Quality of chemically modified hemp fibers

By:

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Table of Contents

List of Figures ........................................................................................................ ii
List of Tables .......................................................................................................... ii
Abstract ................................................................................................................ 1
1. Introduction .......................................................................................................... 3
2. Experimental ......................................................................................................... 5
  2.1. Material ........................................................................................................... 5
  2.2. Methods .......................................................................................................... 5
    2.2.1. Chemical treatment .................................................................................. 5
    2.2.2. Determination of weight loss and chemical composition ...................... 5
3. Results and discussion ......................................................................................... 7
  3.1. Influence of chemical treatment on chemical composition ......................... 7
  3.2. Fineness of modified hemp fibers ................................................................. 7
4. Conclusions ......................................................................................................... 9
References ............................................................................................................. 11
Index .................................................................................................................... 13
List of Figures
Figure 1. Effect of variation of modification condition on the fineness of hemp fibers. .... 7
Figure 2. Influence of test length and bundle fineness on the tenacity of hemp fiber bundles. ................................................................................................................................................. 8

List of Tables
Table 1. The chemical treatment scheme and list of samples.................................................. 5
Abstract

Applying hemp fibers to the apparel sector requires improved quality fibers. In this paper, hemp fibers were modified with sodium hydroxide solutions (5% and 18% w/v), at room and boiling temperature, for different periods of time, and both under tension and slack, in order to partially extract noncellulosic substances, and separate the fiber bundles. The quality of hemp fibers was characterised by determining their chemical composition, fineness, mechanical and sorption properties. The modified hemp fibers were finer, with lower content of lignin, increased flexibility, and in some cases tensile properties were improved.
1. Introduction

Hemp (*Cannabis sativa*) was most likely the first plant cultivated by mankind for its textile use (Lu and Clarke, 1995). Fast growing and not very demanding as to climate, soil quality, and nutrients, hemp was farmed all over the world until its ban in the 1930s by most Western counties. This ban together with intensive development of chemical fibers after the Second World War had an influence on the total textile fiber situation, characterised by the significant elimination of natural fibers, except cotton, from textile products. Worldwide, chemical fibers and cotton have largely replaced bast fibers, primarily because of their more cost-efficient production and nearly universal product possibilities.
2. Experimental

2.1. Material

The fibers used in this investigation were good-quality water-retted hemp obtained from ITES Odzaci, Serbia. Chemical composition of used fibers are: water solubles – 1.70%, fats and waxes – 1.59%, pectin – 1.55%, α-cellulose – 76.12%, lignin – 5.65% and hemicellulose – 12.28%. All used chemicals are p.a. grade.

2.2. Methods

2.2.1. Chemical treatment

Hemp fibers were modified by treating the fiber samples with sodium hydroxide solutions (5% and 18% w/v), 1:50 liquor ratio, at room and boiling temperature, for different periods of time (5, 10, 15 and 30 min), and both under tension and slack, followed by neutralisation with 1% acetic acid solution, washing with distilled water, and overnight drying in air. The chemical treatment scheme and list of samples are shown in Table 1.

Table 1. The chemical treatment scheme and list of samples

<table>
<thead>
<tr>
<th>Modification conditions</th>
<th>Sample code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concentrations of NaOH</td>
<td>Sample code</td>
</tr>
<tr>
<td>Temperature</td>
<td>Time (min)</td>
</tr>
<tr>
<td>Unmodified sample – control</td>
<td>HC</td>
</tr>
<tr>
<td>5%, Slack</td>
<td>Room temperature</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2.2.2. Determination of weight loss and chemical composition

Loss in weight, as result of chemical treatment, was determined by the direct gravimetric method. Chemical composition of unmodified sample and each of modified samples was
determined according to the scheme of Soutar and Bryden by successively removal of water solubles, fats and waxes, pectin, lignin and hemicellulose.
3. Results and discussion

3.1. Influence of chemical treatment on chemical composition

The chemical compositions of alkali modified hemp fibers and those of the control sample, and the weight loss are given in Table 1. The weight loss, to a large extent, is due to solubilisation of the hemicelluloses and the part-removing of the lignin (and other minor constituents) from hemp fibers. The reduced contents of hemicelluloses, from 12.28% to 1.93%, and lignin, from 5.65% to 2.07%, after modification with 5% NaOH, 30 min, at boiling temperature, suggest that part of the components which make fibers stiff and difficult to process have been removed. There is an evident tendency for the residual noncellulosic substances level to be reduced by increasing the severity of treatment (NaOH concentration, temperature and duration). However, a certain amount of hemicellulose residues remain in the structure because of considerably stable hemicellulose hydrogen bonding to cellulose fibrils. Also, according to the literature, lignin cannot be totally removed by the alkali process because degradation or fragmentation of lignin is very limited due to presence of strong carbon–carbon linkages and other chemical groups such as aromatic groups, which are very resistant to chemical attack. The high concentration of α-cellulose in all modified fibers is evidence that the fiber cellulose remain unimpaired.

![Figure 1. Effect of variation of modification condition on the fineness of hemp fibers.](image)

3.2. Fineness of modified hemp fibers

Technical hemp fibers can acquire, as result of modification, a high level of divisibility, which determines fineness. After removal, in the modification process, of the
noncellulosic substances the fineness of modified fibers was reduced about 10-fold, from 22.70 tex for unmodified to 2.23 tex for H18SR30 sample. The changes in fineness of the hemp fibers after modification are shown in Fig. 1.

![Graph showing the influence of test length and bundle fineness on the tenacity of hemp fiber bundles.](image)

Figure 2. Influence of test length and bundle fineness on the tenacity of hemp fiber bundles.
4. Conclusions

Hemp fibers were modified with sodium hydroxide solutions with the aim to remove noncellulosic substances and improve quality of hemp fibers (fineness, flexibility, etc.). Analyses of obtained results showed that as a result of the modification the fibers acquired a high level of divisibility, with good levels of the physical and mechanical properties.
References


Index

Fiber  composition, 5  composition treatment, 5  treatment, 5

Fineness, 7
Hemp, 3, 5, 9
weight loss, 5, 7