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STUDYING THE USE AND EFFECT OF THE ENVIRONMENTAL WASTE (NATURAL CORN FIBER) IN REINFORCING THE UNSATURATED POLYESTER RESIN ON SOME MECHANICAL PROPERTIES.

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Abstract
The current research investigates the effect of reinforcement with corn fibers and volume fractions (2%, 4%, 6%, and 8%) on the unsaturated polyester resin. The overlay was prepared by manual molding at room temperature. The results revealed that the reinforcement of the base material with fibers led to enhancing the mechanical properties (impact and hardness) by increasing the reinforcement percentages, whereas the tensile strength values decreased by increasing these percentages.
Keywords: corn fiber, unsaturated polyester, hardness, impact resistance, tensile strength.

Introduction:

Natural fibers and their multiple uses have gained attention recently, which have been a crucial component in the creation of new products in a variety of industries, including the production of automobiles, airplanes, submarines, building materials, packaging, and others. These fibers are among the elements of sustainability that are included in the environmentally friendly green overlay materials. (Kaebernick et al, 2003).

It was used as a reinforcing material for thermoplastic polymer-based composite materials. These natural fibers are distinguished from their counterparts used in the traditional reinforcement of materials such as glass fibers, carbon, Kevlar et al., in that they:

- have a specific resistance.
- Abundantly available.
- Light weight.
- Low density.
- Low cost.
- Easy to separate.
- Non-corrosive
- Better thermal properties
- Reduce wear and tear.
- Reduce skin and respiratory irritation.
- Low friction of processing equipment.
- Renewable.
- The ability to absorb noise.
- Biodegradable. (Singha and Thakur, 2008)

One of the biggest challenges for researchers is the high cost of construction materials like nanoparticles and synthetic fibers. There has been a rising prerequisite to identify substitute natural materials like corn fibers, Indian hemp, bamboo, coconut, flax, corn slabs, and others to be utilized to reinforce polymeric materials and others due to these economic and environmental considerations. Therefore, efforts were intended for using the wastes of these materials, like using their fibers, particles, outer or inner shell, or using them in the form of plates or sheets, which are considered among the environmental wastes in strengthening polymeric and building materials, as well as other ones. Thus, we have a couple of benefits: the first: ridding the environment of these wastes, and the second, the use of these wastes to aid such materials. Thus, the issue of recycling has become a priority in the industrial world today. (Al-Atrachi, 2013).

The corn fiber was obtained from the fruits of the corn plant and is considered one of the most widely used natural fibers because of its ability to absorb nitrogen and phosphorous in the soil as well as its ability to accumulate carbon dioxide at a great rate. Corn fiber is also a good source of cellulose and has good economic and environmental advantages. (Aji et al, 2009). Moreover, it can be employed to reinforce composite materials due to its good mechanical properties. (Aji et al, 2009), (Touzinski et al, 1973). The current research aims at studying the effect of corn fiber reinforcement of unsaturated polyester with volumetric fractions of (2%, 2%, 6%, 8%) on the mechanical attributes like tensile, hardness and impact.

Research Objectives:

The aim of the current research is to produce internal structural sections from corn fiber waste by using them as reinforcing materials for unsaturated polyester resin (UPS) and reducing environmental pollution resulting from throwing such waste.

Practical section:

Materials used:

First: the base material (unsaturated polyester):

Unsaturated polyester (UPS) is as a transparent liquid with a moderate viscosity (of Saudi origin) and a density of (1.2 g/cm3). It can be hardened by adding a transparent hardener. It is a compound of methyl ethyl ketone peroxide (MEKP) at a rate of (2g) per (100g) of resin. A solidification accelerator is added, which is cobalt (Co-Catalyst), which is in the form of a dark-colored liquid in the form of drops, with an addition ratio of (0.2g) per (100g) of resin for the purpose of increasing the speed of the resin solidification process. After a period of half an hour, it begins to turn into a gelatinous substance at room temperature.

Second: Supporting Material:

Corn fiber (CF) was collected from corn plant located in Iraq and extracted by special mechanical methods. It was cleaned and washed with distilled water, then dried by means of a hot air oven at a temperature of (100 °C) for 15 minutes, and then cut into lengths of (15 mm) as shown in Figure (1).

Figure (1) Corn fibers before and after the cutting process

Sample preparation:

Hand lay-up molding method was employed to prepare the samples. An aluminum mold manufactured with the dimensions required for the samples was used. The samples were prepared according to the volume fractions prepared for this research (2%, 4%, 6%, 8%). 'Unsaturated polyester' (UPE) was blended with its hardener at a percentage of 100:2 (g) using a glass rod and gradually to ensure that no bubbles formed and to reach a state of homogeneity. Corn fibers were added to the unsaturated polyester continuously to obtain a volume fraction of fibers of (2%). This process was repeated for the other volume fractions. The volume fraction of the fiber (Vf), which is related to the weight fraction of the fiber (Ψ), can be calculated by using the following equation. (Mohamed, 2004)

$$Vf = \frac{1}{1+\frac{1-\Psi}{\Psi} x \frac{\rho_f}{\rho_m}} \quad \text{……. (1)}$$

$$\Psi = \left(\frac{W_f}{W_c}\right) x100\% \quad \text{……... (2)}$$

$$W_c = W_f + W_m \quad \text{……. (3)}$$

W_f , W_m , W_C: The weight of the overlay material, the base material, and the support material, respectively, is measured in (g) units.

: ρ_f , ρ_m The density of the basic material in addition to the density of the aiding material are measured in g/cm3.

The overlay is gently poured into the metal mold and then the sample is left inside the mold to solidify. Upon completion of the molding process, the sample is subjected to heat treatment. This is done by placing it inside a (Hot Air Oven) at a (50°C) and for (60 min) to complete the solidification process and get the best crosslinking of the polymeric chains and get rid of the stresses generated on the sample during the casting process.

Mechanical tests:

Tensile test

Tensile specimens were prepared with standard dimensions as shown in Figure (2) according to American specifications (ASTM D-638-03). (Astm, 2003). Tensile testing of the samples was made by using the tensile device type (LARYEE Yaur Tasting Solution). As the sample is installed in the position designated for it among the jaws to hold the sample firmly in order not to move it during the examination. When turning on the device, the handles begin to tighten the sample from the top and bottom, and apply a tensile force with a strain rate (mm/min5) for all samples. Using the graph of the device, the results were obtained directly in the form of a curve (stress - strain) for the purpose of calculating the tensile properties (tensile strength, tensile of elasticity and ductility coefficient). Figure (3) shows the tensile samples before and after the test.

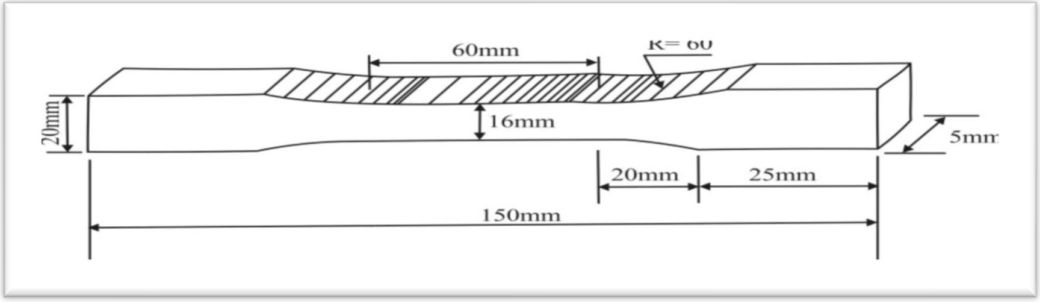

Figure (2) Standard dimensions of tensile specimens based on the international standards (ASTM).

Figure 3: Tensile specimens pre and post testing.

Impact test

The Charpy Impact Test manufactured by the American company Testing Machine INC., AMITYVILLE, New York, was used in order to calculate the energy required for fracture, through which it is possible to calculate the impact resistance of the material. This device mainly consists of a pendulum and an energy meter, where the hammer of the device, which carries an energy of (7.5) joules, is lifted to the ultra-height and fixed, where the sample

is positioned in the place designated for it horizontally between the two supports of the device. The energy meter is first zeroed, then the pendulum is released employing the lever installed on the scale, and with a swinging motion, the potential energy is transformed into kinetic energy, part of which is lost in the sample fracture, so the meter indicator reads the sample's fracture energy (UC). Figure (4) shows the impact resistance samples before and after the test. The dimensions of the sample according to the specification of hardness (ISO 179)) are as follows: the length of the sample is (55) mm, the width is (10) mm, the thickness is (5) mm, and the impact resistance I.S (Impact Strength) was calculated from the following mathematical relationship: (Crawford, 1987)

$$I.S = U_C / A \quad \ldots\ldots\ldots (4)$$

whereas :

UC: fracture energy measured in KJ.

A: the cross-sectional area of the sample in m2.

Figure 4 Impact test samples before and after the examination

Hardness test:

The Shore (D) method was used to measure the hardness of the sample, which is of the type (HUATEC GROUP Hardness Tester HT-6600C Shore D), manufactured by the Chinese company (HUATEC). The apparatus includes a surface-penetrating instrument in the form of a needle to record the amount of surface hardness of the sample. All hardness tests were conducted at the laboratory temperature (27 ◦C), where the samples were set based on the American international specifications [ASTM-D 2240], as illustrated in Fig(5). (Astm Standard). Figure (6) illustrates the prepared hardness test samples. The hardness test of the polymeric samples helps us to understand the mass cohesion and strength of the material. This test was carried out in order to determine the surface hardness of samples made from polymeric materials and their fiber overlays, as well as for the different reinforcement ratios. The test was carried out at lab temperature (27°C) and consisted of taking ten readings for each sample, extracting the average of those readings, and determining the hardness value.

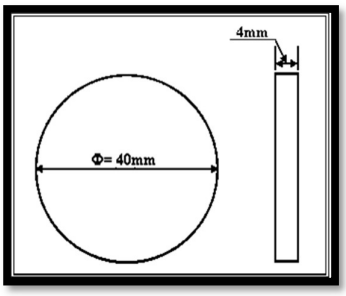

Figure (5) Standard dimensions of hardness samples according to American Standards (ASTM)

Figure 6: Hardness test samples.

Results and discussion:

Coefficients of tensile elasticity:

The results shown in Table (1) and Figure (7) regarding the tensile strength values showed that the tensile strength decreases with increasing reinforcement ratios. The reason for this is due to the lack of interaction between the base material and the support through the interface due to the surface nature of the base material. The results revealed that the lowest percentage of tensile strength was at (8%), because increasing the reinforcement of the fibers may lead to their agglomeration along the base material. This agglomeration led to difficulties in achieving a uniform distribution of the reinforced material, which leads to a weakening of the tensile strength. The natural fibers have poor compatibility with the base material, and this is consistent with the researcher. (Sai, et al. 2020)

Table (1) Tensile strength values with volume fraction of fibers.

Sample number	Volume Fraction (%) CF	Tensile strength(Mpa)
1	2	6.61
2	4	6.49
3	6	6.16
4	8	4.47

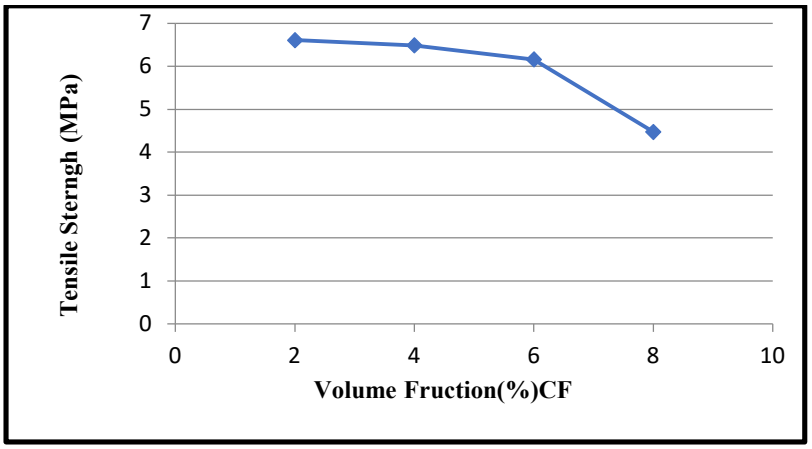

Figure (7) The relationship among tensile strength values and volumetric fracture of fibers.

Impact test

The results in Table (2) and Figure (8) regarding 'impact resistance' IR values of the organized samples illustrated that there was a major enhancement in the IR of entire samples when they were reinforced with corn fibers. This is attributed to the presence of those reinforcing fibers that endure the majority of the impact stress applied to the material and transmitted from the base material to those fibers through the interface. Those fibers disseminate the outer kinetic stress applied to a greater size of the specimen and decrease the probability of stress concentration at its core region. Thus, the fibers will hinder the growth of the fracture. This is consistent with the researcher. (Abbas, 2012)

Table (2) Impact strength values with fiber volumetric fraction.

Sample number	Volume Fraction CF(%)	Impact Strength (KJ/m2)
1	2	0.32
2	4	0.36
3	6	0.43
4	8	0.58

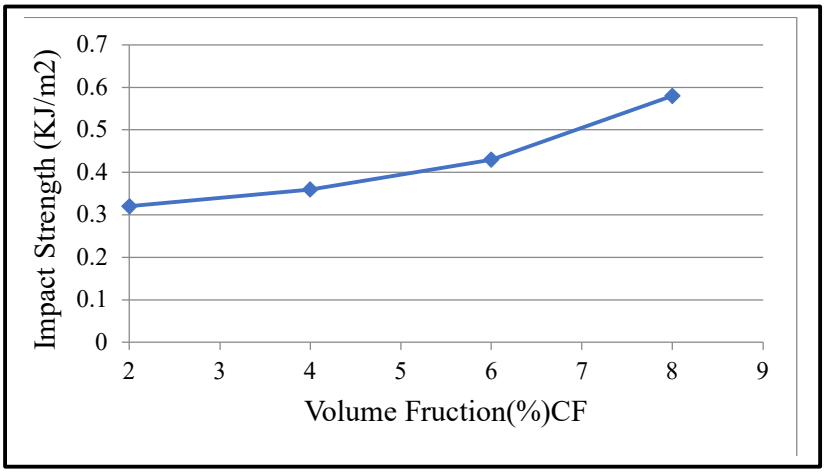

Figure 8: Relationship between impact strength values and fiber volumetric fracture.

Hardness Test:

The hardness test of the polymeric samples helps us to recognize the consistency of the material mass and strength. Thus, such a test was carried out to determine the surface hardness of samples made from polymeric materials and their fiber composites, as well as for different reinforcing levels. Each sample had measurements obtained, from which the average hardness value was then calculated. A lab temperature of 27°C was used for the test..

The results in Table (3) and Figure (9) concerning the values of hardness for the organized samples revealed that there was a major enhancement in the hardness property of entire samples when they were reinforced with corn fibers. This is attributed to the presence of these reinforcing fibers, which are distinguished by their maximum hardness. This agrees with the researcher (Al-Atraqchi, 2013). The external stresses applied from the matrix to the supporting fibers are transmitted through the interface. The polymeric chains are prevented from moving by these fibers. The mechanical qualities, especially hardness, are improved as a result. As a result, this increases the resistance of the materials supported by these fibers against scratching and penetration, and the reinforcing fibers also increase the rigidity of the polymeric material. Consequently, The composite material that has been developed has higher hardness values. The prepared samples durability is increased by the enormous adhesion force these fibers will produce between them and the resin through a small but robust region known as the interface. Furthermore, these fibers will disseminate the load placed on them, that decreases the rate of penetration of the surface of the superimposed material and increases its values of hardness. Additionally, another reason for increasing the hardness values of the prepared material with increasing the rate of fibers added to the polymeric base material is that the fibers occupy the greatest possible space inside the resin, which allows for better dissemination of the load placed on it. This is consistent with the researcher. (Al-Zubaidi, 2015)

Table (3) Hardness strength values with fiber volume fraction

Sample number	Volume Fraction CF(%)	Hardness (shore – D) (N/mm^2)
1	2	83.1
2	4	84.4
3	6	85.7
4	8	86.3

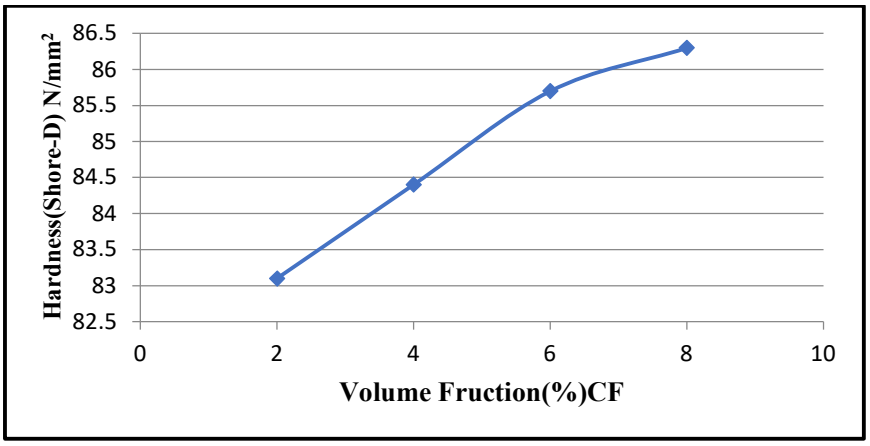

Figure (9) The correlation among hardness values and volume fraction of fibers.

Conclusions.

The most important conclusions reached in this research are:

1- The mechanical attributes ('hardness and impact resistance') of the organized overlays improve according to the effect of adding reinforced corn fiber (CF).
2- The tensile strength is negatively affected by the addition of reinforced corn fiber (CF), as the tensile strength decreases with increasing the reinforcement ratios.
3- According to the aforementioned, corn fiber (CF) is suitable for several structural applications that demand strong mechanical characteristics.

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