

Studying the effect of chemical solutions on diffusion coefficient of composite material reinforced with Kevlar-carbon fibres.

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Abstract :

In this research the effect of immersion in chemical solutions have been studied including acids ,alkalise ,salts .three groups of specimens have been prepared .the first group have 1 layer of Kevlar-carbon fibres ,the second group have two layers of Kevlar-carbon fibres while the third group have three layers . the three groups of specimens have been immersed synchronizly in acids(HNO_3),Alkalise (NaOH), salt (NaCl) results showed remarkable effect of NaOH solution in comparison with HNO_3 solution .for NaCl solution pure PE showed fluctuation in weight gain and less absorption than the reinforced composites .reinforcing with 3 layers of carbon-kevlar fibres showed good stability against acids while 2 layer reinforcing showed better stability for NaOH solution.

Introduction :

The composite polymer materials are important materials in the modern age due to what these materials have done in the field of modern industry, where these materials have properties makes them efficient, such as corrosion resistance ,lightness in weight ,ease of formation (1,2).the importance of polymer composites has come from their use in the industry of aeroplanes ,rocket parts ,boats which they are exposed to environmental conditions and chemical solution. In 1985 (Ehrenstein and Bledzki) studied the effect of acidic environment (HCL) on the properties of both (glass fibres and composite material of polymeric base reinforced with glass fibers in which they found that cracks on fibres were the result because of reaction with acidic environment which is increased by increasing concentration of the acid which accelerates corrosion (3).in 1995 (s.k.shringarpun) studied the effect of adding(H_2SO_4) acid and oxalic acid in different temperatures(110,100,90,80) °C

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on the activation energy of phenol resin by immersing it in these acids for a range of periods (1.5-6)hours(4). In 2001 (B.M.Deya'a) studied the effect on different acids such as (HNO_3 , HCL) on mechanical properties of Epoxy reinforced with glass fibres[5] while (H.A.Sallal) in (2007) studied immersing polymeric materials epoxy reinforced with steel fibres in(H_2SO_4) acid with three concentrations (20%,-40%-60%) then weighting the samples every three days and studying the change in dimensions and deformation in specimens where he found that increasing the days of immersing decreases the specimens weight due to different acid concentrations [6] .

Experimental part:

Sample preparation:

The (hand lay –up molding)method has been used to prepare a composite of unsaturated polyester of density (1.2 gm/cm^3) reinforced with hybrid fibers of Kevlar –carbon of volume fraction 5% with several layers of fibers (1,2,3) making plates of sample then cutting them in dimensions of (1*1) cm to be ready for immersion process .

Immersion samples method in solutions:-

Three suitable bottles have been prepared filled with (HNO_3) acid , NaOH alkaline , NaCL salt with the same concentration of normality (5 N) .then specimens have been immersed in solutions at room temperature closing the tops of the bottles tightly to limit the evaporation of water and changing the solution concentrations .the samples were taken out of the bottles every week using pair of stainless steel tongs for (20months to measure the change in it's weight in order to study the diffusion coefficient. The diffusion of chemical solution satisfy to Fick's law of diffusion which states :

$$F_x = - D \frac{dc}{dx} \dots\dots(1) [7]$$

where :

F_x : Flux of molecules .

D : diffusion coefficient.

$\frac{dc}{dx}$:gradient of concentration.

this is true for stable state in which concentration does not change with time we can calculate diffusion coefficient from the figure between weight gain as function of square root of time which is given by:

$$D = \frac{\pi (k_b)^2}{4M_\infty} \dots\dots(2)$$

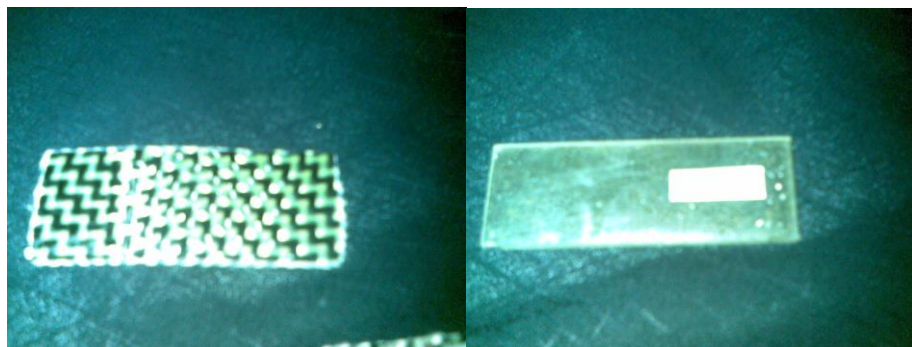
where:

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k: slope of linear part for curve of weight gain as function of square root of time.

b: thickness of sample.

M_{∞} : water closet when reaching to saturation (higher value of gain weight of mass).



Fig(1): shows pure polyester sample

Fig(2) :shows 2layer reinforced PE

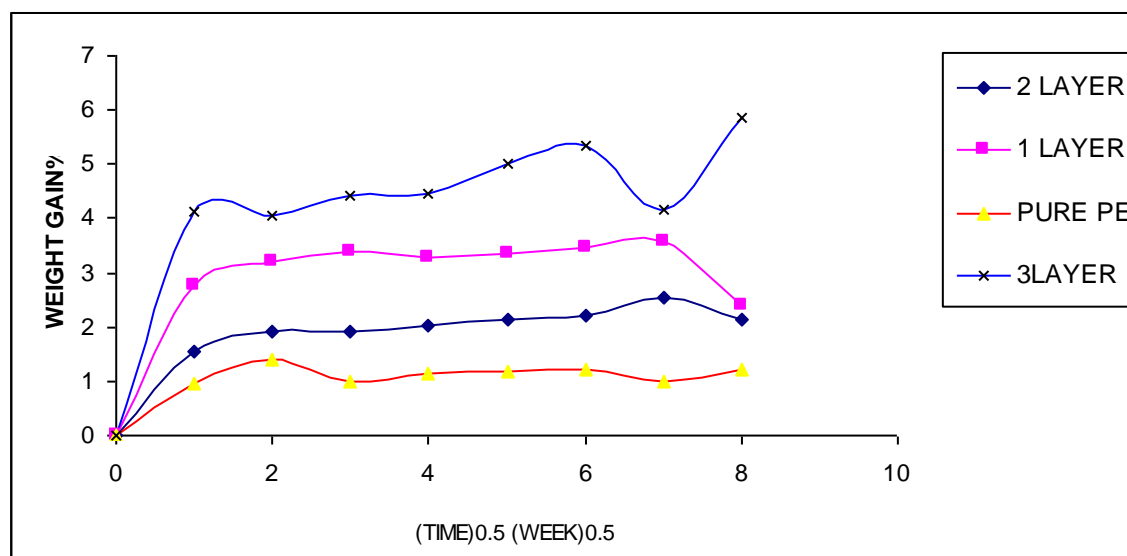


Fig (3) :shows weight gain as function of time for samples immersed in (HNO_3) acid.

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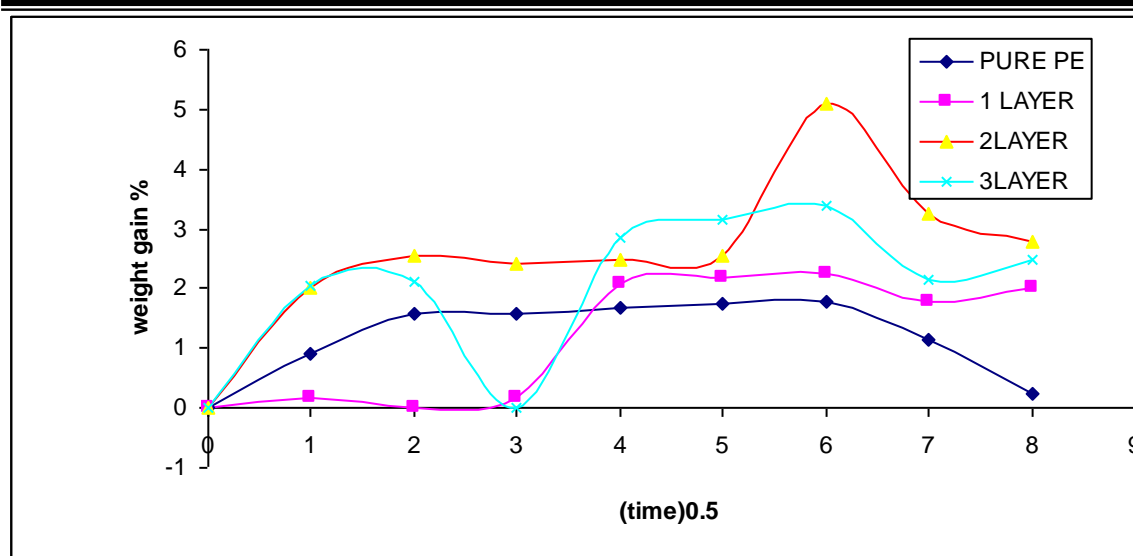


Fig (4) :shows weight gain as function of time for samples immersed in (NaOH) alkaline.

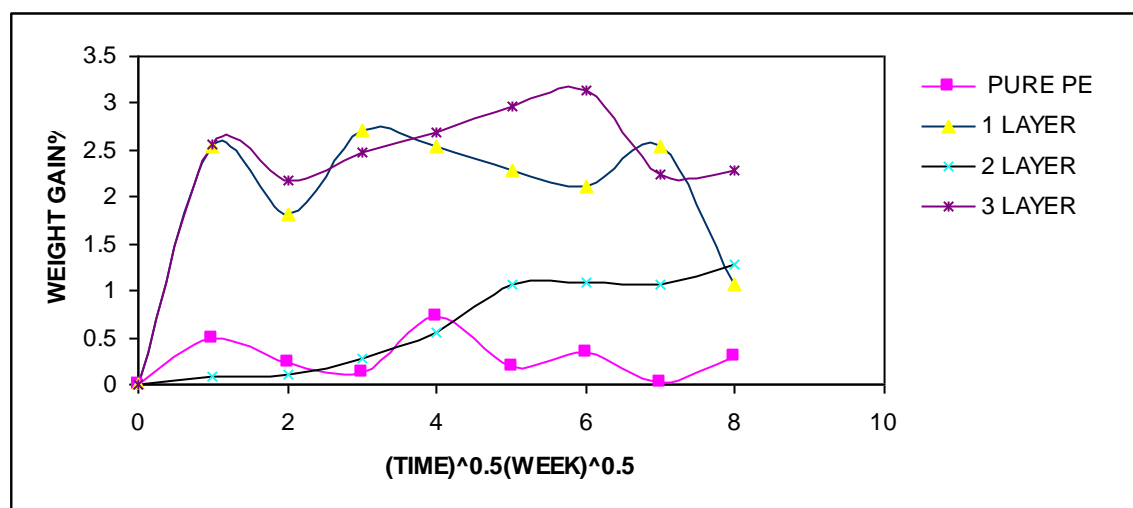


Fig (5) :shows weight gain as function of time for samples immersed in (NaCL) salt.

Results & discussion :

The absorption rate of chemical solution and it's absorbed amount of composite material is controlled by many factors such as:- chemical structure of the resin ,the inter crosslinking coefficient ,adhesion force of reinforcing materials with the used resin i.e efficiency of the interfacial surface region[8] .figure(3) shows the results of immersion the samples in (HNO₃) acid with normality (5N) showed for pure PE increasing absorption of the acid with same mode for 8 weeks of immersion where the sample weight was 0.496 gm before immersion and 0.5036 gm after immersion with diffusion coefficient

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(6.3702×10^{-4}) as it is known polymers have good resistance to chemical attack but it is so familiar to these polymers to suffer from hydrolysis because of unpreferable reactions for long time exposure as it is found by (thakkar) et.al who found changes in weight and colour and disappear in gloss of epoxy reinforced with fiber glass immersed in (HCL,NaOH)as compared before immersion [9] .the reinforced PE with one layer of Kevlar and carbon fibre matt showed more absorption with increasing weight gain % effected by the Kevlar and carbon fibre matt leading to more absorption with diffusion coefficient of (6.584658×10^{-4}) which means that reinforcing with one layer of Kevlar and carbon fibre matt lead to more absorption than pure PE. For reinforced PE with 2 layer of Kevlar and carbon fibre matt the results showed less weight gain in comparison with reinforcing with one layer matt but more diffusion coefficient while the most weight gain was observed at samples with 3 layers of matt where diffusion coefficient values was (1.13853×10^{-3})so that we can say that the best the best resistance to HNO_3 acid was noticed at samples reinforced with 3 layers of matt and more time of resistance to acid before degradation ,the diffusion of acid caused breakage in bonds and some bubbles on fibres sides leading to defects on interphase between fibre and matrix .as far as we are concerned with immersion in (NaOH) base of normality (5N) the results in figure(4) showed increasing in weight gain for PE reinforced with 1 layer matt remarkably especially for the first three weeks of immersion reaching saturation level as compared with 2 layer reinforcing .three layer reinforcing showed the most weight gain in comparison with other samples leading to diffusion coefficient of (6.2499×10^{-4})which makes us conclude that the NaOH diffused much more in composite of 3 layer of Kevlar and carbon fibre matt .generally the Na H alkaline had more effect than acid because NaOH is considered as an aggressive solution and have a noticeable effect on polymers because they attack the matrix leading to plasticization of matrix , transmitting to the interfacial surface between matrix and fibre decreasing bonding between them with increasing immersion and that is what agreed by (K.VanDen Abeele and K.Vande Veide)[10] .speaking on NaCL salt the diffusion coeffecint was (1.7×10^{-2}) for pure PE , ,Fig (5)shows the most weight gain was for 2 layer reinforcing especially at the sixth week which showed a noticeable increasing in weight gain ,for 1 layer reinforcing the most absorption occurred after 4 weeks of immersion with diffusion coefficient of (3.9×10^{-3}) this is due NaCL molecules that create an interface between matrix and fibre causing decreasing in shear inter forces [10] .

Conclusion:

This research deal with the chemical effect of certain chemical solutions with the same normality (5N) of (HNO_3 ,NaOH,NaCL) solutions on composite

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of polyester reinforced with Carbon- Kevlar fibre :we found that the alkaline solution (NaOH)effect is more than the acidic solution effect of (HNO₃) on specimens and that 3layer reinforcing have good stability against acids in comparison with (NaOH).while for NaCL solution ,purePE had fluctuated weight gain and less absorption of NaCL solution than other samples followed by composite with 2 layer reinforcing . concluding that cracks in fibres is because of reaction with it's surroundings leading to undesirable reaction which appears due to long period exposing for environment including water and it's alkaline and acidic solution.

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دراسة تأثير الغمر بالمحاليل الكيميائية على معامل الانتشار لمركب هجيني مدعم بألياف الكفلر-كاربون .

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الخلاصة:

تمت في هذا البحث دراسة تأثير الغمر بالمحاليل الكيميائية والمتضمنة حامض، قاعدة، ملح . و قد تم تحضير ثلاث مجاميع من العينات :تتضمن المجموعة الأولى عينات لمركبات مدعمة بطبقة واحدة من ألياف الكفلر-كاربون في حين تتضمن المجموعة الثانية عينات مدعمة بطبقتين من الألياف والمجموعة الثالثة تتضمن عينات مدعمة بثلاث طبقات من الألياف وبكسر حجمي مقداره 5% لغرض مقارنتها مع البولي استر النقي و حساب معامل الانتشار لها بعد غمرها لمدة شهرين في محاليل حامض (HNO_3) وقاعدة ($NaOH$) وملح ($NaCl$) وبصورة متزامنة و بعيارية مقدارها (5N) لتظهر النتائج تأثيرا ملحوظا لمحلول أ ل ($NaOH$) على المركبات بالمقارنة مع نفس العينات عند غمرها بحامض (HNO_3) . بينما بالنسبة لنفس العينات فعند غمرها بملح ($NaCl$) أظهر البولي استر النقي تذبذبا في قيمة الريح بالوزن وقل امتصاصية من المركبات الاخرى المدعمة بالاليف بينما اظهر التدعيم بثلاث طبقات استقرارية جيدة تجاه الحامض زفي حين كانت العينات المدعمة بطبقتين من ألياف الكفلر - الكربون استقرارية افضل وامتصاصية لمدة اطول لمحلول ($NaOH$).