Graphene vs. reduced graphene oxide: fluorescence quenching in hybrid nanostructures.

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Abstract

Since its discovery in 2004, graphene has been one of the most studied materials. Although at first, reduced graphene oxide (rGO) was considered less important, and was described often as a distorted form of highly crystalline graphene, easy and cheap processing, combined with solubility in various solvents, has made rGO a very attractive material for coupling with other nanostructures. It has been already shown that graphene as well as rGO are very strong energy acceptors.[1-7] The efficiency of the energy transfer depends on particular design and choice of the components comprising the hybrid nanostructure.

In our experiments we probe interactions in hybrid nanostructures consisting of silver nanowires (AgNW) and natural photosynthetic complexes peridinin-chlorophyll-protein (PCP) placed in the vicinity of graphene and rGO. In such nanostructures, in addition to the energy transfer, also strong plasmonic interactions take place. These effects were studied using advanced fluorescence microscopy and spectroscopy techniques.

Two architectures of hybrid nanostructures were examined. Firstly, we simply mixed PCP, AgNW and rGO in a polymer matrix. Secondly, we fabricated a more complex structure, where PCP was chemically bound via biotin-streptavidin to AgNW. The conjugate (PCP@AgNW) was then either mixed with rGO or deposited on rGO, as well as on mono- or bilayer graphene.

The experiment conducted on the mixture showed that plasmonic fluorescence enhancement of PCP [8] is almost completely cancelled by the presence of rGO. The degree of quenching strongly depends on the time of mixing, and the sequence of adding ingredients. In contrast, for the PCP@AgNW conjugate mixed with or deposited on rGO no interaction is observed, suggesting that the rGO flakes do not penetrate the conjugate thus inhibiting the energy transfer and quenching. Finally, deposition of the PCP@AgNW conjugate on mono- or bilayer CVD graphene leads to strong quenching of fluorescence intensity. In addition, substantial reduction of plasmon scattering at the ends of the nanowires is observed when deposited on graphene.

The results indicate that graphene and 2D graphite-derived materials can be considered as strong candidates for applying in artificial photosynthesis, optoelectronics, and biosensor design.

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