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Supervisor Expression of Interest

MSCA - Marie Sklodowska Curie Action - (PF) Postdoctoral Fellowship 2025

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Department Name: Department of Aerospace Science and Technology

Research topic: Self-Healing Materials

MSCA-PF Research Area Panels:

- ☐ ECO_Economic Sciences
- X ENG_Information Science and Engineering
- ☐ ENV_Environmental and Geosciences
- ☐ LIF_Life Sciences
- ☐ MAT_Mathematics
- ☐ PHY_Physics
- ☐ SOC_Social Sciences and Humanities
- ☐ CHE_Chemistry

Brief description of the Department and Research Group (including URL if applicable): The Department of Aerospace Science and Technologies (link) graduates about 30% of aerospace engineers in Italy. Research activities include space science, structural dynamics and aeroservoelasticity, aerodynamics, materials science and technology, crashworthiness. The Aerospace MAterials and TECHnologies (AMATECH) group is working on the development and validation of reliable technological processes, allowing the production of aerospace structures and components suited to real applications. The group has a large experience on innovative materials and structures thanks to several basic and applied research, in co-operation with Italian and international industries and research institutions.

TITLE of the project: Self-HEaling MATerials for Space (SHEMATS)

Brief project description: Self-healing materials are attracting significant attention due to their potential to enhance the safety, reliability, and longevity of space missions. These materials possess the capability to autonomously repair damage without human intervention, making them ideal for mitigating risks associated with micrometeoroid impacts, orbital debris, and structural fatigue in space environments. Despite their promising applications, challenges such as exposure to radiation, extreme temperatures, and vacuum conditions must be addressed to ensure their effectiveness in space. Both extrinsic and intrinsic self-healing systems have demonstrated efficiency in ground applications. Although initial findings indicate promising results for intrinsic self-healing materials, the understanding of their behavior in the space environment is still insufficient. There is no conclusive evidence of their effectiveness in real space conditions or of how their self-healing functionality will be maintained over time following exposure to the space environment. In particular, the effects of space radiation on self-healing polymeric materials for extraterrestrial applications remain unclear, and further exploration is needed to assess their healing efficiency over time and functional behavior across a wide temperature range. To date, no self-healing mechanism has successfully combined the necessary physical and mechanical properties with substantial healing efficiency for space applications. A novel approach is therefore required, not only to study and improve existing self-healing technologies but also to develop new, tailored solutions specifically designed for future space applications.

This research aims to investigate the feasibility, performance, and long-term viability of self-healing materials in space applications. The primary objectives of this study are: (i) to evaluate the impact of space conditions—including radiation, temperature extremes, and vacuum—on the healing efficiency of self-healing materials; (ii) to assess the effectiveness of self-healing materials in repairing accidental damages (e.g. caused by micrometeoroids and orbital debris); (iii) to explore advanced self-healing composites, such as nanocomposites and supramolecular polymers, for space applications; (iv) to develop testing methodologies for validating self-healing materials under simulated space conditions.

To achieve these objectives, a combination of experimental testing, simulations, and material development will be employed. The research will begin with the identification and development of self-healing polymers and nanocomposites incorporating healing functionalities. Their self-healing performance will then be evaluated under simulated space conditions, with selected materials exposed to radiation, vacuum, and extreme temperature cycles. A benchmark comparison of these self-healing materials against conventional space-grade materials in terms of durability and weight will help identify the most promising candidates for inclusion in various space systems, such as space suits, habitats, spacecraft, and satellite structures.

The integration of self-healing materials in space missions has the potential to significantly enhance spacecraft and astronaut safety by reducing risks associated with damage and structural failures. Additionally, these materials can extend the operational lifespan of space infrastructure, leading to cost savings and reduced maintenance requirements. By enhancing sustainability, self-healing materials align with the goals of future long-duration space exploration missions, including lunar bases and Mars exploration. Self-healing materials hold immense potential for revolutionizing space exploration by improving durability and safety. However, further research is essential to address the challenges posed by the space environment and ensure their successful implementation in real-world missions. The proposed study aims to provide valuable insights into the development and optimization of self-healing materials for space applications.