Effect of Alkali Treatment on Mechanical Properties of Tapsi Fiber Reinforced Polyester Composites

R. Meenakshi Reddy, D. Mohana Krishnudu, B. Madhusudhan Reddy and P. Venkateshwar Reddy

Abstract These days, NFCs are accentuating the greatest potential for engineers in numerous applications. A natural fiber polymer composite (NFC) offers the designer to acquire the fundamental properties in a munificent degree by the choice of fibers and matrix. Tapsi fiber reinforced polyester composites were made up with a statute of blends. The tensile, flexural, and impact properties of Tapsi fiber reinforced polyester composites were studied. The mechanical properties such as tensile strength, flexural strength, and impact strength of the Tapsi fiber reinforced polyester composites were assessed according to the ASTM guidelines. The impacts of alkali treatment (NaOH) of the fibers on these properties were likewise studied. It was observed that the mechanical properties of the polyester composite improved with increment in the fiber content. These properties were observed to be far and away superior when alkali-treated tapsi fibers were utilized as a part of the composites.

Keywords Tapsi fiber · Tensile strength · Flexural strength · Impact strength

1 Introduction

The research area of natural fiber composites (NFC) is aggravating rapidly in comparison with the synthetic fibers such as glass, owing to its several diversified applications—low cost, bio-degradability, low environmental impact, and wide range of other applications. NFCs are having the greatest potential for engineers in many applications. A NFC offers the designer to obtain the essential properties in an extensive extent by the choice of fibers and matrix. Many studies on the composites made from polyester matrix and natural fibers were reported in the literature [1]. Wong et al. [2] investigated the failure initiation of the short bamboo fiber reinforced polyester composites and noticed that the strength of the specimen increased with increase in fiber content of the specimen. Satishkumar et al. [3] studied and compared the tensile

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properties of the snake grass fiber with the traditional natural fibers. Mohan Rao et al. [4] fabricated the composite specimens of grass stalk fibers using retting and chemical (NaOH) extraction processes, the fibers were incorporated into a polyester matrix, and the tensile properties of fibers were determined. Obuko et al. [5] investigated on the development of eco-friendly composites using bamboo fibers by evaluating the basic mechanical properties and reported that the steam explosion technique is essential to extract the bamboo fibers. Osorio et al. [6] studied the morphological aspects of both treated and untreated bamboo fiber composites and reported that the treated fibers have good mechanical strengths when compared to the untreated fiber composites. Varadharajulu et al. [7] investigated on the chemical resistance of epoxy-coated bamboo fibers. Mandal and Alam [8] investigated on the dynamic mechanical properties and morphology of short glass/bamboo fiber reinforced polyester composites by varying the fiber content and percentage of glass fiber by bamboo fiber. Oushabi et al. [9] studied the mechanical, chemical, thermal, and morphological properties of the palm fibers and reported that the alkali treatment improves the thermal resistance of date palm fibers. Krishnudu et al. [10, 11] investigated on mechanical properties of natural fiber like coir-Luffa cylindrical and prosperous juliflora hybrid composites. In the present work, investigation is carried out to know the mechanical properties of tapsi fiber composites such as tensile, flexural, and impact strength. Study on these properties is vital in comparison with physical properties.

2 Materials and Methods

The following subsections deal with the Materials and methods used in the current study.

2.1 Matrix

In this work, unsaturated polyester bechances as a matrix and Methyl ethyl ketone peroxide transpires as a catalyst and cobalt naphthenate as an accelerator. The fundamental element of this resin is possession of fantastic mechanical and dynamic quality. It has a span of realistic usability of two years; the tapsi fibers utilized as a part of the present study were acquired from the Tripura state in INDIA in dried form. To evacuate hemi-cellulose and oily nature of these fibers, they are soaked in 5% NaOH solution for 1 h and then washed with water altogether. Tapsi fiber is acquired from the Tungabhadra waterway of Andhra Pradesh. A similar strategy is taken after for both the fibers for alkali treatment.

2.2 Alkali Treatment

Tapsi fibers underwent treatment with 10% sodium hydroxide (NaOH) solution at 30 °C, maintaining a ratio of 15:1 and immersed in the alkali solution for one hour. The fibers were then initially washed with tap water repetitively to eliminate NaOH, neutralized with acetic acid and again, finally, washed thoroughly with distilled water, and dried in a hot air oven at 100 °C for a period of 24 h.

2.3 Preparation of the Composite and Test Specimen

For preparing the composite, molding box is arranged at first with a glass of size 200 mm × 200 mm × 3 mm. The shape is covered with a fine layer of fluid arrangement of polyvinyl alcohol (PVA) that acts as a releasing specialist; further, a thin covering of hard wax is covered over it, and in conclusion, another fine layer of PVA was covered. Each coat was allowed to dry for 30 min at room temperature. A 3 mm thick plate was produced using the mix of polyester, catalyst, and accelerator. At that point, the molding box was stacked with the blend of matrix and taps fibers in arbitrary orientation with shifting rate and was set in vacuum broiler, which is kept up at 70 °C for three hours to finish the curing, a great many cures the plate was expelled from the molding box with simple tapering method. The samples are fabricated by varying weight % of fibers that are designated as C5 (5 wt% of tapsi fiber), C10 (10 wt% of tapsi fiber), C15 (15 wt% of tapsi fiber), C20 (20 wt% of tapsi fiber), and C25 (25 wt% of tapsi fiber). It was cut into samples for tensile tests with measurements of 150 × 15 × 3 mm^3 according to ASTM-D 3039-76 determinations. The gauge length of the samples was kept up at 100 mm for this test. For both tensile and flexural tests, 50 kN load cell sample sizes are cut in accordance with ASTM-D 618 (i.e.,150 mm × 15 mm × 3 mm) for flexural testing. The impact testing specimens (62.5 mm × 12.7 mm × 3 mm) were prepared. The sample was tested by utilizing INSTRON 3369 universal testing machine with the crosshead speed kept up at 5 mm/min. The temperature and humidity of this test were kept up at 22 °C and 50%, respectively. For each test, five samples were tested, and the average value was noted. For correlation purpose, the specimens of matrix material were also prepared in similar lines.

3 Results and Discussion

3.1 Tensile Load Measurement

The composite specimens C5, C10, C15, C20, and C25 are tested for tensile properties in a universal testing machine (UTM). The tensile strength was determined using INSTRON-3369 model UTM. The crosshead speed for tensile test was maintained at 10 mm/min. The temperature and humidity of this test were maintained at 18 °C and 50%, respectively. In each case, five samples were tested, and average values were calculated. The tensile strength for five samples is shown in Fig. 1. It is observed that the tensile strength of composite is increased as the fiber weight increases in the composite sample for both treated and untreated. Treated samples posses elevated tensile strength when compared to untreated samples, and a maximum of 78 MPa is observed for both C20 and C25 treated samples.

3.2 Flexural Strength Measurement

The composite specimens C5, C10, C15, C20, and C25 are tested for flexural properties (three-point bend test) in a universal testing machine (UTM) and , a span length of 10 cm was maintained. The flexural strength was determined using INSTRON-3369 model UTM. The crosshead speed for flexural test was maintained at 10 mm/min.

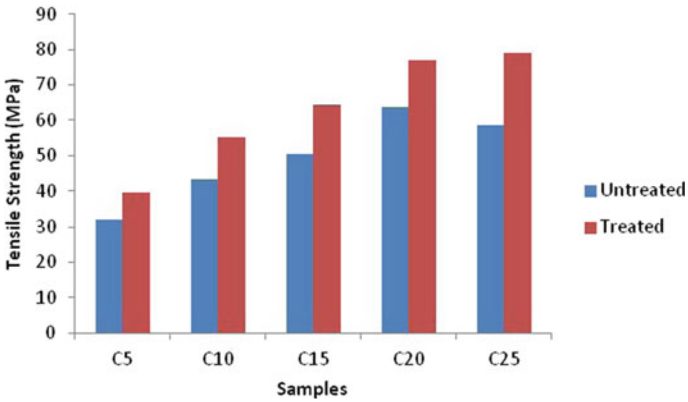

Fig. 1 Variation of maximum tensile strength with tapsi fibers reinforced polyester composites for both treated and untreated samples

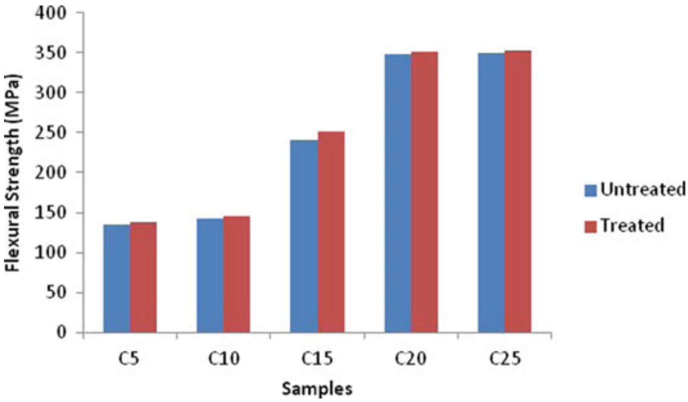

Fig. 2 Variation of maximum flexural strength with tapsi fibers reinforced polyester composites for both treated and untreated samples

The temperature and humidity of this test were maintained at 18 °C and 50%, respectively. In each case, five samples were tested, and average values were calculated and is shown in Fig. 2. The increase in fiber weight content in the matrix system offered better stiffness to the samples, which in turn provide enhanced flexural resistance of the composite sample. However, the flexural strength of the composite samples C20 and C25 attained an equal amount of flexural strength (350 MPa). This is due to inadequate matrix to hold the bulky weight fraction of fibers.

3.3 Impact Strength Measurement

The composite specimens C5, C10, C15, C20, and C25 are tested for impact strength in an impact tester. The impact strength was determined using IZOD impact testing machine. In each case, five samples were tested, and average values were calculated and is shown in Fig. 3. From Fig. 3, it was observed that impact strength increases with fiber content. It was also observed from Fig. 3 that treated hybrid composites have more impact strength when compared to untreated hybrid composites. Improvement of impact properties for treated composites is due to the removal of hemi-cellulose and lignin.

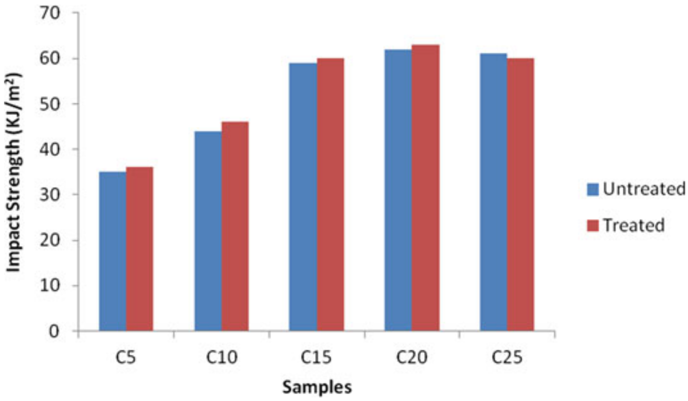

Fig. 3 Variation of maximum impact strength with tapsi fibers reinforced polyester composites for both treated and untreated samples

4 Conclusion

The hybrid composites of tapsi fiber reinforced polyester were readied, and their mechanical properties were studied. The impact of tapsi fiber percentage on these properties was studied. These hybrid composites with treated fiber composite samples were found to display great mechanical properties. It was discovered that treated fibers have good bonding between matrix and fibers. The hybrid composites with treated tapsi fibers were found to have superior mechanical properties because of the disposal of undefined powerless hemi-cellulose segments from the tapsi fibers might be in charge of this conduct. The maximum tensile strength of the composite samples C20 and C25 is almost equal to 72.62 MPa, which is higher in comparison with remaining three samples. Likewise, the maximum flexural and impact strengths of the composite samples are almost equal for both C20 and C25 samples during their corresponding tests.

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