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Effect of Chemical Solutions on Some Mechanical Properties of (Fe + Cu/UPE)

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ABSTRACT

This research includes the preparation of polymeric composites by (Hand lay-up method) of unsaturated polyester resin as a matrix material and (iron, copper) particles as strengthening materials with different weight ratios (5%, 10%, 15%, 20%). The hardness and impact strength properties are studied before and after immersion in (NaOH) solution and (HCl) solution at a normality of (0.3N) and for a period of one immersion (30 days). The results showed that the hardness and impact values increased with the increase in the percentage of iron and copper before immersion, after immersion, that hardness and impact strength values increased with increasing the iron and copper ratio of the compounds For all samples, but their value was lower than in normal conditions. And also these values in the (HCL) solution were lower than the (NaOH) solution.

1. INTRODUCTIN

The study of the mechanical properties of composites materials is one of the most important things that must be taken into consideration because it determines the behavior of these materials under the influence of stress on them, and under the influence of most external conditions. Such as pressure, temperature, time of stress, and speed of stress, which have greatly effect on the mechanical properties of composite materials with a polymeric basis[1]. The composites materials are a building consisting of two or more materials with different specifications that are related to each other in a specific way to give the desired composition and have better properties than the properties of the materials used in their composition if they are used separately [2,3].The reinforcing materials are in the form of particles, sheets, or fibers, and they thus combine the good properties of the various materials involved in their installation. In addition to get rid of the defects in them to be more suitable for industrial application. Therefore, it can be said that the composite material consists of two phases, the first phase, which includes the matrix material and the second phase, and it includes the reinforced materials [4].The composite material may consist of one or more basic phases and one or more reinforcing materials to obtain the several composites by the correlation of the reinforcing materials with the matrix material and the resulting material is called the hybrid composites materials [5].

In view of the fact that the composites materials have good weight and electrical and thermal insulation, the need for their use in many civil and military fields has increased, which motivated many workers in this field to make some adjustments to their properties, especially their mechanical properties, by supporting them with other materials to access the ideal properties In using a lot of applications [6,7,8]. Therefore, in this research, samples of a composite material with a polymeric matrix supported with copper (Cu) and iron (Fe) particles are prepared.

THEORETICAL PART

1. **Hardness:** Hardness is considered one of the mechanical properties that is important for studying the surface of the material, and it is known as the resistance of the surface of the material to scratching or stitches. It is the resistance of the material to localized deformation, and the hardness of the material depends on the type of material that connects the molecules or atoms with the surface type and temperature [9]. The hardness test is considered one of the easy tests because it does not need complex and expensive devices. In addition, we do not need to prepare special samples, and the samples are not subject to damage because they are not broken when the test is conducted and they are

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not greatly deformed [10] . In this research, the surface of polymeric materials manufactured using the (shore D) method, which is a measure of the material's resistance to penetration, which is measured by a special needle. And figure (1) shows the process of penetration of the needle into the sample.

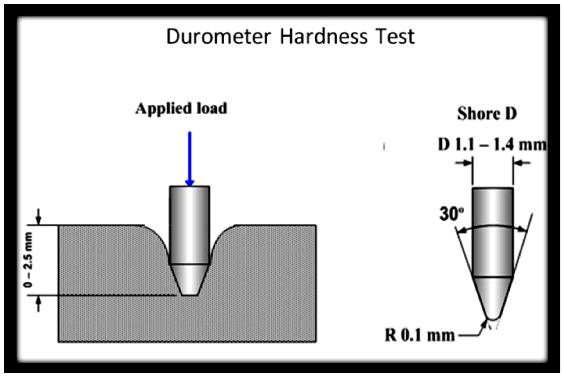


Fig: 1: Shore-D hardness testing

2. Impact: The impact test is a measure of the polymeric composites resistance to refraction under the effect of stress at a high speed. The impact resistance can be defined as the amount of energy absorbed during the collision of an object with a specific mass to the cross-sectional area of the sample at the break, the impact strength is calculated from the following equation [11,12].

$$I.S = \frac{E_C}{A} \dots \dots \dots \dots (1\text{-}1)$$

Where: I.S : Impact Strength(kJ/m^2), E_C : Breaking energy (J), A : Cross section area (m^2). And figure (2) shows the schematic diagram for the impact strength instrument.

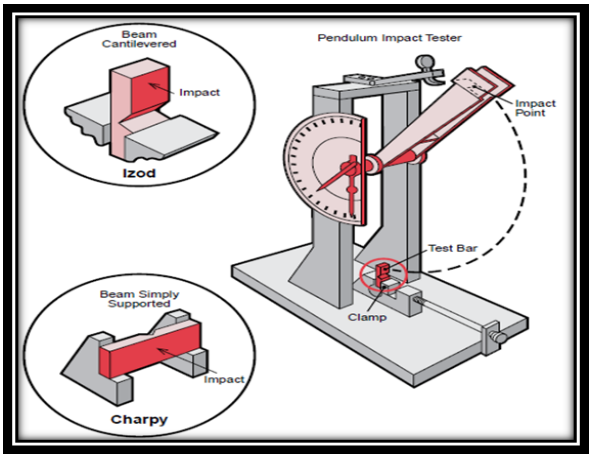


Fig . 2: Shows the test method for the impact strength instrument by Charpy and Izod.

Impact resistance depends on several variables, including substance type, stress distribution, manufacturing conditions, environmental conditions, strain rate and temperature. In general, the impact resistance of ductile polymers is higher than that of fragile polymers, while rubber polymers have very high impact resistance. The effect of the temperature change on the impact resistance is limited to the non-compliant resins. It is found that the impact strength of these materials is almost constant for temperatures between (80-200 C). As for the resin compliant resins, the impact resistance depends entirely on the heat, as the impact resistance increases with increasing temperature due to the relaxation of the bonds and the molecular bonding forces, which allows the absorption of a greater amount of energy into the plastic behavior [13].

2.EXPERIMENTAL PART

2.1 Used Materials

2.1.1. Matrix Material: The matrix material used in this study is unsaturated polyester resin (Siropol-8341) and produced by the Saudi (SIR) Company for Resins. This resin turns into a solid-state after adding its hard of the type of (Ethyl peroxide methyl ketone) at a rate of (2gm) per (100gm) of polyester to interact at room temperature. The properties of unsaturated polyester resin in this study are shown in table (1) according to product company.

Table 1: The properties of unsaturated polyester resin

Properties	Quantity
Density	1.2 – 1.5 (g /cm^3)
Young's Modulus	2000 – 4500 (Mpa)
Tensile Strength	40 – 90 (Mpa)
Poisson's Ratio	0.37 – 0.39
Heat distortion temperature	50 – 110 (°C)
Thermal conductivity	0.2 (Wm^{-1} K^{-1})
Coefficient of thermal expansion	100 – 200 (10^{-6} K^{-1})

2.1.2. Reinforcement Materials

a. Copper: The copper particles used in this research have a grain size ranging between (50-75 microns), a density (8.9 gm/cm^3), a purity of 99.8%, and they have a melting point of (1083^{O}C).

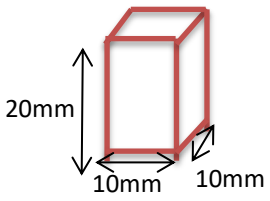
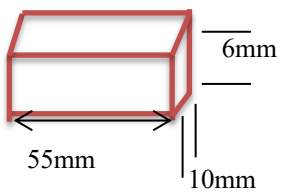
b. Iron: The iron particles used in this research have a grain size ranging between (55-63 microns), a density (7.8gm/cm3), a purity of 99.9% and they have a melting point of (1538 ^{O}C).

2.1.3. Immersion Solutions: The immersion solutions used in this study are NaOH and HCL solutions have normality (0.3N). These solutions have been prepared in the laboratories of Anbar University. All specimens are immersed in NaOH and HCL solutions for 30 days, and at the laboratory temperature.

2. 2.Specimens Preparation

The method (Hand lay-up molding) is used in the process of preparing samples because it is one of the easy, successful and common methods, Unsaturated polyester resin is prepared by adding a hardener to it with ratio (2gm hardenes:100 gm UPE) and mixes it well by the electric mixer for a homogeneous mixture and that avoid bubbles, and the iron and copper powder are added together with different weight percentage (5, 10, 15, 20) Wt%. Gradually into the mixture and stirring in order to obtain homogeneity for a period (8-10) minutes. The mixture is then poured into the molding with dimensions (30 x 30 cm) and a thickness of (1 cm) for the hardness test samples and with dimensions of (30 x 30 cm) and a thickness of (0.6 cm) for the impact test samples and left for a period of (72) hours at room temperature to for solidification. Specimens are then extracted from the molding and heat-treated in oven at (50 oC) for a period of (6) hours for (Curing). Castings are cut into samples according to the specification of the device samples for each test and according to the international standard specifications. And then after the process of smoothing and polishing the samples using the silicon carbide sheets with different degrees of smoothness. Table (2) shows the standard dimensions of the impact and hardness test, and figure (3) shows a photographic image of the impact and hardness samples.

Table 2: shows the standard dimensions of the impact and hardness test.

Standard Specifications	Sample's dimensions	Test
ASTM		hardness
ISO-D256-87		impact

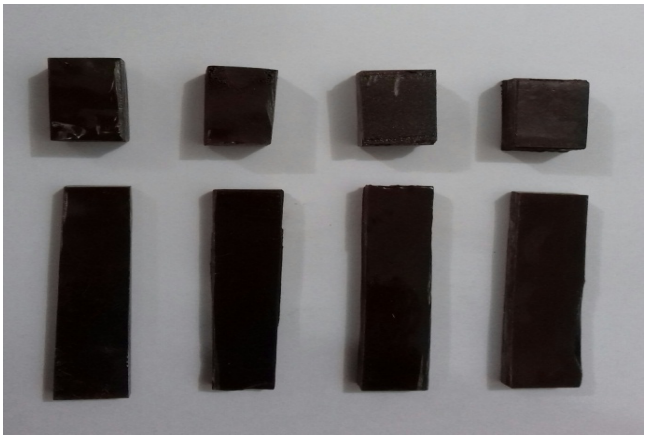


Fig . 3: Impact and hardness samples

3.RESULTS AND DISCUSSION

3.1.Hardness Test

3.1.1. Hardness Test Results in Natural Conditions

The hardness test for samples is measured in normal conditions and after immersion in NaOH and HCl solutions at laboratory temperature, the experimental results are shown in table (3). From table (3) we notice that the hardness values increase with increasing Wt% of iron and copper particles as shown in fig (4), this behavior agrees with results [14].

Table 3: Hardness values in natural conditions and after immersion in NaOH and HCl solutions.

Wt%	Composite material	Hardness (N/mm^2)		
		N.C	Immersion 30 day	
			NaOH	HCL
5	UPE95%+Cu2.5%+Fe2.5%	83.33	82.33	82
10	UPE 90%+ Cu5%+Fe5%),	84.33	83.66	83.33
15	UPE 85%+ Cu7.5%+Fe7.5	85.66	85	84.5
20	UPE 80%+ Cu10%+Fe10%	86.66	85.66	85

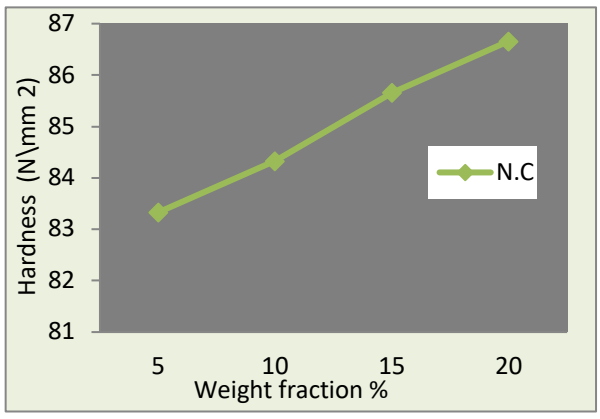


Fig . 4: Variation hardness with weight fraction in natural condition.

Reason of increasing the hardness with increasing filler content due to that copper and iron particles of high density led to filling (dam) and reducing gaps and voids formed during the molding process. This leads to increased

tangles and agglutination that reduced the movement of unsaturated polyester particles and chains and thus increased the resistance of the material's surface to stitching and deformation [14]. Also hardness of the material depends on the type of forces that bind the atoms or molecules in the material. The stronger of the bonding, the more the hardness value increases, so the strong bonding at the interface between the polyester resin and iron and copper particles lead to an increase in hardness.

3.1.2. Hardness Test Results After Immersion in NaOH and HCl

The experimental results of the hardness test after immersion in NaOH and HCl solutions with normality (0.3N) for a period of (30) days at laboratory temperature are shown in table (3). From table (3) it is noted that hardness values increases with increasing weight ratio of copper and iron particles, but its value is less than normal conditions as shown in fig (5).

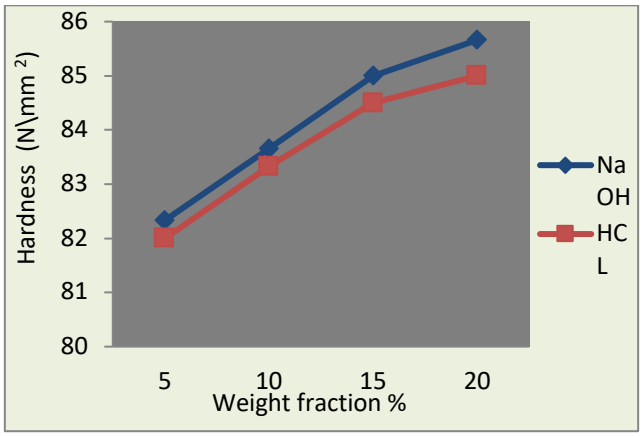


Fig. 5: Variation hardness with weight fraction after immersion in NaOH and HCl .

Notice from figure (5) the decrease in the values of hardness after immersion in NaOH and HCl solutions, the reason for this is due to the penetration of NaOH and HCl solutions into the area of the interface which leads to their decomposition and separation from each other and cause the material to fail. As the spread of the NaOH and HCl solution breaks the bonds between the polymeric chains and the appearance of bubbles that are a phenomenon of deformation in the material. The entry of chemical solutions into the polymer leads to weak linkage between the base material and other additives, and this, in turn, works to increase the porosity. Thereby increasing the absorption of the substance to the chemical solutions leads to an increase in the ductility of the material, Thus the hardness value decreases[15]. Also from Figure 5. Notice that the hardness values in the HCl solution are lower compared to the NaOH solution. It is because of the effectiveness of the HCl solution to penetrate and break the bonds between the polymeric chains. Fig (6) shows a comparison of the hardness values with weight fraction in natural condition and after immersion in the (HCL) and (NaOH) solutions.

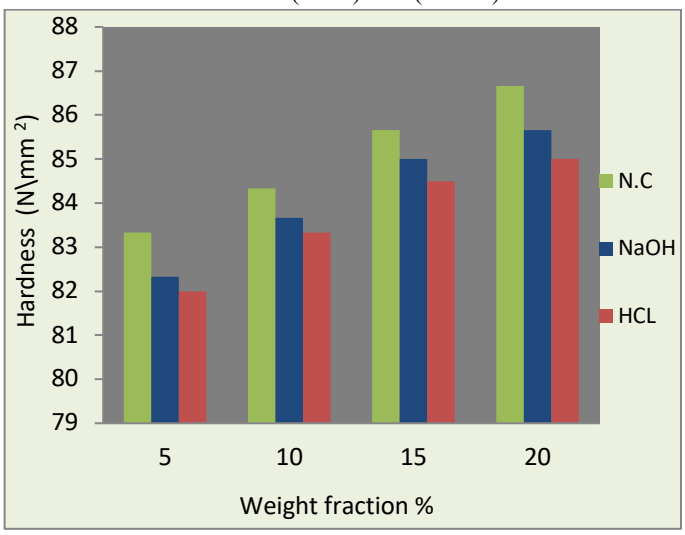


Fig. 6: Shows a comparison of the hardness values with weight fraction in natural conditions and after immersion in the (HCL) and (NaOH) solution

3.2. Impact Strength Test

3.2.1. Impact Strength Test Results in Natural Conditions

The impact strength test for samples is measured in normal conditions and after immersion in NaOH and HCl solutions at laboratory temperature, the experimental results shown in table (4). From table (4) we notice that the impact strength values increase with increasing weight fraction of iron and copper particles as shown in fig (7), this behavior agrees with results [16].

Table 4: Impact strength values in natural conditions and after immersion in NaOH and HCl solutions.

Wt %	Composite material	Impact strength (KJ/m^2)		
		N.C	Immersion (30) days	
			NaOH	HCL
5	UPE95%+Cu2.5%+Fe2.5%	0.642	0.512	0.47
10	UPE 90%+ Cu5%+Fe5%),	0.672	0.56	0.522
15	UPE 85%+ Cu7.5%+Fe7.5	0.690	0.6	0.569
20	UPE 80%+ Cu10%+Fe10%	0.745	0.66	0.63

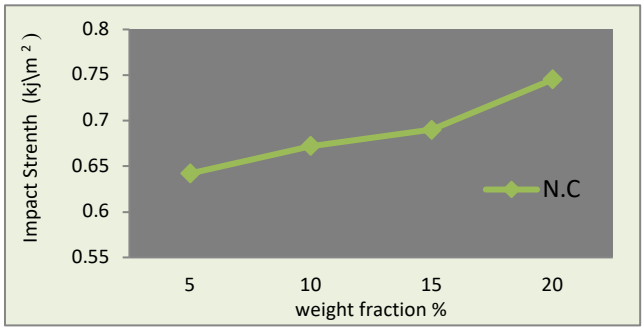


Fig . 7: Variation impact strength with weight fraction in natural condition.

The reason for the increased impact strength with increase in the weight breakage of iron and copper particles, is due to the action of these particles as barriers to cracks developing during the composite material. That is, it works to impede the growth of the crack, and this will lead to change the shape and direction of the crack, which leads to its transformation into a group of secondary cracks, thus increasing the surface area of the fracture and the energy expended. Also from other factors that have increased the impact strength are that the copper particles possess high ductility and the iron particles possess high durability, lead to increases the durability of the composites material, thus increasing the value of impact strength [16].

3.2.2. Impact Strength Test Results After Immersion in NaOH and HCl

The experimental results of the impact strength test after immersion in NaOH and HCl solutions with normality (0.3N) for a period of (30) days at laboratory temperature are shown in table (4). From table (4) it is noted that impact strength values increases with increasing weight ratio of copper and iron particles, but its value is less than normal conditions as shown in fig (8).

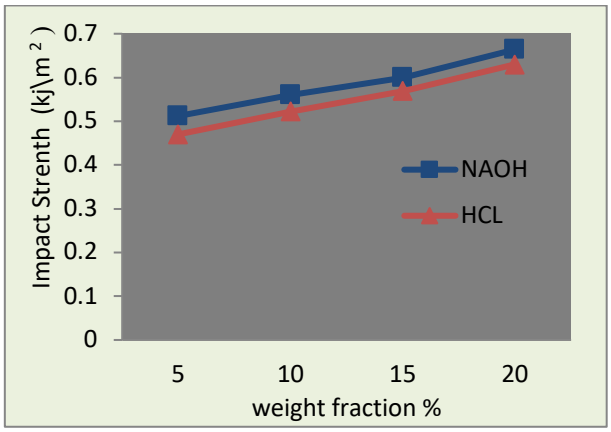


Fig .8: Variation impact strength with weight fraction after immersion in NaOH and HCl .

From Figure (8) the decrease in the values of impact strength after immersion in NaOH and HCl solutions can be viewed. The reason for this is because the NaOH and HCl solutions cause composite material fail, and that is by generating internal stresses resulting from the accumulation of particles within the structure of the superposition. And this leads to site failure at much lower stresses than in the natural state, and that the penetration of chemical solutions into the sample works to break the bonds and the appearance of some distortions in the sample represented by small bubbles at the interface. Thus the impact strength value decreases [17]. Fig (9) shows a comparison of the impact strength values with weight fraction in natural condition and after immersion in the (HCL) and (NaOH) solutions.

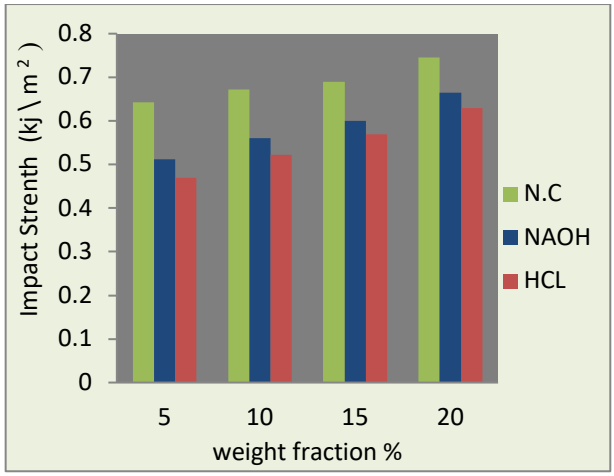


Fig. (9): Shows a comparison of the impact strength values with weight fraction in natural condition and after immersion in the (HCL) and (NaOH) solutions.

4.CONCLUSIONS

- The hardness values increase with the increase in the percentage of iron and copper particles
- The impact strength values increase with the increase in the percentage of iron and copper particles
- Decreasing the impact strength and hardness values after immersion in (NaOH) and (HCl) solution compared to the normal condition, and their value in (HCl) solution is less than that of (NaOH) solution.

REFERENCES

[1] Salih M. K.,2016, "Study of the effect of fiber type and the number of reinforcing layers on some mechanical properties of polymeric overlays", Journal of university of Anbar for pure science, Vol. 10, No .3 , PP. 93- 98.

[2] Callister.W.D., 2003,"Materials science &Engineering An Introduction", Jownwiley & sons , Inc.

[3] Hassan.H.S.,2014, " Study of mechanical properties for unsaturated polyester reinforced with glass fiber", Journal of university of Anbar for pure science, Vol. 8, No.2, PP. 91- 96.

[4] Al-rawi.K.R., and Majeed.N.H.,2015, " Mechanical and thermal properties of epoxy-graphite composites" Baghdad Journal of Science, , Vol. 12, No .1, PP. 40-45.

[5] Gibson.R.F.,1994,"Principles of composite material mechanics", Mc. Graw Hill, Inc, New York.

[6] Ibrahiem.R.E.,and Sulyman.E.Z.,2019, " Preparation polymeric composites from epoxy with randomly woven fiber glass and studies the mechanical properties" Al-Rafidain Science Journal, Vol. 28, No. 3, PP. 105- 115.

[7] Alaa.M. H.,2012,"Study The physical properties of polymer Blends Reinforced by Metal Laminates and Microcotton ,"Master Thesis, University Of Technolongy, Department Of Material Applied Sciences.

[8] Dinokaran.K.,and Alagar.M.,2003,"Development and characterization of vinyl ester oligomer (veo) modified unsaturated polyester intercross linked and composites", International T. of Polymeric materials, Tayler and Francis Inc. Vol. , PP()m2003., vol. 52 (11-12),pp. 957-966.

[9] William.D.,and Callister.Jr.,2007, "Materials science and Engineering An Introduction", 7th ed.

[10] Kopeliovich.D., 2012,"Shore (Durometer) Hardness Test", Subs & Tech, last modified: 28 Apr.

[11] Ibrahim.B. K.,2019, "Effect of sulfuric acid solution on thermal conductivity and impact strength of epoxy resin reinforced by silicon dioxide powder" Iraqi Journal of Physics, Vol.17, No. 41, PP. 82- 90, (2019).

[12] Skoog.D.A.,West.D.M.,Holer.F.J.,and Crouch.S.R., 2013, "Fundamental of Analytical Chemistry. 9th Edition, Cengage Learning" .

[13] بلقيس محمد ضياء " تسليح ودراسة خواص، الابوكسي والبولي استر غير المشبع" اطروحة دكتوراه , قسم العلوم التطبيقية الجامعة التكنلوجية, 2006) .

[14] Musa B. H. ,2014," Effect of glass powder on some mechanical properties of polymer matrix composite material", Journal of Al-Nahrain University, Vol.17. No. 2, PP.108-115.

[15] Khaleel H. K.,2016 " Effect of chemical solutions on some of the physical and mechanical properties for Particulate / Epoxy Composites", M.Sc. thesis, University of Anbar, College of Education for Pure Sciences, Department of physics.

[16] Atewi.A.H.,2012, "Study of some mechanical properties for a polymer material reinforcement with chip or powder copper", Engineering Journal, Vol.18, No .5, PP.103- 113.

[17] Dheyaa.B.M., and Mnajid.A. H.,2012," Effect of liquids absorption on some mechanical and thermal properties for polymeric composites", Proceedings of international conference on engineering and information technology, ISBN:978-1-77136-064-7,Canada.

تأثير المحاليل الكيميائية على بعض الخواص الميكانيكية لمتراكبات (Fe + Cu/UPE)

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الخلاصة:

يتضمن هذا البحث تحضير متراكبات بوليمريه بطريقة القولبة اليدوية من راتنج البولي استر غير المشبع كماده اساس ودقائق الحديد والنحاس كمواد مقويه وبنسب وزنيه مختلفة ,(5%, 10%, 15%, 20%) و تم دراسة خاصية الصلادة ومتانة الصدمة قبل وبعد الغمر في محلول (NaOH) ومحلول (HCl) وبعياريه (0.3N) ولمدة غمر واحده (30) يوما، اظهرت النتائج العملية ان قيمة الصلادة والصدمة تزداد مع زيادة النسبة المئوية للحديد والنحاس قبل الغمر، اما بعد الغمر زادت قيم الصلادة والصدمة ايضا ولكن كانت قيمتها اقل من الظروف الطبيعية , وكانت قيمتها في محلول (HCl) اقل من محلول (NaOH).

الكلمات المفتاحية: بولي استر غير مشبع , الصلادة , متانة الصدمة, الحديد, النحاس.