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COMBUSTION SYNTHESIS OF CONSTRUCTION MATERIALS FROM LUNAR AND MARTIAN REGOLITH MIXED WITH MAGNESIUM

Abstract

Use of lunar and Martian regolith for in-situ production of construction materials would decrease the amounts of materials transported from Earth in exploration missions. Sintering regolith in a furnace, however, requires a lot of energy. One alternative approach is based on thermite reactions between regolith and added aluminum or magnesium, which could be obtained by recycling the lander parts. Recently, it has been shown that magnesium exhibits a number of advantages over aluminum in these applications. Mixtures of JSC-1A lunar regolith simulant with magnesium are combustible and compaction of the products immediately after the combustion process forms ceramics that are denser and stronger than common bricks. The combustion synthesis of construction materials from regolith and magnesium needs only a small amount of energy for triggering the process, while the combustion propagation over the mixture is self-sustained. However, the reaction mechanisms in this process are not well understood and the feasibility of using Martian regolith has not been studied. In the present work, combustion of two Martian regolith simulants (JSC-Mars-1A and Mojave Mars) with magnesium was studied using thermodynamic calculations and combustion experiments. To understand the reaction mechanisms in these mixtures as well as in the mixtures of JSC-1A lunar regolith simulant with magnesium, thermoanalytical experiments and X-ray diffraction analysis of combustion products were conducted. It has been shown that the Martian regolith simulants thermodynamically provide higher combustion temperatures than JSC-1A. The combustion characteristics of their mixtures with magnesium have been determined experimentally. The mixtures of JSC-Mars-1A with magnesium burn more vigorously than those based on Mojave Mars, which is apparently associated with the higher content of iron oxide in JSC-Mars-1A. Thermoanalytical studies have shown that iron oxide plays a dominant role in the combustion of JSC-Mars-1A simulant with magnesium. For Mojave Mars and JSC-1A simulants, which include more silica and less iron oxide, silica exhibits a significant effect on the combustion, promoting reactions at lower temperatures. Thus, the contents of iron oxide and silica in regolith play critical roles in its combustion with magnesium: iron oxide ensures intensive combustion, while silica facilitates the ignition. Since regolith compositions are different in different areas of the Moon and Mars surfaces, the obtained results should be taken into account during selection of landing sites for the future exploration missions.