APPLICATION OF OPTOACOUSTIC SPECTROSCOPY IN BIOMEDICINE

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The optoacoustic (OA) spectroscopy is based on a sequence of several physics process: optical excitation of the medium, nonradiative relaxation of excited particles, heating of the medium, formation of acoustic waves and their detection. The use of laser as radiation sources in OA spectroscopy has resulted in essential modifications of conventional OA methods:high resolution spectroscopy of weak absorption media, detection of ultra-low concentration of impurities, OA microscopy and etc. (see for example [1]). The aim of this short revue is to give some information and our results about application laser OA methods in biology and medicine.

OA method has by now one-century long history and is based on the effect discovered by Bell in 1880. Bell called his first device photophone, since he tried to develope it for creation a new type of telephone communication. Recently we created new device called biophotophone which principle of operation is based on direct OA generation and stimulation sound in different zones of human ear and use ear as detector of OA effects. This technique is useful for study hearing process and diagnosis some ear's diseases.

For study problems of bioecology including the influence of pollution on ecosystem the transportable installed in the car OA gas analyser with the CW CO_2 laser was built. The laser provides the frequency modulated regime on any lines with simultaneous power stabilization on them for efficient suppresion of background absorption. The potentialities of. this device is illustrated by the result of regional monitoring NH_3 in the atmosphere, the rate at which NH_3 is emitted into air from ammonium fertilized soil, NH_3 distribution along cereal heigts with high concentration sensitivity up to 0.5 ppb.

The problem of selective analysis of multicomponent mixtures can be solved by combination OA and gas-chromatographic methods [2]. To widen the spectral range of such system several types of IR laser were used at the same time: $^{12}C^{16}O_2$ laser (9.2-10.8μm); $^{13}C^{16}O_2$ (9.6-11.4μm); $^{12}C^{16}O$(5.2-6μm) and He-Ne laser (3.39 μm). The experiments were performed with different methods of scanning in laser OA spectrometer: at one fixed laser line; successive scanning at different lines; discrete frequency modulation at two lines; the multiplex mode operaton-comprise simultaneous transmission of several laser beams with different wave-length modulated at different sonic frequencies through the OA detector at exit chromatographic column; fast scanning with special type of CO_2 laser [2]. The potentialities combined gas chromatograph-OA cell system were demonstrated by trace detection of tuberculostearic acid(TBA) in speciments of patients with tuberculosis [3]. The thing is that the TBA a substance normally not found in the body is present as a structural component in form of phospholipids in the wall membrane of culture of various pathogenic mycobacterial species. It is means that new laser OA technique can be considered as rapid and sensitive microanalytical method for early diagnosing some deseases. It is possible to use

OA detection up 0.1 cm^3 [2] and for liquid chromatography[2.4]. In last case pulsed lasers like nitrogen (337 nm), excimer KrF (248 nm) and 4th harmonic Nd:YAG laser (266 nm) were used as irradiation sources together with piezoelectric OA detector. The possibilities of operation of a liquid chromatography in combination with OA spectroscopy were demonstrated by detecting vitamin A in blood plasma concerning cancer problem. The detection threshold was 0.3 pg/ml. In last experiments new modification OA detector with the laser beam going perpendicular to the axis of quarts capillar cell with piezoelectric transducer at the end cell was used [4].

When high-power laser radiation interects with matter very large acoustic waves can be produced via different physical mechanisms such as fast thermal expansion, evaporation, dielectric breakdown etc. Some power OA effect with the formation of shock waves or sample destruction can be useful for high-pressure biomedical studies. The OA quasi-hydrostatic effect in *acoustically closed volume* with liquid was used for destruction gall-stones. The experiments were carried out with Nd:YAG laser with pulse energy up 0.1-1J and 4 ms duration. The new methods includes grasping the stone in a Dormie trap, forming a narrow channal in the stone by train low-power laser pulses and final destruction stone by one. high-power laser pulse [5]. In extracorporal laser shockwaves lithotrispy laser is used for forming shockwaves via optical breakdown under focused laser radiation [5]. The our experiments confirm the possibility of remote fracturing of kidney stones using the power OA effect.

The mechanical OA effect causes liquid to be ejected through the nozzle of small volume irradiated by short laser pulse. Our experiments show the usefulness of this effect for medical purposes, for example for the OA medical injector which was made by inserting a light fiber in the needle of a medical syringe. This device is based on the formation and ejection of droplets of medicine being produced by the thermal energy deposited by laser pulse in a small volume between the end fiber and the nozzle of the needle [5].

To predict the influence of shock waves on biological tissue, for example in laser ophthalmology or laser stone fructuring experiments were carried out on OA formation of short ascoustic pulses up to 2×10^3 atm near different cell structures [6].

Comparative analyses of applications laser and ultrasound medical systems shows that they can essentialy supplement each other and in combination bring new efficacious results. The transformation laser light energy in ultrasound energy on the end of contact thermal scalpel allow to improve the cutting process. Another point concludes that by putting ultrasonic oscillations on optical fiber as part of contact laser scalpel it would have a increased speed and greater efficiency in laser surgery. The possibilities of the new laser-ultrasonic biomedical technology is demonstrated by using pulse repitition Nd:YAG laser and low frequency ultrasonic technique in surgery for cutting soft and dense biotissues in clinical condition [7].

Recently we have shown that combination electrostimulation with laser therapy and OA effect provide very effective treatment of prostate.

One of the basic problems in laser medicine is due with control some technical and biological parameters during laser treatment. This problem also could be solved by using some modification OA methods. For example, gas-microphone OA method allow to research mechanisms of laser therapy by detection small variation temperature and photochemical process in irradiation zone. Photothermal OA radiometry provide remote control of absorption coefficient and temperature monitoring during laser surgical operation [8]. OA piezoelectric technique is very useful for measurement of absorption coefficient in strong absorption biosamples. This technique is based on the dependence between the pulse OA signal front and depth of the radiation penetration into the biosubstances [9].

The future trends OA spectroscopy in medicine and biology are disscused.

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