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Effect of Chemical Solutions on physical Properties of (Epoxy / Al2O3) Composite

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Abstract: -The aim of this paper is to study the effect of chemical solutions absorption on some mechanical and thermal properties for polymeric/ceramic composite [Epoxy resin reinforced by nano aluminium oxide powder (Al2O3 20 nm/Gamma)with volume fractions of 1% and 3% .Specimens were prepared using Hand lay-up moulding . Physical tests for different times were applied to the specimens including [Bending test ,surface Hardness , and Thermal conductivity] .
All tests have been accomplished in normal conditions (without immersion) and with immersion using diluted Hcl and NaOH solutions (0.2 N) for 9 weeks period .
In normal conditions, Results showed increasing in the values of flexural strength ,Young's modulus , surface Hardness , and thermal conductivity . After immersion the specimens in chemical solutions it was observed that the value of flexural strength , young's modulus ,surface Hardness were decreased . on the other hand , the immersion in chemical solutions leads to increase in thermal conductivity coefficient K.It is worthily to mention that the effect of the acidic solution was greater than the basic solution .

Keywords: - *polymer , nano alumina , Reinforcement , chemical solutions, Absorption .*

I. INTRODUCTION

For better overall performance we require unusual combinations of properties that cannot be provided by conventional materials like metals , ceramics and polymers .Thus a new class of materials known as composites were developed which show extra ordinary combination of properties which are suitable for many industrial applications .Therefor thy gained an outstanding status among the various engineering materials .
Generally speaking a composite material is a combination of two or more materials having compositional variations and depicting properties .[1] .Nanocomposite materials have considered one of the most important categories of advanced materials which have emerged at the end of the last century .
F.S = 3PL/2bd2 (N/mm2) …….(1)
Where
F.S:Flexural strength , P:max.lood (N) , L:distance between two supports(mm)
b: width of the specimen(mm) , d:thickness of the specimen(mm)
Modulus of elasticity also can be calculated according to Eq.(2).[3]
E = MgL3 / 48 IS ……(2)
Where :
E:Modulus of elasticity , Mg : applied lood
I: moment of inertial for a simple bar= bd3/12 [3] , S:deflection

Polymer is a bad conductor materials ,so thermal conductivity is due to vibrational motion of molecular chains and it could be affected by crystal structure ,degree of crystallinity and in composites (type , amount , grain size of fillers and interface region and environments) could affect the thermal conductivity . [4]
This property can be evaluated using lee,s disc apparatus ,and due to Eq.(3).
K[TB –TA]/dS = e [TA + 2/r (dA + 1/4 dS) TA + 1/2r dS TB] …….(3)
K:thermal conductivity (w/m.k)
ds : thickness of sample
TA,TB,TC : temperature of disc A,B,C respectively
r : radius of the disc , dA,dB,dC:thickness of disc A,B,C respectively
e : heat amount through the disc [5]

II. MATERIALS AND METHODS

The materials which are used in this work consist of:
1- Epoxy resin, as a matrix ,type (Quickmast 105) with density (1.118 g/cm3),Flexural strength (>60 N/mm2) and viscosity (1.0 poise), excellent bond, non-shrink, resistance to chemicals .[6]

2- nano alumina oxide powder (Al2O3 20 nm /Gamma) filler with density (3.89 g/cm3) as a reinforcement material [7]

A hand layup technique was applied to prepare the specimens of composite materials with volume fractions (1%) and (3 %).The samples were about (4 hours), then the specimens were cut according to (ASTM)for Bending and Hardness test

while the specimens for thermal conductivity test were cut according to lees Disk technique . Some of the specimens were immersed in Acid solution (Hcl) of (0.2 N) and other in Base solution (NaOH) of (0.2 N).

III. RESULTS AND DISCUSSION

One can notice from figures 1 to 4, that the Bending strength and modulus of elasticity for the composite material under the influence of applied load for specimens of 3% volume fraction was bigger than that of the 1% volume fraction and that of the unreinforced epoxy resin specimens .Hence ,an increase in the ratio of reinforcement of Alumina nanoparticles increased the strength of the material,because the penetration of Alumina particles in the epoxy led to increasing the crosslinking ,in other words, increased the strength of the molecular chains thread. The stress applied on the composite material is distributed on each of the matrix material and the reinforcement material .However, after immersing it in chemical solutions we find that bending strength values and modulus of elasticity of the composite material starts decreasing in a manner that is commensurate with increasing the immersion duration [8] and the influence of acidic solution was found bigger than that of a base solution.

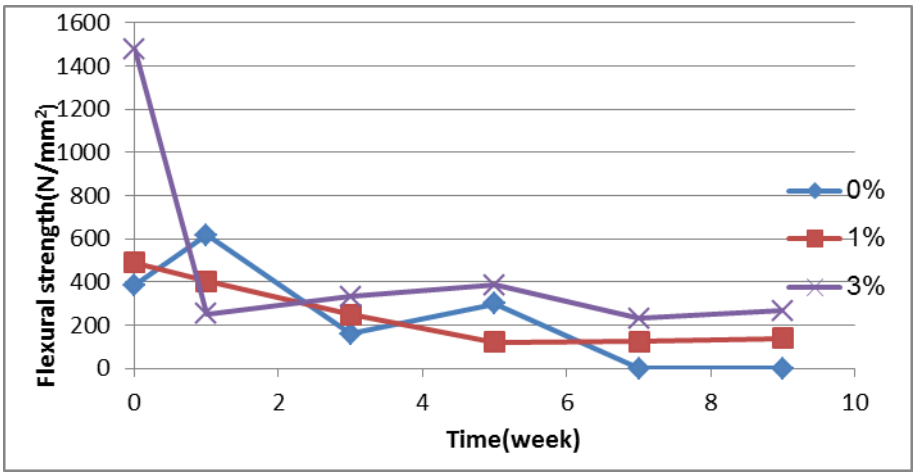


Fig 1: variation of flexural strength before and after immersion into Hcl solution

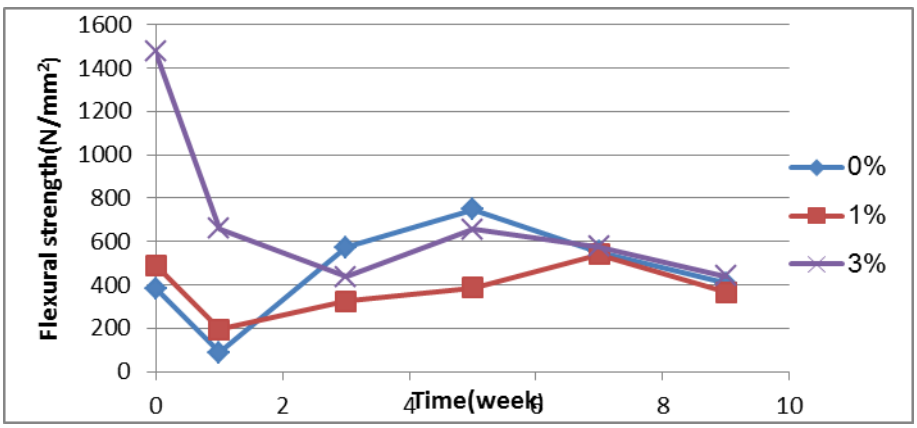
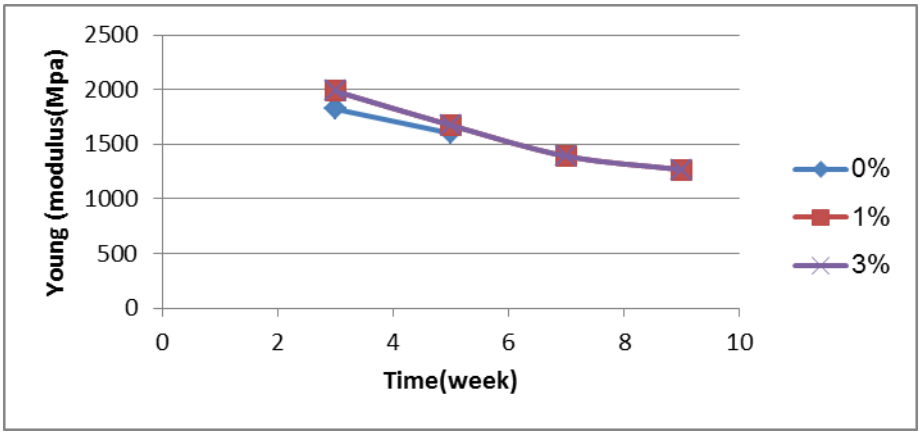
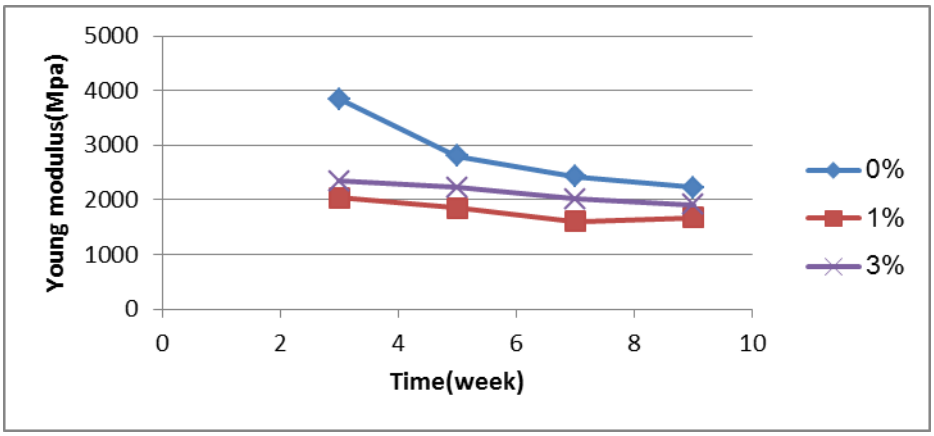


Fig.2 :Variation of flexural strength before and after immersion into NaOH solution



.Fig.3: variation of young,s modulus before and after immersion into Hcl solution



.Fig.4: variation of young,s modulus before and after immersion into NaOH solution

One can also notice from figures 5 and 6 that the values of Hardness increased as well in a manner that is commensurate with increasing the ratio of reinforcement ,where the interconnection between the big molecules and surface of the particles could be presumed as adding interlacement interconnection in the polymer net leading consequently to increasing hardness of the material [9] and following immersion the values decrease in a manner that is commensurate with length of the immersion period.

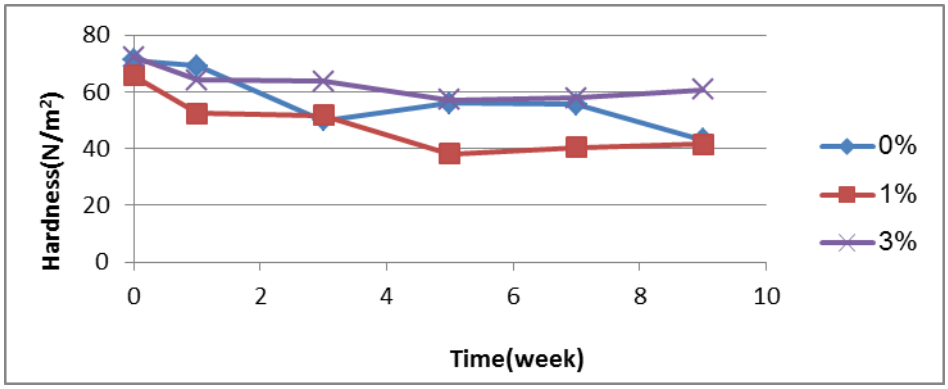


Fig.5:variation of surface Hardness before and after immersion into Hcl solution .

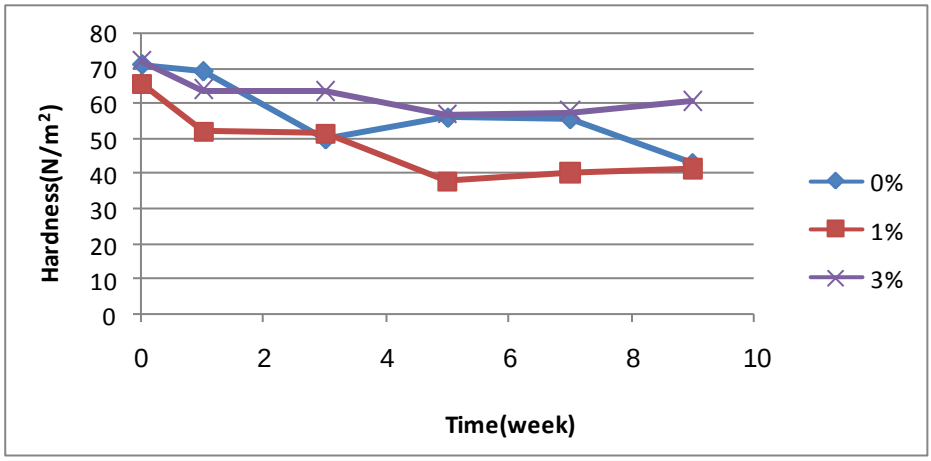


Fig.6:variation of surface Hardness before and after immersion into NaOH solution

Also on the other hand it's noticed that the reinforcement by the Alumina nanoparticles and immersion in chemical solutions lead to increase the thermal conductivity of the composite material. The high stacking density of the Alumina powder lead to decreasing the air voids that work as an insulating medium which lead to increasing the thermal conductivity of the composite [10],also ,penetration of the chemical solutions using the interface area and the cracks that occur during the molding process work to weaken the forces of molecular links of the matrix material, hence, the chains movement increases and for what the chemical reaction of solutions produces of degradation of the material which increases the thermal conductivity capability [11] ,note figures 7 & 8.

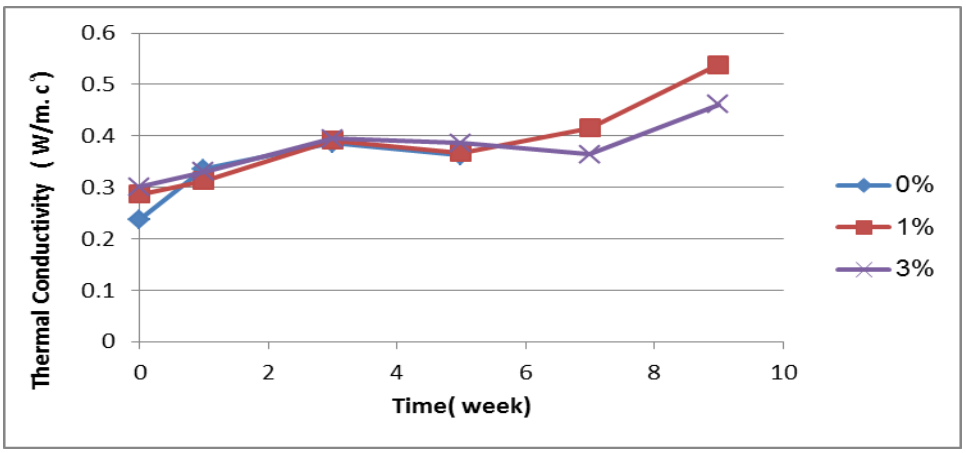


Fig.7: variation of thermal conductivity before and after immersion into Hcl solution.

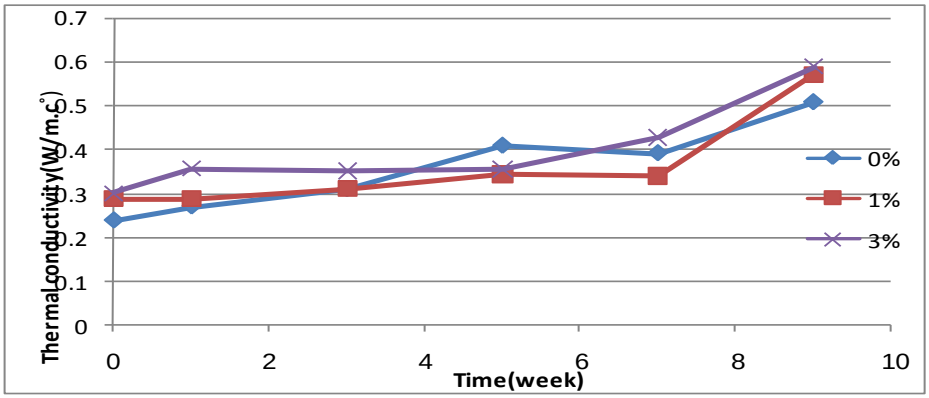


Fig.8: variation of thermal conductivity before and after immersion into NaOH solution.

IV. CONCLUSIONS

1- Reinforcement by Alumina nanoparticles leads to improving the mechanical properties of the composite material , and that is proportionate with increasing the ratio of reinforcement .
2- Composite material absorption of chemical solutions influences its mechanical and physical properties both equally , where it leads to a decrease in the mechanical properties values and increases the thermal conductivity.
3- Increasing the ratio of reinforcement increases the capability of the composite material to withstand immersion conditions in chemical solutions.
4- The influence of the acidic solution (Hcl) was bigger than that of a base solution (NaOH) .

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