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HELIUM ION IMPLANTATION INTO JSC-1A LUNAR REGOLITH SIMULANT FOR A VOLATILES EXTRACTION EXPERIMENT

Abstract

A prototype volatiles extraction system is being developed to demonstrate a process for acquiring helium-3 from mare region lunar regolith. This helium-3 would be used to fuel future fusion power plants that would produce little to no radioactive waste. From another perspective, helium-3 is only a small portion of the volatiles released from the extraction process being investigated. Hydrogen, helium-4, carbon dioxide, carbon monoxide, methane, nitrogen, and water (from hydrogen reduction within the extraction system) are by-products of the process. These volatiles could be vital in supporting people in space (space stations, Lunar or Martian outposts) for extended periods of time. Before demonstrating the evolution of helium-3 out of regolith simulant, simulant that is embedded to a known concentration must be available in order to gauge the performance of the extraction system. Beyond the Apollo and Lunakhod lunar soil samples, there is no regolith or regolith simulant that has already been implanted with solar wind volatiles that is available for experimental studies. An implantation device is being developed to implant helium-4 into batches of JSC-1A simulant. Helium-3 will only be used after the device's operational performance is completely tested in order to keep costs down. In a dc glow discharge an electrical potential, or voltage, is held between two parallel electrodes (plates) under a controlled pressure environment. Empirical results have given curves of the required breakdown voltage to start a glow discharge as a function of the product of pressure and distance between the electrodes for a given gas. These curves are referred to as Paschen curves. For helium ions to implant in regolith simulant with approximately the same average energy as the helium ions do on the lunar surface, an 8 kV potential is required. Using this as the breakdown voltage, a pressure-distance product (Pd) can be determined. It should be noted that Paschen curves are nonlinear and that there are actually two different pressure-distance products that could initiate the glow discharge at an 8 kV breakdown voltage. To avoid the additional cost of using a high vacuum system for the implantation device, the larger pressure-distance product of 933 Pa-m was selected. The preliminary design utilizes a borosilicate glass bell jar as the vacuum chamber. The concept of the implantation device is that regolith will be implanted with helium when it flows out of a wedge shaped hopper and between the electrodes.