IOCM 2025 Conference
The 4th International Online Conference on Materials
3–6 November 2025 | Online
MDPI
Advanced PolyMat
Sapienza Materials Engineering
Sapienza Università di Roma

Advanced Multifunctional Polyimide/Graphene Nanocomposites for Long-Duration Space Missions

F. Blondelli[1], E. Toto[1], S. Laurenzi[2], M.G. Santonicola[1*]

[1]Department of Chemical Engineering Materials Environment, Sapienza University of Rome, Rome, Italy
[2]Department of Astronautical Electrical and Energy Engineering, Sapienza University of Rome, Rome, Italy
francesca.blondelli@uniroma1.it; mariagabriella.santonicola@uniroma1.it*

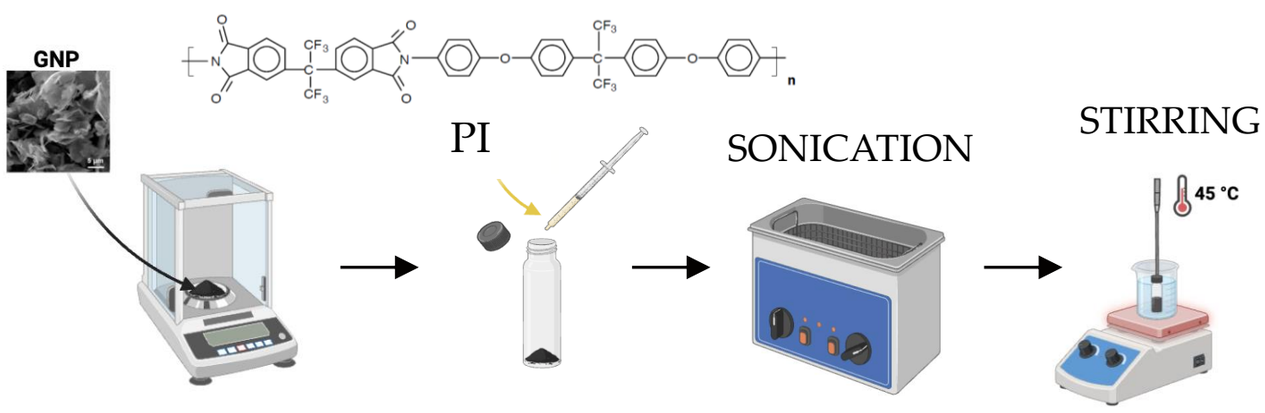
INTRODUCTION & AIM

The development of advanced materials for space environments requires an optimal combination of thermal stability, electrical conductivity and low density. These materials need to maintain their structural and integrity during long missions in harsh space conditions. Here, nanocomposite membranes based on aromatic and fluorinated polyimide with 5-20 wt% of graphene nanoplatelets (GNPs) were synthesized and characterized. An eco-friendly chemical approach was employed using a green and bio-based solvent, dimethyl isosorbide (DMI). Several experimental techniques were used to assess their potential applications in space environment.

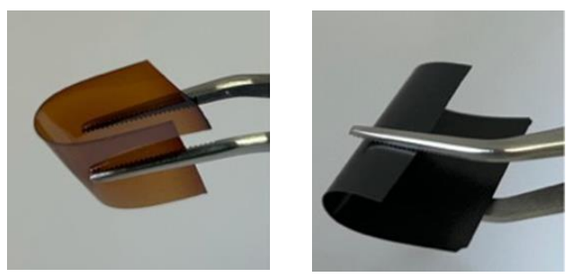
METHODOLOGY

Step 1: Synthesis of fluorinated and aromatic PI in DMI

Step 2: PI/GNP dispersions preparation (GNP: 5-20 wt%)

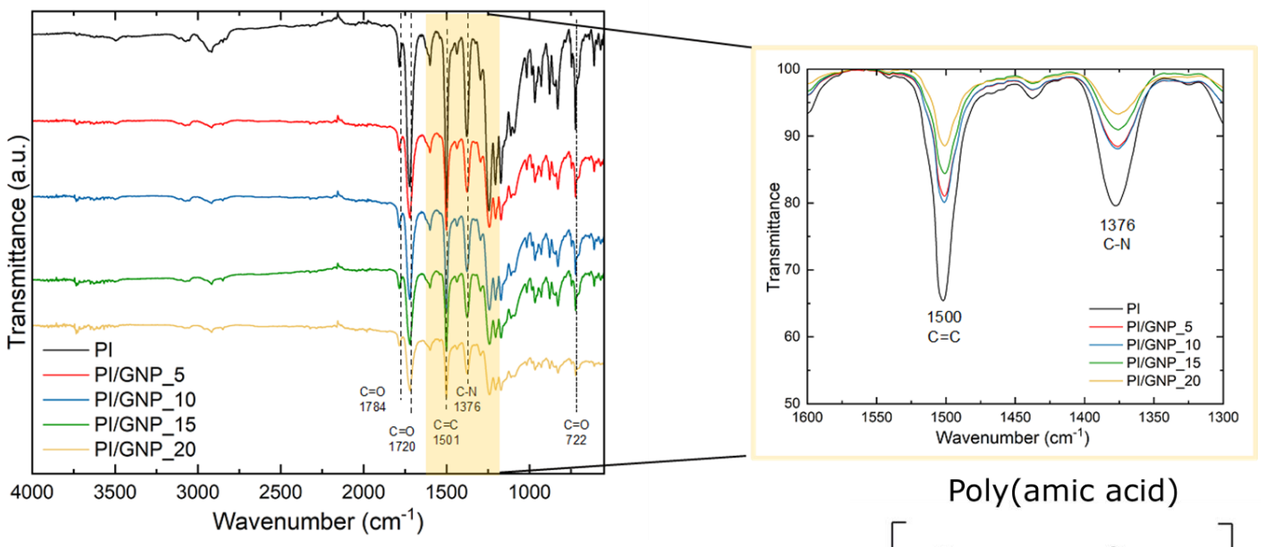


Step 3: Thermal treatment in oven: from 25 °C to 200 °C under vacuum



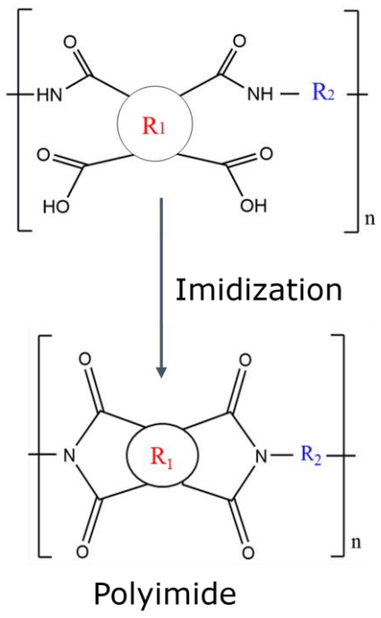
PI and PI/GNP flexible samples (thickness: 99 – 126 μm)

FTIR ANALYSIS



$$ID = \frac{A_{1376}/A_{1500}}{A_{1376(300)}/A_{1500(300)}}$$

Imidization Degree ID (%)	
PI	97.6
PI/GNP_5	96.3
PI/GNP_10	98.8
PI/GNP_15	98.3
PI/GNP_20	99.6

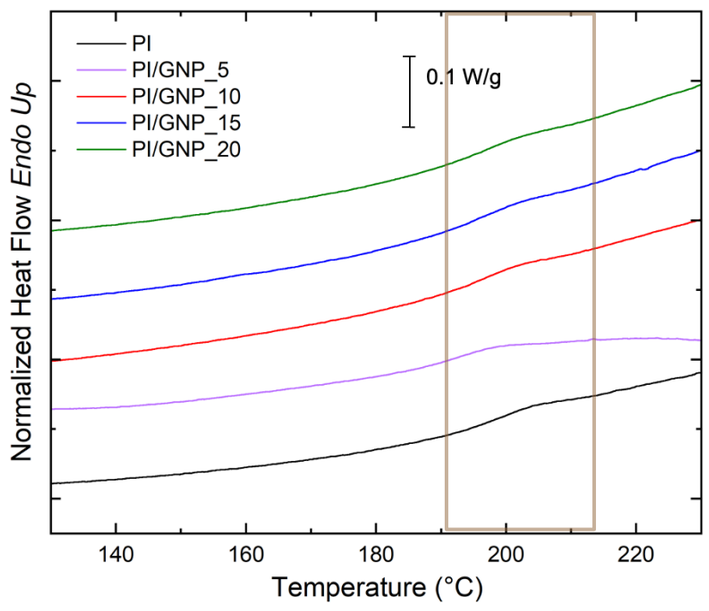


SURFACE WETTABILITY

Sample	WCA (°)	SFE (mJ/m²)	γ^d (mJ/m²)	γ^p (mJ/m²)
PI	94.4 ± 1.3	32.94	31.66	1.28
PI/GNP_5	99.0 ± 1.7	21.93	19.80	2.12
PI/GNP_10	102.2 ± 2.0	19.71	17.98	1.74
PI/GNP_15	104.0 ± 2.1	19.18	17.80	1.38
PI/GNP_20	107.6 ± 0.7	19.05	18.35	0.70

Surface hydrophobicity increases with increasing of GNP

THERMAL ANALYSIS & DENSITY



2nd heating run by DSC

PI and PI/GNP show a high T_g (~200° C), confirming their applicability in the space environment

The density values are suitable for space applications, where lightness is a crucial factor

Density (g/cm³)	
PI	1.447 ± 0.023
PI/GNP_5	1.447 ± 0.035
PI/GNP_10	1.533 ± 0.043
PI/GNP_15	1.550 ± 0.063
PI/GNP_20	1.582 ± 0.021

CONCLUSION

- Lightweight PI/GNP nanocomposites are successfully fabricated using the green bio-based solvent DMI
- Hydrophobic behavior increased with GNP loading
- FTIR analysis confirmed the successful imidization of PI
- Thermal analysis shows T_g values around 200 °C, suggesting their potential use in the space environment.