

Effect of NaOH on some physical properties of Novalac /TiO₂ composite

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Abstract

Aim of present work is to evaluate the tensile strength, impact strength, and hardness of (Novalac/TiO₂) composite with ($V_f = 12\%$ optimum value of volume fraction for calculating properties) of prepared by open molding (hand lay-up) technique. Thermal conductivity (k), and weight gain % after immersed in NaOH solution 0.5 M for 60 days were calculated. Results showed a decreasing in mechanical properties with different ratios, Diffusion coefficient (D) calculated ($D=2.3 \times 10^{-12} \text{ m}^2/\text{sec}$).

Key words

Tensile strength, open molding technique, impact strength, weight gain.

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تأثير NaoH على بعض الخصائص الفيزيائية لمتراكب النوفالاك/TiO₂

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الخلاصة

تم في هذا البحث دراسة خصائص متانة الشد، الصدمة، والصلادة لمتراكب (النوفالاك / اوكسيد التيتانيوم TiO₂) بكسر حجمي (12 %) والذي يمثل أفضل قيمة للخواص المدروسة في هذا البحث بطريقه القولية اليدوية، معامل التوصيل الحراري (K value) والرجح في الوزن تم حسابه بعد الغمر في محلول NaOH 0.5 M ولفترة 60 يوم. أظهرت النتائج التدني في الخواص الفيزيائية مع زيادة زمن الغمر، وتم حساب معامل الانتشار للمحلول D فوجد يساوي ($2.3 \times 10^{-12} \text{ m}^2/\text{sec}$).

Introduction

A composite materials can be defined as a microscopic combination of two or more materials differing in form to create a new material having a medium properties from the components; reinforcement with fillers is to restrain movement of the matrix phase (particle/matrix) interaction leads to strengthening the material in the

atomic molecular level and causes increment in the resistance of the composite material against distortion and this depends on the way of the particles dispersions in the matrix [1]. Composites are important materials that are now used widely, not only in the aerospace industry, but also in a large and increasing number of commercial mechanical engineering

applications, such as internal combustion engines; machine components; thermal control and electronic packaging; automobile, train, and aircraft structures and mechanical components, such as brakes, drive shafts, flywheels, tanks, and pressure vessels; dimensionally stable components; process industries equipment requiring resistance to high-

temperature corrosion, oxidation, and wear; offshore and onshore oil exploration and production; marine structures; sports and leisure equipment; and biomedical devices. There are many types of composite materials according to type of matrix and reinforced materials as in Table 1 and Fig. 1 Shows the reinforcement forms [2].

Table 1 Types of Composite Materials

Reinforcement	Matrix			
	Polymer	Metal	Ceramic	Carbon
Polymer	X	X	X	X
Metal	X	X	X	X
Ceramic	X	X	X	X
Carbon	X	X	X	X

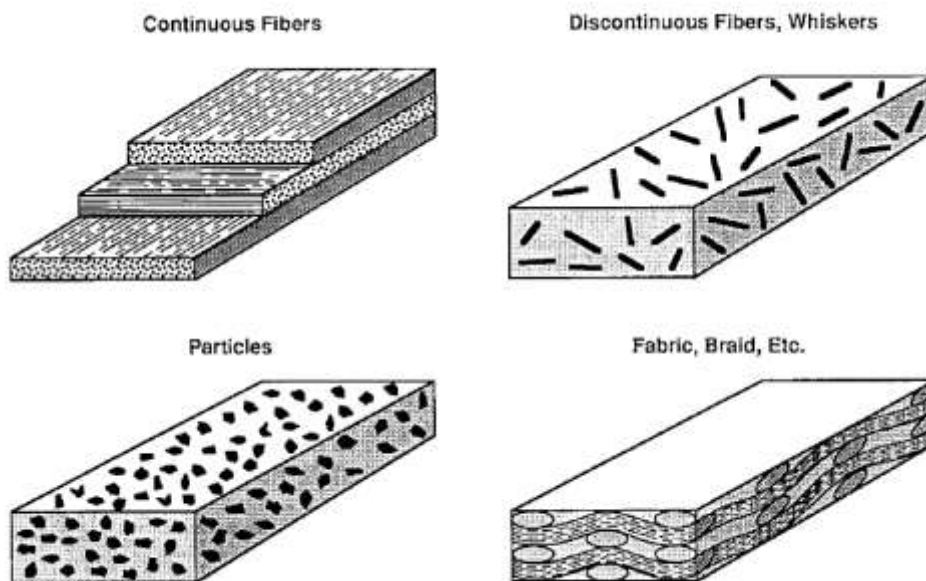


Figure 1 Reinforcement forms.

Novalac resin: Novalac are prepared under acidic conditions with an excess of phenol, Novalac oligomers once formed, that most common cross linking reagent for novalac is (HMTA), used with (5-15)% to produce nitrogen containing (cross linked network). It is used for an excellent electrical and chemical

resistance [3]. Habaib et al studied novolac resin is used as a matrix in the composite which reinforced with some ceramic particles such as alumina, silica, and, limestone as paint. Novolac - alumina (N-A), novolac- silica (N-S), and novolac-limestone (N-L) composites contain (10-30) wt% reinforcing materials. The composites

exhibit the mechanical properties like adhesion, impact and hardness better than the mechanical properties of novolac resin [4].

Xian et al studied the epoxy-based nano-composite containing a low concentration of nanometric TiO₂ (4 vol. %), graphite powder (7.21 vol. %), and 2.14 vol. % aramid particles was developed as a coating material. The mechanical and tribological performance of the composites was investigated. The epoxy filled only with TiO₂ possessed significantly improved impact strength and flexural properties, whereas the further incorporation of graphite and aramid particles had a deleterious effect on most of the mechanical proper more[5].

As grain size of the particles decreased, so the interphase region will become larger compared with micro composites, so the nano composites have a great modification in mechanical properties [6].

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

$$I.S = \frac{U}{A} \left(\frac{J}{m^2} \right) \quad (1)$$

where I.S : impact strength

U: energy of fracture

A: cross section area of the sample

Also tensile strength is the maximum force of pulling sample before fracture can be calculated from:

$$T.S = \frac{F}{A} \left(\frac{N}{m^2} \right) \quad (2)$$

T.S: tensile strength; F: applied maximum force; A: cross section area.

Hardness Shore D is indicated of how the surface of the sample can resist the indentation pin [7].

The diffusion coefficient according to 2nd Fick's law in diffusion which refers to predicts how diffusion causes the

concentration to change with time and can be calculated by Eq. 3 [8]:

$$D = \pi \left(\frac{kb}{4M_{\infty}} \right)^2 \quad (3)$$

D= diffusion coefficient(m²/sec)

K= slop between weight gain and root square time.

b = thickness of the sample, M_∞ = maximum weight gain before degradation and it was found 2.3*10⁻¹² m²/sec for the immersed sample in NaOH.

Lee's disc used to determine the coefficient of thermal conductivity of a bad conductor, Lee's disc apparatus consist of a metallic disc resting on a 5 cm deep hollow cylinder (steam chamber) of same diameter. It has inlet and outlet tubes for steam. In addition, it has radial holes to insert thermometers. Thermal conductivity is the property of a material. It indicates the ability of a material to conduct heat. When steam is passed through the cylindrical vessel a steady state is reached soon. At the steady state, heat conducted through the bad conductor is equal to heat radiated from the Lees disc.

Eq. (4) show the calculation of thermal conductivity according to Lee's disc method [10]:

$$IV = \pi r^2 e (T_A + T_B) + 2\pi r e [d_A T_A + d_B \frac{1}{2} (T_A + T_B) + d_C T_C] \quad (4)$$

Experimental part

Materials used

Novolac resin is provided a stone, and grinded with a mortar to achieve a powder form, then using alcohol as a solvent, the novolac now as a resin and also the hardener Hexamethylenetetramine (HMTA) also it is grinded, the applied to novolac resin with a percent 12%. The density of the product is (0.9) g/cm³.

TiO₂ particles were used as filler with the novolac resin with volume fraction V_f 12% using weight method. TiO₂ has purity 99% with density 4.26 g/cm³;

and particle size (60.4 μm), surface area (13.4) m^2/g . supplied by M/S. U.K TIOXIDE company.

Duple shape for tensile test was a according to ASTM 0638-2006. [10]. Also for impact, using ISO179 [11].

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.

Results and discussion

1- Impact resistance: mechanism of failure occurring in material due to quick stress, and can be calculated according to Eq. 1, Fig. 2 showed the values of impact strength before and after immersing in NaOH solution (0.5 M) it was reduced by 13% after 60 days. The failure occurs by destroying all bonds between matrix and fillers, so the interphase region is more affected by the solution [12].

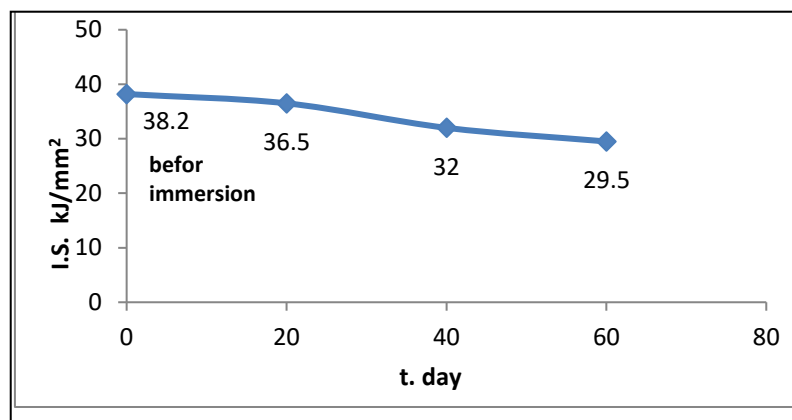


Fig.2: Impact strength of (Novalac/TiO₂) before and after immersion in NaOH solution.

Fig. 3 showed the change in tensile strength value after immersion in NaOH solution, but the reduction was 14% after 8 weeks and as adhesion between polymer and particles plays a substantial role, when a high shear

stress induced rewetting at the interface the chance of crack initiation is high, but with good adhesion, the particles form region of stress concentration which may initiate the crack formation [13].

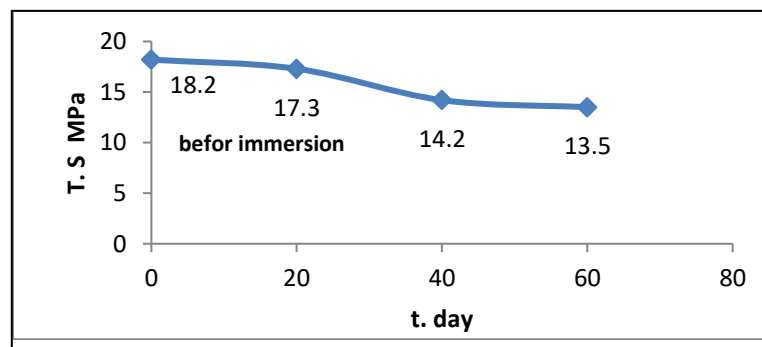


Fig.3: Tensile strength of (Novalac/TiO₂) before and after immersion in NaOH solution.

Also Shore D hardness decreased with immersion NaOH solution by 40% after 8 weeks as in Fig. 4. A NaOH

solution leads to degrade the material, since the specimens became significantly softer [14].

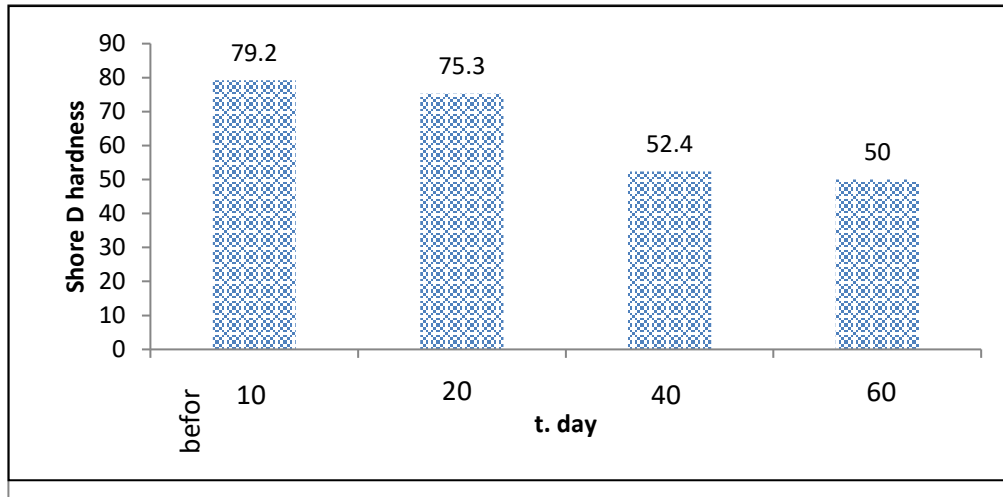


Fig.4: Shore D hardness vs. time of (Novalac/TiO₂) before and after immersion in NaOH solution.

Lee's disc results of the coefficient of thermal conductivity (k) for the specimen before and after immersion in NaOH solution showed in Fig.5, decreased by 13% after immersion in solution as the value of (k) was noticed; this because depending of thermal conductivity on mean free path

the distance that the phonon moved between two collisions), thermal conductivity decreases with increasing if mean free path of phonon, NaOH leads to weaken of cross-linking between the polymer chain which leads to increase of the mean free path and decrease of thermal conductivity [15].

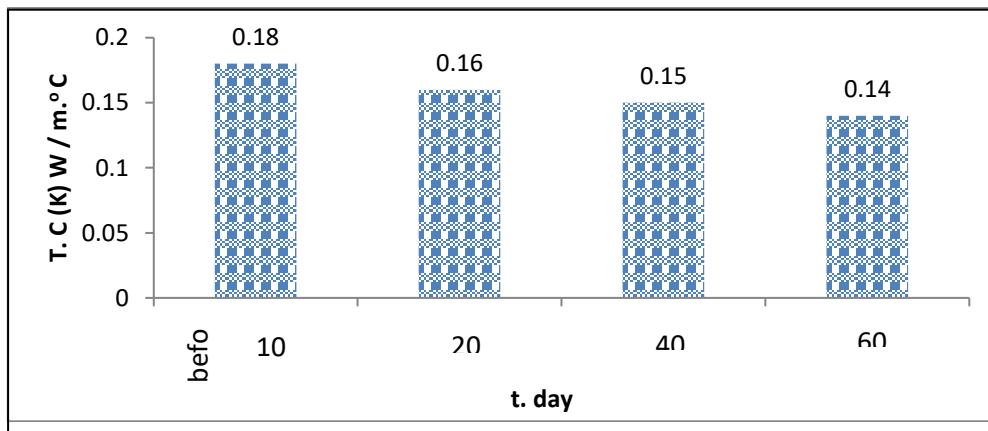


Fig.5: Change in Thermal conductivity of (Novalac/TiO₂) before and after immersion in NaOH solution.

Fig.6 showed the relation between weight gain% for the sample immersed in NaOH solution for 60 days, 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 vitational and

voids, so the distance between the polymer chains will be increased and destroying the interphase region [16]. Diffusion coefficient (D) was calculated according to Eq. (3) and it was found 2.3×10^{-12} m²/sec for the specimen after 60 days immersed in NaOH solution.

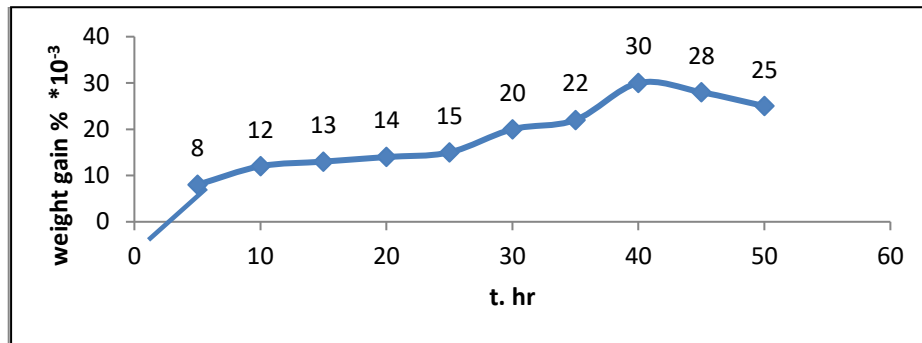


Fig.6: Weight gain versus root square of time for (Novalac/TiO₂) after immersion in NaOH solution.

Conclusions

- 1- tensile strength, impact strength Shore D hardness values decrease with increasing the time immersion for the specimen in NaOH solution (0.5 M).
- 2- Weight gain % increased with time of immersion till 45 days then decreased after that (degradation occurs).
- 3- Thermal conductivity (k) decreased with time of immersion for 60 days by 13% of it is original value.

References

- [1] V. D. Callister, "Material Science and Engineering – An introduction", 5th ed., John Wiley & Sons, Inc. New York, 2000.
- [2] M. Kutz, "Mechanical Engineers' Handbook: Materials and Mechanical Design", Volume 1, Third Edition, John Wiley & Sons, Inc. 2006.
- [3] NIIR Board, "Polymer & Plastic Technology Handbook", Put. Asia Pasific Business Pressinc, 2006.
- [4] Habaib A. Al Tae, Hadi Al Lami, & Fawziea M. Hussien Al-TAQANI Jour, 2 (2011) 145-152.
- [5] G. Xian, R. Walter, F. Haupt, Journal of Synthetic Lubrication 21, 4 (2005) 269-285
- [6] S. Advani, "Processing and Properties of Nanocomposites", World Scientific pub. Co. Pte. 2007.
- [7] Balkees M. Deya'a, Fawziea M. Hussien, Intihah Gatia Dway, Eng. & Tech. Journal, 29, 10 (2011) 1971.
- [8] Balkees M. Al-Dabbagh, Al-Nahrain University Journal, 11, 1 (2008) 22-28.
- [9] Balkees M. Al-Dabbagh, Saad Gazi Mohammad, Journal of College of Education, 523 (2011) 6.
- [10] ASTM D 638-2006.
- [11] Dr. Rekesh Dogra; "Advances in Materials Science", Pub S. K. Kataria & Sons, 2010.
- [12] J. S. Wu, K. Friedrich, M. Grosso, Composites, 20, 3, (1989) 223-233.
- [13] Vander, A. K. "From Polymer to Plastic", Dupblue print delft. University press, Netherland, 2002.
- [14] Eliseu A. Münchow, Ana Cláudia A. Ferreira, Raissa M. M. Machado, Tatiana S. Ramos, Sinval A. Rodrigues -Junior & Cesar H. Zanchi, Braz. Dent. J. 25, 4 (2014) 321-6
- [15] C. Chi. M. Ma, J. of Applied Polymer Sci. 79 (2001) 631-637.
- [16] Al-Azzawi, Ali H. R. "The effect of some solutions on the physical properties of particulate composites", Ph.D. Thesis, University of Technology, Baghdad, 2008.