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EVALUATION OF THE MECHANICAL PROPERTIES OF PERIWINKLE SHELL FOR BRAKE PADS PRODUCTION.

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ABSTRACT

Automobile brake pads are one of the most important materials to be considered in vehicle safety and functionality. In the production of brake pads, there is need to consider their cost, durability and environmental sustainability. This study investigated the production of brake pads by using periwinkle shell as an abrasive material, Bakelite powder as a binder and glass fibre as reinforcement; an alternative to asbestos-based materials. Samples were prepared in different binder-to-abrasive ratios, namely 10:90, 20:80, 30:70, 40:60 and 50:50, and then compared with an industrially produced brake pad which serve as the control. Among the samples, sample 2 with the 20:80 binder-to-abrasive ratio had the best flexural strength of 51.16 MPa, impact strength of 0.0297J/mm^2 and a shore D hardness of 76 while sample 3 with the 30:70 ratio had the highest Shore D hardness of 77, a flexural strength of 16.0 MPa and impact strength of 0.007J/mm^2. Both samples were harder than the control which had a Shore D hardness of 53. These results indicate that periwinkle shell could serve as a promising, low-cost and environmentally friendly alternative to conventional abrasive in the production of automobile brake pads.

Keywords; Periwinkle shell, Bakelite powder, flexural test, Impact, Brake pad.

INTRODUCTION

The production of automobile brake pads has been in existence since 1902 (Lanchester, 1902). Traditionally, asbestos has been the basic abrasive material used in the production of brake pads due to its effective performance characteristics. However, the adverse health and environmental effects associated with asbestos have led to the search for harmless and sustainable alternatives (Gautier & Faga, 2022). The study therefore proposes the use of periwinkle shell as an environmentally friendly and cheaper abrasive material in the production of brake pads that can provide comparable quality to asbestos-based products.

Periwinkle shells, considered as waste products from the seafood industry were before now used for some construction purposes but are now largely discarded as byproducts (Aimikhe & Lekia, 2021). Rich in calcium carbonate, periwinkle shells exhibit good abrasion resistance, making them suitable for wear-resistant applications like brake pads (Elakhame et al., 2017; Ikpambese & Lawrence, 2018). Using them as abrasive in the production of brake pads does not only addresses environmental concerns but also reduces dependence on costly and toxic industrial materials (Aimikhe & Lekia, 2021; Gautier & Faga, 2022).

Apart from the abrasive, Bakelite powder is a kind of phenol-formaldehyde resin and works very well as a binder due to its excellent mechanical and thermal properties Pizzi & Ibeh, 2022). Owing to its strong bonding with reinforcing agents and abrasives, it has been considered a very good polymer matrix for heat-bearing and durable materials (Pizzi & Ibeh, 2022; Ekpruke et al., 2022). Properties such as safety, durability, toughness, hard-wearing and performance under changing conditions make up a good brake pad material and these properties lie on certain properties like density, flexural strength, resistance to impact, wear and friction (Adekunle et al., 2022). The aim of this study is to use periwinkle shell as abrasive and Bakelite powder as binder due to their numerous advantageous properties to produce non-expensive and eco-friendly brake pads.

MATERIALS AND METHODS

Composition and Proportions: - The composition and proportions of the periwinkle shell and binder in the brake pad were determined based on their properties and requirements performance. The composition mixtures of Periwinkle Shell and Binder for the brake pad were 90 and 10, 80 and 20, 70 and 30, 60 and 40, 50 and 50 respectively. Also, other materials like grinder, digital weighing balance, standard test sieve, heating oven, ziplock bag, fiber glass, hydraulic press, shore scale dirometer, hardness tester, microscope, tribometer, flexural testing machine.

Figure 1 shows the physical outlook of raw periwinkles employed for this study while figure 2 shows the crushed periwinkle shell powder in a bowl.

Figure 1: Raw periwinkle shell

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Figure 2: Crushed periwinkle shell to powder in a bow

The periwinkle shell was purchased from a local market in Choba Port Harcourt. It was washed with detergent to remove dirt and later oven dried to about 210°C for it to be brittle. Thereafter, it was crushed with the grinding machine and was sieved into different grit sizes of 63mm, 90mm, 125mm, 180mm, 260mm, 355mm, 500mm, 710mm, 1.4mm and 2.200mm respectively using standard test sieve.

Material Processing Technique

After sieving, 500mm grit size was selected for the production of the brake pad. Then a scale was used to measure different quantities of the periwinkle shell and bakelite (binder) with varied ratio of 90:10, 80:20, 70:30, 60:40 and 50:50, then the periwinkle grit size was mixed with the bakelite using their different ratios (Boyun, 2024) Some part of the mixture was poured into the mold and then the fibre glass (reinforcement) was cut into the size of the mold and was added and the remaining mixture was poured and the fibre glass was embedded in the mixture as a reinforcement which gave the brake pad good mechanical strength while being heated. Before pouring of the mixture into the mold, the mold was lubricated with tac for easy removal of the product after compaction. The product was heated from 171°C to 200°C, this was regulated to 30mins interval to avoid burning of the mixture using the hydraulic press, and when the process was completed, a blower was used to cool the press before ejecting the compressed product (Edokpia, et al; 2024) This was repeated on all the sample ratios. After the cooling, the various tests were carried out for comparison if the brake pad was of a good quality compared to the commercially available brake pad. The flexural test on the samples was carried out to know the flex and bending properties of the product, it also helps to know the required force that will bend the product under three-point loading conditions as revealed by Liu, et al. (2022). The microscopic structural test to reveal the physical properties of the samples was conducted. The impact test that revealed the ability of the product to withstand severe conditions was done on the samples.

RESULTS AND DISCUSSION

Percent Composition

Table 1 shows the composition of Periwinkle Shell samples

Table 1: The composition of the periwinkle shell samples using XRF machine.

Element	Composition (%)	±
P	0.74	0.090
S	0.73	0.076
Cl	5.21	0.082
Ca	57.72	0.215
Mn	1.34	0.154
Fe	2.59	0.177
Co	1.55	0.112
Sr	0.06	0.016
Zr	0.09	0.017
Ag	0.22	0.061
U	0.23	0.035

Source: Turrent Engineering Services Ltd

It was observed from table 1 that the periwinkle shell composed of several elements of which Calcium is the major element with the highest percent composition in the periwinkle shell abrasive.

Hardness Test

This can be defined as the measure of a material's resistance to surface indentation or scratching. Hardness is an important factor in brake pad production and performance. It reveals the wear resistance, friction coefficient, heat dissipation, noise and vibration. Figure 3 shows the results of hardness test on the samples.

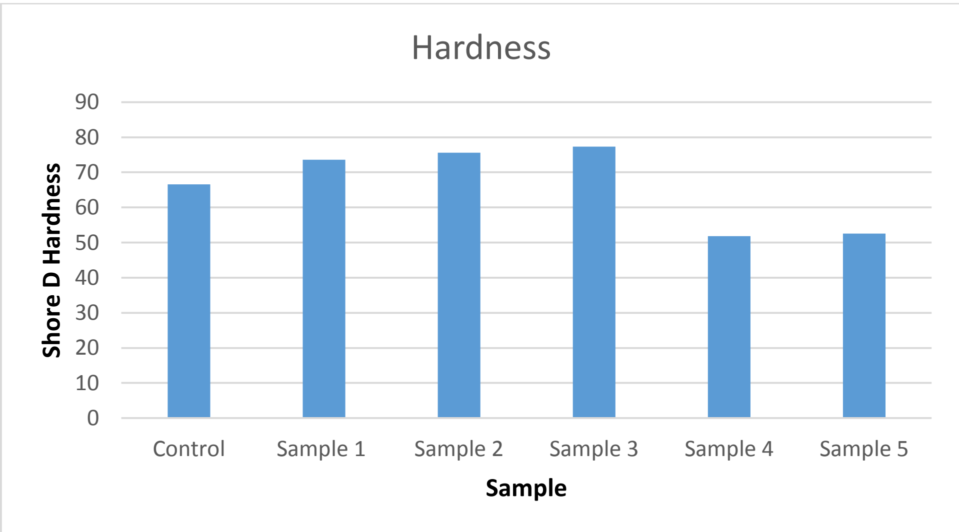

Figure 3: Hardness Analysis of the brake pad samples

From the result, sample 4 (S4) had the lowest hardness of about 52, while sample 3 (S3) has the highest hardness of about 77. The industrially produced brake pad (control) has a hardness of about 53, while sample 2 (S2) had hardness of about 76. Figure 4 shows the flexural strength of the samples.

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Flexural Strength

The Figure 4 shows the result from the flexural strength of the brake pad produced in comparison to the control. Samples 1,2 and 3 have flexural strengths of 19.4, 51.1, and 16.0MPa respectively and are better than the control (the industrial brake pad) that has flexural strength of 13.8MPa. This shows that periwinkle shell (Sample 3 and 4) can serve as a better substitute for the commercially produced brake pads, unlike samples 4 and 5 with the flexural strength of 2.4 and 1.3 MPa which cannot serve as substitute due to low flexural strength.

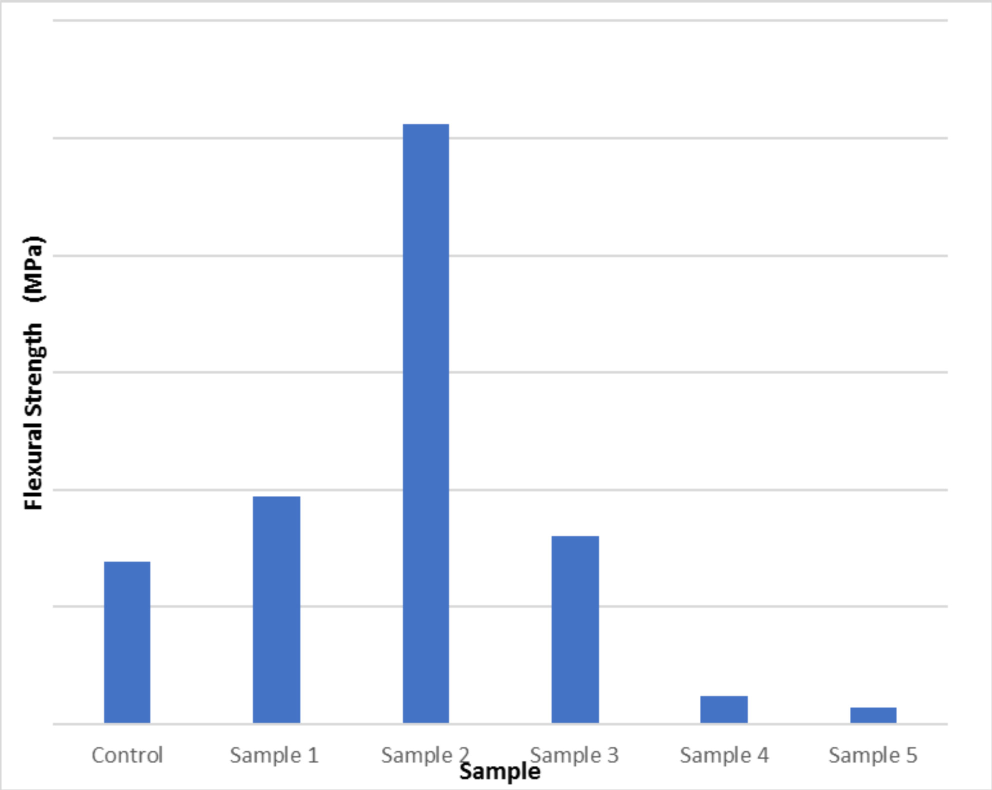


Figure 4: Flexural Strength of brake pad samples

Impact Test

The Figure 5, shows the impact test carried out in comparison to the control sample. Sample 1 and 2 had impact strength of 0.0191 J/mm^2 and 0.0297 J/mm^2 respectively which are higher than the control which has a value of 0.0066 J/mm^2. Sample 3 had a close result as the control with a value of 0.0070 J/mm^2. The samples 4 and 5 had very low impact strength of 0.0024 J/mm^2 and 0.0031 J/mm^2 respectively. This is as a result of the poor binding between the abrasive and the binder thereby showing that they cannot withstand any impact on collision with very hard object.

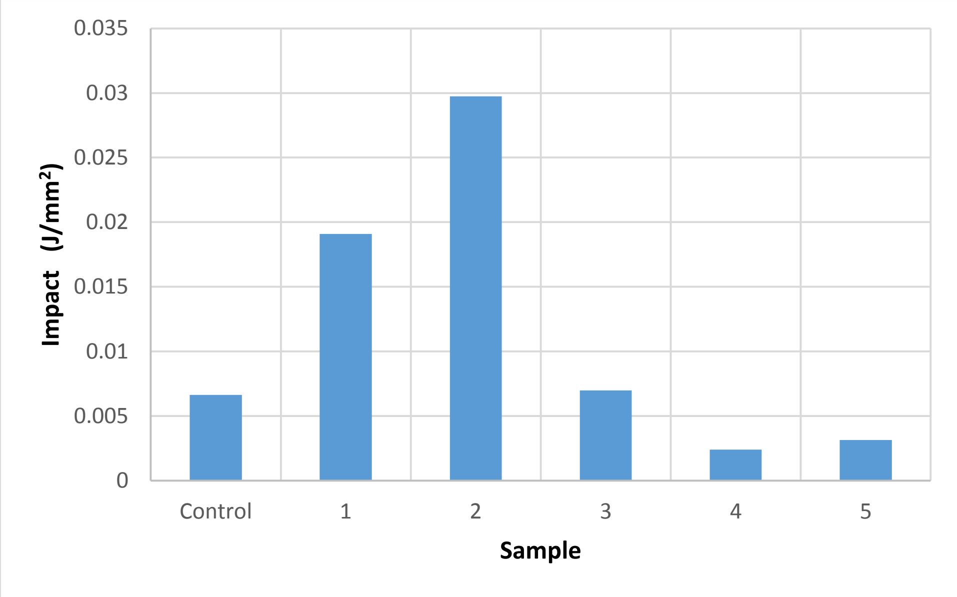
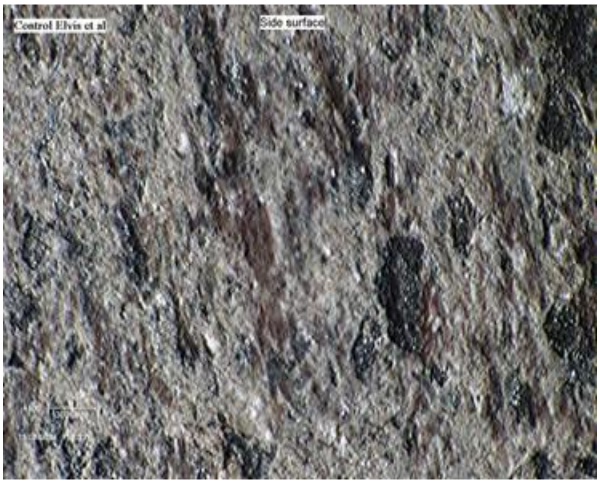


Figure 5: Impact Test

Micrograph of the brake pad

From the microscopic examinations of the periwinkle abrasive brake pad presented in figure 3, it was observed that there were even distribution of the abrasive particles (white) mixed with the Bakelite (green). The pores were also seen (black) and the fibre glass also used as the reinforcement (red) streaks. Although the grain size was large and the abrasive also was coarse compared to that of the commercial brake pad. From the micrograph, sample 2 and 3 wore more than sample 1, which is observed with the lines shown on sample 2 and 3. Sample 4 and 5 have no lines but showed porosity which can be seen in the dark areas indicating that some grains left those spots. Figure 5 shows the micrographs of the control and samples respectively.



(A) Control

(B) Sample 1

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(C) Sample 2

(D) Sample 3

(E) Sample 4

(F) Sample 5

Figure 6: Micrographs of the Control and Samples

CONCLUSION AND RECOMMENDATION

The results above show that the brake pad produced from the periwinkle shell abrasive and Bakelite powder had better results than the industrially produced brake pad. The best sample was sample 2 which has a mixture of 80% Bakelite and 20% abrasive. In the case of flexural strength, sample 1,2 and 3 did better than the control (the industrially produced brake pad) which has 13.85N/mm^2 while sample 1, 2 and 3 had 19.45N/mm^2, 51.15N/mm^2 and 16.02N/mm^2 respectively. For the impact test, sample 1 and 2 gave betters result of 0.019J/mm^2 and 0.029J/mm^2 respectively than the control that has an impact strength of 0.006J/mm^2. This shows that sample 1 and 2 withstands more impact than the commercial product before they start to deform. Sample 3 had the same result with the control. In the entire test carried out, sample 2 was the best and can serve as a substitute for the industrially produced brake pad. It is therefore recommended for production as commercial brake pads. This is because it is environmentally sustainable and contributes to waste recovery as raw materials can be locally sourced and it can also serve efficiently as abrasive brake pads that is good for any automobile manufacturing industry.

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