Synthesis and decoration of graphene with metal nanoparticles

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Graphene is a perfect substrate material; bulk synthesis of graphene and its decorations with metals can open to interesting opportunities in the field of energy storage or heterogeneous catalysis [1].
We were able to obtain gram amount of thermally exfoliated graphene (TEGO) and we tuned different synthetic approaches for the decoration and functionalization of TEGO with metal nanoparticles (NPs), in particular of Ni [2] and Pt [3].
In particular we have developed a novel 2-steps method for the bulk synthesis of Pt and Ni decorated graphene, avoiding its exposure to air. The size and the distribution of NPs was controlled and optimized by varying the thermal decomposition rate, the nature and the concentration of the metal precursor. In particular, we have investigated different organic precursors and metal carbonyl clusters, such as $Ni(acac)_2$ and $(TBA^+)_4[Pt_{19}(CO)_{22}]^{4-}$.
We have observed the formation of NPs with diameter less than 20 nm and even the formation of single metal atoms (depending on the synthesis) on the graphene layers.
The morphological and topological properties of the samples have been investigated by means of high resolution transmission electron microscopy (HRTEM, HAADF-STEM).
The main result shown in this work is that single metal atoms can be generated on graphene, thus giving the opportunity to explore the properties of individual metal atoms.

References

[1] C. Huang et al., Energy Environ. Sci., 5 (2012) 8848
[2] M. Gaboardi, G. Magnani et al. J. Mater. Chem. A, 2 (2014) 1039
[3] M. Gaboardi, G. Magnani et al. ACS Nano, submitted

Figures

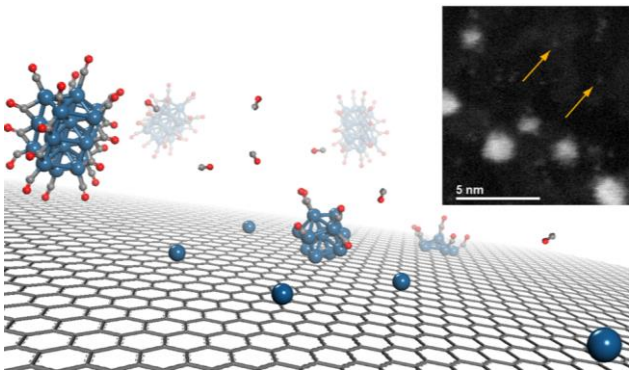

Figure 1: Theoretical image of the different Pt nanoparticles and atoms obtained on the graphene layer. Inset: STEM image of the PtC_{100} sample obtained from Pt_{19} carbonyl cluster.