2D Materials Enhanced Composites: Shaping the Future of Aerospace Structures

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2D materials are revolutionizing the development of advanced composites by enhancing their multifunctionality and performance, paving the way for the next generation of aerospace structures. These enhancements include improved mechanical properties, energy storage capabilities, EMI shielding, and real-time sensing [1, 2]. In addition to traditional applications, 2D materials are now being explored in the manufacturing of high-performance hydrogen storage tanks, where their interaction with fibers and matrices plays a crucial role in increasing strength, durability, and performance under extreme conditions, including cryogenic environments essential for hydrogen storage. This presentation will explore how 2D materials, such as graphene, can transform aerospace structures and components. A comprehensive roadmap will be presented that shows how graphene-enhanced composites are central to the "factory of the future". The interaction between graphene with both thermoset and thermoplastic matrices, as well as its interaction with different reinforcements will be examined to showcase how these composites optimize mechanical properties, particularly for aerospace and hydrogen storage applications.

Furthermore, we will discuss the integration of graphene-based smart sensors into composites, allowing for real-time structural health monitoring during manufacturing and in-service use. These sensors bridge the gap between physical aerospace structures and cyber-physical systems, generating data that can drive intelligent, adaptive manufacturing processes [3, 4]. While graphene offers immense potential as an interface between physical components and digital technologies, several technical challenges remain. The presentation will address these challenges and outline future opportunities for integrating graphene-based sensing networks with digital twin technologies, improving production efficiency, and reducing material defects.

References

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