Electrochemical Control of Charge Current Flow in Nanoporous Graphene

Isaac Alcón
Gaetano Calogero, Nick Papior, Mads Brandbyge
Catalan Institute of Nanoscience and Nanotechnology, Campus de la Universitat Autònoma de Barcelona, Av. de Serragalliners, s/n, 08193 Bellaterra (Barcelona), Spain
isaac.alcon@icn2.cat

During the last decade, on-surface fabricated graphene nanoribbons (GNRs)[1] have gathered enormous attention due to their semiconducting π-conjugated nature and atomically precise structure.[2] A significant breakthrough was the recent fabrication of nanoporous graphene (NPG) as a 2D array of laterally bonded GNRs.[3] This covalent integration of GNRs could enable complex electronic functionality at the nanoscale, however, for that it is crucial to externally control the electronic coupling between GNRs within NPGs which, to date, has not been possible. Here I will explain how, using quantum chemical calculations and large-scale transport simulations, we have recently demonstrated such control is enabled in a newly designed quinone-NPG (q-NPG) thanks to its GNRs inter-connections based on electroactive para-benzoquinone units. As a result, the spatial distribution of injected currents in q-NPG may be tuned, with sub-nanometer precision, via application of external electrostatic gates and electrochemical means.[4] Our results provide a fundamental strategy to design organic nanodevices with built-in externally tunable electronics and spintronics, which is key for future applications such as bio-chemical nanosensing and carbon nanoelectronics.

References

[1] J. Cai, P. Ruffieux, R. Jaafar, M. Bieri, T. Braun, S. Blankenburg, M. Muoth, A. P. Seitsonen, M. Saleh, X. Feng, K. Müllen, R. Fasel, *Nature* 466 (2010) 470
[2] Z. Chen, A. Narita, K. Müllen, *Adv. Mater.* 32 (2020) 2001893
[3] C. Moreno, M. Vilas-Varela, B. Kretz, A. Garcia-Lekue, M. V. Costache, M. Paradinas, M. Panighel, G. Ceballos, S. O. Valenzuela, D. Peña, A. Mugarza, *Science* 360 (2018) 199
[4] I. Alcón, G. Calogero, N. Papior, M. Brandbyge, *Adv. Funct. Mater.* (2021) 2104031, https://doi.org/10.1002/adfm.202104031

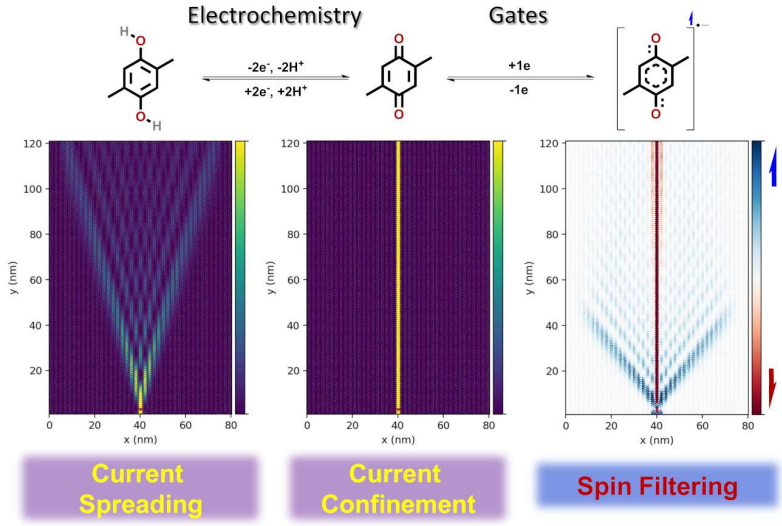

Figure 1: The spatial (spin) distribution of injected electric currents depends on the electronic configuration of quinoidal units bridging GNRs within the q-NPG.