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Review

Mechanical properties of kenaf fibre reinforced polymer composite: A review

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HIGHLIGHTS

- Kenaf fibres regarded as potential materials for polymer composite based industries.
- Mechanical properties of kenaf fibre composite comparable to glass fibre composite.
- Kenaf composites nowadays used as construction materials for different buildings.

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ABSTRACT

Kenaf regarded as an industrial crop in Malaysia and also grown commercially in other part of world for different applications. It is certainly one of the important plants cultivated for natural fibres globally, next to cotton, which is endemic to ancient Africa. It has great potential to use as automotive and construction materials due its long fibres derived from outer fibrous bark, the bast. Natural fibres such as kenaf getting attention of researchers and industries to utilize it in different polymer composites based products due to environmental awareness of consumers and government regulation in some countries. In many research studies, kenaf fibres are reinforced with polymer matrix to form fibre reinforced polymeric composites which perfectly improve the features of the polymers. Mechanical properties of kenaf fibres is comparable to existing materials and it will play an important role to utilize as the material of choice for a varied range of structural and non-structural industrial products with polymer matrix. The innumerable properties of kenaf fibres in original and reprocessed plastics are demonstrated by many recent studies and research efforts make it suitable construction materials (such as boards of different densities, breadths, along with fire and insect resistance). In this review work, we try to explore and highlights the previous work involving mechanical properties of kenaf fibre reinforced polymer composites to provide a perfect source of literature for doing further research in this topic to explore it as construction and building materials.

Contents

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1. Introduction

FRP usually referred to as fibre reinforced polymer composite is a quite new material in the various applications such as construction and building industry compared to concrete and steel [1]. Composites possess the desired and preferred properties by coalescing dissimilar constituents in a cautious and judicious way. Generally they possess higher specific modulus and high specific strength enabling them as a valuable material in huge number of industrialized requests which requires such features [2]. Carbon fibres and glass fibres integrated in polyester resin are the traditional and conventional fibre reinforced composite materials. These composite materials have excellent mechanical properties but these materials cause environmental pollution due to the non-degradability of fibres [3]. Natural fibre reinforced composites found to be an alternative solution to the ever depleting petroleum sources thus they receive greater attention, attraction from research scientist and community. Manufacturer and scientists attracted towards natural fibre based composites due to its biodegradability, light in weight, nontoxic and relatively stronger and consider being virtuous products which can be use in construction industry, automotive industry and for furniture production [4].

Natural fibre composites have better formability, abundant, renewable, cost effective, possess tool wearing rates, thermal insulation properties, acoustic properties, sufficient energy requirements and safer towards health [5]. Many innumerable demerits such as hydrophilic in nature, poor fibre/matrix interfacial adhesion and poor thermal stability of natural fibres can be overcome by chemical treatment or compatibilizer which amended the adhesion between the fibre and matrix. Composite of polymers and kenaf fibre possess the variances and incomparability in terms of their polarity structures [6]. Based on the origin natural fibres are categorized as animal based and plant based. Animal-based fibres are wool, silk, etc. and natural fibres based on plant includes sisal, coir, ramie, jute, bamboo, pineapple and many more [2]. Lignocellulosic fibres possess many compensations of being financially reasonable to manufacture such as lightweight, eco-friendly, harmless to health, high stiffness and specific strength which provides a probable substitute to the synthetic or artificial fibre [7,8]. The reinforcing capability of the fibres mainly influenced by various aspects such as polarity of the fibre, mechanical strength of the fibres, surface appearances, and existence of reactive centres [9]. Moreover many of the natural fibres properties are governed by several factors such as climate, harvest, maturity, variety, decortications, retting degree, disintegration (steam explosion treatment, mechanical), fibre modification, technical and also textile processes (spinning and carding) [9]. In spite of these promising features shown by natural fibres certain major drawbacks are also underlined like water absorption, strength degradation, lack in thermal stability lowered impact properties [10,11] but it has been found that these can be improved and overcome by hybridization with either natural or synthetic fibre. Bast fibres derived from natural fibres such as hemp, flax, kenaf and jute have high specific strength, low density and are extremely concerned in several industrial applications [12]. Kenaf fibres are gratifying increasingly widespread throughout the world and even in Malaysia as the significant natural materials source contributing towards the development of eco-friendly assets for the automotive, sports industries, food packaging and furniture [13], textiles, paper pulp, and fibreboards based industries [14]. Inferior thermal resistance are displayed by kenaf as compared to artificial or synthetic fibres such as (aramid, glass fibres) like all other natural fibres [1].

Kenaf is in an advantageous position when compared with other lignocellulosic fibre crops since it has a short plantation cycle, flexibility to environmental conditions and requires relatively lowered quantity of pesticides and herbicides [15]. Kenaf fibres receive much attention owing to its prospective probability as polymer reinforcements in the natural fibre composite industry. Researchers claimed that mechanical strength and thermal properties of kenaf composite are superior to other type of natural fibre polymer composites, thus regarded as a suitable applicant for high-performance natural fibre polymer composites [14]. The kenaf fibre as reinforcement materials are full-fledged noticeably from the past decade along with other products such as extruded plastic fencing, decking, and furniture padding [3]. Kenaf composites can eventually, supplement and substitute petroleum based composite materials in many of the known industrial applications, and thus proposing innovative environmental, agricultural, manufacturing and consumer profits formulation methods [16,17].

2. Kenaf fibre

Kenaf is comparatively commercially available and economically cheap amongst other natural fibre reinforcing material. Customarily kenaf denoted as industrial kenaf due to of its great interest for the production of industrial raw materials. Kenaf fibre belongs to species of *Hibiscus cannabinus* where genus is *Hibiscus* and family *Malvaceae* obtained from stems of plants [18] which also includes cotton (*Gossypium* spp.) and okra (*Abelmoschus esculentus* L. Moench). Kenaf is wild dicotyledons plant of subtropical and tropical parts of Africa and Asia. The word kenaf is of Persian origin explaining the plant having short day, warm season and annually herbaceous plant, with the average diameter of fibre is 67.6 μm [19]. Kenaf is a hardy, strong and tough plant with a fibrous stalk, resistant to insect damage and requires relatively fewer amount of or no pesticides [20]. Fig. 1 showing the kenaf plantation and fibre. Kenaf is compliant to several types of soils and to grow effectively, need only nominal chemical treatment, characteristically some fertilizer and a single herbicide treatment [20]. The three types of fibre: bast, core, and pith constitutes the kenaf plant [21]. However, kenaf is characterized by two distinct fibres bast and core comprising 35% and 65% respectively [22]. The bark and core fibre, considered as two distinct types of raw material that can be distinguished by their chemical composition anatomical appearances [21]. The pith comprises entirely of parenchymatous cells, which are polygonal in shape not typically prismatic [23]. According to researchers, the kenaf bast fibres possess striking mechanical properties that make them as a replacements to glass fibres in polymer composites as reinforcing elements [23,24]. Fibre length, fibre content, and fibre orientation of kenaf fibre affects physical and mechanical properties of kenaf fibre reinforced soy based biocomposites [25]. Transmission electron microscopy is better tool to investigate cell wall ultrastructure and morphology of kenaf fibres [22]. Figs. 2 and 3 illustrate transverse sections of kenaf cell wall fibres composed of intercellular layers (primary and secondary wall-S_1, S_2, S_3) and its core fibres