Peripheral neuron survival and outgrowth on graphene

Domenica Convertino[1,2]

Stefano Luin[1], Laura Marchetti[2], Camilla Coletti[2]

[1]NEST, Scuola Normale Superiore, P.zza San Silvestro, Pisa, PI, Italy
[2]Center for Nanotechnology Innovation @NEST, Istituto Italiano di Tecnologia, P.zza San Silvestro, Pisa, PI, Italy

domenica.convertino@sns.it

In recent years, new materials have been suggested as alternative candidates for tissue engineering applications. In particular graphene and other carbon-based nanomaterials have been proposed in life-science applications and nerve tissue regeneration (1,2,3).

Several studies have used graphene-based materials as biocompatible substrates for growth and differentiation of different cell types, including neural cells. However, in the majority of works regarding regenerative applications, carbon nanotubes and graphene were not in pristine form (2,3).

In this work, we investigate the potential of pristine graphene as a conductive peripheral neural interface. Epitaxial graphene obtained via thermal decomposition on silicon carbide (SiC) (4) is the ideal substrate for this investigation thanks to its high crystalline quality, scalability, thickness homogeneity and cleanliness. We investigate two cellular models: (i) PC12 cells, a non-neuronal cell line constituting a widely-used model for peripheral sympathetic neurons upon Nerve Growth Factor (NGF) stimulation; (ii) dorsal root ganglion (DRG) primary sensory neurons, a model to study regenerative axon growth, due to their capacity to regenerate the peripheral axon after injury.

Optical microscopy and viability assays indicate that PC12 cells grow well on graphene, compared to standard controls (see Fig. 1). Notably, PC12 on graphene show a remarkably increased neurite length: at day 5, neurites on graphene are 22% and 35% longer than on culture wells and glass, respectively. In addition, the survival rate is comparable to that retrieved on controls.

Culture of DRG primary neurons also shows a positive outcome on graphene: neurons survive both on bare and coated graphene until day 17, with a dense axon network.

These results confirm the potential of graphene as an active substrate in nerve guidance conduit devices. Indeed, graphene could be used as an active neural guide: it would not only allow for the transmission of electrical signals between neurons but its external electrical stimulation could be used to enhance axon regeneration.

References

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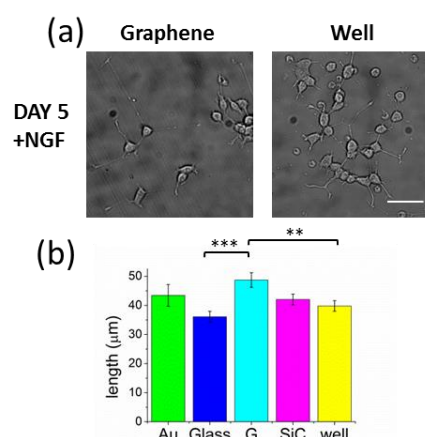
Figures

Figure 1: (a) PC12 cells differentiation at day5 on graphene and polystyrene well in the presence of NGF (50 ng/ml) (scale bar: 50 μm); (b) quantification of neurite outgrowth (** $p<0.01$, *** $p<0.001$)