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The Effect of Particle Sizes on the Performance of Filler: A Case Study of Rice Husk and Wood Flour

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Abstract: The essence of this research paper is to gauge the effect of particle size and particle size distribution of filler on rubber compounds. It also involves the comparison of the level of reinforcement and gauge the possibility of utilizing the low cost locally sourced filler [(rice husk and wood flour) with a commercial filler calcium carbonate ($CaCO_3$)] as an alternative material in rubber compounding. Thus, the use of rice husk and wood flour as filler will in no doubt promote self employment among the teaming unemployed youths thereby reducing poverty and creating wealth for the people. Test like moisture content, pH, ash content, hardness resistance, abrasion resistance, compression set and flex fatigue were subsequently carried out on the vulcanizate. These properties were compared with that of $CaCO_3$ filled vulcanizate. The result reveals that at 212um, rice husk has hardness resistance of 50 (IRHD) and flex resistance 8690rpm and wood flour has better hardness resistance of 57 (IRHD), flex fatigue resistance of 10955rpm (yet to fail) and abrasion resistance of 21.0122%.

Key words: Vulcanizate · Curing · Compounding · Filler · Wood flour · Rice husk.

INTRODUCTION

Fillers are chemical substances added to rubber not only to increase hardness and modulus but improve processability, resistance to abrasion, tensile and tear strength. They are also added to rubber compound to reduce cost and used as pigment [1]. Fillers could be of many types, namely: reinforcing fillers, semi - reinforcing fillers and non - reinforcing fillers. Moreover, filler could be classified based on sources. Viz.

- Filler from mineral deposit, e.g. calcium carbonate, silica.
- Fillers from organic materials, e.g. phenolic resin, high styrene resin, cyelised natural rubber serves as a good source of filler.
- Filler from fibrous materials, e.g. wood flour, asbestos.
- Filler from crop pests, e.g. rice husk [2].

Rice husk is sourced from rice grains and it is obtained by winning rice grains using a groundnut machine which separate the rice from the husk [3]. It is a non - black, non - reinforcing filler and an inert material used mainly as cheapen or to reduce compounding cost. It is also a cellulose material which can be grinded to some particles (powder) and used as filler in the plastic and rubber products manufacture [4].

Wood flour is locally prepared filler obtained from wood. In native it is known as saw dust. It has low specific gravity and of different grades. The property of the grades is dependent on the parent tree. The different tree species grown are Iroko, Obeche, Mahogany, etc. [5].

Characterization of The Filler: Bearing the service conditions in mind, the materials were carefully sourced and formulated. Rice husk and wood flour was locally procured and grounded to fine powder after proper drying. It was then sieved using different mesh sizes of 212um, 150um and 118um. A formulation for Shoe sole was carried out using the different mesh size of rice husk and wood flour and 212um for $CaCO_3$ (Table 1). Characterization of the fillers was therefore carried out to assess the inherent properties of the fillers before usage. These properties includes: Moisture content %, pH level and ash content %.

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Table 1: Formulation table of shoe sole in ppw

	Parts per Weight						
Material	i.	ii.	iii.	iv.	v.	vi.	vii.
NR	100	100	100	100	100	100	100
ZnO	10	10	10	10	10	10	10
Stearic acid	1	1	1	1	1	1	1
TMQ	1	1	1	1	1	1	1
TMTD	1	1	1	1	1	1	1
TMTM	1	1	1	1	1	1	1
MBTS	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Sulphur	2	2	2	2	2	2	2
Processing oil	1	1	1	1	1	1	1
Rice husk	-	13 (212um)	13 (150um)	13 (118um)	-	-	-
Wood flour	-	-	-	-	13 (212um)	13 (150um)	13 (118um)
$CaCO_3$	13 (212um)	-	-	-	-	-	

MATERIALS AND METHODS

Materials Used:

- Rice husk and wood flour
- Natural rubber, NR
- Calcium carbonate, $CaCO_3$
- Zinc oxide and sulphur
- Stearic acid
- TMTM, TMTD, MBTS and TMQ
- Processing oil

Apparatus Used:

- Dessicator
- Oven
- Digital weighing balance
- $30cm^3$ prolain crucible
- Muffle furnace
- Groundnut machine
- Digital pH meter
- Wallace De Mattia flexing machine
- Compression moulding machine
- Press for compression set test
- Indentor for hardness resistance test

Experimental: Moisture content test was carried out by weighing 4grams each of rice husk and wood flour and $CaCO_3$ (powder) and aged in an oven; after 1 hour, the sample was cooled in a dessicator and weighed. The sample was further aged for 15 minutes and then cooled in the dessicator and weighed; this process of 15 minutes aging, cooling and weighing continues until a constant weight was observed. 30grams each of $CaCO_3$, rice husk and wood flour (powder) was dissolved into 100ml of distilled water for 12hours. Thereafter, the pH meter was used to determine the pH value of the samples. Ash content was determined by putting 4grams each of dried powder of $CaCO_3$, rice husk and wood flour into a $30cm^3$ prolain crucibles and putting them in a furnace at a temperature of 550 ± 5°C. After three and half hours, the crucibles was removed from the furnace and cooled in the dessicator and weighed.

Bearing the service conditions in mind, the materials were carefully sourced and formulated. Shoe sole was formulated for using the different particle sizes of rice husk and wood flour and $CaCO_3$ for the various shoes sole as indicated by (Table 1). Using the internal mixer, the formulated materials were carefully compounded. The cured polymer was cut into "performs" and feed into the mould cavity of the compression moulding machine. The mould was introduced between the platens and a force of $50Nm^2$ was also applied thereby closing the moulds. On closing the mould, the male part engages the female part at a temperature of 200°C for 5 minutes means of hydraulic press. Tests like hardness resistance, compression set, flex fatigue resistance and abrasion resistance were carried out on the vulcanizate respectively.

RESULTS AND DISCUSSION

The results shows that the fillers (rice husk and wood flour) has percentage moisture of 2.5% and 6.25%, pH value of 9 and 5.5 and ash content of 12.5% and 10% respectively. The low value of moisture content, % amount to the fact the fillers was sufficiently dried and there will be no pronounce defects of moisture on the final vulcanizate (Table 2 and Fig. 1). pH result shows that rice husk is alkaline. This means that the filler will have an accelerating effect on the vulcanizate, hence alkaline

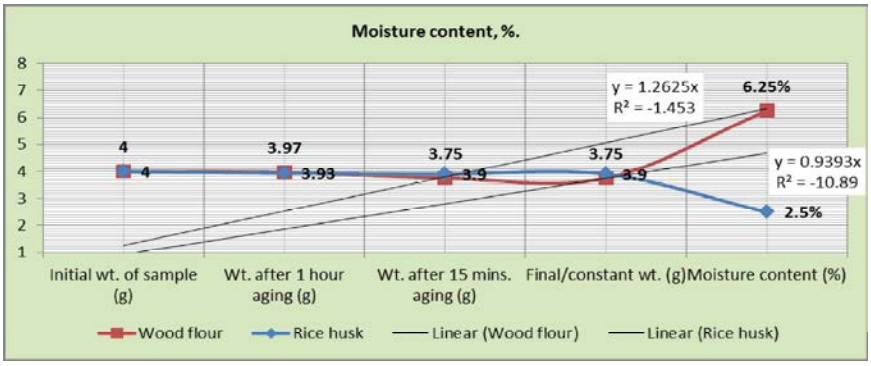

Fig. 1: Moisture content

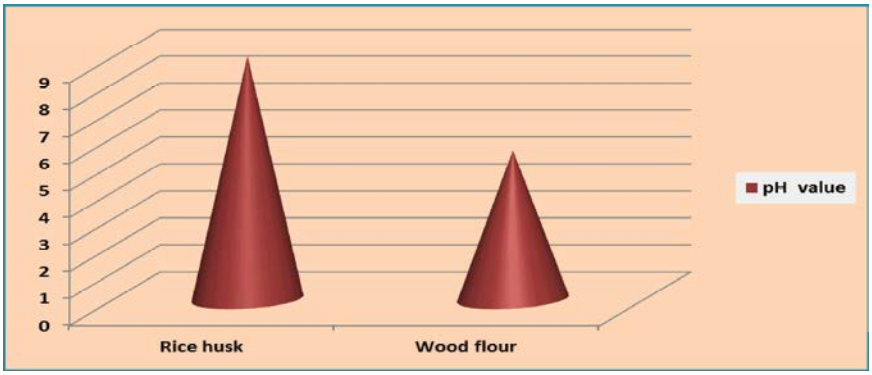

Fig. 2: pH values

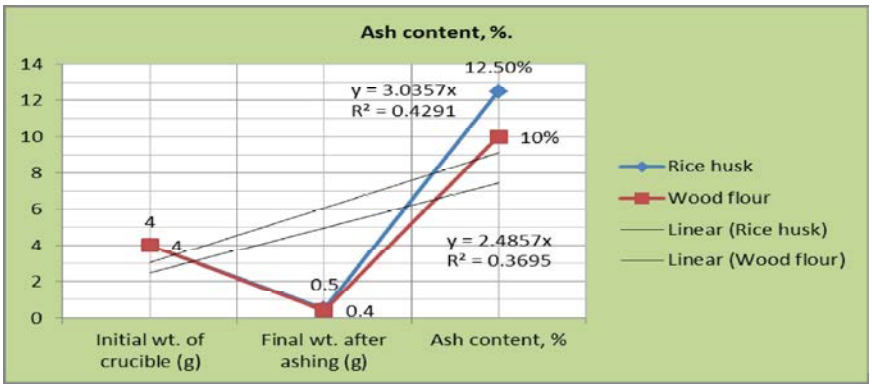

Fig. 3: Ash ccontent

Fig. 4: Hardness resistance

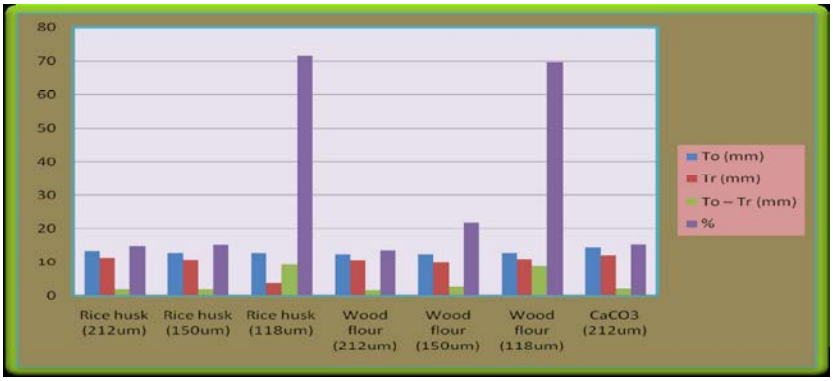

Fig. 5: Compression set resistance

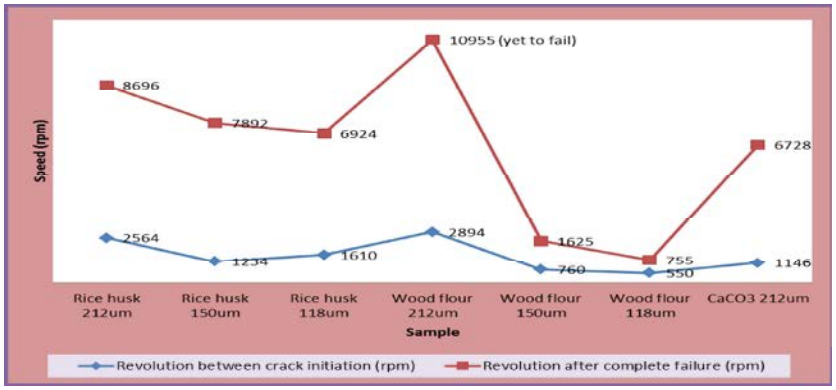

Fig. 6: Flex fatigue resistance

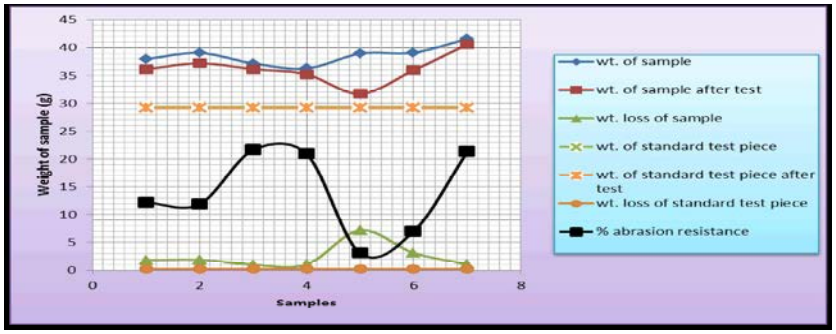

Fig. 7: Abrasion resistance

Table 2: Moisture content results

Parameters	Rice husk	Wood flour
Initial weight of sample (g)	4.00	4.00
Weight after one hour aging (g)	3.93	3.97
Weight after 15 mins. Aging (g)	3.90	3.75
Final / constant weight (g)	3.90	3.75
Moisture content %	2.50	6.25

Table 3: pH content results

S/N	Sample	Method	pH
1	Rice husk	Calometric method	8.46
2	Rice husk	Electrometric method	9.00
3	Wood flour	Calometric method	4.20
4	Wood flour	Electrometric method	5.50

Table 4: Ash content results

Parameters	Rice husk	Wood flour
Initial weight of crucible (g)	4.0	4.0
Final weight after ashing (g)	0.5	0.4
Ash content %	12.5	10.0

Table 5: Hardness resistance results

S/N	Materials	Hardness (IRHD)
1	Rice husk (212um)	50
2	Rice husk (150um)	49
3	Rice husk (118um)	25
4	Wood flour (212um)	57
5	Wood flour (150um)	51
6	Wood flour (118um)	20
7	$CaCO_3$	45

Table 6: Compression set resistance

S/N	Sample	T_o (mm)	T_r (mm)	T_o - T_r (mm)	%
1	Rice husk (212um)	13.50	11.50	2.00	14.85
2	Rice husk (150um)	13.00	11.01	1.99	15.31
3	Rice husk (118um)	13.00	3.70	9.30	71.54
4	Wood flour (212um)	12.50	10.80	1.70	13.60
5	Wood flour (150um)	12.50	9.78	2.72	21.74
6	Wood flour (118um)	13.00	11.20	8.70	69.60
7	$CaCO_3$	14.50	12.26	2.24	15.45

Table 7: Flex fatigue resistance

S/N	Sample	Revolution between crack initiation	Revolution after complete failure
1	Rice husk (212um)	2564	8696
2	Rice husk (150um)	1234	7892
3	Rice husk (118um)	1610	6924
4	Wood flour (212um)	2894	10955 (yet to fail)
5	Wood flour (150um)	760	1625
6	Wood flour (118um)	550	755
7	$CaCO_3$	1146	6728

Table 8: Abrasive resistance

S/N	Wt. of sample (g)	Wt. of sample after test (g)	Wt. loss of sample (g)	Wt. of standard test piece (g)	Wt. of standard test piece after test (g)	Wt. loss of standard test piece (g)	% abrasion resistance
1	37.9379	36.1245	1.8134	29.3534	29.1313	0.2210	12.1870
2	39.0330	37.1750	1.8580	,	,	,	11.8945
3	37.1682	36.1459	1.0223	,	,	,	21.6179
4	36.2628	35.2058	1.0570	,	,	,	20.9082
5	38.9074	31.7115	7.1979	,	,	,	3.0703
6	39.1027	35.9578	3.1449	,	,	,	7.0275
7	41.6262	40.5891	1.0371	,	,	,	21.3094

materials have accelerating effect on vulcanization; but as for wood flour, it will have a retarding effect on the vulcanizate, since acidic materials have retarding effect on vulcanization (Table 3 and Fig. 2). The percentage loss of carbon is considerably low. This shows that the fillers will not have much reinforcing properties (Table 4 and Fig. 3).

As the particle size decreases, Hardness resistance for rice husk and wood flour increases; this means that the smaller the particle size, the better the hardness resistance of the material (Table 5 and Fig. 4). More so, as particle size for rice husk and wood flour increases, the better the compression sets resistance (Table 6 and Fig. 5). The flex life is higher with smaller particle size of 8696 for rice husk and 10955 (yet to fail) wood flour (Table 7 and Fig. 6); this shows that the flex fatigue resistance of rice husk and wood flour is good as compared to $CaCO_3$. At smaller particle size, rice husk has 12.1870 % abrasive resistance and wood flour 20.9082 % (Table 8 and Fig. 7). This means that the abrasive resistance of rice husk is poor while that of wood flour is nice.

CONCLUSION

The result reveals that at 212um, rice husk has hardness resistance of 50 IRHD and flex fatigue resistance of 8690 and wood flour has better hardness resistance of 57 IRHD, flex fatigue resistance of 10955 (yet to fail) and abrasion resistance of 21.0122% as compared to $CaCO_3$. This further reveals that particle size variation has effect on the physical properties of the vulcanizate or product; and that rice husk is a non black non - reinforcing filler and wood flour non black semi - reinforcing filler.

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