ISSN:0971-1260
Vol-22-Issue-4-October-December-2019

Experimental Investigation on Thermal Properties of Pongamia shell powder filled Areca-Phenolic resin Composites

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Abstract

Improving the thermal properties and the fire resistant characteristics of polymers was the main challenge for extend their use to most of the applications. In this research work, the composition of the Phenolic resin was fixed to 65% by volume. It iscombined with varying proportion of the areca fibre and Pongamia shell powder by volume to weight ratio and represented by APC 05, APC 10, APC 15 and APC 35 respectively. The prepared composite mixture was poured into mould cavity, kept it in an oven and heated to the temperature of 140°C for about 20 minutes. Finally, it is cooled to the room temperature for about 24 hours. Thermal and fire-resistant properties are investigated. Thermal stability increases with increase in fiber concentration. Optimum composition of this work APC 15 can be used in the Chemical Industry, Automobiles, Ship building, Wind Thermal-interface materials.

Keywords: Specific Heat, DSC, TGA.

1. INTRODUCTION

Having mass, durability, strength, shape, stiffness, cost, etc as parameters and using integrated design process, composites are manufactured optimally. Customers should be made aware of these parameters influenced by newly developed design tools. Low thermal conductivity and relatively high flammability are the characteristics of Polymer materials. Hence it is a combined challenge to develop an effective, environment friendly flame retardant system of polymer materials and to find comparatively high thermal conductivity polymer's application as heat sink in an electronic circuitry. Conductive fillers are added to enhance thermal conductivity of polymer materials. In addition fire retardants are also used as fillers in polymer materials to achieve declined flammability which in turn decreases the production of volatiles and hence pollutants. The current research work fabricates and analyses a new polymer matrix composite material showing pro environment nature exhibiting good thermal and fire retardant properties. To achieve this, Phenolic resin is used as matrix, Areca fibres as reinforcement and Pongamia shell powder as filler.

1.1. Material Selection

Phenolic Resin as Matrix, Reinforcement as Areca Fibre and Pongamia Shell Powder as filler are selected to fabricate the composite specimens.

2. LITERATURE SURVEY

Terese E Glodek etal.,[1] have prepared fire retardant and mixed with polymer resin to decrease flammability. Reduce production and inhibit pyrolisis by using vinyl ester composite by combining fatty acids vinyl ester resin with environment friendly particulate fire resistant. Various proportions were blended into commercial and fatty acid brominated vinyl ester resin.

A Shojaei et al., [2] have investigated the thermal conductivity of rubber based composite friction material. Different thermally conductive fillers including brass chips, copper, aluminum oxide and talc are used. Thermal conductivity is more in aluminum chip filled composite because of higher volume fraction of the filler.

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3. FABRICATION OF THE COMPOSITES

3.1 Alkali Treatment

The obtained areca fibres have some acidic contents, so there PH value is more than 7. It may leads chemical reaction with Phenolic resin and also from previous studies it is clear that chemically treated areca fibres shows better adhesion and gives a good mechanical strength in the composites. Thus extracted fibres have to be alkali treated before fabrication process. In the alkali treatment process, areca fibres are treated in the solution of 10% Potassium hydroxide, where total volume of the solution was fifteen times the weight of areca fiber. The fibres are kept in alkaline solution for about 36 hours at temperature of 30° C. Fig.1 shows the alkali treatment of areca fibres.

Fig.1 Alkali Treatment of Fibres

3.2 Details of Fabricated Specimens

After the proper selection of the materials and the required pre-treatment of the selected material the fabrication process was performed. Before the fabrication process the mould cavity has to be fabricated using MS square rod of thickness 3.2 mm, length 25 mm and breadth 14 mm suitable for the inserting in the electric oven. Initially the mould cavity was wrapped with aluminum foil from the inside with a tile at the bottom of the mould for a flat and good surface finish. Then the other tile was also wrapped by aluminum foil. Fig. 2 shows the aluminum wrapped mould cavity and fig. 3 shows Experimental Setup placed in Electric Oven.

Fig. 2 aluminum wrapped mould cavity

ISSN:0971-1260
Vol-22-Issue-4-October-December-2019

Fig. 3 shows Setup placed in Electric Oven

Specimens were prepared for different proportion by using base material, reinforcement and the filler materials, whose details are given as shown in the Table 1. The materials are usually mixed according to % volume by calculating mass required to fill the mould cavity. The mixture poured into the mould cavity and carefully rolled over the thickness of the mould using Hand Layup technique. Then the other tile was also wrapped with aluminum foil and placed gently on the mould cavity. The set of the foil wrapped tiles and mould was placed over a M S plate, which has threaded holes at its corners. Then after proper aligning the other MS plate with free holes was placed over the mould setup and the whole set up was tightened using bolt and nuts. At the end the whole set up was placed over a stainless-steel tray and gently placed in the oven. After the specimen reaches a temperature of 110°C the whole setup is reversed for further equal distribution of heat to both sides and again heated for a temperature of about 145°C of the mould, since re-crystallization of Phenolic resin occurs at 145°C. Fig. 4 shows the Fabricated Specimens.

Table 1 Details of composite material fabricated

Sl. No.	Designation	% of Areca Fibre	% of Pongamia Pod Powder	% of Phenolic Resin
1	APC 05	05	30	65
2	APC 10	10	25	65
3	APC 15	15	20	65
4	APC 35	35	00	65

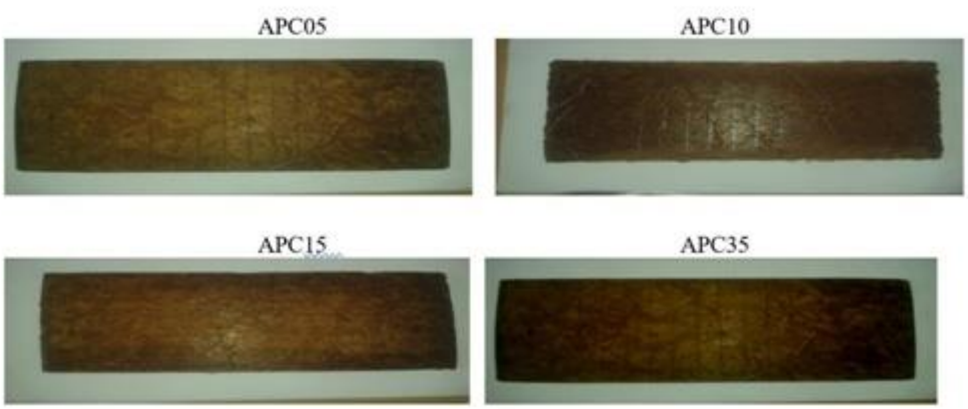

Fig.4 Fabricated Specimens

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4. EXPERIMENTATION

4.1 Properties Tested

The fabricated slabs were prepared to specimens according to the following ASTM standards whose details are given in Table 2.

Table2 ASTM Standards

Property	ASTM Standards
Thermal	Differential Scanning Calorimeter – ASTM E 2602 Thermo Gravimetric Analysis – ASTM E 1131 Specific Heat

5. RESULTS AND DISCUSSION

5.1 Differential Scanning Calorimeter

Table 3 Glass Transition Temperature

Composite materials	Glass Transition Temperature in °C
APC05	163
APC10	175
APC15	182
APC35	192

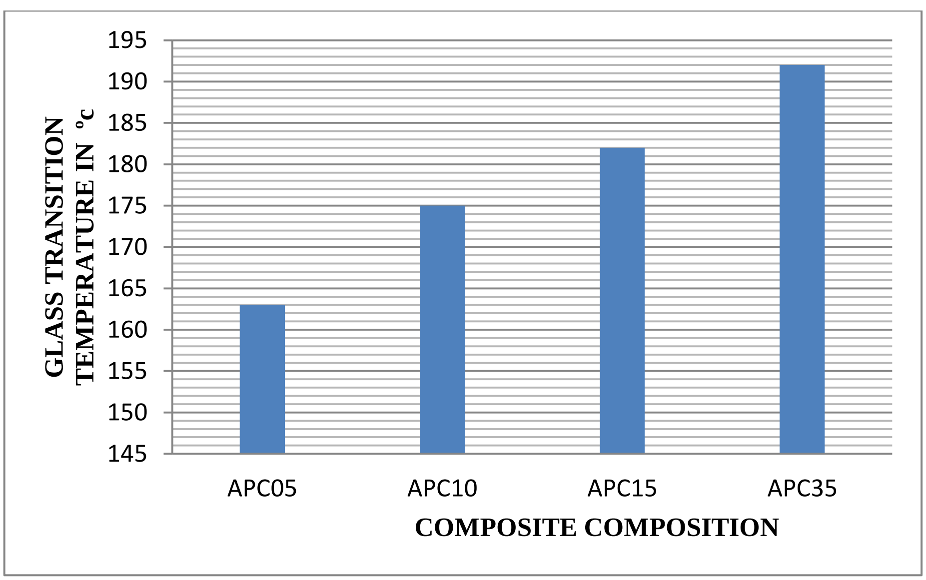

Fig.5 Glass Transition Temperature V/S Composite Composition

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The Fig. 5 represents Glass Transition Temperature (T_g) V/S Proportion of the composite specimens. It is noted that the T_g increases with the increase in composition of areca fibre. APC35 composite has the highest T_g Value of 192°C and at this temperature material change from a hard and brittle state into Elastic and Ductile state. Because Pongamia powder concentration increases the voids between molecules and thermal conductivity of composite material increases. So when heat was applied mobility of electrons also increases rapidly so it attains glass transition (phase transition) state quickly. Hence Glass transistion temperature reduces with the increase in powder and T_g increases with increse in fiber proportion, So Thermal Stability increases with increase in the fiber proportions.

5.2 Thermo Gravimetric Analysis

Table 4 Weight Loss with Temperature

Composite materials	Weight loss at 600ºC in %	Weight loss at 900ºC in %
APC 05	50.90	98.20
APC 10	50.60	97.60
APC 5	46.50	95.70
APC 35	48.40	98.50

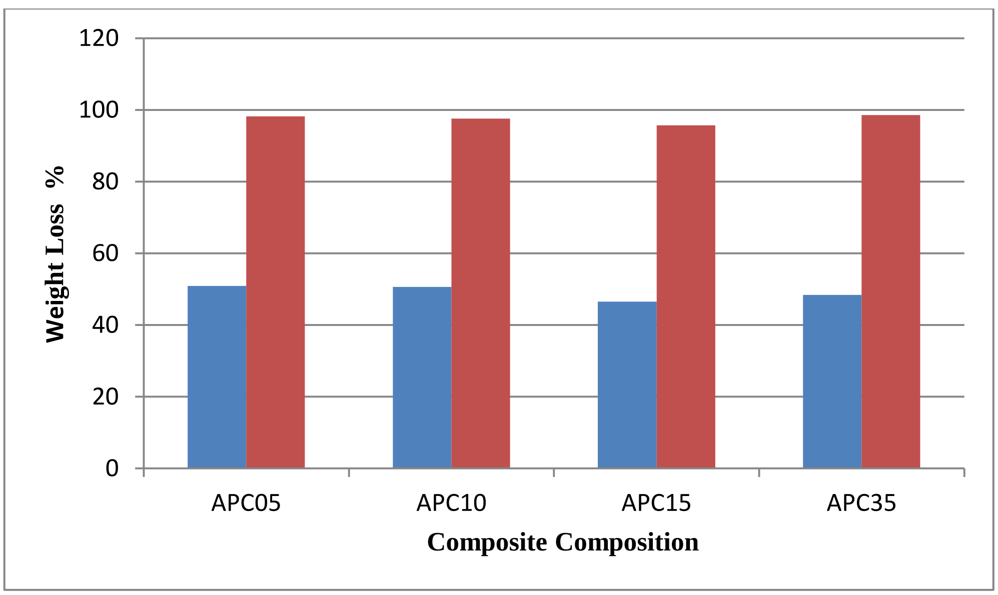

Fig. 6 Weight Loss V/S Composite Composition

The Fig. 6 represents the graph of loss of weight in percentage v/s polymer composite composition. Fig. 6 indicates the loss of weight is little more in APC 05, APC 10 in comparison with APC 15, APC 35. High proportions of Pongamia shell powder in Polymer makes polymer to loose weight little early than the polymers having lesser proportions of pongamia shell powder or absence of it. Higher proportion of Pongamia shell powder elevates the porosity among the molecules of composites and results in reduced density. It is evident that this porous polymer’s molecular bonds breaks at lower temperature because of higher proportions of shell powder. This is a direct indicative that degradation temperature decreases with increased shell powder proportions. It is observed that the composite APC 15 exhibits higher thermal degradation.

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5.3 Specific Heat

Table 5 Specific Heat

Composite materials	Trial No.	Initial Temperature of water in K	Final Temperature of water in K	Final Temperature of specimen in K	Mass of Specimen in kg	Average Specific heat, kJ/kg K
APC05	1	298.3	297.2	353	0.689×10^{-3}	4.50
	2	298.7	297.8	353	0.650×10^{-3}	
APC10	1	298.1	297	348	0.801×10^{-3}	5.01
	2	298.6	297.3	348	0.873×10^{-3}	
APC15	1	297.3	296.1	343	0.639×10^{-3}	5.90
	2	297.7	296.3	343	0.737×10^{-3}	
APC35	1	297	296	338	0.684×10^{-3}	6.04
	2	297.2	295.8	338	0.870×10^{-3}	

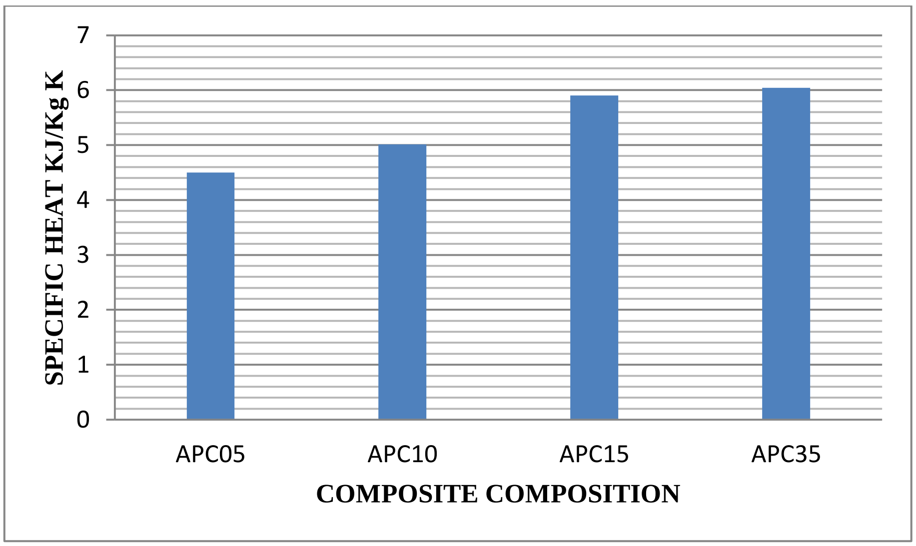

Fig.7 Specific Heat V/S Composite Composition

The Fig.7 represents the graph of specific heat v/s. Composite composition. It is noted that specific heat increases with increase in fiber composition. Due to the increase in fiber concentration, more amount of heat is required to increase its temperature. Also it was clear that the thermal stability increases with increase in the fiber proportion and thermal conductivity will increases with increase in the powder concentration, so the heat transfer between molecules are more. Hence specific heat reduces with the increase in powder concentration.

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6. CONCLUSION

The outcome of the research work carried are listed below

- From results it was found APC05 shows minimum value of specific heat of 4.5 kJ/kg K and it was also found that specific heat increase with increase in fibre proportion.
- In DSC, it was observed that APC35 shows maximum T_g of 192°C and it was also found that T_g value decrease with decrease in the fiber concentration.
- APC 15 shows minimum weight loss of 46.50 % and 95.70 % at 600°C and 900°C respectively in TGA test. It is observed that weight loss rate reduces with more fiber proportion and also there is little increase in higher concentration.
- Optimum composition of this work APC 15 can be used in the Chemical Industry, Automobiles, Ship building, Wind Thermal-interface materials

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