Effect of water on the properties of some polymeric composites

Assit.prof.Dr.Balqees M.Dhyae* **Dr.Khansaa D.Salman****

Received on: 14/3/2007
Accepted on: 31/1/2008

Abstract:-

The effect of water was studied on some physical and mechanical properties including (Roughness, Hardness, Compression Strength), and diffusion coefficient was calculated using Ficks' 2nd law for a polymeric composite materials PVC+carbon black, Epoxy+Al powder, Epoxy + E-glass (chapped)), with volume fraction Vf=30% reinforcement for all specimens, results showed the negative effect of water on these properties which is differed between one specimen and other, PVC+CB was affected more than Epoxy+E-glass then Epoxy+Al powder and the diffusion coefficient (D) was less for Epoxy+Al then PVC+CB and the less value was for Epoxy + E-glass .

الخلاصة

تم في هذا البحث دراسة تأثير الماء على بعض الخصائص الفيزياوية والميكانيكية (الخشونة، الصلادة، متانة الانضغاط) اضافة الى حساب معامل الانتشار باستخدام قانون فك الثاني، لمواد متراكبة ذات اساس بوليمري مختلف (البولي كلوريد الفانيل مع اسود الكربون، الايبوكسي مع مسحوق الالمنيوم والايبوكسي مع الياف الزجاج المتقطعة) وبكسر حجمي 30% لكل منهم، اظهرت النتائج التأثير السلبي الواضح للماء على هذه الخواص وقد تفاوتت بين نموذج واخر حيث ان النموذج الاول (PVC+C.B) تأثر بشكل اكبر يليه الايبوكسي مع الياف الزجاج ثم الايبوكسي مع مسحوق الالمنيوم وللخواص كافة. اما معامل انتشار الماء (D) فكان، نموذج الايبوكسي مع مسحوق الالمنيوم اقل امتصاصية للماء يليه البولي كلوريد الفانيل مع اسود الكربون واقلهم تأثراً كان الايبوكسي مع الياف الزجاج المتقطعة.

Introduction

Although particulated fillers reinforcement were used in awide range industry but still more of their properties were unknown, so the replacement of fillers can simplify the manufacturing process, while using of fibers can also improve anisotropic performance, the main objective of this paper is to show how the water effects the properties[1].

Metal and ceramic fillers were used as a reinforcement to enhance the electrical and thermal properties of the composite in addition to improve the mechanical properties, as example (SiO_2)

*Dept.of Applied Sciens.UOT.Baghdad-Iraq
** Dept.of Electromechanical UOT.Baghdad-Iraq

https://doi.org/10.30684/ etj.29.5.5
University of Technology-Iraq, Baghdad, Iraq/2412-0758

Silica was used with thermoplastic polymers to reduce the thermal conductivity and thermal expansion of polymers, mechanism of reinforcing with powders give a high viscosity and good adhesion, depending on grain size of particles used, [2]. Fillers used randomly in rubbers then phenolic resin was used recently with woodflour and celleluse to improve physical properties due to aspect ratio.

Many types of reinforcements were knows such as:

1. Fiber reinforced composites.
2. Particulated reinforced composites
3. Laminated reinforced composites.
4. Flakes reinforced composites.

All these types affected by solutions (especially water). Degradation may occur including (aggressive liquids), especially particulated composites due to porosity occurs and in the interface region (between matrix and fillers),[3].

Some fillers work on improving mechanical bonds like carbon black with polyethylene and polyunylechloride in a pipes industry.

Ideal fillers own physical properties including:- [4]

1. Good strength to weight ratio.
2. Good wetting properties.
3. Inflammable.
4. Chemical resistance.
5. Thermal insulator.
6. Controlled grain size.
7. Good diffusion properties.

Aim of this project is to study the effect of water on some physical properties on polymeric composites mentioned above.

Experimental

Epoxy resin used produced from (FORSOC) Co. types Ep10, with density 1.2g/cm^3 with amino hardener used with 1:4 of resin, chapped fiber (E-glass) was used in addition to Al powder 5μ_m as a reinforcement with Epoxy, using hand lay up method (square mold), PVC with carbon black was delivered from industrial company (saudi regime)) using extruder to produce a water pipe, E-glass used with density 2.5 g/cm^3 and modulus 130 GPa [5,6], all specimens were with volume fraction Vf 30% using the weight method.

Specimens were cut for tests according to ASTM D695, ISO 179, DIN 8062 standards, Brinell hardness was used and hydraulic press used to evaluate compression strength for all specimens.

While assessment of surface roughness was done by using Talysurf-4 apparatus product by English Taylor-Hobson Company. For each specimen take the average of three measurements reading directly from the apparatus, by automatic scanning with fine needle and take the average for all areas with magnification X500 for the first and second specimens, while the magnification for the third specimen X1000.

Ficks' 2nd law was used to calculate the diffusion coefficient (D) after 6 weeks immersed in water [7].

$$D = \pi \left[\frac{kb}{4\mu_\infty} \right]^2 \text{ --------- Ficks' } 2^{nd} \text{ law}$$

where b: thickness of the sample (2 mm).

k: weight gain per unit time.

μ_∞ : max weight absorbed.

Results and discussion

Results from the current study are discussed to other in table shown below, Table (1) shows the values of roughness for specimens used.

Table (1) Roughness values

No.	Specimen	Roughness (μ_m)
1	PVC + carbon black	0.011
2	Epoxy + glass fiber	0.025
3	Epoxy + Al powder	0.01

Table (2) shows the values of hardness for all specimens before and after immersion in water, where the specimen (Epoxy+Al) gained higher value compared with others, where it is less affected by water than (PVC+CB) and (Epoxy +E-glass) this may be due to good adhesion occured between Epoxy and Al powder as it is a fine particles (5 μ_m) and owend a better behavior with adhesive resin (Epoxy) rather than other samples.

Fig.4 showed the hardness difference for samples before and after immersion in water.

Table (2) Hardness values

Specimen No.	As it is	after immersion in water
1	27	22
2	21	17
3	33	30

Table (3) shows values of compression strength, it was noticed that (Epoxy+Al powder), gained higher value compared with Epoxy +E-glass and PVC+carbon black, it also due to higher bond occurs between Al powder and good adhesion resin (Epoxy resin), also water affected these values and caused to decreas clearly by 44% in Epoxy+Al, 50% in Epoxy+E-glass and 24% for PVC + carbon black.

Fig.5 shows the compression strength values for samples before and after immersion in water

Table (3) Compression strength values

Specimen No.	compression strength (MPa)	
	as it is	after immersion in water
1	468	392
2	159	112
3	258	202

In general the powder composites affected clearly by water more than fiber composite and this can be discussed as the powder composite contains pores and when the liquid diffused through the materials causes a damage in the interface region (between matrix and rein forcement) ,depending on the time of immersion, thickness of the sample, surface area and adhesion force between matrix and reinforcement,[8,9].

Table (4) shows values of diffusion coefficient (D), calculated from figures 1,2 and 3 (the weight gain % versus root square time after immersing samples in water for 6 weeks).

Table (4) Diffusion coefficient (D) values

Specimen No.	D mm^2/min
1	$0.3*10^{-8}$
2	$0.376*10^{-8}$
3	$0.03*10^{-6}$

From this table it was noticed that specimen (3) Epoxy+Al powder was less affected by water due to good adhesion force between Al and Epoxy resin [10], and the fiber glass causes cracks with the resin in specimen 2 which let the water to come through the interface region (between matrix and fiber) and this also with PVC+carbon black as black as the thermoplastic polymers is higher affected than thermoset (Epoxy) because it is not a cross linked chains, (but linear or branched) which gained a weakend bonds like vander waals bond and later cause a damage in the sample.

Conclusion

1. Greater value for roughness was for Epoxy + E-glass fiber composite.
2. All properties were affected by water including compression, hardness.
3. Highest values for hardness and compression strength were found for Epoxy +Al powder composite compared with others.
4. Epoxy +Al powder composite has less diffusion coefficient value (better) than others.

References

1- Hull D. " An introduction to composite materials ", Cambridge university press (1981).
2- Seymour R. B., "Polymer composits", I st pub. Utrecht Netherlands, 1990.
3- Richardson M.O.W.,. "Polymer Eng ineering Composites" Applied science pub. London, 1977.
4- Weeton.and.D.M. Peters Engineering guide to composite materials" ,published to American metals , 1987. USA.
5- DIN 8061, DIN 8062.
6- Whittle A.J., plastics, Rubber and composites, IOM communications Vol 30,No 9,2001.
7- Dewimille,B. "Composites" Vol.13, No 14 , 1982.
8- رغد حسين محمد، "دراسة تأثير الظروف الجوية (الاشعاع والمحاليل الكيميائية) على بعض خصائص متراكبات الايبوكسي" اطروحة ماجستير- قسم العلوم التطبيقية/ الجامعة التكنولوجية، 2004 .
9- ورود مهدي، "تأثير المحاليل الحامضية على بعض الخواص الفيزياوية والميكانيكية لمتراكبات الايبوكسي" اطروحة ماجستير قسم العلوم التطبيقية/ الجامعة التكنولوجية، 2006 .
زيد غانم،"دراسة السلوك الفيزياوي لخلائط بوليمرية واخرى مدعمة تحت تأثير المحاليل الكيميائية" اطروحة ماجستير قسم العلوم التطبيقية/ الجامعةالتكنولوجية، 2006 .

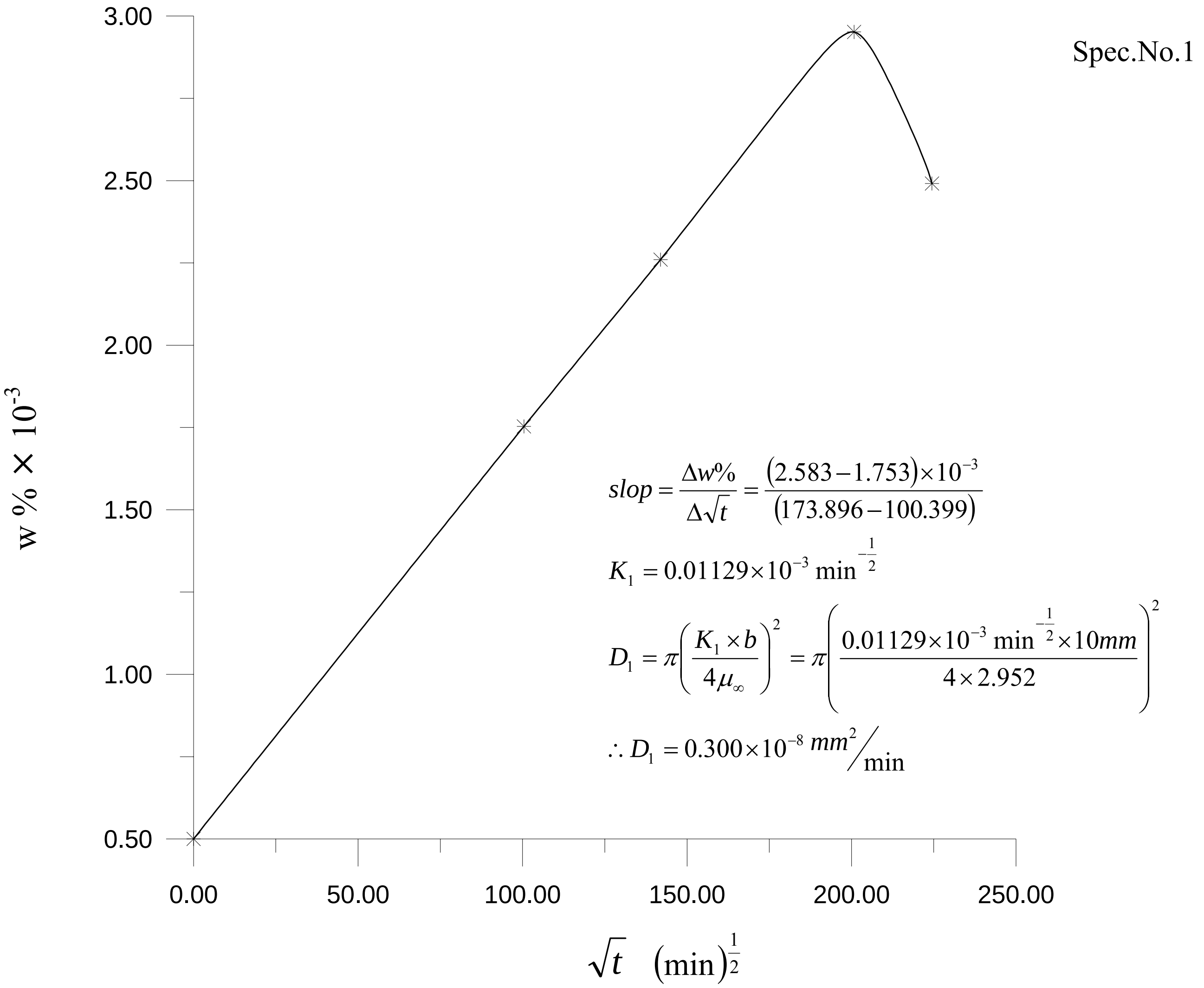


Fig (1): Ficks' curve for diffusion of water in PVC+ Carbon black composite

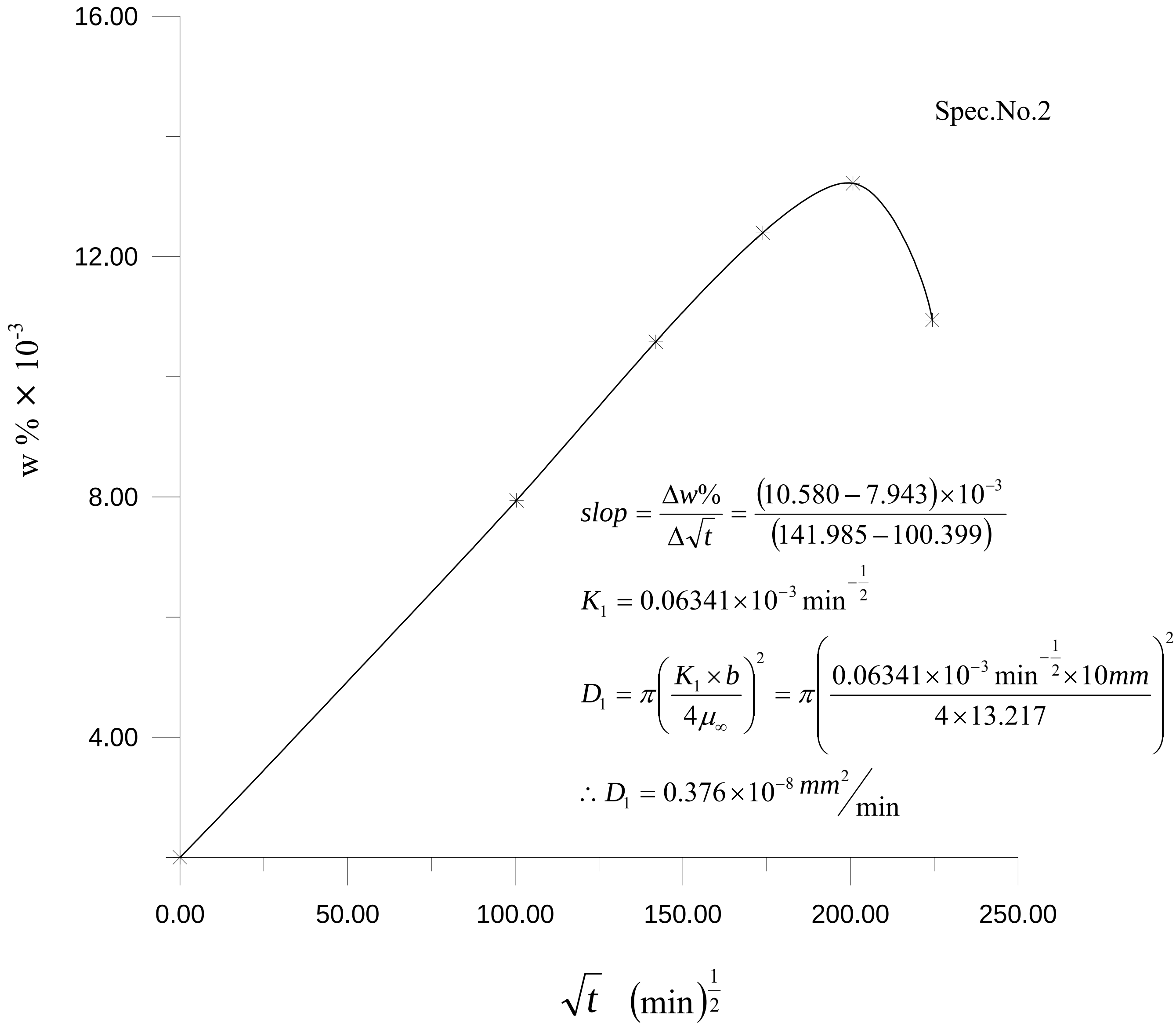


Fig (2): Ficks' curve for diffusion of water in Epoxy+ E-glass fiber composie.

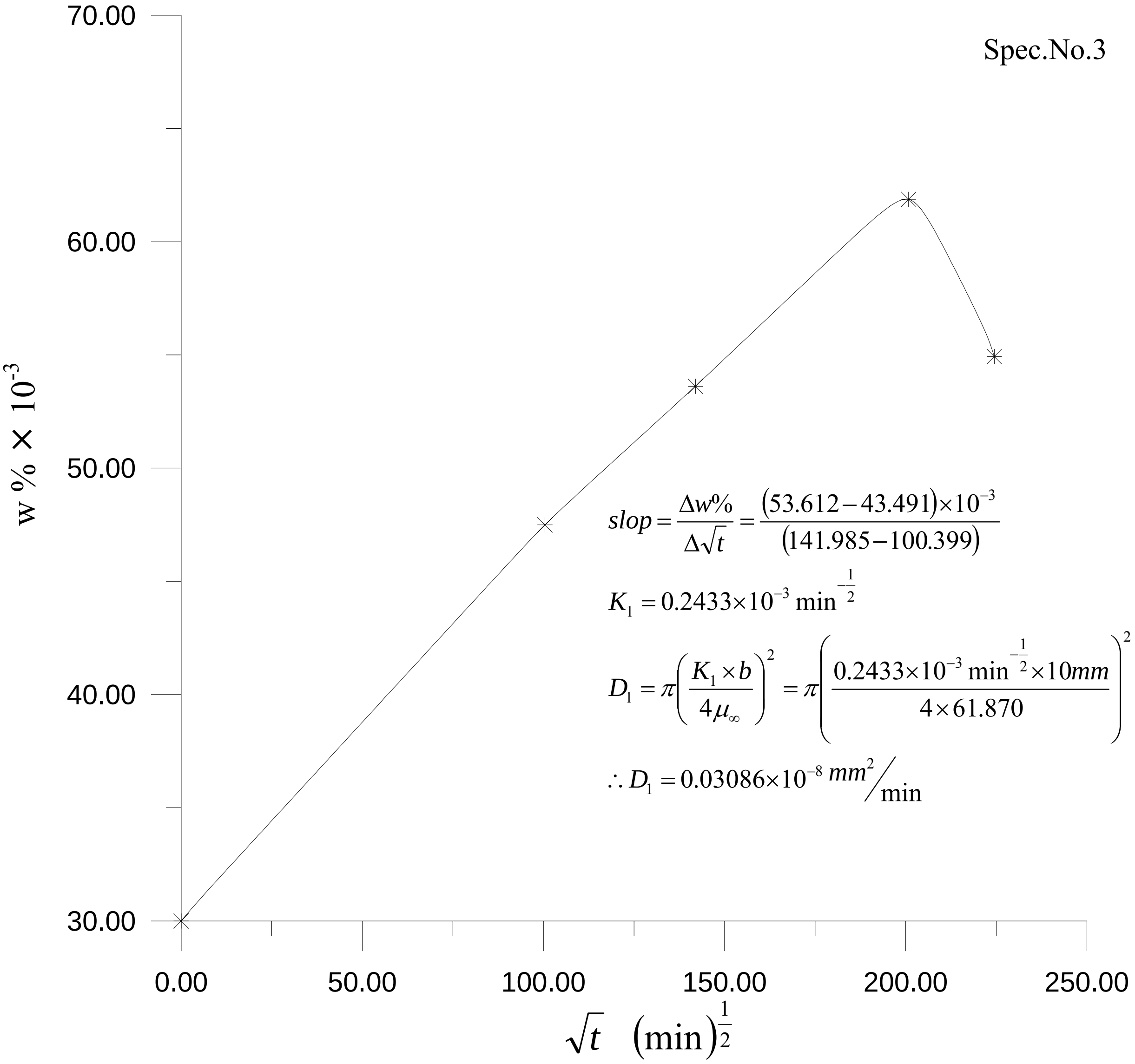
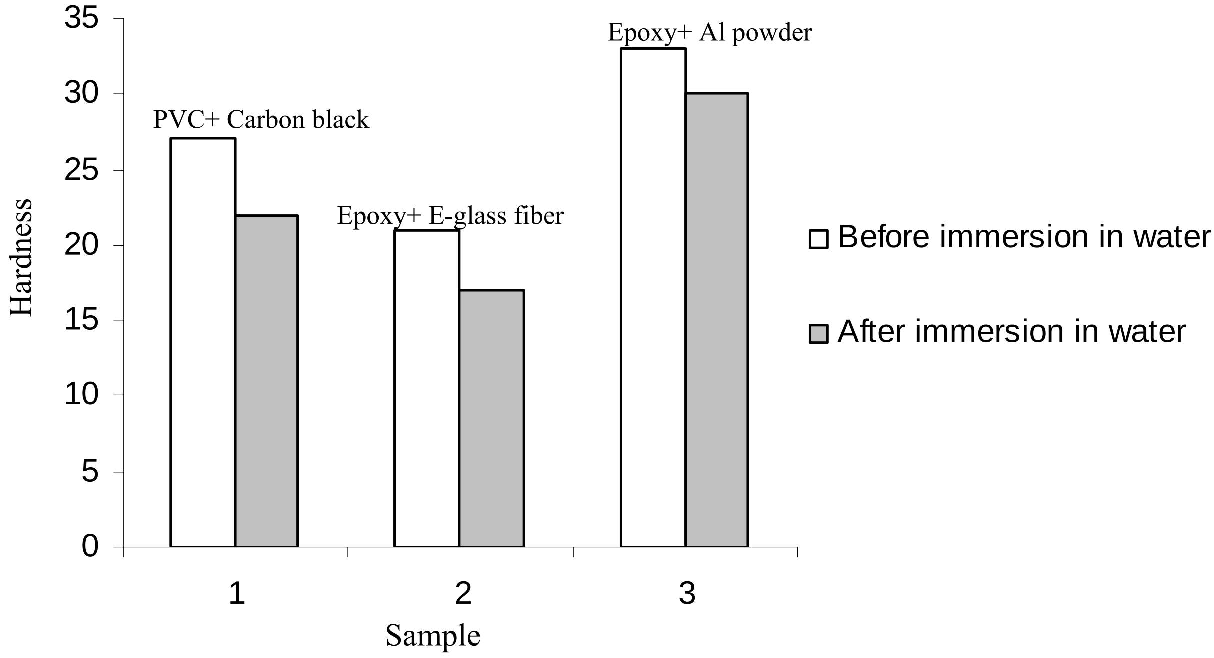
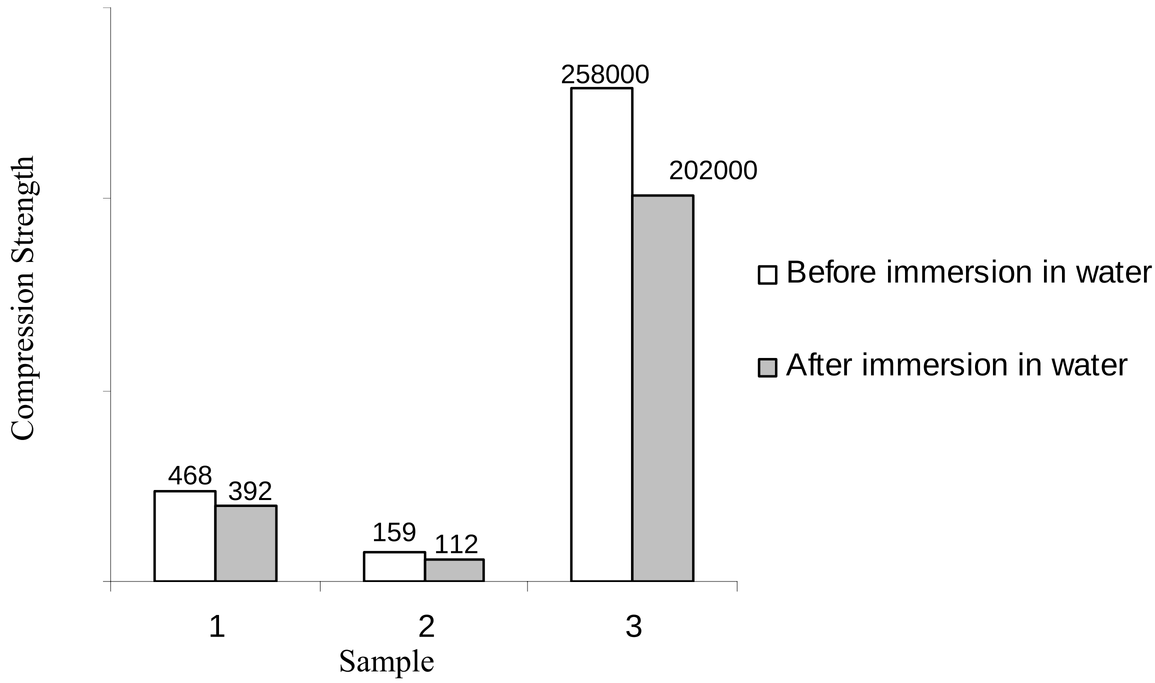


Fig (3): Ficks' curve for diffusion of water in Epoxy+ Al powder composite.



Fig(4): Hardness difference for samples before and after immersion in water



Fig(5): Compression Strength difference for samples Before and After immersion in water