Carbon precursor structures and graphene on palladium nanoparticles

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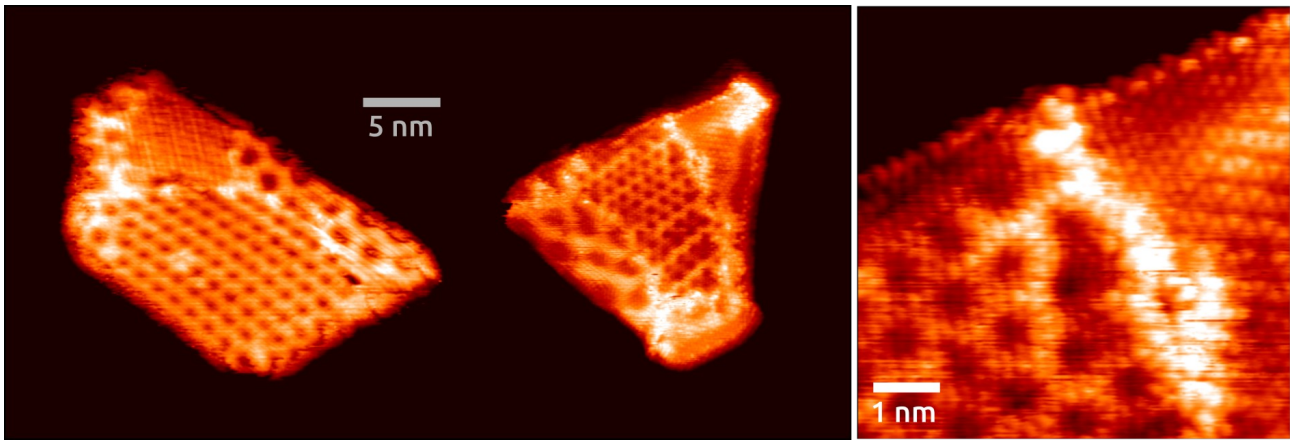
Carbon either *adsorbed on* or *absorbed inside* metal nanoparticles (NPs) plays a major role in heterogeneous catalysis, particularly in catalyst de-activation, hydrogenation reactions, the Fischer-Tropsch synthesis and the synthesis of carbon nanotubes. Since a few years, carbon is synthesized also in the form of graphene directly on metal NPs by, e.g., chemical vapor deposition (CVD). Such core-shell *graphene encapsulated NPs* (G@NPs) have very interesting properties for applications in electrocatalysis, in particular with respect to cheap and reactive NP material: thanks to the protecting graphene shell a long-term activity and high stability against degradation in several environments is achieved [1]. Even more, the graphene-NP ensemble optimizes the electronic structure of graphene and thereby triggers the catalytic activity on the inert graphene surface. Since recently, G@NPs are also believed to form a new class of catalysts that lead to *catalysis under cover* [2]: the graphene wall and NP facets form a nanocontainer, in which reactions take place as demonstrated recently with G@PtNPs [3].

Important in all such G@NP related studies is an atomic-scale characterization of the graphene structure with an access to defects and the graphene edges, which both play a large role in electrocatalysis and in catalysis under cover: in the latter, basic reactant or product molecules like oxygen, hydrogen, CO and water can enter or leave the nanocontainer by passing through the defects and edges of graphene.

In this contribution, an atomic-scale scanning tunnelling microscopy (STM) study is presented [4], which documents preliminary growth stages and the structural properties of graphene on HOPG supported palladium NPs (PdNPs). It is shown that an annealing of PdNPs at 650°C in a few tens of Langmuir of ethylene (ethene) leads first to a carbon precursor structure covering the NP's (111) facets. At higher ethylene exposures, the precursor structure turns into single-layer graphene encapsulating the PdNPs. Graphene encapsulated PdNPs with a size larger than ~30 nm exhibit mostly one single and almost defect-free graphene sheet on a facet. Such a perfect growth does not take place on the facets of smaller NPs where several graphene nanosheets and defects are generally observed (see Figure).



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