Effect of Nano SiO_2 Particles on some Physical Properties of (UP/PU) Blend Composite

Hanaa Sh. Mahmood
Ibn-Alhaytham Collage, University of Baghdad/ Baghdad
Email:hanaamhmood43@yahoo.com

Received on: 12/3/2015 & Accepted on:12/11/2015

ABSTRACT:

The effect of SiO_2 physical properties (Shore D hardness, impact strength, 3 pts bending, thermal conductivity, and weight gain) after and before immersion in different liquid solution (water, HCL 0.2 N , and NaOH 0.2 N), of (UP/PU) blend was studied. Hand lay-up technique was applied using unsaturated polyester and polyurethane blend as a matrix and silicon oxide nano particles (Nano SiO_2) as a filler with volume fraction (3% V_f) .

Results showed that liquids affected bending properties and thermal conductivity (k) by decreasing values, while the impact strength, and weight gain also studied for 4 weeks and it increase with increasing of immersion time in liquids.

Keywords: hand lay-up, nano SiO_2, impact strength, weight gain.

تأثير دقائق السيليكا النانوية على بعض الخصائص الفيزيائية لخليط متراكب (بولي يورثان /بولي أستر)

الخلاصه :

تم دراسه تاثير دقائق السيليكا النانويه على بعض الخصائص الفيزيائيه (صلاده شور ، مقاومه الصدمه ، الانحناء، التوصيليه الحراريه والربح في الوزن) قبل وبعد الغمر في سوائل (الماء ، حامض الهيدروكلوريك بتركيز ٠,٢ مولاري ، هيدروكسيد الصوديوم ، ٠،٢ مولاري) لمده (٤) اسابيع على خليط من البولي يورثان والبولي استر الغير مشبعين ، استخدمت تقنيه القولبه اليدويه في تصنيع عينات الخليط المتراكب (بولي يورثان/ بولي استر) كماده اساس ودقائق السيليكا كماده تقويه.

اظهرت النتائج ان دقائق السيليكا تؤثر على جميع الخواص حيث تقل مقاومه الثني والتوصيليه الحراريه. ويزداد كل من الربح في الوزن والصلاده ومقاومه الصدمه بعد الغمر في السوائل المختلفه.

INTRODUCTION:

The huge congress in industry and new techniques for finding a new materials having new properties not existing in metal, ceramic, or polymer alone, so a new composite materials using a mixed materials to achieve a new one with a new physical properties especially when adding nano fillers particles like SiO_2 , TiO_2 and other nano oxides to reach optimum values of these properties.[1]

Resins like unsaturated polyester or polyurethane can be used as a binder (matrix) due to its adhesion property and also light weight and as a bad conductor materials; when using these resins as a blend to achieve a better properties as the unsaturated polyester is a brittle when hardend. [2]

Liu 2003 studied nanocomposites of nano SiO_2 with epoxy resin as a matrix ; and found that T_g decreased and a good transparency and distribution of nanoparticles using SEM.[3]

Also Marur (2004) studied the effect of volume fraction and gain size of alumina Al_2O_3 (50-500) nm and found that the fracture toughness decreased with increasing of volume fraction. [4]

https://doi.org/10.30684/etj.34.1B.11
2412-0758/University of Technology-Iraq, Baghdad, Iraq

In (2006), Zehang studied the improvement of nanocomposite properties with decreasing of distance between the particles at high adding of Nano silica, he was found that the Young's modulus, impact strength, of nanocomposite increase with increasing of the weight fraction of nanosilica and it optimum value at 14%, also the homogenous of distribution leads to improvement of strength and stiffness of epoxy. [5]
Also Zhzng and Chang (2007) studied Nano TiO_2 compared with carbon fiber and graphite as a reinforcement materials used with epoxy resin and found that nano materials have better strength properties. [6]

Nanoparticles is a small groups of atoms with grain size of $\leq$ 100 nanometer , there are many ways to produce nanoparticles as sol gel, thermal chemical vapor deposit and electrospraying technique and other techniques. [6]
There are many factors which affected the polymeric composites using nanoparticles:
a. type of nano particles.
b. surface treatment
c. synthesis
d. distribution of nanoparticles in the matrix.
e. preparation technique of nanocomposite.

Impact strength can be defined as the maximum energy absorbed by the specimen before fracture per unit area:[7]

$$I.S = \frac{U\ (J)}{A} \qquad \ldots (1)$$

Where
I.S : impact strength
U: energy of fracture
A: cross section area of the sample

Bending test is used to established the elasticity of material by using eq.

$$E = \frac{MgL^3}{48\ IS} \qquad \ldots . (2)$$

L: length of specimen, I: moment of inertia and it equal:

$$I = \frac{bd^3}{12} \qquad \ldots (3)$$

Materials and methods

Nano silica (Nano SiO_2) from NANOSHELL LLC, America with 99.5% purity and 15-20 nm granular size was used.

Unsaturated polyester with 1.4 gm/cm^3 density, thermal conductivity (0.2 W/m.K) was used, Iraqi production.
Unsaturated polyurethane with (1.13) gm / cm^3 density also used. Jordin production.

Three samples with (90:10, 70:30, 50:50) weight ratios blends were prepared by lay-up technique.

Then the optimum ratio is (70:30) was reinforced with (3% V_f) weight fraction of nanosilica.

Tensile test was measured according to ASTM 0638-2006. [8], also for impact strength, using ISO179. [9]

As well as using 4 digits microbalance for calculating the weight gain after immersion in NaOH solution. The weight gain after immersion in NaOH solution was measured.
Lee's disc technique was used for calculating thermal conductivity of the specimen.

Result and Discussion:

1- Impact resistance: mechanism of failure occurring in material due to quick stress, and can be calculated according to (eq. 1), fig. 1 showed the values of impact strength of all blends for limiting the optimum sample (OMR) as a matrix. This fig shows the second sample with (30:70) % ratio of (PU/US) has the optimum value of impact strength.

Fig (2) show the impact strength of optimum sample reinforced by Nano (SiO2) with (3% Vf) before and after immersion in water, it was increased by 125% after 4 week . The increase in the values of impact strength after immersion was related to the plasticization effect [10-11]

Also Shore D hardness increased after immersion in water for (4) weeks as in fig (3), this is because there is a secondary bonded created and leads to a cross linking between resins blends after immersion in water. [12]

Lee's disc results of the coefficient of thermal conductivity (k) for the specimen before and after immersion in water showed in Fig (4) , results showed there is an decreasing by 35% after immersion in water as the value of (k) was noticed ; affected by the values of heat capacity at low temperature while (k) inversely proportional with temperature; this means that it depends on the mean free path (the distance that the phonon moved between tow collisions) so the liquid solution affect the interphase region between polymer and fillers (SiO_2) and causing the water to pass through the specimen causing to break chemical bonds and reduce the interphase causing bubble and holes to take place so the mean free path decrease rapidly, which leads to the rapid decrease of its thermal conductivity.[13]

Fig (5) shows the bending strength of optimum sample reinforced by Nano (SiO_2) with (3% V_f) before and after water. Bending strength decreases after immersion in water. The failure occurs by destroying all bonds between matrix and fillers, so the interphase region is more affected by the solution [14]

Fig (6) showed the relation between weight gain% for the sample immersed in NaOH, HCL and water solution for 4 weeks, when the sample immersed in the chemical solution, it was found that the weight increased as the molecules of the solution will pass through the polymer to occupy the micro vitiation and voids, so the distance between the polymer chains will be increased and destroying the interphase region. [15]. Fig (7. a-b) show the surface image of OMR sample , we notice that after immersion in NaOH, the surface of sample is more roughness than before immersion this is because there is an degradation was happened.

CONCLUSIONS:

1- Bending strength, values decrease with increasing the time immersion for the specimen in all solutions.

2- Impact strength Shore D hardness and weight gain % increased with time of immersion till 4 weeks. .

3- Thermal conductivity (k) decreased with time of immersion for 4 weeks .

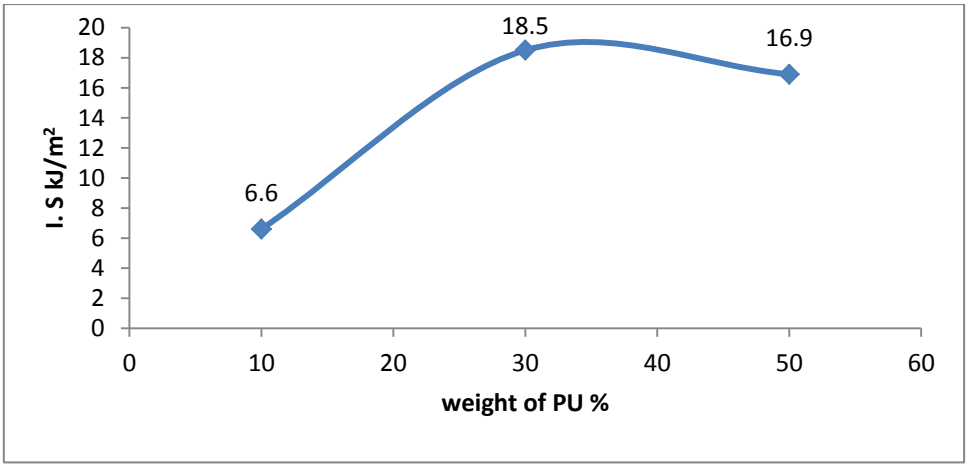
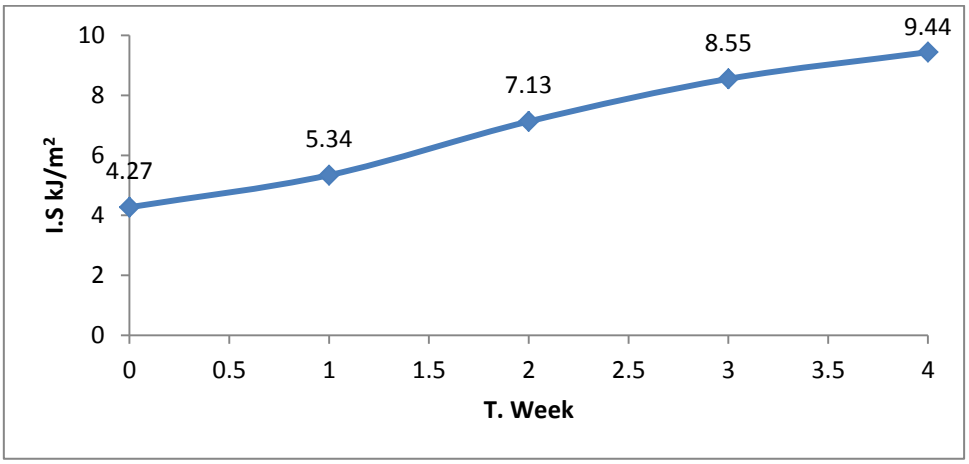


Figure (1). Impact strength of (UP/PU) blends



Figure(2). Impact strength of (optimum UP+PS)/SiO_2) nanocomposite with (3% V_f SiO_2) before and after immersion in water

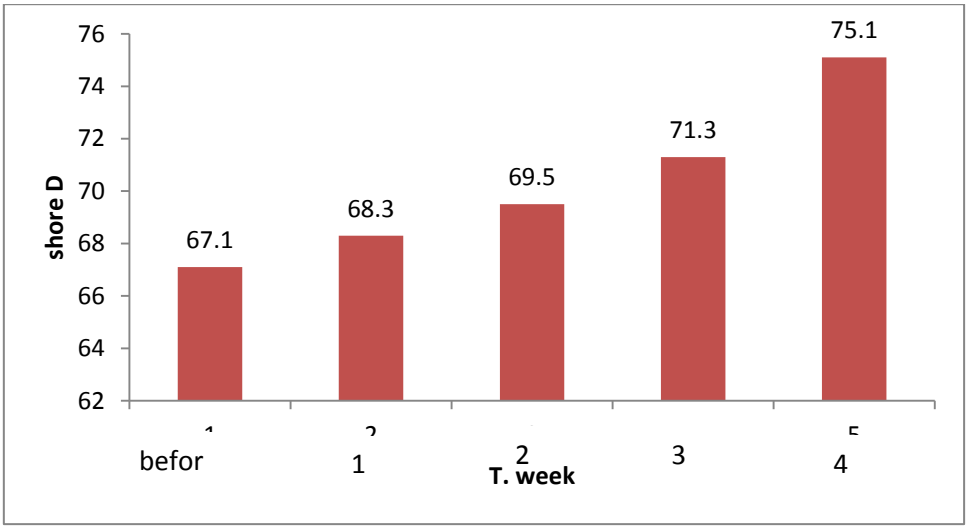


Figure (3). Shore D hardness vs. time of immersion to (optimum UP+PS)/SiO_2) nanocomposite with (3% V_f SiO_2) before and after immersion in water

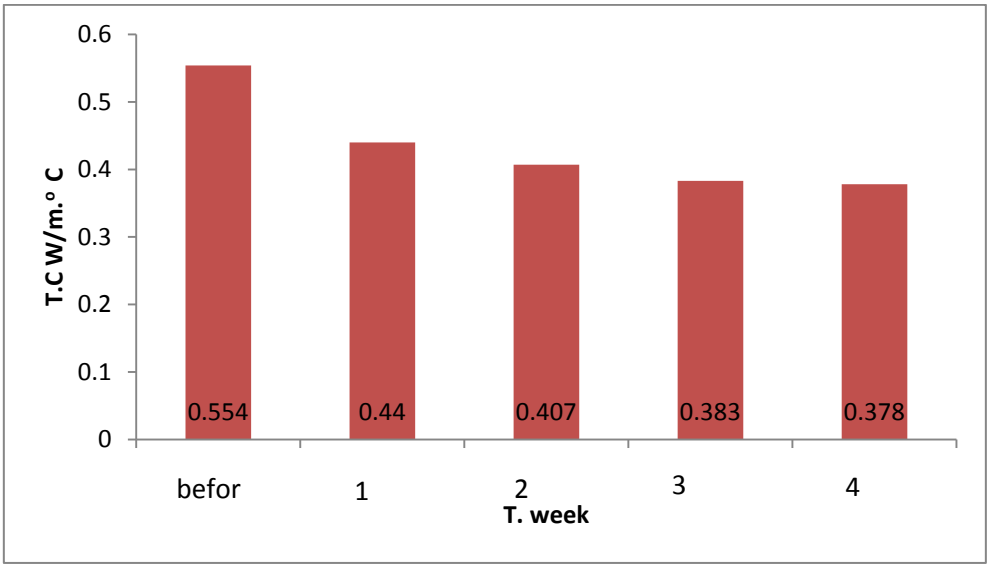


Figure (4). Change in Thermal conductivity of (optimum UP+PS)/SiO_2) nanocomposite with (3% V_f SiO_2) before and after immersion in water

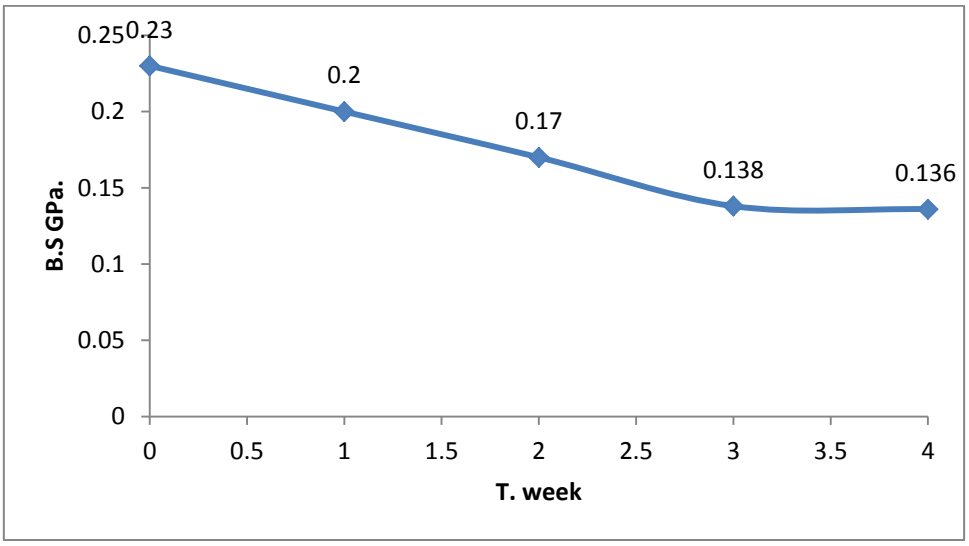
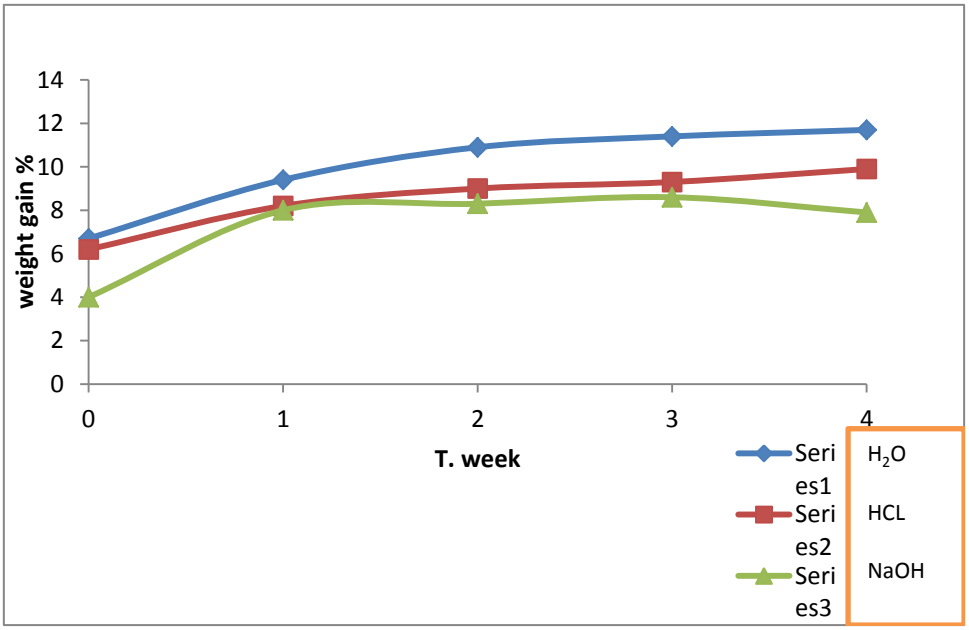


Figure (5). Change in bending strength of (optimum UP+PS)/SiO_2) nanocomposite with (3% V_f SiO_2) before and after immersion in water



Figure(6). Change in the weight gain of (optimum UP+PS)/SiO_2) nanocomposite with (3% V_f SiO_2) before and after immersion in different solutions.

(a) **(b)**

Figure (7. a-b) The surface image of OMR sample , a. before immersion b. after immersion

REFERENCES

[1]. V. D. Callister, (2000)" Material Science and Engineering – An introduction", 5th ed. , John Wiley &Sons, Inc. New York.

[2]. P. A. Thornton and V. J. Colaugdo (1985)," Fundamental of Eng. Materials", Prentice. Hall, New Jercy.

[3]. Liu, Y. L. Hsu, C. Y. Wei, W. L. and Jeng R. J. (2003)"preparation and thermal properties of epoxy –silica nanocomposite ", polymer vol. 44, PP. 5159-5167.

[4]. P. R. Marur , R. C. Batra (2004), "Static and Dynamic Fracture Toughness of Epoxy/Alumina Composite with Submicron Inclusion ", Jour. Of material science , vol. 39 PP 1437-1440,

[5].Change, L., and Zhzng Z., (2004) :Applied Science and Manufacturing ", vol.35,pp.112-128

[6]. Chen, X. and Mao, S.S. (2007) " Titanum dioxide nanomaterials synthesis , properties , modification and applications" Chem. Rev, vol.107, pp.2891-2959.
[7]. S. Advani ,(2007), " Processing and Properties of Nanocomposites", World Scientific pub. Co. Pte.
[8]. ASTM D 638-2006
[9]. Dr. Rekesh Dogra; " Advances in materials Science", 2010, Pub S. K. Kataria & Sons.
[10]. Eyassu Woldesenbet, Nikhil Gupta & Jack R. Vinson, (2004). "Determination of Moisture Effects on Impact Properties of Composite Materials", Journal of Material Science, Vol. 37, No. 13, pp. 2693-2698,
[11]. Dr. Balkees M.Deya'a, Dr.Fawziea M. Hussien & Intihah Gatia Dway, (2011), "Studying the Impact Strength of (Epoxy with TiO2 and MgO) Composite", Eng. & Tech. Journal, Vol. 29 , No.10 .
[12]بلقيس محمد ضياء و أحمد ستار جبار(٢٠١١)، " دراسة الخصائص الميكانيكية لمادة متراكبة دقائقية مبنية على أساس (خليط بوليمري) " ، مجلة الهندسة والتكنولوجيا، المجلد ٢٩، العدد٢،
[13] . بلقيس محمد ضياء و سعد غازي احمد و م . وليد خالد عبد الظاهر (2011)، " دراسه خاصيه التوصيل الحراري في ظروف مختلفه لمواد متراكبه دقائقيه "، مجله كليه التربيه – جامعه النهرين ، العدد ٦. المجلد ٢٥٣
[14]. Al-Azzawi , Ali H. R. (2008) " The effect of some solutions on the physical properties of particulate composites", Ph. D. Thesis, University of Technology , Baghdad.

[15]. Qayes A. Abbas, (2011) " Effect of water absorption on impact strength for epoxy-glass fibers composite", J. of universityof anbar for pure science : Vol.5:NO.2