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INTERDISCIPLINARY TOPICS

The NMR Investigation of the Electromagnetic Irradiation Effects on Bacteria[1]

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Abstract—The luminous marine bacteria (*Photobacterium leiognathi*, strain 54) are influenced by a nonthermal-intensity millimeter electromagnetic field, which was studied by nuclear magnetic resonance (NMR). It is shown that the proton spectrum of luminous bacteria depends on the electromagnetic irradiation effect (ν = 42.2 GHz).

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1. INTRODUCTION

The problem of the effect of electromagnetic fields on biological objects has several aspects, including some medical problems [1]. It is possible that millimeter electromagnetic fields can imitate control signals produced by cells and take part in correction of metabolic processes [2]. The mechanisms of the biological effect of nonthermal electromagnetic waves remain obscure [3]. The purpose of this paper is to investigate some potentialities of nuclear magnetic resonance (NMR) in studying the millimeter-range electromagnetic-field-induced effect on the marine luminous bacteria.

2. METHOD AND RESULTS

The *Photobacterium leiognathi*, strain 54, bacteria were irradiated for 15 h using a G4-141 standard generator (frequency 42.2 GHz and intensity 5 mWt/cm^2). The NMR studies were carried out using a Bruker AVANCE-200 (5 T) high-resolution spectrometer.

The influence of millimeter electromagnetic radiation on bacterial luminescence was studied (Fig. 1). The radiation-induced stimulation effect depended on the stages of bacterial growth and the composition of the culture medium [4]. Some factors which may increase the bacterial luminescence intensity are an increase in the concentration of luciferase and substrates, and an improvement of the properties of the reaction medium caused by changes in its parameters. The NMR method can help to evaluate medium changes.

This study indicates that the magnetic resonance can be used to detect small changes that take place in the bacterial culture as a result of their vital activity. The proton spectrum is the most informative among different observed nuclear spectra (^{31}P, ^{13}C) of the luminous bacteria. It consists of nearly 50 peaks. The most powerful signal is the water signal. We used a special water-suppression program in the NMR investigations. A preliminary analysis of proton NMR spectra (at 200 MHz, T = 300 K) shows the spectrum modifications after bacteria exposure to the electromagnetic waves radiation as seen in Figs. 2 and 3.

These results show that nuclear magnetic resonance is sensitive to changes of the metabolism which take

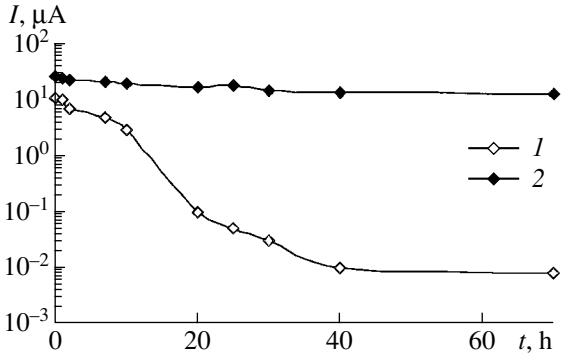

Fig. 1. The bioluminescence intensity changes after a 15-h exposure of cells of luminous bacteria to radiation (ν = 42.2 GHz) in a unfavorable medium (6% NaCl): (*1*) for control cells and (*2*) for cells exposed to radiation. *I* is the current of the photoelectron multiplier; *t* is the time after irradiation.

[1] The text was submitted by the authors in English.

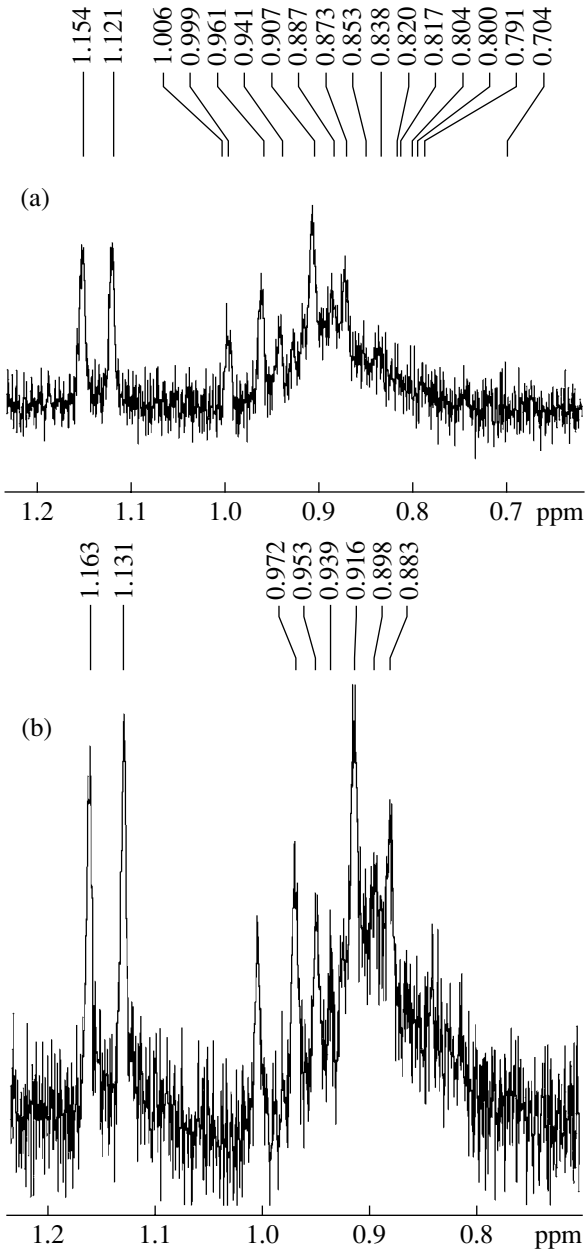

Fig. 2. Fragments of ^{1}H NMR spectra of the bacterial culture (ν = 200 MHz, T = 300 K) in the range of 0.8–1.3 ppm: (a) control cells and (b) cells after exposure to radiation.

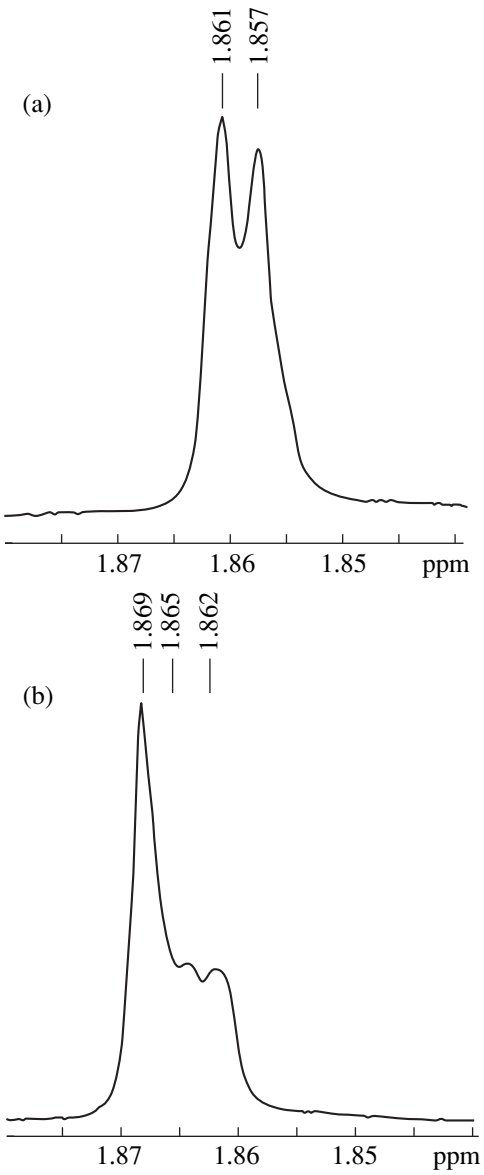

Fig. 3. Fragments of ^{1}H NMR spectra of the bacterial culture (ν = 200 MHz, T = 300 K) in the range of 1.84–1.88 ppm: (a) control cells and (b) cells after exposure to radiation.

place in the bacterial culture under the effect of millimeter nonthermal electromagnetic radiation.

3. CONCLUSIONS

These results confirm the effect of electromagnetic waves on the bacteria. The bioluminescence changes which take place due to the effect of nonthermal millimeter electromagnetic field are accompanied by modifications of the NMR spectrum. The NMR method makes it possible to perform electromagnetic-wave-induced studies in biosystems. NMR techniques can be utilized in evaluations of the changes that take place as a result of the vital activity of bacteria and of the role of the medium in these millimeter-electromagnetic-wave-effect experiments too.

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