Effect of the dose of administered upconversion nanoparticles on the refractive index of tissues in the development of model liver cancer

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Motivation

- Photodynamic therapy (PDT) is a non-surgical method of cancer treatment, which is currently being intensively used with high efficiency
- The necessary components of PDT are a photosensitizer (PS), localized in the area of the disease, and a source of radiation of the appropriate wavelength
- Upconversion nanoparticles play an important role in the application of PDT, which helps to treat malignant tumors with high efficiency [1, 2].
- Since the development of pathology changes the structure and composition of biological tissues, and, consequently, their optical properties undergo significant changes, several research groups have proposed using the refractive index, as one of the main optical parameters, as a marker for differentiating normal and pathological biological tissue , including experimental diabetes in animals [3].
- Also, the refractive index is an important optical characteristic that is necessary for a complete description of the optical properties of biological tissues.

[1] Abdel-Kader M. H. Photodynamic therapy. – Berlin: Springer-Verlag, 2016. P. 317.
[2] Филоненко Е.В. Флюоресцентная диагностика и фотодинамическая терапия – обоснование применения и возможности в онкологии // Фотодинамическая терапия и фотодиагостика. 2014. № 1. С. 3-7.
[3] Giannios P., Koutsoumpos S., Toutouzas K.G., Matiatou M., Zografos G.C., and Moutzouris K. «Complex refractive index of normal and malignant human colorectal tissue in the visible and near-infrared» // J. Biophotonics. 2017. V.10 (2). P. 303–310

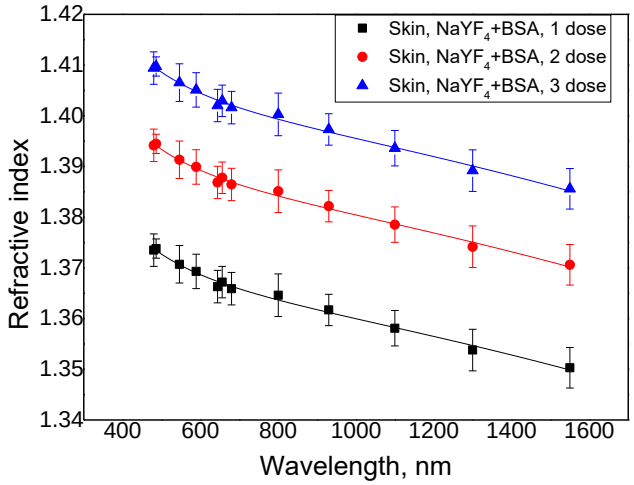
Materials and methods

- Skin, slices of adipose tissue, muscle tissue, model liver cancer
- Tissue thickness 600 μm
- Nanoparticles are injected into a vein
- NaYF4+BSA and NaYF4+BSA+FA nanoparticles in single, double and triple doses
- Multi-wavelength Abbe refractometer DR-M2/1550: 480, 486, 546, 589, 644, 656, 680, 800, 930, 1100, 1350, 1550 nm

Experimental results

1. Skin

A



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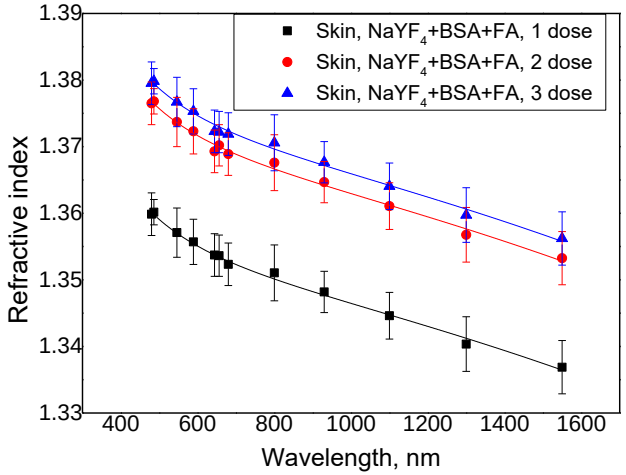
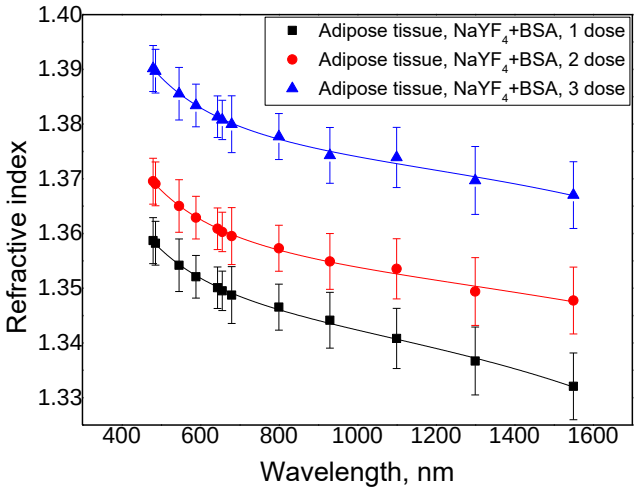


Fig. 1. Dispersion dependence of changed skin samples after the injection of various doses of nanoparticles: A) NaYF4+BSA B) NaYF4+BSA+FA

2. Adipose tissue

A



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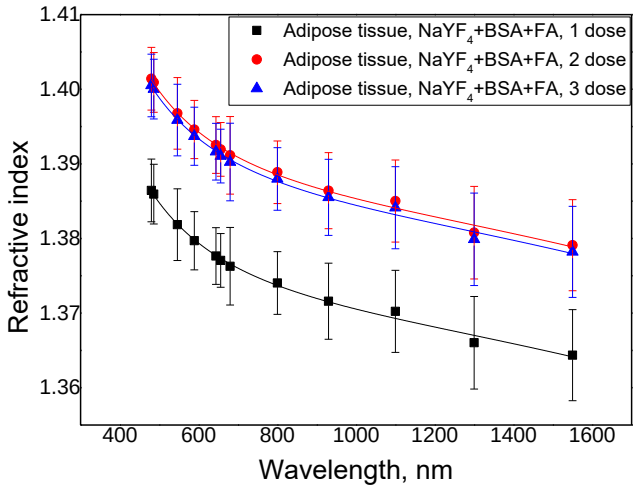
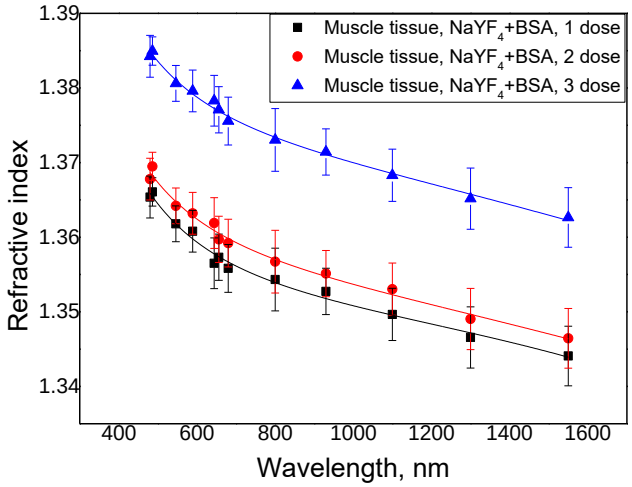


Fig. 2. Dispersion dependence of changed adipose tissue after the injection of various doses of nanoparticles: A) NaYF4+BSA B) NaYF4+BSA+FA

3. Muscle tissue

A



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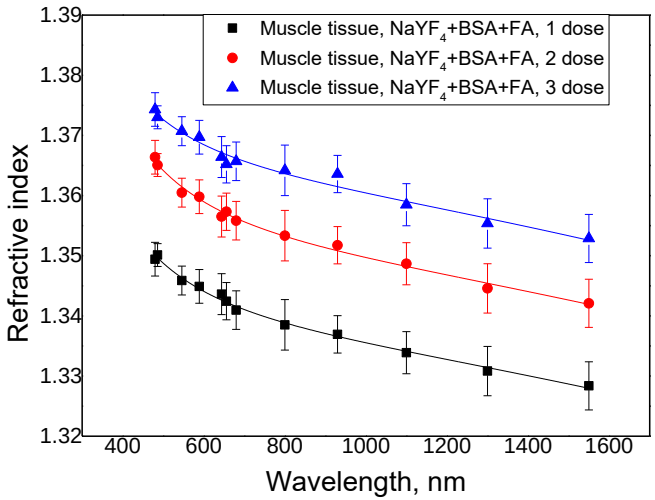
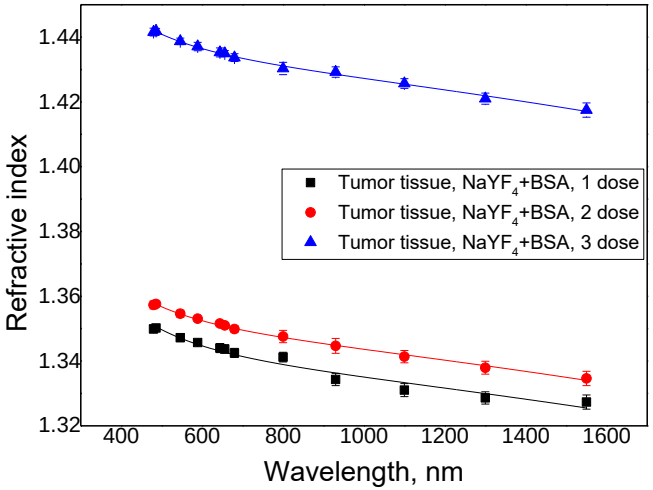


Fig. 3. Dispersion dependence of changed muscle tissue after the injection of various doses of nanoparticles: A) NaYF4+BSA B) NaYF4+BSA+FA

4. Model liver tumor tissue

A



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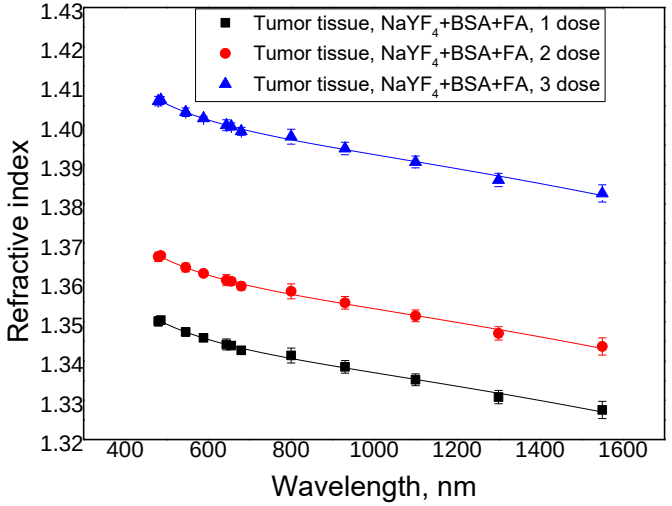

Fig. 4. Dispersion dependence of changed model liver tumor tissue after the injection of various doses of nanoparticles: A) NaYF4+BSA B) NaYF4+BSA+FA

Refractive index at a wavelength of 589 nm for tissues after administration of various doses of nanoparticles

Skin		
	$NaYF_4$+BSA	$NaYF_4$+BSA+FA
1 Dose	1.3693	1.3557
2 Dose	1.3899	1.3723
3 Dose	1.4051	1.3753
Adipose tissue		
	$NaYF_4$+BSA	$NaYF_4$+BSA+FA
1 Dose	1.3521	1.3797
2 Dose	1.3629	1.3946
3 Dose	1.3834	1.3937
Muscle tissue		
	$NaYF_4$+BSA	$NaYF_4$+BSA+FA
1 Dose	1.3608	1.3449
2 Dose	1.3632	1.3598
3 Dose	1.3796	1.3697
Model liver tumor tissue		
	$NaYF_4$+BSA	$NaYF_4$+BSA+FA
1 Dose	1.3457	1.3459
2 Dose	1.3531	1.3623
3 Dose	1.4371	1.4018

Conclusions

- The introduction of nanoparticles of various types and photodynamic therapy causes changes in the refractometric properties of tissues.
- At the same time, smaller differences in the refractive index values are observed for tumor tissue without PDT and after PDT.
- The lower value of the refractive index of tumor tissue after PDT may be due to the fact that PDT leads to partial destruction of nanoparticles and cells of tumor tissue, which helps to reduce its density and corresponds to a lower refractive index.
- A comparative analysis of the refractive indices of various biological tissues after the introduction of various doses of nanoparticles of this type showed that tissues with a higher dose injected are characterized by a higher refractive index than tissue samples taken near the tumor development with the introduction of nanoparticles of lower doses.
- The obtained result may be associated with the accumulation of nanoparticles in tumor tissue and tissues surrounding it and suggests that the refractive index can be used to assess the accumulation of nanoparticles in tissues.

Thank you for attention !

Acknowledgments

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