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ELASTOMERIC COMPOSITIONS FOR THE PRODUCTION OF RUBBER ARTIFACTS USED IN SHOE MANUFACTURING AND CIVIL CONSTRUCTION

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ABSTRACT

Sugar cane bagasse is a common byproduct of the alcohol and sugar industries. In the present work we describe the preparation of elastomeric agglomerates containing SBR [poly(styrene-butadiene)] and bagasse or kaolin as inert filler. The experimental results and a series of laboratory and field tests show that the sugar cane bagasse agglomerate can be very appropriate and useful for practical applications, especially in the manufacture of shoe soles.

RESUMO

O bagaço de cana-de-açúcar é um subproduto comum da indústria açucareira e do álcool. O presente estudo descreve a preparação de aglomerados elastoméricos contendo SBR [poli(estireno-butadieno)] e bagaço de cana ou caulim como carga inerte. Os resultados experimentais e uma série de ensaios de laboratório e de campo mostram que o aglomerado com bagaço de cana-de-açúcar pode ter várias aplicações práticas, especialmente na fabricação de solas de sapatos.

KEYWORDS: Sugar Cane Bagasse, Elastomeric Composites, Agglomerates.

INTRODUCTION

Sugar cane bagasse has been used in many countries of the world for the manufacturing of composite agglomerated materials employed on a large scale in buildings, furniture and means of transportation[1]. It is a byproduct of the sugar and alcohol industries with a chemical composition consisting mainly of lignin and cellulose[2]. It represents about 25% of the milled or ground sugar cane and at times there is a surplus of up to 30%, since its use as fuel depends upon the energy requirements of the industrial complex[3,4,5].

Because of its physical and chemical properties, sugar cane bagasse can be used as an inert filler for elastomeric composites employed for the manufacture of rubber artifacts in the place of kaolin and carbonates[6,7]. When added to plastifying materials such as phenolic resins, it facilitates the industrial processing of the vulcanizate and improves mechanic properties such as hardeness, resistance to abrasion and to heat[7,8].

The purpose of this work is to use finely divided bagasse

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mixed with phenolic resin and incorporate it into elastomers in varying proportions. The study of the physical and mechanical properties of the different rubber composites should give some clues for the possible use of some of these new materials for the production of rubber artifacts for the shoe , furniture and construction industries.

MATERIALS AND METHODS

Sugar cane bagasse (SCB) was ground, dried and sifted to obtain fractions that were 35/60 and 60/100 Mesh. These were subsequently added to SBR elastomers of [poly(styrene-butadiene)] together with other ingredients whose composition is expressed in "parts per hundred parts of rubber" (phr). The formulations are described in Tables I and II.

TABLE I. FORMULATIONS OF RUBBER COMPOSITES.

	I (phr)	II (phr)	III (phr)
SBR 1502	100,0	100,0	100,0
Stearic Acid	2,0	2,0	2,0
Zinc Oxide	5,0	5,0	5,0
Vulkanox HS	1,0	1,0	1,0
Sicosil 45	30,0	30,0	-
Polyethylene Glycol (PEG-4000)	3,0	3,0	-
Mercaptobenzothiazol (MBT)	1,5	1,5	1,0
Diphenylguanidine (DPG)	1,5	1,5	1,0
Sulfur	2,0	2,0	2,0
Phenolic Resin	5,0	5,0	20,0
Sugar Cane Bagasse (SCB 35/60)	-	-	200,0
Sugar Cane Bagasse (SCB 60/100)	25,0	-	-
Kaolin	-	25,0	-
TOTAL	176,0	176,0	332,0

Samples of kaolin (pH=6,3 and 0,4% residue of 325 Mesh) were added to the elastomer under the same conditions as bagasse. Formulations I and II, using 25 phr of filling and 5 phr of phenolic resin, Thor MD 278, were intended for the manufacture of rubber artifacts for the shoe industry, since they gave better properties according to results already described[9,10].

Formulation III was intended for the production of new materials to be used as wood substitutes. The ingredients were homogenized in an open blender or mixer. The test samples were vulcanized at 165ºC and their mechanical and physical properties were determined using the following tests: D 2240-75 for Hardness Shore A and D,D 412-75 for Tension at Break and Elongation, D 297-77 for Hydrostatic Density, 55516 for Abrasion, 53.507 for Progressive Tear, 53.543 for Flexion and MB 26 for Tension of Flexion and the PFI Method was used for Special Abrasion. These tests have been described by ASTM/DIN. The density of the filler was determined by using a pycnometer and the determination of the volatile material was performed using the D 1817 method, described in the literature[11,12].

TABLE II. CHARACTERIZATION OF FILLERS.

Property/ Filler	Density (25°C)	Humidity (%)
SCB 35/60 Mesh	1,40	6,34
SCB 60/100 Mesh	1,40	6,12
Kaolin 200/ 325 Mesh	2,60	0,30

Field tests were performed using rubber composites in the soles of shoes used by mailmen during their regular working schedule for 25 days. Comparisons were done between soles made from sugar cane bagasse and kaolin, fiberboard, agglomerate industrially available and elastomeric agglomerate with sugar cane bagasse.

RESULTS AND DISCUSSION

As can be seen in Table II, kaolin has a density 85% higher than sugar cane bagasse. This leads to a higher hydrostatic density and lesser efficiency in volume (bulk) in terms of material processing. This means that for the same mass of composites, one containing sugar cane bagasse and the other kaolin, that with bagasse will produce a greater number of parts.

Analysis of the results summarized in Tables III and IV, compared to the compositions containing kaolin, indicates that the rubber compositions with sugar cane bagasse have a higher hardness and resistance to progressive tear.

On the other hand, hydrostatic density and abrasion exhibit lower values as does resistance to flexion. This means that rubber compositions with sugar cane bagasse have the characteristics necessary for the use in shoe soles production. The field tests showed that soles of shoes used by mailmen and made with elastomeric compositions containing sugar cane bagasse met the requirements. These results are in agreement with previous studies described by our group[10] and show that the blending of phenolic resins and sugar cane bagasse is satisfactory and reinforces the desired properties of the compositions.

TABLE III. MECHANICAL PROPERTIES OF RUBBER COMPOSITES.

Property	Composition	Value Obtained
Hardness Shore A	SCB	75
	Kaolin	68
Elongetion(%)	SCB	520
	Kaolin	600
Tension at Break (MPa)	SCB	9,3
	Kaolin	13,6
Hydrostatic Density (g/cm^3)	SCB	1,15
	Kaolin	1,21
Abrasion ($mm^3/40m$)	SCB	232
	Kaolin	262

TABLE IV. SPECIFIC PROPERTIES EVALUATED FOR SHOE MANUFACTURING.

Test	Especification	Composition	Value Obtained
Progressive Tear	8,0 N/mm	SCB	14,4 N/mm
		Kaolin	10,2 N/mm
Flexion	Maximum Progression 4 mm	SCB	passes test
		Kaolin	passes test
Special Abrasion PFI	Parameter for outdoor shoes 0,8 mm	SCB	0,33 mm
		Kaolin	0,42 mm

Ther are specific interactions at the elastomer-filler interface such as covalent and hydrogen bonds and these are well known. The effect of vulcanizing agents such as sulfur or phenolic resins on these interactions have also been described[7,13]. These compounds, as well as the reinforcing filler tend to form cross-linking between the polymer chains. Figure 1 illustrates the relationship between the density of crosslinking or reticulation, nature of polymer and filler, and some properties of the vulcanizate[7].

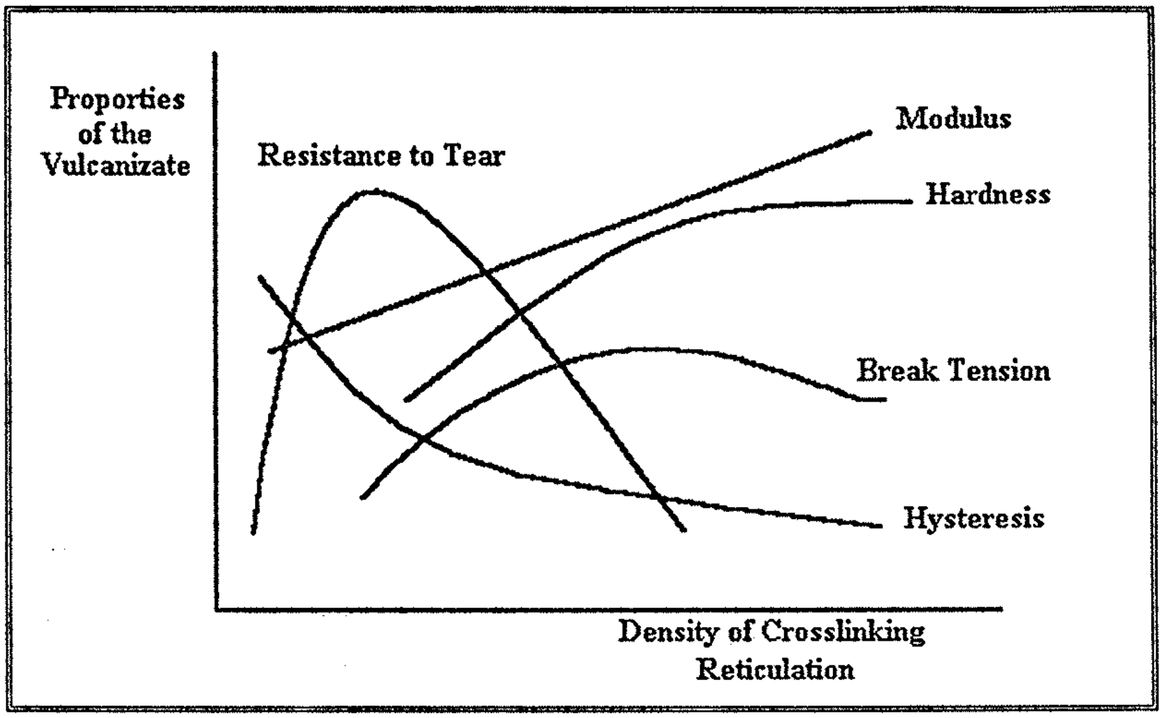

FIGURE 1. RELATIONSHIP BETWEEN PROPERTIES OF THE VULCANIZATE AND INTENSITY OF RETICULATION.

When compared to fiberboard and agglomerates commercially available, the agglomerated elastomer containing sugar cane bagasse has a higher flexibility. It deforms under a flexion tension of 1,5 MPa without tear and it returns to the original position at the end of the test. The other materials used in this study break under the flexion tension conditions described in Table V. The elastomeric agglomerate may be cut, nailed or

TABLE V. MECHANICAL PROPERTIES OF AGGLOMERATE.

Test	Commercial Fiberboard	Commercial Agglomerate	Sugar Cane Bagasse Elastomers
Flexion Tension (MPa)	6,1	2,0	1,5
Hardness Shore D	60	60	40

secured with screws with a performance similar to that of wood. Its hardness depends on the amount of phenolic resin and of sugar cane bagasse present in the composition and it may reach Hardness Shore 40 values similar to those of agglomerate and fiberboard.

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