Cold Atmospheric Plasma Technology for Decontamination of Space Equipment


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Abstract

Future planned space expeditions require the compliance of the planetary protection policy [1]. Therefore, COSPAR (Committee on Space Research) defines five categories of missions with different decontamination standards [1]. The common sterilization methods like dry heat and H2O2 could have a negative effect on heat-sensitive materials [2]. In medicine, low-temperature plasma is already used for sterilization of medical equipment and proved its positive effect to human skin.

Material and Methods

Technical description and parameters

- Use of two cylindrical plasma electrodes with 12 mm diameter, manufactured by terraplasma GmbH (a)
- Flow rate of 5.5 l/min is generated by an external and chemical resistant pump (c)
- Treatment chamber 1 dimensions: 7.4 x 9.1 x 8.0 cm³ ~ 0.54 l (b)
- Treatment chamber 2 dimensions: 14.6 x 15.0 x 8.2 cm³ ~ 1.80 l (b)
- Treatment chamber 3 dimensions: 16.6 x 16.6 x 9.2 cm³ ~ 2.60 l (b)
- Flow rate of 5.5 l/min is generated by an external and chemical resistant pump (c)
- Specific conditions for sample treatment:
  - f = 10 kHz, U = 6.4 kV<sub>v</sub>, P ~ 3.6 W
  - treatment time 0.54 l: 0, 2.5, 5, 7.5 and 10 min
  - treatment time 1.8 l: 0, 2.5, 5, 7.5, 10, 15 and 20 min
  - treatment time 2.6 l: 0, 5, 10, 15, 20, and 30 min

Test description

- Samples are SIMICON bio-indicators with average plate count of 2.6 x 10<sup>5</sup> cfu of B. atrophaeus spor es ATCC 9372 on V4A stainless steel plates.
- Treatment of 3 samples at once located in a petri dish lid (b)
- Extensive protocol is necessary to solve the treated spores in liquid (alternating ultrasound and shaking)
- Filtration process allows a detection limit of 6-log reduction
- Different ozone concentrations:
  - 0.54 l volume
  - 1.8 l volume
  - 2.6 l volume

Results

Log reduction vs. treatment time for different plasma treatment volumes.

Conclusion and Outlook

- New investigations demonstrate an inactivation of B. atrophaeus about 5 log after 10 min in a 0.54 l treatment volume, about 5.5 log after 20 min in a 1.8 l treatment volume and about 5.7 log after 30 min in a 2.6 l treatment volume. This result can be explained by the decreasing of the ozone concentration due to the increasing of the treatment volume (ozone saturation in 0.54 l volume after 4 min; ozone saturation in 1.8 l volume after 6 min; ozone saturation in 2.6 l volume after 7 min).
- The predominant ozone concentration during a certain time span is responsible for the percentage of spore inactivation.
- Compared to former results of Shimizu et. al. (inactivation of 3 - 4 log after 30 min treatment time) [1], the new setup provides a significant improvement of the inactivation process. Additionally, no ozone capture device is needed.
- Further activities will concentrate on larger treatment volumes and on the influence of different plasma and humidity conditions to the samples.

References


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