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Physical Behavior of Areca Leaf-Carbon Nanotube-Vinyl Ester and Eupatorium Fiber-Carbon Nanotube-Vinyl Ester Reinforced Hybrid Polymer Composites

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Abstract:*The work is based on the absorptive property of composite material. Composites have wide applications in construction, transport, food packaging, marine technology, automobile, sports equipments and medical purposes. It was intended to prepare the composites and characterized for physical behavior. The two different types of natural fibers such as areca leaf and eupatorium fibers were introduced into the vinyl ester matrix. In various percentages of weight the materials were mixed together. The carbon nanotube has the property to resist the water absorption. On this basis it was intended to introduce the carbon nanotube in micro quantities. The prepared composites are subjected to the sea water to investigate absorption capacity of the composite materials. The results showed that, the increase in the amount of natural fibers increased the rate of absorption with time and then it is saturated. Further it was compared with one of the non hybrid composite for the better studies.*

Key words: *natural fibers, carbon nanotube, vinyl ester, water absorption..*

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I. Introduction

The modernization of lifestyle of living beings need in demand of highly durable and reliable materials[1, 2]. To furnish the necessity of technological and materialistic field several materials have been developed with significant properties [3]. In this regard, there are many properties which are improvised by utilizing different kinds of materials[4]. The engineering technological fields are polarized towards the preparation of composite materials to acknowledge these aspects[5, 6]. Now a days, the composite consisting of natural fibers gaining more importance over the other conventional materials. This is due to their light weight, relative stiffness, biodegradability, corrosive resistance, easily availability of raw materials[7, 8, 9]. The properties can be geared up and enhanced by incorporating other materials effectively[10,11]. The demerits caused due to the presence of one type fiber can be neutralized by the addition of another material. Henceforth, two different kinds of materials interact together to give new call of material called hybrid composites[12,13].

Even though there are favorable characters in natural fibers a few drawbacks may be thoughtful subject in composite technology. But those could be re-emerged and properties can be enhanced by incorporating other materials or modifying the nature of the fibers[14, 15, 16]. Hence natural fibers have the ability to replace some of the synthetic reinforced composites in property wise[17, 18]. In this context, the absorption of water is one of the major drawback in composite materials. This is due to the hydrophilic nature of natural fibers present in the composites[19, 20, 21]. The rate of water absorption can be overcome by incorporating hydrophobic materials to the composite[22]. By this one could avoid the absorptive property of the composites.

In this study, it was intended to incorporate multiwalled carbon nanotube as reinforcement material. It has promising applications in the automobile, aerospace, packaging, medical and construction fields as nanocomposites[23, 24, 25]. Since its discovery, carbon nanotube has been employed in vast areas due to their substantial importance in terms of physical, mechanical, thermal and electrical properties[26, 27]. They have an unique properties such as greater aspect ratio, stress transfer between fiber and matrix, hydrophobic character, low density etc makes composites for better use for applications[28, 29, 30, 31, 32].

II. Material And Methods

The paper presents the water absorption capacity of areca leaf-CNT-vinyl ester and eupatorium-CNT-vinyl ester hybrid polymer composites. These are prepared for various weight percentages of composites and subjected to water absorption test.

Materials: Two different types of natural fibers were introduced such as areca leaf and eupatorium fiber. Areca leaf is widely distributed in South India and they are least utilized. They have good mechanical property and people use it for agriculture purpose. Along with this eupatorium is other type of plant naturally spread in the coastal Karnataka (India) region. It has good tensile strength but unutilized. These two natural fibers are extracted from the source and washed with water to remove particles and dusts. They were cut into short fibers (4-6 mm) and again made to dry in oven at 50^0C for about 2 hours. It was taken out, rested in desicator to keep away from moisture and used directly during the preparation of composites whenever required. These are introduced as short fiber reinforcement materials to composite.

Carbon nanotube (CNT) is other reinforcement fiber and it is multiwalled nanomaterial. It was procured from Sigma Aldrich with high purity. These natural fibers and CNT introduced into vinyl ester which is a matrix phase for the preparation of hybrid composites. Other than reinforcement materials, Methyl ethyl ketone peroxide as catalyst, Cobalt naphthanate as accelerator and Boron trifluoride as promoter (all these chemicals were procured from Chemicote engineers, Bangalore-India) used for curing purpose.

Figure 2.1: Eupatorium plant

Figure 2.2: Extracted eupatorium fiber

Figure 2.3: Areca leaf

Figure 2.4: Extracted areca leaf fiber

Figure 2.5: Carbon nanotube

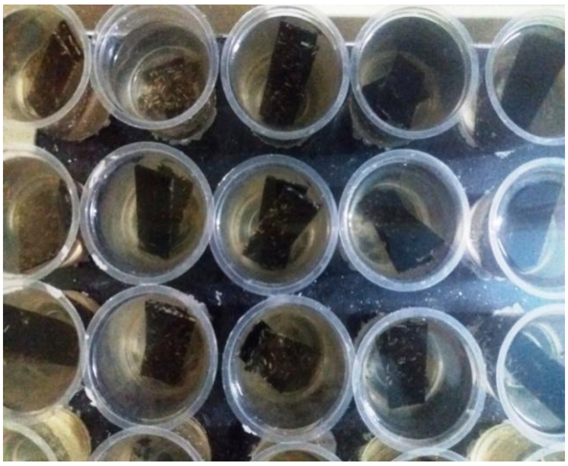

Figure 2.6: Absorption test

Methodology: The exact quantity of carbon nanotube was weighed and mixed in to weighed vinyl ester resin. It was then kept under ultrasonication chamber for the complete dispersion of CNT. After 6 hours of ultrasonication, the CNT-vinyl ester mixture was removed. The areca leaf was weighed and mixed to CNT-vinyl ester mixture and stirred for 3 minutes for finer wetting of fibers. Later the accelerator, promoter and catalyst are added and stirred for 2 minutes. It was then poured into cleaned mold. The sheet is applied on the surface of the mixture and weights are infix over it, left for 24 hours of curing. After completion of process the composite is removed from the mold and cut into rectangular shape, weighed initial weight of material and introduced for absorption tests in the sea water. The gaining of weight was noted everyday till it was reached saturation. The percentage of weight gained in each day was calculated using the formula,

$$\text{Water absorption (\%)} = \frac{W_2 - W_1}{W_1} \text{ X } 100$$

W_1 is the weight sample before immersing into sea water
W_2 is the weight of sample after 24 hours of immersion

The composites were prepared for 6%, 8%, 10%, 12% and 14% of weight percentage. Within these base amount, the CNT and Leaf fibers are varied up to five variations such as 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. Below 6% amounts, the fiber was floating and above 14% of weight the fibers haven't mixed properly.

The similar methods were continued for the preparation and absorption tests of eupatorium-CNT-vinyl ester polymer composites. The sample preparation is restricted from 2%, 4% and 6% of base amounts. This is due to the floating and inappropriate dispersal of fibers below 2% and above 6% in the CNT-vinyl ester mixtures respectively.

III. Result

Analysis of physical behavior is one of the most desirable way to examine the overall properties of the composites. The absorption test determines the probability of the composites to the areas where they can afford. Firstly, the results of the absorption behavior of areca leaf-CNT-vinyl ester composites are given below in the series of graphical figures.

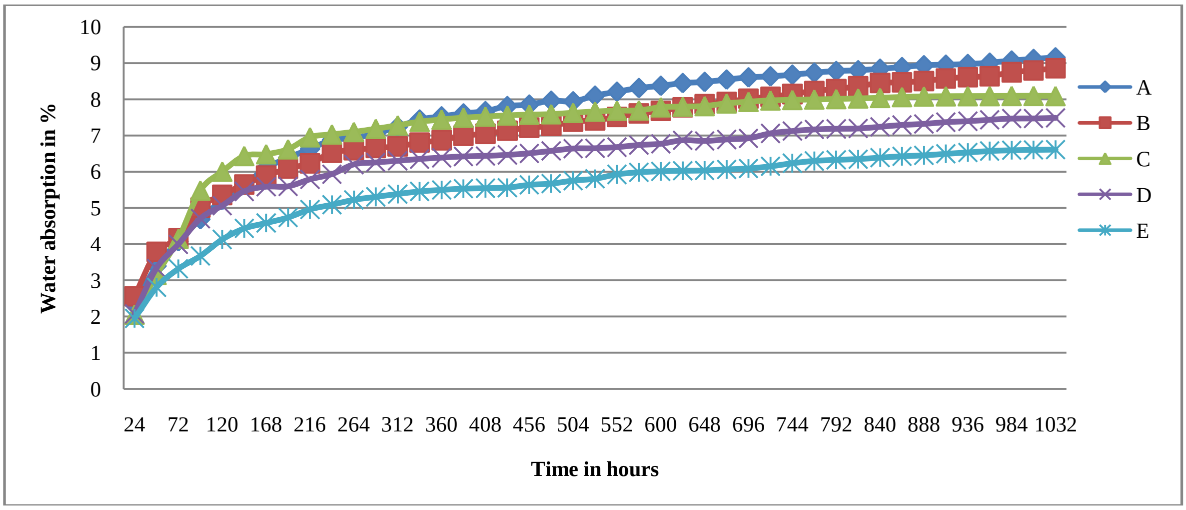

Figure 3.1: Water absorption for 6% fillers

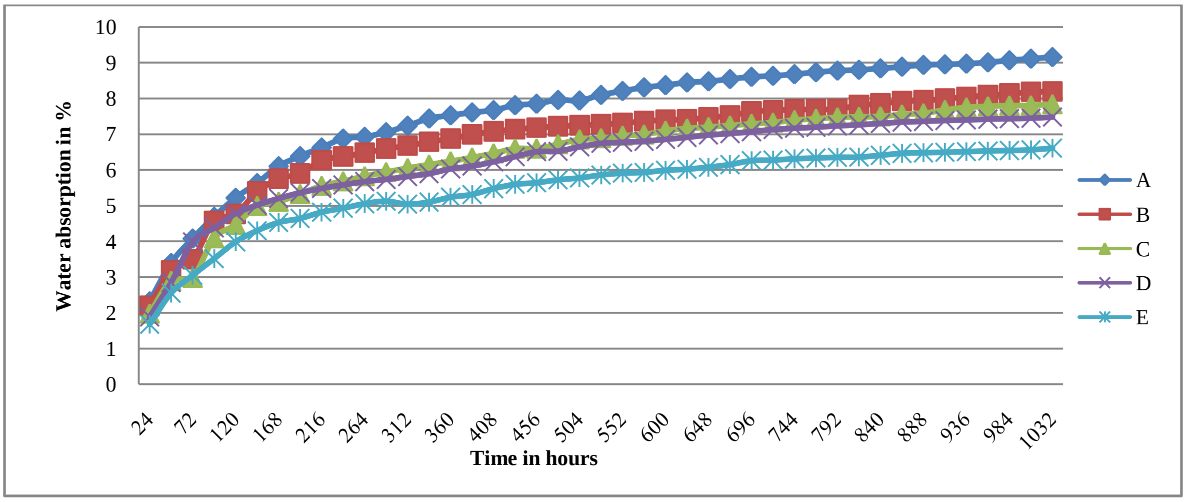

Figure 3.2: Water absorption for 8% fillers

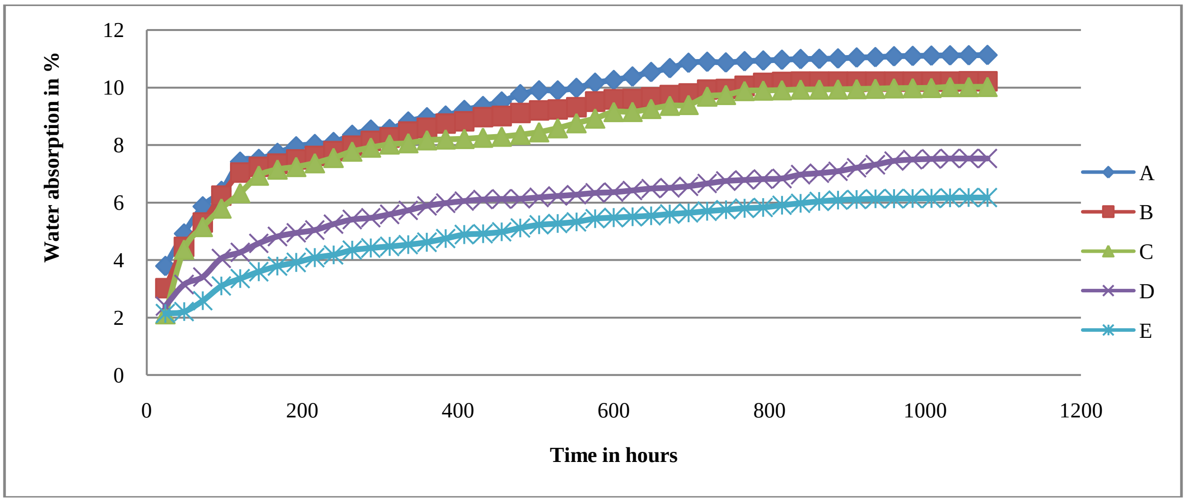

Figure 3.3: Water absorption for 10% fillers

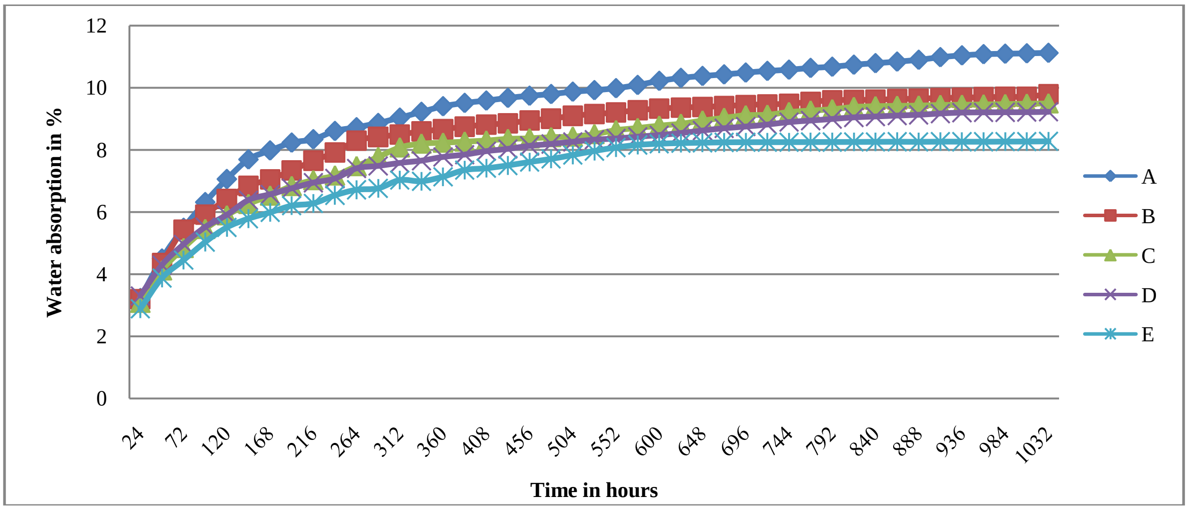

Figure 3.4: Water absorption for 12% fillers

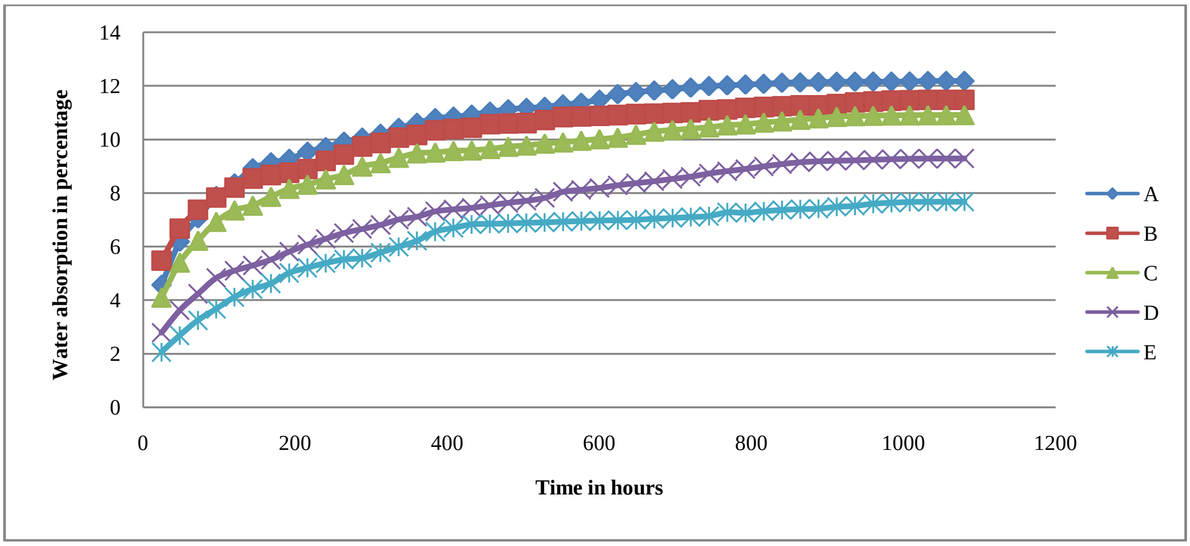

Figure 3.5: Water absorption for 14% fillers

The above Figure 3.1, 3.2, 3.3, 3.4 and 3.5 shows that, the increase in the amount of areca leaf fiber in the composites increases absorption rate. It is found that 14% fillers (fiber + CNT) have the higher rate of absorption. Within the each amount of each fillers of composites, there is decrease in the absorption rate from the material A to E in all the composites. In these composites the fiber amount is decreases and CNT is increased. Hence CNT being hydrophobic enhances water resistance of the composites.
In the following, the results of eupatorium-CNT-vinyl ester composites are figured out.

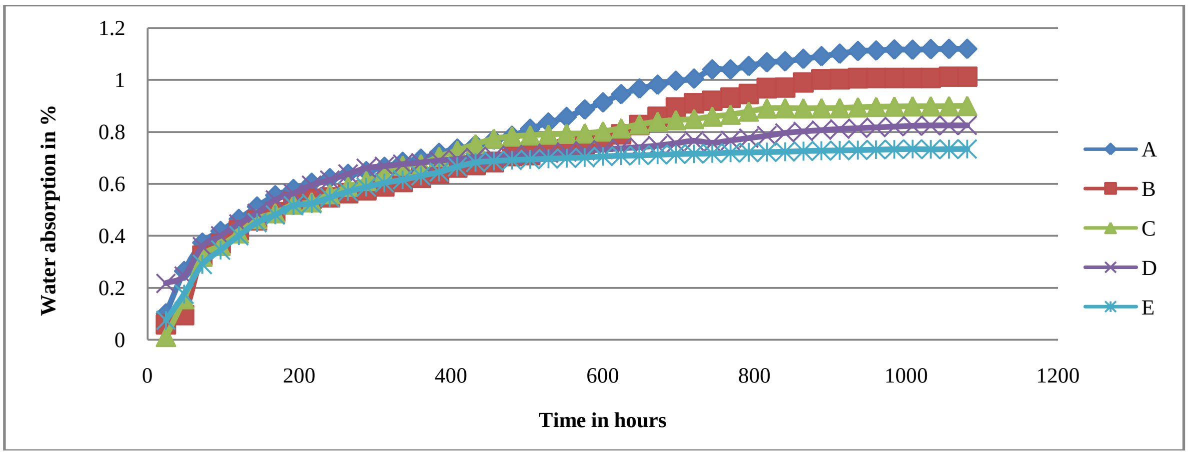

Figure 3.6: Water absorption for 2% fillers

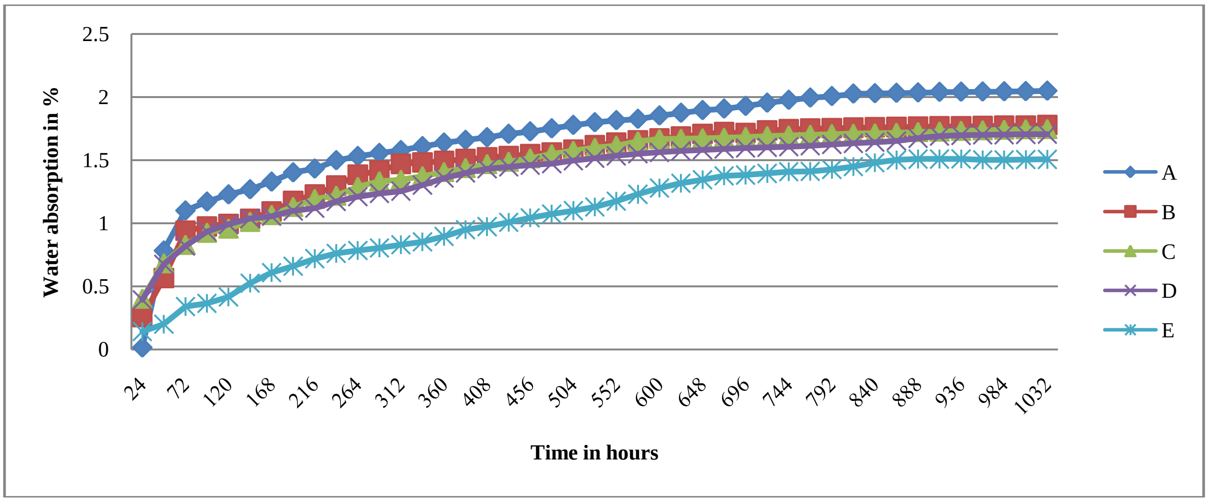

Figure 3.7: Water absorption for 4% fillers

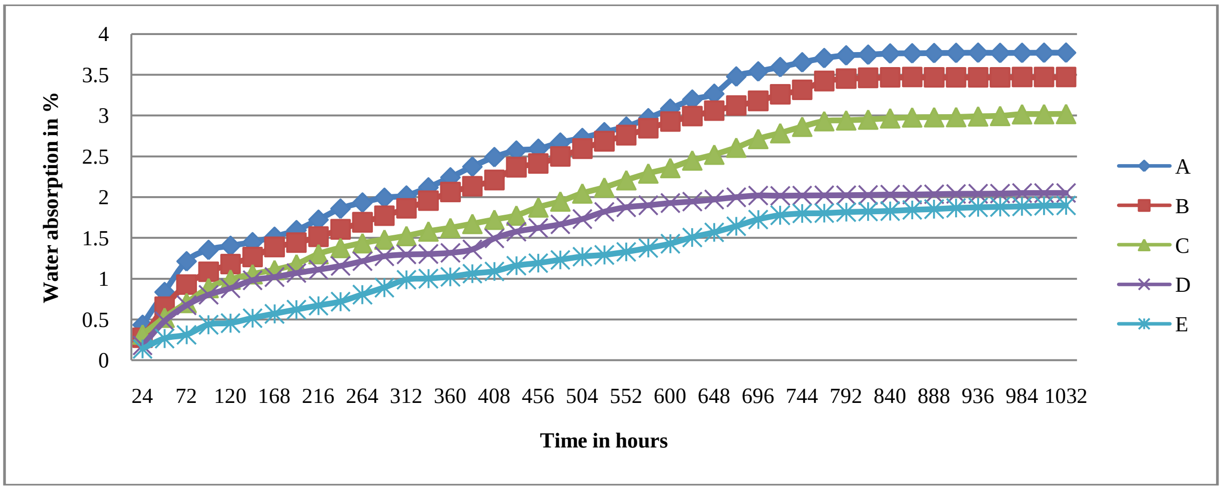

Figure 3.8: Water absorption for 6% fillers

The above Figure 3.6, 3.7 and 3.8 are related to the eupatorium-CNT-vinyl ester polymer composites. It shows the similar trends attained in the areca leaf-CNT-vinyl ester composites. Where there is decrease in the eupatorium fiber load and increase in the CNT load, there is decrease in the absorption capacity.

The water absorption test also conducted for non hybrid areca leaf-vinyl ester, eupatorium-vinyl ester composites and CNT-vinyl ester composites. It was done to understand the influence of fiber and CNT on the rate of absorption of hybrid composites. It was done at particular amount of fillers and CNT added where it got higher absorption rate for hybrid composite. The results of this test is plotted below Figure 3.9,

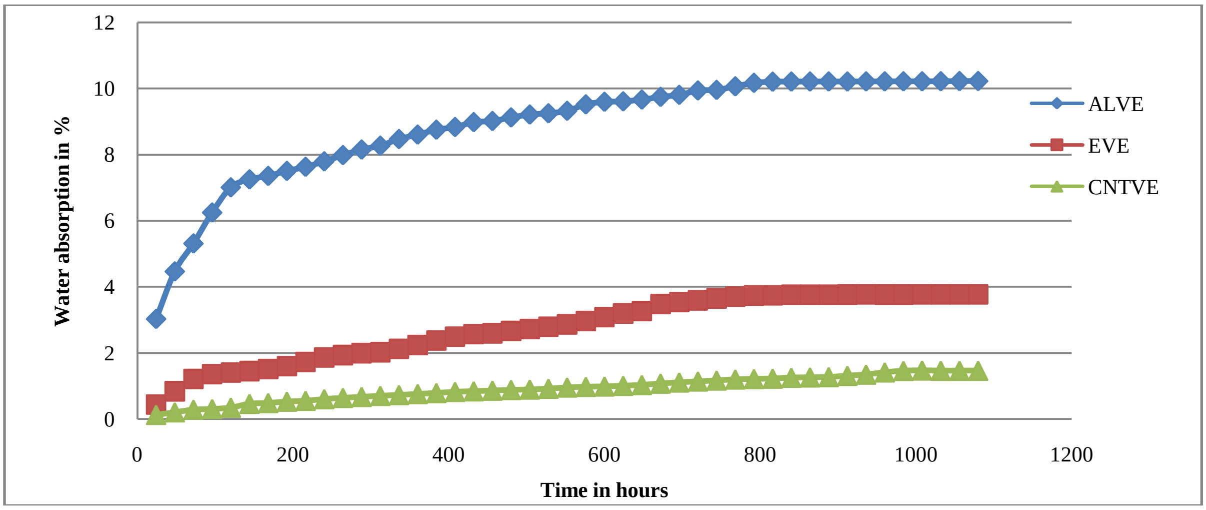

Figure 3.9: Water absorption for individual composites

In the graph, non hybrid areca leaf-vinyl ester (ALVE) absorbs more amount of water when compared with eupatorium-vinyl ester (EVE) composite. There is large difference in absorption rate between those two non hybrid composites. When it is dealing with CNT-vinyl ester (CNTVE), it absorbs less amount of sea water. Hence this shows that, presence of natural fibers increases water absorption and when it is replaced with CNT it was decreased. Also there is abrupt decrease in the absorption rate for CNTVE alone. This is due to absence of absorbing materials (natural fibers) in the composites.

IV. Discussion

Natural fibers and CNT are incorporated to vinyl esters successfully. The rate water absorption have been increased with time and saturated. By the addition of CNT to composites, the water absorption resistance has been increased. The eupatorium reinforced hybrid composites showed lower absorption capacity than areca leaf reinforced composite. This may be due to the lesser amount of cellulose contents in the eupatorium fiber. Addition of CNT again made two composites to absorb lower rate of absorptive capacity. This is due to the replacement of hydrophilic fibers by hydrophobic CNT materials. Therefore the better water absorption resistance is found in eupatorium-CNT-vinyl ester composites. Hence it may sustain the mechanical properties which is important aspects in the several applications of composites.

V. Conclusion

Eupatorium-CNT-Vinyl ester hybrid composites show significant physical behavior over Areca leaf-CNT-Vinyl ester hybrid composites.

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