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RESEARCH

Synergistic effects of basalt and carbon fibers on the physical, mechanical, and thermal properties of nylon composites

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Abstract

In the current study, the influence of short basalt fiber reinforcement (BF) (10–30 wt.%) and its hybridization with short carbon fiber (CF) as secondary reinforcement (5–10 wt.%) on the physical and thermomechanical characteristics of nylon 6 (N) were investigated. The BF and BF/CF hybrid nylon composites were prepared using melt blending in a twin-screw extruder, followed by the injection molding process. The control specimens (without reinforcements) were also prepared and tested for comparison. The density, strength (tensile, flexural, and impact), microhardness, and thermal degradation evaluations were executed as per the standards of ASTM. The results revealed that the basalt reinforcement in the nylon is beneficial in improving the thermomechanical properties. In particular, the composites containing 20 wt.% of BF show higher properties compared to the other BF composites and control matrix. Furthermore, the reinforcement of CF enhanced the properties of the composites due to their superior strength and stiffness. Specifically, the BF composites containing 10 wt.% of CF exhibit increases of 18.69 and 12.6% in tensile and flexural strengths, respectively, as well as enhancements of 11.06 and 23% in tensile and flexural modulus, respectively. The scanning electron microscopic images revealed a good interface adhesion compatibility between the fibers and the matrix.

Keywords Basalt fiber · Carbon fiber · Polyamide · Twin-screw extruding · Injection molding

Introduction

The focus on the application of short fiber-reinforced composites is significantly increasing owing to their strength-to-weight ratio, balanced isotropic characteristics, and their moldability [1]. Adding short fibers to polymers improves their mechanical, thermal, and tribological properties, which means that they could be used in the sports, aircraft, and car industries [2]. The short fibers are used as reinforcements in epoxy, polyester, vinyl ester, and specifically thermoplastics such as polypropylene and nylon by several material researchers to enhance their strength and durability properties [3]. Apart from the primary characteristics of fibers and polymers, the properties of composites are influenced by the size, content, aspect ratio, and the orientation of the fibers [4–7]. In this context, the thermoplastic-based composites are fabricated using different manufacturing methods such as film stacking, hot compaction, matrix infusion and injection molding, powder and solution impregnations, and fiber intermingling [8]. In particular, the process of extrusion followed

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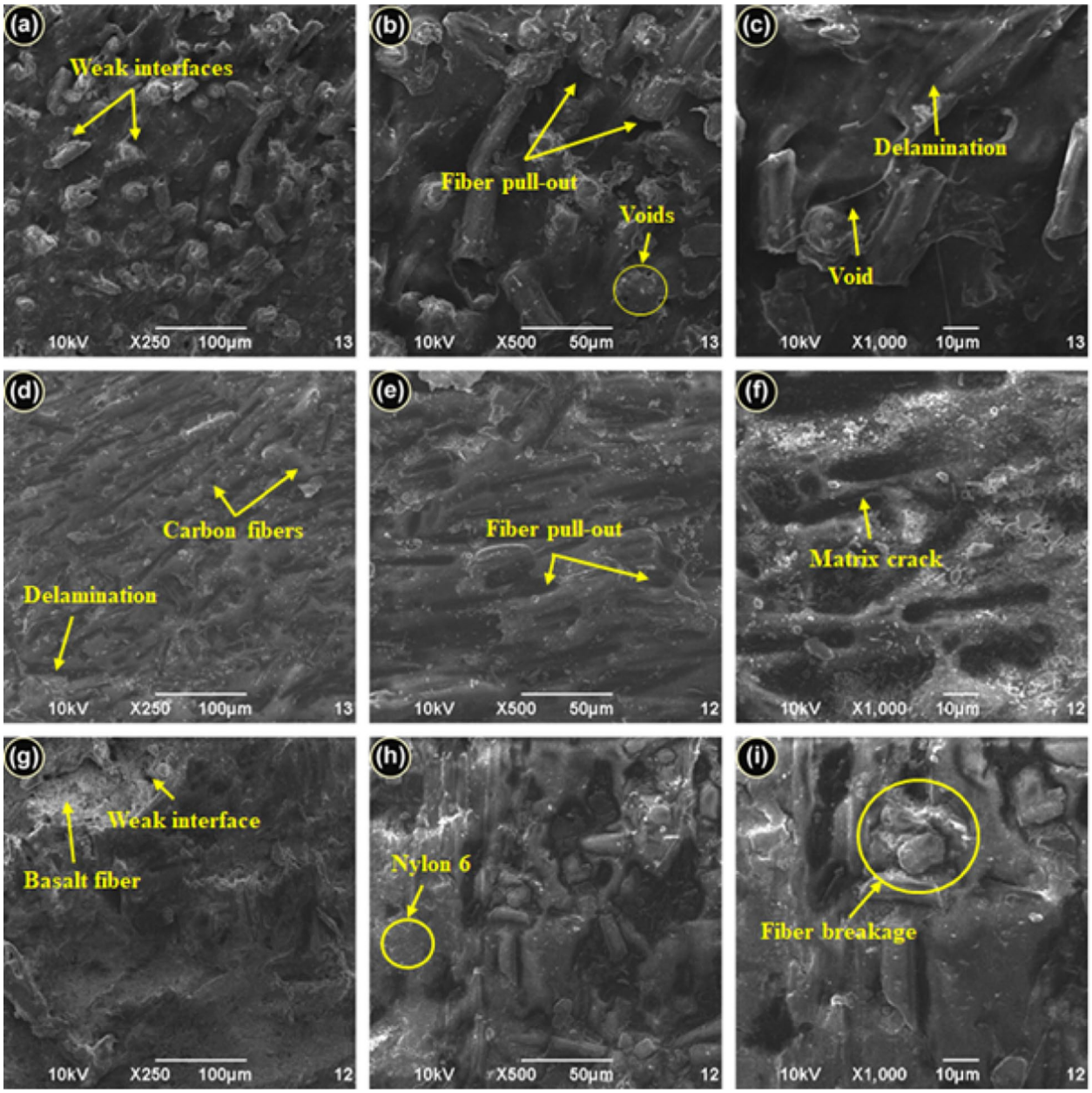

Fig. 7 Fractured surface morphology of the composites: **a**–**c** N/B20, **d**–**f** N/B20/C5, and (**g**)–(**i**) N/B20/C10

Conclusions

The influence of BF content and hybridization effect on the physical, mechanical, and thermal properties of Nylon 6 composites was investigated. The physical property data indicated that the hybridization effect lowered the density and void content in the composites, resulting in substantial improvements in their overall characteristics. Furthermore, the mechanical properties of the BF composites are higher than those of pure Nylon 6, indicating the encouraging effect of BF. Especially, the nylon reinforced with 20 wt.% of BF displayed higher mechanical properties. Furthermore, the experimental results clearly demonstrate that the addition of CF as a secondary reinforcement significantly enhances the properties of the composites, primarily due to its increased strength and stiffness. The thermal investigation indicated that the hybrid composites exhibit thermal stability up to 490.44 °C (T_{Max}) with a residue above 24%. The morphological analysis indicated that the hybrid composites showed improved adhesion with fewer fiber pull-outs/voids, which elevated the properties of hybrid composites. Thus, it can be concluded that the nylon reinforced with 20 wt.% of BF and 10 wt.% of CF records better overall properties, and it

can be recommended for automobile and aircraft interior applications.

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Author contribution All authors reviewed the manuscript.

Data availability No datasets were generated or analysed during the current study.

Declarations

Ethics approval The authors hereby state that the present work is in compliance with the ethical standards.

Conflict of interest The authors declare no competing interests.

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