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Review on Natural and Carbon Fiber Filled Hybrid Composite

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Abstract: **During the past 10 years, a lot of fundamental and applied researches have been carried out in polymer matrix Nano composites. Due to the molecular size and their reinforcement, polymer Nano composites offer ample possibility to develop new material with un- usual properties. Thermo set polymers have been widely used for engineering components, adhesives and matrix for fiber reinforced composites due to their good mechanical properties compared to those of thermoplastic polymers .Carbon Fiber having strength 4127, laminate strength 1600, Density 1.58,Stength to weight 1013,Youngs Modulus 125 to 181 .Carbon fibers with diameters in the range of 6-10 µm posses' high elastic modules.**

In this paper an attempt is made to discuss behaviour of composites and hybrid composites of short sansevieria trifasciata carbon fiber in a polyester matrix under thermal, mechanical, structural, chemical and physical conditions with the considerations of the effects of fiber length, fiber content, and coupling agent.

Key words: Sansevieria trifasciata; fibers, polymers, hybrid composites

I. INTRODUCTION

Development of polymer composites with natural fibers and fillers as a sustainable alternative material for some engineering applications, particularly in aerospace applications and automobile applications are being developed. Natural fibers show superior mechanical properties such as stiffness, flexibility and modulus compared to glass fibers. The main advantages of natural fibers are of low cost, light weight, easy production and friendly to environment. Composite materials are intended to obtain desired characteristics of two or more distinct materials which are present in the coposites. The reinforcement can be synthetic (e.g. glass, carbon, boron and aramid). [2]

Composites are a blend of two or more components, one of which is made up of stiff, long fibers or particulate material called a filler/reinforcement, and the other, a binder or matrix or resin which holds the filler in place. [3]

They are two types of fibers that are used as reinforcement, natural and synthetic fibers. [5]

Carbon fibers are a new breed of high strength materials. Carbon fiber has been described as a fiber containing at least 90% carbon obtained by the controlled pyrolysis of appropriate fibers. Carbon fibers with diameters in the range of 6-10 um possess high elastic moduli and strengths and are used as a reinforcing material in epoxy and polyesters resins for manufacture of high stiffness composites.[3] Carbon fiber Tensile strength (4127),Compressive strength, stiffness, Heat Resistance, Chemical Resistance are Excellent and young's modulus is 125-181. [7]

The general class of Hybrid composite developed by combining natural fiber and synthetic fiber or natural fiber or synthetic fiber with epoxy, polyester, phenolic, poly vinyl ester, poly urethane resins, etc., [8].

II. PROPERTIES OF FIBERS

A. Source, and Classification of Lignocellulose Fibers

Lignocellulose fibers are natural fibers. Natural fibers are the most copious and renewable bio-based materials source in nature. Natural fibers are primarily based on their origins, either coming from plants, animals, or minerals fibers. All plant fibers are composed of cellulose, while animal fibers consist of proteins (hair, silk, and wool) Lignocellulose fibers have been being used as reinforcing or filling materials for the past 3000 years, in association with polymeric materials.

TABLE 1. FIBER SOURCE.

Fiber Source	Species	Origin
Piassava	Attaleafunifera	Leaf
Pineapple	Ananuscomosus	Leaf
Sisal	Agave Sicilian	Leaf

B. Fibers Chemical Compositions and Properties of Natural Fibers

The chemical composition of natural fibers greatly depends on the type and nature of fiber. The variation in chemical composition of plants. Chemical composition of some important natural fibers is illustrated in Table 2 .Natural fibers themselves regarded as the naturally occurring composites comprising mainly of helically wound cellulose micro fibrils, embedded in amorphous lignin matrix. Cellulose (a-cellulose), lignin, pectin's, hemicelluloses, and waxes are the major components of natural fibers.

TABLE 2. CHEMICAL COMPOSITIONS OF SOME IMPORTANT NATURAL FIBERS.

Natural Fibers	**α-Cellulose**	**Pentose's**	**Lignin**
Sisal	47–62	8–9	21–24
Pine apple	69.5	4.4	17.8
Wheat grass	21.4	-	–
Rice	28–48	12–16	23–28
Sugar grass	32–48	19–24	27–32

The mechanical properties of natural fibers are, relatively, much lower than those of glass fibers.. Researchers in many cases reported the comparison of mechanical and physical properties of natural fibers with E-glass.

TABLE 3. PROPERTIES OF NATURAL FIBERS

Fiber Type	Density Kg/m3	Water Absorption %	Modulus of Elasticity E(GPa)	Tensile Strength (MPa)
Sisal	800-700	56	15	268
Banana	950-750	60	23	180-430
Coconut	145-380	130-180	19-26	120-200

III. BIO COMPOSITES

Performance of the natural fiber polymer composites influenced by several factors, such as fibers micro febrile angle, defects, structure, physical properties, chemical composition, cell dimensions, mechanical properties and the interaction of a fiber with the polymer matrix. The most important matters in the development of natural fiber reinforced composites are (i) surface adhesion characteristics of the fibers, (ii) thermal stability of the fibers, and (iii) dispersion of the fibers in the case of thermoplastic composites

IV. CARBON FIBER

Carbon fibers are a new breed of high-strength materials. Carbon fiber has been described as a fiber containing at least 90% carbon obtained by the controlled pyrolysis of appropriate fibers. Carbon fibers provide such composites with improved properties such as greater strength, higher electrical and thermal conductivity and toughness.Polymeric composited with carbon fibers are used to make parts for automobiles, airplanes, parts for electromagnetic support for catalytic particles. Several methods are known in the art for producing carbon fibers.

A first method involves dehydrogenating and graphitizing organic polymer filaments by heating them in a suitable atmosphere to make continuous carbon fibers with diameters typically between 1 and 5 µm. A second method involves producing discontinuous carbon fiber segments by vaporizing a hydrocarbon and then with a carrier gas contacting the hydrocarbon vapor with a suitable metal catalyst.

This type of carbon fiber is known as "vapor grown carbon fiber" or VGCF. Typical VGCF consists of fibers a few µm in diameter with lengths ranging from a few microns to several centimeters. Carbon fibers with diameters in the range of 6-10 µm posses' high elastic modules and strengths and are used as a reinforcing material in epoxy and polyester resins for manufacture of high stiffness composites.

A. Classification of carbon fibers

Carbon fibers are classified by the tensile modulus of the fiber. Tensile modulus is a measure of how much pulling force a certain diameter fiber can exert without breaking. Carbon fibers classified as "low modulus" have a tensile modulus below 34.8 million psi (240 million kpa). Other classifications, in ascending order of tensile modulus, include "standard modulus," "intermediate modulus," "high modulus," and "Ultrahigh modulus carbon fibers have a tensile modulus of 72.5-145.0 million psi (500 million-1.0 billion kpa).
As a comparison, steel has a tensile modulus of about 29 million psi (200 million kpa) . Thus the strongest carbon fiber is about five times stronger than steel.

B. Raw Materials

The raw material used to make carbon fiber is called the precursor. About 90% of the carbon fibers produced are made from polyacrylonitrile. The remaining 10% are made from rayon or petroleum pitch.

C. The Manufacturing Process

The process for making carbon fibers is partially chemical and partly mechanical. The precursor is heated to a very high temperature with- out allowing it to come in contact with oxygen. Without oxygen, the fiber cannot burn.
Instead, the high temperature causes the atoms in the fiber to vibrate violently most of the non-carbon atoms ate expelled.
In Textile Terms and Definitions, carbon fiber has been described as a fiber containing at least 90% carbon obtained by the controlled pyrolysis of appropriate fibers. The term "graphite fiber" is used to describe fibers that have carbon in excess of 99%.The most prevalent precursors are polyacrylonitrile (PAN), cellulosic fibers (viscose rayon, cotton), petroleum or coal tar pitch and certain phenolic fibers.

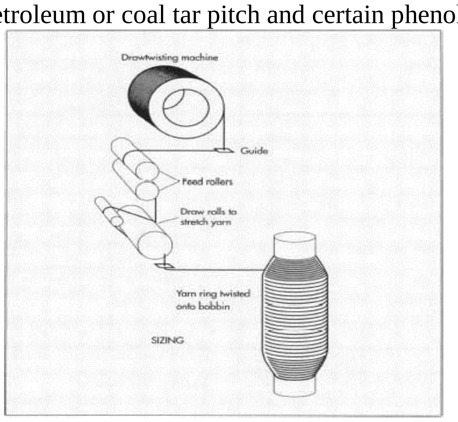

Fig 1: Manufacturing Process

This process is called carbonization and leaves a fiber composed of long, tightly the fibers are coated to protect them from damage during winding operations and Spinning, Stabilizing, Carbonizing,Treating surface, Sizing.

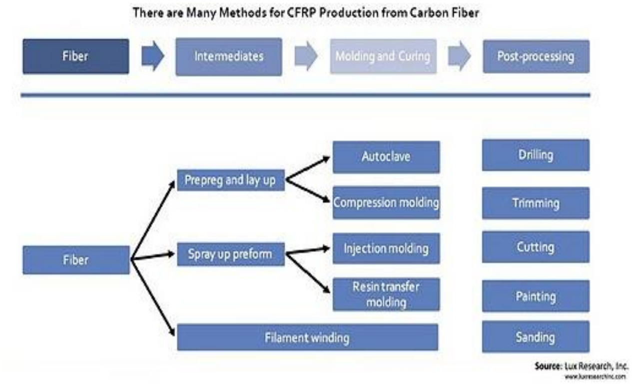

Fig 2: CFRP Manufacturing Process

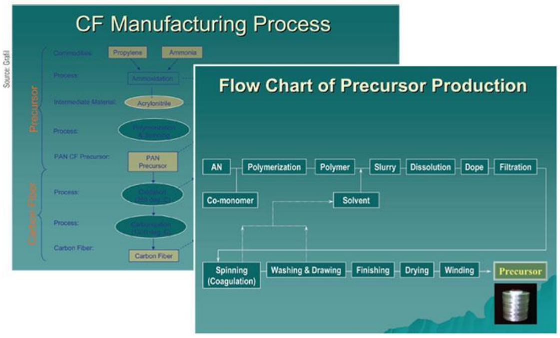

Fig 3. Flow chart of CF Procesor

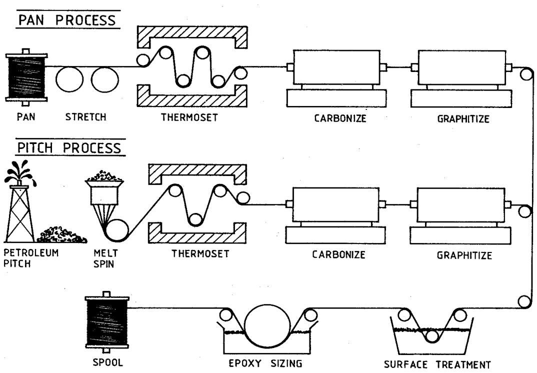

Fig 4. Schematic of PAN and pitch based carbon fiber manufacturing procedure.

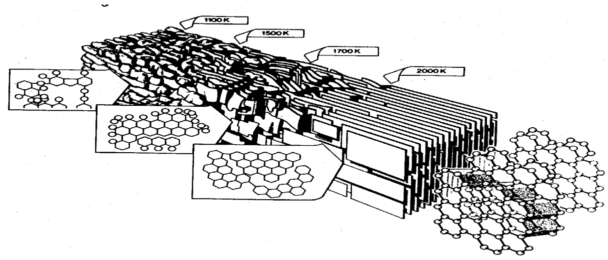

Fig5. Structural model for carbon fibers during graphitization.

D. Carbon fibers from polyacrylonitrile (pan)

There are three successive stages in the conversion of PAN precursor into high-performance carbon fibers. Oxidative stabilization: A temperature range of 200-300°C. During this process the non-carbon elements are removed as volatiles to give carbon fibers with a yield of about 50% of the mass of the original PAN. Graphitization:
Depending on the type of fiber required, the fibers are treated at temperatures between 1500-3000°C, which improves the ordering, and orientation of the crystallites in the direction of the fiber axis.

E. Carbon fibers from Rayon

The conversion of rayon fibers into carbon fibers takes place in three phase process
Stabilization: Stabilization is an oxidative process that occurs through steps. In the first step, between 25-150°C, there is physical desorption of water. The next step is a dehydration of the cellulosic unit between 150-240°C.
Finally, thermal cleavage of the cyclosidic linkage and scission of ether bonds and some C-C bonds via free radical reaction (240-400° C) and, thereafter, aromatization takes place.
Carbonization: Between 400 and 700°C, the carbonaceous residue is converted into a graphite-like layer.
Graphitization: Graphitization is carried out under strain at 700-2700°C to obtain high modulus fiber through longitudinal orientation of the planes.

F. The carbon fiber fabrication from pitch

generally consists of the following four steps:
Pitch preparation: It is an adjustment in the molecular weight, viscosity, and crystal orientation for spinning and further heating.
Spinning and drawing: In this stage, pitch is converted into filaments, with some alignment in the crystallites to achieve the directional characteristics.
Stabilization: In this step, some kind of thermosetting to maintain the filament shape during pyrolysis. The stabilization temperature is between 250 and 400 °C.
Carbonization: The carbonization temperature is between 1000-1500°C.

TABLE 4. THE COMPOSITION OF PAN FIBERS AT DIFFERENT TREATMENT STEPS.

Treatment step	Carbon (wt%)	Nitrogen (wt%)	Hydrogen (wt%)	Oxygen (wt%)
Untreated	68	26	6	-
Thermoset	65	22	5	8
Carbonize	>92	<7	<0.3	<1
Graphitize	100	-	-	-

G. Properties

The tensile strength of the precursor is higher in the tenacity of the carbon fiber. Tensile strength and modulus are significantly improved by carbonization under strain. With PAN based carbon fibers, the strength increases up to a maximum of 1300ºC and then gradually decreases.

However, similar high modulus type pitch-based fibers deform by a shear mechanism with kink bands formed at 45° to the fiber axis On bending, the fiber fails at very low strain.

H. Different material properties

TABLE 5. POTENTIAL LIGHT WEIGHT MATERIALS

Potential Lightweighting Materials

Lightweight Material	Material Replaced	Mass Reduction (%)
Magnesium	Steel, Cast Iron	60 - 75
Carbon Fiber Composites	Steel	50 - 60
Aluminum Matrix Composites	Steel , Cast Iron	40 - 60
Aluminum	Steel, Cast Iron	40 - 60
Titanium	Alloy Steel	40 - 55
Glass Fiber Composites	Steel	25 - 35
Advanced High Strength Steel	Mild Steel, Carbon Steel	15 - 25
High Strength Steel	Mild Steel	10 - 15

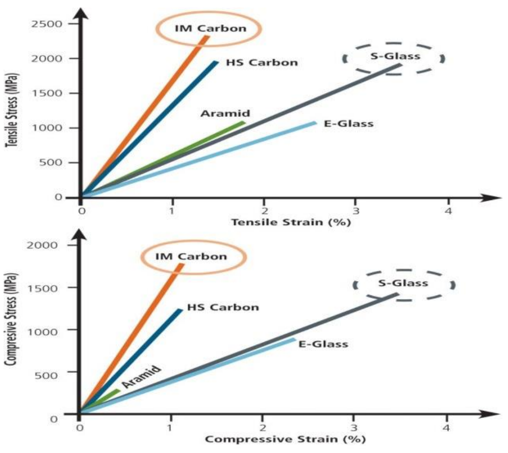

Fig 6. Tensile and Compressive Strain

TABLE 6. TENSILE STRENGTH

Material	Fibre Strength	Laminate Strength
E Glass	3450	1500
Carbon Fiber	4127	1600
Kevlar	2757	1430
Epoxy	N/A	12-40

Weight per Unit Volume or Density of Carbon fiber, Kevlar, and E Glass

TABLE 7. DENSITY AND STRENGTH TO WEIGHT RATIO

Material	Density of Laminate grams/cc	Strength-to-Weight
E Glass	2.66	564
Carbon Fiber	1.58	1013
Kevlar	1.44	993
Epoxy	1-1.15	28

TABLE 8. MODULUS OF ELASTICITY

Material	Young's Modulus
E Glass	30-40
Carbon Fiber	125-181
Kevlar	70.5-112.4
Epoxy	3

TABLE 9. COMPARISON CHART OF GLASS, ARAMID AND CARBON FIBRE

	Glass	Aramid	Carbon Fibre
Cost	Excellent	Fair	Poor
Weight to Strength Ratio	Poor	Excellent	Excellent
Tensile Strength	Excellent	Excellent	Excellent
Compressive Strength	Good	Poor	Excellent
Stiffness	Fair	Good	Excellent
Fatigue Resistance	Good-Excellent	Excellent	Good
Abrasion Resistance	Fair	Excellent	Fair
Sanding/Machining	Excellent	Poor	Excellent
Conductivity	Poor	Poor	Excellent
Heat Resistance	Excellent	Fair	Excellent
Moisture Resistance	Good	Fair	Good
Resin Adhesion	Excellent	Fair	Excellent
Chemical Resistance	Excellent	Fair	Excellent

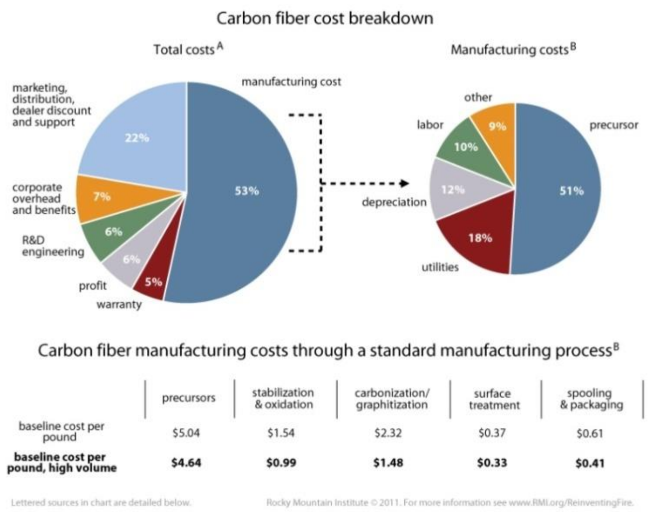

Fig 7. CF Manufacturing Cost

I. *Applications*

The two main applications of carbon fibers are in specialized technology, which includes aerospace and nuclear engineering, and in general engineering and transportation, which includes engineering components such as bearings, gears, cams, fan blades and automobile bodies. Such as rehabilitation of a bridge in building and construction industry. Others include: decoration in automotive, marine, general aviation interiors, general entertainment and musical instruments and after-market transportation products.

TABLE 10: CHARACTERISTICS AND APPLICATIONS OF CARBON FIBERS

Physical strength, specific toughness, light weight	Aerospace, road and marine transport, sporting goods
High dimensional stability, low coefficient of thermal expansion, and low abrasion	Missiles, aircraft brakes, aerospace antenna and support structure, large telescopes, optical benches, waveguides for stable high-frequency (GHz) precision measurement frames
Good vibration damping, strength, and toughness	Audio equipment, loudspeakers for Hi-fi equipment, pickup arms, robot arms
Electrical conductivity	Automobile hoods, novel tooling, casings and bases for electronic equipment's, EMI and RF shielding, brushes
Biological inertness and x-ray permeability	Medical applications in prostheses, surgery and x-ray equipment, implants, tendon/ligament repair
Fatigue resistance, self-lubrication, high damping	Textile machinery, genera engineering
Chemical inertness, high corrosion resistance	Chemical industry; nuclear field; valves, seals, and pump components in process plants
Electromagnetic properties	Large generator retaining rings, radiological equipment

V. SANSEVIERIA TRIFASCIATA

Sansevieria trifasciata, also called snake plant, mother-in-law's tongue or Saint George's sword (in Brazil) is a species of flowering plant in the family Asparagaceae, native to tropical West Africa from Nigeria east to the Congo.It is an evergreen perennial plant forming dense stands, spreading by way of its creeping rhizome, which is sometimes above ground, sometimes underground. Its stiff leaves grow vertically from a basal rosette. Mature leaves are dark green with light gray-green cross-banding and usually range between 70–90 centimetres (28–35 in) long and 5–6 centimetres (2.0–2.4 in) wide.

The specific epithet *trifasciata* means "three bundles".It is commonly called the snake plant (not to be confused with the very similarly named Nassauvia serpens), because of the shape of its leaves, or mother-in-law's tongue because of their sharpness. Sansevieria trifasciata in like a flower. Some other members of its genus, S. trifasciata yields bowstring hemp, a strong plant fibre once used to make bowstring.

It is popular as a houseplant because it is tolerant of low light levels and irregular watering; during winter it needs only one watering every couple of months .S. trifasciata is considered by some authorities as a potential weed in Australia, although widely used as an ornamental, in both the tropics outdoors in both pots and garden beds and as an indoor plant in temperate areas.

VI. HYBRID COMPOSITE

Hybrid composites are the systems where one type of reinforcing or filler material is incorporated or added in a mixture of dissimilar or different matrices (blends) or two or more reinforcing or filling materials are present in a single matrix or both approaches are combined Hybrid bio composites are usually designed and processed by the combination of a synthetic fiber and natural fiber (biofiber) in a matrix or with combination of two natural fiber/biofiber in a matrix.

The hybrid composite properties are exclusively governed by the length of individual fibers, orientation, fiber to matrix bonding, content, extent of intermingling of fibers, and arrangement of both of the fibers. Moreover, successful use of hybrid composites is determined by the mechanical, chemical, and physical stability of the fiber/matrix system. Few combinations of hybrid composites are given below in table 11.

TABLE 11. HYBRID COMPOSITES

Natural Fiber	**Polymer Matrix**
Palmyra/glass	Roof lite resin
Bamboo/glass	Vinyl ester
Jute/glass Polyester	(isothalic)
Coir/glass	Phenolic resin
Banana/kenaf	Polyester
Natural fiber/glass	Epoxy vinyl ester
Jute/biomass	Bispheno
Sisal/kapok	Unsaturated Polyester
Oil palm EFB/jute	Epoxy resin
Kenaf/glass	Epoxy resin
Cellulose/glass	Epoxy resin
Jute/cotton	phenolic
Jute/glass	Polypropylene (PP)
Kenaf/glass	Natural rubber

Cotton/waste silk	Polycarbonate (PC)
Wood flour/glass	Poly vinyl chloride

VII. CONCLUSION

The Effect of fiber length, fiber content, and coupling agent on various natural fiber and combination of carbon fibre in polymer and polyester matrix is studied. It is shown that sansevieria trifasciata and carbon fiber in a polyester matrix has good thermal, mechanical, structural, chemical and physical properties and Carbon Fiber has excellent strength, Stiffness, Resistance than the other fibers.

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