

Enhanced absorption or transparency in hybrids of nanoparticles and graphene

The appealing side of nanotechnology lies in the fact that ordinary materials show surprising properties when their size is reduced to billionths of meters (nanometers). For example, we all know that silver is gray and gold is yellow, but when they are turned into nanoparticles these colors change, and the whole rainbow can be reproduced by controlling the geometrical shape and the assembly of the metals. Another famous nanotechnology example is graphene, namely what you would get if the graphite of your pencil can be spread on a sheet up to produce a layer with the thickness of one atomic layer. Scientists investigated the physical properties of these nanomaterials for several years, and many things are now well known about the optical, electronic and mechanical behaviour. However, what happens when Ag or Au nanoparticles are combined with graphene is still not well understood.

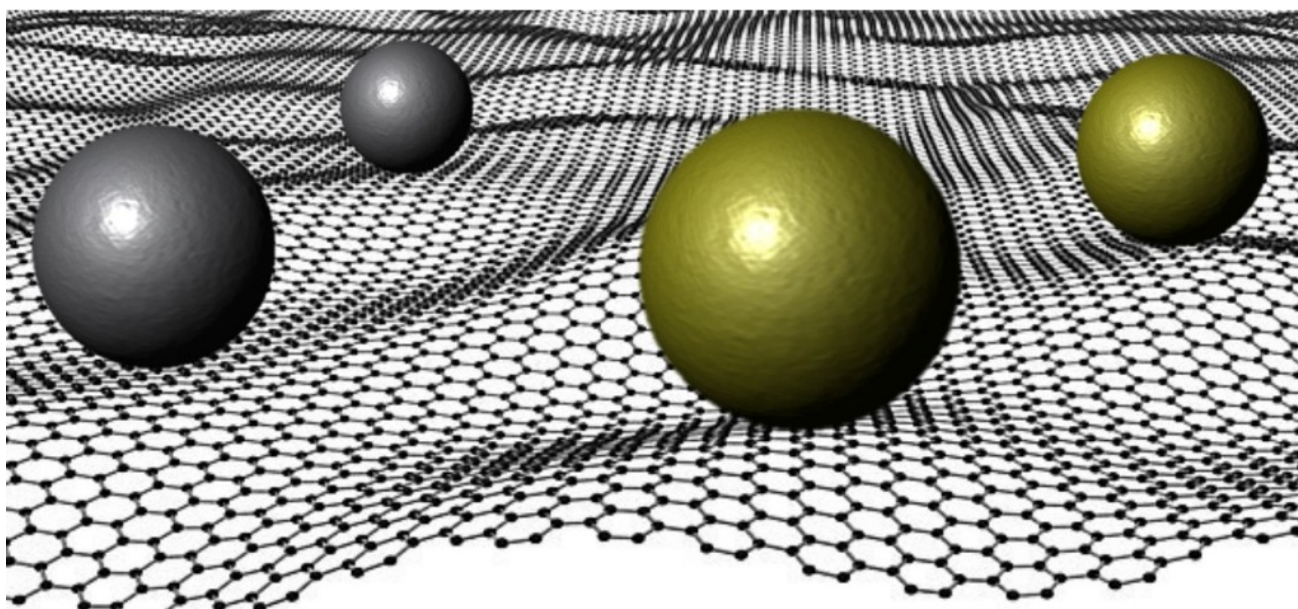


Fig. 1.

Hybrid structures composed of Ag or Au nanoparticles and graphene are promising for several uses, such as the creation of transparent conducting inks, the photothermal treatment of cancer, the ultrasensitive detection of molecules, the production of chemicals with low energy consumption and the conversion of sunlight into electric power. Therefore, understanding the changes in

physical properties when noble metal nanoparticles and graphene are coupled at the nanoscale is highly important.

A recent study shed light on the optical properties of these nanohybrids, evidencing how the coupling can lead to the improvement or worsening of the light absorption performances. In particular, Ag nanoparticles always undergo to a decrease of their ability to absorb and scatter light, when coupled with graphene. This is desirable for the creation of transparent conducting films, but it is not for all those phenomena related to the conversion of light into heat or to focusing of the incident photons on subnanometric region of spaces, often called electromagnetic near field enhancement.

Instead, when gold nanoparticles are coupled with graphene, a different response is observed depending on the shape of the nanoparticle: nanospheres experience a moderate increase of their light absorption ability, whereas rods and discs behave like Ag.

Increasing the number of graphene layers around the nanoparticle will always result in a remarkable shielding of the optical response of metal nanoparticles. Complete obscuration of the nanoparticle is achieved for a shell with thickness of only few nanometers. The distance between graphene and the metal nanoparticles is crucial for the occurrence of such a phenomena, since the effect is appreciable only for a separation below 5 nm.

This study also evidenced a counterintuitive finding, because it showed that the coupling of objects with a well defined light absorption ability can generate an hybrid with lower absorbing performance. In other words, coupling of two absorbing objects produced a more transparent one!

These results will help materials scientists in the design of hybrid nanoparticles with the most appropriate performances for a specific application, among the many possible.

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Publication

[Surface plasmon resonance of silver and gold nanoparticles in the proximity of graphene studied using the discrete dipole approximation method.](#)

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