THz spectroscopy of dry pellets of rat blood plasma

A. Lykina[1], M. Konnikova[2], M. Chernyaeva[4], P. Gavrilova[1], I. Mustafin[3], E. Domracheva[4], V. Anfertev[4], D. Vrazhnov[5], V. Prischepa[6], Y. Toropova[7], D. Korolev[7], A. Shkurinov[2]

[1]ITMO University, Saint-Petersburg 199004, Russia
[2]Moscow State University, Moscow 119991, Russia
[3]Ioffe Institute, Saint-Petersburg 194021, Russia
[4]IPM RAS, Nizhny Novgorod 603950, Russia
[5]Tomsk State University, Tomsk 634050, Russia
[6]ISPMS SB RAS, Tomsk 634055, Russia
[7]Almazov National Medical Research Centre, Saint-Petersburg 197341, Russia

***Abstract*—This work is devoted to the development of a suitable phantom of a biological object for measurements in the THz frequency range and for approbation with various diagnostic methods developed in different THz laboratories. The phantoms were represented as the pellets of laboratory rat blood plasma in the diabetic and the control groups. These objects were analyzed in various laboratories, using THz pulsed spectroscopy and a high-resolution THz spectrometer based on a backward wave oscillator. The components of the dry blood plasma were identified by the detected spectral lines.**

I. INTRODUCTION

Blood glycation has been accepted to be a simple but efficient marker for diabetes. Increased glucose concentration leads to glycolisation of proteins (human or animal albumin), which is a nonenzymatic process of glucose attachment to the amino groups of proteins. As shown in some experiments of O.P. Cherkasova, V.L. Vaks, and O.A. Smolyanskaya, the blood plasma is the most promising object of study, since changes among its composition caused by pathological processes may considerably affect the optical properties of the blood plasma of human or animals within the THz frequency range. However, liquid samples are difficult to study, since they cannot be stored for a long time, their biochemical properties change during the experiment. In this article, it was decided to analyze a comfortable phantom of a biological object for measurements in the THz frequency range.

II. MATERIAL AND METHOD

Venous blood was obtained from laboratory rats (Laboratory of Almazov National Medical Research Centre) of the control and diabetic groups, centrifuged to obtain blood plasma, dried and pressed into a pellet. The diameter of each pellet was 5 mm while the measured thickness was 0.95 – 1.81 mm.

In this work, the samples were studied on a pulsed terahertz setup in transmission mode in two different laboratories (ITMO University [1] and MSU [2]). A high-resolution terahertz spectrometer based on a backward wave oscillator (IPM RAS [3]) was also used.

Biochemical parameters were measured to control the results of the study in the clinical diagnostic laboratory of Almazov National Medical Research Centre.

III. RESULTS AND DISCUSSION

The refractive index spectra and absorption spectra of rat blood plasma in the control and diabetic groups are presented in Fig. 1.

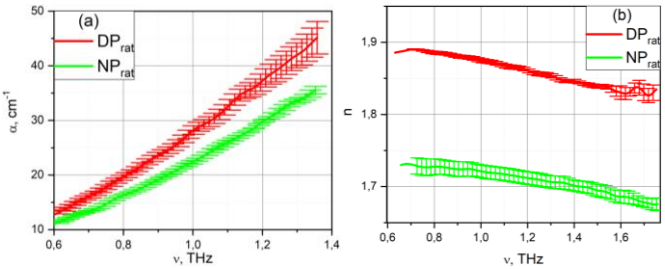

Fig. 1. THz characteristic properties of rat blood plasma in the control (NP_{rat}) and diabetic groups (DP_{rat}): (a) absorption coefficient; (b) refractive index.

Based on the results, it was found that there are differences between blood plasma with and without diabetes. The refractive index of rat blood plasma at 1 THz has a value of 1.72 in the control group and 1.87 in the diabetic group. The absorption coefficient at 1 THz in the control group is 22.5 cm^{-1} and in the diabetic group is 28.45 cm^{-1}.

Using a high-resolution THz spectrometer, the spectral lines of substances such as carbonyl sulfide (OCS), methyl mercaptan (CH_3SH), butyronitrile (C_3H_7CN), acetaldehyde (CH_3CHO), formic acid (HCOOH) were detected in blood plasma samples. The rat blood plasma of the diabetic group differs from the control group by the presence in the spectrum the lines of acetone (CH_3COCH_3), propionitrile (C_2H_5CN) and methyl formate (CH_3OCHO).

IV. ACKNOWLEDGMENTS

The reported study was funded by RFBR according to the research project #17-00-00275 (#17-00-00270, #17-00-00272, #17-00-00184, #17-00-00186) and by the Government of the Russian Federation (Grant 08-08).

REFERENCES

[1] O.A. Smolyanskaya, V.N. Trukhin, et al. “Terahertz spectra of drug-laden magnetic nanoparticles,” *Colloidal Nanoparticles for Biomedical Applications XIV*, vol. 10892, pp. 108920L, 2019.

[2] O. Cherkasova, M. Nazarov, A. Shkurinov “Noninvasive blood glucose monitoring in the terahertz frequency range,” *Optical and Quantum Electronics*, vol. 3, pp. 217, 2016.

[3] V.L.Vaks, E.G.Domracheva, et al. “Exhaled breath analysis: physical methods, instruments, and medical diagnostics”, *Physics – Uspekhi*, vol. 7, pp. 684-701, 2014.