UNIVERSITI PUTRA MALAYSIA

PROPERTIES OF SUGAR PALM/GLASS FIBRE-REINFORCED THERMOPLASTIC POLYURETHANE COMPOSITES

ATIQAH BINTI MOHD AFDZALUDDIN

IPTPH 2018 4

PROPERTIES OF SUGAR PALM/GLASS FIBRE-REINFORCED THERMOPLASTIC POLYURETHANE COMPOSITES

By

ATIQAH BINTI MOHD AFDZALUDDIN

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

April 2018

DEDICATION

To

My parents

The most patience and supportive persons in my life who’s always believe in her daughter’s potential to finish for what she had started.

My beloved husband

I could never have completed this without your faith, support and constant encouragement. Thank you for believing in myself and my dream.

My dearest kids

Fateh, Tariq and Salahuddin, who were no help in writing this thesis but their presence in my life worth more than everything in this world.

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

PROPERTIES OF SUGAR PALM/GLASS FIBRE-REINFORCED THERMOPLASTIC POLYURETHANE COMPOSITES

By

ATIQAH BINTI MOHD AFDZALUDDIN

April 2018

Chairman : Mohammad Jawaid, PhD
Faculty : Institute of Tropical Forestry and Forest Products

Sugar palm fibres are abundantly available in Malaysia and South Asian countries. In addition to the wide availability and the ease to grow and harvest the sugar palm, the properties of its fibres, such as high wear resistance, low cost of raw material, biodegradability, environmental friendliness are certain advantages. However, despite the advantages, they also have some drawbacks, for example, high water absorbance, low thermal stability and debonding between the polymer matrix and natural fibre, which cause limitations in utilizing natural fibres for different applications. Nonetheless, such drawbacks can be overcome by several modification methods were employed to strengthen the properties of natural fibres composites i.e (1) surface modification by using of 6% alkaline, 2% silane, and combined 6% alkaline-2% silane treatment, (2) fiber treatment and the reinforcement of thermoplastic polyurethane, (3) hybridization of sugar palm (SP) with glass (G) fibre, and (4) surface modification of treated sugar palm with glass fibre reinforced TPU hybrid composites. The findings show that the mechanical, morphological and structural properties of SP fibre were 2% silane treatment were compatible with TPU matrix. The influence of SP fibre at varying loading (0-50 wt%) on the physical, mechanical and thermal properties of TPU composites were evaluated. In term of physical properties, the density, water absorption and thickness swelling increases with increasing fibre loading. Conversely, the 2% silane treated were enhanced the physical properties of SP/TPU composites. Improvement in tensile, flexural, and impact properties of composites were reported for 2 % silane treated at higher SP fiber loading. Moreover, the treated SP fiber exhibited satisfactory values of storage modulus and thermal degradation. In addition, the effect of hybridization of SP with G fibres were also investigated. Hybridization of SP/G at weight ratio (30/10, 20/20, 10/30, and 0/40) were developed by melt-mixing compounding followed by hot pressing moulding. The findings indicated that hybridization of SP with G fibres enhanced the tensile, flexural, and impact properties of hybrid composites. The thermal stability were also improved in the SP/G/TPU hybrid composites. Lastly, the fiber treatment based SP/G/TPU hybrid composites were fabricated and characterized its properties. In terms of physical properties, the obtained results showed that treated hybrid composites with combined 6% alkaline-2% silane exhibited the lower density, thickness swelling and water uptake. Mechanical properties (tensile, flexural and impact) of treated hybrid composites enhanced as compared to untreated hybrid composites. However, treated 30/10 SP/G hybrid composites showed moderate range of storage modulus, loss modulus, damping factor and good thermal stability. Thus, treated hybrid 30/10 SP/G/TPU showed better physical, mechanical and thermo mechanical properties over untreated hybrid composites and it is suitable for light weight density and structural applications which can be recommend for automotive parts.

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

SIFAT-SIFAT POLIURETANA TERMOPLASTIK BERTETULANG GENTIAN ENAU/KACA

Oleh

ATIQAH BINTI MOHD AFDZALUDDIN

April 2018

Pengerusi : Mohammad Jawaid, PhD
Fakulti : Institut Perhutanan Tropika dan Produk Hutan

Gentian Pokok Enau mudah didapati di Malaysia dan negara-negara Asia Selatan. Selain mudah ditanam dan dituai, sifat gentian pokok enau seperti tahan haus, kos bahan mentah yang rendah, keterbiodegradasikan dan mesra alam juga merupakan kelebihannya. Namun terdapat juga kekurangan; gentian ini memiliki kadar serapan air yang tinggi, kestabilan terma yang rendah dan penyahikatan antara matriks polimer dan gentian semula jadi, yang mengehadkan penggunakan gentian semula jadi tersebut dalam pelbagai aplikasi. Walau bagaimanapun, kekurangan ini boleh diatasi melalui beberapa kaedah pengubahsuaian bagi mengukuhkan sifat komposit gentian semula jadi. Antaranya, (1) pengubahsuaian permukaan menggunakan rawatan 6% beralkali, 2% silana dan gabungan 6% alkali-2% silana, (2) rawatan gentian dan pengukuhan poliuretana termoplastik, (3) penghibridan gentian enau (SP) dengan gentian kaca (G), dan (4) pengubahsuaian permukaan gentian enau terawat dengan komposit hibrid TPU bertetulang gentian kaca. Dapatan menunjukkan bahawa sifat mekanik, morfologi dan struktur gentian enau (SP) dengan rawatan 2% silana serasi dengan matriks TPU. Pengaruh gentian SP pada bebanan yang berlainan (0-50 wt%) terhadap sifat fizikal, mekanik dan terma komposit TPU dinilai. Daripada segi sifat fizikal, ketumpatan, penyerapan air dan pengembangan ketebalan bertambah dengan peningkatan bebanan gentian. Sebaliknya, rawatan 2% silana mempertingkatkan sifat fizikal komposit SP/TPU itu. Peningkatan dalam sifat tegangan, lenturan dan impak komposit dilaporkan selepas rawatan 2% silana pada bebanan gentian SP lebih tinggi. Tambahan pula, gentian SP terawat mempamerkan nilai modulus simpanan dan degradasi terma yang memuaskan. Di samping itu, kesan penghibridan SP dengan gentian G juga dikaji. Penghibridan SP/G pada nisbah berat (30/10, 20/20, 10/30 dan 0/40) dibangunkan dengan penyebatian pencampuran lebur yang diikuti dengan pengacuan kempa panas. Dapatan menunjukkan bahawa penghibridan SP dengan gentian G mempertingkat sifat tegangan, lenturan dan hentaman komposit hibrid itu. Kestabilan terma juga dipertingkatkan dalam komposit hibrid SP/G/TPU. Akhir sekali, komposit hibrid rawatan gentian SP/G/TPU ini dicipta dan sifatnya

digambarkan. Daripada segi sifat fizikal, keputusan yang didapati menunjukkan bahawa komposit hibrid yang dirawat dengan gabungan 6% alkali-2% silana mempamerkan ketumpatan yang lebih rendah, pengembangan ketebalan dan penyerapan air. Sifat mekanik (tegangan, lenturan dan impak) komposit hibrid terawat bertambah bagus dibandingkan dengan komposit hibrid tidak terawat. Bagaimanapun, komposit hibrid SP/G 30/10 terawat menunjukkan julat sederhana modulus simpanan, modulus kehilangan, faktor redaman dan kestabilan terma yang baik. Dengan demikian, hibrid SP/G/TPU 30/10 terawat menunjukkan sifat fizikal, mekanik dan mekanik terma yang lebih baik berbanding komposit hibrid tidak terawat dan sesuai untuk kegunaan struktur dan ketumpatan ringan di bahagian automotif.

ACKNOWLEDGEMENTS

Subhanallah walhamdulillah walailaha illallah wallahuakbar.

First of all, all praises shall go to the Almighty Allah SWT, the most beneficient and the most merciful. Peace and blessings be upon the final messenger, Muhammad SAW, upon his family and his righteous companions. Thank you so much Allah SWT for embracing my heart and guiding me throughout journey of my PhD study. My deepest appreciation goes to Institute of Tropical Forestry and Forest Products (INTROP), Universiti Putra Malaysia for giving this opportunity to complete this highest tier of my study. My sincerest thankful to my main supervisor, Dr. Mohammad Jawaid for all his guidance, support and commitment in ensuring the completion of this research study. I would also like to express my thanks to the member of the supervisory committee: Prof. Ir. Mohd Sapuan Salit and Dr. Mohamad Ridzwan Ishak for their support and guidance during my PhD works.

To my parents, no words can describe how much I love both of you, Mohd Afdzaluddin and Shuroiya. Thank you for your undying love, du'a and moral support to me during PhD study. To my husband Mohd Ereiyuskha, thank you for your utmost support and accompany me through up and down. Verily, you are not only my life partner but also my best friend ever. To my kids Fateh, Tariq and Salahuddin, this is an exclusive gift from mama to all of you. I'm sorry for the insufficient family time that I stole and put into this work. You all have been my great sons and thank you for embracing me throughout of this study.

Lasty, I would like to extend my sincerest thanks to Malaysian Higher Education for the MyBrain15 scholarship, UPM for providing Putra Grant (Vot No. 9441501) for this work and also thankful to INTROP lecturers, officers, staffs, colleagues from UPM, outside UPM, government agencies and all for directly or indirectly support and assistance that gathered me strength and courage to reach this finish line.

May Allah SWT bless all of us.

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:

Mohammad Jawaid, PhD
Fellow Researcher
Institute of Tropical and Forestry Product
Universiti Putra Malaysia
(Chairman)

Mohd Sapuan Salit, PhD
Professor, Ir
Faculty of Engineering
Universiti Putra Malaysia
(Member)

Mohamad Ridzwan Ishak, PhD
Senior Lecturer
Faculty of Engineering
Universiti Putra Malaysia
(Member)

____
ROBIAH BINTI YUNUS, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

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 2012-2013) are adhered to.

Signature: ______________________________
Name of Chairman of Supervisory Committee: Dr. Mohammad Jawaid

Signature: ______________________________
Name of Member of Supervisory Committee: Professor Ir. Dr. Mohd Sapuan Salit

Signature: ______________________________
Name of Member of Supervisory Committee: Dr. Mohamad Ridzwan Ishak

TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ISO	Isosorbide
pMDI	Polymeric Methylene Diphenylisocyanate
RO	Rapeseed Oil
ASTM	American Society For Testing And Materials
BDO	1,4-Butanediol
DEA	Diethanolamine
DMA	Dynamic Mechanical Analysis
DTG	Derivative Thermogravity
E’	Storage Modulus
E”	Loss Modulus
EFB	Empty Fruit Bunch
FTIR	Fourier Transform Infrared Spectroscopy
G	Glass
GL	Glycerol
HMDI	Hexamethylene Diisocyanate
IFSS	Interfacial Shear Strength
MDI	4, 4’ Diphenylmethane Diisocyanate
NCO	Isocyanate
NFC	Natural Fibre Composites
OH	Hydroxyl
OPEFB	Oil Palm Fruit Bunch
PAN	Polyacrylonitrile
PEG	Polyethylene-Glicol
PLA	Poly Vinyl Chloride
PU	Polyurethane
SEM	Scanning Electron Microscopy
SGF	Short Glass Fibre
SIPNs	Semi-Interpenetrating Polymer Networks
SOPEP	Soybean Phosphate Ester Polyol
SP	Sugar Palm
SPF	Sugar Palm Fibre

Tan δ	Tan Delta
TDI	Diisocyanate
TEA	Triethanolamine
Tg	Glass Transition Temperature
TGA	Thermogravimetric Anlaysis
TMP	Thermo Mechanical Pulp
TNSP	Treated 6 % Alkaline Sugar Palm
TNSSP	Combined Treated 6% Alkaline-2% Silane Sugar Palm
TPSO	Thevetiaperuviana Seed Oil
TPU	Thermoplastic Polyurethane
TSSP	Treated 2% Silane Sugar Palm
UTSP	Untreated Sugar Palm
VARTM	Vacuum Assisted Resin Transfer Molding

CHAPTER 1

INTRODUCTION

1.1 Introduction and Background

Polymer composites materials with specific characteristics for a specific application, with an added value of environmentally friendly materials, have gained a lot of attention due to the limited availability of the resources (Shaniba et al., 2010; Väisänen et al., 2016). Due to the market demand, the research on composites using natural fibres as the reinforcing filler and biodegradable polymers as matrices are also gaining a lot of attention. At the present time, synthetic polymers were combined with various reinforcing fillers to improve the properties and to obtain the characteristics demanded in actual applications (Koronis et al., 2013). Polyurethanes (PU) is one of the most extensively used plastics both in developed and developing countries due to its advantages regards to the economical factor (price), the ecological (recycling behaviour), and technical requirements (higher thermal stability). On-going research is currently conducted to replace synthetic fibres with lingo-cellulosic fibres as reinforcing fillers. Compared to talc, silica, glass, carbon and other synthetic fibres, the lingo-cellulosic fibres (corn stalk, rice husk, rice straw, jute, abaca, sawdust, wheat straw, and grass) are lightweight, able to reduce wear on the machine used for their production, easily available, renewable, and inexpensive (Swolfs et al., 2014; Thakur et al., 2014b).

In the automotive industry, the definition of an environmental-friendly vehicle represents a vehicle with low carbon emission during operation. In-line with this development, there is a rising demand for light-weight vehicles where some of the metal components can be replaced with composites. Carbon fibre composites have been well-equipped in limited-edition cars, for instance. Composites originated from natural resources are highly in demand similar to other composites in the current market. It is to be expected in future, natural fibre composite (NFC) market reach $ 3.8B and it implies that there is a healthy grow in NFC demand (Brief, 2011). Although the market performance is still lower than steel, the improvement on the materials will increase the growth of natural fibre composites in various applications. An automotive components inside a vehicle made of steels which have been proven to be reliable in terms of performance. However, due to aggressive efforts towards reducing the vehicle weight to meet more stringent automotive policies by the regulatory body worldwide, lighter and renewable materials such as natural-based polymer composite, is an excellent material substituting the traditional engineering material to develop a similar component. Natural-based polymer composite or biocomposite exhibits a significant weight reduction compared to steel, and while being a renewable material, biocomposite is able to meet the automotive policy which is to increase the recyclability percentage of components in a vehicle (Al-Oqla et al., 2016; Rwawiire et al., 2015). Thus, in this research, the potential of using natural-synthetic hybrid composites to manufacture the automotive interior part will be explored.

Sugar palm tree is a promising source of natural fibres which are abundantly available in Southeast Asia, particularly in Malaysia (Sanyang et al., 2016). These fibres are used in many applications due to its superior strength and durability. Among the natural fibres, sugar palm fibres are well known for its high durability and their resistance to seawater (Mukhtar et al., 2016). These two characteristics are the main advantages of sugar palm fibres. Bachtiar et al. (2011) have developed the sugar palm fibre reinforced high impact polystyrene (HIPS) composites and studied its properties, resulting in an improvement on the properties after treatment conducted. Another investigation was carried out by Ishak et al. (2013) on sugar palm fibres, its polymers and composites, in which a number of advantages were observed in order to develop composites materials using the sugar palm fibre (Ishak et al., 2013). Research conducted by Bachtiar et al. (2012b) on untreated short sugar palm fibre/HIPs composites subjected to flexural, impact, and thermal properties, found that the impact performance of these natural fibre composites is poor. The development of the hybrid composites provides a new perspective to the manufacturing industry to reduce the dependency on synthetic fibres which often related to high potential hazard, particularly for human and the environment as well.

1.2 Problem statement

There are many advantages associated with the usage of natural fibres as the composite materials. Most natural fibre composites provide a healthier working condition than the synthetic fibre composites. The trimming, cutting, and mounting of synthetic fibre components produces dust in which causes skin irritation and respiratory diseases to human beings. Besides, natural fibres are less abrasive in nature compared to synthetic fibres. Therefore, natural fibres that offer good thermal and insulating properties are easily recyclable and biodegradable. However, natural fibre composites also have its own disadvantages such as low mechanical properties, low impact strength, poor moisture resistance, poor microbial and fire resistance, and low durability. In order to overcome these flaws, natural fibre can be combined with a stronger synthetic fibre in the same matrix to produce hybrid composites.

Sugar palm fibres (SPF) as compared to other natural fibres on the basis of cost, abundant, local issue were reported (Ishak et al., 2013; Sahari et al., 2012; Sanyang et al., 2016). It is known for its high durability and resistance to seawater. These two properties of using SPF as reinforcement are not based on excellent characteristics, but also on its fast-growing palm in topical regions especially in South East region of Asia. Though, SPF also like natural fibres, faces poor adhesion between hydrophobic polymers that lead to poor properties of the composites. Therefore, by proper fibre treatment before fabricating the composites can improve the properties of the material.

Hybridization of natural fibre with stronger and more corrosion-resistant synthetic fibre, for example, glass fibre or carbon fibre, can also improve the stiffness, strength, as well as the moisture resistant behaviour of the composite. Automotive industries are the main industries the incorporate the use of natural fibres because of the materials properties which are lightweight, high strength-to-weight ratio, and minimum environmental impact. The advantages of using one type of fibre could complement what are lacking in using two or more types of different fibres in a hybrid composite. As a result, a balance in performance and cost could be achieved through a proper material design. However, only a few studies on the properties and characterisation of natural/synthetic fibre reinforced polymer hybrid composites are available today, and mostly, cases on surface treatment are not well-addressed.

A proper weight fraction of natural fibre (such as sugar palm fibre) and synthetic fibre (such as glass) can possibly develop a hybrid composite which can match the thermo-mechanical properties similar to the synthetic fibre reinforced composite with a significant amount of weight and surface treatment. The SPF treatment with NaOH and silane could significantly increase the interfacial bonding between fibre/matrix and ultimately improve the overall performance of hybrid composites. Biocompatibility and thermal stability are the main issues in which can inspire the new formulation of hybrid composites towards the benefits of incorporating biocomposites.

Therefore, the aim of this study is to develop an innovative formulation of untreated and treated sugar palm and glass (SP/G) fibre hybrid composites for a potential application in automotive parts. With this aim, the physical, mechanical and thermal properties of untreated and treated hybrid composites and hybrid composites were compared to find best suitable hybrid composites for automotive parts. Finally, it is expected that the utilisation and usage of SP/G/TPU hybrid composites would lead to the fabrication of biocomposites for automotive part applications.

1.3 Research Objectives

1. To characterise the effect of alkaline and silane treatment on physical, mechanical, and morphological properties of sugar palm fibres
2. To investigate the effect of sugar palm fibre loading on physical, mechanical, and thermal properties of thermoplastic polyurethane composites
3. To evaluate the effect of silane treatment on physical, mechanical, and thermal properties of sugar palm fibre/thermoplastic polyurethane composites
4. To evaluate the effect of surface modification on physical, mechanical, and thermal properties of sugar palm/glass reinforced thermoplastic polyurethane hybrid composites
5. To develop and investigate the effect of glass fibre loading on the physical, mechanical, and thermal properties of sugar palm/thermoplastic polyurethane hybrid composites

1.4 Significance of study

1. The findings from the current study are expected to improve the knowledge in developing composites from sugar palm fibre and thermoplastic polyurethanes.
2. The development of renewable materials with improved properties in this study is expected to aid in addressing the environmental problems regarding the alternative material for petroleum-based materials.
3. The problems associated with the properties of natural fibres could be improved by introducing treatment of the natural fibres.
4. In terms of hybrid composites, this study will explore the new potential materials of sugar palm/glass fibres reinforced thermoplastic polyurethane composites for different applications.
5. In addition, this study also employs fibre treatments for the development of hybrid composites. Thus, added a significance study for the treatment of natural fibres and its effect on the improvement of fibre/matrix interfacial bonding of composites.

1.5 Scope of study

In this research, fibre modification made of sugar palm fibre was performed with various treatment such as using alkaline 6%, silane 2%, and the combination of alkaline 6%-silane 2% for three hours. The characterisations of both physical and mechanical properties were then performed and the most effective fibre treatment was further investigated for the development of sugar palm/TPU composites. The development of SP/TPU composites were fabricated through melt-mixing compounding, followed by hot pressing moulding. The characterisation of their physical, mechanical, and thermal properties was performed. The best SP fibre loading were then used to be treated with the most effective fibre treatment in order to investigate the effect of fibre treatment on SP/TPU composites. Besides, the fibre loading for the SP/TPU was also used to be substituted with the hybrid composites. The physical, mechanical, and thermal properties of the untreated and treated SP/TPU composites were investigated. The hybridization of the composites was carried out by substituting sugar palm and glass fibre as the reinforcement and the thermoplastic polyurethane as the matrix. The physical, mechanical, and thermal properties were also investigated for comparison. The optimum properties of hybrid composites were then undergone further pre-modification of sugar palm fibre. The properties such as physical, mechanical, and thermal properties again were observed. The potential of the properties of the hybrid composite was evaluated as a new potential material to be used in automotive part applications.

1.6 Thesis organization

This thesis is organised in accordance with the alternative thesis format of Universiti Putra Malaysia, which is based on the publications of this study. Each research chapter represents a separated study inclusive of introduction, methodology, results and discussion, and conclusions. The details of the thesis structure are as follows:

Chapter 1

The problems that initiate this research and the research objectives were clearly highlighted in this chapter. The significance of this work and the scope of the study were also explained in details in this chapter.

Chapter 2

This chapter presents the a comprehensive literature review on the areas related to the topic of the thesis. Moreover, the research gaps obtained from the review were also clarified in this chapter.

Chapter 3

This chapter presents the methodology used in this study for the preparation of materials, testing procedure, and data collection.

Chapter 4

This chapter presents the second article entitled "Effect of Alkali and Silane Treatments on Mechanical and Interfacial Bonding Strength of Sugar Palm Fibres with Thermoplastic Polyurethane". In this article, the properties of the sugar palm fibre for both untreated and treated composites were investigated.

Chapter 5

This chapter presents the third article entitled "**Moisture Absorption and Thickness Swelling Behaviour of Sugar Palm Fibre Reinforced Thermoplastic Polyurethane**". The influence of fibre loading (0-50 wt%) of sugar palm fibre on physical properties (density, thickness swelling, and water absorption) of thermoplastic polyurethane was evaluated.

Chapter 6

This chapter presents the fourth article entitled "Mechanical and Thermal Properties of Sugar Palm Fibre Reinforced Thermoplastic Polyurethane Composites: Effect of Silane Treatment and Fibre Loading". In this article, the effect of silane treatment and fibre loading (0-50 wt%) of sugar palm fibre reinforced thermoplastic polyurethane was investigated in terms of mechanical and thermal properties.

Chapter 7

This chapter presents the fifth article entitled "**Effect of Surface Treatment on Mechanical Properties of Treated Sugar Palm/Glass Fibre Reinforced Thermoplastic Polyurethane Hybrid Composites".** In this article, the effect of sugar palm/glass fibre reinforced thermoplastic polyurethane treatment on mechanical properties were investigated.

Chapter 8

This chapter presents the "**Physical Properties of Treated Sugar Palm Fibre Reinforced Thermoplastic Polyurethane".** The physical properties of silane treatment on sugar palm fibre reinforced thermoplastic polyurethane were characterise in this article.

Chapter 9

This chapter presents the "**Physical and Mechanical Properties of Sugar Palm/Glass Fibre Reinforced Thermoplastic Polyurethane Hybrid Composites".** The effects of sugar palm/glass fibre loading (30/10, 20/20, 10/30, and 0/40 wt%) on physical and mechanical properties were evaluated.

Chapter 10

This chapter presents the "**Physical and Thermal Properties of Treated Sugar Palm /Glass Fibre Reinforced Thermoplastic Polyurethane Composites".** The effect of surface modification on physical (density, thickness swelling, water absorption) and thermal (DMA and TGA) properties were characterised in this article.

Chapter 11

This chapter presents the overall conclusions from the whole study and future recommendations for further improvement of this study.

REFERENCES

Abdel-Magid, B., & Mourad, A. (2012). *Long-term effect of seawater on glass/thermoset composites.* Paper presented at the Fifteenth European Conference on Composite Materials (ECCM 15), Venice, Italy.

Abdelmouleh, M., Boufi, S., Belgacem, M. N., & Dufresne, A. (2007). Short natural-fibre reinforced polyethylene and natural rubber composites: effect of silane coupling agents and fibres loading. *Composites Science and Technology, 67*(7), 1627-1639.

Abdelmouleh, M., Boufi, S., Belgacem, M. N., Dufresne, A., & Gandini, A. (2005). Modification of cellulose fibers with functionalized silanes: effect of the fiber treatment on the mechanical performances of cellulose–thermoset composites. *Journal of Applied Polymer Science, 98*(3), 974-984.

Abdullah, N. M., & Ahmad, I. (2013). Potential of using polyester reinforced coconut fiber composites derived from recycling polyethylene terephthalate (PET) waste. *Fibers and Polymers, 14*(4), 584-590. doi:10.1007/s12221-013-0584-7

Abeysinghe, C. M., Thambiratnam, D. P., & Perera, N. J. (2013). Flexural performance of an innovative hybrid composite floor plate system comprising glass–fibre reinforced cement, polyurethane and steel laminate. *Composite Structures, 95*, 179-190.

Acharya, S. D. S. (2014). Study on mechanical properties of natural fiber reinforced woven jute-glass hybrid epoxy composites. *Advances in Polymer Science and Technology, 4*(1).

Adroja, P. P., Koradiya, S., Patel, J., & Parsania, P. (2011). Preparation, mechanical and electrical properties of glass and jute–epoxy/epoxy polyurethane composites. *Polymer-Plastics Technology and Engineering, 50*(9), 937-940.

Afdzaluddin, A., Maleque, M. A., & Iqbal, M. (2013). *Synergistic effect on flexural properties of kenaf-glass hybrid composite.* Paper presented at the Advanced Materials Research.

Agrawal, R., Saxena, N., Sharma, K., Thomas, S., & Sreekala, M. (2000). Activation energy and crystallization kinetics of untreated and treated oil palm fibre reinforced phenol formaldehyde composites. *Materials Science and Engineering: A, 277*(1), 77-82.

Ahmad, F., Choi, H. S., & Park, M. K. (2015). A review: natural fiber composites selection in view of mechanical, light weight, and economic properties. *Macromolecular Materials and Engineering, 300*(1), 10-24.

Akil, H. M., Santulli, C., Sarasini, F., Tirillò, J., & Valente, T. (2014). Environmental effects on the mechanical behaviour of pultruded jute/glass fibre-reinforced polyester hybrid composites. *Composites Science and Technology, 94*, 62-70.

Al-Oqla, F. M., Sapuan, S., Ishak, M., & Nuraini, A. (2016). A decision-making model for selecting the most appropriate natural fiber–Polypropylene-based composites for automotive applications. *Journal of composite materials, 50*(4), 543-556.

Algood, R., Sharma, S., Syed, A. A., Rajulu, A. V., & Krishna, M. (2006). Compression properties of E-glass/polyurethane composites. *Journal of Reinforced Plastics and Composites, 25*(14), 1445-1447.

Ali, E. S., & Ahmad, S. (2012). Bionanocomposite hybrid polyurethane foam reinforced with empty fruit bunch and nanoclay. *Composites Part B: Engineering, 43*(7), 2813-2816.

AlMaadeed, M. A., Kahraman, R., Khanam, P. N., & Madi, N. (2012). Date palm wood flour/glass fibre reinforced hybrid composites of recycled polypropylene: Mechanical and thermal properties. *Materials & Design, 42*, 289-294.

Amico, S., Angrizani, C., & Drummond, M. (2008). Influence of the stacking sequence on the mechanical properties of glass/sisal hybrid composites. *Journal of Reinforced Plastics and Composites*.

Amin, M., Anuar, K., & Haji Badri, K. (2007). Palm-based bio-composites hybridized with kaolinite. *Journal of Applied Polymer Science, 105*(5), 2488-2496.

Antunes, M., Cano, Á., Haurie, L., & Velasco, J. I. (2011). Esparto wool as reinforcement in hybrid polyurethane composite foams. *Industrial Crops and Products, 34*(3), 1641-1648.

Arenz, S., & Lausberg, D. (1990). *Glass fiber reinforced thermoplastic polyurethanes: a new material for exterior body parts* (0148-7191). Retrieved from

Arrakhiz, F. Z., El Achaby, M., Kakou, A. C., Vaudreuil, S., Benmoussa, K., Bouhfid, R., . . . Qaiss, A. (2012). Mechanical properties of high density polyethylene reinforced with chemically modified coir fibers: Impact of chemical treatments. *Materials & Design, 37*, 379-383.

Asim, M., Jawaid, M., Abdan, K., & Ishak, M. R. (2016). Effect of Alkali and Silane Treatments on Mechanical and Fibre-matrix Bond Strength of Kenaf and Pineapple Leaf Fibres. *Journal of Bionic Engineering, 13*(3), 426-435.

Asumani, O. M. L., Reid, R. G., & Paskaramoorthy, R. (2012). The effects of alkali–silane treatment on the tensile and flexural properties of short fibre non-woven kenaf reinforced polypropylene composites. *Composites Part A: Applied Science and Manufacturing, 43*(9), 1431-1440.

Atiqah, A., Jawaid, M., Ishak, M., & Sapuan, S. (2017). Moisture Absorption and Thickness Swelling Behaviour of Sugar Palm Fibre Reinforced Thermoplastic Polyurethane. *Procedia Engineering, 184*, 581-586.

Atiqah, A., Jawaid, M., Ishak, M. R., & Sapuan, S. M. (2017). Effect of Alkali and Silane Treatments on Mechanical and Interfacial Bonding Strength of Sugar Palm Fibers with Thermoplastic Polyurethane. *Journal of Natural Fibers*, 1-11. doi:10.1080/15440478.2017.1325427

Atiqah, A., Maleque, M., Jawaid, M., & Iqbal, M. (2014). Development of kenaf-glass reinforced unsaturated polyester hybrid composite for structural applications. *Composites Part B: Engineering, 56*, 68-73.

Atiqah, A., T Mastura, M., A Ahmed Ali, B., Jawaid, M., & M Sapuan, S. (2017). A Review on Polyurethane and its Polymer Composites. *Current Organic Synthesis, 14*(2), 233-248.

Azmi, M. A. (2012). Rigid polyurethane foam reinforced coconut coir fiber properties. *International Journal of Integrated Engineering, 4*(1).

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

Bachtiar, D., Salit, M. S., Zainuddin, E., Abdan, K., & Dahlan, K. Z. H. M. (2011). Effects of alkaline treatment and a compatibilizing agent on tensile properties of sugar palm fibre-reinforced high impact polystyrene composites. *BioResources, 6*(4), 4815-4823.

Bachtiar, D., Salit, M. S., Zainudin, E. S., Abdan, K., Dahlan, M., & Zaman, K. (2013). Thermal properties of alkali-treated sugar palm fibre reinforced high impact polystyrene composites. *Pertanika Journal of Science & Technology, 21*(1), 141-150.

Bachtiar, D., Sapuan, S., & Hamdan, M. (2008). The effect of alkaline treatment on tensile properties of sugar palm fibre reinforced epoxy composites. *Materials & Design, 29*(7), 1285-1290.

Bachtiar, D., Sapuan, S., Khalina, A., Zainudin, E., & Dahlan, K. (2012a). Flexural and impact properties of chemically treated sugar palm fiber reinforced high impact polystyrene composites. *Fibers and Polymers, 13*(7), 894-898.

Bachtiar, D., Sapuan, S., Khalina, A., Zainudin, E., & Dahlan, K. (2012b). The flexural, impact and thermal properties of untreated short sugar palm fibre reinforced high impact polystyrene (HIPS) composites. *Polymers & Polymer Composites, 20*(5), 493.

Bachtiar, D., Sapuan, S., Zainudin, E., Khalina, A., & Dahlan, K. (2010). *The tensile properties of single sugar palm (Arenga pinnata) fibre.* Paper presented at the IOP Conference Series: Materials Science and Engineering.

Bachtiar, D., Sapuan, S., Zainudin, E. S., Khalina, A., & Dahlan, K. (2010). *The tensile properties of single sugar palm (Arenga pinnata) fibre.* Paper presented at the IOP Conference Series: Materials Science and Engineering.

Bakare, I., Okieimen, F., Pavithran, C., Khalil, H. A., & Brahmakumar, M. (2010). Mechanical and thermal properties of sisal fiber-reinforced rubber seed oil-based polyurethane composites. *Materials & Design, 31*(9), 4274-4280.

Batouli, S. M., Zhu, Y., Nar, M., & D'Souza, N. A. (2014). Environmental performance of kenaf-fiber reinforced polyurethane: a life cycle assessment approach. *Journal of cleaner production, 66*, 164-173.

Benhamou, K., Kaddami, H., Magnin, A., Dufresne, A., & Ahmad, A. (2015). Bio-based polyurethane reinforced with cellulose nanofibers: a comprehensive investigation on the effect of interface. *Carbohydrate polymers, 122*, 202-211.

Beyler, C. L., & Hirschler, M. M. (2002). Thermal decomposition of polymers. *SFPE handbook of fire protection engineering, 2*, 32.

Bhuva, B., & Parsania, P. (2010). Studies on jute/glass/hybrid composites of polyurethane based on epoxy resin of 9, 9′-bis (4-hydroxy phenyl) anthrone-10 (EBAN) and PEG-200. *Journal of Applied Polymer Science, 118*(3), 1469-1475.

Bindal, A., Singh, S., Batra, N., & Khanna, R. (2013). Development of glass/jute fibers reinforced polyester composite. *Indian Journal of Materials Science, 2013*.

Bledzki, A. K., Zhang, W., & Chate, A. (2001). Natural-fibre-reinforced polyurethane microfoams. *Composites Science and Technology, 61*(16), 2405-2411.

Borchani, K. E., Carrot, C., & Jaziri, M. (2015). Untreated and alkali treated fibers from Alfa stem: effect of alkali treatment on structural, morphological and thermal features. *Cellulose, 22*(3), 1577-1589. doi:10.1007/s10570-015-0583-5

Borsa, J., László, K., Boguslavsky, L., Takács, E., Rácz, I., Tóth, T., & Szabó, D. (2016). Effect of mild alkali/ultrasound treatment on flax and hemp fibres: the different responses of the two substrates. *Cellulose, 23*(3), 2117-2128. doi:10.1007/s10570-016-0909-y

Braga, R., & Magalhaes, P. (2015). Analysis of the mechanical and thermal properties of jute and glass fiber as reinforcement epoxy hybrid composites. *Materials Science and Engineering: C, 56*, 269-273.

Brief, L. (2011). Opportunities in natural fiber composites. *Lucintel LLC, Irving (TX)*.

Brooks, R. E., & Moore, S. B. (2000). Alkaline hydrogen peroxide bleaching of cellulose. *Cellulose, 7*(3), 263-286. doi:10.1023/a:1009273701191

Bruckmeier, S., & Wellnitz, J. (2011). Flexural creeping analysis of polyurethane composites produced by an innovative pultrusion process. *Sustainable Automotive Technologies 2011*, 13-18.

Câmara Mileo, P., De Oliveira, M. F., Luz, S. M., Rocha, G. J., & Gonçalves, A. R. (2010). *Evaluation of castor oil polyurethane reinforced with lignin and* *cellulose from sugarcane straw.* Paper presented at the Advanced Materials Research.

Charlon, M., Heinrich, B., Matter, Y., Couzigné, E., Donnio, B., & Avérous, L. (2014). Synthesis, structure and properties of fully biobased thermoplastic polyurethanes, obtained from a diisocyanate based on modified dimer fatty acids, and different renewable diols. *European Polymer Journal, 61*, 197-205.

Chen, J., Zhang, Z.-x., Huang, W.-b., Yang, J.-h., Wang, Y., Zhou, Z.-w., & Zhang, J.-h. (2015). Carbon nanotube network structure induced strain sensitivity and shape memory behavior changes of thermoplastic polyurethane. *Materials & Design, 69*, 105-113.

Cheng, F., Hu, Y., & Yuan, J. (2014). Preparation and characterization of glass fiber-coir hybrid composites by a novel and facile Prepreg/Press process. *Fibers and Polymers, 15*(8), 1715.

Chethana, M., Madhukar, B. S., Somashekar, R., & Hanta, S. (2014). The Influence of ginger spent loading on mechanical, thermal and microstructural behaviours of polyurethane green composites. *Journal of composite materials, 48*(18), 2251-2264.

Ching, K. Y., Chee, C. Y., Afzan, M., Kang, L. Z., & Eng, C. K. (2015). Mechanical and thermal properties of chemical treated oil palm empty fruit bunches fiber reinforced polyvinyl alcohol composite. *Journal of Biobased Materials and Bioenergy, 9*(2), 231-235.

Choi, H. Y., & Lee, J. S. (2012). Effects of surface treatment of ramie fibers in a ramie/poly (lactic acid) composite. *Fibers and Polymers, 13*(2), 217-223.

Chowdhury, M. N. K., Beg, M. D. H., Khan, M. R., & Mina, M. F. (2013). Modification of oil palm empty fruit bunch fibers by nanoparticle impregnation and alkali treatment. *Cellulose, 20*(3), 1477-1490. doi:10.1007/s10570-013-9921-7

Correa, R., Nunes, R., & WZ Filho, F. (1998). Short fiber reinforced thermoplastic polyurethane elastomer composites. *Polymer Composites, 19*(2), 152-155.

Cui, Y. H., Lee, S., & Tao, J. (2008). Effects of alkaline and silane treatments on the water-resistance properties of wood-fiber-reinforced recycled plastic composites. *Journal of Vinyl and Additive Technology, 14*(4), 211-220.

Da Silva, V. R., Mosiewicki, M. A., Yoshida, M. I., Da Silva, M. C., Stefani, P. M., & Marcovich, N. E. (2013a). Polyurethane foams based on modified tung oil and reinforced with rice husk ash I: synthesis and physical chemical characterization. *Polymer Testing, 32*(2), 438-445.

da Silva, V. R., Mosiewicki, M. A., Yoshida, M. I., da Silva, M. C., Stefani, P. M., & Marcovich, N. E. (2013b). Polyurethane foams based on modified tung oil and reinforced with rice husk ash II: Mechanical characterization. *Polymer Testing, 32*(4), 665-672.

Dashtizadeh, Z., Ali, A., Abdan, K., & Behmanesh, M. (2012). The use of infrared thermography in detecting the defects in kenaf-poly urethane composites. *Polymer-Plastics Technology and Engineering, 51*(11), 1155-1162.

Datta, J., & Głowińska, E. (2014). Effect of hydroxylated soybean oil and bio-based propanediol on the structure and thermal properties of synthesized bio-polyurethanes. *Industrial Crops and Products, 61*, 84-91.

Datta, J., & Kopczyńska, P. (2015). Effect of kenaf fibre modification on morphology and mechanical properties of thermoplastic polyurethane materials. *Industrial Crops and Products, 74*, 566-576.

Davoodi, M., Sapuan, S., Ahmad, D., Ali, A., Khalina, A., & Jonoobi, M. (2010). Mechanical properties of hybrid kenaf/glass reinforced epoxy composite for passenger car bumper beam. *Materials & Design, 31*(10), 4927-4932.

De Rosa, I. M., Santulli, C., Sarasini, F., & Valente, M. (2009). Post-impact damage characterization of hybrid configurations of jute/glass polyester laminates using acoustic emission and IR thermography. *Composites Science and Technology, 69*(7), 1142-1150.

Devi, L. U., Bhagawan, S., & Thomas, S. (2010). Dynamic mechanical analysis of pineapple leaf/glass hybrid fiber reinforced polyester composites. *Polymer Composites, 31*(6), 956-965.

Drobny, J. G. (2014). *Handbook of thermoplastic elastomers*: Elsevier.

Dwan'isa, J.-P. L., Mohanty, A., Misra, M., Drzal, L., & Kazemizadeh, M. (2004a). Biobased polyurethane and its composite with glass fiber. *Journal of materials science, 39*(6), 2081-2087.

Dwan'isa, J.-P. L., Mohanty, A., Misra, M., Drzal, L., & Kazemizadeh, M. (2004b). Novel soy oil based polyurethane composites: Fabrication and dynamic mechanical properties evaluation. *Journal of materials science, 39*(5), 1887-1890.

El-Meligy, M. G., Mohamed, S. H., & Mahani, R. M. (2010). Study mechanical, swelling and dielectric properties of prehydrolysed banana fiber–Waste polyurethane foam composites. *Carbohydrate polymers, 80*(2), 366-372.

El-Shekeil, Y., Sapuan, S., Abdan, K., & Zainudin, E. (2011). *Effect of Alkali Treatment and pMDI Isocyanate Additive on Tensile Properties of Kenaf Fiber Reinforced Thermoplastic Polyurethane Composite.* Paper presented at the Proceedings of 2011 International Conference on Advanced Materials Engineering (ICAME 2011).

El-Shekeil, Y., Sapuan, S., Abdan, K., & Zainudin, E. (2012). Influence of fiber content on the mechanical and thermal properties of Kenaf fiber reinforced thermoplastic polyurethane composites. *Materials & Design, 40*, 299-303.

El-Shekeil, Y., Sapuan, S., & Algrafi, M. (2014). Effect of fiber loading on mechanical and morphological properties of cocoa pod husk fibers reinforced thermoplastic polyurethane composites. *Materials & Design, 64*, 330-333.

El-Shekeil, Y., Sapuan, S., Azaman, M., & Jawaid, M. (2013). Optimization of blending parameters and fiber size of kenaf-bast-fiber-reinforced the thermoplastic polyurethane composites by Taguchi method. *Advances in Materials Science and Engineering, 2013*.

El-Shekeil, Y., Sapuan, S., Jawaid, M., & Al-Shuja'a, O. (2014). Influence of fiber content on mechanical, morphological and thermal properties of kenaf fibers reinforced poly (vinyl chloride)/thermoplastic polyurethane poly-blend composites. *Materials & Design, 58*, 130-135.

El-Shekeil, Y., Sapuan, S., Khalina, A., Zainudin, E., & Al-Shuja'a, O. (2012). Effect of alkali treatment on mechanical and thermal properties of Kenaf fiber-reinforced thermoplastic polyurethane composite. *Journal of thermal analysis and calorimetry, 109*(3), 1435-1443.

El-Shekeil, Y., Sapuan, S., Khalina, A., Zainudin, E., & Al-Shuja'a, O. (2012). Effect of alkali treatment on mechanical and thermal properties of Kenaf fiber-reinforced thermoplastic polyurethane composite. *Journal of thermal analysis and calorimetry, 109*(3), 1435-1443.

El-Shekeil, Y. A., Salit, M. S., Abdan, K., & Zainudin, E. S. (2011). Development of a new kenaf bast fiber-reinforced thermoplastic polyurethane composite. *BioResources, 6*(4), 4662-4672.

Engels, H. W., Pirkl, H. G., Albers, R., Albach, R. W., Krause, J., Hoffmann, A., . . . Dormish, J. (2013). Polyurethanes: versatile materials and sustainable problem solvers for today's challenges. *Angewandte Chemie International Edition, 52*(36), 9422-9441.

Farsi, M. (2010). Wood-plastic composites: influence of wood flour chemical modification on the mechanical performance. *Journal of Reinforced Plastics and Composites, 29*(24), 3587-3592.

Ferry, J. D. (1980). *Viscoelastic properties of polymers*: John Wiley & Sons.

Fiore, V., Di Bella, G., & Valenza, A. (2011). Glass–basalt/epoxy hybrid composites for marine applications. *Materials & Design, 32*(4), 2091-2099.

Garrido, M., Correia, J. R., Keller, T., & Branco, F. A. (2015). Adhesively bonded connections between composite sandwich floor panels for building rehabilitation. *Composite Structures, 134*, 255-268.

Gassan, J., Dietz, T., & Bledzki, A. K. (2000). Effect of silicone interphase on the mechanical properties of flax-polyurethane composites. *Composite Interfaces, 7*(2), 103-115.

Gharbi, A., Hassen, R. B., & Boufi, S. (2014). Composite materials from unsaturated polyester resin and olive nuts residue: the effect of silane treatment. *Industrial Crops and Products, 62*, 491-498.

Ghasemzadeh-Barvarz, M., Duchesne, C., & Rodrigue, D. (2015). Mechanical, water absorption, and aging properties of polypropylene/flax/glass fiber hybrid composites. *Journal of composite materials, 49*(30), 3781-3798.

Głowińska, E., & Datta, J. (2015). Structure, morphology and mechanical behaviour of novel bio-based polyurethane composites with microcrystalline cellulose. *Cellulose, 22*(4), 2471-2481.

Gooch, J. W. (2010). *Encyclopedic dictionary of polymers* (Vol. 1): Springer Science & Business Media.

Goriparthi, B. K., Suman, K., & Rao, N. M. (2012). Effect of fiber surface treatments on mechanical and abrasive wear performance of polylactide/jute composites. *Composites Part A: Applied Science and Manufacturing, 43*(10), 1800-1808.

Gujjala, R., Ojha, S., Acharya, S., & Pal, S. (2014). Mechanical properties of woven jute–glass hybrid-reinforced epoxy composite. *Journal of composite materials, 48*(28), 3445-3455.

Hadjadj, A., Jbara, O., Tara, A., Gilliot, M., Malek, F., Maafi, E. M., & Tighzert, L. (2016). Effects of cellulose fiber content on physical properties of polyurethane based composites. *Composite Structures, 135*, 217-223.

Hamilton, A. R., Thomsen, O. T., Madaleno, L. A., Jensen, L. R., Rauhe, J. C. M., & Pyrz, R. (2013). Evaluation of the anisotropic mechanical properties of reinforced polyurethane foams. *Composites Science and Technology, 87*, 210-217.

Hamouda, T., Hassanin, A. H., Kilic, A., Candan, Z., & Bodur, M. S. (2015). Hybrid composites from coir fibers reinforced with woven glass fabrics: Physical and mechanical evaluation. *Polymer Composites*.

Haneefa, A., Bindu, P., Aravind, I., & Thomas, S. (2008). Studies on tensile and flexural properties of short banana/glass hybrid fiber reinforced polystyrene composites. *Journal of composite materials, 42*(15), 1471-1489.

Hanifawati, I., Hanim, A., Sapuan, S., & Zainuddin, E. (2011). *Tensile and flexural behavior of hybrid banana Pseudostem/glass fibre reinforced polyester composites.* Paper presented at the Key Engineering Materials.

He, J. Y., Ming, M., & Wang, K. J. (2011). *Theoretical prediction and experimental research on the tensile Strength of GF-TPU composite.* Paper presented at the Advanced Materials Research.

Hong, C., Hwang, I., Kim, N., Park, D., Hwang, B., & Nah, C. (2008). Mechanical properties of silanized jute–polypropylene composites. *Journal of Industrial and Engineering Chemistry, 14*(1), 71-76.

Hosseini, N., Ulven, C., Webster, D., & Nelson, T. (2012). *Utilization of flax fibers and glass fibers in a bio-based resin.* Paper presented at the The 19th International Conference on Composite Materials.

Huda, M. S., Drzal, L. T., Mohanty, A. K., & Misra, M. (2006). Chopped glass and recycled newspaper as reinforcement fibers in injection molded poly (lactic acid)(PLA) composites: a comparative study. *Composites Science and Technology, 66*(11), 1813-1824.

Huda, M. S., Drzal, L. T., Mohanty, A. K., & Misra, M. (2008). Effect of fiber surface-treatments on the properties of laminated biocomposites from poly (lactic acid)(PLA) and kenaf fibers. *Composites Science and Technology, 68*(2), 424-432.

Husić, S., Javni, I., & Petrović, Z. S. (2005). Thermal and mechanical properties of glass reinforced soy-based polyurethane composites. *Composites Science and Technology, 65*(1), 19-25.

Ibraheem, S. A., Ali, A., & Khalina, A. (2011). *Development of green insulation boards from kenaf fibres part 1: Development and characterization of mechanical properties.* Paper presented at the Key Engineering Materials.

Im, H., Roh, S. C., & Kim, C. K. (2013). Characteristics of thermoplastic polyurethane composites containing surface treated multiwalled carbon nanotubes for the underwater applications. *Macromolecular Research, 21*(6), 614-623.

Ishak, M., Leman, Z., Sapuan, S., Salleh, M., & Misri, S. (2009). The effect of sea water treatment on the impact and flexural strength of sugar palm fibre reinforced epoxy composites. *International Journal of Mechanical and Materials Engineering (IJMME), 4*(3), 316-320.

Ishak, M., Sapuan, S., Leman, Z., Rahman, M., & Anwar, U. (2011). Characterization of sugar palm (Arenga pinnata) fibres: tensile and thermal properties. *Journal of thermal analysis and calorimetry, 109*(2), 981-989.

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

Ishak, M., Sapuan, S., Leman, Z., Rahman, M., Anwar, U., & Siregar, J. (2013). Sugar palm (Arenga pinnata): Its fibres, polymers and composites. *Carbohydrate polymers, 91*(2), 699-710.

Ishak, M. R., Leman, Z., Salit, M. S., Rahman, M. Z. A., Anwar Uyup, M. K., & Akhtar, R. (2013). IFSS, TG, FT-IR spectra of impregnated sugar palm (Arenga pinnata) fibres and mechanical properties of their composites. *Journal of thermal analysis and calorimetry, 111*(2), 1375-1383. doi:10.1007/s10973-012-2457-5

Ishak, M. R., Leman, Z., Sapuan, S. M., Salleh, M. Y., & Misri, S. (2009). The effect of sea water treatment on the impact and flexural strength of sugar palm fibre reinforced epoxy composites. *International Journal of Mechanical and Materials Engineering, 4*(3), 316-320.

Jandas, P., Mohanty, S., & Nayak, S. (2012). Renewable resource-based biocomposites of various surface treated banana fiber and poly lactic acid: characterization and biodegradability. *Journal of Polymers and the Environment, 20*(2), 583-595.

Jarukumjorn, K., & Suppakarn, N. (2009). Effect of glass fiber hybridization on properties of sisal fiber–polypropylene composites. *Composites Part B: Engineering, 40*(7), 623-627.

Jawaid, M., Abdul Khalil, H. P. S., & Abu Bakar, A. (2010). Mechanical performance of oil palm empty fruit bunches/jute fibres reinforced epoxy hybrid composites. *Materials Science and Engineering: A, 527*(29–30), 7944-7949.

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

Jawaid, M., Khalil, H. A., & Alattas, O. S. (2012). Woven hybrid biocomposites: dynamic mechanical and thermal properties. *Composites Part A: Applied Science and Manufacturing, 43*(2), 288-293.

Jayabal, S., Natarajan, U., & Murugan, M. (2011). Mechanical property evaluation of woven coir and woven coir–glass fiber-reinforced polyester composites. *Journal of composite materials, 45*(22), 2279-2285.

Jayabal, S., Natarajan, U., & Sathiyamurthy, S. (2011). Effect of glass hybridization and staking sequence on mechanical behaviour of interply coir–glass hybrid laminate. *Bulletin of Materials Science, 34*(2), 293-298.

Jin, L., Chunhong, W., Wenting, H., Xinmin, Y., & Zilong, R. (2014). Surface Modifi cation of Kenaf Fiber and Application of It on Polypropylene Composite. *Engineering Plastics Application, 2*, 007.

Jin, L., Wang, H., & Yang, Y. (2013). Polyurethane composites in situ molecularly reinforced by supramolecular nanofibrillar aggregates of sorbitol derivatives. *Composites Science and Technology, 79*, 58-63.

Júnior, J. H. S. A., Júnior, H. L. O., Amico, S. C., & Amado, F. D. R. (2012). Study of hybrid intralaminate curaua/glass composites. *Materials & Design, 42*, 111-117.

Khalid, M. F. S., & Abdullah, A. H. (2013). *Storage Modulus Capacity of Untreated Aged Arenga pinnata Fibre-Reinforced Epoxy Composite.* Paper presented at the Applied Mechanics and Materials.

Khalil, H. A., Hanida, S., Kang, C., & Fuaad, N. N. (2007). Agro-hybrid composite: the effects on mechanical and physical properties of oil palm fiber (EFB)/glass hybrid reinforced polyester composites. *Journal of Reinforced Plastics and Composites, 26*(2), 203-218.

Khalil, H. A., Suraya, N., Atiqah, N., Jawaid, M., & Hassan, A. (2013). Mechanical and thermal properties of chemical treated kenaf fibres reinforced polyester composites. *Journal of composite materials, 47*(26), 3343-3350.

Kim, S., Park, H., Jeong, H., & Kim, B. (2010). Glass fiber reinforced rigid polyurethane foams. *Journal of materials science, 45*(10), 2675-2680.

Koronis, G., Silva, A., & Fontul, M. (2013). Green composites: a review of adequate materials for automotive applications. *Composites Part B: Engineering, 44*(1), 120-127.

Ku, H., Wang, H., Pattarachaiyakoop, N., & Trada, M. (2011). A review on the tensile properties of natural fiber reinforced polymer composites. *Composites Part B: Engineering, 42*(4), 856-873.

Kumar, H., & Siddaramaiah. (2005). Study of chemical and tensile properties of polyurethane and polyurethane/polyacrylonitrile coated bamboo fibers. *Journal of Reinforced Plastics and Composites, 24*(2), 209-213.

Kumar, N. M., Reddy, G. V., Naidu, S. V., Rani, T. S., & Subha, M. (2009). Mechanical properties of coir/glass fiber phenolic resin based composites. *Journal of Reinforced Plastics and Composites, 28*(21), 2605-2613.

Kumar, V., & Kumar, R. (2012). Dielectric and mechanical properties of alkali-and silane-treated bamboo-epoxy nanocomposites. *Journal of composite materials, 46*(24), 3089-3101.

Kuranska, M., & Prociak, A. (2012). Porous polyurethane composites with natural fibres. *Composites Science and Technology, 72*(2), 299-304.

Kushwaha, P. K., & Kumar, R. (2010a). 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. (2010b). Studies on water absorption of bamboo-epoxy composites: Effect of silane treatment of mercerized bamboo. *Journal of Applied Polymer Science, 115*(3), 1846-1852.

Kutty, S. K., & Nando, G. B. (1991). Short kevlar fiber–thermoplastic polyurethane composite. *Journal of Applied Polymer Science, 43*(10), 1913-1923.

Lee, N., Kwon, O.-J., Chun, B. C., Cho, J. W., & Park, J.-S. (2009). Characterization of castor oil/polycaprolactone polyurethane biocomposites reinforced with hemp fibers. *Fibers and Polymers, 10*(2), 154-160.

Lee, S.-Y., Chun, S.-J., Doh, G.-H., Kang, I.-A., Lee, S., & Paik, K.-H. (2009). Influence of chemical modification and filler loading on fundamental properties of bamboo fibers reinforced polypropylene composites. *Journal of composite materials*.

Leman, Z., Sapuan, S., Saifol, A., Maleque, M. A., & Ahmad, M. (2008). Moisture absorption behavior of sugar palm fiber reinforced epoxy composites. *Materials & Design, 29*(8), 1666-1670.

Leman, Z., Sapuan, S. M., Azwan, M., Ahmad, M. M. H. M., & Maleque, M. (2008). The effect of environmental treatments on fiber surface properties and tensile strength of sugar palm fiber-reinforced epoxy composites. *Polymer-Plastics Technology and Engineering, 47*(6), 606-612.

Leman, Z., Sapuan, S. M., Saifol, A. M., Maleque, M. A., & Ahmad, M. M. H. M. (2008). Moisture absorption behavior of sugar palm fiber reinforced epoxy composites. *Materials and Design, 29*(8), 1666-1670. doi:10.1016/j.matdes.2007.11.004

Li, G., Li, E., Wang, C., & Niu, Y. (2015). Effect of the blocked ratio on properties of natural fiber–waterborne blocked polyurethane composites. *Journal of composite materials, 49*(16), 1929-1936.

Li, L. H., & Chen, Y. I. (2015). Boron nitride nanotubes and nanoribbons Produced by Ball Milling Method. *Nanotubes and Nanosheets: Functionalization and Applications of Boron Nitride and Other Nanomaterials*, 33.

Li, X., Tabil, L. G., & Panigrahi, S. (2007). Chemical treatments of natural fiber for use in natural fiber-reinforced composites: a review. *Journal of Polymers and the Environment, 15*(1), 25-33.

Li, Y., Hu, C., & Yu, Y. (2008). Interfacial studies of sisal fiber reinforced high density polyethylene (HDPE) composites. *Composites Part A: Applied Science and Manufacturing, 39*(4), 570-578.

Lou, C. W., & Lin, J. H. (2011). Evaluation of bamboo charcoal/stainless steel/TPU composite woven fabrics. *Fibers and Polymers, 12*(4), 514.

Luo, H., Zhang, C., Xiong, G., & Wan, Y. (2016). Effects of alkali and alkali/silane treatments of corn fibers on mechanical and thermal properties of its composites with polylactic acid. *Polymer Composites, 37*(12), 3499-3507.

Maafi, E. M., Malek, F., Tighzert, L., & Dony, P. (2010). Synthesis of polyurethane and characterization of its composites based on alfa cellulose fibers. *Journal of Polymers and the Environment, 18*(4), 638-646.

Maleque, M., & Atiqah, A. (2013). Development and characterization of coir fibre reinforced composite brake friction materials. *Arabian Journal for Science and Engineering, 38*(11), 3191-3199.

Maleque, M., Atiqah, A., Talib, R., & Zahurin, H. (2012). New natural fibre reinforced aluminium composite for automotive brake pad. *International Journal of Mechanical and Materials Engineering, 7*(2), 166-170.

Maleque, M. A., Afdzaluddin, A., & Iqbal, M. (2012). *Flexural and impact properties of kenaf-glass hybrid composite.* Paper presented at the Advanced Materials Research.

Maleque, M. A., Atiqah, A., Fazal, M., Iqbal, M., & Paruka, P. (2015). *Effect of Electron Beam Radiation on Water Absorption of Hybrid Kenaf-Glass Unsaturated Polyester Composite.* Paper presented at the Advanced Materials Research.

Mandal, S., & Alam, S. (2012). Dynamic mechanical analysis and morphological studies of glass/bamboo fiber reinforced unsaturated polyester resin-based hybrid composites. *Journal of Applied Polymer Science, 125*(S1).

Marcovich, N. E., Reboredo, M. M., & Aranguren, M. I. (1998). Dependence of the mechanical properties of woodflour–polymer composites on the moisture content. *Journal of Applied Polymer Science, 68*(13), 2069-2076.

Merlini, C., Soldi, V., & Barra, G. M. (2011). Influence of fiber surface treatment and length on physico-chemical properties of short random banana fiber-reinforced castor oil polyurethane composites. *Polymer Testing, 30*(8), 833-840.

Milanese, A. C., Cioffi, M. O. H., & Voorwald, H. J. C. (2011). Mechanical behavior of natural fiber composites. *Procedia Engineering, 10*, 2022-2027.

Milanese, A. C., Cioffi, M. O. H., & Voorwald, H. J. C. (2012). Flexural behavior of sisal/castor oil-based polyurethane and sisal/phenolic composites. *Materials Research, 15*(2), 191-197.

Miléo, P., Mulinari, D., Baptista, C., Rocha, G., & Gonçalves, A. (2011). Mechanical behaviour of polyurethane from castor oil reinforced sugarcane straw cellulose composites. *Procedia Engineering, 10*, 2068-2073.

Mishra, S., Mohanty, A., Drzal, L., Misra, M., Parija, S., Nayak, S., & Tripathy, S. (2003). Studies on mechanical performance of biofibre/glass reinforced polyester hybrid composites. *Composites Science and Technology, 63*(10), 1377-1385.

Misri, S., Leman, Z., Sapuan, S., & Ishak, M. (2010). *Mechanical properties and fabrication of small boat using woven glass/sugar palm fibres reinforced unsaturated polyester hybrid composite.* Paper presented at the IOP Conference Series: Materials Science and Engineering.

Mohamed, M., Anandan, S., Huo, Z., Birman, V., Volz, J., & Chandrashekhara, K. (2015). Manufacturing and characterization of polyurethane based sandwich composite structures. *Composite Structures, 123*, 169-179.

Mohamed, M., Hawkins, S., & Chandrashekhara, K. (2015). Manufacturing and Performance Evaluation of Polyurethane Composites Using One-part and Two-part Resin Systems. *Polymers & Polymer Composites, 23*(5), 333.

Mohamed, M., Huo, Z., Hawkins, S., Chandrashekhara, K., Birman, V., & Volz, J. S. (2013). Moisture effects on performance of polyurethane composite sandwich panels manufactured using VARTM.

Mohamed, M., Vuppalapati, R., Hawkins, S., Chandrashekhara, K., & Schuman, T. (2012). *Impact characterization of polyurethane composites manufactured using vacuum assisted resin transfer molding.* Paper presented at the ASME 2012 International Mechanical Engineering Congress and Exposition.

Mohammed, A. A.-s., Bachtiar, D., Siregar, J. P., Rejab, M. R. B. M., & Hasany, S. F. (2016). Physicochemical Study of Eco-Friendly Sugar Palm Fiber Thermoplastic Polyurethane Composites. *BioResources, 11*(4), 9438-9454.

Mohan, T., & Kanny, K. (2017). Mechanical and Thermal Properties of Nanoclay-Treated Banana Fibers. *Journal of Natural Fibers*, 1-9.

Mondal, S., Memmott, P., & Martin, D. (2012). Preparation and characterization of polyurethanes from spinifex resin based bio-polymer. *Journal of Polymers and the Environment, 20*(2), 326-334.

Mosiewicki, M., Casado, U., Marcovich, N., & Aranguren, M. (2012). Moisture dependence of the properties of composites made from tung oil based polyurethane and wood flour. *Journal of Polymer Research, 19*(2), 9776.

Mostafa, A., Shankar, K., & Morozov, E. (2015). Behaviour of PU-foam/glass-fibre composite sandwich panels under flexural static load. *Materials and Structures, 48*(5), 1545-1559.

Mothé, C., de Araujo, C., De Oliveira, M., & Yoshida, M. (2002). Thermal decomposition kinetics of polyurethane-composites with bagasse of sugar cane. *Journal of thermal analysis and calorimetry, 67*(2), 305-312.

Mothé, C., de Araujo, C., & Wang, S. (2008). Thermal and mechanical characteristics of polyurethane/curaua fiber composites. *Journal of thermal analysis and calorimetry, 95*(1), 181-185.

Mridha, S., Keng, S., & Ahmad, Z. (2007). The effect of OPWF filler on impact strength of glass-fiber reinforced epoxy composite. *Journal of mechanical science and technology, 21*(10), 1663-1670.

Mukhopadhyay, M. (2005). *Mechanics of composite materials and structures*: Universities Press.

Mukhtar, I., Leman, Z., Ishak, M. R., & Zainudin, E. S. (2016). Sugar palm fibre and its composites: a review of recent developments. *BioResources, 11*(4), 10756-10782.

Mwaikambo, L. Y., & Ansell, M. P. (2002). Chemical modification of hemp, sisal, jute, and kapok fibers by alkalization. *Journal of Applied Polymer Science, 84*(12), 2222-2234. doi:10.1002/app.10460

Nam, T. H., Ogihara, S., Tung, N. H., & Kobayashi, S. (2011). Effect of alkali treatment on interfacial and mechanical properties of coir fiber reinforced poly (butylene succinate) biodegradable composites. *Composites Part B: Engineering, 42*(6), 1648-1656.

Narish, S., Yousif, B., & Rilling, D. (2011). Adhesive wear of thermoplastic composite based on kenaf fibres. *Proceedings of the Institution of Mechanical Engineers, Part J: Journal of Engineering Tribology, 225*(2), 101-109.

Nayak, S. K., & Mohanty, S. (2010). Sisal glass fiber reinforced PP hybrid composites: Effect of MAPP on the dynamic mechanical and thermal properties. *Journal of Reinforced Plastics and Composites, 29*(10), 1551-1568.

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), 32-38.

Nunna, S., Chandra, P. R., Shrivastava, S., & Jalan, A. (2012). A review on mechanical behavior of natural fiber based hybrid composites. *Journal of Reinforced Plastics and Composites, 31*(11), 759-769.

Oliveira, P. F. d., & Marques, M. d. F. V. (2014). Comparison between coconut and curaua fibers chemically treated for compatibility with PP matrixes. *Journal of Reinforced Plastics and Composites, 33*(5), 430-439.

Oprea, S. (2011). Preparation and characterization of the agar/polyurethane composites. *Journal of composite materials, 45*(20), 2039-2045.

Ornaghi, H. L., Bolner, A. S., Fiorio, R., Zattera, A. J., & Amico, S. C. (2010). Mechanical and dynamic mechanical analysis of hybrid composites molded by resin transfer molding. *Journal of Applied Polymer Science, 118*(2), 887-896.

Ornaghi, H. L., da Silva, H. S. P., Zattera, A. J., & Amico, S. C. (2011). Hybridization effect on the mechanical and dynamic mechanical properties of curaua composites. *Materials Science and Engineering: A, 528*(24), 7285-7289.

Orue, A., Jauregi, A., Unsuain, U., Labidi, J., Eceiza, A., & Arbelaiz, A. (2016). The effect of alkaline and silane treatments on mechanical properties and breakage of sisal fibers and poly(lactic acid)/sisal fiber composites. *Composites Part A: Applied Science and Manufacturing, 84*, 186-195.

Palaskar, D. V., Boyer, A., Cloutet, E., Alfos, C., & Cramail, H. (2010). Synthesis of biobased polyurethane from oleic and ricinoleic acids as the renewable resources via the AB-type self-condensation approach. *Biomacromolecules, 11*(5), 1202-1211.

Panthapulakkal, S., & Sain, M. (2007). Injection-molded short hemp fiber/glass fiber-reinforced polypropylene hybrid composites—Mechanical, water absorption and thermal properties. *Journal of Applied Polymer Science, 103*(4), 2432-2441.

Patel, H., Ren, G., Hogg, P., & Peijs, T. (2010). Hemp fibre as alternative to glass fibre in sheet moulding compound Part 1–influence of fibre content and surface treatment on mechanical properties. *Plastics, Rubber and Composites, 39*(6), 268-276.

Patel, V., & Parsania, P. (2010). Preparation and Physico-Chemical Study of Glass—Sisal (Treated—Untreated) Hybrid Composites of Bisphenol-C based Mixed Epoxy—Phenolic Resins. *Journal of Reinforced Plastics and Composites, 29*(1), 52-59.

Pavithran, C., Mukherjee, P., Brahmakumar, M., & Damodaran, A. (1991). Impact properties of sisal-glass hybrid laminates. *Journal of materials science, 26*(2), 455-459.

Phillips, L. (1976). On the usefulness of glass-fibre-carbon hybrids. *Brtttsh Plastics Federation Congre,~ s*.

Pothan, L. A., George, C. N., John, M. J., & Thomas, S. (2010). Dynamic mechanical and dielectric behavior of banana-glass hybrid fiber reinforced polyester composites. *Journal of Reinforced Plastics and Composites, 29*(8), 1131-1145.

Pothan, L. A., Oommen, Z., & Thomas, S. (2003). Dynamic mechanical analysis of banana fiber reinforced polyester composites. *Composites Science and Technology, 63*(2), 283-293.

Properties, A. S. D. o. M. (1996). *Standard test method for tensile properties of plastics*.

Puglia, D., Monti, M., Santulli, C., Sarasini, F., De Rosa, I. M., & Kenny, J. M. (2013). Effect of alkali and silane treatments on mechanical and thermal behavior of Phormium tenax fibers. *Fibers and Polymers, 14*(3), 423-427.

Qidwai, M., Sheraz, M. A., Ahmed, S., Alkhuraif, A. A., & ur Rehman, I. (2014). Preparation and characterization of bioactive composites and fibers for dental applications. *Dental Materials, 30*(10), e253-e263.

Rácz, I., Andersen, E., Aranguren, M. I., & Marcovich, N. E. (2009). Wood Flour—Recycled Polyol Based Polyurethane Lightweight Composites. *Journal of composite materials, 43*(24), 2871-2884.

Raimar, J. (2012). BASF's Polyurethanes Division. Driving efficiency, comfort and sustainability. *BASF, September, 5*.

Ramamoorthy, S. K., Skrifvars, M., & Rissanen, M. (2015). Effect of alkali and silane surface treatments on regenerated cellulose fibre type (Lyocell) intended for composites. *Cellulose, 22*(1), 637-654. doi:10.1007/s10570-014-0526-6

Rana, A., Mandal, A., & Bandyopadhyay, S. (2003). Short jute fiber reinforced polypropylene composites: effect of compatibiliser, impact modifier and fiber loading. *Composites Science and Technology, 63*(6), 801-806.

Rana, R., & Purohit, R. (2017). A Review on mechanical property of sisal glass fiber reinforced polymer composites. *Materials Today: Proceedings, 4*(2), 3466-3476.

Rashid, B., Leman, Z., Jawaid, M., Ghazali, M., & Ishak, M. (2016a). Physicochemical and thermal properties of lignocellulosic fiber from sugar palm fibers: effect of treatment. *Cellulose, 23*(5), 2905-2916.

Rashid, B., Leman, Z., Jawaid, M., Ghazali, M., & Ishak, M. (2017). Effect of treatments on the physical and morphological properties of SPF/phenolic composites. *Journal of Natural Fibers*, 1-13.

Rashid, B., Leman, Z., Jawaid, M., Ghazali, M. J., & Ishak, M. R. (2016b). The mechanical performance of sugar palm fibres (ijuk) reinforced phenolic composites. *International Journal of Precision Engineering and Manufacturing, 17*(8), 1001-1008.

Ray, D., Sarkar, B., Das, S., & Rana, A. (2002). Dynamic mechanical and thermal analysis of vinylester-resin-matrix composites reinforced with untreated and alkali-treated jute fibres. *Composites Science and Technology, 62*(7), 911-917.

Rials, T. G., Wolcott, M. P., & Nassar, J. M. (2001). Interfacial contributions in lignocellulosic fiber-reinforced polyurethane composites. *Journal of Applied Polymer Science, 80*(4), 546-555.

Ridzuan, M. J. M., Majid, M. S. A., Afendi, M., Mazlee, M. N., & Gibson, A. G. (2016). Thermal behaviour and dynamic mechanical analysis of Pennisetum purpureum/glass-reinforced epoxy hybrid composites. *Composite Structures, 152*, 850-859.

Rozman, H., Ahmadhilmi, K., & Abubakar, A. (2004). Polyurethane (PU)—oil palm empty fruit bunch (EFB) composites: the effect of EFBG reinforcement in mat form and isocyanate treatment on the mechanical properties. *Polymer Testing, 23*(5), 559-565.

Rozman, H., Ang, L., Tay, G., & Abubakar, A. (2003). The mechanical properties of rice husk-polyurethane composites. *Polymer-Plastics Technology and Engineering, 42*(3), 327-343.

Rozman, H., Tay, G., Abubakar, A., & Kumar, R. (2001). Tensile properties of oil palm empty fruit bunch–polyurethane composites. *European Polymer Journal, 37*(9), 1759-1765.

Rozman, H., Tay, G., & Abusamah, A. (2003). The effect of glycol type, glycol mixture, and isocyanate. *Journal of wood chemistry and technology, 23*(3-4), 249-260.

Russo, P., Acierno, D., Marletta, G., & Destri, G. L. (2013). Tensile properties, thermal and morphological analysis of thermoplastic polyurethane films reinforced with multiwalled carbon nanotubes. *European Polymer Journal, 49*(10), 3155-3164.

Rwawiire, S., Tomkova, B., Militky, J., Jabbar, A., & Kale, B. M. (2015). Development of a biocomposite based on green epoxy polymer and natural cellulose fabric (bark cloth) for automotive instrument panel applications. *Composites Part B: Engineering, 81*, 149-157.

Saba, N., Jawaid, M., Alothman, O. Y., & Paridah, M. (2016). A review on dynamic mechanical properties of natural fibre reinforced polymer composites. *Construction and Building Materials, 106*, 149-159.

Sahari, J., Sapuan, S., Ismarrubie, Z., & Rahman, M. (2011). *Comparative study of physical properties based on different parts of sugar palm fibre reinforced unsaturated polyester composites.* Paper presented at the Key Engineering Materials.

Sahari, J., Sapuan, S., Zainudin, E., & Maleque, M. (2012). Sugar palm tree: a versatile plant and novel source for biofibres, biomatrices, and biocomposites. *Polymers from Renewable Resources, 3*(2), 61.

Sahari, J., Sapuan, S. M., Ismarrubie, Z. N., & Rahman, M. Z. A. (2011) Comparative study of physical properties based on different parts of sugar palm fibre reinforced unsaturated polyester composites. In*: Vol. 471-472. Key Engineering Materials* (pp. 455-460).

Sahari, J., Sapuan, S. M., Zainudin, E. S., & Maleque, M. A. (2013). Effect of water absorption on mechanical properties of sugar palm fibre reinforced sugar palm starch (SPF/SPS) biocomposites. *Journal of Biobased Materials and Bioenergy, 7*(1), 90-94. doi:10.1166/jbmb.2013.1267

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

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

Sajna, V., Mohanty, S., & Nayak, S. K. (2014). Hybrid green nanocomposites of poly (lactic acid) reinforced with banana fibre and nanoclay. *Journal of Reinforced Plastics and Composites, 33*(18), 1717-1732.

Salehian, P., Karimi, K., Zilouei, H., & Jeihanipour, A. (2013). Improvement of biogas production from pine wood by alkali pretreatment. *Fuel, 106*, 484-489.

Saliba, C. C., Oréfice, R. L., Carneiro, J. R. G., Duarte, A. K., Schneider, W. T., & Fernandes, M. R. F. (2005). Effect of the incorporation of a novel natural inorganic short fiber on the properties of polyurethane composites. *Polymer Testing, 24*(7), 819-824.

Samal, S. K., Mohanty, S., & Nayak, S. K. (2009). Banana/glass fiber-reinforced polypropylene hybrid composites: Fabrication and performance evaluation. *Polymer-Plastics Technology and Engineering, 48*(4), 397-414.

Sankar, R. M., Meera, K. S., Mandal, A. B., & Jaisankar, S. (2013). Thermoplastic polyurethane/single-walled carbon nanotube composites with low electrical resistance surfaces. *High Performance Polymers, 25*(2), 135-146.

Sanyang, M. L., Sapuan, S., Jawaid, M., Ishak, M. R., & Sahari, J. (2016). Recent developments in sugar palm (Arenga pinnata) based biocomposites and their potential industrial applications: A review. *Renewable and Sustainable Energy Reviews, 54*, 533-549.

Sapuan, S., Lok, H., Ishak, M. R., & Misri, S. (2013). Mechanical properties of hybrid glass/sugar palm fibre reinforced unsaturated polyester composites. *Chinese Journal of Polymer Science, 31*(10), 1394-1403.

Sapuan, S., Pua, F.-l., El-Shekeil, Y., & AL-Oqla, F. M. (2013). Mechanical properties of soil buried kenaf fibre reinforced thermoplastic polyurethane composites. *Materials & Design, 50*, 467-470.

Sareena, C., Ramesan, M., & Purushothaman, E. (2012). Utilization of peanut shell powder as a novel filler in natural rubber. *Journal of Applied Polymer Science, 125*(3), 2322-2334.

Sarikanat, M. (2010). The influence of oligomeric siloxane concentration on the mechanical behaviors of alkalized jute/modified epoxy composites. *Journal of Reinforced Plastics and Composites, 29*(6), 807-817.

Sathaye, A. (2011). *Jute fibre based composite for automotive headlining* (0148-7191). Retrieved from

Sathishkumar, T., Navaneethakrishnan, P., Shankar, S., Rajasekar, R., & Rajini, N. (2013). Characterization of natural fiber and composites–A review. *Journal of Reinforced Plastics and Composites, 32*(19), 1457-1476.

Satyanarayana, N., Xie, X., & Rambabu, B. (2000). Sol–gel synthesis and characterization of the Ag 2 O–SiO 2 system. *Materials Science and Engineering: B, 72*(1), 7-12.

Sawpan, M. A., Pickering, K. L., & Fernyhough, A. (2011a). Effect of fibre treatments on interfacial shear strength of hemp fibre reinforced polylactide and unsaturated polyester composites. *Composites Part A: Applied Science and Manufacturing, 42*(9), 1189-1196.

Sawpan, M. A., Pickering, K. L., & Fernyhough, A. (2011b). Effect of various chemical treatments on the fibre structure and tensile properties of industrial hemp fibres. *Composites Part A: Applied Science and Manufacturing, 42*(8), 888-895.

Seydibeyoğlu, M. Ö., & Oksman, K. (2008). Novel nanocomposites based on polyurethane and micro fibrillated cellulose. *Composites Science and Technology, 68*(3), 908-914.

Sgriccia, N., Hawley, M., & Misra, M. (2008). Characterization of natural fiber surfaces and natural fiber composites. *Composites Part A: Applied Science and Manufacturing, 39*(10), 1632-1637.

Shah, D. U., Vollrath, F., & Porter, D. (2015). Silk cocoons as natural macro-balloon fillers in novel polyurethane-based syntactic foams. *Polymer, 56*, 93-101.

Shaniba, V., Sreejith, M., Aparna, K., Jinitha, T., & Purushothaman, E. Mechanical and thermal behavior of styrene butadiene rubber composites reinforced with silane-treated peanut shell powder. *Polymer Bulletin*, 1-18.

Shanmugam, D., & Thiruchitrambalam, M. (2013). Static and dynamic mechanical properties of alkali treated unidirectional continuous palmyra palm leaf stalk fiber/jute fiber reinforced hybrid polyester composites. *Materials & Design, 50*, 533-542.

Shanmugam, D., Thiruchitrambalam, M., & Thirumurugan, R. (2014). Continuous unidirectional palmyra palm leaf stalk fiber/glass—polyester composites: static and dynamic mechanical properties. *Journal of Reinforced Plastics and Composites, 33*(9), 836-850.

Sharba, M. J., Leman, Z., Sultan, M. T., Ishak, M. R., & Hanim, M. A. A. (2015). Effects of kenaf fiber orientation on mechanical properties and fatigue life of glass/kenaf hybrid composites. *BioResources, 11*(1), 1448-1465.

Sharma, N. K., & Kumar, V. (2013). Studies on properties of banana fiber reinforced green composite. *Journal of Reinforced Plastics and Composites, 32*(8), 525-532.

Silva, R., Spinelli, D., Bose Filho, W., Neto, S. C., Chierice, G., & Tarpani, J. (2006). Fracture toughness of natural fibers/castor oil polyurethane composites. *Composites Science and Technology, 66*(10), 1328-1335.

Silva, R., Ueki, M., Spinelli, D., Bose Filho, W., & Tarpani, J. (2010). Thermal, mechanical, and hygroscopic behavior of sisal fiber/polyurethane resin-based composites. *Journal of Reinforced Plastics and Composites, 29*(9), 1399-1417.

Singha, A., & Rana, R. K. (2012). Natural fiber reinforced polystyrene composites: Effect of fiber loading, fiber dimensions and surface modification on mechanical properties. *Materials & Design, 41*, 289-297.

Siyanbola, T., Sasidhar, K., Rao, B., Narayan, R., Olaofe, O., Akintayo, E., & Raju, K. (2015). Development of Functional Polyurethane–ZnO Hybrid Nanocomposite Coatings from Thevetia peruviana Seed Oil. *Journal of the American Oil Chemists' Society, 92*(2), 267-275.

Stewart, R. (2010). Building on the advantages of composites in construction. *Reinforced Plastics, 54*(5), 20-27.

Stirna, U., Fridrihsone, A., Lazdiņa, B., Misāne, M., & Vilsone, D. (2013). Biobased polyurethanes from rapeseed oil polyols: structure, mechanical and thermal properties. *Journal of Polymers and the Environment, 21*(4), 952-962.

Sunija, A., Ilango, S. S., & Vinod Kumar, K. (2015). Thespesia populnea Reinforced Cashew Nut Husk Tannin-Based Polyurethane Composites. *Journal of Natural Fibers, 12*(5), 481-493.

Suresha, B. (2010). Friction and dry slide wear of short glass fiber reinforced thermoplastic polyurethane composites. *Journal of Reinforced Plastics and Composites, 29*(7), 1055-1061.

Swolfs, Y., Gorbatikh, L., & Verpoest, I. (2014). Fibre hybridisation in polymer composites: a review. *Composites Part A: Applied Science and Manufacturing, 67*, 181-200.

Tábi, T., Tamás, P., & Kovács, J. (2012). Chopped basalt fibres: a new perspective in reinforcing poly (lactic acid) to produce injection moulded engineering composites from renewable and natural resources. *eXPRESS Polymer Letters, 7*(2), 107-119.

Tay, G., Rozman, H., & Abusamah, A. (2003). The Effect of Glycol Type, Glycol Mixture, and Isocyanate/Glycol Ratio on Flexural Properties of Oil Palm Empty Fruit Bunch-Polyurethane Composites. *Journal of wood chemistry and technology, 23*(3-4), 249-260.

Tayfun, U., Dogan, M., & Bayramli, E. (2014). Effect of surface modification of rice straw on mechanical and flow properties of TPU-based green composites. *Polymer Composites*.

Tayfun, U., Dogan, M., & Bayramli, E. (2016). Influence of surface modifications of flax fiber on mechanical and flow properties of thermoplastic polyurethane based eco-composites. *Journal of Natural Fibers, 13*(3), 309-320.

Thakur, V. K., Thakur, M. K., & Gupta, R. K. (2014a). Raw natural fiber–based polymer composites. *International Journal of Polymer Analysis and Characterization, 19*(3), 256-271.

Thakur, V. K., Thakur, M. K., & Gupta, R. K. (2014b). Review: raw natural fiber–based polymer composites. *International Journal of Polymer Analysis and Characterization, 19*(3), 256-271.

Thiruchitrambalam, M., Athijayamani, A., Sathiyamurthy, S., & Thaheer, A. S. A. (2010). A review on the natural fiber-reinforced polymer composites for the development of roselle fiber-reinforced polyester composite. *Journal of Natural Fibers, 7*(4), 307-323.

Tran, T. P. T., Bénézet, J.-C., & Bergeret, A. (2014a). Rice and Einkorn wheat husks reinforced poly (lactic acid)(PLA) biocomposites: effects of alkaline and silane surface treatments of husks. *Industrial Crops and Products, 58*, 111-124.

Tran, T. P. T., Bénézet, J.-C., & Bergeret, A. (2014b). Rice and Einkorn wheat husks reinforced poly(lactic acid) (PLA) biocomposites: Effects of alkaline and silane surface treatments of husks. *Industrial Crops and Products, 58*, 111-124.

Uawongsuwan, P., Yang, Y., & Hamada, H. (2015). Long jute fiber-reinforced polypropylene composite: Effects of jute fiber bundle and glass fiber hybridization. *Journal of Applied Polymer Science, 132*(15).

Uma Devi, L., Bhagawan, S., & Thomas, S. (2012). Polyester composites of short pineapple fiber and glass fiber: tensile and impact properties. *Polymer Composites, 33*(7), 1064-1070.

Väisänen, T., Haapala, A., Lappalainen, R., & Tomppo, L. (2016). Utilization of agricultural and forest industry waste and residues in natural fiber-polymer composites: A review. *Waste Management, 54*, 62-73.

Vajrasthira, C., Amornsakchai, T., & Bualek-Limcharoen, S. (2003). Fiber–matrix interactions in aramid-short-fiber-reinforced thermoplastic polyurethane composites. *Journal of Applied Polymer Science, 87*(7), 1059-1067.

Valadez-Gonzalez, A., Cervantes-Uc, J., Olayo, R., & Herrera-Franco, P. (1999). Effect of fiber surface treatment on the fiber–matrix bond strength of natural fiber reinforced composites. *Composites Part B: Engineering, 30*(3), 309-320.

Velmurugan, R., & Manikandan, V. (2007). Mechanical properties of palmyra/glass fiber hybrid composites. *Composites Part A: Applied Science and Manufacturing, 38*(10), 2216-2226.

Vilay, V., Mariatti, M., Taib, R. M., & Todo, M. (2008). Effect of fiber surface treatment and fiber loading on the properties of bagasse fiber–reinforced unsaturated polyester composites. *Composites Science and Technology, 68*(3), 631-638.

Villalón, M., Salas-Zuñiga, R., Reyes-Zamora, U., Radillo, R., Reyes-Araiza, J. L., & Manzano-Ramírez, A. (2016). Effect on dynamic, quasi-static elastic moduli of glass fiber laminates. *Green Materials, 3*(4), 113-119.

Wan Busu, W., Anuar, H., Ahmad, S., Rasid, R., & Jamal, N. (2010). The mechanical and physical properties of thermoplastic natural rubber hybrid composites reinforced with Hibiscus cannabinus, L and short glass fiber. *Polymer-Plastics Technology and Engineering, 49*(13), 1315-1322.

Wang, L.-l., Dong, X., Liu, X.-g., Xing, Q., Huang, M.-m., Hu, H.-q., & Wang, D.-j. (2013). Microstructure and rheological properties of thermoplastic polyurethane and its composites. *Acta Polymerica Sinica*(3), 367-376.

Westman, M. P., Fifield, L. S., Simmons, K. L., Laddha, S., & Kafentzis, T. A. (2010). *Natural fiber composites: a review*. Retrieved from

Wilberforce, S., & Hashemi, S. (2009). Effect of fibre concentration, strain rate and weldline on mechanical properties of injection-moulded short glass fibre reinforced thermoplastic polyurethane. *Journal of materials science, 44*(5), 1333-1343.

Wongsriraksa, P., Togashi, K., Nakai, A., & Hamada, H. (2013). Continuous natural fiber reinforced thermoplastic composites by fiber surface modification. *Advances in Mechanical Engineering, 5*, 685104.

Woo, E., Seferis, J., & Schaffnit, R. (1991). Viscoelastic characterization of high performance epoxy matrix composites. *Polymer Composites, 12*(4), 273-280.

Wu, G., Fan, Y., He, X., & Yan, Y. (2015). Bio-polyurethanes from Sapium sebiferum oil reinforced with carbon nanotubes: synthesis, characterization and properties. *RSC Advances, 5*(99), 80893-80900.

Xie, Y., Hill, C. A., Xiao, Z., Militz, H., & Mai, C. (2010). Silane coupling agents used for natural fiber/polymer composites: A review. *Composites Part A: Applied Science and Manufacturing, 41*(7), 806-819.

Yaakob, Z., Min Min, A., Satheesh Kumar, M., Kamarudin, S., Hilmi, M., & Khairul Zaman, H. (2010). Oleic acid-based polyurethane and its biocomposites with oil palm trunk fiber dust. *Journal of Thermoplastic Composite Materials, 23*(4), 447-458.

Yakubu, A. S., Amaren, S., & Saleh, Y. D. (2013). Evaluation of the wear and thermal properties of asbestos free brake pad using periwinkles shell particles. *Usak University Journal of Material Sciences, 2*(1), 99-108.

You, C., Xie, Q., Zeng, Y., Li, Y., & Jia, D. (2011). Structure and properties of unsaturated polyester/thermoplastic polyurethane/bagasse composites. *Polymer Materials Science & Engineering, 6*, 017.

Yu, T., Ren, J., Li, S., Yuan, H., & Li, Y. (2010). Effect of fiber surface-treatments on the properties of poly (lactic acid)/ramie composites. *Composites Part A: Applied Science and Manufacturing, 41*(4), 499-505.

Yu, Y. H., Choi, I., & Nam, S. (2014). Cryogenic characteristics of chopped glass fiber reinforced polyurethane foam. *Composite Structures, 107*, 476-481.

Yu, Y. H., Nam, S., & Lee, D. (2015). Cryogenic impact resistance of chopped fiber reinforced polyurethane foam. *Composite Structures, 132*, 12-19.

Zafar, M. T., Maiti, S. N., & Ghosh, A. K. (2016). Effect of surface treatment of jute fibers on the interfacial adhesion in poly (lactic acid)/jute fiber biocomposites. *Fibers and Polymers, 17*(2), 266-274.

Zahari, W., Badri, R., Ardyananta, H., Kurniawan, D., & Nor, F. (2015). Mechanical properties and water absorption behavior of polypropylene/ijuk fiber composite by using silane treatment. *Procedia Manufacturing, 2*, 573-578.

Zang, Z., Tang, G., Li, J., & Li, S. (2012). Mechanical property improvement of plasma treated carbon fiber-reinforced polyurethanes (PUR) composites with SiO2 filler. *Polymer-Plastics Technology and Engineering, 51*(7), 696-700.

Zang, Z., Tang, G., Wei, G., Wang, D., Chang, D., Huang, J., & Yan, W. (2012). The mechanical and tribological properties of anodic oxidation treatment carbon fiber-filled PU composite. *Polymer-Plastics Technology and Engineering, 51*(15), 1501-1504.

Zhang, F., Liu, W., Wang, L., Qi, Y., Zhou, D., & Fang, H. (2015). Flexural behavior of hybrid composite beams with a bamboo layer and lattice ribs. *Journal of Reinforced Plastics and Composites, 34*(7), 521-533.

Zhang, J., Wu, D., Yang, D., & Qiu, F. (2010). Environmentally friendly polyurethane composites: preparation, characterization and mechanical properties. *Journal of Polymers and the Environment, 18*(2), 128-134.

Zhang, S., & Horrocks, A. R. (2003). A review of flame retardant polypropylene fibres. *Progress in Polymer Science, 28*(11), 1517-1538.

Zhang, Y., Li, Y., Ma, H., & Yu, T. (2013). Tensile and interfacial properties of unidirectional flax/glass fiber reinforced hybrid composites. *Composites Science and Technology, 88*, 172-177.

Zhou, F., Cheng, G., & Jiang, B. (2014). Effect of silane treatment on microstructure of sisal fibers. *Applied Surface Science, 292*, 806-812.

Zhu, J., Zhu, H., Njuguna, J., & Abhyankar, H. (2013). Recent development of flax fibres and their reinforced composites based on different polymeric matrices. *Materials, 6*(11), 5171-5198.

Zia, K. M., Bhatti, H. N., & Bhatti, I. A. (2007). Methods for polyurethane and polyurethane composites, recycling and recovery: a review. *Reactive and Functional Polymers, 67*(8), 675-692.

Zo, H. J., Joo, S. H., Kim, T., Seo, P. S., Kim, J. H., & Park, J. S. (2014). Enhanced mechanical and thermal properties of carbon fiber composites with polyamide and thermoplastic polyurethane blends. *Fibers and Polymers, 15*(5), 1071-1077.

Zonatti, W. F., Guimarães, B. M. G., Duleba, W., & Ramos, J. B. (2015). Thermoset composites reinforced with recycled cotton textile residues. *Textiles and Clothing Sustainability, 1*(1), 1.

Zuhudi, N. Z. M., Lin, R. J., & Jayaraman, K. (2016). Flammability, thermal and dynamic mechanical properties of bamboo–glass hybrid composites. *Journal of Thermoplastic Composite Materials, 29*(9), 1210-1228.