Novel Study of CNT/PDMS Composite Canal Typed EEG Electrodes

Joong Hoon Lee, Seung Min Lee, Hang Jin Byeon, Jeong Hun Kim, Joung Sook Hong and Sang-Hoon Lee

ELECTROENCEPHALOGRAM (EEG) is the electrical signals that are recorded along the scalp. It is a useful and representative method to diagnose the neurological conditions and brain disorders. With the recent advances in intelligent technology and computer technology, the number of EEG study-based BCI and U-healthcare applications is steadily rising. Nonetheless, the electrodes and systems for EEG recording have limitations such as inconvenient setup, patient discomfort, connection difficulty, poor biocompatibility, immobility and so on. In this paper, we propose a carbon nanotube polydimethylsiloxane (CNT/PDMS) composite canal typed ear electrodes (CEE) to improve the aforementioned problems. The shape of canal typed ear electrode (CEE) is same as general canal typed earphone's rubber cap [see Fig.1 (a)], so the electrode can be attached to the skin completely without any sticky materials simply by putting it into the ear canal. Because of its perfect attachment, the noise is significantly reduced, making the signal to noise ratio (SNR) high. In addition, this earphone shaped electrode can trigger auditory stimulation and record EEG signals simultaneously [see Fig.1 (b)], opening up many possibilities for applications in BCI field. This canal typed ear electrode (CEE) is made of CNT/PDMS which combines the properties of CNTs and PDMS. The PDMS has become a popular material for biomedical applications for its nontoxicity, high gas/ water permeability, and adaptability to many fabrication methods. CNTs are widely used in biomedical research areas also, because of its outstanding electrical, mechanical and thermal performances in the biomedical applications [1] . We tested its electrical and mechanical performance by measuring the electric conductance as a function of strain and young's modulus using the Instron5900 series. The performance of the newly developed electrodes was good enough to be used as EEG electrodes. Furthermore, custom made CNT/PDMS composite CEE performance on EEG was evaluated by alpha rhythm detection. We successfully recorded the alpha rhythm with a high signal quality [see Fig.2]. The biocompatibility test was conducted in vitro by culturing human epithelial cells on the electrode, and by continuously attaching the CNT/PDMS on the skin for a week. This test verified the biocompatibility of newly developed electrodes. These results indicated that the CNT/PDMS composite CEE could be widely used for EEG recording in U-health care and BCI fields.

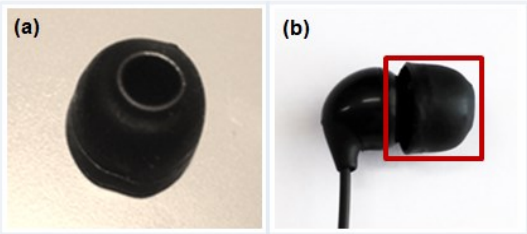

Fig 1. (a) Image of fabricated CNT/PDMS composite canal typed ear electrode. (b) The CNT/PDMS composite CEE (red square) is used in combination with earphone shaped EEG recording device.

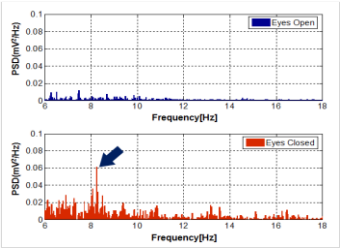

Fig. 2. PSD of alpha rhythm appearance. Upper graph shows eyes open case and lower graph shows eyes closed case

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Joong Hoon Lee is with Department of Bio-convergence Engineering, College of Health Science, Korea Univ, Korea. (e-mail: lefa3@hanmail.net).
Seung Min Lee is with Department of Biomedical Engineering, College of Health Science, Korea Univ, Korea. (e-mail: phd.smlee@gmail.com).
Hang Jin Byeon is with Department of Bio-convergence Engineering, College of Health Science, Korea Univ, Korea. (e-mail: hjhjbyeon@gmail.com).
Jeong Hun Kim is with Department of Bio-Medical, KU-KIST Graduate School of converging Science and Technology, Korea Univ, Korea. (e-mail: neromijung@gmail.com).
Joung Sook Hong is with Department of Chemical Engineering, Soongsil University, Korea. (e-mail: polymer@ssu.ac.kr).
Sang-Hoon Lee is with Department of Biomedical Engineering, College of Health Science, Korea University, Korea. (corresponding author to provide phone: 82-2-940-2881; fax: 82-2-921-6818; e-mail: dbiomed@korea.ac.kr).