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Effects of Extraction Techniques on the Mechanical Properties of Sisal Fibers

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ABSTRACT

The economic and ecological benefits of composites reinforced with plant fibres are encouraging the development of these materials. Indeed, the nature of the fibres encourages the promotion of an environmentally-friendly industry. However, mechanical and chemical treatments are required to extract the plant fibres and improve their adhesion and dispersion in the matrix. The main aim of this study is to analyse the properties of natural sisal fibres. Following simulations of the tensile test, it is possible to determine the impact of the fibre extraction method on its mechanical characteristics.

Keywords: Plant fibres, Extraction, Mechanical Properties, Sisal

1 Introduction

Industries and institutions around the world are showing increasing interest in plant fibres because of their mechanical strength, low weight, biodegradability and low cost [1]. Since 2002, plant fibre production has been insufficient to meet growing demand [2,3]. Several authors are developing plant fibres for composite materials. However, extraction is a major obstacle, particularly for long fibres. Various extraction methods exist, including mechanical decortication, sea water retting, soil burial and chemical extraction with sulphur. This study focuses on the influence of sisal agave extraction methods on its mechanical properties, using two techniques: water retting and mechanical extraction.

2 Research Methodology and experimental

2.1 presentation of fibres:

Sisal is the name given to the fibres from the leaves of certain agaves, in particular Agave sisalana. The fibres are about 1 metre long and have a diameter of 0.2-0.4 mm.

2.2 Fibre extraction::

- Organic retting

Biological retting involves immersing the sisal leaves in a closed drum filled with water for 15 to 21 days, at an ambient temperature of around 25°C. This method is designed to accelerate biodegradation and facilitate subsequent fibre extraction. The fibres are then rinsed, washed with water, air-dried and brushed.

- Mechanical retting

Mechanical retting, also known as lamination, is a process that involves compressing the blades of sisal fibre between two cylinders in order to remove the outer covering of the plant and free the fibres. The fibres are then rinsed with water and air-dried.

2.3 Fibre testing:

As part of our research into fibres, we used an optical microscope to determine the diameter of the fibres. The images obtained revealed a variation in fibre diameter. For our study, an average diameter of 250 µm was used for the rest of the calculations. We used a Zwick/Roell tensile testing machine (ASTM D3822) to

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test the sisal fibres. A specific protocol was used to fix the fibres, which were then loaded at a constant speed. The forces were measured using a load cell. This tensile test protocol enabled us to determine the average stresses and Young's moduli of the different sisal fibres.

Figure1: Organic retting

Figure2: Mechanical retting

3 Results and Discussion

3.1 Tensile behaviour of Sisal fibres

The two illustrations show the appearance of the tensile curves obtained from the stress-elongation in 10 fibres tested. All the curves first show permanent elastic deformation, then from a certain elongation, a different plastic deformation is obtained. It is possible to make a sharp transition, leading to rupture, which makes it possible to define the maximum stress.

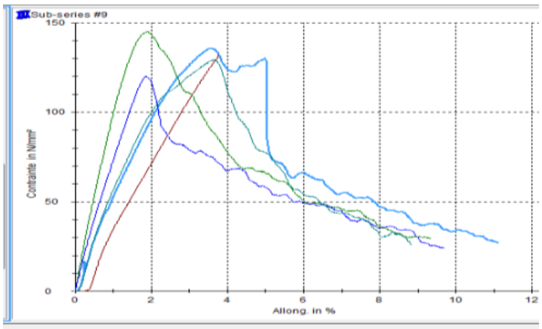

Figure3: Rouissage biologique

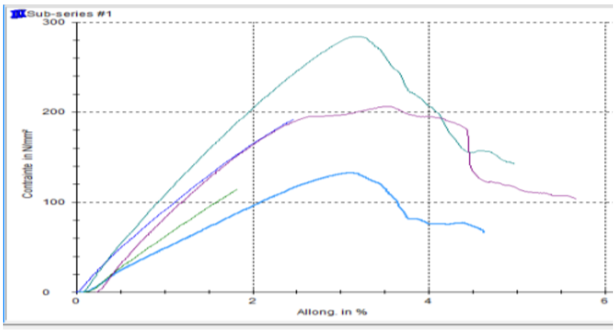

Figure4: Rouissage mécanique

3-2- Mechanical properties of the fibre

The values of the mechanical characteristics in tension (stress in N/mm^2, strain in %) are shown in Table 1. It can be seen that mechanically extracted fibers have a higher maximum stress, while those extracted by water retting have a higher stress at break.

Table 1: Mechanical properties of fibers

TESTS	Mechanical rolling			Organic Roeing		
	σ (MPA)	ε (%)	E (MPA)	σ (MPA)	ε (%)	E (MPA)
1	187.22	12.46	37.39	66.35	4.62	132.85
2	282.11	9.86	56.36	114.80	1.83	114.80
3	194.99	12.01	8.21	192.57	2.47	192.57
4	187.07	13.05	38.96	142.20	4.98	284.25
5	135.70	11.61	8.21	103.17	5.67	206.34

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These results highlight significant differences. Biological retting methods allow better separation of the fibres from the woody core, thereby reducing the mechanical load. Although fibres obtained by biological retting require more careful handling, they offer superior quality suitable for a variety of applications.

4 Conclusions

In conclusion, the study reveals that the different extraction techniques, whether mechanical or biological, have a significant influence on the mechanical quality of plant fibres. These results underline the crucial importance of choosing the appropriate extraction method according to the mechanical characteristics required for a given application.

Specifically, mechanically extracted fibres have a higher maximum stress, while those obtained by biological retting have a better breaking strength. These findings highlight the advantages and disadvantages of each method, offering ways of optimising plant fibre production according to the specific needs of industries and end applications.

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