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Study of Some Properties of the Esparto Grass Fiber Waste (ALFA Fiber)

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ABSTRACT

Natural fibers are used in many fields such us textile, technical or medical applications. They presented multiple characteristics and even the fiber waste can be used efficiently. In this survey, we opted to measure some esparto fiber waste properties in order to determine their potential use. The studied waste fibers were obtained from a chemical extraction and mechanical one using a Shirley Analyser. To characterise these fibers, some tests were made like crystallinity rate, morphological structure and absorbent properties (absorbent capacity and retention). Meanwhile a comparison between the fiber waste properties and chemical extracted esparto fibers has been investigated.

Keywords: absorption capacity, alfa fiber waste, crystallinity, extraction, retention

I. Introduction

In addition to their multiple uses, natural fibers have shown many efficient properties such us heaviness, resistance or flexibility which give them a wide ranges of applications in textile field. In fact they are recyclable and nature-friendly and nowadays they are exploited in automobile and medical applications. In this perspective, we are interested in esparto fiber which confirmed its application in filtration domain (Ben Maraoug, 2009) and composite materials (Ghali 2006, Paiva 2006). Esparto fiber can be found in different states: technical and long fibers which have a good resistance (Ben Brahim 2007) or ultimate which are fine and short and in this case they can provide an absorbent potential to water (Bessadok 2007) or colorants (Ben Marzoug 2009).

This depends on the extraction method: In our previous study (Sayeb 2008), we optimized the extraction process of these fibers to obtain ultimate cellulosic fibers. A mixed process was used which combined sodium hydroxide extraction process and hydrogen peroxide bleaching process (Ben Marzoug 2008).

The mechanical extraction enables the extraction of technical fibers often used in composite materials (Msahli 2002, Chaabouni 2005), non-woven fabrications and also in blends. In this study, we attempted to characterise the esparto fiber waste obtained from a chemical extraction using sodium hydroxide then sodium hypochlorite. The characterisation was based on the measurement of the crystallinity rate, the morphological structure and the absorbent properties. A comparison between these fibers properties and the ultimate obtained using mixed

process has also been made in order to detect the effect of the Shirley Analyser.

II. Experimental

Material characteristics

The studied fiber is an esparto fiber waste obtained from a mechanical extraction using the Shirley Analyser. These fibers have already been extracted chemically with a sodium hydroxide (120 g/L) at 100 ° C during 2 hours and bleached with sodium hypochloride (12 g/L) at 60 ° C during 1 hour. In this case the obtained fibers are linked with lignin and hemicelluloses substances. The chemically treated fibers underwent a mechanical action by fine needles to separate fibers more efficiently. But this caused damages to fibers and produce very short fibers which are considered as waste fibers. The fibers were released and the waste was recovered. Waste fibers, however, are too short to be used in non-woven applications. That's why they can be mixed with long fibers for textile applications.

Waste fibers are compared to ultimate fibers extracted by combined method using sodium hydroxide and hydrogen peroxide. Indeed the cellulosic esparto fibres used in this work were extracted using a method containing 30 g/l of sodium hydroxide, 35 ml/L of hydrogen peroxide 3 g/L of wetting agent (Subitol LSN, BEZEMA) and 25 mL/L of stabilizer of hydrogen peroxide (Contavan GAL). Fibres were treated under pressure (1,5 bars) at a temperature of 90 °C for 90 minutes.

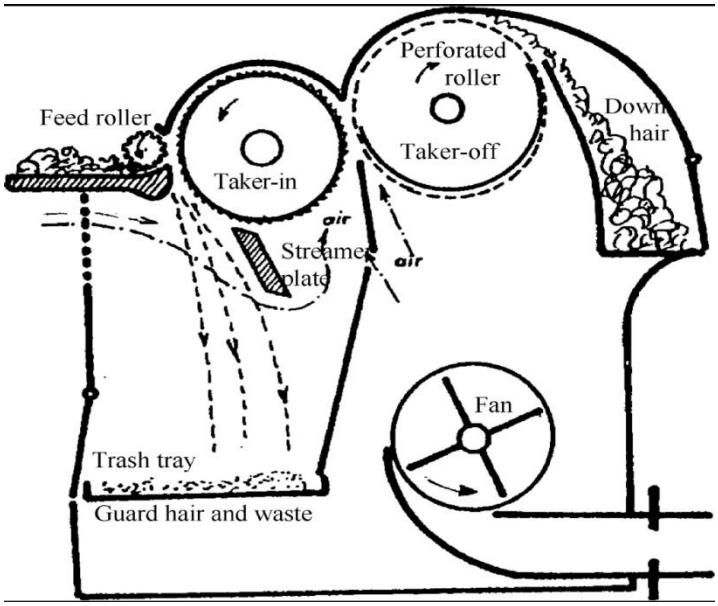


Figure 1. Schematic diagram of the Shirley Analyser

The Shirley Analyser uses a cleaning technique combining mechanical and airflow actions as follows:

- Esparto fibers are taken by feed roller to be presented to the following parts of the machine.
- The taken-in with the help of its needles opens the mass of the fibers so that it can be cleaned later in the machine.
- A variable airflow separates used fibers and dust and trash by the use of performed roller.
- Finally, the guard fibers and waste are collected in the trash tray and used fibers are recovered in the fibers box.

Test characterisations

To determine the esparto waste properties some tests were conducted. These tests are:

- *Morphology:* the microscopeak structure of esparto fiber waste was obtained by Scanning Electron Microscopy (SEM) (XL30 ESEM type peaktures). The electron microscope was used at low vacuum and a load neutralization pressure equal to 1.3 10^{-4} mbar. A sample of fibers was chosen and analysed using SEM.

- *Crystallinity rate measurement*: crystallinity rate measures the percentage of arranged and aligned macromolecular chains in a fiber structure. In order to assess the influence of the mechanical treatments caused by the A Shirley analyser on fiber crystallinity, X-ray diffractograms analysis were applied. X-ray diffractograms were obtained with a panalytical X'Pert PRO MPD diffractometer, having a X-ray tube producing monochromatic Cu Kα radiation (λ = 1.789 A°). The study of crystallinity was based on the method proposed by Nelson and O'Connor (1964). Empirically, diffraction peak heights at reflection of (002) (2θ= 26 º) (crystallinity) and peak heights at 2θ= 18.5º (amorphous zone) were used to determine crystallinity percentage.

$$\text{Cristallinity} \quad (\%) = \frac{I_{002} - I_{am}}{I_{002}} \times 100 \quad (1)$$

Lignin rate

This measurement was achieved according to Yochihara (1984) method which is Klason modified method. The physicochemical properties studied through these control tests are parameters which can reveal absorption or retention capacities: crystallinity rate was studied to have an idea about the structure of the fibers 'the small size and imperfect packing on microfibrils' and thus get information about absorbency potential.

Absorption and retention capacities are linked to hydrophilic groups and amorphous zones.
It is worth mentioning that the mechanical treatment exerted a random effect and produced an incomplete separation. The chemical treatment, however, attacked the chemical group leading to a total separation.

Absorption capacity and retention measurement

The absorption capacity and retention are defined below:
- Total absorbency measures the liquid quantity remained in the material after a time of impregnation and draining.
- The retention measures the liquid quantity that is still linked to the fiber after sample centrifugation. The sample was previously impregnated and drained.

These tests were realized according to:
– STN2: 117/87 standards for total absorbency and retention measurement.
– STN2: 138/90 standards for strike through measurement.

Fibrous mass was overcome by a non woven and then it was weighted and immersed in a liquid test solution (0.9 % NaCl solution at ambient temperature)

III. Results and Discussion:

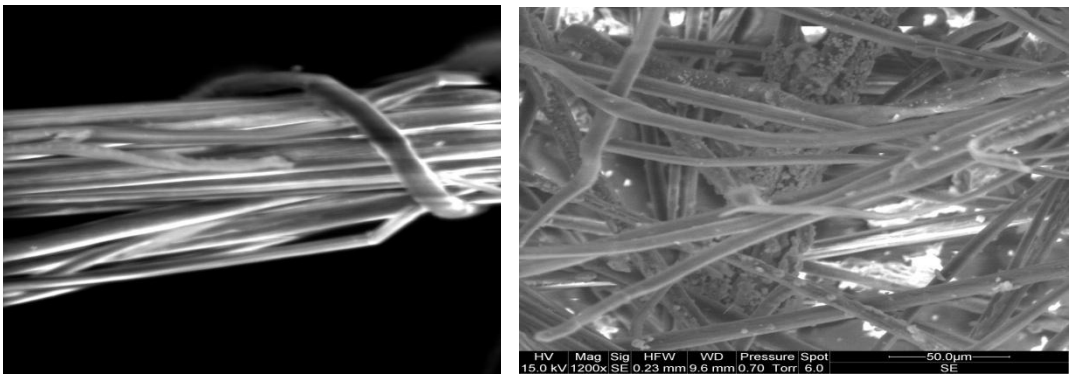
Morphology

Studies of morphologic characteristics which, can ensure a comparison between different extraction methods, provide more information about the surface. In addition, thanks to image treatment, the fiber diameter can be evaluated.

Figure 2a illustrates a treated sample with 35 ml/L of hydrogen peroxide at 35 % and 30 g/L of sodium hydroxide and demonstrates that fibers are totally separated. This figure also reveals that there is no lignin material on the surface of fibers.

Figure 2b illustrates waste esparto fibers and shows that fibers still contain substance of lignin. Besides, we can note that the two figures depict the same diameter of fiber (ultimate and waste fibers).

This finding confirms that waste fibers can be exploited because of their fineness. Indeed, fine fiber has an important specific surface and can absorb a significant amount of liquids. The presented result also proved that this kind of fiber is considered interesting property.



(a) (b)

Figure 2. Morphologic images

Crystallinity rate measurement

Surface state of fiber is a fundamental characteristic which determines liquid contact, however it can not define the absorption capacity. The crystallinty rate is measured to study the microstructure of the fiber which is intimately linked to the absorption capacity property.

Fiber waste present a difference with a peak at 38° (figure 3). Indeed this peak exists in the case of the waste fibers which mean that the microstructure of this fiber is different. So, ultimate fiber is composed by one component which is cellulose. This result proves that waste fibers contain hemicelluloses and lignin substances. We also note that those fibers have a lower peak intensity compared to fibers extracted with mixed process. This peak is linked to crystallinity.

Peak at 18.5 is linked to amorphous zone. This peak is divided into two peaks in the case of waste fibers. This result demonstrates microstructure difference.

Crystallinity rate of fiber waste is about 67 %. Nevertheless it is about 70 % for mixed process extracted fiber.

Lignin and hemicellulose are more amorphous than cellulose (Flby 2004), but aamorphous zones offer more free volume which can store more water but these substances have no more absorbent chemical groups.

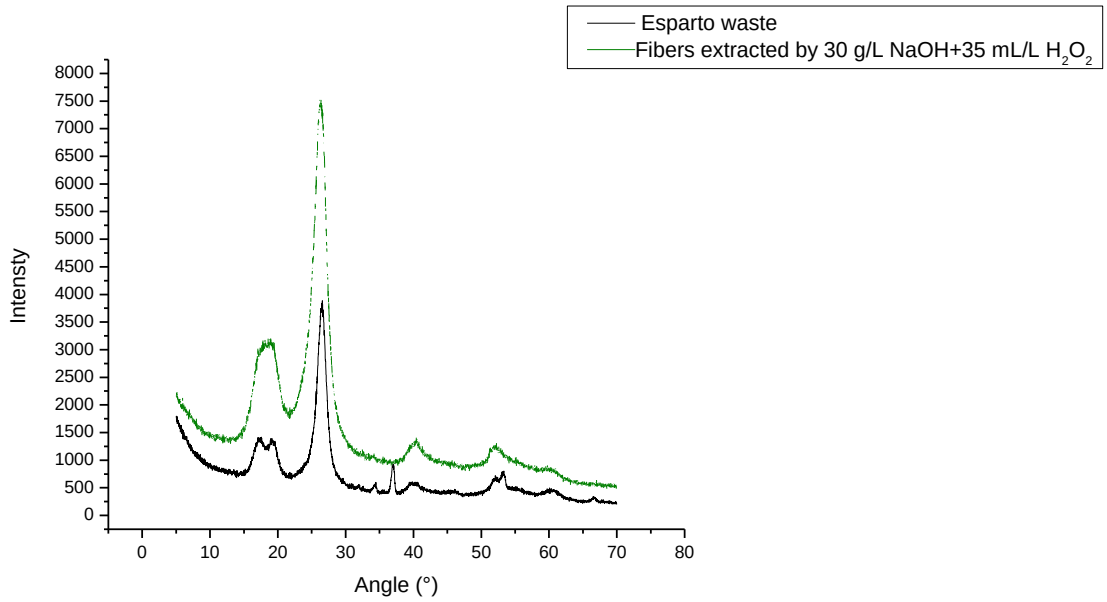


Figure 3. Crystallinity measurement

Lignin rate

Evaluation of lignin rate for fiber waste is about 11 %, while this rate for mixed process extracted fiber is less than 1 %. In consequence, this parameter can affect the wettability and fiber absorption. Indeed this product is hydrophobic substance but is more amorphous than cellulose. So it affects adsorption and absorption of water. It does not allow the adsorption process but when water penetrates into the fiber the retention improves.

Absorption capacity and retention measurement

Three measurement tests were conducted and the mean peak was therefore calculated. We find a mean value of 10,8 g/g in the case of waste fibers which is quite superior than absorption capacity of fluff pulp usually used in hygenic product (Carlos 2007, Colin 2003). But absorption capacity of ultimate cellulosic fibers can be superior to 13 g/g. This difference is explained by the existence of lignin substances which is a hydrophobic component.

Concerning the retention value, however it is still equal to fluff pulp one and the value does not exceed 0.9 g/g in the case of waste fibers. But the retention of cellulosic fibers can exceed 1.2 g/g. Retention capacity is not so important. This result is explained by small amorphous zone in the two kinds of fibers which is quite equal to 30 %.

This work demonstrates that esparto fibers at different states (waste fibers or cellulosic fibers) have a significant absorption and retention capacities. This work confirms that esparto fiber is an interesting product which can be used in filtration domains or in hygienic products.

IV. Conclusions

In other studies, many characteristics of ultimate esparto fibers extracted with combined method are investigated. This method is confirmed to give a total separation at adequate quantities of sodium hydroxide and hydrogen peroxide. The obtained fibers are so fine and short. The wastes produced by mechanical extraction

are also short and fine and can offer some potential of liquid absorption. In this study, a comparison between the two kinds of fiber was made.

Comparing the mixed process extracted fiber with waste fibers, we can notice that homogeneity is fulfilled, no damage is caused and a short treatment time is given. The rate of lignin is evaluated; it is inferior to 1 %.

This result was obtained under particular conditions using a combined. However, in the case of waste fibers, the rate of lignin was so high and equal to 11 %. The crystallinity index is given and it is equal to 70 % for fibers extracted using the combined method however this index is equal to 67 % for waste fibers.

Besides, the fiber wastes still offer a certain potential of liquid absorption and may be used as an absorbent fiber in hygienic products even in blends with fuff pulp.

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