UNIVERSITI PUTRA MALAYSIA

PROPERTIES OF SHORT KENAF FIBER-REINFORCED THERMOPLASTIC POLYURETHANE COMPOSITES

YOUSUF ALI GUMAAN EL-SHEKEIL

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By

YOUSUF ALI GUMAAN EL-SHEKEIL

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Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Doctor of Philosophy

August 2012

DEDICATION

This thesis is gratefully dedicated to:

My Beloved Father and Mother for their unlimited sacrifices, encouragements and support throughout my life

My Wife for her patience and understanding

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Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

PROPERTIES OF SHORT KENAF FIBER-REINFORCED THERMOPLASTIC POLYURETHANE COMPOSITES

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August 2012

Chairman : Mohd Sapuan Salit, PhD, PEng

Faculty : Engineering

This research was carried out to produce a new composite material from kenaf (*Hibiscus Cannabinus*) bast fiber and thermoplastic polyurethane (TPU/KF). The effect of processing parameters (i.e. temperature, time and speed in the internal mixer) on tensile strength were studied. The effect of different fiber sizes; namely, <125, 125-300, and 300-425 µm on tensile, flexural, and impact strengths and thermogravimetric analysis (TGA) were studied. Fiber loading (i.e. 20, 30, 40 and 50 % fiber by weight) was tested using tensile and flexural properties and impact strength. Further characterizations for the 30% fiber loading using hardness and abrasion resistance were performed. Effect of sodium hydroxide (NaOH) treatment on TPU/KF mechanical properties was determined. Effect of polymeric Methylene Diphenyl Diisocyanate (pMDI) additive on mechanical and thermal properties of TPU/KF composites was also investigated. Effect of pMDI chemical treatment was studied in two procedures. First, fibers were chemically treated with pMDI. Second, pMDI chemical treatment was used with NaOH pretreated fibers. Temperature, time and speed were optimum at 190 °C, 11 min, and 40 rpm, respectively.

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Fiber size and fiber loading were optimum at fibers between 125 and 300 µm and 30% fiber loading. Tensile strength decreased by 37, 47 and 62% for 2, 4 and 6% NaOH concentrations; respectively. Flexural and impact strengths have also deteriorated. These results were supported by Fourier Transform Infrared Spectroscopy (FTIR), Scanning Electron Microscopy (SEM) and TGA. It was noticed that the addition of 2, 4 and 6% pMDI did not show a significant change in tensile or thermal properties. These results were also confirmed by FTIR, TGA and Differential Scanning Calorimetry (DSC). pMDI chemical treatment has slightly increased tensile strength, while NaOH+pMDI chemical treatment showed increase in tensile strength and modulus by 30% and 42% respectively, however no significant change was noted in strain. This increase was evident by FTIR, which showed a better H-bonding and SEM which showed a better fiber-matrix adhesion.

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Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

SIFAT- SIFAT KOMPOSIT POLIURETANA TERMOPLASTIK BERTETULANG GENTIAN KENAF

Oleh

YOUSUF ALI GUMAAN EL-SHEKEIL

Pengerusi : Mohd Sapuan Salit, PhD, PEng

Fakulti : Kejuruteraan

Kajian ini telah dijalankan untuk menghasilkan bahan komposit baru dari gentian kulit kenaf (*Hibiscus cannabinus*) dan poliuretana termoplastik (TPU/KF). Kesan parameter pemprosesan (iaitu suhu, masa dan kelajuan dalam pencampur dalaman) ke atas kekuatan tegangan telah dikaji. Kesan saiz gentian yang berbeza iaitu, <125, 125-300, dan 300-425 μm pada kekuatan tegangan, lenturan, dan hentaman dan analisis termogravimetri (TGA) telah dikaji. bebanan gentian (iaitu gentian 20, 30, 40 dan 50% mengikut berat) telah diuji menggunakan sifat tegangan dan lenturan dan kekuatan hentaman. Pencirian lanjut untuk bebanan gentian 30% menggunakan kekerasan dan rintangan lelasan telah dijalankan. Kesan rawatan natrium hidroksida (NaOH) ke atas sifat mekanikal TPU/KF telah ditentukan. Kesan bahan tambah polimer Metilena Diphenil Diisosianat (pMDI) ke atas sifat mekanikal dan termal komposit TPU/KF telah juga dikaji. Kesan rawatan kimia pMDI telah dikaji dalam dua prosedur. Pertama, gentian telah dirawat secara kimia dengan pMDI. Kedua, rawatan kimia pMDI telah digunakan dengan gentian terprarawat NaOH. Suhu, masa dan kelajuan adalah optimum masing-masing pada 190 ° C, 11 min, dan 40 rpm. Saiz gentian dan bebanan gentian adalah optimum pada gentian antara 125 dan 300 μm dan benanan gentian 30%.

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Kekuatan tegangan menurun sebanyak 37, 47 dan 62% masing-masing untuk 2, 4 dan 6% kepekatan NaOH; kekuatan. Lenturan dan hemtaman juga telah merosot. Keputusan ini telah disokong oleh Spektroskopi inframerah transformasi Fourier (FTIR), eikroskopi elektron pengimbasan (SEM) dan TGA. didapati bahawa penambahan pMDI sebanyak 2, 4 dan 6% tidak menunjukkan perubahan yang ketara dalam sifat tegangan atau haba. Keputusan ini juga telah disahkan oleh FTIR, TGA dan kalorimeter pengimbasan perbezaan (DSC). Rawatan kimia pMDI telah meningkat sedikit kekuatan tegangan, manakala rawatan kimia NaOH + pMDI menunjukkan peningkatan dalam kekuatan tegangan dan modulus masing-masing sebanyak 30 dan 42%, namun tiada perubahan ketara telah dicatatkan dalam terikan. Peningkatan ini adalah dibuktikan oleh FTIR, yang menunjukkan ikatan-H dan keputusan SEM menunjukkan ikatan gentian-matriks yang lebih baik.

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I certify that a Thesis Examination Committee has met on August 8th 2012 to conduct the final examination of Yousuf Ali Gumaan El-Shekeil on his thesis entitled "Properties of Short Kenaf Bast Fiber-Reinforced Thermoplastic Polyurethane Composites" 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 Doctor of Philosophy.

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

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DECLARATION

I declare that the thesis is 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 Universiti Putra Malaysia or at any other institutions.

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Date: 8/August/2012

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TABLE OF CONTENTS

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