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Research article

Compressive behavior of walnut (Juglans L.) shell particles reinforced composite

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Abstract

In the present paper walnut particle reinforced composite was developed in an open mould. Walnut particle reinforced composite was prepared with epoxy matrix with 10 – 40 weight percentage (wt%) of walnut particles and the effect of the reinforcement of particles on the water absorption capacity and compressive strength have been evaluated. The water absorption capacity was found to increase with increasing percentage of walnut shell particle. Ultimate compressive strength and Percentage reduction in length in compression increases with increment of walnut particle wt% remarkably. There was a major increase in ultimate compressive strength between 20 to 30 wt% of walnut shell particle with the maximum value of 50 MPa at 30 wt% of walnut particles. This study hence exploits the potential of walnut particle to be used in natural particle based composites.

Keywords: *Composite material, compressive properties, natural particle*

1. Introduction

The use of natural plant particles as reinforcement in polymer composites for making low cost engineering materials has generated much interest in recent years. The advantages of natural plant particles over traditional particles are acceptable as good specific strengths and modulus, economic viability, low density, reduced tool wear, enhanced energy recovery, and reduced dermal and respiratory irritation and good bio-degradability [1]. Nature is blessed with an ample availability with different kinds of particles like coconut shell, walnut shell etc. The importance of presence of these natural particles lies in the fact that they can be used for the development of natural particle based composites which opens the avenues for value added applications. These natural particle composites hold their importance to be used in housing and construction sector as a substitute of wood. Natural fibers and particles thus have attracted the attention of researchers due to their low density with high specific strengths, abundance, availability, renewability and being environmental-friendly [2]. Tensile and flexural strengths of coconut spathe and spathe-fiber reinforced epoxy composites were evaluated to assess

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the possibility of using it as a new material in engineering applications [3,4]. The stringent environmental considerations like deforestation have led to thinking to replace wood with various synthetic materials, such as polymer composites. An attempt has been made to reinforce organic bio particle in an ultra-high molecular weight polyethylene (UHMWPE). Prepared by powder metallurgy route, these composites have been evaluated for its mechanical properties [5]. Pyrolysis of organic bio 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 [6]. Organic bio particles reinforced composites showed 80% better elongation at break and 20% better Charpy impact strength than soft wood composites [7].

Although not much work has been done considering walnut shell particle an attempt has been made to use it as reinforcement of epoxy matrix to develop composite. 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. Material and Method

2.1. Epoxy Resin

Epoxy resin of Brush Bond make CY230 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. Fully cured mixture has excellent mechanical, electrical properties and highly resistant to chemical and atmospheric attack. The castings have good ageing characteristics. It is odorless, 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 colorless, odorless and completely nontoxic.

2.2. Hardener

Hardener HY951 was a yellowish-green liquid. Hardener HY951 purchased from M/s Resinova Chemie Limited, India has been used as curing agent. In the present investigation 8 wt% has been used in all material developed. The weight percentage of hardener used in the present investigation is as per recommendation of Misra [8].

2.3. Walnut Shell Particles

Reinforcing agents were added to the resin to improve the mechanical strength. 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 color. 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. 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 walnut particles in resin was kept in the furnace at a temperature of 90 ± 10 °C for two hours as per the recommendation of Singh [9]. The electric furnace (Temperature Range 0-600°C) was 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 HY951 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 compressive testing.

The compression test is simply the opposite of the tension test with respect to the direction of loading. In some materials such as brittle and fibrous ones, the tensile strength is considerably different from compressive strength. Therefore, it is necessary to test them under tension and compression separately. Compression tests results in mechanical properties that include the compressive yield strength, compressive ultimate strength, and compressive modulus of elasticity in compression, % reduction in length etc. All the compression tests of composites are conducted in 100 kN servo hydraulic UTM machine (model 2008, ADMET make) under displacement control mode. The specimen aspect ratio of 2.0 is kept for all the tests. The specimen configuration is shown in Fig. 1.

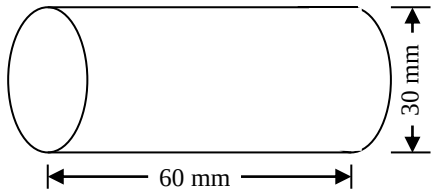


Fig. 1 Specimen geometry for compression test

Recommended curing conditions suitable for a mixture of 92 parts by weight of Araldite CY-230 and 8 parts by weight of hardener HY –951 is given in Table 1.

Table 1
Curing temperature and time for Araldite CY-230 with hardener HY – 951 material

Curing temperature (°C)	Minimum curing time
20	14-24 h
40	12-16 h
60	5-7 h
70	1-3 h
100	10-30 min
130	5-10 min

Prolonged curing time or increasing curing temperature gives slightly better thermal stability and thus constant mechanical and electrical properties over a large range of temperatures. In the present investigation curing was done at 70°C for 2-3 hour.

3. Results and Discussion

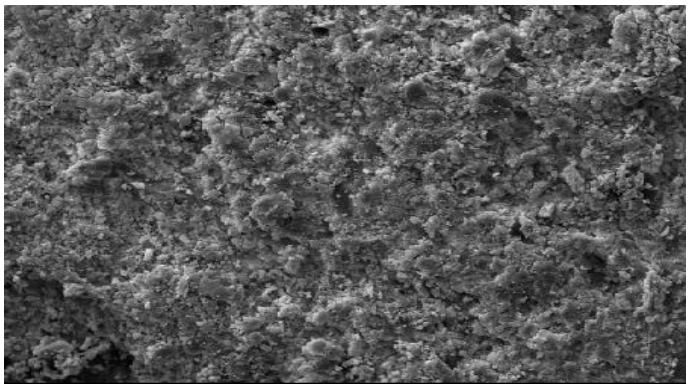
3.1. Scanning Electron Microscope (SEM)

The morphology of composite material is determined by the way the organic and inorganic compounds are mixed. Since this mixing is on a nano scale, this can best be studied by scanning electron microscopy (SEM) or transmission electron microscopy (TEM). In general SEM shows features in the micrometer range where TEM visualized a nanometer range, but the sizes of structures visible with both methods depend also on the contrast in the samples. In SEM both surfaces and cross-sections of coatings can be studied. In general, though, the surface of the coating is not representative for the coating as a whole and therefore the study of cross-sections is preferred. Also with TEM cross-sections of the coatings were studied. Important for the preparation of samples for both techniques is not to damage the object to be studied: a thin coating layer supported by a thick substrate, during preparation.

The state of dispersion of particles into the resin matrix plays a significant role on the mechanical properties of the composite. Various methods such as SEM, TEM etc. can be used to evaluate the particle dispersion in the composite. In the present investigation SEM was carried out for hybrid composite containing different weight percentage of walnut particles to evaluate the particle size, particle matrix interface and dispersion of the walnut particles in the epoxy resin matrix. The scanning electron micrograph study generally performed by scanning electron microscope, which uses electron to form an image with high resolution or magnification. The images are obtained through microscopic investigation with LEO435V6. To obtained the scanning electrons micrographs square samples are cut from the cast material and are silver coated to avoid the artifacts associated with sample charging and then placed inside a chamber in which an electron beam is fall on the material. The accelerated voltage was 20 kV. Different images are taken at various magnification ranges.

Fig. 2 shows the SEM photograph of composite material investigated in the present work. The good dispersion of walnut particle in the resin matrix has been observed. Fig. 2a shows SEM of pure epoxy resin. Fig. 2b shows the SEM photograph of composite containing 40 wt% of walnut particles. It is seen from the Figs. 2b that walnut particles are well dispersed in the epoxy resin matrix in a preferred orientation. The absence of any voids around the particle indicates a good adhesion between walnut particle and epoxy matrix. From the Fig. 2b it is also evidence that there is no chemical reaction between walnut particles and epoxy resin.

(a)



(b)

Fig. 2 Scanning electron micrograph for (a) (CY-230 + 8 wt% HY-951) at magnification of 80000X and (b) 40 wt% walnut reinforced composite at magnification of 1000X

3.2. Water Absorption Capacity

Weight of the specimen of sized (15mm x 10mm x 10mm) were taken then dipped the specimen in to ground water for 24 hours. After 24 hrs again weights were taken, the difference between weight of specimen before and after the absorption indicates the water absorption capacity of the casting. Water absorption capacity is crucial factor to be taken into account when considering the effect of water on the composite material developed. The effect of water absorption is important in case the material that has been developed when used for applications comes in contact of water. The effect is presented in Fig. 3 after time frame of 24 hrs.

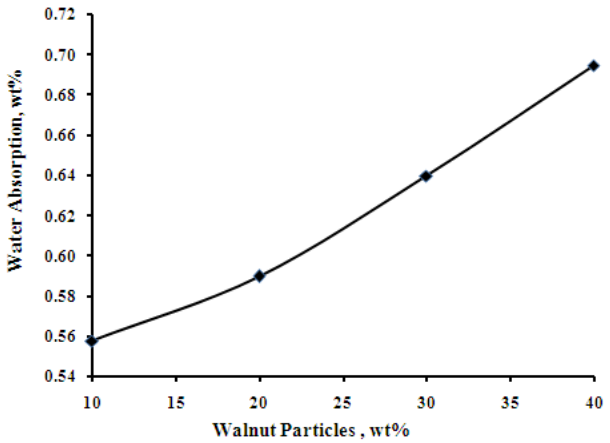


Fig. 3 Variation of moisture absorption with wt% of walnut shell particle

The water absorption capacity was found to increase with increasing percentage of walnut shell particle. The water absorption capacity was found to be maximum for 40 wt% of coconut particle reinforced composite. The water absorption is due to the hydrophilic nature of the walnut shell.

3.3. Compressive Properties

The results of the compressive test are shown in Table 2. The compressive stress strain curves are shown in the Fig. 4. The compression tests are carried out at different strain rates of 0.1 mm/sec. All tests are conducted under displacement control mode. The variation of compression strength with wt% of walnut shell particle is shown in various Figs. 5. A remarkable difference can be noticed in the value of the compressive strength with different wt% of walnut shell particle. It can be noticed that addition of walnut shell particle improves the ultimate compressive strength of the composite materials. From the present results, it can be said that the ultimate compressive strength has increased considerably due to addition of Walnut shell particle.

Table 2
Ultimate strength in compression with different wt% of walnut shell particle (S)

S.N	10 wt% S	20 wt% S	30 wt% S	40 wt% S
Ultimate Strength (MPa)	33.03	34.28	49.10	50.00
Modulus of Elasticity (MPa)	922.14	866.23	805.66	801.76
Reduction in length (%)	50.83	69.94	78.09	79.81

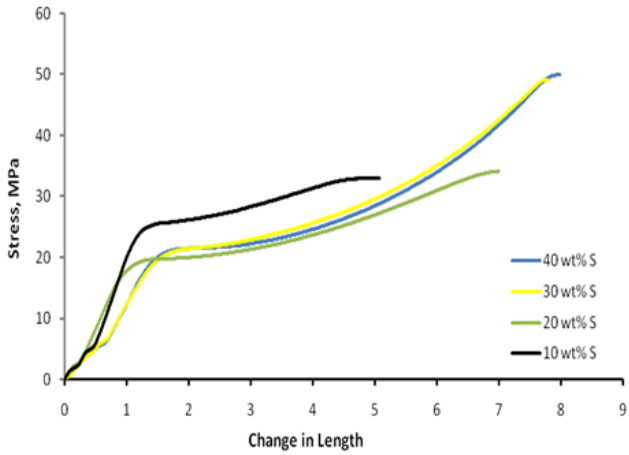


Fig. 4 Stress -Strain curve in compression with different wt% of walnut shell particle

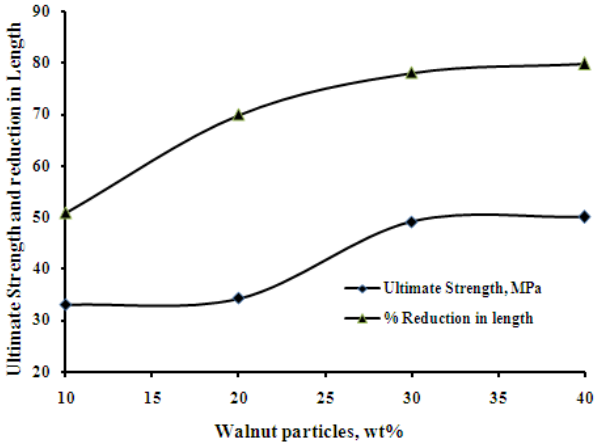


Fig. 5 Effect of wt% of walnut shell particle on ultimate strength and % reduction in length

From Table 2 it can be observed that modulus of elasticity is decreases as increasing in walnut particle wt%. This behavior is due to composite material become more ductile as increasing the walnut particle in the composite material this behavior is also verified by the ultimate strength increases with increasing the walnut wt%.

4. Conclusions

It is observed that composite prepared with epoxy resin and walnut shell particle shows general change in properties. There is a continuous increase in water absorption capacity with the increasing wt % of walnut shell powder. It is due to improper bonding between reinforcing element and matrix material which creates a lot of gaps which increases moisture absorption capacity. There is a considerable enhancement in the compressive strength of the composite. Ultimate strength in compression shows increase which makes the composite useful for high compressive applications.

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