Study the effect of diffusion properties for chemically treated fiber reinforced polyester

Asst. Prof. Dr. Wafaa Mahdi Salih
Materials Engineering Department
University of Technology
Baghdad, Iraq
wafasaleah121@yahoo.com

***Abstract*—This research studied the effect of composite materials reinforced fiber and prepared from material (polyester with various natural fibers) then studied the effect of chemical treatment on the same fiber immerse in (10%) NaOH solution for half an hour and then compared the diffusion properties for two types of solutions and compared the results of the same test for composite materials without and with chemical treatment. The result shows that solution would be absorbed in the pure then the composite reinforced before treatment and composite reinforced after treatment has the small absorbed and it clear that the type of fiber has an effect in absorbed sisal more than that in hemp, lufa but the palm leaf, because that the fiber/matrix interface plays the role of a channel for a solution to penetrate into the composite; this penetration normally starts at cut edges. And the diffusivity coefficients of salt water in the materials (under test) have converged compared with that of pure matrices, due to the interface defects or in-homogeneity that exists in the blends and composites.**

And the research conclusions are:-

1- From the results generated, it can be establish that (NaOH) treatment of different fibers have better reinforcing property than the untreatment fiber.

2- The treatment was observed to improve the good results of the composite samples.

3- That such sorts of environments must be avoided when composites are used.

4- The palm leaf fiber gave the best reinforcing for treated fiber composite comparing with the other fibers reinforcement because of the nature of crosslinking.

Keywords-palm leaf; polyester; Natural fiber;chemically treated fiber.

I. INTRODUCTION

A composite material is a macroscopic combination of two or more distinct materials, having a recognizable interface between them. Composites are used not only for their structural properties, but also for electrical, thermal, tribological, and environmental applications .Modern composite materials are usually optimized to achieve a particular balance of properties for a given range of applications. Given the vast range of materials that may be considered as composites and the broad range of uses for which composite materials may be designed, it is difficult to agree upon a single, simple, and useful definition. However, as a common practical definition, composite materials may be restricted to emphasize those materials that contain a continuous matrix constituent that binds together and provides form to an array of a stronger, stiffer reinforcement constituent. There salting composite material has a balance of structural properties that is superior to either constituent material alone. The improved structure properties generally result from a load-sharing mechanism. Although composites optimized for other functional properties (besides high structural efficiency) could be produced from completely different constituent combinations than fit this structural definition, it has been found that composites developed for structure applications also provide attractive performance in these other functional areas as well. As a result, this simple definition for structural composites provides a useful definition for most current functional composites [1].

All parts made of composites are designed to sustained long life. This is why they are made of non degradable materials. But this advantage has become disadvantage due to the fact composite are not easy to dispose off after their proposed life. Girisha C, Sanjeev amurthy and unti Ranga Srinivas, (2012) studied the Natural fibers (Sisal and Coconut coir) reinforced Epoxy composites were subjected to water immersion tests in order to study the effect of water absorption on the mechanical properties. Natural fibers like coconut coir (short fibers) and sisal fibers (long fibers) were used in hybrid combination and the fiber weight fraction of 20%, 30% and 40% were used for the fabrication of the composite. Water absorption tests were conducted by immersing specimens in a water bath at 25 ºC and 100 ºC for different time durations [2].

Srinivasa C. V, and Bharath K. N, (2012) studied the extracted of fibers from the areca husk were chemically treated and composites were prepared using urea-formaldehyde resin with randomly orientated of fibers. Based on the criteria that fibers are the main load-bearing agents, the composites were prepared with 60% of areca fibers and 40% of the matrix. The specimens were immersed in seawater, river water, pond water and ground water at room temperature. Areca composites showed more absorption of pond water compared to bore-well water and seawater. Present work reveals that areca composites absorb less amount of water when compared to conventional wood- based particle board [3].

Saheb D. Nabi, and Jop J. P., (2007) studied natural fiber reinforced composites is an emerging area in polymer science. These natural fibers are low cost fibers with low density and high specific properties. The natural fiber composites offer specific properties comparable to those of conventional fiber composites [4].

Tingting Chen,Wedni, Liu, and Renhui Que, (2013) prepared hemp fiber reinforced unsaturated polyester composite by hand lay out compression molding. Hemp fiber was treated with iso cryanatoethyl methacrylate (IEM), using dibutyl tindilaurate as a catalyst [5].

Giuseppe Cristaldi, Alberta Latteri, Giuseppe Recca, and gianluca Cicala, (1999) made few studies deal with structural composites based on natural reinforcements. These studies are mainly oriented to the housing applications where structural panels and sandwich beams are manufactured out of natural fibers and used as roofs [6].

Marandi. S. M., Bagheripour. M. H., Rahgozar. R. and Zare. H., (2008) investigated the palm fibers in date production have filament textures with special properties such as: low costs, plenitude in the region, durability, lightweight, tension capacity and relative strength against deterioration. Thus, it is possible to use the palm fibers as an alternative low cost natural material for soil reinforcement [7].

Dhakal H.N., Zhang Z.Y., Richardson M.O.W., (2006) studied the effects of water absorption on the mechanical properties of the hemp. HFRUPE composites specimens containing different fiber volume fraction were prepared. Water absorption tests were conducted by immersing specimens in a de-ionised water bath at 250 C and 100 0C for different time durations [8].

Rajni A. , Saxena N. S., Kanan B.and Sharma S., (2006) Study the thermal condition and diffusion through polyester composites using transient plane source technique, thermal properties like thermal conductivity, thermal diffusivity and specific heat of polyester composites of banana fibers (treated and untreated) are measured simultaneously at room temperature and normal pressure[9].

II. EXPERIMENTAL PART

A. Specimens preparation

Specimens preparation involves several stages starting from raw materials selection, mould preparation and completed with the specimen's cutting. This will be explained in the following paragraphs.

B. Raw materials

The specimen of composite material in this study is a mixture two different materials, which is combination; produce a material that has some of the best qualities of each. The two materials are unsaturated polyester resin as a (matrix) and natural fiber as a (reinforcement).

C. The matrix

The matrix used was an unsaturated polyester resin that was obtained from Al- Saudi Company of industrial resin limited.

D. Natural fibers

The natural fiber used in this research was:-

Hemp fiber

Lufa fiber

Sisal fiber

Palm leaf

E. Preparation of composite without treatment

Composite was made using a glass mould having dimensions (20.5x20.5x1.5) CM , width, high respectively ,for four type of fibers. The ratio of hardener which was added to polyester is (98:2), every (98 gm) from polyester adding (2 gm) hardener, then mixed the solution very well before poured it to obtain homogeneity. The frond fibers were put in mould and the resin poured onto fibers. The mould left for 48 hour to get solid samples curing process.

F. Fibers Treatment

Fibers were cut according to the dimension of the mold. Then the fibers rinsed in water and left to dry at room temperature or dryer device before being put in an oven for (3 hours) at (50 ºC) before laying up as a first step then immersed fibers in (10%) NaOH solution in glass receptacle at room temperature for (30 min) , see figure (1).Then dry the fiber by leaving it at room temperature or dryer device before being used.

G. Preperation of composite with treatment

Repeat paragraph (E) using treatments fibers for four different fibers.

H. The Balances Instruments

The sensitive balance was utilized; an electronic with four digits, which was used to measure the weight of the samples that used for diffusivity test shown in figure (2). The weight change (%) of the diffusivity samples after each period of immersion is calculated from the relationship:

$$Weight\ gain\ \% = \frac{W_2 - W_1}{W_1} \qquad (1)$$

Where: W_1: weight of immersed specimen and W_2: weight of dry specimen.

Figure 1. Chemical treatment of fibers.

Figure 2. Sensitive balance.

I. *The Test Specimens*

The test specimens were two types, type one from: polyester-fiber. Figure (3) shows the test specimens in salt water solution for four types.

J. *Measurements:Diffusion Measure*

Calculate diffusion coefficient in the polymeric to blend and in composite material. The balance is also an electronic type AE 160/4 Digits manufactured by (Metler/England) with four digits. It is used to measure the weight of the samples that are used in diffusivity test as shown in figure (2).

The diffusion coefficient (D) is calculated from the equation (Fick's second law):

$$D = \pi\left(\frac{KT}{4Mm}\right)^2 \qquad (2)$$

Where: K: the slope of straight line of the curves, which represent the relations between the weight gain percent (%) and square root of time ($\sqrt{time}$). t: the thickness of the specimen. Mm: the apparent maximum water content (the saturation level).

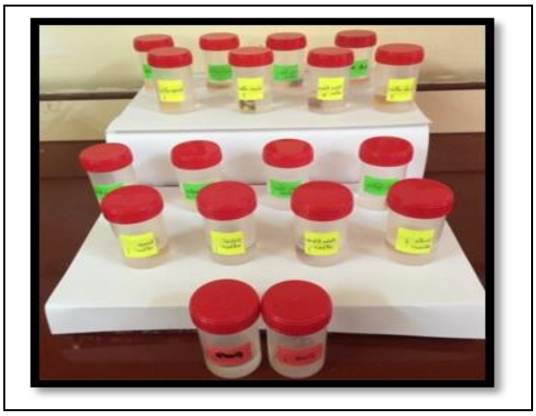

Figure 3. Test specimens.

III. Results and Discussions

A. *Measure results (Diffusion Measure Results)*

Measure results are usually presented in the form of curves; the shape of the curves for fiber reinforced composites varies according to the type of fiber, and the direction of the fiber in the specimen.

The percentages of the solutions that are gained by composites with the types of natural fibers were observed in Fig. (4). Shows that the solution would be absorbed in the palm leaf composites more than the other types of composites, because of the nature of crosslinking.

Figs. (5) to (8) show that solution would be absorbed in the pure then the composite reinforced before treatment and composite reinforced after treatment has the small absorbed and it is clear that the type of fiber has an effect in absorbed sisal more than the other fibers Because that the fiber/matrix interface plays the role of a channel for a solution to penetrate into the composite; this penetration normally starts at cut edges.

This type of channels found in the composites, which means they gained quantity of solution by composites, is more. And the diffusivity coefficients of salt water in the materials (under test) have converged compared with that of pure matrices, due to the interface defects or in-homogeneity that exists in the blends and composites.

B. *Calculate of diffusion coefficient*

Salt water solution in the composites is calculated from Table (I) , according to the second Fick's law. The results are shown in Table (II). From this table, it can be seen, that the diffusivity coefficients of salt water in the materials (under test) has increased compared with that of pure matrices, due to the interface defects or in-homogeneity that exists in the blends and composites. in addition to the diffuse coefficient varies for different fibers, and the results were recorded the largest percentage value of palm leaf composite (4.41 % and 4.84 %) respectively, which means minimum absorption resistance , followed by lufa, hemp fibers composite and finally sisal fiber composite (1.051 % , 1.81 %) respectively at unteatment and treatment because of (maximum absorption resistance).

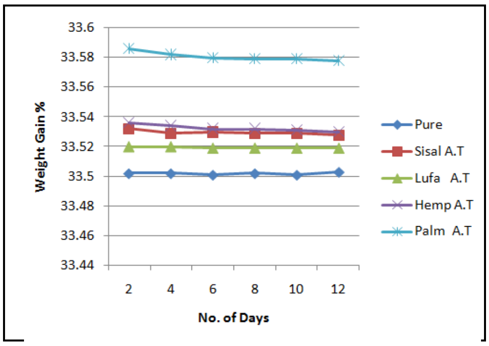

Figure 4. weight gain% of composites after treatment as a function of time squared for salt solution.

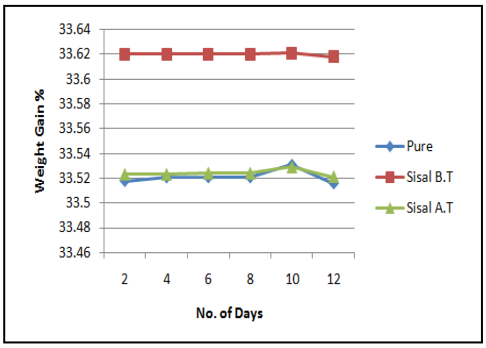

Figure 5. weight gain% of composites (polyester- sisal fiber as a function of time squared for salt solution before &after treatment

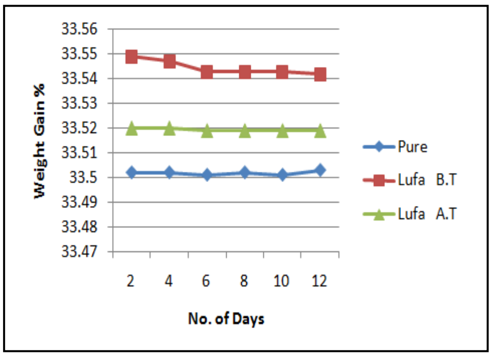

Figure 6. weight gain% of composites (polyester- lufa fiber as a function of time squared for salt solution before &after treatment.

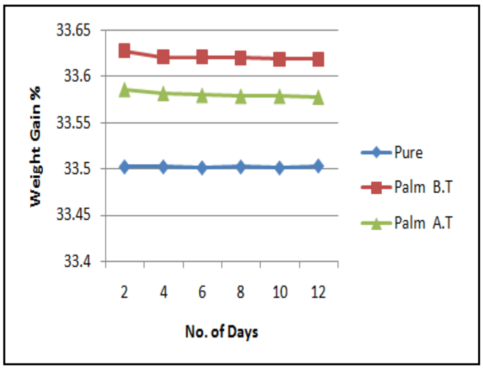

Figure 7. weight gain% of composites (polyester- palm leaf as a function of time squared for salt solution before &after treatment.

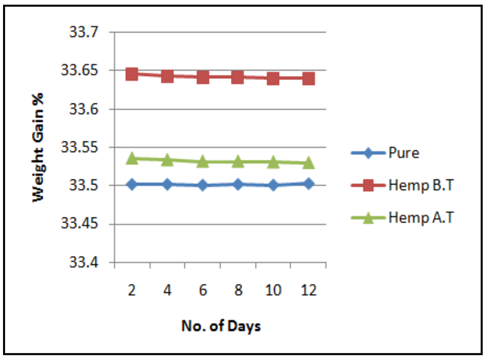

Figure 8. weight gain% of composites (polyester- Hemp fiber as a function of time squared for salt solution before &after treatment.

TABLE I. THE RESULT OF SALT WATER SOLUTION FOR THE SPECIMENS.

Sample	**W_1**	**W_2 after 2 days**	**W_3 after 4 days**	**W_4 after 6 days**	**W_5 after 8 days**	**W_6 after 10 days**	**W_7 after 12 days**
Type 1 (Salt Water)							
Pure (polyester)	*1.9840*	*1.9850*	*1.9859*	*1.9867*	*1.9884*	*1.9893*	*1.9950*
Sisal before treatment	*0.9707*	*0.9765*	*0.9826*	*0.9843*	*0.9858*	*0.9872*	*0.9886*
Sisal after treatment	*1.6967*	*1.7045*	*1.7061*	*1.7086*	*1.7098*	*1.7108*	*1.7117*
Palm leaf before treatment	*1.1472*	*1.1606*	*1.1625*	*1.1653*	*1.1674*	*1.1686*	*1.1707*
Palm leaf after treatment	*1.3399*	*1.3525*	*1.3581*	*1.3612*	*1.3639*	*1.3672*	*1.3692*
Lufa fiber before treatment	*1.5748*	*1.5857*	*1.5947*	*1.5968*	*1.6004*	*1.6057*	*1.6097*
Lufa fiber after treatment	*1.7888*	*1.7910*	*1.7935*	*1.7944*	*1.7954*	*1.7964*	*1.7981*
Hemp fiber before treatment	*1.0739*	*1.0799*	*1.0831*	*1.0847*	*1.0874*	*1.0887*	*1.0909*
Hemp fiber after treatment	*1.6699*	*1.6803*	*1.6873*	*1.6897*	*1.6927*	*1.6949*	*1.6953*

TABLE II. DIFFUSION COEFFICIENT OF THE BLENDS AND THEIR COMPOSITES

Type of composite according to natural fiber composites	**Diffusion coefficient (D) %**	
	Untreatment fiber	**Treatment fiber**
Sisal fiber	***1.051***	***1.81***
hemp fiber	***1.293***	***1.443***
lufa fiber	***2.63***	***2.912***
Palm leaf	***4.41***	***4.84***

IV. CONCLUSION

1- From the results generated, it can be establish that (NaOH) treatment of different fibers have better reinforcing property than the untreated fiber.

2- The treatment was observed to improve the good results of the composite samples.

3- That such sorts of environments must be avoided when composites are used.

4- The palm leaf fiber gave the best reinforcing for treated fiber composite comparing with the other fibers reinforcement because of the nature of crosslinking.

5- Avoid the effect of environment when composites immerse in different solutions.

6- The increase of diffusion leads to decrease in diffusion coefficient.

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