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# Aligned Carbon Nanofiber Materials Direct Neurite Orientation

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**INTRODUCTION:** Neural materials have experienced reduced effectiveness when implanted for long time periods due to poor interactions between the biomaterial surface and the local neuronal cell populations. The reduced efficacy of these implants is largely due to glial scar tissue formation produced by astrocytes. It is desirable to design implants that retain functionality, but mimic select properties (for instance, dimension) of native tissue in order to reduce chronic implant difficulties such as glial scar tissue formation around implant surfaces. This reduced scar tissue formation would improve the interface between neural biomaterials (for example, electrodes) and neurons. Carbon nanofibers can be formulated to mimic the nanoscale dimensions of macromolecules in the brain (such as proteins) and have unique material properties including high conductivity and high strength to weight ratios. These properties make carbon nanofibers attractive candidates for neural biomaterial applications. Recent results indicated reduced astrocyte functions in vitro [1] and may therefore lessen scar tissue formation in vivo while at the same time enhancing neuronal cell interactions. Further promising neuronal responses could be obtained if neuronal cell orientation (especially neurite and axon extension) could be controlled by carbon nanofiber directionality as it has been in grooved materials [2,3].

**METHODS:** For this purpose, we describe the use of polycarbonate urethane (PCU) and aligned carbon nanofiber composites for neural applications. Specifically, this study aligned 60 nanometer (diameter) carbon fibers in PCU matrices by placing them between parallel electrodes and applying a homogeneous electrical field immediately before the polymer hardened. To determine neuron responses, pheochromocytoma cells (PC-12 cells) were seeded onto the aligned carbon nanofiber substrates coated with laminin and were cultured for 11 days in standard conditions.

**RESULTS:** In Fig. 1A and 1B, the blue color highlights the aligned carbon nanofibers with the yellow arrow indicating their general orientation in PCU. Most importantly, results of this study showed that the aligned carbon nanofibers guided the general direction of neurite growth from neuronal cells (in green).

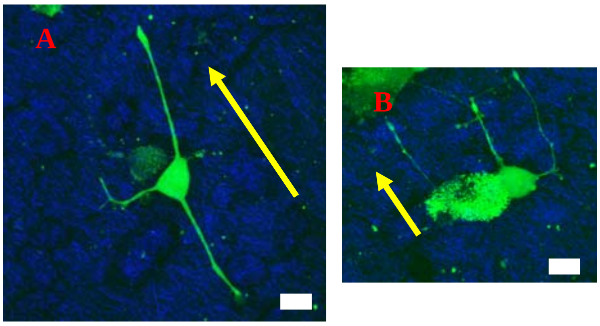


Fig. 1: Neurite alignment in neurons parallel to carbon nanofiber orientation in PCU composites. Panels A and B show confocal images of PC-12 cells (green) on aligned carbon nanofibers (blue) with neurite extension parallel to the general direction of carbon nanofiber alignment in PCU. Scale bars are 20 µm.

**DISCUSSION & CONCLUSIONS:** These results suggest the possibility of using aligned carbon nanofiber materials to control neurite and axon extension for various central and peripheral nervous system applications including neural networks [4], electrodes, neural tissue engineering bridges [5], and neural probes. Collectively, this series of studies highlights the promise carbon nanofibers have to reduce scar tissue formation at a neural implant interface while at the same time increasing interactions with neurons for guided control over neurite and axon orientation to improve various neural applications.

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