

HYDROPHOBIC SURFACES OF SPACECRAFT COMPONENTS ENHANCE THE AGGREGATION OF MICROORGANISMS AND MAY LEAD TO HIGHER SURVIVAL RATES ON MARS.

A. C. Schuerger¹ and R. G. Kern², ¹Dynamac Corporation, Mail Code DYN-3, Kennedy Space Center, FL 32899, schueac@kscems.ksc.nasa.gov; ²Jet Propulsion Lab, Mars Exploration Directorate, Pasadena, CA 91109.

Introduction: In order to minimize the forward contamination of Mars, spacecraft are assembled under cleanroom conditions that often require several procedures to clean and sterilize components. Surface characteristics of spacecraft materials may contribute to microbial survival by protecting spores from sterilizing agents, including UV irradiation on the surface of Mars. The primary objective of this study was to evaluate the effects of surface characteristics of several spacecraft materials on the survival of *Bacillus subtilis* spores under simulated Martian conditions.

Methods: Endospores of *Bacillus subtilis* HA-101 were grown in a liquid sporulation medium, washed, and concentrated according to the procedures of Mancinelli and Klovstad [1]. Monolayers of *B. subtilis* endospores were prepared on spacecraft materials by depositing 1.25×10^6 endospores in 100 μ l of sterile deionized water (SDIW) to the upper surfaces of 1-cm² coupons. Eight spacecraft materials were used for these studies and included: two brands of uncoated aluminum 6061-T6, graphite, astroquartz, chem-film (i.e., alodine) treated aluminum, clear-anodized aluminum, black-anodized aluminum, and stainless steel. Spacecraft materials were UV-sterilized for 1 hr prior to deposition of monolayers by exposure to a Hg-lamp (254 nm) at an intensity of 6.5 W m⁻². Microdrops of suspended endospores were dried at 25 °C overnight in either a laminar flow hood or incubator.

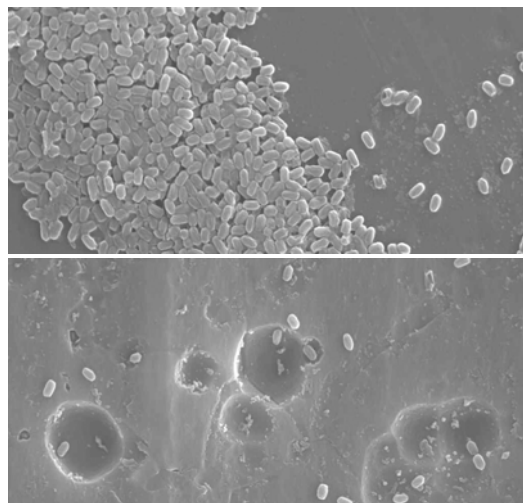
Monolayers of *B. subtilis* were then exposed to Martian conditions of pressure (8.5 mb), temperature (-10 °C), high CO₂ atmosphere, and irradiated with a Mars-normal UV-VIS-NIR spectrum. The simulations were conducted within a low-pressure Mars chamber at KSC as described elsewhere [2]. Monolayers were exposed to 1 min or 1 hr of Mars-normal UV irradiation adjusted to simulate clear-sky conditions on equatorial Mars ($\tau = 0.5$) at the mean orbital distance of Mars. Mars simulations lasted 4 hrs total elapsed time from initial evacuation of room air from within the Mars chamber to repressurization of the chamber. In addition, bacterial monolayers on all eight spacecraft materials were coated with gold and imaged with SEM.

Results: When exposed to 1 min of Mars-normal UV, the numbers of viable *B. subtilis* spores were reduced 3-4 decades for both brands of Al 6061, stainless steel, chem-film treated Al, clear-anodized Al, and black-anodized Al. In contrast, bacterial su-

vival was reduced only 1-2 decades for monolayers on graphite and astroquartz when bacterial spores were exposed to 1 min of Mars-normal UV irradiation.

When bacterial monolayers were exposed to 1 hr of Mars-normal UV irradiation, no viable bacteria were recovered from both brands of Al 6061, stainless steel, chem-film treated Al, clear-anodized Al, and black-anodized Al. In contrast, bacterial survival was reduced 2-3 decades for monolayers on graphite and astroquartz when bacterial spores were exposed to 1 hr of Mars-normal UV irradiation.

SEM images of the bacterial monolayers revealed that endospores of *B. subtilis* formed large aggregates of multi-layered spores on the hydrophobic graphite (Fig. 1A) and astroquartz materials but not on the other six spacecraft materials (Fig. 1B shows clear-anodized aluminum).



Conclusions: The higher survival rates for spores of *B. subtilis* on graphite and astroquartz were attributed to the formation of large multi-layered aggregates of spores in which the lower layers were protected from UV irradiation by the overlying cells. Aggregates of endospores formed on the hydrophobic surfaces of graphite and astroquartz but did not form on the hydrophilic materials. Results indicate that the surface characteristics of spacecraft materials may contribute to the survival of microorganisms when vehicles are landed on Mars and exposed to direct and diffuse UV irradiation.

References: [1] Mancinelli, R. L. and Klovstad, M. (2000) *Planetary Space Sci.*, 48, 1093-1097. [2] Schuerger A. C. et al., (2003) *Icarus*, [in press].