

IAF MATERIALS AND STRUCTURES SYMPOSIUM (C2)  
Interactive Presentations - IAF MATERIALS AND STRUCTURES SYMPOSIUM (IP)

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## HIGH-PERFORMANCE POLYIMIDE MEMBRANES FOR USE IN SOLAR SAIL PROPULSION

### Abstract

Solar sailing is a propulsion technology that is capable of driving vehicles and artificial satellites in space without the use of chemical propellants or electrical systems. This propulsion utilizes the solar radiation pressure resulting from the momentum transfer of solar photons reflected off the sail membrane, which is made of an aluminum-coated thin polymer film. The choice of the polymeric material to be used as solar sail membrane is crucial aspect as it influences the correct deployment of the structure and its efficacy as propulsion system during the space mission. For this aim, high-performance polymeric membranes with enhanced properties, including radiation resistance, thermal stability, lightness, flexibility, mechanical toughness and resistance to tearing, are required. Currently, fully aromatic polyimides (PI) possess most of the qualities above and therefore they represent the best candidates for developing polymeric membranes suitable for solar sailing in space environment.

In this work, we synthesized several types of polyimides with aromatic chemical structure using various organic solvents, including greener alternatives to traditional toxic solvents, and tested their properties for potential use in solar sail missions. Thin polyimide membranes with thickness in the range from 2 to 5  $\mu\text{m}$  were fabricated and their chemical and physical properties investigated using several experimental techniques, from infrared spectroscopy to calorimetry and dynamic-mechanical analysis. Results in terms of degree of imidization, thermal stability, hydrophobicity level and mechanical properties were used to assess the potential use of the in-house-made PI membranes for the Helianthus mission, a test study case of the research program on Solar Photonic Propulsion, which is under development jointly between Sapienza University of Rome and the Italian Space Agency. The Helianthus mission is a synchronous solar sail mission with the Earth-Moon barycenter that may be used for warning of solar storms caused by coronal mass ejection.

**Acknowledgements** This work is performed jointly under the Implementing Agreement between the Italian Space Agency and DIAEE – Sapienza University of Rome n. 2019-28-HH.0 - CUP n. F84I19001070005

related to R&D activities on solar photonic propulsion. The Implementing Agreement is based on the Framework Agreement between ASI and “La Sapienza” n. 2015-1-Q.0. This research is partially funded through grants from the Italian Ministry of University and Research (Rita Levi Montalcini Programme) and Sapienza University of Rome (grant number RM11916B88EB34A0) to M.G.S.