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Fabrication and Mechanical Characterization of Walnut/Polyester Composites

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ABSTRACT:

Use of natural fibres as reinforcement in polymeric composites has been increased during last few decades. They are potential alternatives to synthetic fibres due to their excellent properties like light in weight, biodegradable, abundant, satisfactory strength etc. Various parts of automobiles are being made by natural fibres that improved fuel efficiency and reduced emissions. The present study focuses on developing new polymer composites by reinforcing walnut shell particulate on the basis of different weight fractions. Mechanical characterization was done for the developed composites which include evaluation of tensile strength, impact strength and hardness. Different weight fractions of walnut shell particulate were used including 0%, 10%, 15% and 20%. Maximum tensile strength was achieved in case of 10% walnut shell reinforced composites. Maximum impact strength and hardness were achieved in case of 20% and 15% reinforcement respectively.

KEYWORDS:

Fibre reinforced polymers; Natural fibre; Mechanical characterization; Fabrication

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1. Introduction

Growing attention is nowadays being paid to natural fibre due to its availability, low cost, low weight. The biggest advantage of using bio-resources is that, they are multifunctional, have flexibility in characteristics, biodegradability [13]. Research on natural resources based materials is increasing in contemporary times for developing advanced materials [2]. Fossil - based resources are finite, and are more strategically located than major petroleum and natural gas reserves. About 98% of all chemicals are derived from petroleum and natural gas [11]. Studies have shown that by 2050, the share bio-resources from plant for chemical and material needs will increase to 50% whereas worldwide utilization of oil will increase by 57% over the next 15 years [15]. The composites are likely to maintain their dominance [9]. A fibre reinforced polymer (FRP) is a composite material consisting of either a polymer matrix of high-strength fibres, such as glass, aramid, carbon or natural fibre [7].

The characteristics of the natural fibre reinforced composites are influenced by fibre content, quantity of filler and its orientation (Ku et al 2007). High fibre content is essential to achieve high performance of the composites as the existence of fibre or other reinforcement in the polymer matrix raises the strength of composite and modulus [4] [8] [17]. Research has shown that 40-mesh hardwood fibres reinforced HDPE composites [1] showed gradual increase in tensile strength. It was maximum at 25% of fibre content by volume. The tensile strengths of 20-mesh hardwood fibres reinforced HDPE composites reduced with increased fibre content. In another research, the increase in fibre content improved the tensile properties initially, it pointed at 20% by volume [17]. It has also been reported that with particle reinforcement, compressive strength improves more than short and long fibre reinforcement [3]. Joseph et al [12] illustrated sisal fibres as reinforcements in polymer composites, could play an important role by its implication in the automotive and transportation industry.

Faqua and Ulven [5] reported that fibre content of treated (alkali and bleached) and untreated flax fibre in PP composites caused inferior loading with compaction resulting in good tensile strength. In another research, the author found that both saline-treated fibre reinforced composite and alkali treated reinforced composite exhibits greater mechanical properties in comparison with untreated fibre reinforced composite [14] [16]. In PLA/Kenaf fibre composites an appropriate reactive coupling agent was obtained by grafting maleic anhydride [6].

In general, the mechanical properties of natural fibre reinforced composites were enhanced by using surface modified fibres. The objective of this research work is to develop a new class of natural fibre polymer composites to explore the potential of walnut shell and to study the effect of fibre content on the mechanical behaviour of neat polymer.

2. Materials and methods

The composite materials were fabricated by using the hand lay-up technique. Based on the formulations, weighed amount of neat unsaturated polyester, catalyst (1.0-1.5 parts per hundred of resin i.e. per hr) and accelerator (0.3-1.0/hr) were mixed together to prepare the matrix. The composites have been fabricated by varying walnut fibre content including 10%, 15% and 20% by weight. The results were compared with neat polyester i.e. 0% walnut shell. Composites are formed with the help of a wooden mould of length of 140mm, breadth of 60mm and thickness of 5mm. Then a mixture of polyester with different weight content of walnut shell powder is made along with the necessary methyl ethyl ketone peroxide hardener and cobalt naphthenate catalyst is added as shown in Fig. 1. The mixture of walnut shell powder and polyester is poured slowly on the mould and then, the matrix is allowed to solidify by putting some weight over it for a period of 24 hours. Silicon oil is also applied on the mould so that, the matrix material does not stick to the mould. Fig. 2 shows a photograph of the developed natural fiber reinforced composites.

Fig. 1: (a) Unsaturated polyester resin (b) Catalyst MEKP (c) Accelerator cobalt naphthenate (d) Crushed walnut shell

Fig. 2: Developed composites

The tensile test specimens were cut according to ASTM D638. The testing was done in standard laboratory atmosphere of 23±2°C and 50±5% relative humidity. Tensile tests were carried out on Universal Testing Machine with a cross head speed of 2mm/min. The precise three tested results were chosen for each developed walnut/polyester composites. Izod test was performed for evaluating impact strength of developed composites. Specimens were prepared according to ASTM D256 standard. Total of three testing results were selected for each developed walnut/polyester composites. During testing hammer velocity was taken as 3.5m/s. Hardness measurement was done according to ASTM D2583 standard. Barcol impresser hardness tester was used for the measurement. Density for developed composites was calculated by water immersion method.

3. Results and discussions

Tensile testing results are shown in Fig. 3. The tensile strength of the composite increases up to 15.6MPa in case of 10% fibre content, from 14.6 MPa in case of neat polyester. Further increase in walnut shell in the composite, the value of tensile strength decreased from 15.6MP to 8.1MPa in 15% composite and further increase in fibre content in composite leads to decrease in tensile strength. Here, maximum tensile strength is observed in composites with 10% walnut shell particulate. The increase of fibre-to-fibre interaction and dispersion of reinforcement in matrix has contributed to this phenomenon. After this 10% of walnut reinforcement, reduction in properties may be attributed to poor adhesion at the interface.

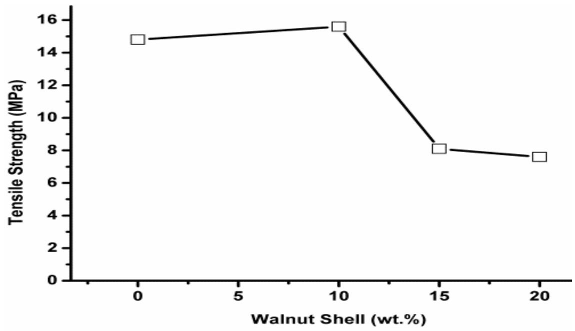

Fig. 3: Tensile strength of developed composites

Table 1 gives the hardness behaviour and measured density of different walnut/polyester composites. As the fibre content in polyester increases in terms of weight %, the hardness increases slowly from 18 in 0% fibre, to 23 in 10% fibre. Then increased slowly up to 24 in 15% fibre and then decreases to 13 in 20% fibre. Considerable increase in the hardness of the composite was observed when the fibre content of the composite was increased. The maximum hardness was found in 15% fibre content specimen. As walnut reinforcement increase from 0% to 20% the density increases. The maximum density of 1.333 g/cm^3 was found in 20% fibre content.

Table 1: Hardness and density of developed composites

Composite type	0% walnut shell	10% walnut shell	15% walnut shell	20% walnut shell
Density (g/cm^3)	1.215	1.283	1.315	1.333
Hardness	18	23	24	13

Impact strength for developed composites is shown in Fig. 4. The impact strength has increased from 2 kJ/m^2 in 0% fibre to 3 kJ/m^2 in 10%, 3.2 kJ/m^2 in 15% fibre content composite and 3.4 kJ/m^2 in 20% fibre content. The composite can withstand quick impact load but when stress is applied slowly, the fibre tends to break out from the matrix thereby leaving weak points or stress concentrated area. Further increase in fibre content improves the impact strength to 3.4 kJ/m^2. The maximum impact strength was found in 20% fibre content specimen. Gradual improvement in impact strength has shown that walnut shell reinforced unsaturated polyester can withstand impact forces to a great extent and can share the load applied in matrix effectively.

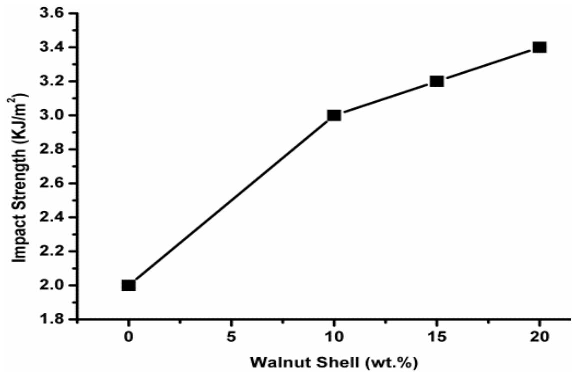

Fig. 4: Impact strength of developed composites

4. Conclusion

The results of the work shows that a useful composite with good properties could be successfully developed using walnut shell as reinforcement in polyester matrix. Significant improvement in impact strength of developed composites was observed. Reinforcement of walnut has less effect on tensile strength of developed composites. Hardness increased up to a certain level of reinforcement and then decreased.

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