

GENERATING A MORE ANALOGOUS LUNAR REGOLITH SIMULANT IN ORDER TO BETTER UNDERSTAND REACTIVITY AND POTENTIAL TOXICITY

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Lunar activities by humans such as mining, exploration, energy production, etc. will become more commonplace in time. However, exposure to lunar dust in large quantities during such activities, has been confirmed as being potentially hazardous. A Permissible Exposure Limit (PEL) of 0.3 mg/m³ lunar dust has been established by a panel of expert pulmonary toxicologists for mission durations of up to 6 months.¹ Previous work on assessing potential toxicity has involved evaluation of the reactivity of various mineral phases present in lunar dusts including olivine, plagioclase, pyroxene, and quartz (control mineral). This work indicated that mafic silicates generate the most reactive oxygen species (ROS) such as hydroxyl radicals (OH^{*}) and hydrogen peroxide (H₂O₂).^{2,3} The results imply that highly reactive iron-rich mineral phases may be the most hazardous to human health. Lunar regolith simulants such as JSC-1A, NU-LHT-2M, and CSM-CL have been assessed for both reactivity and toxicity.⁴⁻⁶ Similar trends appear in relation to the dependence of silicate-FeO content and reactivity but no discernable relationship exists between toxicity and reactivity. In all of these works, however, the question remains whether the simulants used adequately reflect the lunar regolith. The simulants used often contain some amount of hydrous mineral and oxidized mineral phases which are absent on the lunar surface. They are generally deficient in metallic iron which may have a strong effect on toxicity. In order to overcome the problems of oxidized and hydrated phases, we have employed a simple reduction experiment similar to the one performed by [8] in order to reduce the materials used for toxicity studies.

Reduction technique. 3 g of lunar regolith simulant JSC-1A was heated under a stream of hydrogen gas at 900 °C in a glass tube for 15 min. This produced metallic iron seen as blebs on the surfaces of grains. These samples, although not perfect simulants of pristine lunar regolith, do provide a cheap and reliable alternative to precious regolith samples. Since toxicity and reactivity experiments involve destructive techniques, this material is well suited for the work described in this summary.

Reactivity study. Three separate aliquots (200 mg each) from three separate batches of both reduced and non-reduced JSC-1A were ground by hand in a mortar and pestle for 10 min. Samples were then incubated in 0.5 mL of the spin-trap compound known as DMPO for 15 min. The resulting slurries were filtered using a 0.2

µm syringe filter; then the filtrates were placed into a 50 µL glass capillary tube. The tubes were in turn, placed into an electron paramagnetic resonance (EPR) spectrometer to measure the amount of OH^{*} generated by the samples. Figure 1 shows a bar graph comparing the amount of OH^{*} generated in solution between non-reduced JSC-1A and reduced JSC-1A.

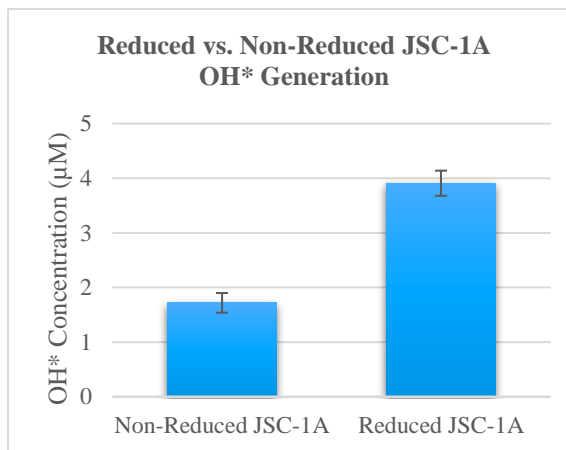


Fig 1. The bar graph shows the large differences in the amount of OH^{*} generated in solution between both reduced and non-reduced JSC-1A most likely due to the metallic iron present after reduction.

Figure 1 clearly indicates that our methodology in reducing JSC-1A has a significant impact on its reactivity. Preliminary data also indicate that cell toxicity levels were also significantly higher using the reduced rather than original JSC-1A. The large difference observed in reactivity in Figure 1 is consistent with the observations made in Wallace et al. (2010) in which JSC-1A was significantly less reactive relative to various tested Apollo soils.

- [1] Scully, R.R. & Meyers, V.E. (2015), Human Research Program, Space Human Factors and Habitability (SHFH) Element. 1-57. [2] Hendrix, D.A. & Hurowitz, J.A. (2019), *GeoHealth*. 3, 28-42. [3] Hurowitz, J. A. et al. (2007), *Earth Planet. Sci. Lett.* 255, 41-52. [4] Turci, F. et al. (2015), *Astrobiology* 15, 371-380. [5] Kaur, J. et al. (2016), *Acta. Astronautica* 122, 196-208. [6] Caston, R. et al. (2018), *GeoHealth* 2, 139-148. [7] Hill, E. (2007), *J. Geophys. Res. Planets* 112, 1-11. [8] Allen C.C. et al. (1994), *J. Geophys. Res.* 99, 23173-23185. [9] Wallace, W.T. et al. (2010), *Earth Planet. Sci. Lett.* 295, 571-577.