Mechanical and thermal properties of water glass coated sisal fibre-reinforced polypropylene composite

G PHIRI[1], ER SADIKU[2], MC KHOATHANE[2]
[1]CSIR Materials Science and Manufacturing, PO Box 395, Pretoria, 0001
[2]Polymer Technology, Faculty of Engineering and Built Environment, Tshwane University of Technology, Pretoria, 0001
Email: gphiri@csir.co.za – www.csir.co.za

INTRODUCTION

- The main aim of this study is to improve the mechanical and thermal properties of sisal fibre-reinforced polypropylene composites.
- Important properties such as tensile strength, elastic modulus, impact resistance and fire resistance contribute to thermoplastic polymer composites being ideal aircraft materials.

MOTIVATION

- One of South Africa's most pressing problems is the provision of suitable, good quality, low-cost aircraft interior.
- This study promotes the use of locally available natural resources to produce thermoplastic composites for aircraft applications.

EXPERIMENTAL

Composite processing

Materials
Polypropylene Homopolymer powder (60%)
Sisal fibre (15%)
Polypropylene-grafted-maleic anhydride (5%)
Sodium Silicate (20%)

Method
The sisal reinforced-polypropylene composites were produced by extrusion compounding at 200, 185, 185 and 200°C temperature zones and were further processed into tensile test dumbbells by injection moulding (180, 190, 200 and 210°C). **Figure 1** shows the processing steps followed to produce composite samples. Up to 15% fibre loading could be achieved and the sisal fibres were coated with water glass to improve fire resistance. In order to improve the adhesion between sisal fibre and PP, maleic anhydride-grafted-polypropylene (MAPP) was used as a compatibiliser.

Composite characterisation

- Tensile properties of the composites were measured with an Instron Model 4302 testing machine (ISO R527) and the Charpy Impact Test machine (ISO 179 method).
- Thermal characterisation (Differential Scanning Calorimetry – Perkin Elmer 7).
- The surface morphology of the fractured composite samples was studied using scanning electron microscopy (SEM).

Figure 1: Composite preparation process: (A) WG coated fibre,

(B) High speed granulator, (C) Composite granules, (D) Single screw extruder, (E) Injection moulder and (F) Composite samples (dumbbells)

RESULTS AND DISCUSSION

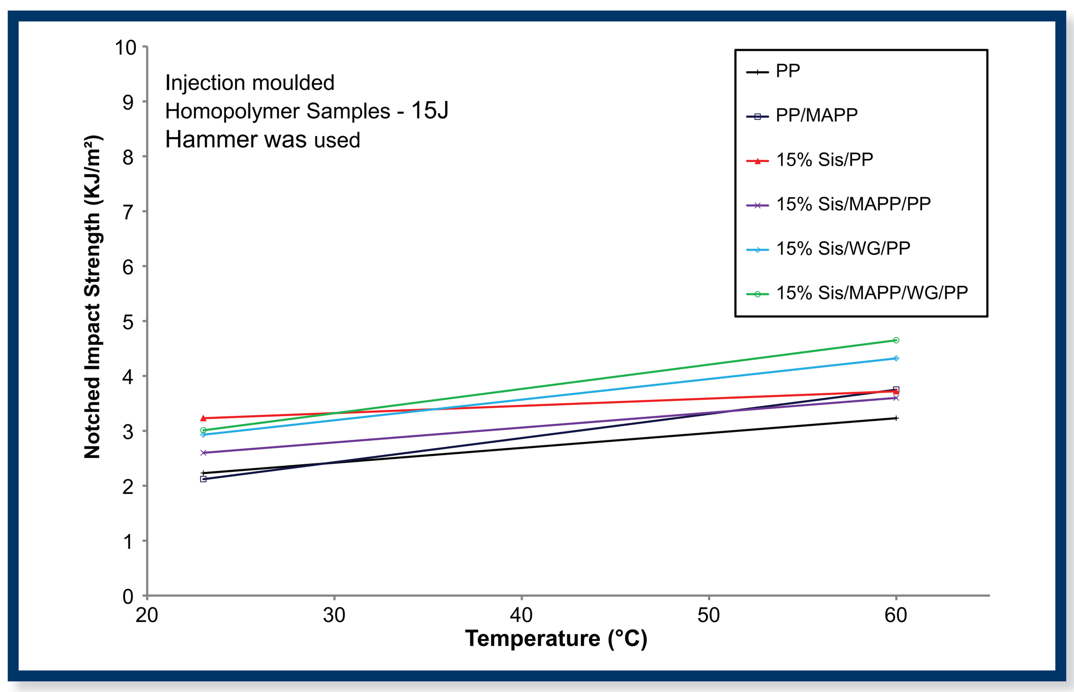

Figure 2: Impact strength of sisal fibre composites at different temperatures

- It is clear from **Figure 2** above that the impact strength of most natural fibre/PP composites increased with an increase in temperature.
- The sisal fibre treated with water glass only showed the higher impact strength at higher temperatures.
- Generally, the impact strength of fibre/PP composites with MAPP compatibiliser was not improved. The low impact strength could be the results of strong interfacial bond strength between the fibres and the matrix.

The surface morphology of fractured impact fibre composite samples

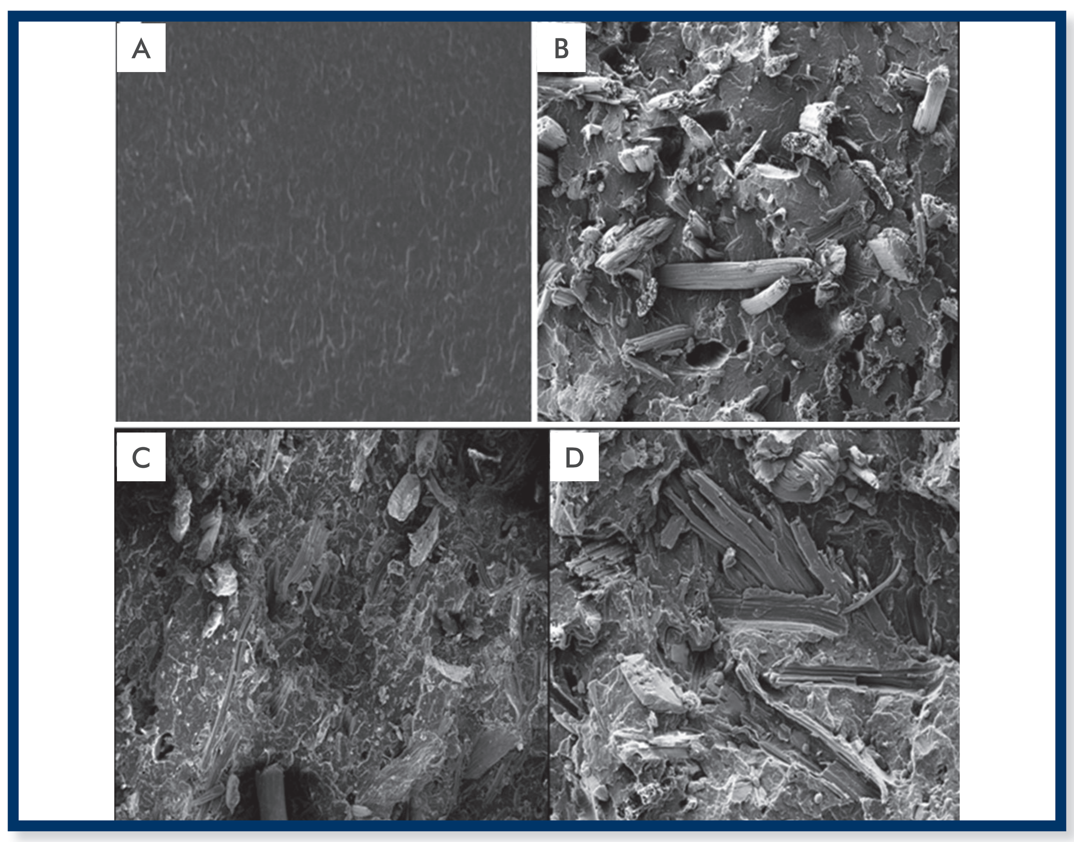

Figure 3: SEM micrographs showing impact fracture surface of Sisal fibre composites. (A) PP, (B) 15% Sisal, (C) 15% Sisal/WG, (D) 15% Sisal/WG/MAPP

- It is clear from **Figure 3** above that the polymer structure changed from a smooth regular structure to an irregular structure with the addition of fibre and water glass.
- The 15% sisal fibre showed a large number of holes, resulting from the pull-out from the matrix.
- Broken fibres embedded in the polymer matrix are observed in (C) and (D) fibre/PP composites due to strong interfacial bonding between the fibre and matrix.

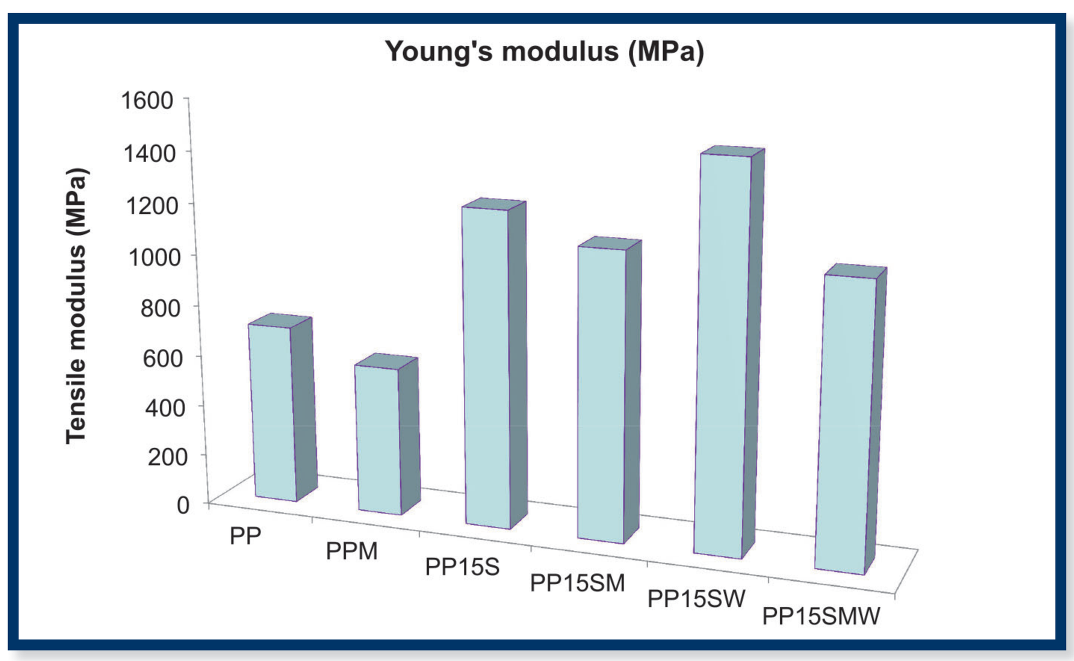

Figure 4: Tensile strength of sisal fibre-reinforced PP composites

In recent years, considerable attention has been given by aircraft manufacturers to the development and utilisation of natural fibres instead of synthetics. This is because natural fibres are a renewable raw material and their availability is more or less unlimited; they have very good heat, acoustic and electrical insulating properties, as well as very good mechanical properties, especially tensile strength.

- It is clear from **Figure 4** above that the addition of water glass content on the fibre/matrix composites increases tensile modulus, while the addition of MAPP decreases the modulus.
- Generally, the tensile modulus of fibre/matrix composites increased with the addition of fibre content and WG content.

CONCLUSIONS

- The impact strength of natural fibres is influenced by temperature.
- The addition of WG gave good results on both impact strength and tensile modulus; this shows that WG-coated fibres might also give good flammability properties.
- The initial findings are promising, but further work is necessary. Thermal results were not yet available for printing.

REFERENCES

[1] Murherjee, P.S. and Satyanarayana, K.G. 1984. Structure and properties of some vegetable fibres, part 1. Sisal fibre, *Journal of Materials Science* 19, pp. 3925–3934.

[2] Chand, N., Tiwary, R.K. and Rohatgi, P.K. 1988. Bibliography resource structure properties of natural cellulosic fibres – an annotated bibliography, *Journal of Materials Science* 23, pp. 381–387.

K-10032 [www.kashan.co.za]