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Mechanical Properties of Carbon Nanotubes Modified Textile Waste/basalt Fibre Hybrid Composites

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Abstract

The awareness regarding the importance of recycling and reusing textile waste has been often overlooked. The widespread disposal of textile waste resulted in a slew of environmental problems. Utilising textile scraps as composite materials, numerous studies and research have been conducted. Basalt fibre is well known for its established mechanical properties. It has been used as an alternative for many synthetic fibres widely. The hybridisation of basalt fibre and textile waste is expected to further improve the mechanical properties of the composite. This would offer up many possibilities in terms of environmental sustainability in the future, leading to less pollution from textile waste. On the other hand, incorporating multi-walled carbon nanotubes is expected to further improve the properties of the matrix system. In this study, the effect of fibre hybridisation and nanomodification on the mechanical properties of the composite material is investigated. The composite specimens were fabricated using the compression molding technique in a silicone rubber mold. Mechanical properties of the composite materials were identified by conducting mechanical tests. The results have proven that hybridisation of fibre and matrix nanomodification improves the composites' impact, tensile, and compressive properties.

Keyword: Basalt fibre; hybridisation; nanomodification

INTRODUCTION

Recycling and reusing fibrous textile waste can be applied in a few methods. One of them is by using it as reinforcement fibre to enhance the composite's mechanical properties. Up to 95% of textiles can be reused and recycled in various fields such as construction, automotive, home furnishing, industrial application, etc. [1]. Textile wastes are diverse in nature, and due to impaired qualities, they are inferior to virgin materials [2]. The hybridisation of textile waste and basalt fibre is expected to improve the mechanical properties of the composite due to basalt fibre's superior properties in contrast to textile fibre. Basalt fibres in composites have resulted in much stronger and stiffer material with relatively high thermal and corrosion resistance. This is why basalt fibre is widely used in automobile architecture [3]. On the other hand, carbon nanotubes has exceptional mechanical qualities have sparked much interest in using them to reinforce composites [4]. As a result, it was hypothesised that the improvements would cascade along with fibre hybridisation. In this study modified matrix reinforced hybrid composites were developed to analyse the enhancement of the mechanical properties of the composites.

METHODOLOGY

The materials chosen include finely crushed textile fabric obtained from post-consumer textile waste, basalt fibre from Innovative Pultrusion Sdn Bhd., Negeri Sembilan, Malaysia, and Multi-Walled Carbon Nanotubes (MWCNT) from CNano Technology, Beijing, China. Epoxy resins, Miracast 1517 was used as the matrix material. The matrix system was incorporated with MWCNT at different weight percentages of 0.5, 0.75 and 1 wt.%. The composite specimens contain 10 wt.% of fibres with 90 wt.% of epoxy resins. The mechanical tests such as impact, open hole tensile, and compression tests were executed according to ASTM D7136, ASTM D5766, and ASTM D695, respectively.

RESULT AND DISCUSSION

Figure 1 indicates that the specific impact strength value has increased by 1.51%, and the specific total energy value has increased by 78.3% due to fibre hybridisation. On the other hand, the MWCNT incorporation has improved the specific tensile strength value by 53.53%. Still, it has decreased the specific total energy value by 13.83%. This concludes that hybridisation and nanomodification have demonstrated an excellent result by improving the impact properties of the textile waste fibre reinforced composite.

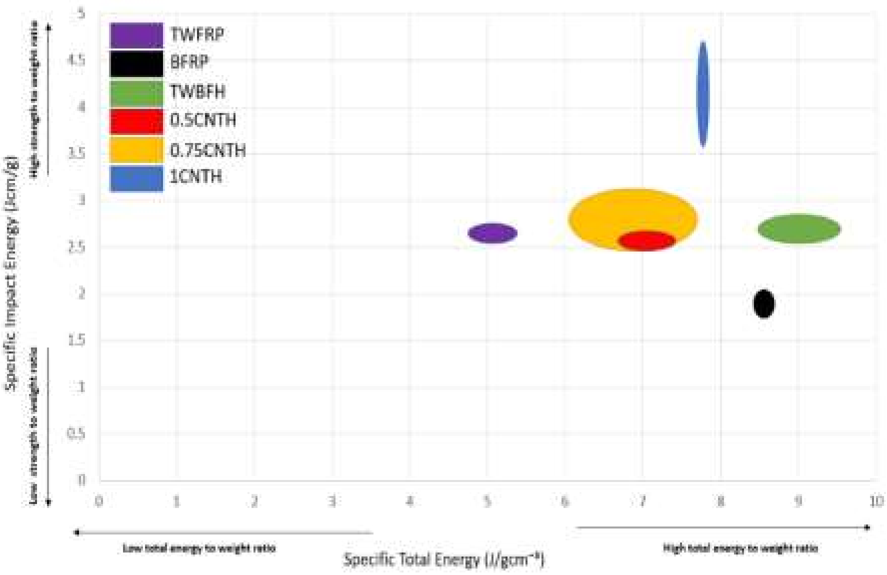

Figure 1 Specific impact strength against specific total energy.

Figure 2 shows that the specific tensile strength of the unhole tensile (UHT) specimens has increased by 10.23%, and the specific tensile modulus has increased slightly by 0.69%. The MWCNT modification has increased the specific tensile strength value by 11.65%; meanwhile, the specific tensile modulus value has regressed by 14.82% compared to the hybrid composite. Figure 3 shows that the open hole tensile (OHT) specimens have also improved by 8.61% in specific tensile strength and 17.42% in terms of specific tensile modulus value due to hybridisation. The MWCNT modified OHT specimens have shown improvement about 12.39% in terms of specific tensile strength but shown decrement by 28.15% in terms of specific tensile modulus value. These results indicate that hybridisation of fibres and MWCNT modification in the matrix system has played a vital role in enhancing the tensile properties.

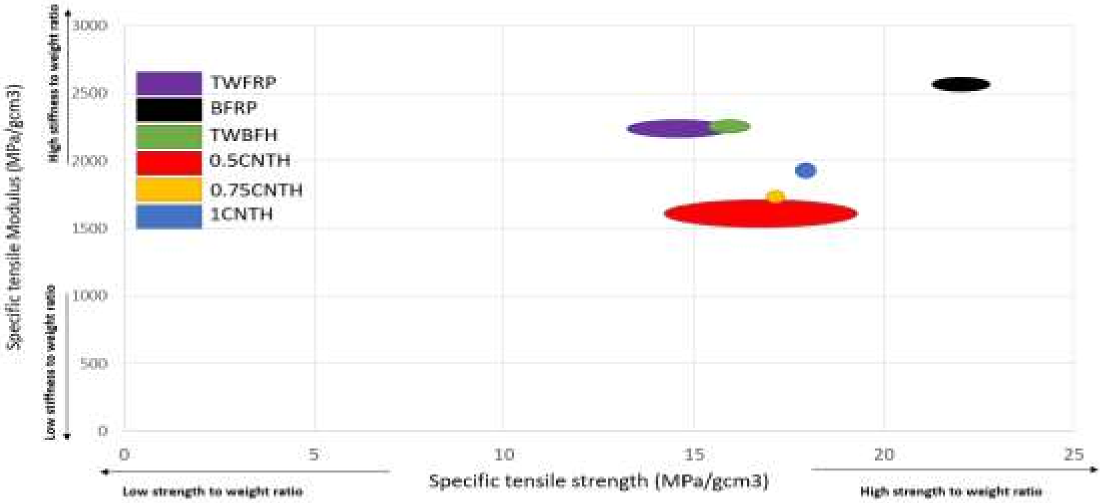

Figure 2 Specific tensile modulus against specific tensile strength of the UHT specimens.

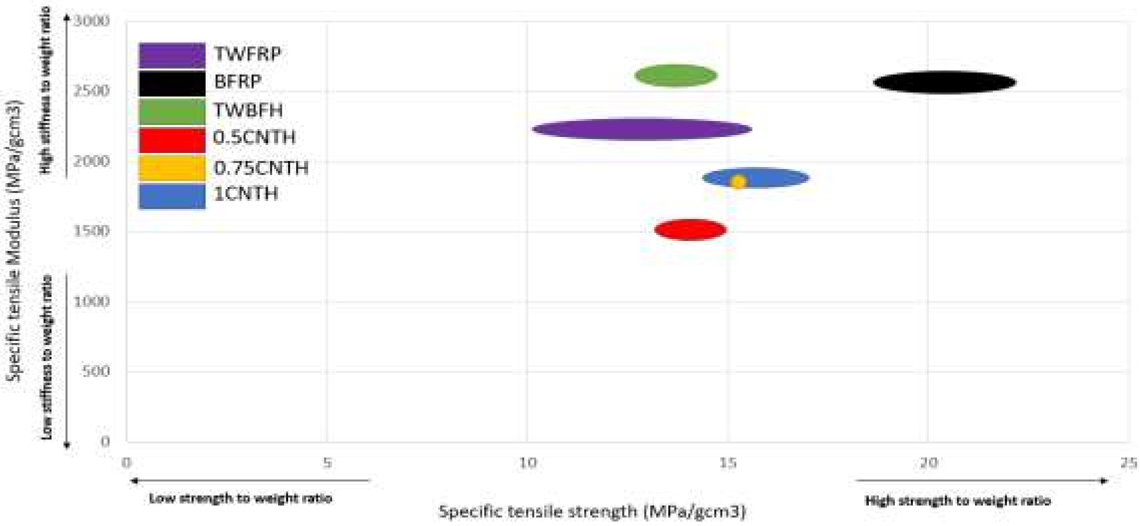

Figure 3 Specific tensile modulus against specific tensile strength of the OHT specimens.

Figure 4 shows that the specific compressive strength value showed the slightest decrement by 1.86%. The specific compressive modulus value has increased significantly by 93.65% due to hybridisation. Again, the MWCNT incorporation has also not contributed much in terms of specific compressive strength. The value showed some regression by 10.55%, but the specific compressive modulus value showed improvement by 32.55%. Agglomeration of fibre is expected to cause inconsistency in the compressive properties of the hybrid specimens. The decrement in the compressive properties of the MWCNT modified specimens is expected because MWCNT is weak under axial compression due to their high aspect ratio and hollow surface.

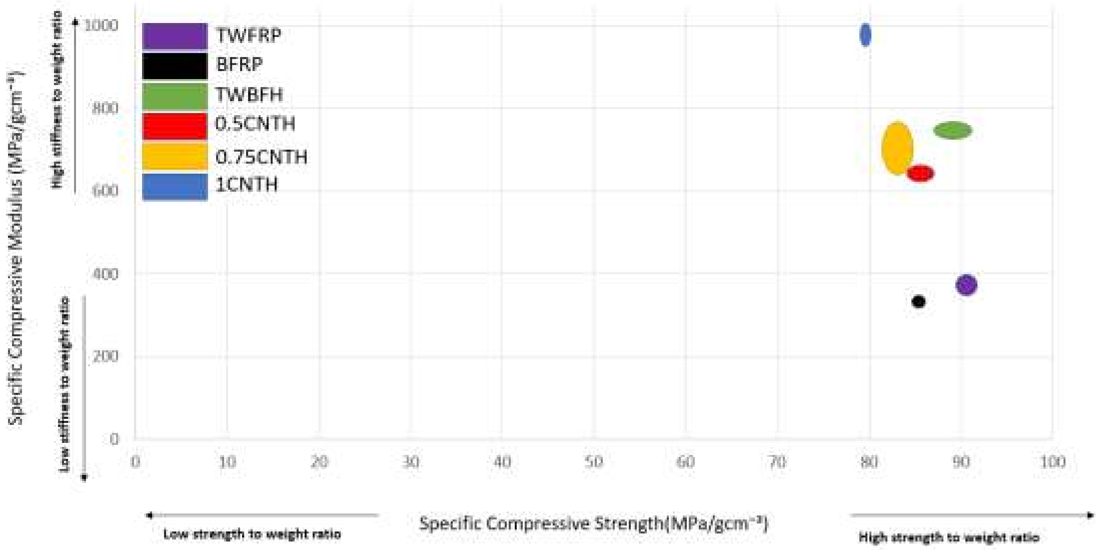

Figure 4 Specific compressive modulus against specific compressive strength.

CONCLUSION

In conclusion, fibre hybridisation and MWCNT modified matrix have improved the specific properties of the composites under tensile and impact loads. However, there is some inconsistency in terms of the specific compressive properties of the composites, which may be due to the agglomeration of fibres and cavity formation within the specimen during the hybridisation. It is also important to note that MWCNT is not strong under axial compressive load; thus, such decrement is expected in MWCNT modified specimens.

ACKNOWLEDGEMENT

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