Controlled deposition and growth of gold nanoparticles on solid substrate

Summary

We present two new methods of surface functionalization with gold nanoparticles:

1. Indirect method in which a solid substrate is modified in a two-step process: first nano-seeds are deposited on the surface from a bulk solution, then the surface decorated with the nano-seeds is immersed in a growth solution.
2. Direct synthesis of flower-like gold nanostructures on the solid substrate.

The functionalized surfaces are successfully applied as substrates for the surface enhanced Raman spectroscopy (SERS).

Indirect method: Preparation of substrates

Glass or silica slides are immersed in an aqueous solution of positively charged nanoparticles and NaCl.

To remove organic (thiol) protecting layer from the nanoparticles deposited on the surface, the slides are immersed in a solution of sodium borohydride in water and ethanol for 20 min.

Indirect method: Growth of nano-structures

Next the slides are immersed in the growth solution. Depending on the density of the seeds deposited on the surface, composition of the growth solution, and the exposition time, the surface can be covered in a controlled way with the nano-structures of different sizes and shapes.

We can cover surfaces with nano-structures having hemisphere, polygon, and flower-like morphology.

Direct method: Synthesis of microflowers

Gold microflowers (MFs) are synthesized directly on the solid substrate from the aqueous solution containing tetrachlorauric acid (HAuCl₄) and hydroxylamine hydrochloride (NH₂OH x HCl).

Morphology of the gold flower-like structures strongly depends on molar ratio of the reagents and reaction time. Short reaction times allow to obtain microflowers with sharp-edge leaves, whereas times longer than 30 minutes give rounded-edge structures. Microflowers are also larger for greater hydroxylamine excess.

Application to SERS

Preparation of the MF-coated surfaces for SERS.

SERS spectra of p-mercaptobenzoic acid on:
(a) surface with attached 5 nm gold nanoparticles,
(b) surface produced using indirect method,
(c) surface produced using direct method.

As reducing agents mercapto succinic acid (A), ascorbic acid (B), and hydroxylamine (C) are used.

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