EXPERIMENTAL INVESTIGATION OF MECHANICAL PROPERTIES OF SISAL FIBER BY USING DIFFERENT RATIO OF NAOH

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Abstract

In last few years, to make low cost construction materials natural fibers are in huge demand. As natural fibers have better mechanical properties, so they can easily replace synthetic fibers. Among various different fibers, in this paper sisal fiber is in focus. Sisal plants are easy to grow and have short period of regeneration in any kind of environment. Each leaf of sisal fiber produces 1000 fibers and a good sisal plant can give us around 200 leaves. The present work aims on the properties of sisal fiber such as tensile strength, tensile extension, compressive strength and flexural strength. For making composites, Hand Lay-Up Technique is used. With this technique, the results obtained shows that sisal fiber with 2% NaOH gives the maximum value of all the properties. For future use, more researches and studies are required.

Keywords: Composites, NaOH, Epoxy, Mechanical properties, Tensile strength, Flexural strength, Compressive strength

1. Introduction

Recently, because of their extensive use in many diverse fields, plastics, including FRP (fiber reinforcedplastics) products have become indispensable to our daily lives. However, the primary raw material used in plastic production is petroleum and there are strong social and economic pressures to conserve petroleum resources.Furthermore, because FRP wastes are non-flammable, they must be disposed of in landfills after use, and this contributes to high environmental loads. In order to reduce the environmental load generated from the disposal of used plastic products, significant attention has been placed on biodegradable plastics. These plastics can be completely resolved into water and carbon dioxide by the action of the microorganism, when disposed of in the soil. Moreover, there are no emissions of toxic gases during incineration. Recently, biodegradable plastics have been used in commercial products such as ball-point pens, toothbrushes, garbage bags, fishing lines, tennis racket strings, wrapping paper and many others. The appRecently, because of their extensive use in many diverse fields, plastics, including FRP (fiber reinforced plastics) products have become indispensable to our daily lives. However, the primary raw material used in plastic production is petroleum and there are strong social and economic pressures to conserve petroleum resources. Furthermore, because FRP wastes are non-flammable, they must be disposed of in landfills after use, and this contributes to high environmental loads. In order to reduce the environmental load generated from the disposal of used plastic products, significant attention has been placed on biodegradable plastics. These plastics can be completely resolved into water and carbon dioxide by the action of the microorganism, when disposed of in the soil. Moreover, there are no emissions of toxic gases during incineration. Recently, biodegradable plastics have been used in commercial products such as ball-point pens, toothbrushes, garbage bags, fishing lines, tennis racket strings, wrapping paper and many others. The application of biodegradable plastics has been restricted due to their relatively lower strength compared to conventional plastics such as poly acetal and nylon. Over the past few years a considerable number of studies have been performed on biodegradable composites containing biodegradable plastics with reinforcements of biodegradable natural fibers. Sisal fiber is the most interesting products as it has the lowest thermal conductivity and bulk density. The addition of planate Sisal reduced the thermal conductivity of the composite specimens and yielded a lightweight product. Sisal–vinyester composites with untreated and treated sisal fibers, and with fiber loading of 17 wt%, were tested intension, flexure and notched Izod impact. The results obtained with the untreated fibers show clear signs of the presence of a weak interface long pulled-out fibers without any resin adhered to the fibers and low mechanical properties were obtained. Although showing better mechanical performance, the composites with treated fibers present. Acetylating of sisal fibers increases the hydrophobic behavior, increases the resistance to fungi attack and also increases the tensile strength of sisal polyester composites. From these results, it is apparent that the usual fiber treatments reported so far did not significantly change the mechanical performance of sisal polyester compositeslocation of biodegradable plastics has been restricted due to their relatively lower strength compared to conventional plastics such as poly acetal and nylon. Over the past few years, a considerable number of studieshave been performed on biodegradable composites containing biodegradable plastics with reinforcements of biodegradable natural fibers. Sisal fiber is the most interesting products as it has the lowest thermal conductivity and bulk density. The addition of planate Sisal reduced the thermal conductivity of the composite specimens and yielded a lightweight product. Sisal–vinyester composites with untreated and treated sisal fibers, and with fiber loading of 17 wt%, were tested intension, flexure and notched Izod impact. The results obtained with the untreated fibers show clear signs of the presence of a weak interface long pulled-out fibers without any resin adhered to the fibers and low mechanical properties were obtained. Although showing better mechanical performance, the composites with treated fibers present.Acetylating of sisal fibers increases the hydrophobic behavior, increases the resistance to fungi attack and also increases the tensile strength of sisal polyester composites. From these results, it is apparent that the usual fiber treatments reported so far did not significantly change the mechanical performance of sisal polyester composites.

Natural Fibers: Fibers obtained from plants such as cotton, hemp, jute, sisal, bamboo, banana, etc., as well as wood and flax seeds are used as reinforcement in polymer matrix composites. It becomes attractive alternative because of its availability, low density and price, and adequate mechanical properties.

Classification Natural Fibers- On the basis of origin, animal, plant and mineral species natural fibers are classified which is shown in figure.

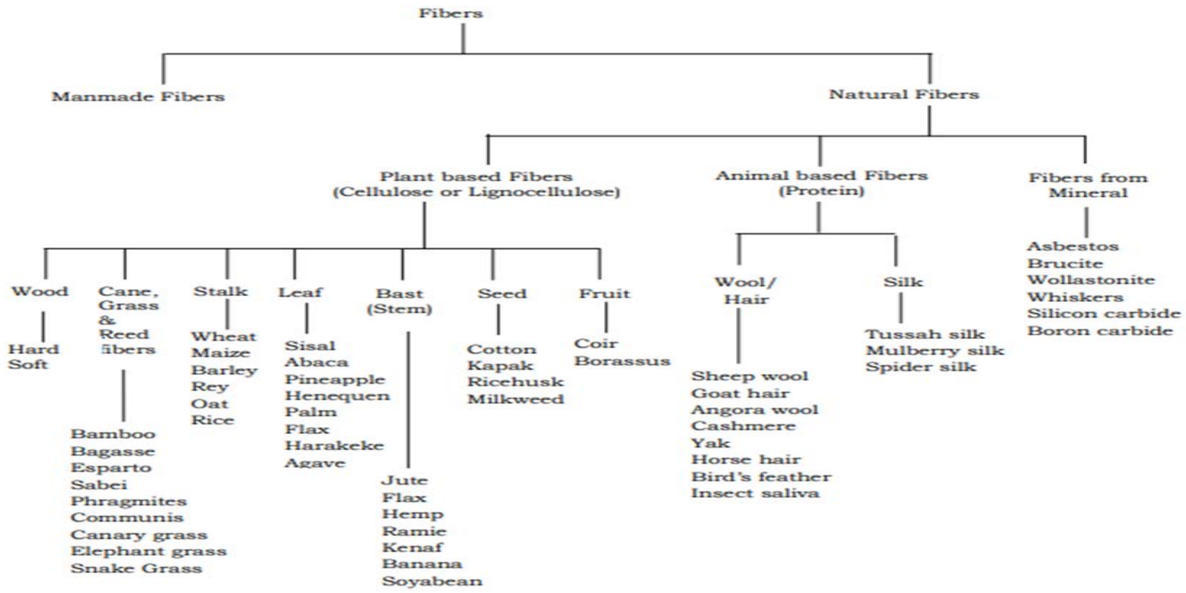

Figure 1 Classification of natural fibers

Sisal Fiber: Sisal fiber is extracted by the plant leaves of Agave Sisal Ana, which is categorized under the heading of "solid fibers," in which sisal is rated in strength and durability next to manila. These fibers were woven by hand in ancient days, and used to make cords, carpets, and garments. It is one of the world's most widely grown hard fibers, accounting for half of the total textile fiber supply. Sisal plants are easy to grow and have short period of regeneration in any kind of environment. Each leaf of sisal fiber produces 1000 fibers and a good sisal plant can give us around 200 leaves.

Figure 2 Sisal Plant

2. ***Surface modification of Sisal Fiber***

- **Formula Calculation**

$$Mol = \frac{a}{Mol\,Weight} \times \frac{100}{V}$$

Where,
a = NaOH (gm.)
Mole Weight = NaOH
V = volume (liter)

Mercerization also known as alkali treatment of natural fibers. This method is used to modify the surface of sisal fiber. In this process 2 mole, 4 mole and 6 mole of the NaOH solution was prepared and sisal fiber fibers were soaked into this solution. Due to this an increase in the amount of amorphous cellulose at the cost of crystalline cellulose and the removal of hydrogen bonding in the network structure. The treatment has been shown to improve the adhesion characteristics, due to improved work of adhesion because it increases the surface tension and surface roughness. The resulting composites showed improvements in the compressive strength and water resistance. It has been suggested that the removal of intracrystalline and inter crystalline lignin and other surface waxy substances by the alkali substantially increases the possibility for mechanical interlocking and chemical bonding. The alkali treatment is simple and is recommended to precede other sophisticated surface modification treatments on plant fibers similar to sisal fiber.

- **Composite Fabrication**

Hand Lay-Up Technique
Hand lay-up technique is one of the most convenient methods to be used with very little investment in infrastructure. Hand lay-up technique is very basic with simple processing steps. In the next step, before putting the polymer on the mold, its surface is sprayed by a gel so that it will not stick to each other. Thin plastic sheets are also used at top and bottom of the plate for more accuracy. Woven mats are cut in the form of mold and kept on the sheet of Perspex. Required amount of thermosetting polymer is mixed in liquid form with a curing agent. And then it is poured on the surface and

with the help of a brush it must be spreaded evenly. Now next layer of the mat is placed on it and with a mild pressure remove sir bubbles from it if present. The same procedure is repeated for every mat till the accurate layer is stacked.

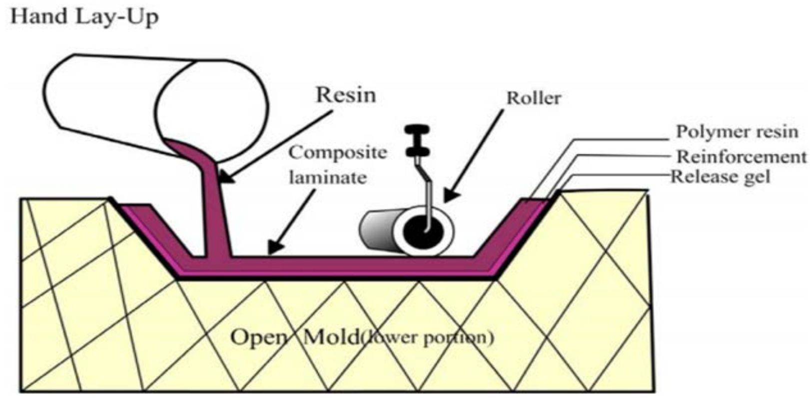

Figure 3 Hand Lay Up Technique

3. Methodology

In this chapter, the procedure and characterization of composites is described. Basically, only three raw materials are used in this research. List of raw material is given below:

1. Sisal fiber
2. Epoxy Material
3. Sodium Hydroxide (NaOH)

As shown in the flow chart below, 4 cases are taken with the raw material: sisal fiber, epoxy material and sodium hydroxide.

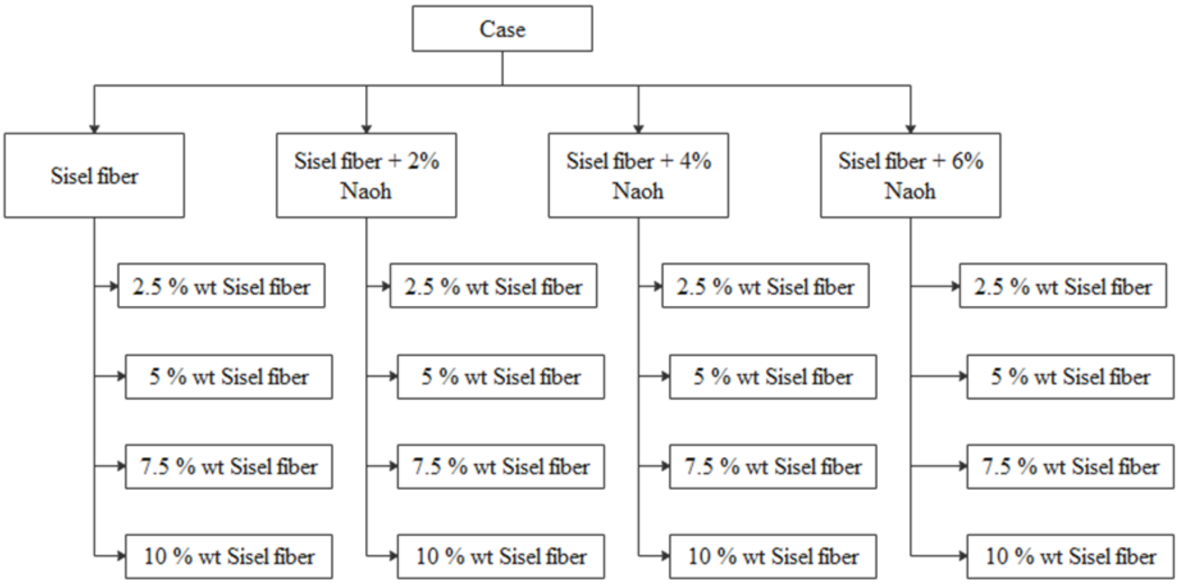

Figure 4 Four Cases of Sisal Fiber

❖ Sample preparation

Four samples have been taken of Sisal fiber, Epoxy Harder, NaOH and distilled water.

1. Sample 1 was a combination of raw Sisal fiber and Epoxy/hardener.
2. Sample 2 was a combination of 2 % NaOH solution modified Sisal fiber with Epoxy/ hardener.
3. Sample 3 was a combination of 4 % NaOH solution modified Sisal fiber with Epoxy/ hardener.
4. Sample 4 was a combination of 6 % NaOH solution modified Sisal fiber with Epoxy/ hardener

4. Mechanical Testing

As a result, hybrid composites were tested to conduct tensile testing, Compressive testing.The measurements of all the research specimens for the individual experiments were established in compliance with the ASTM requirements.

Universal testing machine is used for test specimen to calculate the mechanical properties by exerting compressive or tensile stresses.

Computer will be used in it so that number of tests can be performed with accuracy. Some other tests which can be used are tension test, spring test, peel test, etc.

Figure 5 Universal Testing Machines

5. Result

Tensile strength Result

The tensile strength of sisal fiber has been tested and results are shown in the figure 6 given below. The graph shows the different categories of the sisal fiber and their tensile strength. From the graph it can be concluded that tensile strength decreases with the increase in wt. percent of the sisal fiber and also 2% NaOH shows the maximum tensile strength.

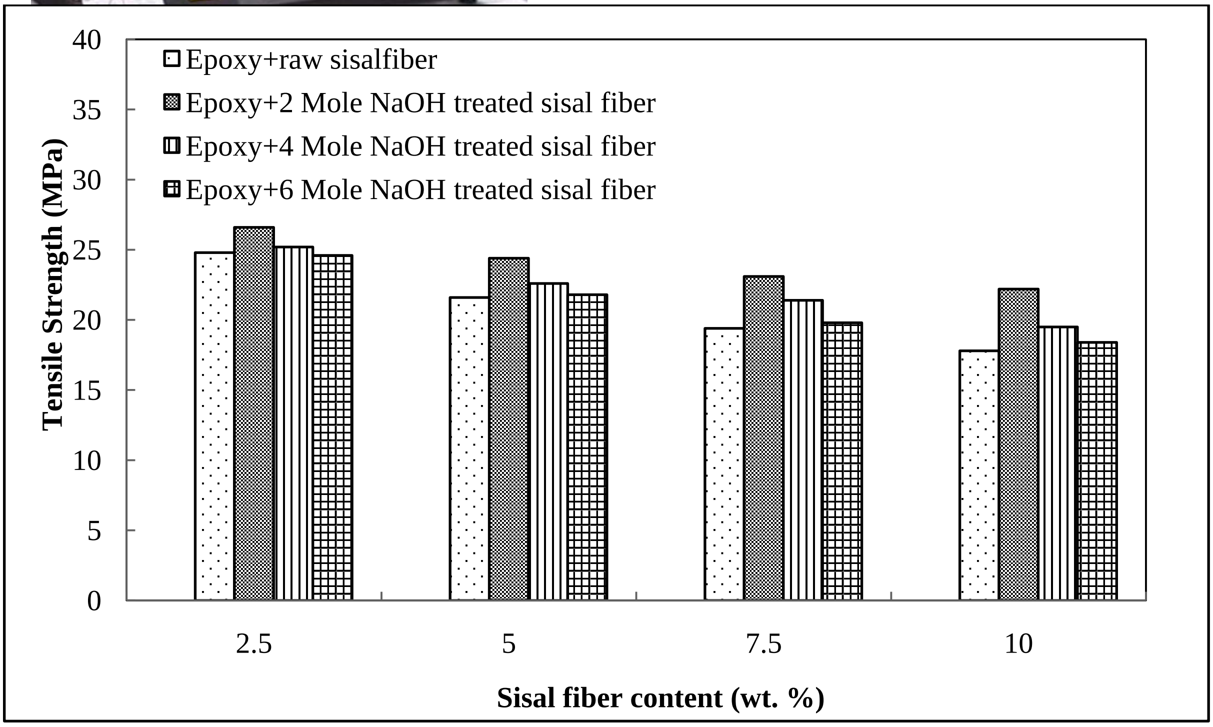

Figure 6 Graph representing tensile strength of different samples

Tensile Extension Result

The tensile extension of sisal fiber has been tested and results are given below in the figure 7. The graph shows the different categories of the sisal fiber and their tensile extension. It is clear from the graph that tensile extension increases with the increase in wt. percent of the sisal fiber, from this it is also concluded that 2% NaOH shows the maximum tensile extension

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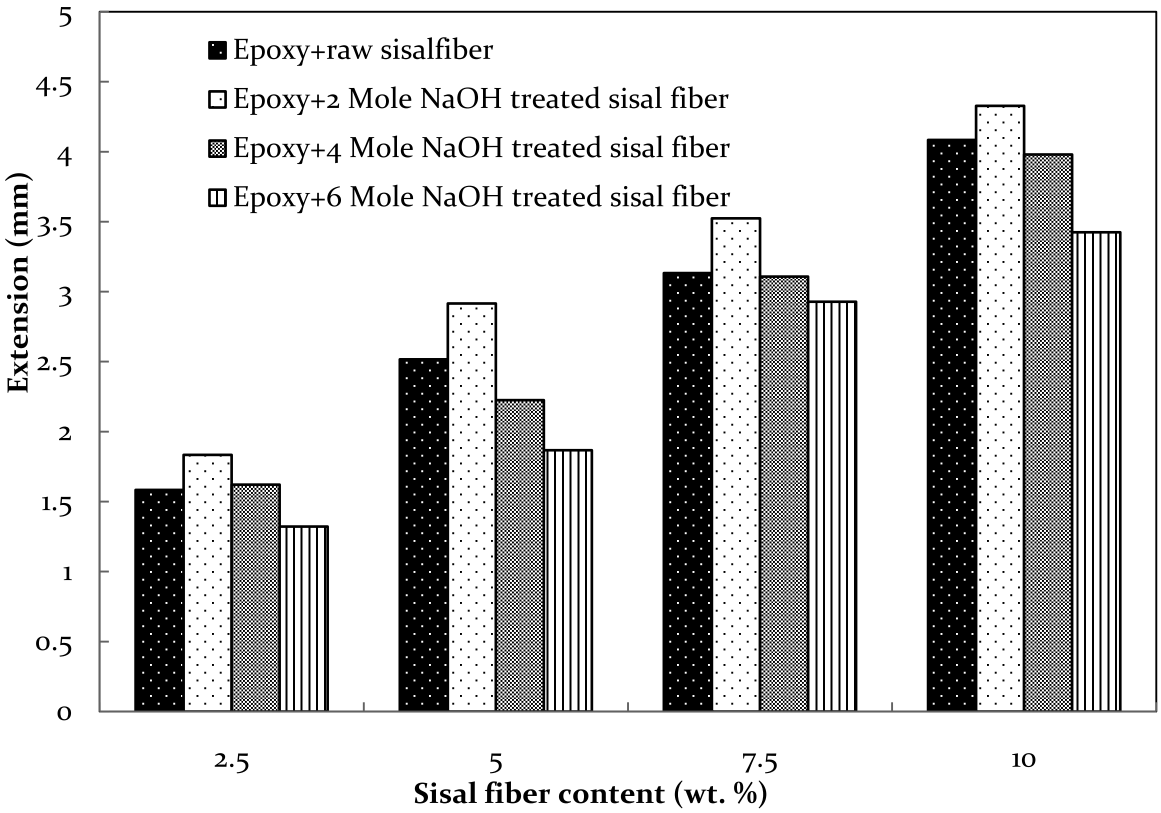

Figure 7 Graph representing tensile extension of different samples

Compressive Test Result

The compressive test of sisal fiber has been tested and the results are given below in the figure 8. The graph shows the different categories of the sisal fiber and their compressive strength test. It is clear from the graph that compressive strength increases with the increase in wt. percent of the sisal fiber. 2% NaOH and 4% NaOH started from the same point but 2% NaOH is showing gradual increase, from this it can be concluded that 2% NaOH shows the maximum compressive strength.

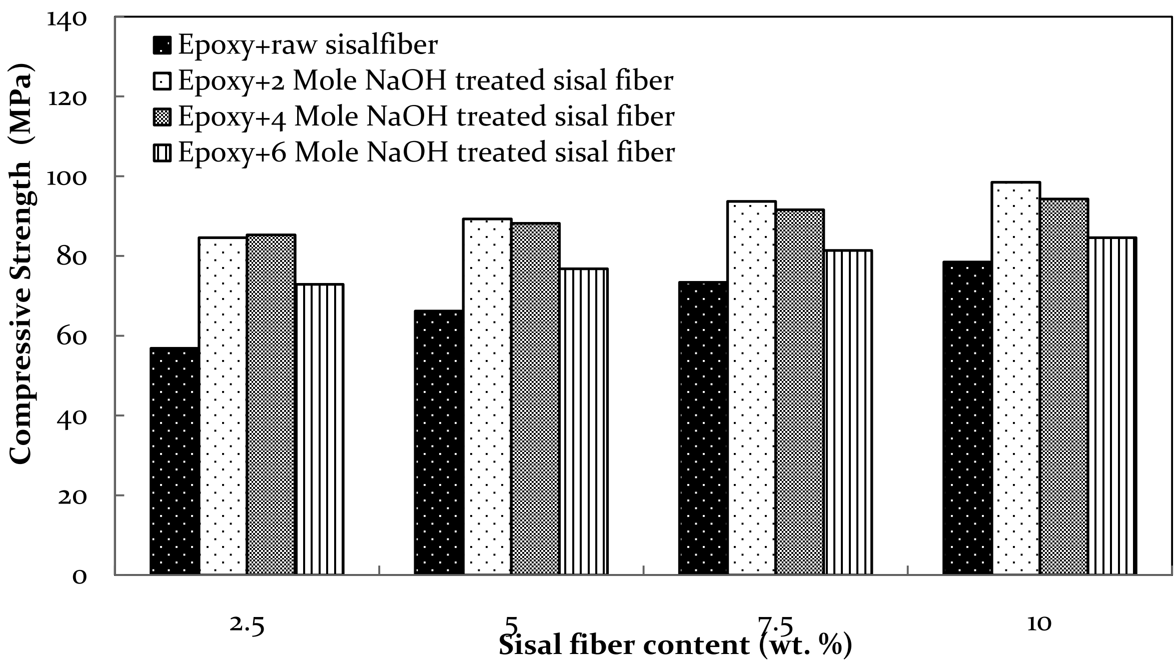

Figure 8 Graph representing Compressive Strength of different samples

Flexural Test Result

The flexural test of sisal fiber has been tested and results are given below in the figure 9. The graph shows the different categories of the sisal fiber and their flexural strength test. It is clear from the graph that 2% NaOH and 4% NaOH started from the same point but 2% NaOH is showing rapid increase, from this it can be concluded that 2% NaOH shows the maximum flexural strength.

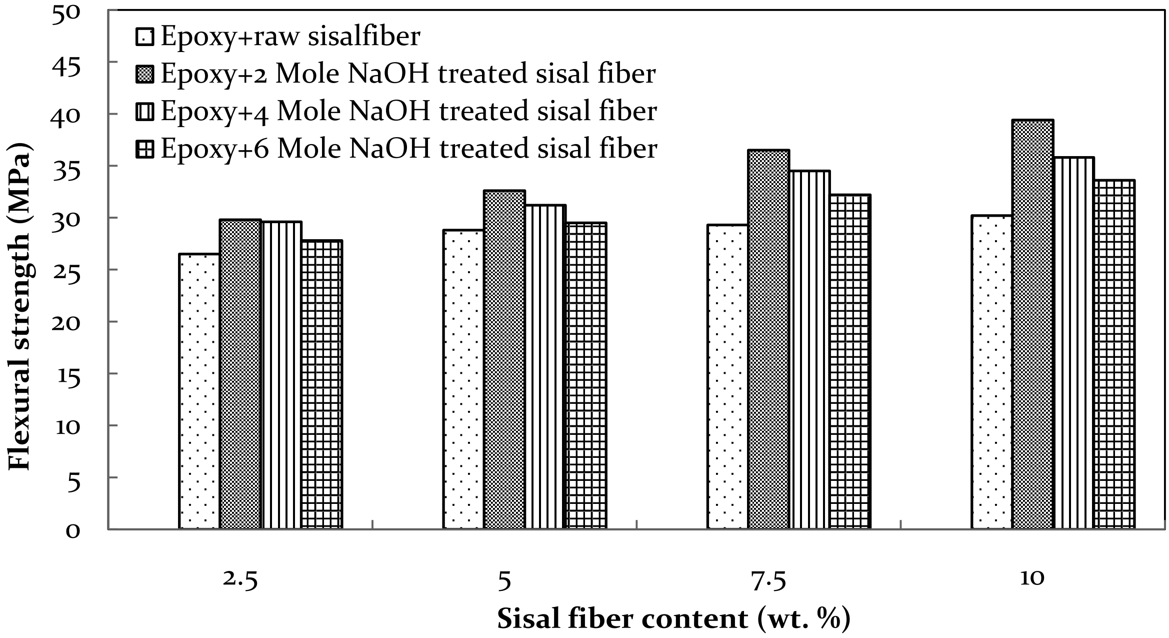

Figure 9 Graph representing Flexural strength of different samples

Conclusion

From the above mentioned results, various properties of sisal fiber are concluded. Compressive and flexural strength is the property of sisal fiber as well as tensile strength and extension also. By the results of these properties, it is concluded that all over strength can be increased with the increase of weight percent of sisalfiber.

- From the above-mentioned results, various properties of sisal fiber are concluded. Compressive and flexural strength is the property of sisal fiber as well as tensile strength and extension also. Water absorption rate of sisal fiber is also tested. By the results of these properties.
- The tensile strength for the 2% NaOH treated and 2.5 wt % composite is more than the comparatively all other composites.
- The compressive strength, flexural strength and extension rate for the 2% NaOH treated and 10 wt % composite is more than the comparatively all other composites.
- The water absorption rate increases with increasing the NaOH percent and the least absorption rate is observed in pure epoxy in all 4 different wt. % of sisal fiber.
- The results also conclude that sisal fibre with 2% NaOH gives the maximum value of all the properties.
- However, to identify more properties of the sisal fibre to improve its mechanical performance further researches and studies are required.

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