

Plasma-Treated LDPE/GNP Liners to Enhance Bonding with CFRP for Hydrogen Storage Applications

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Abstract

Hydrogen storage is critical for the widespread adoption of hydrogen as a clean energy source, especially in high-pressure applications like fuel cell vehicles [1,2]. Type IV hydrogen storage tanks, featuring a polymer liner paired with a carbon fiber-reinforced polymer (CFRP) outer layer, are a promising option due to their lightweight structure and capacity to store hydrogen at pressures up to 700 bar, with polyethylene being one of the most suitable liner materials for these tanks [2,3]. However, a key challenge with these systems is the potential for delamination between the liner and CFRP during rapid depressurization, which can occur due to differences in material properties and hydrogen permeation [3]. Improving the bonding between the liner and CFRP is essential to enhance the overall reliability and safety of these hydrogen storage tanks. Plasma treatment has shown promise in improving the adhesion between polymers and composites by modifying surface energy, roughness, and chemistry [4]. Additionally, graphene nanoplatelets (GNP) have emerged as a potential additive for enhancing the properties of polymers, including bonding performance [2]. This study investigates the effects of varying GNP concentrations on the bonding performance of plasma-treated low-density polyethylene (LDPE)/GNP composites with CFRP. The experimental results from the wedge peel tests, shown in Figure 1, indicate that plasma treatment significantly improved the bonding performance of LDPE/GNP with CFRP across all GNP concentrations. While GNP incorporation initially reduced wedge peel strength and fracture energy in untreated samples due to increased surface roughness, plasma treatment mitigated these effects, enhancing both surface wettability and interfacial interactions. The combination of GNPs and plasma treatment produced a synergistic effect, with higher GNP content yielding improved bonding performance after treatment. These findings suggest that plasma-treated LDPE/GNP composites offer a promising route for improving the performance of hydrogen storage systems, optimizing the interface between the LDPE liner and CFRP for safer, more reliable operation.

References

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Figures

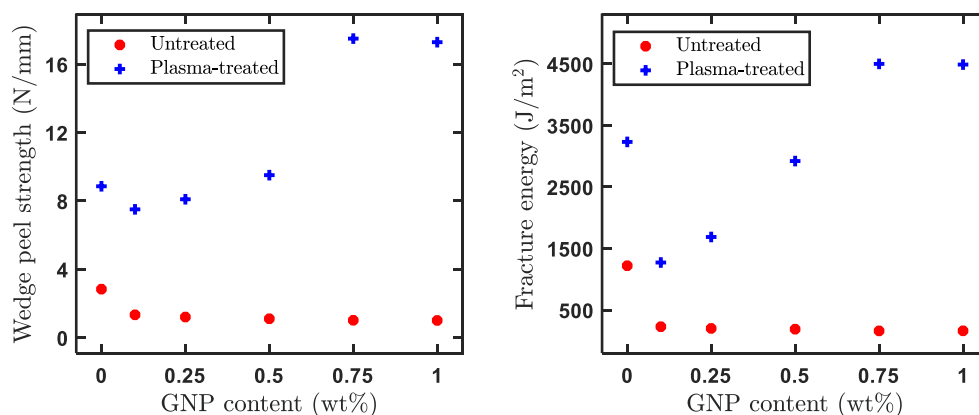


Figure 1: Wedge peel test results of LDPE/GNP bonded with CFRP.