FABRICATION METHODS OF EGG POLYMER MATRIX AND INNER BANANA TRUNK POLYMER MATRIX USING INJECTION MOULDING VERSUS VACUUM ASSISTED RESIN TRANSFER MOLDING PROCESS

By:
AMIRA BINTI MUHAMMAD NOR

(Matric no.: 120783)

Supervisor:
DR.RAMDZIAH MD. NOR

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Universiti Sains Malaysia

Declaration

Declaring this thesis is written by Amira Muhammad Nor, with titled ‘Fabrication methods of egg polymer matrix and inner banana trunk polymer matrix using injection moulding versus vacuum assisted resin transfer molding process’. The results are solely based on Amira’s finding and investigation and there were no part that has been plagiarised by any resources. Though, materials that are taken are properly acknowledge and clearly references.

Signature:

Student name: Amira Binti Muhammad Nor

Matrix number: 120783

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Abstrak

Pembuangan agrikultur merupakan salah satu masalah di Malaysia, jadi ia menjadi pendorong kepada penyelidikan dalam bidang bahan yang membawa pembaharuan and bio-terurai. Tujuan eksperimen ini adalah untuk mengunakan semula bahan buangan semulajadi yang tidak mempunyai nilai untuk menjadikannya kepada bahan yang mempunyai nilai. Salah satu cara untuk meperluaskan penggunaan pengisi atau fiber semula jadi adalah dengan menambahkan ia ke bahan plastik untuk dijadikan komposit baru yang dapat menandingi prestasi komposit dengan pengisi atau fiber sintetik. Selain itu, daripada menggunakan pengisi atau fiber sintetik dalam membuat komposit, perubahan kepada pengisi atau fiber semula jadi amat diperlukan untuk mengurangkan bahan buangan semulajadi dan mengurangkan kos bahan. Kajian ini memberi tumpuan kepada fabrikasi matrik polimer mengunakan bahan semulajadi iaitu kulit telur ayam dan bahagian dalam batang pisang mengunakan dua jenis proses iaitu proses injeksi molding dan penghantaran resin dengan bantuan vakum (VARTM). Kedua-dua proses ini disiasat dan dinilaidari segi fabrikasinya dan hasil akhir seperti rupa bentuknya. Dua jenis specimen yang akan dihasilkan mengunakan dua jenis pengisi.

Abstract

Agriculture waste has been one of the concerns in Malaysia, that motivating research to be made in the field of renewability and biodegradable material. This experiment aim is to reuse the waste of natural material that does not give any economic value and adding value to the material. One way to widen the application of natural filler or fiber is by adding it in plastic to create new composite that able to achieve the performance as synthetic fiber or filler. In consequence to that, instead of using synthetic filler in making composite, there is in need for transition to natural filler to help in reducing natural waste and reducing the material cost. This study solely focus on fabricating polymer matrix using natural material which is chicken egg shell and inner banana trunk by using two types of processes which is injection moulding process and vacuum assisted resin transfer molding. Both processes were investigated and evaluated in terms of steps in fabricating and end result such as appearance. Two type specimens were fabricated reinforced each with egg shell and inner banana trunk.

1.0 Introduction

1.1 Agriculture Waste

In the world of technology of this day and age, resources usually are fully utilized to fulfill the demand from the customer and any waste produced would consider being non-beneficial to the constitutional. Every year, generally the average person produces 2 kilograms of waste daily leads to over than 23,000 tonnes of waste is produced daily in Malaysia and this amount is predicted to be increase to 30,000 tonnes by the year 2020 [1]. The amount of waste generated continues to increase due to the increasing population and development, and only less than 5% of the waste is being recycled. Apart from that, agriculture waste is a part of major waste that contributed to Malaysia waste where two millions agriculture wastes are produced annually which a big concern for this country and there are not many alternatives in trying to reuse back the waste rather than resorting to waste disposal which contribute little to nothing to the environment [2].

Since Malaysia is having tropical humid climate and received plentiful of rain throughout the year which is suitable for growing crop. Nonetheless, with the increasing amount crop extraction especially banana causing the left over tree to be cut off and leaving the bottom part of stem and rhizome. Since, banana tree only grow fruit once in a lifetime and it takes around 10-12 months to be harvested. Usually, after harvesting the banana tree will be cut down to make room for new tree to grow from the underground stem and the cut off banana trunk are consider as agriculture waste and many farmers are facing problem to dispose the banana trunk [3].

Another major agriculture waste is eggshell, especially chicken eggshell is considered useless and discarded after use. In order to combat this issue, this thesis describes in helping to reduce everyday waste that household, restaurant and farmer produced. The waste used is specified and chosen based on non-economic viable it is, and how major the waste has cause to the environment and does not give any value to human. Hence, banana trunk and egg shells are chosen to be the material to be reinforced into the polymer. Currently, banana trunks waste has become a problematic waste with no economically-viable uses and same goes for egg shells; it has been describe as an agriculture waste that

can contribute to pollution to the environment if waste keeps on accumulating. Hence, this thesis would be focusing on using common eggshells.

1.2 Composite

Composite is mixture of two or more constituent or phases. Composite has been a popular subject for researcher to study to improve the properties of composite material. Especially now, researcher tend to go for natural filler to reduce the quantity for synthetic filler while improving the mechanical properties of composite.

There are four major categories in polymer matrix: polymer matrix composite (PMC), metal matrix composite (MMC), ceramic matrix composite (CMC) and carbon matrix composite (CMC). PMC are classified as thermoplastic and thermosetting composites and this thesis will be focusing on PMC.

1.3 Polymer

Generally, polymer are made up of combination of smaller molecular units called monomers that take place by chemical process to form long chain of molecules and known as polymerization. There are two main types of polymerized molecules which are thermoplastics and thermosets. Thermoplastics have separated chain of molecules it is made in such a way so that the molecule can slide over one another and return back to its original position. Thermosets has chains of molecules that are cross-linked and when it became solid it can no longer softened and go back to its original position. Polymers are made of two polymerization processes which is addition polymerization does not created any by-product while condensation polymerization which created by-product of water, nitrogen or hydrogen gas.

Usually the property of final plastic material will be determined by the type of additive into the pure polymer. The additive can be fillers or extenders to decrease the quantity of polymer used or to toughen the product. Colour can be added to the polymer such as pigments or stabilizers to reduce degradation and plasticizers can be added to modify the polymer characteristics [4].

1.3.1 Thermoplastics

Thermoplastic generally is ductile and tougher than thermosets which is used in wide variation either purely or with additive. Since thermoplastic has the ability to go back to its original position it can be amorphous or semi-crystalline molecular arrangement. Thermoplastic usually show low creep resistance compared to thermosets. It can easily be influenced by solvent compared to thermosets. Thermoplastic resins are easier to join together with the filler in a machine compared to thermosets that has complicated process to combine resin with filler which required careful preparation and adhesive. Thermoplastic require higher temperature of forming and pressure compared to thermoset. The common type of thermoplastic resin used is polypropylene, nylon, PEEK, polypropylenes, and polyester.

Polypropylene (PP)

Polypropylene is commonly known to be used in automotive industry for the car body or component, machine parts, and household item. Polypropylene is low-cost, low density, versatile plastic and available in many grade so that it could be used for the purpose of product functionality. The lowest density that it has is 0.9g/cm^3 of all thermoplastic. Polypropylene gives out good strength, stiffness, chemical resistance and fatigue resistance.

Polyetheretherketone (PEEK)

PEEK is the new generation of thermoplastic that provides the option to be used at high temperature. The glass transition temperature (T_g) for PEEK 143 Celsius and crystalline melting temperature is apolypropyleneroximately 336 celcius. The water absoption for PEEK is 10 times lower than epoxy which 0.5 percent at room temperature whereas epoxy has 4 to 5 percent water absorption. PEEK composite are only chosen to be made if there is need for critical characteristics such as in aerospace structure which is in satellite parts and fuselage because of the high material cost.

Polyphenylene Sulfide (PPS)

Polyphenylene Sulfide has T_g of 85 celcius and crystalline melt temperature is 285 celcius. This composite have the characteristic of great strength and chemical resistance at elevated temperature and can be continuously at 225 celcius.

Nylons

The other name of nylon is called polyamides. There are several grades of nylon for example nylon 6, nylon 6, nylon 11 and etc., that can gives out mechanical and physical properties based on the function of product. Nylons offer good appearance and good lubricity. Nylon resin like to absorb moisture hence causing it to affect the properties and dimensional stability of the parts. The appearance of nylon is used in making housing, gears, bearings, bushing and sprockets. Usually, injection molding process is widely used for nylon resin.

1.3.2 Thermosets

Thermosets structure are made of cross-linked molecular chain which causing the molecules to be rigid and not flexible. Hence causing thermoset can never be reformed once it is cured. If the cross-link of molecule is higher in number the thermosets will be more rigid and thermally stable. Thermosets are brittle in nature so filler and reinforcement are needed to make it stable. The process ability of thermosets resin is easier and the permeation of resin throughout the entire filler is better since the resin is mostly used during room temperature for various techniques. Thermoset has high thermal dimensional stability, rigidity, electrical chemical and solvent resistance. The common type of resin used in thermosets is epoxy, polyester, vinylester, phenolics, cynate esters, bismaleimides, and polyimides.

Epoxy

Epoxy has very flexible resin system and capable of broad range of properties and processing capabilities. It has low shrinkage and good adhesion with wide variety of material. Epoxy is the most widely used resin with substrate materials and used in many application. Epoxy has many different grades that can be used for different type of application needs. Epoxy can be made into the performance desired by formulating it with other material; all parameter can be change according to desired product such as

mechanical properties of epoxy, the curing rate, processing temperature need. The chemical reaction for epoxy curing is with amines, anyhydrides, phenols, carboxylic acids, and alcohol. There a several epoxides group contain in epoxy liquid resin such as diglycidyl ether of bisphenol A (DGEBA) which contain three-membered ring of two carbon atoms and one hydrogen atom. Hardener is added for the curing reaction to takes place such as diethylenetriamine (DETA). The DGEBA molecules form 3D cross-linking network during curing and form to solid epoxy resin. With a proper selection of hardener the curing can be control according to desire. The higher the cure rate, the lower the process cycle time and higher production volume. Epoxies come in my forms such as liquid, semi-solid and solid forms. The liquid form usually used in RTM, pultrusion, hand-layup and other process that used various reinforcing fibres such as glass, carbon, aramid, and boron. While semi-solid epoxies are used in vacuum bagging and auto clave process. Solid epoxy is used for bonding purposes. However epoxy is more on the costly side compared to polyester and vinylester, which are not used for cost-sensitive markets unless heavy performance are needed.

Phenolic

Phenolic are made from the reaction of phenol (carbolic acid) and formaldehyde and catalysed by acid or base. Instead of phenol it can be substitute to urea, resorcinol, or melamine to obtain different kind of properties. Since water is generated during curing process the characteristic is quite different than any other thermoset resin. The water is removed during the processing by bumping the press in compression molding process. Phenolic is commonly used for product that non-critical in colour since it only can produced in darker colour. Phenolic product are known to be flame-resistant, however there are many characteristic that phenolic can offer when they reinforced with filler, such as high temperature, conduct electricity, wear resistant, and good chemical resistance and dimensional stability. The application of phenolic are mainly in aircraft interior, stowbins, galley walls and with any other product that is low-cost, flame resistant and low smoke production. Phenolic resin can be used in many composite manufacturing techniques such as injection molding, RTM, filament winding, compression molding and compression molding.

Polyester

Polyesters are made from the reaction of unsaturated difunctional organic acids with di-functional alcohol. The acids used are maleic, fumaric, phthalic, and terephthalic. For the alcohol contains ethylene, glycol, propylene glycol and halogenated glycol. For curing reaction styrene is added to promote cross-linking between carbon-carbon double bonds in saturated polyesters molecules and styrene molecule. However with the health concern regarding styrene emission the use of reduced styrene with catalyst is promoted for curing the polyesters. From all thermoset resin polyester is the cheapest in the market it provides good corrosion resistance and it can operate in room temperature.

Vinyl ester

Vinyl ester is created by the chemical reaction between unsaturated organic acid and with an epoxide-terminated molecule. The molecule in vinyl esters contain less cross-linking compared to polyester or epoxy causing it to gives out high ductility and toughness. Vinyl esters are broadly used in RTM, SMC, pultrusion and filament winding. It provides good corrosion and chemical resistance and suitable to use for FRP tanks and pipes in chemical industries. Vinyl esters are cheaper than epoxy and suitable for producing low cost and high volume product especially in automotive industries.

Cynate Esters

Cynate Esters gives good strength and toughness, good electrical properties and lower moisture absorption compared to others resin. The high-temperature properties can be achieved to be similar to bismaleimide and polymide resins with proper formula. Cynate esters are formed by the reaction of bisphenol esters and cynic acids that cyclotrimerize to produce triazine rings during second cure. It has better curing reacton compared to epoxy. The application used for cynate esters are in spacecraft, aircraft, missiles, antennae, radomes, microelectronics and microwave products.

Polyurethane

The reaction of polyisocynate and a polyhydroxyl group producing polyurethane. It gives off good wear,tear and chemical resistance, toughness and high resilience. Polyurethane

is used for reinforced reaction injection molding (RRIM) and structural reaction injection molding (SRIM) processes. The isocynate and polyol are mixed in ratio of 1:1 in reaction chamber and quickly injected into closed mold which contain short or long fiber reinforcements. SRIM and RRIM processes required less cost and high volume production methods. Polyurethane resin is very famous in automotive industry such as bumper, body panels, hoods, and etc. for unfilled polyurethane are used for making cushion matress foam and etc. this resin can be thermoset or thermosetting depending on the selection of polyols according to the function.

Bismaleimide (BMI) and Polymide

For the high temperature apolypropylenelication BMI and polyamide are commonly used which the glass transition temperature (Tg) could achieve until the range of 550 to 600 Fahrenheit whereby some of the polyimide able to achieves Tg more than 700 Fahrenheit. This temperature is much higher than epoxy and polyester. The BMI and polyimides is difficult to use since it produces volatile and moisture during imidization and curing. Hence, when using this resin proper air expelling required during curing avoiding defect such as voids and delamination. This resin has lower toughness values compared to epoxy and cynate esters [5].

1.4 Natural Filler and Fibre reinforced polymer composite

Nowadays, there is high interest in using natural filler and fiber to be reinforced into polymer instead of synthetic filler. Many industries and researcher are opting to incorporate natural filler and fiber to be application into our daily product. Natural fiber provides many advantages such as easy to obtain, cheap, biodegradable, renewable and recyclable. There are many types of natural filler and fiber plant based in the market such as jute, flax, cotton, hemp, ramie, kenaf, bamboo and etc. Same goes for natural filler animal based they are mainly comes from animal wool and hair. Natural filler reinforced polymer able to give high degradable capability composite. Since, there are popular demands in researching about filler and fiber reinforced polymer to make it easier to process and low cost because these fiber are considered waste [6]. Now, natural fiber and filler reinforced with polymeric product able to compete with current product such as in packaging, automotive and consumer goods. Many researches has been done just to

lessen the dependency of using synthetic filler or fiber just to lower down material cost and to increase the capability of producing greener material. Basically is win-win situation for the environment and for user by producing natural based composite. Many advantages comes from using polymer reinforced with natural fiber or filler where the properties tend to gets better rather than only individual component. The polymer acts as a main strength to keep the fiber or filler together in shape and distributed the stresses evenly throughout the composite. Natural fiber or filler composites-based are capable of exhibit high tensile strength, impact strength and flexural strength compared to metallic material. However, the markets are in custom of using synthetic fiber or filler because of their well-known strength compared to natural filler or fiber. Since the cost of synthetic fiber or filler are high and affecting the environment. The increasing demand of environmentally, renewable, low cost material causing high interest in using natural fiber or filler to be reinforced into plastic to substitute synthetic fiber or filler. However, the problem faced currently, how to make the production of natural fiber or filler based polymer easier and able to achieve the performance exactly similar to synthetic filler or fiber or even better performance [7].

1.4.1 Classification of natural fiber

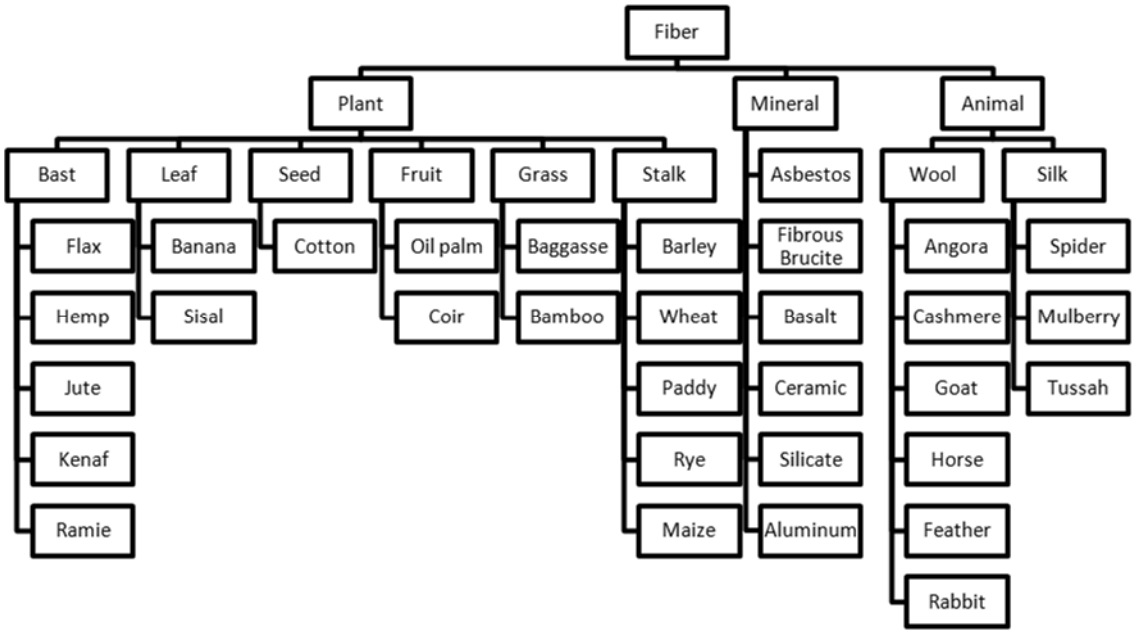

Figure 1.1: Classification of natural fiber (Courtesy of Spherical and Fibrous Filler Composites by Vikas Mittal, 2016, 129)

1.5 Manufacturing fabrication techniques for composite

The Manufacturing fabrications techniques for composite are split into two categories which is open mold and closed mold process.

1.5.1 Open mold

Typically, for open mold process thermosetting resin are used. It is one of the easiest resins to handle because firstly the process started with; mix in the formulation of resin, the resin is pour into the mold and remove it from the mold without the need to add give external heat. For open mold only one mold are used and it represent positive and negative surface. The main matrix used for open mold is polyester and epoxy and typical reinforcement is e-glass fibres. There are many form of reinforcement can be applied to the mold surface for example in mats, woven roving or yarns form. Hence, for this process it is preferable to use a prepregs to ease laying process. During curing depending on resin used there are little to no pressure are needed.

There are few advantages of using open mold such as less cost compared to closed mold, large and complex structure can be made, and wide selection of in mold material available. However there are also few drawbacks from using open mould process, such as product has one surface finished and smooth and required full labor skill time, and attention. Usually, the curing time is longer for open mold compared to closed mold process.

Wet lay-up process

There are 3 type of wet lay-up process which is hand lay-up, automation in lay-up and automation in spray-up. Hand lay-up is the oldest method to fabricate composite. The working principle is where layer of resin and reinforcement are applied manually to open mould surface layer by layer according to desire thickness. The general steps in hand lay-up is cleaning the mould, gel coating is applied to surface mold, when gel coat partially set, lay up the successive layer of resin and fiber in from of mat or cloth then each layer is

rolled to fully impregnate fiber with resin, and let the part hardened and remove part. Resin must be catalyzed with hardener to allow curing to occur.

Automation in lay-up is the same step as in hand lay-up but with the help of automated tape-laying machine to fasten the laying process. The fiber are mounted into the machine and distributed through catalyzed matrix resin for fiber wetting. Lamination is place back and forth across the mould for every layer. It is suitable for simple, uniform and large geometry.

Spray in lay-up also comes from the same method of hand lay-up but with the help of spray gun during laying process. The laying process runs simultaneously by spraying the matrix resin while laying the fiber together. After laying matrix and fiber finished the surface of part need to be rolled out using hand roller or automated roller to make it compact.

Automation in spray up derived from the spray-up process, where it is run relying on computerized machine to do the work. However this kind of process only critical for parts that is complex, high quality requirement and consistent part results.

Bag molding

Another method of wet lay-up is bag molding where it is separated to two basic ways of doing it which is by vacuum it or giving pressure to the parts. The reason for bag molding it can help in driving out any volatiles by giving pressure during process. the general process of vacuum bagging is applying the reinforced fiber to the surface of mold and all the polymeric sheet needed for the desired part together, seal all the edges, vacuum is drawn to apply pressure to plastic bag against the laminated component, check the air leakage if no leakage proceed with resin matrix to be drawn into the fiber and let the resin cure. The sheet must not be permanently adhesive to parts and flexible. Example of sheet used for the process is nylon and polyvinyl. Vacuum method gives out better adhesion between of layer of reinforcement content and matrix. The maximum amount of pressure applied must not exceed 98kpa.

Pressure bag molding has a slight different from vacuum bagging where the pressure is applied from the outside instead of the air is being removed from the inside. Pressure bag techniques is a positive pressure is applied by blowing air to inflate into elastomeric bag by giving pressure to the laminated bag covering the open mold. The pressure can be applied up to 300kPa.

Autoclave molding process

Autoclave is a pressure vessel where wide variety of materials is being process inside with complex chemical reaction takes place in the pressure vessels according to cure cycle schedule given to parts. There are many materials can be processed in the vessel such as metal bonding adhesives, thermoplastic laminates, metal, ceramics and carbon matrix material. Since the operating condition can go up to 700 celcius and 15 MPa [8].

1.5.2 Closed mold

Closed mold or in other names is matched die process. It can be used to fabricate 3 dimensional components. The major techniques in closed mould are transfer molding, compression molding and injection molding.

Transfer molding

Resin transfer molding (RTM) is a method where it is a reactive process where matrix resin and curing agents are flow through the mold and cure in the mold which contain reinforced fiber fabric.

Compression molding

The working principle of compression molding is by the pressure given at elevated temperature that causes the compound to flow in the mold. As the resin flow through the mold completely filling up the heated mold and then curing occur. Then after it cure in the mold the part is being ejected out from the mold. After removed from mold the part need to undergo post cure in heated oven. For part that went through Compression molding techniques produces good rigidity, strength such as compression, impact and tensile and good surface finish part.

Injection molding

Injection molding is one of the good techniques to produce 3 dimensional composite parts. Both thermoplastic and thermoset are able to be used in injection molding. The mold is filled up at a very high pressure causing in short filling time in injection molding. Hence, injection molding is very convenient in high volume production and high level of automation. Other than that, curing takes only few seconds since it is under high pressure between 10-20MPa [9].

1.6 Goals and objectives

The primary goals of this thesis are to use injection molding and vacuum bagging process to fabricate the sample for polymer polymer matrix and inner banana trunk polymer matrix according to the material testing standard. The objective of the work is:

1. To identify matrix for the natural filler
2. To optimise the formulation of natural filler into matrix resin.
3. To fabricate eggshell polymer and banana trunk matrix
4. To observe the defects exist at sample

1.7 Problem Statement

Waste is produce daily causing an increase in waste every day. Hence, this thesis is made to help reduce everyday waste that comes from household, restaurant and farmer produce. For this thesis the waste is specified and chosen based non-economic viable to the human and it can be said as one of the agriculture waste that contribute to pollution to the environment. Then, banana trunk and egg shells are chosen to be the filler for the composite. So in this thesis the aim is to fabricate egg polymer matrix and inner banana trunk polymer matrix using two types of methods injection molding versus vacuum assisted resin transfer molding process.

2.0 Literature Review

In journal of "Fabrication and Property Evaluation of Banana-Hemp Glass Fiber Reinforced Composite" stated using the waste of banana product which available in our country, Malaysia helps in reducing environmental pollution. Since, banana has many advantages in terms of mechanical properties compared to synthetic fiber [10]. Between synthetic fibre reinforced composite and natural fibre reinforced composite, natural fibre reinforced composite are renewable, biodegradable, environmentally friendly, light weight. [11,12]. This paper specifies on describing the experimental study of hybridizing banana and hemp fiber with glass fiber and prepared hybrid composite laminates. The results shown indisputably increase in mechanical properties such as in flexural strength and impact strength, if there are hybridization of more than one natural fiber into the polymer. However, there an undeniably increase in tensile strength banana-glass fiber composites. These results help in gaining more information in terms in fabricating banana reinforced composite. The composites are prepared by using hand lay-up. The material is epoxy resin and hardener with the ratio of 10:1 and the curing time is 20 minutes once it's mixed. The layers are arranged by top, middle and bottom laminated with glass-fiber the second and fourth layer are with natural fiber. The composites are cure for 12 hours with the help of weight press. However, this paper stated only to use laboratory extracted fiber and certainly not on banana trunk only. Hence, there is in need of more study using banana trunk as filler in reinforced composite [13].

In journal of 'Preparation and Characterization of Reinforced Egg Shell Polymer Composites' by Senthil J. et al. stated that eggshell has the potential to be reinforced with polymer. Since, eggshells is one of the major waste in poultry area it can provide benefits in renewability, degradable, environmentally friendly material. This journal stated that generally, 95% of dry eggshells are made up of Calcium carbonate ($CaCO_3$). The majority of true shells are composed of long column of $CaCO_3$. Smooth eggshells are better than rough because rough-shelled fracture easily and large eggshell break easily

compared to small one because hen can only provide certain amount of calcium to the shells if eggshells gets bigger the amount of calcium will be the same. The material was prepared by washing the eggshells with deionized water, dried and grinded into fine particles. The matrix chosen was general purpose polyester resin and 15wt% and 20wt% weight ratio of eggshells powder as filler material. The catalyst used is 1.5% in the resin. The sample was made by pouring the mixed resin into mold let it cure for 6 hours. The results obtained for this journal was composite with weight ratio of 20wt% eggshell has higher tensile property than 15wt% while for flexural property 15wt% eggshells shown to exhibit higher value than 20wt% [14].

In journal of "Fabrication of Continous GFRP Composites using Vacuum Bag Moulding Process" stated the step by step procedure to fabricate SIKA E-Glass Fiber Reinforced Polymeric (GFRP) composite using vacuum bagging. This paper stated that to produce the best vacuum bag system is to have under 14 Psi (0.96252 bar). However, FRP only needed around the range of 5- 10 Psi [15]. Quality of composites could be improves by reducing the void content, using vacuum bagging process where all the air is being pump out of the bag covering the mould [16]. The specimens are being produced using the following equipment : Vacuum pump, Matrix material (Resin and Hardener), Reinforcement material (SIKA Wrap uni-directional glass fiber – 430 GSM), Mylar sheet; 100 microns mylar sheet, Peel ply fabric; smooth woven fabric, Perforated sheet; solid release film, Breather sheet; stretchable thin cloth, Bagging sheet; nylon film bag, tacky tape; 10mm diameter, flow tube and flange. The method started out by cleaning the mold surface and prepares the material. The resin is prepared by mixed ratio of 1:10 by weight and mixed for a few minutes to release gas. The layer of fabric is arranged one by one by spreading it then; peel ply is placed to ease peeling the laminate after dried out. Next, placed perforated sheet to absorb excess resin and two layers of breather sheets and flange is placed on the top of the setup and seals the setup. Connect he flange to tube that connected to vacuum pump. During the sucking the air out check the air leakage by observing the pressure, if constant means no leak if there is pressure changes mean leaking occur. Then press the bag film closed to the mold. The curing process takes around 24-28 hours at atmospheric pressure. The procedure explain in this paper could

help in the process of vacuum bagging for fabricating banana trunk and eggshell reinforced polymer [17].

As for eggshell reinforced plastic, there is not any journal published for eggshells as filler, the closest journal found was eggshells used as filler in concrete but not in plastic as in the experiment needed. Based in journal of "Egg Shell As a Fine Aggregate in Concrete for Sustainable Construction" stated there has been an increase in eggshell waste that driven for this paper. Since, concrete is type of composite material composed of coarse granular material embedded in a hard matrix of material (the cement or binder) that fills the space among the aggregate particles and glues them together. Concrete can be said in easier way as; concrete = filler + binder. However, the results stated that eggshell cannot be used as fine aggregate in the production of concrete at 100% level of replacement maybe partially added to concrete mix. Hence, there is in need for a study in fabricating and testing in composite using eggshell as filler [18].

In journal of 'Natural fiber hybrid composite' by Maries Idicula et al. stated that the way to fabricate hybrid sample by using RTM techniques using short and randomly oriented, very well mixed banana and sisal fiber reinforced polyester composites. The volume ratio is preserve at 1:1 between banana and sisal fiber. Based on journal the RTM techniques appliedd in this journal by letting the polyester resin mixture to pass through the closed mold which containing fibers in form of mat. The vacuum is applied simultaneously for 12 hour for curing process. Then the sample undergo post-cure for another 12 hour and 50 celcius in the oven [19].

In journal of 'Fabrication and testing of natural fibre composites: Vakka, sisal, bamboo and banana' by K. Murali et al. stated the manufacturing techniques used to produce sample is by compression molding and hand lay-up. The unidirectional composite were prepared by using polyester matrix with natural fibers. The catalyst used in resin is 1.5 percent by each volume of matrix resin each. This journal stated that, the fiber configuration and volume fraction are the main factors that can affect the properties of composite. The fiber configuration used in the sample is limited to unidirectional and continuous fiber only. In tensile testing the length of specimen used 160mm and for flexural testing is 100mm. The post-cure occur for 2 hour at 80 celcius [20].

In journal of 'Experimental study of bamboo using banana and linen fibre reinforced polymeric composites' by Ramachandran M. et al. stated that has been an interest in reinforcing natural fiber with polymeric composites to obtain better mechanical properties. Bamboo, banana and linen fiber are some of the fiber that is widely cultivated and has high profitable potential. Banana fiber contains multiple celled lingo cellulosic fiber that obtains from pseudo stem of banana plant. The lumens are large in relation to the wall thickness, cross markings are and fiber tips either pointed or flat. Banana fibre has high mechanical properties that can be blend easily with various other fibres or materials (Ramachandran et al. 2015). This journal explained in details about study of bamboo fiber, banana fiber and linen fiber with matrix resin epoxy. The banana, bamboo and linen fibre are cut into 2-4mm of length and mixed with epoxy resin and kept for 11-12 hour. All samples are prepared using hand-layup technique. The ration used is 90:10 for epoxy:bamboo, 90:5:5 for epoxy:bamboo: banana and 90:5:5 for epoxy:bamboo:linen respectively [22].

In journal of 'Scalable Fabrication of Natural-Fiber Reinforced Composites with Electromagnetic Interference Shielding Properties by Incorporating Powdered Activated Carbon' by Changlei Xia et al. stated that the fabrication technique used in this journal is VARTM and four types of composite are made. The 3 fiber are treated with PAC10, PAC20 and PAC30 respectively. The polymer matrix used is unsaturated polyester resin with 1.5 percent of t-BP catalyst. The fabrication started with applying the release agent into the mold surface and the preform are placed in on the mold. The vacuum bag is place over the mold. After the vacuum tubes were inserted in the bag, resin infusion was carried out by a vacuum that was created between the mold and the bag. The catalyzed resin enters infusion tubes. The vacuum pulled the resin along the distribution layer into the preformed mats. The resin-infused preforms were cured in two temperatures which is 100 Celsius for 2 h, and then 150 Celsius for 2 h. Once the resin cured and cooled down to room temperature, the vacuum bag and distribution layer were removed. Then, the surface topologies of the un-treated kenaf fibers and Fiber/PAC30 were examined using a Quanta 200 environmental scanning electron with an accelerating voltage of 20 kV and magnifications of 1000 times and 2000 times. Before the SEM tests, specimens were

coated by a gold sputtering coater for 5 min to prevent charging of the specimen by the SEM electron beam [22].

In journal of 'Abaca fibre reinforced polypropylene composites and comparison with jute and flax fibre polypropylene composites' by A.K Bledzki et al. stated that abaca or banana fiber that comes from pseudo-stem or trunk contains cellulosic fiber [23]. Combination of polypropylene and banana fiber using compression molding technique has been patented by Rieter Automotive and defined that abaca fibre has a high tensile strength, rotting resistant and its specific flexural strength is close to that of glass fibre [24]. The material used is polypropylene as matrices and abaca fiber as reinforcement starting from 30wt% fiber loading up to 50wt%. The composition also include with coupling agent which is maleic anhydride poly-propylene copolymer (MAPP) together with acid 37–43 mg KOH/g and without the coupling agent. The processing method used in this experiment firstly by mixing abaca fiber and propylene is high-speed mixer cascade mixer. The fiber was dried at 80 celcius to ensure moisture content below 1 percent before mixing. Fiber and polypropylene are placed in the hot mixer at different proportion. The material are heated to melting temperature, polypropylene melting temperature is 173 celcius. The hot agglomerates granules are placed at cool mixer where it cooled down at room temperature using cold water. Then, the agglomerates granules are dried at 80 Celsius for 24 hours and ready for injection molding process. The temperature used in injection is between 150-180 Celsius along the zone and the mold temperature is 80 Celsius. The results obtained in this journal shown tensile and flexural strengths increasing tendency up to 40wt% of fibre loading. Then tensile and flexural strengths decreased with increasing fibre load. The highest strength properties observed at 40wt% fibre loading can be explained by better fibre distribution in matrix material and less fibre fractures. Therefore the bond between fibre and matrix often represent whether the fiber will improve the properties of composites by transferring an applied load. Coupling agent promotes bonding between matrix and fiber where the adhesion are greatly increase by formation of ester linkages between MAPP and OH groups of cellulose [25, 26]. The interfacial adhesion of treated fibre composites is much better than untreated fibre composites. However, for composition without MAPP at 40wt% shown to have less fiber pull out and fiber de-bonding [27].