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NATURAL FIBER REINFORCED POLYMER COMPOSITES FOR AUTOMOTIVE INDUSTRY-A EXPATIATE REVIEW

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ABSTRACT

The term ‘composite’ in material science refers to a material made up of a matrix containing reinforcing agents. Reinforcement is the part of the composite that provides strength, stiffness, and the ability to carry a load. In the recent years, considerable investigations have been made in natural fibers such as kenaf, jute, flax, siasl bamboo, coir and okra as a reinforcement in polymer matrix. Natural fibers are not only strong and light weight but also relatively very cheap and these fibers improve the environment sustainability of the parts being constructed. The natural fibers do not cause allergic reactions or skin irritation and gives better insulation and it can be easily degradable. Manufacturing companies are in constant search of new materials to lower costs and profit margins. Natural fibers are low-cost fibers with high specific properties and low density. Performance characteristics that predestine polymer use in automotive applications include corrosion resistance, low density, good impact toughness and chemical resistance. This review is carried out to evaluate the development and properties of natural fibre reinforced biodegradable polymer composites. They are the materials that have the capability to fully degrade and compatible with the environment.

KEY WORDS: Banana, Kenaf, PALF, Sugarcane, Sodium hydroxide

INTRODUCTION

Increased environmental, social and economic awareness, high rate of oil resources depletion and consciousness throughout the world has developed an increasing interest in natural fibres and its applications in various fields. The utilisation of natural fibre as reinforcement in polymer composites, both thermoplastic and thermoset matrices such as polyesters, epoxies and elastomers are attracting much attention in replacing the synthetic fibre for engineering application. Natural fibres are now considered as serious alternative to synthetic fibres for use in various fields due to their advantages such as low density, low cost, acceptable specific strength, biodegradability and renewability. Various types of natural fibers have been investigated for use in composites including jute, bamboo, flax, sisal, coconut and coil. The properties of natural fibres can vary

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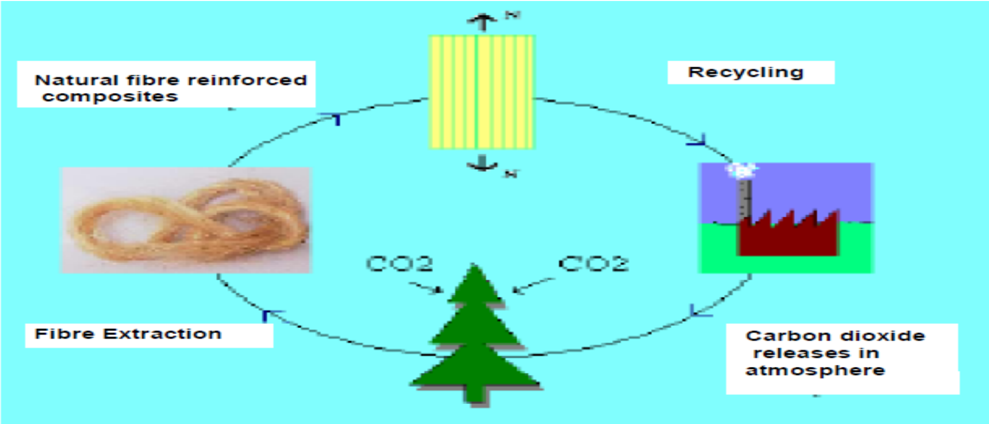
depending on the source, age and separating techniques of the fibres. The bast fibre has high potential as a reinforcing fibre in polymer composites. The development of natural fibre reinforced biodegradable polymer composites promotes the use of environmentally friendly materials. The use of green materials provides alternative way to solve the problems associated with agriculture residues. The development of betel nut fiber reinforced composite material as a replacement for synthetic plastic provides three key advantages:

1. Utilization of an abundant supply of betel nut fiber, thereby providing economic benefit to poor rural people.
2. Reducing the existing dependency on non-renewable resources
3. Reducing plastic waste and associated harmful substances from the process of plastic incinerations.

NATURAL FIBER COMPOSITES (NFC)

Natural fiber composites can be a combination of either natural fibers/synthetic resin or natural fibers/bio-resin. Bioresin means bio-degradable resin. Both synthetic and bio-resin can be either in the form of thermoset or thermoplastic type of resin. Natural fibers/thermoplastic composites have been used in automotive applications. However, most composites for infrastructure are made out of thermoset resins. NFC has been used also in biomedical applications for bone and tissues repair and reconstruction. Several studies have been done in an attempt to investigate the properties of natural fiber composites.



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ADVANTAGES OF NATURAL FIBRE

Natural fibre has both ecological and economic advantages.

- Environmentally friendly
- Fully biodegradable
- Non toxic
- Easy to handle
- Non-abrasive during processing and use
- Low density/light weight
- Compostable
- Source of income for rural/agricultural community
- Good insulation against heat and noise
- Renewable, abundant and continuous supply of raw materials
- Low cost
- Enhanced energy recovery
- Free from health hazard (cause no skin irritations)
- Acceptable specific strength properties
- High toughness
- Good thermal properties
- Reduced tool wear
- Reduced dermal and respiratory irritation
- Ease of separation

DISADVANTAGES OF USING NATURAL FIBER AND THE REMEDY

Although natural fibers are obtained from renewable sources and the polymer composites based on them are environmentally friendly as compared to the SFRPCs, there are also some disadvantages, which are related to the utilization of unmodified/raw fibers in the preparation of the composites. These disadvantages are as quality variations, high moisture uptake and low thermal stability of the raw fibers. High moisture uptake is the major drawback of the natural fibers. This phenomenon weakens the interfacial bonding between the polymer matrix and fiber and causes deterioration of the mechanical properties. The high moisture sensitivity of some fiber such as lingo-cellulosic fiber causes even the dimensional instability and limits the use of natural fiber as reinforcement in composite materials. Unfortunately, in addition to advantages we have several disadvantages of natural fibers:

- Large scatter of all the parameters.
- Properties depend on growing and processing conditions;
- Degradation of properties (moisture, heat, flame).
- Fibers are short; that means lower performance of their composites.

- Structure is highly inhomogeneous
- Low thermal stability
- Stress – strain response is nonlinear.
- Hygroscopicity.
- The fibres degrade after being stored for a long period
- The relatively high moisture absorption

In order to overcome this problem and ultimately to improve the fiber-matrix adhesion, in many cases, a pre-treatment of the fiber surface or the incorporation of surface modifier is required during the composite preparation. Many investigations have been reported in the literature on the influence of various type of chemical treatment on the physical and mechanical properties of NFRPCs. The adhesion between the natural fiber and the polymer matrix can be increased by modifying the fiber surface. Chemical treatment by removing organic residue from the surface of the fiber can also enhance the adhesion because the surface of natural fiber is coarse in structure and thus, enable an interlocking mechanism with the matrix. In this study, chemical retting was used. The procedure for chemical treatment involves NaOH solution, water washing, and drying. The concentration of sodium hydroxide and soaking time were the key factor affecting the treatment. There are five chemical treatments compositions/concentrations (NaOH and soaking time) The fibers were washed thoroughly under the warm tap water for seven times after soaked in NaOH and then dried in room temperature for 12/24 hours.

Treatment	NaOH (%)	Soaking time (Hr)
1	3	12
2	3	24
3	6	12
4	6	24
5	9	12

PROPERTIES OF NATURAL FIBER COMPOSITES

Many factors influence mechanical properties of natural fibers. In many cases, the experimental conditions are different. The mechanical properties of the natural fiber material depend largely on lengths and diameters of individual fibers. Table 1 shows the type and properties of the common natural fibers. It is shown in the table that flax and jute have the highest tensile strength.

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Table 1: Properties of some natural fibres

Types of fibres	Fibres	Density (g/cm^3)	Elongation (%)	Tensile strength (MPa)	Young modulus (GPa)
Stem fibres	Bamboo	0.6-0.91	1.4	193-600	20.6-46.0
	Flax	1.5	1.2-3.2	345-2000	15-80
	Hemp	1.48	1.6	550-900	26-80
	Jute	1.3	1.16-1.5	393-800	13-55
	Kenaf	1.45	1.6	157-930	22.1-60
	Ramie	1.5	1.2-3.8	400-938	61.4-128
Leaf fibres	Banana	0.72-0.88	2.0-3.34	161.8-789.3	7.6-9.4
	Pineapple	1.07	2.2	126.6	4.4
	Sisal	1.5	3.0-7.0	468-700	9.4-22
Fruit fibres	Coir	1.2	17-47	175	4.0-6.0
	Oil palm	0.7-1.55	4-18	50-400	0.57-9.0
Wood fibres	Softwood Kraft (spruce)	1.5	-	1000	18-40
	Hardwood Kraft (birch)	1.2	-	-	37.9
Synthetic fibres	E-glass	2.5	2.5	2000-3500	70
	S-glass	2.5	2.8	4570	86
	Aramide	1.4	3.3-3.7	3000-3150	63.0-67.0

NATURAL FIBRE COMPOSITES FOR THE AUTOMOTIVE INDUSTRY

Natural fiber composites are being used for manufacturing many components in the automotive sector. Typical market specification natural fiber composites include elongation and ultimate breaking force, flexural properties, impact strength, acoustic absorption, suitability for processing and crash behaviour. Plant fibers are mainly used in the part of car interior and truck cabins. The use of plant fiber based automotive parts such as various panels, shelves, trim parts and brake

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shoes are attractive for automotive industries worldwide because of its reduction in weight about 10%, energy production of 80% and cost reduction of 5%.

BANANA FIBRES

Banana (Musa) is a high herbaceous plant normally of 2–16 m high although banana leaves can be used as fibres in polymer composites, majority of work on banana fibres focused on the use of banana pseudo-stem (trunk) fibres as the reinforcement or filler in polymer composites. Pseudo-stem fibre is a bast fibre and it can be extracted after the fruit bunch was harvested by scrapping with a blunt knife or by using an extractor machine. Banana stem fibres are extracted by initially cutting into lengths of convenient size, and peeling layer-wise The individual sheaths were dried under sun for 2 weeks and then they were soaked in water for two more weeks. Once the lignin and cellulose were separated, the sheaths were dried again and the fibres were ripped off. Banana fibres are used to make high quality textile for generations and in Japan it was used to make famous Japanese dress called kimono. It was also reported that banana fibres were used as reinforcing fibres in polymer composites and in paper making.


Banana trees


Banana leaf


Banana Pseudo stem


Preparing of banana Pseudo stem fibres


Drying of banana stem under the sun

COCONUT FIBRES

Coconut (Cocos nucifera) is the plant of a species of palm. It is a tropical plant of the Areceae (Palmae) family. Coconut fibres are mainly taken from coirs and to a lesser extent, coconut shell and spathe is used normally in the form of fillers. Coconut spathe, the covering of the coconut inflorescence, is an under-exploited material with considerable potential. This part of coconut tree

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is left out because demonstrates no good mechanical properties. Spathe is used as decorative as sold in gift shops in Kota Kinabalu, Sabah, Malaysia. Substantial research has been carried out on coconut coir fibre and coconut shell filler and their composites. Coir is the seed-hair fibrous material found between the hard, internal shell and the outer coat (endocarp) or husk of a coconut. Coir fibre is a coarse, stiff and reddish brown fibre and is made up of smaller threads, consists of lignin, a woody plant substance, and cellulose. Coir has been used for making twine, mats and brooms. It was also used in hydroponic growing.

A coconut plant

Young coconut fruits

Matured coconut fruit

Coir fibres

Coconut shells

coconut spathe

KENAF FIBRES

Kenaf (Hibiscus cannabinus L.) was a native of West Africa and had been cultivated from around 4000 B.C. It is a member of the Hibiscus gene and a family of Malvacea which is similar to cotton and okra. Kenaf is a warm season plant, which requires a short period of sunlight. It has been grown for several 1,000 years for fibre and food. It is a common wild plant of tropical and subtropical Africa and Asia. It is a high carbon dioxide absorbent plant. Kenaf is a fast growing tree and could be harvested in just 4–5 months. It has very short life cycle and cultivation of kenaf produced high biomass output. Kenaf stalk is made up of a soft inner core and a fibrous outer bast

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surrounding the core. The kenaf bast fibre has the potential as a reinforcing fibre in thermoplastic composites because of its superior toughness and high aspect ratio in comparison with other fibres.


Kenaf Plant


Kenaf stem


Long Kenaf Fiber

SUGARCANE FIBRES

Sugarcane (Saccharum Officinarum) is one of the major crops in Tropical region. Sugarcane stalk, from which bagasse fibres are derived, consists of an outer rind and an inner pith. Bagasse fibres are obtained after the extraction of the sugar-bearing juice from sugarcane. Extracting sugar cane fibres from the plant stalks was considered to be a difficult and costly task. Bagasse or sugar cane pulp fibres (sometimes called sugarcane bagasse) should be alkalinised, dried and milled before they can be used as high quality fibres. Utilization of sugarcane bagasse may contribute to environmental and economic development. Effort has been made to commercialize sugar cane fibres as useful products. Bagasse has been used as a combustible. Material for energy supply in sugar cane factories as in thermal power station in Guadeloupe (the French West Indies). Bagasse was also reported to be used in pulp and paper industries and for board materials. Bagasse ash form bagasse fibres can be used as secondary filler in silica or carbon black filled natural rubber compound.


Sugarcane stalk


Sugarcane decortication machine


Drying bagasse fibres

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PINEAPPLE LEAF FIBRES (PALF)

The scientific name of pineapple plant is Ananas comosus L. Pineapple is a longleaf desert plant that can be grown in dry condition belonging to the Bromelicea family. The plant is normally grown in nurseries for the first year or so and matures about 12–20 months old. The width of each leaf is about 50–75 mm. The fibres are contained in the spiky leaf of plant. Pineapple is a fibrous plant and it was reported that its fibres was as reinforcement or filler in composites. The majority of the research work carried out on pineapple leaf fibre (PALF) composites has been done in India and some South East Asian countries like Malaysia and Thailand. This could be due to the fact that the raw materials can be obtained there very cheaply, and so there is a great potential to commercialize this product and to enhance the quality of life of the people living in rural areas. Conventional methods for PALF extraction include scraping, retting and decorticating with a decorticator start from long fresh leaf and use mechanical force to remove soft covering material to provide long fibres.

Figure: Pineapple

Figure: PALF Extraction

Figure: White and silky PALF

CONCLUSION

Finally in this review conclude from the previous researches. Natural fiber composites as the name implies is made of natural resources thus possesses environmentally beneficial properties such as biodegradability. The natural fiber is one of the best composite materials by developed new engineering materials. Natural fibers result in lighter composite materials as compared to SFRPCs with equivalent mechanical strength. Natural fibers are biodegradable and their productions are associated with lower emission than that in the production of synthetic fiber. Also high natural fiber contents in composites at the expense of polymer itself results in the economy of energy in wide aspect, since the production of polymer is more energy consuming than that of the natural fiber.

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