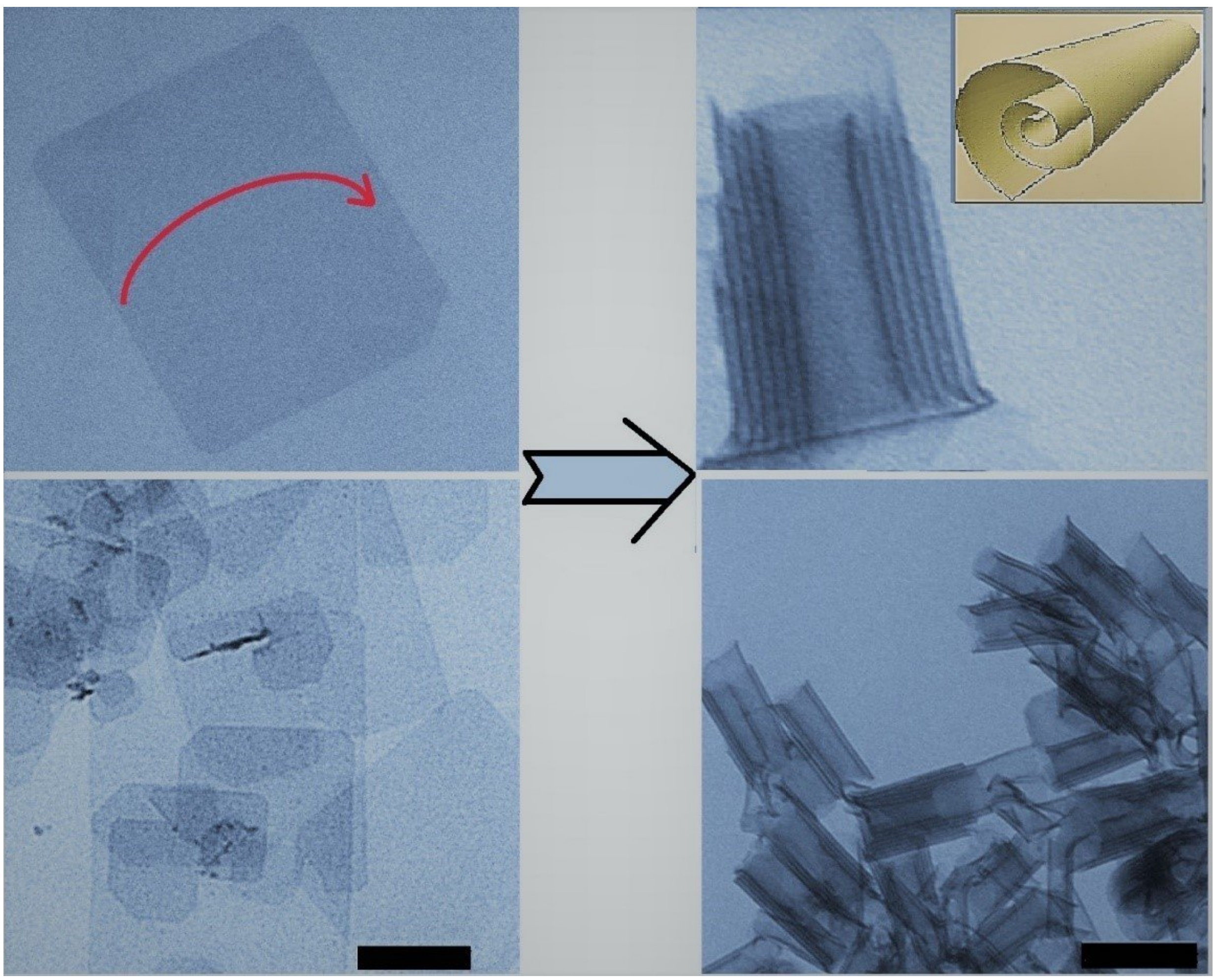
Scientists roll 2-D cadmium telluride into nanoscrolls

April 24 2018



TEM images of 2-D cadmium telluride sheers. Left: initial flat sheets. Right: sheets after folding. Upper right corner: a scheme of a folded sheet Credit: Roman Vasiliev

A team of scientists from the Faculty of Chemistry and the Faculty of Materials Science, MSU, together with foreign colleagues, discovered that two-dimensional sheets of cadmium telluride can spontaneously fold into nanoscrolls. This effect may be used in electronics and photonics. The results of the study were published in *Chemistry of Materials*.

In the course of the study, the team focused on 2-D semiconductor materials. These include graphene, phosphorene, 2-D layers of molybdenum disulfide, and 2-D perovskites that have recently attracted lots of attention from scientists. These materials are one atom thick crystals with 2-D electronic properties. Researchers believe that they may be used for the development of new devices.

"We studied 2-D cadmium telluride CdTe and discovered an unexpected effect of spontaneous folding of its ultrathin (only 1 nm) sheets that are also called colloidal quantum wells," said Roman Vasiliev, a co-author of the work, Ph.D. of Chemical Sciences, and Associate Professor of the Faculty of Chemistry and the Faculty of Materials Science, MSU.

Colloidal quantum wells are a new generation of colloidal quantum dots. Quantum dots are distinguished by their luminescent properties and are used in commercial devices, such as TV sets. Quantum wells, a 2-D type of quantum dots, are being studied today, but we already know that they possess very narrow luminescence bands, which is important for bright color rendering in light-emitting devices.

The team studied the properties of 2-D sheets of cadmium telluride by exchanging organic molecules attached to their surface and securing the stability of nanoparticles. In order to synthesize 2-D cadmium telluride, the scientists used the colloidal method and obtained them in a flask. The scientists obtained cadmium telluride nanoparticles in an organic solvent in the presence of surfactants. By changing the conditions of the reaction, they grew the particles into one-nanometer-thick sheets.

At first, the authors of the work grew flat 2-D sheets covered with oleic acid as a stabilizer. They managed to obtain sheets with a length reaching hundreds of nanometers and a thickness of one nanometer. The team started replacing the molecules of oleic acid with other organic molecules and analyzing sizes and shapes of the obtained nanoparticles, as well as their composition and crystal structure. At this stage, they used a transmission electron microscope.

In the course of the study, the team discovered that when a specific type of stabilizer (thiols) is used, flat sheets of cadmium telluride suddenly fold into perfect scrolls. When attached to the surface of a sheet, thiol molecules increase its thickness by one monolayer (0.15 nm) and cause mechanical stresses, making the sheet fold in a certain crystallographic direction. The folding takes place for all nanoparticles at once, and the radius of the fold is the same for all nanostructures.

"The study opens new prospects for manipulations of 2-D materials and nanoparticles. The folding effect came as a surprise for us. It resembles the process of making origami, but in this case, the sheets are one nanometer thick. Knowing how to change spatial shape of nanoparticles, we could use them in the manufacturing of optic materials with anisotropic behavior and polarized luminescence. We could create active light-emitting matrices for displays that would reduce energy consumption and increase brightness and intensity of various devices. Perhaps, we could also develop new nano-devices, for example, tube-shaped transistors. These interesting properties may be of use in new generations of light-emitting and sensor devices, as well as in optic and optoelectronic technologies and nanotechnologies," concluded the scientist.

More information: Roman B. Vasiliev et al, Spontaneous Folding of CdTe Nanosheets Induced by Ligand Exchange, *Chemistry of Materials* (2018). DOI: 10.1021/acs.chemmater.7b05324

Provided by Lomonosov Moscow State University