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Editorial: Next generation of materials for space applications

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Editorial on the Research Topic
Next generation of materials for space applications

The next-generation of materials for space applications must meet several requirements including extended durability, radiation resistance, light weight, and high strength. Moreover, the goal is to develop more sustainable and demisable materials (Hedayati and Stulova, 2023a; Hedayati and Stulova, 2023b). Current challenges also include the growing performance requirements of space missions, long-term on-ground storage and the impact of specific lunar/planetary environmental factors such as the presence of regolith.

This Research Topic, with five articles submitted, explores the latest advances in materials selection and synthesis for space applications.

The study by Ichimura and Yamashiki analyzed and assessed the status of essential life support elements (air, water, and food) and wellbeing elements (clothing, hygiene, and healthcare) on the International Space Station. The authors' results showed that resupply missions involve not only gas tanks and water bags but also a significant number of spare items for maintenance of recovery systems. They discovered that each resupply mission is inefficient as resupplies account for only 0.21% of the total launch mass. The researchers stated that as humans explore the Moon and beyond, frequent resupplies will become impractical due to higher launch costs and longer delivery times, and they proposed developing technologies to realize a sustainable human presence in space.

The review article by Pernigoni and Grande provided an overview of the most significant innovations in the field of materials for space applications, along with the related advantages and challenges. After introducing the main environmental factors in space and their potential risks and effects on materials, the authors proceeded with the description of novel materials for space applications, subdivided into polymers, metals, semiconductors, composites, and mixtures. Innovations in manufacturing techniques and *in situ* resource utilization were also briefly discussed.

Gupta et al. explored the feasibility of using Microbially Induced Calcite Precipitation (MICP) to repair damaged sintered lunar bricks. Their systematic approach revealed that while initial damage significantly compromised the mechanical properties of these bricks, subsequent repairs using a MICP-based slurry resulted in a meaningful recovery of their compressive strength.

Instead of heavy metals, Tarikuzzaman et al. proposed using waste human hair as a building material in space due to its high tensile strength and availability during long-term missions. They measured the workability, compressive strength, and porosity of concrete with different hair compositions. Increased workability and porosity were observed with increased hair concentrations. Compressive strength slightly decreased with increased hair concentration.

Due to their good thermal conductivity and thermal shock resistance, ultra-high temperature ceramics such as zirconium diboride (ZrB2) have been investigated as promising materials to be used in reusable thermal protection systems. Meanwhile, radiation exposure in space can degrade the properties of these materials, especially during prolonged missions. In another interesting contribution, Rønning and Tang studied the interaction of electron radiation, which can be found in the outer Van Allen belt, with ZrB2. They investigated the response of the thermo-optical properties of ZrB2 to increasing electron radiation fluences. The ZrB2 samples were characterized by their microstructure, thermal conductivity, coefficient of thermal expansion (CTE), emittance, absorptivity, and surface roughness before and after irradiation.

We would like to express our appreciation to the authors, the reviewers, and the Editorial office of Frontiers in Space Technologies, all of whom contributed greatly to this Research Topic. We hope that the articles published here will open new avenues in the field of novel materials for space applications.

Author contributions

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References

Hedayati, R., and Stulova, V. (2023a). 3D Printing for Space habitats: requirements, challenges, and recent advances. *Aerospace* 10 (7), 653. doi:10.3390/aerospace10070653

Hedayati, R., and Stulova, V. (2023b). 3D printing of habitats on mars: effects of low temperature and pressure. *Materials* 16 (14), 5175. doi:10.3390/ma16145175