CHARACTERIZATION OF THE MECHANICAL AND MOISTURE ABSORPTION PROPERTIES OF KENAF REINFORCED POLYPROPYLENE COMPOSITES

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Abstract

Great interest has been generated in the use of natural fibres as environmentally friendly reinforcing materials in polymeric composites, which do not require high load bearing capabilities. kenaf fibres extracted from kenaf plants (hibiscus cannabinus) have been identified as an attractive option due to its production cost and the ability of the kenaf plants to grow in a variety of climatic conditions. Polypropylene (PP) has a relatively low production cost, excellent corrosion resistance, good retention of mechanical properties and less recycling challenges in comparison to other matrix systems such as thermosets. Given the individual advantages of kenaf fibre and polypropylene, kenaf reinforced polypropylene composites (kenaf/PP composites) have considerable commercial interest in the composite industry. However, limitations arise with respect to the mechanical performance and to the resistance to moisture absorption when natural fibres are used.

This study focuses on the improvement of the mechanical properties (e.g. tensile, flexural, fatigue and impact properties) and the resistance to moisture absorption of kenaf reinforced polypropylene composites by means of fibre treatments (e.g. alkali and alkali-silane treatments) and the use of filler materials (e.g. functionalized multi-wall carbon nanotubes). Kenaf reinforced polypropylene composites are manufactured by a modified compression moulding using the film–stacking technique. The crux of this technique is that kenaf mats are impregnated with polypropylene powder in order achieve a uniform material distribution and to lower the manufacturing temperature, thereby preventing the thermal alteration of the composite constituents (e.g. kenaf fibres) and silano functional groups attached to the multi-wall carbon nanotubes. Fibre treatments including alkali treatments and alkali followed by silane treatments (alkali-silane) are considered in order to improve the fibre-matrix interfacial adhesion. The concentrations of the alkali solutions range from 1% to 8% in intervals of 1% by mass. Fibre contents ranging from 20% to 35% in interval of 5% by mass are considered for both kenaf and glass fibre reinforced plates. Functionalized multi-

wall carbon nanotubes are used as filler material in order to improve the mechanical properties of the composite plates. The concentrations of the multi-wall carbon nanotube (MWCNT) range from 0.1% to 1.25%.

Mechanical test and microscopic examination results showed that alkali treatments improve the mechanical properties of kenaf/PP composites. However, the improvements due to alkali-silane treatments were found to be more significant because additional silane treatments substantially enhanced the fibre-matrix interfacial adhesion. Material failures in untreated kenaf/PP composites and alkali treated kenaf/PP composites were mainly characterized by fibre pull-outs, whereas in alkali-silane treated kenaf/PP composites they were characterised by fibre breakage. Alkali concentrations of 5% and 6% NaOH are found to the optimum concentrations for both alkali treatment and alkali-silane treatment.

The use of functionalized MWCNTs as filler material improved furthermore the mechanical properties of kenaf/PP-MWCNT composites in comparison to those of kenaf/PP and glass/PP composites. The main contributing factors of the improvements were found to be the enhancement of the interfacial adhesion between the nanoparticles and the matrix, and also between the nanoparticles and kenaf fibres. Material failures in kenaf/PP-MWCNT composites were characterized by fibre breakage and matrix cracks. The optimum MWCNT concentrations were found to be 0.5% and 0.75%. 30% fibre contents was found to be the optimum fibre content for both kenaf/PP and kenaf/PP-MWCNT composites. Test results showed that the fibre treatments, especially alkali-silane treatment, improved the resistance to moisture absorption of the composites. Test results also showed that the manufacturing technique, which enables the manufacturing of composite plates with layers of different moisture diffusion resistances, has a significant influence on the resistance of kenaf/PP composites. The addition of multi-wall carbon nanotubes to the polypropylene matrix did not alter the moisture absorption resistance of kenaf/PP-MWCNT composites. The impregnation of kenaf and fibre glass mats with polypropylene powder significantly lowered the manufacturing temperature to below the typical melting temperature of the unreinforced polypropylene.