DBD plasma jet in helium, argon and nitrogen: energy balance and bactericidal activity

O. Stepanova[1], M. Pinchuk[2], A. Lazukin[3], O. Rybalchenko[1], O. Orlova[1], A. Astafiev[2], A. Kudryavtsev[1]

[1] *Saint Petersburg State University, Saint Petersburg, Russia*
[2] *Institute for Electrophysics and Electric Power of Russian Academy of Sciences, Saint Petersburg, Russia*
[3] *Moscow Power Engineering Institute, National Research University, Moscow, Russia*

The paper presents the experimental evaluations of bactericidal activity of dielectric-barrier discharge (DBD) plasma jets in helium, argon and nitrogen applied to *E. coli* cells freshly-inoculated on an agar surface in a grounded Petri dish. Sinusoidal high-voltage signals with the frequency of 7.5, 32 and 84 kHz were used to supply a plasma generator. The energy deposited into a discharge cell is distributed between a discharge region and a plasma jet. A balance of the energy changes with the varying of the voltage frequency. The effect of the energy balance of the system "DBD – plasma jet" on the dimensions and purity of the zones of bacterial inhibition has been considered. The biggest and the purest inhibition zones were obtained in the case of argon plasma jet. Inhibition zones formed under the nitrogen plasma jet have a heavy growth of bacteria near their boundaries. Helium plasma jets create relatively small, but pure inhibition zones.

1. Introduction

A dielectric-barrier discharge (DBD) plasma jet is usually formed in a noble gas flow which is passed through a discharge gap. Two distinct spatial regions, a main discharge and a plasma jet, can be distinguished [1]. The energy distribution between the two regions depends on whether a treated object is grounded or not. This paper presents the experimental evaluations of bactericidal activity of DBD plasma jets in helium, argon and nitrogen for the case of the grounding of an additional electrode which is located under a Petri dish with freshly-inoculated bacteria.

2. Experimental setup and procedure

To supply a DBD plasma jet generator, high-voltage sinusoidal power suppliers with a frequency of 7.5, 32 and 84 kHz were used. An electrical scheme of the experimental setup was equipped with the electrical parameters diagnostics. The energy deposited into the discharge and the energy transported to the Petri dish by the plasma jet was calculated using charge–voltage Lissajous figures. To investigate the effect of energy balance on the bactericidal activity of the plasma jet, *Escherichia coli* M17 cells freshly-inoculated on the agar nutrient medium in Petri dishes were used. The distance between the outlet of the discharge tube and agar surface was 10 mm. The duration of all treatments was 2 min.

3. Results

Bactericidal activity of the plasma jet was estimated according to the dimensions and purity of the zones of bacterial inhibition. Analysis was conducted for the zones which did not undergo heating up to the agar melting, so the modes of treatments by the jet which is close to the transition to an arc were excluded. The biggest (15-25 mm in a diameter) and the purest inhibition zones were obtained in the case of the argon plasma jet. But the argon plasma jet is easily transferred into the arc with the increasing of the voltage frequency. Inhibition zones formed under the nitrogen plasma jet are relatively large (about 15 mm on the average), but they have a heavy growth of bacteria near their boundaries - they are not pure. Helium plasma jets create small (maximal diameter is 10 mm), but pure inhibition zones. Various balances of the deposited energy have been obtained at the applying of voltages with different voltage frequencies. For example, for the helium plasma jet at frequencies of 7.5 and 32 kHz the energy deposited into the jet is higher than the amount of energy deposited into the discharge, whereas at 84 kHz this ratio is changed. For the argon plasma jet discharge energy is higher than jet's energy for the all analyzed values of voltage frequency.

The work was partially supported by Saint Petersburg State University (grant no. 0.37.218.2016) and the Russian Foundation for Basic Research (grant no. 16-08-00870).

4. References

[1] A. Shashurin, M. Keidar. Phys. Plasmas **22** (2015) 122002.