IAF SPACE EXPLORATION SYMPOSIUM (A3)
Virtual Presentations - IAF SPACE EXPLORATION SYMPOSIUM (VP)

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LUNAR WATER HARVESTING: WATER ADSORPTION ON JSC-1 LUNAR SIMULANT, ZETA ADSORPTION ISOTHERM APPROACH

Abstract

Strong evidence for the presence of water in the form of ice in permanently shadowed regions of the Moon has emerged from remote sensing satellites over recent years. This has sparked renewed interest to analyze pristine lunar samples originally gathered 50 years ago during the Apollo missions. The presence of water on Moon implies the interaction of water molecules with the solid lunar surface or sub-surface (e.g. with rock, pebbles, regolith). Adsorption-desorption isotherms of water provide one means of characterizing the capacity of the lunar surface to store water at the molecular scale: water vapor molecules accumulate and “stick” onto empty sites of a test sample as a function of temperature and pressure, yielding information on the water storage capacity of the test sample.

However, proper interpretation of adsorption isotherm data requires equilibrium measurements and a physically accurate adsorption model. It is therefore surprising that many adsorption isotherm studies of the Apollo samples have not been performed in equilibrium conditions, were susceptible to transient chemisorption effects (such as hydroxylation), and relied on an isotherm model that had been known to lead to non-physical results (such as the prediction of infinite vapor adsorption at saturation conditions).

Here, we use the Zeta Adsorption Isotherm (ZAI), based on quantum mechanical principles and validated through applications in the oil and gas industry, to characterize the adsorption of water onto JSC-1 lunar simulant in conjunction with new experiments performed in a dynamic vapor sorption chamber for over four months. To our knowledge, the experimental data represent the only water sorption studies of lunar simulant to be free of adsorption-desorption hysteresis, thereby indicating equilibrium conditions were achieved in the measured pressure range.

The methods presented here can be applied to Apollo lunar samples (both pristine and non-pristine) and our initial estimates indicate approximately four times more surface area available for water adsorption on the Moon than has been reported in the literature; the work thus has important implications for any technology seeking to harvest water from the lunar surface.