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A way to improve the sorption properties of raw jute fabric by sodium alginate treatment

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Sodium alginate aqueous solutions of different concentrations (0.5, 1.0, or 2.0%) were used for improving the sorption properties (evaluated through the determination of water retention power (WRP) and wetting time (WT)) of raw jute fabric. The influence of drying conditions (never-dried samples, samples dried at 60 °C or at room temperature) on the sorption properties of alginate-treated jute fabrics was also studied. Independently on the examined method (centrifuge or water absorption method), the same trend of improvement in WRP of alginate-treated fabrics was observed. The WRP of never-dried fabric treated with 2.0% sodium alginate solution determined using the water absorption or centrifuge method increased by 4.8 or 3.3 times compared to raw jute fabric, respectively. Moreover, the WT of jute fabrics decreased from 206.9±6.6 s down to 1.7±0.1 s after the treatment with 0.5% sodium alginate solution. The improved sorption properties of alginate-treated jute fabrics are attributed to the alginate layer on the fabric surface having a higher number of accessible carboxyl groups as well as hydroxyl groups capable of forming new hydrogen bonds with water molecules.

Introduction

As the most important ligno cellulosic fiber, jute represents an economical, sustainable, readily available, and renewable resource. Thanks to its excellent physico-mechanical and chemical properties, this natural fiber can be used for various conventional and non-conventional applications. The well-known conventional application of jute fibers is for the production of packaging materials such as sacking cloth, hessian, as well as carpet backing. Non-conventional applications of jute fibers are usually connected with the production of various jute based-composites with defined properties and targeted end-uses. In light of that, jute fabric with enhanced sorption properties could find novel application as geo-prebiotic supports for cyanobacteria growth in biocarpet engineering, *i.e.*, to promote a sustainable relationship between the microbiota and abiotic constituents on the degraded land surface. In our previous work [1], we reported that the treatment with chitosan enhanced the sorption properties of raw jute fabric. As a continuation of the research within the topic, in this work, the influence of the treatment with another polysaccharide, *i.e.*, sodium alginate on the jute fabric sorption properties was studied. Sodium alginate is a non-toxic, biocompatible, anionic polysaccharide with good sorption properties originating from the presence of carboxyl and hydroxyl groups in its structure [2]. In order to obtain jute fabrics with enhanced sorption properties, raw jute fabric was treated with 0.5, 1.0, or 2.0% sodium alginate aqueous solutions. After the treatment, different methods were employed for fabric drying and their effect on water retention power and wetting time was studied.

Results and Discussion

Water retention power (WRP)

As an important indicator of fabric sorption properties, WRP, representing the total amount of retained water in its structure [3], was studied according to two different methods (*i.e.* centrifuge and water absorption methods), Figure 1.

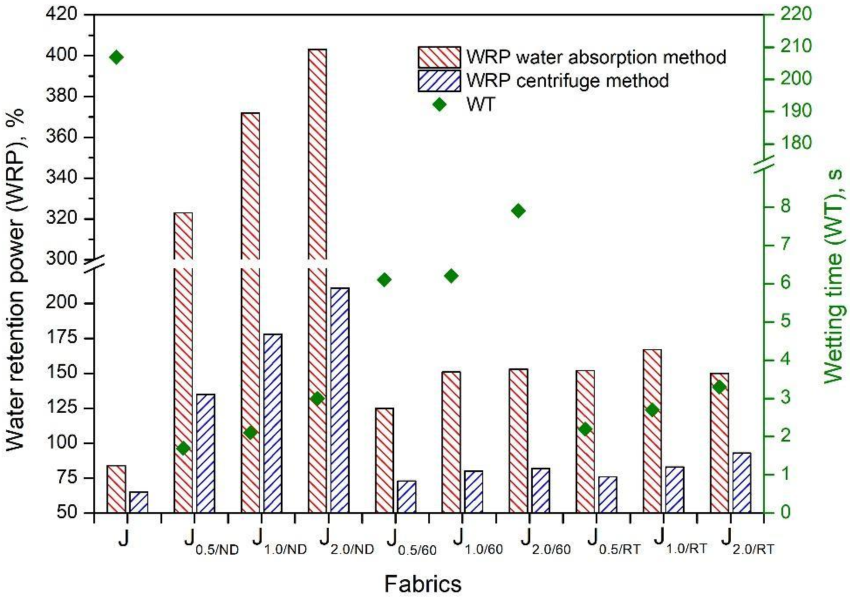

Figure 1. WRP and WT of raw and alginate-treated jute fabrics

The WRP of raw jute (J) determined by water absorption and centrifuge methods accounted for 84% and 65%, respectively. Among three sets of samples, never-dried ones ($J_{0.5/ND}$, $J_{1.0/ND}$, $J_{2.0/ND}$) possessed the highest increment in WRP, whereby $J_{2.0/ND}$ is characterized by 4.8 (water absorption method) or 3.3 times (centrifuge method) higher WRP compared to raw jute fabric. It is interesting to note that the results obtained for WRP using the different testing methods followed the same trend. Sodium alginate treatment enriched the jute fabrics' surface with functional groups available for forming the new hydrogen bonds with water molecules contributing to higher WRP values. Considering in parallel the different drying methods (at 60 °C and at room temperature), it is evident that they significantly decreased the WRP in comparison to never-dried samples. A small difference between WRP of differently dried fabrics can be explained by the different rates of water evaporation from the samples' surface affecting the structure of the formed alginate layer. Furthermore, its hornification makes dried fibers more resistant to reswelling and behaves as a kind of barrier to water penetration.

Wetting time (WT)

Besides WRP, WT is another important indicator of fabrics' sorption properties. Before measuring the WT, the never-dried samples were left to dry under the same conditions as the samples dried at room temperature. As can be seen from Figure 1, the treatment with sodium alginate positively affect the WT. For example, the WT of raw jute (J) decreased from 206.9±6.6 s down to 1.7±0.1 s after the treatment with 0.5% sodium alginate solution (sample $J_{0.5/ND}$). There are no differences between the WT of never-dried samples subsequently dried at room temperature and those dried at room temperature. On the other hand, the drying samples at 60 °C resulted in higher WT compared to the samples dried at room temperature. Moreover, the effect of the concentration of sodium alginate aqueous solution on WT should not be neglected. Namely, the utilization of a higher concentration of sodium alginate aqueous solution implies the formation of a denser alginate layer which is more prone to hornification during the drying at 60 °C, Figure 1.

Experimental Part

Treatment of jute fabric with sodium alginate aqueous solution

Before the treatment with sodium alginate aqueous solution, raw jute fabric was washed in distilled water at boiling temperature for 30 min to remove water-soluble substances. Immediately after squeezing, jute fabric was dipped into 0.5, 1.0, or 2.0% sodium alginate (low viscosity, Alfa Aesar) aqueous solution (material to liquid ratio of 1:20) at an ambient temperature for 24 h. Thereafter, the fabrics were immersed in 2.0% aqueous solution of $CaCl_2$ (material to liquid ratio of 1:20) at an ambient temperature for 24 h, and rinsed with distilled water. Three sets of samples were prepared regarding the drying procedure. One set of samples was never-dried, the other was dried at 60 °C for 24 h, while the last set of samples was dried at room temperature.

Sorption properties

The WRP was determined following the standard centrifuge method ASTM D2402-07(2018), and the water absorption method based on ASTM D570-98(2018) standard, while the WT measurements were performed according to standard AATCC 79 (2018). The WRP and WT are presented as the mean values of six and three measurements per sample, respectively.

Tretman natrijum-alginatom kao način da se poboljšaju sorpciona svojstva sirove tkanine jute

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Vodeni rastvori natrijum-alginata različitih koncentracija (0,5, 1,0 ili 2,0%) korišćeni su za poboljšanje sorpcionih svojstava (procenjenih određivanjem sposobnosti zadržavanja vode (WRP) i vremena kvašenja (WT)) sirove tkanine jute. Takođe je proučavan uticaj uslova sušenja (neosušeni uzorci, uzorci sušeni na 60 °C ili na sobnoj temperaturi) na sorpciona svojstva tkanina jute tretiranih alginatom. Nezavisno od metode ispitivanja (centrifugiranjem ili apsorpcijom vode posle potapanja), dobijen je isti trend poboljšanja sposobnosti zadržavanja vode tkanina tretiranih alginatom. Sposobnost zadržavanja vode nesušene tkanine tretirane 2,0% rastvorom natrijum-alginata, određene metodom apsorpcije vode posle potapanja ili centrifugiranjem, povećana je 4,8 ili 3,3 puta u

poređenju sa sirovom tkaninom jute, respektivno. Štaviše, tretman tkanina jute 0,5% rastvorom natrijum-alginata dovodi do smanjenja vremena kvašenja sa 206,9±6,6 s na 1,7±0,1 s. Poboljšana sorpciona svojstva tkanina jute tretiranih alginatom pripisuju se sloju alginata na njihovoj površini sa većim brojem dostupnih karboksilnihi hidroksilnih grupa sposobnih da formiraju nove vodonične veze sa molekulima vode.

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