

Description of *Bacillus odysseensis* sp. nov., isolated from the Mars Odyssey spacecraft

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A round spore-forming *Bacillus* species that possesses an exosporium was isolated from surfaces of the Mars Odyssey spacecraft. This novel species was characterized on the basis of phenotypic characterization, 16S rDNA sequence analysis, and DNA-DNA hybridization. Strain 34hs-1 belongs to the genus *Bacillus* and is a Gram-positive, rod-shaped eubacterium that produces endospores. High 16S rDNA sequence similarity values were found with members of the genus *Bacillus*. The 16S rDNA sequence similarity between strain 34hs-1 and *B. fusiformis* as well as *B. silvestris* was 96%. Our assertion that strain 34hs-1 represents a distinct bacterial species within the genus *Bacillus* is supported by DNA-DNA hybridization studies (<18% reassociation value between Type strain 34hs-1<sup>T</sup> and closely related species) and proposing the name *B. odysseensis* (o.dys.se.en' sis. N.L. masc. adj. odysseensis pertaining to the Mars Odyssey [L. Odyssea] spacecraft, from which the organism was isolated).

The spores of this novel bacterial species exhibited resistance to desiccation, H<sub>2</sub>O<sub>2</sub>, UV, and  $\gamma$ -radiation conditions. Of 45 strains tested, *B. odysseensis* spores were the most consistently resistant and survived all of the challenges posed, those being exposure to conditions of desiccation (100% survival), H<sub>2</sub>O<sub>2</sub> (26% survival), UV (10% survival at 660 J/m<sup>2</sup>), and  $\gamma$ -radiation (0.4% survival). Ultra thin sections of *B. odysseensis* spores showed the presence of an exosporium, spore coat, cortex, and core. Microscopic analyses revealed the destruction of *B. odysseensis* spores by  $\gamma$ -radiation while the remnants of exosporia were left behind, whereas spores oxidized by H<sub>2</sub>O<sub>2</sub> formed "doughnut-like" structures. Further analysis showed highly-electron dense structures in the exosporia when compared to the H<sub>2</sub>O<sub>2</sub>-untreated control. The presence of an exosporium in spores of *B. odysseensis* is presumed to play a role in its elevated resistance properties; however, other exosporium-bearing *Bacillus* species isolated in this study such as *B. cereus* and *B. thuringiensis*, along with their representative type strains, were susceptible to  $\gamma$ -radiation and H<sub>2</sub>O<sub>2</sub>.