UNIVERSITI PUTRA MALAYSIA

MECHANICAL PROPERTIES OF MILLET (Pennisetum glaucum [Linn.]) HUSK FILLED HIGH DENSITY POLYETHYLENE COMPOSITES

HAMMAJAM ALHAJI ABBA

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By

HAMMAJAM ALHAJI ABBA

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

February 2014

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DEDICATION

This thesis is dedicated to my family and the entire Muslim Ummah for their support

Abstract of thesis presented to the senate of Universiti Putra Malaysia in fulfillment of the requirement for the degree of Master of Science.

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Chair: **Nur Ismarrubie Binti Zahari, PhD**
Faculty: **Engineering**

Millet husk (MH) is by product of cereal grain millet (*p. glaucum*) from mill. The main purpose of this research was to study the potential of this by product as filler for thermoplastic composites as an alternative to inorganic filler and other natural fibers. The chemical compositions of the fiber were 50.44 %, cellulose, 23.17 % hemicelluloses and 13.19 % lignin respectively. The fiber thermal properties were investigated by means of thermogravimetric analyzer (TGA) and thermal decomposition of the fiber was found to be stable at 245 °C. The moisture content was determined using oven-dry value analysis, thus indicated stability for the fiber-matrix interaction in millet husk-high density polyethylene (MH-HDPE) composites fabrication. Three different fiber sizes; 250 µm, 500 µm and 750 µm were pulverized in this study, consisting of 10 %, 20 % 30 % and 40 % by weight fiber loadings. The MH-HDPE composites were prepared by applications of internal mixer, accompanied by compression molding process. The mechanical properties; tensile, flexural and impact were tested using Instron universal testing machine. The morphologies of fractured surfaces were studied by using scanning electron microscope (SEM). Tensile strength decreases, while tensile modulus increased by increasing the millet fiber loading. The tensile strength of MH-HDPE composites were higher 19.2 % at 10 % fiber loading for 250 µm fiber sizes, 11 % at 10 % fiber loading for 500 µm fiber sizes and 9 % at 10 % fiber loading for 750 µm fiber sizes. While, the tensile modulus of MH-HDPE composites were higher 40 % at 40 % fiber loading for 250 µm fiber sizes, 35.2 % at 40 % fiber loading for 500 µm fiber sizes and 41.2 % at 40 % fiber loading for 750 µm fiber sizes. Flexural stress of the MH-HDPE composites were higher 37 % at 40 % fiber loading for 250 µm fiber sizes, 24.5 % at 20 % fiber loading for 500 µm fiber sizes and 32 % at 20 % fiber loading for 750 µm fiber sizes. while flexural modulus higher 64 % at 40 % loading for 250 µm fiber sizes, 58 % at 30 % fiber loading for 500 µm fiber sizes and 53 % at 40 % fiber loading for 750 µm fiber sizes. The impact strength of the MH-HDPE composites was slightly higher at 10 % fiber loading for all the fiber sizes. The reason why flexural and impact properties gave lower values for fiber loading above 10 % are possibly due to the fiber-to-fiber interaction, void and dispersion problems. Further, impact strength considerably

decrease for all the fiber sizes as the fiber loadings increase compare to unfilled (100%) HDPE composites. Hence at 10% fiber loading, there was slight improvement in strength for 250 % µm fiber size. Thus, the composites tensile and flexural modulus increases as the fiber loading increase. The flexural strength increase up to 20 % fiber loadings, but decrease as loading increases. Tensile strength increase at 10 % fiber loading, but decrease as the fiber loadings increase above 10 % fiber loadings. While the impact strength decrease as the fiber loading increase for all the fiber sizes.

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

SIFAT-SIFAT MEKANIKAL SEKAM SEKOI (*Pennisetum glaucum* [Linn.]) YANG DIPENUHI KOMPOSIT POLIETILENA BERKETUMPATAN TINGGI

Oleh

HAMMAJAM ALHAJI ABBA

Februari 2014

Pengerusi: **Nur Ismarrubie Binti Zahari, PhD**
Fakulti: **Kejuruteraan**

Sekam sekoi (MH) ialah produk sampingan bijirin sekoi (pennisetum glaucum) daripada kilang. Tujuan utama kajian ini ialah untuk mengkaji potensi produk sampingan ini sebagai bahan isian untuk komposit termoplastik sebagai alternatif kepada bahan isian bukan organik dan gentian semulajadi yang lain. Komposisi kimia bagi gentian tersebut ialah masing-masing 50.44 % selulosa, 23.17 % hemiselulosa dan 13.19 % lignin. Sifat-sifat termal gentian tersebut telah dikaji menggunakan penganalisis termogravimetri (TGA) dan penguraian termal bagi gentian tersebut didapati stabil pada suhu 245°C. Kandungan kelembapan telah ditentukan dengan menggunakan analisis nilai ketuhar-kering, sekaligus menunjukkan kestabilan untuk interaksi gentian-matriks dalam pembuatan komposit sekam sekoi-polietilena berketumpatan tinggi (MH-HDPE). Dalam kajian ini, tiga saiz gentian yang berbeza; 250 µm, 500 µm dan 750µm yang telah dihancurkan terdiri daripada 10 %, 20 %, 30 % dan 40 % muatan gentian serat. Komposit MH-HDPE telah disediakan melalui aplikasi pengadun dalaman, diiringi dengan proses pengacuan mampatan. Sifat-sifat mekanikal; ketegangan, kelenturan dan hentaman telah diuji dengan menggunakan mesin penguji universal Instron. Ciri-ciri morfologi pada permukaan yang retak telah dikaji dengan menggunakan mikroskop elektron imbasan (SEM). Kekuatan dan modulus ketegangan meningkat dengan menambah muatan gentian sekoi. Kekuatan tegangan komposit MH- HDPE adalah 19.2 % lebih tinggi pada 10 % tambahan serat XQWXN P VDL] VHUDW SDGD WDPEDKDQ VHUD SDGD WDPEDKDQ VHUDW XQWXN P VDL] VHUDV komposit MH- HDPE lebih tinggi 40% pada 40 % tambahan se UDW XQWXN P VL VHUDW SDGD WDPEDKDQ VHUDW XQWXN P V WDPEDKDQ VHUDW XQWXN P VDL] VHUDW- 7HNDQ +'3(DGDODK OHELK WLQJJL SDGD WDPEDKDQ VH SDGD PXDWDQ VHUDW XQWXN P VDL] VHUDW VHUDW XQWXN P VDL] VHUDW 8QWXN PRGXOXV OHN WLQJJL SDGD SUHPLXP XQWXN P VDL] VHUDW XQWXNP VDL] VHUDW GDQ SDGD WDPEDKDQ VHUD Kekuatan impak bagi komposit MH- HDPE meningkat sedikit kepada 10 % tambahan

serat untuk semua saiz serat. Sebab-sebab sifat lenturan dan kesan memberi nilai-nilai yang lebih rendah untuk pemuatan serat di atas 10% adalah mungkin disebabkan oleh interaksi gentian ke gentian , masalah ruang kosong dan penyebaran tidak rata. Selanjutnya, kesan kekuatan berkurang untuk semua saiz serat apabila bebanan serat meningkat berbanding dengan komposit HDPE (100%)tanpa serat . Oleh itu, pada 10 W D P E D K D Q V H U D W W H U G D S D W V H G L N L W S H Q L Q J N D W serat .Komposit tegangan dan lenturan modulus bertambah apabila peningkatan muatan serat. Kekuatan lenturan meningkat sehingga 20 % beban serat, kemudian menurun apabila muatan bertambah. Tegangan kekuatan meningkat pada 10 % tambahan serat, tetapi berkurang apabila bebanan serat meningkat melebihi 10% bebanan serat. Manakala kekuatan impak menurun apabila muatan serat untuk semua saiz serat ditambah.

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I certify that a Thesis Examination Committee has met on 20 February 2014 to conduct the final examination of Hammajam A. Abba on his thesis entitled "Mechanical Properties of Millet (*Pennisetum glaucum* [Linn.]) Husk-Filled High Density Polyethylene 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 Master of Science.

Members of the Thesis Examination Committee were as follows:

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Date: 21 April 2014

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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Faculty of Engineering
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Date:

DECLARATION

Declaration by the student

I hereby confirm that:

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Declaration by Members of Supervisory committee

This is to confirm that:

- x the research conducted and the writing of this thesis was under our supervision;
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Signature: _____
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Of Supervisory
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Signature:_____
Name of member
of Supervisory
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