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Precious metal gets picky

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Not only jewelry-loving ladies but also scientists and technologists are fascinated by gold–particularly in the form of the smallest clumps imaginable.

Gold nanoparticles stand out through their unique optical, electronic, and catalytic properties and are the ideal "building blocks" for nanostructures. Composite materials with a one or two-dimensional arrangement of the gold nanoparticles are especially interesting for the construction of components on the nanoscale. Japanese scientists have now shown that crystals of organic compounds are the ideal partner for such gold composite materials.

Gold nanoparticles do not colonize all the surfaces of the organic crystal evenly, they are choosy, and occupy only certain faces. The researchers working with Seiji Shinkai and Kazuki Sada employ millimeter-sized single crystals of the amino acid L-cystine. A single crystal is composed of a single, uniform crystal lattice. Cystine crystallizes in the form of hexagonal prisms. Such a crystal has two parallel hexagonal surfaces the edges of which are linked together by six rectangular faces.

If the transparent crystal is immersed for two hours in a solution of gold nanoparticles it becomes purple. Under the microscope it can be seen that only the two hexagonal faces are purple. The sides, that is, the rectangular faces remain colorless. The purple coloration arises from deposited gold nanoparticles. Clearly the tiny gold particles are choosy and populate exclusively the hexagonal faces of the prism.

Why?

The cystine molecules are arranged in layers in the crystal, these layers are parallel to the hexagonal faces. The layers are held together by a two-dimensional network of hydrogen bonds that run between the amino and the acid groups of the amino acid. These polar groups lie on the surface of the two hexagonal faces and attract the gold particles by electrostatic interactions. The rectangular faces, however, are made up of alternating layers of polar and nonpolar groups. The density of attractive polar groups here is too low to draw the gold particles onto these faces.

The face-selective coverage also works with microscale crystals. The gold coating could be used, for example, to selectively bind other materials. Through the attractive and repulsive forces between coated and uncoated faces of the crystals it should be possible to make the crystals stack in a direction-dependent manner and so form defined aggregate structures in a targeted fashion.

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