Diffusion of Salt Water and Alkaline Solutions in Polyester Reinforced by Glass Fibers

Dr. Wafaa Mahdi Salih
Center of Training and Workshops, University of Technology/Baghdad
Rand Mohamad Ali
Center of Training and Workshops, University of Technology/Baghdad
Email:Rand_Mohamadali@yahoo.com

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ABSTRACT

The solubility and kinetics of moisture transport mechanisms in type of resin and fibers have been investigated the physical tests group comprised the determination of diffusion coefficient (D) of (0.3 salt water), (0.5 NaOH), (0.5 KOH). The study has been oriented to investigate a theme that has a crucial interest in most industrial applications, also the effect of (Salt water, NaOH, KOH) on the composites. The composite plate contains two type of fibers, the first type: polyester-woven fiber and the second type: polyester–(random+woven) fibers. The result shows the solution would be absorbed in the first type more than that in second type. Because of 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, , while alkaline solutions has effect on the composites. Salt water and NaOH, in composites are more than their identical in KOH, Since polyester has high resistance to alkine as. The diffusivity coefficient of saltwater in UP s is larger than that of NaOH and KOH.

الانتشارية للماء الملحي والمحاليل القاعدية للبولي استر المقوى بالياف الزجاج

الخلاصة

تم توقع الذوبان وآليات الرطوبة في المواد المركبة المتكونة من الراتنج وألالياف حيث تم تحديد معامل الانتشار لنسب المحاليل (0.3 ماء ملحي)،(0.5 هيدروكسيد الصوديوم)،(0.5 هيدروكسيد البوتاسيوم) وكذلك مقارنة النتائج لما له من تاثير في معظم التطبيقات الصناعية ،وكذلك تاثيره على المواد المركبة ذات الاربعة طبقات من الالياف. المادة المركبة موضوع الدراسة تحتوي على نوعين من الأليـاف النوع الأول : البولي استر وأليـاف المنسوجة والنوع الثاني : البولي استر والاليـاف (المنسوجة+ العشوائية) ،اظهرت النتائج ان الانتشارية في النوع الأول أكثر من ذلك في النوع الثاني ، وثبت أن المحاليل القاعدية ذات تاثير ملحوظ على المواد المركبة .كما ان معامل الانتشارية للماء

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الملحي اعلى من هيدروكسيد الصوديوم والذي بدوره اعلى من هيدروكسيد البوتاسيوم لان البولي استر ذو مقاومة عالية للمواد القاعدية .

INTRODUCTION

The diffusion and solubility characteristics of H,O and other molecular species in composite materials have been discussed in numerous papers, mostly on studies conducted in the last fifteen years (Sacher E. and J.R. Susko [1-3] illustrated the highlighted the limited understanding of the actual solution and transport processes in resins and resin-glass composites, particularly the role of chain chemistry and sinks, i.e., chain sites or cavities, in affecting the sorption-description process. Materials are pore-free is activated diffusion. The process by which permeation occurs when these materials are pore-free is activated diffusion. The molecules dissolve in the surface of a polymer, equilibrating with the atmosphere, establish a chemical potential, and diffuse in the direction of the gradient. Thus two fundamental properties are of interests which lead to an understanding of the phenomena. The first of these is solubility (c), which is related to the partial pressure *(P)* through Henry's law (c = *yP),* where y is an activity coefficient. The second property is the diffusion constant *(D),* which is the ratio of the molecular flux (Q) divided by the gradient of the concentration *(dc/dx)* of the diffusing species, i.e., Fick's law, Q = *Ddc/dx.* These parameters can be evaluated as functions of concentration and temperature, Padmavathi Surathi [4] discussed Fiber-Reinforced Polymer (FRP) composites offer many advantages over conventional materials for applications in the marine and civil infrastructure areas. Their increasing widespread use emphasizes the need to predict their performance over long periods of time after being subjected to exposure to different environmental conditions. The kinetics of fluid sorption E-glass/vinylester composites is studied widely using the Fickian and Langmuir diffusion models. The time and temperature dependence of the rate of diffusion and maximum moisture content are analyzed and moisture kinetics data is assessed is assessed for use in performance predictions. Bair H.E. et al.[5], the diffusion coefficient normally increases with concentration. This has been discussed as a plasticizing effect and is often accompanied by a decrease in glass transition temperature *T,.* Although this behavior is exhibited by H,O in some composites, a more common behavior appears to be decrease in the diffusion coefficient with increasing concentration, salih, W.M.[6], discussed the effect of physical properties polyester fiber glass and investigated diffusion test and comprised the diffusion coefficient This paper introduce experimental study of solubility and kinetics of moisture transport mechanisms in type of resin and fibers have been investigated the physical tests group comprised the determination of diffusion coefficient (D) of (0.3 Salt water) , (0.5 NaOH) , (0.5 KOH).

EXPERIMENTAL SETUP

Materials Unsaturated Polyester*:* It is most widely utilized and least expensive polymer resins. This matrix material is used primarily for glass fiber-reinforced composites. A large number of resin formulations provide a wide range of properties for this polymer,[7]. The density of unsaturated polyester used in the present work was 1.19 gm/ cm^3. The hardener used with UP was methyl ethyl ketone peroxide (MEKP) in the ratio (2wt.%) and activated cobalt octate (0.5wt.%) as accelerator. The mechanical properties of unsaturated polyester illustrated in table (1)

Glass Fiber – Reinforced Polymer (GFRP) Composite: Fiber glass is simply a composite consisting of glass fibers(table2 represent the mechanical properties of glass fiber), either continuous or discontinuous contained within a polymer matrix, this type of composite is produced in the largest quantities. The composition of the glass is most commonly drawn into fibers, fiber diameters normally range between (3 – 20) µm. Glass is popular as fiber reinforcement material for several reasons,(Ing-Nan Jan et al.,[9]:-

1. It is easily drawn into high – strength fibers from the molten state.

It is readily available and may be fabricated into a glass **.**

2. Reinforced plastic economically using a wide variety of composite –manufacturing techniques.

3. As a fiber, it is relatively strong, and when embedded in a plastic matrix it produces a composite having a very high specific strength.

Table (3) represents the sample dimensions and standard specimens.

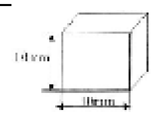
Table (1) Mechanical properties of unsaturated polyester resin 8

Specific Density	Modulus of Elasticity N/mm²	Tensile stress at break N/mm²	Density g/cm^3
1.22	3600	65	1268

Table (2) Mechanical properties of E-glass [5]

Strength (GPa)	Young of Modulus (GPa)	Diameter (um)	Density g/cm^3
20	76	11	26

Table (3) sample dimensions and standard specimens

Test	Sample dimension	Standard Specification
diffusivity		[illegible]

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 Fig.1. The weight change (%) of the diffusivity samples after each period of immersion is calculated from the relationship:

$$\textbf{Weight gain\%} = \frac{W2-W1}{W1}$$

Where:
w1: weight of immersed specimen.
w2: weight of dry specimen.

Figure (1) Sensitive balance

The test specimens

The test specimens were two types the type one from: polyester- woven and random fibers the type two from: polyester –random fibers Fig.2 shows the test specimens in (Salt water, NaOH, KOH) solutions for two types

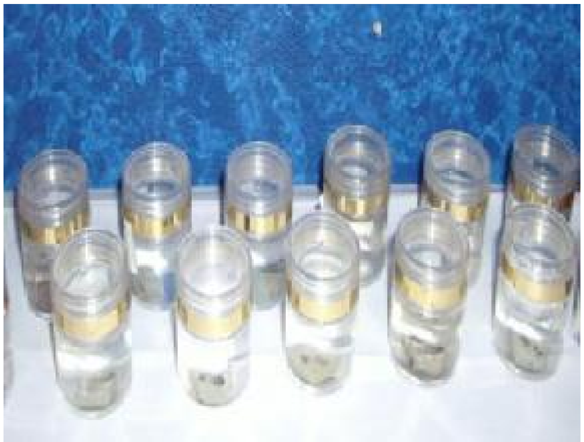


Figure (2) Test specimens 3

Diffusion Coefficient Measurement

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 weigh of the samples that are used in diffusivity test as shown in Fig.1.

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

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

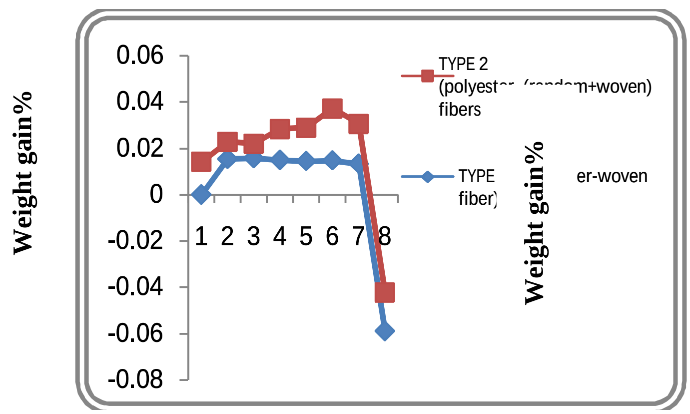
Where: K: the slope of straight line of the curves, which represent the relations between the weight gain percent (%) and square root of time ($\sqrt{\text{time}}$).

t: the thickness of the specimen.

Mm: the apparent maximum water cont
ent (the saturation level).

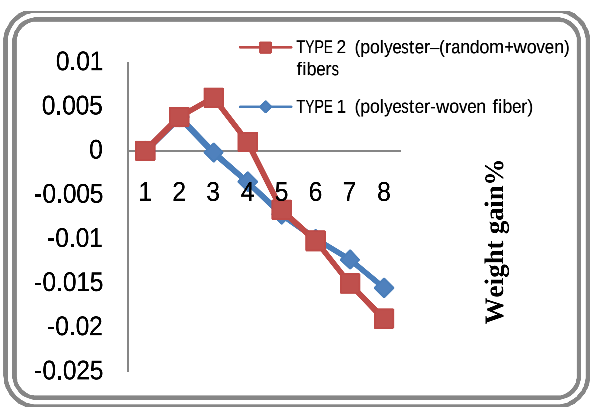
RESULTS AND DISCUSSION

Fig. (3 -5) shows the percentages of the solutions that are gained by composites with two types of E-glass. From these figures, it is quite clear that solution would be absorbed in the first type of composites more than that in second type of composites. 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 composites which contain glass fibers would undergo stress-corrosion resulting from the leaching out of the network modifier, from the glass structure. This sort of stress corrosion occurs more rapidly in acid or alkaline environments than that in water alone. It is clear, that this phenomenon is confirmed by this work, Both above mentioned two mechanisms look logical, but it is essential to add, that the existence of micro cracks, flaws, voids or any other in-homogeneity in the blends and composites would enhance the process of penetrating of the solution into those materials, therefore, fewer defects and more homogeneity would definitely lead to reduce the absorbed solution by these materials. In addition Fig.(3 - 5) clearly shows that saltwater, NaOH and KOH solutions wick into type 1 of composites more than they are drawn into type 2 composites, this is, due to the textural nature of the fibers (woven) or (woven-random), which give addition channels to the solution to permeate into this composites through the fiber itself. This leads to the conclusion that such sorts of environments must be Avoided when composites are used.



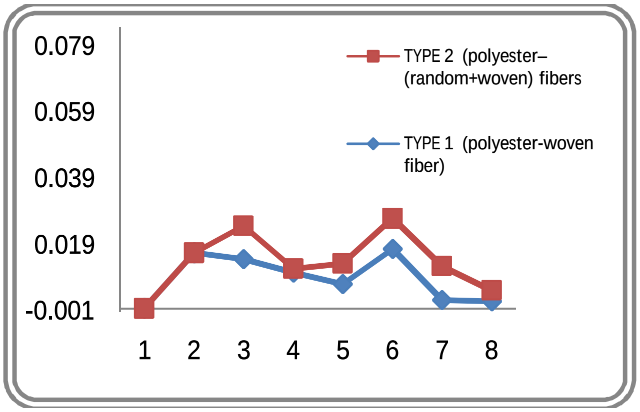
Time ˆ0.5 (day)

Figure (3) Weight gain% of composites in salt water as a function of time squared



Time ˆ0.5 (day)

Figure (4) Weight gain% of composites in(NaOH) solution asa function of time squared



Time ˆ0.5 (day)

Figure (5) Weight gain% of composites in(KOH) solution as a function of time squared

Salt water ,NaOH and KOH in the composites are calculated, according to the second Pick's law. The results are shown in Table (4). 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. The same idea can be built for NaOH and KOH solutions, due to the same reason. The same table shows that the diffusivities of salt water and NaOH, in composites are more than their identical in KOH because polyester has high resistance to alkine as is known. The diffusivity coefficient of saltwater in UP s is larger than that of NaOH and KOH.

Table (4) Diffusion coefficient of the blends and their composites

Specimen	diffusion coefficient (D) Polyester resin and E-glass fibe		
	0.3 SALT WATER	0.5 NaOH	0.5 KOH
TYPE 1 (polyester-woven fiber)	0.0441	0.0263	0.01443
TYPE 2 (polyester–(random+woven) fibers	0.0484	0.02912	0.0181

CONCLUSIONS

The result shows the solution would be absorbed in the first type (polyester-woven fiber) more than that in second type (polyester–(random+woven) 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,, while alkaline solutions has effect on the composites. salt water and NaOH, in composites are more than their identical in KOH because polyester has high resistance to alkine as is known. The diffusivity coefficient of saltwater in UP s is larger than that of NaOH and KOH

REFERENCES

[1] Sacher and J. R. Susko, "Water Permeation of Polymer Films I. Polyimide", J. Appl. Poly. Sci.23, 1979, pp.2355-2364.

[2] Sacher and J. R. Susko, "Water Permeation of Polymer Films
III. High Temperature Polyimides", J. Appl. Poly. Sci. 26, 1981, pp.679-686.

[3] E. Sacher and J. R. Susko, "Water Permeation of Polymer Films IV. Teflon FEP," J. Appl .Poly .Sci. 27, 1982, pp.3893-3902.

[4] Surathi Padmavathi "Hydrothermal effects on Durability and moisture Kinetics of Fiber- Reinforced Polymer Composites" Interim Report Submitted to the California Department of Transportation Under Contract,2006,No. 59A0309 University of California, San Diego.

[5] E. Bair, G. E. Johnson, and R. Memweather, "Water Sorption of Polycarbonate and Its Effect on the Polymers 'Dielectric Behavior" , J. Appl. Phys. 49, No.10. 1978.

[6] Salih, W.M," Study the Effect of Physical Properties of Polyester - Fiber Glass", Australian Journal of Basic and Applied Sciences 3(4), 2009, pp. 4120-4124.

[7] Long Fiber Composite,
http://www.camt.usyd.edu.au/education/MECH3300/Lecture7/lect ure7.htm

[8] Reihart T.J. and others ,"Engineered Materials Handbook Volume 1, Composites", ASM International,1987.

[9] Lin, "Comparisons of Physical Properties of Intercalated and Exfoliated Clay/Epoxy Nan composites", American Chemical Society, 44, 2005, pp.2086 – 2090.