Construction of inorganic nanoparticle superlattices with binary protein crystals

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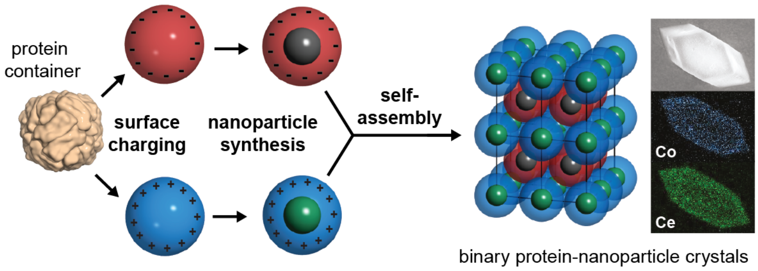
Nanoscale crystals of semiconductor, metal or metal oxide materials are versatile building blocks for nanomaterials with novel electric, optic, catalytic and magnetic properties.[1] For material fabrication, the nanoparticles can be organized via bottom-up approaches such as self-assembly. To this end, biomolecules, for example DNA,[2] are used as functional linkers for the assembly of inorganic nanoparticles. However, structuring of nanoparticles with atomic precision still represents a major challenge.

Here, we use two protein containers as atomically precise building blocks, engineered with opposite surface charge,[3] and construct a new type of biohybrid material.[4] Self-assembly of the charged protein containers yields binary structures with crystalline order, which were characterized with single crystal X-ray diffraction to high resolution. Moreover, prior to assembly of the charged protein containers, the cavity of the containers can be filled with metal oxide nanoparticles. The controlled assembly of these protein-nanoparticle composites produces highly ordered binary nanoparticle superlattices as free-standing biohybrid crystals, with up to a few hundred micrometers in size. Because the protein container is the primary building block with an atomically precise shell, the crystal lattice is solely defined by the protein shell and not the cargo particle. As a consequence, so far unrivaled long-range order and large domain sizes of nanoparticle superlattices could be achieved.[4] Moreover, because the structure and lattice parameters of the protein-nanoparticle crystals are independent of their nanoparticle cargo, binary protein materials based on charged protein containers may serve as a generally applicable matrix for the precise assembly of a variety of cargo. We are currently assessing the application potential of these biohybrid materials, e.g. in catalysis.



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