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A review on natural areca fibre reinforced polymer composite materials

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Abstract

Natural fibres, nowadays; have become the matter of discussion in the research field amongst various scientists to inculcate it in the formation of composites instead of production of composites using synthetic fibres like glass, carbon and aramid. This is due to various advantages associated with natural fibres like eco-friendly, low cost, availability in abundance and its bio-degradability. Lots of work has been carried out in the production of natural fibre reinforced polymer composites, using natural fibres like jute, hemp, cotton, sisal, kenaf, bagasse, areca, abaca, bamboo etc. and their properties have been studied. Here is an attempt made on the literature survey of areca fibre reinforced polymer composites where different properties of areca fibres, its maturity level, surface treatment effect on properties of fibres, composite formation with different matrices, its mechanical properties, thermal and acoustic properties related to different composites has been highlighted.

Keywords: natural fibres; natural fibre composites; betel nut/areca nut fibres and composites; chemical treatment; mechanical properties.

1. Introduction

Basically, composite is defined as the material consisting of binder which is a continuous phase and the fibrous filler as reinforcement which is the discontinuous phase. Matrix present in the polymer composites supports the reinforcement and helps to stay it in proper position and orientation. Ductility is more and hardness is less for the polymeric resin and this resin is responsible for the toughness of composites. Reinforcement is harder than matrix and it is embedded into matrix. Reinforcement is the load carrying material and it strengthens the composites by imparting its properties into the matrix.

Composites can be classified based on matrix and based on the reinforcement. Based on matrix, there are three types; metal matrix composites, ceramic matrix composites and polymer matrix composites. It is very simple to manufacture the polymer matrix composites than metal matrix and ceramic matrix composites because polymer processing does not require high temperature and pressure and the types of equipment needed for composite fabrications are simple. Polymer matrix composites are further classified into thermoplastic, thermoplastic elastomeric and thermoset polymer composites. Based on the shape of reinforcement, the composite classification can be made as particulate composites, fibrous composites and laminate composites. Fibrous composites are subdivided into short fibre (discontinuous) reinforced and long fibre (continuous) reinforced polymer composites. Based on the occurrence of fibres, again fibrous composites can be classified into natural fibre reinforced composites and synthetic fibre reinforced composites.

Over past several years, lots of work has been done in the field of development of natural fibre reinforced polymer composites; where the focus is more on cellulose based fibres which is naturally available, is incorporated into the polymer matrix to form bio-composites [1]. These cellulose fibres have properties like high strength, specific stiffness, availability, light weight, non-hazardousness, renewability, non-

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abrasiveness, which reduces wear in processing equipment, and biodegradability [2-5]. Whereas the synthetic fibres such as Kevlar, carbon, glass, etc. even though have got very high strength and stiffness [6], but the problems associated with them like biodegradability, recyclability, initial processing cost, health hazards made to find an alternative source for the production of composites. Hence these composites with high strength could be extensively used in marine applications, constructive industry, transport and automotive industry, etc. [7-9]. The comparative properties of the natural fibres with conventional man-made fibres are presented in Table 1.

Natural fibre is characterized by its fineness, adaptability and good aspect ratio [10]. Agro-waste fibres can be referred to as lignocellulosic and they possess appropriate superior properties suitable to be used as fibre reinforcement in polymer composites [11]. As a result of this many such fibres like sisal [12], jute [13], abaca [14], soybean [15], oil palm [16], hemp [17], flax [18], bamboo [19], henequen [20] etc. are been used as reinforcement in designing polymer composites which have been well recognized. Lots of research work has been carried out, till the date, where different naturally occurring fibres were considered for the manufacture of polymer composites. An attempt has been made to brief up an idea about the same.

1.1. Survey on natural fibre composites

Mwaikambo et al. (1999) [21] studied the effect of chemical treatment on the properties of hemp, sisal, jute and kapok fibres for composite reinforcement. It showed that mercerization would change the surface topography and their crystallographic structure. The interfacial bonding between the matrix and the fibre would be more effective due to chemical treatment which brings better mechanical properties to the composites prepared.

Han-Seung Yang et al. (2004) [22] revealed the morphological study and mechanical properties related to rice husk flour filled polypropylene composites. The tensile strength was conducted according to the ASTM D638-99 standard. The tensile strength decreased with increasing fibre loading; however, the tensile modulus showed improvement with increasing trend. The composites showed maximum properties at 40% fibre loading.

Herrera-Franco et al. (2005) [23] investigated the composite formed by the coupling of short henequen fibres and polyethylene matrix. The fibres were subjected to alkali and silane treatment. The tensile strength and the flexural strength were found out according to the ASTM standards D638 and D790 respectively. It was reported that the silane treatment changed the adhesion between the fibre and the matrix. The mechanical properties increased for treated fibre composites compared to untreated fibre composites and the maximum effect was seen on the fibre matrix interface shear strength.

Fibres were in three ways to form the composite; particle size, short fibre (3 mm size) and long fibre (6 mm size). The composite was prepared using the compression moulding machine (SANTECH INDIA Ltd).

It was observed that the mechanical properties of urea-formaldehyde resin were much lower as compared to the fibre reinforced composite.

Table 1. Comparative properties of natural fibres with conventional manmade fibres [6].

Name of the fibres	Density (g/cm^3)	Tensile Strength (MPa)	Young's modulus (GPa)	Specific Strength ($GPa/g/cm^3$)	Specific modulus ($GPa/g/cm^3$)	Elongation at break (%)
Jute	1.3-1.4	393-773	13-26.5	0.3-0.5	10-18.3	1.16-1.5
Flax	1.50	345-1100	27.6	0.2-0.7	18.4	2.7-3.2
Hemp	1.14	690	30-60	0.6	26.3-52.6	1.6
Sisal	1.45	468-640	9.4-22.0	0.3-0.4	6.4-15.2	3-7
PAlF	1.52	413-1627	34.5-82.51	0.3-1.1	22.7-54.3	1.6
Cotton	1.5-1.6	287-800	5.5-12.6	0.2-0.5	3.7-7.8	7.0-8.0
E-glass	2.5	2000-3500	70	0.8-1.4	28	2.5
S-glass	2.5	4570	86	1.8	34.4	2.8
Aramid	1.4	3000-3150	63-67	2.1-2.2	45-47.8	3.3-3.7