Water Extraction from Icy Lunar Simulants using Low Power Microwave Heating

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Water Extraction from Icy Lunar Simulants using Low Power Microwave Heating

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1) Introduction

- Water ice deposits exist in Lunar polar regions of permanent shadow at temperatures as low as 30 K [1].
- The deposits could be a crucial resource required to sustain a human presence on the lunar surface.
- Recent work has shown microwaves efficiently heat lunar simulants, with promising results for the extraction of water from icy simulants [2, 3].
- We have heated lunar simulants doped with water at temperatures of <120 K in a microwave heating unit (MHU) to explore the extraction efficiencies and optimum heating times of the process.

2) Method

- Three simulants were used: LHS-1 (Highlands), OPRH3N (Highlands), and OPRL2NT (High-Ti Mare).
- Deionized water was mixed with simulant and left to distribute for 12 hours before being cooled in liquid nitrogen for 90 minutes (Figure 1).
- 250 W, 2.45 GHz microwaves were propagated into a ~1 mbar cavity for various heating times (Figure 2).
- The water mass before and after microwave heating was used to estimate the extraction efficiency, η:

\[ η = 1 - \frac{\text{final water content}}{\text{initial water content}} \]

3) Results

i. OPRL2NT & OPRH3N samples containing 5 & 10 wt. % water content were cooled to 120 K. They were both heated for 30 minutes to check how water content and simulant type affects the extraction efficiency. The results are shown in Table 1.
   - The average extraction efficiency for both 5 & 10 wt. % samples are higher for OPRL2NT.
   - This could be due to the differing chemical compositions or water absorption characteristics of each simulant.

ii. LHS-1 samples at 5 wt. %, cooled to 100 K, were heated at various heating times to find the optimum heating time to maximise the extraction efficiency. The results for this are shown in Figure 3.
   - The extraction efficiency increases from 10 % at 35 minutes up to 96 % at 65 minutes whereupon the extraction efficiency seems to plateau.
   - The extraction efficiencies for LHS-1 samples are much lower than for previous experiments due to the lower initial temperatures possible.

<table>
<thead>
<tr>
<th>Simulant</th>
<th>Average Extraction Efficiency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5 wt. %</td>
</tr>
<tr>
<td>OPRL2NT</td>
<td>67.2 ± 5.0</td>
</tr>
<tr>
<td>OPRH3N</td>
<td>59.2 ± 3.6</td>
</tr>
</tbody>
</table>

4) Future Work

i. Research the optimum heating time for samples with different water contents ranging from 1 to 10 wt. %.
ii. Increase the power from 250 W up to a maximum of 1 kW to investigate how power alters the optimum heating time.
iii. Develop complex icy lunar simulants that represent other possible lunar conditions including granular icy simulant and frosty icy simulant.
iv. Construct an upgraded system:
   - Use cold traps to collect released water vapour allowing more accurate calculations of the extraction efficiency.
   - Develop a dynamic mass measuring system that will allow the mass to be measured while the MHU is on.

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