Graphene Functionalisation Using Hydrophobin Proteins

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Since the first experimental realisation of 2D material graphene [1], vast amount of new physics has emerged. Graphene has also been mentioned as a candidate to replace silicon in microelectronics and, because of its optical properties, is a good candidate for transparent electrodes in display technology. Partially the properties are arising from graphene being chemically inert. This is beneficial in many instances but may be disadvantageous, e.g., in sensor applications. One possibility to add functionalities to graphene is to use proteins as linkers. Hydrophobin is a small protein with a hydrophobic patch that attaches to a hydrophobic surface [2]. Hydrophobins form a one-monolayer thick ordered 2-dimensional film that can be used to link biomolecules or nanoparticles onto hydrophobic surfaces. This has been demonstrated with graphite and silicon [3].
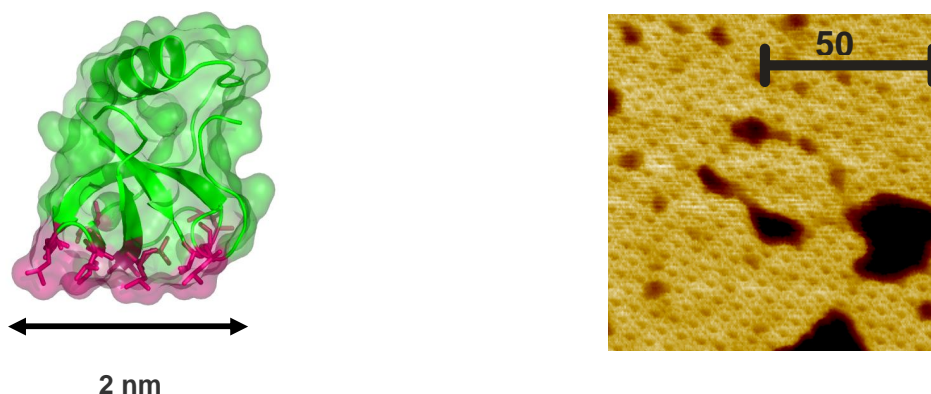

Fig 1. (left) Structure of a hydrophobin HFBI protein. The protein has a hydrophobic patch in the other end of the body, shown red in the picture. (right) Hydrophobins form a one monolayer thick 2-dimensional ordered film that can be transferred onto hydrophobic surfaces, such as graphene. The lattice constant of the hexagonal lattice is about 6 nm.

The aim in this work is to demonstrate that using hydrophobins one can functionalise the otherwise chemically inert graphene surface. In Figure 2 is shown a TEM image of a graphene flake onto which 3 nm Au nanoparticles have been attached using hydrophobins as linkers. The functionalisation is based on an in-situ process. It was found out that hydrophobin solution enhances the exfoliation of graphene from graphite and simultaneously the graphene surface is covered by the proteins [4]. By using engineered hydrophobins that link to gold nanoparticles, the graphene surface can be coated with a monolayer thick and non-agglomerated nanoparticle layer. The same approach can be used to link layers of other proteins or biomolecules for, e.g., sensor applications. The first electrical measurements show that a dry protein film decreases the mobility of a graphene FET about 50 %.
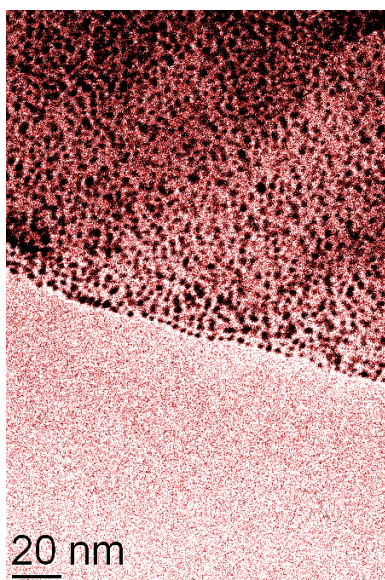
Fig. 2. TEM image of graphene flake covered with a monolayer of hydrophobin proteins to which 3 nm gold nanoparticles have been attached.

References

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