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Verification and Development Simulating UV Irradiation in Space with an In-Situ Friction Experiment Device

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Introduction

During orbit, space equipment is exposed to severe solar radiation. Electromagnetic waves with wavelengths ranging from 1014 m for rays to 104 m for radio waves make up the solar radiation spectrum. The solar radiation energy is enormous, and the solar constant may be used to quantify it. It is defined as the total radiant energy per unit area of the outer edge of the atmosphere perpendicular to the solar rays at the mean distance between the sun and the earth within a unit period, which is around 1353 21 W/m2. UV light with a wavelength of 100400 nm produces around 117.7 W/m2 of energy in the solar radiation spectrum, accounting for just 8.7% of total solar radiation energy, but it has a significant influence on the characteristics of materials, particularly polymer materials. UV radiation may be further separated into vacuum ultraviolet radiation with a wavelength of less than 200 nm, medium ultraviolet radiation with a wavelength of 200–320 nm, and near-ultraviolet radiation with a wavelength of 320–400 nm, based on the properties of photons of different wavelengths. Finally, the UV irradiated in-situ friction experimental device's validation tests were detailed. The in-situ ultraviolet irradiation device was found to achieve the expected irradiation effect, and the irradiation would lead to changes in the surface structure and properties of the PTFE material, while also achieving the need for in-situ spatial friction property testing of the material, providing favorable conditions for future testing.

The atmospheric composition, gas pressure, temperature, humidity, and UV radiation levels on the Martian surface differ dramatically from those on Earth. Environmental conditions are directly connected to the mineral phases and spectral properties of various Martian minerals. Some hydrated minerals, for example, gain or lose structural water, and water's Raman peak moves or deforms in response to low temperatures. Environmental factors, on the other hand, have a big influence on some measuring procedures. The spectrum signature of Laser-Induced Breakdown Spectroscopy (LIBS) is highly dependent on the gas species and gas pressure around the target. As a result, environmental simulation is essential for Martian mineral identification and analysis; it is also the only practical means to simulate Martian circumstances in the lab and analyse genuine Martian data. As a result, the ChemCam and SuperCam teams calibrated and recalibrated their LIBS prediction model using simulated Mars conditions before and throughout the mission. Indeed, planetary simulation chambers have seen significant advancements in methodological models and instrumental designs as a result of their indispensable role, allowing for a variety of simulated experiments involving Mars, the Moon, and asteroid/cometary/solar system small bodies for mineral analysis, astrobiology, instrument calibration/materials testing, planetary exploration studies, and so on.

According to the design indexes above, the developed space UV irradiation device should not only cover the entire UV spectrum range as much as possible but also recognize that the radiation intensity is far greater than that of the sun in the same wavelength range, to conduct accelerated tests. Using twin light sources, it is

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proposed to replicate vacuum UV radiation, near UV radiation, and medium UV radiation, respectively. The deuterium lamp is immediately hung in the vacuum chamber and near the sample table for simulation since short-wavelength vacuum UV rays cannot travel through the quartz window and are quickly absorbed by the air. To simulate the near UV radiation device, a special light source and light path transformation mechanism are used. UV irradiation has a significant impact on material characteristics. Solar ultraviolet irradiation in space will have a significant impact on the tribological properties of solid lubricants such as polymer self-lubricating coatings, MoS2 coatings, and diamond-like films, particularly some polymer materials. However, these polymer materials have good mechanical properties, high wear resistance, excellent self-lubricating properties, chemical stability, and many other advantages, and are widely used in the aerospace field, so researchers are interested. The first is to simulate the test on the ground, which is currently the best means of studying the impact of space environmental factors on materials and is usually designed as a kind of accelerated test, simulating the environment on the ground for a week, and this is not a conventional test. The second is to simulate the test on the ground, which is currently the best means of studying the impact of space environmental factors on materials and is usually designed as a kind of accelerated test, simulating the environment on the ground is comparable to tens to hundreds of weeks of vehicle exposure in orbit, ensuring a longer service life for the spacecraft. The Marshall Space Flight Center of NASA completed the design and put into service the CEETC2 and CEETC3 systems in 1990 and 1996, respectively, and conducted ground simulation testing of space UV radiation. Sugimura investigated the effects of vacuum UV irradiation on the performance of organic silane self-assembled monolayers. Tokoroyaman was used to test the UV radiation resistance of different carbon films. The wavelength of the vacuum ultraviolet beam utilized was 172 nm, and the irradiation intensity was 100 W/m2, which was roughly 1 times the solar constant. UV rays of 254, 312, and 365 nm can be emitted by the apparatus. Because being able to generate only one wavelength of ultraviolet radiation is insufficient for simulating the environment in space, Zhang built a set of space UV simulation equipment in 1995. A novel form of simulated space UV irradiation apparatus was constructed in this study by several efforts, including light source selection and optical route design, to produce ultraviolet rays that match the ultraviolet spectrum of solar light. At the same time, the device may be utilized with the current MSTS-1 vacuum friction and wear tester, which meets the requirements for space UV irradiation simulation and in-situ tribological performance testing. Polytetrafluoroethylene (PTFE) material is used to test and verify the device's operation.

A novel form of simulated space UV irradiation apparatus was constructed in this study by several efforts, including light source selection and optical route design, to produce ultraviolet rays that match the ultraviolet spectrum of solar light. The device may also be utilized in conjunction with the current MSTS-1 vacuum friction and wear tester, which meets the criteria for space UV irradiation simulation and in-situ tribological performance testing. Polytetrafluoroethylene (PTFE) material is used to test and verify the device's operation. PTFE and its composite materials are solid lubricating materials with a low friction coefficient and strong thermal stability that are frequently employed in the contemporary space environment. The light source, power supply, and controller are the key components of a near UV irradiation apparatus. High power stable current source, timed alarm, programmable electric shutter, high voltage mercury xenon lamp trigger circuit, and safety circuit are all part of the power supply and control circuit. A light source, focusing mechanism, concentrator, UV transmission filter, integrating lens group, and collimator make up the light source device's construction. In the near UV irradiation device's light path concept the light source is at the ellipsoid reflector's first focus, and the light from the light source converges towards the second focus on the optical integrating mirror group. The integrating mirror group superimposes light lines from several spatial regions and projects them onto the collimator.

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