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NU-LHT-2M lunar simulant outgassing characterisation

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Abstract

Nowadays interest towards ice in space is increasing. One of the reason why stays in the great importance icy the volatiles elements play in the exobiology and pre-biotic components potential existence.

The ESA Juice mission towards the Jupiter icy Moons, in preparation for flying in 2022 is just an example, as well as the on going, proposed and future missions focusing on asteroids with samples return.

More nearby in time, the first incoming challenge is represented by the lunar 27 ESA-Roscosmos mission, supposed to land n the Moon south Pole to collect and analyze in situ icy volatiles.

Icy volatiles sampling in vacuum is quite a tough operation: icy gases immediately sublimate as soon either the pressure decreases – because of the extraction – or the temperature increase – because of the friction provoked by the mechanical energy injected in the soil to crack it and collect the specimen. The risk is, therefore, to penetrate the soil, collect subsurface samples supposed to have the volatiles content required to run scientific analysis and to release to the instruments soil with no volatiles at all inside, because of the occurred sublimation in vacuum.

Currently, no validated model exists on sublimation phenomenon for gases trapped in a soil composite while in vacuum. Therefore experimental tests would be beneficial to characterize it and tune both the tool to sample and the operations to run while sampling the icy planetary soil.

At Politecnico di Milano-Aerospace Science & Technology Dept. the design and setup of a dedicate experimental facility to assess the gasses and icy volatiles sublimation phenomenon in vacuum are under development. A vacuum chamber, equipped with soil inside – either dry or wet - which correctly reproduces the polar Moon conditions is a challenge also in the setting up activities: soil is prepared in air at sea temperature, therefore, even the dry soil traps air molecules which contribute to the sublimation as soon as the soil undergoes a vacuum creation procedure; the amount of gases coming from trapped air has to be distinguished from gases being part of the simulated icy volatiles purposely inserted in the soil to run the scientific test.

Previous tests, performed at Glenn Research Center[1,2], have identified how lunar soil simulants, inserted in a thermal vacuum chamber, increase the time needed to reach the target pressure because of the gas load, coming from the simulant, provoked by the air trapped between the soil particles, and the water vapor absorbed by the simulant when exposed to atmospheric conditions.

Therefore, to correctly support the design of a planetary icy soil sampler the terrestrial infrastructure must firstly quantify the gas load produced by the soil during the chamber pressure decreases and provoked by the trapped air; then it must be equipped to monitor and measure the gas load, in vacuum, provoked by the tool-soil energy exchange.

Th NU-LHT-2M is used as Moon highlands simulant. A scaled experimental set up, made up of a soil chamber and a vacuum chamber, connected by a pressure regulated line is currently under integration. The two chambers scheme allows to better control the potential soil sputtering and boiling as soon as the pressure starts decreasing. Moreover, the two chambers scheme is required to keep the experiment completely independent from a classical TVAC internal chamber with suffer from any particle which can enter the pump line, jeopardizing the complete plant because of pump failure. Last, the sytem can be easily cooled down just inserting the whole in a freezing plant, dcouling the vacuum from the temperature variation processes. The vacuum chamber is connected to a classical TVAC, to create a 10^{-5} bar pressure conditions; then it is disconnected from the TVAC and connected to the soil chamber to start the experiment. Gases emission quantification is obtained by vacuometers located on the line and in the scaled vacuum chamber which will receive the amount of sublimated gases. A different n mass on the soil will be the added measurement as well. A trap along the line is also inserted to quantify the amount of solid soil particles sputtered with respect to the flow rate imposed by the flow control valve located between the soil and te vacuum chamber.

The two chambers are cylindrical and stay in a 70x 80 cm envelope at most.

Tests will run first on the dry soil, room temperature to characterize the amount of air and vapour trapped during the soil preparation and to assess the admissible flow rate while decreasing the pressure for vacuum preparation to avoid surface particles sputtering and boiling.

Wet soil test will then run, at temperature conditions as well, leaving the low temperatures vacuum tests as last.

The facility design, implementation and calibration will be critically discussed and presented, together with the preliminary results of the tests which are supposed to be performed shortly.

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[1]Julie E. Kleinhenz and R. Allen Wilkinson. "Development and testing of an ISRU soil mechanics vacuum test facility". In: (2014).

[2]Julie E Kleinhenz. "Lunar polar environmental testing: Regolith simulant conditioning". In: 7th Symposium on Space Resource Utilization. 2014, p. 0689.