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STUDIES ON FINISHED LEATHER SCRAPS AS FILLER ON THE MECHANICAL AND ABSORPTION PROPERTIES OF NATURAL RUBBER COMPOUND

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ABSTRACT

Waste leather scraps were processed and sieved into a particle size of 212um. The sieve particle was then compounded with natural rubber at 0, 10, 20 and 30 pphr respectively, then analysed for hardness test, tensile strength, compression set, and solvent test. The results obtained reveal that as the filled leather scraps increased from 0-30 pphr, the hardness value increased from 21.66 – 32.33 IRHD. The same trend was also noticed in the results for tensile strength were the increase in the filler in the rubber matrix from 10-30 pphr also required a higher breaking load that as well increased the tensile strength from 2.5-4.5 Mpa. For the compression set, were the increase in leather scraps loadings from 0-30g, led to the percentage compression set increase from 10.9 percent to 5.3 percent which show that the higher the filler loading the better the percentage compression of the composite. The solvent test for N-hexane, acetic acid, xylene and CCL_4 showed that the higher the loadings of the leather scraps the more solvent the compound absorbs, this was because more pore area were created with increase in filler loadings to retain more solvent, however, acetic acid absorbed the least solvent with 8.7 % being the least at 10pphr and 23.1 % being the highest at 30 pphr loading respectively

KEYWORDS
Leather scraps, solvent, natural rubber, mechanical properties, filler

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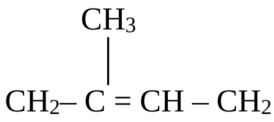
INTRODUCTION

Leather is a fibrous protein consisting of collagen fibres in a three-dimensional cross-linked network. Chrome and vegetable tanning of leather improve the appearance of physical, chemical and biological properties. After tanning, the leather is cut into different desired sizes in a footwear workshop, which leads to the emission of waste that constitutes environmental pollution. Natural rubber based on leather wastes as filler is reported to be useful for many applications, such as construction materials, shoe soles, flooring materials and mouldings with good anti-static properties, air permeability and good appearances. When leather waste is added to a polymer matrix, the former could function as short fibre reinforcement for the matrix and the inherent nature of the leather is retained during processing (El-Nashar et al., 2014)This is done to improve compound characteristics and mechanical properties and minimize production costs (Okele et al., 2015).

It is, therefore, prudent to use and consider the leather waste in the particulate form and study its effectiveness as filler. One modification technique is adding fillers to a polymer to generate a composite with improved properties, such as enhancement in mechanical strength, electrical conductivity or thermal stability (Okele et al., 2019). At present, more environmentally friendly composites with natural rubber are being developed. The global production of polymers from sustainable natural sources grew by more than 400% between 2016 and 2019. These materials, also known as green composites, eco-composites, bio-composites, or eco-friendly composites, have ecological and environmental properties comparable to those of their conventional counterparts (Torres et al., 2023).

Natural rubber is a high-molecular-weight polymer of isoprene, which essentially has its isoprene in the cis 1,4 configuration (Okele et al., 2016).



$$CH_2 - \overset{\overset{\displaystyle CH_3}{|}}{C} = CH - CH_2 \ldots\ldots\ldots\ldots\ldots \text{ figure 1}$$

Natural rubber is harvested from the milky white latex of different species of trees. The outstanding source is *Hevea Brasilinesis,* which has achieved considerable commercial importance A diagonal incision is made at the bark of the tree, allowing the latex to exude (Oboh, et al., 2018).

Composites are multifunctional materials of two or more distinct components. Macroscopically, they have identifiable distinct interfaces that separate them. Polymer composites have discontinuous phases (fillers) embedded in a continuous phase (polymer) (Okele et al., 2018). They are termed hybrid composites when two or more discontinuous phases are incorporated into a continuous phase. Hybrid fillers reinforced composites have been reported to enhance the mechanical, thermal, and damping properties compared to single filler-reinforced composites. To reduce dependence on expensive conventional fillers like carbon black and silica, much research effort has been devoted to developing agro-based waste materials as fillers that will give moderate tensile mechanical properties. The environmental, economic and health issues are usually associated with conventional reinforcing fillers for natural rubber compounds such as fossil fuel-based. Carbon black and non-black silica fillers have motivated considerable research and development interests in particulate cellulose-rich natural fibres due to their renewability and sustainability, high specific strength and stiffness, and low weight and cost.

Several authors have reported poor interfacial interaction and mechanical properties when natural fibres are used as "micro-sized particulate filler without chemical compatibilizers" for the production composites. Improved interfacial bonding and interaction was also reported when particulate natural fibre was used as nano-filler due to increased surface area and flexibility. The different types of additives used in the processing of rubber materials include: vulcanizing agents, accelerators, activators, antidegradant, softeners, fillers, colorants, etc. (Okele et al., 2016). Additives are materials when incorporated into a polymer base, help to ensure easy processing, reduce cost of the product and enhance service properties (Egwaikhide et al., 2007).

MATERIALS AND METHODS

Materials

Low-density polyethylene was sourced from polymer workshop NILEST, Sodium hydroxide (NaOH) from Haddis Chemicals Samaru, Zaria, and Kenaf fibre from Graceland, Hanwa, Sabon

Gari Local Government Area of Kaduna State, Nigeria. Table 1 shows the list of equipment used for the production and analysis of the biofibre reinforcing polymer composite.

Methods

All methods of processing and analysis were carried out in accordance with ASTM methods.

Table 1: Equipment

S/No	EQUIPMENT	MANUFACTURE/MODEL	LOCATION
1	Two Roll Mill	Model 5183-0	NILEST
2	Weighing balance	Electric balance model HC-D	NILEST
3	Tensometer	Mansonto tensometer no	A.B.U ZARIA
5	DMA	NETZSCH DMA 242	A.B.U ZARIA
6	Hardness	Model 1011	NILEST, Zaria.
7	Milling machine	Thomas Wiley. Laboratory Machine	NILEST
8	Compression moulding machine		NILEST.

Table 2: Formulation

S/NO	Ingredients	1	2	3	4
1	Natural Rubber	100	100	100	100
2	ZnO	5	5	5	5
3	Stearic Acid	2	2	2	2
4	TMQ	1.5	1.5	1.5	1.5
5	MBTS	1.5	1.5	1.5	1.5
6	Finished Leather scraps	--	10	20	30
8	Sulphur	2.5	2.5	2.5	2.5

Materials collection and preparation

The leather crumb used for this research was obtained from the footwear department, and all other materials were obtained from the polymer department, both at the Nigerian Institute of Leather and Science Technology, Samara-Zaria. The leather waste was dried at 1000C in an air oven, and after cooling to ambient temperature, it was shredded into smaller particles and ground using a laboratory mill before sieving to a particle size of 180 µm.

RESULTS AND DISCUSSIONS

Results

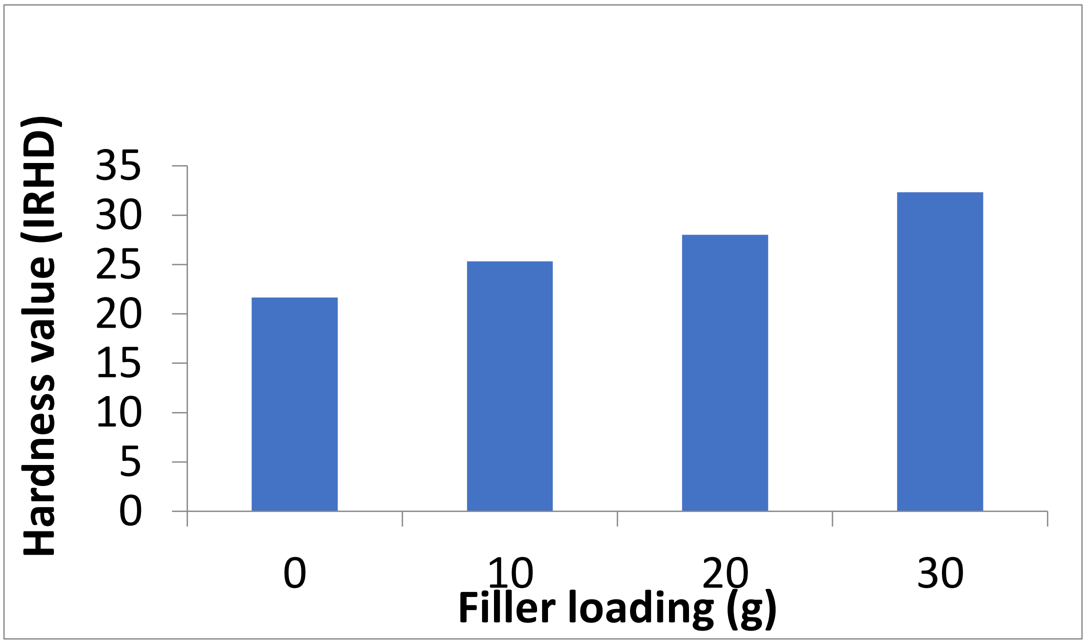


Figure 1: Results of hardness value against filler loadings

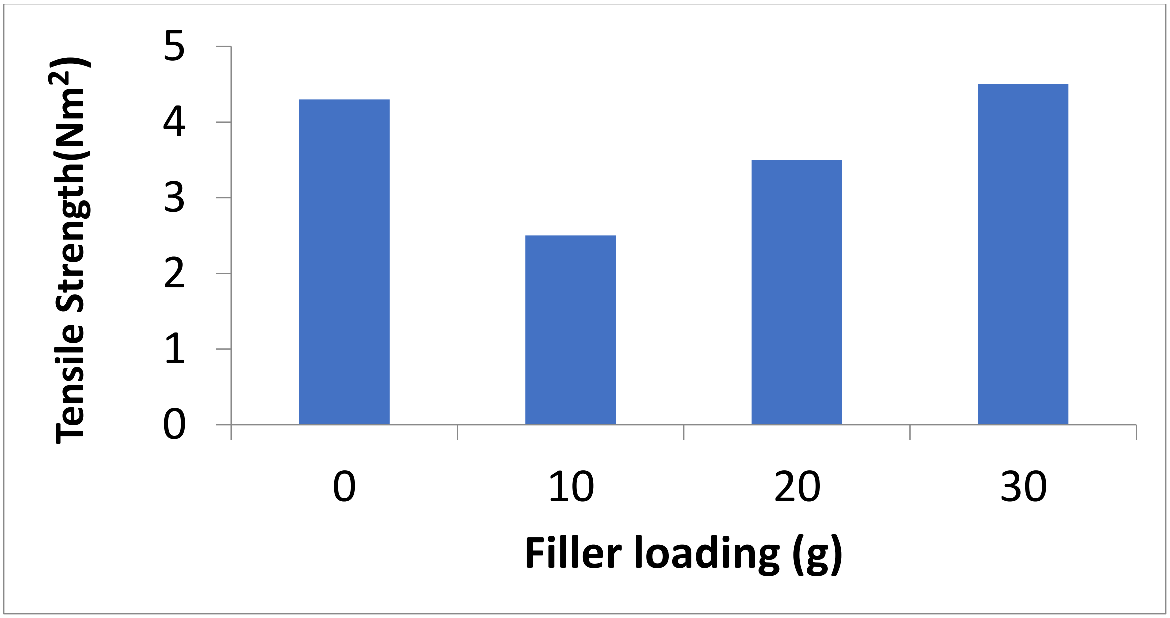


Figure 2: Results of tensile strength against filler loadings

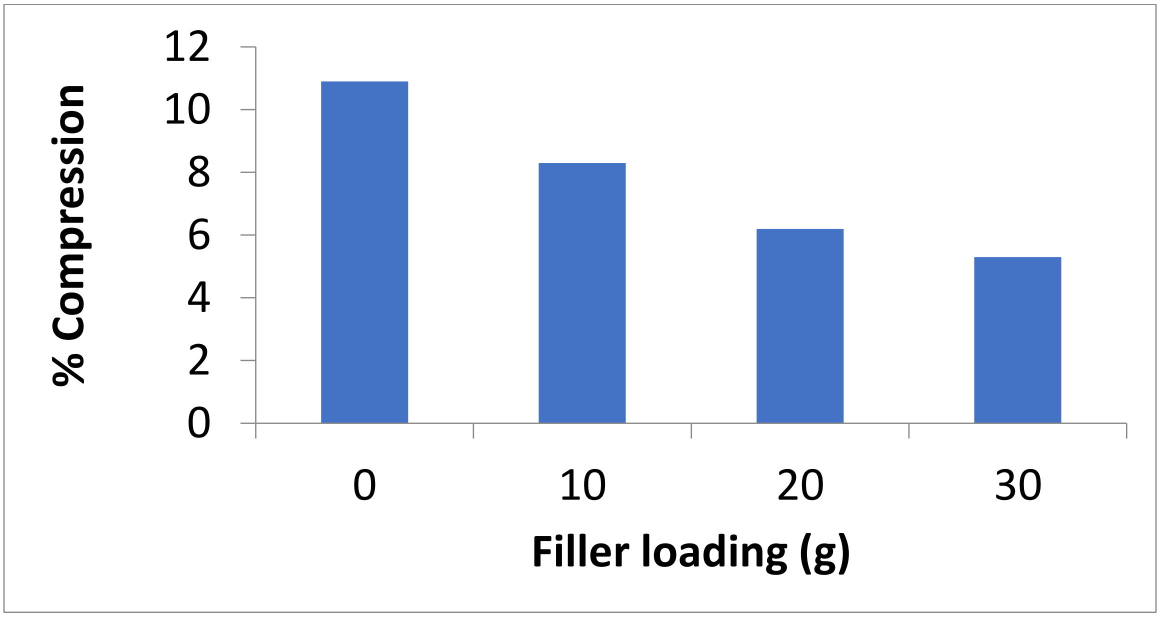


Figure 3: Results of % compression against filler loadings

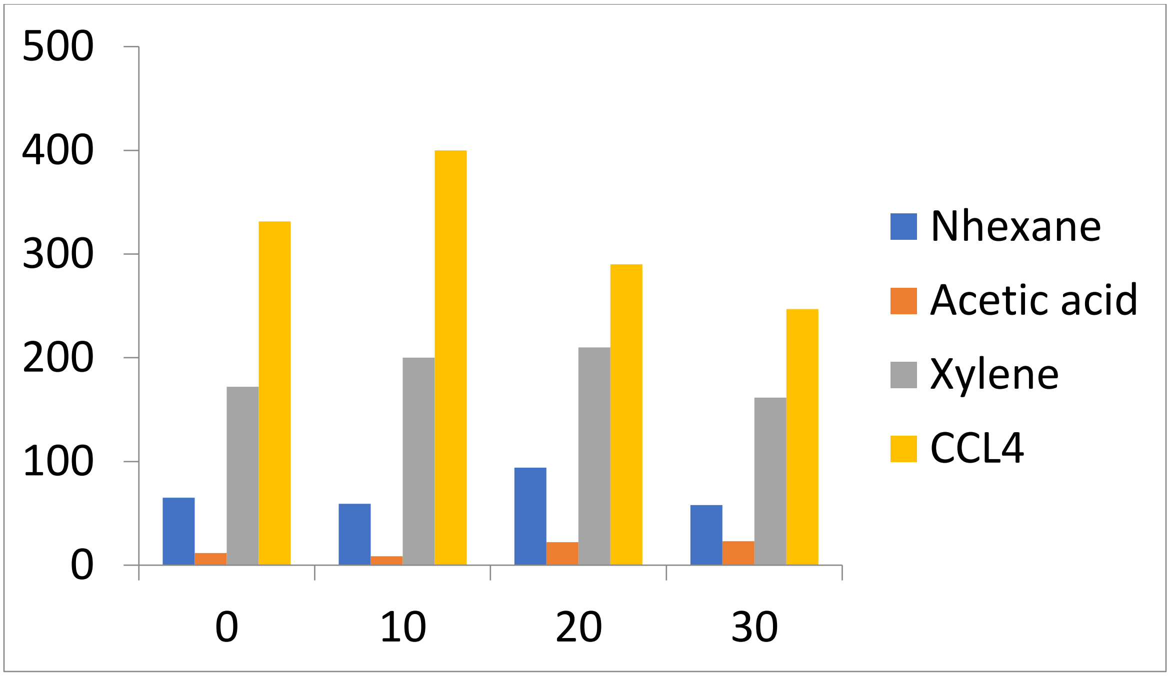


Figure 4: Results of solvents absorptions against filler loadings

DISCUSSION

Hardness Resistance on the Composites

Hardness is the measure of the relative resistance of the surface of samples to indentation by an indentor of a specified dimension under a specified load. It is generally known that fillers increase the hardness of materials (Egwaikhide et al., 2007). Figure 1 shows that as the leather scraps loading was increased from 0-30g, the hardness resistance also increased from 21.66 to 32.33 IRHD, respectively, which means that as the filler loading increased, the resistance to the hardness of the composites also increased.

Tensile Strength on the Composites

The tensile strength, which is the force per unit of the cross-sectional area of the sample (Okele et al., 2020), was analysed, with the results shown in Figure 2. The tensile strength initially decreased from 0-10g loading and further increased from 10-30g of filled leather scraps. This is an indication of reinforcement of the filler.

Compression Set on the composites

Compression set which is an aspect of permanent set, is the amount of residual displacement in a rubber after a distorting load has been removed and it is time and temperature dependent and is affected by the affinity of the rubber for the filler surface (Okele et al., 2018). The results for the compression set as expressed in percentage of the initial thickness of the specimen are presented in Figure 3, As the leather scraps loadings were increased from 0-30g, the percentage compression set also increase from 10.9 percent to 5.3 percent which show that the higher the filler loading the better the percentage compression of the composites.

Solvent Absorption

The solvent absorption studies of natural rubber vulcanizates filled with leather scraps were studied. The compounds were analysed. The solvent test was carried out using four different solvents: acetic acid, N-hexane, Xylene and CCl_4. The results obtained from Figure 4 showed that CCL_4 has the highest absorption of the solvent of up to 331.3 %, 400 %, 290 % and 247 % as the filler loading was increased from 0 – 30 g of leather scraps and acetic acid with the least absorption rates of the composites with solvent uptake between 8.7 % to 23.1 % respectively. This result is in line with the tensile value behaviour of the composites.

CONCLUSION

The studies of the finished leather scraps on the utilization of rubber compounds reveal remarkable effects on natural rubber's physical and mechanical properties. This has shown evidence of reinforcement on the compound from the results obtained for the tensile, compression and hardness tests, respectively. This was not so in the case of the solvent uptake, most in the case of CCL4, with a very high percentage of solvent, up to 400 % for composites filled with 10 g of leather scraps, but this was not so in the case of acetic acid which had the least. Cure characteristics of the compound should be carried out to ascertain the actual curing times as the leather scraps is acidic and as well trying further to reduce the particle size of the leather scraps.

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