Natalia Sedelnik

Institute of Natural Fibres
ul. Wojska Polskiego 71 b
60-630 Poznań, Poland
e-mail: natalia@infoglob.com

Properties of Hemp Fibre Cottonised by Biological Modification of Hemp Hackling Noils

Abstract
This paper presents the effect of biologically modifying hemp hackling noil on the physical/mechanical and chemical properties of the hemp fibre. As a result of treating hemp-hackling noil with the Polish enzymatic preparation Pektopol, the technical fibre bundles undergo separation into smaller units. The hemp thus cottonised is soft and very easy to further separate into still smaller bundles of elementary fibres in the subsequent operations of mechanical processing. This paper presents the changes in length and fineness of the hemp-noil fibres both after their biological modification and after carding the already modified fibres.

Key words: *hemp noil, enzymatic preparation, cottonised hemp fibre, physical and mechanical properties of cottonised hemp.*

Introduction

All technical hemp fibres, including the hackling noil, occur as compact bundles of elementary fibres that are characterised by a high degree of lignification of both their cell walls and the intermediate lamellae that cement the elementary fibres into bundles. A characteristic feature of the fibre bundle of hemp is its high lignin content, ranging from 3.7% to 8% depending on the origin and variety of the plant [1-3]. These specificities of hemp are of decisive importance as regards the separation and reduction of the fibre bundle in the cottonising process. It is much easier to obtain cottonised flax of evened-up linear density and length of the fibre than it is to obtain cottonised hemp of similar characteristics. The technical hemp fibre is coarser than the technical flax. It is stiffer and more susceptible to damage in the mechanical processing operations.

In Poland, the conventional methods of cottonising the technical bast fibres have been for many years directed towards improving the spinning properties of cottonised flax and hemp. Although the elementary fibres of flax and hemp are similar to cotton in mean length, they differ from cotton in structure, i.e. in what is critical for the spinning properties of the cottonised fibre. The fibre of cotton is a spirally twisted ribbon, which makes cotton fibres inter-adherent and elastic, while the elementary bast fibres are rod-shaped, and are therefore neither inter-adherent nor elastic [1]. The outer shape of an elementary bast fibre remains unchanged throughout the cottonising process even if the most drastic methods are applied. That is why improvement of the cottonising process was directed toward modifying the chemical composition of the bast fibre so as to improve its separation, flexibility and softness. In parallel with the work on modification of the chemical-and-mechanical method of cottonising bast fibres, in recent years the possibility of using enzymes in the cottonising process has been investigated. In the years 1998-2002, a research project concerned with the biological modification of technical bast fibres was carried out at the Institute of Natural Fibres, Poznań. First of all, a technology for cottonising technical bast fibres through biological modification was developed and implemented in industry [4]. During the last three years of that period, a technology for biological modification of the technical hemp fibre was developed and implemented.

Scope of Research

In planning the research work, the differences in chemical composition between the flax and the hemp fibres were taken into account. The Polish enzymatic preparation Pektopol was selected for biological modification of the technical hemp fibre. After numerous laboratory experiments, it was found that a level of hydrolysis of the intermediate lamellae ensuring sufficient separation of the technical hemp fibre could be attained through:

- increasing the enzyme concentration of the bio-modifying bath;
- introducing pre-scouring of the technical hemp fibre prior to its bio-modifying treatment in order to soften the pectinous gums (which cement the fibre bundles) and facilitate their enzymatic hydrolysis;
- increasing the time of exposure to enzymes of the technical hemp fibre

Table 1. Sequence of operations in biological modification of hemp hackling noil.

Variant I	Variant II	Variant III	Variant IV
		Scouring without use of detergents	Scouring without use of detergents
		Rinsing	Rinsing
Treatment with 2% enzyme bath	Treatment with 3% enzyme bath	Treatment with 2% enzyme bath	Treatment with 2% enzyme bath
			Keeping fibre in bath for 24 hours
Removal of bath	Removal of bath	Removal of bath	Removal of bath
Scouring with use of detergents	Scouring with use of detergents	Scouring with use of detergents	Scouring with use of detergents
Final operations	Final operations	Final operations	Final operations

while it is being subjected to pre-scouring.

To develop a suitable technology, four commercial-scale variants of biological modification based on the laboratory-scale results were prepared and tested. All variants were tested using a single lot of hemp hackling noil with a linear density of 4.2 tex and a mean length of fibres of 274 mm. The sequence of technological operations in the individual variants is presented in Table 1. The final phase of the bio-modifying process comprised the following operations: rinsing; application of softening agents; centrifuging, and drying.

Evaluation of the results of bio-modifying the technical hemp fibre was based on analysis of:
- changes in the linear density, length and chemical composition of the fibres directly after their bio-modifying treatment;
- the effect of carding the bio-modified hemp fibre on its properties;
- changes in the structure of hemp-fibre bundles after their biological modification and carding.

The physical/mechanical and chemical properties of the hemp fibre were tested at the laboratories of the Institute of Natural Fibres, Poznań. The carding experiments were performed on a TURBO-type Octir flat card, with permanent flats and saw-tooth clothing, at Bonitex S.A., Bolesławiec. The changes in structure of the hemp-fibre bundles were examined under a JSM-5200 LV (JEOL) scanning microscope [5]. The pictures were imaged and recorded at the Institute of Fibre Physics of the Technical University of Łódź.

Table 2. *Linear density and length of fibres of hemp hackling noil before and after application of various variants of biological modification.*

Parameter	Unit	Before modification	After modification variant			
			I	II	III	IV
Mean linear density of fibre	tex	4.2	3.24	2.78	2.7	2.54
	Nm	238.1	308.6	359.7	370.4	393.7
Reduction of linear density	%	0	22.9	33.8	35.7	39.5
Mean fibre length	mm	274.0	67.0	61.0	56.8	48.4
Reduction of fibre length	%	0	74.4	77.7	79.3	82.3

Test Results

In all samples of the technical hemp fibres subjected to biological modification, changes were noted in the linear density and length of the fibres and in the structure of the elementary fibre bundles. The changes in the fibre properties following modification are presented in Table 2.

The changes in technical hemp fibres due to their biological modification can be seen in Figures 1-4, which show microscopic images of the surface and cross-sections of the fibres before and after modification. To illustrate the post-modification changes, photomicrographs of variant IV are shown, as in this variant the changes in fibre length and linear density were the greatest.

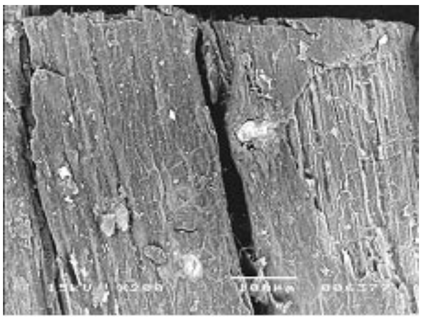

Figure 1. *Surface of a technical hemp fibre.*

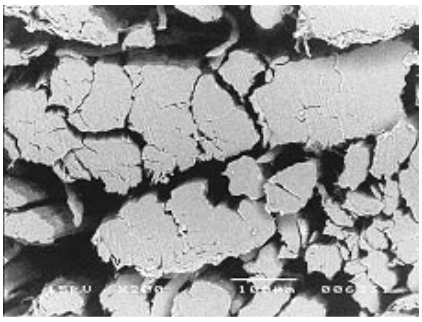

Figure 2. *Cross-section of a technical hemp fibre.*

Figure 3. *Surface of a hemp fibre after biological modification, variant IV.*

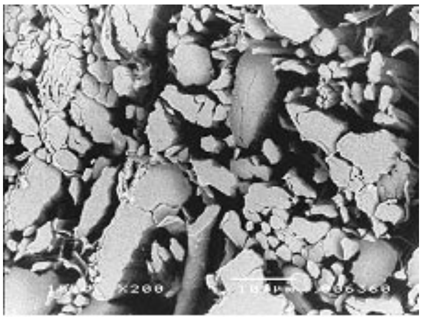

Figure 4. *Cross-section of a hemp fibre after biological modification, variant IV.*

In the photomicrographs it is clearly seen that as a result of the biological modification the previously compact, rough-surfaced fibre bundles have become separated into smaller units of elementary fibres. A weakening of the binding of fibres in the bundles is of decisive importance for further separation of the hemp fibres in subsequent mechanical operations, especially flat carding. The changes in fibre properties after flat carding compared to the changes directly following biological modification are presented in Figures 5 and 6. Carding after modification not only reduces the mean length and linear density of the modified hemp fibres, but also evens up the length of the fibres.

In carding, further changes take place in the structure of the fibre bundles. Both the surface of the fibres (Figure 7) and their cross-section (Figure 8) are changed. The effect of the biological modification on the chemical composition of the hemp fibre is presented in Table 3.

In rating the results of the individual variants of biological modification, account was taken of the fact that cellulose (being the predominant component of bast fibres) must be the chief determinant of their capability for spinning. On the other hand, hemicellulose and (to some extent) pectin are the primary components of the binding substance of the elementary bast fibres, while lignin plays the part of a stabiliser and screen for other fibrogenous substances [6]. Laboratory analyses of the chemical composition of hemp fibre before and after modification in Variants III and IV showed that the level of cellulose was the highest, and that of hemicellulose, pectin and lignin the lowest. In

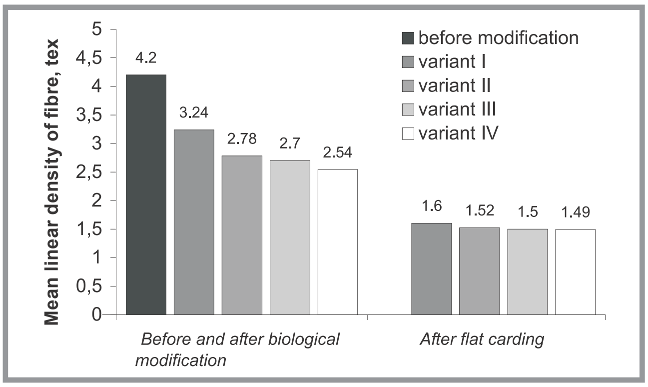

Figure 5. Mean linear density of hemp fibre before and after biological modification and after flat carding.

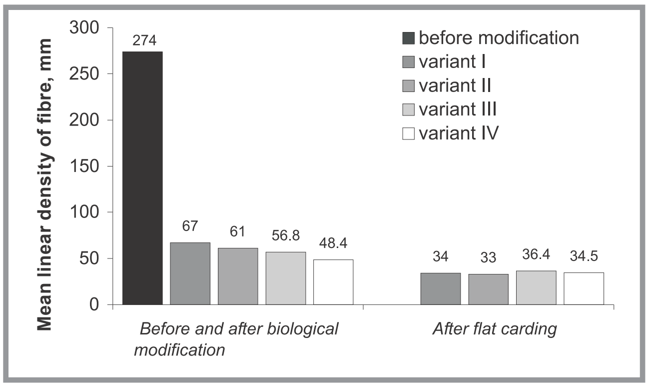

Figure 6. Mean length of hemp fibre before and after biological modification and after flat carding.

the variants mentioned, cellulose content was increased by 6.4%, while hemicellulose was reduced by 27.6-27.78%, lignin by 17.87-22.77%, and pectin by 98.37%.

Sensory tests showed the biologically modified hemp fibre to be soft and flexible. These characteristics were more pronounced after carding, an operation that further reduced the linear density of the fibres and evened up their length.

Conclusions

- The biological modification of hemp consists in the Polish preparation Pektopol separating, by its enzymatic action, the compact fibre bundles of hemp into smaller units that can be further separated in the mechanical processing operations.
- Biological modification of the technical hemp fibre reduces its linear density by 30-40%, and its mean length is reduced 5.5 times compared to the input length.
- In flat carding the bio-modified hemp fibre is made even finer and shorter, and is evened up in length so that it approximates cotton. After the flat-carding operation, the linear density of the hemp fibre is reduced on average by 63%, and in length by on average 87%. After flat carding, the bio-modified hemp fibre reaches a mean linear density of about 1.5 tex and a mean length of about 34 mm.
- Following biological modification, the chemical composition of the hemp fibre is changed to a degree that indicates a good capability for spinning. There is a slight increase in cellulose content, while the content of the cementing vegetable substances is reduced: hemicellulose by 28%, pectin by 98%, and lignin by 23%.
- The cottonised hemp fibre produced through biological modification of hemp hackling noil is characterised by softness and excellent separation of the fibre bundles into smaller clusters of elementary fibres in the subsequent mechanical operations, which makes it possible to process the cottonised hemp in blend with cotton or various manmade fibres by techniques other than the flax-spinning technique.

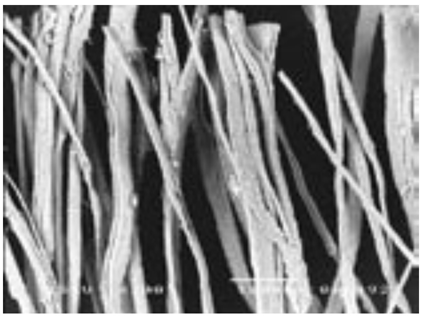

Figure 7. Surface of modified hemp fibre after carding, variant IV.

Figure 8. Cross-section of modified hemp fibre after carding, variant IV.

Table 3. Results of analysis of chemical composition of hemp fibre before and after biological modification of hemp hackling noil.

Variant of modifying treatment	Chemical composition of hemp fibre, %			
	cellulose	hemicellulose	lignin	pectin
Before modification	73.98	19.76	5.27	1.84
After modification: Variant I	76.26	15.46	4.41	0.16
Variant II	77.23	14.61	4.5	0.29
Variant III	78.72	14.33	4.33	0.03
Variant IV	78.69	14.27	4.07	0.03

Editorial note:

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