Synthesizing and exploration of tamarind seeds - Epoxy composites

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Abstract

Composite technology is the best way of value addition for agricultural waste like tamarind seeds. The tamarind seeds are used in this research as powder form. The various proportions were used to prepare seven different composites. The matrix materials are Epoxy-LY 556 and hardener. The accelerator is Methyl Ethyl Kethone Peroxide and the Catalyst was Cobalt. The Compression moulding techniques employed to prepare the composite plates. The compression strength, tensile strength damping characters were analyzed and presented. The best composite was suggested. Based on the application requirements remaining composites may be used.

Keywords: *Tamarind Seeds, Epoxy-LY 556, Compression moulding, tensile strength*

1. Introduction

The magic of value addition can be made with help of composite i.e. scrap as raw material [1, 2]. The tamarind seed usually a agricultural waste, but recently found some medical drug applications [3], preparing gum [4], biomedical i.e. Bio-inspired nanocomposites for bone tissue engineering [5], the composite films using polyvinyl alcohol and carboxymethyl tamarind gum and the developed films can be explored for skin tissue engineering and drug delivery applications [6]. A complex coacervate was prepared by [7] with whey protein isolate (WPI) and tamarind seed mucilage (TSM) and the WPI-TSM complex coacervate can be used as an economic and nutritionally valuable alternative for food additives. spice fused tamarind seed starch edible films for meat packaging [8]. The environmental friendly composite material can be made with tamarind seed gum and banana fibre. It is biodegradable also. The composite strength varies with kind of banana fibre. The red banana fibre used composites are more stronger than poovan banana tee fibres[9]. The green composite can be manufactured by Using biopolymer cellulose as the matrix and 25 wt.% tamarind nut powder as filler must be loaded [10]. This research also made such attempt of preparing eco friendly green composite and also bio degradable composite with tamarind nut powder with epoxy matrix. The objective of the research is to fabricate seven different composite plate and explore of its characteristics.

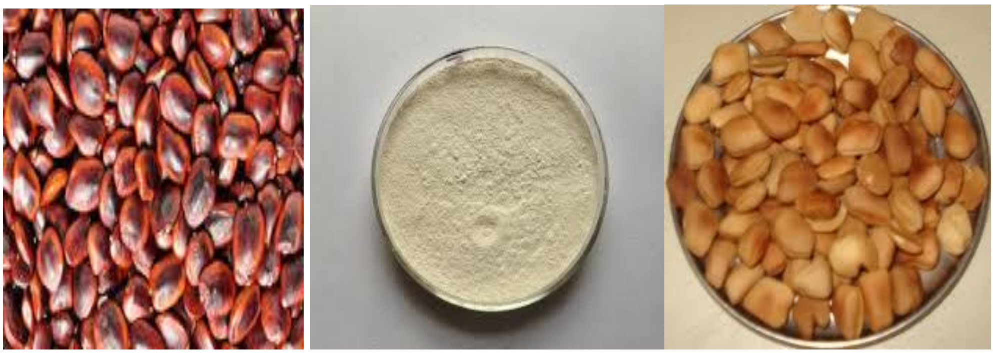
2. Materials and methods

2.1. Matrix Phase

The details of the composite matrix is: Reinforcement material – Tamarind seeds powder; Matrix material - Epoxy-LY 556 ; Hardener-2-, aminoethylethane-1, 2-diamin; Accelerator - Methyl Ethyl Kethone Peroxide and the Catalyst-Cobalt.

2.2. Reinforcement Phase

The tamarind seeds are considered as Reinforcement Material for this composite synthesis and exploration. The tamarind seeds were collected from tamarind, which are seen as unused in road sides from various village areas. Tamarind seeds powder is natural filler. Usually seed fiber obtained from the outer shell, or husk, of the coconut, the fruit of Cocas nucifera etc. The coarse, stiff, reddish brown Filler is made up of smaller threads, each about (a micrometer is about 0.004 in.) in diameter, composed of lignin, a woody plant substance, and cellulose. The individual fiber cells are narrow and hollow, with thick walls made of cellulose. They are pale when immature but later become hardened and yellowed as a layer of lignin is deposited on their walls. Mature brown coir fibers contain more lignin and less cellulose than fibers such as flax and cotton and are thus stronger but less flexible. Brown fiber is obtained by harvesting fully mature Tamarind Seeds when the nutritious layer surrounding the seed is ready to be processed into copra and desiccated Tamarind seeds. The fibrous layer of the fruit is then separated from the hard shell (manually) by driving the fruit down onto a spike to split it. Machines are now available which crush the whole fruit to give the loose fibers. The Tamarind seeds with shell, shell removed and powdered was shown in the figure 1 from left to right respectively.



(a) (b) (c)

Figure 1 Tamarind seeds (a) with shell (left) b) without shell (middle) c) Tamarind seeds powder

2.3. Physical Properties

A tamarind seed is very similar to peat in appearance. It is light to dark white in color and consists primarily of particles in the size range 0.2-2.0 mm (75-90%). Unlike sphagnum peat, there are no sticks or other extraneous matter. Tamarind seeds powder has a similar dry density, water holding capacity (WHC) and available water content as sphagnum peat. The air-filled porosity (AFP) is slightly lower but this is compensated for by a more even distribution of moisture in the mix.

2.4. Chemical Properties

Tamarind seed powder is less acidic than sedge or sphagnum peat and smaller amounts of lime are needed to achieve a pH suitable for growing plants. Table 1 gives the chemical properties of the Tamarind seed powder.

Table 1. Chemical Properties of the Tamarind seeds powder

Material	Moisture %	pH	EC dS/m	N%DWt	P	K	Cl
Tamarind seeds powder	13	5.1	0.80	0.5	0.3	0.4	0.07

2.5. Matrix Material

The Epoxy resin LY556 which is used as the matrix material in our project this resin is purchased from Covai seenu & company, Coimbatore. We have used 3kg of our project. Epoxy LY 556, chemically belonging to the " **epoxide** " family is used as the matrix material. Its common name is Biphenyl Diglycidyl Ether. The hardener with IUPAC name NN0-bis (2-aminoethylethane-1, 2-diamin) used with the epoxy has the designation HY-951. The epoxy resin and the hardener were supplied by Geo polymers Ltd, chennai. The matrix used to fabricate the fiber specimen was epoxy LY 556 of density 1.15 to 1.20 g/cm3, mixed with hardener HY951 of density 0.97 to 0.99 g/cm^3. The weight ratio of mixing epoxy and hardener was 10:1.

Figure 2. Epoxy Resin with Hardener

3. Composite fabrication

A stainless steel mould having dimensions of 300 × 300 × 3 mm^3 is used for composite fabrication. The Tamarind seeds particulates are mixed with polyester resin by the simple mechanical stirring and the mixture is poured into Moulds in the Compression Moulding Machine (30 Ton capacity) conforming to the requirements of various testing conditions and characterization standards. The figure 3 illustrates the prepared die for making polymer composites. There are seven composites with different proportions. The mould is compressed by upper jaw in the Compression moulding machine at temp of 80°C with the pressure of 2.6Mpa for two hours.

Table 2. Particulate Composites designation and proportions

Particulate Composites	T1	T2	T3	T4	T5	T6	T7
Tamarind seeds powder Weight Percentage	0	5	10	15	20	25	30
Epoxy Resin with Hardener Weight Percentage	100	95	90	85	80	75	70

4. Exploration of particulate composites
4.1. Mechanical Testing
4.1.1. Tensile Test

The tensile behavior of particulate composites was measured using the Universal Testing Machine (Make: FIE Pvt Ltd, Yadrav& Model: UNITEK-94100) at a cross-head 22 Stroke of 1000mm and Clearance between columns=650mm.Range of testing=0KN to 100KN.Power supply=1PH, 230V A.C and 50 Hz. As per the ASTM D638-08 standard. The specimens were cut from the fabricated composite in the approximate length, Width and thickness of 250 mm, 25 mm and 3 mm respectively. when tested on Alagappa chettiar university at karaikudi. Ten identical specimens were tested to obtain the average tensile strength value. The photographic image of the particulate composite specimens after tensile fracture is shown in Figure.

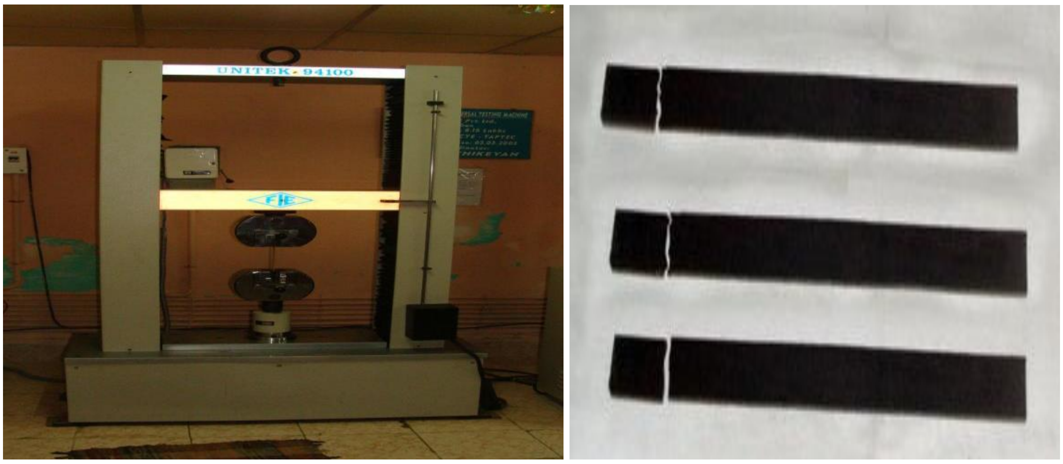


Figure 3 The tensile testing machine and particulate composite samples

4.1.2. Impact Test

Impact tests are used in studying the toughness of material. A material's toughness is a factor of its ability to absorb energy during plastic deformation. Brittle materials have low toughness as a result of the small amount of plastic deformation that they can endure.

$$\text{Impact strength } (kJ/m^2) = \frac{Impact\ energy(J)}{crosssectionalarea(M2)} * 10^3$$

The impact value of a material can also change with temperature .The results are expressed in energy lost per unit of thickness (such as J) .Alternatively, the results may be reported as energy lost per unit cross-sectional area at J/m². The dimensions of a standard specimen 64x12.7x3 mm for ASTM D256 are mm. The Izod impact test differs from the Charpy impact test in that the sample is held in a cantilevered beam configuration as opposed to a three-point bending configuration.

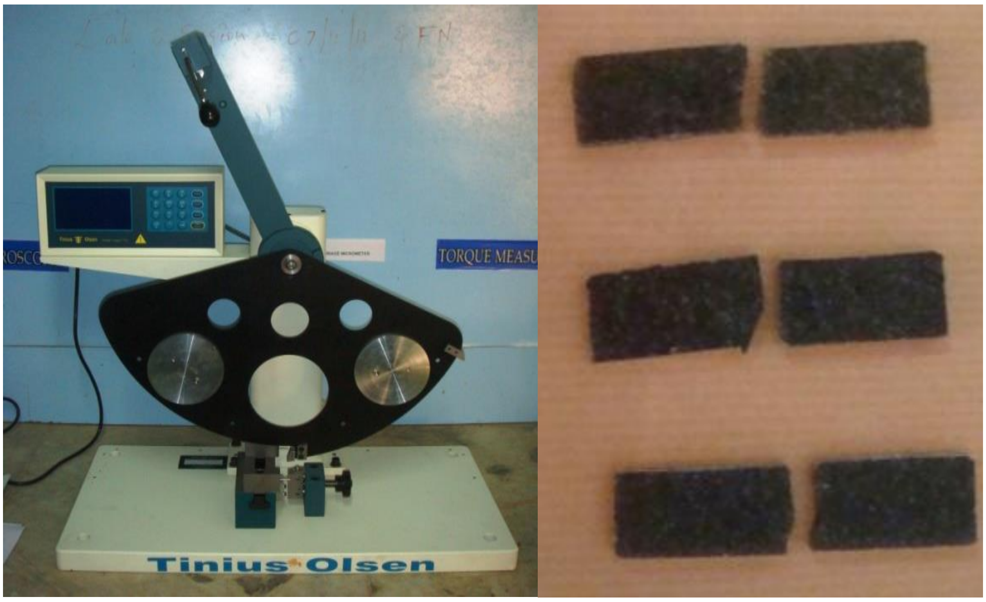


Figure 4 The impact testing machine and particulate composite samples

4.1.3. Compression Test

The Compressive strength was conducted according to ASTM E 3410 standard using universal testing machine. The plot shows interaction between compressive strength and no of experiments. Compressive strength of polymer composites were performed in digital display with compression load of 5kg.It should be noted that the Compressive results of the composites reported in this work are the average of sevan independent specimens

Figure 6 The Compression testing machine and particulate composite samples

The figure 7 shows the relation between compressive strength and no of experiments. The maximum compressive strength was 76 MPa with 30 wt % of tamarind seeds and 70 wt % of epoxy. This is due to the more amount of cellouse presence in the tamarind, moreover particulate tendency have to withstand more compressive comparatively to tensile load, the least compressive strength was observed with 40 MPa in 5 wt % of tamarind and 95 wt % of Epoxy composites.

Table 3. Mechanical Properties of Particulate Composites

Particulate Composites	T1	T2	T3	T4	T5	T6	T7
Compressive strength (MPa)	35	40	53	62	65	71	76
Tensile strength (MPa)	10	6.1	8	9.5	11	14	9.5
Impact energy (J)	2	2.6	3.4	4.1	4.9	5.5	5.1

5. Results and discussion

This section presents the mechanical properties of the tamarind seeds are filled polyester composites prepared for this present investigation. Details of processing of these composites and the tests conducted on them have been described in the previous chapter. The results of various characterization tests are reported here. This includes evaluation of compressive strength, tensile strength and impact strength and modal analysis has been studied and discussed. The interpretation of the results and the comparison among various composite samples are also presented

5.1. Mechanical Behaviour of Tamarind Seeds Epoxy Composites

The tamarind seeds composites in different and filler content of up to 30 wt % were taken as input variables in this present in epoxy composites for various combinations are given in Table 3.

5.2. Compressive Strength of Tamarind Seed Filled Epoxy Composites

The Compressive strength was conducted according to ASTM E 3410 standard using universal testing machine. The plot shows interaction between compressive strength and no of experiments. Compressive strength of polymer composites were performed in digital display with compression load of 5kg.It should be noted that the Compressive results of the composites reported in this work are the average of ten independent specimens.

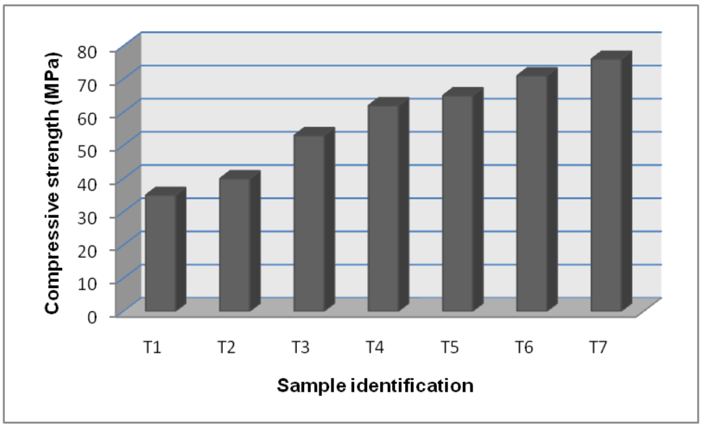


Figure 7 compressive strength of seven different particulate composite

The figure 7 shows the compressive strength of seven different particulate composites. The maximum compressive strength was 76 MPa with 30 wt % of tamarind seeds and 70 wt % of epoxy. This is due to the more amount of cellouse presence in the tamarind, moreover particulate tendency have to withstand more compressive comparatively to tensile load, the least compressive strength was observed with 40 MPa in 5 wt % of tamarind and 95 wt % of Epoxy composites.

5.3. Tensile Strength of The Tamarind Seeds Filled Epoxy Composites

The Tensile strength was conducted according to ASTM D 656 in using universal testing machine. The plot shows interaction between compressive strength and samples. Tensile strength of Epoxy composites were noted in digital display with load of 1 to 2.5kg.It should be noted that the tensile results of the composites reported in this work are the average of three independent specimens.

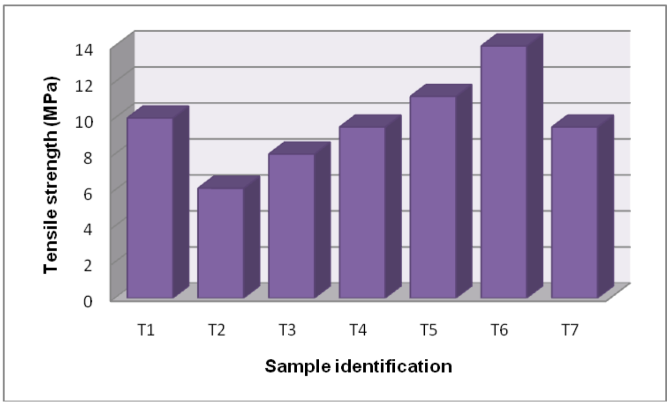


Figure 8 tensile strength of seven different particulate composite

The maximum tensile strength was obtained in 25 wt % of tamarind seeds and 75 wt % of epoxy composites at 14MPa.The maximum and minimum tensile strength was 8 and 14 MPa respectively. The minimum tensile strength was attained at 10 MPa in 10 wt % of tamarind seeds and 90 wt % of epoxy composites. When compare to neat epoxy resin, the strength of the polymer composites increased gradually beyond the 10 wt % of reinforcement. The figure 8 shows the tensile strength of seven different particulate composite

The adhesion between tamarind increasing the strength of the composites, moreover particulates behave as a gum nature while addition of epoxy in tamarind, it is the chance to higher tensile strength in 25 wt % of particle loading.

5.4. Impact strength of the tamarind seeds filled epoxy composites

Figure.10 shows the Impact strength in kJ/m^2 or toughness of seven different composites. The impact tested samples were shown in Figure 9. The maximum structural property was obtained in all different compositions. The average impact strength of Tamarind seeds epoxy composites is J.

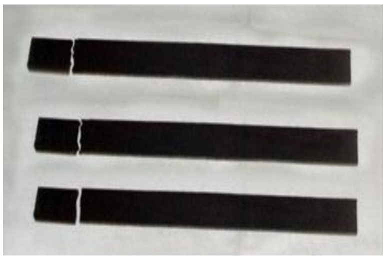


Figure 9 Tamarind seeds filled epoxy composite specimens after impact fracture

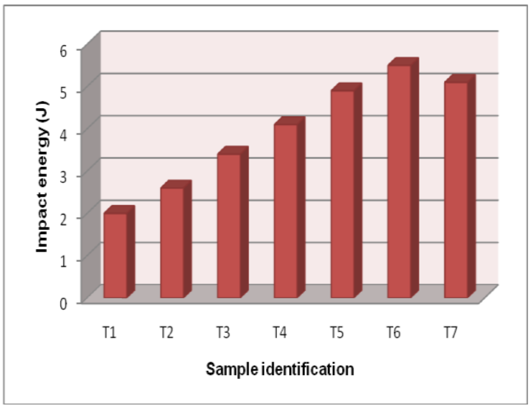


Figure 10 Impact strength or Toughness of seven different particulate composite

The Figure 4.4.2 shows the interaction between hardness and sample identification. A maximum value of the impact strength of 5.5 J was obtained in T-6 composition that is 25 wt % of tamarind seeds and 75 wt % of epoxy composites. The minimum impact strength was 2.0 J attained with 0 wt % of tamarind seeds with 100 wt % of epoxy composites. This is due to resistance of free particles presence in the tamarind seeds, low amount of lignin and high amount of cellouse presence in the Tamarind seeds.

5.5. Modal Analysis of Tamarind –Epoxy Composites.

Experimental investigation of modal analysis on tamarind filled epoxy composites were studied with varying weight percentage of content. This is fundamental natural frequencies and the associated modal damping was as obtained to study the effect of tamarind addition on free vibration characteristics. By using a modally tuned impact hammer the specimens are excited at six equally spaced locations. Readings are taken by applying the impulse force using piezoelectric impact hammer from the tip of the specimen to six equally spaced locations to get more measurement data. The output response is measured by using data acquisition system with the inbuilt software. The output was taken in the form of frequency response function with the help of DEW soft 7.3software. The table 4.2 shows the damping values of polymer composites.

Table 4 Damping observations of seven different particulate composite

Sample identification	Tamarind seeds (wt %)	Epoxy (wt %)	Natural frequency(Hz)
T1	0	100	31
T2	5	95	41
T3	10	90	60
T4	15	85	63
T5	20	80	51
T6	25	75	45
T7	30	70	65

It is observed that the addition of tamarind seeds increases the damping characteristics. This indicates that less stiffness of composites due to poor compatibility of tamarind seeds and epoxy composites, which could decrease the natural frequency of composites. It is well known fact that the increasing the stiffness of any material can increase the modulus value.

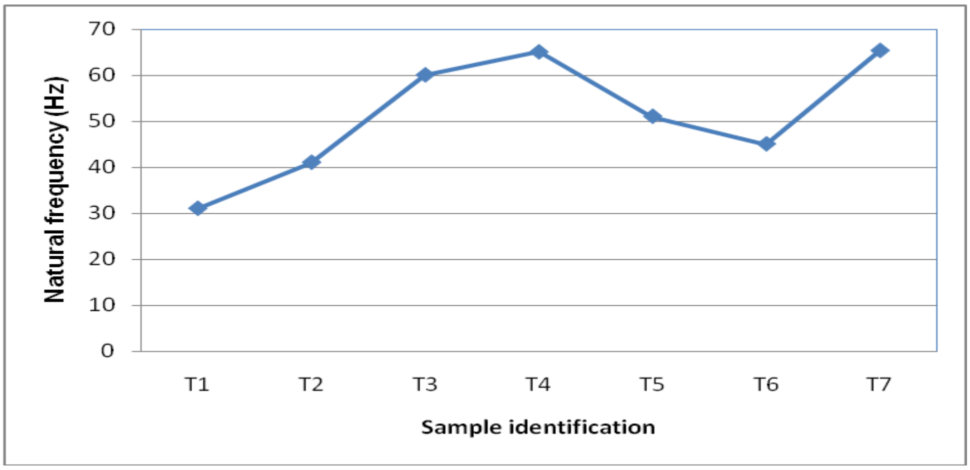


Figure 11 Damping behaviors of the tamarind seeds filled epoxy composites

Generally the value of natural frequency modulus depends on the young's modulus and mass of inertia of material system. From the results among all, the natural frequency 65 Hz was found for 30 wt % of tamarind seeds with 70 wt % of epoxy composites. This is due complex mechanism of energy absorbed by tamarind seeds composites.

6. Conclusion

The mechanical behaviors of Tamarind seeds particulate were studied in this investigation. The particulate composites were fabricated as per the different combinations of the fabrication parameters.

The composites were fabricated through 30 wt % of particulate content and 100-70 wt % of resin content and finished surface has examined through roughness value.

The maximum compressive strength was 76 Mpa with 30 wt % of Tamarind seeds and 70 wt % of Epoxy resin. The maximum Tensile strength was 11.2 MPa attained with 20 wt % of Tamarind seeds with 80 wt % of Epoxy composites. The maximum Impact Energy was 5.5 J with 25 wt % of Tamarind seeds and 75 wt % of Epoxy resin.

The results among all, the natural frequency 65 Hz was found for 30 wt % of tamarind seeds with 70 wt % of epoxy composites. This is due complex mechanism of energy absorbed by tamarind seeds composites. Natural particulates are biodegradable, easily available, and low cost and provide an opportunity for the development of natural material as reinforcement material. The performance tests of fiber composite products are to be carried out to commercialize products.

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