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Study Generator of a Cold Plasma for Sterilization

Azat Talgatovich Gabdrakhmanov

Department of Energy and Information, Kazan Federal University
Naberezhnye Chelny, Russian Federation

Irek Husnemardanovich Israphilov

Department of Energy and Information, Kazan Federal University
Naberezhnye Chelny, Russian Federation

Azat Talgatovich Galiakbarov

Department of Energy and Information, Kazan Federal University
Naberezhnye Chelny, Russian Federation

Abstract

An effective method of sterilization and disinfection of various surfaces using cold plasma is presented in this work. The results of interaction of the cold-plasma with the test objects are presented.

Keywords: sterilization, cold plasma, electric discharge

1 Introduction

The occurrence of new medical materials based on different polymers requires quick, cheap and safe methods of their sterilization. As a rule, for sterilization use moist and dry heat, a filtration, processing by radiation and chemical biocides [1]. These methods mainly are low-productive and expensive, and also aren't always ecologically safe [2], as, for example, in case of biocides.
Another problem - the protection of industrial materials, the equipment, electronics, military and space applications, etc. from biodegradation and micro-

biologically induced corrosion. This problem is connected with damaging action of biofilms on industrial materials. Microorganisms comprising a biofilm, as we know, are very steady to usual substances of sterilization. All above-mentioned demands development of fast, safe and cheap methods of deactivation. In this regard cold plasma at atmospheric pressure, which is generated directly in liquids, gases or on the surface, can be of special interest. During treatment with cold plasma produced a wide range of environmentally sound particles (free radicals O and OH , ozone , nitrogen oxides , ultraviolet light, etc.) which destroy biologically dangerous pollutants - pathogens and chemical toxicants.
For this purpose a cold plasma generator was developed and studied for sterilizing and disinfecting surfaces [3].

2 Research facility

Figure 1 shows a diagram of a cold plasma generator. The plasma torch consists of a ceramic body 1; grid electrodes of the cathode and the anode 2; copper tube 3 for supplying electric current to the cathode and the plasma-generating gas to the discharge zone; quartz insulator 4.

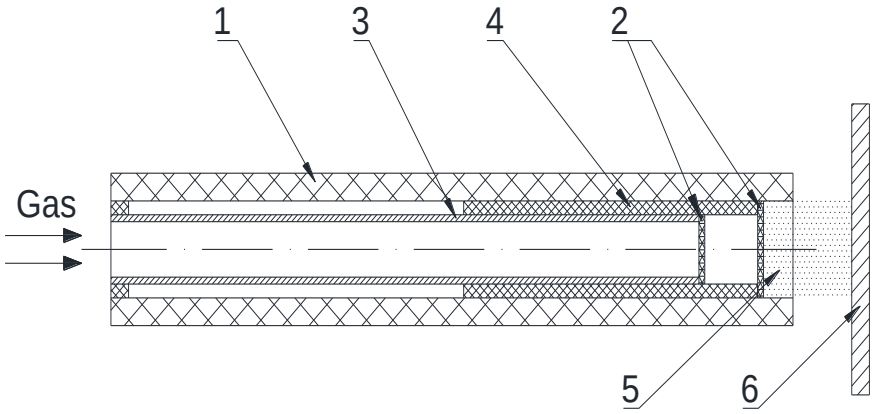


Figure 1: Cold plasma generator circuit

In this plasma generator occurs ionization of the working gas - air at atmospheric pressure using of the low power pulsed arc, which burning between two electrodes of the grids 2. Through these grid electrodes freely gets the plasma forming gas (air) to the flash chamber supplied the compressor through the brass tube.3 The discharge burns uniform over the entire on a surface of electrodes and all the supplied gas interacts with the gas which turns into a plasma. Under the influence of low-power pulsed arc electrodes are heated slightly, as the mechanism of electron emission in this case is autoelectronic and also they are actively cooled by the plasma-generating gas flow . Power consumption is less than 100 watts.

Depending on the inter-electrode gap l changing nature of the discharge, and thereby changes the efficiency of interaction of the discharge and the plasma-generating gas (Figure 2).

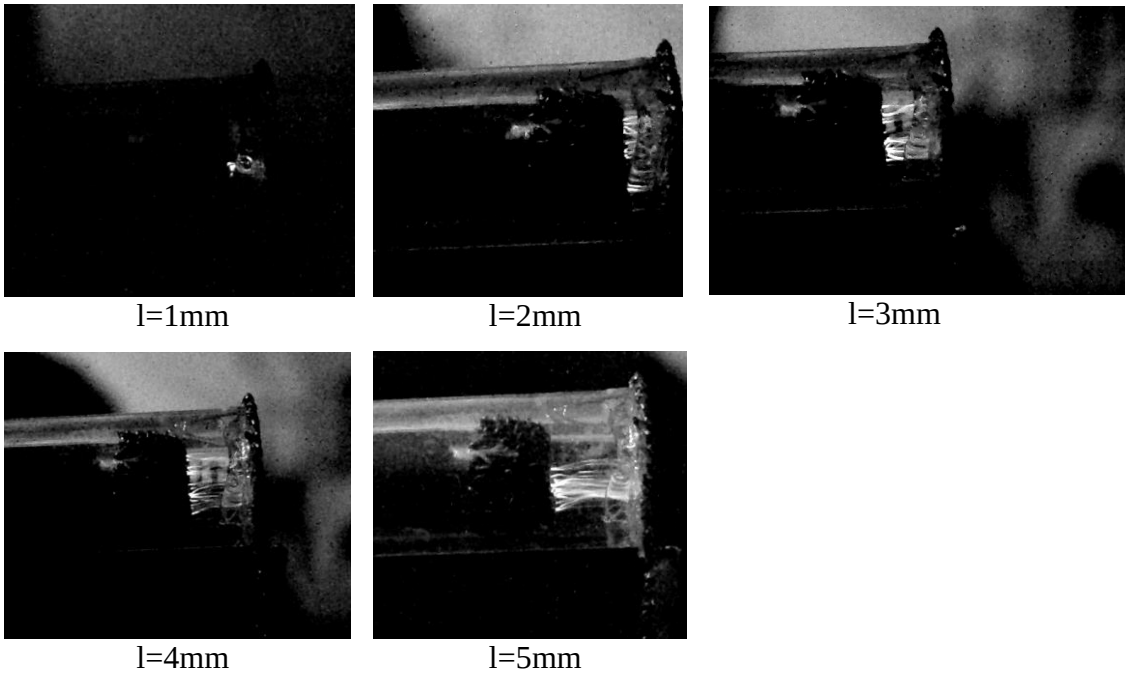


Figure 2: Photos of the discharge at different interelectrode gaps

As a result of researches was revealed that the most efficient is the interelectrode gap l = 4 mm. In this discharge gap covers almost the entire surface of the electrode , and unlike the gaps 2 and 3 mm and where the discharge occupies the large surface area of electrodes , increases the total surface interaction with gas, thereby is achieved the maximum ionization of the plasma-generating gas and the sterilizing property of plasma grows.

One of the main requirements for a cold plasma for sterilization and disinfection, is the conservation of the living tissue , it is possible at temperatures to +500 C. For this purpose, was measured the plasma temperature at the outlet of the device , the results of research are presented in Figure 3.

The initial temperature of the plasma-generating gas in all cases was +20C, the gas (air) G = 100 l/h the temperature of the plasma at the outlet does not exceed +45 C, and the maximum is at l = 4mm, which confirms the high intensity of the interaction with the gas discharge at such a gap.

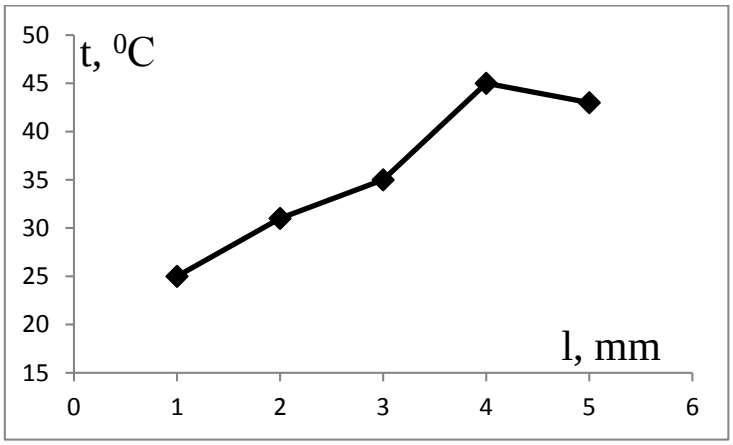


Figure 3: Temperature curve from cold plasma interelectrode gaps l.

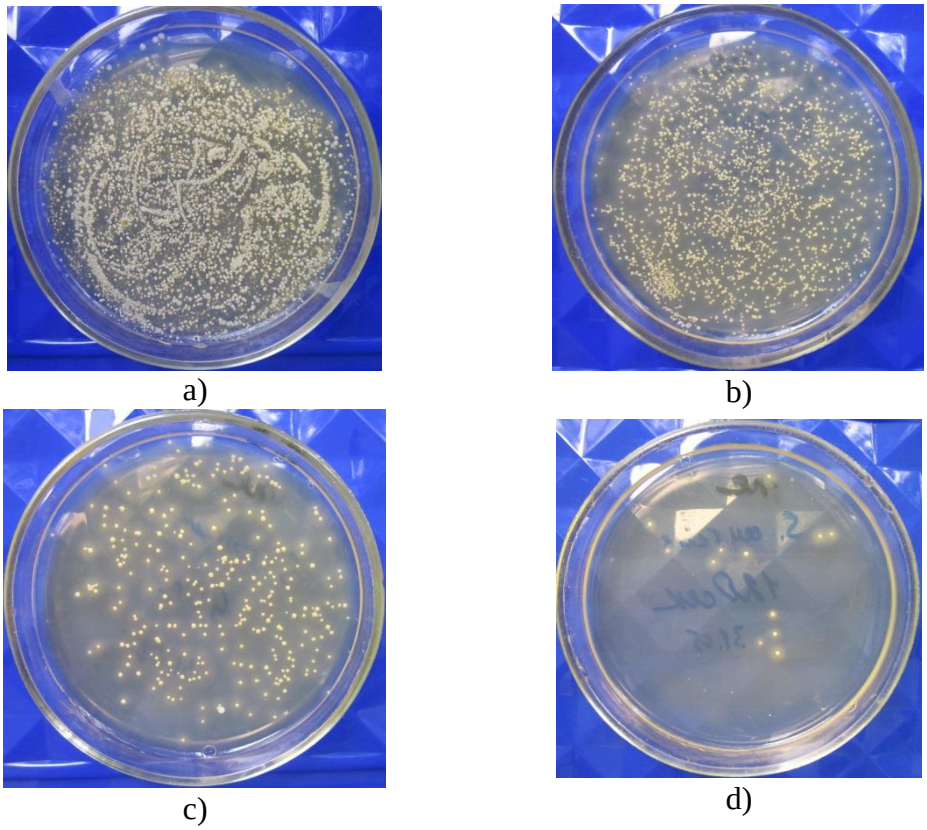
3 Results of experimental investigation

To evaluate the effectiveness of sterilization cold plasma generator , the treatment was made of cold plasma of various surfaces (test objects).

The first stage of preparation of a surface for treatment is infection with a 2-milliard suspension of test objects with microbes of cultures Staphylococcus aureus and an enteric bacterium. To infect a sterile test-objects (of 25 pieces) in a Petri dish pour 5 ml of bacterial suspension evenly moisten all test objects . The Petri dish was capped and left in the test bacterial suspension for 20 minutes. Then in aseptic conditions the cambric test objects impregnated of culture, transfer to a surface of the sterile filtered paper (2 layers at the bottom of the Petri dish), cover them from above with sterile paper and close Petri's cup a cover. For fixing of microorganisms on cambric test objects in 10 minutes after removal of excess of liquid test objects transfer to the surface of dry, sterile filter paper in the Petri dish with a sterile cover sheet on top of filter paper and dried in an oven at 37 ° C for 20 minutes with ajar lids.

After preparing the test objects , processing infected microbes surface flow of cold plasma . Test objects were treated on both sides, turning them sterilized tweezers. The duration of impact to the surface of test objects of a particular microbial species was 1, 1.5 and 2 minutes , respectively.

After the treatment, test objects were placed in a test tube with saline for 10 minutes so as to all surviving microorganisms moved into the liquid. Then inoculation was carried with 0.1 ml of suspension in a special medium (for the enteric bacterium - nutrient agar and medium Endo, for Staphylococcus aureus - nutrient agar and yolk -salt agar). So for the control of experiment were prepared control samples. Treated and control samples were placed in an incubator for incubating the microorganism of enteric bacterium for 24 hours and Staphylococcus for 48 hours (at 37 ° C). The results of the experiment are shown in Figure 4 and table 1-2.



a) b) c) d)

Figure 4: Samples after of the plasma treatment: a) the control sample of the bacteria Staphylococcus aureus without treatment; b) the sample after treatment with 60 seconds; c) the sample after treatment with 90 seconds; d) the sample after treatment with 120 seconds; microorganisms - Staphylococcus aureus.

Table 1

Colibacillus

Nutrient agar			Medium Endo		
Duration of exposure, s.	The number of colonies	Efficiency, %	Duration of exposure, s.	The number of colonies	Efficiency, %
60	1	99,24	60	1	99,21
90	1	99,24	90	1	99,21
120	1	99,24	120	1	99,21
Without treatment	132	-	Without treatment	128	-

As the enteric bacterium is a semi-pathogenic virus (less resistant culture of bacteria to different types of sterilization), processing duration in 60 seconds is sufficient to lead more than 99% of colonies to an inactivation.

Table 2

Staphylococcus aureus

Nutrient agar			Yolk-salt agar		
Duration of exposure, s.	The number of colonies	Efficiency, %	Duration of exposure, s.	The number of colonies	Efficiency, %
60	576	78,4	60	336	76,5
90	224	91,6	90	146	89,8
120	52	98,1	120	12	99,2
Without treatment	2670	-	Without treatment	1430	-

So as the Staphylococcus aureus is a pathogenic virus, the exposure time of 60 seconds is not enough to achieve high results inactivation. Increasing the processing time of the test object, high efficiency of impact is achieved.

As a result of researches it was revealed that cold plasma is an effective remedy for an inactivation of microorganisms and destroys, depending on time of influence (figure 4), to 99,3% of bacteria.

Despite the progress made in the laboratory-scale trials, the treatment with cold plasma at atmospheric pressure, not yet widely spread practice. From our point of view, new sources of cold plasma at atmospheric pressure can be widely used in medicine, to protection of industrial materials from biodegradation and biological corrosion, disinfection of food and food raw materials, processing of fabrics, envelopes, plastic films, plastic cards and other areas.

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