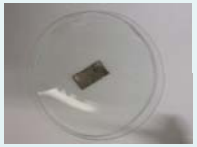
The Functionalization of Graphene

Wenzhi Yang, Helena Grennberg, Department of Biochemistry and Organic Chemistry, Uppsala University
Sultan Akhtar, Klaus Leifer, Department of Engineering Sciences, Uppsala University

Molecular functionalization of graphene is a key to materials applications. This could be by covalent and non-covalent strategies, the latter more interesting since this causes no damage to the carbon lattice, but also more challenging since this can be more difficult to detect by "standard" graphene methods such as Raman spectroscopy, microscopy (light, AFM, STM and TEM). Pyrene derivatives are established tools for non-covalent functionalization of carbon nanotubes that should interact with graphene in the same fashion.

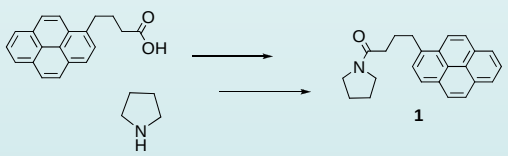
Suspensions of graphene, prepared directly from graphite by sonication-assisted exfoliation, has been treated with pyrene derivatives **1** – **3**. The assemblies, in suspension and/or after deposition on solid supports, have been characterized by spectroscopic as well as microscopic methods. The accumulated evidence, also including direct comparisons of carbon nanotubes at the same conditions, proves the successful non-covalent functionalization of graphene.

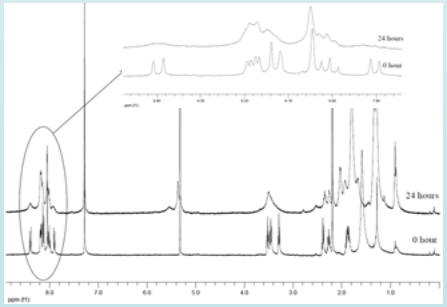

Graphite foil

sonication

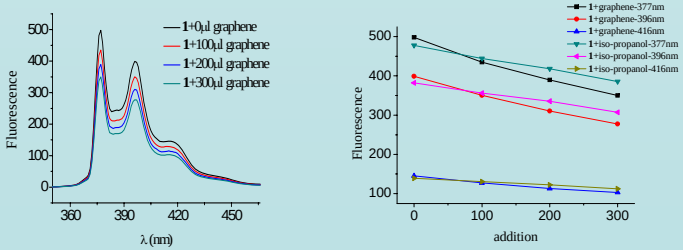

Graphene dispersion

Spectroscopy



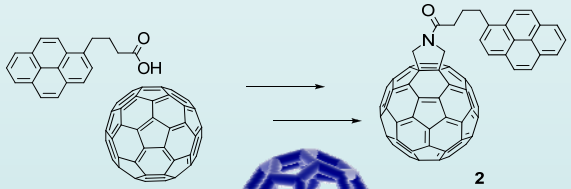


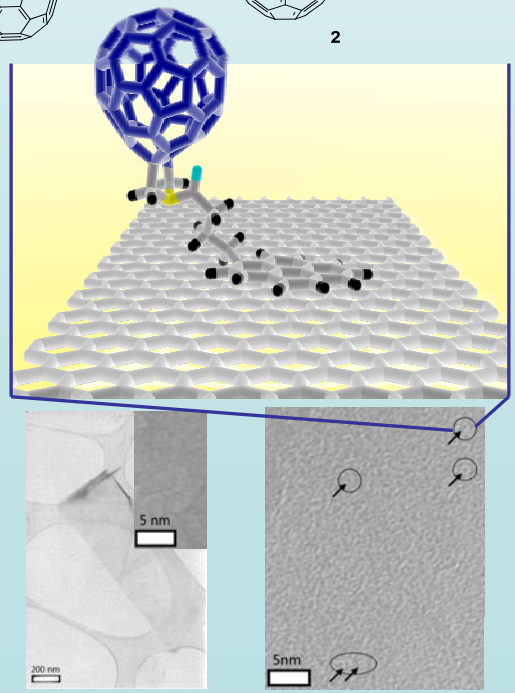
^{1}H NMR of compound **1** in $CDCl_3$ before (lower) and after incubation with graphene flakes for 24h (upper)



The fluorescence spectra of compound **1** in iso-propanol, excitation at 240 nm (Left). The intensity at all wavelengths decreases with addition of increasing amounts of graphene suspension in the same solven. The intensity decrease is larger than what is observed when adding only solvent to compound **1**, shown graphically in the right panel.

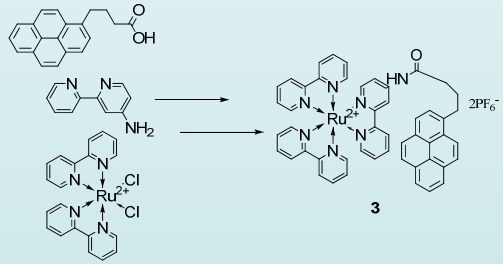
Microscopy

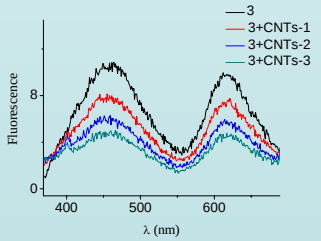




TEM images of the flake from graphene sespension (left) and the flake from graphene suspension treated with compound **2**. The contrast was enhanced digitally for both images with scale bar 5 nm.

Photophysically interesting?





The fluorescence spectra of compound **3** in $CHCl_3$ with addition of increasing amounts of carbon nanotube solution (CNTs), excitation at 350nm. As expected, the intensity of the fluorescence decreased.

Acknowledgment: Göran Gustavsson foundation and Gahns fond (post-doctoral stipend for WY). The graphene research at Uppsala univeristy is supported by the KoF programme.