Fabricatio of porous materials with novel crystal structures assembled from nanoparticles

The research paper, published in Science and involving CIC biomaGUNE researchers, reveals the potential to further expand the extensive family of nanostructured materials

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(Donostia-San Sebastián, 26 October 2017). A research team involving CIC biomaGUNE researchers has devised a method for the fabrication of porous materials – technically referred to as macroporous or mesoporous materials – with hitherto unseen crystal structures.

The work, published in the prestigious journal Science, reveals the potential to further expand the family of nanostructured materials and lays the ground for the discovery of highly interesting properties. As Luis Liz-Marzán, Scientific Director and Ikerbasque Research professor at CIC biomaGUNE, explains: "These crystal structures are not made of atoms but of nanoparticles; in other words, they are nanostructured crystals, also referred to as supercrystals or supracrystals".

To explain and highlight the scientific dimension of the findings of the research, Dr. Liz-Marzán adds: "The most singular characteristic of the structures obtained is that they exhibit relatively large and perfectly ordered gaps. This is very difficult to obtain using currently existing methods. The key to fabricating these materials lies in using mixtures of two types of nanoparticles – gold and iron oxide in this case – to form binary crystals. Subsequently, one of the components can be selectively removed and gaps left in its place. A wide variety of structures with brand new properties can be obtained by varying the sizes of the two components".

Initially, the new materials have been applied in the technique referred to as SERS (Surface Enhanced Raman Scattering). The gaps between nanoparticles generate electric fields which enable the detection of very few molecules. Applications in other fields such as metamaterials (through new structures made of nanoparticles) and catalysis (a process favoured by the presence of a very large surface area for catalytic reactions to take place) are likely.

Two years of research

The work behind the article entitled *"Tunable Porous Nanoallotropes Prepared from Binary Nanoparticle Superlattices Self-Assembled at the Liquid-Air Interface"* started over two years ago. The research has been conducted by a multidisciplinary team of researchers composed of Luis Liz-Marzán (CIC biomaGUNE, Ikerbasque and CIBER-BBN), Marc Coronado-Puchau (CIC biomaGUNE), Judith Langer (CIC biomaGUNE and CIBER-BBN), Thumu Udayabhaskararao (Weizmamm Institute of Science, Israel), Thomas Altantzis (University of Antwerp, Belgium), Lothar Houben (Weizmamm Institute of Science, Israel and Ernst Ruska-Centre for Microscopy and Spectroscopy With Electrons, Germany), Ronit Popovitz-Biro (Weizmamm Institute of Science, Israel), Lela Vukovic (University of Texas, USA), Petr Král (University of Texas and University of Illinois, USA), Sara Bals (University of Antwerp, Belgium), and coordinated by Rafal Klajn (Weizmamm Institute of Science, Israel).

The fabrication was conducted in Israel using chemical and self-assembly methods, structural characterisation was conducted in Belgium using three-dimensional electron microscopy, SERS detection tests were conducted in CIC biomaGUNE and the theoretical model was developed in the United States using a method referred to as molecular dynamics.

To perform this work, the conditions required to obtain a perfect arrangement of the two nanoparticle types, and for the subsequent removal of one of them without destroying the structure, had to be found. Three-dimensional characterisation, together with the identification of properties, proved considerably difficult due to the complicated nature of the structures. A theoretical model also had to be drawn up to understand the process.

To put the scale of this research into perspective, a nanometre is one billionth of a metre, and, comparatively, the thickness of a hair is 100,000 nanometres.

About CIC biomaGUNE

The Centre for Cooperative Research in Biomaterials (CIC biomaGUNE), located in the Donostia-San Sebastián Technology Park, conducts cutting-edge research at the interface between Chemistry, Biology and Physics, and particularly on the properties of molecular level biological nanostructures and their biomedical applications.