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Effect of Chemical Solution on Some of the Mechanical Properties of the Polymer Composites Reinforced

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ABSTRACT

This work has been done with using of polyproplyen (pp) as a matrix, which reinforced with fibers glass (glass fiber short , glass fiber woving roving , and glass fiber short +, glass fiber woving roving). The research also studies the Mechanical properties (Creep-Impact) of the Samples with the same volume fraction (30%) and comparing the results.These tests are carried out on samples under the influence of normal conditions room temperature (23+3^{o}C) and after immersion of all samples in the chemical solutions (KOH-HCL- $NaCO_3$). The normality for all these chemical solutions is 0.5. The results showed when time immersion increase these properties are decreased, which indicates the negative effects of these chemical solutions on the mechanical properties. Tests showed that the results of the values of each of the creep resistance and impact increases after immersion in chemical solutions, and that the solution KOH is more influential. Results show that samples of blend reinforced [PP + f.g (w.r+r)] possess better creep resistance, and sample of [PP+f.g (w-r)] possess better impact resistance at all conditions tests (room temperature and after immersion in chemical solutions).

Introduction

All composite materials, the fibre type has evoked the most interest among Researchers concerned with structural application. Initially most work was done with strong, stiff fibers of solid, circular cross section in a much weaker, more flexible matrix, i.e. glass fibers in synthetic resins. Since the fibrous form of most materials is many times stronger than its bulk form, Researchers have long sought ways of making practical use of fibers as engineering materials. The most efficient method yet found is to combine a fibrous material of high tensile strength and high modulus of elasticity with a light weight bulk material of lower strength and lower modulus of elasticity. [1].

Composite materials are materials which are made by artificially combining two or more components. Thus, interfaces are present in a composite material and they tend to govern the properties of a composite material, in other word a composite is any material made of more than one component [2].

A reinforcement that embellishes the matrix strength must be stronger and stiffer than the matrix and capable of changing failure mechanism to the advantage of composite. Fibers are the most important class of reinforcements, as they satisfy the desired conditions and transfer strength to the matrix constituent. Influencing and enhancing their properties as desired. Glass fibers are the earliest known fibers used to reinforce materials. Ceramic and metal fibers were subsequently found out and put to extensive use, to render composites stiffer and more resistant to heat [3].

The most commonly used, E-glass (E for electrical), draws well and has good strength, stiffness, electrical and weathering properties. In some cases, C- glass (C for corrosion) is preferred, having better resistance to corrosion than E-glass, but a lower strength. Finally, S-glass (S for strength) is more expensive than E – glass, but has a higher strength, Young's modulus and temperature resistance [4].

The toughness of a material is associated with its ability to absorb shock or impact loads without fracture. The engine, suspension and bumper units are frequently subjected to shock loads. Impact testing can be used to compare new materials with other which have proved satisfactory in service. The presence of a notch in the specimen will create stress intensity in this region. The notch effects can be created by poor – quality, machined – surface finishes and by inferior weld runs, hence the importance of notch impact testing methods [5].

Creep is the gradual increase in strain that occurs in a material when it is subjected to a constant load over an extended period of time. Viscoelastic materials, such as polymers can undergo creep at relatively low stress levels and often at temperatures below room temperature. Dimensional stability under stress is essential in many applications so creep can be a significant problem

The creep mechanism is sufficiently complex so that no direct correlations are established between the creep behavior of any given material and its other mechanical characteristics, such as tensile and yield strengths, hardness, plasticity...etc. , and their composites are necessarily to be determined experimentally, either in actual service or through long time tests under static loads at ambient temperature [6] .

Creep will ultimately lead to rupture either by ductile or brittle failure. At load temperatures and high loads creep rupture will be brittle, at intermediate loads and temperatures failure will be ductile, and after long lifetimes slow low energy brittle failures will occur. It is these slow low energy brittle failures that are more problematic in the prediction of life expectancy [7,8].

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Experimental part

Use a polyproplyne (density 0.90 g/cm^2) as materials matrix, fiber glass [short fiber(density of 0.277 Kg/m^2), Woven roven with angle of (0^0-90^0) density (0.5 Kg/m2)]. As materials reinforcement, six samples ,[pp+ f.g(Random) , pp+ f.g(woven roven) , pp+ f.g(sandwich(w-r+r))], were prepared from materials composite manner thermal compression and constant volume fraction,. These tests are carried out on samples under the influence of normal conditions room temperature (23+3^{o}C) and after immersion of all samples in the chemical solutions (KOH-HCL- NaCO3) . The normality for all these chemical solutions is 0.5, Then the results were compared before and after immersion.

There are a number of different types of impact tests. These tests depend on the sample geometry and the method of measurement. These include the widely used Izod and Charpy tests in which a hammerlike weight strikes a specimen and the energy-to-break is determined from the loss in the kinetic energy of the hammer[9].

The Charpy impact test is used. The type of scientific device, which has been used, is (TMI) which means (Testing Machine Incorporation). It is made in New York, USA. Hammers with various fracture energies are used. Hammers of (2, 5 and 30 Joul).

Impact strength is calculated from the relation [10].

I.S =U/A (J/m^2) (1)

Where

I.S. = impact strength.

U = Energy of fracture in (joule).

A = Cross section area in (m^2).

Creep test

Creep characteristics at different applied stresses were investigated by using the instrument. After fixing the sample in situ, the required stress was applied; ΔL was determined by the dial gauge against the recorded time. It is possible to find out the relation of strain - time (ε-t) by dividing ΔL by the original length of the sample. To make the applied stress constant for all specimens, the following equation is used [11].

$$\sigma = \frac{P}{A} = \frac{(2.96 + 8m \cdot 0.81)}{A} \quad (2)$$

The amount (2.96) represents special constant for the instrument of creep.

P: The amount of applied force to the sample (N).

m : The sum of the used masses (kg), which represents the masses of the beam + hanger + supporting pins that belong to the instrument in addition to the hanged mass.

A: The cross sectional area of the sample (m^2).

using equation (3) can Calculation of strain (ϵ)[12].

$$\varepsilon = \Delta L / Lo \quad (3)$$

Results and Discussion

Impact test is an attempt for measuring opposition to growth of craze, any opposition to growth of craze from any solid material depend on the mechanism of energy absorption [13].

In normal conditions , from fig .(13,14,15) results show that hybrid composite (pp reinforced with glass fibers(woven roven) and glass fibers (rondum)) has highest value of impact strength , While the lowest value for the impact resistance of composite material [PP+f.g(r)].

In general, there is an increase in fracture energy for samples, which have been reinforced with fibers glass , to all samples . Fibers bear the highest part of impact stress, fibers here act as a crack stopper. Fig.(13,14,15) shows an increasing of I.S due to the presence of those reinforcing materials. The reason behind this increase, is that the fibers tend to distribute the stresses on larger volume of the part instead of localizing them. The increase of I.S of hybrid-composites is more than that of E-glass-composites only [14].

For all types of chemical solutions, which have been used in this work, results show a decrease of impact strength for all samples. While samples of blend reinforced fibers show an increase in the values of impact strength especially after of immersion in KOH, HCl and $NaCO_3$ then values of impact strength are decreased. generally, highest values of impact strength after of immersion in Na CO3 as compared with immersion samples in the other chemical solutions. It should be mentioned that because of the chemical complexity of polymers, their degradation mechanisms are not well understood.

When polymers are exposed to liquids, the main forms of degradation are swelling and dissolution. Swelling may be considered to be a partial dissolution process in which there is only limited solubility of the polymer in the solvent. Dissolution, which occurs when the polymer is completely soluble, may be thought of as just a continuation of swelling. Resistance to attack by acidic and alkaline solutions is, in general, much better for polymers than metals [15] .

The test is carried out at normal conditions then after of immerging samples in chemical solutions. Below the discussion of curves(1,2,3,4,5,6,7,8,9,10,11,12).

At normal conditions, sample of reinforced with glass fibers has a high creep resistance, this is noticed from the small rates of strain under load.

Then sample of blend reinforced with w-r+r a creep resistance less,. while sample of blend reinforced with Al fibers glass randum failed to bear the applied load and it was broken just applying load. i.e. it reached to the plastic deformation while all of samples stayed in region of with elastic deformation.

The mechanism of creep in plastic materials is related to the pull-out of molecular chains when applying loads, stresses cause a pulling-out of molecular chains which means weakness in molecular joined as a result of weakness of bonds which leads finally to a failure [16].

This situation can be explained as:- in the sample of blend reinforced hybrid (f.g(w.r+r) , which recorded high creep resistance, several possibilities lead to this result, such as both fibers and matrix carry load, or the matrix is in creep a way from the which means that no end stresses act on the fibers, and finally, the most popular reason is that the transition between the creeping part and the rigid part of a fiber is discontinuous [17].

Generally, for all samples one can notice that from curves an increase with strain rates takes place after immersion of samples in chemical solutions. The samples of blend reinforced with hybrid (f.g w-r+r) still possess a high creep resistance, followed by samples of reinforced with fiber glass(w-r), and samples of reinforced with fiber glass , finally a failure has been occurred in creep resistance for samples of reinforced with fiber glass (r).

This situation can be explained as diffusion of corrosive liquids through the matrix materials lead to substantial reductions in mechanical properties [18].

Creep resistance is one of these mechanical properties. Some times the rate of strain decreases after immerging in

chemical solutions especially in HCl and KOH. In acids the cations of glass are replaced by H+ - ions of the acidic environment. The etching effect of bases on the other hand is to remove entire layers from the glass surface in a rather uniform way. There is a development of fibre core and fibre shell observed in E-glass, the thickness of the surface region increase with increasing extraction time. The development of such core/shell morphology observed when exposing E-glass to diluted hydrochloric acid. Glass content, test temperature, and the aggressiveness of the chemical environment affect the results [18].

Generally ,This is clear from the results of creep resistance for samples The salt solution is the most effective solutions on samples.

Conclusions

The results showed that, the mechanical tests values increased when glass fiber reinforced. Values of parameters related to the mechanical tests are reduced when samples are immerged in chemical solutions. Samples of blend reinforced with hybrid (w-r+r) succeed to prove better mechanical properties in most of the mechanical tests that have been done in this research.

While samples of blend reinforced with fiber glass (r) failed in most of the mechanical tests, they have weak mechanical properties, which means that they have limited applications.

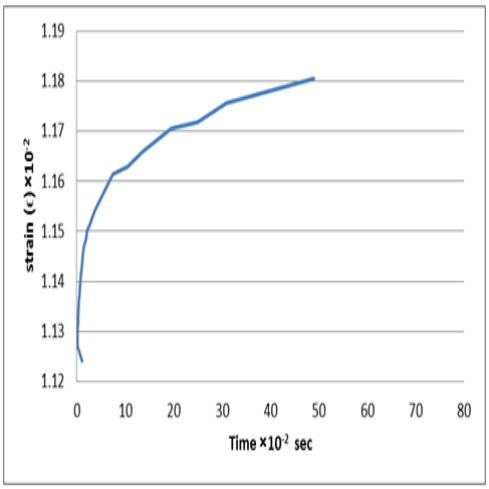

Fig 1. Variation in the (creep_ strain) with the time to PP+f.g(r) before immersionin chemical solutions

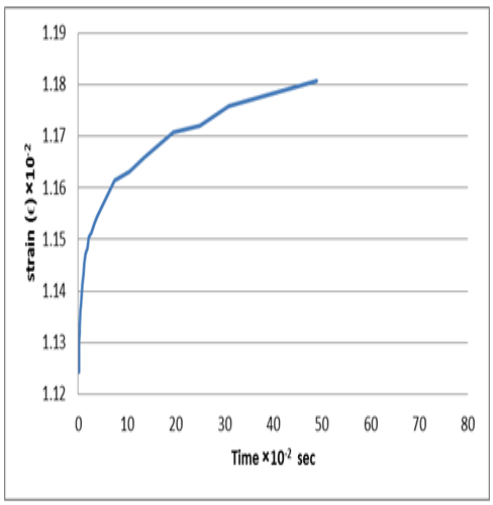

Fig 2. Variation in the (creep_ strain) with the time to PP+f.g(r) after immersion KOH

In general, it can be concluded that composites of those blends have high resistance to creep, which gives them wider opportunity of applications compared with their blend. All the chemical solutions have a great effect on samples due to the obtained results, but KOH is the most effective solution, followed by Na CO3, and finally HCl.

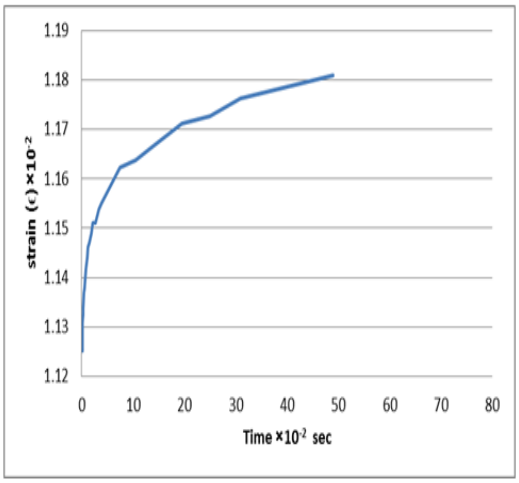

Fig 3. Variation in the (creep_ strain) with the time to PP+f.g(r) after immersion HCl .

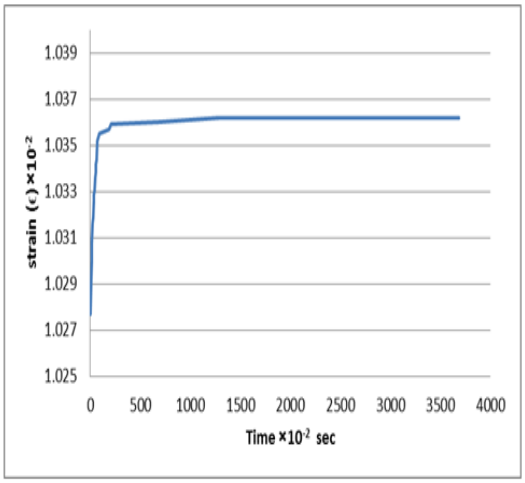

Fig 4. Variation in the (creep_ strain) with the time to PP+f.g(r) after immersion $NaCO_3$

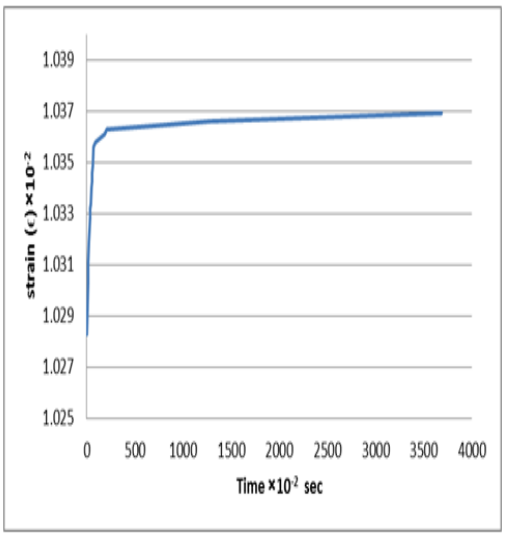

Fig 5. Variation in the (creep_ strain) with the time PP+f.g(w.r) before immersionin chemical solutions.

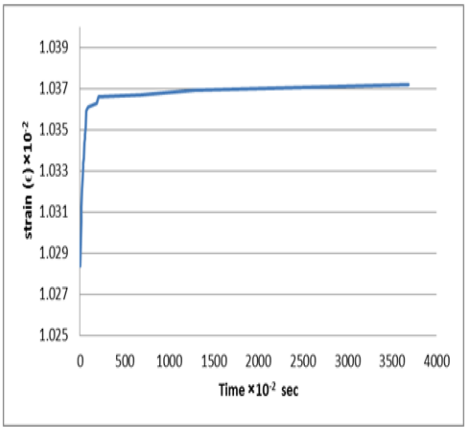

Fig 6. Variation in the (creep_ strain) with the time to PP+f.g(w.r) after immersionin KOH

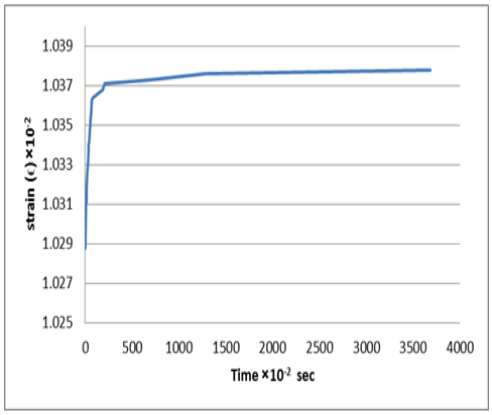

Fig 7. Variation in the (creep_ strain) with the time to PP+f.g(w.r) after immersionin HCl

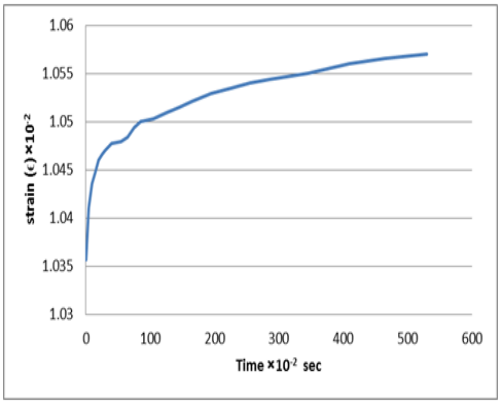

Fig 8. Variation in the (creep_ strain) with the time to PP+f.g(w.r) after immersionin $NaCO_3$

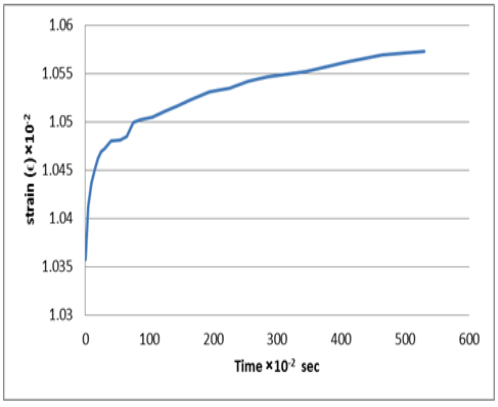

Fig 9. Variation in the (creep_ strain) with the time to PP+f.g(w.r+r) before immersionin chemical solutions.

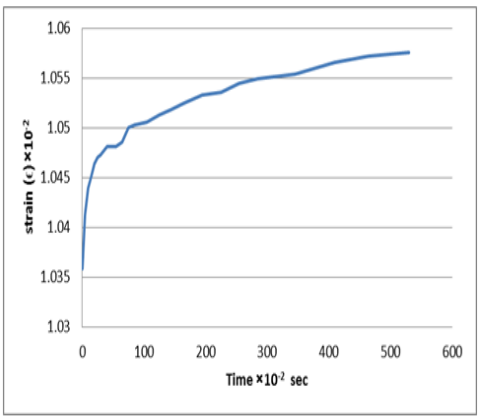

Fig 10. Variation in the (creep_ strain) with the time to PP+f.g(w.r+r) after immersionin KOH.

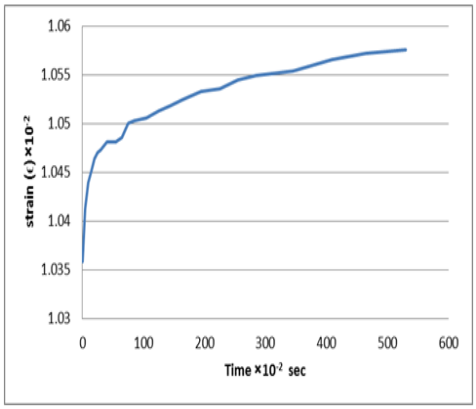

Fig 11. Variation in the (creep_ strain) with the time to PP+f.g(w.r+r) after immersionin KOH..

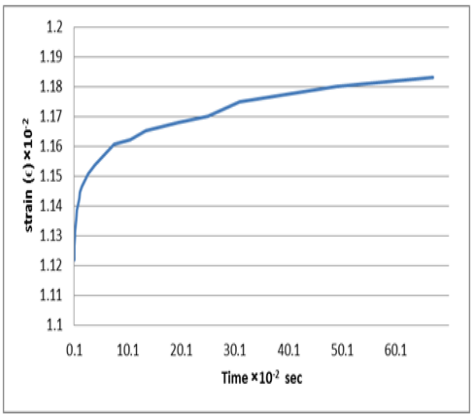

Fig 12. Variation in the (creep_ strain) with the time to PP+f.g(w.r+r) after immersionin $NaCO_3$.

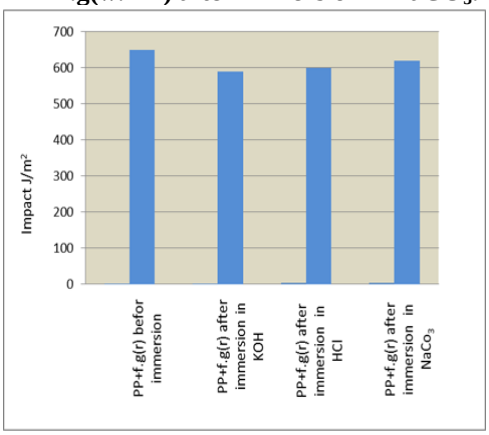

Fig 13. Variation in the impact values to PP+f.g(r) before and after immersionin.

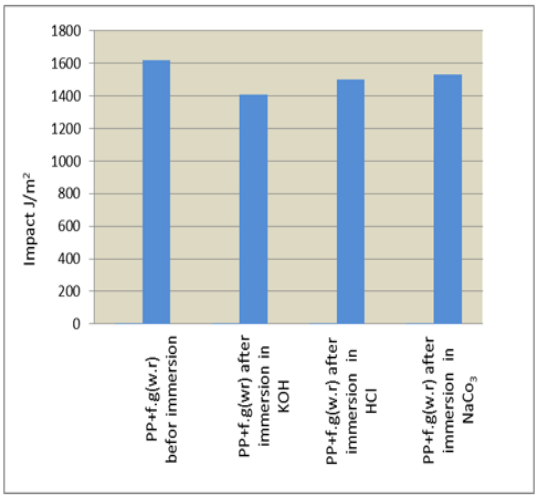

Fig 14. Variation in the impact values to PP+f.g(w.r) before and after immersionin.

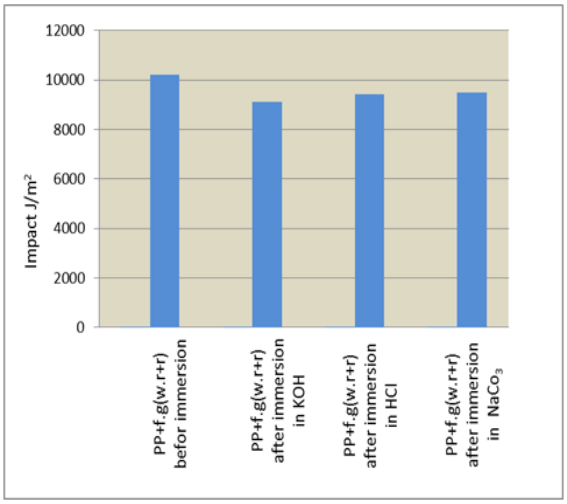

Fig 15. Variation in the impact values to PP+f.g(w.r+r) before and after immersionin

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