STUDY OF OPTICAL CHARACTERISTICS CHANGES OF THE BIOLOGICAL TISSUES AFTER THE INJECTION OF NANOPARTICLES OF VARIOUS TYPES WITHOUT AND AFTER PDT

D. K. Tuchina,[1,2] E. N. Lazareva,[1,2] A. A. Doronkina,[1] R. A. Anisimov,[3] M. V. Lomova,[3] A. M. Mylnikov,[4] N. A. Navolokin,[4,5,6] V. I. Kochubey,[1,2] I. Yu. Yanina[1,2*]

[1]Department of Optics and Biophotonics, Saratov State University (National Research), Saratov, Russian Federation

[2]Laboratory of laser molecular imaging and machine learning, Tomsk State University (National Research), Russian Federation

[3]Education and Research Institution of Nanostructures and Biosystems, Saratov State University (National Research), Russian Federation

[4]Department of Pathological Anatomy, Saratov State Medical University, Saratov, Russian Federation

[5] Research-Scientific Institute of Fundamental and Clinic Uronephrology, Saratov State Medical University, Saratov, Russian Federation

[6] Pathological Department, State Healthcare Institution "Saratov City Clinical Hospital No. 1 named after Yu.Ya. Gordeev" st. them. Kholzunova A.I., Saratov, Russian Federation

*e-mail: irina-yanina@list.ru

Motivation

Currently, in medicine and pharmacology, the method of targeted transport of drugs is becoming increasingly relevant, making it possible to increase the concentration of delivered drugs in a certain place and block or greatly limit their accumulation in healthy organs and tissues.

Motivation

Directed transport makes it possible to increase the duration and effectiveness of the drug and reduce side effects.

Motivation

Traditional medicines have a number of **disadvantages**:

❖when a drug is administered, its ineffective use occurs, associated with the distribution of the drug throughout almost the entire body and, as a result, the inability to maintain a therapeutic concentration in the required place for a certain time.

Motivation

Traditional medicines have a number of **disadvantages**:

❖due to the lack of targeting of delivery, the drug does not reach all biological targets or reaches, but in a concentration significantly lower than the therapeutic one. Therefore, in order to achieve the required concentration of the drug in the lesion, it is necessary to administer deliberately inflated doses of the drug.

Motivation

Traditional medicines have a number of **disadvantages**:

❖non-directed effect of drugs, i.e. interaction with non-target biological objects leads to side effects, which is especially undesirable when using toxic drugs.

Motivation

The development of drug delivery systems is aimed at increasing the therapeutic efficacy, tolerability and safety of drug therapy.

Motivation

Nanoparticle carriers are used in targeted drug delivery.

Delivery systems are created by enclosing drugs either in a nanocapsule, in which the drug is contained in a cavity surrounded by a permeable membrane, or in a nanosphere, in which the drug is dispersed throughout the volume.

Motivation

A significant advantage of such delivery systems is the protection of active drugs from degradation and metabolism.

Delivery systems are also obtained by binding drugs to the surface of a nanoparticle carrier; in this case, it is not protected from degradation in the body under the influence of the environment.

Motivation

In this case, complex conjugates can be created, consisting of a carrier to which molecules of a pharmaceutical substance are attached, a vector responsible for directed transport, sometimes a fragment that makes it possible to track the conjugate, as well as surfactant molecules on the surface of nanoparticles that reduce the recognition of nanoparticles by macrophages.

Motivation

Theranostic technologies enable visualization and therapy in oncology using nanomethods with the possibility of targeted delivery of both active agents and imaging compounds.

Motivation

One of the directions in targeted drug delivery is the use of nanostructured particles, nanoparticles or nanocontainers.

The nanocontainer is designed and has the capacity necessary to load a large number of drug molecules. Its advantage is that it binds to a targeting ligand, resulting in a significant reduction in the amount of targeting ligand. Thus, it is possible to significantly reduce the amount of targeting ligand while still delivering a larger amount of the substance.

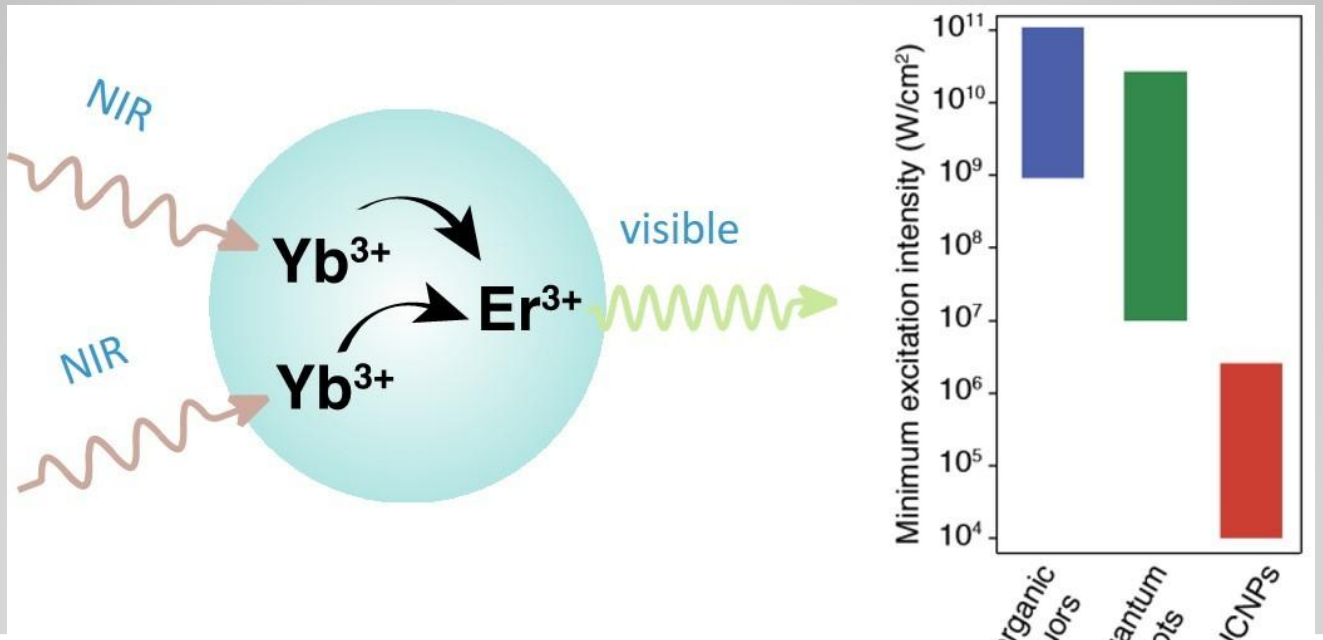
Motivation

Over the past two decades, the attention of scientists has been riveted to *upconversion nanoparticles (UPCNPs)* and the prospects for their biomedical application.

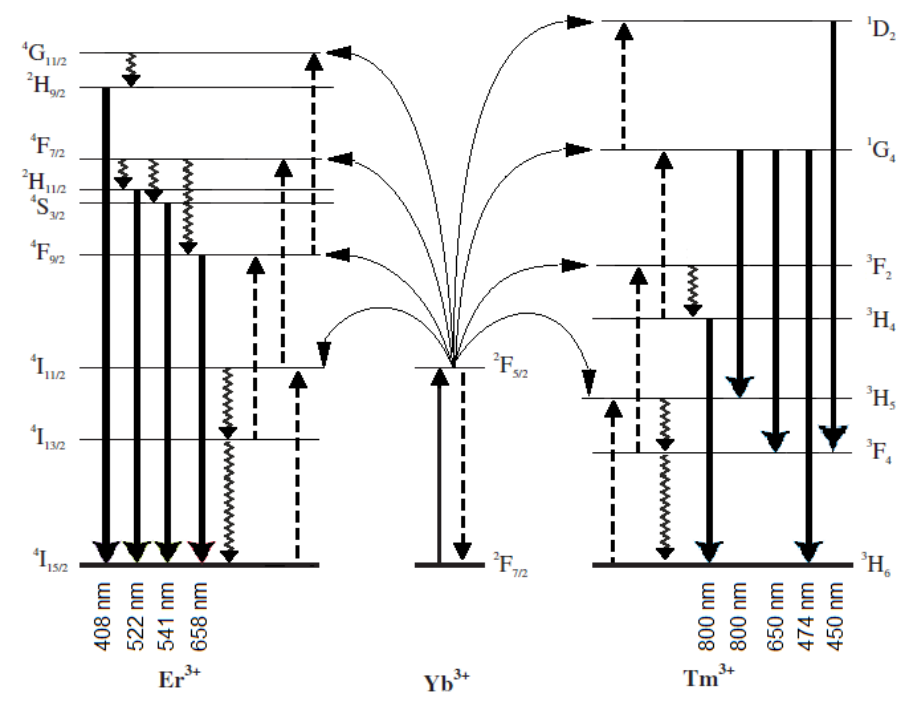
Motivation

- *UCNPs* are particles that luminesce in the visible region of the spectrum when excited in the IR region.
- Luminescence arises due to the summation of the energy of several absorbed quanta of exciting radiation with the radiation of one quantum with a higher energy.
- The phenomenon of upconversion luminescence (UCL) is observed in inorganic crystals called upconversion phosphors doped with certain trivalent rare earth metal (RE) ions.

- It thereby converts two or more low-energy excitation photons, which are generally NIR light, into shorter wavelength emissions (e.g., NIR, visible, and UV).



Motivation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$^4I_{13/2}$
$^4I_{15/2}$
408 nm
522 nm
541 nm
658 nm
Er^{3+}
$^2F_{5/2}$
$^2F_{7/2}$
Yb^{3+}
$^1D_2$
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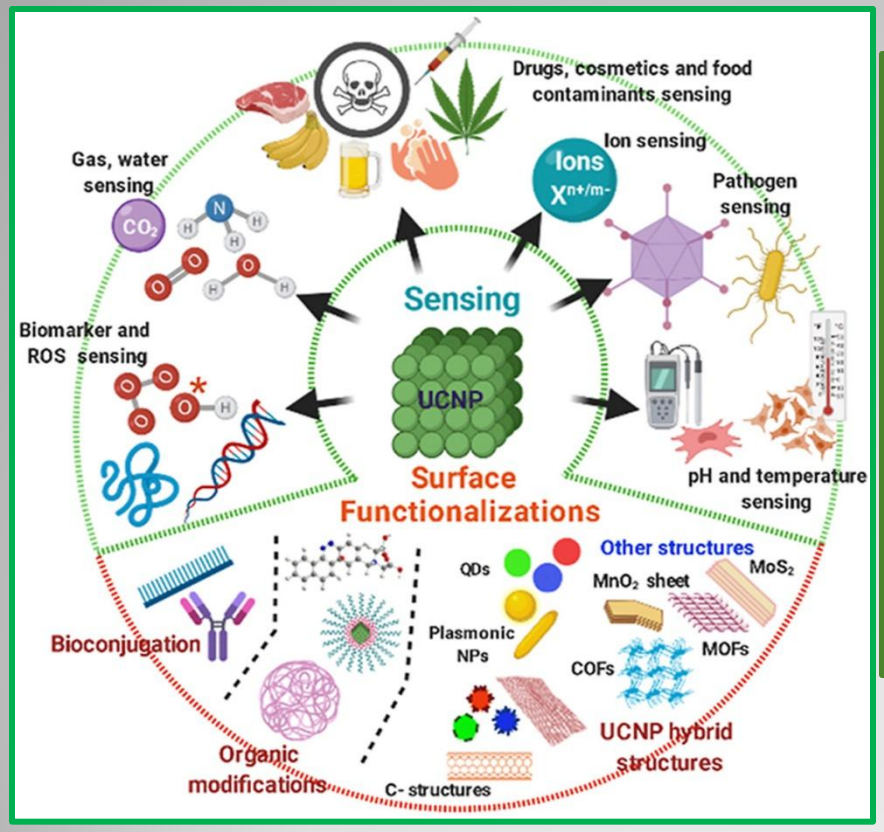
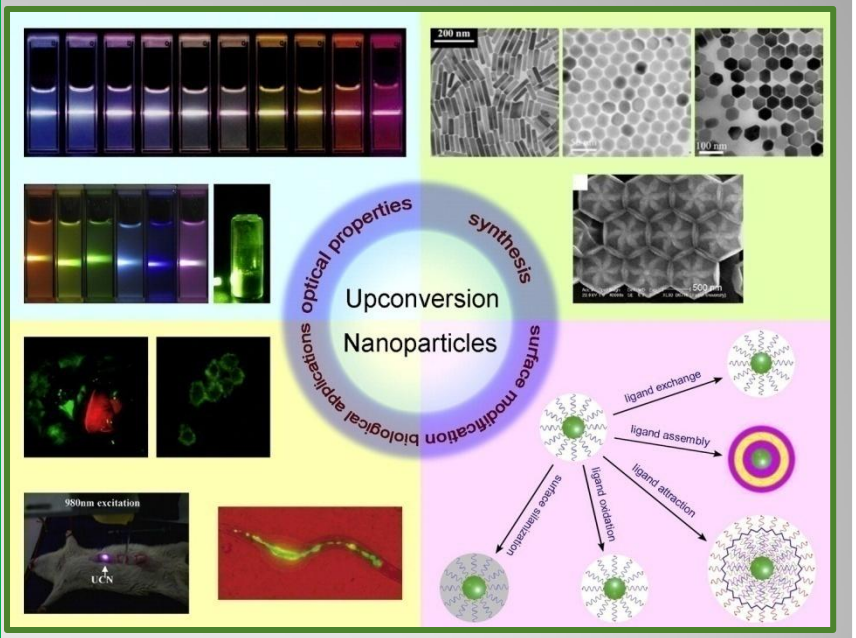
800 nm
800 nm
650 nm
474 nm
450 nm
Tm^{3+}

Motivation



https://doi.org/10.1016/j.trac.2021.116256



https://doi.org/10.1016/j.nano.2011.02.013

PHOTODYNAMIC THERAPY

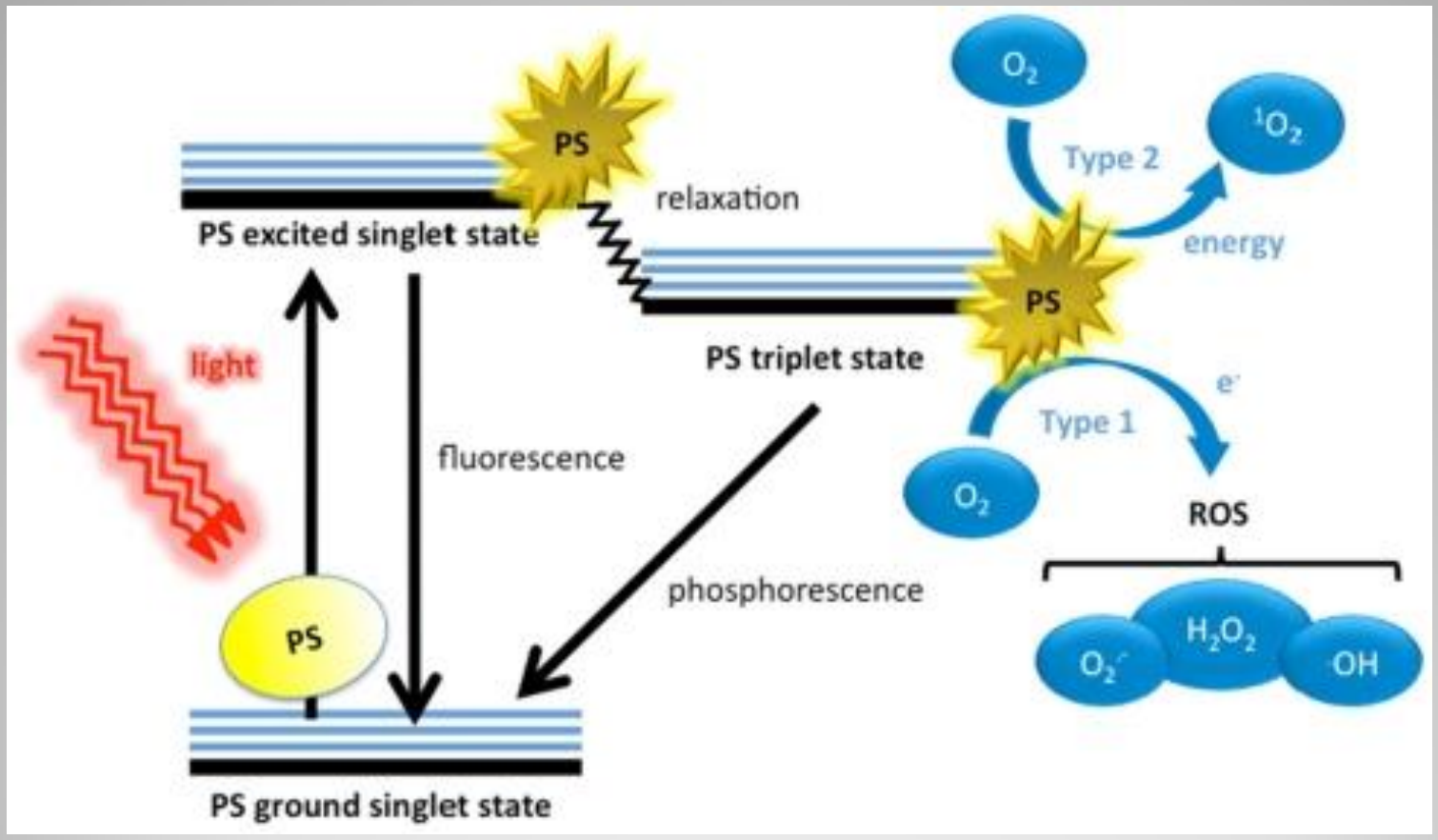
Person with cancer receives a drug called a photosensitizer.

In 24 to 72 hours, cancer cells absorb the photosensitizer.

Cancer cells that absorbed the photosensitizer are exposed to light.

Light causes photosensitizer to make a form of oxygen that kills cancer cells.

cancer.gov/about-cancer/treatment/types/photodynamic-therapy



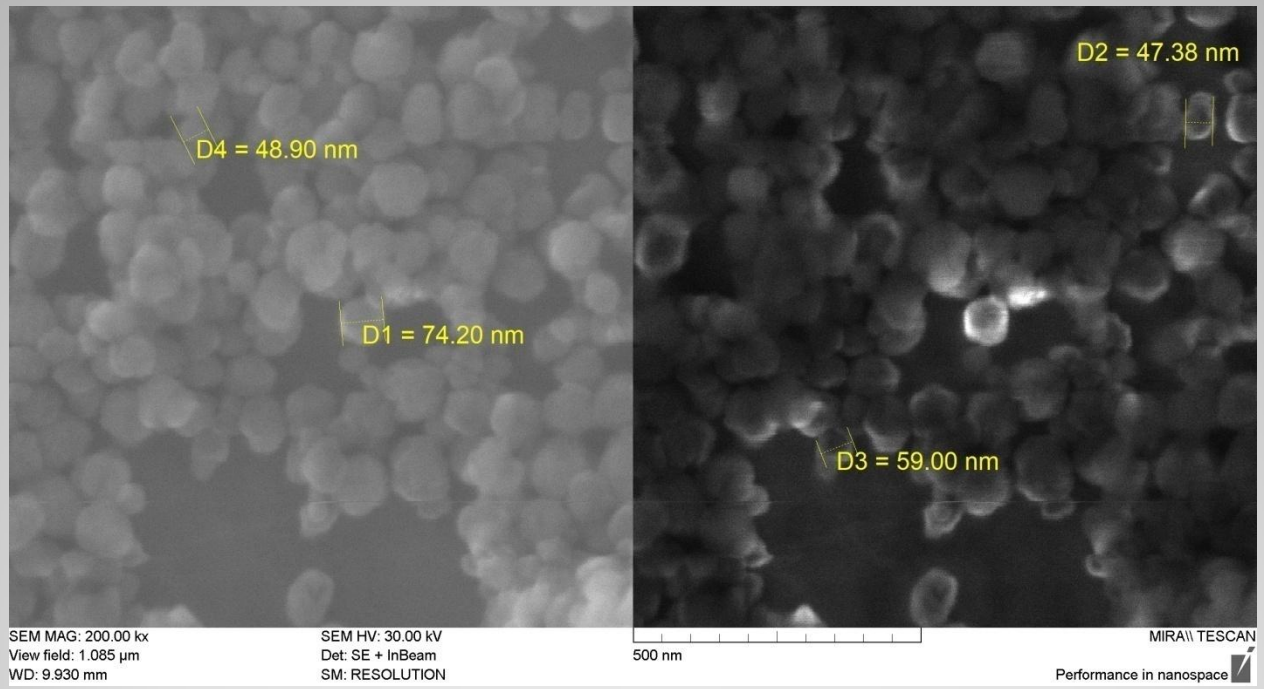
Dai T, Fuchs BB, Coleman JJ, et al. Concepts and principles of photodynamic therapy as an alternative antifungal discovery platform. *Front Microbiol*. 2012;3:120. Published 2012 Apr 10. doi:10.3389/fmicb.2012.00120

- It is important to know the **optical properties of tissues**, as this allows one to evaluate the effect of different nanoparticles, nanocontainers on the optical properties of tissues in the irradiation zone, which must be taken into account when calculating the loading of the active agent into the carrier.

Aim

- Obtain submicron-sized core-shell systems containing UCNPs and a photosensitizer
- To conduct a comparative study of the effect of the introduction of UCNPs, $CaCO_3$, $CaCO_3$+BSA, and $CaCo_3$+BSA/UCNPs/BSA, $NaYF_4$ (unannealed)+HAS+MB, $NaYF_4$+HSA+FA+Cy3 on the optical parameters of biological tissues in the area of tumor development at room and physiological temperatures

Materials and methods



SEM image of the $[NaYF_4: Yb^{3+}, Er^{3+}]$ UCNPs.

Materials and methods

- 1. Submicron $CaCO_3$ particles were used as the core.
- The shells were deposited using the sequential adsorption method.
- A protein (bovine serum albumin, BSA) was frozen into calcium carbonate particles, to which the Cy3 and Cy5 dyes were conjugated. UCNPs were adsorbed onto the surface of the resulting particles, followed by a layer of BSA with Cy3 and Cy5 dyes.

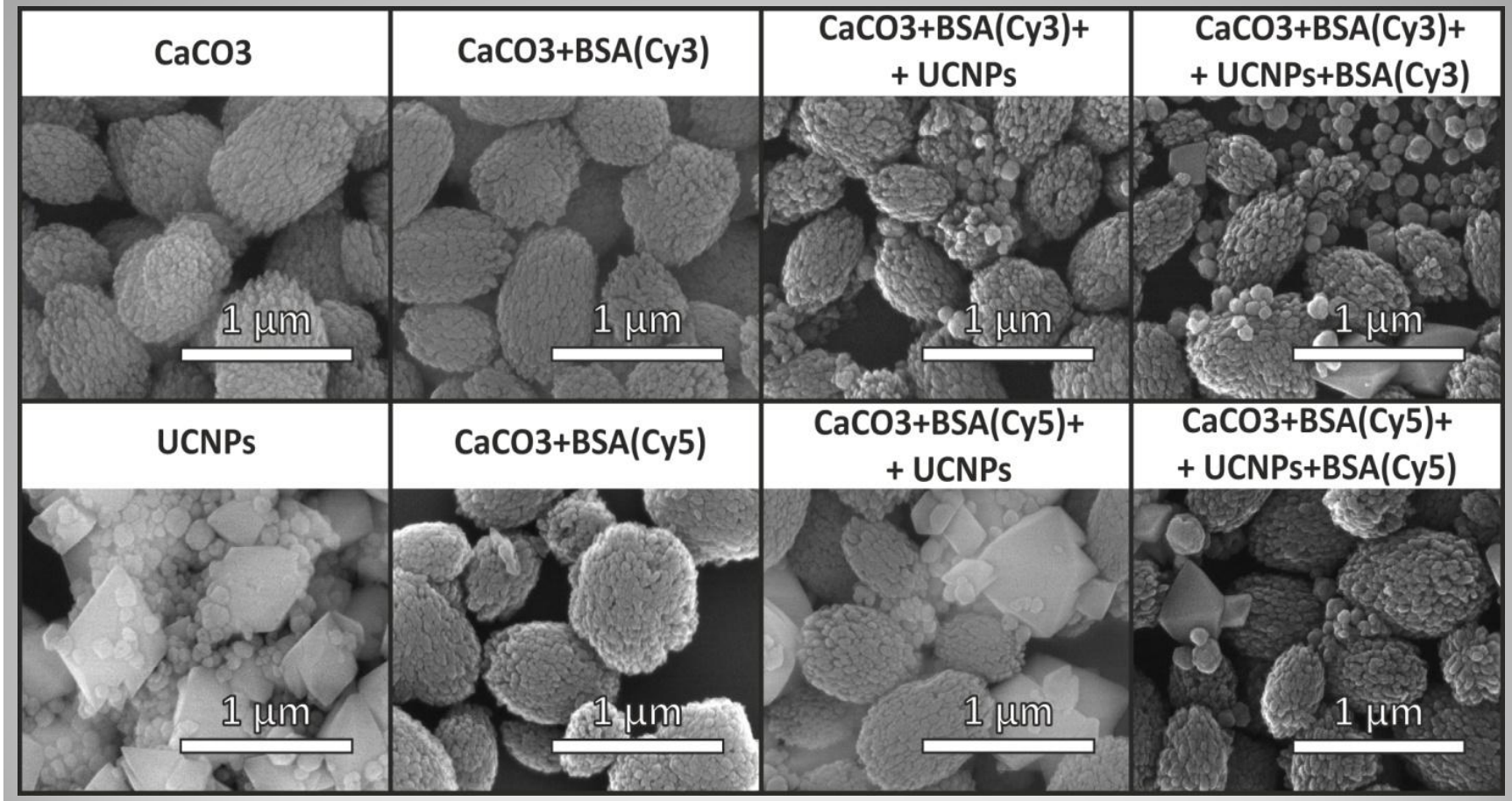
Materials and methods

- 2. To attach the dye to the shell, we chose methylene blue and the sodium salt of fluorescein.
- To crosslink the photodynamic dye with the shell of nanoparticles, we coated their surface with human serum albumin (HSA).

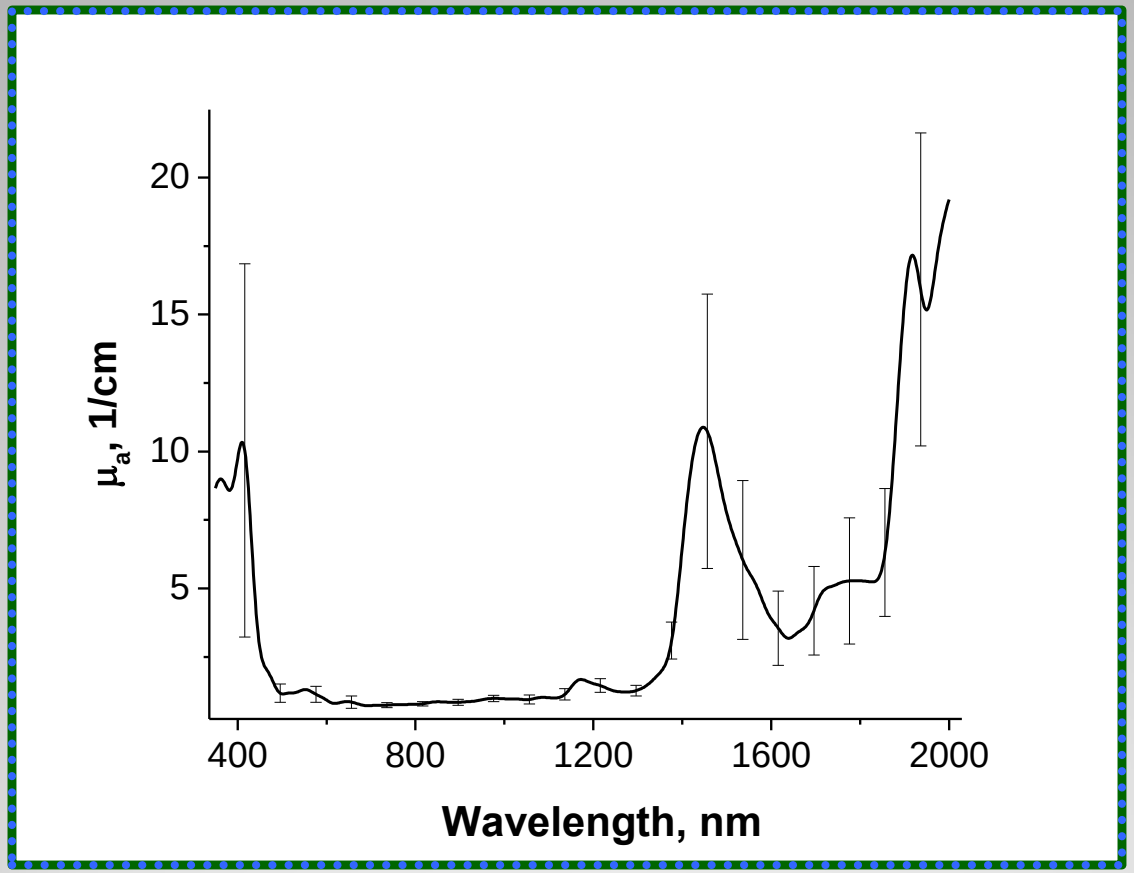
Materials and methods

- Measurements of the total and collimated transmission spectra, as well as the diffuse reflectance spectra of biological tissues of rats taken from the area of tumor transplantation, were carried out in the spectral range of 380-2000 nm on a Perkin Elmer Lambda 950 spectrophotometer (USA).

Results and discussion

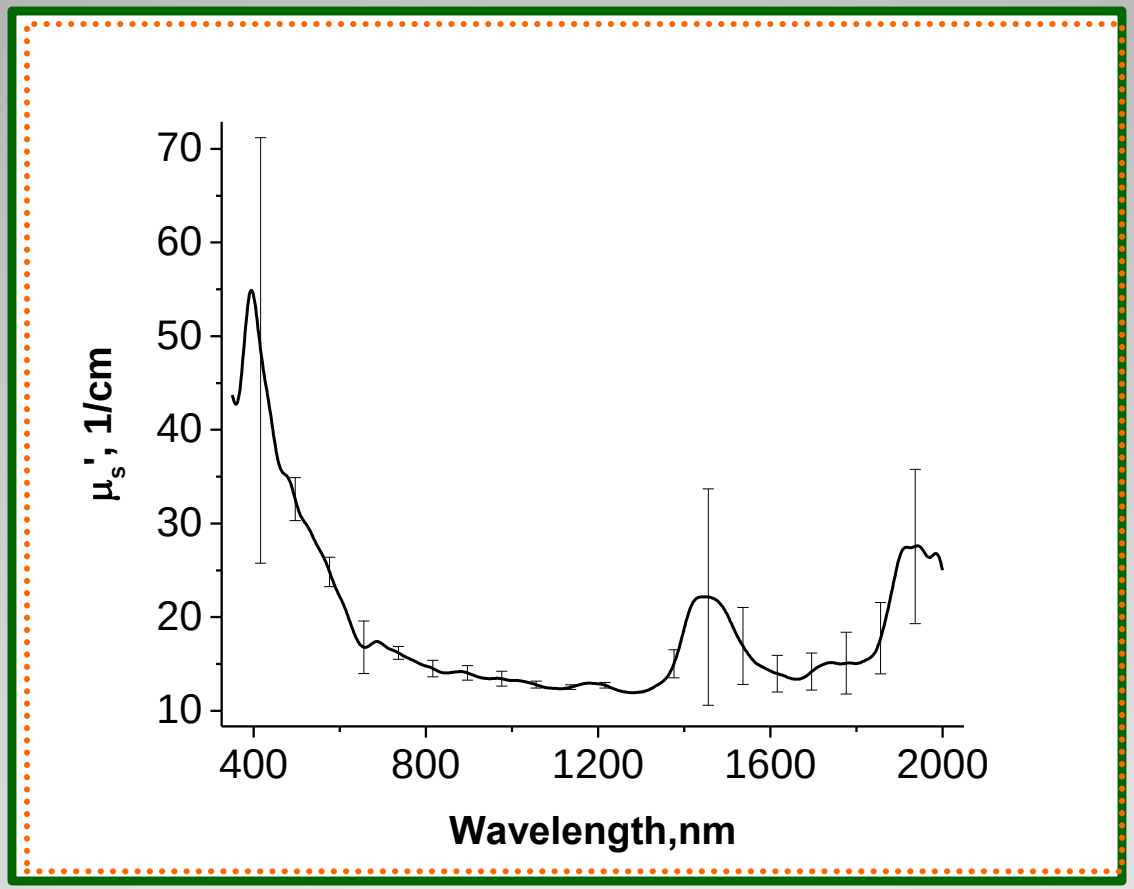


Results and discussion



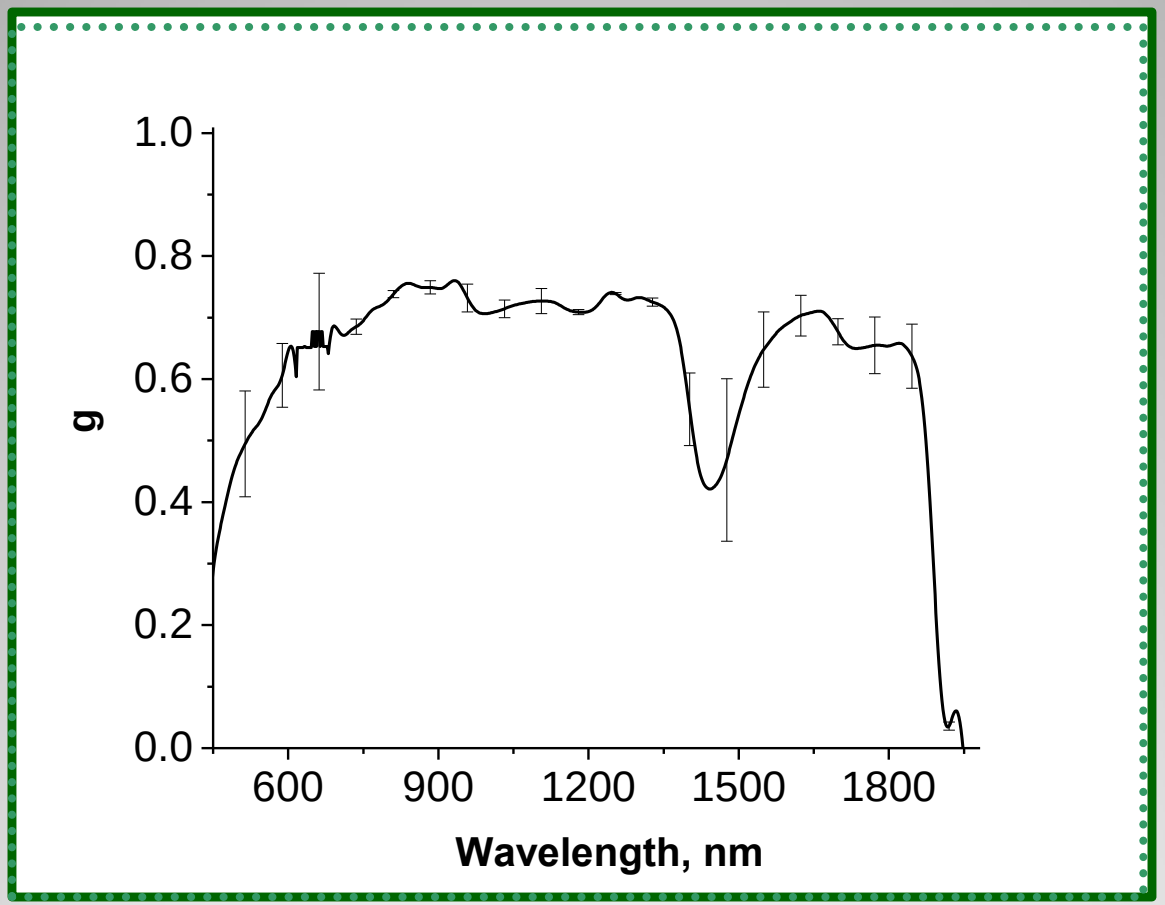
Healthy Skin

Results and discussion



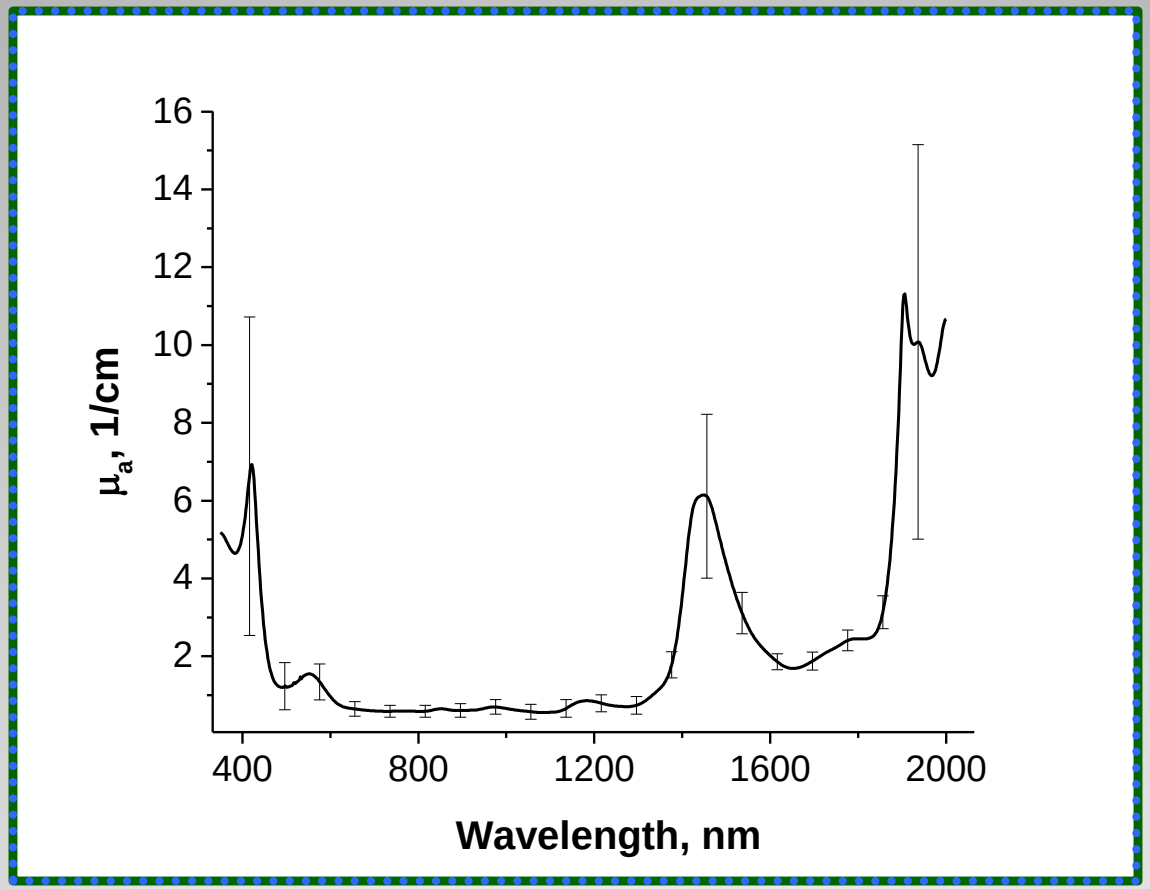
Healthy Skin

Results and discussion



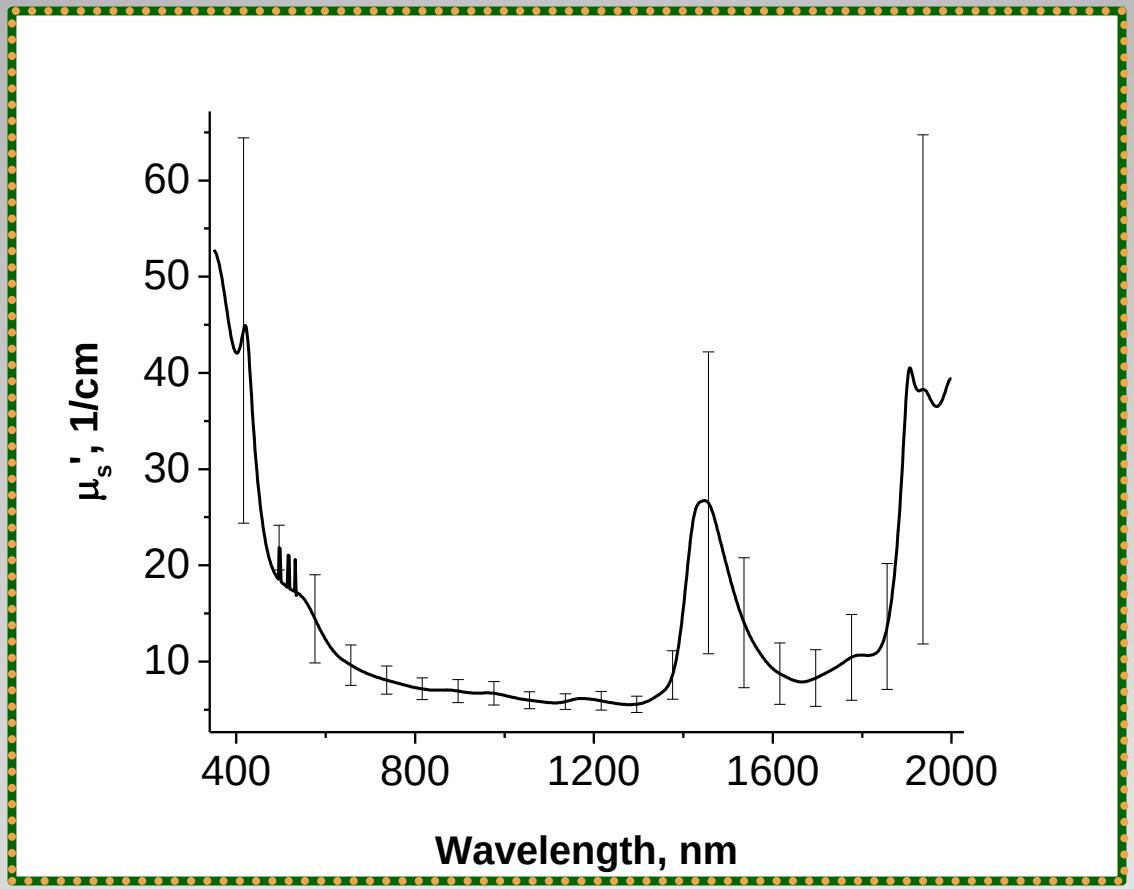
Healthy Skin

Results and discussion



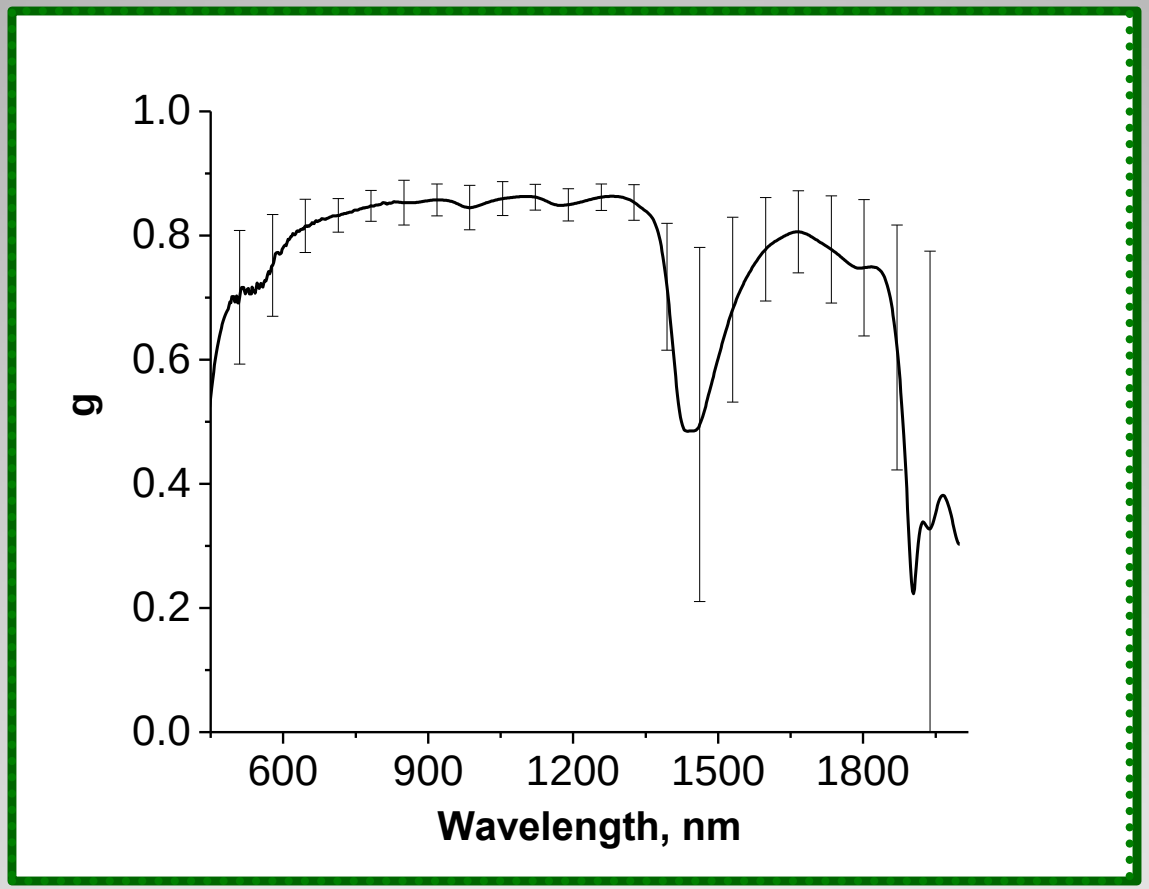
Healthy Adipose Tissue

Results and discussion



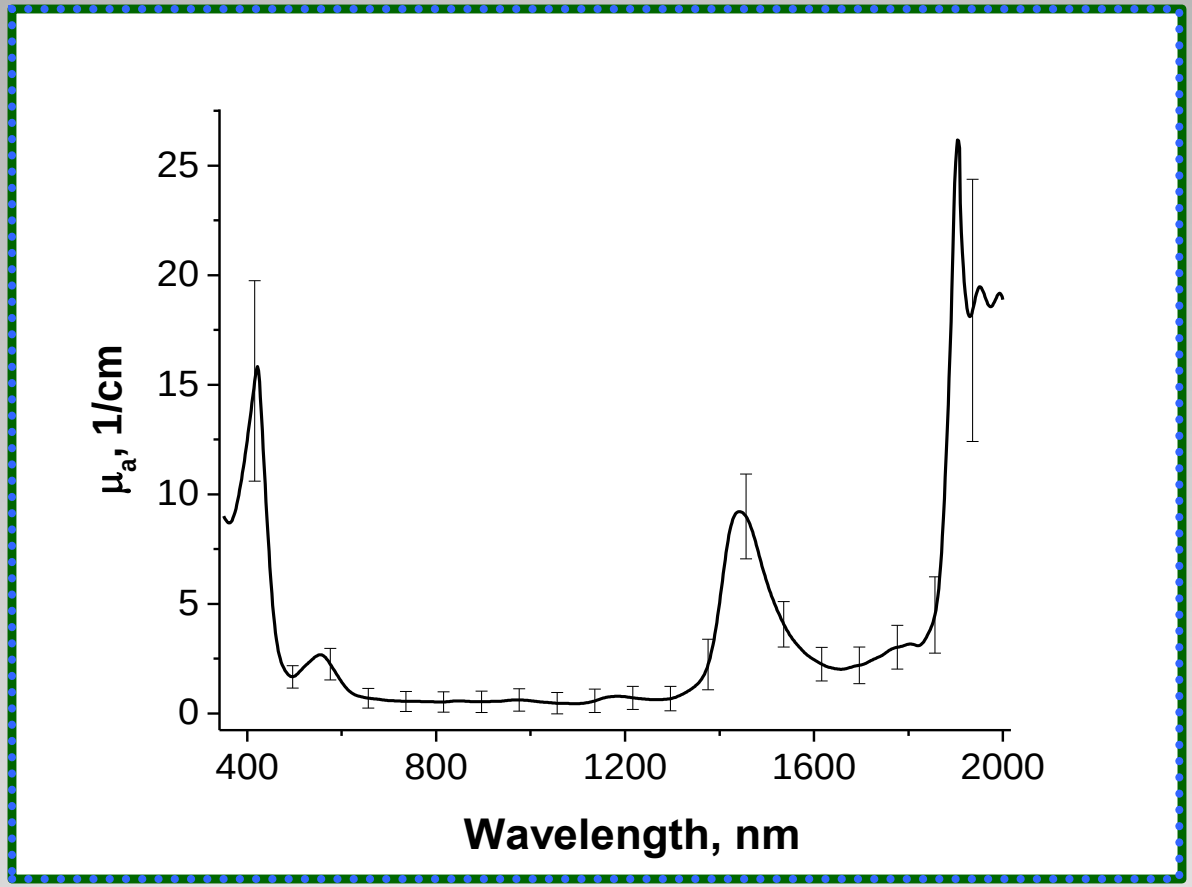
Healthy Adipose Tissue

Results and discussion



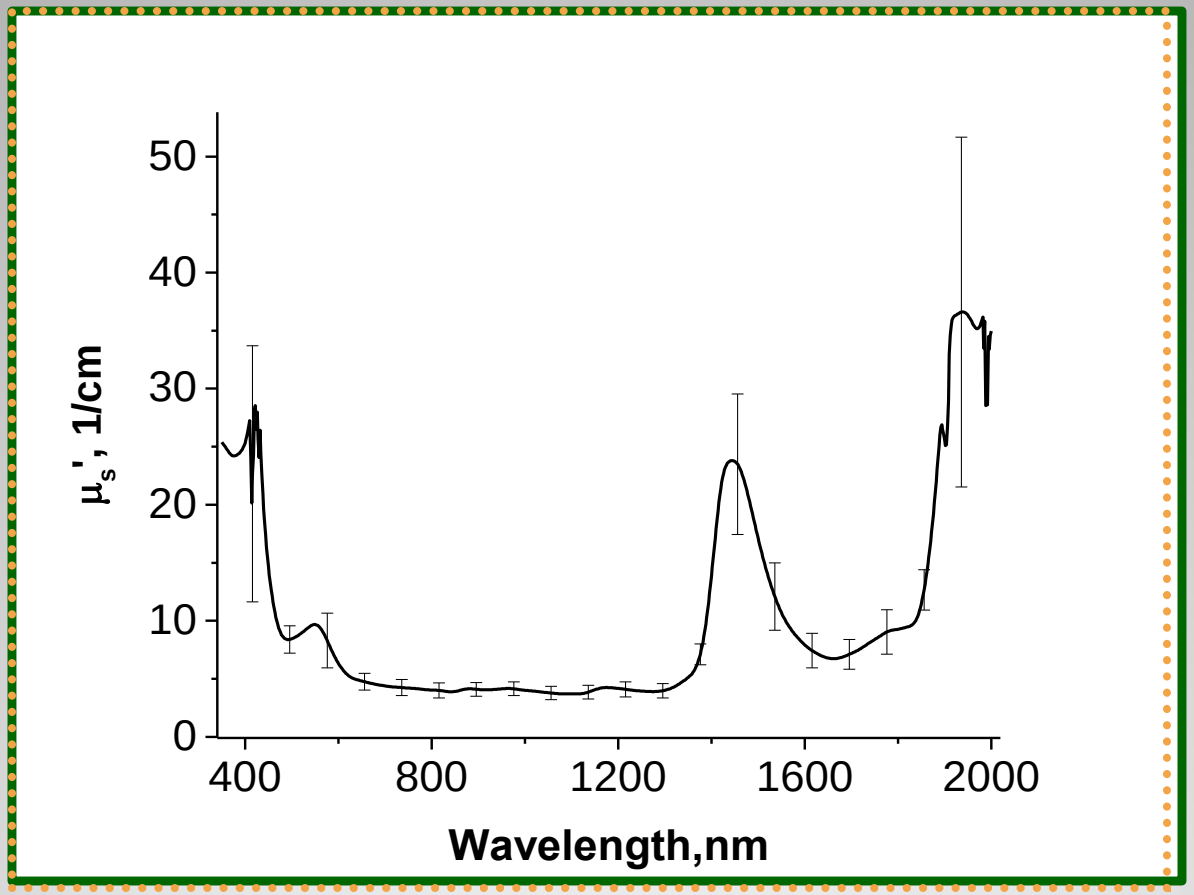
Healthy Adipose Tissue

Results and discussion



Healthy Muscle

Results and discussion



Healthy Muscle

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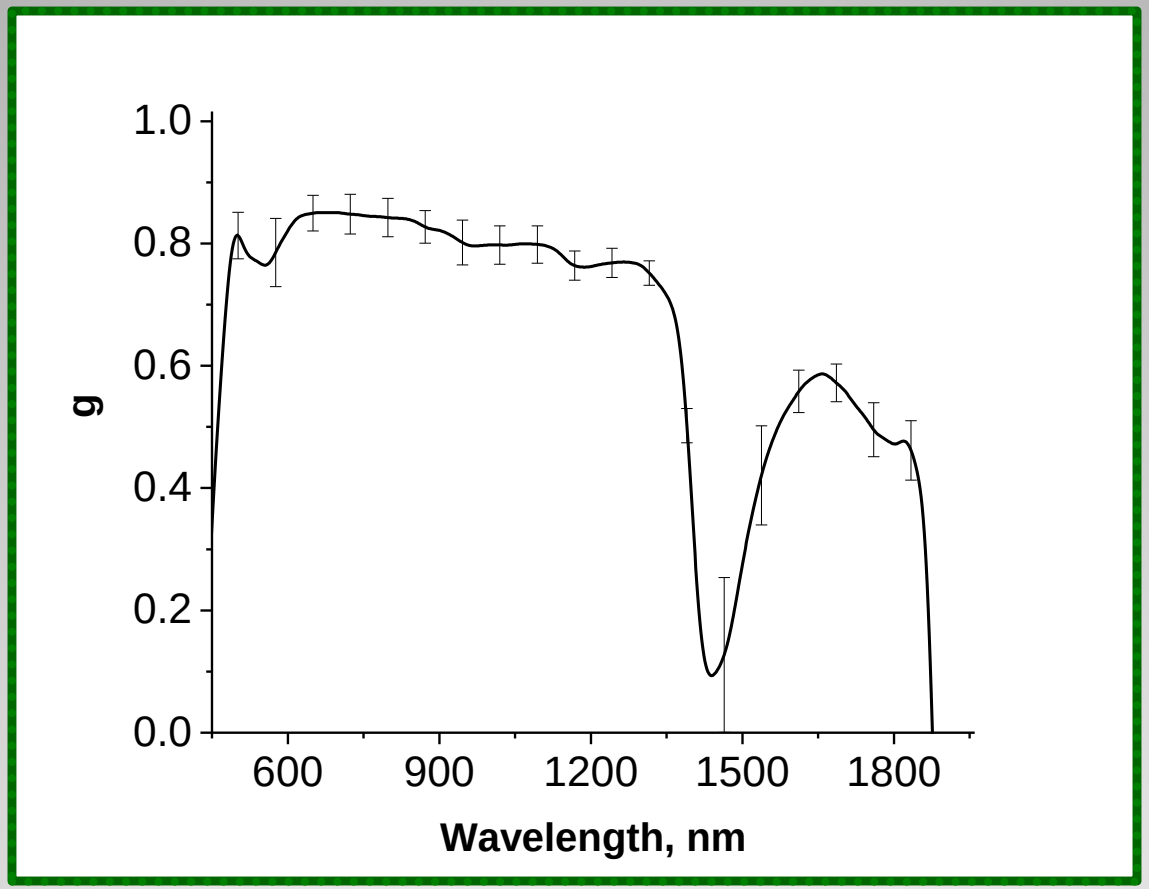

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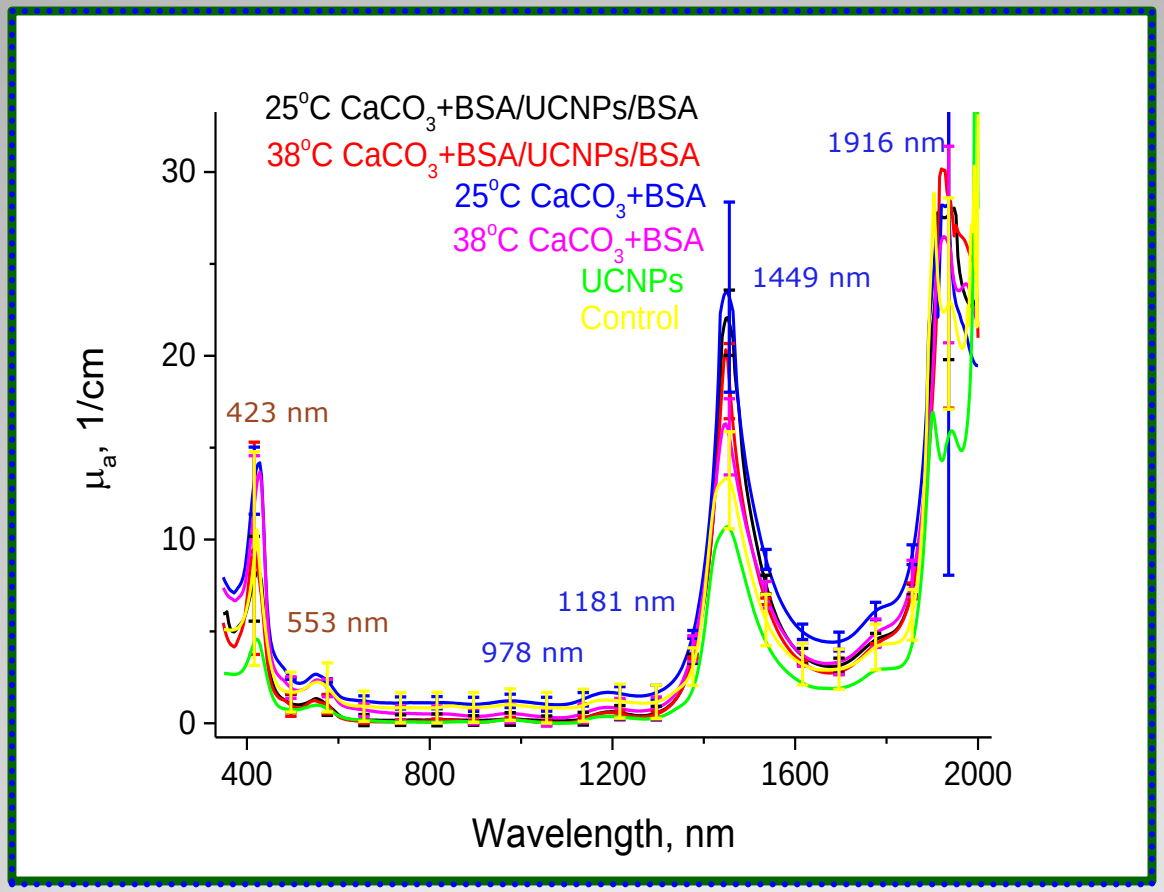
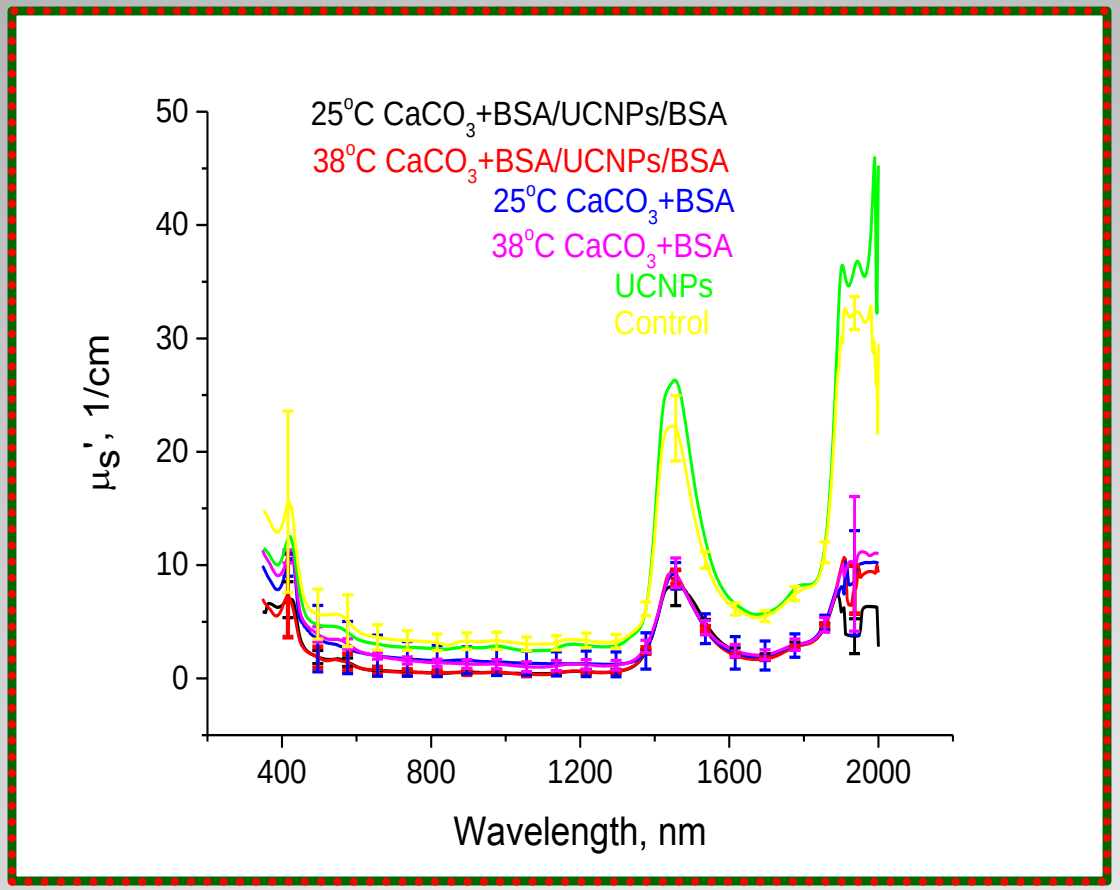


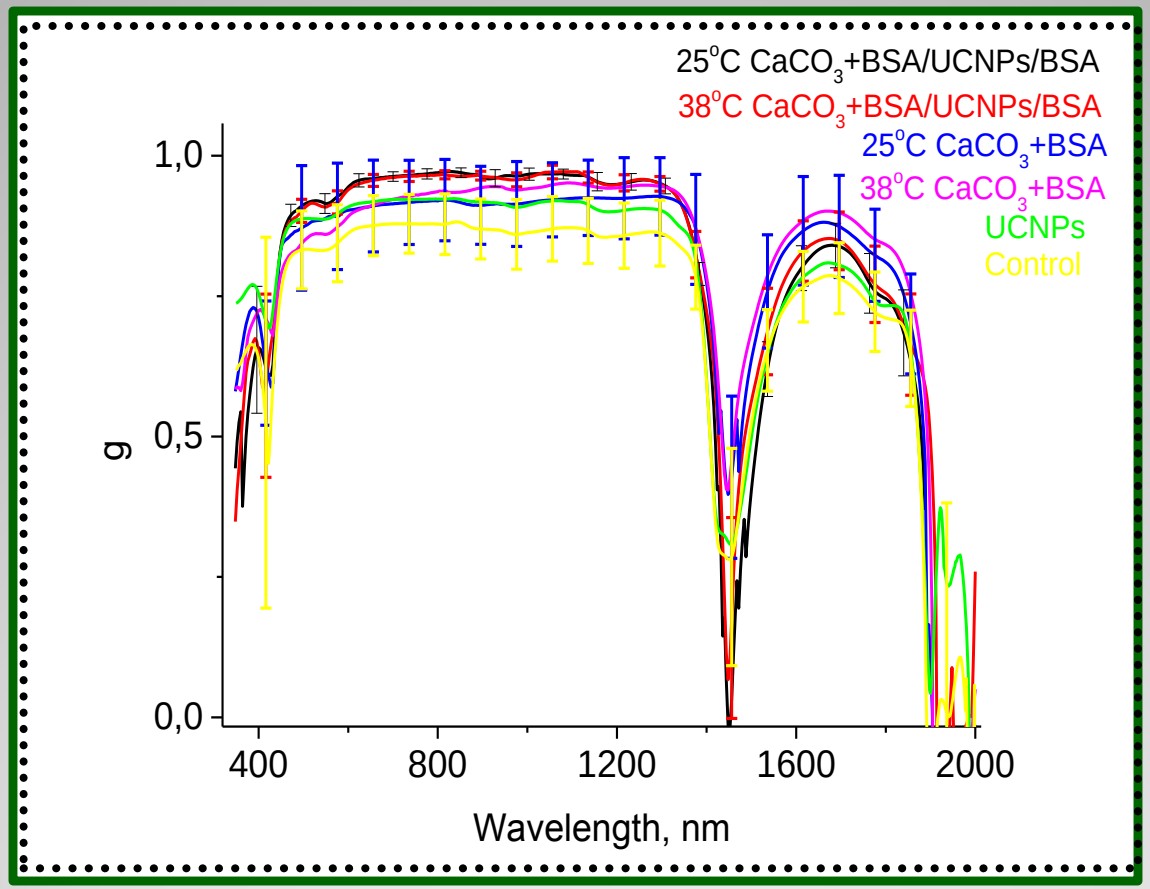
Tumor tissue

Results and discussion



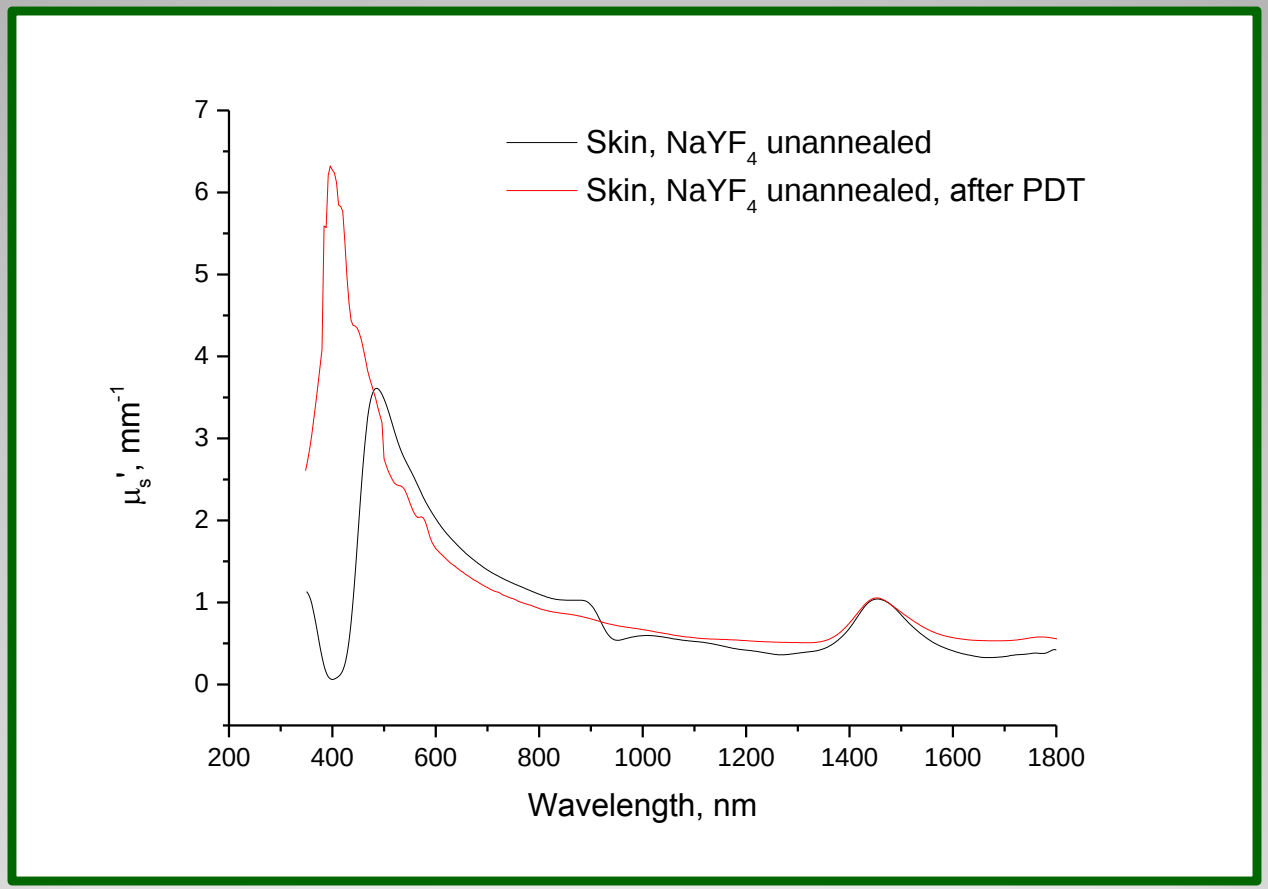
Tumor tissue

Results and discussion



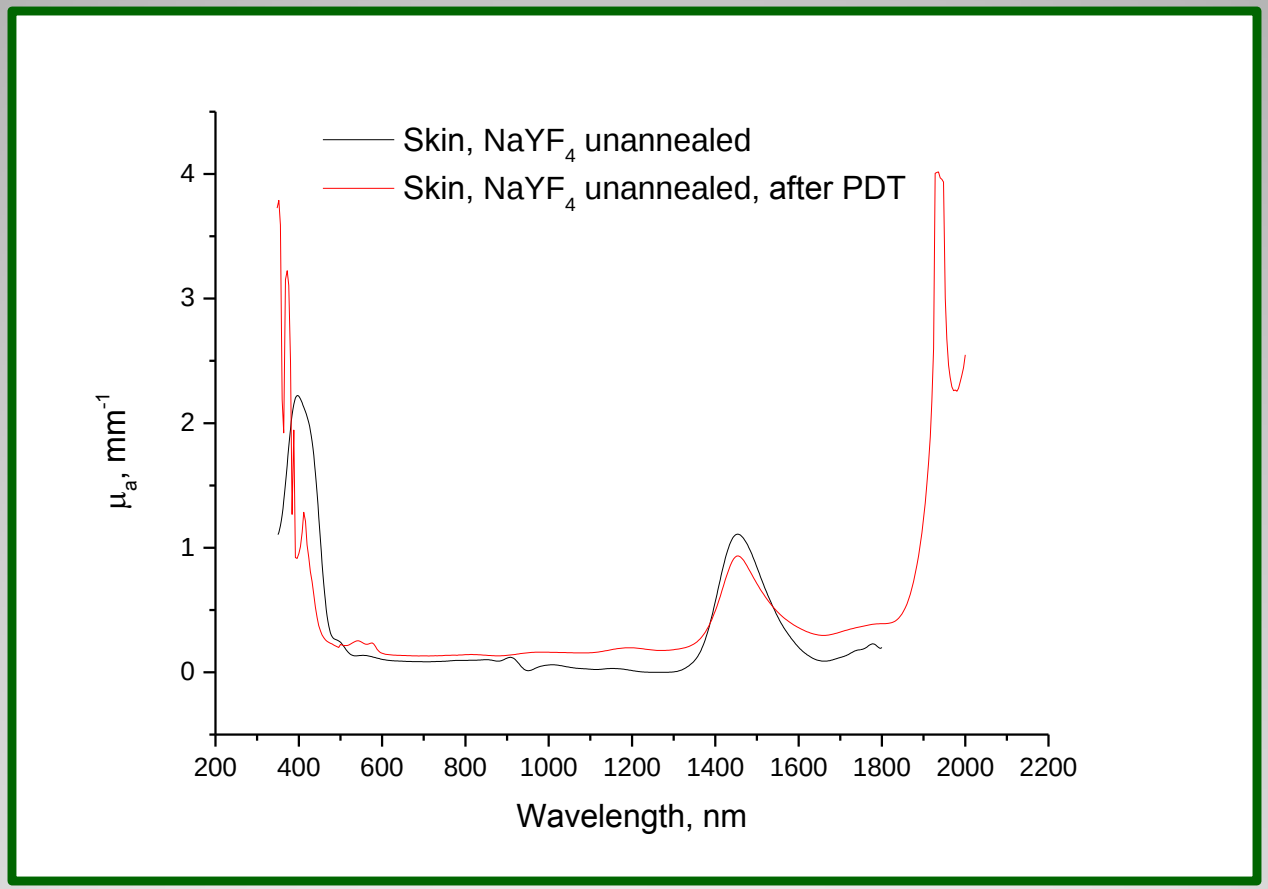
Tumor tissue

Results and discussion



Healthy Skin

Results and discussion



Healthy Skin

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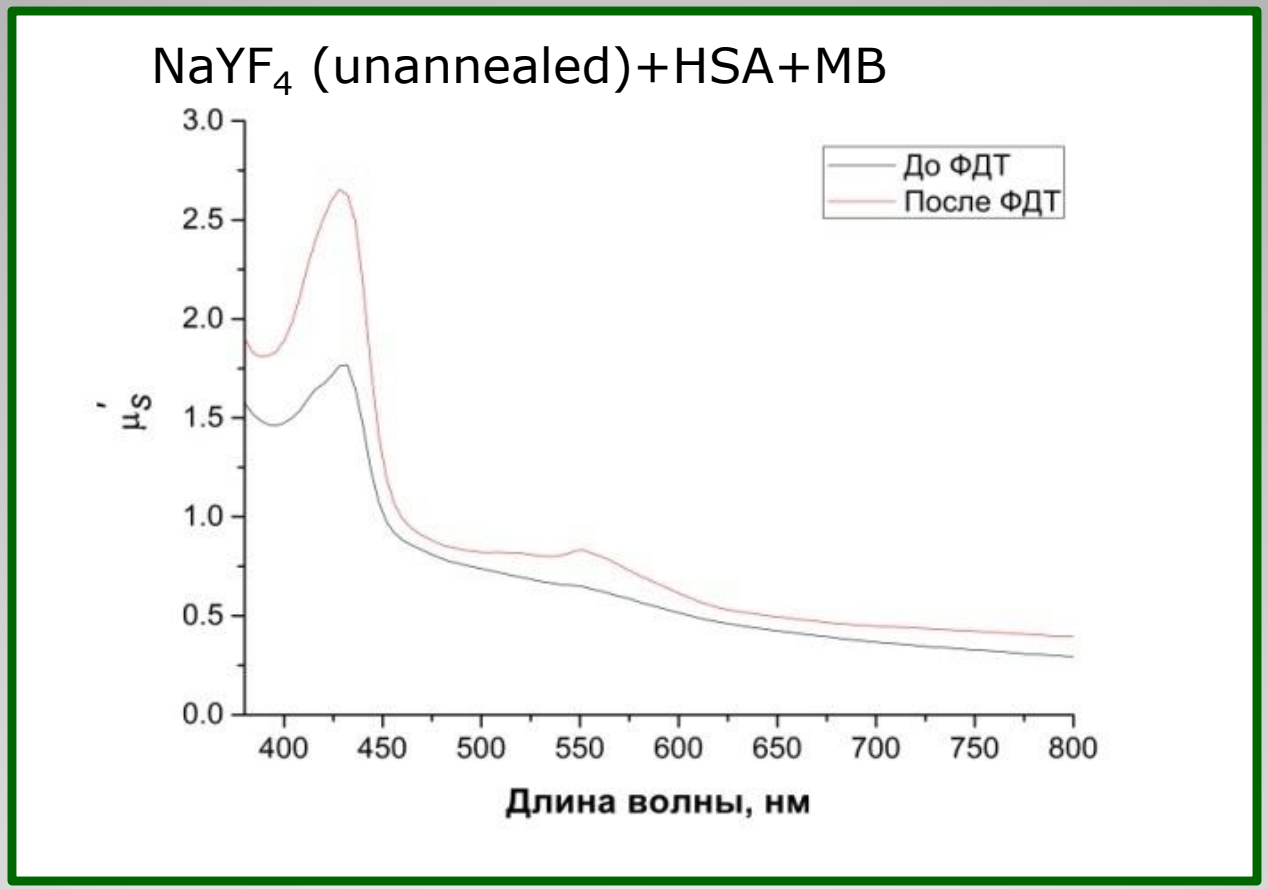

Healthy Muscle

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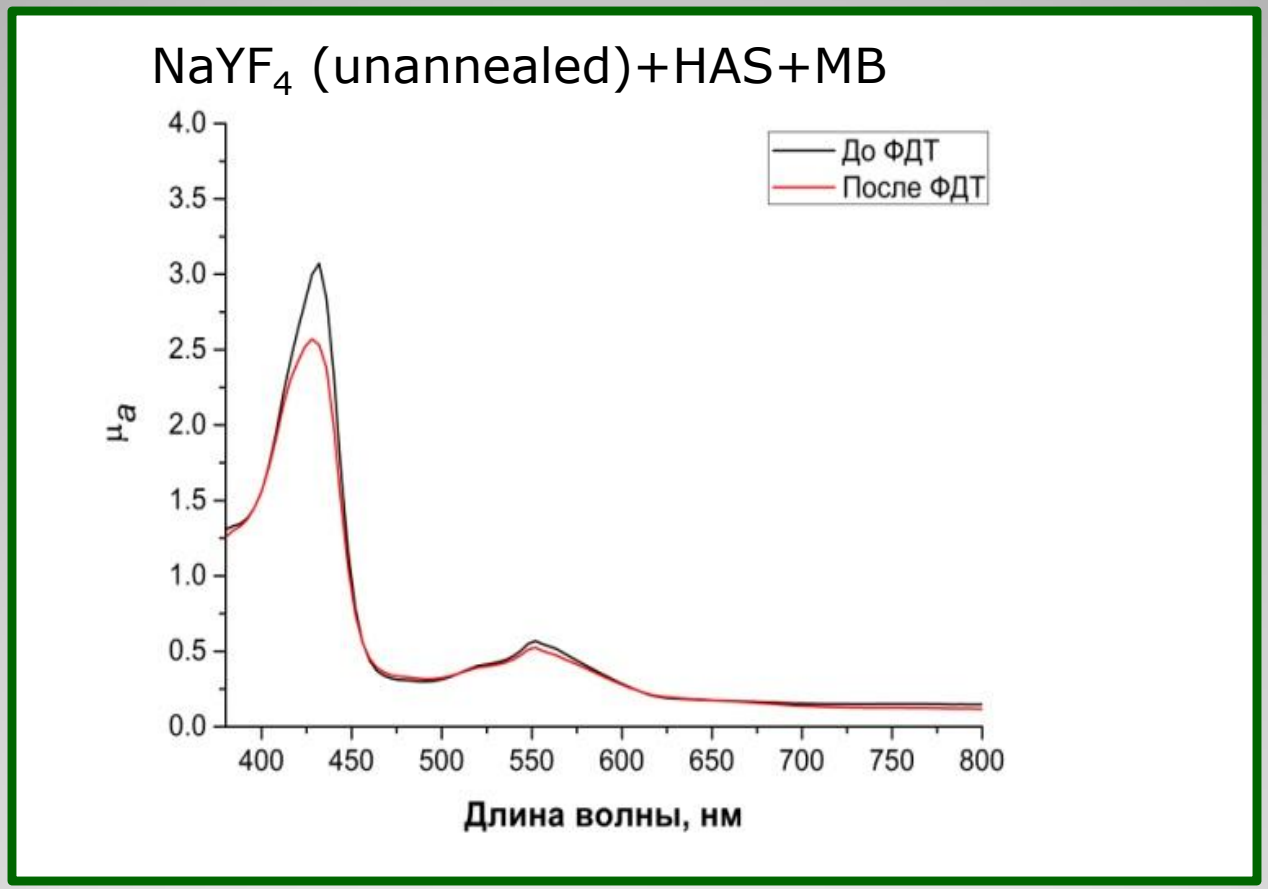

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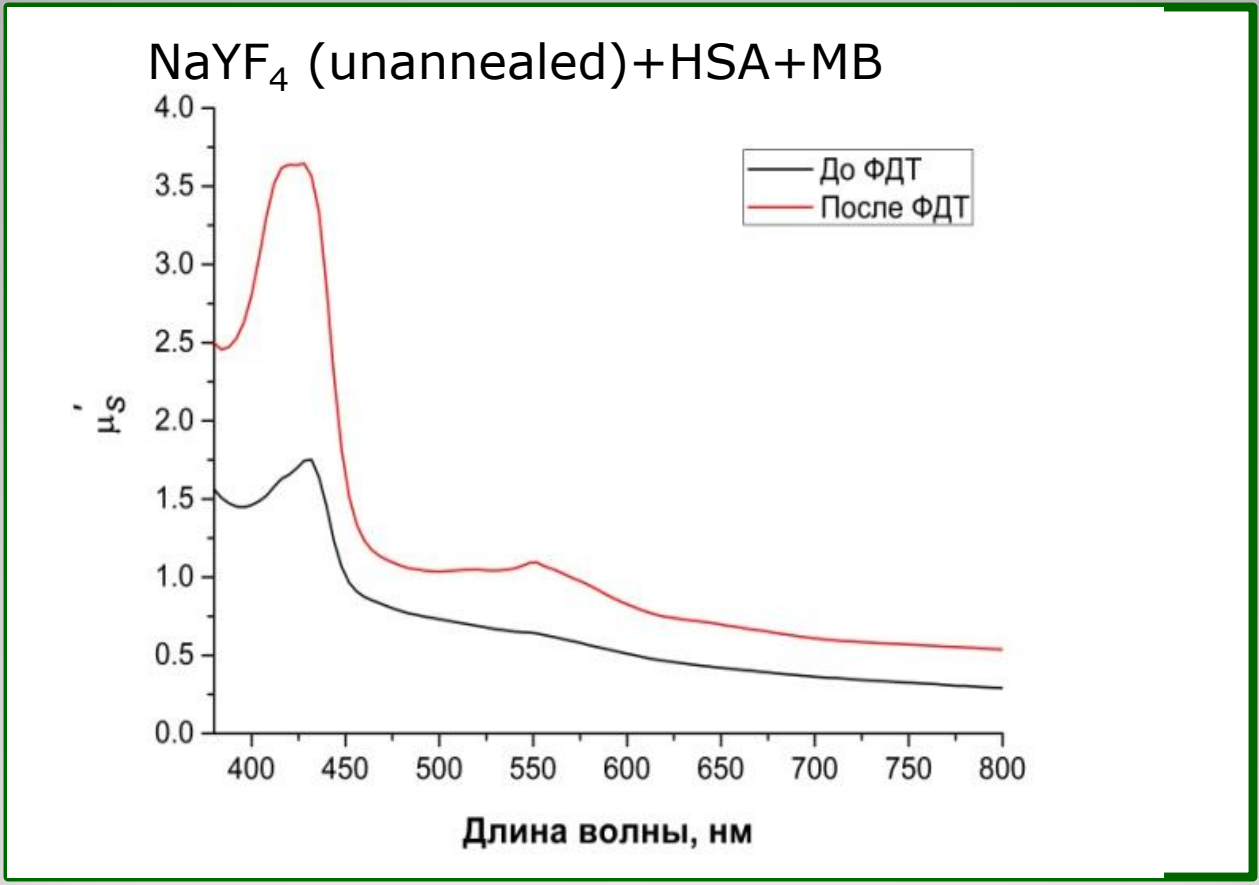
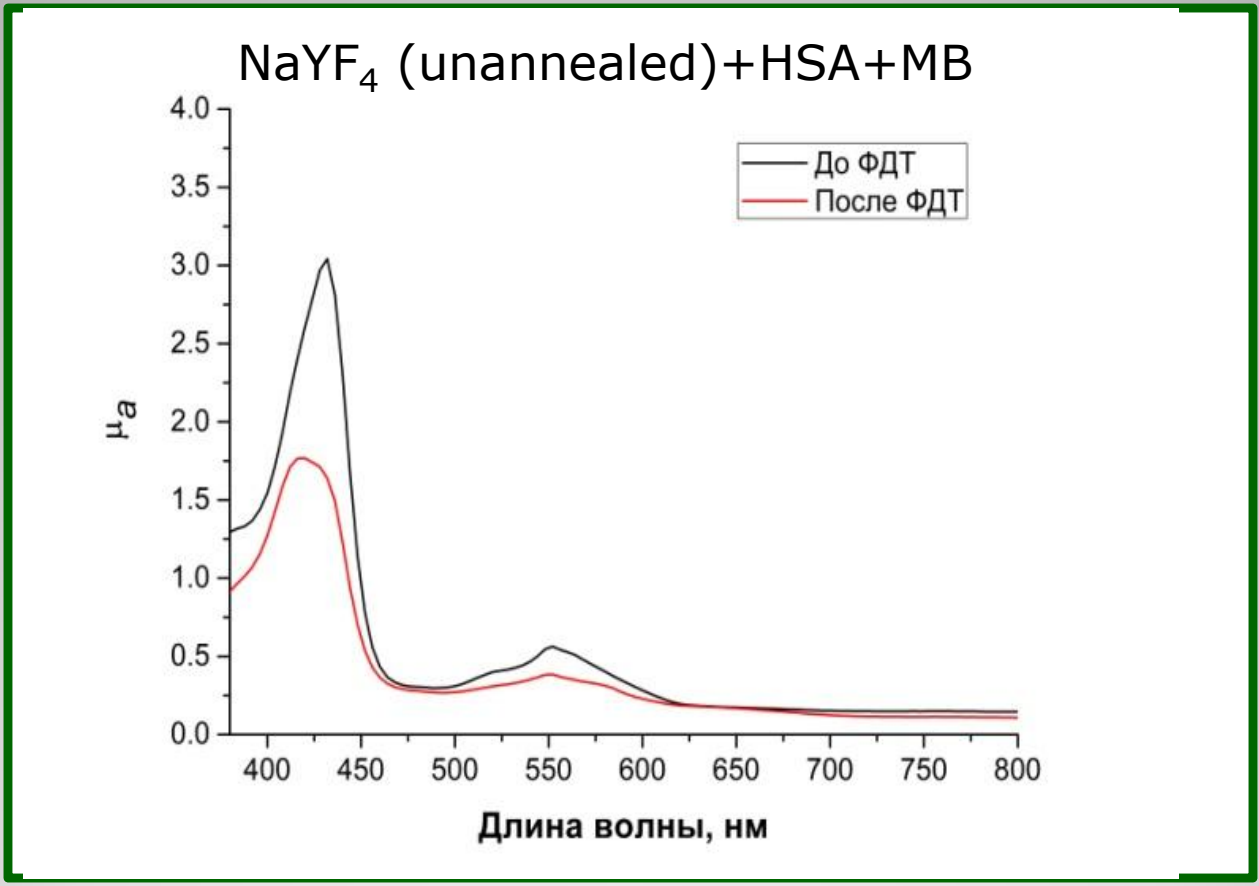
Results and discussion



Muscle taken from the area under the tumor

Results and discussion



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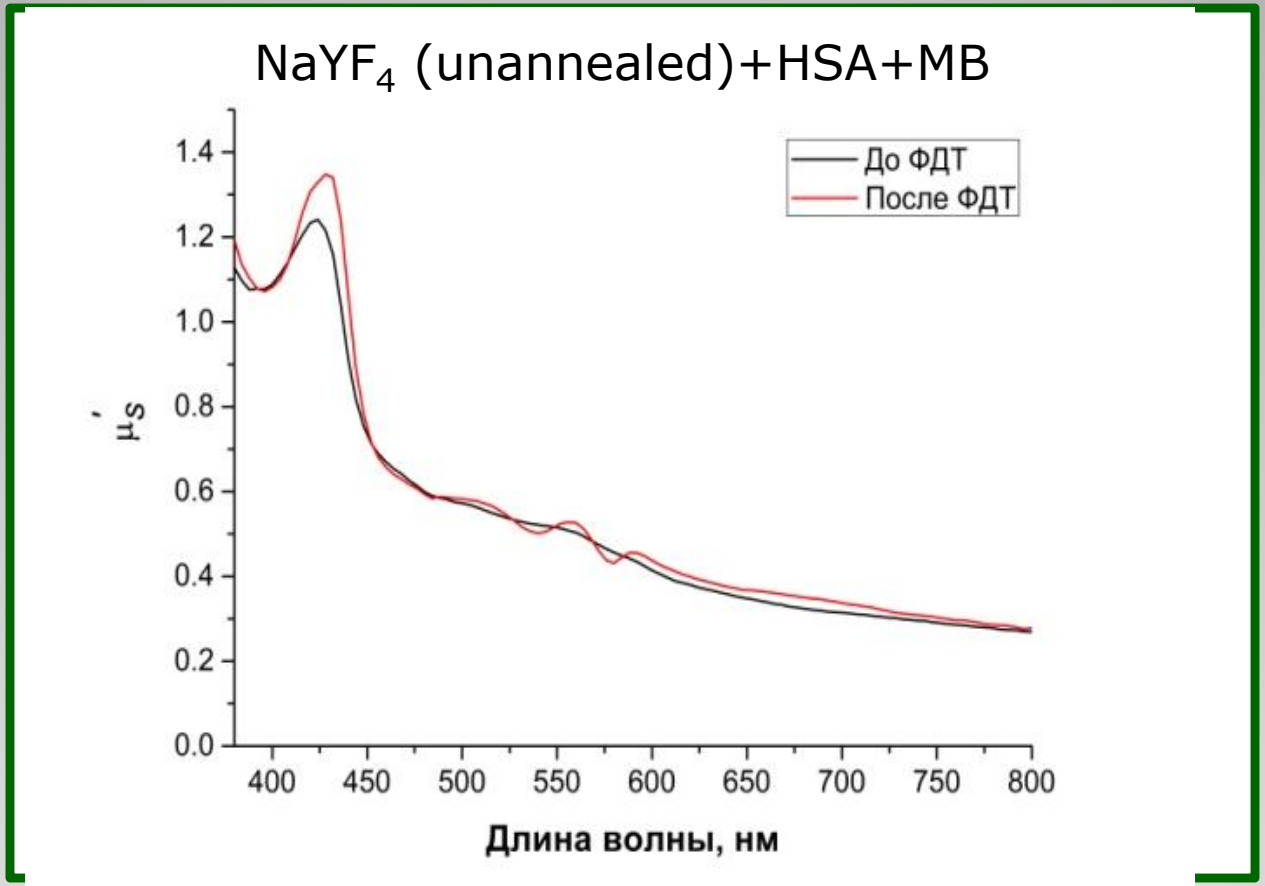
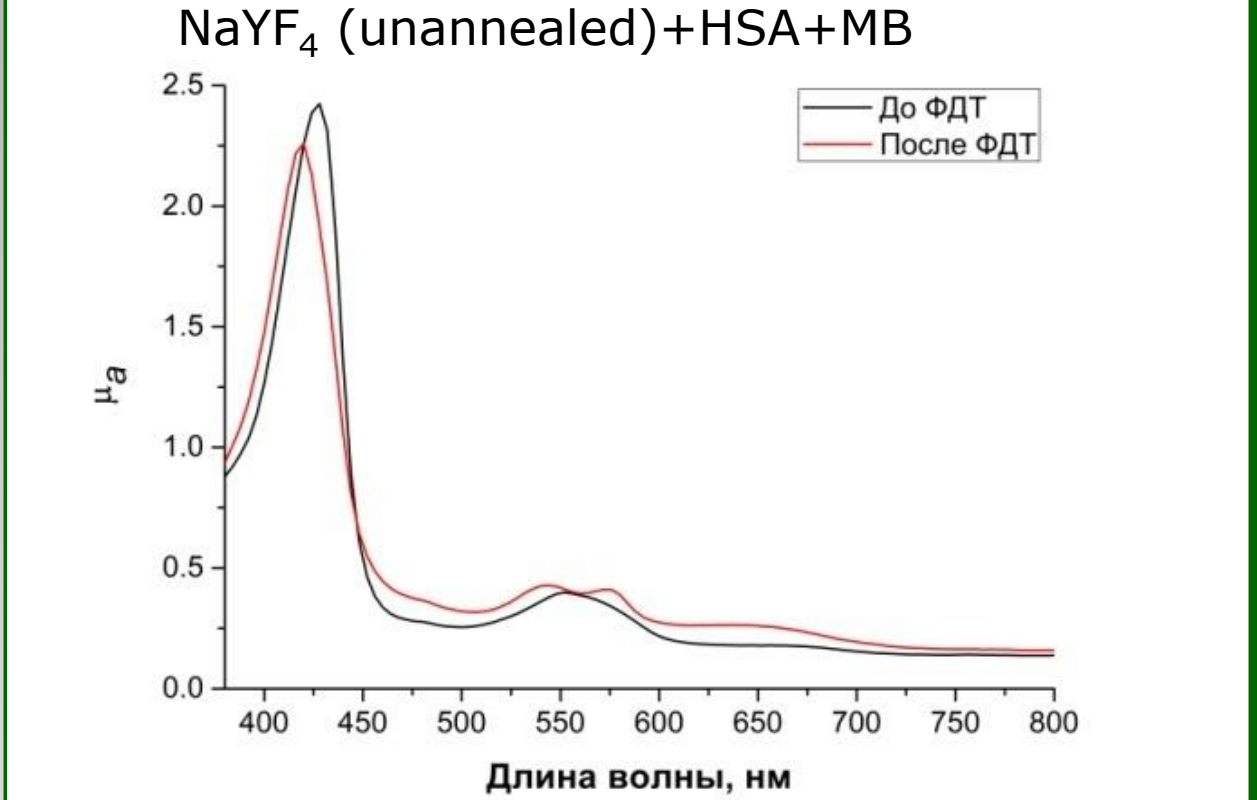


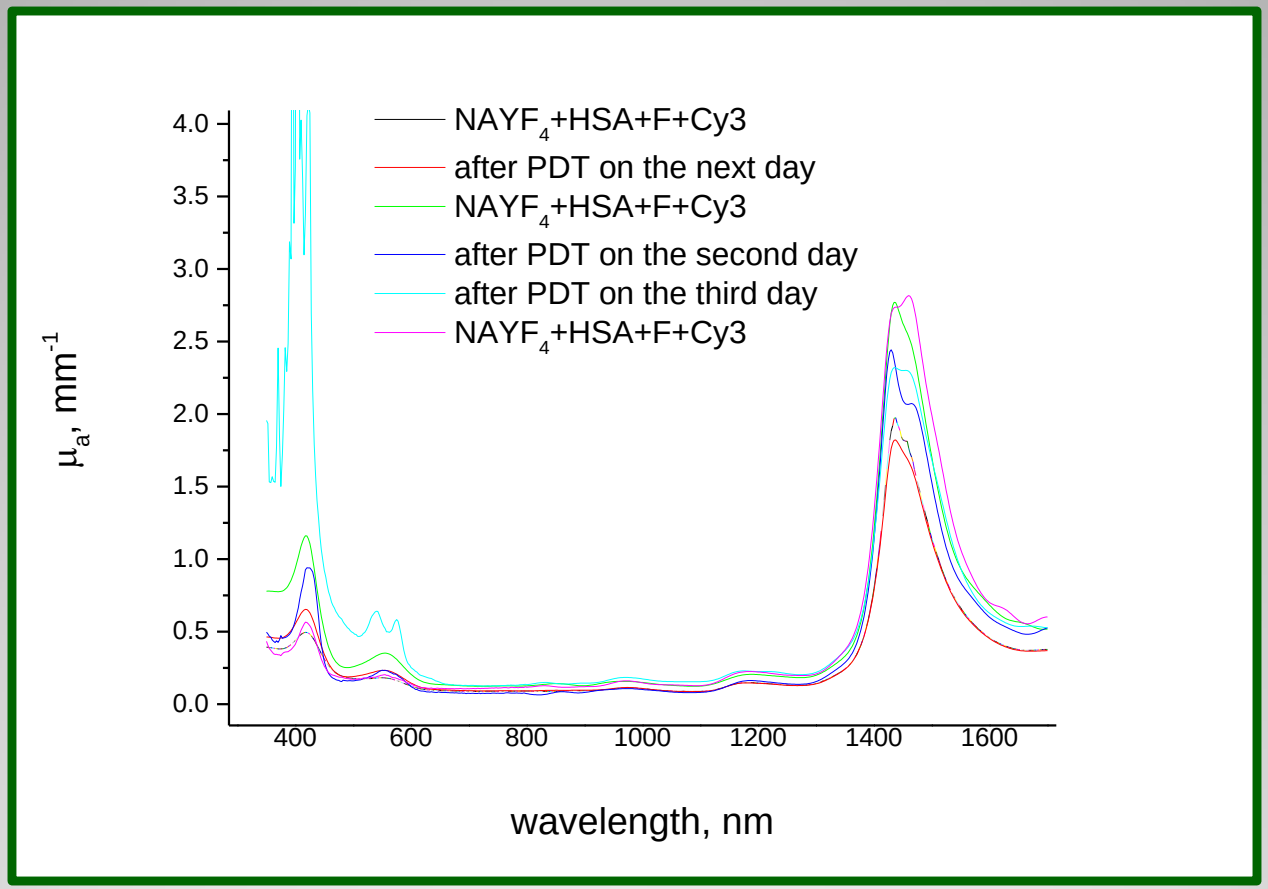
Tumor tissue

Results and discussion



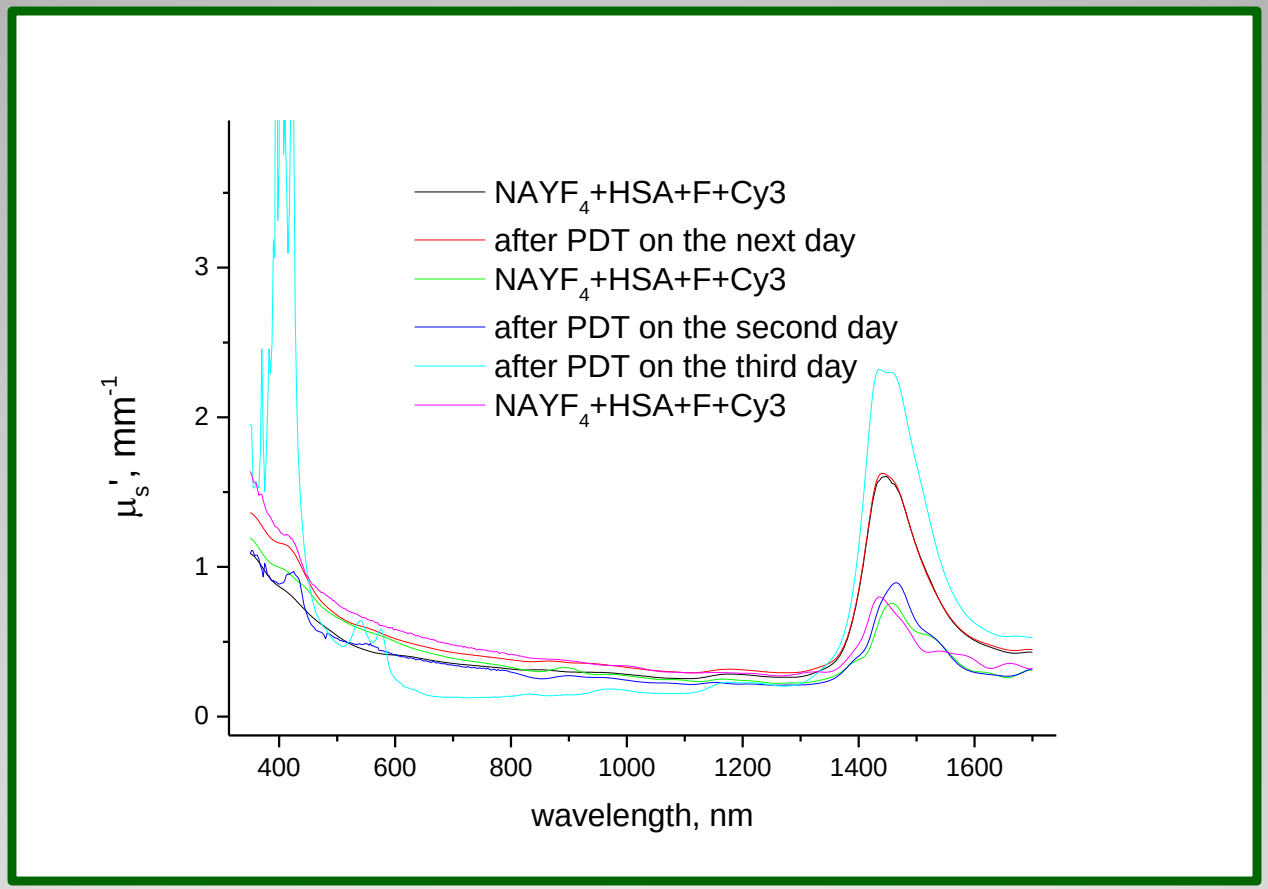
Tumor tissue

Results and discussion



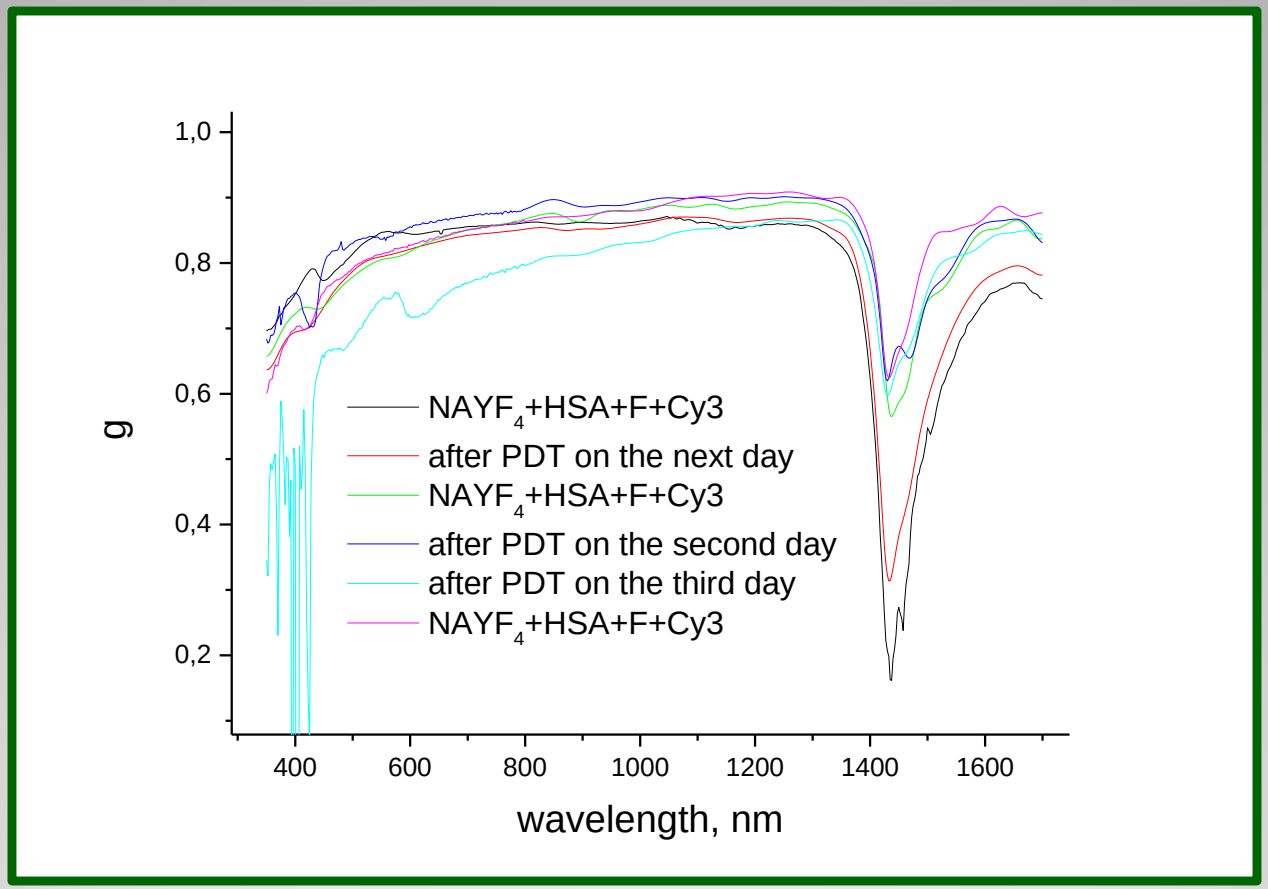
Tumor tissue

Results and discussion



Tumor tissue

Results and discussion



Tumor tissue

Conclusion

- It was obtained submicron-sized core-shell systems containing UCNPs and a photosensitizer
- It was conducted a comparative study of the effect of the introduction of UCNPs, $CaCO_3$, $CaCO_3$+BSA, and $CaCo_3$+BSA/UCNPs/BSA, $NaYF_4$ (unannealed)+HSA+MB, $NaYF_4$+HSA+FA+Cy3 on the optical parameters of biological tissues in the area of tumor development at room and physiological temperatures
- With the introduction of large $CaCO_3$ particles, an increase in water filling and blood filling of tumor tissues was observed. As the absorption in the water bands increases, the scattering decreases. The introduction of particles has little effect on the anisotropy factor. Differences are observed in the spectra measured at room and physiological temperatures.

ACKNOWLEDGMENTS

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