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Experimental study on particle size and filler loading reinforcement of sugarcane baggase on natural rubber compound

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ABSTRACT

Natural rubber crumb was reinforced with sugar cane bagasse in various proportions (30g, 45g and 60g) and particle size (120µm, 150µm and 180µm). The samples obtained were evaluated for physico-mechanical properties which included tensile properties, hardness, compression set and abrasion resistance. The studies revealed that sugar cane bagasse is slightly acidic and is non- black semi-reinforcing filler when compared with the blank sample and estimated standard results of natural rubber. The abrasion test revealed that increase in filler loading reduces the abrasion resistance, i.e increases the percentage wear of the material and the higher the particle size the better the abrasion resistance as the best abrasion result was revealed at 180µm. The tensile properties revealed a better result at particle filler 18µm and for compression set, increase in filler loading showed little or no difference in the result.

INTRODUCTION

Polymeric materials have been replacing other conventional materials like metals, glass and wood in a number of applications. The use of various types of fillers incorporated into the polymer has become quite common as a means of reducing cost and to impart certain desirable mechanical, thermal, electrical and magnetic properties to the polymers. Due to the energy crisis and high prices of petrochemicals, there has been a greater demand to use more and more fillers to cheapen the polymeric materials while maintaining and/or improving their properties. The advantages that filled polymer systems have to offer are normally offset to some extent by the increased complexity in the rheological behaviour that is introduced by the inclusion of the fillers.

Natural rubber and synthetic rubber are converted to serviceable products by combining them wilh fillers[1]. Fillers are materials which when added to rubber mix enhance the properties[11]. These properties are physical in nature which include hardness, tensile strength. flex fatigue, stiffness and to some extent. the chemical properties[1]. Fillers improve the processing characteristics, reduce cost and also acts as auxiliary components necessary for vulcanisate.

Fillers can either be reinforcing, semi-reinforcing or non-reinforcing. Reinforcing fillers enhance the physical properties of the cured article. An example of these is carbon black. In 1905, S.C. Note discovered that fine particulate carbon black included in rubber used on the outer part of a tyre almost doubled the lifespan of the tyre.

There are also non-reinforcing fillers. They reduce cost and improve processing characteristics for example by reducing nerve in the processing of rubber. Non-reinforcing fillers have little or no effect on the physical properties of the rubber[8]. They act as cheapener by increasing the bulk of the products. Examples of these include talc, barites, mica powder, whiting and china clay[12].

Semi-reinforcing fillers are partially reinforcing. These include soft clay, calcium carbonate and antimony.

Sugar cane chaff is waste the is chewed from sugar and if discarded and start decaying, it attracts insects such as flies. If decaying in a moist environment, produces an unpleasant smell or odour which attracts insects (flies).

Though the cane fibre does not get decayed easily, if it is in a very dry environment, the water is being evaporated by heat leaving the fibre dry, and after some days, it begins to form crumps, with these expression above, if sugar cane fibre is being preserved well as earlier stated, it could serve as filler in the compounding of natural rubber (NR) when properly grind and sieved, this will make it useful and no longer a waste and hazard to health and the environment.

The aim of this work is to assess the effects of blending sugarcane bagasseon properties of naturalrubber vulcanisate. This is with a view to reduce product cost.

MATERIALS AND METHODS

Crumb grade of natural rubber was obtained from Integrated Rubber Products Plc. Benin, The sugar cane chaff was obtained from samaru environ in Zaria. It was dried, grinded and sieved to particle size. Zinc oxide, stearic acid, trimethyl quinoline (TMQ), mercaptobenzolethiazolesulphenamide (MBTS), sulphur,and processing oil were sourced from Integrated Rubber Products Plc. BeninCity.

TABLE 1 : Characteristics of sugar cane chaff

Parameter	Sugarcane Bagasse
pH(%)	6.14
Moisture content (%)	0.95

SAMPLE PREPARATION

The sugar cane chaff was characterized. The value of the pH, and moisture content of the sugar cane chaff were determined. (See TABLE 1).

All the samples of the filler blends were prepared following the recipes in TABLE 2.

Compounding of the formulations was carried out on a standard laboratory rollmillin accordance with A SIMD3I32 procedures. Sample moulding and curing was done on an electrically heated laboratory moulding press to optimum cure state.

TABLE 2: Standard Rubber Formulation

ASSESSMENT OF VULCANISATE PROPERTIES

The tensile strength, hardness, compression set and abrasion tests were carried out using the standard methods.

RESULTS AND DISCUSSION

Physico-mechanical properties of samples

TABLE 2 : Formulation: nr filled with S.C.B with particle size (120um)

S/NO	Ingredients	1	2	3	4
	Natural Rubber	100	100	100	100
	Zinc oxide	4	4	4	4
	Stearic Acid	2	2	2	2
	TMQ	1.5	1.5	1.5	1.5
	Sugar cane bagasse	--	30	45	60
	MBTS	2	2	2	2
	Sulphur	2.5	2.5	2.5	2.5
	Processing oil (paraffinic)	1	1	1	1

DISCUSSION OF RESULTS

The moisture content of the filler (sugarcane bagasse) was low (0.95 %), and this is used to predict the defect arising from shrinkage during curing particularly for products that are processed at elevated temperatures. Although filler heat pretreatment may obviate this problem.

The pH of the filler slurry shows that the filler (sugarcane chaff) with pH of (6.5) is slightly acidic. It is generally well known that acidic fillers retards the cure rate (longer cure time) while alkaline filler accelerates cure rate (shorter cure time).

The tensile mechanical property is referred to as the ultimate tensile strength,modulus at 300% strain and elongation at break. The ultimate tensile strength is the stress in (Mpa) or force per unit of the original cross sectional area at the point of rupture of a specimen as the result of the strain applied. It is used to determine a compound's susceptibility to deterioration by oil, heat, weather under tensile stress etc. it also tells whether the product has been properly vulcanized, the ingredients thoroughly blended and the mix kept free from foreign matters. The tensile strength result as shown in TABLE (8) indicates that there is decrease in the tensile strength as the filler loading increases from 30pphr to 60pphr and was the same as the particle size of the filler increases from 120um to 180um,this is so because there is no carbon content in the filler.

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 fillers increase the hardness of a material. The hardness results as shown on TABLE (5) indicates that the higher the filler loading the better the hardness, irrespective of the particle size of the filler, except for that of sample filled with (30 pphr) which later show a decrease at 60pphr filler loading, this is because particle size did not play any major difference on the hardness of the material. This result is expected because as more filler gets into the rubber, the elasticity of the rubber chain is reduced resulting to a more rigid vulcanisate.

Gavan (1969), defined abrasion as the un-

TABLE 3 : Formulation: nr filled with S.C.B with particle size (150um)

S/NO	Ingredients	1	2	3
	Natural Rubber	100	100	100
	Zinc oxide	4	4	4
	Stearic Acid	2	2	2
	TMQ	1.5	1.5	1.5
	Sugar cane bagasse	30	45	60
	MBT	2	2	2
	Sulphur	2.5	2.5	2.5
	Processing oil (paraffinic)	1	1	1

TABLE 4 : Formulation: nr filled with S.C.B with particle size (180um)

S/NO	Ingredients	1	2	3
	Natural Rubber	100	100	100
	Zinc oxide	4	4	4
	Stearic Acid	2	2	2
	TMQ	1.5	1.5	1.5
	Sugar cane bagasse	30	45	60
	MBT	2	2	2
	Sulphur	2.5	2.5	2.5
	Processing oil (paraffinic)	1	1	1

Batch factor = 2

TABLE 5 : Hardness test result (shore-a durometer)

S/No	Particle Size (μm)	Filler Loading (g)			
		0	30	45	60
1	0	39			
2	120	--	46	50	49
3	150	---	47	48	55
4	180	--	47	48	50

TABLE 6 : Abrasion resistance test result (%)

S/No	Particle Size (μm)	Filler Loading (g)			
		0	30	45	60
1	0	0.91			
2	120	--	2.98	3.37	3.72
3	150	--	2.38	3.77	8.72
4	180	--	2.27	2.72	3.71

TABLE 7 : Tensile stress result (n/m^2)

S/No	Particle Size (μm)	Filler Loading (g)			
		0	30	45	60
1		1.4×10^5			
2	120	--	$3.6 x 10^5$	$5.5 x 10^4$	$1.9 x 10^5$
3	150	--	3.3×10^5	2.5	2.5
4	180	--	2.2×10^5	1.9×10^5	1.9×10^5

TABLE 8 : Compression set result (%)

S/No	Particle Size (μm)	Filler Loading (g)			
		0	30	45	60
1		6			
2	120	--	8	8	9
3	150	--	10	10	10
4	180	--	10	11	11

wanted 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 abrasion, types of fillers, the nature of the interface and the strength of adhesion between the phases. Abrasion resistance is higher (low wear) when the filler particles are larger compared to the size of abrasive particles, if the adhesion between the filler and matrix is good.

The results in TABLE (6) indicate that the abrasion resistance of the vulcanisate decreases marginally with increasing filler loading and with decrease in particle size. The marginal decrease in abrasion resistance with increasing filler concentration may be that as filler loading increases, the strength adhesion between the polymer and filler decreases. A situation may have been reached were there is no enough polymer to wet (bond) the filler to the polymer phase, i.e. adhesion between the filler and the polymer matrix is not good enough.

There was an indication on the result for compression set that the higher the particle size of the filler the higher the percentage compression and there was no reasonable difference in the increase in filler loading, if not for only sample filled with 45pphr which was at the same level throughout as the filler loading was increased, i.e it was 10% compression for both 30, 45, and 60 pphr filler loading (see TABLE 7).

CONCLUSION AND RECOMMENDATION

Conclusion

Comparing the reinforcing properties of the vulcanisate of the filled and unfilled, the properties of the filled are better than the unfilled samples, which is an indication of reinforcement of the sugarcane bagasse and as well can be classified as a semi-non black reinforcing filler.

However, due to the target of this research work, which aimed at the production of a foot mat with necessary properties such as abrasion resistance and compression set, having sample with the best abrasive property as the filler loading decreases. The mechanical properties of the vulcanisate are a function of particle size and filler loading. It was found out that the agricultural by-product is slightly acidic with low moisture content.

Recommendation

This research work has revealed certain properties of the sugar cane bagasse. In order to modify and establish these findings, the following recommendations have been put forward from some of the problems encountered:

(i) Sugar cane bagasse powder should be used in the manufacture of molded rubber products such as foot mat, shoe sole, floor tiles that requires less tensile stress during service life because of the inherent reinforcing properties in them.

(ii) Sugar cane bagasse powder may perfectly serve as an extender or diluents i.e. to increase the bulk with corresponding lightness in weight of the polymer product with a reduction in cost.

(iii) Sugar cane bagasse powder values for hardness obtained may not be used to design products for rubber mounts instead be employed in hard casing like battery case.

(iii) Due to the poor interaction between the filler and the polymer matrix, it is advised to set a standard on the limit of filler incorporated into a standard polymer matrix as increase in filler loading takes a longer time to get into the polymer matrix.

And filler pre-treatment should be done to enable good interaction between the polymer and the filler.

REFERENCES

[1] E.J.Asore; An introduction to rubber technology, 1st Edition, Josen Books, Benin City, **(2000)**.

[2] ASTM 1415, Standard Method of Testing Hardness of Rubber, **(1983)**.

[3] ASTM D1509, Standard Method of Testing Moisture Contentm, **(1983)**.

[4] ASTM D1512, Standard Method of Testing pH, **(1983)**.

[5] ASTM D395, Standard Method for Testing Permanent Set, **(1983)**.

[6] ASTM D412, Method for Testing Tensile Properties of Rubber, **(1983)**.

[7] ASTM D671, Testing Method for Fatigue **(1983)**.

[8] R.O.Babbit ed; Vanderbilt rubber handbook, R.T.Vanderbilt Company, Norwalk.Conn., **(1978)**.

[9] R.R.Barihart; Rubber compounding: Kirl-othmer encyclopedia of chemical technology, 3rd Edition, John Wiley and Sonces Inc., **20**, **(1982)**.

[10] D.Bernard; "Encyclopedia for polymer science and technology", Inter-science New York, **(1970)**.

[11] C.M.Blow; "Rubber technology and manufacture" 2nd Edition, Butter wort, London, **(1982)**.

[12] C.M.Blow; Rubber Technology Manufacture, 2nd Edition Butterworth Scientific, London, **(1982)**.

[13] A.Y.Coran; Science and technology of rubber F.R. Eiriched, Academic Press, New York, 292 **(1978)**.

[14] A.S.Craig; Rubber technology, Oliver and Boyd London, **(1963)**.

[15] E.M.Demurer; "Proceeding of international rubber conference" Loughborough, John Willey and Sons Inc, **(1981)**.

[16] J.H.Dubion; "Plastics" 5th Edition, Applied Science Publishers Limited, London, **(1984)**.

[17] Eirich, F.R.Ed; Science and technology of rubber, Academic Press Inc., New York, **(1978)**.

[18] F.M.Gavan, J.U.Scnmitz, W.E.Brown; Testing of polymers, Inter-Science, New York, **3**, 139 **(1969)**.

[19] F.M.Gavan, J.U.Schmits, W.E.Brown; "Testing of polymer inter-science" New York, **3**, **(1969)**.

[20] A.N.Gent; Engineering with rubber, How to design rubber components, 1st Edition Hanser, munich, **86**, **(1992)**.

[21] C.Hepum; Filler reinforcement of rubber", Plastic and rubber international, Hamser Publisher, Nurich, Vienna, New York, **(1984)**.

[22] W.Hofmann; Rubber technology handbook, Reprint/ Gardner Publications, Inc.CT.Ohio, **(1996)**.

[23] E.N.Lawrence; Mechanical properties of polymers and composites, Marcel Dekker Inc., New York, **2**, **(1974)**.

[24] J.K.Less; "Polymer engineering science", Wtec Hyper Publishers, London, **(1968)**.

[25] T.B.Lewis, L.E.Nelson; "Applied polymer science", Greenland Publishers, **(1970)**.

[26] M.Morton; Rubber Technology, 2nd Edition, Van Nostrand Reinhold Company, New York, **(1973)**.

[27] L.E.Nelson; "Mechanical properties of polymers and composites", Marcel Dekler Inc., New York, **(1974)**.

[28] Overview of curing and crosslinking, Pro.Rubber Plastics Technology, R.P.Quirk, **(1978)**.

[29] D.Parkinson; "Reinforcement of rubber", Lakeman and Co; London, **(1957)**.

[30] M.O.W.Richardson; "Wear", Academic Press, New York, **(1971)**.