# A wide characterization of paraffin-based fuels mixed with styrene-based thermoplastic polymers for hybrid propulsion

M. Boiocchi[1], P. Milova[2], A.K. Golovko[3], L. Galfetti[4], L.A. Di Landro[5]
*Politecnico di Milano, Milan, 20156, Italy*

## Abstract

Paraffin-based materials have been proved to be very attractive fuels because of their high regression rates observed in hybrid rocket propulsion systems. The main drawback of paraffin waxes is represented by low mechanical properties. In order to develop a family of fuels, with ballistic and mechanical properties suitable for high-thrust class boosters, two paraffin-based fuels were investigated and characterized using two different pure paraffinic waxes and a styrene-based thermoplastic elastomer as strengthening material. A styrene-ethylene-butylene-styrene block copolymer grafted with maleic anhydride (SEBS-MA) [1], [2] was melt-mixed with the paraffinic wax under nitrogen atmosphere to prevent oxidative phenomena. The thermal behavior of petroleum waxes (paraffin slack wax) and paraffin-based fuels was studied using differential scanning calorimetry (DSC) and thermo-gravimetric analysis (TGA-DTA) investigating the influence of the different paraffin wax properties. DSC data show two partially overlapping melting peaks (32 - 34°C and 53 - 54°C), and a third extended peak (243 – 273°C) linked to the evaporation/pyrolysis of the wax. The viscosity of the melt layer, main responsible for the entrainment effect, was studied using a Couette viscosimeter; the storage modulus (G') was studied using a parallel-plate rheometer. All the mixtures containing SEBS-MA, show a rheological response supposedly affected by the storage time: three weeks of ageing cause an increase in viscosity between 110% and 25% linked with the rotational frequency. The chemical composition of the pure paraffinic materials was studied using gas-chromatography (GC), which was also applied for the analysis of the strengthened material ageing. Mechanical properties were investigated by using an uniaxial tensile tests in order to measure the influence of the thermoplastic polymer used. Firing tests carried out on pure paraffin wax and strengthened paraffinic samples, show similar regression rate values at low $G_{ox}$ (<100 $Kg/m^2s$) because of the not completely developed entrainment effect.

## References

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[1] Post-Doc Research Fellow, Politecnico di Milano, Department of Aerospace Science and Technology

[2] PhD Candidate, Politecnico di Milano, Department of Aerospace Science and Technology

[3] Professor, Siberian Branch of the Russian Academy of Sciences, Institute of PetroleumChemistry, Tomsk, Russia

[4] Professor, Politecnico di Milano, Department of Aerospace Science and Technology

[5] Professor, Politecnico di Milano, Department of Aerospace Science and Technology