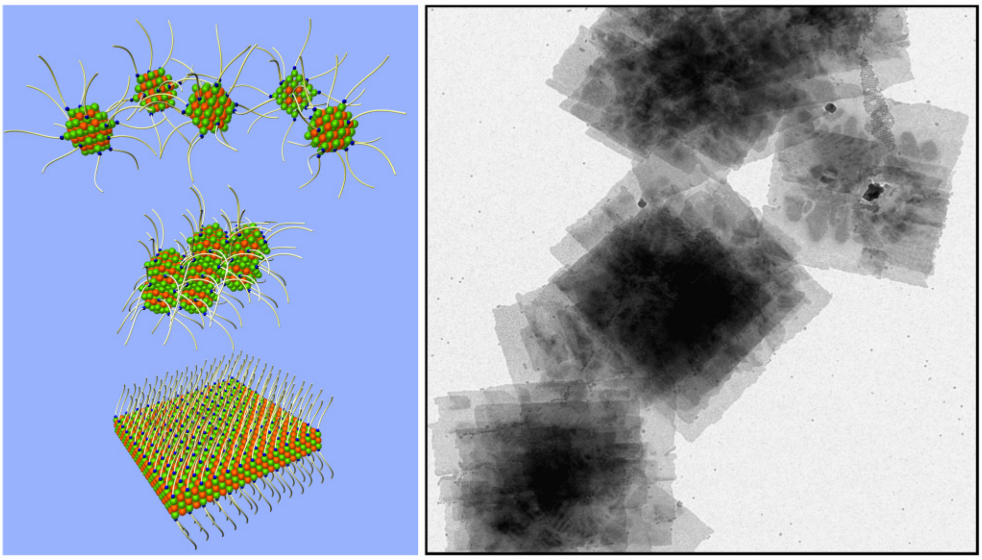
Press release: University of Hamburg / IMDEA Nanoscience Madrid

Two-dimensional nanostructures by self-organisation: Organic molecules call nanocrystals to order

The controlled synthesis of complex structures in the nanometer range and their integration into modern technologies represents a challenge with high potential. A group of German and Spanish scientists succeeded now in synthesizing materials which form two-dimensional nanostructures by self-organization mechanisms. The scientists from Hamburg and Madrid present their finding now in the present issue of „Science". The structures can find applications in flexible electronic devices, in solar cells, or in photodetectors.

Nanotechnology is one of the key technologies of the 21st century. Materials with extensions of a few nanometers (a millionth of a millimeter) exhibit optical, magnetic, electrical, and/or photoelectrical properties which depend on the size of the structures. The methods of colloidal chemistry allow the controlled synthesis of large amounts of identical nanocrystals. Due to the possibilities of application of nanoparticles they are heavily investigated by scientists and engineers. The results find applications in efficient light emitting diodes, solar cells, novel sensors, photodetectors, and flexible transistors. Furthermore, they are in use in the biological and medical sector. Research on the field of colloidal chemistry is partially driven by the fact that solution based nanostructures are inexpensive and easy to be processed.



(left) Scheme of individual nanocrystals merging into a two dimensional structure. (right) Electron-microscopy image of synthesized lead sulfide sheets with a lateral dimensions in the micrometer range and a height of about two nanometers.

Historically, colloidal chemists have been fascinated by the mechanisms and processes of self-organization of matter in nature. They are aiming to controllably synthesize complex structures with improved or novel properties and functionalities. Colloidal chemistry is a branch of chemistry which deals with the synthesis, characterization, and modification of dispersed, solid materials. Thus, it is clear that it also deals with the mechanisms of crystallization and organization of matter. Some years ago, it was discovered that microorganisms can trigger the accumulation of iron-containing products in the form of nanocrystals, which aggregate in an oriented manner in high perfection. This mechanism, nowadays known as "oriented attachment", has boosted intensive work in the laboratories all around the world as a model to understand, to follow, and to synthesize more complex structures with desired properties and functionalities.

An international group led by Prof. Horst Weller and Prof. Christian Klinke from the **University of Hamburg**, together with Dr. Beatriz H. Juárez from **IMDEA Nanoscience** in Madrid, has developed a precise procedure to extend this mechanism to form continuous two dimensional structures, single crystals with extensions in the micrometer range in plane and with a thickness of about two nanometers. By means of this procedure, cubic nanocrystals coalesce with well defined crystalline orientations. A profuse study of the formation mechanism of these structures has revealed that the driving force in the formation of such crystals is the packing of organic molecules on the nanocrystals surface (see figure), guiding their oriented attachment mechanism. This finding, now published as cover story in the prestigious journal "**Science**", may also hold for other examples of shape control in colloidally prepared nanostructures and may explain the outstanding role of a few organic molecules in colloidal nanochemistry.

The development of solution-based devices made out of nanocrystals is partially motivated by the low fabrication costs compared to traditional synthetic approaches. The two dimensional structures have been integrated in a solution-processed photo-detector device. The photo-electrical response of these structures shows that such structures belong to a new generation of high performance materials.

REFERENCE:

"*Ultra-thin PbS sheets by two-dimensional oriented attachment*"

Constanze Schliehe, Beatriz H. Juarez*, Marie Pelletier, Sebastian Jander,
Denis Greshnykh, Mona Nagel, Andreas Meyer, Stephan Foerster, Andreas Kornowski,
Christian Klinke, Horst Weller

Institute of Physical Chemistry, University of Hamburg, 20146 Hamburg, Germany
* IMDEA Nanoscience, Campus de Cantoblanco, Madrid, Spain

Science 329 (2010) 550.

Contact:

Prof. Horst Weller, Institute of Physical Chemistry, University of Hamburg, Germany.
Phone: +49 40 42838 3463. E-mail: weller@chemie.uni-hamburg.de

Prof. Christian Klinke, Institute of Physical Chemistry, University of Hamburg, Germany.
Phone: +49 40 42838 8210. E-mail: klinke@chemie.uni-hamburg.de

Web site: www.chemie.uni-hamburg.de/pc