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MECHANICAL PROPERTIES OF ALKALI TREATED AGAVE AMERICANA (RAMBAANS) FIBRE REINFORCED EPOXY COMPOSITE

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Abstract— Composite based on short Agave Americana (Rambaans) fibre (untreated and alkali treated) reinforced epoxy resin using three different fibre length (3 mm, 5 mm, and 10 mm length) are prepared by using open mould technique. The composite thus prepared were subjected to the evaluation of different mechanical properties such as tensile and impact strength. The results obtained suggest that composites reinforced with Agave Americana fibre exhibited better mechanical properties than neat epoxy. All mechanical test showed that alkali treated fibre filled composites withstand more fracture strain than untreated fibre composites.

Keywords— Composite; Agave Americana fibre; Alkali treatment; Epoxy Polymer; Tensile and Impact strength

I. INTRODUCTION

With growing environmental awareness, ecological concerns and new legislations, bio-fibber-reinforced plastic composites have received increasing attention during the recent decades. The composites have many advantages over traditional glass fiber or inorganic mineral-filled materials, including lower cost, lighter weight, environmental friendliness, and recyclability. In addition, uses of their composites have established comparable performance with those of glass fiber composites with possibility for their use as structural components as well [1-3]. When such materials are used in composites, developing countries, which produce these, become part of global composite industry as developer and manufacturer leading to increased revenues and creation of jobs [4]. In view of the above, many attempts have been made to characterize the lignocellulosic fibers either individually [5-6], or as part of their composites research [7]

These composite materials have received much commercial success in the semi structural as well as structural applications [8-11]. For example, interior parts such as door trim panels from natural fiber polypropylene and exterior parts such as engine and transmission covers from natural fiber–polyester resins are already in use.

Agave Americana is a monocotyledon plant that belongs to the Agavaceae family. It normally grows in tropical, subtropical and temperate regions of the world. Traditionally, its fibres have been used in ropes and other textile applications. It can be extracted from the leaves in various ways including heating these leaves in hot water, retting them in seawater [12], or using other chemical or mechanical means.

In this study we used epoxy resin as matrix materials and Agave Americana as fibre have been used to prepare biocomposite material. The main objective of the work is to analyse the static and dynamic properties of alkali treated chopped Agave fibre reinforced epoxy composites at different fibre length and fibre weight %.

II. METHODOLOGY

A. The raw Agave fibre Procurement of Materials

The Bisphenol A type epoxy resin (CY230) used for the study was purchased from M/s Petro Araldite Pvt. Limited, Chennai, India. Hardener (HY-951) was purchased from M/s CIBATUL Limited, India and Agave Americana (Rambaans) fibre used in the present investigation was arranged from local market. Agave Americana fibre extracted from agave Americana plant leaves

B. Procedure for Extraction of Fibre from the Plant

Agave leaves were harvested and their margins were trimmed to avoid the thorns. Then the leaves were sun dried for 2 days to remove excess moisture. Retting of the leaves was carried out by immersing them in water for minimum 2 weeks. This facilitates maceration of the fleshy layers of the leaves. The retted leaves were then manually beaten to remove the flesh. The cured fibres were then thoroughly washed and combed to free the flesh thoroughly and was air dried for two to three days at room temperature. The dried fibres were thinned by ramming it in order to remove the unwanted short and broken fibres. The entire fibre extraction process takes 20–25 days.

C. Alkali Treatment of Fibre

The raw Agave fibre was washed with water for three to four times for complete removal of the plant debris and dried at room temperature for 48 hours. The raw fibre were immersed in sodium hydroxide solution for 2 hours and then washed with very dilute hydrochloric acid (HCl) to remove the excess alkali. Then, the fibre was rinsed with cold water twice or thrice. The rinsed fibres were dried at room temperature for 2–3 days. In this study the fibers were treated with 5%, 10%, and 15% NaOH solutions.

D. Preparation of Agave Americana Fibre filled composites

The treated and untreated Agave Americana fibre at different length and different weight percent was completely dissolved in epoxy resin at 100°C using magnetic stirrer with hot plate at a speed of 500 rpm for 1 hour. The epoxy resin and fibre mixtures were kept in still air and allowed to reach 40°C. Next, 10 wt% of polyamide (HY 951) was added and stirred at a speed of 200 rpm for 3 min. Thereafter, the blends were poured in different moulds previously coated with releasing agent. Then the mixture was cured at room temperature for 24 hours. After that, each specimen was cut and polished with sandpaper. Finally, the specimen was post-cured at 120°C for 2 h in a mechanical convection oven. The biocomposites thus prepared are named as alpha-numeric system to indicate the fiber length and wt % of fiber. The letter L is used for length and W is used for wt %. For example, L3W10 indicates the fiber length as 3 mm and 10 wt % fiber.

III. RESULTS AND DISCUSSION

A. Tensile Strength

The effect of NaOH treated fiber of different length and wt % on the ultimate tensile strength and ductility have been presented in Figs. 1-4. Figures reveal that as the % of NaOH solution increased the ultimate strength as well as ductility increases. The maximum value is attained for the fiber treatment with 10 % NaOH solution. Thereafter, the strength and ductility decreases due to higher % of NaOH treated fibers. NaOH alkaline treatment is one of the most commonly used chemicals in the mercerisation process since it is able to hydrolyse and remove impurities present in cellulose. At 10 % NaOH concentration, no precipitation of lignin or other non-cellulosic material on the fiber surface may improves the properties. At higher NaOH concentration, a larger residue on the surface may be one of the causes for properties reduction. NaOH treatment also removes the waxy and fatty acids residues which is also responsible for the enhancement of the properties. Confirmation of the cause can be studied from the chemical analysis, SEM and XRD studies.

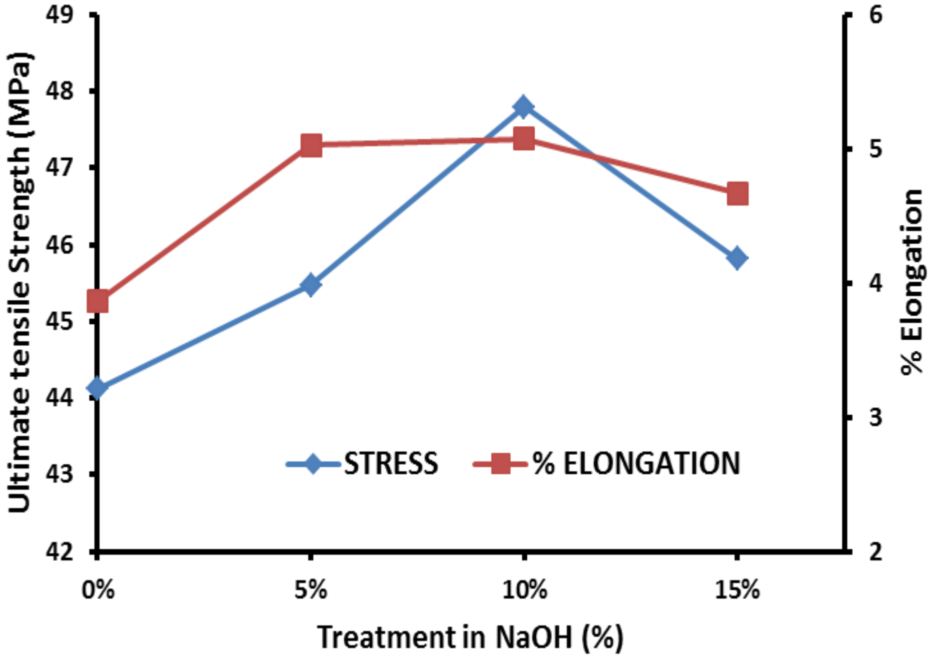

Fig. 1 : Effect of NaOH Treatment on Ultimate Tensile Strength and % Elongation

In Fig 2-4, the effects of fiber length and fiber wt % on the ultimate strength and ductility are shown for 10 % treated fibers. It is seen that 10 wt% fiber shows the higher ultimate strength for fixed fiber length whereas 5 wt% of fiber shower higher ductility. Increasing length of fiber shows overall decreasing nature of both the properties. This may be due to debonding of fiber during tensile loading. Loss of ductility with higher fiber content is due the restriction of plastic deformation.

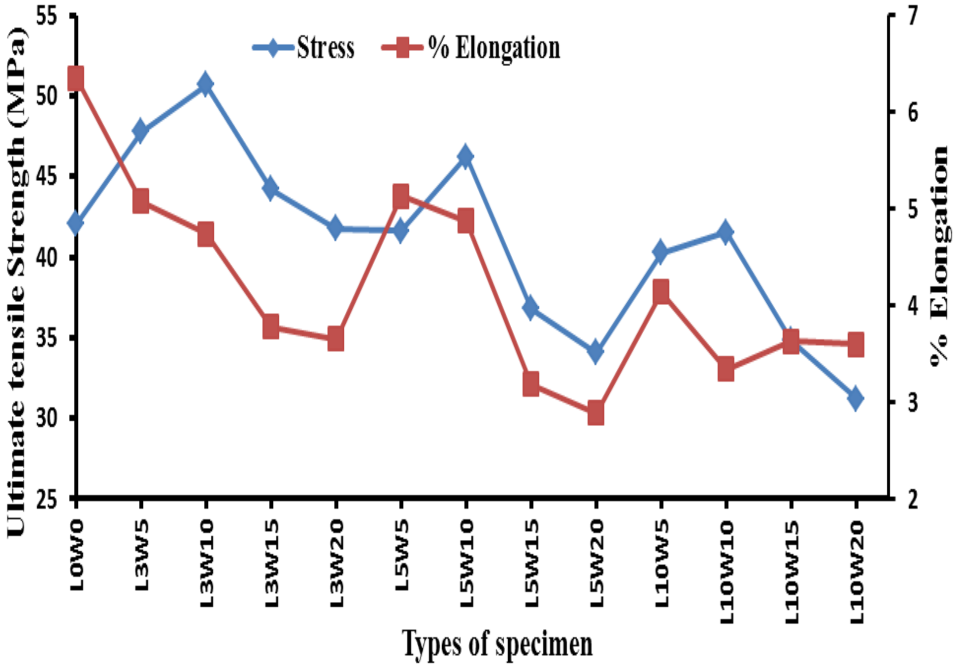

Fig. 2: Ultimate Tensile Strength and % Elongation

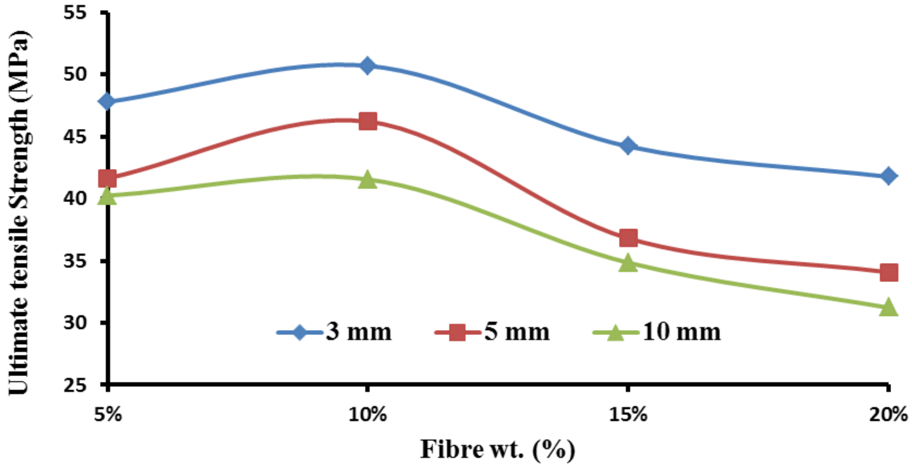

Fig. 3: Effect of Fibre Length on Ultimate Tensile Strength

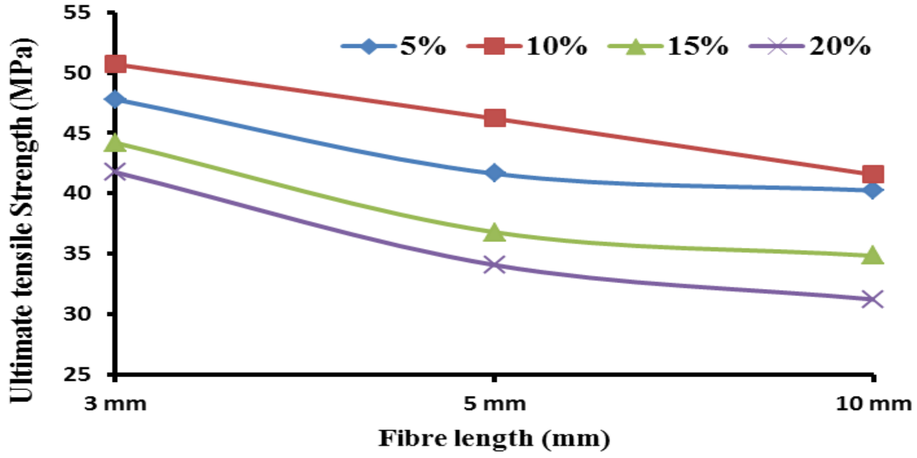

Fig. 4: Effect of Fibre Weight on Ultimate Tensile Strength

B. Impact Strength

Fig. 5-7 shows the impact strength of NaOH treated Agave Americana fiber reinforced biocomposites. Highest impact strength is observed aor 10% NaOH treated composite. With higher concentration of NaOH, impact strength decreases.

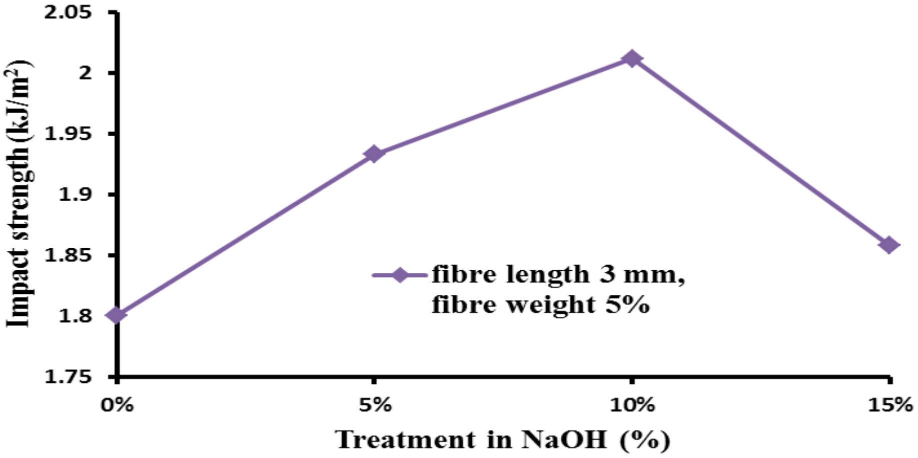

Fig. 5: Effect of NaOH Treatment on Impact Strength

In Fig. 6 it is seen that impact strength increases with the increase of fiber length. Fig. 7 shows the effect of wt % of fiber content on the impact strength. With increasing fiber content and fiber length impact strength increases. As the length of fibers increased, the fibers in the composites absorbed more energy, thus higher impact strength is achieved with increasing fiber length. Energy required for the fracture of the fiber depend upon the volume of the fiber. Fiber fracture energy is therefore low for fiber debonding and higher for fibre pull-out. In the present case as the fiber fracture is prevailed over fibre pullout, the impact energy increases with the increase of the fiber content.

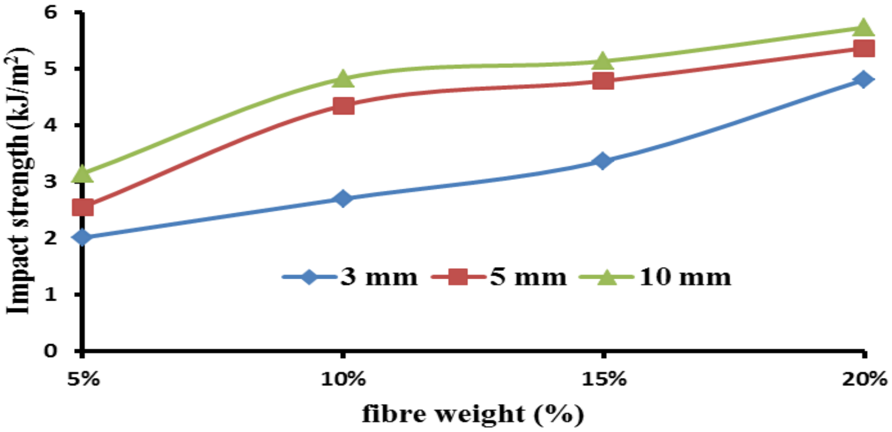

Fig. 6: Effect of Fibre Length on Impact Strength

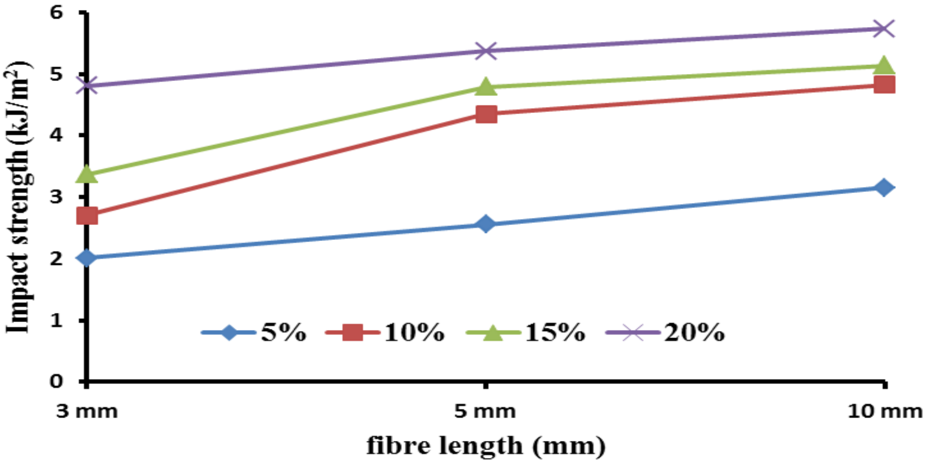

Fig. 7: Effect of Fibre Weight on Impact Strength

IV. CONCLUSIONS

The result of present study showed that useful composites with good strength could be successfully developed using Agave Americana fibre reinforced epoxy composites. It can be seen that 10% NaOH treated fibre filled composite have highest Ultimate tensile strength, higher % elongation and highest impact energy as comparison of untreated, 5% NaOH treated and 15% NaOH treated fibre filled composites. So we can get optimal result at 10 % NaOH treated fibre filled composite.

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