Characterisation of Water contaminated by Lunar Regolith and Selection of an associated Water Purification System

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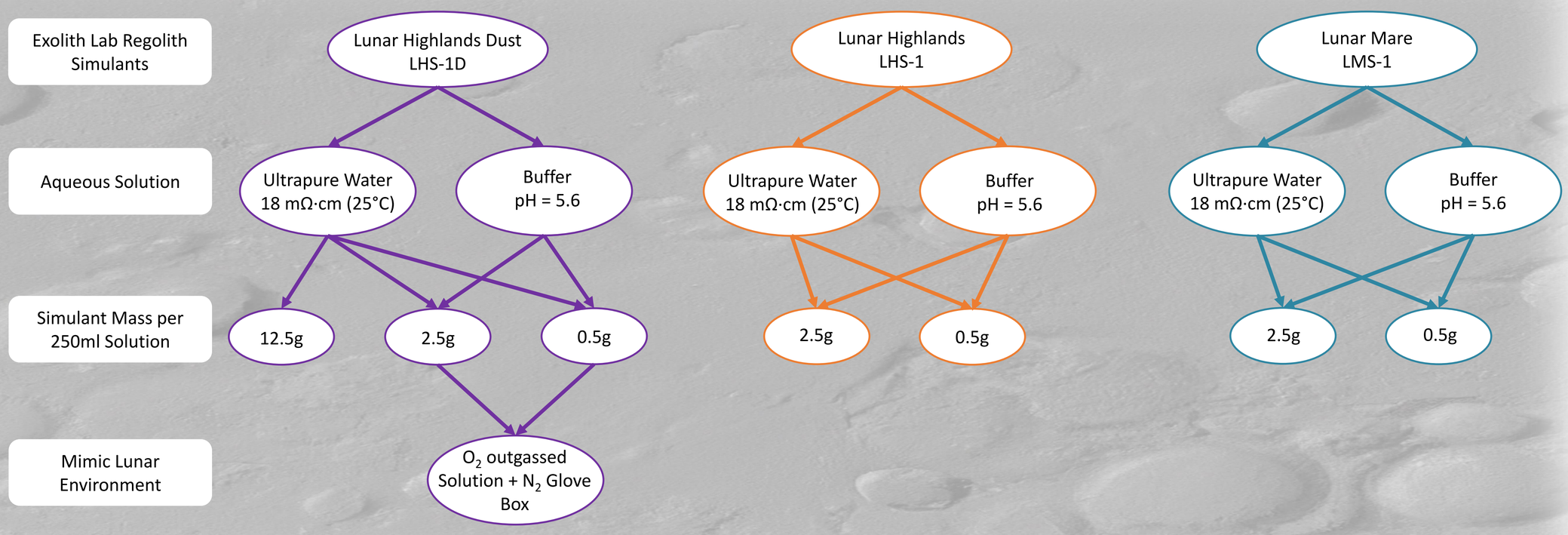
1. Introduction

In future lunar habitats, the contact between lunar dust and liquid water will be inevitable, as reported in the In-Situ Resource Utilization Gap Assessment Report, 2021 and the Dust Mitigation Gap Assessment Report, 2016. It is therefore necessary to understand and characterise water contaminated by lunar regolith. The experimental results provide a basis for the development of a lunar water simulant and associated water purification system.

2. Dissolution Experiments

The dust dissolution experiments were conducted using three different *Exolith Lab* regolith simulants. For the dissolution experiments, 250mL of the aqueous solution was mixed with a defined simulant mass on an overhead shaker. After a specified time (two minutes up to three days) a sample was taken for measurement of pH and elemental concentrations of aluminium, calcium, iron, potassium, magnesium, manganese, sulphur, silicon, and titanium by inductively coupled plasma optical emission spectrometry (ICP-OES).
The experimental results are the element concentrations in the solution and the pH as a function of time. After three days, the turbidity of the solutions was also measured. The following figure gives an overview of the different experimental parameters. In total, 17 different test batches were performed and correlated in order to develop a water simulant and a possible water treatment system.

3. Test Batch Parameters of Lunar Regolith Dissolution Experiments



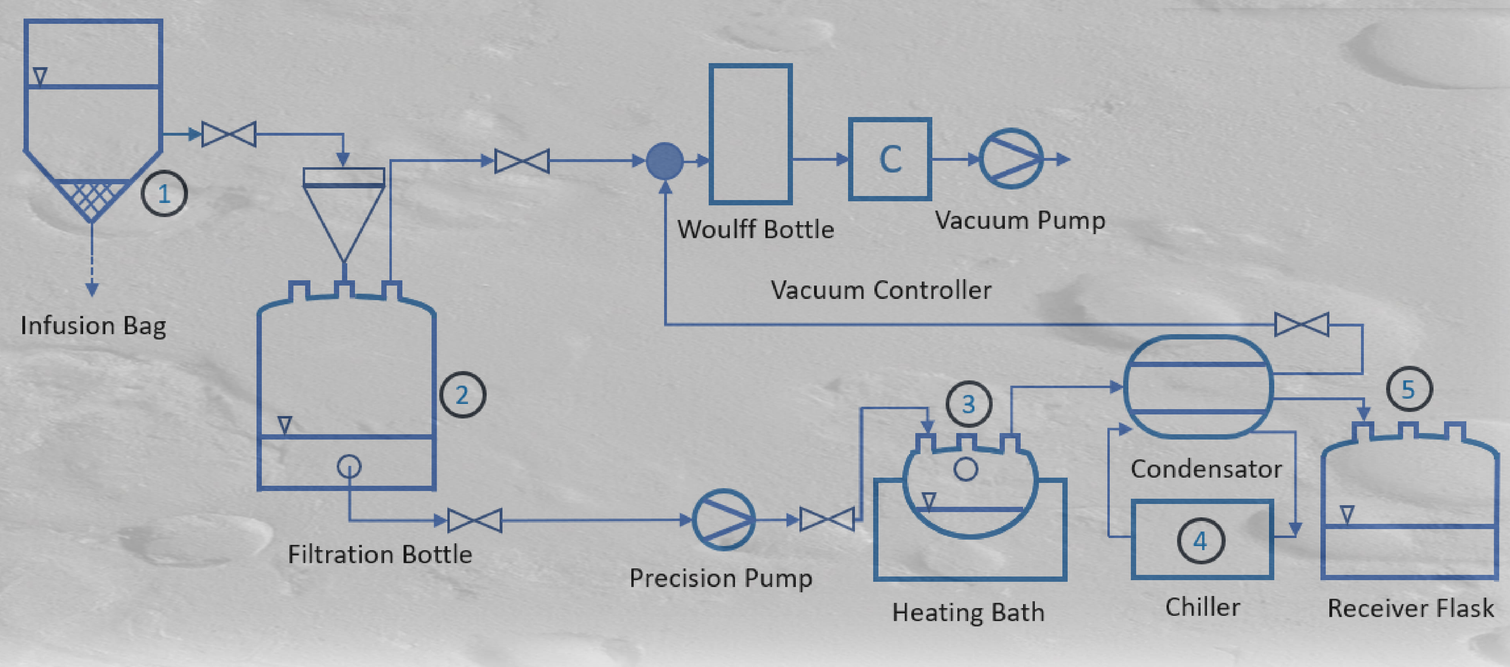
The experimental results are used to develop lunar water simulants and a water purification system.

4. Lunar Water Purification System

A schematic drawing of the lunar water purification system is shown on the right, with a picture of the experimental set-up below.

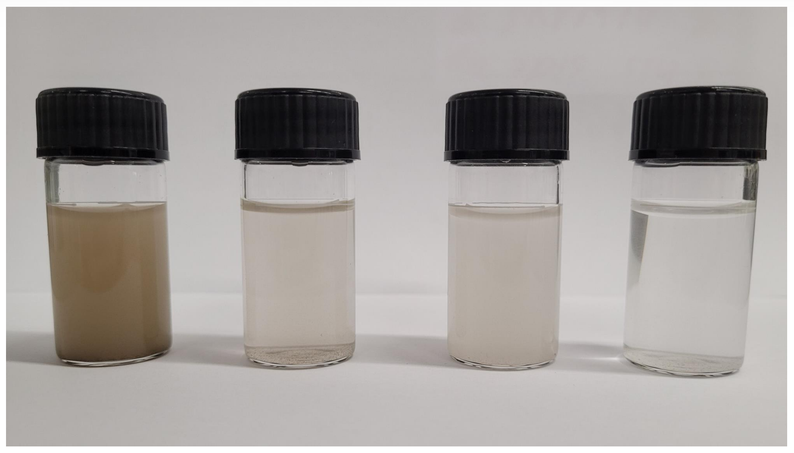
Steps of lunar water purification:

- Sedimentation in infusion bag
- Büchner vacuum filtration
- Precision pump pumps maximum possible amount of water into evaporation flask inside heating bath
- Steam condenses in condensator, cooled by chiller unit
- Distillate is collected in receiver flask
- Woulff bottle is used to protect vacuum pump and controller from polluted water
- Vacuum controller ensures correct pressure level
- Vacuum pump conveys liquid and steam



5. Measuring Points

The numbers in the schematic drawing in section 4 indicate the measuring points. Measuring point **(1)** is inside the infusion bag to determine the pH value and the electric conductivity. The second measuring point **(2)** is inside the filtration bottle, to determine the filling level. This is to protect the downstream precision pump from sucking in air. Inside the evaporation flask inside the heating bath **(3)** the temperature, the pH value, and the electric conductivity are measured. As a safety measurement to ensure proper function, the temperature of the cooling fluid inside the chiller **(4)** is measured. The last measuring point **(5)** is inside the receiver flask where the temperature, pH, and electric conductivity are measured.



Turbidity samples, from left to right: LMS-1 1:100, LMS-1 1:500, LHS-1 1:100, LHS-1 1:500

6. Outlook

In the future, the purification system can be optimised in terms of hardware and software. A system to control the sedimentation will be developed. At this stage, the sedimentation is determined via a time constant instead of using a sensor. Filters with different filter material or different mesh size can be used for Büchner vacuum filtration, resulting in different water purities. The temperature of the heating bath can be adjusted to optimise the distillation. To investigate different volatiles, simulants with different compositions, particle sizes and additional elements can be tested to simulate LCROSS volatiles. This will bring the lunar water purification system as close as possible to real lunar operating conditions.

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