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Using Corn Fiber Waste as a Reinforced Material for Thermosetting Resin and Studying some of its Mechanical Properties

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Abstract

In this paper corn fiber has been used as a reinforced material that can be defined as agricultural residues that can be recycled and used to strengthen unsaturated polyester resin or other polymeric materials through which low-cost structural segments can be produced with high quality. current research discusses studying the impact of corn fiber reinforcement with volume fractures (2%, 4%, 6%, 8%) for unsaturated polyester resin. The superimposed material was prepared by manual molding at room temperature. Results showed that reinforcement of fiber core material led to enhancement of mechanical properties (Effect and toughness), the highest value of impact strength was recorded at 8% volumetric fracture, which reached (0.58 (KJ/m2), the highest value of hardness at 8% volumetric fracture at 86.3 (N/m2), while tensile strength values decreased with increased reinforcement ratios as stomach samples recorded the lowest value at volume break of 8%, which is 4.47 (MPa).

Keywords : Corn Fiber, Hardness, Impact, Tensile Strength, Unsaturated Polyester Resin.

استخدام مخلفات الياف الذرة كمادة مدعمة لراتنج متصلد حرارياً ودراسة بعض خصائصهُ الميكانيكية

الخلاصة

في هذا البحث استخدمت ألياف الذرة التي تعد من المخلفات الزراعية التي يمكن اعادة تدويرها واستخدامها في تدعيم راتنج البولي استر غير المشبع (او مواد اخرى) ، حيث يمكن من خلالها انتاج مقاطع هيكلية واطئة الكلفة، تركز هذا البحث على دراسة تأثير التدعيم بألياف الذرة وبكسور حجمية (2%, 4%, 6%, 8%) على بعض الخصائص الميكانيكية لراتنج البولي استر غير المشبع، وقد تم تحضير المتراكب بطريقة القولبة اليدوية بدرجة حرارة الغرفة. وقد أظهرت النتائج ان تدعيم المادة الاساس بالألياف ادى الى تحسن الخصائص الميكانيكية (الصدمة ، الصلادة) بزيادة نسب التدعيم حيث سجلت أعلى قيمة لمقاومة الصدمة عند الكسر الحجمي 8% والتي بلغت 0.58 (KJ/m^2) ، وأعلى قيمة للصلادة كانت عند الكسر الحجمي 8% بمقدار 86.3 (N/m^2) ، بينما انخفضت قيم مقاومة الشد مع زيادة نسب التدعيم للعينات التي تم تحضيرها، إذ سجلت ادنى قيمة عند الكسر الحجمي 8% ، والتي كانت 4.47 (MPa) .

1. Introduction

We note that there has been increasing interest in natural fibres and their multiple applications in recent times, making them a prerequisite in designing new products across different fields such as automobiles, submarines, construction, packaging and others. These

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natural fibers are environmentally friendly green sustainable elements [1] and are used as reinforcing materials for plastics and others. These natural fibers have distinct advantages from their counterparts such as glass fibres, carbon fibres and cavlar, in terms of light weight, low density, low cost, corrosion resistance, good thermal properties, regeneration ability, noise absorption, and biodegradability [2].

One of the biggest challenges faced by researchers is the high cost of building materials, and due to the increase in these economic and environmental requirements, the need to find alternative natural materials, such as corn fiber, Indian cannabis, bamboo, coconut, linen, corn bars, etc., has been increased for use in promoting polymeric materials and others due to these economic and environmental considerations. The aim of the efforts was, therefore, to use the wastes of such substances, such as the use of their fibers , particles or outer or inner coating, or in the form of sheets or sheets, considered to be environmental wastes, in the promotion of polymeric and construction materials, as well as other materials. Thus, we have two benefits, the first: to rid the environment of this waste, and the second, to use this waste to help this material [3].

Corn fibers have been obtained from corn plant fruits and are considered one of the most commonly used natural fibers due to their ability to absorb nitrogen and phosphorus into the soil as well as their ability to accumulate carbon dioxide at a significant rate. Corn fiber is also a good source of cellulose and has good economic and environmental advantages [4]. Moreover, it can be used to enhance composite materials due to their good mechanical properties [5]. The research aims to study the impact of corn silk fiber strengthening for unsaturated polyester with volume fractures (2%, 4%, 6%, 8%) on mechanical features such as tensile, hardness and impact.

2. Materials and Methods

2.1. The matrix (unsaturated polyester)

Unsaturated polyester (UPS) is a transparent liquid with moderate viscosity (of Saudi origin) and density (1.2 g/cm^3). It can be hardened by adding a transparent hardened. It is a compound of methyl ethylketone peroxide (MEKP) at a rate of (2 g) per (100 g) resin. A hardening accelerator, cobalt (Co-Catalyst), which is in the form of a dark-colored liquid in the form of drops, is added by an additional ratio (0.2g) per resin (100g) for the purpose of increasing the speed of the resin hardening process. After a half-hour period, you start to turn into a gel at room temperature.

2.2. Reinforcement Material

Corn fibers (CF) were collected from the maize plant located in Iraq and extracted in special mechanical ways. Cleaned and washed with distilled water, then dried by hot air oven at a temperature (100 ° C) for 15 minutes, then cut into lengths (15 mm) as shown in Figure (1).

Figure -1 Corn fibers: (A) before the curing process, (B) after the curing process

2.3. Sample Preparation

Manual molding method was used to prepare samples. An aluminum mold manufactured with the required dimensions was used for samples. The samples were prepared according to the size fractures prepared for this research (2%, 4%, 6%, 8%). The "unsaturated polyester" (UPE) is blended with its 100:2 (g) hardness using a glass rod and gradually to ensure that bubbles do not form and reach homogeneity. Corn fiber has been constantly added to unsaturated polyester for a large portion of fiber (2%). This process was repeated for other size fractures. The volume fracture of fiber (Vf), associated with the weight fracture of fiber (Ψ), can be calculated using the following formula [6].

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

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

$$W_c = W_f + W_m \quad (3)$$

W_f , W_m , W_C: weight of the composite material, matrix material and reinforcement material, respectively, is measured in (g) units.

ρ_f , ρ_m density of matrix in addition to the density of the reinforcement material are measured in g/cm^3.

The vehicles are gently poured into the metal mold and then leave the sample inside the mold to be hardened. When the casting process is finished, the sample is subject to thermal treatment. This is done by placing it inside (hot air oven) at (50 ° C) and (60 minutes) to complete the sclerosis process, get the best tangle of polymer chains and get rid of the stresses generated on the sample during the casting process.

2.4 Measurement of Mechanical Properties

2.4.1 Tensile Measurement

Tensile samples with standard dimensions as shown in figure (2) were prepared in accordance with American specifications (ASTM D-638-03) [7]. The test was performed using the type of tensile device (LARYEE Yaur Tasting Solution) as shown in figure (3).

When the sample is installed in the assigned position between the jaws to hold the sample firmly so as not to move it during the test. When operating the machine, the handles start to tighten the sample from top and bottom, apply the tensile strength at a stress rate (mm/mm 5) for all samples. Using the device graph, the results were obtained directly in the form of a curve (stress - stress) for the purpose of calculating the tensile properties (tensile strength, flexibility tightening and viscosity coefficient). Figure 4 shows tensile samples before and after testing.

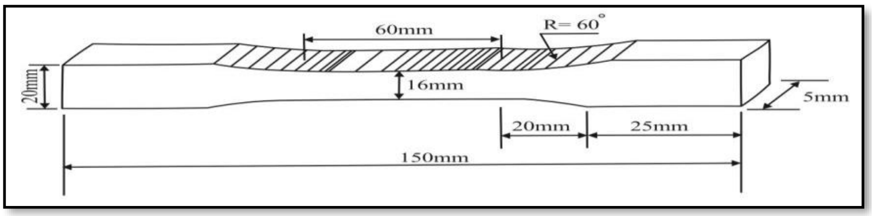

Figure -2 Standard dimensions of tensile samples according to the international standards (ASTM)

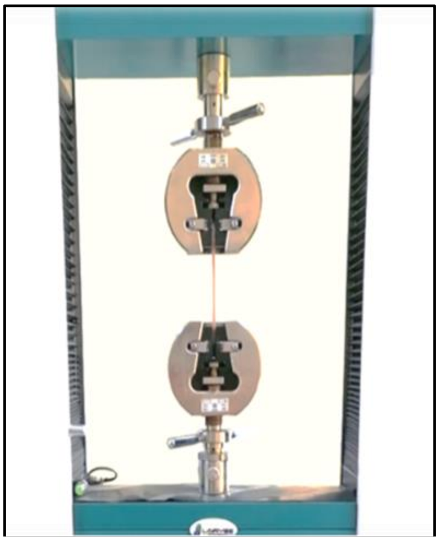

Figure -3 Tensile testing device

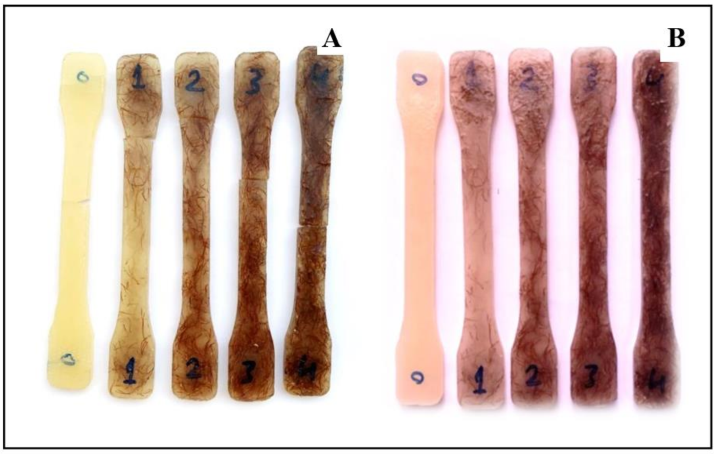

Figure -4 Tensile samples: (A) before, (B) after testing

2.4.2 Impact measurement

Charby Effect Test (shown in Figure 5) made by American company Testing Machine INC was used. AMITYVILLE, New York, to calculate the energy required for fracture, through which the material's impact resistance can be calculated. This device is mainly composed of a pendulum and an energy meter, where the machine hammer, which carries power (5.5) joules, is lifted to the maximum height and installed, where the sample is placed in the designated place, horizontally, between the two pillars of the device. The power meter is whistled first, then the pendulum is released using the lever mounted on the scale, and with the swing movement, the latent energy turns into kinetic energy, part of which is lost in the sample break, so the meter indicator reads the sample break power (UC). Figure 6 shows pre-test and post-test impact resistance samples. The following are sample dimensions according to stiffness specifications (ISO 179): sample length (55) mm, width (10) mm, thickness (5) mm, impact resistance I.S (impact force) calculated from the following mathematical relationship [8]:

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

where :

U_C: fracture energy measured in KJ.
A: cross-sectional area of the sample in m^2.

Figure -5 Impact testing device

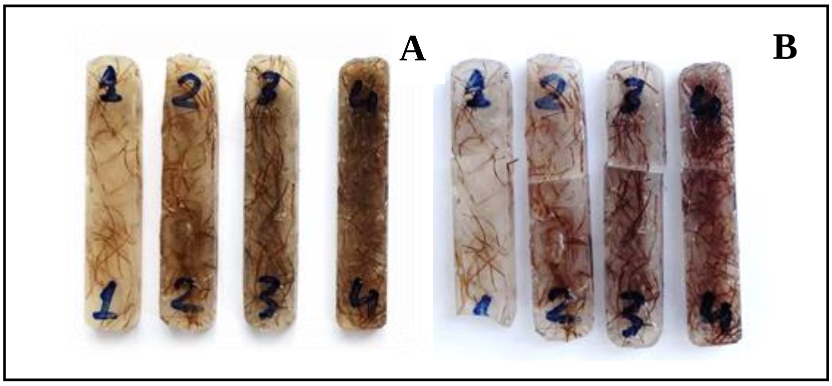

Figure -6 Impact test samples before and after testing

2.4.3 Hardness measurement

Shore (D) method was used to measure the hardness of the sample, a type (HUATEC GROUP Hardness Tester HT-6600C Shore D), shown in figure (7), made by the Chinese company (HUATEC). The machine includes a surface penetration tool in needle form to measure the hardness of the sample surface. All laboratory temperature tests (27 ◦C) were conducted, with samples manufactured in accordance with American international standards [ASTM-D 2240] [9], as shown in figure 8. Figure 9 shows the stomach hardness test samples. The hardness test of polymeric samples helps us understand the hardness and coherence of the material mass. This test was conducted to determine the hardness of the surface of samples made of polymeric materials and their fibrous compounds, as well as for different reinforcement ratios. For this test, 10 readings were recorded per sample, and then calculated their average to find the hardness value.

Figure -7 Hardness measurement device

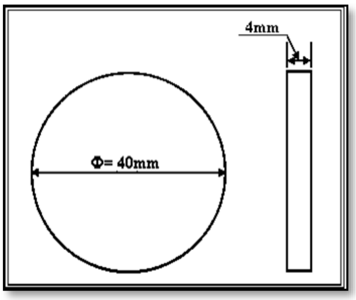

Figure -8 Standard dimensions of hardness samples according to (ASTM)

Figure -9 Hardness test samples.

3. Results and Discussion

The experimental results showed that there was an improvement in the mechanical properties (hardness and impact strength) of the prepared samples, while the value of tensile strength decreased with increased reinforcement ratios. Table 1 shows the results obtained.

Table 1- Experimental results of mechanical tests

Volume fractions %	Mechanical property		
	Hardness (N/m^2)	Impact Strength (KJ/m^2)	Tensile Strength (MPa)
2	83.1	0.33	8.61
4	84.4	0.38	7.48
6	85.7	0.45	6.16
8	86.3	0.58	4.47

3.1. Coefficients of tensile elasticity

Results shown in figure 10 for tensile strength values showed that tensile strength decreased with increased reinforcement ratios. This is due to the lack of interaction between the matrix and the reinforcement material through the interface due to the matrix's surface nature. The results showed that the lowest proportion of tensile strength was (8%) because increased fiber strengthening may lead to their aggregation along the base material. This conglomerate makes it difficult to achieve a uniform distribution of the crucifix, resulting in poor tensile strength. Natural fibers are poorly compatible with the base material, and this corresponds to the researcher's opinion [10].

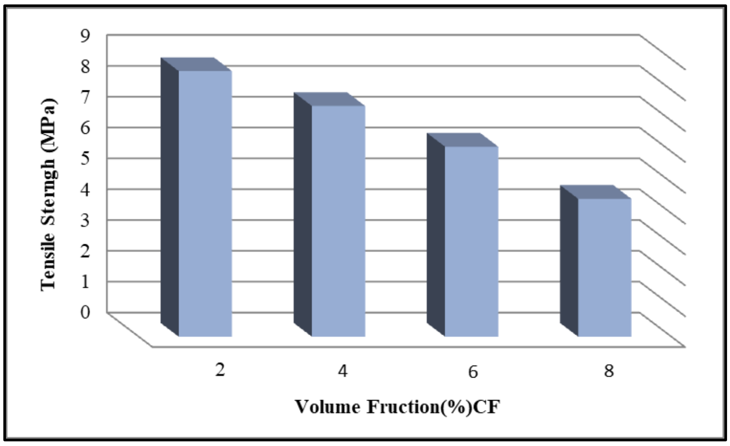

Figure -10 Relationship between tensile strength values and volumetric fracture of fibers.

3.2. Impact measurement

Results in figure (11) regarding impact strength values for structural samples showed that there was a significant improvement in IR for entire samples when reinforced with corn fiber. This is because there are those reinforced fibers that bear the majority of the impact stress applied to the material and are transported from the base material to those fibers via the interface. This fiber spreads external motor stress applied to a larger area of the sample and reduces the possibility of stress concentration in its central region. Thus, fiber will impede fracture growth. This is consistent with the researcher [11].

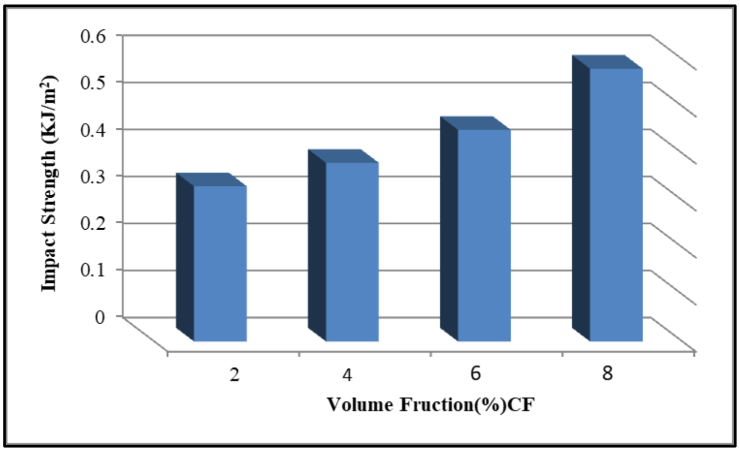

Figure -11 Relationship between impact strength values and fiber volumetric fracture.

3.3. Hardness measurement

Results in figure 12 on the hardness values of the prepared samples showed that there was a significant improvement in the hardness property of the entire samples when reinforced with corn fiber. This is due to the presence of these reinforced fibers, which have maximum rigidity. This is consistent with the researcher [3]. The external pressures applied from the matrix are transferred to the supporting fibers via the interface. Polymeric chains are prevented from moving by these fibers, as a result, mechanical qualities are improved, especially hardness, therefore, this increases the resistance of the materials supported by these fibers against scratching and penetration, and reinforced fibers also increase the hardness of the polymeric material. Thus, the developed composite material has higher hardness values. The strength of the prepared samples is increased by the enormous adhesion force these fibers will produce between them and the resin through a small but powerful area known as the facade. Moreover, these fibers will distribute the load applied to them, which will reduce the penetration rate of the upper surface of the material and increase the hardness values. In addition, another reason for increasing the hardness values of prepared materials by increasing the rate of fiber added to the polymer base material is that the fiber takes up as much space as possible within the resin, allowing for better spread of the load placed on it. This is consistent with the researcher [12].

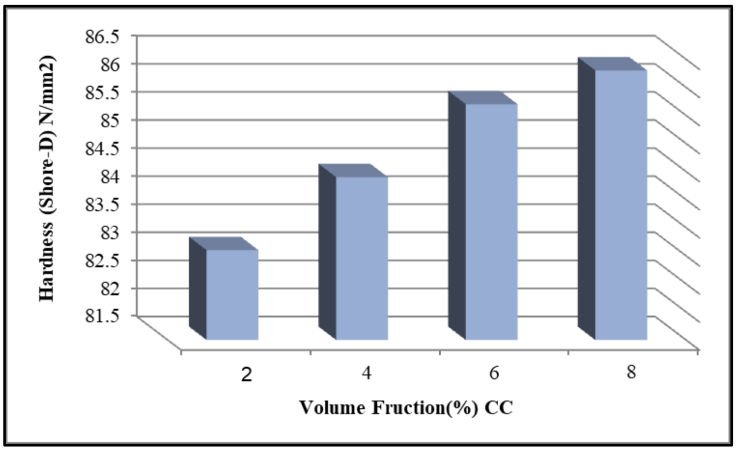

Figure -12 Relationship between hardness values and volume fraction of fibers.

4. Conclusions

Mechanical properties (hardness and impact resistance) of structural compounds are improved due to the effect of adding corn fiber, and the tensile strength is adversely affected by adding these reinforcements, as the tensile strength decreases with increased reinforcement ratios, as follows:

1. The hardness of samples had a higher value (86.3) N/m2 at 8% volume break.
2. The impact strength of samples was obtained up to a maximum (0.58) KJ/m2 size of 8%.
3. Tensile strength is found to be (4.47) MPA at 8% volume break, which is the low value.

According to the above, corn fiber can be used in some structural applications that require good mechanical properties.

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