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COMPARATIVE STUDY OF SINGLE- AND MULTI-WALL CARBON NANOTUBES WITH APPLICATION IN CEREBRAL ANEURYSM

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Abstract. Helping improve humanity is one of the promises of nanotechnology and nanomedicine. This paper will highlight some of the research findings in the nanomedicine area by testing some single- and multi-walls carbon nanotubues in rats cerebral aneurisms.

Keywords: *nanomedicine, carbon nanotubes, cerebral anevrism, laser, photodynamic therapy, porphyrin*

2000 Mathematics Subject Classifcation: 05C65, 62H30

1. Introduction

Carbon nanotubes are expected to be of use in biomaterials engineering.Some of the most important characteristics of nanotubes include their nanometer diameter (∼0.4 nm to > 3 nm (SWNTs) and ∼1.4 nm to >100 nm (MWNTs), length of several micrometers (up to centimeters), large aspect ratio (10-1000), terapascal scale Young's modulus, excellent elasticity, ultra-small interlayer friction, excellent field-emission properties, current carrying capacity (∼1TA/cm3), high heat transmission (∼3 kW/mK). The discovery of carbon nanotubes (NTs) has the potential of revolutionizing the biomedical research as they can show superior performance because of their impressive structural, mechanical, and electronic properties (will be discussed in detail in a separate section latter) such as small size and mass, high strength, higher electrical and thermal conductivity, etc.

By assembling as-grown NTs, more complex structures can be built. Nanotube intermolecular and intramolecular junctions are basic elements for such structures. In this potential area of application, nanoparticles are introduced into a living organism for neuron regeneration. Neurons and glial cells incubated for several days yielded to some connections between the islands are clearly apparent and interconnected networks are formed following the exact pattern of the NT (nanotube) templates. The bridging consists either of an axon or bundles of axons and dendrites. As they complete this step axons and dendrites begin to form and to build connections.

One of the most prominent diseases of the arterial system is the appearance and growth of aneurysms. An aneurysmis a severe and permanent deformation of the arterial wall that results in an abnormal widening of the vessel. The present work is focused on aneurysms that are located in the cerebrum (cerebral aneurysms). There are several questions surrounding this pathology that are remaining unanswered. First comes the question of pathogenesis. While aneurysms are widely studied, the underlying mechanisms and the reasons that are causing the creation of aneurysms are -until now- not well understood. The questions that are following are conceming cerebral aneurysm's growth and rupture.

With the present work we tried to give answers to the above mentioned questions with the use of computational simulations.

In the present study we focus on the in vivo behavior of two types of carbon nanotubes (single- and multi-wall nanotubes). The nanotubes were implanted

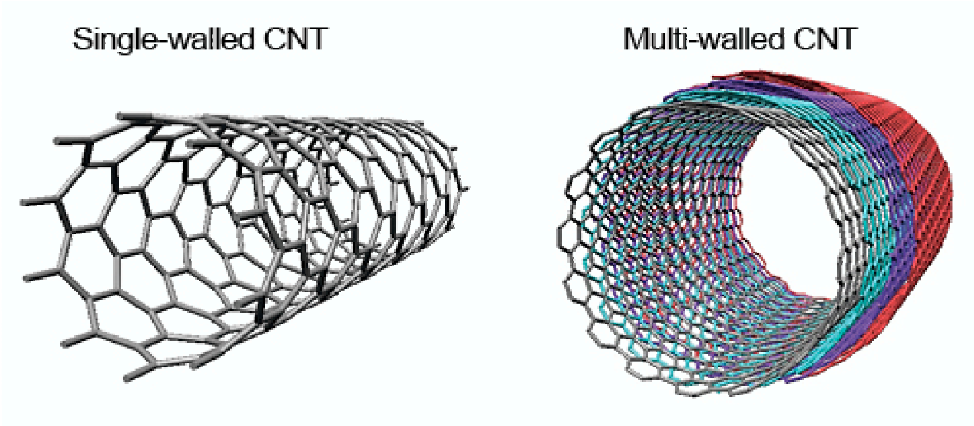


Figure 1: The structure of CNT

into the neuronal rat cells. Comparative analysis of the tissue reaction to the presence of the two types of carbon nanotubes was made. It was observed that multi-wall carbon nanotubes were found to form large aggregates within the living tissue, while distinctly smaller particles consisting of single-wall nanotubes were easily phagocytosed by macrophages and transported to local lymph nodes.

2. Materials And Methods

2.1. Methods

Carbon nanotubes are hexagonal networks of carbon atoms, 1 nm in diameter and 1-100 nm in length, as a layer of graphite rolled up into a cylinder. There are two types of nanotubes: single-walled nanotubes (SWNTs) and multi-walled nanotubes (MWNTs), which differ in the arrangement of their graphene cylinders. These are small macromolecules that are unique for their size, shape, and have remarkable physical properties. Nanotubes offer some distinct advantages over other drug delivery and diagnostic systems due to very interesting physicochemical properties such as ordered structure with high aspect ratio, ultra-light weight, high mechanical strength, high electrical conductivity, high thermal conductivity, metallic or semi-metallic behavior and high surface area.

2.2. Apparatus

A Hitachi S-2700 electron microscope operating at 10 kV, was used to obtain TEM images. Pictures were taken by a camera (SC35, Olympus, Japan) mounted on an optical microscope (IX-70, Olympus), using the x40 and x100 magnifications, and Nikon camera mounted on an Nikon fluorescence microscope, using the x10 and x40 magnifications. SEM images have ben obtained with a scanning electron microscope Nikon T600 laser scanning microscope. The images were collected with an immersion objective and displayed on a charge-coupled device camera.

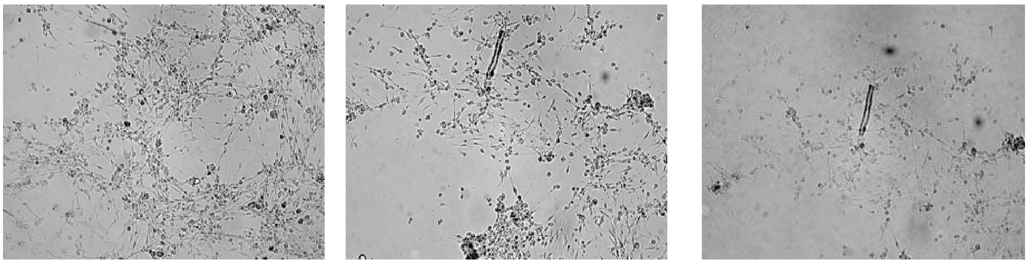
2.3. Cell cultures

Dissociated cortical cultures from mice, were prepared and maintained as follows: the entire cortices from one-day-old Charles River rats were finely chopped. The cortical tissue was digested with 0.065at 37.1C with 5

3. Results And Discussion

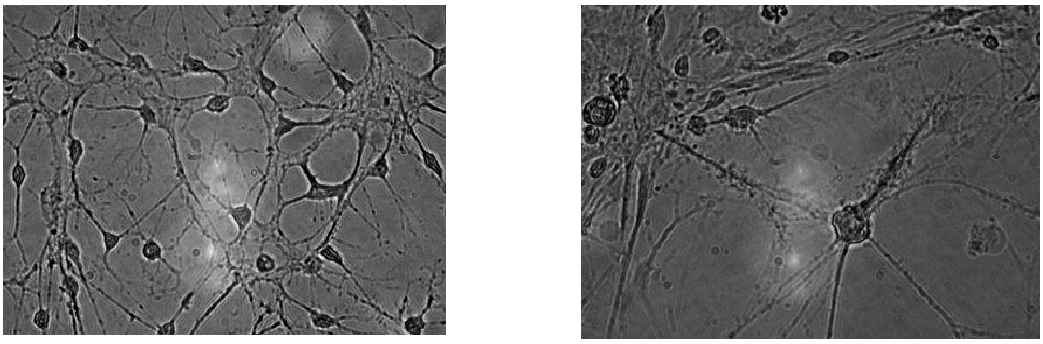
Carbon nanotubes (CNTs) are nanometer-scale cylindrical graphitic structures that exhibit extraordinary physical properties as determined by their structure [6]. Developing neural implants and the process of neuron regeneration are extremely difficult. Nerve cells require the right environment and the right growth factors at the right time to grow and proliferate. The electrical conductive properties of these nanotubes offer the possibility of using it as a replacement to transmit and receive signals. The resulting 'hair like' conductive wires that incorporate the properties of electrodes, permeable microfluidic conduits and the porosity of the CNTs was found to promote cell growth, migration and proliferation. The bridging consists either of an axon or bundles of axons and dendrites. In some cases the bridge is covered with clusters of cells [7]. These bridges form very efficiently over quartz surfaces which are apparently very poor surfaces for cell attachment. Fig. 2 shows the evolution of a network generated by SWCNT and MWCNT. The data show that cells first aggregate at the NT islands. As they complete this step axons and dendrites begin to form and to build connections.

Also, has been observed for MWCNT higher connections than for SWCNT, Figure 3.



(a) (b) (c)

Figure 2: The microscopy images fo neuronal cells control (a) generated by MWCNT (b) and SWCNT (c)



SWCNT MWCNT

Figure 3: The microscopy images fo neuronal cells generated by SWCNT (a) and MWCNT (b)

4. CONCLUSIONS

Neurons and glial cells were incubated for several days in order to investigate the effectiveness of the method. Connections between the islands are clearly apparent and interconnected networks are formed following the exact pattern of the MWCNT templates. The bridging consists either of an axon or bundles of axons and dendrites. A networkover after three and five days after incubation, has been observed. The data show that cells first aggregate at the MWCNT islands. As they complete this step axons and dendrites begin to form and to build connections.

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