The Analysis of Osteoblast Cellular Response to the reaction of Electromagnetic Field at 2.4 GHz

Shen Cherng

Department of Electrical Engineering, Chengshiu University,
Niaosong, Taiwan 833, Republic of China
cherngs@csu.edu.tw; 011886-7731-0606 ext 3423

Abstract: Cellular response to the external electromagnetic field is a non-stationary process. All frequency components may exist at the times. This report provides the study of osteoblast cell line system under the exposure of electromagnetic field at 2.4 GHz. Conclusively, 20% gap junctional intracellular communication (GJIC) modulation within osteoblast cells was observed after 60 minutes exposure electromagnetic field at 2.4 GHz, 200 watt-hour absorbing rate. [The Journal of American Science. 2005;1(3):48-50].

Key words: gap junctional intracellular communication (GJIC); non-stationary process

1. Introduction

No direct clinical evidence has shown any human health effect as well as any mechanism can clearly explain the observed laboratory biological effect [1] in the regular electromagnetic field environment. This report demonstrates the study of the Osteoblast cellular response to the reaction of electromagnetic field at both 2.4 GHz in 200 watt-hour absorption power. Theoretically, four different types of cellular responding signals, deterministic, stochastic, fractal and chaotic signals are categorized for biological system [2]. A deterministic signal is one whose values in the future can be predicted if enough information about its past is known and stochastic signal is impossible to predict an exact future value even if one knows it's entire past history. Fractal signals have the property that they look very similar at all levels of magnification, which is referred as scale-invariance. Chaotic signals are deterministic signals with sensitive dependence on some conditions that cannot be predicted exactly in the future. Experimentally, gap junctional intracellular communication (GJIC) within the cells may induce the signals from varying surface current [3]. In a cell, six connexin 43 subunits oligomerze in the Golgi apparatus into a connexon, called hemi channel and be transported to plasma membrane of the cell. Before pairing process, hemi channels are closed to avoid leakage of cellular contents and entry of extra-cellular materials. During the pairing of connexons and aggregation into plaques at the plasma membrane, connexin 43 is phosphorylated at least twice and connexons are attracted to those located on the adjacent cells. Two connexons join in an end-to-end manner to form a complete channel. The channel aggregate into large gap junction plaques open to connect two cells for cell-to-cell communication and is called gap junctional intracellular communication (GJIC), which can be modulated by environmental factors. Since the function of the GJIC, cultured cells coupled together in vitro except the stem cells and cancer cells [4]. In this article, we introduce a concept to recognize the non-stationary magnetic fluctuation process caused by the cellular response of the reaction of Electromagnetic field and clarify the correlation aspects for both time and frequency somewhat arbitrarily. For frequency aspects, we present one idea around the notion of local regularity. For time aspects, we present a list of domains. The magnetic field fluctuations being created by the induced GJIC surface current of the osteoblast cell system is basically a non-stationary process. We also introduce the scrape loading dye transfer technique to identify the GJIC modulation by observing the diffusive range of the fluorescence [5]. The varied diffuse range of Lucifer yellow fluorescence expresses the cellular response under the exposure of external electromagnetic field at intrinsic-resonance frequency ω. Since GJIC is affiliated with many pathological endpoints [5], GJIC modulation can be used to evaluate the cellular response of the reaction of external Electromagnetic field.

2. Theory

Mathematically, the sequence V(t) can be written as V(t) = { V1,V2,…….VN-1, VN }. We should be able to calculate the SNR spectrum of V(t) if existed signal buried in sequence. Membrane surface electrical current distribution induced within osteoblast cells may cause GJIC modulation [3]. In the following, we will use osteoblast cells induced electromagnetic fluctuation as V(t). Most of the signals in practice are time domain signals. In our case, signal information is hidden in the frequency content of V(t). The frequency spectrum of V(t) is basically the spectral components of the signal. The frequency spectrum of a (signal) process shows what frequencies exist in the process. However, if the process is not stationary, we have to know which signal corresponds to which frequency band. Assume the response electromagnetic fluctuation V(t) and τ be a period of sample time, we can get

$$\Psi_V^{\psi}(\tau, s) = \frac{1}{\sqrt{s}} \int V(t) \psi^* (\frac{t-\tau}{s}) dt$$

where

$$\psi_{r,s} = \frac{1}{\sqrt{s}} \psi (\frac{t-\tau}{s}),$$

r and, s are parameters controlling the integration.

We presume 「Meyer Wavelet」 as the good fit mother wavelet for the transformation. Different mother wavelets may result shift of the location of the signal in time domain V(t).

3. Cell Culture

The osteoblast cell line ***in vitro*** was obtained from D.T. Yamaguchi, Research Service and Geriatrics Research, Education, and Clinical Center, VAMC, West Los Angeles, California, USA It was maintained in D-medium (Formula 78-5470EF, GIBCO, Grand Island, NY, USA), supplemented with 10% fetal bovine serum (GIBCO) and 50 μg/ml gentamicin (Quality Biological, Inc., Gaithersburg MD, USA). The cells were incubated at 37°C in a humidified atmosphere containing 5% CO2 and 95% air and were fed or trypsinized every two to three days.

4. Bioassay of GJIC

The scrape load/dye transfer (SL/DT) technique was used to measure the GJIC within cells. After exposure to ELF at intrinsic frequency, the cells were rinsed with phosphate buffered saline (PBS), and a PBS solution containing 4% concentration Lucifer yellow fluorescence dye is injected into the cells by a scrape using a scalpel blade. Afterwards the cells were incubated for 3 min and extra cellular dye was rinsed off and fixed with 5% formalin. We then measured the area of the dye migrated from the scrape line using digital images taken by an epifluorescent microscope and quantitated with Nucleotech image analysis software for the GJIC images. Since GJIC is affiliated with many pathological endpoints, we use GJIC as a scale factor to evaluate the electromagnetic field reaction for cell system. Scrape loading dye transfer of Lucifer yellow is used to measure gap junction intracellular communication (GJIC) modulation under the exposure of electromagnetic field. The intrinsic resonance detected in SNR spectrum of the mouse osteoblast cells system is very likely to be a chaotic signal, which is not fully predictable.

5. Results

Figure 2 and Figure 3 show the GJIC fluorescent images. Since the GJIC of cells was quantified with the measurement of the average distance of dye migration, GJIC was reported in this article as a fraction of the control (FOC) in Figure 1. An FOC value equals to 1.0 indicates normal GJIC. The FOC value more than 1.0 indicates excitation.

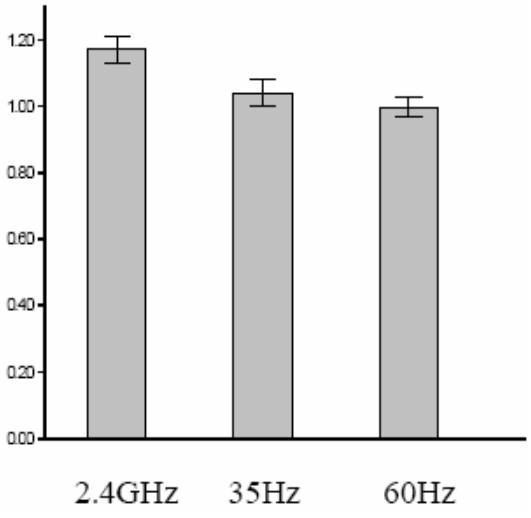

Figure 1. FOC schematic drawin.

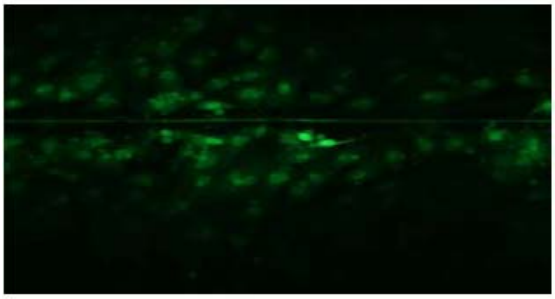

Figure 2. Osteoblast cells GJIC in control.

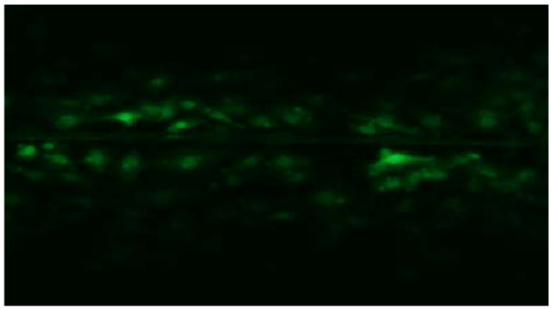

Figure 3. Osteoblast cells GJIC after 2.4 GHz treatment.

6. Discussion

Experimental results depicted that the GJIC within cells relates to both the background noisy magnetic field fluctuation and the signal. In this report, by using basic wavelet transformation, it has a good time and poor frequency resolution at higher frequencies, and good frequency and poor time resolution at lower frequencies. Fortunately, GJIC modulation supports the result. We are in prepare to discuss where in time the spectral component is appeared and how long the spectral component is elapsed within osteoblast cells in the next journal.

7. Conclusion

The main feature of our research introduced is that the cellular response relating to the change of GJIC being in 2.4 GHz frequency band. The magnetic fluctuation expression for cell induced GJIC has been identified by specific external field signal at 2.4 GHz, which modulates the GJIC 20% within the cells. Based on the application of WT, which predicts the existence of the intrinsic signal, our study depicted that we were able to obtain the confirmation that the electromagnetic field can modulate 20% GJIC promotion within the cells at 2.4 GHz.

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