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IR SPECTRAL ANALYSIS OF BROUSSONETIA POPYREFERA PLANT

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IR SPECTRAL ANALYSIS OF BROUSSONETIA PAPHYREFERA PLANT

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Abstract - in this study, a method for determining the concentration of lignin, cellulose and hemicellulose in plant materials using Fourier-transform IR spectroscopy of *Broussonetia papyrifera* was developed and tested. The procedure is based on the use of calibration functions that reflect the dependence of the intensity of analytical absorption lines on the concentration of lignin (1512 cm⁻¹) and cellulose (1450 cm⁻¹) in standard samples; indirect correlation was used for hemicellulose. The model samples were ternary mixtures composed of lignin, bacterial cellulose and hemicellulose in different proportions. The proposed method was tested on a wide range of plant biomass samples.

Keywords. *Broussonetia papyrifera* (L.) Vent. (BP), natural cellulose fibers, fiber extraction, polymers, natron method, natural fibers.

Annotatsiya: Ushbu tadqiqot *Broussonetia papyrifera* uchun Furye konvertatsiyasi IQ spektroskopiyasi yordamida o'simlik xom ashyosidagi lignin, tsellyuloza va gemitsellyuloza kontsentratsiyasini aniqlash usulini ishlab chiqdi va sinovdan o'tkazdi. Texnika analitik yutilish chiziqlari intensivligining standart namunalardagi lignin (1512 sm⁻¹) va tsellyuloza (1450 sm⁻¹) kontsentratsiyasiga bog'liqligini aks ettiruvchi kalibrash funktsiyalaridan foydalanishga asoslangan; gemitsellyuloza uchun bilvosita korrelyatsiya ishlatilgan. Model namunalari turli nisbatlarda lignin, bakterial tsellyuloza va gemitsellyulozadan tashkil topgan uch tomonlama aralashmalar edi. Tavsiya etilgan usul o'simlik biomassasi namunalaringing keng assortimentida sinovdan o'tkazildi.

Kalit so'zlar: *Broussonetia papyrifera* (L.) shamollatish. ((BP), tabiiy tsellyuloza tolalari, tola ekstraksiyasi, polimerlar, antron usuli, tabiiy tolalar.

Аннотация: в данном исследовании был разработан и апробирован метод определения концентрации лигнина, целлюлозы и гемицеллюлозы в растительном сырье с использованием ИК-спектроскопии с преобразованием Фурье для *Broussonetia papyrifera*. Методика основана на использовании калибровочных функций, отражающих зависимость интенсивности аналитических линий поглощения от концентрации лигнина (1512 см⁻¹) и целлюлозы (1450 см⁻¹) в стандартных образцах; для гемицеллюлозы использовалась косвенная корреляция. Модельные образцы представляли собой тройные смеси, состоящие из лигнина, бактериальной целлюлозы и гемицеллюлозы в различных пропорциях. Предлагаемый метод был протестирован на широком спектре образцов растительной биомассы.

Ключевые слова: *Broussonetia papyrifera* (L.) Жерло. (BP), натуральные целлюлозные волокна, экстракция волокон, полимеры, натроновый метод, натуральные волокна.

Introduction

In Uzbekistan, the need for cellulose and its simple and complex esters and paper and paper products, as well as compositional materials based on them, is increasing day by day. For this reason, comprehensive measures have been implemented to organize scientific research in the field at a high level and provide the domestic market with quality cellulose and its products. To expand the reserves of cellulose and its esters, there are other types of perennials and perennials, fiber waste from various industrial enterprises, in addition to cotton lint. These

are plants that hold cellulose in their composition, such as topinambur plant stem, poplar tree, wheat straw, rice pod. The fact that the cellulose formed during their synthesis has a high molecular mass and high quality indicators of compositional polymer materials obtained on its basis is one of the main factors.

We know that plant waste has unique properties for producing renewable energy and valuable chemicals, and can contribute to solving the problems currently associated with the use of conventional fuels. The development and

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implementation of the technology of chemical and biotechnological processing of plant biomass into biofuels and chemicals is currently an urgent task. In this context, information on the initial composition of plant biomass is essential for predicting the efficiency of any processing method. Most analytical methods for the determination of cellulose, hemicellulose and lignin are based on their separation and then isolation. However, these methods are dangerous and labor-intensive, require large quantities of products, generate large amounts of chemical waste, and do not always provide reliable results. It is desirable to create simple and fast spectroscopic methods for the determination of these components, among which IR spectroscopy is the most effective method.

For example, the use of IR spectroscopy for wood analysis began in the second half of the 20th century under the leadership of Karklin and continues today. In Russia, similar research is being conducted by Derkacheva's group. For example, IR spectroscopy has been developed to determine lignin in paper and sulfated cellulose, and to evaluate the condensation and precipitation of lignin during the cooking of sulfated cellulose. Fourier transform IR (FTIR) spectroscopy is characterized by the speed and ease of sample preparation and does not require large amounts of test samples, as it has been successfully used in wood analysis. Infrared spectra help to distinguish types of wood and to determine the place of their growth.

Currently, interest in this topic is very high in other countries; for example, the review summarizes advances in the use of IR spectroscopy to study plant biomass. Three methods of Fourier-transformed IR spectroscopy (attenuated total reflection (ATR), diffuse) reflection and transmission) were compared

in In recent years, the use of near-infrared spectroscopy (NIRS) for the qualitative and quantitative analysis of plant materials has attracted more and more interest, but this method requires more complex mathematical methods.

Experiments and their analysis

In our research, using the natron method of cellulose extraction, we proved that the alkali concentration used in the process does not affect the formation of functional groups in the cellulose substance. Researches were carried out in different concentrations of NaOH alkali (NaOH-10%, NaOH-8%, NaOH-6%). When the obtained celluloses were subjected to IR spectroscopy, the functional groups formed in them were listed in the table below (Table 1).

Table 1

Functional groups of obtained celluloses

Broussonetia papyrifera	
Functional groups	Areas of focus cm^{-1}
$\nu(\text{OH}), \text{cm}^{-1}$ OH	3382,86-3411.05
$\nu(\text{CH}_2), \text{cm}^{-1}$ CH ₂	2901,42-2899.77
$\delta(\text{HOH}), \text{cm}^{-1}$ HOH	1647,11-1638.40
$\delta_s(\text{CH}_2\text{OH}) + \delta(\text{CH}), \text{cm}^{-1}$ CH ₂ OH	1429,66
$\delta(\text{OH}) + \delta(\text{CH}) + \gamma(\text{CH}_2), \text{cm}^{-1}$	1372,99
$\delta(\text{OH}) + \delta(\text{CH}_2), \text{cm}^{-1}$	1162,52
$\nu(\text{COC})$ ko'prik c, cm^{-1}	1033,24
$\nu_a(\text{COC})$ -ko'prik + $\delta(\text{C1H}) \text{cm}^{-1}$	898,60
$\delta(\text{CC}_2\text{O})\text{cp}, \text{cm}^{-1}$	616,66
$\delta(\text{C}_2\text{C}_5\text{O}_5) + \delta(\text{C}_4\text{C}_5\text{O}_5), \text{cm}^{-1}$	560,31
	522,79
	438,81

We can see from the table that the main formed functional groups are formed in the 2000-3450 cm^{-1} range of the IR spectrum. See pictures 1, 2 and 3 below to understand this more fully.

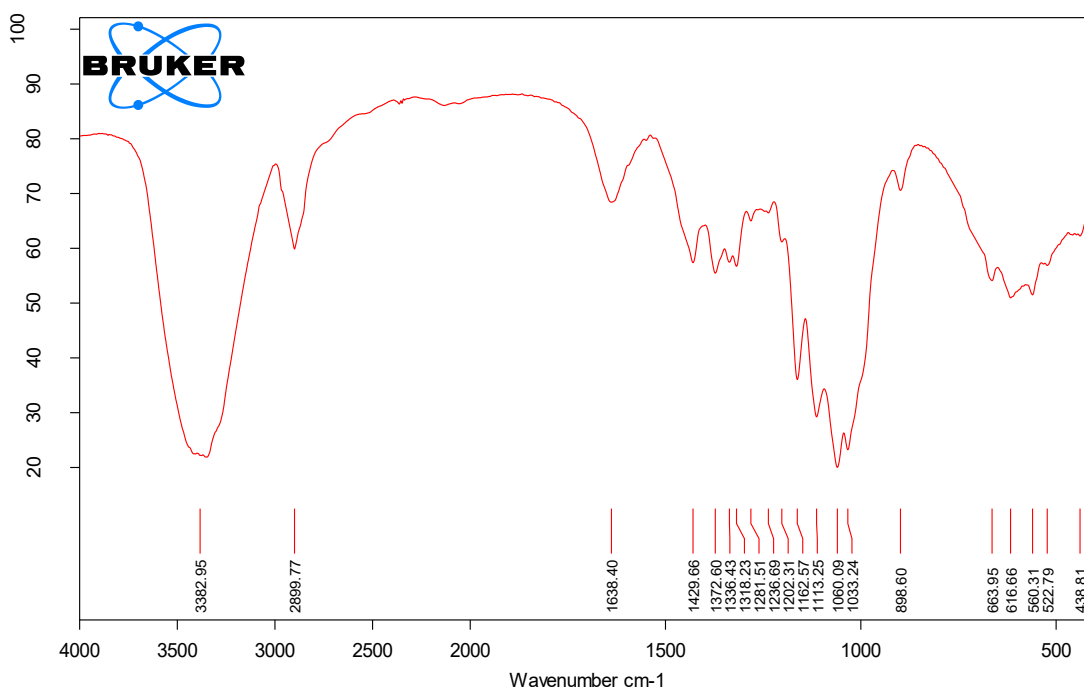


Fig. 1. IR of Broussonetia papyrifera cellulose cooked in 10% NaOH solution

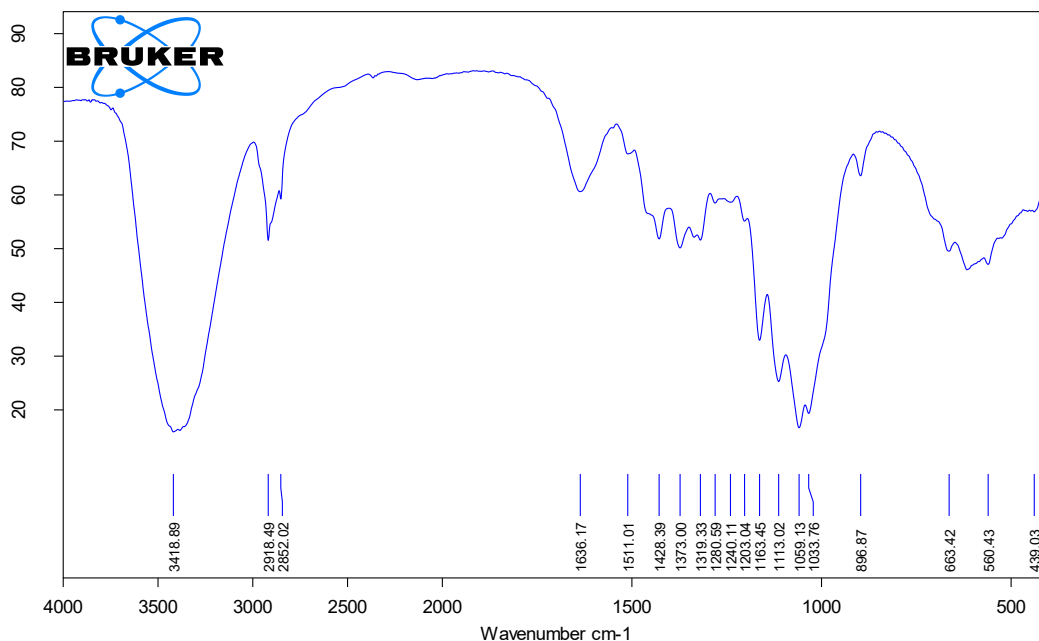


Fig. 1. IR of Broussonetia papyrifera cellulose cooked in 8% NaOH solution

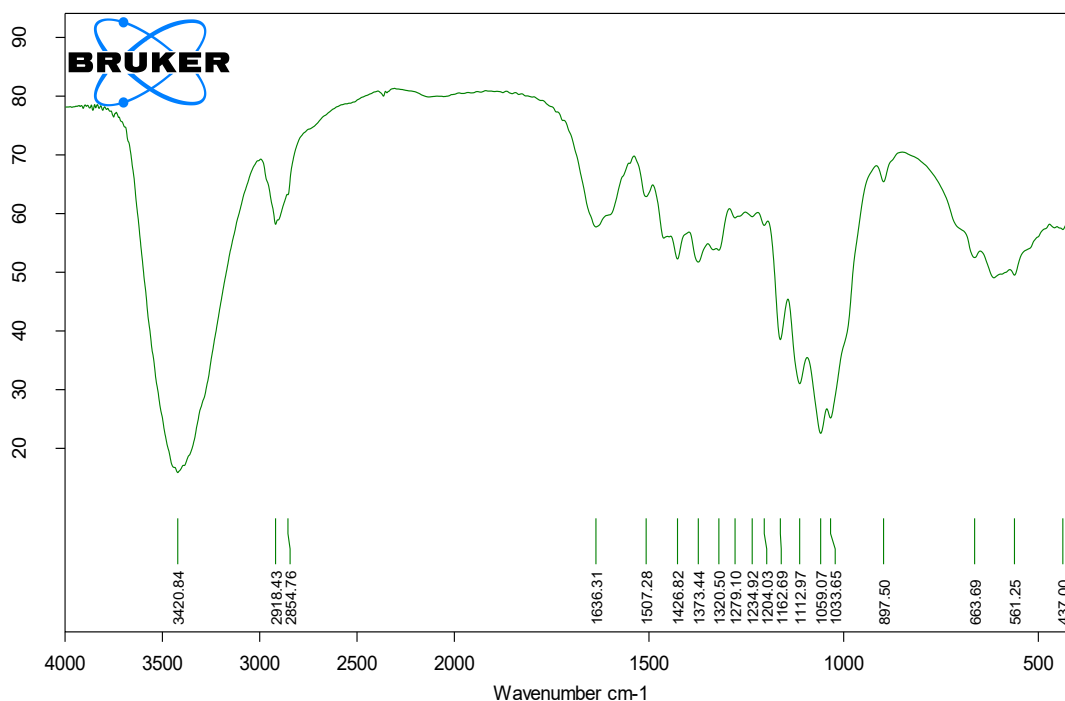


Fig. 1. IR of Broussonetia papyrifera cellulose cooked in 6% NaOH solution

As can be seen from the figures, the spectra of cellulose show significant differences in the intensity and position of some absorption bands. 1512 cm^{-1} (the combined area between 1490 and 1530 cm^{-1}), which is mainly due to the skeletal vibrations of the aromatic ring, is necessary for the identification of lignin. This choice seems to be more appropriate because cellulose and hemicellulose do not have absorption bands in this region. Cellulose was identified using an absorption band at 1450 cm^{-1} (combined area between 1405 and 1480 cm^{-1}), which was mainly assigned to shear vibrations of the methylene group and intra-bending vibrations of the OH group. This selection was made in a similar manner to the data. The

absorption band at 2072 cm^{-1} (integrated area between 2050 and 2084 cm^{-1}) belonging to the internal standard $\text{Pb}(\text{SCN})_2$ was used to normalize the integrated areas of the analytical bands selected for quantitative analysis. As for hemicellulose, it differs structurally from cellulose in the presence of acetyl and carboxyl groups. However, the bending of the absorption frequencies of these groups coincides with the vibrational lines.

In the range of 3400-3450 cm^{-1} of the IR spectrum, valence vibrations of hydroxyl groups corresponding to intermolecular and intramolecular hydrogen bonds are manifested. Valence vibrations of C-H bonds in the methylene and methine groups of

cellulose appear in the 2900-2950 cm⁻¹ range, and in the 1600-1640 cm⁻¹ range, the vibrations of adsorbed water molecules appear. Absorption lines in the areas of 1400 cm⁻¹, 1390 cm⁻¹, 1310 cm⁻¹, 1100-1110 cm⁻¹ correspond to the deformation vibrations of the -CH, -CH₂, -OH, -CO groups and the valence vibrations of the C-O group.

Conclusions

Thus, the IR spectrum of lignin, cellulose and hemicellulose in the plant was analyzed. This analysis showed that the properties of this plant cellulose, such as functional groups and reactivity, were demonstrated. In addition, the possibility of obtaining cellulose esters was shown.

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