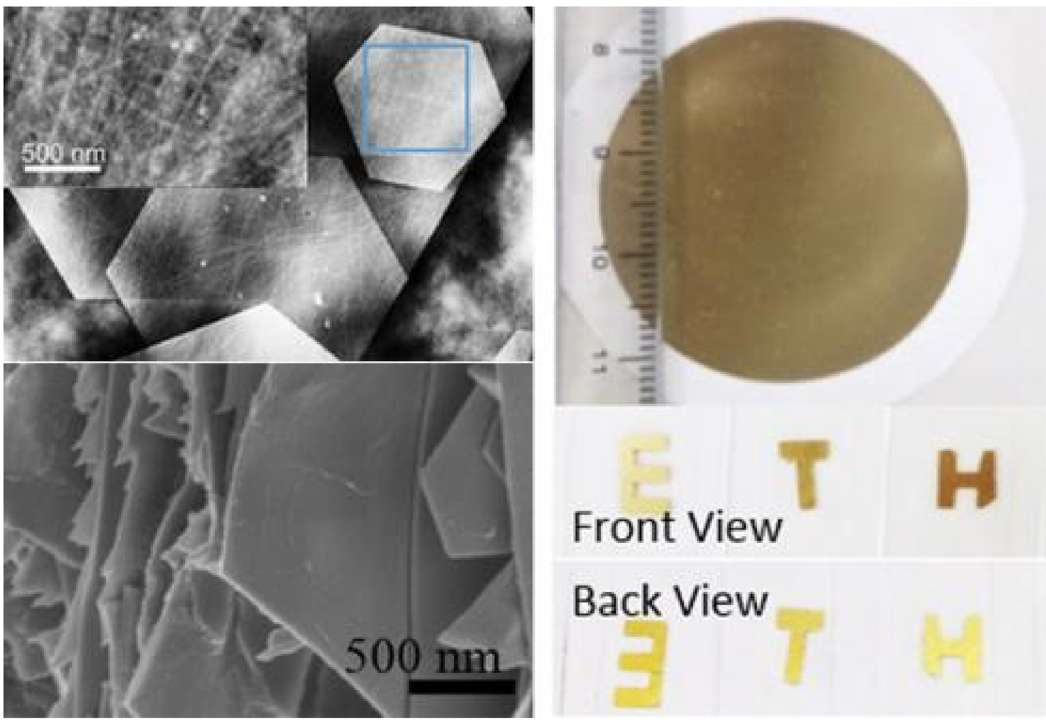
Hybrid material as gold-leaf substitute

June 18 2013, by Peter Rüegg



The hybrid film on a filter (r.a.) and on glass (ETH logo). REM reveals the micro (upper left) and nano (bottom left) structure of this particular material. Credit: Li, C., Adv. Mater. 2013

(Phys.org) —A team of researchers headed by Professor Raffaele Mezzenga has created a hybrid material out of gold and milk proteins that looks like a wafer-thin gold leaf. Thanks to its properties, it could be used in a vast range of applications from gastronomy to the jewellery industry.

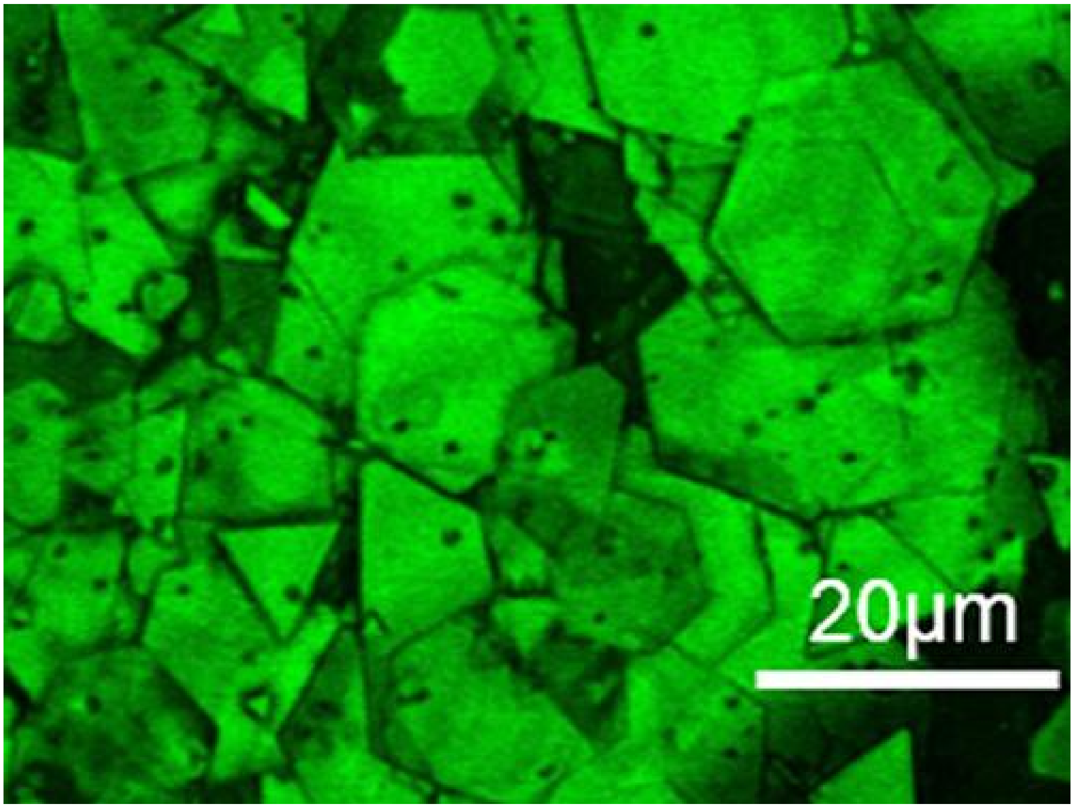
Raffaele Mezzenga, professor of food and soft materials, came up with the idea of "gold paper" a year ago. At the time, his group was working on an unusual hybrid material, a wafer-thin, paper-like mixture of graphene and protein fibres (see ETH Life report). The recipe is universally applicable and relatively simple: you mix fibroid objects with plate-like entities in a watery solution and filter the mixture with the aid of vacuum. The plates and fibres congregate and remain on the filter as a thin film.

As a result, Mezzenga set two of his team members, Chaoxu Li and Sreenath Bolisetty, the task of producing a kind of gold leaf out of protein fibres and gold plates. First of all, the researchers had to make the fibres by stretching them naturally from milk globular proteins, the so-called beta-lactoglobulin, with the aid of heat and acid. Like all proteins, milk proteins are also composed of a chain of numerous individual amino acids that form complex compact structures under native conditions. Heat or chemicals break open the compact configuration, causing the chains to unravel.

Gold monocrystals and fibres tied up

Several of these milk protein fibres then organise themselves into thicker, helical fibres. The researchers added gold in the form of a salt to the acidic solution of the fibres. The protein fibres allow the gold to reduce into small plates with a diameter of one micrometre and a thickness of 100 nanometres. The gold grows as a so-called monocrystal and the gold ions form a crystal lattice completely devoid of any defects.

Gold plates and fibres then accumulate in layers. The thin film that remains after filtration is formed in much the same way as paper from cellulose. The novel hybrid material is very stable, but remarkably changes its physical and optical properties when it comes into contact with water.



Luminous gold: Confocal optical microscopy image of the hybrid film with 87 weight per cent gold shows the remarkable plasmon resonance of this new material. Exiting wavelength is 488 nm, the collected signal ranged from 518 to 561 nm. Credit: Li, C., Adv. Mater. 2013

Hybrid food decoration

Mezzenga sees an initial application in gastronomy. In culinary applications, pure gold has an approved E-number code (E-175) allowing his use as additive in foods and indeed gold leafs have long been used to decorate desserts, drinks and other specially prepared foods. Because the new hybrid material is made of gold and dietary proteins, the researchers do not anticipate any hurdles in using it for culinary purposes, thereby considerably reducing the cost of using pure gold.

Even more interesting, however, are the unusual optical properties of the "gold paper", especially as the gold is available as monocrystals. These properties change according to the pH value, for instance, which means the hybrid material could be used for acidity measurements in sensors. The "paper" is also conductive to varying degrees depending on its composition and lends itself to applications in microelectronics.

Clock face made of lactogold leaf

Because, at face value, the gold paper is barely distinguishable from gold leaf – it has the lustre and colour of gold – it may also be interesting for the clock and jewellery industries, which could reduce their demand for the precious metal with protein gold leaf. In order to imitate gold leaf, the hybrid material only needs a ratio of one third weight percentage of gold. The new material would thus be just the ticket for gold-plating the numbers on the faces of wristwatches, for instance. "When you consider how much pure gold costs, this new material makes a massive difference," says the ETH-Zurich professor. On the one hand, it could help to reduce the global demand for gold and thus relieve the pressure on natural resources; on the other hand, the hybrid material broadens the fields of application for the metal.

The researchers have filed a patent for their invention. Mezzenga hopes that industry will show an interest in the new material. "Gold is a delicate subject. Nonetheless, the potential for applications is vast."

More information: Li, C., Bolisetty, S. and Mezzenga, R. (2013). Hybrid Nanocomposites of Gold Single-Crystal Platelets and Amyloid Fibrils with Tunable Fluorescence, Conductivity, and Sensing Properties. *Adv. Mater*. doi: 10.1002/adma.201300904

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