SYNTHESIS, FUNCTIONALIZATION AND PROPERTIES OF BACTERIAL CELLULOSE

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INTRODUCTION

Biodegradable cellulose polymer is in environment in the form of microfibrils in the cell walls of wood, plant etc. It can be also synthesized by bacteria in the form of nanofiber networks – it is bacterial cellulose or in other words – biocellulose (BC) [1]. This nanocellulose (NC) properties can be modified by substitution of its hydroxyl groups with some functional groups, such as specific acids, chlorides, oxides or dyes to enrich some characteristics or to obtain new properties, e.g. luminescent ones.

The promise of research and the use of bionanocellulose (BNC) can be traced in many industries. For example, in flexible electronics, where nanofibrils act as a biodegradable, thermally and chemically resistant substrate for electronic components. Layer-by-layer deposition of gold and oxide nanoparticles makes it possible to obtain a material that can be used as an electrode for supercapacitors used as a voltage source, that is, to become an alternative to batteries. It is also possible to use NC as a substitute for plastic or glass for the production of super-thin and flexible screens. Due to its structural similarity with graphene, it is possible to use BNC in various filters. In medicine, it is considered as a material for the production of ultra-absorbent aerogels. Considering the possibility of producing high-reinforced materials, it is also used in the military sphere.

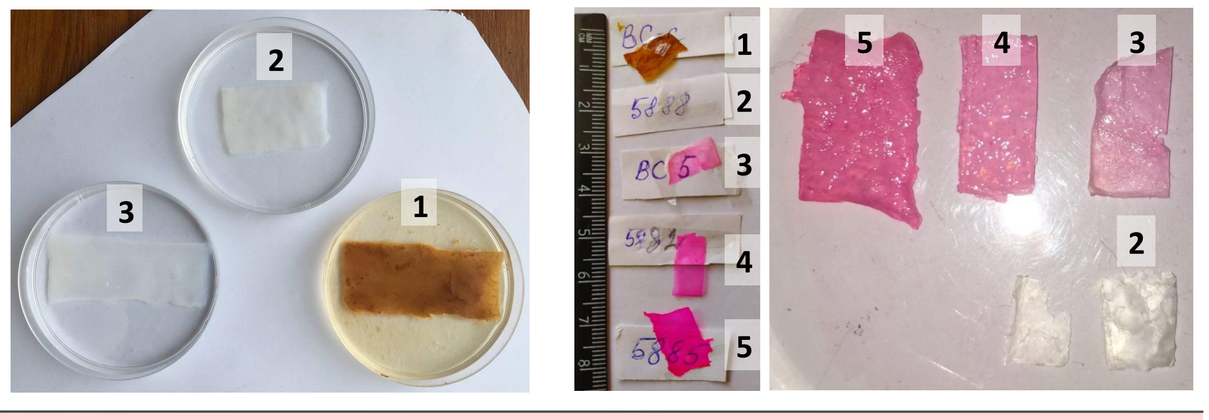
The main purpose of the work is to study the procedure for obtaining and structural analysis of bacterial nanocellulose, to determine the optimal methods for studying BC-based films and to perform photoluminescence study, X-ray diffraction analysis and measure the ellipsometric parameters of BC-based films with the addition of fluorescent dye Rhodamine C of different concentrations, which were grown and purified in our laboratory from Kombucha tea membranes.

SAMPLES AND METHODS

Black tee, sugar and Komagataeibacter xylinus were used to grow the BC samples. They were then rinsed under running water and soaked in water for a long time. After the samples were then soaked in a 2% solution of NaOH for 24 hours and washed with acetic acid solution. Finally, the samples were washed with distilled water to neutral pH and then were dried. Some of the samples were functionalized with dyes and Rhodamine C was particularly used to give BC new luminescent properties. To prepare such composites, the BC samples were soaked for some time in 5 % water solution of ethanol. Different characterization techniques have been used to study structural, mechanical and optical properties of elaborated nanostructured biocellulose. The samples were characterized using X-ray powder diffraction (XRD), scanning electron microscopy (SEM), optical reflectance ellipsometry, optical scattering of light, IR, Raman and luminescence spectroscopy. Some mechanical characteristics such as hardness and tensile strength were measured too. The obtained data were analyzed in terms of finding a correlation between both mechanical, structural characteristics and optical properties.

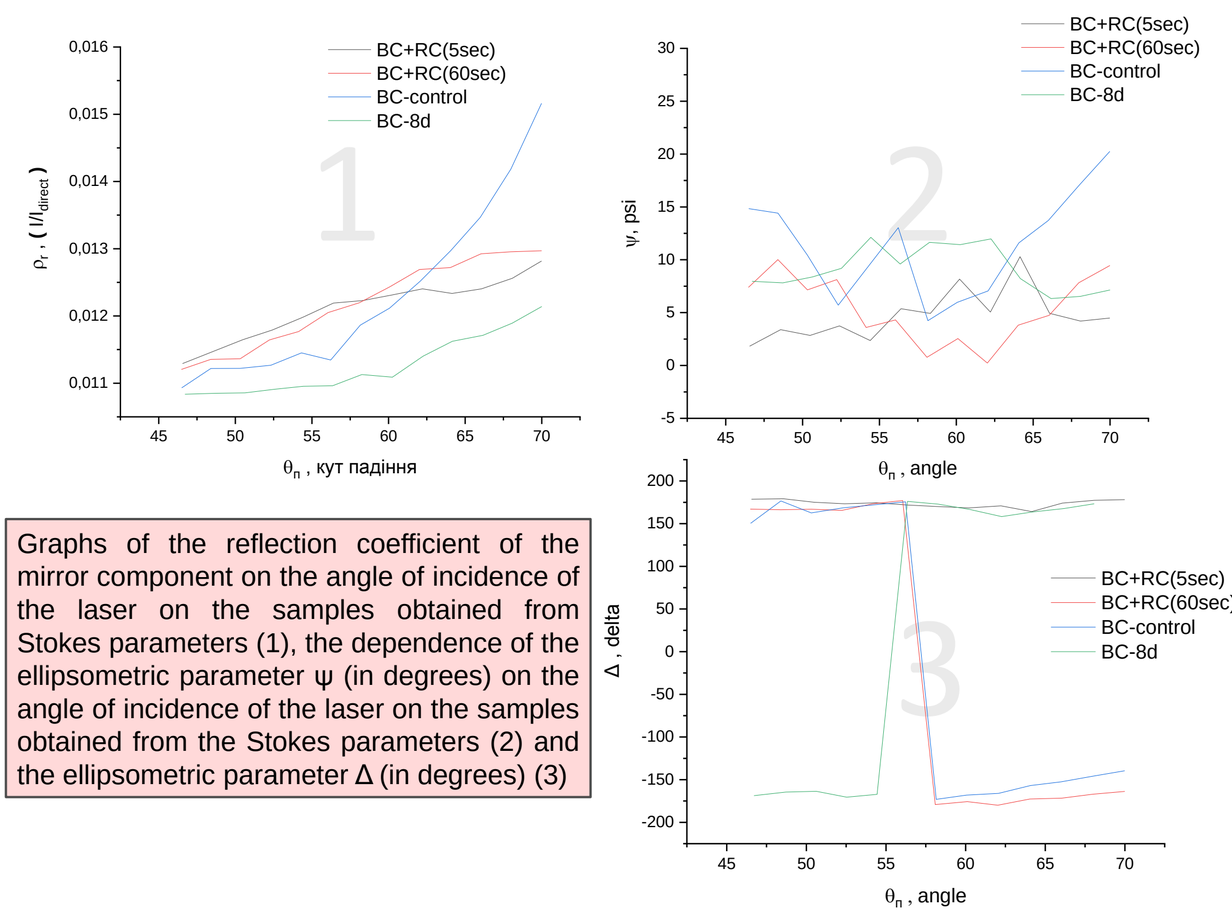
RESULTS

RESEARCH OBJECT



The object of the study is BC films formed by culture of producing bacteria komagataeibacter xylinus (as part of a Tea fungus culture). In the first image you see a sample (1), which was cut from one of these mushrooms, more precisely from one of its layers. They were then treated with 2% alkaline NaOH solution (2, 3) and washed to achieve a neutral acidity level. The second films functionalized with dyes and Rhodamine C (3-5)

STOKES PARAMETERS

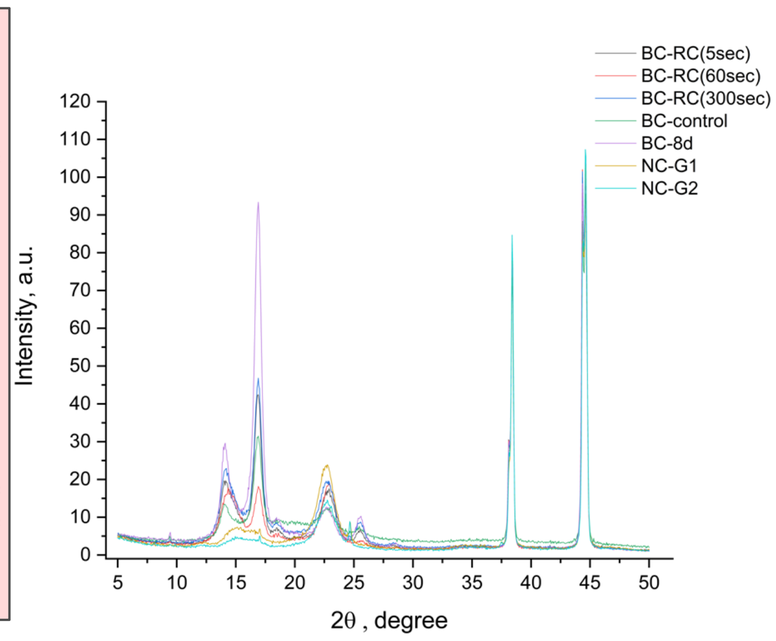


Graphs of the reflection coefficient of the mirror component on the angle of incidence of the laser on the samples obtained from Stokes parameters (1), the dependence of the ellipsometric parameter ψ (in degrees) on the angle of incidence of the laser on the samples obtained from the Stokes parameters (2) and the ellipsometric parameter Δ (in degrees) (3)

Stokes parameters and derived data were obtained using ellipsometric research methods

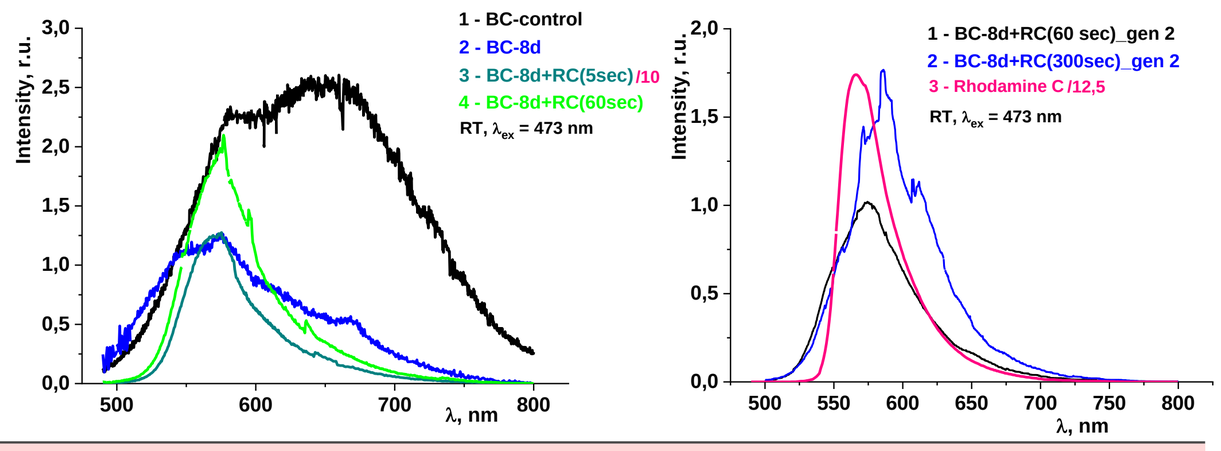
X-RAY DIFFRACTION ANALYSIS OF BC-BASED FILMS

Comparison with the literature showed that the spectral details located in the range of scattering angles 10 - 30º 2Θ correspond to scattering on the atomic planes of cellulose, while the peaks observed in the range 35 - 50º 2Θ are caused by scattering on the aluminum substrate on which the investigated pins were fixed. As a result, we can attest to the prospects of using the X-ray phase analysis method to study the structure of nanocellulose obtained by various methods, and its changes as a result of processing and introduction of additional components, in particular the dyes.



X-ray scattering spectra of the BC Films

PHOTOLUMINESCENCE OF BC-BASED FILMS WITH RHODAMINE C



Luminescence spectra of BC-based films GEN-1 (1-4) and GEN-2 (1-2) with Rhodamine C (3); T = 300 K; λ_{ex} = 473 nm

CONCLUSIONS

The analysis of the results of the various optical methods application for obtaining structural, morphological and optical characteristics of biocellulose confirmed the prospects of application:

a) the method of photoluminescence;
b) ellipsometric method;
c) the method of X-ray phase analysis.

it is planned the following research methods will be applied in the future: optical light absorption and scattering; Raman scattering; infrared absorption.

The relationship between the characteristics obtained by the above methods and optical and electron microscopy data and data on the mechanical hardness and tensile strength of the samples will also be investigated.