Hybrid Interlaminar Toughening of Carbon/Epoxy Composites Using Nanoparticles and Veils

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Abstract

Carbon fibre/epoxy composites manufactured through out-of-autoclave (OoA) processes often suffer from reduced interlaminar fracture toughness, limiting their structural performance. In this work, a multi-scale hybrid toughening strategy was developed by integrating nano-scale core–shell rubber (CSR) particles and micro-scale thermoplastic fibre veils within the interlaminar regions to enhance the damage tolerance of OoA composites. The interlaminar fracture behaviour, static mechanical properties, fatigue resistance, and low-velocity impact performance of the hybrid-toughened laminates were systematically evaluated. The results demonstrate that CSR nanoparticles and thermoplastic veils provide complementary toughening mechanisms, leading to substantial improvements in fracture toughness, static strength, fatigue life, and impact resistance. This study highlights a scalable and effective interlaminar reinforcement route compatible with OoA manufacturing, offering a promising pathway for the next generation of high-performance composite materials.

References

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[2] Wang S, Katnam KB, İnal O, Zou Z, Taylor J, Sprenger S, Potluri P, Soutis C, Composites Part B: Engineering, 287 (2024) 111867.
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Figures

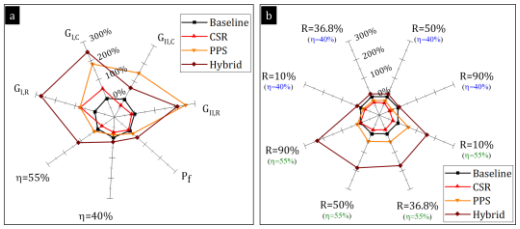

Figure 1: Comparison of the interlaminar fracture energies, static and fatigue performance

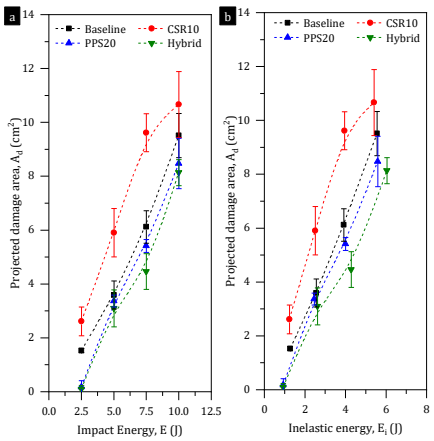

Figure 2: Comparison of the low-velocity impact performance