# Mechanical characterization of carbon fibre Elium composites by hybrid toughening of PDA WMCNTs sizing and PPS veil interleaving

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The investigation examines the impact of hybrid toughening involving polydopamine (PDA) and multi-walled carbon nanotubes (MWCNTs) sizing, as well as the Polyphenylene sulphide (PPS) veil interlayer, on CF Elium®-based composites. Mechanical characterization such as three-point bending test, interlaminar shear strength (ILSS), and mode I fracture toughness tests are performed.

## INTRODUCTION

Carbon fiber thermoplastic composites have gained significant attention in various industries due to their exceptional mechanical properties and lightweight nature. The adhesion between the fiber and matrix is crucial for transferring load efficiently and ensuring the composite's overall structural integrity. Improving the fiber matrix adhesion has become a significant area of research and development in the field of carbon fiber thermoplastic composites.

## EXPERIMENTAL

- Carbon fibre Elium composites are fabricated by cold vacuum assisted resin infusion method.
- 2g PDA and 0.5 g acid treated MWCNTs were added to 1L deionized water. The mixture was then stirred using a magnetic stirrer for 24 hours. Carbon fibres were immersed in the solution for 24 hours. Subsequently, the fibres were dried at 50oC for 36 hours.
- The hybrid composites are then fabricated by placing a layer of thermoplastic Polyphenylene sulfide (PPS) veils.

**A mussel inspired method.**

Lee et al. (2007) discovered that the distinctive adhesion of mussels was due to the co-existence of catechol and amine groups of polydopamine (PDA) within mussel proteins.

Sun et al. (2022) applied PDA-CNT sizing treatment on short CFs, and achieved an improvement of 39.4% in interfacial shear strength (IFSS) at 25% relative weight ratio.

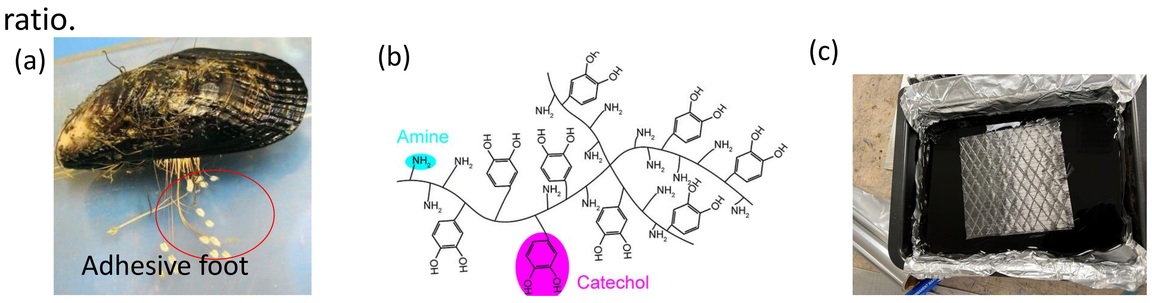


Fig. 1. (a) Mussel's adhesive foot (b) Structure of PDA (c) PDA MWCNT coating

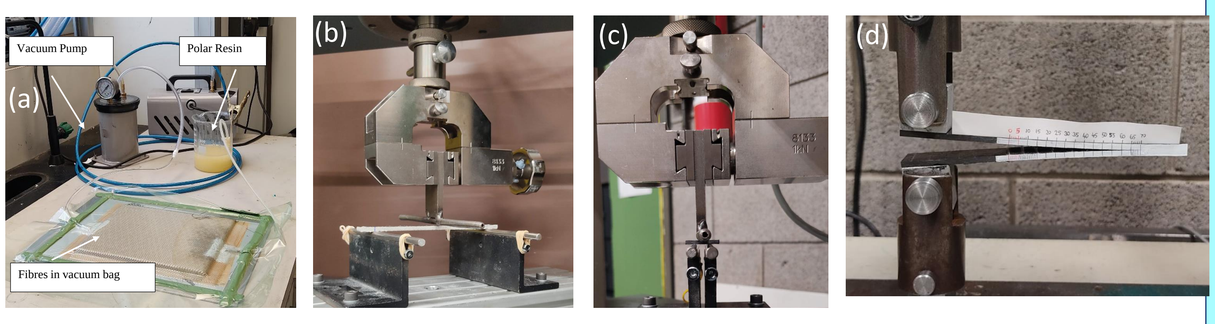


Fig. 2 (a) Vacuum assisted resin infusion (b) Three-point bend test (C) ILSS (d) Mode I interlaminar fracture toughness test

## RESULTS

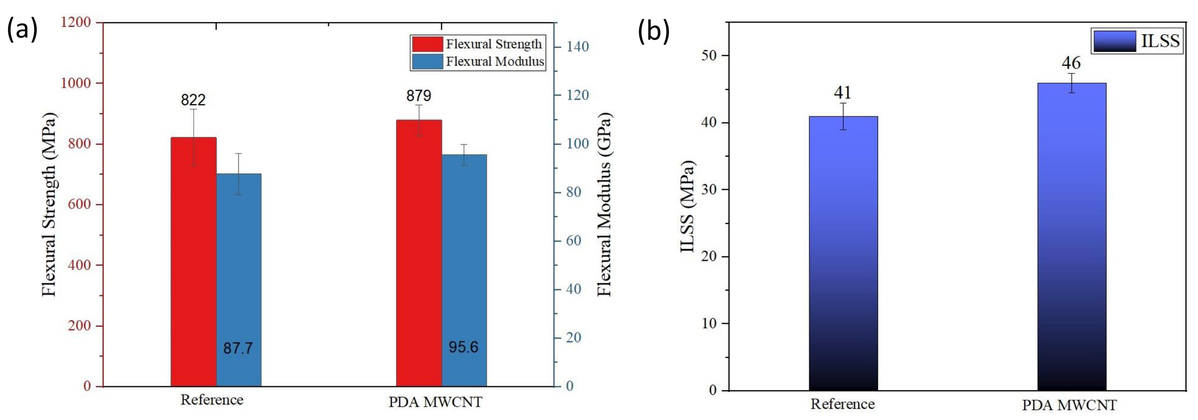


Fig. 3. (a) Flexural properties (b) ILSS of untreated and PDA MWCNT treated carbon fibre.

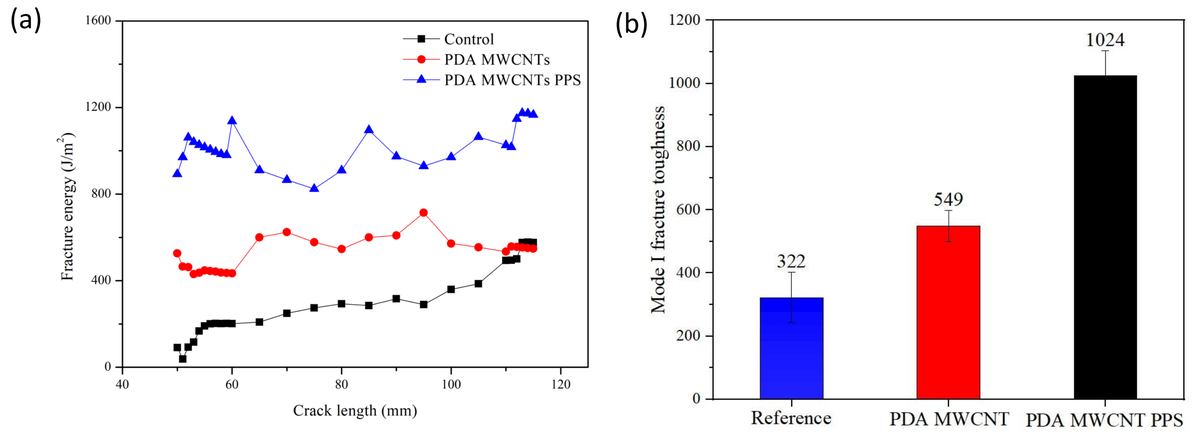


Fig. (a) R-curve (b) Mode I fracture toughness values of reference, PDA MWCNT and hybrid PDA MWCNT PPS carbon fibre composites.

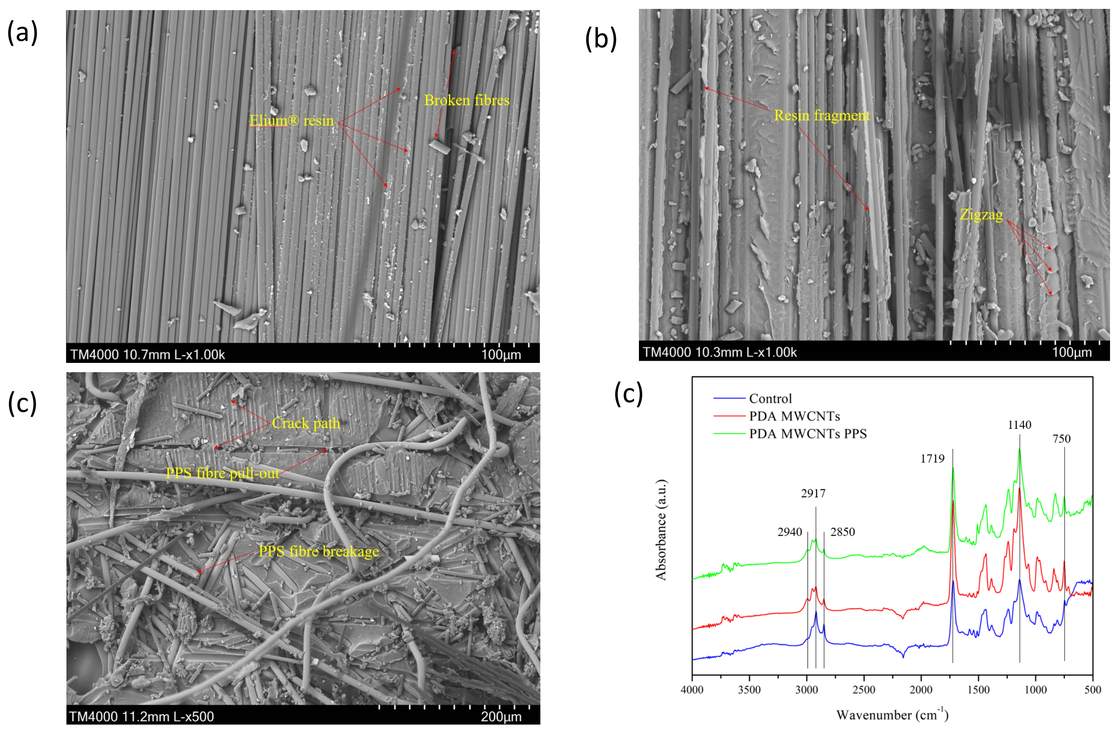


Fig. SEM images of the Mode I delaminated composites (a) reference (b) PDA MWCNT (c) PDA MWCNT PPS carbon fibre composites (d) FTIR images of the samples

## CONCLUSION

- The flexural and interlaminar shear strength values of the PDA MWCNT coated carbon fibre composites improved by 6% and 12% respectively.
- Mode I fracture toughness values of the PDA MWCNT coated carbon fibre composites improved by 65 % and the hybrid PDA MWCNT PPS composites improved by 208%.
- The SEM images of the Mode I delaminated surface shows the fibre and resin delamination, whereas the PDA MWCNT sized CFRP showed the cohesive mode of failure with the presence of fibre bridging. The PDA could firmly link MWCNTs onto CF surface and MWCNTs providing a lager interfacial contact area.
- PPS fibre pull-out and breakage is the main toughening mechanism of PPS veil, as observed from SEM.
- FTIR analysis illustrated increased C=O stretching intensity due to carboxyl groups, indicating successful sizing of PDA and MWCNTs.

## REFERENCES

Sun, Z., Guo, F.L., Li, Y.Q., Hu, J.M., Liu, Q.X., Mo, X.L., Huang, P. and Fu, S.Y., 2022. Effects of carbon nanotube-polydopamine hybridization on the mechanical properties of short carbon fiber/polyetherimide composites. Composites Part B: Engineering, 236, p.109848.

Lee, H., Dellatore, S.M., Miller, W.M. and Messersmith, P.B., 2007. Mussel-inspired surface chemistry for multifunctional coatings. science, 318(5849), pp.426-430.