КОРОТКІ ПОВІДОМЛЕННЯ

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RESEARCH OF THE INFLUENCE OF POLARIZED UV RADIATION ON THE STRUCTURE OF PHOTOSENSIBLE BIOPOLIMER BY THE MUELLER

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The study of dispersed media of biological origin by the methods of optics of light-scattering media is used to identify the influence of the shape, orientation structure and polydispersity of the components of this medium on its optical characteristics. A comprehensive study of the characteristics of light scattering and absorption makes it possible to detect physiological and morphological changes in cells caused by temperature and chemical factors, as well as to conduct a rapid qualitative analysis. Given that the light scattering matrix contains all the information about the dispersed medium available by optical methods, it is advisable to use the Mueller matrix method to study the biological environment. Experimental studies of the effect of polarized UV radiation on the structure of amphiphilic macromolecules composing the light-sensitive purple membrane were carried out. Polarization characteristics and Mueller matrix of thin films containing such photoactive biopolymers were measured.

Key words: Mueller matrix method, photoactive biopolymers, polarized UV radiation.

Introduction. The methods of optics of light-scattering media are widely used to study dispersed media of biological origin in order to identify the influence of the shape, orientational structure, and polydispersity of the components of this media on its optical characteristics. A comprehensive study of the characteristics of light scattering and absorption makes it possible to detect physiological and morphological changes in cells caused by temperature and chemical factors, as well as to conduct a rapid qualitative analysis. Given that the light scattering matrix contains all the information about the dispersed medium available by optical methods, it is advisable to use the Mueller matrix method for the study of biological environments (Arkhelyuk et al., 2021; Podkamen, Arkhelyuk, 1995; Podkamen et al., 1995).

Materials and methods. The experimental investigations of the influence of polarized ultra-violet (UV) radiation on the structure of the amphiphilic macromolecules composing the light-sensitive purple membrane. The polarizable characteristics as well as Mueller matrix thin films containing such photoactive biopolymers are measured.

The measurements were made on Stokes-goniometer in the field of anglers scattering $\alpha = 0 \div 170^0$. The probing was conducted on the wave-length λ=632,8 nm.

The object was placed toward the normal irradiated beam. The films with the different molecules degree of order in the layer are used. The extent of the polarization was determined in correlation:

$$P = \frac{I_{0,0} - I_{0,90}}{I_{0,0} + I_{0,90}} \quad \text{and} \quad P = \frac{I_{90,90} - I_{90,0}}{I_{90,90} + I_{90,0}},$$

where $I_{0,0}$, $I_{0,90}$, $I_{90,0}$, $I_{90,90}$ - the intensities of the polarized component with the azimuths for the polarizer and analyzer relatively to the referential plane in accordance with the low indexes. P measurements were conducted for the two object orientations θ=0°, 90° correspondently to the referential plane.

The measurements were carried out on a laboratory Stokes-goniometer, the schematic diagram of which is shown in Fig. 1.

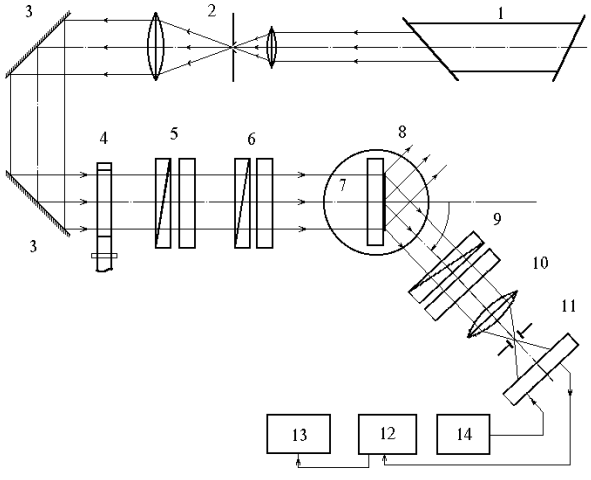

Fig. 1. Schematic diagram of a laboratory Stokes-goniometer

A continuous laser diode with a radiation wavelength λ = 670 nm was used as a source of monochromatic light. With the help of the illuminator, sight 2, the output beam of the laser diode is converted into a parallel light beam with a diameter of D ~ 2 mm and an aperture of 2γ = 30′. Swiveling mirrors 3 with external coating make it possible to reduce the longitudinal dimensions of the Stokes-goniometer. For controlled attenuation, a block of neutral filters 4 with known attenuation coefficients is used. The system of polaroid and quarter-wave plate 5 converts the linearly polarized light of the laser diode (1) into circularly polarized, which provides light beams with different shapes and azimuths of polarization during the experiment. The polarizing device 6 consists of a linear polaroid that rotates in a frame and provides a linearly polarized beam with the required polarization azimuth, and in combination with λ / 4 - circularly polarized radiation. The test sample 8 is placed in a circular frame on the stage at the geometric center of rotation of the goniometric unit 7. The rotary arm of the goniometer is equipped with a receiving system, which consists of an analyzer 9 (λ / 4 plate and polaroid) and a receiver-sight 10, which provides the reception of optical radiation in aperture angle 2γ = 30′.

To receive weak streams of light scattered by the samples, an FEU-106 photomultiplier tube is used, which was powered by a high-voltage power supply unit 14, and the photocurrent was measured using a digital ampere-voltmeter. In other cases, photodiode FD-288A (11) with a constant signal amplifier (12).

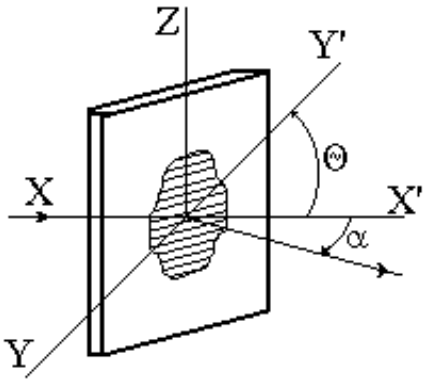

Fig. 2. Object location scheme

The entire receiving device rotated around the geometric center of the goniometric unit 7 in the horizontal plane by 175 ° with fixation every 5 °. The test specimens were adjusted relative to the geometric center of rotation of the goniometer using linear displacements of the stage in three mutually perpendicular planes, including vertical displacements. In addition, a mount can be placed on the stage for studying plane isotropically and anisotropically scattering objects, which allows you to change the spatial orientation of the object (Fig. 2).

Results. The appearance of the oriental anisotropy in the biopolymeric films is caused by the polarizable selective absorption the UV amphiphilic macromolecules of the polarized light in the process of irradiation. If first the macromolecules were chaotic, then because of their disposition toward the azimuth of the irradiate light polarization they gain principal orientation. Due to the reference (Podkamen, Arkhelyuk, 1991) and the results of our measurements the parameter of nonspheric is Δ=0,18 for the investigated objects, i.e. the form of the amphiphilic macromolecules differ from spheric.

The effective size of macromolecules was defined by the angle of scattering α, where the component of matrix scattering light (MSL) f_{33}=0. In our case α=98° that indicates to the effective size of the macromolecule 1÷2 μm.

Conclusions. The comparative characteristics of the angular distribution of nonzero component f_{ik} MSL films which contain amphiphilic molecules have revealed that the increasing time of the irradiation by the polarized UV light causes the following:

1. The degree of the principal orientation of the optical heterogeneities system, i.e. macromolecules, is increased. The enlarge of the absolute meaning f_{13} of small and big angles of scattering prove it.
2. The effective size of the indicated scattering light centers is increased. The estimation was made in consecutive reduction of the absolute component meaning f_{22} in its minimum and increasing α equal f_{33}=0.
3. The increasing of the parameter of non-sphericity of the scattering centers with the increasing time of the samples irradiation prove the raising $|f_{33}-f_{44}|$ in α≥150°.

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ДОСЛІДЖЕННЯ ВПЛИВУ ПОЛЯРИЗОВАНОГО УФ-ВИПРОМІНЮВАННЯ НА СТРУКТУРУ ФОТОЧУТЛИВОГО БІОПОЛІМЕРУ ЗА МАТРИЧНИМ МЕТОДОМ МЮЛЛЕРА

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Дослідження дисперсних середовищ біологічного походження методами оптики світлорозсіювальних середовищ використовуються для виявлення впливу форми, орієнтаційної структури та полідисперсності компонентів цього середовища на його оптичні характеристики. Комплексне дослідження характеристик розсіювання та поглинання світла дає змогу виявити фізіологічні та морфологічні зміни клітин, викликані температурними та хімічними факторами, а також провести швидкий якісний аналіз. Враховуючи те, що матриця світлорозсіювання містить всю інформацію про дисперсне середовище, доступну оптичними методами, для дослідження біологічного середовища, доцільно використовувати матричний метод Мюллера. Проведено експериментальні дослідження впливу поляризованого УФ-випромінювання на структуру амфіфільних макромолекул, що входять до складу світлочутливої мембрани. Виміряно поляризаційні характеристики, а також матрицю Мюллера тонких плівок, що містять такі фотоактивні біополімери.

Ключові слова: матричний метод Мюллера, фотоактивні біополімери, поляризоване ультрафіолетове випромінюван

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