Low-dimensional materials as platform for sensing and water purification

Artur Ciesielski
Université de Strasbourg & CNRS, 8 allée Gaspard Monge, Strasbourg, France
ciesielski@unistra.fr

Low-dimensional materials (LDMs) exhibiting a high surface-to-volume ratio are unique scaffolds whose interactions with the environment drive their application as sensitive elements in chemical sensing. They allow prompt reconfiguration of the architectures of the sensor, whose response to the detection of chosen analyte becomes no longer limited by extrinsic factors such as the slow diffusion of target molecules through the active material or the presence of structural traps for small molecules/ions. The unique features of LDMs determine the highest responsiveness, sensitivity, and reversibility combined with the lowest limit of detection (LoD) in the sensing process.
Pristine LDMs are being widely exploited as highly sensitive elements in chemical and physical sensors, although they suffer from the lack of intrinsic selectivity towards specific analytes. Here, we showcase the most recent strategies explored in our laboratory on the use of (supra)molecular interactions to harness selectivity of suitably functionalized 0D and 2D materials for chemical and physical sensing. We discuss how to achieve selectivity in chemical sensors along with other relevant characteristics, such as high sensitivity, response speed, and reversibility, by suitable functionalization and incorporation of low-dimensional materials into powerful transducers.
We will discuss piezoresistive pressure sensor based on a millefeuille-like architecture of reduced graphene oxide (rGO) intercalated by covalently tethered molecular pillars holding on-demand mechanical properties are fabricated. By applying a tiny pressure to the multilayer structure, the electron tunnelling ruling the charge transport between successive rGO sheets yields a colossal decrease in the material's electrical resistance.
We will also discuss novel generation of humidity sensors based on a simple chemical modification of rGO with hydrophilic moieties, i.e., triethylene glycol chains. Such a hybrid material exhibits an outstandingly improved sensing performance compared to pristine rGO such as high sensitivity (31% increase in electrical resistance when humidity is shifted from 2 to 97%), an ultrafast response (25 ms) and recovery in the subsecond timescale, low hysteresis (1.1%), excellent repeatability and stability, as well as high selectivity toward moisture.

REFERENCES

[1] Authors, Journal, Issue (Year) page C. Anichini, A. Aliprandi, S. Manoj Gali, F. Liscio, V. Morandi, A. Minoia, D. Beljonne, A. Ciesielski, P. Samorì, ACS Appl. Mater. Interfaces, 12 (2020) 44017
[2] C.-B. Huang, S. Witomska, A. Aliprandi, M.-A. Stoeckel, M. Bonini, A. Ciesielski, P. Samorì, Adv. Mater. 31 (2019) 1804600
[3] C.-B. Huang, A. Ciesielski, P. Samorì, Angew. Chem. Int. Ed. 59 (2020) 7319
[4] C. Anichini, W. Czepa. D. Pakulski, A. Aliprandi, A. Ciesielski, P. Samorì, Chem. Soc. Rev, 47 (2018) 4860
[5] R. Furlan de Oliveira, V. Montes-Garcia, A. Ciesielski, P. Samorì, Mater. Horiz. (2021) *in press*