Local Field Measurement of Optical Characteristics of Organic Phantoms

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By using optical diagnostic methods of materials in the near field on biological tissues we can detect structural changes caused by physical damage or chemical deterioration. As a phantom of muscle tissue serves a paper with tubular cellulose structure. Local field measurement provides information on similarity with muscle tissue and its possible use.

1 Introduction

Every time a new method of measurement is to be used, it is better to employ phantoms first, especially when the subject in question is of biological nature. Generally it is held that a special gel is sufficient representative of a majority of properties of biological tissue [1]. When it comes to a specific sort of tissue, here muscle tissue, other phantoms could be employed, because they would be required to represent different structure, than gel could provide. Cellulose fibers should have enough of a similarity with myofibers to provide a good enough idea of how an actual muscle sample would fare and how the primary detection beam would behave during the measurement.

2 Chemical composition

Chemical structure can be seen both as similar, and different, depending on the level of comparison we choose. Main building blocks are carbon and hydrogen, as in any organic molecule, but where the muscles have many peptide chains, cellulose only has glucopyranose units linked together with β-(1→4)-glycosidic bonds. The main difference between the links of cellulose chain and α-D-glucose in its glucopyranose form, which can be found in abundance in muscles not as a building block, but in the form of glycogen as an energy supply, is the optical orientation. This makes the photon scatter in the same way as it would in muscle tissue, with the difference of the pattern.

3 Structure

The polymer chain forms fibers with a typical length of 1 to 3 mm, and the usual width around 40 µm. The length of muscle fibers is measured in tens of centimeters, but they are aproximately 100 µm wide [2], which puts the important size dimensions for perpendicular illumination into comparable scale.

Fig. 1 *Image of a paper phantom acquired from laser scanning confocal microscopy*

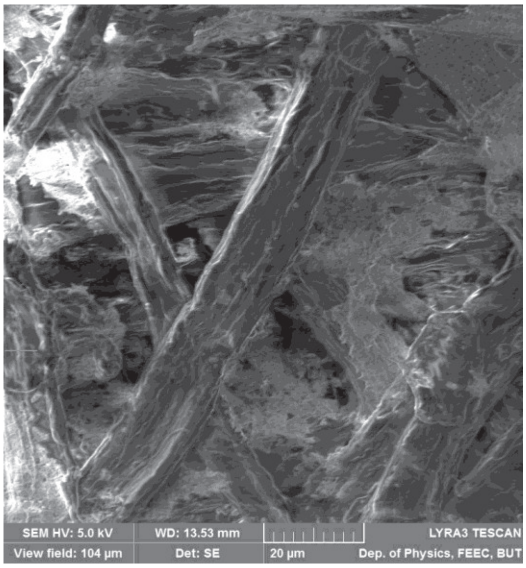

Fig. 2 *Image of a paper phantom acquired from scanning electron microscopy*

4 Absorption

Cellulose shows the greatest absorption in the UV spectrum. The longer the wavelength of the incident light is, the less it gets absorbed and the deeper it penetrates. It is commonly known that for the muscle tissue the red laser (λ ~ 650 nm) has the

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highest penetration in the visible spectrum. The same type of laser can be used for the cellulose fibers without the worry for any disparity caused by different absorptio coefficient.

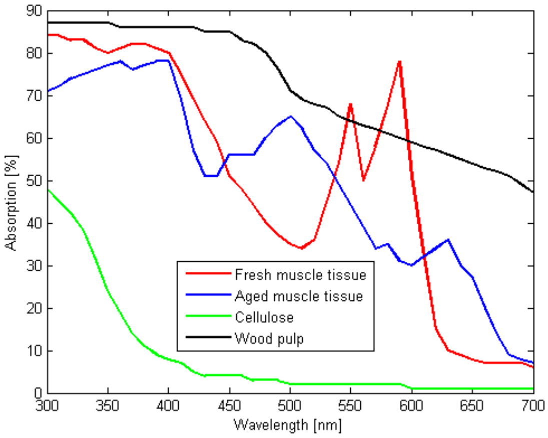

Fig. 3 *Wavelength dependant absorption of organic materials in the visible spectrum.*

5 Reflection

Reflection on a muscle fiber is expected to be the highest detectable on the edges of the fiber, and less so in the center. Measurement of cellulose fibers in near field yielded results consistent with the expectations of reflective pattern of the myofibers. Unfortunately, the paper sample is very difficult to clean properly to get rid of dust particles, thus bringing a pollution noise into the image.

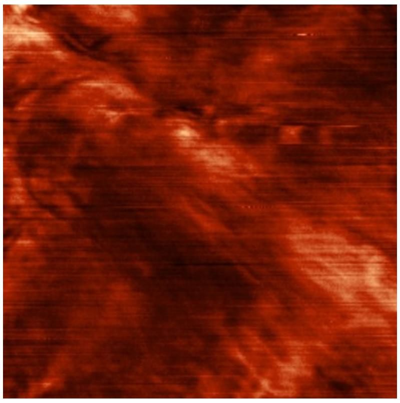

Fig. 4 *Image of light reflection on the surface of a paper phantom from a near field optical microscope*

6 Irregular optical properties

Biological tissue is known to cause polarization and with a correct setup one can detect backscattering within the fibers. Even though cellulose fiber cannot compete with the intricacy of a photon – tissue non-linear optical interaction, if the cellulose fibers are not chemically dried, low amounts of backscattered or polarized photons can be detected [3].

7 Conclusion

Cellulose fibers are in many respects similar to muscle fibers, as far as general optical properties are concerned, be it basic photon propagation patterns or special optical properties. Considering the likeness of the two, we can use cellulose for the testing of measurement setup for biological tissues, with certain reserves, to a certain degree of efficiency, without the need for complex gel and artificial polymer phantoms.

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