

The interaction of pyrene derivatives with graphene nanoplatelets

Andrea SCHLIERF¹, Emanuele TROSSI¹, Huafeng YANG², Cinzia CASIRAGHI²,
Vincenzo PALERMO¹

¹ISOF Istituto Sintesi Organica e Fotoreattività, Bologna, Italy

²The Photon Science Institute, University of Manchester, UK

schlierf@isof.cnr.it

Graphene has raised intensive research interest as a promising material for future carbon-base nanoelectronics, while upscalable low cost production of this remarkable material is still a bottleneck when heading towards graphene based applications. At the moment, chemical exfoliation of graphene is the most promising technique to obtain large quantities at low cost and easily processable. A wide amount of research works demonstrated, in the last years, that several different classes of molecules can exfoliate graphite flakes into soluble graphene sheets with different efficiencies in achieving soluble aggregates and obtaining mono- and multi-layer sheets.

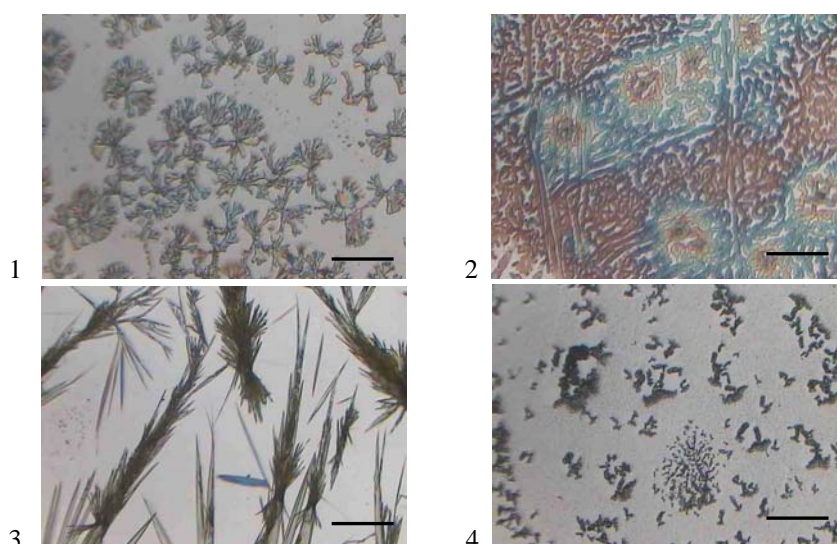


Fig. Macroscopic morphology of different pyrene derivatives on silicon (scale bar 100 μ m)

A class of molecules which seems very effective in exfoliation and stabilizing graphene sheets are small poly-aromatic hydrocarbons (pyrenes, perylenes, anthracenes, etc.) functionalized with flexible or possibly polar sidechains. While graphene exfoliation is widely performed in academic and industrial labs, a clear understanding of the exfoliation mechanism at molecular level is still missing. Macroscopic models have been used to correlate exfoliation efficiency to empirical solubility parameters quantifying the dispersive, polar, and hydrogen bonding properties of the solvent, or more simply to the surface tension or the refractive index of the solvent.

Using a quite simplistic description of this process, these molecules act as “molecular wedges”, with the polyaromatic part interacting with the graphene through π - π stacking, while the negatively charged part (the acid) favours sheet solubility in solvent, hindering re-aggregation. The true picture is likely much more complex, with a relevant interaction of both the aromatic and polar moieties with the graphene surface.

To better unravel the complex interaction between graphene and organic molecules, and possibly improve the exfoliation efficiency, we have performed a comparative study of the self-assembly with a whole series of pyrene derivatives, having an increasing number of functionalization and polar character. We studied different self-assembling behaviours of those model compounds both in solution and on different substrates in presence or not of graphene sheets, applying optical microscopy (OM), atomic force microscopy (AFM) and UV-Vis spectroscopy.

References

- [1] J. Jang, *Mater. Chem.*, **2011**, 21, 3462–3466
- [2] X. Dong, *Phys. Chem. Chem. Phys.*, **2010**, 12, 2164–2169
- [3] X. Pan, *J. Phys. Chem. C*, **2012**, 116, 4175–4181
- [4] X. An, *Nano Lett.* **2010**, 10, 4295–4301
- [5] J. Coleman, *Adv. Funct. Mater.* **2009**, 19, 3680–3695
- [6] R.S. Swathi, *J. Chemical Physics*, **2008**, 129, 054703