



Water Absorption Behavior of Areca Leaf-Carbon Nanotube-Epoxy and Eupatorium Fiber-Carbon Nanotube-Epoxy Reinforced Hybrid Polymer Composites

M.M. Sujay, H.R. Shivakumar
Department of Chemistry, KVG College of Engineering,
Sullia-574327, Karnataka, INDIA

Abstract: The natural fibers such as areca leaf and eupatorium fiber were introduced as reinforcement materials with matrix. In order to enhance the water resistance property it was intended to incorporate multiwalled carbon nano tube into fiber-matrix. Two different types of composites such as areca leaf-carbon nanotube-epoxy and eupatorium-carbon nanotube-epoxy of different weighing percentages were prepared and immersed in sea water at room temperature. The experiment was continued till the composite gets saturated. The results showed that eupatorium-carbon nanotube-epoxy composite absorbs lower amount of water.

Key words: natural fiber, carbon nanotube, polymer composite, water absorption

I. Introduction

The technological innovation seeks the development of new materials in the recent years [1]. In these aspects, the synthetic and natural fiber composites are the two distinct features growing in engineering and industrial field [2]. Out of these two composites, the natural fiber polymer composites are gaining more interests due to their environmental friendly nature and good mechanical properties [3]. On environmental concern, they have extensive usability in construction, packaging, medical, defense and automobile industries [4,5]. The ease of utilization natural fiber composites in these fields are due to their some advantages such as economic, biodegradability, light weight, easily available raw materials for the preparation, resistance against corrosion [6,7,8]. In spite of advantages, they have some demerits. But they can be overcome by incorporation some other reinforcement material during the preparation process. This allows the formation of new class of material and termed as hybrid composites [9, 10]. The main cause of natural fiber on composite materials is due to the hydrophilic nature of fiber used. The hydrophilicity of natural fiber is due to presence of lignin, pectin, hemicellulose etc. [11]. This attracts moisture or water more rapidly than synthetic fiber material. There are some aspects for the water content to diffuse through the materials. The water molecules diffuse through micro pores in the polymer, also they can enter through micro cracks of the material [12,13]. The properties of the material are changed significantly by weakening and destruction of bond at fiber and matrix phase and reduction in the mechanical properties [14,15]. In this work two different types of natural fiber composites were prepared. The materials were immersed in sea water for 44 days under normal temperature condition.

II. Materials and Methodology

A. Materials

Natural fibers: Areca leaf fiber collected from the leaf of areca nut tree. The species are widely spread in coastal regions of the Karnataka. It is considered as one of the prominent commercial crop cultivating in South India. The leaf was initially washed and dried in sunlight. The fiber was then extracted from the leaf as length of 4-6mm and 2mm width and dried in oven for complete removal of moisture content (Fig.1). The other type of fiber is Eupatorium (Fig.2) extracted from stem of eupatorium plant. They are also largely distributed in coastal Karnataka and easily available fibers. The similar extraction technique was continued as areca leaf fiber. These two fibers are known to be as short fibers and also considered as first reinforcement materials.

Figure 1. Areca leaf fiber



Figure 2. Eupatorium fiber



Figure 3. Water absorption test



The second reinforcement materials is multiwalled carbon nanotube (purity >95%, length 0.5 nm) procured from Sigma Aldrich. The matrix phase is epoxy resin (LY 556, Density 1-1.5 g/cm³) procured from the Zenith industrial supplies Bangalore, India, a thermosetting material having promising properties over other resins. Hardener (HY 951) procured from Zenith industrial supplies Bangalore, India for curing of the composites.

B. Methods

The calculated amount of epoxy resin and multiwalled carbon nanotube mixed together and kept under ultrasonication process for uniform mixing of carbon nanotube (CNT) in the resin. The extracted areca leaf fiber was calculated as per requirement and mixed with uniform mixture of epoxy-CNT. This mixture was stirred up to 2-3 minutes for complete mixing of fiber. The hardener was added and again stirred for 5 minutes. The prepared mixture was mould in Teflon mould or mild steel mould and surface of the mould covered by polymer sheet. Later weight was placed on the mould and kept for 24 hours for curing. The material was then removed and cut into required size for water absorption test as per ASTM D-570. Various percentage of materials have been prepared for areca leaf fiber polymer composites such as 6%, 8%, 10%, 12%, 14%, 16% of weight fractions. Under these each percentage of weight fractions, the fiber volume and CNT volume are varied into five composite,

A=99.8% Fiber+0.2% CNT

B=99.6% Fiber+0.4% CNT

C=99.4% Fiber+0.6% CNT

D=99.4% Fiber+0.8% CNT

E=99.0% Fiber+1.0% CNT

The similar processing techniques have been followed for Eupatorium fiber polymer composites. But the variation of percentage has been carried for 2%, 4% and 6% of volume fractions. Above 6% volume fraction the fibers were not mixing properly. The prepared rectangular materials were dried completely and weighed before immersing into sea water. The successive weights were noted down for each 24 hours of duration till the samples get saturation (Fig. 3).

The effect of water absorption was investigated by taking weight differences of the samples and they were calculated by percentage of water absorption for each 24 hours immersion by the following formula, [16,17].

$$\text{Percentage of water absorption (\%)} = \frac{(W_t - W_o) \times 100}{W_o}$$

W_t is the weight sample after each immersion.

W_o is the initial weight of the sample.

III. Result and Discussion

Water absorption behavior

The water absorption of specimen conducted was noted down and they are plotted as percentage of water absorption v/s time in hours. The results of 6%, 8%, 10%, 12%, 14% and 16% filler volume fractions of areca leaf-CNT-epoxy composites. Also the graphs are plotted for 2%, 4% and 6% filler volume fractions of eupatorium-CNT-epoxy composites.

Areca leaf-CNT-Epoxy polymer composites: The results are plotted in the following graphs (Fig. 4, Fig. 5, Fig. 6, Fig. 7, Fig. 8 and Fig. 9),

Figure 4. Water absorption rate for 6% fillers

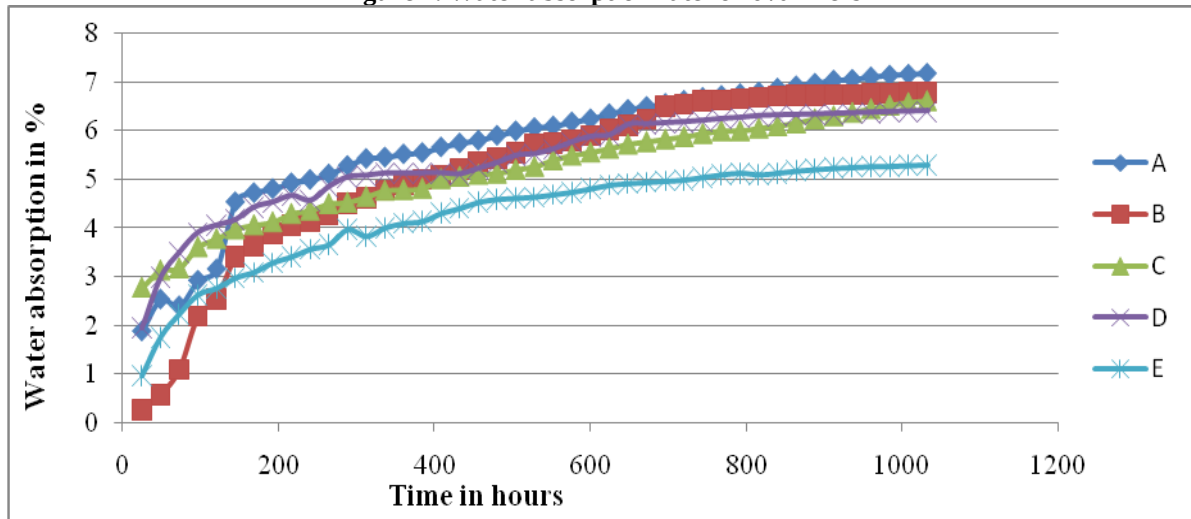


Figure 5. For 8% Fillers

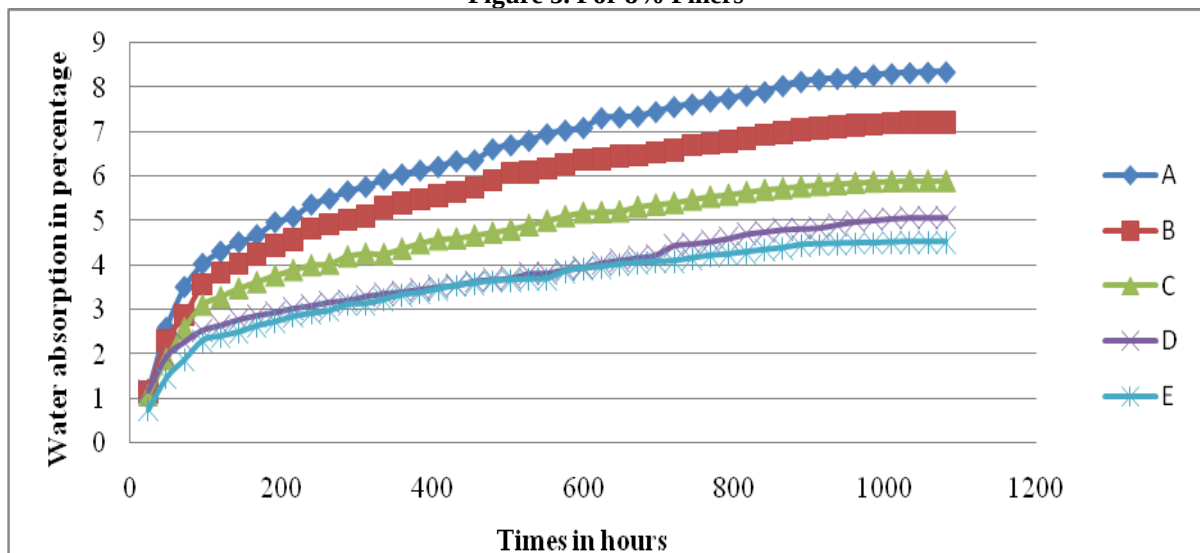


Figure 6. For 10% Fillers

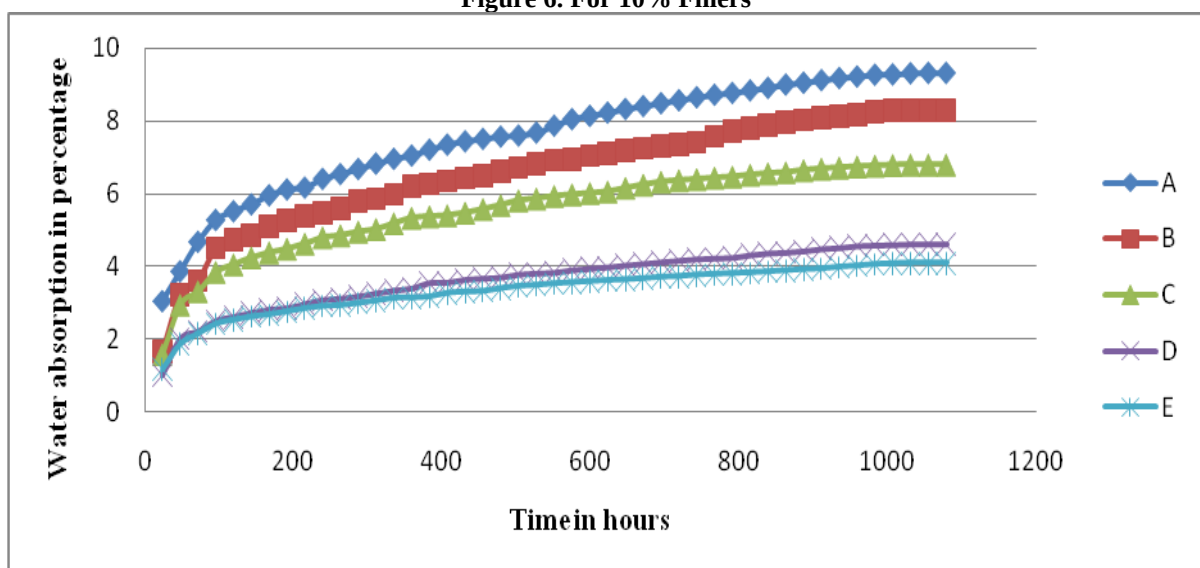


Figure 7. For 12% Fillers

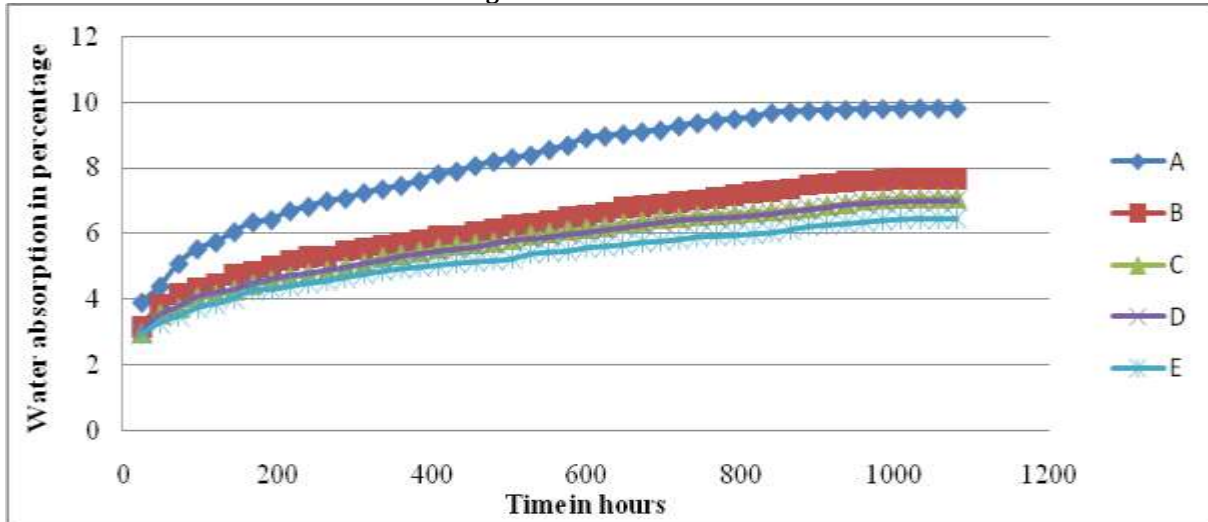


Figure 8. For 14% Fillers

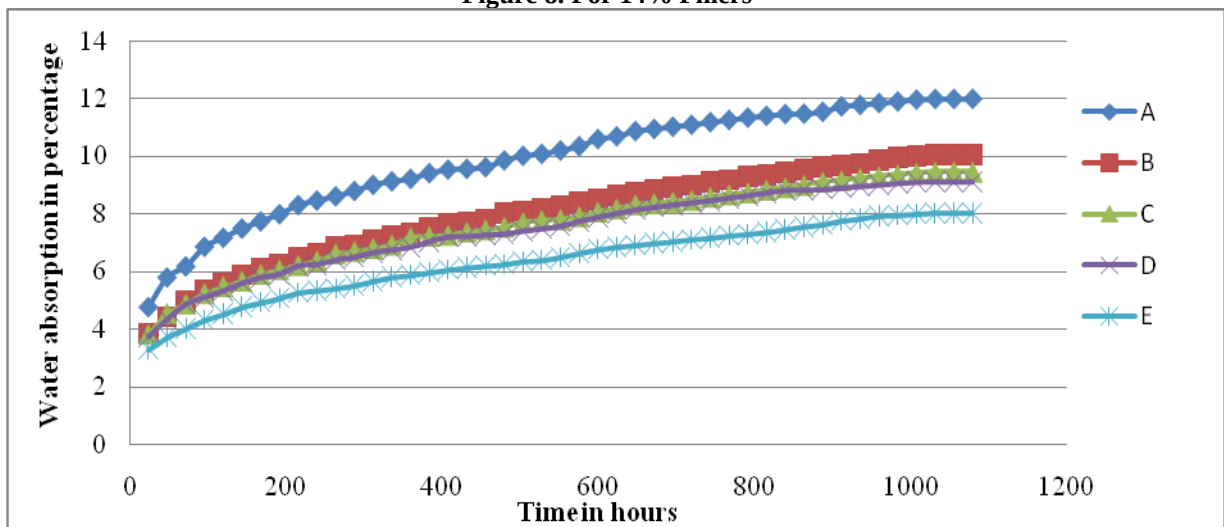
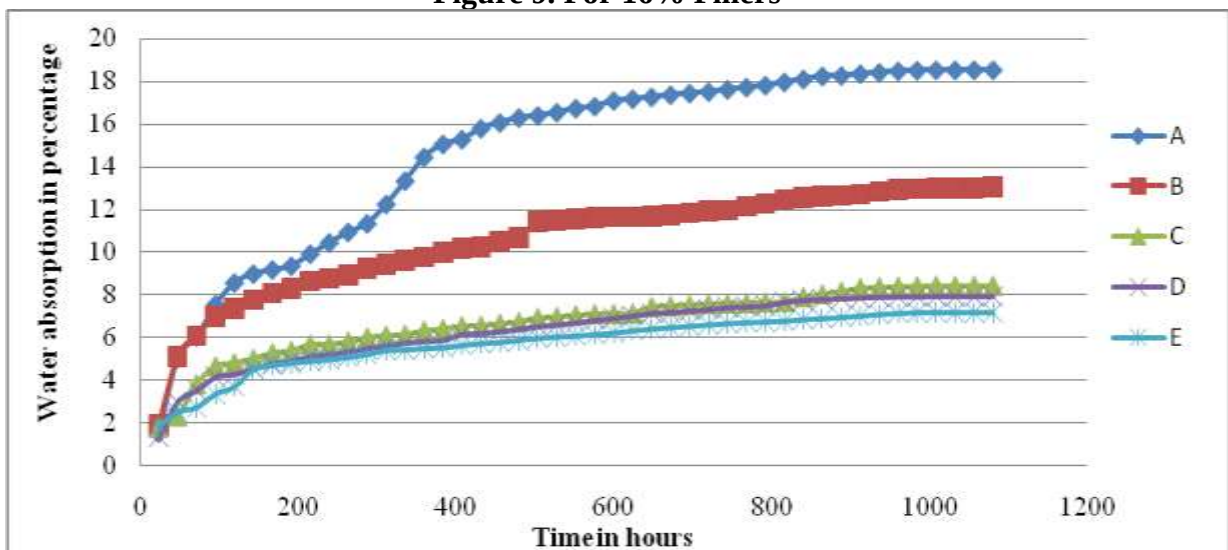


Figure 9. For 16% Fillers



Eupatorium-CNT-Epoxy polymer composites: The results are plotted in the following graphs (Fig. 10, Fig. 11 and Fig. 12)

Figure 10. For 2% Fillers

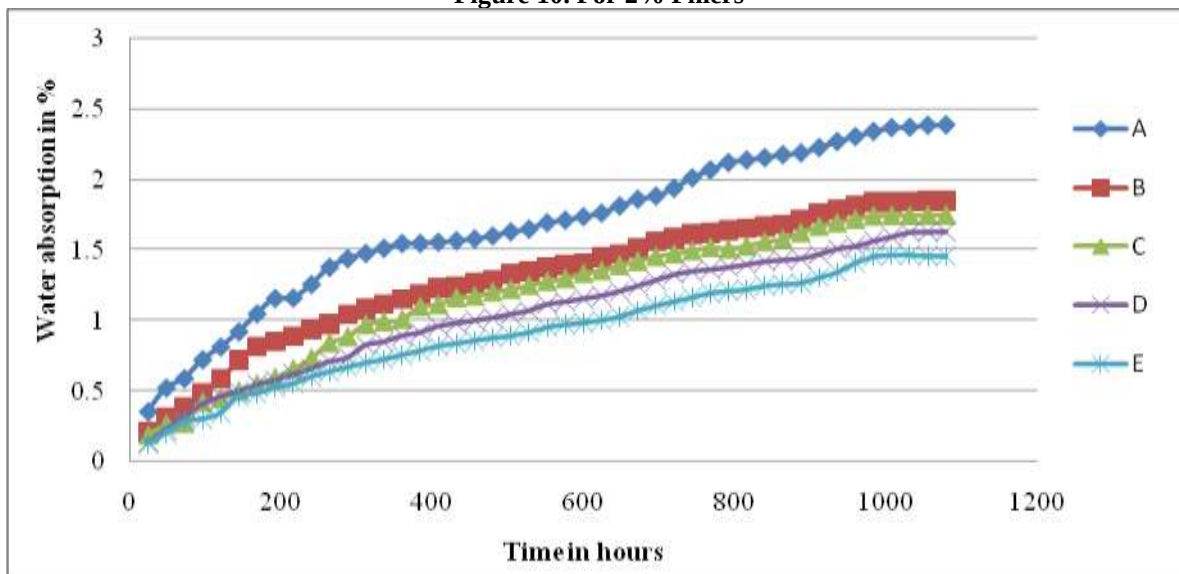


Figure 11. For 4% Fillers

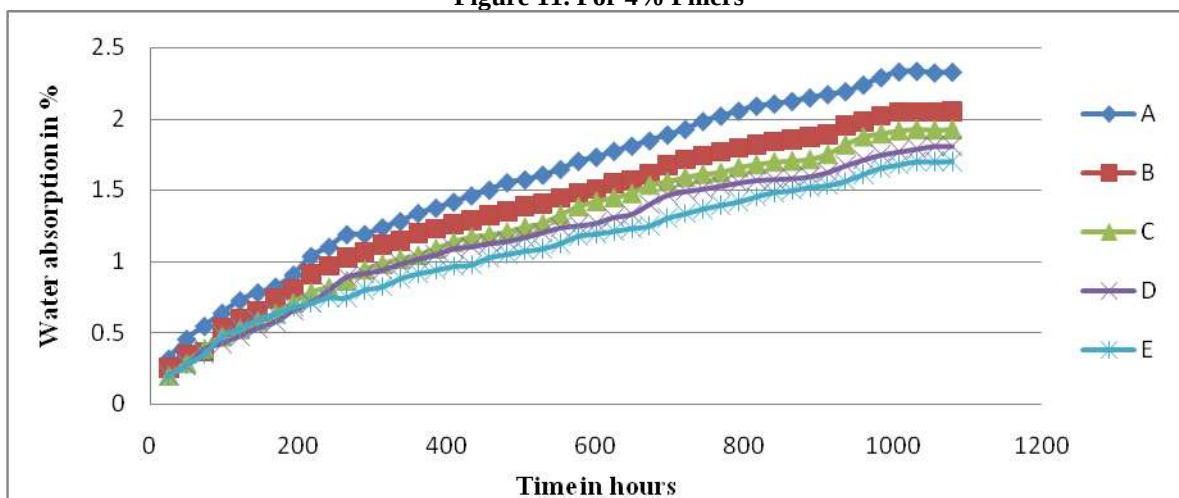
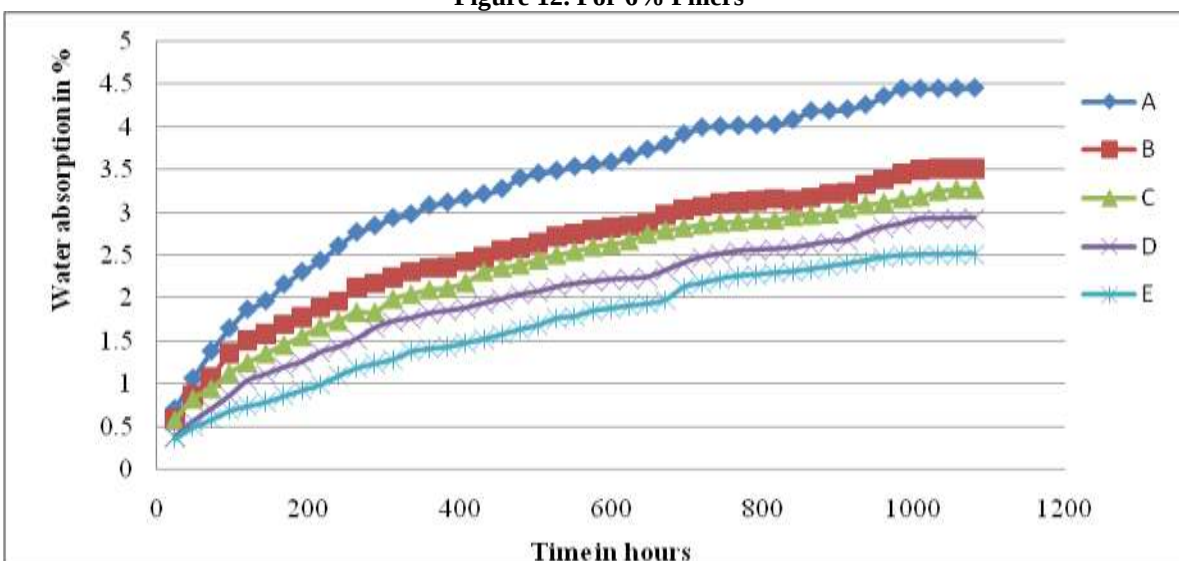
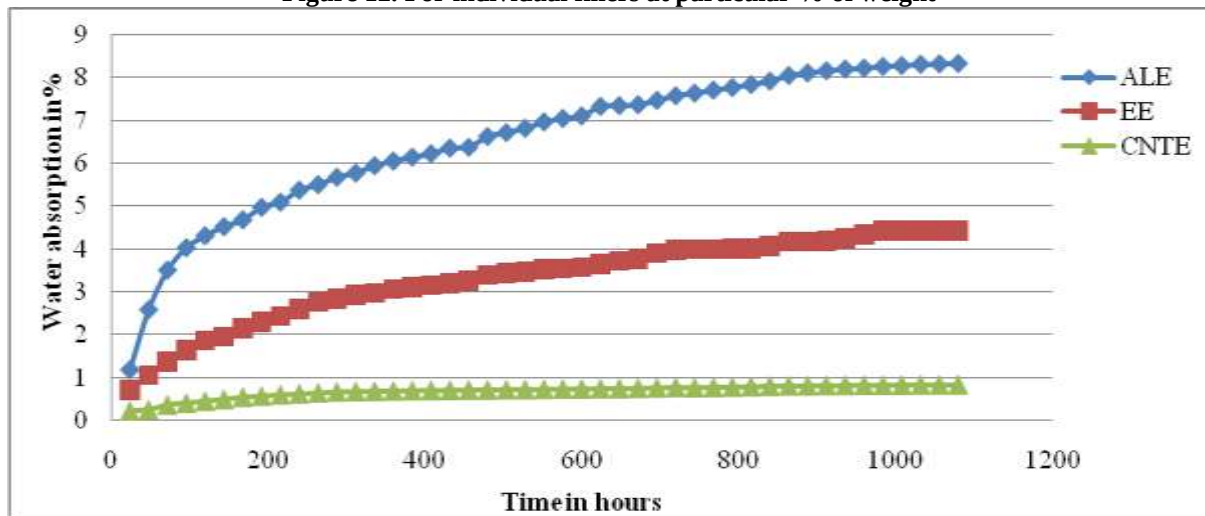


Figure 12. For 6% Fillers



The water absorption behavior of non hybrid composite: The absorption rate of non hybrid composite such as areca leaf-epoxy, eupatorium-epoxy and CNT-epoxy composites at particular weight percentage of fillers are also displayed in the below Fig. 13,

Figure 12. For individual fillers at particular % of weight



The water absorption test was carried until the samples approaches 80% equilibrium. From the above Fig. 4, 5, 6, 7, 8, 9 it is observed that when the filler volume increased the absorption of water molecules also increased. This is due to the presence of natural fiber which is hydrophilic in nature. Within the variation of filler content in the composites, when the percentage of natural fiber decreased and CNT increased, there is a decrease in water absorption. In order to analyse the effect of presence of individual materials in the composite, the comparison was done for higher water absorption rate of hybrid composite with non hybrids at the similar weights. In each percentage of composite fillers, 99.8% of natural fiber and 0.2% of CNT has highest absorption rate. But it is decreased when percentage of natural fiber decreased and CNT increased up to 99.0% natural fiber and 1.0% CNT fractions. This trend is continues for all volume percentage of composites. In 6% non hybrid areca leaf-epoxy composites (ALE at 99.8% fiber + 0.2% CNT) (Fig. 13), the percentage of water absorption is found to be 8.32% which is greater than hybrid areca leaf-CNT-epoxy composites. Also when it goes with non hybrid CNT-epoxy composites, it shows 0.8284% water absorption percentage. This implies there is some resistance by the hybrid composites against water absorption. This resistance may be due to presence of CNT in the materials.

The similar trend is observed in eupatorium-CNT-epoxy polymer composites (Fig. 10, 11, 12). But extent of water absorption is lower than areca leaf-CNT-epoxy composites. This lower absorption of water may be due to eupatorium fiber which has lower content of cellulose. In both the composites, in initial stage the water absorption rate increased largely and proportion of increasing rate was decreases when time goes on. At some stage they attain equilibrium later the rate of absorption became constant. When water absorption behavior of these hybrid composites are compared with non hybrid composite of 2% weight of eupatorium-epoxy (EE at 99.8% fiber + 0.2% CNT) (Fig. 13), the eupatorium-epoxy (4.44%) shows higher water absorptive value than hybrid eupatorium-CNT-epoxy composite (2.38%) (Fig. 9). From the overall results, non hybrid natural fiber-epoxy composite shows greater absorption property than natural fiber-CNT-epoxy hybrid composites. This implies that there is little tendency for CNT to resist absorption of water that is observed in hybrid natural fiber-CNT-epoxy composites.

IV. Conclusion

The natural fibers such as areca leaf fiber and eupatorium fiber were considered as reinforcement fillers incorporated with mixture of multiwalled carbon nanotube and epoxy resin. The combination of these three materials leads to formation of hybrid polymer composites. The water absorption is one of the draw back in natural fiber used composites. It reduces the durability of the composites when they exposed into environment. But this draw back can be reduced by incorporating second reinforcement material such as carbon nanotube. By the result it is concluded that when there is increase in content of natural fiber the water absorption capacity increases. This is mainly due to hydrophilic nature of cellulose content present in fibers. The eupatorium-CNT-epoxy composite shows lower water absorption capacity when compared with areca leaf-CNT-epoxy composites. This is due to aspect ratio of eupatorium fiber which is greater than areca leaf fiber and low cellulose content in eupatorium fiber.

Abbreviations:

CNT : Carbon nanotube
 ALE : Areca leaf-epoxy composite
 EE : Eupatorium-epoxy composite
 CNTE : Carbon nanotube-epoxy composite

V. References

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