Characteristic of Hybrid Chestnut Shell Fillers / Epoxy Composite

Dr.Sewench N.Rafeeq
Department of Applied Science, University of Technology/Baghdad
Samah M.Hussein
Department of Applied Science, University of Technology/Baghdad
Email:smh_1982@yahoo.com

Received On: 13/9/2012 & Accepted On: 10/1/2013

ABSTRACT

This paper presents the study of characteristic including (mechanical, thermal, and some dielectric properties) of chestnut shell filler/ epoxy composite. Composite plate was made by hand-layup technique. The filler content was 5% by weight. The tensile, impact, hardness, flexural strength and compression were showed to be increased while Young's modulus was little increased. The dielectric strength, dielectric constant, and volume resistivity were evaluated. The bending (Young's modulus values) and hardness tests were also estimated as a function of water submersion time at room temperature for a period up to 8weeks. The obtained results indicated that the composite has responded to water absorption.

خصائص متراكب الأيبوكسي/حشوة قشرة الكستناء الهجينة

الخلاصة

يوضح هذا البحث دراسة للخصائص المتضمنة (الميكانيكية والحرارية و بعض خصائص العزل الكهربائي)لمتراكب الايبوكسي المدعم بحشوة قشرة الكستناء.تم تصنيع المتراكب بالتقنية اليدوية وبنسبة وزنية (٥%) لدقائق الكستناء.ان دراسة الشد والصدمة والصلادة ومتانة الانحناءوالانضغاطية اظهرت زيادة بقيمتها بينما معامل يونك للأنحناء كانت زيادتة طفيفة .لقد تم قياس متانة العزل وثابت العزل الكهربائي والمقاومة الحجمية ايضا.ان اختبار الانحناء والصلادة قد قيس كدالة لزمن غمر دام ٨ اسابيع عند درجة حرارة الغرفة.بينت النتائج المستحصلة استجابة المتراكب لعملية امتصاص الماء.

INTRODUCTION

The first fillers used for polymer composites were basically inorganic. In fact synthetic fibers such as nylon, rayon, aramid, glass, polyester and carbon are extensively used for the reinforcement of plastics [1, 2].

https://doi.org/10.30684/etj.31.3B.10
2412-0758/University of Technology-Iraq, Baghdad, Iraq

Over the last decade, polymer composites containing vegetable fillers have received considerable attention both in the literature and in various industries. The automobile industry is a major productive sector in which many parts, traditionally made of pure plastic or glass fiber composites, are currently being replaced by natural fiber composite [3-6]. Vegetable fillers they are also referred to as cellulosic fillers can be generally classified as bast, leaf, seed-hair, cereal straw or grass fibers, depending on their origin [7]. Compared to inorganic fillers, the main advantages of cellulose fillers are, light in weight, have high specific properties, abundant, recyclable biodegradable,

Non-abrasive, non-hazardous and inexpensive [7-9]. Vegetable fillers can be considered as naturally occurring composites consisting mainly of cellulose fibrils embedded in a cementing of other, mostly hemicelluloses and lignin matrix [10-12]. The elementary unit of a cellulose macromolecule is anhydro-d-glucose, which contains three alcohol hydroxyls (-OH). These hydroxyls form hydrogen bonds inside the macromolecule itself (intramolecular) and between other cellulose macromolecules (intermolecular) as well as with hydroxyl groups from the air. Therefore, all plant fillers are of a hydrophilic nature; their moisture content reaches 8-13% [10-14].

Several cellulosic products and wastes such as shell flour, wood flour and pulp have been used as fillers in polymers, primarily to achieve cost savings and also to impart some desirable properties like decreasing shrinkage after molding, increasing elastic modulus and creep resistance, references can be found in [10]. The recycling Potential applications of natural fillers based composites in railways, aircraft, irrigation systems, furniture industries, and sports and leisure items are currently being researched. Cotton-polymer composites are reported to be the first fiber reinforced plastics used by the military for radar aircraft [15]. Agricultural fibers such as rice straw, wheat straw or oil palm frond can be easily crushed to chip particles and may be used as substituted.

Many studies had been carried out on the utilization of natural fillers and fibers such as short silk fibers[9], kenaf [16],sisal[17], jute[18], oil palm[19], empty fruit bunch [20], coir[21,22], sugar palm[23] , rice husk ash[24] , and coconut shell powder[25] as fillers and reinforcement materials . However, no references were found in the literature that used the chestnut shell fillers in polymers. Thus, it is the objective of this work to investigate the basic mechanical properties of this composite.

The scientific name of Chestnut is (Aesculus Hippocastanum), the chestnut fillers can be obtained directly from natural resource; it is cheap and also has advantages due to its renewable nature, and easy availability. In this study, the mechanical performances of chestnut shell filler/epoxy composite are measured and evaluated. Although various researches have been carried out on other natural fillers in composites, reports on the use of chestnut are not available.

MATERIALS AND METHODES

https://doi.org/10.30684/etj.31.3B.10
2412-0758/University of Technology-Iraq, Baghdad, Iraq

Materials

Chestnut fruit shell is smooth outer surface and contains fines fibers in the inner side, so that two types of fillers were obtained after milling the shell, both particles and fine fibers like wool which have been called fibrils. As a result hybrid fillers were obtained from the same source Figure (1). Fibrils and particulate forms were obtained from chestnut fruit shell. Chestnut fruit shell was extracted from the fruit. This was cleaned and ground using a grinding machine to get fine fibrous and particulates forms fillers. The produced fillers were dried in an oven at ١٠٠°C to remove residual moisture and then a constant weight was obtained. The ground particulate form was therefore sieved with a mesh of sieve of size106μm. Epoxy resin group type Quick mast 105 (DCP) was used as the matrix. Specific gravity and viscosity of the epoxy resin were 1.04 and 1 poise respectively at 3٥°°C. The ratio between resin and hardener for this study was 3:1 by weight.

Preparation of the composites

The composite with the filler loading 5% by weight percentage was fabricated using hand lay- up technique with size glass mould of (200×150×3 mm^{٣}). Initially epoxy resin and hardener were mixed together based on the weight ratio to form a matrix. Then a plastic sheet was placed in the bottom of the mould and the mixture was poured into the mould. For the preparation of epoxy/chestnut shell filler composite some of the weighted fillers were added to epoxy resin with continuous mixing to disperse the fillers in the matrix. This process was continued until weighted materials were finished. Then the mixture was poured into the mould. Then it was covered by plastic sheet. The curing time was around 24hrs applied at room temperature (28-30°C), after solidification, the casting sheet was released from the mould and placed in an oven at (55°C)for (3hrs)to post cure the considered sheet .

Finally, composites plates were cut into the tensile and flexural specimens based on ASTM standard D638 and D790, respectively. The specimens were cut and machined to produce samples conforming to the ASTM standards D256-87. D790-86 and D695 for (impact, bending and flexural strength, compression and tensile strength) test respectively and hardness testing, as well as for thermal conductivity and dielectric properties testings. All these tests were carried out for pure epoxy, and reinforced epoxy composite.

Three-point bending test

The modulus measures the resistance of materials to elastic deformation; the stress (σ) is related to the strain (ε) within linear elastic deformation of materials by Young's modulus (E) (Hook's law).

Three-point bending test system (Phywe) is used to determine the modulus of elasticity. The distance between the supports was fixed at 80mm. The following equations are used to determine Young's modulus of the specimens [26, 27].

$$E = \frac{Mgl^3}{48IS} \qquad \text{..... (1)}$$

$$I = \frac{bd^3}{12} \quad \ldots. (2)$$

Where E is Young's modulus (N/m^2), M is the mass, g is gravitational acceleration ($9.8 \frac{m}{Sec^2}$), l is the length of the specimen, I is the moment of inertia, S is the deflection and ($\frac{M}{S}$) is the slope of linear part of the mass- deflection relation, b and d are the width and thickness of the specimen, respectively.

Impact strength test

The Charpy impact test is used. This test determines the amount of energy absorbed by a material during fracture, which refers to the material's toughness. The impact strength test for specimens was obtained by using Charpy impact instrument (Testing Machines INC. AMITYVILLE, New York). Pendulum of energy (5 Joul) was used in this test of the specimen. The impact strength is calculated from the following relation [28]:

$$\text{Impact strength (I.S)} = \frac{Energy\ of\ \ fracture(Joul)}{Cross-Sectional\ \ area(m^2)} \quad \ldots. (3)$$

Hardness

Hardness is a measure of materials resistance to localized plastic deformation. For measuring surface hardness properties of samples, a Shore hardness (Scale D) instruments of model (TH 210) with integrated probe Standards: ISO 9001 was utilized.

Tensile strength

After longitudinal fixing of the specimen by the upper and lower jaws of the equipment, tensile load was applied at rate of (44.362N) and maximum force reached (449.539 N). The tensile strength test for specimens of dimension (10×14×5.52) mm^3.Testing machine (JIANQIAO), model/CZL203-2000Kg, work in range (2000kg), accuracy (0.03%F.S) and sensitivity (2.0465),this test is used to calculate the ultimate tensile strength(UTS)and elongation(ΔL)for the specimen under the testing.

$$\sigma = F / A \quad \ldots. (4)$$

$$\varepsilon = \Delta L / L \quad \ldots. (5)$$

Where A is the sectional area, σ is the stress and ε is the strain.

Compression and flexural strength tests

Compression and flexural strength tests are carried out by using the hydraulic piston type (Leybold Harris, No. 36110). This device contains a digital vernier is used with the compression test for strain measurement [29, 30].

Compression strength= Load/ cross section area …. (6)

Flexural strength= 3 F.L/ 2 b h^2 ….. (7)

Where F is the load necessary to produce fracture in the bending test, L is the distance between supports, b is the width of beam specimen, and h is the specimen height.

Thermal conductivity test

Lee's disc instrument is used to calculate thermal conductivity of the samples under test. The heat (e) (W/ m^2.K) that flows through across sectional area of the sample per unit time is calculated from the following equation [31]:-

$$IV = \pi r^2 e(T_A + T_B) + 2\pi r e\left[d_A T_A + d_S \frac{1}{2}(T_A + T_B) + d_B T_B + d_C T_C \right] \ldots (8)$$

Where

I is the current value through the electrical circuit.

V is the supplied voltage.

r is the radius of disc (2cm).

T_A, T_B and T_C are the temperature of the brass discs A, B and C, respectively.

d_A, d_B and d_C are the thickness of the brass discs A, B and C, respectively.

d_S is the thickness of the sample.

The values of thermal conductivity K (W/m. K) are calculated by applying the equation:-

$$K\left(\frac{T_B - T_A}{d_S} \right) = e\left[T_A + \frac{2}{r}\left(d_A + \frac{1}{4} d_s \right) T_A + \frac{1}{2r} d_S T_B \right] \quad \text{.... (9)}$$

Dielectric strength

The dielectric strength measurement was carried out using a breakdown test cell BAUR (0-60) KV designed with the appropriate electrodes and the breakdown tests were carried out in a medium of transformer oil. The dielectric breakdown voltage was measured at several points for testing samples. The test was carried out at room temperature (25°C).The dielectric strength was obtained from the following equation [32]:

$$E = \frac{V}{t} \quad \text{…. (10)}$$

Where E is the Dielectric strength, V and t are breakdown voltage (KV) and sample thickness (mm), respectively.

Dielectric properties

The capacitance and resistance were measured directly at room temperature using a Bench LCR/ ESR Meter model (BK precision 889B) by varying the frequency (100Hz-200KHz). Dielectric constant (έ) can be calculated from the capacitance using the equation:

$$\varepsilon' = \frac{Ct}{\varepsilon_o A} \qquad \text{…….. (11)}$$

Where C- capacitance of the material, t- thickness of the sample, ε_o- permittivity of free space
(8.85×10^{-12} Fm-1), and A- area of sample under electrode.
The insulation resistance of a material depends on its volume resistance, thus the volume resistivity (ρ) can be calculated by using the equation:

$$\rho = RA/t \qquad \text{….(12)}$$

Where R is volume resistance, A is the area of cross section, and t is the thickness of thesample.

Water absorption effect

The effects of moisture (water absorption) on bending and hardness properties for composite were studied during time of 8 weeks. Specimens for bending and hardness tests were submerged in tap water at room temperature (23°C). The specimens were removed from the water after certain periods of time, and testing then resubmersed in water.

RESULTS AND DISCUSSION

Three – point bending tests

The test results for bending property of chestnut shell filler/ epoxy composite presented in Figure (2)and(3), which shows the effect of load on deflection of the samples.

The Young's modulus which is used as an indication of a material's stiffness in static bending condition can be derived from the tangential slope of the load-displacement curve and calculation according to the relation(1). The obtained result as shown in Table (2) indicates no effected change in modulus value as compared with virgin (1600 MPa). There are many factors affecting the modulus of the composite. The factors are the intrinsic properties of the materials or fillers, modulus, the bonding force between the matrix and fillers that is responsible for the efficiency of load transfer in the composites, filler distribution, aspect ratio and orientation of the fibers in the composite, particle size of particulate fillers, and filler content[33].

In this experiment, no remarkable increase in modulus is noticed, so this due to filler intrinsic properties, and also the fibrous distribution in epoxy is random. Moreover, the

particulate form has smooth surface and a large particle size, hence a small surface area, since the modulus can be enhanced by the surface area of fillers.

Impact Test

The toughness of a material is associated with its ability to absorb impact loads without fracture.

Impact test is an attempt for measuring resistance to growth of crack; the impact strength is calculated by using the relation (3).

Table (1) shows that the sample of chestnut shell filler / epoxy composite has high value (10.16KJ/m^2) of the impact strength as compared with virgin epoxy (1.8KJ/m^2). This indicates that fillers impart toughness of the composite as a result of the slowing up of cracks in the neigh boarhound of the filler.

The adhesion between epoxy and fillers and good dispersion is improved values of impact strength for composite. In this experiment the toughening mechanism related to the fillers as fine fibrils bridging and crack deflection mechanisms may be act with some elasticity of particulates filler, which increased the absorption energy and impede of crack propagation result large impact strength.

Hardness

The measured hardness value of composite is presented in Figure (4) and Table (3). The hardness of composite is higher than virgin epoxy value (66). This must be expected because as filler get into the matrix the loading stress is shared by fillers resulting more rigid. It should be mentioned that surface hardness depends also on the bonding at the matrix and filler interface, and the distribution of fillers within the matrix. This result may be explained that both forms of filler were contributed to hardness of composite, since movement of the matrix is restrained in the vicinity of each particle, and the stress is spread through distributed fibers thus enhanced composite hardness.

Tensile strength

Ultimate tensile strength (UTS) was calculated and the results are shown in Table (1). The (UTS) was increased from (1.513MPa) to (5.99MPa) with addition of chestnut shell filler, which corresponds to an increasement of 26.9%. This result due to some interaction between components may be better with fibrous form fillers, so the filler could hold the load when matrix was transferred. It is expected that the filler content 5wt.% is not sufficient, may be UTS increased when the filler content is taken higher than the present.

Compressive and flexural strength

Figure (5) shows the (stress- strain) curve for sample due to compression. The ultimate compressive strength (UCS) of composite (89Mpa) is higher than virgin epoxy (70Mpa). The flexural strength result is shown in Table (1). In flexural test various mechanisms such as compression, tension, and shearing take place simultaneously [34]. It is noticed that the flexural strength increased from (63 MPa) to (101.37MPa) by using chestnut shell filler with epoxy resin. The result of the flexural strength of the chestnut shell filler/ epoxy composite is higher than the result obtained by Sapuan et al. [35] for coconut shell filler/epoxy composite.

Thermal conductivity

The conductivity of a composite is affected by the interface adhesion between fillers and matrices, since the conductivity may be impaired by the presence of some voids or cracks in the vicinity of the interface. Moreover the moisture content of natural fillers. The results obtained in Table (1) indicating of low thermal conductivity behavior. It can be said that chestnut shell fillers are behave as thermal insulator material.

Dielectric strength

The effect of filler content on dielectric strength of composite is shown in Table (1) .It is noticed that the dielectric strength value of the composite is lower than that of virgin epoxy (19.4 KV/m). This is due to the presence of polar groups which facilitate the flow of current and consequently lower breakdown voltage [36].

Specific volume resistivity

This study is important to evaluate the ability of an insulating material to resist the leakage of electric current. Figure (6) presents the variation of volume resistivity with frequency. As noticed the volume resistivity decreased with increasing frequency. This is due to the presence of polar groups, which facilitate the flow of current.

Dielectric constant

The dielectric constant of a material depends upon the polarizability of the molecules. Figure (7) shows the variation of dielectric constant values with increasing frequency. The presence of natural fillers in epoxy leads to presence of polar groups which give rise to dipole or orientation polarizability, and hence an increase in dielectric constant as compared with virgin value (3.9-4.1) [36].

Water effect

Figures (3) and (4) show Young's modulus and hardness values of composite as a function of submersion times. During the periods of submersion times Young's modulus is in between decrease and increase behavior, as well as hardness. These results due to water absorption or diffusion effects, a diffusion pathway can preexist or can be created under mechanical solicitation. The existence of such a pathway is also related to the filler connection. Two forms of fillers were present in composite which differ in dispersion, interfacial adhesion, and in stress load mechanisms, that caused the un uniform resultant. In fact moisture diffusion in polymeric composites has been governed by three different mechanisms. The first one involves diffusion of water molecules inside the micro gaps between polymer chains. The second mechanism is capillary transport into the gaps and flaws which interfaces between fiber and the matrix. The third one is transport of microcracks in the matrix arising from the swelling of fibers [37].

The reduction in Young's modulus was due to the diffusion of water molecules and the formation of a thin layer in between filler and matrix [38]. At the same time there was an increase in hardness, absorbed water molecules fill into cavities and cracks within the composite, so, more fillers were relaxed and diffused at surface, which caused this increase. After periods of time some increased is obtained in Young's modulus that may be due to diffusion of water through composite leads to break bonding between particulate fillers and matrix. Reducing in flexibility and an increasing in Young's modulus were resulted. It must be mentioned here that few

particles were seemed in water after periods of time; of course the surface lost its hardness, as a result obtained.

CONCLUSIONS

Composite of chestnut shell filler (5 wt. %) based on epoxy resin matrix was introduced. Mechanical, thermal conductivity and dielectric properties were investigated. It is found that:

- An increase in hardness, impact, tensile strength, compression, and flexural strength, while for Young's modulus no remarkable changed.

-Thermal conductivity result indicated of insulator composite behaves. - The effect of present filler polar group induces of decreasing in dielectric strength and volume resistivity, and increasing dielectric constant.

Hardness and bending properties of the composite were affected through submersion period times in water.

It is expected that the present behavior may be improved more by an increase of filler content, which is currently will be studied**.**

REFERENCES

[1]. Lawrence, C. B.,Russel, G. T. Anron, B. Accelerated test methods to determine the long term behavior of FRP composite structures: Environmental effect. Journal of Reinforced Plastics and Composites, Lancaster, v.14, p.(559-587), June, 1995.

[2]. Erich, F. Antonios, G.; Michel, H. Carbon fibers and their composites. High Temperatures and High Pressures, London, v.16, p.(363-392), 1984.

[3]. Paul Wambua, Jan Ivens, and Ignaas Verpoest. "Natural fibres: can they replace glass in fibre reinforced plastics, Composites Science and Technology, 63(9): p. (1259-1264), 2003.

[4]. Kozlowski, R.; Mieleniak, B. New trends in the utilisation of byproducts of fibre crops residue in pulp and paper industry, building engineering, automotive industry and interior furnishing. In Proceedings of the 3rd International Symposium on Natural Polymers and Composites ; Mattoso, L., Leao, A., Frollini, E., Eds.; May 14-17th 2000, Sao Pedro, Brazil; p.(504-510) ,2000.

[5]. Leao, A. L.; Rowell, R.; Tavares, N. Application of natural fibers in automotive industry in Brazil - Thermoforming process. Prasad, P. N., Mark, J. E., Kandil, S., Kafafi, Z. H., Eds.; In Science and technology of polymers and advanced materials. Plenum Press: New York, p. (755-760), 1998

[6]. Dahlke, B.Larbig, H.Scherzer,H.,D.Poltrock, R. Natural fiber reinforced foams based on renewable resources for automotive interior applications. J. Cellular Plast., 34 (4), p.(361-379), 1998 .

[7]. Muhammed Jannah Bin Josoh,"Studied on the properties of woven natural fibers reinforcement unsaturated polyester composites"Thesis submitted in fulfillment of the requirements for the degree of Master of Science, Universiti Sains Malaysia 2008.

[8]. Ahmed Said Azizi Samir,Fannie Alloin, and Alain Dufresne, Review of Recent Research into Cellulosic Whiskers, Their Properties and Their Application in Nanocomposite Field, Reviews, Biomacromolecules, 6,(2) p. (612-626), 2005.

[9].Lee, S.M., Cho, D., Park, W.H., Lee, S.G., Han, S.O. & Drzal., L.T.. Novel silk/poly(butylene succinate) biocomposites: the effect of short fibre content on their mechanical and thermal properties. Composites Science and Technology 65:p.(647-657),2005.

[10]. Kuruvilla Joseph, Romildo Dias Tolêdo Filho, Beena James, Sabu Thomas, and Laura Hecker de Carvalho, A review on sisal fiber reinforced polymer composites. Revista Brasileira de Engenharia Agrícola e Ambiental, 3 (3), p. (367-379), 1999.

[11]. Maya Jacob John, Rajesh D. Anandjiwala, Recent Developments in Chemical Modification and Characterization of Natural Fiber-Reinforced Composites, polymer composites -2008,Published online in Wiley InterScience (www.interscience.wiley.com).2007 Society of Plastics Engineers.

[12]. Alain Dufresne and Mohamad N. Belgacem,Cellulose- reinforced composites: from micro- to nanoscale, Polimeros: Cieėncia e Tecnologia, Overview, 2010.

[13]. Ragunathan Santiagoo, Hanafi Ismail, and Kamarudian Hussin, Mecanical properties, water absorption and swelling behavior of rice husk powder filled(PP/ NBRr/ RHP) biocomposites using silane as acoupling agent,Bioresources 6(4),p.(3714- 3726), 2011.

[14]. Mantanis, G.I., Swelling of lignocellosic material in water and organic liquids. Ph.D. Thesis, University of Wisconsin-Madison, Wisconsin, USA1994.

[15]. Piggot, M. R. Load bearing fibre composites. Oxford:Pergamon Press, 1980.

[16] Shinji Ochi. "Mechanical properties of kenaf fibers and kenaf/PLA composites". Mechanics of materials, 40 (4-5):p.(446-452), 2008.

[17]. Flavio de Andrade Silva, Nikhilesh Chawla, Romildo Dias de Toledo Filho. "Tensile behavior of high performance natural (sisal) fibers". Composites Science andTechnology, 68(15-16):p.(3438-3443), 2008.

[18]. Sabeel Ahmed, K. S. Vijayarangan. "Tensile, flexural and interlaminar shear properties of woven jute and jute-glass fabric reinforced polyester composites". Journal of materials processing technology, 207 (1-3):p.(330-335), 2008

[19]. Maya Jacob, Sabu Thomas, K.T. Varughese. "Mechanical properties of sisal/oil palm hybrid fiber reinforced natural rubber composites". Composites Science and Technology, 64(7-8):p. (955-965), 2004.

[20]. Mohd Zuhri Mohamed Yusoff, Mohd Sapuan Salit, and Napsiah Ismail , Tensile Properties of Single Oil Palm Empty Fruit Bunch (OPEFB) Fibre, Sains Malaysiana 38(4), p.(525–529), 2009.

[21]. Brahmakumar, M. C. Pavithran, and R.M. Pillai. "Coconut fibre reinforced polyethylene composites: effect of natural waxy surface layer of the fibre on fibre/matrix interfacial bonding and strength of composites". Composites Science and Technology, 65(3-4):p.(563-569), 2005.

[22]. Sanjay Kindo, Study on mechanical behavior of coir fiber reinforcement polymer matrix composites, thesis submitted in partial fulfillment of the requirements for the degree of bachelor of Technology in Mechanical Engineering, department of mechanical engineering national institute of technology, Rourkela 769008 May 2010.

[23]. Bachtiar, D. S.M. Sapuan, M.M. Hamdan. "The effect of alkaline treatment on tensile properties of sugar palm fiber reinforced epoxy composites". Materials and Design, 29 (7): p.(1285-1290), 2008.
[24]. Krynallis, Comparative study on the properties of rice straw/polypropylene and micaceous clay/polypropylene composites, Thesis submitted in fulfillment of the requirements for the degree of Master of Science August 2009.
[25].Siddhartha K. Pradhan, E.S. Dwarakadasa, Philip J. Reucroft, Processing and characterization of coconut shell powder filled UHMWPE, Materials Science and Engineering A,367,p.(57-62), 2004.
[26]. Hatnagar, M. S. B. "Eng. Mate. Tech." 3rd Butter Worth Oxford, (1998).
[27]. Khurmi and R.S. Sedha, R. S. "Materials Science" S. Chand & Company LTD. India, (2008).
[28]. Chawla, K. K. Composite Materials (Science and Engineering), Springer – Verlag New York Inc. , (1987).
[29]. Nielsen, L.E. Mechanical Properties of Polymers, Rienhold, New York, 1962.
[30]. Hpper, C.A.," Modern Plastic Handbook", Mc Graw Hill Co., New York, 2000.
[31]. Tolf G. and Clarin P.," Fiber Composite Hybrid Materials", Applied Science Publisher LTD, London, (1981).
[32]. Mohd Zuhri Mohamed Yusoff, Mohd Sapuan Salit, and Napsiah Ismail , and Riza Wirawan , Mechanical Properties of Short Random Oil Palm Fibre Reinforced Epoxy Composites, Sains Malaysiana, p.(87–92), 39(1)(2010).
[33]. James, M. G. " Mechanics of Materials", sixth edition, Thomson, Canada, (2004).
[34]. Sapuan, S.M. M.Harimi and M.A.Maleque, The Arabian Journal for Science and Engineering, Volume 28, No 2B, October 2003.
[35]. Murali M. R. K., Mohana R. K., Ratna P. A.V. , Fabrication and testing of natural fibre composites: Vakka, sisal, bamboo and banana", Materials and Design Vol.31, PP. 508–513, (2010)..
[36]. Hazizan Md Akil, Leong Wei Cheng, Z.A. Mohd Ishak, A. Abu Bakar, and M.A. Abd Rahman, Water absorption study on pultruded jute fibre reinforced unsaturated polyester composites, Composite Science Technology, Vol.69, p.(1942-1948), 2009.
[37]. Andrzej Korneliusz Bledzki, Marta Lucka, Abdullah Al Mamun, and Janusz Michalski, Biological and electrical resistance of acetylated flax fiber reinforced polypropylene composites, Bioresources 4 (1), p. (111- 126), 2009.

(a)

(b)

Figure (1) chestnut shell fillers (a) fiber (wool).

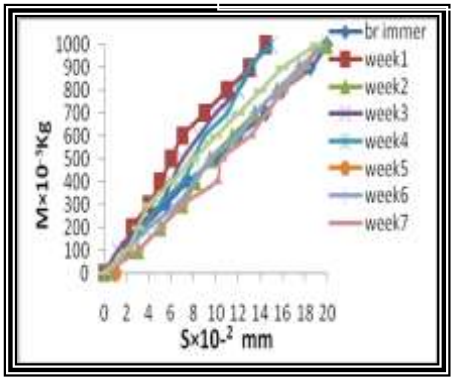

Figure (2) the mass versus the deflection before and after the immersion for all weeks.

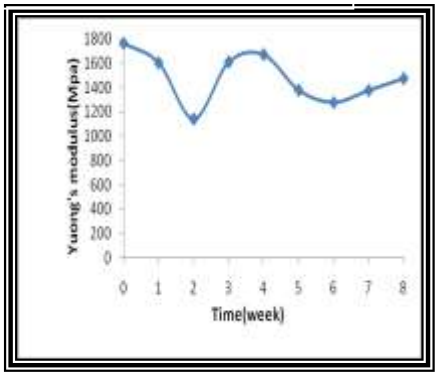

Figure (3) the young's modulus value versus the time for chestnut shell filler/epoxy composites.

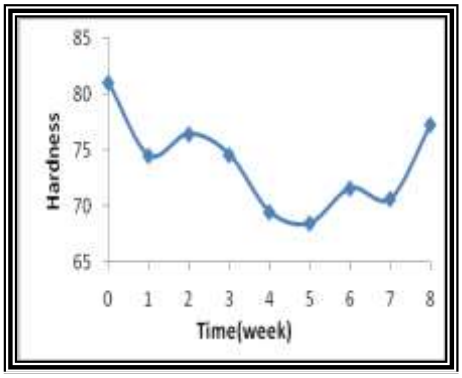

Figure (4) the hardness value versus the time for chestnut shell filler/epoxy composites.

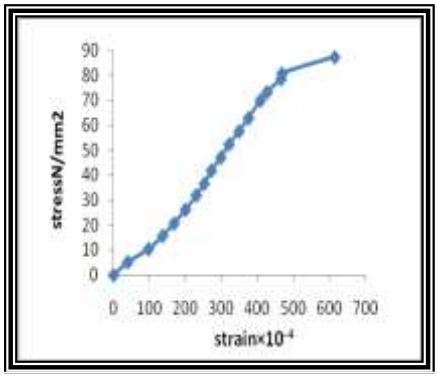

Figure (5) the compression (stress – strain) for chestnut shell filler/epoxy composites.

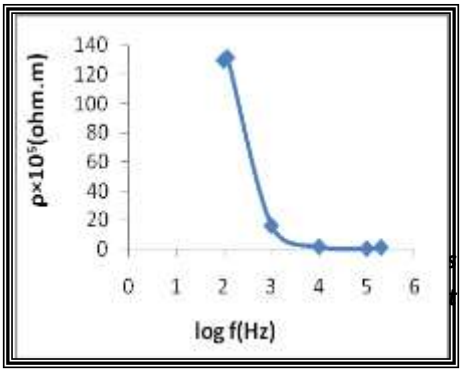

Figure (6) The Volume Resistivity Versus

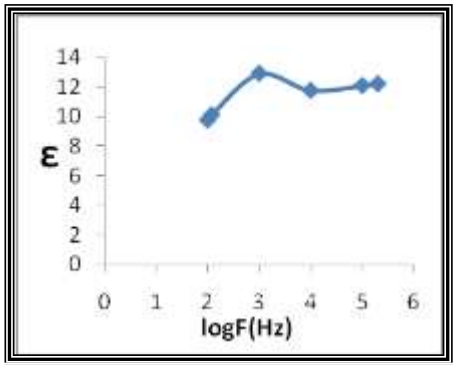

Figure (7) the Dielectric constant versus the logarithm frequency for chestnut shell filler/epoxy composites.

The Logarithm Frequency For Chestnut Shell Filler/Epoxy Composites.

Table (1) the value of tests.

The test	value
Impact strength (5Joul)	10.16 KJ/m2
Thermal conductivity	0.5 W/m. K
Compression strength	89 Mpa
Tensile strength	5.99 Mpa
Flexural strength	101.37 Mpa
Dielectric strength	12.95 KV/m

Table (2) the value of young's modulus.

Time(week)	Young's modulus (Mpa)
Before immersion	1763.8
1	1603.5
2	1142.4
3	1610.4
4	1671.4
5	1379.3
6	1278.5
7	1377.2
8	1475.3

Table (3) the value of hardness.

Time (week)	Hardness
Before immersion	81.03
1	74.53
2	76.45
3	74.60
4	69.50
5	68.50
6	71.61
7	70.67

8	**77.3**