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Mechanical behaviour of Walnut reinforced composite

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Abstract
In the present work walnut particles reinforced (10%wt-40%wt) epoxy matrix composite was fabricated in open mould. Physical property-density and Mechanical property-tensile properties have been evaluated. Role of particle wt% reinforcement observed for density and tensile properties-ultimate tensile strength, modulus of elasticity and % elongation. Increase of wt % of walnut particle from 10%wt to 20%wt was very much effective for loss in ultimate tensile strength and gain in % elongation, in comparison to increase in 20-40% wt. Effect on modulus of elasticity was almost consistent.

Key words: composite material, walnut particle reinforcement, epoxy matrix, tensile property, Modulus of elasticity

1. Introduction
Nature is blessed with an ample availability with different kinds of fibres/particulates such as Jute, Coir, Sisal, Pineapple, Ramie, Bamboo, Banana etc. The advantages of natural plant fibres/particulates over traditional fibres/particulates are acceptable as good specific strengths and modulus, economical viability, low density, reduced tool wear, enhanced energy recovery, reduced dermal and respiratory irritation and good biodegradability [1] &[2]. The development of fibre composites serves the dual strategy of prevention of depletion of forests resources by reducing or replacing the need of wood stems with polymer composites or polymer based composites and getting good economic returns thus promoting more cultivation and development of natural fibres/particulates.

Reinforcement particles/flours are not very effective in improving fracture resistance but they enhance the stiffness of the composite to a limited extent. Particle fillers are widely used to improve the properties of matrix materials such as to modify the thermal and electrical conductivities, improve performance at elevated temperatures, reduce friction, increase wear and abrasion resistance, improve machinability, increase surface hardness and reduce shrinkage

An attempt has been made to reinforce coconut shell. Powders (CSP) in a ultra high molecular weight polyethylene (UHMWPE) prepared by powder metallurgy route, these composites have been evaluated for its mechanical properties and compared with pure UHMWPE (0 vol% CSP) [5]. Pyrolysis of sugarcane bagasse and coconut fiber was studied by thermal analysis in order to characterize their thermal behavior and to identify their constituents by the aid of their thermo gravimetric curves and to determine their heat capacity by means of DSC [6]. Tensile and flexural strengths of coconut spathe and spathe-fibre reinforced epoxy composites were evaluated to assess the possibility of using it as a new material in engineering applications [4].

Many materials when they are in a fibrous form exhibit very good strength property but to achieve these properties the fibres/particulates should be bonded by a suitable matrix. The matrix isolates the fibres/particulates from one another in order to prevent abrasion and formation of new surface flaws and acts as a bridge to hold the fibres/particulates in place. A good matrix should possess ability to deform easily under applied load, transfer the load onto the fibres/particulates and evenly distributive stress concentration.

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A very limited research papers were found on composite made from walnut reinforcement. Production of polymer of Composite Board from Walnut Shell and improvements of its features was done to produce an urea-formaldehyde (UF) based polymer composite board to be useful in various areas.[11] Therefore in the present paper walnut shell particle based composite has been fabricated with an idea of exploring the potential of walnut shell as reinforcing element for epoxy matrix composite.

2. Materials and methods

2.1 Epoxy Resin

Epoxy resin of Brush Bond make S-Y 12(319) used was purchased from M/s RESINOVA CHEMIE LIMITED India. It is a liquid solvent free epoxy resin. It has versatile applications in technical and industrial applications. Curing takes place at room temperature and atmospheric pressure after addition of hardener. Cure shrinkage is generally very less and may be still further reduced by the addition of fillers. The resin can be coloured easily. Fully cured mixture has excellent mechanical, electrical properties and highly resistant to chemical and atmospheric attack. The castings have good ageing characteristics. It is odourless, tasteless and completely non-toxic. Resin can be stored for at least a year if they are stored under cool, dry conditions in the original containers.

It is also good solvent and has good chemical resistance over a wide range of temperature. has been used as matrix material. The epoxy used is colourless, odourless and completely nontoxic.

2.2 Hardener

Hardener SY31(B) was a yellowish-green liquid. Hardener SY31(B) purchased from M/s RESINOVA CHEMIE LIMITED, India has been used as curing agent. In the present investigation 8 % wt/wt has been used in all material developed. The weight percentage of hardener used in the present investigation is as per recommendation of Singh V.K. (2002).

2.3 Walnut shell particles

Reinforcing agents were added to the resin to improve the mechanical strength and wear properties. The walnut particles residue was widely generated in high proportions in the agro-industry by the grinding of the walnut shell. It is generally light brown to dark brown in colour. The walnut shells are underutilized, renewable agricultural material.

The walnut shells were obtained from nearby local market. The particles were removed and the shell was crushed into smaller pieces manually. Thereafter the walnut shell powder was obtained by grinding the crushed shell in Willy's mill. The particle size of 1.00 mm was obtained using two sieves 0.5 mm and 1 mm successively. It is mixed in the resin up to the limits, the flow-ability of the mixture is maintained for the purpose of the pouring the mixture in the vertical mould. There is no compression applied in this arrangement. It is mixed in the resin up to the limits, the flow-ability of the mixture is maintained for the purpose of the pouring the mixture in the vertical mould.

2.4 Method of specimen preparation

The solution obtained by mixing wall nut particles in resin was kept in the furnace at a temperature of 90 ± 10 $^{\circ}$C for two hours as per the recommendation of Singh V.K., 2009. The electric furnace (Temperature Range 0-600^{0}C) used for this purpose. At each interval of 30 minutes the solution have been taken out from the furnace and remixed by mechanical stirrer at high speed. After two hours the whole solution is taken out and allowed to cool to a temperature of 45°C. When a temperature of 45°C has been attained the hardener HY-951 is mixed immediately. Due to addition of hardener high viscous solution has been obtained which is again mixed mechanically by high speed mechanical stirrer. The viscous solution so obtained is poured in to different moulds for sample preparation for tensile testing.

The viscous solution obtained from resin, hardener and filler materials is poured in different moulds for specimen preparation for tensile testing. Flat plates as required for tensile test. Annealing is used to induce ductility, soften material, relieve internal stresses, refine the structure by making it homogeneous, and improve cold working properties.

3 Results and Discussions

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3.1 Density

Density is one of the most important physical properties of the material. The density of walnut shell particle reinforced composite are presented in Table 1.

Table 1: Density (g/cm^3) of walnut shell particle reinforced composites

S. No.	Walnut shell particle (10 wt%) (gm/cm^3)	Walnut shell particle (20 wt%) (gm/cm^3)	Walnut shell particle (30 wt%) (gm/cm^3)	Walnut shell particle (40 wt%) (gm/cm^3)
1	1.173	1.20	1.15	1.03
2	1.176	1.16	1.13	1.05
3	1.176	1.14	1.20	1.10
Mean	1.175	1.170	1.160	1.060

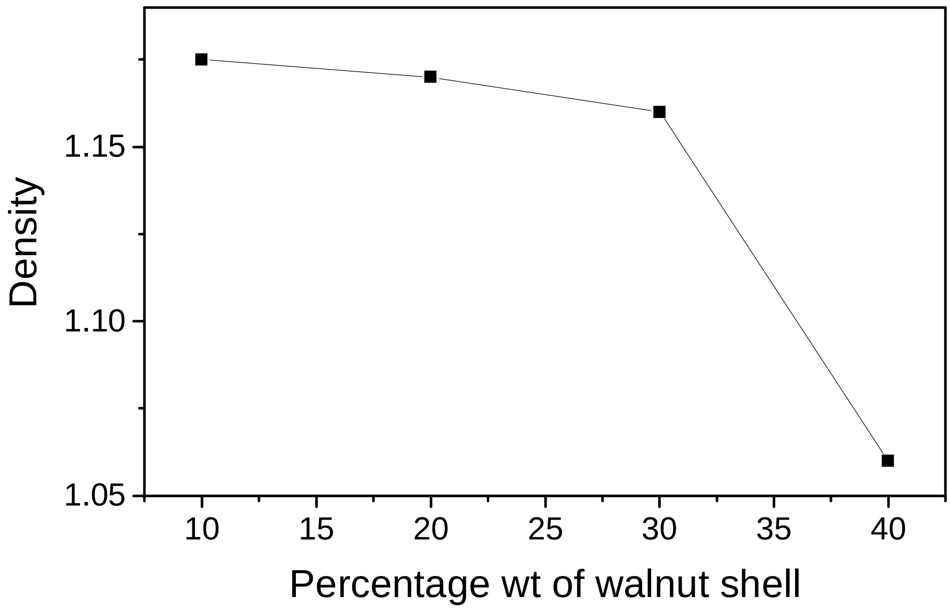

Figure 1: Density variation with wt % of walnut shell particle

From table 1 and figure 1 it can be seen that density decreases with increasing percentage of walnut shell particle. It can be further seen that there is a slow drop in density between 10 to 30 % of walnut shell particle but there is drop in density between 30%wt to 40 %. Presence of Porosity/voids would be there which decreases the density because there was no pressure applied. Flow of material was properly maintained in mould required air removal for 30%wt reinforcement.

2.2 Tensile Properties

The tensile stress-strain curve for unfilled epoxy resin and composite material containing 10 wt %, 20 wt %, 30 wt %, 40 wt % of walnut shell particle are shown in figure 2. All tests are conducted as per ISO in 100 kN servo hydraulic Universal Testing machine at different strain rates of 0.01 mm/min

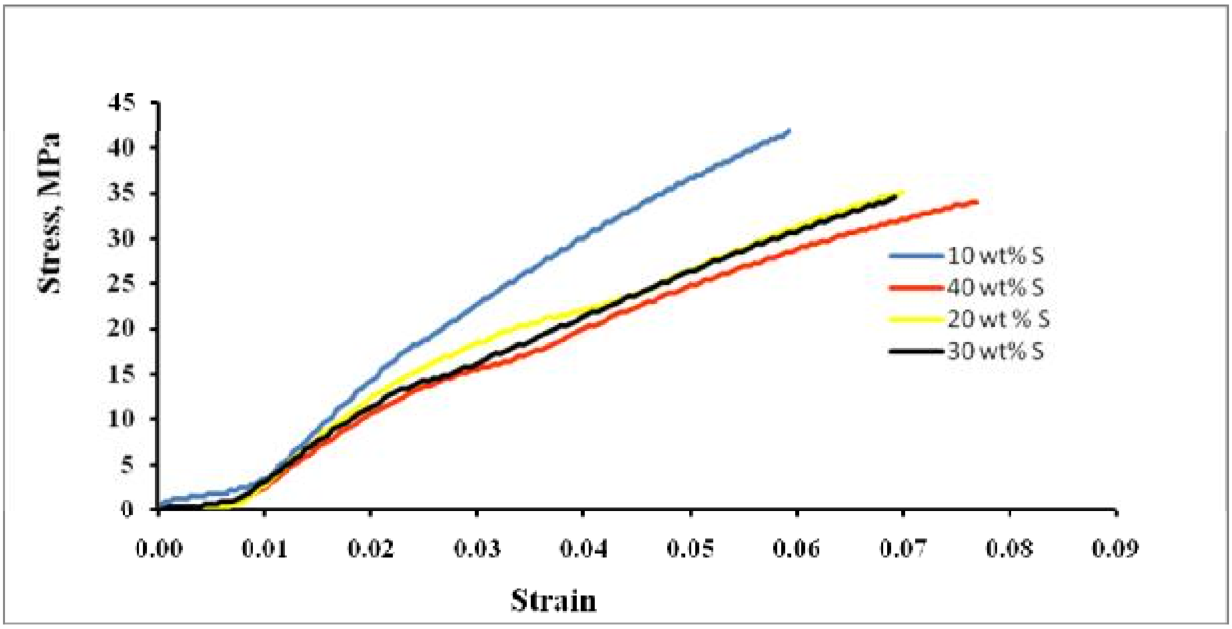

Figure 2: Stress- strain diagram for different wt% of walnut shell particle

The effect of particle reinforcement into epoxy resin matrix can be easily observed in the stress-strain diagram.

Table 2: Various mechanical properties for different wt % of walnut shell particle

S.N	10 wt% S	20 wt% S	30 wt% S	40 wt% S
Ultimate Strength, MPa	41.818	35.151	34.545	33.939
Modulus of Elasticity, MPa	932.34	905.63	878.23	821.23
% Elongation	5.928	5.928	6.927	7.693

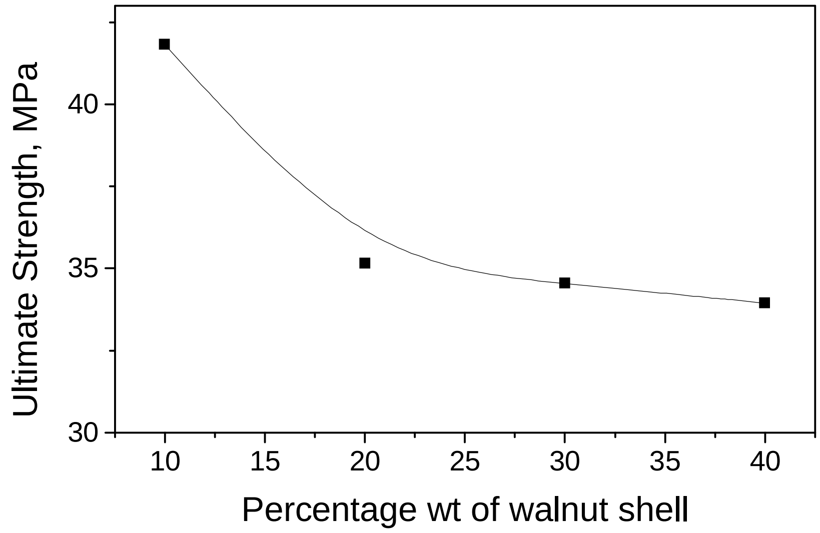

Figure 3: Ultimate strength variation for different wt% of walnut shell particle

From above figure it can be stated that ultimate strength is highest for 10% walnut particle of 42.95 M Pa and further drops abruptly at first up to 20% and then drops slowly further to a value of 34.0 M Pa. The drop in tensile strength is due to porosity, poor adhesion and poor interfacial interaction between epoxy and shell particles.

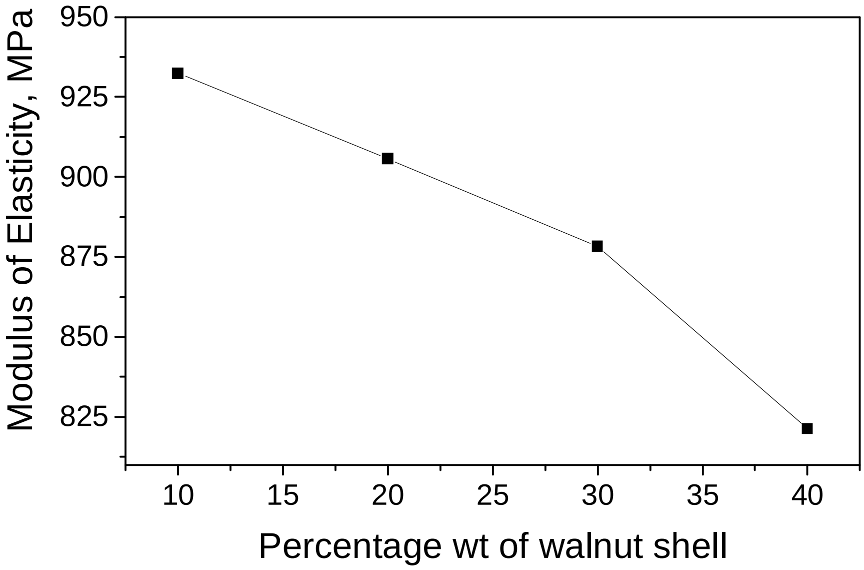

Figure 4: Modulus of elasticity, E (MPa) different wt% of walnut shell particle

From table 2 and figure 4 it can be seen that there was drop in modulus of elasticity with increasing percentage of walnut shell particle and is maximum for the value of 932.34 for 10% walnut particle. This was due to increase in % elongation beyond 20%wt reinforcement. Reason would be poor adhesion and poor interfacial interaction between epoxy and shell particles.

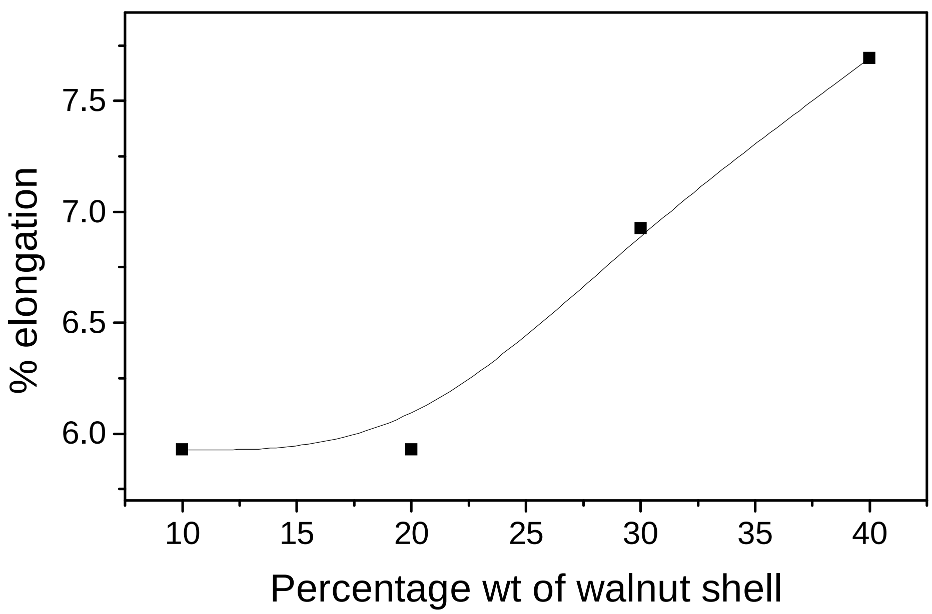

Figure 5: Percentage elongation for different wt% of walnut shell particle

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From figure 5 it is observed that percentage elongation is almost constant up to 20% wt of walnut particle and then rises sharply further up to 40%.

Conclusions

From the investigations and discussions, the following conclusion has been drawn-

1) The density reduces with the increase of reinforcement of shell particles. But rate of increase is more beyond 30%wt reinforcement. Density obtained is very suitable for light weight applications.
2) Tensile strength of 33-41 MPa achieved from these walnut shell particles reinforcement is sufficient for materials replacing wood.

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