Reactive Oxygen Species Generation by Lunar Simulants

Abstract

NASA is considering establishing a base on the Moon to support the development of future space missions. Human explorer might be at the base for prolonged stay (e.g., 15-90 days) and exposure to dust particles is inevitable. Building on earlier work on mineral toxicity, we have started a research program focused on the activity of lunar dust in the context of inhalation exposures.

While the mineralogical composition of lunar regolith has been well documented, other factors, such as partial melting due to space weathering, UV irradiation, and dryness may also contribute to the toxicity of lunar dust. For example, the presence of elemental iron “nano-particles” in agglutinative material in the respirable size fraction has been recognized as a possible health concern. As a first step, we have evaluated the generation of Reactive Oxygen Species (ROS) by several Lunar simulants.

Background and Objectives

ROS are chemically reactive molecules containing oxygen and include superoxide (O₂⁻), hydrogen peroxide (H₂O₂), and hydroxyl radicals (•OH). Previous studies have shown that mineral dust can generate ROS when dispersed in water. Minerals generate ROS either by surface defects or stepwise reduction of molecular oxygen. In the human body, ROS are produced by various endogenous systems and they play an important role in the normal functioning of cells. However, increased levels of ROS as a result of exposure to mineral dust can lead to oxidative stress, inflammation, genotoxicity (DNA damage) or apoptosis (programmed cell death). Therefore, our aim is to study:

• H₂O₂ formation by a suite of lunar simulants dispersed in water and in Simulated Lung Fluid (SLF) using a real-time electrochemical probe
• •OH radical formation using a spin-trap technique followed by detection using Electron Spin Resonance (ESR) spectroscopy

Figure 1. Formulation pathways of ROS by Lunar Simulants and its effect on human cells

Figure 2. H₂O₂ formation by Lunar simulants in Air. H₂O₂ formation in the absence of EDTA were near or below the detection limit. Out of all simulants CSM-CL-S and OB-1 showed highest reactivity. Notice the decrease in reactivity of mechanically crushed samples with time

Figure 3. •OH radical formation by simulants studied using Electron Spin Resonance (ESR) spectroscopy

Summary and Conclusion

• Fresh crushed samples are more reactive than uncropped samples
• Reactivity decreases over time
• H₂O₂ and •OH formation is higher in N₂ atmosphere compared to that in air
• Highest reactivity shown by fresh crushed CSM-CL-S and OB-1 in N₂ environment (highest glass content)
• Preliminary results with SLF showed continuous formation of H₂O₂ as compared to that in DI where H₂O₂ concentration after reaching peak values in 10-20 minutes starts to decline

Acknowledgement

This work was supported by NASA SSSERVI award establishing Remote in Situ and Synchrotron Studies for Science and Exploration (RIS²E) at Stony Brook University.