Scientific Research Publishing

Open Journal of Composite Materials, 2023, 13, 47-55
https://www.scirp.org/journal/ojcm
ISSN Online: 2164-5655
ISSN Print: 2164-5612

Mechanical Characterization of Rubber Latex-Based Carpets (*Hevea bresiliensis*): Influence of Rubber Latex Content and Fiber Fabrics (Cotton and Mosquito Nets) on Wear Resistance of Rubber Latex-Based Carpets

Assoumou Joseph Yomanfo, Obre Sery Paul Jolissaint, Edjikémé Emeruwa, Maméry Adama Serifou

Soil, Water and Geomaterials Laboratory (UFR-STRM), Felix Houphouet-Boigny University, Abidjan, Ivory Coast
Email: assoumoujosephyomanfo@yahoo.fr

How to cite this paper: Yomanfo, A.J., Jolissaint, O.S.P., Emeruwa, E. and Serifou, M.A. (2023) Mechanical Characterization of Rubber Latex-Based Carpets (*Hevea bresiliensis*): Influence of Rubber Latex Content and Fiber Fabrics (Cotton and Mosquito Nets) on Wear Resistance of Rubber Latex-Based Carpets. *Open Journal of Composite Materials*, **13**, 47-55.
https://doi.org/10.4236/ojcm.2023.133004

Received: April 11, 2023
Accepted: May 28, 2023
Published: May 31, 2023

Abstract

This work focuses on the development of carpets from sand, fabrics of cotton fiber and mosquito nets and rubber latex. Following a study on the choice of the best formulations, the quantity of rubber latex used for shaping varies between 14% and 18% (latex/sand + latex ratio) for the carpet with the fabric of mosquito nets and between 16% and 18% for the one made with the fabric of cotton fiber. Thus, with a mixture of sand, fiber fabrics (cotton and mosquito nets) and rubber latex, carpets were developed. In addition, the wear test carried out on these samples indicates that it is possible to produce carpets with the new material made of rubber sand and latex: SABLATEX At room temperature. Following the characterization test, it resorts to only 16% latex with cotton fiber fabric, allowing to have carpets with good mechanical characteristics.

Keywords

Carpet, Rubber Latex, Wear Test, Latex Content, Fiber Fabrics

1. Introduction

Carpets are types of coating intended for installation on all types of supports. They are of variable shapes and are used for various purposes (carpets, playgrounds, etc.).

Carpets are mostly made of wool and rarely silk [1]. Today, carpets are at the heart of technological advances despite a history dating back to antiquity [2].

Their manufacture is difficult and poses problems (eye aches, equipment, time, physical effort) for manufacturers. In addition, they are manufactured from synthetic materials that emit volatile organic compounds indoors often they become sources of many diseases (cancer for example). This study was considered with the aim of developing a process for making 100% natural carpet. This work aims to develop carpets by an environmentally friendly process from readily available raw materials. It is innovative because no researcher has carried out relevant research in this field.

2. Materials and Method

2.1. Presentation and Characteristics of Raw Materials

Sand, fiber fabrics (cotton and mosquito nets) and rubber latex are the raw materials used to make carpets. These raw materials were chosen because of their availability and the environmental damage caused by net fiber fabrics. The sand comes from a quarry located in the municipality of Port-Bouët. It is taken from the Ébrié lagoon using a dredge. This sand has been subjected to particle size and mineralogical analysis. It is a white sand composed of quartz and feldspar grains whose particles of more than 500 µm have been removed to give the carpets a fine texture.

It is used as a binder. Rubber latex coagulates in the open air in a short time, so to keep it liquid longer, we add ammonia in a ratio of 0.04. The fiber was collected in the commune of ABOBO and ANYAMA. Observations with an optical microscope revealed that the surface of the net fiber fabric is smooth with well-individualized woven fiber. Cotton is made of fibrils. These line the surface of the fiber (Figure 1).

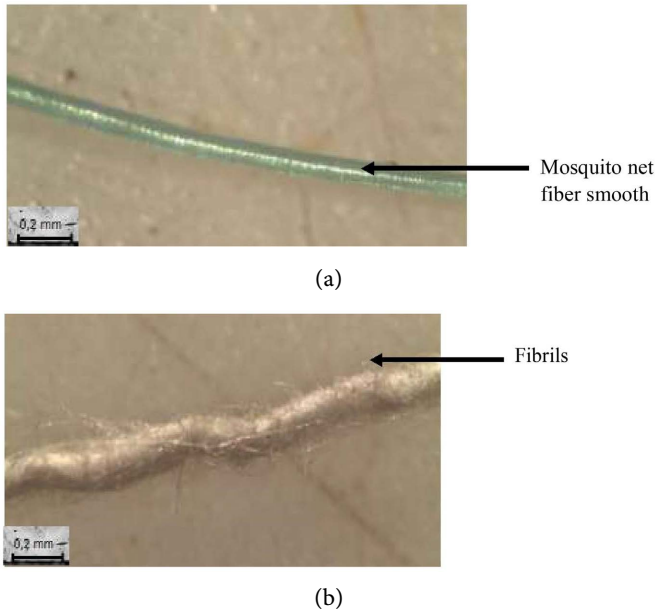

Figure 1. Structure of fiber fabrics seen on the surface (magnification × 30); (a) Net fiber fabric; (b) Woven fabrics of cotton fiber.

2.2. Carpet Development Methods

The carpets were made in several stages. The sand to the 500 μm diameter sieve is mixed with liquid latex at varying levels between 10 and 20% (Table 1). The production of the carpets requires a mould of dimensions (e = thickness × l = width × L = length): 2.5 mm × 160 mm × 80 mm. The fiber was cut to the dimensions of the mould. The latex/sand + latex ratio is presented in Table 1.

Rubber latex is added to the sand and then the mixture is made. This mixture is done with a mixer for 30 seconds to obtain a homogeneous mixture. After mixing, a material called SABLATEX is obtained. This material is then cast into a mould.

The moulding consists first of the laying of fiber fabrics in the mould of dimension (e = thickness × l = width × L = length): 2.5 mm × 160 mm × 80 mm. Then the addition of the sand mixture is poured into the mould followed by the laying of the second fiber fabric in the mould and demoulding.

Finally, after demoulding, the sample is dried for 7 days in an aerated room at room temperature.

2.3. Carpet Characterization Method: Carpet Wear

Before you begin to format your paper, first write and save the content as a separate text surface. This form of wear manifests itself in polishing, scratching, micro-ploughing, and the removal of particles. The procedure used in this test was to immerse the carpets in water for 24 hours and then dry them in the open air to a constant mass.

Before each test, the samples are weighed. We then have the mass Mi and the dimensions of the surfaces. Then, each exterior is subjected to a cycle of 25 brushings. A brushing cycle is a round trip of the scraper paper (GXK51-P80) over the entire length of the carpet while ensuring that more than half of the paper remains permanently in contact with the surface of the carpet. For the measurement of wear, we have used the device in Figure 2. At the end of brushing, the surfaces are thoroughly cleaned to remove any loose parts and the carpet is then weighed; we obtain a mass Mf. The balance has an accuracy of 0.1 g.

Table 1. Formulation of mixtures.

Sand (g)	Latex (g)	Latex/sand + latex ratio (%)
900	100	10
880	120	12
860	140	14
840	160	16
820	180	18
800	200	20

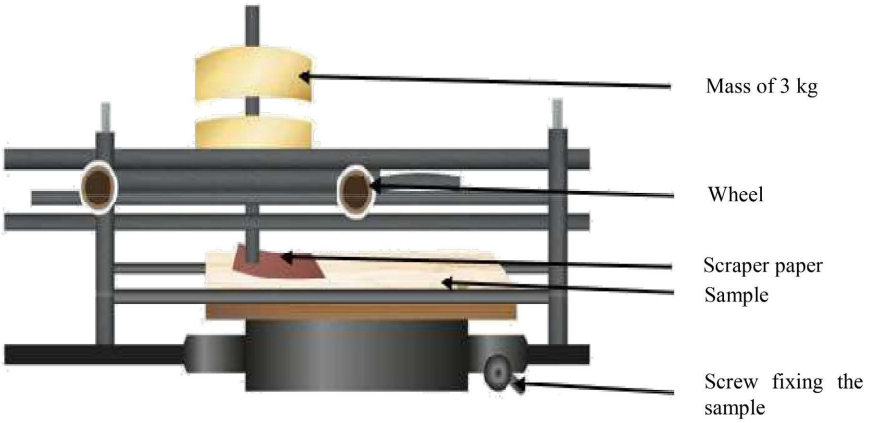

Figure 2. Wear measurement device [3].

Wear is given by the formula:

$$\mu = \left(M_i - M_f\right) / M_f \quad (1)$$

where μ is the wear expressed in g/cm^2;

M_i is the mass (g) of the dry sample before brushing;

M_f is the mass (g) of the sample after brushing and;

S_f is the brushed surface (cm^2).

3. Results and Discussion

Figure 3 below shows the results of the wear variation as a function of the latex content for carpets with cotton fiber and mosquito net fabrics.

These curves show that wear decreases when the latex content increases, regardless of the type of fiber tissue.

Indeed, for latex contents varying:

- From 14% to 16%, wear slowly decreases (0.033; 0.017 g/cm^2) for the carpet with the net fiber fabric.

Indeed, at these contents, the latex content is low and does not manage to coat the particles of sand as well as the fiber tissue. The set of latex-sand and net fiber are not consolidated. When brushing, it will have a loss of carpet mass and take-off of fiber fabric (**Figure 4(b)**). We also note that the mass loss at these levels was observed by [4] [5] [6].

From 16% to 18%, wear drops with a strong variation of 0.017 to 0.07 g/cm^2 for the carpet with the mosquito net fiber fabric and from 0.08 to 0.02 g/cm^2 for the carpet with the cotton fabric.

Drop in wear resistance between 16% and 18% for carpets with both types of fiber fabrics (**Figure 4(c)** may be explained by the fact that the amount of latex becomes sufficient to strengthen the bonds between the sand particles and the latex as well as the fiber tissues. Thus, when brushing, the mass loss of carpets is very low.

It therefore decreases with the increase in latex content. The latex, thanks to its binding properties, coats the sand particles to form a structure consistent

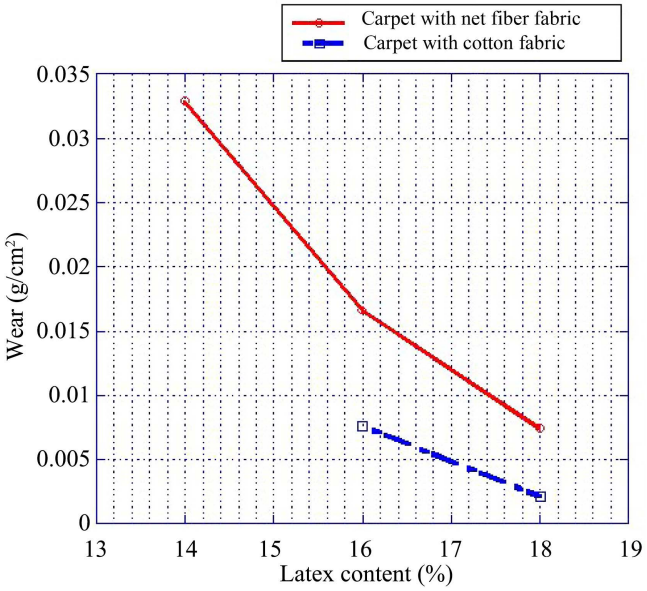

Figure 3. Wear resistance curves as a function of the latex content of carpets.

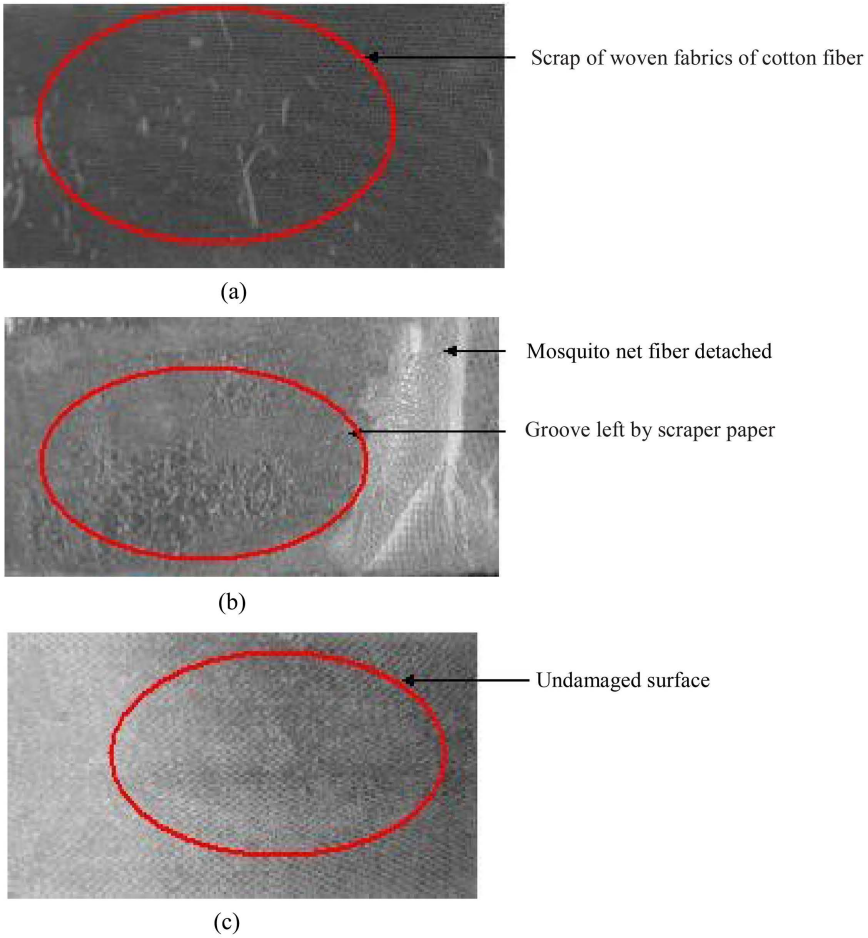

Figure 4. Influence of latex content on carpet wear. (a) 16 and 18% latex mats with cotton fiber fabric; (b) 14% latex mats with mosquito net fiber fabric; (c) 16 and 18% latex mats with mosquito net fiber fabric.

with the fiber fabrics. It is the progressive formation of this structure that is the basis for the reduction of surface erosion of carpets. When the latex content increases, there is a lot of binder on the carpet. The contact zones between the latex, the fiber fabrics and the sand become more solid and the particles are more difficult to tear away, hence the decrease in wear rate. Our results are consistent with those of [4] [5] [6]. However, it should be noted that the surface erosion of carpets with cotton fiber fabric is much lower than that of carpets with mosquito net fabric. The bonding mode and the fiber tissue arrangement mode are not the same. Indeed, cotton fiber fabrics are in the form of a network and nodes. When brushing the knots give the carpet a certain solidity. These nodes form a network of fibers. This is the cause of the different meshes on the surface of the fiber fabrics. These observations suggest that the mesh of the cotton fiber fabric has many nodes as that of the net fiber fabric. However, a structure with many meshes will be very solid against friction. The wear resistance values are 0.032 to 0.017 g/cm^2 and 0.017 to 0.07 g/cm^2 for the carpet with the net fiber fabric and 0.08 to 0.02 g/cm^2 for carpet with cotton fabric when increasing the latex content are lower than those obtained in the work of [4] and [5] This means that carpets with fiber fabric have good wear resistance. This is due to the addition of fiber tissues. The results of the work of [6]. Showed that between 13% and 16%, the wear dropped with a strong variation and increased from 0.52 to 0.05 g/cm^2 respectively for 8 mm and 0 mm thick carpets, 25 to 0.03 g/cm^2 for those 6 mm thick. The wear resistance obtained by these authors is superior to the results of this study on wear resistance. Fiber fabrics, therefore, improve the mechanical properties of carpets.

In fact, the wear resistance values (0.032 to 0.017 g/cm^2 and 0.017 to 0.07 g/cm^2) for the carpet with the net fiber fabric and (from 0.08 to 0.02 g/cm^2) for carpet with cotton fabric when increasing the latex content are greater than those of 0.52 to 0.05 g/cm^2 for carpets of 8 mm thickness and 0.25 to 0.03 g/cm^2 for carpets of 6 mm thickness obtained in [6] with latex contents ranging from 13% to 16%.

For a better understanding of the effect of latex on cohesion, observations with an optical microscope were made on the surface of the carpets. **Figure 5** shows microscopic images observed on the surface of carpets containing 14% and 18% latex.

By linking these images (**Figure 5**) we notice that:

For carpets made with 14% latex content, the binder is deposited in places between the sand grains and in some areas, we see only unpainted sand grains. As a result, there is not enough binder to coat the sand particles and fabric with mosquito net fiber (**Figure 5(a)**). This explains the strong surface erosion of carpets with the net fiber fabric.

At this content, the carpet with the cotton fiber fabric could not be made. Indeed, there is no adhesion between the fabric of cotton fiber and the sablatex material. The poor adhesion between the fabric of cotton fiber and the sablatex

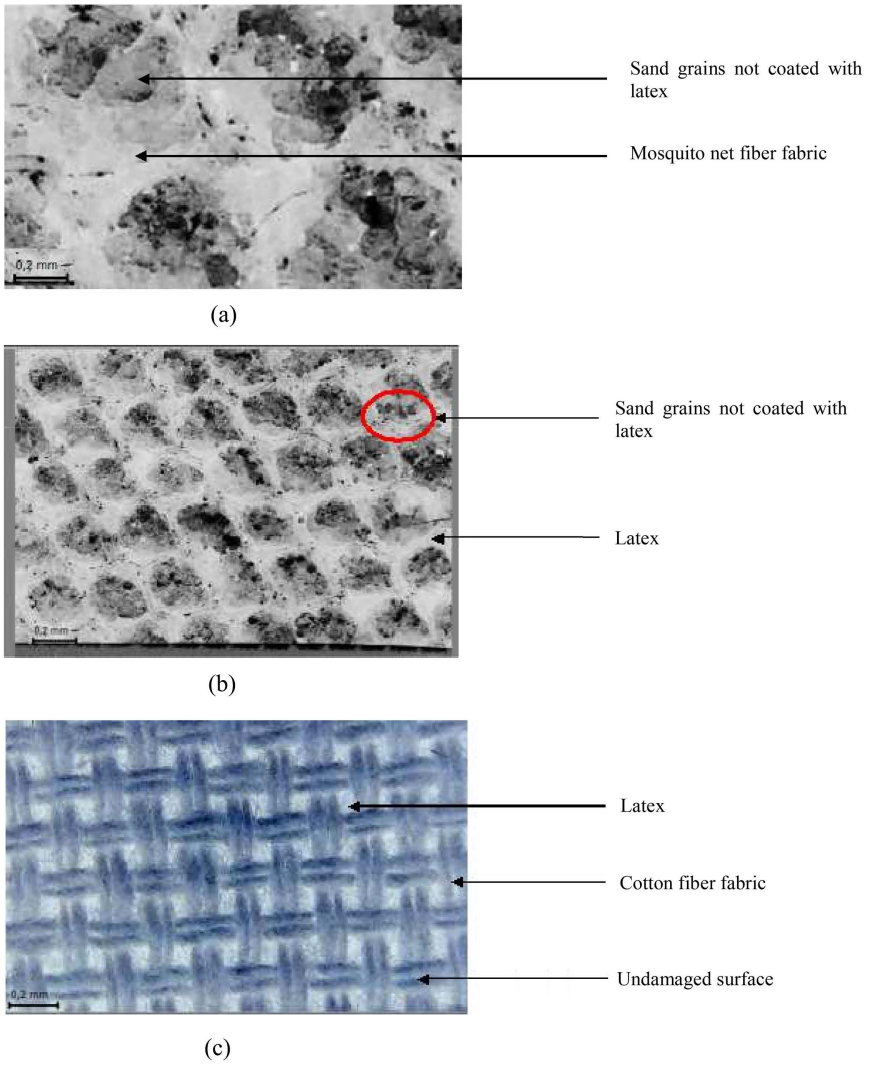

Figure 5. Microscopic observation of the surface of the mats. (a) 14% latex mats with mosquito net fiber fabric; (b) 18% latex mats with mosquito net fiber fabric; (c) 16 and 18% latex mats with cotton fiber fabric.

material is from the lack of binder between the various constituents of the material and that of the cotton fiber fabrics.

Cotton fabric fiber is a highly hydrophilic bio-based material. The binder present in the sablatex material is absorbed by the cotton fiber fabrics. Once the rubber latex is absorbed, the sand grains and the fiber fabrics can no longer join together, hence the cracking observed with the naked eye in the sablatex material.

For the latex content of 16% and 18%, the latex is found between sand grains as well as on their surfaces and fiber fabrics. It is therefore sufficient to coat sand particles and fiber fabrics of all kinds (**Figure 4(a)** and **Figure 4(c)**). Hence the low surface erosion of carpets with both types of fiber fabrics is used. These results reflect the work of [5]. Finally, the latex, thanks to its binding properties, coats the sand particles and the fibers to form a coherent

structure. The sand particles contained in the sand for the carpet with the fiber fabric of net not being well encased in the matrix when brushing there will be a significant loss of mass (**Figure 4(b)**).

In short, the study of the mechanical behavior of rubber latex stabilized carpets shows that they are influenced by the latex content and the addition of fiber fabrics.

The carpets are coatings, they will be subjected to harsh stresses, therefore, we will advise the carpet elaborated with fabrics of cotton fiber with 18% latex for any use for the study of the mechanical behavior of the carpets.

In sum, the study of the mechanical behaviour of rubber latex-stabilized carpets shows that these are influenced by the latex content and the addition of fiber fabric.

Carpets are coverings, they will be subjected to heavy stresses, and therefore we recommend the carpet made with cotton fiber fabric with 18% latex for any use in the study of the mechanical behaviour of carpets.

4. Conclusions

At the end of our study, we can say that we have just developed a new type or carpet made with latex. In order to improve its mechanical properties, fiber fabric reinforcements have been added. The wear decreases from 0.032 to 0.017 g/cm^2 for the carpet with the mosquito net fiber fabric and from 0.08 to 0.02 g/cm^2 for the carpet with the cotton fabric when the latex content increases.

This work has enabled us to propose a new process for using rubber latex in the production of carpets.

The presence of rubber latex in this study meets two needs: it is capacity to be used as a binder thanks to its sticky power and its properties of softness, elasticity, flexibility and resistance. There is a decrease in wear with increasing latex content. Wear tends to cancel out at 18% latex content.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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