IAF SPACE EXPLORATION SYMPOSIUM (A3)
Interactive Presentations - IAF SPACE EXPLORATION SYMPOSIUM (IP)

Author: Mr. Ankush Sookram
Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia

Dr. Susan Holmes
Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia
Prof. Stuart Bateman
Royal Melbourne Institute of Technology (RMIT) University, Australia
Dr. Ranya Simons
Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia
Dr. Tu Le
Royal Melbourne Institute of Technology (RMIT) University, Australia

EVALUATING THE ROLES OF SURFACE ENERGY AND ROUGHNESS IN LUNAR DUST ADHESION USING ALUMINIUM AS A TESTBED

Abstract

Lunar dust consists of fine and highly abrasive particles that carry an electrostatic charge and poses a major challenge to lunar exploration missions. When adhering to spacecraft and equipment surfaces, lunar dust can hinder instrument performance, cause mechanical wear in joints and seals, and compromise thermal control systems. Although both surface chemistry and topography play key roles in dust adhesion, the contribution of these two factors under lunarlike conditions remains poorly understood. To address this knowledge gap, our study uses aluminium as a testbed material to evaluate the roles of surface roughness and surface energy. Although aluminium is not the only material used in lunar missions, it is common in structural space components, making it an ideal baseline for dust–mitigation research. We applied hot water treatment (HWT) to generate nanostructured boehmite (γ–AlO(OH)) layers, thereby changing both roughness and surface energy in a controlled manner. Additionally, we prepared mechanically roughened samples, which replicate topographical changes while keeping the surface chemistry constant, as well as hydrophobic—coated HWT samples to isolate the influence of surface energy from topography. A range of characterisation techniques is employed to investigate the effects of each treatment. Scanning electron microscopy (SEM) and atomic force microscopy (AFM) reveal topographical changes, while X–ray photoelectron spectroscopy (XPS) and water contact angle (WCA) analyses confirm changes in surface chemistry and wettability. Dust adhesion tests are carried out using a lunar dust simulant under controlled laboratory conditions, highlighting the extent to which each surface modification enhance or inhibit dust adhesion. We then employed image analysis to quantify dust adhesion. Rather than proposing a novel coating solution, this research aims to deepen our fundamental understanding of lunar dust adhesion mechanisms. Preliminary observations suggest that both increased roughness and altered surface chemistry can significantly influence dust adhesion; however, their relationship is complex and requires further investigation. By understanding how each parameter independently affects adhesion, we aim to guide the design of dust–resistant materials for spacecraft surfaces, lunar habitats, and rover components. The insights gained here will ultimately support the development of durable materials capable of withstanding dusty extraterrestrial environments, thereby enhancing mission reliability.