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Experimental Investigation of HDPE Composites with Epoxy and Plant Resin

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ABSTRACT: The epoxy based composite materials are harmful to living beings when they inhaled it, such as skin allergies, asthma and eye irritation and often headache etc. also epoxy is the thermoset resin which cannot be recycled and also it causes the environmental pollution. So the alternate solution of epoxy is the plant resin. Which is no hazardous and also gives good physical properties than the epoxy based composite material. Here we combined the high crystalline structure polymer with complete amorphous structure. The combination of high crystalline and amorphous polymer gives different results.

I. INTRODUCTION

The composite material plays a major role in the industrial defence as well as in the aerospace application. Due to its high strength to weight ratio it replaces the metal alloys with significant quantity. When two or more different material are combined, the result is a composite material. The first use of composite data back to the 1500B.C. when Egyptians and Mesopotamian settlers used a mixture of mud and straw to create strong and durable buildings. The composites are generally non homogeneous material because it combines two material which has different property. Any composite material consist of following material. Matrix, reinforcement, interfaced region

II. METHODOLOGY

Properties of crystalline and amorphous structure:

A. Crystalline structure (semi crystalline HDPE)

In reality there is no 100% crystalline structure in any polymer. Degree of crystallinity determines the crystalline structure of polymer. HDPE contains high crystalline structure of about 60%. The high crystallinity causes the material to be more brittle and less toughness. So the high crystalline structure does not withstand at high tensile strength.

B. Amorphous structure (Epoxy and plant resin)

The epoxy and plant resins both have polymeric structure but epoxy is synthetic and allergic but plant resin is harmless. They have amorphous structure. That means the unit cells in the solid will not repeat its arrangement they are randomly oriented. The amorphous structure withstand at high impact stress. But it cannot withstand at high tensile stress. The strength and the stiffness of the epoxy is less than the plant resin. Also the plant resin is biodegradable

C. Curing time for the epoxy based composites:

Generally curing time for epoxy is 2 to 3 days. For complete dryness it needs 3 days.

D. Curing time for plant based resin composites:

For plant based resin composites it needs roughly 5 hours. So curing time for plant based composites are less than the epoxy based composite material

Plant resin and natural fiber:

Prosopis juliflora is a tree which produces the thicker resin harder than the epoxy. The native of this plant is Australia. This plant causes the water scarcity in many countries especially Tamilnadu. The major use of this tree is to burning wood for fire. Reinforcements are generally used to increase the hardness of the material. Reinforcements are two types natural and synthetic fiber. Natural fibers are eco friendly than the synthetic fiber. Any natural fiber consist of the following component cellulose, hemicelluloses, pectins, lignin. Cellulose is the crystalline structure in the plant cell wall. It is generally polysaccharide component, higher the cellulose means higher tensile strength. Jute fiber has higher cellulose content of about 71%. So it can withstand at higher tensile strength. But the resilience of the jute fiber is minimum, on the other hand banana fiber has less cellulose content of about 26%. But its resilience is higher. The major disadvantages of the natural fiber is it is hydrophilic in nature. All natural resins contain the basic compound called turpenes. It is also called as chemical cry of the plants. There are totally 36000 species of turpenes are found till the date. The turpenes are used by the plants to communicate with each other. The turpenes are generally referred by as the smell. The highly volatile turpenes are smells stronger than the weak ones. Higher the crystalline structure in the solid the thermal conductivity is also much higher. But the amorphous structure in the solid cannot withstand at high temperature. Lignin is a complex hydrocarbon structure in the plant cell wall. It is difficult to extract and convert it into biofuel. If it is possible it is great alteration of the petroleum fuels.

Structure of HDPE and LDPE:

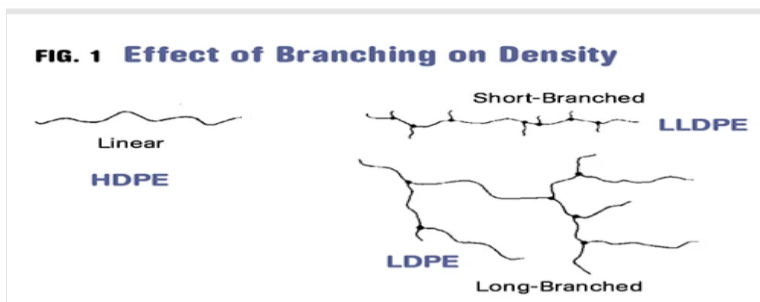


Figure 1

From this diagram if we separate the axis of the HDPE and LDPE. The HDPE looks similar in both the sides(semi crystalline). But LDPE is randomly oriented.(amorphous)

Structure of cellulose in plant fiber:

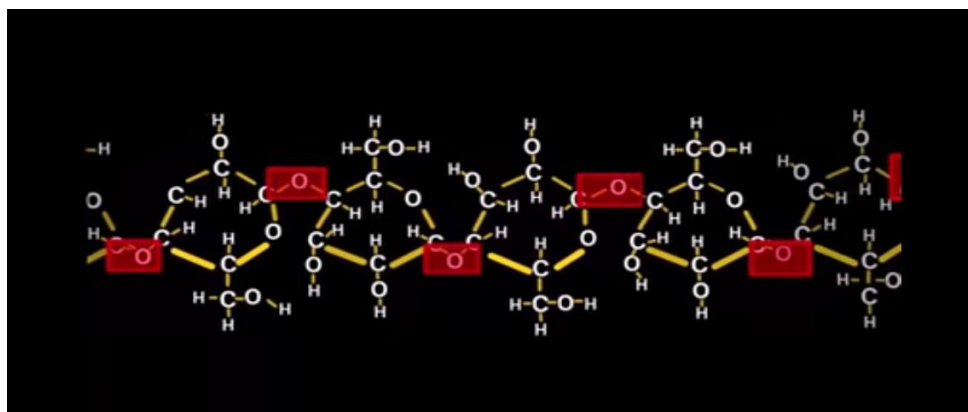


Figure 2

The above figure represents the structure of cellulose. It is just a glucose molecule which flip 180 degree with each other.

III. EXPERIMENTATION

HDPE and epoxy with jute and banana fiber as a reinforcement:

The combination of HDPE powder and Epoxy resin gives the strong polymer structure. It can withstand both tensile and impact stress than the previous one. Because here both the semi crystalline and complete amorphous structure are combined. Increasing the jute fiber increases the hardness of the composite material. Hence epoxy and HDPE acts as a basic matrix and the reinforcement gives the additional strength to it. While increasing the banana fiber the hardness decreases but the impact strength increases.

HDPE and plant resin with jute and banana fiber as a reinforcement:

The physical property of the prosopis juliflora tree resin is completely differ from the epoxy, such as melting temperature curing time etc. but it acts as best matrix material than the epoxy. The reinforcement combined with plant resin is more easier than the epoxy. While increasing jute fiber increasing hardness and increasing banana fiber decreasing hardness.

HDPE and epoxy based composite material with jute and banana fiber having different composition as reinforcement:



Figure 3

HDPE and plant resin based composite material with jute and banana fiber having different composition as a reinforcement:



Figure 4

The curing time for different composition is vary slightly. But the hardness of the material is significantly higher than the epoxy based composite. Brinell hardness and Rockwell hardness both are the macro hardness test which is used to find the hardness of the material.

Mass fraction of the epoxy and HDPE composite material:

Net weight: 30g

Epoxy + HDPE = 50% epoxy and 50% HDPE

Epoxy + HDPE + Jute fiber = 50% epoxy and 30% HDPE and 16% of jute fiber

Epoxy + HDPE + banana fiber = 50% of epoxy and 16% of HDPE and 30% of banana fiber.

During this experiment by varying the HDPE with addition of reinforcement gives the role of crystalline structure in composites.

Mass fraction of the plant resin and HDPE composites:

Net weight: 25g

Plant resin + HDPE = 40% of the plant resin and 60% of the HDPE

Plant resin + HDPE + jute fiber = 40% of the plant resin and 40% of the HDPE and 20% of the jute fiber.

Plant resin + HDPE + banana fiber = 40% of the plant resin and 20% of the banana fiber 40% of the banana fiber.

During this experiment by varying the HDPE with the addition of the reinforcement gives the role of crystalline structure in composites. The plant resin acts as a perfect matrix material for natural fibers than the synthetic fibers

Hardness test result in the epoxy HDPE composites:

Epoxy + HDPE = 25

Epoxy + HDPE + jute fiber = 30

Epoxy + HDPE + banana fiber = 28

Hardness test result in the plant resin HDPE composites:

Plant resin + HDPE = 27

Plant resin + HDPE + jute fiber = 33

Plant resin + HDPE + banana fiber = 32

It clearly shows that the hardness in the plant resin matrix composites are quite better than the epoxy. But the disadvantages of the plant resin is it cannot withstand as high temperature. Other than that it is eco friendly and very easiest way to prepare a composite material.

Prosopis juliflora plant



Figure 5

PH value of the prosopis juliflora resin:

Prosopis juliflora has the lowest PH and hence it is most acidic in nature. The gum is most adhesive and that increase in both ionic strength and PH favour. Noval excipients from plant sources are an incredible step ward in the field of pharmaceuticals for new drug discovery for the welfare of human being. Plant based materials are used by people inn various walk of the life, hence making it imper- ative that they shall be introduced in medicines too. Not just active ingredients but usage of plant based natural excipients in medicines will be the infallible trend very soon. The fact that *Prosopis juliflora* is an abundantly available plant resource will further make it a stronger candidate as to why it's gum exudate is suitable as an excipient. Steps must be taken to ensure that the *Prosopis juliflora* gum passes all regulatory requirements for use in approved forms

Test for flavonoid:

10% aqueous extract of the sample powder was made followed by vortex and ferric chloride and lead acetate tests were per- formed on it 5% aqueous extract of the sample was used to perform the Ben- edict Test, Iodine Test and the Molisch Test.

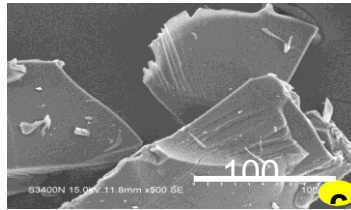


Figure 6

Figure 6 represent the *Prosopis juliflora* gum synthesized gold-palladium sputter-coated particles of different size TGDTA (Thermogravimetry Differential Thermal Analysis):

The thermodynamic qualities are very important to understand the dehydration and evaporation processes which are governed by water transition into crystalline or gaseous nature. The curves of TGDTA for mesquite gum depict at different proportions of water. The first stage was occurred after loss of water at set temperature (Tonset) at around 260°C, this loss can be attributed to typical polysaccharide content with 77.35%. The second stage was occurred with a residual content of 39.77% at end set temperature (Tendset) around 310°C, the residue proceeded towards the carbonization

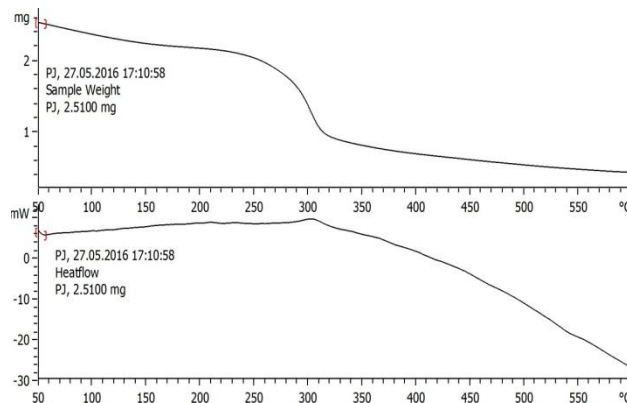


Figure 7

Phytochemical Tests:

The phytochemical tests showed a clear presence of carbohydrate, flavonoid and cardiac glycosides in the *Prosopis juliflora* gum extudate. However, the tests performed are basic and preliminary in nature and requires the validation of other instrumental analysis (Fig. 6). The failure of experiment in some of the cases may be indicative of the presence of certain impurities alongside the sample powder or it may also imply that a water extract of the sample may not be suitable for the performance of such tests.

Test for protein:

A 10% aqueous extract was made by mixing the powder in double distilled water followed by vortex till the powder

IV. CONCLUSION

From the Rockwell hardness test of the specimen . it clearly shows that the plant resin matrix composite especially *prosopis juliflora* plant resin posses great strength and resistance to scratch than the epoxy based composites material. Hence it is suitable only for natural fibers synthetic fiber reinforced composites are preferred epoxy for a matrix material. Quickest curing method in epoxy may gives the hardness near to plant resin matrix composites. But it needs some effort to do that. Generally quickest cooling method in the metal give rise to the martensitic structure. But is polymer it wont happens, instead of that it increases the brittliity of the material.



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