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# Study of Physico-Mechanical Properties of Recycled Low Density Polyethylene/Sisal Fiber Composite

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**Abstract:** The physico-mechanical properties of recycled low density polyethylene/sisal fibre composite was investigated. It was prepared using two-roll mill at 160$^oC$. The basic materials used were Recycled Low Density Polyethylene and Sisal Fibre. The compounding composition was fixed at the ratio of 100/0, 95/5, 90/10, 85/15, 80/20, 75/25, of Recycled Low Density polyethylene and Sisal Fibre respectively. By varying the filler loading mechanical properties (i.e Hardness, Impact, Abrasion, and Water absorption,] showed that during hardness test, increase in filler Loading with LDPE will increase the hardness result. Impact test shows that there is increase as the filler loading keeps increasing. Water absorption test shows that samples without filleri. econtrol sample didn't absorb water. While there were increased in water absorption as the filler loading increases. Abrasion test result shows that increase in the filler loading decreases the weight of the composites, showing poor abrasion resistance as the filler loading increase from 5g-25g.
**Keywords:** Fibre, Recycled, Impact and Sisal

## Introduction

The increasing use of polymeric materials can be observed in our daily life, in uncounted consumer goods around us. However, the production and use of plastics has a range of environmental impacts. Plastics production requires significant quantities of resources, primarily fossil fuels, both as a raw material and to deliver energy for the manufacturing process. The disposal of plastics products also contributes significantly to their environmental impact. This isBecause most plastics are non-degradable, they take a long time to break down, possibly up to hundreds of years. With more and more plastics products, particularly plastics packaging, being disposed of soon after their purchase, the landfill space required by plastics waste is a growing concern. Thereby, the interest on recycled materials developed frompost-consumer polymers has gained an increasing attention. The largest fraction of polymers wastes consistsof polyolefin, such as polyethylene(PE) and polypropylene (PP) therefore recycling is an alternative destination for thesematerials (Garcia and Stefani, 2007).

To obtain products from recycled material may be necessary specific properties that are not present in original plastic. The environment friendly alternative way to the modification of some properties of polymers is the utilization of natural fibers forming composite materials, and this area presented a crescent development in the last 20 years (Iwatake, 2008). The natural fibers, besides presenting many advantages in relation to synthetic fibers (low cost, renewability, biodegradability, abundance), could also present better mechanical performance from its composites than the ones obtained with synthetic fibers, such as the glassfibers.(Garcia and Stefani, 2007) Thus, natural fibers, such as fibers of wood, jute, kenaf, hemp, sisal, pineapple, rice husk, etc., have successfully been applied to improve mechanical properties of plastic composites. Among natural fibers, sisal is one of the most used in the world, and Brazil is one of the biggest producers. The exceptional mechanical characteristics of sisal are already making its application in automotive industry and civil construction possible, (Suppakarn and Jarukumjorn, 2009).

## Materials

**Table 1: Materials**

| Materials/ Apparatus |
|---|
| Recycled Low-Density Polyethylene (RLDPE) |
| Sisal Fibres |
| NaOH |
| Distilled water |
| Knife |
| Scissors |
| Beakers |
| Measuring cylinder (1000 ml) |
| Wooden Harmer |
| Plastic Bucket |
| pH Paper |
| Processing Oil |

**Table 2: Equipment**

| Equipment | Manufacturer | Model Number |
|---|---|---|
| Weighing Machine | S. Metler; | |
| ResilImpactor | Pianezz-Torino Italy (Ceast) | 6957 |
| Hardness Tester | Francisco Munoz Irles, C.B | 5019 |
| Abrasion Resistant Machine | Supplier | 2001-50 |
| Two Roll Mill | North Berggen, New Jersey USA | 5183 |
| Compression Moulding Machine | WenzhonZhiguaryHore Making Machine Co. Ltd. | |

## Method

### Extraction of Sisal Fiber

Sisal *(Agave Sisalana)*leaves were obtained from the National Research Institute for Chemical Technology (NARICT) farm, Basawa Zaria. Fibres were extracted from the leaves using the local extraction method known as “decortications”. This involves gradual beating of the leaves with subsequent drying in an open space for seven minutes enabling the gradual removal of moisture from the leave fibres. This method ended when almost all the lignin, wax, pectin binding the fibres together have been removed. The fibers were washed thoroughly to remove dirt andsun dried for 1 hour to remove moisture. Finally the fibres were combed in other to stretch them for better appearance.

### Fiber Preparation

The fibers were prepared by treating them with(1% w/v) NaOH solution and dried at room temperature for 72 hours to remove moistures. This was done by dissolving 200g of the NaOH into 1800 ml of distill water and then the extracted sisal fibers were soaked in the NaOH solution for 24 hrs. Treatedsisals were used for the composites formation.

The dried sisal fibres were weighed and subjected to size reduction by hand cutting using scissors.

**Formulation Table for compounding at various ratios**

**Table 3: formulation Table**

| Samples of Composites | Composition (weight g) | |
|---|---|---|
| | RLDPE (g) | Fiber (g) |
| A | 100 | 00 |
| B | 95 | 5 |
| C | 90 | 10 |
| D | 85 | 15 |
| E | 80 | 20 |
| F | 75 | 25 |

**Formation of Recycled Low Density Polyethylene/Sisal Composite**

The Recycled Low Density Polyethylene and the treatedsisalcomposites were formedusing two roll mill with model No. 5183. The machine was on set to 160$^o$C and was allowed to attain the temperature. The recycled Low Density Polyethylene was introduced to the two roll millthrough the nip of the rolls. A band was allowed to form and the nip was tightened for the formation of the bank. Thetreated sisal fiber was then introduced and the composite was thoroughly mixed using knife for 5 minutes and the composite formed was sheeted out.

**Molding Process**

The composites from the above process were placed in a clean well lubricated mold of thickness 2mm.The mold was placed in between the platens of the compression moldingmachine of after which the machine was set at 130$^o$C and was allowed to attain the temperature for easy flow during compression. Later the samples were compressed for 10 minutes and were allowed to cool for 10 minutes and then sampleswere removed.

**Test for Mechanical Properties**

Three samples each of the material were tested from the composites made of RLDPE/fiber sisal composites.

**Hardness Test**

The samples for hardness test were measured using (Durometer) in accordance with ASTM D2240. The samples were cuts in round shapes of 2.2cm and mounted on the plate as the handle of the machine was pulled which lift up the plate to the pin which had contact with the sample. The test was carried out at temperature. Three replicates were tested for each sample, and the average values were calculated using;

Average Hardness = $\frac{1st+2nd+3rd}{3}$(shores) - - - - (3.1)

**Impact Test**

The procedure use was in accordance with ASTM D256. Samples were sectioned to 62mm x 13mm x 2mm dimensions after which three samples each were prepared samples were mounted on the machine, and a swinging pendulum released, under gravity to hit the sample. The energy at impact was read directly from a dial indicator of the machine and the average values of the results obtained were computed. This was used for calculation of impact strength using the equation 3.2

Impact strength $= \frac{Impact\ Energy}{Thickness}$ (J/m) (3.2)

**Water Absorption**

Water absorption was carried out according to ASTM D570. The samples each were cut andmeasuring 50mm x 15mm x 2mm and weighed using weighing balance. The weighed samples were each immersed in a beaker half filled with distilledwaterand was allowed to standfor 24hrs, and then removed and cleaned with a silk material, and the values were recorded. The percentage water absorption was calculated using equation 3.3

% water absorption $= \frac{W_{2-}W_1}{W_1}\ X\ 100$ (3.3)

Where : $W_2$=weight of sample after been immersed in water

$W_1$ =initial weight of sample before been immersed in water

**Abrasion Resistance**

The test was carried out using abrader machine; each sample was weighed before the absorption. The sample was placed on the sample holder, and was rugged for 2 min and the final weight was taken and the percentage weight was calculated.

## Results and Discussion

**Result of Impact Strength Test**

| Samples | Thickness (mm) | Impact Energy (J) | Impact Strength (J/mm) |
|---|---|---|---|
| 0/100 | 2 | 0.24 | 0.12 |
| 5/95 | 2 | 0.27 | 0.14 |
| 10/90 | 2 | 0.49 | 0.24 |
| 15/85 | 2 | 0.51 | 0.25 |
| 20/80 | 2 | 0.77 | 0.38 |
| 25/75 | 2 | 0.95 | 0.48 |

Impact Strength = $\frac{Impact\ \ Energy}{Thickness}\ J/mm^2$

**Results**

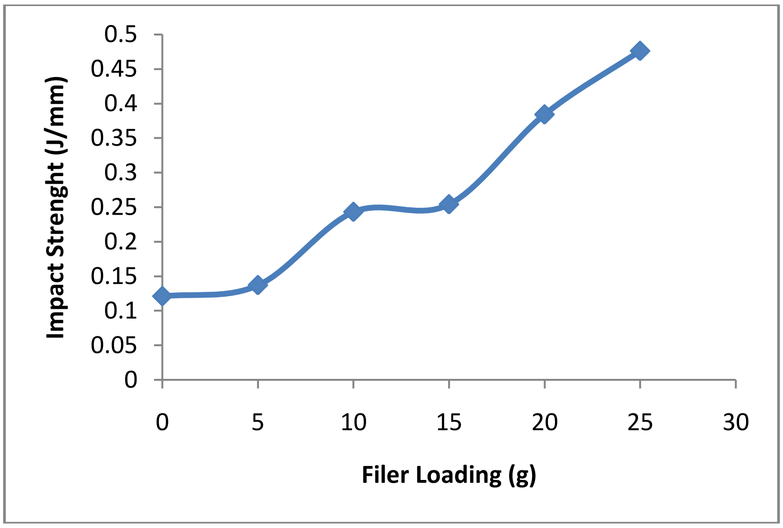


Fig. 1 Effect of treated sisal fibres on impact strength of recycled low density polyethylene

**Result Hardness Test**

| Sample | Hardness (IRHD) |
|---|---|
| 0/100 | 82 |
| 5/95 | 85 |
| 10/90 | 88 |
| 15/85 | 90 |
| 20/80 | 92 |
| 25/75 | 93 |

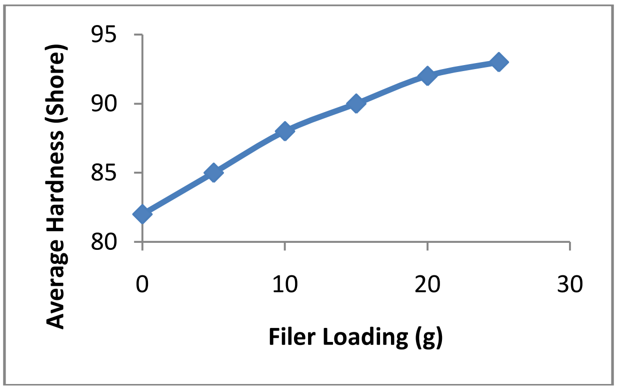


Fig. 2 Effect of treated sisal fibres on hardness of recycled low density polyethylene

**Result of Abrasion Test**

| Sample | Mass 1 (g) | Mass 2 (g) | % Abrasion |
|---|---|---|---|
| 0/100 | 2.00 | 1.97 | 1.50 |
| 5/95 | 2.30 | 2.20 | 4.35 |
| 10/90 | 2.21 | 2.10 | 4.98 |
| 15/85 | 2.21 | 2.10 | 4.98 |
| 20/80 | 2.10 | 2.10 | 3.81 |
| 25/75 | 2.00 | 2.00 | 3.50 |

$V = \frac{(Mi - M2)}{mi} * 100$

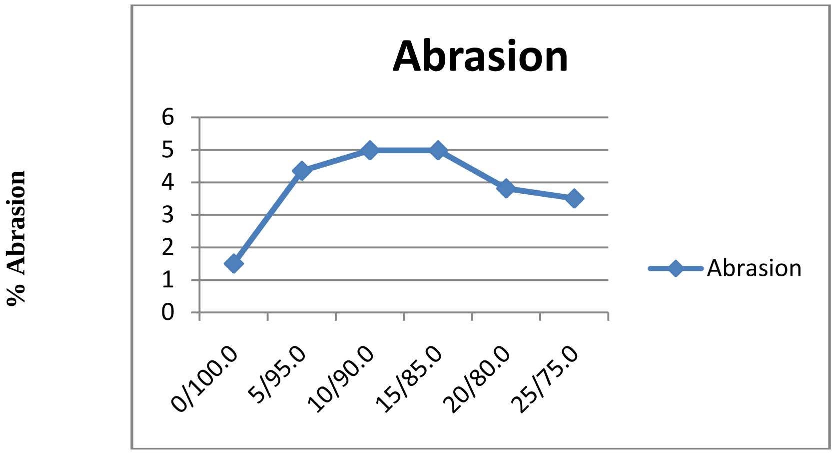


Fig. 3 Effect of treated sisal fibres on abrasion of recycled low density polyethylene

**Result of Water Absorption Test** **PP Loading**

| Sample | Initial Weight (g) | Final Weight (g) | Water Absorbed (%) |
|---|---|---|---|
| 0/100 | 0.5 | 0.52 | 4.00 |
| 5/95 | 0.6 | 0.63 | 5.00 |
| 10/90 | 0.5 | 0.56 | 12.00 |
| 15/85 | 0.6 | 0.69 | 15.00 |
| 20/80 | 0.6 | 0.7 | 16.67 |
| 25/75 | 0.5 | 0.59 | 18.00 |

% water absorbed = $\frac{Wf - Wi}{Wi} x\ 100$

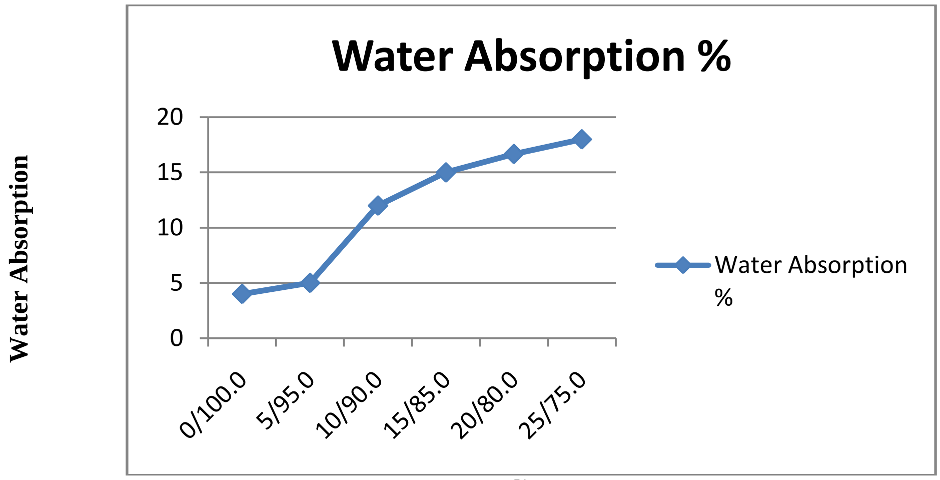


Fig. 4 Effect of treated sisal fibres on water absorption of recycled low density polyethylene

## Discussion

The impact strength result reveals that as the fibre content was increasing from 5-25g respectively, the resistant to impact also increased from 0.12-0.48J/mm respectively. It was observed that the un-reinforced Recycled Low Density Polyethylene (LDPE) has lowest impact strength property of (0.12J/mm).

Hardness as measured in this study is the relative resistance of the surface of samples to indentation by an indentor of specified dimension under a specified load. It is generally known that filler increases the hardness of a material.

The hardness result as shown in figure 2, reveals that the higher the fibre content loading in the rLDPE, the higher the hardness resistant

Gravan*et al*. (1969), defined abrasion as the unwanted progressive loss of substance from the surface of a body brought about by a mechanical action from the rubbing of one surface against another. The abrasion of filled polymers depends on the relative size of the filler particle, the size of abrader, type of filler, and the nature of interface and strength of adhesion between the phases. Abrasion resistance is higher (low wear) when the filler particles are larger compared to the size of the abrasive particles, if the adhesion between the filler and the polymer matrix is good. The abrasion resistant result as shown in figure 3 reveals that as the fibre content is increasing, the resistant to abrasion was also increasing, i.e with lower abrasion percentage. Loadings between 5-15g were having the lowest abrasion resistant i.e higher wear percentage, this could be as a result of insufficient filler to fill the polymer matrix resulting to in homogenous compound.

Figure 4 shows the result of water absorption. It was observed that the unreinforced Recycled Low Density Polyethylene (LDPE) has 4% water absorption which is the lowest. As the filler loading increases, the percentage water absorption increased. The increase in percentage water absorption with increase in weight content of filler loading would be related to the fact that the presence of agro filler in the polymer matrix tend to increase water absorption since agro filler are naturally hydrophilic. Hence as the filler loading increases, it is expected that percentage of water absorption increased.

## Conclusion and Recommendation

### Conclusion

The essence of this project work is to study of physico-mechanical properties of recycled low density polyethylene/sisal fiber composite. At the endof this work it was observed that;

Reinforcing LDPE with sisal fiber on the impact property was highest at 25g at weight content loading of the filler and least at 5g weight content loading of the filer. Reinforcement on the hardness shows the least hardness at 5g weight content of the filler loading and abrupt increase at 10 –25g.It shows an increase on the control and marginally decreases on filler loading. On abrasion, the material show gradual decrease on filler loading. From the results obtained, it can be said that sisal has optimum properties.

**Recommendations**

i. We recommend that further research should be carried on this so as to improve the performance of the filer (Sisal) on plastics materials.
ii. We also recommend that study should be carried out on this such as flammability, tensile strength, Scanning electron microscopy and other solvents test.
iii. Sisal fibre has excellentimpact resistance and hardness properties;therefore, it can be used for application in product like foot tiles, were impact and abrasion are paramount properties.

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