Photoacoustic Signal in the System of a Thin Oil Layer on the Water Surface

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Abstract: Thin layers of oil spread on the water surface were studied by photoacoustic spectroscopy (PAS) methods and discussed in terms of their structural and thermal properties. Signatures of the depth profiles derived from the signal amplitude-phase data point to the sharp phase separation at the interfaces and suggest the formation of organized structures (inverted lamellar micelles) of surfactants dissolved in a non-polar (oil) medium.

BACKGROUND, METHOD AND APPARATUS

Photoacoustic radiation patterns in fluids depend on both the time dependence of the exciting optical irradiation, and the profile of the optical energy absorbed in space. In the presented studies, two techniques of sample irradiation were used: with a sinusoidal light intensity modulation (in the frequency range 1 - 1000 Hz) and working in a pulse regime (pulse duration about 10 ns), respectively.

![FIGURE 1. Block diagram of the continuous light modulation PAS system.](image1)

A block diagram of the former one is depicted in Fig. 1. A laser diode (type SDL-73311) is a source of modulated light of the wavelength 680 nm. The laser beam is, by a fiber wire, provided to the measuring cell of author's construction. The photoacoustic signal received by a microphone is phase-sensitive detected using a lock-in amplifier (type SR 850). An internal generator of the amplifier is also used for operating the laser diode controller (LDC 400). All data collection and further processing is realized by a PC computer working in the GPIB standard.

![FIGURE 2. Block diagram of the pulse mode PAS system.](image2)
The second set-up block diagram is presented in Fig. 2. The system consists of a pulse light source being a dye laser, with a pulse time duration less than 10 ns, pumped by a Nd:YAG laser. Our measuring cell with a PZT detector of the acoustic pressure, is of similar construction as already described by Khan et al. [1]. The signal was collected and averaged by the digitizing oscilloscope (TDS 410A). A PC computer controls the measuring procedure. More thorough and comprehensive information on the thermal parameters and structure of thin (0.025 - 0.25 mm thick) layers of olive oil spread on the water surface were derived due to application of these two independent methods.

RESULTS AND CONCLUSIONS

Signatures of the depth profiles, obtained from the measurement of amplitudes and phases, point to the presence of interfacial regions at air - oil and oil - water interfaces with surfactant molecules adsorbed from the bulk liquid phases.

![Image of surfactant organized structures](image-url)

**FIGURE 3.** Surfactant organized structures at the water-oil interface (A), (B) and in bulk oil (inverted micelles).

Moreover, they indicated the oil layer occurring at a depth of 9 - 13 μm beneath the oil interface of different properties than the surrounding oil. Such organized structures of surfactants dissolved in olive oil at a certain concentration (above CMC) and temperature (Krafft point) known as lamellar (plate) inverted micelles are likely to occur in non-polar liquids [2]. For a general view see Fig. 3.

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REFERENCES