DEVICES FOR PRE-STERILSZATION TREATMENT OF ENDOSCOPES BY OZONE AND ULTRASOUND

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In the article, the specially designed devices for pre-sterilization treatment of laparoscopic, endoscopic and other long-length surgical equipment from organic compounds (blood and alkali) in ultrasonic tank-container with ozone has been proposed. The first device was equipped with a bath (up to 30 l), ten ultrasonic emitters with a total power 300 W, and four modular ozone generators based on dielectric barrier discharges. The second device equipped with 3.5 liter volume bath was also designed having a glass pipe 1 meter long, 8 cm in diameter with one ozone module and immersion ultrasonic emitter. During treatment, the ozonized water was injected both into the internal and external surfaces of endoscopes. The output ozone concentration reached 30 mg/l with dry air flow rate 0.3 l/min. Phenolphthalein test and "Delatest" solution method determined the remains of alkali and blood, respectively.

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INTRODUCTION

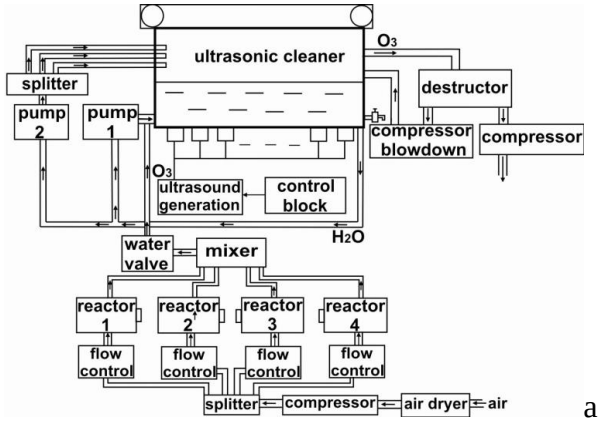
Nowadays, low-temperature disinfection and sterilization of complex-shaped medical equipment are being intensively investigated. It is well known that ozone technologies are the most promising one for low-temperature sterilization instead of ethylene oxide (EtO), hydrogen peroxide (H_2O_2) or other liquid chemical sterilization methods [1-3]. Sterilizers based on combined action of ozone and ultrasound is a key solution to complete elimination of various pollutants [4-8]. It should be noted that effectiveness of sterilization of medical equipment depends on the cleanness of the initial surfaces being treated. The necessary steps to prepare medical instruments include disinfection, pre-sterilization treatment and the following sterilization itself. The pre-sterilization step is intended to eliminate fat, alkali, blood and mechanical pollutants from the surface. Such pollutants form a so-called "protecting film" around microorganisms decreasing the influence of either thermo or chemical sterilization. This problem can be solved by using ozone and ultrasonic bath in combination with disinfecting solution applied for pre-sterilization. Ultrasonic waves spreading in aqueous medium saturated with high ozone concentrations initiate various physical phenomena: acoustic waves, cavitations, decontamination, sonoluminescence, etc. The main factors influencing effective cleaning are acoustic waves and cavitations. Special attention is paid to the method where the pre-sterilization is combined with disinfection in one process.

In the present activity, the devices for pre-sterilization treatment of medical tools with internal cavities by ozone with ultrasonic cavitations in water medium has been designed and investigated.

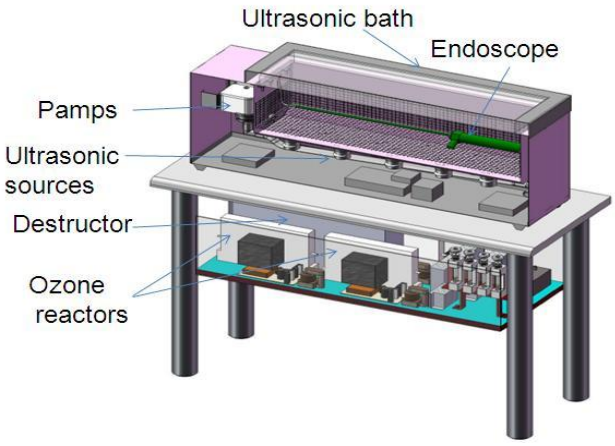
1. EXPERIMENTAL SETUP

The first device [9], the ultrasonic bath with volume 28 L (750 x170 x128 mm) has ten ultrasonic emitters with total power 300 W, and four modular ozone generators based on dielectric barrier discharges.

The schematic diagram and common view of the device for pre-sterilization treatment of endoscopes is shown in Fig. 1a,b.



a



b

Fig. 1. A – schematic diagram of device for presterilization treatment; b – common view of the device

The frequency of ultrasonic emitter comprised 30 кHz with a total power 300 W. Ozone was injected into ultrasonic bath from 4 modular ozone generators based on dielectric barrier discharges [10]. Parameters of generators were as following: 0.3 l/min at dry air

flow rate, power – 30 W, output ozone concentration – 30 mg/l.

The maximal ozone concentration in distilled water reached 6 mg/l. An additional pump was used to feed ozonized water into internal surface of endoscope.

The second device, the working chamber 3.5 liter glass tube 1 meter long and 8 cm in diameter with one ozone module and immersion ultrasonic emitter (Fig. 2).

Fig. 2. Sterilizer with glass pipe camera

These devices were equipped with ozone meters and automatic control microprocessor based system.

The ozone concentration from the reactor was measured using M454 DIN (USA) ozone monitor and photoelectric counters. Ozone concentration in water was determined by monochromatic device MDR-2 on line with PC. The treated water was analyzed by multi-monitor RNT–028. Oxidation dynamics of indigo water solution was measured by means of image analyzer based on microscope-spectrophotometer MCFU-K ("Lomo", Russia).

2. RESULTS AND DISCUSSION

In the first case, we focused on elimination of an alkali solution from the surface of endoscopic equipment. To perform pre-sterilization tests, the "Lotos" washing solution was used. The 1.5 g powder was dissolved in an ultrasonic bath filed up to 15 liters. Fig. 3 shows the change of ozone concentration in US bath.

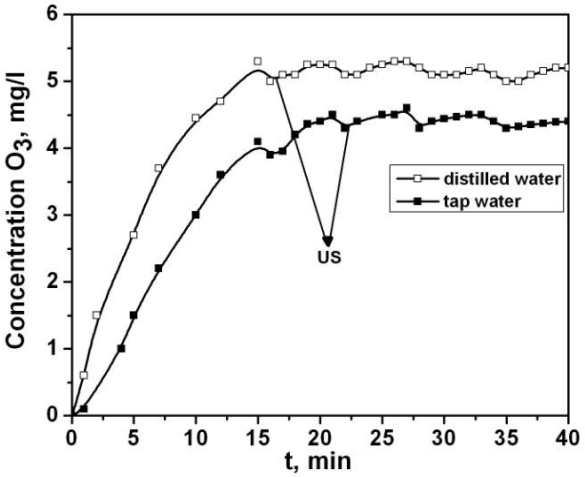


Fig. 3. Ozone concentration in ultrasonic bath with aqueous solution

Ultrasonic sources were switched at 15 min intervals during ozone injection leading to a temporary reduction of ozone concentration due to increasing the temperature of solution. Alkali elimination test was carried out every 5 min using phenolphthalein solution (Fig. 4).

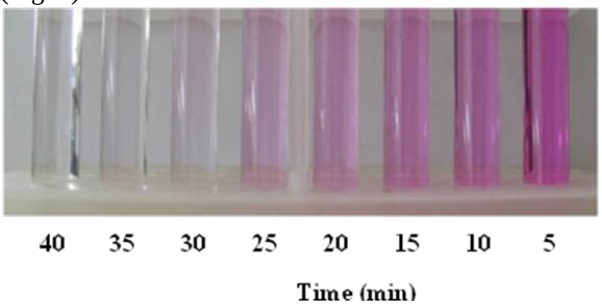


Fig. 4. Changing of the alkali solution on exposition time

In our case, the turning of the solution to a rose color indicated the quality of treatment. It was revealed that the positive result on eliminating the traces of alkali was achieved after 30 minute exposure.

It was established that to eliminate an alkali solution from the surface of endoscope by using ozone only takes 35 minutes, whereas ultrasonic washing without ozone generation do not provide elimination of alkali.

In the second case a number of experiments were carried out in order to eliminate organic residue (blood) from endoscopic equipment. We used the same technique applied for elimination of alkali. Previously contaminated tools were placed into the US bath filled with distilled water. "Delatest" test system was used to determine the amount of blood traces on the surface of treated tool. It was revealed that blood traces were still presented on the surface of the treated tool during combined action of ozone and ultrasound for 30 minutes. Total elimination of blood traces took place only after 40 min Separate ultrasonic washing do not provide positive results.

In order to test our pre-sterilization method a set of spectroscopic investigations have been carried out registering optical spectrum change of indigo solution in water. Fig. 5 shows variation of the optical spectrum in absorption of indigo solution at a water flow rate 0.3 l/min during exposition time from 10 to 60 minutes. Indigo solution absorption peak was registered at 520 nm. The absorption peak decreased with increasing the period of discharge switching on. The change in color of the indigo solution was also confirmed visually.

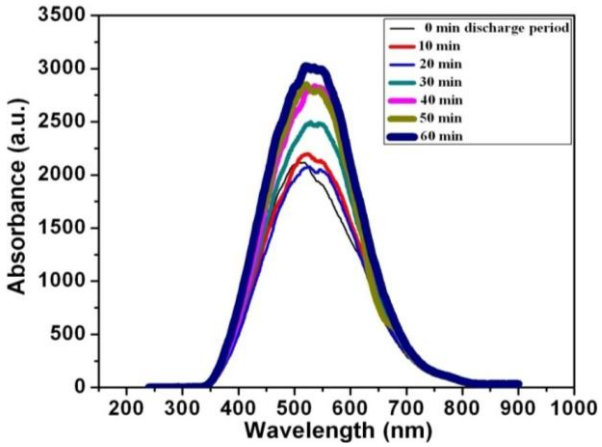


Fig. 5. Optical spectrum of indigo solution

In some cases the “Aniozim” disinfecting solution was also used in order to increase the efficiency of sterilization. Such solution is recommended by the Ministry of Health of Ukraine for pre-sterilization purposes. This solution was added into ultrasonic bath with tools contaminated with blood and alkali. After pre-sterilization during 5, 10, 15 and 20 minutes the phenolphthalein test and "Delatest" solution method do not reveal blood and alkali traces on the tools surface.

CONCLUSIONS

The device for pre-sterilization treatment of long-length surgical tools in ultrasonic bath saturated with ozone has been designed. Phenolphthalein test method and "Delatest" solution allowed determining the remains of alkali and blood, respectively. It was revealed that total elimination of alkali and blood traces from the internal and external surfaces of endoscopes in 15 l bath volume with 1.5 g “Lotos” substance took place during 30 min. It was determined that the best results have been obtained using combined effect of ozone and ultrasound, in contrast to their separate utilization.

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УСТРОЙСТВА ДЛЯ ПРЕДСТЕРИЛИЗАЦИОННОЙ ОБРАБОТКИ ЭНДОСКОПОВ ОЗОНОМ И УЛЬТРАЗВУКОМ

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Представлены специально разработанные устройства для предстерилизационной обработки лапароскопического, эндоскопического и другого длинномерного хирургического оборудования от органических соединений (крови) и щелочи в ультразвуковой ванне с озоном. Первое устройство было оснащено ванной (до 30 л), десятью ультразвуковыми излучателями с общей мощностью 300 Вт, и четырьмя модульными генераторами озона на основе диэлектрического барьерного разряда. Второе устройство – это рабочая камера, объемом 3,5 л в форме стеклянной трубы длиной 1 м и диаметром 8 см с одним модулем озона и погружным ультразвуковым излучателем. Во время обработки озонированная вода вводилась во внутренние и наружные поверхности эндоскопов. Выходная концентрация озона – 30 мг/л при скорости протока воздуха – 0,3 л/мин. Используя метод фенолфталеиновой пробы и тест-систему "Delatest" определяли остатки щелочи и крови соответственно

ПРИСТРОЇ ДЛЯ ПЕРЕДСТЕРИЛІЗАЦІЙНОЇ ОБРОБКИ ЕНДОСКОПІВ ОЗОНОМ І УЛЬТРАЗВУКОМ

В.С. Таран, В.В. Красний, О.В. Щебетун, А.С. Лозіна

Представлені спеціально розроблені пристрої для передстерилізаційної обробки лапароскопічного, ендоскопічного та іншого довгомірного хірургічного обладнання від органічних сполук (крові) і лугу в ультразвуковій ванні з озоном. Перший пристрій був оснащений ванною (до 30 л), десятьма ультразвуковими випромінювачами з загальною потужністю 300 Вт і чотирма модульними генераторами озону на основі діелектричного бар'єрного розряду. Другий пристрій - це робоча камера, об'ємом 3,5 л у формі скляної труби довжиною 1 м і діаметром 8 см з одним модулем озону і занурювальним ультразвуковим випромінювачем. Під час обробки озонована вода вводилася у внутрішні і зовнішні поверхні ендоскопів. Вихідна концентрація озону – 30 мг/л при швидкості протоку повітря – 0,3 л/хв. Використовуючи метод фенолфталеїнової проби і тест-систему "Delatest" визначали залишки лугу і крові відповідно.