Graphene and the brain: interaction of graphene flakes with neurons and astrocytes

Mattia Bramini
Martina Chiacchiaretta, Anna Rocchi, Ester Vazquez, Andrea Armirotti, Tiziano Bandiera, Fabrizia Cesca, Fabio Benfenati

Center for Synaptic Neuroscience and Technology, Istituto Italiano di Tecnologia, L.go Rosanna Benzi 10, 16132, Genova, Italy

mattia.bramini@iit.it

There is an increasing interest toward the use of graphene (G) and G-based materials for biomedical applications, especially for targeting the central nervous system. To fulfil this goal, it is mandatory to characterize the effects elicited by different types of graphene when in contact with the main neural cell populations, with the goal to evaluate G biocompatibility and accordingly any unwanted effects that G-based materials could potentially induce to living systems. We are conducting our research within the Graphene Flagship European project, focusing our attention on primary neurons [1] and glial cells [2, 3]. We are characterizing the molecular mechanisms of G flake internalization together with the possible inflammatory responses. Moreover, we are exploring the possibility of using G-based supports as biocompatible scaffolds for biomedical applications, trying to exploit the conductive properties of this material to modulate and control the activity, differentiation and connectivity of neural networks grown in strict contact with such scaffolds. Our results show that although exposure to G materials does not impact cell viability and network formation, it does nevertheless have important effects on neuronal and glial physiology. We demonstrated that G oxide (GO) flakes impact on several cellular processes including synaptic activity, intracellular Ca^{2+} dynamics and astrocyte glutamate uptake, thus on one side warranting caution when planning to employ this material for neurobiological applications, but on the other side suggesting GO materials could have protective effects in neuropathologies characterized by hyperexcitability. Finally, we are investigating the molecular and cellular mechanisms by which G materials interact with the blood-brain barrier [4], to assess the possibility of using these materials for drug delivery applications targeted to the central nervous system.

References

[1] Bramini et al, ACS Nano, 10 (2016), 7154-7171
[2] Chiacchiaretta, Bramini et al, Nano Letters, 18 (2018), 5827-5838
[3] Bramini et al, Small (2019) *in press*
[4] Bramini et al, ACS Nano, 8 (2014), 4304-4312

Figures

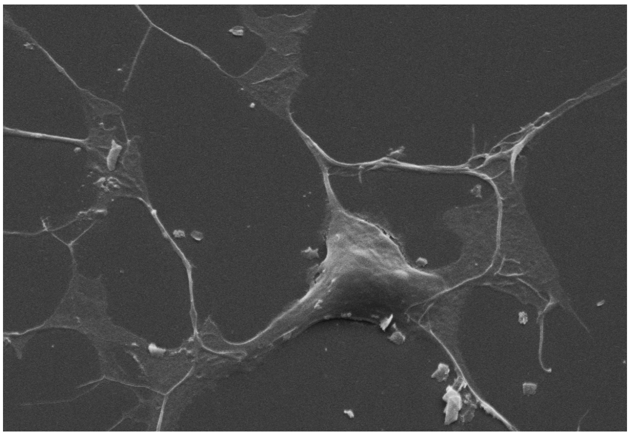

Figure 1: Scanning electron microscopy micrograph of primary neurons exposed to graphene flakes