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Research on brain device interface construction that using nano material

ナノ材料を用いたブレインデバイスインターフェース構築に関する研究

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The culture and differentiation of neural stem cell (NSCs) is expected of the research on the reproduction medical treatment of the center nerve are accomplished on carbon nanotube film chemically modified functional group (F-CNT) with chemical modification method and plasma-activation technique. We carried out the experiment and consideration concerning a F-CNT synthesized by chemical modification method and plasma activation method from the viewpoint of nerve-fusion type CNT based BMI development.

1. Introduction

The regenerative medicine that uses the embryonic stem cells (ES cells) is remarkable. At the same time, the field of the research of the regenerative medicine of the central nerve by neural stem cell (NSCs) is a research with a considerable possibility. On the other hand, the living body signal is taken out directly of the brain, and the research is advanced actively as for "Brain-Machine Interface (BMI)" to aim at diversified use. It was common sense of the medicine for many years impossible when the center nerve organizations such as the brains and vertebras received damage once to reproduce. However, being highlighted as a method of solving this problem is a reproduction medical treatment of the center nerve by using NSCs. A lot of results of a basic research which succeed in the function reproduction of the center nerve system by transplanting NSCs cultured in the outside of the body to the vertebra are reported now. Therefore, the expectation is sent to the achievement at the early stage of the reproduction medical treatment of the accident rule nerve disease which uses human NSCs. NSCs is a cell which can repeat fission, the breeding, and subculture, at the same time, is a cell which has the ability which differentiates into three kinds of cells which compose neurons, astrocytes, and oligodendrocytes.

In particular, carbon nanotubes (CNTs), such as single-walled and multi- walled carbon nanotubes (SWCNTs and MWCNTs), discovered in 1991 and 1993, are interesting molecular wires with unique electronic properties, excellent thermal conduction, and high mechanical flexibility, and they have particular potential for the construction of organic-inorganic hybrid devices. In particular, research and development of biosensors that use CNTs, is actively pursued in the field of medical biotechnology.

On the other hand, the cell culture on the inorganic materials has the report example which uses the porous silicon, the Ti-Au electrode, hydrogenated amorphous silicon, and poly(dimethylsiloxane) (PDMS). In addition, the neuronal cell culture by CNT covered with neurotrophin which is one of neuronal cell growth factors (NGF) is reported.

We report on the experiment and consideration concerning a carbon nanotube film chemically modified functional group (F-CNT) by chemical modification method and plasma activation technique from the viewpoint of nerve-fusion type CNT based BMI development.

2. Material and method

2.1 Synthesis of F-CNT

We accomplished the synthesis of the functional group modified CNT films (size: 1 × 1cm) by using two chemical modification methods. One is synthesized by graft treatment of a solution (5 ml) containing 1,4-diaminobutane at room temperature for 24 h with stirring so that we might promote chemical modification. Another one is plasma activation method, and the experimental apparatus used for plasma activation, which consists of a glass chamber (160 mm diameter, 180 mm height), a magnetron-type electrode with a built-in permanent magnet (46 mm in diameter), a power supply, a rotary pump, and a glass plate that puts CNT film at a distance of 20 mm from the electrode. The experimental conditions are as follows; gas pressure: 1 Pa, power: 15 W (applied voltage: 1 kV, current: 15 mA), and process time: 15 min, respectively. The gas used for the production of amino group is atmospheric air with evaporating ammonia.

The non-treatment CNT film (Control-CNT) and F-CNT confirms chemical modification using

Fourier transform infrared absorption spectrophotometer (FT-IR)

2.2 Evaluation of F-CNT using culture cell

The experiment was conducted by preparing a serum-free culture medium (0.1 ml) containing mouse fibroblasts (NIH3T3; cell concentration: 1 $\times 10^4$ cells/mL) and F-CNT film on a 12well plate. The 12well plate including Control-CNT and F-CNT placed in a CO_2 incubator (temperature: 37°C; CO_2 density: 5%). The culture time was 24 h.

3. Results

The FT-IR spectra in case of the chemical modification method and plasma activation method are shown in Fig.1 and Fig.2. The spectra that corresponds to amino group are observed in 3500-3000 and 1650-1500 cm^{-1}. It is thought that amino group is formed on the CNT film surface.

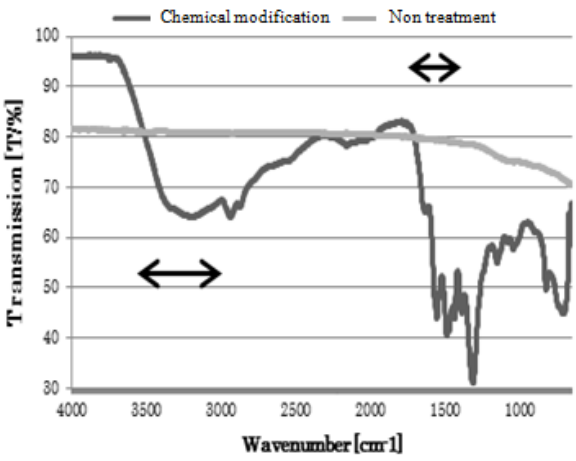

Fig.1 FT-IR spectra
(chemical modification method)

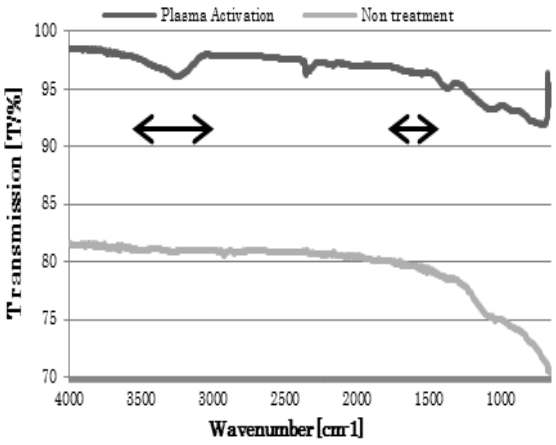

Fig.2 FT-IR spectra
(plasma activation method)

According to the experiment of the cell culture, as shown in Table.1, the result of the cell numbers of F-CNT increasing compared with C-CNT was obtained.

Table.1 The cells experiment

Time (h)	Cell number ($\times 10^4$ cells/mL)	
	Control-CNT	F-CNT
6	17.7	17.3
12	14.7	39.7
18	18.0	43.7
24	21.0	51.0
30	23.3	52.0
36	29.0	53.0
42	27.0	60.7

The measurement that confirms hydrophilic by distilled water or the medium is done, therefore hydrophilic due to the irradiation of nitrogen and oxygen ions is seen overall in the plasma-activation area. The proliferation of the NIH3T3 cells is hardly observed for Control-CNT, and when the NIH3T3 cells on the F-CNT are observed over the wide area. In addition, NIH3T3 cells are observed to extend on the F-CNT surface, and it turns out that plasma activation method is effective to the biocompatibility improvement between NIH3T3 cells and F-CNT surface.

4. Summary

We report on the experiment and consideration concerning a carbon nanotube film chemically modified functional group (F-CNT) by chemical modification method and plasma activation technique from the viewpoint of nerve-fusion type CNT based BMI development. According to FT-IR analysis, the spectra that corresponds to amino group are observed. In addition, the number of cells of F-CNT increasing compared with C-CNT was obtained. Therefore, it is thought that plasma activation method is effective for the biocompatibility improvement between NIH3T3 cells and F-CNT surface.

5. References

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