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RESEARCH ARTICLE

THE EFFECT OF AIR BUBBLING TREATMENT ON THE WATER ABSORPTION PROPERTY OF BANANA FIBRE REINFORCED COMPOSITES

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ABSTRACT

The effect of alkaline treatment in combination with air bubbling in banana fiber mat on the water absorption property of the fiber composite has been experimentally studied. Hot water immersion test is done on the samples. Water uptake was quantified for the composite disc under different processing conditions. The studies have revealed that the fibre surface modification rate is enhanced by the combination of air bubbling with the general process of alkaline treatment. This shows the importance of this method of fibre treatment and this shall encourage other researchers to develop an adequate system to expedite fabrication for better quality of woven banana fibre composites for various sectors such as household utility or automobile parts.

INTRODUCTION

The interest to develop biofibre reinforced composite is growing day by day on the onset of environmental awareness to address the issues of waste management. Natural fibers are being used as reinforcement in thermoplastic and thermoset resin matrices. The thermoplastics offer recycling possibilities whereas the thermosets achieve improved mechanical properties [1]. With the improvement in the properties of the fibre reinforced plastics, these are now widely accepted for use in structural and non structural applications. Biofibres are hard cellulose fibres which are environment friendly being degradable, renewable and inexpensive material. The different fibers that are playing a major role in the segment are jute, flax, banana, sisal and pineapple [2]. It is found that these fibers possess good mechanical properties and they also offer good electrical resistance, thermal and acoustic insulation [2,3]. They also have shock and fracture resistance properties.
Surface modification is done to improve bonding and affinity towards matrices. Much work is done on the thermal treatment, alkaline treatment and enzymatic treatment on the fibers. It is well known that alkaline treatment cleans the fiber surface of its impurities, modifies the surface structure to increase the surface area and also modifies the fiber composition to some extent. With the increase in surface area, the cellulose microfibrils get exposed, which in turn improves the wettability and impregnation [4]. Researchers have investigated into the effect of various fiber pre-treating solutions [5]. Different kinds of bio fibers have been treated with sodium hydroxide and used as reinforcement in polymers [6, 7]. It is observed that most of the fiber modification processes take up much time. The present work is done to investigate a method to reduce the time for the alkaline treatment of the fibers. Fiber mats are submerged in the alkaline solution and air is bubbled through the solution. After various exposure times, these mats are processed into composite plates and the water absorbance rate is found out. The results obtained indicate that this could be a promising process for the alkaline treatment.

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Experimental

The banana fibers were worked upon to make the fiber composites and then the water absorption tests were carried out as follows:

Weaving of the fibers

The untreated banana fibers were taken into small bunches. A wire frame was used in which these bunches were weaved through each other to make mats of plain texture as shown in Fig.1.

Chemical treatment

These mats were treated with 5% NaOH solution. Samples were treated for different exposure times in the solution. Another batch of samples were taken in a large bowl containing 5% NaOH solution to which a small amount of Epsom salt was added. An aqua pump was put into the bowl. A curved pipe with holes on its surface was connected to the pump. This helps in proper distribution of air bubbles through a larger area in the solution. Fiber mats were immersed in the solution for different timings. These samples were later washed with distilled water and dried in oven for 24 hours at 80 ^{o}C.

Mould preparation

The mould used for the woven fibre composites is fabricated from mild steel plates as shown in fig.2. The different parts of the mould assemble to form a mould cavity of dimensions 200mm x 200mm x 10mm. Bolts are put on all the four sides of the mould which can be tightened to apply pressure.

Preparation of the resin

Bisphenol epoxy based vinyl ester resin is obtained from ECMAS resins pvt ltd. To the resin is added promoter and accelerator in proportions as mentioned by manufacturer. The fiber mats are immersed in this resin for 1 hour. These fiber mats were then used for preparing the composites as usual.

Preparation of the composite

The bottom plate of the mould is taken, and a Teflon sheet is placed on it. A de-bonding agent is coated over the Teflon sheet. Over this, the frame is put to obtain the mould cavity. Resin is taken in small batches to which promoter, accelerator and catalyst is added in recommended proportions. When the resin becomes slightly tacky, it is poured very slowly into the mould cavity. On this thin resin layer, a resin drenched mat is put. A roller is slowly rolled over the mat to remove any trapped air. Prepared resin is poured over the mat and the process of alternate mat and resin is repeated upto three mats and five resin layers. Over this uncured composite, another Teflon sheet coated with de-bonding agent is put. On the Teflon sheet, the three plate assembly is put. The fourth unit of large plate is put to complete the mould assembly. Bolts are tightened and the mould is left for 24 hours to cure at room temperature. The composite plate is then cured in an oven for 24 hours at 80 ^{o}C. Specimens of required dimensions as per ASTM standards are cut to carry out water absorption tests.

Water absorption test

Water absorption tests of the specimens were carried out according to the method described in ASTM D570 that included the boiling water immersion test. The specimen samples in the shape of circular discs of 50.8 mm diameter and 3.2 mm thickness were taken. The composite specimens were first dried in an oven at 50 ^{o}C for 24 hours, and then cooled to room temperature in a desiccator weighed to the nearest one-tenth of a milligram with an analytical balance. The specimens were immersed in distilled water maintained at 50 ^{o}C for 30 minutes and for 2 hours as per ASTM procedure. Further immersion test is also carried out for a total of 10 hours. At the end of the immersion time, they were removed and placed in distilled water maintained at room temperature for cooling. The surface was wiped with tissue paper to remove any traces of excess water and then the samples were weighed again. The average weight of 5 samples was considered. The percentage increase in weight was calculated by dividing the weight gain by the initial dry weight:

$$\%\ \text{Water absorption} = \frac{Wet\ weight - Dry\ weight}{Dry\ weight} \ x\ 100$$

RESULTS AND ANALYSIS

When the fiber is treated in alkaline solution, impurities such as wax, cuticles and lignin get removed from the fiber, making the fiber surface rough and porous. Fig.3 shows the SEM image of the fibers which are untreated and image of the fibers which are treated with alkaline solution in combination with air bubbling.

Fig.1: Banana fibre weaved into mats.

Fig.2: The mould

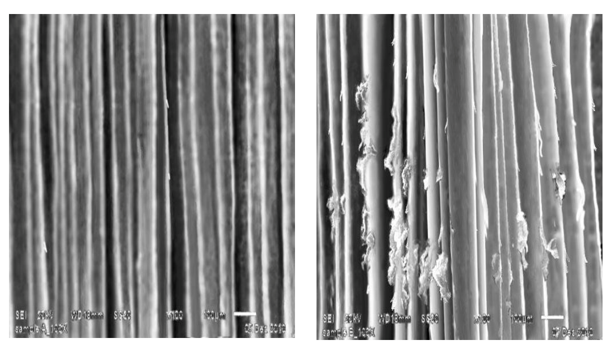

Fig.4 : SEM image of untreated and treated fibers

The untreated banana fibers presented a smooth surface and the fibers treated with air bubbling-alkaline solution shown an unevenness and heavy roughness on the surface. This enables higher resin penetration into the fiber. Hence fiber/matrix

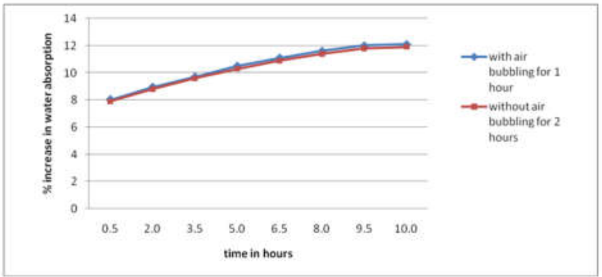

Fig.5- Water absorption test for fibers conditioned with and without air bubbling (for 1 hr and 2 hrs respectively)

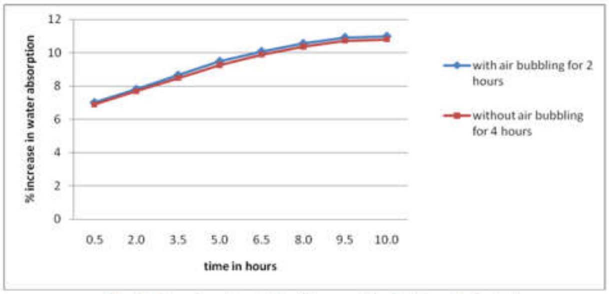

Fig. 6. Water absorption test for fibers conditioned with and without air bubbling (for 2 hrs and 4 hrs respectively)

interaction is improved allowing less water uptake. Fig.4 and Fig.5 show the variation of % increase in water absorption when the specimens are treated in alkaline solution with and without air supply for different periods of time. The present work demonstrates the advantage of using air bubbling process through the alkaline solution during fiber treatment. The 30 minute boiling water immersion test shows that the increase in water absorption for fibers subjected to 2 hours of alkaline treatment without air bubbling is 7.92%. Same test for fibers subjected to 1 hour of alkaline treatment with air bubbling has a gain in water content of 8.02%. Specimens weighed after 2 hours immersion test has shown water uptake of 8.83% and 8.94% respectively.

Tests were also done for fibers conditioned for 4 hours in alkaline solution and 2 hours in alkaline solution with air bubbling. 30 minutes boiling water immersion test shows a moisture gain of 6.89% and 7.01% respectively. 2 hours immersion test resulted in increase in water absorption of 7.68% and 7.81% respectively. The observation is that there is negligible difference in moisture uptake when: The fiber is subjected to alkaline treatment for 2 hrs and when fibers are treated with alkaline solution in combination with air bubbling for 1 hr. Similarly it is observed that the moisture uptake is nearly same for fibers treated with alkaline solution for 4 hrs and for fibers treated with alkaline solution in combination with air bubbling for 2 hrs.

Conclusion

The fiber soaked in alkaline solution releases ionized phenolic hydroxyl groups. When air bubbles are introduced in this solution, the oxygen in the air reacts in the triplet state with the released ionized phenolic hydroxyl groups, causing delignification of the fiber. As oxygen has low solubility in alkaline solution, good distribution of air bubbles in the solution is necessary for better delignification rate and roughness of fiber surface. Addition of metallic salts is required to drive the reaction. It can be conveniently stated that air bubbling combined alkaline treatment can have nearly same effect on percentage water absorption but reduces the processing time by nearly half the conventional process of normal alkaline treatment.

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