MECHANICAL ENGINEERING

DIMEAS - Green polymers for applications in the automotive sector

Funded By	Dipartimento DIMEAS
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Context of the research activity	The research focuses on the development and characterization of recyclable and eco-sustainable green polymeric materials for applications in the automotive sector. The goal is to reduce the environmental impact of vehicles throughout their entire life cycle, through experimental testing and predictive modeling, in line with circular economy principles and European climate regulations.
	Every year, approximately 8 million tons of non-recyclable waste, originating from the end-of-life management of transport vehicles, are generated within the European Union alone. This figure reflects a significant and pressing environmental challenge that requires immediate and effective intervention. In particular, the proper handling and reduction of such waste have become priorities in the broader context of sustainable development, especially in the automotive sector, which is one of the main contributors to industrial waste production. This urgency is further intensified by increasingly stringent European regulations that aim not only at reducing pollutant emissions during vehicle operation but also at minimizing environmental impacts throughout the entire life cycle of vehicles, from production to disposal. In response to these regulatory and environmental pressures, the automotive industry has progressively adopted innovative strategies and solutions. One of the most widespread approaches has been the growing use of lightweight metal alloys and composite materials. The main objective of this shift is to achieve significant reductions in vehicle weight, which in turn leads to lower energy consumption, reduced greenhouse gas emissions during the operational phase, and improved overall efficiency. This is particularly beneficial for hybrid and electric vehicles, where reduced weight translates into an extended driving range and enhanced performance, thus supporting the broader transition towards low-emission mobility. Nonetheless, while weight reduction provides substantial benefits during the use phase of the vehicle, it does not fully address the broader environmental concerns related to the vehicle's entire life cycle. In particular, the issue of waste management at the end of a vehicle's life remains a critical point. Lightweight materials often pose challenges in terms of recyclability, and

Objectives	without proper end-of-life strategies, their environmental benefits during use may be offset by their impact during disposal. Therefore, automotive manufacturers are increasingly exploring and adopting recyclable materials for both structural and non-structural vehicle components, with the dual aim of reducing environmental impact and complying with circular economy principles. In this context, new classes of recycled polymeric materials have been adopted with the aim of limiting the degradation of mechanical properties. These materials represent a crucial innovation for reducing the environmental footprint of vehicles, as they combine acceptable mechanical performances with recyclability and lower environmental impact. The integration of green polymers into automotive applications is ongoing but to push and support this trend, it is necessary to increase the knowledge of their mechanical behaviour under operational conditions. The primary objective of this research activity is to advance and consolidate scientific and technical expertise on these innovative and environmentally sustainable materials. This knowledge will serve as a foundation for the design and broader integration of components based on green polymers within the automotive industry. To achieve this goal, the research will focus on two main lines: • The development and implementation of appropriate experimental testing methodologies, specifically designed to accurately characterize the mechanical properties of green polymeric materials under different loading and environmental conditions. • The formulation and validation of advanced analytical and numerical models capable of reliably simulating the mechanical response of components realized with green polymers, thereby supporting their design and integration in real-world automotive applications. This research will contribute to promoting a more sustainable and circular approach in the automotive sector, aligned with the objectives of the European Green Deal and the transition towards climate-neutral mobility.

Skills and competencies for the development of the activity	Experimental characterization and numerical modeling of polymeric materials for automotive applications. Structural health monitoring of polymeric components. Polymeric materials for automotive applications: design, manufacturing, modeling, and testing.