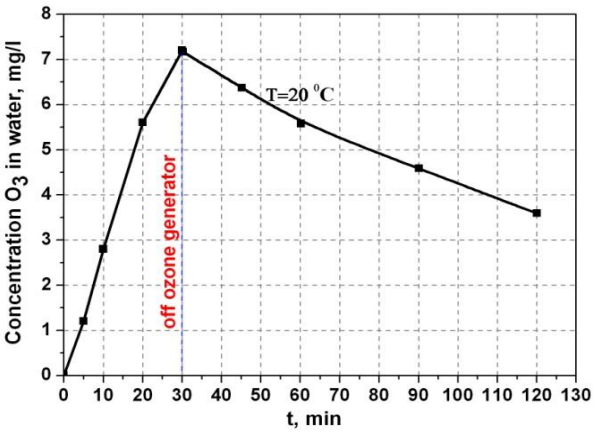

Fig. 5. Growth rate and ozone half-life

In our case, a change in color of the solution indicates the quality of the treatment. It has been established that the time required for removal of alkaline solution from the surface of the instrument is not less than 20 min.

Fig. 6 shows the visual change in color of the alkaline solution during ozonation.

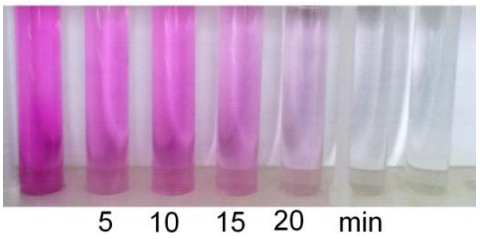

Fig. 6. Change in color of the alkaline solution during sterilization

The experiments have been carried out to eliminate organic residues (blood) from the surface of a medical instrument showed that the blood traces were not presented on the surface after 10-min treatment (the "Delatest" test system was used to determine the number of blood traces).

CONCLUSIONS

1. Low-temperature ozone sterilizer based on reactor with electrolytic cell for processing of small-sized surgical and dental instruments has been developed. Studies have shown that the highest ozone concentration in water in the sterilization bath was achieved at 400 ml. When increasing the volume of water to 600 ml, the ozone concentration is minimal.

2. The method of neutralizing of alkaline solution from the surface of a medical instrument was investigated. Samples for elimination of an alkaline solution were processed in 1% alcohol solution of phenolphthalein. It has been established that than the time required for removal of an alkaline solution from the surface of the instrument by means of ozonization, is not less than 20 min. The carried out experiments to eliminate organic residues (blood) from a medical instrument showed that the traces of blood were not presented on the surface of the instrument after a 10-min treatment (the "Delatest" test system was used to determine the number of blood traces).

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НИЗКОТЕМПЕРАТУРНЫЙ ОЗОНОВЫЙ СТЕРИЛИЗАТОР С РЕАКТОРОМ НА ОСНОВЕ ЭЛЕКТРОЛИТИЧЕСКОЙ ЯЧЕЙКИ

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Представлен низкотемпературный озоновый стерилизатор на основе реактора с электролитической ячейкой для обработки малогабаритных хирургических и стоматологических инструментов. Максимальная концентрация озона в воде составляла 7,5 мг/л в течение 10 мин. Проведенные исследования показали, что наибольшая концентрация озона в воде в емкости для стерилизации достигается при объеме воды 400 мл. При увеличении объема воды до 600 мл концентрация озона в воде имеет минимальное значение. Исследован метод нейтрализации щелочного раствора с поверхности медицинского инструмента. Образцы для удаления щелочного раствора обрабатывали 1 %-ным спиртовым раствором фенолфталеина. Установлено, что для удаления щелочного раствора с поверхности инструмента с помощью озонирования требуется время не менее 20 мин. Проведенные эксперименты по удалению органических остатков (крови) с поверхности медицинского инструмента показали, что следы крови не были обнаружены на поверхности инструмента после 10-мин обработки (для тестирования следов крови использовалась тест-система «Делатест»).

НИЗЬКОТЕМПЕРАТУРНИЙ ОЗОНОВИЙ СТЕРИЛІЗАТОР З РЕАКТОРОМ НА ОСНОВІ ЕЛЕКТРОЛІТИЧНОГО ЕЛЕМЕНТУ

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Представлений низькотемпературний озоновий стерилізатор на базі реактора з електролітичним елементом для обробки малогабаритних хірургічних та стоматологічних інструментів. Максимальна концентрація озону у воді становила 7,5 мг/л протягом 10 хв. Проведені дослідження показали, що найбільша концентрація озону у воді в ємності для стерилізації досягається при обсязі води 400 мл. При збільшенні обсягу води до 600 мл концентрація озону у воді має мінімальне значення. Досліджувався метод нейтралізації лужного розчину на поверхні медичного інструменту. Проби на усунення лужного розчину проводилися за допомогою 1 %-го спиртового розчину фенолфталеїну. Встановлено, що для усунення лужного розчину з поверхні інструменту за допомогою озонування необхідно не менше 20 хв. Проведені експерименти з усунення органічних залишків (кров) з медичного інструменту показали, що сліди крові не були представлені на поверхні інструменту після 10-хвилинної обробки (для визначення кількості слідів крові використана тестова система «Делатест»).