Graphene-Modified Composite Tanks for High-Integrity Hydrogen Storage

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Abstract

This work presents a comprehensive framework that combines materials innovation, manufacturing optimization, and structural modeling to enable the next generation of lightweight, high-performance, and graphene-enhanced hydrogen storage tanks for sustainable energy applications. The study focuses on improving liner permeability and cryogenic performance by incorporating both commercially available and in-house–produced graphene synthesized at Khalifa University. The integration of graphene into polymer liners significantly enhanced gas barrier properties and mechanical stability under cryogenic conditions, offering improved safety and efficiency for hydrogen containment.

In parallel, the composite shell of the storage tank was fabricated using filament winding, with a systematic investigation into winding parameters and defect formation mechanisms. Optimization of winding angles was carried out to achieve the desired balance between hoop and axial strength, while process monitoring techniques were employed to identify and mitigate common manufacturing defects such as voids and fiber misalignment. Furthermore, numerical modeling and impact simulations were performed to assess the structural integrity and energy absorption characteristics of the tanks under operational loading.