CHAPTER 4

STUDY ON MECHANICAL AND WATER ABSORPTION PROPERTIES OF ALKALI TREATED SISAL/BAMBOO HYBRID COMPOSITES

4.1 RESEARCH METHODOLOGY

In this research work, the effects of chemical treatment of fiber and solution concentration on the mechanical properties of short natural fiber reinforced polyester hybrid composite are investigated. Hybrid composites consisted of 50% bamboo and 50% sisal out of the 20% weight percentage of fiber reinforcement. The bamboo and sisal fibers are subjected to a 10% sodium hydroxide solution treatment for 24 h. The mechanical properties of composites with treated fibers are compared with untreated fiber composites. The fractured surface of the treated fiber composite specimen is studied using SEM.

4.2 EXPERIMENTAL SETUP SPECIFICATIONS

4.2.1 Alkali Treatment of Bamboo/Sisal Fibers

In this contribution, the short bamboo and sisal fibers and are soaked in a 10% NaOH solution at room temperature. The fibers are kept immersed in the alkali solution for 24 h. The fibers are then washed with fresh and distilled water to remove any NaOH sticking to the fiber surface and to neutralize with dilute acetic acid at several times. The short bamboo and sisal fibers then dried at room temperature (33˚ C) for 24 h followed by oven drying at room temperature for 24 h.

4.2.2 Preparation of Specimen

In this chapter, the fiber length and its weight percentage of the tested materials are having the same specifications as stated in chapter 3. Mold is prepared in a similar manner as that for untreated fiber composites and the compressed form of fibers (sisal, untreated sisal/bamboo and alkali treated sisal/bamboo) is removed from the mould. This is followed by applying the releasing agent on the mould, after which a coat of unsaturated polyester is applied. The compressed fiber is laid over the coat of unsaturated polyester, ensuring uniform distribution of fibers.

In the room temperature (31°C), curing time of composite is 24 hours to 35 hours (Bachtiar et al. 2008). This composite needed 30 hours. The unsaturated polyester mixture is then poured over the fiber uniformly and compressed for a curing time of 30 h. After the curing process, test samples are cut to the required sizes prescribed in the ASTM (Standard test method) standards (Venkateshwaran et al. 2011).

4.3 RESULTS AND DISCUSSIONS

4.3.1 Tensile, Flexural and Impact Properties

Tensile, flexural, impact and water absorption testing are carried out in a similar manner to that of testing carried out for untreated specimen. The mechanical properties for treated fibers reinforced composites are shown in Table 4.1. The effects of fiber length and fiber weight percentage on mechanical properties are shown in Figure 4.1, 4.2 and 4.3.

Table 4.1 Effects of fiber length and weight percentage on mechanical properties of treated sisal/unsaturated polyester composites

Fiber length (cm)	**Fiber weight (%)**	**Tensile strength (MPa)**	**Flexural strength (MPa)**	**Impact strength (kJ/m^2)**
5	10	13.1	30.2	8.2
	15	18.3	39.8	9.3
	20	16.1	48.2	12.8
10	10	12.6	28.5	9.2
	15	26.5	41.2	15.7
	20	22.5	51.2	16.6
15	10	20.7	38.5	11.8
	15	21.7	45.7	21.4
	20	26.7	64.5	23.7

It is evident from the Figure 4.1, Figure 4.2, Figure 4.3 and Table 4.1 that maximum tensile strength is observed as 26.7 MPa, maximum flexural strength as 64.5 MPa and the maximum impact strength as 23.7 kJ/m^2. These mechanical properties are for the fiber length of 15 cm and the weight percentages of 20 for all cases. So, 15 cm fiber length and 20% weight are chosen for further experimentation as the fiber length and weight percentage which provide maximum mechanical properties for the case of treated sisal-unsaturated polyester composite.

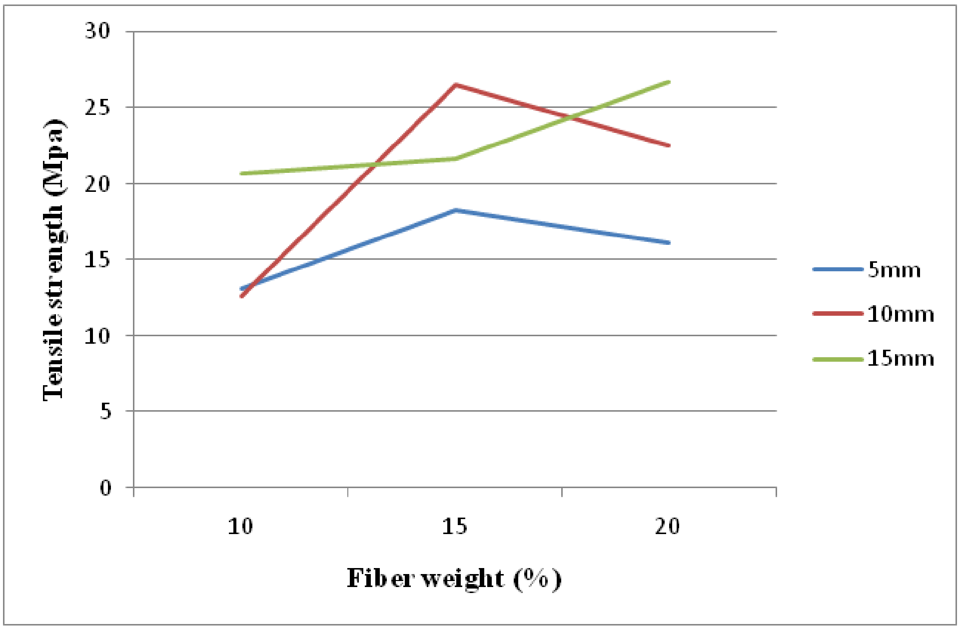


Figure 4.1 Graphical illustrations of tensile properties of treated sisal/unsaturated polyester composites

Figure 4.1 shows the graphical illustrations of tensile properties of treated sisal/unsaturated polyester composites.

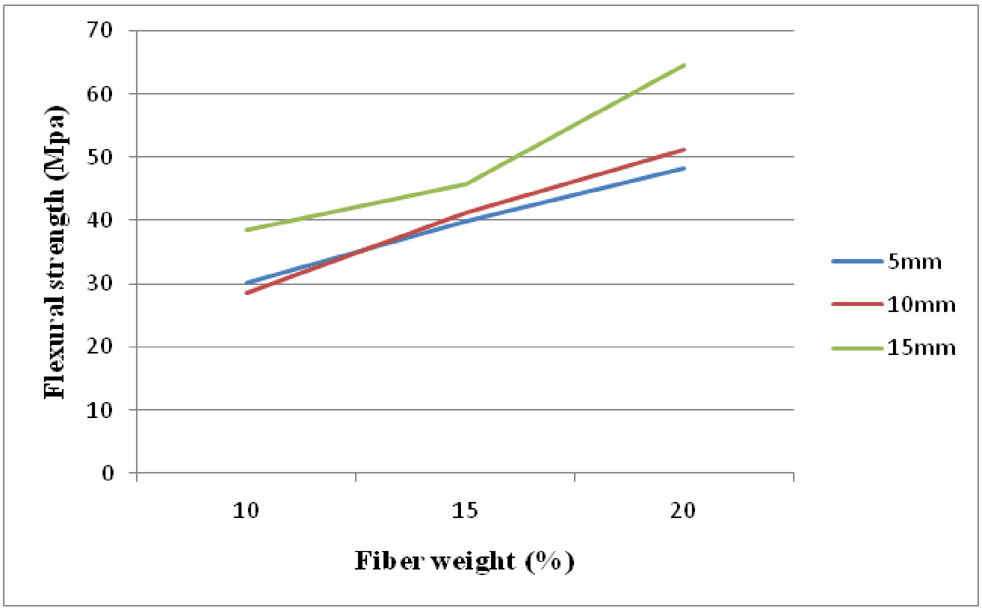


Figure 4.2 Graphical illustrations of flexural properties of treated sisal/unsaturated polyester composites

Figure 4.2 shows the graphical illustrations of flexural properties of treated sisal/unsaturated polyester composites.

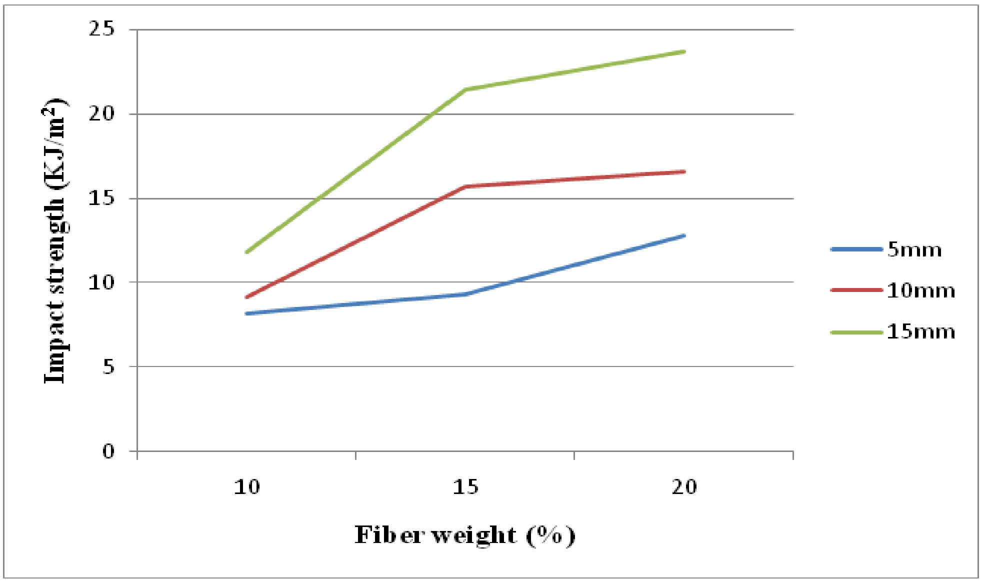


Figure 4.3 Graphical illustrations of impact strength properties of treated sisal/unsaturated polyester composites

Figure 4.3 shows the graphical illustrations of impact properties of treated sisal/unsaturated polyester composites.

4.3.2 Comparison of Experimental Results for Treated Materials to Untreated Materials

The alkali treated bamboo/sisal fibers are used as reinforcement to polyester based matrices. The alkali treated hybrid composite specimens are prepared by keeping the weight ratio of bamboo and sisal 50:50.

The same testing of composite is used for the treated sisal/bamboo. Bamboo and sisal fiber hybrid polyester composites prepared with treated bamboo and sisal fibers exhibited a significant increase in all mechanical strength properties.

The treated hybrid bamboo/sisal polyester composite mechanical properties are 38.4 MPa of tensile strength, 78.2 MPa of flexural strength and

30.4 kJ/ m^2 of impact strength for 15mm fiber length and 20% of weight ratio in contrast to 23.4 of tensile strength, 56.7 MPa of flexural strength and 19.1 kJ/ m^2 of impact strength for the composites with untreated fibers. Table 4.2 shows the mechanical and moisture absorption properties of treated/untreated Hybrid Composites.

Table 4.2 Mechanical and moisture absorption properties of treated/untreated hybrid composites at 50:50

	Tensile strength (MPa)	Flexural strength (MPa)	Impact strength (MPa)	Water absorption %
Untreated	23.425	56.713	19.120	19.620
Treated	38.415	78.215	30.324	9.124

From Table 4.2 the treated hybrid composite compared with untreated hybrid composite increased to 30% of tensile strength, 27.49% of flexural strength, and 36.9% of impact strength.

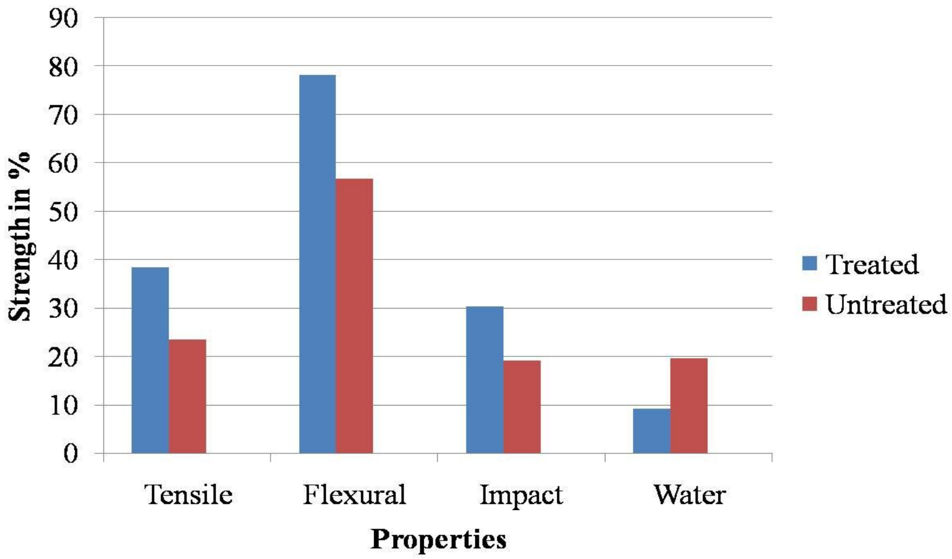


Figure 4.4 Comparisons of mechanical and moisture absorption properties of treated/untreated hybrid composites

Figure 4.4 illustrates the comparisons of mechanical and moisture absorption properties of treated/untreated Hybrid Composites. A negative percentage difference in water absorption represents the decrease in water absorption with treated specimens.

4.3.3 Scanning Electron Microscopy Analysis

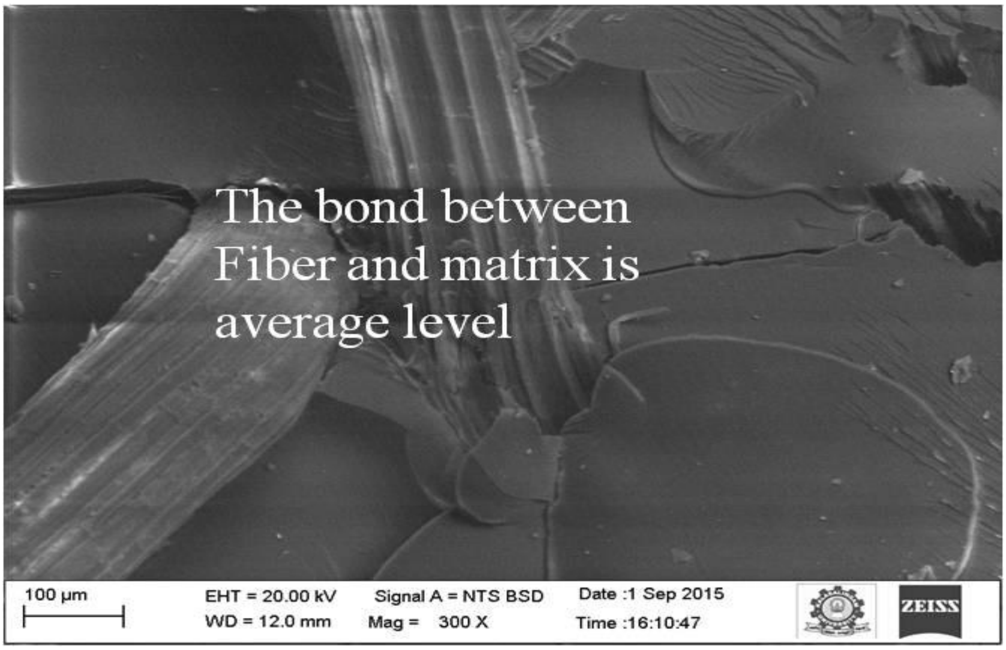
The fractographic studies are carried out on the tensile and flexural and impact fracture surfaces of short bamboo/sisal polyester hybrid composites using scanning electron microscope. Interfacial properties, such as fiber–matrix interaction, fracture behaviour and fiber plate of samples after mechanical tests are observed using Hitachi–S3400N (SEM).

Athijayamani et al. (2010) analyzed bond strength between fiber components for obtaining best results with different fiber components which was based on 10% NaOH. The authors analyzed and reported that there was a good bond between fiber component exist based on the natural resources.

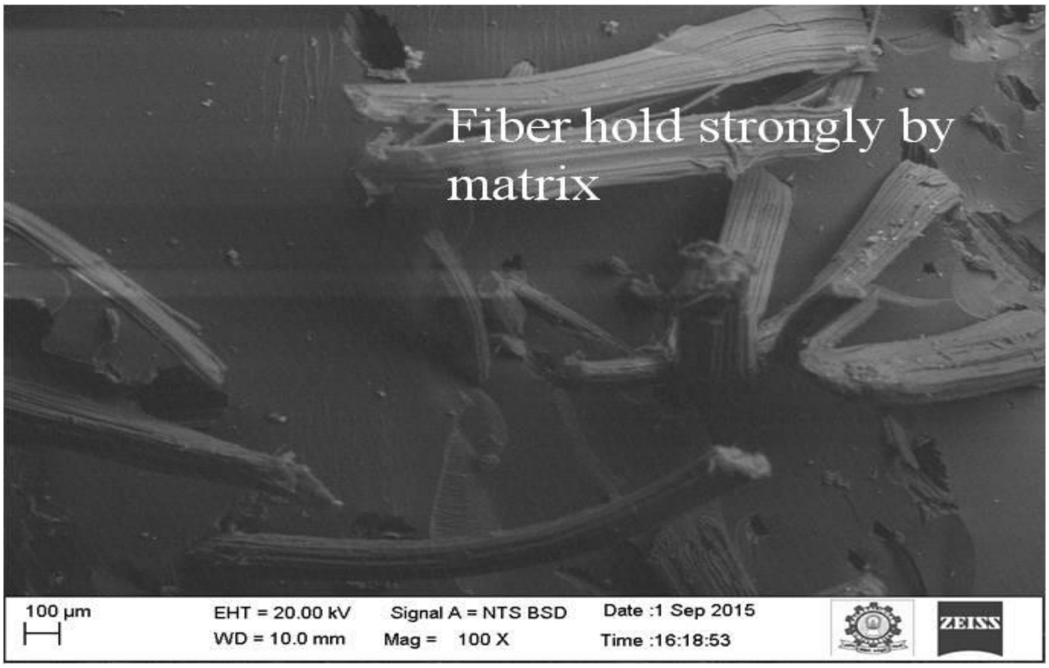
Athijayamani et al. (2015) and Modibbo et al (2009) used 10% NaOH processing technique for improving the properties of various functional parameters with respect to different sources. During washing with sodium hydroxide, the wax, cuticle layer, and part of lignin and hemi cellulose were removed. The major reaction takes place between the hydroxyl groups of cellulose and the chemical used for the surface treatment. Mechanical and wear behaviour of CRFRV composite was improved using alkali treatment.

Thiruchitrambalam et al. (2009) investigated the effect of alkali and SLS (Sodium Lauryl Sulphate) treatment on Banana/Kenaf Hybrid composites and woven hybrid composites. The fibers were treated with 10% of sodium hydroxide (NaOH) and 10% Sodium Lauryl Sulfate (SLS) for 30 minutes. The authors obtained good mechanical strength using alkali treatment.

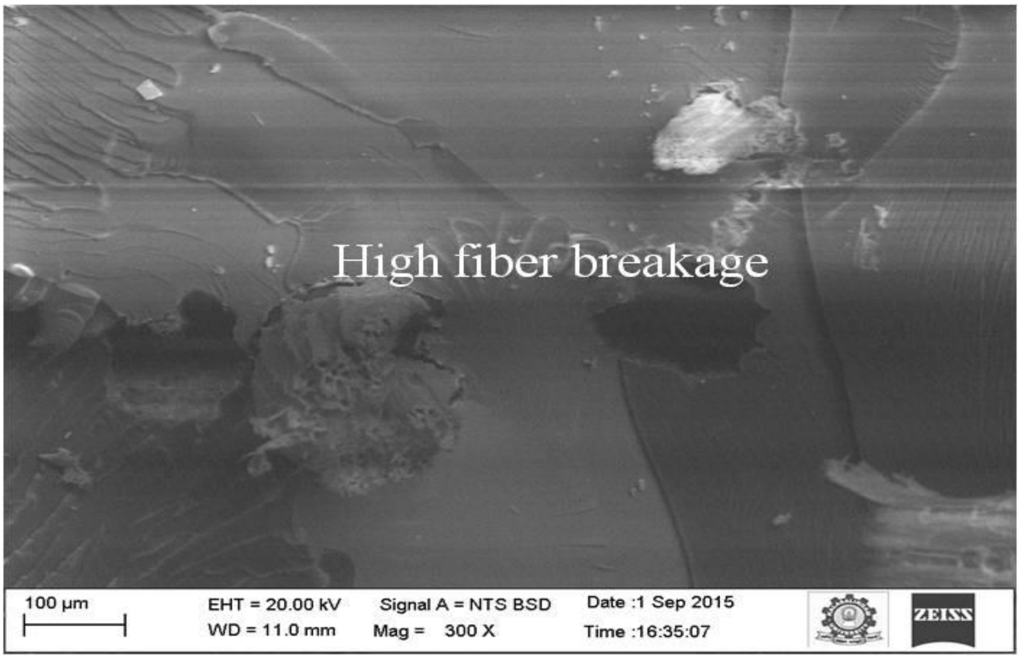
SEM image of the interfacial bonding between fiber and matrix for hybrid composite made with different (5%, 10%, and 15%) NaOH concentrations are shown in Figure 4.5 (a, b and c).



(a)



(b)

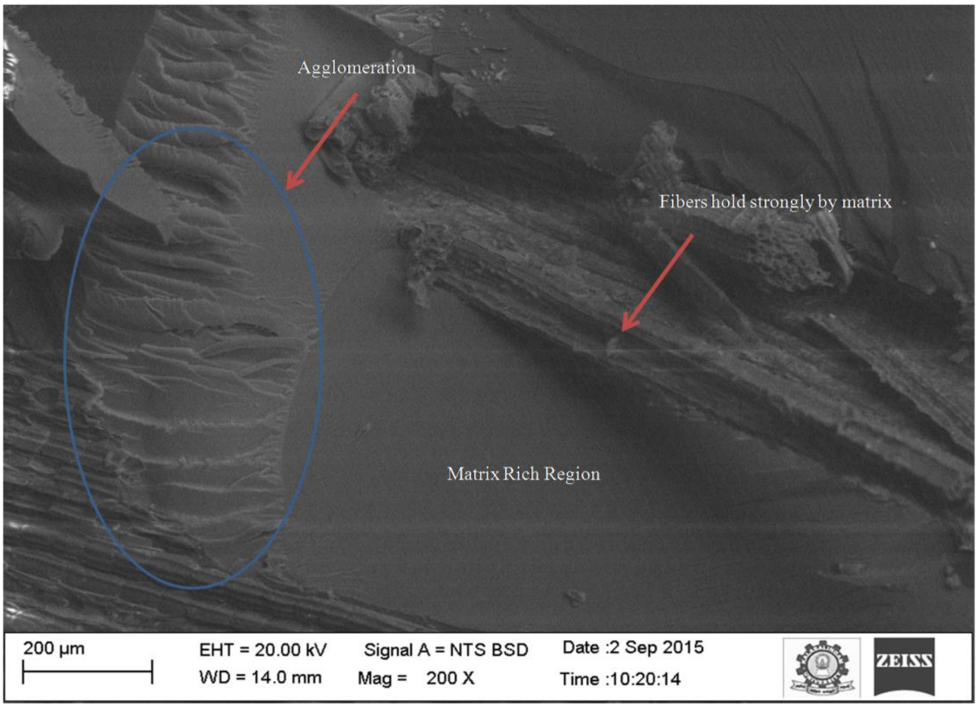


(c)

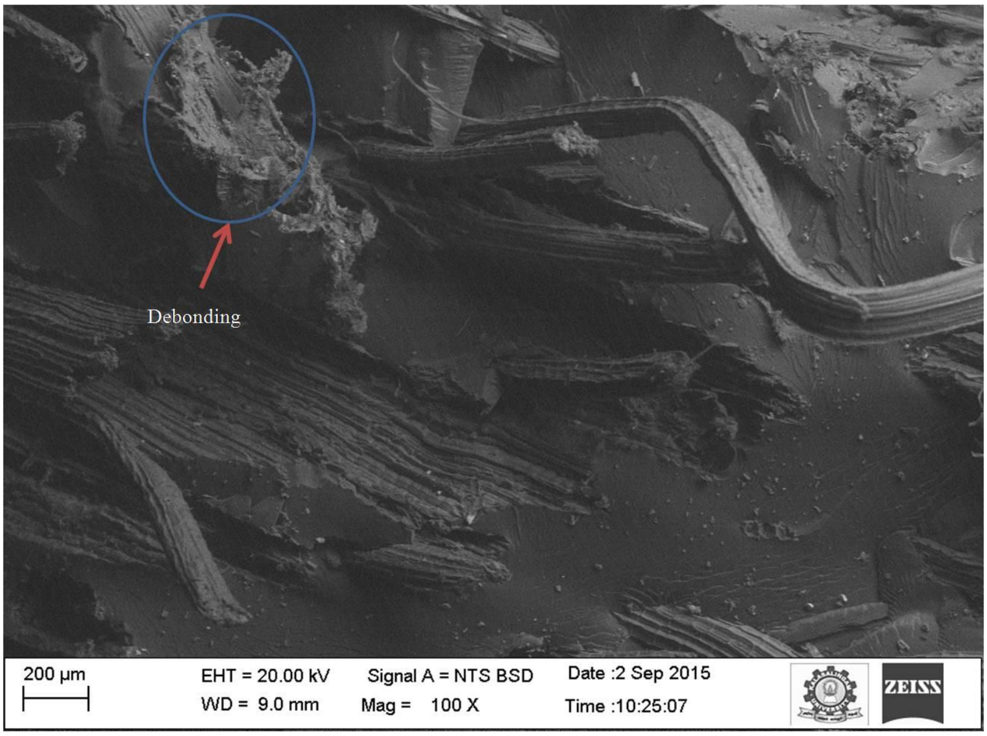
Figure 4.5 SEM results of interfacial bonding between fiber and matrix for (a) 5% NaOH treatment, (b) 10% NaOH treatment and (c) 15% NaOH treatment

Figure 4.5 (c) shows high fiber breakage at 15% NaOH concentration, where as Figure 4.5 (a), (b) shows low fiber breakage and got better result at 10% NaOH concentrations. Hence 10%NaOH concentration is used for chemical treatment of fibers.

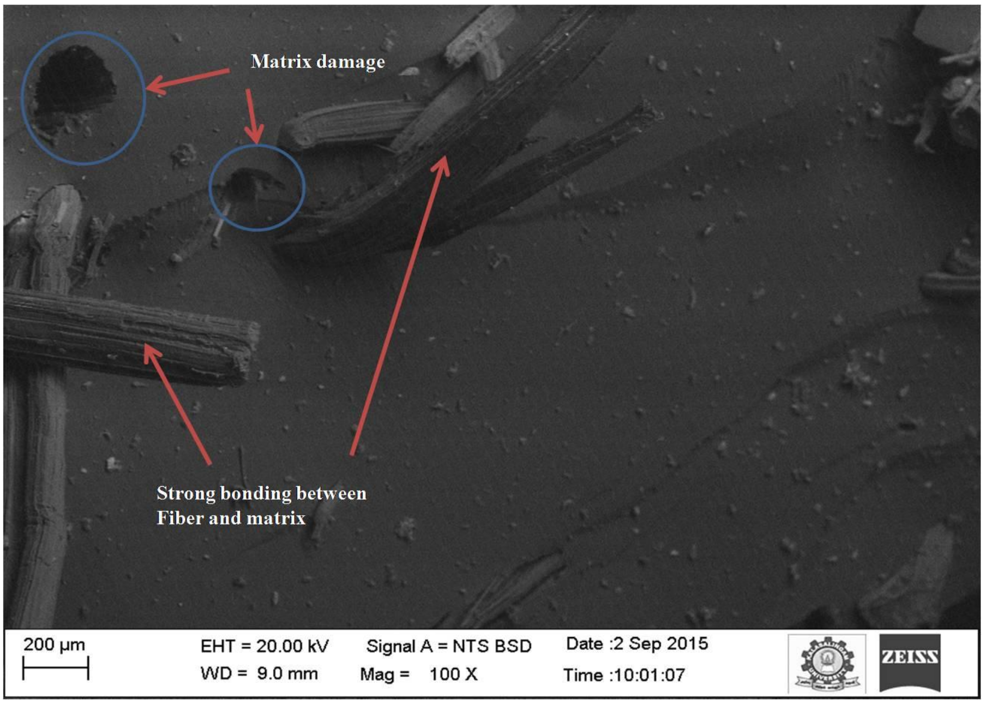
SEM image of the fractured surface of hybrid composite made with treated fiber after tensile, flexural and impact test is shown in Figure 4.8 (a, b and c). From SEM images, It may be seen that the composite failures during tensile, flexural and impact tests are due to debonding and the fiber pullout. It is also identified that the brittle fractures of most of the fibers are identified during this study. This is due to alkali treatment of fibers.


Agglomeration
Fibers hold strongly by matrix
Matrix Rich Region
200 µm
EHT = 20.00 kV
WD = 14.0 mm
Signal A = NTS BSD
Mag = 200 X
Date :2 Sep 2015
Time :10:20:14
ZEISS

(a)


Debonding
200 µm
EHT = 20.00 kV
WD = 9.0 mm
Signal A = NTS BSD
Mag = 100 X
Date :2 Sep 2015
Time :10:25:07
ZEISS

(b)



(c)

Figure 4.6 SEM results of fractured surface for 50/50 hybrid composite treated at 10% NaOH concentration after (a) tensile test, (b) flexural test and (c) impact test

4.4 SUMMARY

In this investigation, Short Bamboo and the sisal fiber hybrid polyester composites prepared with treated bamboo and sisal fibers showed a significant increase in all mechanical strength properties. The positive effects are achieved in tensile, flexural and impact strength. By increasing the treated Bamboo fiber concentration in short Bamboo/sisal fiber hybrid polyester composite, the tensile, flexural and Impact strength may be improved. The treated hybrid composite compared with untreated hybrid composite increased to 30% of tensile strength, 27.49% of flexural strength, 36.9% of impact strength and moisture absorption behaviour is decreased enormously. Good interfacial bonding between the matrix and the fiber in treated hybrid composite was obtained, which is evident from SEM analysis. Interfacial bonding between fiber and matrix can also be improved by chemical treatment with coupling agent. The treated composite is bonding better than untreated hybrid composite.