A REVIEW ON NATURAL FIBERS

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ABSTRACT

Over the last thirty years composite materials, plastics and ceramics have been the dominant emerging materials. The volume and number of applications of composite materials have grown steadily, penetrating and conquering new markets relentlessly. Modern composite materials constitute a significant proportion of the engineered materials market ranging from everyday products to sophisticated niche applications. While composites have already proven their worth as weight-saving materials, the current challenge is to make them cost effective. This review paper discuss about world wide review report on natural fibers and its applications. Also, this paper concentrates on biomaterials progress in the field of orthopaedics. An effort to utilize the advantages offered by renewable resources for the development of biocomposite materials based on bio epoxy resin and natural fibers such as Agave sisalana; Musa sepientum; Hibiscus sabdariffa and its application in bone grafting substitutes.

Keywords: *Natural fibers; Orthopaedics; Bioepoxy resin.*

1. INTRODUCTION

1.1. Definition of composite

The most widely used meaning is the following one, which has been stated by Jartiz "Composites are multifunctional material systems that provide characteristics not obtainable from any discrete material. They are cohesive structures made by physically combining two or more compatible materials, different in composition and characteristics and sometimes in form". The weakness of this definition resided in the fact that it allows one to classify among the composites any mixture of materials without indicating either its specificity or the laws which should given it which distinguishes it from other very banal, meaningless mixtures. Kelly very clearly stresses that the composites should not be regarded simple as a combination of two materials. In the broader significance; the combination has its own distinctive properties. In terms of strength to resistance to heat or some other desirable quality, it is better than either of the components alone or radically different from either of them. Beghezan defines as "The composites are compound materials which differ from alloys by the fact that the individual components retain their characteristics but are so incorporated into the composite as to take advantage only of their attributes and not of their short comings", in order to obtain improved materials. Van Suchetclan explains composite materials as heterogeneous materials consisting of two or more solid phases, which are in intimate contact with each other on a microscopic scale. They can be also considered as homogeneous materials on a microscopic scale in the sense that any portion of it will have the same physical property.

1.2. Merits of Composites

Advantages of composites over their conventional counterparts are the ability to meet diverse design requirements with significant weight savings as well as strength-to-weight ratio. Some advantages of composite materials over conventional ones are as follows:

- Tensile strength of composites is four to six times greater than that of steel or aluminium (depending on the reinforcements).
- Improved torsional stiffness and impact properties.
- Higher fatigue endurance limit (up to 60% of ultimate tensile strength).
- 30% - 40% lighter for example any particular aluminium structures designed to the same functional requirements.
- Lower embedded energy compared to other structural metallic materials like steel, aluminium etc.
- Composites are less noisy while in operation and provide lower vibration transmission than metals.
- Composites are more versatile than metals and can be tailored to meet performance needs and complex design requirements.

- Long life offer excellent fatigue, impact, environmental resistance and reduce maintenance.
- Composites enjoy reduced life cycle cost compared to metals.
- Composites exhibit excellent corrosion resistance and fire retardancy.
- Improved appearance with smooth surfaces and readily incorporable integral decorative melamine are other characteristics of composites.
- Composite parts can eliminate joints / fasteners, providing part simplification and integrated design compared to conventional metallic parts.

Broadly, composite materials can be classified into three groups on the basis of matrix material. They are:
a) Metal Matrix Composites (MMC)
b) Ceramic Matrix Composites (CMC)
c) Polymer Matrix Composites (PMC)

a) Metal Matrix Composites

Metal Matrix Composites have many advantages over monolithic metals like higher specific modulus, higher specific strength, better properties at elevated temperatures, and lower coefficient of thermal expansion. Because of these attributes metal matrix composites are under consideration for wide range of applications viz. combustion chamber nozzle (in rocket, space shuttle), housings, tubing, cables, heat exchangers, structural members etc.

b) Ceramic matrix Composites

One of the main objectives in producing ceramic matrix composites is to increase the toughness. Naturally it is hoped and indeed often found that there is a concomitant improvement in strength and stiffness of ceramic matrix composites.

c) Polymer Matrix Composites

Most commonly used matrix materials are polymeric. The reason for this are two fold. In general the mechanical properties of polymers are inadequate for many structural purposes. In particular their strength and stiffness are low compared to metals and ceramics. These difficulties are overcome by reinforcing other materials with polymers. Secondly the processing of polymer matrix composites need not involve high pressure and doesn’t require high temperature. Also equipments required for manufacturing polymer matrix composites are simpler. For this reason polymer matrix composites developed rapidly and soon became popular for structural applications. Composites are used because overall properties of the composites are superior to those of the individual components for example polymer/ceramic.
Composites have a greater modulus than the polymer component but aren’t as brittle as ceramics.
Two types of polymer composites are:
- Fiber reinforced polymer (FRP)
- Particle reinforced polymer (PRP)

1.3 Fiber Reinforced Polymer

Common fiber reinforced composites are composed of fibers and a matrix. Fibers are the reinforcement and the main source of strength while matrix glues all the fibers together in shape and transfers stresses between the reinforcing fibers. The fibers carry the loads along their longitudinal directions. Sometimes, filler might be added to smooth the manufacturing process, impact special properties to the composites, and / or reduce the product cost. Common fiber reinforcing agents include asbestos, carbon / graphite fibers, beryllium, beryllium carbide, beryllium oxide, molybdenum, aluminium oxide, glass fibers, polyamide, natural fibers etc. Similarly common matrix materials include epoxy, phenolic, polyester, polyurethane, polyetherethrketone (PEEK), vinyl ester etc. Among these resin materials, PEEK is most widely used. Epoxy, which has higher adhesion and less shrinkage than PEEK, comes in second for its high cost.

1.4 Particle Reinforced Polymer

Particles used for reinforcing include ceramics and glasses such as small mineral particles, metal particles such as aluminium and amorphous materials, including polymers and carbon black. Particles are used to increase the modules of the matrix and to decrease the ductility of the matrix. Particles are also used to reduce the cost of the composites. Reinforcements and matrices can be common, inexpensive materials and are easily processed. Some of the useful properties of ceramics and glasses include high melting temp., low density, high strength, stiffness, wear resistance, and corrosion resistance. Many ceramics are good electrical and thermal insulators. Some ceramics have special properties; some ceramics are magnetic materials; some are piezoelectric materials; and a few special

ceramics are even superconductors at very low temperatures. Ceramics and glasses have one major drawback: they are brittle. An example of particle reinforced composites is an automobile tire, which has carbon black particles in a matrix of poly-isobutylene elastomeric polymer. Polymer composite materials have generated wide interest in various engineering fields, particularly in aerospace applications. Research is underway worldwide to develop newer composites with varied combinations of fibers and fillers so as to make them useable under different operational conditions. Against this backdrop, the present work has been taken up to develop a series of PEEK based composites with glass fiber reinforcement and with ceramic
fillers and to study their response to solid particle erosion.

1.5 Characteristics of the Composites

A composite material consists of two phases. It consists of one or more discontinuous phases embedded in a continuous phase. The discontinuous phase is usually harder and stronger than the continuous phase and is called the „reinforcement„ or „reinforcing material‟, whereas the continuous phase is termed as the matrix. The matrix is usually more ductile and less hard. It holds the dispersed phase and shares a load with it. Matrix is composed of any of the three basic material type i.e. polymers, metals or ceramics. The matrix forms the bulk form or the part or product. The secondary phase embedded in the matrix is a discontinuous phase. It is usually harder and stronger than the continuous phase. It servers to strengthen the composites and improves the overall mechanical properties of the matrix. Properties of composites are strongly dependent on the properties of their constituent materials, their distribution and the interaction among them. The composite properties may be the volume fraction sum of the properties of the constituents or the constituents may interact in a synergistic way resulting in improved or better properties. Apart from the nature of the constituent materials, the geometry of the reinforcement (shape, size and size distribution) influences the properties of the composite to a great extent. The concentration distribution and orientation of the reinforcement also affect the properties. The shape of the discontinuous phase (which may by spherical, cylindrical, or rectangular cross-sanctioned prisms or platelets), the size and size distribution (which controls the texture of the material) and volume fraction determine the interfacial area, which plays an important role in determining the extent of the interaction between the reinforcement and the matrix. Concentration, usually measured as volume or weight fraction, determines the contribution of a single constituent to the overall properties of the composites. It is not only the single most important parameter influencing the properties of the composites, but also an easily controllable manufacturing variable used to alter its properties.

1.6 Natural Fiber Reinforced Composites

The interest in natural fiber-reinforced polymer composite materials is rapidly growing both in terms of their industrial applications and fundamental research. They are renewable, cheap, completely or partially recyclable, and biodegradable. Plants, such as flax, cotton, hemp, jute, sisal, kenaf, pineapple,ramie, bamboo, banana, etc., as well as wood, used from time immemorial as a source of lignocellulosic fibers, are more and more often applied as the reinforcement of composites. Their availability, renewability, low density, and price as well as satisfactory mechanical properties make them an attractive ecological alternative to glass, carbon and man-made fibers used for the manufacturing of composites. The natural fiber-containing composites are more environmentally friendly, and are used in transportation (automobiles, railway coaches, aerospace), military applications, building and construction industries (ceiling paneling, partition boards), packaging, consumer products, etc.

1.7 Classification of Natural Fibers

Fibers are a class of hair-like material that are continuous filaments or are in discrete elongated pieces, similar to pieces of thread. They can be spun into filaments, thread, or rope. They can be used as a component of composites materials. They can also be matted into sheets to make products such as paper or felt. Fibers are of two types: natural fiber and man made or synthetic fiber. Figure 1 shows the classification of natural fibers.

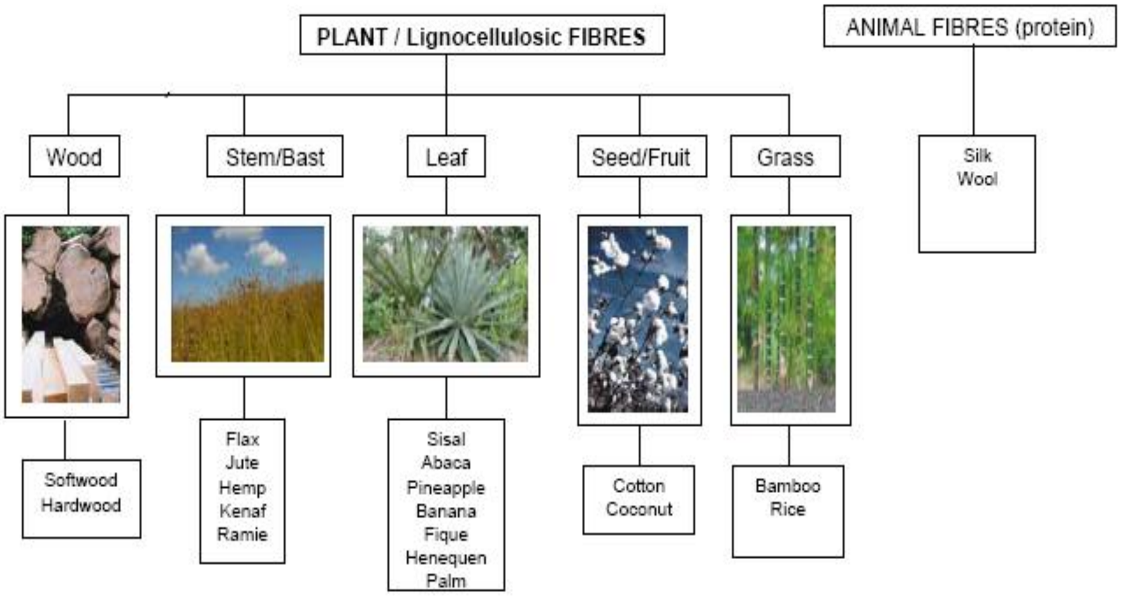

Figure 1. Classification of natural fibers

2. SOURCES OF NATURAL FIBRES

Natural fibers include those made from plant, animal and mineral sources. Natural fibers can be classified according to their origin.

2.1 Vegetable fibers

Vegetable fibers are generally comprised mainly of cellulose: examples include cotton, jute, flax, ramie, sisal, and hemp. Cellulose fibers serve in the manufacture of paper and cloth. This fiber can be further categorized into the following:

- Seed fiber: Fibers collected from seeds or seed cases. E.g. cotton and kapok.
- Leaf fiber: Fibers collected from leaves. e.g. sisal and agave.
- Bast fiber or skin fiber: Fibers are collected from the skin or bast surrounding the stem of their respective plant. These fibers have higher tensile strength than other fibers. Therefore, these fibers are used for durable yarn, fabric, packaging, and paper. Some examples are flax, jute, kenaf, industrial hemp, ramie, rattan, soybean fiber, and even vine fibers and banana fibers.
- Fruit fiber: Fibers are collected from the fruit of the plant, e.g. coconut (coir) fiber.
- Stalk fiber: Fibers are actually the stalks of the plant. E.g. straws of wheat, rice, barley, and other crops including bamboo and grass. Tree wood is also such a fiber.

The most used natural fibers are cotton, flax and hemp, although sisal, jute, kenaf, and coconut are also widely used. Hemp fibers are mainly used for ropes and aerofoils because of their high suppleness and resistance within an aggressive environment. Hemp fibers are, for example, currently used as a seal within the heating and sanitary industries.

2.2 Animal fibers

Animal fibers generally comprise proteins; examples include silk, wool, angora, mohair and alpaca.

- Animal hair (wool or hairs): Fiber or wool taken from animals or hairy mammals. E.g. sheep's wool, goat hair (cashmere, mohair), alpaca hair, horse hair, etc.
- Silk fiber: Fiber collected from dried saliva of bugs or insects during the preparation of cocoons. Examples include silk from silk worms.
- Avian fiber: Fibers from birds, e.g. feathers and feather fiber.

2.3 Mineral fibers

Mineral fibers are naturally occurring fiber or slightly modified fiber procured from minerals. These can be categorized into the following categories:

- Asbestos: The only naturally occurring mineral fiber. Varietions are serpentine (chrysotile) and amphiboles (amosite, crocidolite, tremolite, actinolite, and anthophyllite).
- Ceramic fibers: Glass fibers (Glass wool and Quartz), aluminum oxide, silicon carbide, and boron carbide.
- Metal fibers: Aluminum fibers.

2.4 Applications of Natural Fiber Composites

The natural fiber composites can be very cost effective material for following applications:
Building and construction industry: panels for partition and false ceiling, partition boards, wall, floor, window and door frames, roof tiles, mobile or pre-fabricated buildings which can be used in times of natural calamities such as floods, cyclones, earthquakes, etc.

- Storage devices: post-boxes, grain storage silos, bio-gas containers, etc.
- Furniture: chair, table, shower, bath units, etc.
- Electric devices: electrical appliances, pipes, etc.
- Everyday applications: lampshades, suitcases, helmets, etc.
- Transportation: automobile and railway coach interior, boat, etc.
- The reasons for the application of natural fibers in the automotive industry include:
- Low density: which may lead to a weight reduction of 10 to 30%
- Acceptable mechanical properties, good acoustic properties.
- Favorable processing properties, for instance low wear on tools, etc.
- Options for new production technologies and materials.
- Favorable accident performance, high stability, less splintering.
- Favorable ecobalance for part production.
- Favorable ecobalance during vehicle operation due to weight savings.
- Occupational health benefits compared to glass fibers during production.No off-gassing of toxic compounds (in contrast to phenol resin bonded wood and recycled Cotton fiber parts).
- Reduced fogging behavior.
- Price advantages both for the fibers and the applied technologies.

2.5. Advantages of Natural Fiber Composites

The main advantages of natural fiber composite are:

- Low specific weight, resulting in a higher specific strength and stiffness than glass fiber.
- It is a renewable source, the production requires little energy, and CO2 is used while oxygen is given back to the environment.
- Producible with low investment at low cost, which makes the material an interesting product for low wage countries.
- Reduced wear of tooling, healthier working condition, and no skin irritation.
- Thermal recycling is possible while glass causes problem in combustion furnaces.
- Good thermal and acoustic insulating properties.

3. LITERATURE SURVEY

Researchers have begun to focus attention on natural fiber composites (i.e., biocomposites), which are composed of natural or synthetic resins, reinforced with natural fibers. Natural fibers exhibit many advantageous properties, they are a low-density material yielding relatively lightweight composites with high specific properties. These fibers also offer significant cost advantages and ease of processing along with being a highly renewable resource, in turn reducing the dependency on foreign and domestic petroleum oil. Recent advances in the use of natural fibers (e.g., flax, cellulose, jute, hemp, straw, switch grass, kenaf, coir and bamboo) in composites have been reviewed by several authors [6–25]. Harish et al. [2] developed coir composite and mechanical properties were evaluated. Scanning electron micrographs obtained from fracture surfaces were used for a qualitative evaluation of the interfacial properties of coir /epoxy and compared with glass fibers. Wang and Huang [1] had taken a coir fiber stack, characters of the fibers were analyzed. Length of the fibers was in the range between 8 and 337 mm. The fibers amount with the length range of 15~145 mm was 81.95% of all measured fibers. Weight of fibers with the length range of 35~225 mm accounted for 88.34% of all measurement. The average fineness of the coir fibers was 27.94 tex. Longer fibers usually had higher diameters. Composite boards were fabricated by using a heat press machine with the coir fiber as the reinforcement and the rubber as matrix. Tensile strength of the composites was investigated. Nilza et al. [3] use three Jamaican natural cellulosic fibers for the design and manufacture of composite material. They took bagasse from sugar cane, banana trunk from banana plant and coconut coir from the coconut husk. Samples were subjected to standardized tests such as ash and carbon content, water absorption, moisture content, tensile strength, elemental analysis and chemical analysis. Bilba et al. [4] examined Four fibers from banana-trees (leaf, trunk) and coconut-tree (husk, fabric) before their incorporation in cementitious matrices, in order to prepare insulating material for construction. Thermal degradation of these fibers was studied between 200 and 700 °C under nitrogen gas flow. Temperature of pyrolysis was the experimental parameter investigated. The solid residues obtained were analyzed by classical elemental analysis, Fourier Transform Infra Red (FTIR) spectroscopy and were observed by Scanning Electron Microscopy (SEM).

This study has shown (1) the relation between botanical, chemical composition with both localization of fiber in the tree and type of tree; (2) the rapid and preferential decomposition of banana fibers with increasing temperature of pyrolysis and (3) the rough samples are made of hollow fiber. Conrad [5] investigates the connection between the distribution of lignin and pectin and the loading of Pb and Zn on coir. The coir consisted mainly of xylem and a fiber sheath. The lignin was evenly distributed in the cell walls of the fiber sheath, but in the xylem, there was no detectable content in the compound middle lamella, and a smaller content of lignin in the secondary walls than in the walls of the fiber sheath. The only detectable content of pectin in the fiber sheath walls was in the middle lamella, cell corners and extracellular matrix, while in the xylem, the pectin was almost evenly distributed in the wall, with a higher concentration in the middle lamella and cell corners. All cell walls facing the lacuna had a high content of pectin. Simple correlation between the loading of metal ions and the distribution of lignin or pectin, these investigations point at no correlation with lignin and a positive correlation with pectin. Passipoularidis and Philippidis [6] studied the influence of damage accumulation metric, constant life diagram formulation and cycle counting method on life prediction schemes for composite materials under variable amplitude (VA) loading. Results indicate that a net improvement is achieved when linear strength degradation is implemented as damage metric in life prediction schemes, over the state-of-the-art PM summation. Din et al. [7] investigated the liquid-phase adsorption of phenol onto coconut shell-based activated carbon for its equilibrium studies and kinetic modeling. Coconut shell was converted into high quality activated carbon through physiochemical activation at 850 ◦C under the influence of CO2 flow. Beforehand, the coconut shell was carbonized at 700 ◦C and the resulted char was impregnated with KOH at 1:1 weight ratio. A series of batch adsorption experiments were conducted with initial phenol concentrations ranging from 100 to 500mgl−1, adsorbent loading of 0.2 g and the adsorption process was maintained at 30±1 ◦C. Chemical reaction was found to be a rate-controlling parameter to this phenol-CS850A batch adsorption system due to strong agreement with the pseudo-second-order kinetic model. Adsorption capacity for CS850A was found to be 205.8mgg−1. Rao et al. [8] aims at introducing new natural fibers used as fillers in a polymeric matrix enabling production of economical and lightweight composites for load carrying structures. An investigation of the extraction procedures of vakka, date and bamboo fibers has been undertaken. The cross-sectional shape, the density and tensile properties of these fibers, along with established fibers like sisal, banana, coconut and palm, are determined experimentally under similar conditions and compared. The fibers introduced in the present study could be used as an effective reinforcement for making composites, which have an added advantage of being lightweight. Dick et al. [9] conduct static and cyclic 4-point bending tests on glass-filled polycarbonate, to collect results for evaluation of a theoretical model on its capability to predict the fatigue life and the residual strength after the cyclic loading The study quantifies the effects of loading conditions, i.e. the stress ratio and the maximum stress level, on the damage development. The paper demonstrates the possibility of expressing each of the model parameters as a function of single variable that is stress ratio, maximum stress level, or a material-dependent constant. Ersoy and Kucuk [10] investigated the sound absorption of an industrial waste, developed during the processing of tea leaves. Three different layers of tea-leaf-fiber waste materials with and without backing provided by a single layer of woven textile cloth were tested for their sound absorption properties. The experimental data indicate that a 1 cm thick tea-leaf-fiber waste material with backing provides sound absorption which is almost equivalent to that provided by six layers of woven textile cloth. Twenty millimeters thick layers of rigidly backed tea-leaf-fibers and non-woven fiber materials exhibit almost equivalent sound absorption in the frequency range between 500 and 3200 Hz. Jacquemin et al [11] proposed an analytical micromechanical self-consistent approach dedicated to mechanical states prediction in both the fiber and the matrix of composite structures submitted to a transient hygroscopic load. The time and space dependent macroscopic stresses, at ply scale, are determined by using continuum mechanics formalism. The reliability of the new approach is checked, for carbon–epoxy composites, through a comparison between the local stress states calculated in both the resin and fiber according to the new closed-form solutions and the equivalent numerical model. Wang et al. [12] investigated the effective thermal conductivity enhancement of carbon fiber composites using a three-dimensional numerical method First a more realistic three-dimensional distribution of fibers dispersed in a matrix phase is reproduced by a developed random generation-growth method to eliminate the overrated inter-fiber contacts by the two-dimensional simulations. The energy transport governing equations are then solved through the three-dimensional structures using a high-efficiency lattice Boltzmann scheme. The resultant predictions agree well with the available experimental data. Compared with the existing theoretical models, the present method does not depend upon empirical parameters which have to be determined case by case, so that it is useful for design and optimization for new materials, beyond prediction and analysis just for existing composites. Yetgin et al. [13] studied the compression and tensile tests for five different adobe mixtures. The important part of this study consisted of uniaxial compressive tests done with natural fiber mixtures. Thus, the results obtained from mechanical tests were presented in the form of stress–strain graphs. In addition, mechanical properties were related to the water content for workability, unit weight and fiber contents and discussions were given. The results show that as fiber content increases, compressive and tensile strengths decrease, and shrinkage rates decrease. Rahman et al. [14] studied the surface treatment of the coir fiber and its mechanical properties. Fiber surface modification by ethylene dimethylacrylate (EMA) and cured under UV radiation. Pretreatment with UV radiation and mercerization were done before grafting with a view to improve the physicomechanical performance of coir fibers. The effects of mercerization on shrinkage and fiber weight losses were monitored at different temperature and alkali concentration. They observed that, fiber shrinkage is higher at low temperature and 20% alkali treated coir fibers yielded maximum shrinkage and weight losses. It was found that higher shrinkage of the polymer grafted fiber showed enhanced physico-mechanical properties. The grafting of alkali treated fiber shows an increase of polymer loading (about 56% higher) and tensile strength (about 27%) than 50% EMA grafted fiber. The fiber surface topology and the tensile fracture surfaces were characterized by scanning electron microscopy and were found improved interfacial bonding to the modified fiber–matrix interface.

Another prior art of Patent [37] Application No US2010191346 titled “BONE IMPLANT”,A bone implant derived from natural bone tissue material, wherein the bone implant is substantially free of non-fibrous tissue proteins, cells and cellular elements and lipids or lipid residues and comprises collagen displaying original collagen fibre architecture and molecular ultrastructure of the natural bone tissue material from which it is derived.

nother prior art of Patent [38] Application No DE3445711 titled “ARTIFICIAL BONE AND METHOD FOR MAKING IT”, A bone replacement material comprises a tri-dimensional supporting structure comprised of elementary bodies which are interconnected and which define intermediate spaces, a coating mass comprised of filling bodies based on calcium compounds, as well as a binder (matrix). The binder and the filling bodies are resorbable, the filling bodies consisting of extremely porous spherical particles having a diameter comprised between 15 and 50 mu m and a porous volume comprised between 50 and 80% to which fibre material may be partially mixed. The bone replacement material is appropriate to produce coating layers of prosthesis which become anchoring parts for said prosthesis. It may also be used to fabricate a complete implant.

Another prior art of Patent [39] Application No 2267291352/KOLNP/2004 titled “A PROCESS FOR THE PREPARATION OF A POLYMER COMPOSITE COMPRISIN INTERNALLY DISTRIBUTED DEPOSITION MATTER”,A process for the preparation of a polymer composite comprising internally distributed deposition matter wherein the process comprises providing a deposit of deposition matter at the surface of a solid stale polymer substrate, contacting the surface deposited polymer with a plasticising fluid or a mixture of plasticising fluids under plasticising conditions to plasticise and/or swell the polymer and internally distribute deposition matter, and releasing the plasticising fluid or fluids to obtain polymer composite.; A polymer composite comprising a porous or non porcus polymer throughout which particulate deposition matter as hereinbefore defined is distributed with desired uniformity, preferably with high uniformity in excess of 80 % for example in excess of 98 %; A scaffold comprising a polymer composite having internally distributed deposition matter, and use of the composite as a support or scaflold drug delivery, for use in bioremediation, as a biocatalyst or biobarrier for human or animal or plant matter, for use as a structural component, for example comprising the polymer and optional additional synthelic or natural metal, plastic, carbon or glass fibre mesh, scrim, rod or like reinforcing for medical or surgical insertion, for insertion as a solid monolith into bone or tissue, as fillers or cements for wet insertion into bone or teen or as solid aggregates or monoliths for orthopaedic implants such as pins, or dental implants such as crowns etc.

Another prior art of Patent [40] Application No US5336465 titled “METHOD OF MAKING BONE-IMPLANTS” , A slurry compound prepared by a sintering powdery material and a binder is press-molded to obtain a contour for the final product applicable to a bone-implant such as hip prosthesis. The molded body is given a programmed movement of rotation and/or swinging to impart a centrifugal force to the sintering particles which direct toward the inner wall of the mold cavity. The final product obtained after sintering has a hollow interior having no communication to the outside. Imparting conditions of rotating/swinging movement may be changed or programmed in order to achieve a desired structure or constitution of the final product. By way of example, larger particles concentrate near the inner wall of the mold to provide a rough, porous surface of the body, whereas it has a dense core consisting mainly of sintered fine particles. A hip prosthesis having a ceramic-rich femoral head and a metal-rich stem may also be produced by so programming the movement imparting conditions.

Another prior art of Patent [41] Application No JP2004269333 titled "CARBON FIBER REINFORCED COMPOSITE MATERIALMOLDING CONTAINING CALCIUMPHOSPHATE BASED MATERIAL, METHOD OF MANUFACTURING THE SAME AND ARTIFICIAL BONE USING THE SAME", To provide a composite material molding suitable for an artificial bone for curing the disease of bone, and having high biocompatibility and excellent mechanical strength. ; SOLUTION: The composite material molding constituted so as to contain at least a calcium phosphate-based material, a carbon fiber material or a carbon fiber-reinforced carbon composite material or further to add an organic natural high polymer or organic synthetic high polymer material. The composite material molding is manufactured by mixing the calcium phosphate-based material with a carbon fiber material or the like or molding and firing the mixture of the materials.
Another prior art of Patent [42] Application No EP0442256 titled "BONE IMPLANT", A bone implant design is proposed in which the implant consists of a main body, in particular of a core and unidirectional fibres which is surrounded by a fibre latticework .The fibre latticework consists of a raised fibre portion in order to maintain the structuring of the latticework on the surface of the fibre netting . The adhesion of the bone material to the implant is promoted by the structured surface. The fibre latticework serves at the same time as a torsion casing.
Another prior art of Patent [43] Application No DE4004475 titled "BONE IMPLANTS WITH FIBRE MESH ON BASE BODY", The bone implant consists of a core with its surface covered by a layer of unidirectional fibres extruding in the longitudinal direction. The fibres are covered with a layer of woven fibres, for a textured surface .The fibre mesh is pref. of twisted fibres, retaining their round cross section. It forms up to 70% fibre portion. The core may be of a composite fibre materialwith a jocket.
Another prior art of Patent [46] Application No WO8600533 titled "BONE IMPLANT",An implant article for treatment in reconstructive surgery of damage caused to bony material, said article comprising a composite of fibre material which may or may not be bio-degradable and is incorporated in a porous matrix of a bio-degradable organic polymer material

Table 1 Properties of Natural fibres

Fibre Type	**Density** Kg/m3	**Water absorption** %	**Modulus of Elasticity** E(GPa)	**Tensile Strength (MPa)**
Sisal	800-700	56	15	268
Roselle	800-750	40-50	17	170-350
Banana	950-750	60	23	180-430
Date Palm	463	60-65	70	125-200
coconut	145-380	130-180	19-26	120-200
Reed	490	100	37	70-140

4. SISAL FIBRE

Sisal fiber is a kind of natural fiber, which possesses high specific strength and modulus, low price, recyclability, easy availability. Using sisal fiber as reinforcement to make sisal fiber reinforced polymer composites has aroused great interest of materials scientists and engineers all over the world. Many researches have been done in recent years, which include the study of mechanical properties of the composites, finding an efficient way to improve the interfacial bonding properties between sisal fiber and polymeric matrices and fiber surface treatment on the mechanical performance of the composites.

Sisal or sisal hemp is an agave. Agave sisalana that yields a stiff fiber used in making rope. It is not really a variety

of hemp, but named so because hemp was for centuries a major source for fiber, so other fibers were sometimes named after it. The Sisal plant has a 7-10 year life-span and typically produces 200-250 commercially usable leaves. Each leaf contains an average of around 1000 fibers. The fiber element, which accounts for only about 4% of the plant by weight, is extracted by a process known as decortication.
In the 19th century, sisal cultivation (the plant being propagated via offsets), was spread worldwide, from Florida to the Caribbean islands and Brazil, as well as to countries in Africa, notably Tanzania and Kenya, and Asia. Among flax, hemp, abaca, sun hemp and other agro-based fiber species, annual sisal production is the second largest worldwide, after cotton.

Sisal does not build up static nor does it trap dust, so vacuuming is the only maintenance required. High spill areas should be treated with a fiber sealer and for spot removal, a dry cleaning powder is recommended. Depending on climatic conditions, sisal will absorb air humidity or release it causing expansion or contraction. Sisal is not recommended for areas that receive wet spills, or rain or snow.

4.1 Uses of sisal

Sisal is valued for cordage use because of its strength, durability, ability to stretch, affinity for certain dyestuffs, and resistance to deterioration in saltwater. Sisal is used by industry in three grades. The lower grade fiber is processed by the paper industry because of its high content of cellulose and hemicelluloses. The medium grade fiber is used in the cordage industry for making: ropes, baler and binders twine. Ropes and twines are widely employed for marine, agricultural, and general industrial use. The higher-grade fiber after treatment is converted into yarns and used by the carpet industry.

Products made from sisal are being developed rapidly, such as furniture and wall tiles made of resonated sisal. A recent development expanded the range even to car parts for cabin interiors. Other products developed from sisal fiber include spa products, cat scratching posts, lumbar support belts, rugs, slippers, cloths and disc buffers. Sisal wall covering meets the abrasion and tearing resistance standards of the American Society for Testing and Materials and of the National Fire Protection Association. Apart from ropes, twines and general cordage sisal is used in low-cost and specialty paper, dartboards, buffing cloth, filters, geotextiles, mattresses, carpets, handicrafts, wire rope cores and macrame. In recent years sisal has been utilized as a strengthening agent to replace asbestos and fiberglass as well as an environmentally friendly component in the automobile industry. Products made from sisal fiber are purchased throughout the world and for use by the military, universities, churches and hospitals.

4.2 Roselle

The Roselle (Hibiscus sabdariffa) is a species of hibiscus native to the Old World tropics. It is an annual or perennial herb or woody-based subshrub, growing to 2–2.5 m tall. The leaves are deeply three- to five-lobed, 8–15 cm long, arranged alternately on the stems.
The flowers are 8–10 cm in diameter, white to pale yellow with a dark red spot at the base of each petal, and have a stout fleshy calyx at the base, 1.5–2 cm wide, enlarging to 3–3.5 cm, fleshy and bright red as the fruit matures. It is an annual plant, and takes about six months to mature.
Roselle is native from India to Malaysia, where it is commonly cultivated, and must have been carried at an early date to Africa. It has been widely distributed in the Tropics and Subtropics of both hemispheres, and in many areas of the West Indies and Central America has become naturalized.

4.3 Uses of Roselle

The seeds are considered excellent feed for chickens. The residue after oil extraction is valued as cattle feed when available in quantity. Nutritionists have found roselle calyces as sold in Central American markets to be high in calcium, niacin, riboflavin and iron.

4.4 Banana Fibre

Banana fiber, a ligno-cellulosic fiber, obtained from the pseudo-stem of banana plant (Musa sepientum), is a bast fiber with relatively good mechanical properties. The ‘‘pseudo-stem’’ is a clustered, cylindrical aggregation of leaf stalk bases. Banana fiber at present is a waste product of banana cultivation and either not properly utilized or partially done so. The extraction of fiber from the pseudostem is not a common practice and much of the stem is not used for production of fibers. The buyers for banana fibers are erratic and there is no systematic way to extract the fibres regularly. Useful applications of such fibres would regularize the demand which would be reflected in a fall of the prices.

4.5 Uses Of Banana&Plantain

Culinary Uses: Banana leaves, pseudostems, fruit stalks and peels can all be used for various culinary purposes. Bananas are primarily eaten as a fruit, either on its own or as a part of a salad. All parts of the banana have medicinal applications as well.
Edible leaf: The tender leaf with the stem in an emergency.
Stem: The tender core is sometimes eaten or extracted for starch.
Flower: Parts of the flower are eaten as an artichoke.
Immature fruit: Boiled or fried as a starchy staple. Can be extracted as Starch or dried as flour.
Mature fruit: The soft pulp can be eaten raw or cooked, or can be incorporated into baked products and fermented beverage.

5. OBJECTIVE OF THIS INVENTION

The present invention concentrates on the progress of biomaterials in the field of orthopaedics, an effort to utilize the advantages offered by renewable resources for the development of biocomposite materials based on biopolymers and natural fibers.

The present invention focuses on the enhanced properties of natural fiber as bone implant. It is a challenge to the creation of better materials for the improvement of quality of life.

The present invention proposes suggestions of using natural fiber–reinforced composite as a plate material, which uses pure natural fibers that are rich in medicinal properties like Sisal (Agave sisalana), Banana (Musa sapientum) and Roselle (Hibiscus sabdariffa) fibers.

The present invention focuses on fabrication of natural fiber powdered material (Sisal, Banana and Roselle) reinforced polymer composite [NFRP] plate material with bio epoxy resin Grade 3554A and Hardener 3554B, instead of orthopaedics alloys such as titanium, cobalt chrome, stainless steel, and zirconium, this plate material can be used for internal and external fixation on human body for fractured bone.

The objective of the present invention is to utilize the advantages offered by renewable resources for the development of biocomposite materials based on biopolymers and natural fibers. The application of biocomposite materials by the inventor in the field of orthopaedics for bone graft substitutes is promising.

Further object of the present invention is that the composite material - a mixture of Banana fiber reinforced composite, Sisal fiber reinforced composite, Roselle fiber reinforced composite, Sisal & Roselle (hybrid) fiber reinforced composite, Banana & Sisal (hybrid) fiber reinforced composite and Banana & Roselle (hybrid) fiber reinforced composite.

It is yet another object of the present invention that the reinforced composite undergoes various tests such as Moisture Absorption Test, Flexural Test, Tensile Test and Impact Test.

It is yet another object of the present invention that the natural fiber reinforced polymer composite material coated by calcium phosphate and hydroxyapatite (hybrid) composite can be used for both internal and external fixation on the human body for fractured bone.

6. SEARCH – KEY WORDS

An extensive –A worldwide search has been conducted as per instructions, in respect of the invention of “NATURAL FIBER BONE PLATES” by using the below mentioned key words and their combinations:

- BONE
- SISAL
- BANANA
- MUSA
- ROSELLE
- HIBISCUS
- FIBRE
- NATURAL
- COMPOSITE

- IMPLANT

2. Final composite material undergoes the fabrication and testing methods as stated below:
   - Moisture absorption test
   - Flexural Test
   - Tensile Test
   - Impact Test

7. CONCLUSION

A lot of research has been done on natural fiber reinforced polymer composites but research on Sisal (Agave sisalana), Banana (Musa sepientum) and Roselle (Hibiscus sabdariffa) polymer composites is very rare. Against this background, the present research work has been undertaken, with an objective to explore the potential of the above said fiber polymer composites and to study the mechanical and material characterization of different composites. In future, the final composite material coated by calcium phosphate and hydroxyapatite (hybrid) composite can be used for both internal and external fixation on the human body for fractured bone.

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8. REFERENCES

JOURNALS

[1] Bledzki AK, Gassan J. Composites reinforced with cellulose based .bres. Prog Polym Sci 1999;24:221–74.

[2] Mwaikambo LY, Ansell MP. Chemical modi.cation of hemp, sisal, jute, and kapok .bers by alkalisation. J Appl Polym Sci 2002;84(12):2222–34.

[3] Jochen Gassan. A study of .bre and interface parameters a.ecting the fatigue behavior of natural .bre composites. Composites Part A: 2002;33(3):369–74.

[4] Ruys D, Crosky A, Evans WJ. Natural bast .bre structure. Int J Mater Product Technol 2002;17(1–2):2–10.

[5] Mishra S, Tripathy SS, Misra M, Mohanty AK, Nayak SK. Novel ecofriendly biocomposites: bio.ber reinforced biodegradable polyester amide composites – fabrication and properties evaluation. J Reinf Plast Comp 2002;21(1):55–70.

[6] Kandachar P, Brouwer R. Applications of bio-composites in industrial products. Mater Res Soc Symp Proc 2002;702:101–12.

[7] Anon. The competitiveness of natural .bers based composites in the automotive sector the Sisal Agribusiness in Brazil.Mater Res Soc Symp Proc 2002;702:113–39.

[8] Santulli C. Post-impact damage characterization on natural .bre reinforced composites using acoustic emission. NDT&E International 2001;34(8):531–6.

[9] Van de Velde K, Kiekens P. Thermoplastic pultrusion of natural .bre reinforced composites. Comp Struct 2001;54(2–3):355–60.

[10] Gassan J, Chate A, Bledzki AK. Calculation of elastic properties of natural .bers. J Mater Sci 2001;36(15):3715–20.

[11] Eichhorn SJ, Baillie CA, Zafeiropoulos N, Mwaikambo LY, Ansell MP, Dufresne A, et al. Current international research into cellulosic .bres and composites. J Mater Sci 2001;36(9):2107–31.

[12] Iannace S, Ali R, Nicolais L. E.ect of processing conditions on dimensions of sisal .bers in thermoplastic biodegradable composites. J Appl Polym Sci 2001;79(6):1084–91.
[13] Braun D, Braun A. Natural thermosets. Kunstst Plast Eur 2001;91(2):36–8, 83–6.
[14] Corbi_ere-Nicollier T, Laban BG, Lundquist L, Leterrier Y, Manson JAE, Jolliet O. Life cycle assessment of bio.bres replacing glass .bres as reinforcement in plastics. Resour Conserv and Recy 2001;33:267–87.
[15] Hepworth DG, Hobson RN, Bruce DM, Farrent JW. The use of unretted hemp .bre in composite manufacture. Composites: Part A 2000;31:1279–83.
[16] Zafeiropoulosa NE, Williamsb DR, Bailliea CA, Matthewsa FL. Engineering and characterization of the interface in .ax .bre/polypropylene composite materials. Part I. Development and investigation of surface treatments. Composites: Part A 2002; 33:1083–93.
[17] Mohanty AK, Misra M, Drzal LT. Surface modi.cations of natural .bers and performance of the resulting biocomposites: an overview. Comp Interfaces 2001;8(5):313–43.
[18] Mohanty AK, Drzal LT, Misra M. Engineered natural .ber reinforced polypropylene composites: in.uence of surface modi-.cations and novel powder impregnation processing. J Adhes Sci Technol 2002;16(8):999–1015.
[19] Silva JLG, Al-Qureshi HA. Mechanics of wetting systems of natural Fibres with polymeric resin. J Mat Process Technol 1999;92–93:124–8.
[20] Cichocki Jr FR, Thomason JL. Thermoelastic anisotropy of a natural .ber. Comp Sci Technol 2002;62:669–78.
[21] Wang wei, Huang Gu, Characterization and utilization of natural coconut fibers composites, journal of Materials and Design(2008).
[22] S. Harish, D. Peter Michael, A. Bensely, D. Mohan Lal, A.Rajadurai,Mechanical property evaluation of natural fiber coir composite, journal of materials characterization(2008).
[23] Nilza G. Justiz-smith, G. Junior Virgo, Vernon E. Buchanan, potential of Jamaican banana, coconut coir and bagasse fibers as composite materials, journal of material characterization(2007).
[24] Ketty Bilba , Marie-Ange Arsene, Alex Ouensanga, Study of banana and coconut fiber Botanical composition, thermal degradation and textural observations, Bioresource Technology 98 (2007) 58–68.
[25] Kathrine Conrad, Correlation between the distribution of lignin and pectin and distribution of sorbed metal ions (lead and zinc) on coir (Cocos nucifera L.), Bioresource Technology 99 (2008) 8476–8484
[26] V.A. Passipoularidis, T.P. Philippidis, A study of factors affecting life prediction of composites under spectrum loading, International Journal of Fatigue 31 (2009) 408–417
[27] Azam T. Mohd Din, B.H. Hameed, Abdul L. Ahmad, Batch adsorption of phenol onto physiochemical-activated coconut shell, Journal of Hazardous Materials 161 (2009) 1522–1529
[28] K. Murali Mohan Rao, K. Mohana Rao, Extraction and tensile properties of natural fibers: Vakka, date and bamboo Composite Structures 77 (2007) 288–295
[29] T.M. Dick , P.-Y.B. Jar , J.-J.R. Cheng, Prediction of fatigue resistance of short-fiber-reinforced polymers, International Journal of Fatigue 31 (2009) 284–291
[30] Sezgin Ersoy, Haluk Kucuk, Investigation of industrial tea-leaf-fiber waste material for its sound absorption properties, Applied Acoustics 70 (2009) 215–220
[31] F. Jacquemin, S. Freour, R. Guillen, Prediction of local hygroscopic stresses for composite structures-Analytical and numerical micromechanical approaches, Composites Science and Technology 69 (2009) 17–21
[32] Moran Wang, Qinjun Kang , Ning Pan, Thermal conductivity enhancement of carbon fiber composites, Applied Thermal Engineering 29 (2009) 418–421
[33] Sukru Yetgin, O zlem C, AVDAR, Ahmet C, avdar, The effects of the fiber contents on the mechanic properties of the adobes, Construction and Building Materials 22 (2008) 222–227
[34] M. Mizanur Rahman a,*, Mubarak A. Khan b, Surface treatment of coir (Cocos nucifera) fibers and its influence on the fibers‟ physico-mechanical properties, Composites Science and Technology 67 (2007) 2369–2376
[35] Thomas GS. Renewable Materials for Automotive applications. Daimler-ChryslerAG , Stuttgart.
[36] Zimmerman, and J.R. Parsons, 'The Design and Analysis of a Laminated Partially Degradable Composite Bone Plate for Fracture Fixation', Journal of Biomedical Material Research, 21(A3), 345-361, 1987

PATENT

[37] Bloor stephen [gb], Proffitt joanne louise [gb], Armitage paul [gb], Dawson christine elizabeth [gb]; Bone implant .US2010191346.

[38] Draenert klaus , Draenert klaus dr med dr med [de];Artificial bone and method for making it.DE3445711.
[39] Howdle steven elvyn,Shakesheff kevin Morris,whitaker martin james,Watson michael steven;a Process for the preparation of a polymer composite comprisin internally distributed deposition matter. University of Nottingham patent no. 226729.
[40] Janome sewing machine co ltd [jp], Terumo corp [jp], Matsunaga noboru [jp], Azeyanagi kazuyoshi [jp], Sogaishi ichirou [jp], Katakura takeo [jp], Ueda yoshihisa [jp], Ohsawa takaaki [jp] ;Method of making bone-implants. US5336465.
[41] Kurumada akira, Nat inst for materials science, Toshiba denko kk ,Kurumada akira, Tanaka junzo, Suetsugu yasushi ;Carbon fiber reinforced composite material molding containing calcium phosphate-based material, method of manufacturing the same, and artificial bone using the same.JP2004269333.
[42] Man technologie gmbh [de] ,Wenner ulrich dipl-ing [de], Dierl rudolf [de] ;Bone implant. EP0442256.
[43] Man technologie gmbh [de] ;Wenner ulrich dipl ing [de] ;Bone implants with fibre mesh on base body. DE4004475.
[44] Metal inst chinese acad sci [cn] ,Sui guoxin [cn], Liu xueyong [cn], Liu yuyin [cn] ;Carbon fiber inforced poly(ether-ether-ketone) composite bone fracture plate.CN1582860.
[45] Plastic dental corp [us], Bahcall james k [us], Olsen f kris [us], Fiorina mark arthur [us], Fiorina mark andrew [us], Davidson james a [us] ;Monolithic dental implant with natural load response.WO2009032790
[46] Univ groningen [nl], Leenslag jan willem [nl], Pennings albert johan [nl], Veth rene pieter hendrick [nl], Jansen henricus wilhelm bernha [nl] ;Bone implant.WO8600533.
[47] Zimmer technologies inc, Lozier antony;Spinal disk prosthesis, spinal disk prosthesis ring part, spinal disk prosthesis pulpy nucleus part, spinal disk prosthesis end plate, and method for transplanting spinal disk prosthesis.JP2004167254.

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