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Tensile Behaviour of Kevlar Fibre & Coir Fibre Reinforced with Epoxy Hybrid Composites

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Abstract —Composites is a one of the promising material nowadays in all which favours the condition to suit the particular application. Kevlar 49 which is a synthetic fibre having good impact properties, coir fibre which is a natural fibre has a potential due to its results to be obtained with other materials by many researcher and of more economic in use. Epoxy pitches are viewed as mixes which contain more than one epoxy gathering, equipped for being changed over to relieved (thermoset) structure with the assistance of solidified restoring operators. With the help of hardener to be added to the hybrid composite and the filler material as Bentonite powder acts as good binder. Treatment of strands (Coir) is likewise taken into the thought to acquire upgrade in the mechanical properties of the composites. The impacts of extreme elasticity (tensile strength), shore-D hardness on the hybrid composites are examined.

1. Introduction

Composite material is made by joining at least two materials – regularly ones that have altogether different properties. The two materials cooperate to give the composite extraordinary properties. Be that as it may, inside the composite you can without much of a stretch differentiate the various materials as they don't break up or mix into one another [1].

P.N.E Naveen et al [2] investigated the static and dynamic mechanical behavior of randomly oriented mixed coir fibre reinforced polyester composite. The mechanical properties have a strong association with the dynamic characteristic and these properties are dependent on the volume percentage of fibers.

U.S Bongarde et al [3] gave a review on natural fibre reinforcement polymer composites. Due to the challenges of petroleum based products and the need to find renewable resources.

Azrin hani Abdul Rashid et al [4] investigated the mechanical properties of woven coir and kevlar reinforced epoxy composites.

Al-Mosawi Ali I et al [5] investigated the mechanical properties of plants and synthetic hybrid fibers composites. The observations made such that, the addition of 50% of palms fibers and 50% Kevlar fibers improves the tensile strength, flexural strength, impact strength and hardness of epoxy resin LY 256, but when reinforcement percentage increased by 10%, all the properties mentioned will be decreased by due to low wettability between fibers and resin and the fibers will extract from resin easily.

K V Sreenivas Rao et al [6] investigated on mechanical properties on coir reinforced epoxy hybrid composites leads to exhibit more compression strength and hardness and increased density in reinforcement increases the tensile and flexural strength.

Chizoba Obele et al [7] investigated the mechanical properties of coir reinforced epoxy resin composites for helmet shell. The composite material made with 30 wt.% coir fiber gave the highest impact strength 26.43 N/mm² and was therefore selected for helmet fabrication. The produced helmet shell has acceptable compressive strength and reduced weight

S Bhargavi Devi et al [8] studied the characterization of hybrid polymer composites. Tensile strength of the hybrid composite material decreases with the increase of fiber loading fraction.



Majid ali et al [9] given the various applications of natural fibers with respect to different fields. By using the coconut fibers the useful products can be obtained, there is a chance of getting improved results of the new products containing coconut fibers.

Syed Altaf Hussain et al [10] studied the mechanical properties of green coconut fiber reinforced HDPE polymer composites. Tensile strength of the composite material increases with increase in fiber volume fraction (V_f) up to 40%, then after decreases slightly. Tensile and flexural strength of the composite material decreases with increase in the fiber length.

From the literature survey it observed that much research work has not been carried out hybrid combination of Kevlar 49 as a synthetic fibre, coir as a natural fibre, Epoxy as a resin matrix and Bentonite powder as a filler material, also treatment of coir fibre with NaOH solution is taken into the consideration. In this present research work experiments have been carried out with an objective of determining tensile behaviour of hybrid composites for different combination and for treatment condition. The authors of this paper have made an endeavor to decide the ductile attributes of the mixture composites. The impact of filler material as a decent restricting operator and the consolidation of filaments in various extents or blends.

2. Experimentation

The manufacture of the mixture composite material example is brought out through the hand lay-up strategy. Short coconut coir strands are fortified with Epoxy LY 556 sap. The low temperature relieving epoxy (Araldite LY 556) and comparing hardener (HY951) are blended in a proportion of Kevlar 49 (Synthetic Fiber) and Coir (Natural Fiber) in the various extents of 90% - 10% ; 80%-20%; 70%-30%; 60%-40% Resin (Epoxy) network and Reinforcement for without treatment condition and with treatment condition, 87%-10%-3%; 84%-10%-%; 81%-10%-9%; 77%-20%-3%; 74%-20%-6%; 71%-10%-9%; 67%-30%-3%; 64%-30%-6%; 61%-30%-9%; 57%-10%-3%; 54%-40%-9%; 51%-40%-9%; Resin (Epoxy) lattice, Reinforcement and Bentonite powder (filler material), for with and without treatment conditions.

Hybrid Composites - according to the ASTM benchmarks, the composite material was fabricated through hand lay-up system for the diverse material mixes additionally the materials made as for the treatment of strands and the incorporation of the filler materials. The figure 1 shows the manufactured composite material, figure 2 shows the ASTM standards and figure 3 shows the fabricated tensile specimens.

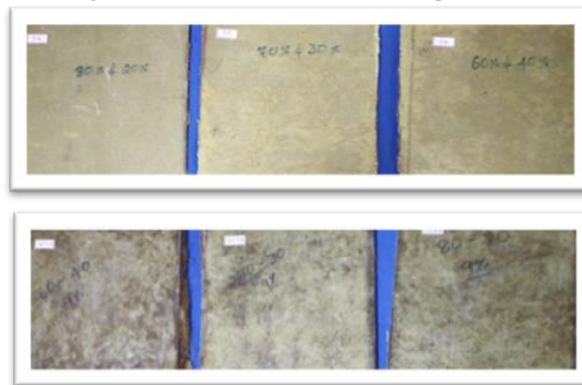


Figure1: Manufactured Hybrid Composite Materials

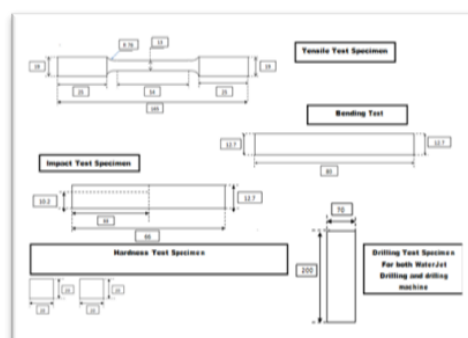


Figure 2: Specimens Dimensions According to ASTM Standards



Figure 3: Fabricated Specimens for Tensile specimen

Tensile strength estimates the power/load which is required to apply away from the material before it breaks. The rigidity of the material is estimated by the most outrageous malleable pressure that can be gotten before it bursts. The failure criteria depend on the plan thought of the materials while it is being produced. Figure 4 visualizes the universal testing machine for tensile test set up (NIE, Mysore, Karnataka State, India)



Figure 4: Universal Testing Machine for Tensile Setup

Shore A and Shore D probes measures the hardness of the plastic form of material. The shore durometer is a kind of hardness measuring device. Higher the number on the scale which highlights the more resistance to the indentation or external force and finally it is considered as harder the materials. Lesser the number on the scale indicates the lesser resistance and finally it is considered as softer materials. Figure 5 shows the universal testing machine for Shore-D hardness set up (NIE, Mysore, Karnataka State, India)



Figure 5: Shore -D Hardness Testing Instrument

3. Results and Discussions

The experimental results obtained are plotted and analyzed. Different proportions of fibers with the epoxy matrix were observed in shades of treatment and without treatment conditions. Fibers inclusions will vary the tensile properties of hybrid composites. Incorporation of filler material in different combinations favors the binding capability of hybrid composites.

3.1. Tensile Test Results with Comparison

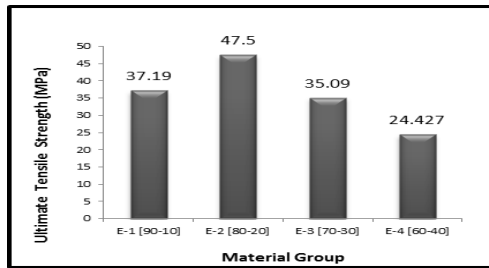


Figure 6: Ultimate Tensile Strength Comparison for Untreated & Without Filler Material Composition

The above figure 6 illustrates the ultimate strength comparison for material group (hybrid composites). *Combination:* Without treatment & without inclusion of filler material (Bentonite powder) Material group: E-1: 90% Resin (Epoxy) matrix & 10 % Reinforcement; E-2: 80% Resin (Epoxy) matrix & 20 % Reinforcement; E-3: 70% Resin (Epoxy) matrix & 30 % Reinforcement; E-4: 60% Resin (Epoxy) matrix & 40 % Reinforcement.

Observation: It is seen from the chart that, for E-2 the quality is higher trailed by E-1, E-3 and E-4. The inclusion of fiber with its orientation makes the reading to show high for E2. It is also observed that, even the fiber percentage is high its orientation makes the value to be lower.

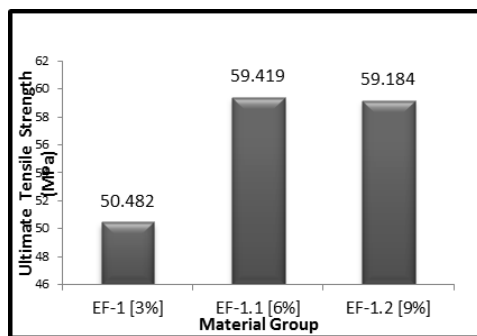


Figure 7: Ultimate Tensile Strength Comparison for Untreated With Filler [90-10] Material Composition

The above figure 7 highlights the ultimate strength comparison for material group (hybrid composites). *Combination:* EF-1: 87% Resin (Epoxy) matrix, 10 % Reinforcement (Kevlar 49 & Coir), 3% of Bentonite powder; EF-1.1: 84% Resin (Epoxy) matrix, 10 % Reinforcement (Kevlar 49 & Coir), 6% of Bentonite powder; EF-1.2: 81% Resin (Epoxy) matrix, 10 % Reinforcement (Kevlar 49 & Coir), 9% of Bentonite powder.

Observation: The purpose of adding the Bentonite powder for experimentation to obtain the better bonding capability for both Kevlar-49 & Coir fibers. The above statement made true for the above experiment results, that, definitive tensile strength increments with the expansion of Bentonite powder in the request for 3-6-9 rate to the epoxy framework.

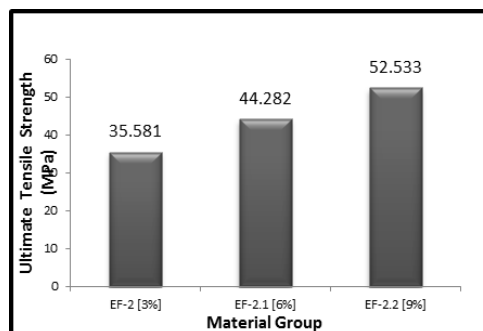


Figure 8: Ultimate Tensile Strength Comparison for Untreated With Filler [80-20] Material Composition

The above figure 8 defines the ultimate strength comparison for material group (hybrid composites).
Combination: EF-2: 77% Resin (Epoxy) matrix, 20 % Reinforcement (Kevlar 49 & Coir), 3% of Bentonite powder; EF-2.1: 74% Resin (Epoxy) matrix, 20 % Reinforcement (Kevlar 49 & Coir), 6% of Bentonite powder; EF-2.2: 71% Resin (Epoxy) matrix, 20 % Reinforcement (Kevlar 49 & Coir), 9% of Bentonite powder.
Observation: The above material group indicates that, the percentage of epoxy is reduced and it is compensated by the inclusion of fibers (both Kevlar 49 & coir). The rigidity/tensile strength are increments as for increment in filler creation. The expansion of filler material and with the expansion in strands. The fiber direction and filler piece improves the composites to be material.

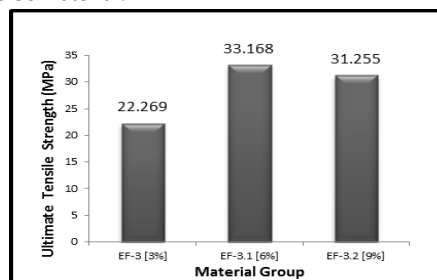


Figure 9: Ultimate Tensile Strength Comparison for Untreated With Filler [70-30] Material Composition

The above figure 9 shows the ultimate strength comparison for material group (hybrid composites).
Combination: EF-3: 67% Resin (Epoxy) matrix, 30 % Reinforcement (Kevlar 49 & Coir), 3% of Bentonite powder; EF-3.1: 64% Resin (Epoxy) matrix, 30 % Reinforcement (Kevlar 49 & Coir), 6% of Bentonite powder; EF-3.2: 61% Resin (Epoxy) matrix, 30 % Reinforcement (Kevlar 49 & Coir), 9% of Bentonite powder.
Observation: From the trial results, it is seen that, EF-3.1 i.e., 6% filler composition in the hybrid composites shows a good tensile strength compared to EF-3.2 having 9% filler composition. EF-3 i.e., 3% filler composition having lesser tensile strength.

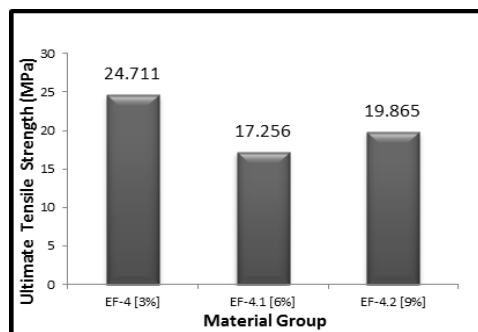


Figure 10: Ultimate Tensile Strength Comparison for Untreated With Filler [60-40] Material Composition

The above figure 10 indicates the ultimate strength comparison for material group (hybrid composites).
Combination: EF-4: 57% Resin (Epoxy) matrix, 40 % Reinforcement (Kevlar 49 & Coir), 3% of Bentonite powder; EF-4.1: 54% Resin (Epoxy) matrix, 40 % Reinforcement (Kevlar 49 & Coir), 6% of Bentonite powder; EF-4.2: 51% Resin (Epoxy) matrix, 40 % Reinforcement (Kevlar 49 & Coir), 9% of Bentonite powder.
Observation: It is observed from the experiment that, EF-4 i.e., 3% filler composition shows better tensile strength even compared with EF-4.2 i.e., 9% filler composition. The reason behind is may be the agglomeration of filler materials with the alignment of both the fibers. This chart shows that the arrangement of strands and filler appropriation assumes a significant job in characterizing the quality of the composites.

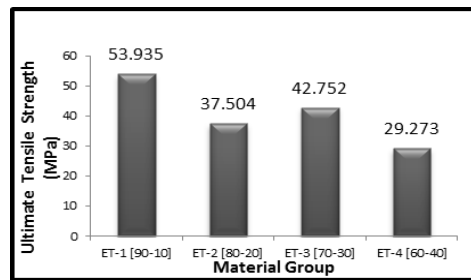


Figure 11: Ultimate Tensile Strength Comparison for Treated Without Filler Material Composition

The above figure 11 clarifies the ultimate strength comparison for material group (hybrid composites). *Combination:* ET-1: 90% Resin (Epoxy) matrix & 10 % Reinforcement; ET-2: 80% Resin (Epoxy) matrix & 20 % Reinforcement; ET-3: 70% Resin (Epoxy) matrix & 30 % Reinforcement; ET-4: 60% Resin (Epoxy) matrix & 40 % Reinforcement. *Observation:* In this case, the fiber is treated with fibers, due to following reasons to be expected. Treatment of fibers increases the inter-laminar strength of the fibers, improves the morphology of fibers, increases the flexural strength compared to untreated fibers, finally mechanical properties will be enhanced. From the graph, it is identified that, ET-1 & ET-2 shows better tensile strength compared to ET-2 and ET-4.

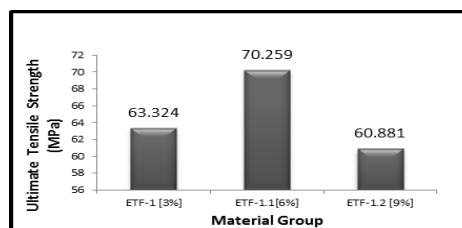


Figure 12: Ultimate Tensile Strength Comparison for Treated With Filler [90-10] Material Composition

The above figure 12 illustrates the ultimate strength comparison for material group (hybrid composites). *Combination:* ETF-1: 87% Resin (Epoxy) matrix, 10 % Reinforcement (Kevlar 49 & Coir), 3% of Bentonite powder; ETF-1.1: 84% Resin (Epoxy) matrix, 10 % Reinforcement (Kevlar 49 & Coir), 6% of Bentonite powder; ETF-1.2: 81% Resin (Epoxy) matrix, 10 % Reinforcement (Kevlar 49 & Coir), 9% of Bentonite powder. *Observation:* From the experimentation the information to be extracted that, ETF-1.1 i.e., 6% filler composition & treatment of fibers influences the increases the tensile strength of the hybrid composites. ETF-1 i.e., 3% filler group shows a good improvement in the tensile strength and ETF-1.2 i.e., 9% filler group shows a lesser strength.

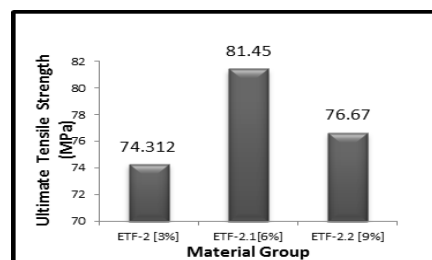


Figure 13: Ultimate Tensile Strength Comparison for Treated With Filler [80-20] Material Composition

The above figure 13 visualizes the ultimate strength comparison for material group (hybrid composites). *Combination:* ETF-2: 77% Resin (Epoxy) matrix, 20 % Reinforcement (Kevlar 49 & Coir), 3% of Bentonite powder; ETF-2.1: 74% Resin (Epoxy) matrix, 20 % Reinforcement (Kevlar 49 & Coir), 6% of Bentonite powder; ETF-2.2: 71% Resin (Epoxy) matrix, 20 % Reinforcement (Kevlar 49 & Coir), 9% of Bentonite powder. *Observation:* From the experimentation results, it is observed that, ETF-2.1 shows higher tensile strength compared to other two groups of materials. 6% filler composition with treated condition favors the improvement in the tensile strength of the hybrid composites.

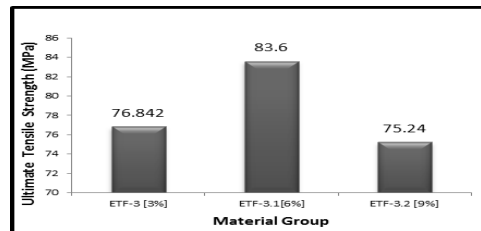


Figure 14: Ultimate Tensile Strength Comparison for Treated With Filler [70-30] Material Composition

The above figure 14 shows the ultimate strength comparison for material group (hybrid composites). *Combination:* ETF-3: 67% Resin (Epoxy) matrix, 30 % Reinforcement (Kevlar 49 & Coir), 3% of Bentonite powder; ETF-3.1: 64% Resin (Epoxy) matrix, 30 % Reinforcement (Kevlar 49 & Coir), 6% of Bentonite powder; ETF-3.2: 61% Resin (Epoxy) matrix, 30 % Reinforcement (Kevlar 49 & Coir), 9% of Bentonite powder. *Observation:* From the experimentation results, it is observed that, ETF-3.1 shows higher tensile strength compared to other two groups of materials. 6% filler composition with treated condition favors the improvement in the tensile strength of the hybrid composites.

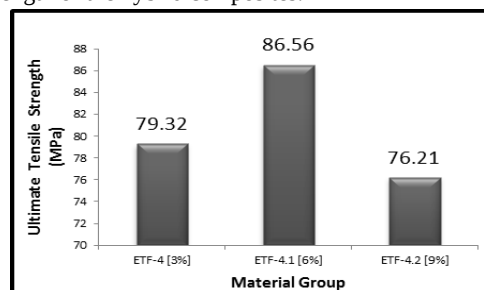


Figure 15: Ultimate Tensile Strength Comparison for Treated With Filler [60-40] Material Composition

The above figure 15 illustrates the ultimate strength comparison for material group (hybrid composites). *Combination:* ETF-4: 57% Resin (Epoxy) matrix, 40 % Reinforcement (Kevlar 49 & Coir), 3% of Bentonite powder; ETF-4.1: 54% Resin (Epoxy) matrix, 40 % Reinforcement (Kevlar 49 & Coir), 6% of Bentonite powder; ETF-4.2: 51% Resin (Epoxy) matrix, 40 % Reinforcement (Kevlar 49 & Coir), 9% of Bentonite powder. *Observation:* From the experimentation results, it is seen that, ETF-4.1 shows higher elasticity contrasted with other two gatherings of materials. 6% filler creation with treated condition supports the improvement in the elasticity of the cross breed composites.

3.2. Shore-D Hardness Test Results with Comparison

Shore D measures the hardness of the plastics, rubber etc. Shore D hardness tester measures the hardness of the material, higher the numbers indicated by the instrument indicates a larger resistance to indentation and thus harder the materials and lesser the value indicates that less resistance and finally, softer the materials.

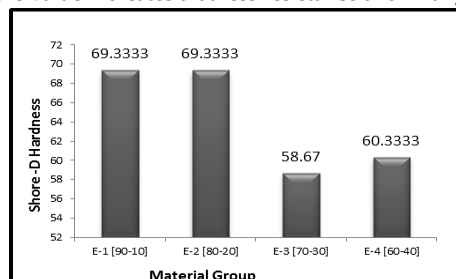


Figure 16: Shore-D Hardness Comparison for Untreated & Without Filler Material Composition

The above figure 16 illustrates the Shore D Hardness comparison for material group (hybrid composites). *Combination:* E-1: 90% Resin (Epoxy) matrix & 10 % Reinforcement; E-2 : 80% Resin (Epoxy) matrix & 20 % Reinforcement; E-3 : 70% Resin (Epoxy) matrix & 30 % Reinforcement; E-4 : 60% Resin (Epoxy) matrix & 40

% Reinforcement. *Observation:* From the experimentation results, E-1 and E-2 shows the same results having higher value of hardness and even E-4 shows almost nearer to the E-1 and E-2. The fibers percentage in the matrix influences the result.

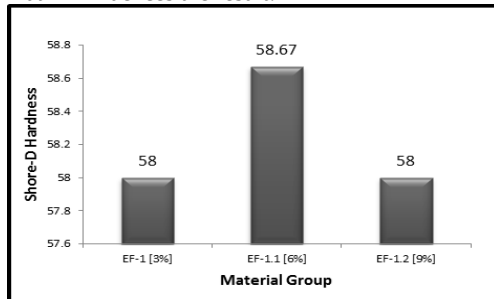


Figure 17: Shore-D Hardness Comparison for Untreated With Filler [90-10] Material Composition

The above figure 17 indicates the ultimate strength comparison for material group (hybrid composites).

Combination: EF-1: 87% Resin (Epoxy) matrix, 10 % Reinforcement (Kevlar 49 & Coir), 3% of Bentonite powder; EF-1.1: 84% Resin (Epoxy) matrix, 10 % Reinforcement (Kevlar 49 & Coir), 6% of Bentonite powder; EF-1.2: 81% Resin (Epoxy) matrix, 10 % Reinforcement (Kevlar 49 & Coir), 9% of Bentonite powder.

Observation: It is observed from the experiment that, EF-1.1 shows a slight improvement in the shore D hardness value compared to other two groups. Almost the same value of the hardness is observed from the results, which highlights the material is harder for the following material group.

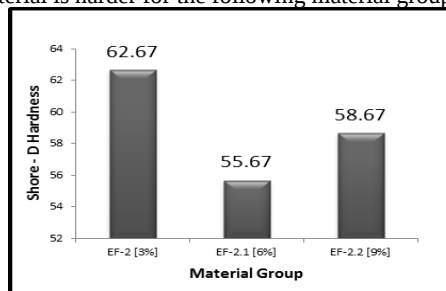


Figure 18: Shore-D Hardness Comparison for Untreated With Filler [80-20] Material Composition

The above figure 18 illustrates the ultimate strength comparison for material group (hybrid composites).

Combination: EF-2: 77% Resin (Epoxy) matrix, 20 % Reinforcement (Kevlar 49 & Coir), 3% of Bentonite powder; EF-2.1: 74% Resin (Epoxy) matrix, 20 % Reinforcement (Kevlar 49 & Coir), 6% of Bentonite powder; EF-2.2: 71% Resin (Epoxy) matrix, 20 % Reinforcement (Kevlar 49 & Coir), 9% of Bentonite powder.

Observation: It is observed from the results, EF-2 i.e., 3% filler composition shows higher hardness compared to other groups i.e., (6% and 9%).

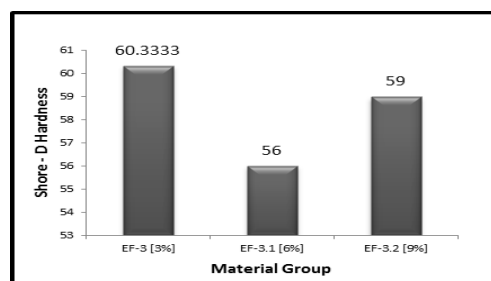


Figure 19: Shore-D Hardness Comparison for Untreated With Filler [70-30] Material Composition

The above figure 19 illustrates the ultimate strength comparison for material group (hybrid composites).

Combination: EF-3: 67% Resin (Epoxy) matrix, 30 % Reinforcement (Kevlar 49 & Coir), 3% of Bentonite powder; EF-3.1: 64% Resin (Epoxy) matrix, 30 % Reinforcement (Kevlar 49 & Coir), 6% of Bentonite powder; EF-3.2: 61% Resin (Epoxy) matrix, 30 % Reinforcement (Kevlar 49 & Coir), 9% of Bentonite powder.

Observation: It is observed from the results, EF-3 i.e., 3% filler composition shows higher hardness compared to other groups i.e., (6% and 9%).

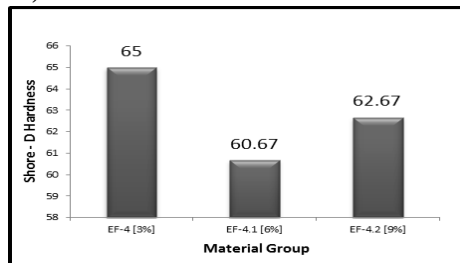


Figure 20: Shore-D Hardness Comparison for Untreated With Filler [60-40] Material Composition

The above figure 20 illustrates the ultimate strength comparison for material group (hybrid composites).

Combination: EF-4: 57% Resin (Epoxy) matrix, 40 % Reinforcement (Kevlar 49 & Coir), 3% of Bentonite powder; EF-4.1: 54% Resin (Epoxy) matrix, 40 % Reinforcement (Kevlar 49 & Coir), 6% of Bentonite powder; EF-4.2: 51% Resin (Epoxy) matrix, 40 % Reinforcement (Kevlar 49 & Coir), 9% of Bentonite powder

Observation: It is observed from the results, EF-4 i.e., 3% filler composition shows higher hardness compared to other groups i.e., (6% and 9%).

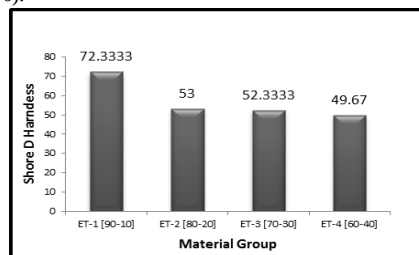


Figure 21: Shore-D Hardness Comparison for Treated Without Filler Material Composition

The above figure 21 illustrates the ultimate strength comparison for material group (hybrid composites).

Combination: ET-1: 90% Resin (Epoxy) matrix & 10 % Reinforcement; ET-2: 80% Resin (Epoxy) matrix & 20 % Reinforcement; ET-3: 70% Resin (Epoxy) matrix & 30 % Reinforcement; ET-4: 60% Resin (Epoxy) matrix & 40 % Reinforcement *Observation:* In this case. The fiber is treated with fibers, due to following reasons to be expected. Treatment of fibers increases the inter-laminar strength of the fibers, improves the morphology of fibers, increases the flexural strength compared to untreated fibers, finally mechanical properties will be enhanced. From the graph, it is indicated that, ET-1 shows a better hardness compared to the other material group.

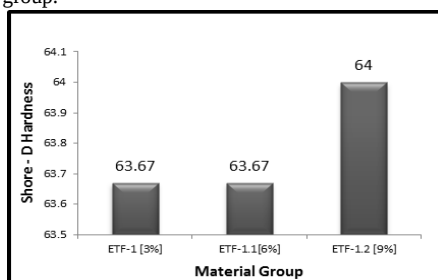


Figure 22: Shore-D Hardness Comparison for Treated Without Filler Material Composition

The above figure 22 illustrates the ultimate strength comparison for material group (hybrid composites).

Combination: ETF-1: 87% Resin (Epoxy) matrix, 10 % Reinforcement (Kevlar 49 & Coir), 3% of Bentonite powder; ETF-1.1: 84% Resin (Epoxy) matrix, 10 % Reinforcement (Kevlar 49 & Coir), 6% of Bentonite

powder; ETF-1.2: 81% Resin (Epoxy) matrix, 10 % Reinforcement (Kevlar 49 & Coir), 9% of Bentonite powder

Observation: From the above graph it is observed that, ETF-1.2 i.e., 9 % filler composition composites show a higher hardness compared to other material group. Due to the more concentration of filler material, the hardness value enhanced by a little percentage compared to 3% and 6 %.

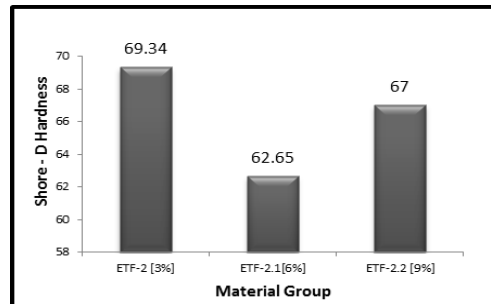


Figure 23: Shore-D Hardness Comparison for Treated With Filler [80-20] Material Composition

The above figure 23 illustrates the ultimate strength comparison for material group (hybrid composites). *Combination:* ETF-2: 77% Resin (Epoxy) matrix, 20 % Reinforcement (Kevlar 49 & Coir), 3% of Bentonite powder; ETF-2.1: 74% Resin (Epoxy) matrix, 20 % Reinforcement (Kevlar 49 & Coir), 6% of Bentonite powder; ETF-2.2: 71% Resin (Epoxy) matrix, 20 % Reinforcement (Kevlar 49 & Coir), 9% of Bentonite powder. *Observation:* From the diagram it is seen that, ETF-2 and ETF-2.2 demonstrates the better hardness as for the 6% proportion of filler material. The treatment factor likewise impacts the hardness esteem.

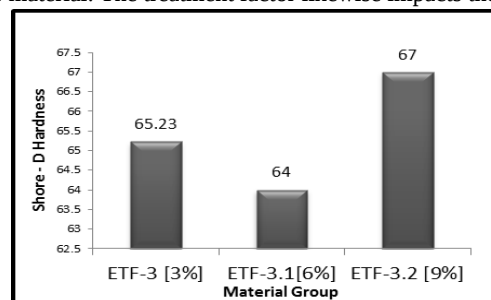


Figure 24: Shore-D Hardness Comparison for Treated With Filler [70-30] Material Composition

The above figure 24 illustrates the ultimate strength comparison for material group (hybrid composites). *Combination:* ETF-3: 67% Resin (Epoxy) matrix, 30 % Reinforcement (Kevlar 49 & Coir), 3% of Bentonite powder; ETF-3.1: 64% Resin (Epoxy) matrix, 30 % Reinforcement (Kevlar 49 & Coir), 6% of Bentonite powder; ETF-3.2: 61% Resin (Epoxy) matrix, 30 % Reinforcement (Kevlar 49 & Coir), 9% of Bentonite powder. *Observation:*

The information is extracted that, ETF-3.2 i.e., 9% filler composition highlighted by the increased value of hardness with the influence of treatment factor.

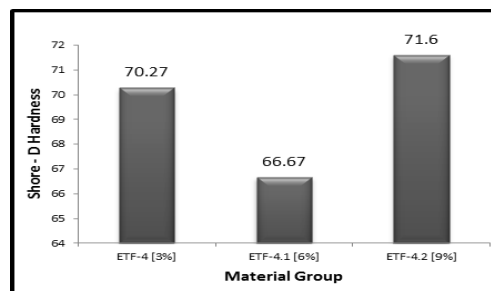


Figure 25: Shore-D Hardness Comparison for Treated With Filler [60-40] Material Composition

The above figure 25 illustrates the ultimate strength comparison for material group (hybrid composites).

Combination: ETF-4: 57% Resin (Epoxy) matrix, 40 % Reinforcement (Kevlar 49 & Coir), 3% of Bentonite powder; ETF-4.1: 54% Resin (Epoxy) matrix, 40 % Reinforcement (Kevlar 49 & Coir), 6% of Bentonite powder; ETF-4.2: 51% Resin (Epoxy) matrix, 40 % Reinforcement (Kevlar 49 & Coir), 9% of Bentonite powder. *Observation:* From the graph, it is observed that, filler material having 9% filler addition shows a high hardness complementing with the 3 % filler composition. Larger the composition of fiber also influences the better indication of the hardness property.

4. Conclusion

The following conclusions are made from the evaluation of the experimental results. The fiber volume percentage plays a vital role in the enhancement of tensile properties and hardness. With the increase in the percentage of coir with the Kevlar 49 fiber which is kept constant (fiber volume) in addition to the epoxy resin matrix, the tensile properties is improved. Shore D hardness is affected by the cross breed mix of the composites. Additionally, the fuse of Bentonite as a filler material goes about as a decent binding specialist. There is a slight decrease in the properties of the hybrid composite since the there is a slight agglomeration of filler material with the resin matrix due to hand lay up process. An indication is observed that, if there is further increase in the coir percentage beyond the 40%, it is difficult to get the better properties of the composites.

5. References

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