Dielectric properties of essential oils at THz frequency range

A. A. Pavlova[1], A. V. Badin[1,*], V. U. Vygovskii[1], K. V. Dorozhkin[1], N. V. Dorozhkina[2]
[1]National Research Tomsk state University, Tomsk, 634050, Russia, [2]Kuzbass State Technical University, Kemerovo, 650026, Russia

Essential oils are producing from natural plants. They are used as ingredients in cosmetics, food products and pharmaceutics. But the wide application of essential oils leads to rising of imitation quantity. Some producers supplement different substances to them: synthetic additives, cheap essential oils, clean kerosene, fat and mineral oils. The presence of them makes the prime cost of product lower, but quality of the end product decrease. This can lead to headaches, allergy, weakness, etc. So, the control of fabricated essential oils is very important. The most popular method of this control is chromatographic analysis that expensive and takes a lot of time [1-2]. At the present paper we suggest a nondestructive method of essential oils investigation in THz frequency range.

Eight samples of essential oils of different plants (Pinus sibirica, Pinus sylvestris, Juniperus communis, Eucalypti, Citrus limon, Mentha and Abiesis) were investigated. Experimental equipment (Figure 1) consisted of Mach-Zehnder interferometer, backward-wave oscillator as a source of monochromatic electromagnetic wave and optoacoustic converter (Golay cell) as a detector of terahertz radiation [3]. Amplitude modulation was set by chopper. The polarization of the radiation was set by grid splitter.

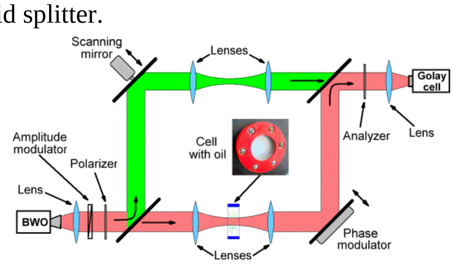

Fig. 1 The experimental setup of the Mach-Zender interferometer for researching of properties of natural essential oils at THz region.

Special quasioptical measurement cell with teflon windows was developed for current research and it was manufactured using 3D printing technology. Thickness of sample layer of researched essential oils was 4.29 mm.

* E-mail: thzlab@mail.ru

From measured spectra of transmission coefficients and phase shifts values of real and imaginary parts of permeability at frequency range of 0.11-0.51 THz were calculated (Figure 2).

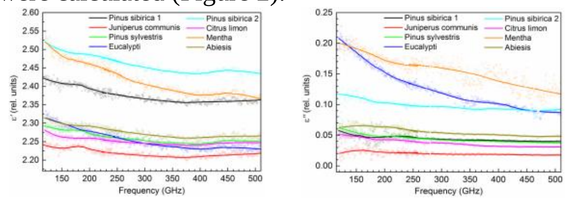

Fig. 2 Real and imaginary part of permittivity of samples of natural essential oils in the frequency range 110-510 GHz at the temperature 297 K.

As shown in graphs (Figure 2) at temperature 297 K the complex dielectric permittivity of essential oils of Junepirus communis, Pinus sylvestris, Abiesis, Pinus sibirica 1 decreases insignificantly with increasing frequency from 110 GHz to 510 GHz . Sample of essential oil (Pinus sibirica 2) have a similar trend of complex permittivity. However, value of imaginary part of sample Pinus sibirica 2 differ from sample of Pinus sibirica 1 at 2.3 times. Probable reason for this difference is the presence of impurities such as moisture. This fact explains disadvantage of steam distillation technology because obtaining natural essential oil with highest quality is required multiple distillation [4]. Distinctive feature of Mentha and Eucalypti samples is presence of anomalous dispersion. With increasing of frequency the real part of dielectric constant of sample of Mentha oil reduced by 6%, imaginary part - by 42%. Real part of dielectric constant of sample of Eucalipti oil reduced by 3.5%, imaginary part - by 59% with increasing frequency.

Thus, current investigation of electromagnetic properties of essential oils can be used in non-contact systems of monitoring of quality of essential oils.

[1] Chem F., Raman W., Raman C. “Quality Control of Commercially Available Essential Oils by Means of Raman Spectroscopy”, J. Agric. Food Chem., Vol. 54, No. 19, pp. 7020–7026, 2006.

[2] Chamorro E.R. et al., “Study of the Chemical Composition of Essential Oils by Gas Chromatography,” Gas Chromatography in Plant Science, Wine Technology, Toxicology and Some Specific Applications, pp. 307–324, 2012.

[3] G. E. Dunaevskii, A. A. Pavlova, V. I. Suslyaev, et. al. “Ferromagnetic fluids based on semisynthetic oils at the THz frequency range”, 41th IRMMW-THz International Conference, 7758460, Copenhagen, Denmark, Sept. 25-30, 1-2, 2016.

[4] Masango P. “Cleaner production of essential oils by steam distillation”, J. Clean. Prod., Vol. 13, No. 8, pp. 833–839, 2005.