PREPARATION AND CHARACTERIZATION OF SHORT ARECA LEAF FIBER REINFORCED EPOXY AND VINYL ESTER COMPOSITES

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ABSTRACT

In this research work natural fiber reinforced polymer composites were prepared by reinforcing epoxy and vinylester resin with short areca leaf fibers. Different blend composites were prepared by varying weight fractions of areca leaf fibers. Their mechanical and physical properties were studied and compared as per the standard procedure. It has been found that the compressive strength of areca leaf fiber reinforced vinylester composites were more than epoxy composites. It was also observed that the type of compressive failure in epoxy/ leaf and vinylester/ leaf composites at all wt% of fibers was breaking. The erosive wear strength at 90^0 *and* 75^0 *nozzle angles were determined. The water absorption properties were also studied. The ruptured surface of both types of composites which exhibited highest compressive strength was analyzed by SEM micrographs.*

Keywords: Areca leaf, Epoxy, Erosive wear, SEM and Vinyl ester.

I INTRODUCTION

During the last few years, natural fibers have received much more attention than ever before from the research community all over the world. Natural fiber reinforced composites prove that it is possible to construct high performance materials with environment friendly resources. Several cellulosic products were preferred as reinforcement mainly to achieve cost savings [1]. The use of wood fibers as a load bearing constituent in composite materials have been gaining increased attention in the field of composites [2, 3]. Recent studies showed that the development of fiber reinforced composite material using plant-based natural fiber such as flax, hemp, bamboo, pineapple, kenaf, sisal, banana, jute, coir etc., as reinforcement due to their availability, cost effectiveness ,world annual production & wide range of properties[4- 9].

The compressive strength is one of the most important and widely measured properties of materials used in various applications The value of compressive stress reached when the material fails

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completely is designated as the compressive strength of that material [10]. Srinivasa and Bharath found that the mechanical properties of areca husk fiber-reinforced epoxy composites depend on the nature of matrix material, the distribution and orientation of the reinforcing fibers, the nature of the fiber-matrix interfaces and of the interphase region [11].

Erosive wear can be described as an extremely short sliding motion and is executed within a short time interval. Erosive wear is caused by the impact of particles of solid against the surface of an object. The impacting particles gradually remove material from the surface through repeated deformations and cutting actions [12]. The rate of erosive wear is dependent upon number of factors. The material characteristics of the particles, such as their shape, hardness, impact velocity and impingement angle are primary factors along with the properties of the surface being eroded. The impingement angle is one of the most important factors and is widely recognized in literature [13].

Moisture diffusion in polymeric composites has shown to be governed by three different mechanisms [14, 15].The first involves the diffusion of water molecules inside the micro gaps between polymer chains. The second involves capillary transport into the gaps & flaws at the interfaces between fiber & the matrix. This is a result of poor wetting & impregnation during the initial manufacturing stage. The third involves transport of micro cracks in the matrix arising from the swelling of fibers (particularly in the case of natural fiber composites). Bharath K.N, Rajesh A.M have studied the moisture absorption property of different weight fraction of randomly distributed areca fiber & maize powder reinforced urea formaldehyde composites [16].The results obtained were shown that moisture absorption decreased with decrease in the fiber to maize powder ratio & moisture absorption was improved with the weight ratio of fibers to maize powder . G.C. Mohan Kumar prepared composites with random distribution of areca husk fibers in Maize stalk fine fiber and Phenol Formaldehyde as a matrix and observed that the amount of moisture in the composite increased with time and later it became constant and he predicted that the water is predominantly absorbed at the fiber and matrix interface [17]. Chkkol et al, carried out water absorption capacity test for the composites made of Urea formaldehyde, Melamine urea formaldehyde and epoxy reinforced with areca husk fibers. Out of these three types of composites least amount of water absorption was found in epoxy reinforced areca husk composites [18]. Amuthakkannan et al, prepared basalt fiber reinforced polymer matrix composites and found that the water absorption behavior of the composites mainly depends on the voids present in the composites, interfacial adhesion between the fiber and matrix, and type of fibers reinforced [19].Ankita Pritam Praharaj et al. Studied the water absorption of randomly oriented paper pulp reinforced Bisphenol-Aglycidyldimethacrylate (BisGMA).They found that the composites with less paper pulp content absorbed less water [20].

In this work polymeric thermosetting materials such as epoxy and vinyl ester were used as matrix materials because they can be processed easily, possess light weight & offer desirable mechanical properties. The reinforcement materials used was naturally available short areca leaf fibers. The fibrous material was used because of the simple reason that most materials are stronger and stiffer in fibrous form than in any other form.

In coastal Karnataka the areca is the main commercial crop. The areca leaf obtained from the areca tree is used for making leaf cups. No attempt has been made till today to utilize it as an useful material for many other applications. Hence, in this present study, areca leaf fiber reinforced epoxy and vinyl ester composites have been prepared with varying weight percentages. Their physico-mechanical and tribological properties have been studied, owing to scientific interest and technological competence.

II EXPERIMENTAL

2.1Raw materials

The clean areca leaves obtained from the areca tree were dried under sunlight till all of its moisture content was removed. Then they were washed with distilled water and kept in an oven for the drying purpose . The epoxy LY 556 was used as a matrix material with hardener HY 951 and also vinyl ester was used as a matrix material with respective catalyst, accelerator and promoter.

2.2 Specimen preparation

2.2.1Epoxy Composites

Required quantities of fibers and resin were weighed, mixed & stirred properly. Hardener was added to the epoxy-fiber mixture in the proper ratio and stirring was continued till uniform mixture was obtained. The composites were prepared with varying weight percentages of fibers. Developed samples were cured for 24 h at room temperature. Then the samples were cut into required size & shape according to the ASTM standard for different testing purposes and post cured.

2.2.2 Vinyl ester composites

In this, definite quantities of vinyl ester and fibers were mixed. Then the respective catalyst, accelerator and promoter were added in the required amount. The similar procedure used in the preparation of epoxy composite was followed.

2.3 Testing methods

The Compression test was carried out in an Universal Testing Machine (Zwick Roell, Jerman make,Model-Z0200) according to ASTMD695 standard and Wear test was conducted in Air Jet Erosion Test Rig as per ASTM G76 standard at 90^0 & 75^0 nozzle angle.

Density was determined by simple water immersion technique according to ASTM D792 standard.

Water absorption capacity was found out according to the procedure described in the ASTM D570 standard. The percentage increase in weight was calculated as,

$$\% \text{ Water absorption} = \frac{\text{Wet weight} - \text{Reconditioned weight}}{\text{Reconditioned weight}} \times 100$$

Scanning electron microscopic (SEM) studies were conducted to analyse the fracture behaviour of composites.

III RESULTS AND DISCUSSION

3.1 Compressive Strength

All epoxy and vinyl ester composites with varying weight percentages of area leaf fibers were subjected to compression test. The results are shown in Fig.1.The type of failure in epoxy and vinyl ester leaf composites was breaking. Maximum compressive strength of 49.80MPa and 135.83 MPa was found in epoxy and vinyl ester composites at 10wt% and 16wt% respectively which is shown in Fig.1.This clearly indicates that the fiber-matrix interfacial bonding was optimum at 10 wt% and 16wt% of fibers in epoxy and vinyl ester composites respectively. The percentage increment in the compressive strength of vinyl ester composites was found to be 45.46% over that of epoxy composites at 10 wt% of fibers. The vinyl ester composites showed an increment in the strength of 309.13% over epoxy composites at 16 wt% of fibers.

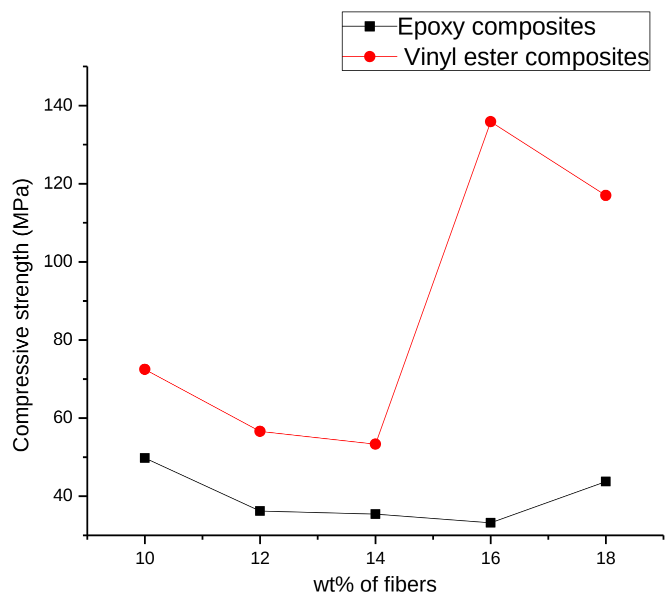

Fig.1.Compressive strength of epoxy and vinyl ester composites

3.2 Wear Test

The erosive wear test results of epoxy and vinyl ester composites at 90^0 and 75^0 nozzle angles are shown in Fig. 2 and Fig. 3 respectively. The rate of erosive wear is dependent upon a number of factors such as type of matrix material, type of fibers used, orientation of fibers, size of fibers and the nozzle angle. The percentage loss in weight at 90^0 nozzle angle was found to be less than at 75^0 nozzle angle in both types of composites which is clearly indicated in the Fig.2and Fig.3.It is clear from the Fig.2 that the minimum percentage weight loss of 0.0068 and 0.0300 was observed at 18wt% and 16wt%of fibers in epoxy composites at 90^0 and 75 º nozzle angle respectively. From Fig.3at 90 º and 75 º nozzle angle the minimum percentage loss in weight of 0.0012 and 0.0365 was observed a 10wt% and12wt% of fibers in vinyl ester composites respectively. A minimum percentage loss in weight of 0.0012 was found in vinyl ester composites at 90 º nozzle angle out of all types of composites.

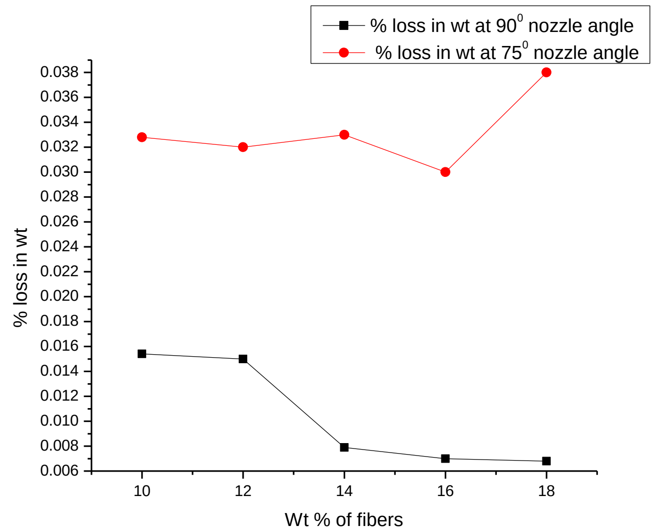

Fig.2. Wear test results of epoxy composites at 90^0 and 75^0 nozzle angle.

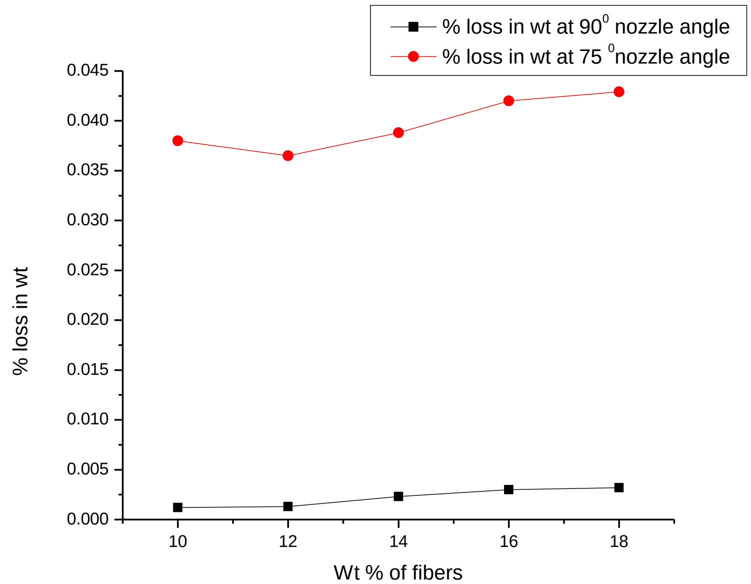

Fig.3. Wear test results of vinyl ester composites at 90^0 and 75^0 nozzle angle

3. 3 Density Test

The density of epoxy and vinyl ester composites with varying weight percentages of fibers is shown in Fig.4**.** The density was found to decrease with increase in fiber content in both types of composites. From the Fig.4, it is clear that a minimum density of 1008.69Kg/m^3 and 898.10Kg/m^3 was found at 18wt% of fibers in epoxy and vinylester composites respectively. The density of vinylester composites was found to be less than epoxy composites at all percentages of fibers. This is because the density of vinylester is less than epoxy.

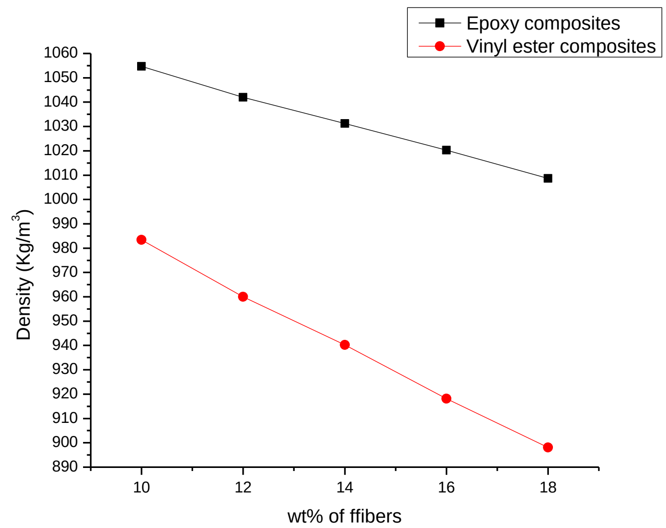

Fig. 4.Density of epoxy and vinyl ester composites

3.4 Water Absorption Test

The water absorption capacity of the composite was measured by the weight gain of the material in regular 24 hrs. of intervals over the period of 15 days. The water absorption test results of the epoxy and vinyl ester composites are shown in Fig.5and Fig. 6 respectively. These results indicate that the water absorption capacity of the composites increases as the weight percentage of fibers increased and later it becomes constant after reaching the saturation level. After analyzing the water absorption capacity of all the composites it is found that the water intake capacity of epoxy composites is less compared with vinyl ester composites. From the Fig.5 and Fig.6, it is clear that a least amount of water absorption of 8.13%& 9.69% was found at 10wt% of both types of composites.

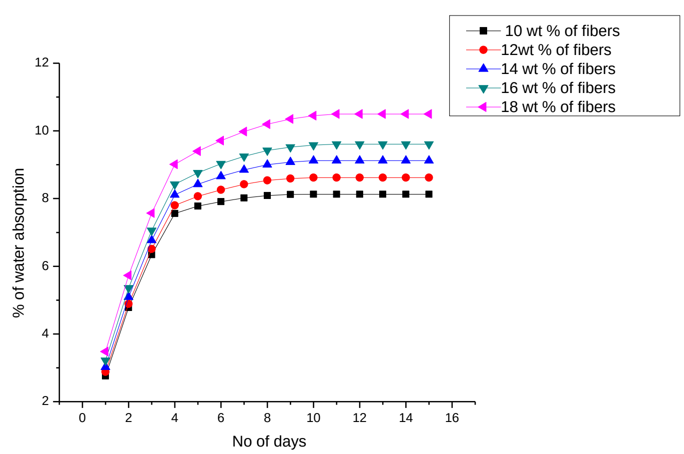

Fig.5.Water absorption test results of epoxy/leaf composites.

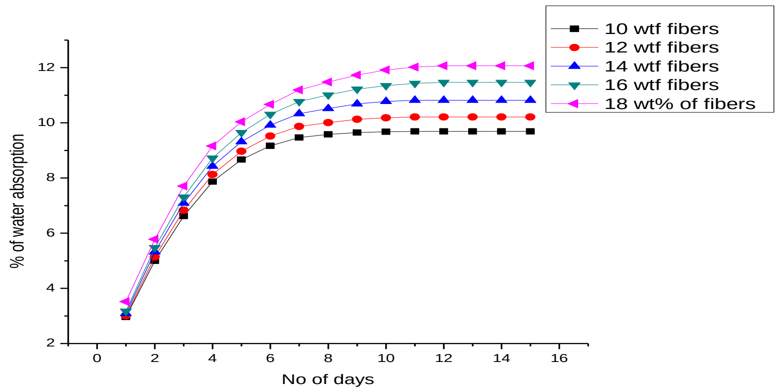

Fig. 6.Water absorption test results of vinyl ester/leaf composites

IV SEM OBSERVATIONS

Morphology of fractured surface of the 10 wt% of epoxy and 16 wt% of vinyl ester composites which exhibited highest compressive strength was examined by scanning Electron Micriscope.The micrographs revealed brittle type of fracture in epoxy and vinyl ester composites due to the formation of cracks which is evident from Fig.7 and Fig.8. The fiber pull out was observed in both types of the composites. This is identified by the holes and cavities in the fractured surface of the epoxy composite which is shown in Fig.9 and cavity in the vinyl ester composite shown in Fig.10.The fiber splitting was observed in epoxy composite which is evident from the Fig. 11.The fibers were found to be broken in vinyl ester composite which is shown in Fig. 12**.** Hence the bonding between fibers and matrix was found to be stronger in vinyl ester composites than the epoxy composites. Due to this reason the compressive strength of vinyl ester composites was higher than the epoxy composites. This also indicates that the nature of failure was not uniform in both types of composites at the fractured surface. It is evident from the SEM images that a combination of matrix cracking, fiber pull out, fiber orientation, breakage and splitting are the predominant failure modes.

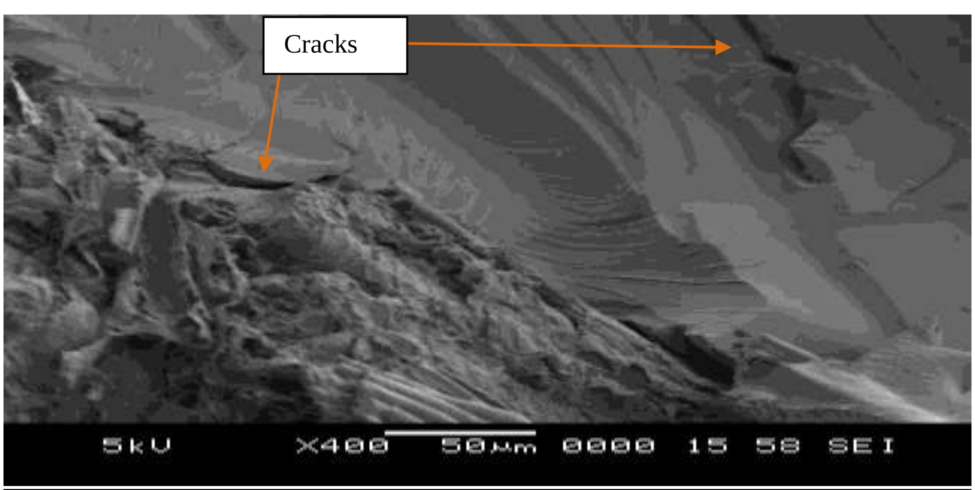

Fig. 7.Cracks formed in the epoxy composite.

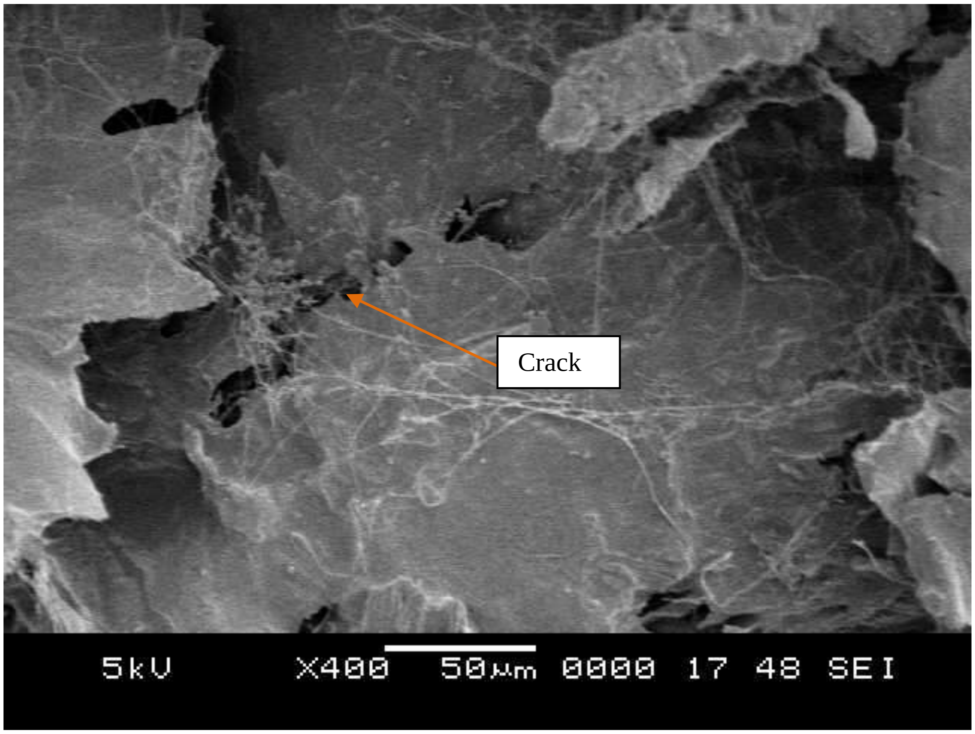

Fig. 8.Crack formed in the vinyl ester composite.

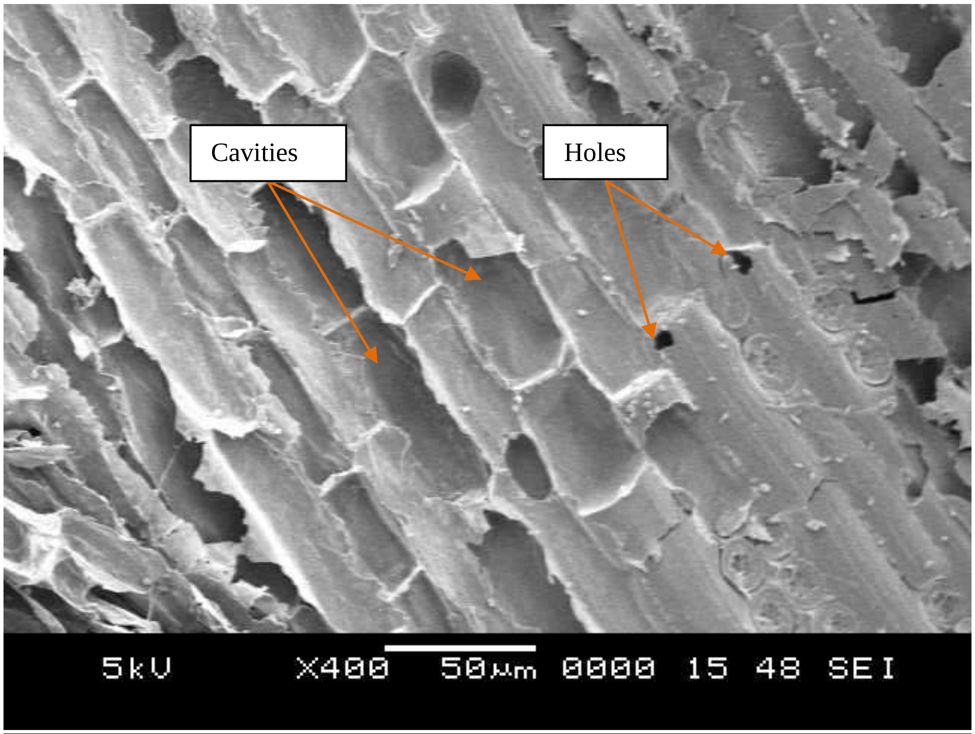

Fig. 9.Cavities and holes formed due to the fiber pull out in the epoxy composite.

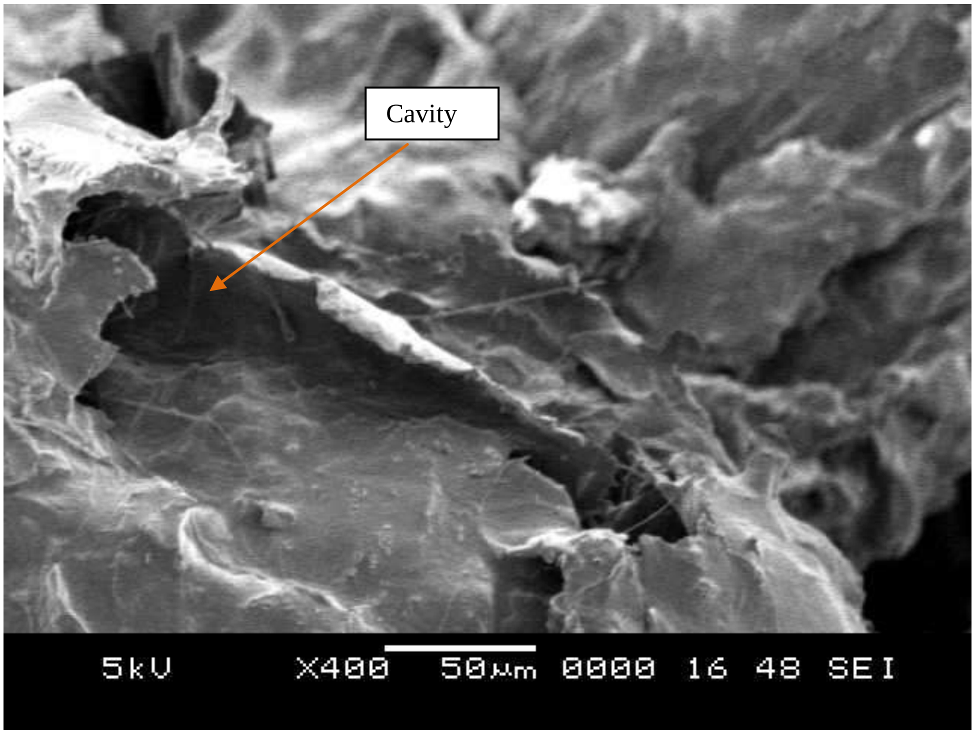

Fig. 10.Cavity formed due to fiber pull out in the vinyl ester composite

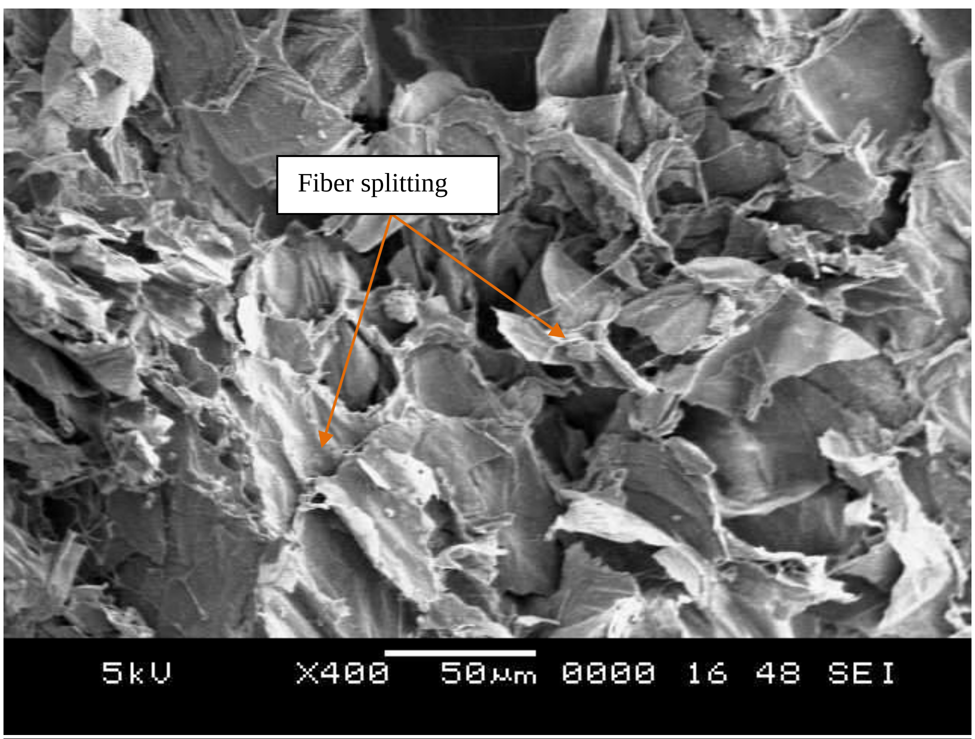

Fig.11.Fiber splitting in the epoxy composite

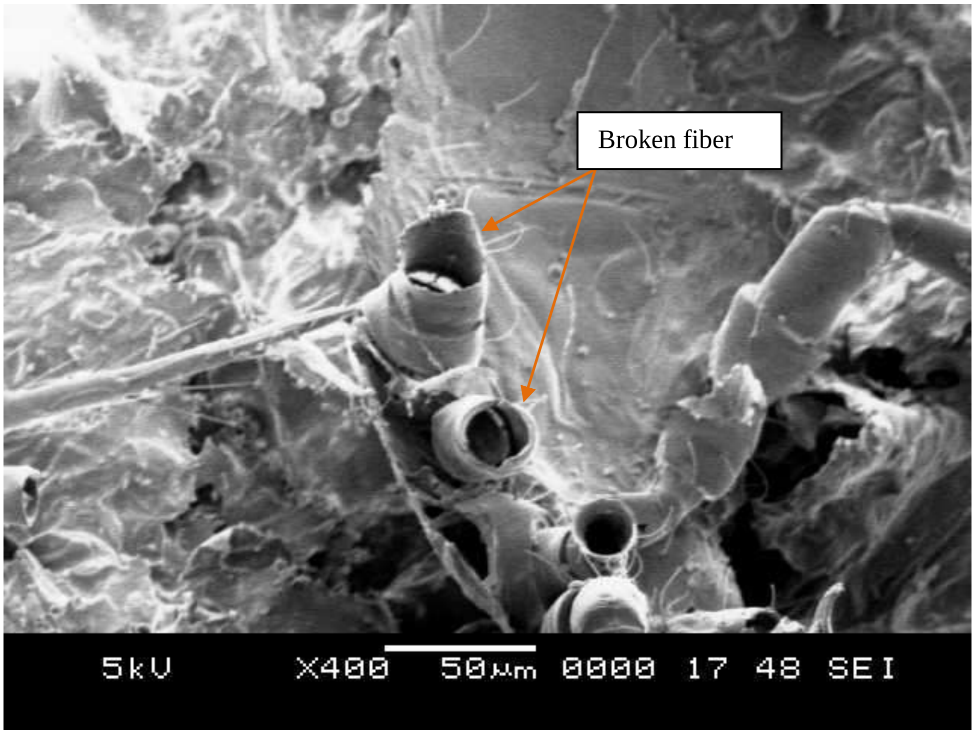

Fig. 12.Broken fiber in vinyl ester composite.

V CONCLUSION

- The results showed that the brittle type of failure occurred in epoxy and vinyl ester composites. The vinyl ester composites exhibited higher compressive strength than the epoxy composites because of the good interfacial bonding.
- The percentage loss of weight in epoxy and vinyl ester composites was found to vary randomly. This is due to the uneven distribution and orientation of fibers. Both types of composites exhibited high wear resistance at 90 º nozzle angle than at 75 º nozzle angle.
- Density of vinyl ester composites was found to be less than epoxy composites.
- The water absorption capacity of all composites was found to increase as the fiber content increased. This is due to the more affinity of fibers to water. The water absorption capacity of epoxy composites was found to be less than the vinyl ester composites at all weight percentages.
- The SEM images indicate that a combination of matrix cracking, fiber pull out, fiber orientation, breakage and splitting are the predominant failure modes.

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