UNIVERSITI PUTRA MALAYSIA

GLASS/SUGAR PALM [Arenga Pinnata (Wurmb. Merr.)] FIBRE-REINFORCED POLYPROPYLENE HYBRID COMPOSITE AUTOMOTIVE SIDE DOOR IMPACT BEAM

ISMA'ILA MUKHTAR

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By

ISMA'ILA MUKHTAR

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

September 2018

DEDICATION

This thesis is dedicated to:

My beloved father and mother for their sacrifices, encouragements, support and patience throughout my entire life

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

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Chairman: **Zulkiflle bin Leman, PhD**
Faculty: **Engineering**

Light-weight and high-performance materials are crucial in an automotive engineering. This is due to the numerous benefits such as low fuel consumption, cost savings and weight reduction. Traditionally, steel which is heavy and absorbed less energy when compared to composite is used as material for side door impact beam. Therefore, replacement of the steel beam is necessary to achieve weight reduction especially for hybrid and electric vehicle as well as improvement in energy absorption. This could be achieved with light-weight material such as natural fibre composites, though they are characterized with inferior mechanical properties. However, the inherent problems associated with natural fibre composites can be addressed through chemical treatments and hybridization. The sugar palm fibre (SPF) was selected based on its abundance especially in Southeast Asia and its proven performances. Therefore, this research describes the development and investigation of an automotive side door impact beam with glass/sugar palm *(Arenga Pinnata)* fibre reinforced polypropylene hybrid composite. In this study, the sugar palm fibre was treated with sodium hydroxide (NaOH) and sodium bicarbonate ($NaHCO_3$). The properties of treated and untreated sugar palm fibre were evaluated through various characterization methods. Composite laminates of hybrid and non-hybrid glass/sugar palm fibre reinforced polypropylene were fabricated and characterized to study the effect of the treatment and hybridization. Consequently, hybrid and non-hybrid composite side door impact beams were fabricated and tested under three-point bending to determine their energy absorption and other performance parameters. The results showed that the treated SPF had an increase in crystallinity, thermal stability, and surface roughness when compared with the untreated fibre. Amongst the two different treatments, sugar palm fibre treated with alkaline had an initial decomposition temperature of 255.47 °C, while sodium bicarbonate treated and untreated fibre had 250.19 °C and 246.76 °C respectively. In both cases, the thermal stability of the fibre was improved. Also, as revealed by the X-Ray Diffraction (XRD) analysis, the cellulose content of SPF treated with alkaline and sodium bicarbonate increased by 22.6 % and 15.6 % respectively when compared with untreated fibre. These findings proved that treatment with the sodium bicarbonate had a significant effect on the physicochemical properties of sugar

palm fibre and the chemical could be an alternative chemical for treating other cellulose fibres. Analysis of hybrid and a non-hybrid composite of SPF and glass fibre reinforced polypropylene composite showed a promising improvement in physiochemical properties of the composite. The tensile strength increased with both alkaline and sodium bicarbonate treatments for the hybrid and non-hybrid composites. The increase was more pronounced with alkaline treated SPF composite (L03) which displayed the highest value of 61.75 MPa. While that of sodium bicarbonate treated SPF composite (L04) recorded 58.76 MPa as against 53.01 MPa for the untreated SPF composite (L02). Likewise, an improvement was noticed for the flexural strength of the hybrid composite by 25.2% from 86.54 MPa to 108.34 MPa for alkaline treatment and by 13.9% from 86.54 MPa to 98.55 MPa for sodium bicarbonate treatment. Both the mechanical properties of the hybrid were significantly high compared to the non-hybrid composite. Furthermore, the results showed that the hybridization between sugar palm with glass fibre and/or chemical treatments gave a positive hybrid effect of the overall performance compared to the SPF/PP single system composite. In overall, the alkaline treatment yielded better performance in comparison with sodium bicarbonate treatment. Finally, the hybrid SPF/glass fibre reinforced PP composite beam (BMHC) exhibited the highest absorbed energy of 139.94 J, followed by glass fibre reinforced PP composite beam (BMC) with 104.47 J. This means that the hybrid composite had the capacity to absorb energy higher than the reference steel structure by 61.9 %. Furthermore, the hybrid composite beam allowed weight reduction up to 59.2 %. While the glass fibre reinforced PP composite beam recorded a reduced weight of 54.5 % when compared with a conventional steel beam. In conclusion, using sodium bicarbonate as the chemical treatment for sugar palm fibre can give the desired surface roughness with comparable thermal stability and tensile strength. Hybrid composite side door impact beam performed better in terms of weight reduction and energy absorption as compared to traditional steel beam.

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

KOMPOSIT HIBRID POLIPROPILENA BERTETULANG GENTIAN KACA DAN IJUK [*Arenga Pinnata* (Wurmb. Merr.)] UNTUK RASUK IMPAK SISI PINTU KERETA

Oleh

ISMA'ILA MUKHTAR

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Bahan ringan dan berprestasi tinggi adalah penting dalam kejuruteraan automotif. Ini adalah kerana faedahnya yang besar seperti penggunaan bahan api yang rendah, penjimatan kos dan pengurangan berat. Secara tradisinya, keluli yang berat dan menyerap kurang tenaga berbanding komposit digunakan sebagai bahan bagi rasuk impak sisi pintu. Oleh yang demikian, penggantian rasuk keluli adalah perlu untuk mencapai pengurangan berat terutama untuk kenderaan hibrid dan elektrik serta peningkatan dalam penyerapan tenaga. Ini boleh dicapai dengan bahan ringan seperti komposit gentian semulajadi, walaupun mereka dicirikan dengan sifat mekanikal yang lebih rendah. Walau bagaimanapun, wujud masalah yang berkaitan dengan komposit gentian semulajadi dapat diatasi melalui rawatan kimia dan penghibridan. Gentian ijuk (SPF) ini dipilih berdasarkan kelimpahannya terutama di Asia Tenggara dan prestasinya yang terbukti. Oleh itu, kajian ini menghuraikan perkembangan dan penyiasatan rasuk impak sisi pintu automotif dengan komposit hibrid polipropilena diperkukuh gentian kaca/ijuk *(Arenga Pinnata)*. Dalam kajian ini, serat ijuk dirawat dengan natrium hidroksida (NaOH) dan natrium bikarbonat ($NaHCO_3$). Ciri-ciri serat ijuk yang dirawat dan tidak dirawat dinilai menggunakan pelbagai kaedah pencirian. Lapisan komposit hibrid dan bukan hibrid polipropilena bertetulang kaca/ijuk telah dihasilkan untuk mengkaji kesan rawatan dan penghibridan. Oleh yang demikian, komposit rasuk impak sisi pintu yang difabrikasi dan diuji di bawah lenturan tiga titik untuk menentukan penyerapan tenaga mereka dan lain-lain parameter prestasi. Keputusan ujian menunjukkan bahawa SPF yang dirawat mempunyai peningkatan kekristalan, kestabilan haba dan kekasaran permukaan apabila dibandingkan dengan serat yang tidak dirawat. Antara kedua-dua rawatan yang berbeza, serat ijuk yang dirawat dengan alkali mempunyai suhu penguraian awal 255.47 °C, manakala serat yang dirawat dan tidak dirawat natrium bikarbonat mempunyai 250.19 °C dan 246.76 °C. Dalam kedua-dua kes, kestabilan haba serat telah bertambah baik. Juga, seperti yang ditunjukkan oleh analisis *X-Ray Diffraction* (XRD), kandungan selulosa SPF yang dirawat dengan alkali dan natrium bikarbonat meningkat masing-masing sebanyak 22.6% dan 15.6%, berbanding dengan serat yang tidak dirawat. Penemuan ini membuktikan bahawa rawatan dengan natrium bikarbonat mempunyai kesan yang signifikan terhadap sifat fizikokimia serat ijuk dan bahan kimia ini boleh menjadi bahan kimia alternatif untuk merawat serat selulosa yang lain. Analisis komposit hibrid dan bukan hibrid polipropilena bertetulang SPF dan gentian kaca menunjukkan peningkatan yang menggalakkan dalam sifat fisiokimia komposit. Kekuatan tegangan meningkat dengan rawatan alkali dan natrium bikarbonat untuk komposit hibrid dan bukan hibrid. Peningkatan ini lebih ketara dengan komposit SPF yang dirawat alkali (L03) menunjukkan nilai yang tertinggi 61.75 MPa. Sementara komposit SPF yang dirawat natrium bikarbonat (L04) mencatatkan 58.76 MPa berbanding 53.01 MPa untuk komposit SPF yang tidak dirawat (L02). Begitu juga penambahbaikan telah diperhatikan bagi kekuatan lenturan komposit hibrid sebanyak 25.2% daripada 86.54 MPa kepada 108.34 MPa untuk rawatan alkali dan 13.9% daripada 86.54 MPa kepada 98.55 MPa untuk rawatan natrium bikarbonat. Kedua-dua sifat mekanik hibrid itu jauh lebih tinggi berbanding komposit bukan hibrid. Selain itu, keputusan menunjukkan bahawa penghibridan antara serat ijuk dengan gentian kaca dan/atau rawatan kimia memberikan kesan hibrid positif terhadap prestasi keseluruhan berbanding komposit sistem tunggal SPF/PP. Secara keseluruhan, rawatan alkali menghasilkan prestasi yang lebih baik berbanding dengan rawatan natrium bikarbonat. Akhirnya, rasuk komposit PP bertetulang hybrid SPF/gentian kaca mempamerkan tenaga tertinggi yang diserap sebanyak 139.94 J, diikuti oleh rasuk komposit PP bertetulang gentian kaca sebanyak 104.47 J. Ini bermakna komposit hibrid mempunyai keupayaan untuk menyerap tenaga tinggi berbanding struktur keluli rujukan sebanyak 61.9%. Selain itu, rasuk komposit hibrid membolehkan pengurangan berat sehingga 59.2%. Sementara itu, rasuk komposit PP bertetulang gentian kaca mencatatkan penurunan berat sebanyak 54.5% apabila dibandingkan dengan rasuk keluli konvensional. Kesimpulannya, menggunakan sodium bicarbonat sebagai rawatan kimia bagi serat ijuk boleh memberi kekasaran permukaan yang diingini berserta kestabilan haba yang setanding dengan kekuatan tegangan. Komposit hibrid rasuk impak sisi pintu menunjukkan prestasi yang lebih baik dari segi pengurangan berat dan penyerapan tenaga berbanding rasuk keluli tradisional.

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I certify that a Thesis Examination Committee has met on (19th September 2018) to conduct the final examination of Isma'ila Mukhtar on his thesis entitled "Glass/Sugar Palm (*Arenga Pinnata* (Wurmb. Merr.)) Fibre Reinforced Polypropylene Hybrid Composite Automotive Side Door Impact Beam" 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:

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

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LIST OF ABBREVIATIONS

ADF	Acid Detergent Fibre
ASTM	American Society for Testing and Materials
CFRP	Carbon Fibre Reinforced Polymer
DSC	Differential Scanning Calorimetry
DTG	Differential Thermal Gravimetry
EA	Energy Absorption
FRP	Fibre Reinforced Polymer
FTIR	Fourier Transform Infrared (spectroscopy)
GF	Glass fibre
GFRP	Glass Fibre Reinforced Polymer
GMT	Glass Mat Thermoplastic
HIPS	High Impact Polystyrene
MAPP	Maleic Anhydride grafted Polypropylene
NDF	Neutral Detergent Fibre
NFC	Natural Fibre Composite
PMC	Polymer Matrix Composite
PP	Polypropylene
SEA	Specific Energy Absorption
SEM	Scanning Electron Microscope
SPF	Sugar Palm Fibre
SPFNH	Sugar Palm Fibre treated with Sodium Hydroxide
SPFNB	Sugar Palm Fibre treated with Sodium Bicarbonate
SPFU	Sugar Palm Fibre untreated
UD	Uni-Directional Fibre
TGA	Thermal Gravimetric analysis
V_f	Volume fraction
W_f	Weight fraction
XRD	X-Ray Diffraction

CHAPTER 1

INTRODUCTION

1.1 Background of the Research

New materials are continuously emerging through research in various fields of engineering for different applications. The performance of these materials needs to be continuously meet or exceed the expectations of designers, manufacturers and end users. In the field of automotive, various type of materials are in use, ranging from metals to composites either for structural or non-structural automotive components. In the case of polymer reinforced composite, natural and synthetic fibres are used as reinforcing materials. Each of the duos has its own strength and weakness, therefore the choice solely depends on the area applications of the composite. In the past years, the manufacturers of components in automotive, aerospace and other related field are shifting from the use of conventional metals to synthetic fibres reinforced polymer composites (Cheon and Jeong 1997, Boria et al. 2015, Friedrich and Almajid 2013). The major impetus is the unique characteristics of the fibre reinforced polymer composite in terms of energy absorption, corrosion resistant and lightweight feature (Yan and Chouw 2013, Ghasemnejad et al. 2009). Equally important, high specific strength and stiffness are another advantages for its usage in high load-bearing applications. Also, the crushing mode of fibre reinforced composites is quite different from that of metallic materials. The former are able to collapse in a progressive controlled manner while the latter is associated with extensive microfracture (Yan and Chouw 2013, Ghasemnejad et al. 2009).

The automotive components made up of fibre reinforced polymer composite (FRP) can either be structural or non-structural parts. The structural components include bumper, side door structure, integral seat, crash box, brake lever etc. (Friedrich and Almajid 2013, Mansor et al. 2013). The side door impact beam as one of the structural member in an automotive was traditionally made up of steel, which is heavy and absorbs less impact energy during a collision. Research conducted on comparative analysis showed that fibre reinforced polymer composite rail absorbed 240% more energy when compared with aluminium and steel rail (Ali et al. 2015). The need to reduce weight and protect car occupants from death and severe injury were the main reason for shifting from metals to fibre reinforced composite materials in automotive engineering. The replacement of these conventional materials with composite will also increase fuel efficiency, but caution needs to be taken not to undermine the safety of the occupants of the automotive car.

Side door impact beam is a structural component that is considered to be a passive safety device in automotive engineering. It's being designed to absorb impact energy during a side collision. They are placed longitudinally between the outer panel and inner panel of a door which serves as an impact absorber to protect occupants in case of side impact collision, see Figure 1.1. In recent time, the synthetic fibres composite namely, glass mat thermoplastic (long or woven form) composite and carbon fibre reinforced polymer composites are employed as a substitute for metals. This is due to it excellent impact absorbing characteristics and lower weight than conventional metallic material (Yuxuan et al. 2004). Despite the high specific strength and lightweight, the synthetic fibre reinforced composites are expensive and pose some environmental challenges.

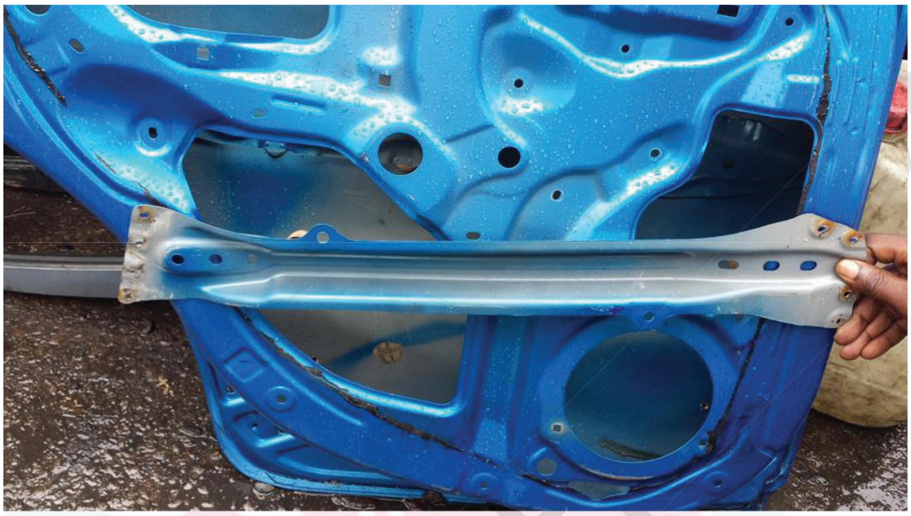

Figure 1.1: Side door impact beam for car occupants' protection

It was obvious that glass and other synthetic fibre reinforced polymer composites have high impact energy absorption than steel (Ghasemnejad et al. 2009, Yuan et al. 1997). Glass fibre reinforced composite though is of high specific strength than steel, but has its own disadvantages. The glass fibres can cause acute irritation to the skin, eyes, and upper respiratory tract. The fibrous glass and other synthetic vitreous fibres, when disturbed, release fibres that can become airborne, inhaled and retained in the respiratory tract (Leman et al. 2008a). Therefore, the synthetic fibres cannot continually be utilised as reinforcement in composite because of the stringent regulation on the level of carbon footprint, global warming and disposal of components.

On the other hand, natural fibre composites are acknowledged to have inferior mechanical properties when compared with fibre reinforced composite (Joshi et al. 2004). The inferior mechanical properties coupled with other limitations make it unsuitable for load-bearing structure. But it has a favourable specific strength when compared with that of glass (Wambua et al. 2003). In addition, scientists, researchers and manufacturers are continually fascinated by the distinctive advantages of natural fibres. These include lightweight, biodegradability, ease of machinability, non-toxic, low cost, non-abrasive, availability, less pollutant emission and low environmental impact (Joshi et al. 2004). Therefore, incorporation of the natural fibres into synthetic fibres will result in synergetic properties of the composite that outweighed the benefit of both reinforcements. Synthetic/cellulosic hybrid composite offer a substantial weight and cost savings. The hybrid composites may not have properties as glamorous as advanced composite, but they are making inroad to displace traditional or conventional materials in manufacturing.

In general, synthetic/cellulosic hybrid composites are manufactured when a natural fibre is incorporated into glass fibre or other synthetic fibres, both serving as reinforcement hosted in a single polymer matrix. The hybrid material will have synergetic effects in terms of superior properties. A research conducted by Hariharan and Khalil (2005) on the hybridization of oil palm fibre with glass fibre reinforced epoxy composite yielded a positive hybrid effect. The result showed that the tensile strength and impact strength properties increase with the addition of glass fibre. In another research, Jeyanthi and Janci (2012) developed a hybrid composite of kenaf and glass reinforced polypropylene by a hot impregnation process. In this research, both mechanical and thermal properties were improved considerably. Likewise, improvement of mechanical, thermal properties and moisture absorption characteristics were seen by adding glass fibre into kenaf reinforced epoxy for bumper beam application (Davoodi et al. 2010) and SPF/glass reinforced epoxy for small boat application (Misri et al. 2010). Also, a hybrid of hemp, flax, kenaf and glass fibre reinforced epoxy for elbow pipe was proposed with improved properties (Cicala et al. 2009). The analysis of this material showed that both cost and weight was reduced by 20% and 23% respectively. In another development, fatigue assessment on glass/kenaf hybrid composite was conducted, and it was shown that the fatigue degradation improved by 6.4% for unidirectional kenaf fibre (Sharba et al. 2015). In all the cases of synthetic/cellulosic reinforced polymer hybrid composites, the improvements were translated into weight reduction, cost saving, a greener environment and reduced health risk.

The present study focuses on using sugar palm fibre and glass fibre reinforced polypropylene composite as material for side door impact beam. The aim is to synthesise a hybrid composite of sugar palm and glass fibre reinforced polypropylene and use it to fabricate the side door impact beam. It is expected that the material will offer desirable properties when compared with glass fibre reinforced polypropylene with added ecological, recycling and economic advantages. In addition, the beam will be a safer structure due to high specific energy absorption. It is obvious from the literature that, there is no study on the hybrid composite of sugar palm and glass fibre reinforced polypropylene with prior treatment of SPF with sodium bicarbonate. The treatment of the sugar palm fibre with the chemical is hoped to improve fibre dispersion, fibre-matrix adhesion and reduction of moisture absorption with less degradation as compared to alkali treatment. The treated and untreated fibre will be characterised to study the effect of fibre treatments on both physical, mechanical, chemical, morphological, and thermal properties for effective utilisation of fibre in automotive industries. The sugar palm fibre and glass fibre hybrid reinforced polypropylene laminate composite will be produced by hot compression moulding. The basic properties related to its application were evaluated; more specifically mechanical properties. At the end of the characterizations, a composite system that yields the best performance was used to fabricate the composite side door impact beam.

1.2 Problem Statements

Protection of car occupant during collision is one of the most important considerations in the design and manufacturing of an automobile. Side impact collision is the second largest cause of death and injury in a motor vehicle crash after the frontal crash (Bedard et al. 2002, Teng et al. 2008). To minimise the damage due impact, an impact beam made of steel is installed within the door structure. The steel beam is designed with different cross-sections ranging from tubular (square or circular) and stamped or pressed beam. Particularly, tubular beams are widely used when compared to stamp beam due to their high energy absorption (Abdollah and Hassan 2013). In terms of material, steel and other metallic material like aluminium and magnesium are currently used as materials for side door impact beam. Early works include the research conducted by Tanabe et al. (1995) which uses steel tubular as beam material and characterized its load and energy absorption capability. While Yoon et al. (2016) use advanced high strength steel (AHSS) to improve energy absorption and reduce deformation. Notwithstanding, these materials are heavy and have low impact energy absorption capability. Therefore, fibre reinforced composites are readily available as a solution to this problem. Replacement of steel side door impact beam with synthetic fibre composites have been proposed in many studies (Cheon and Jeong 1997, Cheon and Lim 1999, Patberg et al. 1999, Erzen et al. 2002, Li et al. 2004). Weight and impact absorption characteristics are the driven factor for the introduction of fibre reinforced composite as material for side door impact beam in a passenger's car for both occupant safety, cost savings and less fuel consumption. The composite beams are characterized with a high capacity for impact energy absorption when compared with steel beams at low temperature.

Despite weight reduction, the synthetic fibres reinforced composite are not user-friendly, heavier, expensive and difficult to degrade when compared with natural fibres. With the global energy crisis and ecological risk, a continual patronage of glass fibre and other synthetic fibres reinforced polymer composites will amount to global unfavourable environmental issues which need to be addressed as quickly as possible. Other issues that are of concern with synthetic fibres are high cost, non-degradable and risk of health associated problems. Also, government policies regarding the use of non-renewable and non-biodegradable materials are becoming stringent over a time and this is pertinent to the good environment of the future generation. Hence, to overcome the dependency on this synthesised fibre polymer composites, several attempts have been made to develop natural fibre reinforced composites from fibres of the different types of plants, animals or minerals. Sugar palm fibre is one of the natural fibres that was discovered as a potential substitute to the synthetic fibres like glass. The sugar palm fibre is obtained from the sugar palm tree, which is a multipurpose tree normally found in most Southeast Asian countries and it's regarded as a potential source of natural fibre. Generally, natural fibres are having some drawback namely; lack of interfacial adhesion between the fibre and the matrix, high moisture absorption, low thermal stability among others. The most common approach to address the issue of interfacial adhesion and moisture absorption is to chemically treat the natural fibre with chemicals. While to address the inferior mechanical properties of natural fibre composite is to hybridize the composite with synthetic fibres. The hybrid is achieved through the incorporation of the natural fibre into the synthetic fibre, thus, leading to the paradigm shift from FRP to hybrid reinforced polymer composites system. The incorporation of the natural fibre comes with a lot of benefits which include but not limited to low density, low cost, availability, renewability, biodegradability, and non-abrasive (Shah et al. 2013, Joshi et al. 2004, Pickering et al. 2016, González-López et al. 2018). Therefore, combining these two different reinforcing materials, a hybrid composite with balance performance especially cost-performance and lightweight can be achieved. There are many studies toward hybridizations which are numerous to mention. But few among them include oil palm and glass fibre reinforced epoxy composite (Hariharan and Khalil 2005), jute-glass and kenaf-glass reinforced polyester (Akil et al. 2010), sisal and glass reinforced epoxy (Palanikumar et al. 2016), and flax/glass reinforced polyurethane polyester (Pandey et al. 2016). All the research highlighted have given the desired composite materials with balanced properties and it can be used in structural and semi-structural application. Currently, a lot of research are ongoing for the incorporation of the hybrid composite into automotive. This research is motivated and drawn from the above sequential stated problems.

In order to address the above-mentioned drawbacks of sugar palm fibre reinforced polymer composite, the fibre will be treated with alkali and sodium bicarbonate. The modification of fibre will improve fibre dispersion and fibre-matrix interfacial adhesion that will guarantee improved properties. Furthermore, the sugar palm fibre will be hybridised with glass fibre which will enhance the strength and water resistance of the hybrid composite. Hybridization can improve the properties and balance the weakness of both cellulosic and synthetic fibres. The hybrid composite will be characterised based on physical, mechanical and impact energy absorption under quasi-static static. The optimized material will be used to fabricate the side door impact beam for Perodua Myvi for protection of the occupants. The fabricated beam will be subjected to quasi-static three-point bending test to assess its energy absorption.

1.3 Research Objectives

The aim of this study was to develop and characterise glass and sugar palm fibre reinforced polypropylene hybrid composite and use it for automotive side door impact beam. The specific objectives were:

1. To determine the effect of chemical treatment of sugar palm fibre using sodium bicarbonate on the physical, mechanical, chemical composition, thermal properties and morphological and compare it with the conventional alkaline treatment.
2. To investigate the effect of the chemical treatments and hybridization on the properties of sugar palm fibre/glass fibre reinforced polypropylene hybrid and non-hybrid composites.
3. To compare the impact energy absorption performance of hybrid and non-hybrid composite side door impact beam with an existing automotive stamped steel impact beam.

1.4 Significance of the Study

A positive hybrid effect can be achieved by combining sugar palm fibre and glass fibre with the prior chemical treatment of the fibre that will be translated into the high-performance composite material. The suggested new material which is termed as "partial eco-friendly hybrid composite" will allow a weight reduction, reduced fuel consumption, less destructive to the environment and essentially cost savings when compared with steel and synthetic fibre reinforced polymer composites. The findings of this research will also provide fundamental information about glass and sugar palm fibre reinforced polypropylene hybrid composite as a material for side door impact beam in an automotive. The utilisation of the sugar palm fibre will motivate the rural people to increase the plantation of the sugar palm tree. This will further boost the economy and wellbeing of the people because of the additional income. With the existing trend of using a significant amount of composites for hybrid cars and electric vehicle (EV) for weight reduction and reduced fuel consumption. This new material will benefit the local automotive manufacturers for the production of automotive side door impact beam and other automotive components. The new material will be cheap because its raw materials are readily available in abundant and that will lower the total cost of the vehicle. The lightweight feature of this novel hybrid composite material is an intrinsic characteristic that will reduce the fuel consumption of a vehicle. Furthermore, the material will be partially biodegradable and emit less of CO_2.

1.5 Research Scope

The study focused on the characterizations of both treated and untreated fibre, these include diameter measurement, density, moisture content, single fibre tensile strength, chemical compositions, thermal, and morphological analysis. The glass and sugar palm fibre reinforced polypropylene hybrid and non-hybrid laminate composites were fabricated using hot compression technique. The hybrid and non-hybrid composites were characterized in accordance with the ASTM standard. The properties investigated for the laminate composite include physical, mechanical and thermal properties. These investigations were done to ascertain its suitability as a material for side door impact beam in an automobile (Myvi). In addition, the full-scale composite beams of 600 mm long were characterized through quasi-static three-point bending test and the performance was compared with the existing steel side door impact beam of Myvi car in Malaysia.

1.6 Thesis Organisation

This thesis is structured into five (5) chapters i.e. ‘introduction’, ‘literature review’, ‘methodology’, ‘results and discussions’, and finally ‘conclusion and recommendation’. Chapter 1 covers the basic background and problems that necessitate the research activities. In addition, the chapter also covers the objectives, scope, and significant contributions of the research. Chapter 2 deals with a comprehensive review of the major topics related to this thesis in a logical manner. This includes the previous work on sugar palm fibre and its characterization, composites and assessment of its properties as well as the potentials of the hybrid composite in the structural and semi-structural application. Further work on literature review includes previous studies on side door impact beam. Mostly researches that focused on type materials, fabrication method and the beam testing.

Chapter 3 of the thesis covers the materials and methodology used in this thesis. While chapter 4 presented the findings and through discussion of the results as well as the implication of the findings. Lastly, chapter 5 which is the final chapter deals with the overall summary of the findings and suggestions for further modifications and/or improvement.

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