UNIVERSITI PUTRA MALAYSIA

PHYSICAL AND MECHANICAL PROPERTIES OF BAMBOO-FILLED EPOXY COMPOSITES FROM SELECTED MALAYSIAN BAMBOO

PARNIA ZAKI KHANI

PHYSICAL AND MECHANICAL PROPERTIES OF BAMBOO-FILLED EPOXY COMPOSITES FROM SELECTED MALAYSIAN BAMBOO

By

PARNIA ZAKI KHANI

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

April 2016

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirements for the Degree of Doctor of Philosophy

PHYSICAL AND MECHANICAL PROPERTIES OF BAMBOO-FILLED EPOXY COMPOSITES FROM SELECTED MALAYSIAN BAMBOO

By

PARNIA ZAKI KHANI

April 2016

Chairman : Associate Professor Rizal Bin Zahari, PhD
Faculty : Engineering

Natural plant fibre composites have been developed for the production of a variety of industrial products, with benefits including environmental protection. Bamboo fibre materials have attracted broad attention as reinforced polymer composites due to their environmental sustainability, mechanical properties, and recyclability. Bamboo culm is a fast growing plant and grows abundantly in Asia, South America, and other diverse climates. Peninsular Malaysia, as a tropical region, has approximately 59 bamboo species from approximately seven genera. From the microstructure analysis of a bamboo culm, it has been revealed that the distribution and the percentage of fibre in wall area varies from bottom to top portion. Therefore, the mechanical and physical properties of a bamboo species are different from bottom to top portion. In this regard, this research aims to investigate four different Malaysian bamboo species, namely Gigantochloa scortechinii (GS), Gigantochloa levis (GL), Dendrocalamus asper (DA), and Dendrocalamus pendulus (DP) divided into three portions (bottom (B), middle (M) and top (T)). It should be noted that the anatomical structure of bamboo species is characterized by vascular bundles, and mechanical, physical and thermal properties of single fibres. In order to extract short fibres from bamboo species a systematic method is proposed, including a combination of alkaline treatment (2% and 4% NaOH) and grinding procedure. In this method, short bamboo fibres with the size of 150µm were distributed in epoxy resin and their mechanical and physical properties were investigated separately. The results show that the mechanical and physical properties of bamboo culms vary between species and along the culm. The results obtained from single fibre tests revealed that the bottom portion of every species possesses the highest mechanical properties. Dendrocalamus asper (DA) as a single fibre showed the highest Young's modulus, strength and thermal stability in comparison with other species. The most optimum mechanical and physical properties of the bamboo fibre-reinforced epoxy composite obtained with a fibre content of 10 wt.%. The mechanical properties of DA, GS and GL fibre reinforced composites decreased by increasing the percentage of alkalization whereas, the properties of DP composites improved through mercerization, where the 2% of

NaOH increased the values even higher than 4% alkaline. The physical properties of DP and GS fibre reinforced epoxy composite improved by 2% sodium hydroxide while DA composite by 4% alkaline. In contrast, untreated GL fibre reinforced composite demonstrated the best mechanical and physical properties, especially at the bottom and the middle portions. The mechanical properties of neat epoxy improved by adding short bamboo fibres. The overall results illustrate that short fibre of DP and GL species present the most suitable option for the purpose of composite production.

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

PENCIRIAN FIZIKAL DAN MEKANIKAL DIPENUHI BULUH KOMPOSIT EPOKSI DARIPADA BULUH MALAYSIA YANG TERPILIH

Oleh

PARNIA ZAKI KHANI

April 2016

Pengerusi : Profesor Madya Rizal Bin Zahari, PhD
Fakulti : Kejuruteraan

Komposit gentian tumbuhan semula jadi telah dibangunkan untuk pengeluaran pelbagai produk industri, dengan manfaat termasuk perlindungan alam sekitar. Bahan gentian buluh telah menarik perhatian luas sebagai komposit polimer bertetulang kerana kemampanan alam sekitar, sifat mekanik, dan kitaran semula. Buluh adalah sejenis tumbuhan yang cepat berkembang dan tumbuh dengan banyaknya di Asia, Amerika Selatan, dan lain-lain kawasan iklim yang pelbagai. Semenanjung Malaysia, sebagai sebuah rantau tropika, mempunyai kira-kira 59 spesis buluh daripada kira-kira tujuh genera. Daripada analisis mikrostruktur tangkai buluh, ianya telah didedahkan bahawa taburan dan peratusan gentian di kawasan dinding daripada bawah ke bahagian atas tangkai adalah berbeza. Oleh itu, sifat-sifat mekanikal dan fizikal spesis buluh adalah berbeza daripada bahagian bawah hingga ke bahagian atas. Dalam hal ini, kajian ini bertujuan untuk mengkaji empat spesis buluh Malaysia yang berbeza, iaitu Gigantochloa scortechinii (GS), Gigantochloa levis (GL), Dendrocalamus asper (DA) dan Dendrocalamus pendulus (DP) dibahagikan kepada tiga bahagian (bawah (B), tengah (M) dan bahagian (T)). Ia harus diperhatikan bahawa struktur anatomi spesis buluh boleh dikategorikan sebagai bandel vaskular, sifat-sifat mekanikal, fizikal dan terma gentian tunggal. Dalam usaha untuk mendapatkan gentian pendek dari spesis buluh tesebut, suatu kaedah sistematik didicadangkan, termasuk gabungan rawatan alkali (2% dan 4% NaOH) dan prosedur pengisaran. Dalam kaedah ini gentian buluh pendek dengan saiz 150μm telah diagihkan di dalam resin epoksi dan sifat-sifat mekanikal dan fizikal mereka telah disiasat secara berasingan. Hasil kajian menunjukkan, sifat mekanik dan fizikal batang buluh berbeza-beza antara spesis dan di sepanjang tangkai itu. Keputusan daripada ujikaji gentian tunggal telah mendapati bahawa bahagian bawah setiap spesis buluh memiliki sifat mekanik yang tertinggi. Gentian tunggal daripada spesis Dendrocalamus asper (DA) menunjukkan bahawa modulus Young, kekuatan dan kestabilan haba yang tertinggi berbanding dengan spesis yang lain. Sifat-sifat mekanik dan fizikal yang paling optimum bagi komposit bertetulang gentian buluh epoksi diperolehi dengan kandungan gentian sebanyak 10 wt.%. Sifat mekanik DA, GS dan GL komposit bertetulang gentian menurun

dengan peningkatan peratusan pengalkalian manakala, sifat-sifat komposit DP diperbaiki melalui rawatan kimia, di mana penggunaan 2% memberi peningkatan nilai lebih tinggi daripada penggunaan 4% alkali. Sifat-sifat fizikal dan bertetulang gentian komposit epoksi untuk DP GS meningkat sebanyak 2% dengan penggunaan NaOH manakala komposit DA sebanyak 4% alkali. Sebaliknya, komposit gentian GL tanpa rawatan menunjukkan sifat-sifat mekanikal dan fizikal terbaik, terutama di bahagian bawah dan bahagian tengah. Sifat mekanik epoksi tunggal bertambah baik dengan penambahan gentian buluh pendek. Keputusan keseluruhan menggambarkan bahawa spesis gentian pendek DP dan GL merupakan pilihan yang paling sesuai untuk tujuan pengeluaran komposit.

ACKNOWLEDGEMENTS

I would like to give my deepest thanks to God Almighty from my heart. My deep respect and appreciation is expressed to my supervisor Assoc. Prof. Dr. Rizal Bin Zahari for his enthusiastic supervision, continuous guidance, kind encouragement and friendly advices throughout my study. I also wish to convey my sincere thanks to my supervisory committee members Dr. Mohamed Thariq Hameed Sultan and Dr. Dayang Laila Abang Abdul Majid for their valuable suggestions, constructive comments and support. My acknowledgement goes to UPM for providing the research facilities.

I wish to offer my special thanks to my beloved Amin and my family members for their love, kindness, encouragement, understanding, constant moral support and inspiration to complete my PhD degree successfully.

I certify that a Thesis Examination Committee has met on 29 April 2016 to conduct the final examination of Parnia Zaki Khani on her thesis entitled "Physical and Mechanical Properties of Bamboo-Filled Epoxy Composites from Selected Malaysian Bamboo" 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.

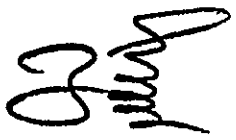
Members of the Thesis Examination Committee were as follows:

Kamarul Arifin Ahmad, PhD
Associate Professor, Ir
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

Faizal bin Mustapha, PhD
Associate Professor, Ir
Faculty of Engineering
Universiti Putra Malaysia
(Internal Examiner)

Mohd Sapuan b Salit @ Sinon, PhD
Professor, Ir
Faculty of Engineering
Universiti Putra Malaysia
(Internal Examiner)

Salim Hiziroglu, PhD
Professor
Oklahoma State University
United States
(External Examiner)



ZULKARNAIN ZAINAL, PhD
Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 28 June 2016

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:

Rizal Bin Zahari, PhD
Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

Mohamed Thariq Hameed Sultan, PhD
Senior Lecturer
Faculty of Engineering
Universiti Putra Malaysia
(Member)

Dayang Laila Abang Abdul Majid, PhD
Senior Lecturer
Faculty of Engineering
Universiti Putra Malaysia
(Member)

BUJANG BIN KIM HUAT, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

Declaration by graduate student

I hereby confirm that:

- this thesis is my original work;
- quotations, illustrations and citations have been duly referenced;
- this thesis has not been submitted previously or concurrently for any other degree at any other institutions;
- intellectual property of the thesis and copyright of thesis are fully-owned by Universiti Putra Malaysia, as according to the Universiti Putra Malaysia (Research) Rules 2014;
- written permission must be obtained from the supervisor and the office of the Deputy Vice-Chancellor (Research and Innovation) before the thesis is published (in the form of written, printed or in electronic form) including books, journals, modules, proceedings, popular writings, seminar papers, manuscripts, posters, reports, lecture notes, learning modules or any other materials as stated in the Universiti Putra Malaysia (Research) Rules 2014;
- there is no plagiarism or data falsification/fabrication in the thesis, and scholarly integrity is upheld as according to the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2014-2015) and the Universiti Putra Malaysia (Research) Rules 2014. The thesis has undergone plagiarism detection software.

Signature: _____ Date: _____

Name and Matric No.: Parnia Zaki khani GS 36052

Declaration by Members of Supervisory Committee

This is to confirm that:

- The research conducted and the writing of this thesis was under our supervision;
- Supervision responsibilities as stated in the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2014-2015) are adhered to.

Signature: _____
Name of
Chairman of
Supervisory Associate Professor
Committee: Dr. Rizal Bin Zahari,

Signature: _____
Name of
Member of
Supervisory
Committee: Dr. Mohamed Thariq Hameed Sultan

Signature: _____
Name of
Member of
Supervisory
Committee: Dr. Dayang Laila Abang Abdul Majid

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

B	Bottom
^{o}C	Degree Celsius
DP	*Dendrocalamus Pendulus*
DA	*Dendrocalamus Asper*
g	Gram
GPa	Gigapascal
GS	*Gigantochloa Scortechinii*
GL	*Gigantochloa Levis*
h	Hour
HCl	Hydrochloric acid
K	Kelvin unit
kN	Kilo Newton
L	Litre
MPa	Megapascal
µm	Micrometre
min	Minute
mL	Millilitre
M	Molar
M	Middle
mg	Milligram
nm	Nanometre
owf	On-weight-of-fibre
Wt.%	Percent by weight
rpm	Revolutions per minute
s	Second
T	Top

CHAPTER 1

INTRODUCTION

1.1 Inroduction

Natural fibres are renewable and environmentally friendly materials; they have low density, low price, and acceptable mechanical properties. Hence, many scientists are interested in replacing them with synthetic materials to conserve the environment. Natural fibres base on their sources are divided into three categories: plant fibres (sisal, hemp, flax, bamboo, etc.), animals parts involving protein (silk, hair, wool, etc.) and minerals (John & Thomas, 2008). The main parts of plant fibres are cellulose, hemicelluloses, lignin, and pectin. In the structure of plant fibres lignin and hemicelluloses matrix held cellulose fibrils together (Jawaid & Khalil, 2011).

Bamboo in comparison with other natural fibres has the fastest growth rate and fixing the carbon dioxide of atmosphere, which makes it the most important plant fibres. It is found that more than 1000 species of bamboo and around 70 genera grow naturally in diverse climates, especially in Asia and South America abundantly (Abdul Khalil et al., 2012; Gratani, Crescente, Varone, Fabrini, & Digiulio, 2008) . Peninsular Malaysia as a tropical state has around 59 bamboo species from approximately seven genera: *Dendrocalamus*, *Gigantochloa*, *Racemobamboos*, *Bambusa*, *Schizostachyum*, *Dinochloa*, and *Thyrsostachys* (Department, 2013; Nations, 2006). In Malaysia bamboo culms are the most significant resources in terms of economic importance after timber (Mohamad, 1994).

Bamboo has several advantages such as light weight, high strength, stiffness, biodegradability, recyclability and even its roots and leaves keep the soil together and protect them against the sun respectively (Janssen, 2000). These properties are caused that bamboo to be used traditionally for manufacturing of living tools. Beside the massive utilization of bamboo in building construction and living tools, it also can be used as reinforced composite materials (Shin, Xian, Zheng, & Yipp, 1989). Bamboo due to its advantages and the widely availability might be used in the sidewall and ceiling panels, insulation blankets and other less load-bearing parts of an aircraft. In addition, bamboo fibre is able to be replaced with glass fibre in the near future (Osorio, Trujillo, Van Vuure, & Verpoest, 2011). Glass fibres have been widely used as a part of aircraft structure (Foreman, 1990). The structure of bamboo culm is shown in Figure 1.1.

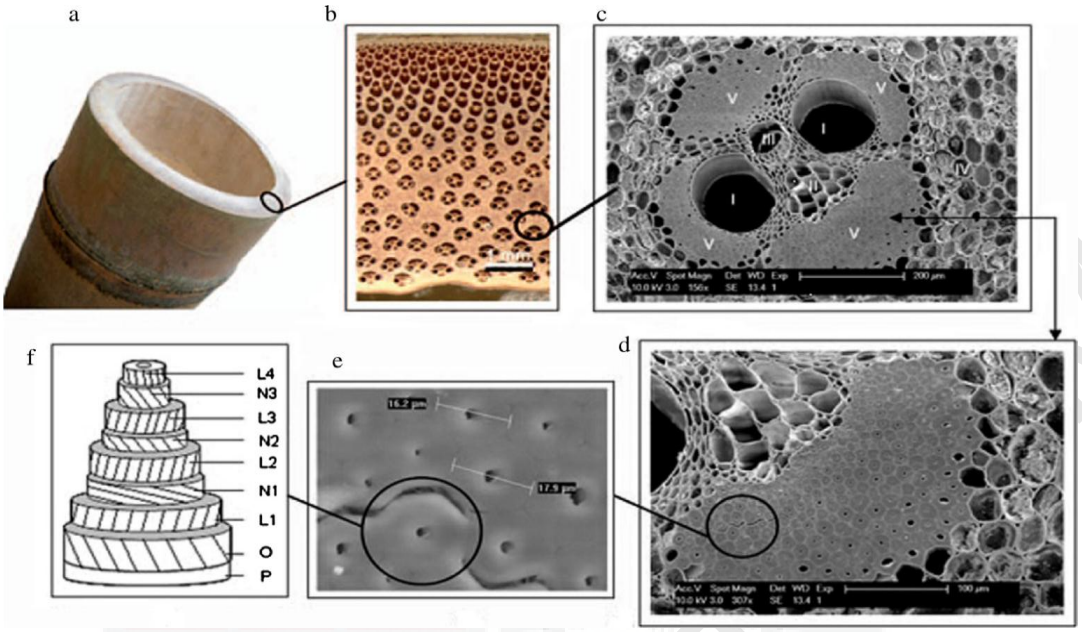


Figure 1.1 (a) Bamboo culm, (b) cross-section of bamboo culm, (c) vascular bundle, (d) fibre strand, (e) elementary fibres (f) model of polylamellae structure of bamboo (Osorio et al., 2011)

1.2 Problem statement

Polymer composite materials and synthetic fibre reinforced composites have been widely used in various industries such as aircraft, automotive and submarine due to their great mechanical and thermal properties. However, the end of life disposal of polymer and synthetic materials is unknown and non-biodegradable. Therefore, the utilization and the manufacturing procedure of these materials will harm the nature. In contrast, lignocellulosic fibres are fully biodegradable and recyclable.

One of the primary objectives in many industries such as automobile and aerospace is to reduce the weight of the vehicles in order to minimize the impact of their products on climate change and improve fuel efficiency. Therefore, the main aim of the researches in the field of aerospace industry is to produce fully recyclable components in the aircraft cabin interior (Reporter, 2008). Moreover, according to EU regulation current vehicles should be replaced with green vehicles in the near future due to very low environmental impact and low usage of carbon energy resources (Union, 2011).

In Malaysia variety of bamboo culms have been widely distributed and easily available in lowland forests, hillsides, riversides and ridge tops (Mohamed & Appanah, 2000). Although bamboo culms are widely available in Malaysia, there has not been comprehensive research on the difference of the species as a reinforcement composite material. In Peninsular Malaysia 59 native bamboo species has been reported in 2000, however, only 16 species are used commercially

(Nations, 2006). In addition, only a few bamboo species have been utilized in the industry due to lack of useful information regarding the mechanical properties of them (Anokye, Bakar, Abare, Kalong, & Muhammad, 2014). Therefore, in order to increase the application of bamboo as reinforced composite materials in various fields of industries due to its massive advantages, it is essential to expand research on different bamboo species. There are only a few investigations on mechanical properties of bamboo species in Peninsular Malaysia, and they have been mostly studied in the form of bamboo strips (Hamdan, Anwar, Zaidon, & Tamizi, 2005, 2009; Rassiah, Megat Ahmad, & Ali, 2014). While, in this research a method has been proposed to explore the suitability of bamboo fibres and detect the most proper species as reinforcement biocomposite materials.

1.3 Objectives of the study

The aim of this research is to analyse four different bamboo species from two genera which belong to the Peninsular Malaysia. In order to, develop a method to extract fibres from a bamboo culm and also to determine their characterization as a bamboo fibre and fibre-reinforced composite. Therefore, the specific objectives of this research are to acquire the aforementioned aims as follows:

i. To develop an extraction method for extracting single fibres with high aspect ratio from four bamboo species, namely, *Dendrocalamus asper* (buluh betong), *Dendracalamus pendulus* (buluh akar), *Gigantochloa levis* (buluh beting) and *Gigantochloa scortechinii* (buluh semantan).
ii. To determine the mechanical, physical and thermal properties of four different bamboo species.
iii. To investigate the mechanical performance of different bamboo species in order to assess its reinforcement ability.
iv. To investigate the effect of chemical treatments of 150µm bamboo fibre in terms of physical and mechanical properties.

1.4 Research scope

i. The four different bamboo species investigated in this research were collected from Pahang in Peninsular Malaysia.
ii. Every bamboo species was divided into three sections as a top, middle and bottom part and fibres from each section were extracted properly.
iii. Mechanical, physical and thermal characterizations of *Dendrocalamus asper* (buluh betong), *Dendracalamus pendulus* (buluh akar), *Gigantochloa levis* (buluh beting) *and Gigantochloa scortechinii* (buluh semantan) with three sections each were tested and analysed.
iv. The short bamboo fibre reinforced composite have been prepared with optimum raw bamboo fibre content (10 wt. %), and chemical treated bamboo fibres with 2 and 4% solution. The prepared composites were tested and analysed separately.

1.5 Thesis Organization

This thesis consists of five main chapters. The first chapter presents a brief background on composites and bamboo fibres reinforced composite. This chapter also includes problem statements, objectives and at the end the research scope of this thesis is presented. The second chapter reviews and classifies various extraction methods that have been used to extract fibres. It also expresses the micro structure of four different bamboo species and the abundance of them in Malaysia. Composite preparation and the combination of plastic matrix and bamboo fibre reinforcement are explained. The employed methodologies are presented in chapter three which consist of fibre extraction procedure, mechanical, thermal, physical properties, and bamboo composite characterization. In the results and discussion chapter, the defined methods and analysis have been evaluated and their results are depicted. Chapter five concludes the results and presents a brief summary and future works.

REFERENCES

Abdul Khalil, H. P. S., Bhat, I. U. H., Jawaid, M., Zaidon, A., Hermawan, D., & Hadi, Y. S. (2012). Bamboo fibre reinforced biocomposites: a review. *Materials & Design, 42*, 353-368.

Ahmad, E. E. M., & Luyt, A. S. (2012). Effects of organic peroxide and polymer chain structure on morphology and thermal properties of sisal fibre reinforced polyethylene composites. *Composites Part A: Applied science and manufacturing, 43*(3), 703-710.

Alomayri, T., Assaedi, H., Shaikh, F. U. a., & Low, I. M. (2014). Effect of water absorption on the mechanical properties of cotton fabric-reinforced geopolymer composites. *Journal of Asian Ceramic Societies, 2*(3), 223-230.

Alwani, M. S., Khalil, H. A., Sulaiman, O., Islam, M. N., & Dungani, R. (2013). An approach to using agricultural waste fibres in biocomposites application: Thermogravimetric analysis and activation energy study. *BioResources, 9*(1), 218-230.

Amada, S., Ichikawa, Y., Munekata, T., Nagase, Y., & Shimizu, H. (1997). Fiber texture and mechanical graded structure of bamboo. *Composites Part B: Engineering, 28*, 13-20.

Amada, S., & Untao, S. (2001). Fracture properties of bamboo. *Composites Part B: Engineering, 32*(5), 451-459.

Anokye, R., Bakar, E. S., Abare, A. Y., Kalong, R. M., & Muhammad, A. (2014). The Difference in Density along the Bamboo Culms of Gigantochloa Scortichinii and Bambusa Vulgaris. *International Journal of Emerging Technology and Advanced Engineering, 4*(10), 638-643.

Aparecido, P., & Giriolli, J. C. (2006). Natural Fibers Plastic Composites for Automotive Applications. *SABIC Innovative Plastics*, 1-9.

Ashimori, M., Katayama, T., Aoyama, E., & Nagai, S. (2004). Study on Splitting of Bamboo Fibers Due to Freezing and Tensile Strength of FRTP Using Bamboo Fibers. *JSME International Journal Series A, 47*(4), 566-569.

Azuan, S. A. S. (2013). Influence of Fibre Volume Fraction and Vacuum Pressure on the Flexural Properties of Sugar Palm Frond Fibre Reinforced Polyester Composites. *Australian Journal of Basic and Applied Sciences, 7*(4), 318-322.

Azwa, Z. N., Yousif, B. F., Manalo, A. C., & Karunasena, W. (2013). A review on the degradability of polymeric composites based on natural fibres. *Materials & Design, 47*, 424-442.

Baley, C. (2002). Analysis of the flax fibres tensile behaviour and analysis of the tensile stiffness increase. *Composites - Part A: Applied Science and Manufacturing, 33*(7), 939-948.

Ball, R., McIntosh, A. C., & Brindley, J. (2008). Feedback processes in cellulose thermal decomposition. Implications for fire-retarding strategies and treatments. *Combustion Theory and Modelling, 8*, 281-291.

Bambooweb.info. Dendrocalamus asper 'Betung Hitam'. from http://www.bambooweb.info/ShowBambooPictures2.php?BooID=138&Desc=&Loc=&Match=138&Cat=*&Genus=*&s=23

Barkoula, N. M., Alcock, B., Cabrera, N. O., & Peijs, T. (2008). Fatigue properties of highly oriented polypropylene tapes and all-polypropylene composites. *Polymers and Polymer Composites, 16*(2), 101-113.

Biagiotti, J., Puglia, D., Torre, L., Kenny, J. M., Arbelaiz, A., Cantero, G., . . . Mondragon, I. (2004). A systematic investigation on the influence of the chemical treatment of natural fibers on the properties of their polymer matrix composites. *Polymer Composites, 25*(5), 470-479.

Bismarck, A., Askargorta, I. A., Springer, J., Lampke, T., Wielage, B., Stamboulis, A., . . . Limbach, H. H. (2002). Surface Characterization of Flax, Hemp and Cellulose Fibers; Surface Properties and the Water Uptake Behavior. *Polymer Composites, 35*(5), 872-894.

Biswas, S., Ahsan, Q., Cenna, A., Hasan, M., & Hassan, A. (2013). Physical and mechanical properties of jute, bamboo and coir natural fiber. *Fibers and Polymers, 14*(10), 1762-1767.

Bledzki, A. K., Fink, H. P., & Specht, K. (2004). Unidirectional hemp and flax EP- and PP-composites: Influence of defined fiber treatments. *Applied polymer, 93*(5), 2150–2156.

Bledzki, A. K., & Gassan, J. (1999). Composites reinforced with cellulose based fibres. *Progress in Polymer Science, 24*(2), 221-274.

Bodros, E., & Baley, C. (2008a). Study of the tensile properties of stinging nettle fibres (Urtica dioica). *Materials Letters, 62*(14), 2147-2149.

Bodros, E., & Baley, C. (2008b). Study of the tensile properties of stinging nettle fibres (Urtica dioica). *Materials Letters, 62*(14), 2143-2145.

Bouffard-vercelli, Y., Dauchez, P., & Delebarre, X. (2003). Proceedings of International Workshop on Bamboo Industrial Utilization *International Network for Bamboo and Rattan*.

Chaowana, P. (2013). Bamboo: An Alternative Raw Material for Wood and Wood-Based Composites. *Journal of Materials Science Research, 2*(2), 90-102.

Chattopadhyay, S. K., Khandal, R. K., Uppaluri, R., & Ghoshal, A. K. (2010). Bamboo Fiber Reinforced Polypropylene Composites and Their Mechanical , Thermal , and Morphological Properties. *Journal of Applied Polymer Science, 119*, 1619-1626.

Chen, H. (2015). Lignocellulose Biorefinery Engineering: Principles and Applications: Woodhead Publishing.

Chen, H., Miao, M., & Ding, X. (2009). Influence of moisture absorption on the interfacial strength of bamboo/vinyl ester composites. *Composites Part A: Applied science and manufacturing, 40*(12), 2013-2019.

Chung, K. F., & Yu, W. K. (2002). Mechanical properties of structural bamboo for bamboo scaffoldings. *Engineering Structures, 24*(4), 429–442.

Corp, A. M. T. (2015). Pate bending rolls and slip roll machines

D570-98, A. (1998). Standard Test Method for Water Absorption of Plastics *ASTM International*. West Conshohocken, PA.

D2734-09, A. (2009). Standard Test Methods for Void Content of Reinforced Plastics *ASTM International*. west conshohocken pa.

D5083-02, A. (2002). Standard Test Method for Tensile Properties of Reinforced Thermosetting Plastics Using Straight-Sided Specimens *ASTM International*. West Conshohocken, PA.

Das, M., & Chakraborty, D. (2009). The effect of alkalization and fiber loading on the mechanical properties of bamboo fiber composites, Part 1: — Polyester resin matrix. *Journal of Applied Polymer ScienceApplied, 112*(1), 489-495.

Defoirdt, N., Biswas, S., Vriese, L. D., Tran, L. Q. N., Acker, J. V., Ahsan, Q., . . . Verpoest, I. (2010). Assessment of the tensile properties of coir, bamboo and jute fibre. *Composites Part A: Applied science and manufacturing, 41*(5), 588-595.

Deo, C., & Acharya, S. K. (2010). Effect of Moisture Absorption on Mechanical Properties of Chopped Natural Fiber Reinforced Epoxy Composite. *Journal of Reinforced Plastics and Composites, 29*(16), 2513-2521.

Department, F. (2013). Rattan and Bamboo. from http://www.forestry.gov.my/index.php/my/?option=com_content&view=article=659&Itemid=1027&lang=en&profile=bubblesblue?profile=wave

Deshpande, A. P., Rao, M. B., & Rao, C. L. (1999). Extraction of bamboo fibers and their use as reinforcement in polymeric composites. *Journal of Applied Polymer Science, 76*, 83-92.

Dong, C., & Davies, I. J. (2012). Flexural properties of macadamia nutshell particle reinforced polyester composites. *Composites Part B: Engineering, 43*(7), 2751-2756.

Eldridge, D. (2013, March 28). Flax weaves its way into cars and aircraft, *European Plastics News*, pp. 1-2.

Fazal, A., & Fancey, K. S. (2008). Performance enhancement of nylon kevlar fiber composites through viscoelastically generated pre-stress. *Polymers and Polymer Composites, 16*(2), 101-113.

Fazita, N., Rawi, M., Jayaraman, K., & Bhattacharyya, D. (2003). Bamboo Fabric Reinforced Polypropylene and Poly(lactic acid) for Packaging Applications : Impact , Thermal , and Physical Propertie. *Polymer Composites*.

Fengel, D., & X Shao, M. (1984). A chemical and ultrastructural study of the Bamboo species Phyllostachysmakinoi Hay. *Wood Science and Technology, 18*, 103-112.

Fiore, V., Bella, G. D., & Valenza, A. (2015). The effect of alkaline treatment on mechanical properties of kenaf fibers and their epoxy composites. *COmposite Part B: Engineering, 68*, 14-21.

Foreman, C. (1990). *Advanced Composites*.

Fu, J., Zhang, X., Yu, C., Guebitz, G. M., & Cavaco-paulo, A. (2012). Bioprocessing of Bamboo Materials. *Fibres and Textiles in Eastern Europe, 1*, 13-19.

Fuentes, C., Tran, L. Q. N., Dupont-Gillain, C., Vanderlinden, W., De Feyter, S., Van Vuure, A., & Verpoest, I. (2011). Wetting behaviour and surface properties of technical bamboo fibres. *Colloids and Surfaces A: Physicochemical and Engineering Aspects, 380*(1), 89-99.

Gardetti, M. A., & Muthu, S. S. (2015). *Handbook of Sustainable Luxury Textiles and Fashion*, : Springer.

Glass, H. D. (1954). Investigation of rank in coal by differntial thermal analysis. *Economic Geology, 49*, 294-309.

Godbole, V. S., & Lakkad, S. C. (1986). Effect of water absorption on the mechanical properties of bamboo. *Journal of Materials Science Letters, 5*(3), 303-304.

Gomes, A., Goda, K., & Ohgi, J. (2004). Effects of Alkali Treatment to Reinforcement on Tensile Properties of Curaua Fiber Green Composites. *JSME International Journal Series A, 47*(4), 541-546.

González, D., Santos, V., & Parajó, J. C. (2011). Manufacture of fibrous reinforcements for biocomposites and hemicellulosic oligomers from bamboo. *Chemical Engineering Journal, 167*(1), 278-287.

Gratani, L., Crescente, M. F., Varone, L., Fabrini, G., & Digiulio, E. (2008). Growth pattern and photosynthetic activity of different bamboo species growing in the Botanical Garden of Rome *Flora - Morphology, Distribution, Functional Ecology of Plants, 203*(1), 77-84.

Grosser, D., & Liese, W. (1971). On the Anatomy of Asian Bamboos, with Special Reference to their Vascular Bundles. *Wood Science and Technology, 5*, 290-312.

Gupta, A., & Kumar, A. (2008). Potential of Bamboo in Sustainable Development. *Asia Pacific Business Review, 4*(3), 100-107.

Haines, P. J. (2002). *Principles of thermal analysis and calorimetry*: Royal society of chemistry.

Hamdan, H., Anwar, U. M. K., Zaidon, A., & Tamizi, M. M. (2005). Physical and mechanical properties of Gigantochloa Scortechini Bamboo Splits and Strips. *Journal of Tropical Forest Science, 17*(1), 1-12.

Hamdan, H., Anwar, U. M. K., Zaidon, A., & Tamizi, M. M. (2009). Mechanical properties and failure behaviour of gigantochloa scortechinii. *Journal of Tropical Forest Science, 21*(4), 336-344.

Han, G., Lei, Y., Wu, Q., Kojima, Y., & Suzuki, S. (2008). Bamboo–Fiber Filled High Density Polyethylene Composites: Effect of Coupling Treatment and Nanoclay. *Journal of Polymers and the Environment, 16*, 123-130.

Han, J. S., & Rowell, J. S. (1996). Chemical composition of fibres. In M. R. Rowell, A. Y. Raymond & K. J. Rowell (Eds.), *Paper and Composites from Agro-Based Resources*.

He, J., Tang, Y., & Wang, S.-Y. (2007). Differences in Morphological Characteristics of Bamboo Fibres and other Natural Cellulose Fibres: Studies on X-ray Diffraction, Solid State 13C-CP/MAS NMR, and Second Derivative FTIR Spectroscopy Data. *Iranian Polymer Journal, 16*(12), 807-818.

He, L., Li, X., Li, W., Yuan, J., & Zhou, H. (2012). A method for determining reactive hydroxyl groups in natural fibers: application to ramie fiber and its modification. *Carbohydrate Research, 348*, 95–98.

Hisham, H. N., Othman, S., Rokiah, H., Latif, M. A., Ani, S., & Tamizi, M. M. (2006). Characterization of Bamboo Scortechinii At Different Ages Gigantochloa. *Journal of Tropical Forest Science, 18*(4), 236-242.

Industries, P. (2009). Knife Ring Flaker, Type PZKR *Economical Production of Quality flakes*.

Ishak, M. R., Leman, Z., Sapuan, S. M., Rahman, M. Z. a., & Anwar, U. M. K. (2013). Impregnation modification of sugar palm fibres with phenol formaldehyde and unsaturated polyester. *Fibers and Polymers, 14*(12), 250-257.

Ishak, M. R., Sapuan, S. M., Leman, Z., Rahman, M. Z. a., & Anwar, U. M. K. (2012). Characterization of sugar palm (Arenga pinnata) fibres Tensile and thermal properties. *Journal of thermal analysis and calorimetry, 109*(2), 981-989.

Jain, S., Kumar, R., & Jindal, U. C. (1992). Mechanical behaviour of bamboo and bamboo composite. *Journal of materials science, 27*, 4598-4604.

Janssen, J. J. (2000). *Designing and building with bamboo*: International Network for Bamboo and Rattan China.

Jansson, J. J. A. (2000). *Designing and Building With Bamboo*. The Netherlands Technical University of Eindhoven Eindhoven.

Jawaid, M., & Khalil, H. P. S. A. (2011). Cellulosic/synthetic fibre reinforced polymer hybrid composites: A review. *Carbohydrate Polymers, 86*, 1-18.

Jena, H., Pradhan, A. K., & Pandit, M. K. (2014). Studies on water absorption behaviour of bamboo – epoxy composite filled with cenosphere. *Journal of Reinforced Plastics and Composites, 33*(11), 1059-1068.

Jindal, U. C. (1986). Development and Testing of Bamboo-Fibres Reinforced Plastic Composites. *Journal of Composite Materials, 20*(1), 19-29.

John, M. J., & Anandjiwala, R. D. (2008). Recent Developments in Chemical Modification and Characterization of Natural Fiber-Reinforced Composites. *Polymer Composites*, 187-207.

John, M. J., & Thomas, S. (2008). Biofibres and biocomposites. *Carbohydrate Polymers, 71*(3), 343–364.

Joshi, S. V., Drzal, L., Mohanty, A., & Arora, S. (2004). Are natural fiber composites environmentally superior to glass fiber reinforced composites? *Composites Part A: Applied science and manufacturing, 35*(3), 371-376.

Kabir, M. M. (2012). *Effects of Chemical Treatments on Hemp Fibre Reinforced Polyester Composites By Mohammad Mazedul Kabir Supervised by Assoc Prof Hao Wang Prof Alan Kin-tak Lau Assoc Prof Thiru Aravinthan A dissertation submitted for the award of Centre of Excellence in En.* (PhD), University of Southern Queenzland.

Kalia, S., & Kaur, B. S. K. I. (2011). *Cellulose Fibers: Bio- and Nano-Polymer Composites*: Springer.

Kaur, V., Chattopadhyay, D., & Kaur, S. (2013). Study on Extraction of Bamboo Fibres from Raw Bamboo Fibres Bundles Using Different Retting Techniques. *Textiles and Light Industrial Science and Technology, 2*(4).

Kim, H., Okubo, K., Fujii, T., & Takemura, K. (2013). Influence of fiber extraction and surface modification on mechanical properties of green composites with bamboo fiber. *Journal of Adhesion Science and Technology, 27*(12), 1348-1358.

Kumar, A., Wang, L., Dzenis, Y. a., Jones, D. D., & Hanna, M. a. (2008). Thermogravimetric characterization of corn stover as gasification and pyrolysis feedstock. *Biomass and Bioenergy, 32*, 460-467.

Kumar, S., Choudhary, V., & Kumar, R. (2010). Study on the compatibility of unbleached and bleached bamboo-fiber with LLDPE matrix. *Journal of thermal analysis and calorimetry, 102*(2), 751-761.

Kumar, V., Kushwaha, P. K., & Kumar, R. (2011). Impedance-spectroscopy analysis of oriented and mercerized bamboo fiber-reinforced epoxy composite. *Journal of materials science, 46*, 3445–3451.

Kushwaha, P. K., & Kumar, R. (2009). The Studies on Performance of Epoxy and Polyester-based Composites Reinforced with Bamboo and Glass Fibers. *Journal of Reinforced Plastics and Composites, 29*(13), 1952-1962.

Kushwaha, P. K., & Kumar, R. (2009). Studies on Water Absorption of Bamboo-Polyester Composites: Effect of Silane Treatment of Mercerized Bamboo. *Polymer-Plastics Technology and Engineering, 49*(1), 45-52.

Kushwaha, P. K., & Kumar, R. (2010). Studies on Performance of Acrylonitrile-Pretreated Bamboo-Reinforced Thermosetting Resin Composites. *Journal of Reinforced Plastics and Composites, 29*(9), 1347-1352.

Lakkad, S. C., & Patel, J. M. (1980-81). Mechanical Properties of Bamboo, a Natural Composite. *Fibre science and Technology, 14*, 319-322.

Lee, S.-H., & Wang, S. (2006). Biodegradable polymers/bamboo fiberbiocomposite with bio-based coupling agent. *Composites Part A: Applied science and manufacturing, 37*(1), 80-91.

Li, S. H., FU, S. Y., Zhou, B. L., Zeng, Q. Y., & Rao, X. R. (1994). Reformed bamboo and reformed bamboo/aluminium composite. *Journal of materials science, 29*, 5990-5996.

Liese, W. (1998). *The Anatomy of Bamboo Culms*. International network for bamboo and rattan.

Liu, H., Huang, Y., Yuan, L., He, P., Cai, Z., Shen, Y., . . . Xiong, H. (2010). Isothermal crystallization kinetics of modified bamboo cellulose/PCL composites. *Carbohydrate Polymers, 79*(3), 513-519.

Lo, T. Y., Cui, H. Z., & Leung, H. C. (2004). The effect of fiber density on strength capacity of bamboo. *Materials Letters, 58*(21), 2595– 2598.

Londoño, X., Camayo, G. C., Riaño, N. M., & López, Y. (2002). Characterization of the anatomy of Guadua angustifolia (Poaceae: Bambusoideae) culms. *Bamboo Science and Culture, 16*(1), 18-31.

López, O. H. (2003). *Bamboo: The Gift of the Gods*. Bogotá, Colombia: Oscar Hidalgo-López

López, O. H. (2003). Physical-mechanical and chemical properties *Bamboo: The Gift of the Gods* (pp. 570).

Mahjoub, R., Yatim, J. M., Mohd Sam, A. R., & Hashemi, S. H. (2014). Tensile properties of kenaf fiber due to various conditions of chemical fiber surface modifications. *Construction and Building Materials, 55*, 103-113.

Malanit, P. (2009). *The Suitability of Dendrocalamus asper Backer for Oriented Strand Lumber*. Hamburg.

Mallick, P. K. (2008). *Fiber-reinforced composites: materials, manufacturing, and design*: Taylor & Francis Group.

Mansaray, K., & Ghaly, A. (1998). Thermal degradation of rice husks in nitrogen atmosphere. *Bioresource technology, 65*(1), 13-20.

Maria, I., Rosa, D., Maria, J., Puglia, D., Santulli, C., & Sarasini, F. (2010). Morphological , thermal and mechanical characterization of okra (Abelmoschus esculentus) fibres as potential reinforcement in polymer composites. *Composites Science and Technology, 70*(1), 116-122.

McMullen, P. (1984). Fibre/resin composites for aircraft primary structures: a short history, 1936–1984. *Composites, 15*(3), 222-230.

Mohamad, A. (1994). Bamboo in Malaysia: conservation status, biodiversity base and its strategic programme: Frim reports.

Mohamed, A. H., & Appanah, S. (2000). *Bamboo - Conservation, Diversity, Ecogeography, Germplasm, Resource Utilization and Taxonomy*: International Plant Genetic Resources Institute.

Mohanty, S., & Nayak, S. K. (2010). Short bamboo fiber-reinforced HDPE composites: influence of fiber content and modification on strength of the composite. *Journal of Reinforced Plastics and Composites, 29*(14), 2199-2210.

Mohanty, S., & Nayak, S. K. (2010). Short bamboo fibre-reinforced HDPE composites: influence of fibre content and modification on strength of the composite. *Journal of Reinforced Plastics and Composites*.

Nakamura, K., Hatakeyama, T., & Hatakeyama, H. (1981). Studies on bound water of cellulose by differential scanning calorimetry. *Textile Research Journal, 51*(9), 607-613.

Nations, U. (2006). Global forest resources assessment update 2005. Rome: Food and Agriculture Organization of the United Nations.

Nayak, S. K., Mohanty, S., & Samal, S. K. (2009). Influence of short bamboo/glass fiber on the thermal, dynamic mechanical and rheological properties of polypropylene hybrid composites. *Materials Science and Engineering: A, 523*(1-2), 32-38.

Nirmal, U., Hashim, J., & Low, K. O. (2012). Adhesive wear and frictional performance of bamboo fibres reinforced epoxy composite. *Tribology International, 47*, 122-133.

Nugroho, N., & Ando, N. (2001). Development of structural composite products made from bamboo II: fundamental properties of laminated bamboo lumber. *Journal of wood science, 47*(3), 237-242.

Ogawa, K., Hirogaki, T., Aoyama, E., & Imamura, H. (2008). Bamboo Fiber Extraction Method Using a Machining Center. *Journal of Advanced Mechanical Design, Systems, and Manufacturing, 2*, 550-559.

Okubo, K., Fujii, T., & Yamamoto, Y. (2004). Development of bamboo-based polymer composites and their mechanical properties. *Composites Part A: Applied science and manufacturing, 35*(3), 377-383.

Osorio, L., Trujillo, E., Van Vuure, A., & Verpoest, I. (2011). Morphological aspects and mechanical properties of single bamboo fibres and flexural characterization of bamboo/epoxy composites. *Journal of Reinforced Plastics and Composites*, 0731684410397683.

Ouajai, S., & Shanks, R. (2005). Composition, structure and thermal degradation of hemp cellulose after chemical treatments. *Polymer Degradation and Stability, 89*(2), 327-335.

Ozturk, S. (2005). The effect of fibre content on the mechanical properties of hemp and basalt fibre reinforced phenol formaldehyde composites. *Journal of materials science, 40*(17), 4585-4592.

Parklands, S. n. (2014). Bamboo land. from http://www.bambooland.com.au/bamboo/gigantochloa-levis

Peltola, H., Madsen, B., Joffe, R., Nattinen, K., & Ttinen, K. (2011). Experimental Study of Fiber Length and Orientation in Injection Molded Natural Fiber/Starch Acetate Composites. *Advances in Materials Science and Engineering, 2011*.

Peng, P., Peng, F., Bian, J., Xu, F., & Sun, R.-C. (2012). A comparative study of bamboo (Phyllostachys incarnata Wen) milled wood lignin and the successively alkali-fractionated lignins. *Wood Science and Technology, 46*(5), 871-885.

Petinakis, E., Yu, L., Simon, G., & Dean, K. (2013). Natural Fibre Bio-Composites Incorporating Poly(Lactic Acid) *Fiber Reinforced Polymers - The Technology Applied for Concrete Repair*: Intech.

Phong, N. T., Fujii, T., Chuong, B., & Okubo, K. (2012). Study on How to Effectively Extract Bamboo Fibers from Raw Bamboo and Wastewater Treatment. *Journal of Materials Science Research, 1*(1), 144-155.

Quintana, C. Department of environment and natural resources. from http://flickriver.com/photos/tags/departmentofenvironmentandnaturalresources/

Rajulu, A. V., Baksh, S. A., Reddy, G. R., & Chary, K. N. (1998). Chemical Resistance and Tensile Properties of Short Bamboo Fiber Reinforced Epoxy Composites. *Journal of Reinforced Plastics and Composites, 17*, 1507-1511.

Rajulu, A. V., Chary, K. N., Reddy, G. R., & Meng, Y. Z. (2004). Void content, density and weight reduction studies on short bamboo fiber – epoxy composites. *Journal of Reinforced Plastics and Composites, 23*(2), 127-130.

Rao, B. K., & Mishra, P. K. (2012). Final Project Report (2007-2012) of National Bamboo Mission Sponsored Research & Development Project on " Hydrologic and Economic Evaluation of Bamboo Plantations in Gullied Lands under Major Ravine Systems of India ".

Rao, K. M. M., & Rao, K. M. (2007). Extraction and tensile properties of natural fibers: Vakka, date and bamboo. *Composite Structures, 77*(3), 288-295.

Rassiah, K., Megat Ahmad, M. M. H., & Ali, A. (2014). Mechanical properties of laminated bamboo strips from Gigantochloa Scortechinii/polyester composites. *Materials and Design, 57*, 551-559.

Ray, a. K., Das, S. K., Mondal, S., & Ramachandrarao, P. (2004). Microstructural characterization of bamboo. *Journal of materials science, 39*, 1055 – 1060.

Razali, N., Salit, M. S., Jawaid, M., Ishak, M. R., & Lazim, Y. (2015). A Study on Chemical Composition, Physical, Tensile, Morphological, and Thermal

Properties of Roselle Fibre: Effect of Fibre Maturity. *BioResources, 10*(1), 1803-1824.

Reporter, C. M. (Producer). (2008). CSIR, Airbus to research use of natural fibres for aircraft components. Retrieved from http://www.engineeringnews.co.za

Riano, N. M., Londono, W., lopez, Y., & Gomez, J. H. (2002). Plant growth and biomass distribution on GuaduaangustifoliaKunth in relation to ageing in the Valle del Cauca – Colombia. *The journal of the American Bamboo society, 16*, 43-51.

Robinson, I. M., & Robinson, J. M. (1994). The influence of fibre aspect ratio on the deformation of discontinuous fibre-reinforced composites. *Journal of materials science, 29*(18), 4663-4677.

Rong, M. Z., Zhang, M. Q., Liu, Y., Yang, G. C., & Zeng, H. M. (2001). The effect of fiber treatment on the mechanical properties of unidirectional sisal-reinforced epoxy composites. *Composites Science and Technology, 61*, 1437-1447.

Rout, J., Misra, M., Thripathy, S. S., Nayak, S. K., & Mohanty, A. K. (2001). The influence of fiber surface modification on the mechanical properties of coir-polyester composites. *Polymer Composites, 22*(4), 468.

Rowell, R. M., Han, J. S., & Rowell, J. S. (2000). Characterization and Factors Effecting Fiber Properties. *Natural Polymers an Agrofibers Composites*, 115-134.

Saheb, D. N., & Jog, J. P. (1999). Natural fiber polymer composites: A review. *Advances in Polymer Technology, 18*(4), 351-363.

Samal, S. K., Mohanty, S., & Nayak, S. K. (2008). Polypropylene-Bamboo/Glass Fiber Hybrid Composites: Fabrication and Analysis of Mechanical, Morphological, Thermal, and Dynamic Mechanical Behavior. *Journal of Reinforced Plastics and Composites, 28*(22), 2729-2747.

Sapuan, S. M., & Bachtiar, D. (2012). Mechanical Properties of Sugar Palm Fibre Reinforced High Impact Polystyrene Composites. *Procedia Chemistry, 4*, 101-106.

Satyanarayana, K. G., Arizaga, G. G. C., & Wypych, F. (2009). Biodegradable composites based on lignocellulosic fibers—An overview. *Progress in Polymer Science, 34*(9), 982-1021.

Schott, W. (2003). Bamboo under the Microscope (pp. 1-24).

Schröder, S. (2012). When and How to Harvest Bamboo. from http://www.guaduabamboo.com/cultivation/when-and-how-to-harvest-bamboo

Sfiligoj Smole, M., Hribernik, S., Kleinschek, K. S., & Kreže, T. (2013). Plant Fibres for Textile and Technical Applications *Advances in Agrophysical Research* (pp. 369-398).

Shao, S., Jin, Z., Wen, G., & Iiyama, K. (2009). Thermo characteristics of steam-exploded bamboo (*Phyllostachys pubescens*) lignin. *Wood Science and Technology, 43*(7-8), 643-652.

Shao, S., Wen, G., & Jin, Z. (2008). Changes in chemical characteristics of bamboo (Phyllostachyspubescens) components during steam explosion. *Wood Science and Technology., 42*(6), 439-451.

Shi, Q., Mou, H., Li, Q., Wang, J., & Guo, W. (2012). Influence of heat treatment on the heat distortion temperature of poly (lactic acid)/bamboo fiber/talc hybrid biocomposites. *Journal of Applied Polymer Science, 123*(5), 2828-2836.

Shi, Z.-j., Xiao, L.-p., Jia-Deng, Xu, F., & Sun, R.-c. (2012). Physicochemical Characterization of Lignin Fractions Sequentially Isolated from Bamboo (Dendrocalamusbrandisii) with Hot Water and Alkaline Ethanol Solution. *Journal of Applied Polymer Science, 125*, 3290-3301.

Shin, F. G., Xian, X.-J., Zheng, W.-P., & Yipp, M. W. (1989). Analyses of the mechanical properties and microstructure of bamboo-epoxy composites. *Journal of materials science, 24*, 3483-3490.

Snipview. (2012). Gigantochloa scortechinii. from http://www.snipview.com/q/Gigantochloa_scortechinii

Sreenivasan, S., Iyer, P. B., & Iyer, K. R. K. (1996). Influence of delignification and alkali treatment on the fine structure of coir fibres (Cocos Nucifera). *Journal of materials science, 31*(3), 721-726.

Takagi, H., & Ichihara, Y. (2004). Effect of Fiber Length on Mechanical Properties of " Green " Composites Using a Starch-Based Resin and Short Bamboo Fibers. *JSME International Journal Series A, 47*, 551-555.

Technology, Z. E. (2009). Double roller crusher: Zhongke Engineering & Technology Co.,Ltd

Thwe, M. M., & Liao, K. (2002). Effects of environmental aging on the mechanical properties of bamboo _glass fiber reinforced polymer matrix hybrid composites. *Composites Part A: Applied science and manufacturing, 33*, 43-52.

Thwe, M. M., & Liao, K. (2003). Durability of bamboo-glass fiber reinforced polymer matrix hybrid composites. *Composites Science and Technology, 63*(3-4), 375-387.

Thwe, M. M., & Liao, K. i. (2003). Environmental effects on bamboo-glass / polypropylene hybrid composites. *Journal of materials science, 38*, 363-376.

Tokoro, R., Vu, D. M., Okubo, K., Tanaka, T., Fujii, T., & Fujiura, T. (2008). How to improve mechanical properties of polylactic acid with bamboo fibers. *Journal of materials science, 43*(2), 775-787.

Trujillo, E., Osorio, L., Fuentes, C., Van, A. W., & Verpoest, I. (2010). *Bamboo fibre thermoplastic for transport applications*. Paper presented at the International Technical Conferences and Forum, Paris.

Trujillo, E., Osorio, L., Vuure, A. W. V., Ivens, J., & Verpoest, I. (2010). *Characterization of polymer composite materials based on bamboo fibres* Paper presented at the 14TH European Conference on Composite Materials Hungary.

Trujillo, E., Osorio, L., Vuure, A. W. V., Ivens, J., & Verpoest, I. (2013). *Assessment of the proeprties of the properties of bamboo fibre and bamboo fibre composites*. Paper presented at the Composite week@ Leuven and texcomp-11

Tujillo, E., Moesen, M., Osorio, L., Vuure, A. W. V., Ivens, J., & Verpoest, I. (2014). Bamboo fibres for reinforcement in composite materials: Strength Weibull analysis. *Composites Part A: Applied science and manufacturing, 61*, 115-125.

Tung, N. H., Yamamoto, H., Matsuoka, T., & Fujii, T. (2004). Effect of Surface Treatment on Interfacial Strength between Bamboo Fiber and PP Resin. *JSME International Journal Series A, 47*(4), 561-565.

Union, T. E. (2011). World Forum for Harmonisation of Vehicles Regulations Regulatory Environment – European Union.

Voronova, M. I., Petrova, S. N., Lebedeva, T. N., Ivanova, O. N., Prusov, A. N., & Zakharov, A. G. (2003). Structural Changes Induced in Flax Cellulose by Alkaline Treatment. *Russian Journal of Applied Chemistry, 76*(12), 1993-1997.

Wahab, R., Mustapa, M. T., Sulaiman, O., Mohamed, A., Hassan, A., & Khalid, I. (2010). Anatomical and physical properties of cultivated two- and four-year-old bambusa vulgaris. *Sains Malaysiana, 39*(4), 571-579.

Wakchaure, M. R., & Kute, S. Y. (2012). Effect of moisture content on physical and mechanical properties of bamboo. *ASIAN JOURNAL OF CIVIL ENGINEERING(BUILDING AND HOUSING), 13*(6), 753-763.

Wallenberger, T. F., & Weston, T. N. (2004). *Natural fibres, Plastic and Composites*: Kluwa Academic Publishers.

Wang, H., Chang, R., Sheng, K.-c., Adl, M., & Qian, X.-q. (2008). Impact Response of Bamboo–Plastic Composites with the Properties of Bamboo and Polyvinylchloride (PVC). *Journal of Bionic Engineering, 5*, 28–33.

Weyenberg, I. V. D. (2005). *Flax fibres as a reinforcment epoxy composites.* Katholieke Universiteit Leuven.

Yang, H., Yan, R., Chen, H., Lee, D. H., & Zheng, C. (2007). Characteristics of hemicellulose, cellulose and lignin pyrolysis. *Fuel, 86*(12), 1781-1788.

Yao, W., & Zhang, W. (2011). *Research on Manufacturing Technology and Application of Natural Bamboo Fibre*. Paper presented at the 2011 Fourth International Conference on Intelligent Computation Technology and Automation

Ying-Chen, Z., Hong-Yan, W., & Yi-Ping, Q. (2010). Morphology and properties of hybrid composites based on polypropylene/polylactic acid blend and bamboo fiber. *Bioresource technology, 101*, 7944-7950.

Yousif, B. F., shalwan, A., Chin, C. W., & Ming, K. C. (2012). Flexural properties of treated and untreated kenaf/epoxy composites. *Materials & Design, 40*, 378–385.

Yu, X. (2007). *Bamboo: Structure and Culture.* (PhD), Universität Duisburg-Essen.

Yu, Y.-L., Huang, X.-A., & Yu, W.-J. (2014). High performance of bamboo-based fiber composites from long bamboo fiber bundles and phenolic resins. *Journal of Applied Polymer Science, 40371*.

Yueping, W., Ge, W., Haitao, C., Gelin, T., Zheng, L., Feng, X. Q., . . . Xushan, G. (2009). Structures of Bamboo Fiber for Textiles. *Textile Research Journal, 80*(4), 334-343.

Yusriah, L., Sapuan, S. M., Zainudin, E. S., & Mariatti, M. (2013). Effect of alkali treatment on the mechanical properties and morphology of betel nut (Areca catchu) husk fibre. *BioResources, 9*, 7721-7736.

Yusriah, L., Sapuan, S. M., Zainudin, E. S., & Mariatti, M. (2014). Characterization of physical, mechanical, thermal and morphological properties of agro-waste betel nut (Areca catechu) husk fibre. *Journal of Cleaner Production, 72*, 174-180.

Zhou, A., Huang, D., Li, H., & Su, Y. (2012). Hybrid approach to determine the mechanical parameters of fibers and matrixes of bamboo. *Construction and Building Materials, 35*, 191–196.