

SURFACE DECONTAMINATION OF “EXOMARS-2020” MARTIAN LANDING MODULE ELEMENTS BY PULSED UV IRRADIATION

S.G. Shashkovskiy¹, E.A. Deshevaya², S.G. Kireev¹, I.A. Zhelaev¹,
A.A. Guridov², N.M. Khamidullina³, D.V. Zakharenko³, N.D. Novikova²
¹ SIE “Melitta”, Ltd., Moscow, 16/10 Miklukho-Maklaya street, 117437 GSP,
Russia

² Russian State Research Centre Institute of Biomedical Problems
of the Russian Academy of Sciences, Moscow, Khoroshevskoe Highway 76A,
123007, Russia

³ Federal State Unitary Enterprise “Scientific-Production Association
named after S.A. Lavochkin”, ROSKOSMOS, Khimki, Moscow Region,
Leningradskaya street, 24, Russia

Contact: kireevsg.melitta@gmail.com

Planetary protection is one of the key issues for heavenly bodies' exploration. The danger of transferring earth living organisms to explored planets and their satellites calls for minimizing the microbiological contamination risk for the landing modules as well as their drop and landing subsystems. As the ExoMars-2020 project includes biological experiments by means of the mars rover equipment, which is part of the landing module, the said equipment belongs to IVb type as per COSPAR classification. This places rather rigid restrictions on the allowed biological contamination level of the landing module. To comply to the planetary protection requirements a wide range of antimicrobial measures as well as a number of steps for successful mission completion are elaborated.

It is known that exposure to ultraviolet (UV) irradiation is one of efficient surfaces disinfection methods. The purpose of this study is researching the possibility of “cold” sterilization of the ExoMars-2020 landing module open surfaces by high-intensity UV irradiation of continuous spectrum.

The efficiency study of test-objects surfaces decontamination was conducted on an experimental model. A pulsed xenon lamp, placed at 20-cm' distance from the test-object, served as a continuous spectrum UV irradiation source. The average UV flow on the decontamination surface (for 200-300 nm range) was 22 W/m² at the pulsed bactericidal flow of 300 kW/m².

As test microorganisms were chosen the most UV-resistant bacteria and fungi strains, isolated from the Baikonur facilities. The initial contamination on test-objects of different materials (plastic, metal, glass, rubber and others) was from 10⁷ CFU/cm² to 10³ CFU/cm². Decontamination efficiency was assessed as per standard procedures. The exposure time to 3.3 Hz light pulses differed in the range from 0.5 to 10 minutes. The test-objects temperature after their irradiation did not exceed 45°C.

The possibility of decontaminating test-objects, previously vacuum-packed in UV transparent materials, was also studied.

It has been shown by experiments that:

- pulsed UV irradiation of continuous spectrum has a high biocidal efficiency – from 99.999% up to 100%;
- disinfection efficiency for polyethylene film packed test-objects exceeds 99.99%;
- test-object material has no effect on decontamination efficiency;
- joint impact of hydrogen peroxide vapor and pulsed UV has the most pronounced antimicrobial effect on resistant microorganism strains.

SURFACE DECONTAMINATION OF “EXOMARS-2020” MARTIAN LANDING MODULE ELEMENTS BY PULSED UV IRRADIATION

Shashkovskiy S.G.¹, Deshevaya E.A.², Kireev S.G.¹, Zhelaev I.A.¹, Guridov A.A.², Khamidullina N.M.³, Zakharenko D.V.³, Novikova N.D.²,

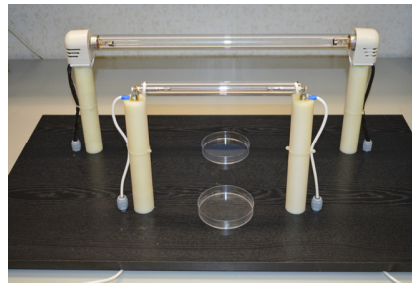
¹ SIE “Melitta”, Ltd., Moscow, 16/10 Miklukho-Maklaya street, 117437 GSP, Russia

² Russian State Research Centre Institute of Biomedical Problems of the Russian Academy of Sciences, Moscow, Khoroshevskoe Highway 76A, 123007, Russia

³ Federal State Unitary Enterprise “Scientific-Production Association named after S.A. Lavochkin”, ROSKOSMOS, Khimki, Moscow Region, Leningradskaya street, 24, Russia

The purpose of this study is researching the possibility of “cold” sterilization of the ExoMars-2020 landing module open surfaces by high-intensity UV irradiation of continuous spectrum.

TOOLS AND TECHNIQUES



Arrangement of samples irradiation

The efficiency study of test-objects surfaces decontamination was conducted on an experimental model. A pulsed xenon lamp, placed at 20-cm distance from the test-object, served as a continuous spectrum UV irradiation source. The average UV flow on the decontamination surface (for 200-300 nm range) was 22 W/m² at the pulsed bactericidal flow of 300 kW/m².

As test microorganisms were chosen the most UV-resistant bacteria and fungi strains, isolated from the Baikonur facilities. The initial contamination on test-objects of different materials (plastic, metal, glass, rubber and others) was from 10⁷ CFU/cm² to 10³ CFU/cm². Decontamination efficiency was assessed as per standard procedures. The exposure time to 3.3 Hz light pulses differed in the range from 0.5 to 10 minutes. The test-objects temperature after their irradiation did not exceed 45°C.

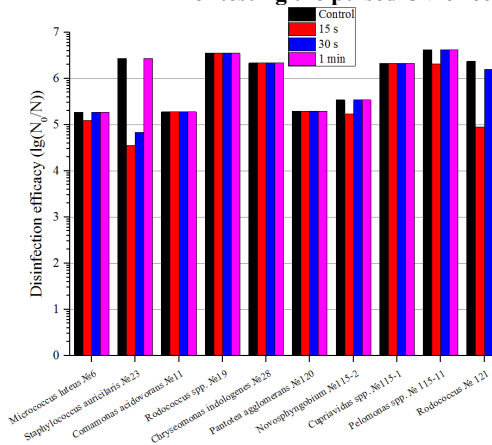
The possibility of decontaminating test-objects, previously vacuum-packed in UV transparent materials, was also studied.

It has been shown by experiments that:

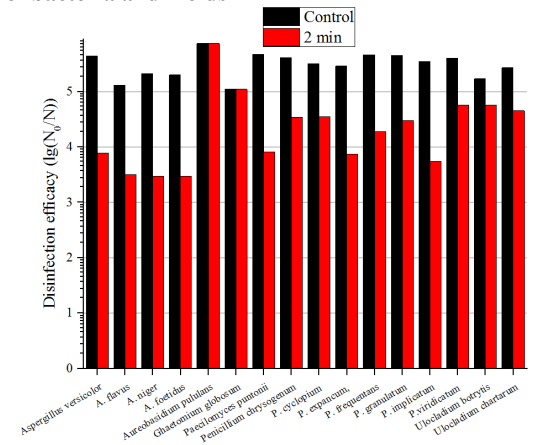
- pulsed UV irradiation of continuous spectrum has a high biocidal efficiency – from 99.999% up to 100%;
- disinfection efficiency for polyethylene film packed test-objects exceeds 99.99%;
- test-object material has no effect on decontamination efficiency;
- joint impact of hydrogen peroxide vapor and pulsed UV has the most pronounced antimicrobial effect on resistant microorganism strains.

RESULTS

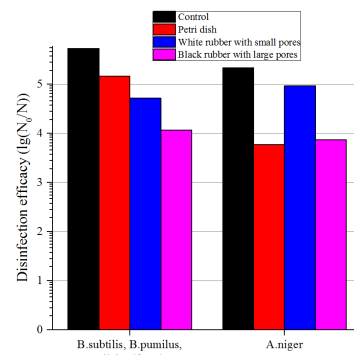
of testing the pulsed UV effectiveness against spores of bacteria and molds



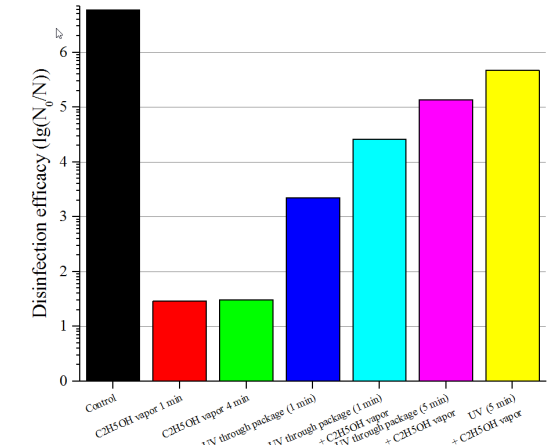
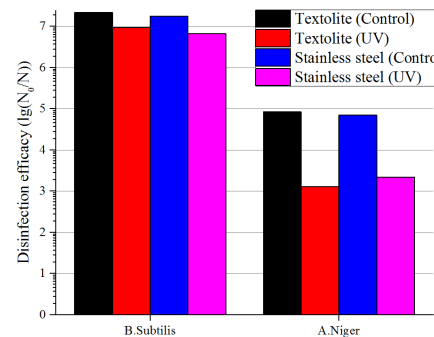
Effectiveness of the pulsed UV radiation (with continuum spectra) against bacteria



Effectiveness of the pulsed UV radiation against mold spores



Evaluation of disinfection efficacy of different material samples



Evaluation of disinfection efficacy of samples contaminated with spores *B. subtilis-51* and *B. licheniformis-73* under the combined action of UV-light and C₂H₅OH