UNIVERSITI PUTRA MALAYSIA

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PREPARATION OF UNIDIRECTIONAL POLYPROPYLENE REINFORCED KENAF COMPOSITE USING MECHANICAL IMPREGNATION METHOD

By

BERNARD MARINGGAL

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in fulfillment of the requirement for the Degree of the Master of Science

October 2010

DEDICATION

TO MY LOVELY FATHER
Maringgal ak Mula

AND

MY LOVELY MOTHER
Chendai ak Jambu

Abstract of thesis presented to the Senate of University Putra Malaysia in fulfillment of the requirement for the degree of Master of Science

PREPARATION OF UNIDIRECTIONAL POLYPROPYLENE REINFORCED KENAF COMPOSITE USING MECHANICAL IMPREGNATION METHOD

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OCTOBER 2010

Chairman : Khalina Abdan, PhD

Faculty : Faculty of Engineering

Kenaf plant is one of the potential sources of natural fibre in Malaysia. Research in kenaf plastic composite is growing tremendously parallel to the high demand from the plastic industry which aiming to produce the natural fibre based materials. In this project, unidirectional kenaf fibres and polypropylene (PP) were used for manufacturing a composite. The composite was prepared by a new developed mechanical impregnation method.

The mechanical impregnation technique involves transferring the PP into unidirectional kenaf fibre and controlling compression pressure given on the composite mould. The mechanical impregnation is composed by three parts; (1) compression moulding, which function to form the composite product by using identified mould, (2) a controlled speed barrel plunger, which is place to melt the polypropylene and transfer

the melted polypropylene into unidirectional kenaf bundle, (3) a load cell, which is to determine the pressure given.

Properties of PP were evaluated using melt flow index test (MFI) and viscosity determination. It was found that the MFI of polypropylene at optimum processing temperature 230°C is 36.7 g/10min. Besides that, PP also showed a zero viscosity behavior or η_0 and a lower Newtonian region were observed at this temperature. PP/Kenaf composite was produced with the optimum processing parameters and mechanical properties were investigated according to tensile test and izod impact test. The thermal properties were determined by dynamic mechanical analysis (DMA) and the morphology of fracture surface was studied using scanning electron micrograph (SEM).

The pressure is stable at 200 Kpa and the tensile strength of PP/Kenaf composite increased to 35.14 Mpa as compared to virgin PP with addition of 40% volume of kenaf fibre. However impact strength was decreased to 130.98 J/M. The dynamic mechanical properties of PP/Kenaf composites showed that the storage modulus (E') and loss modulus (E") decreases with increase in temperature. However, the storage modulus (E') and loss modulus (E") of PP/Kenaf composite was increased as compared to virgin PP. This finding showed that the addition of kenaf fibres in composite influenced the elasticity of PP. In addition, the tan δ properties were decreased because the relative damping peak height is affected by the concentration of

the measured materials. It was also found that the glass transition temperature (T_g) of PP/Kenaf composite was shifted to the lower temperature at 14.7°C.

From the scanning electron micrograph (SEM), it can be clearly seen that the PP is fully penetrated in the unidirectional kenaf fibre and this also illustrated the efficiency of mechanical impregnation process. However, the micrograph of impact test found that the fibre pull out and showed the fibre breakage behavior.

These imply that, the preparation of unidirectional polypropylene reinforced kenaf composite using mechanical impregnation method will create opportunities to the small medium industry and fresh entrepreneur to increase the composite production by implementing a lower energy and lower cost for economic growth in Malaysia. Therefore, it will improve the smart materials production where only through this material the balance of the ecology can be maintained. Finally, the sources of resources can be diversifying according to the composite based industries, particularly in terms of natural fibre.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk Ijazah Master Sains.

PENYEDIAAN UNI-ARAH POLIPROPILENA MEMPERKUKUHKAN KOMPOSIT KENAF DENGAN MENGGUNAKAN KAEDAH IMPREGNASI MEKANIKAL

Oleh

BERNARD MARINGGAL

OCTOBER 2011

Pengerusi : Khalina Abdan, PhD

Fakulti : Fakulti Kejuruteraan

Tanaman kenaf berpotensi sebagai penyumbang terbesar dalam pengeluaran gentian asli di Malaysia. Penyelidikan dalam bidang komposit plastik kenaf semakin meningkat memandangkan permintaan dalam industri plastik untuk menghasilkan produk yang berasaskan bahan gentian asli. Dalam projek ini, gentian kenaf uni-arah dan polipropilena (PP) digunakan untuk menghasilkan produk komposit. Komposit disediakan dengan kaedah baru dibangunkan iaitu impregnasi mekanikal.

Kaedah impregnasi mekanikal melibatkan pemindahan PP ke atas gentian kenaf uni-arah dan tekanan mampatan diberikan ke atas acuan komposit tersebut secara terkawal. Mesin impregnasi mekanikal mempunyai 3 bahagian; (1) acuan mampatan berfungsi untuk membentuk produk komposit dengan menggunakan acuan yang telah dikenalpasti, (2) tong pelocok kawalan laju sebagai tempat pencairan PP dan

memindahkan PP lebur ke dalam gentian kenaf, (3) sel beban untuk menentukan tekanan yang dikenakan.

Ciri – ciri PP diuji berdasarkan piawai ujian plastik seperti ujian indeks leburan (MFI) dan ujian kelikatan. Didapati bahawa ujian indeks leburan (MFI) bagi PP pada suhu pemprosesan optima iaitu 230°C, adalah 36.7 g/10min. Selain daripada itu, diperhatikan bahawa PP menunjukkan kelikatan sifar η_0 dan rantau Newtonian rendah ditemui pada suhu ini. Didapati juga bahawa, nilai indeks leburan semakin meningkat dengan meningkatnya suhu dan kelikatan didapati berkurangan dengan peningkatan suhu pemprosesan.

Komposit PP/Kenaf telah dihasilkan dengan menggunakan parameter pemprosesan yang optima dan sifat mekanikal diuji dengan kaedah ujian tegangan dan ujian hentaman. Sifat terma ditentukan dengan ujian mekanikal dinamik (DMA) dan morpologi permukaan patah dikaji dengan mikroskop imbasan electron (SEM). Dengan pertambahan 40% isipadu gentian kenaf dan tekanan stabil pada 200Kpa, didapati kekuatan tegangan komposit PP/Kenaf meningkat ke 35.14 Mpa. Walaubagaimanpun, kekuatan hentaman menurun pada 130.98 (J/M). Sifat mekanikal dinamik komposit PP menunjukkan modulus penyimpanan (E') dan modulus pelepasan (E") menurun dengan pertambahan suhu. Namun begitu didapati bahawa nilai modulus penyimpan (E') dan modulus pelepasan (E") komposit PP/Kenaf adalah bertambah berbanding dengan PP. Penemuan ini menunjukkan bahawa penambahan gentian kenaf dalam komposit telah mempengaruhi ketegaran PP. Tambahan lagi, sifat tan δ telah menurun kerana puncak

relatif tinggi redaman sangat dipengaruhi oleh kepekatan bahan diukur. Selain daripada itu didapati juga bahawa suhu peralihan kaca komposit PP/Kenaf berpindah ke suhu yang lebih rendah iaitu pada 14.7°C.

Daripada kajian mikroskop imbasan elektron (SEM), jelas menunjukkan bahawa PP lebur menembusi sepenuhnya ke dalam gentian kenaf uni-arah dan ini juga menunjukkan keberkesanan proses impregnasi mekanikal. Namun begitu, didapati mikrograf dari sampel ujian hentaman menunjukkan sifat gentian kenaf terkeluar dan patah.

Secara tidak langsung, penyediaan komposit PP diperkukuh oleh uni-arah gentian kenaf dengan menggunakan kaedah impregnasi mekanikal akan mencipta peluang untuk industri bersaiz kecil dan pengusaha baru untuk meningkatkan pengeluaran komposit dengan menerapkan tenaga dan kos yang lebih rendah untuk pertumbuhan ekonomi di Malaysia amnya. Selain daripada itu, ia juga akan meningkatkan pengeluaran bahan pintar di mana hanya melalui bahan ini keseimbangan ekologi dapat dipertahankan. Akhir sekali, sumber gentian asli boleh dipelbagaikan dan sesuai dengan industri berasaskan komposit.

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Thank you!

I certify that a Thesis Examination Committee has met on 28 October 2010 2011 to conduct the final examination of Bernard Anak Maringgal on his thesis entitled "Preparation of Unidirectional Polypropylene Reinforced Kenaf Composite Using Mechanical Impregnation Method" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

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DECLARATION

I declare that the thesis is on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently submitted for any other degree at University Putra Malaysia or other institutions.

BERNARD MARINGGAL

Date: 28 October 2010

TABLE OF CONTENT