Effect on the performance parameters of furnace and microwave compressive molded PVA with epoxy reinforced by coir fiber

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Abstract

This paper aims to determine the effect on performance parameter of furnace & microwave compressive molded polymer composite consisting polyvinyl alcohol (PVA) & epoxy matrix reinforced by coconut fiber. The influences of heat on the mechanical properties of the composites were analyzed. The volumetric amounts of fiber and the matrix were kept same for all the samples that are arranged in randomly oriented discontinues form however there is difference in temperature and heating device. The muffle furnace has external heating whereas microwave gives internal heating via radiation. Tensile test, hardness test, charpy impact test and bi-degradability test were carried out to evaluate the characteristics of the material. It was observed that the PVA and Epoxy was blended together and the heat provided eliminated the air voids in the composite, had good dispersion of fiber and interfacial adhesion between them. It showed slight variation on the mechanical characteristics and led to the conclusion that the material is most useful when strength to weight ratio is needed.

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1. Introduction

Polymer matrix composites are the most common advanced composites used widely in variety of products available in the market which made life easier and crave on its advancement. Primarily, these composites consist of a polymer thermosetting or thermoplastic reinforced by fiber (natural, carbon or boron). Thermosetting resins such as epoxy, polyester, polyurethane, silicon and phenolic are commonly used in composites requiring higher performance applications. As the constituent have low density resulting polymer composites often show excellent specific properties. They yield great strength and stiffness along with resistance to corrosion and the reason for these being most common is due to their low cost, high strength and simple manufacturing principles [1, 4].

Mostly epoxy resin have clutch for numerous employments beyond fiber reinforced polymer composites. Generally, epoxies are thermosetting polymer resins and these resin molecule contains one or more epoxide groups. Now days, epoxy adhesives are available in local hardware stores, and epoxy resins are widely used as the binder in counter tops or coatings for floors [5-11]. The multitude of uses for epoxy continues to grow, and varieties of epoxies are constantly being developed to befitting the industries and products they are used in includes metal coatings, used in electronics, electrical components, high tension electrical insulators, paint brush manufacturing, fiber-reinforced plastic materials and structural adhesives etc. Polyvinyl alcohol (PVA) resins, as a water soluble synthetic polymer, it is colorless and odorless. This polymer is regarded to be a truly biodegradable synthetic polymer which is non-toxic, density of 1.19 g/cm^3, melting point of 180 °C and having properties such as high tensile strength and flexibility, good oxygen and aroma barrier properties, excellent emulsifying and adhesive properties, and high resistance to oil and grease. Widely it has been used in paper making, textiles, coatings, and as moisture barrier for dry food with inclusions [12-17]. PVA can be modified with various fillers to enhance its film performance and the dispersion state of fillers in this polymer is critical in determining the final property of the polymer composites [2, 12,18-19]

Similarly, Natural fibers composites have natural fibres that are originated by plants, animals and geological process. These fibres are used as a reinforcement constituent in composite materials. These fibers contain lingo cellulose in nature. Eco-friendly, lightweight, strong, renewable, cheap and biodegradable is the inherent feature of natural fibres. These fibers can be used to reinforce both thermosetting and thermoplastic matrices and they provide sufficient mechanical properties in particular stiffness and strength at acceptably low price levels. The natural fiber composites offer

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Significant opportunities for improved materials from renewable resources with enhanced support for global sustainability. These days Industries are attracted towards natural fiber composites because of their low density and ecological advantages over conventional composites. [1, 2] Coir Fiber is one of the versatile products of the Coconut palm also known as the Tree of Life. The palm also known as coconut tree is truly a source of renewable raw materials for both food and non-food products and this makes the coconut tree & the coconuts unique. Coir fiber is a lingo cellulosic fiber extracted from the coconut husk. The fiber is extracted from either Green Coconut Husks or Mature Brown Coconut Husks and both raw materials result in fiber types with slightly different characteristics. These fiber have high specific strength and modulus, low density, reduced dermal and respiratory irritation, enhanced energy recovery, and low cost. Coconut fibres are popular in the composites industries these days because of its outstanding biodegradability and environmental friendliness which tries outperform the conventional glass, carbon, basalt, and aramid. [1,2, 18,19]

2. Materials

The raw materials that are used in this experiment are available as commercial products. Coconut fibre that are gone in waste and are available everywhere in India, NaOH solution (10% w/v), PVA powder of Kuraray POVAL from Parnami Dyes & chemicals, Tilak bazaar, Delhi. Teflon blocks of 200mm×80mm×50mm is acquired from Mahindra Metals near Ajmeri Gate, Delhi, Alumina ceramic corundum crucible of 100×30×20 mm is bought from Amazon online shopping site and lastly epoxy is purchased from bohriali.com.

2.1. Methodology

The coconut fibres were separated and soaked with NaOH (10% w/v) mixed with distilled water for at least 3 hours, and then these fibres are washed with distilled water to remove the first layer of the fiber. Then they are dried in the sun for 3days and chopped into 10mm length. The PVA granules were dissolved in distilled water at a ratio of 2:10 in a pot. The solution was heated in a gas burner and stirred until the PVA granules were completely dissolved. Similarly the matrix is prepared by mixing PVA and Epoxy resins in the ratio of 2:2:1 followed by adding coir fiber and pour on the mold. The samples were prepared by heating in the microwave oven and muffle furnace. The mold is cured for 12 hours until it turns out to semi solid state and compressive force of 100N was provided and we have to be very careful as some of the epoxy and polyvinyl alcohol are squeezed out. Lastly the mold was cured for 72 hours. The same process was repeated for other samples.

2.2 Characterization

2.2.1 Tensile test

KIPL-PC2000, Tensometer was used to investigate the tensile strength. The sample (75mm × 9.8 mm × 6.3 mm) was tested with 2 mm/min cross speed, in room temperature.

Table 1: Composition of Fiber, PVA and epoxy with percentage weight proportion of the samples

Sample No:	Heating device	Temp (°c)	PVA	Epoxy	Coir fiber
1,	Muffle furnace	150 °c	40%	40%	20%
2	Microwave oven	150 °c	40%	40%	20%
3	Muffle furnace	180 °c	40%	40%	20%
4	Microwave oven	180 °c	40%	40%	20%
5	Muffle furnace	200 °c	40%	40%	20%
6	Microwave oven	200 °c	40%	40%	20%

Table 2: The setting of hot pressing

Parameter	Condition
Temperature (℃)	150-200
Force (N)	100
Preheat time (min)	3
Venting time (min)	4
Full pressing cycle (min)	5
Cooling time (min)	5

Fig.1. Tensometer

2.2.2 Hardness test

Shore A Durometer was used to investigate the hardness value of the composite. This test is performed according to ASTM D2240-2015.

Fig. 2. Durometer Shore A type

2.2.3 Impact test

Charpy impact test (Notched) was carried out according to ISO 179-2009.

Fig.3. Charpy Impact Test

2.2.4 Bio-degradability test

Soil Burial test was carried out by evaluating the weight loss of the sample over time. The weight loss was determined twice a week and was calculated using the equation.

$$\text{Weight Loss (\%)} = \frac{(W_i - W_d)}{W_i} \times 100$$

Where, W_d is the dry weight of the film after being washed with distilled water, and W_i is the initial dry weight of the specimen.

Fig.4 (a): Flower Pot for bio-degradable test

Fig.4 (b): Specimen for degradability test

3.Results and Discussion

3.1 Tensile test

From fig. 5, sample 6 displayed the maximum tensile stress at 6. 65 Mpa where as sample 2 and 4 showed least tensile strain at 0.03975mm/mm. Sample 2 showed least tensile stress at 6.2439 Mpa. These results indicate that the presence PVA affects the strain values of the composite. The tensile strength increased with increasing heat provided however the difference of heating device affects it.

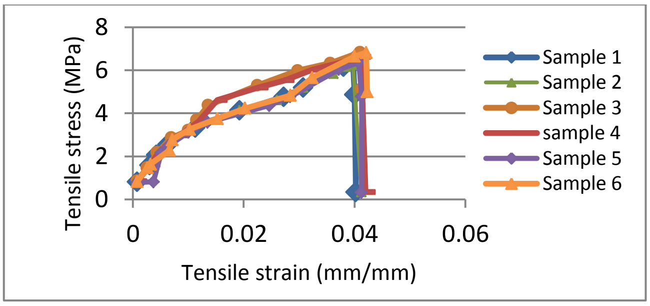

Fig. 5. Stress versus Strain

From figure 6 by the union of the coir fibre with the PVA and Epoxy, the Young Modulus, E value of composite increases and decreases with the difference of temperature and the cross sectional area of the test sample. The maximum value of Young's Modulus was obtained at sample 3 with the microwave heated at 180° c. and minimum value of Young Modulus at sample 5 which specify the ineffective stress transfer between the fiber and matrix.

In figure 7, the result indicates that strain at maximum stress have similar values which indicates well toughening effects.

3.2 Hardness test

There is a significant effect on the hardness of the composite with the increasing heat. Fig. 9, shows the hardness values of the composite sample. It was observed that the hardness value increases as the temperature increases as well as due t different heating device and because of the hard and brittle phase of the ceramic body in the matrix. It is observed that the sample 5 and 6 has the highest hardness value and may have the inherent properties such as high strength and high modulus. This can be the result of high heat provide that is 200° C.

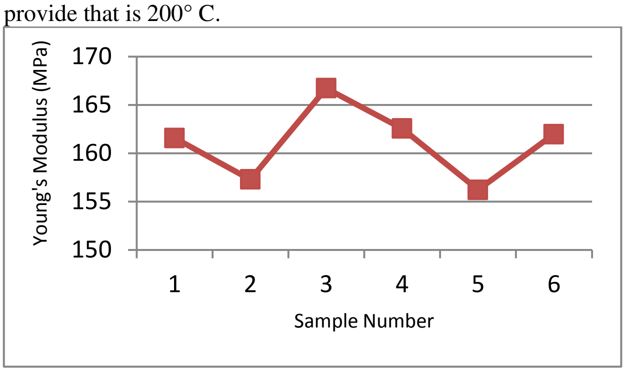

Fig. 6. Young's Modulus of each sample

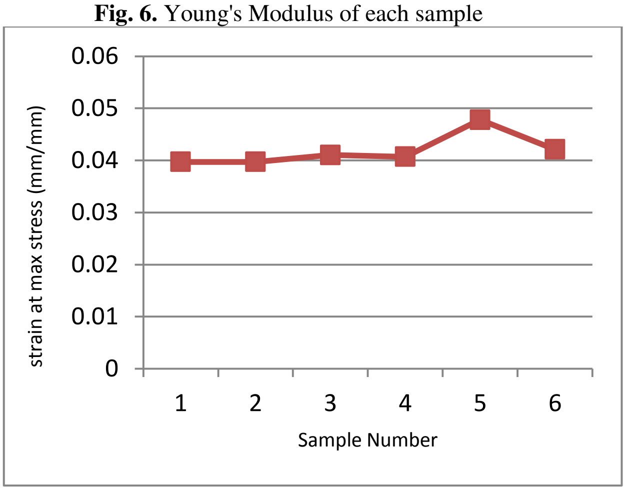

Fig.7. Strain at maximum stress

Fig.8 Specimen after tensile test

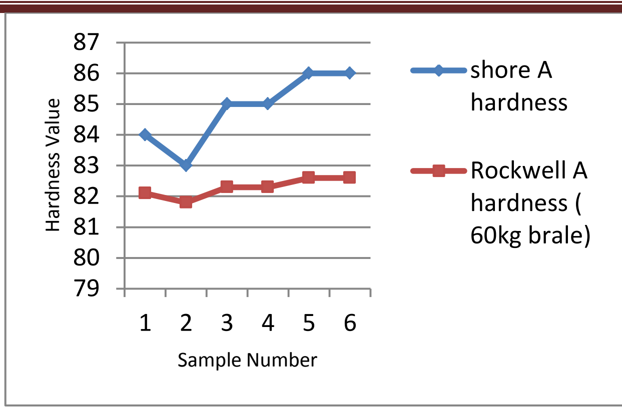

Fig. 9 Hardness value for individual sample

3.3 Impact Test

Figure 10, illustrates the charpy impact strength results of the palm kernel fibre reinforced with PVA and epoxy. It is clear from the figure that the impact strength at failure increase from sample 1 to 6 while sample1 & 2 showed decreased in the impact strength due to the less heat provided than that of other and reduction of elasticity of the material thereby reducing the deformability of the matrix .It is notable that the sample developed may have lower area under the stress-strain curves and therefore poor toughness. This shows the predictable result, as coir fiber being rigid ceramic body that acts as a barrier against the mobility of dislocation. The highest impact strength is showed by sample 6 i.e, 2.5Kj.

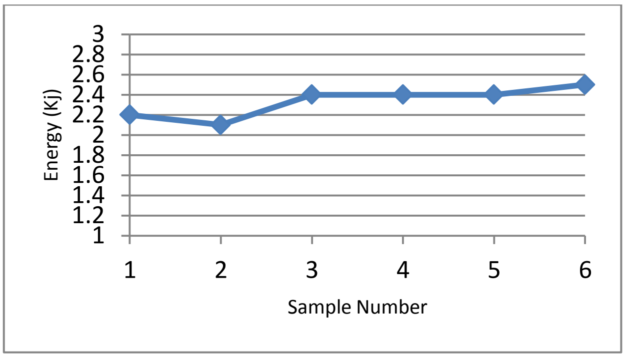

Fig.10. Energy absorbed by the samples

Fig.11 Sample after impact test

3.4 Bio-degradability test

Figure 12, represents the result of soil burial bio-degradability test. In the graph it shows gradual increase in weight loss (%) as the number of days increases. Since the first test result was below expectation as there was only slight weight reduction, may be due to the abundant washing done. There is maximum weight loss at 63rd day and shows increasing weight loss (%). Since this process requires time to degrade however it has its bio-degradability characteristics.

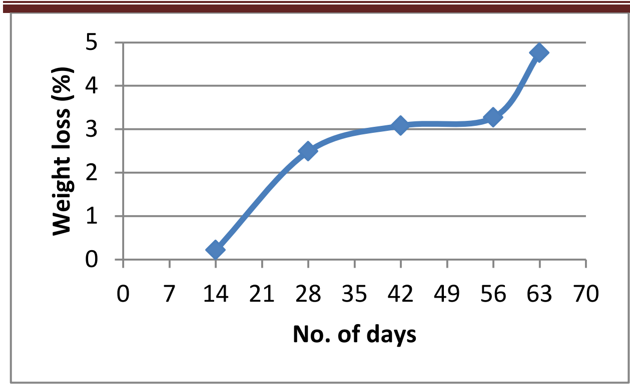

Fig. 12 Weight loss (%) vs. No. of days

4.Conclusions

The research was carried out to investigate the effect on the performance parameter of the furnace and microwave compressive molded PVA & epoxy reinforced by coir fiber. PVA and Epoxy was successfully integrated with coir fiber to form composites. The effects of internal heating via microwave and external heating via muffle furnace on mechanical properties of composite were studied. The results showed that the mechanical properties of the composite are dependent on the heat provided. The results of mechanical properties testing showed that the young's modulus and hardness of the composite were improved in microwave oven which provides heat via radiation. Similarly, sample 6 i.e. heat through microwave oven at 200°c showed the best results. However, sample 5 i.e. heat through muffle furnace at 200°c have comparatively lower values. The hardness value increases with the increase in the temperature apart of different heating device. Since there in uniform bond between the epoxy and PVA with fiber and due to the heat provided the air vents in the mixtures are avoided so for that after heating the mixture should be stirred and let it settle and cool as the mixture is in liquid state. The impact test showed that the composite provided with higher heat have an increase in impact strength. The results showed that the composite material have its bio-degradability characteristics.

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