Potential of Carbonized Bagasse Filler in Rubber Products

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Abstract
The potential of carbonized bagasse (waste from sugar cane) as filler in rubber products have been investigated. The products were evaluated for Tensile strength, Compression test, Abrasion resistance, Hardness and Elongation at break. Results shows that as the filler loading increased the tensile strength, abrasion resistance, Hardness properties improved. It was also observed that decrease in filler loading enhanced the Elongation at break and compression set properties. The possibility of utilizing the low cost bagasse as an alternative filler material in natural rubber have been achieved in the work.

Keywords: bagasse, filler, hardness, tensile strength, rubber products

INTRODUCTION
One of the most important and abundant agro fiber resources is sugar cane with a worldwide annual production of 1170 million metric tonnes in 2005 (FAO, 2006). Large quantity of the bagasse, sugar cane waste is generated in Nigeria. These wastes create pollution, environmental hazard and disposal problem in the country. Traditionally, bagasse has been used as fuel in the sugar factories and, in smaller quantities, for cellulose and paper production. Small quantities are also employed by the particleboard industry in China and Pakistan (Berns and Caesar, 2000) as well as in Cuba, Argentina, and Venezuela (Fernández, 2000). Fillers is one of the major additives used in natural rubber compound and has marked effect and influence on rubber materials. Fillers are particulate or fibrous materials that are used to reinforce rubber composites for enhanced physical properties (Billmeyer, 1981). In rubber industry, fillers that are commonly in use are carbon black, china clay and calcium carbonate. Carbon black is derived from petro-chemical sources but the unstable price of crude oil has led to the search for filler that are derived from other sources (Ski, 1970). The purpose of this work was to investigate the potential of using carbonized bagasse as fillers in rubber products. Several researchers have carried out work on the use of agro waste as fillers in rubber products. Osarenmwida and Ilori, 2002 investigated the use of rice husk in rubber product. They investigated the hardness, tensile strength, compression, abrasion resistance and rheological properties of product and found rice husk filler performance satisfactory. Investigation into the effect on the rheological, physico-mechanical and swelling properties of natural rubber vulcanize using coconut fibre were carried by Egwaikhide et al, 2007(a). They observed that the tensile strength increased to an optimum of 7.35MPa and hardness of product increased with increased filler loading, while percentage compression set, abrasion resistance decreased with increase filler loading. In other reports, the use fillers like cocoa pod husk, rubber seed shells (Okiemen and Imanah, 2003) , palm kernel husk Egwaikhide et al, 2007(b) and wood flour were examined. The results obtained from these studies indicated a potential for the utilization of agricultural residues as fillers in natural rubber compounds. Since bagasse, an agricultural waste is readily available in Nigeria, its use as filler in rubber product is hoped will be cheaper, increase the availability of fillers in the country and lead to the conversion of waste to wealth.

MATERIALS AND METHOD

MATERIALS
Natural rubber used is crumb which was produced by Rubber research institute (Iyanomo) near Benin City, Nigeria and was used as received. The rubber compounding chemicals such as zinc oxide, stearic acid, processing aid, N-Cyclohexylbenzylthiazyl sulphenamide (CBS), Trimethyl Quinoline (TMQ) were of commercial grades. Sugar cane was sourced from uokha village in Owan East Local Government Area of Edo State, Nigeria.

METHODS

Filler Preparation: The obtained sugar cane stalks where peeled with knife and then masticated and sun dried. The sun dried sugar cane bagasse was placed inside an oven incinerator at a temperature range of 480°C to ensure uniform and total carbonization of the bagasse. Carbonized bagasse was then ground using electric milling machine to granules and the granules was then filtered by a sieve to particle size of 600microns.
**Compounding:** The recipe used in the formulation of the natural rubber compound is given in Table 1. Mixing was carried out on a laboratory two-roll mill in accordance with the method described in the American Society for testing and materials (ASTM – D3184 – 80).

Table 1: Recipe for compounding the natural rubber mixes.

<table>
<thead>
<tr>
<th>COMPOUNDS</th>
<th>FORMULATIONS</th>
</tr>
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<tbody>
<tr>
<td>INGREDIENTS (Phr) A B C D</td>
<td></td>
</tr>
<tr>
<td>Natural Rubber (NR)</td>
<td>100 100 100 100</td>
</tr>
<tr>
<td>Stearic acid</td>
<td>2 2 2 2</td>
</tr>
<tr>
<td>Zinc Oxide</td>
<td>5 5 5 5</td>
</tr>
<tr>
<td>Sulphur</td>
<td>2 2 2 2</td>
</tr>
<tr>
<td>N-Cyclohexyl/benzyl/benzyl thiayl sulphenamide (CBS)</td>
<td>15 15 15 15</td>
</tr>
<tr>
<td>Carbonised bagasse (Filler)</td>
<td>- 10 30 50</td>
</tr>
<tr>
<td>Processing aid</td>
<td>2 2 2 2</td>
</tr>
<tr>
<td>Trimethyl Quinoline (TMQ)</td>
<td>1 1 1 1</td>
</tr>
</tbody>
</table>

**Mechanical properties**

**Hardness test:** A pocket size hardness tester was placed on sample and the indentor on the surface and then applied force on the sample by the hardness tester. The corresponding deflection of the pointer which indicate the hardness value of the sample in international Rubber Hardness Degree (IRHD) was read and recorded.

**Abrasion resistance:** Wallace Akron tester was used in accordance with BS method

\[
\text{Abrasive resistance index} = \frac{F \times 100}{t_i} \text{......... (1)}
\]

**Tensile Test:** A standard cutter was used to cut the vulcanizate rubber sheet into dumb-bell shape test piece. The thickness and width measured of the test pieces was measured and recorded. The two ends of the test piece was inserted into the jaw of the Monsanto Tensile Tester at cross-head speed of 500 mm min .when the tensometer was set-on the test piece was subject to loading until it failed. The tensile strength at break was calculated and the elongation at break.

**Compression Test:** A standard disc specimen dimension was compressed between parallel steel plates in the Wallace compression set machine for 6 hours. The difference between the original thickness of the specimen and the thickness after the test gave the compression set which is

\[
\text{Compression set} = \frac{F}{t_i} \times 100 \text{......... (2)}
\]

Where \( t_i \) is initial thickness and \( t_f \) is final thickness
The results obtained shows that tensile strength, abrasion resistance index and hardness increased as the filler loading increased. For example, when the filler loading was 10 phr, the tensile strength, abrasion resistance index and hardness were 11.80 Mpa, 50.75% and 22 IRHD respectively but when the filler loading increased to 40 phr it was 33.40 Mpa, 68.75% and 40 IRHD respectively (see fig. 1, 4 and 5). These results agree with results obtained for rice husk filler [6], coconut fibre (Egwaikhide et al, 2007(a) and palm kernel husk (Egwaikhide et al, 2007(b). The result suggests that the bagasse filler is of reinforcing nature and have inherent reinforcing potential. This is because when more filler enter the rubber matrix; the elasticity of the rubber chain is reduced resulting to a more rigid vulcanizate. The produced rubber compound may therefore be used in manufacture of moulded rubber product like shoes soles that required less stress during services life and hard casing like battery case (Morton, 1987). It was also observed that Elongation at break decreased with increase in filler loading (Fig. 2). This may be due to the adherent of the filler to the polymer phase leading to the stiffness of the polymer chain and hence limit elongation when a strain is applied (Abode, 2010). Elongation at break increase with increase cross-linking as attributed to the space between cross - linking, which put more of the stress on a relative few of the net – work chain. When a product is compressed and then allowed to relax, it will completely recovered to it original dimension, this divergence from its original form is called compression set. It was observed that the compression set decreases with increase in filler loading (see Fig.3). This is expected because as filler loading concentration increase in the polymer matrix, then the void space reduced hence, the decrease in percentage compression (Abode, 2010).

Results from Osarenmwinda and Ilori,2002 shows that the properties of natural rubber using carbon black filler were hardness (63.75 IHRD), ultimate tensile strength 51.00 Mpa, compression percentage 5.39% and abrasive resistance 59.4%. These results when compared with one obtain from this study shows carbon black filler performance slightly better than bagasse filler. For example the optimum tensile strength from fig 1 was 33.40 Mpa with the use bagasse filler. This slightly lower than tensile strength value obtain with commercial carbon black which was 51.00 Mpa obtained by Osarenmwinda and Ilori, 2002. Also the hardness and compression set using carbon black filler was 63.75 IRHD and 5.39% respectively (Osarenmwinda and Ilori,2002). When compared to results using bagasse filler which were 40 IRHD and 32.81 % respectively (Figs. 3 and 4) it was observed that carbon black was slightly better. We can conclude that carbonized bagasse filler has good potential of being used in natural rubber products.

**CONCLUSION**

The potential of carbonized bagasse, an agricultural waste as filler in natural rubber have been investigated. This work presented in this paper shows the possibility of utilizing the low cost bagasse, an agricultural waste as alternative filler material in natural rubber. Since bagasse, is readily available, its use as filler in rubber product is hoped will be cheaper, increase the availability of fillers in the country, reduce environmental pollution, create employment and lead to the conversion of waste to wealth.
REFERENCE


