Programmed Porous Nanostructures with Biomolecular Machines and Nanoparticles

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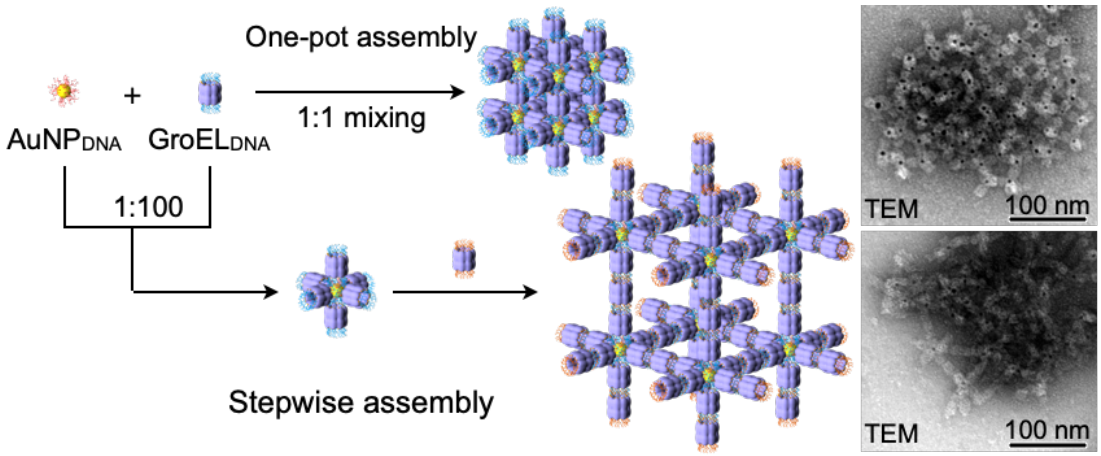
We report a class of supramolecular architectures, analogous to metal organic frameworks but with ultra-large pore sizes on the order of several tens of nanometers, consisting of gold nanoparticles (AuNPs) and the biomolecular machine GroEL.

In nature, the chaperonin protein GroEL assists in protein refolding by capturing denatured proteins within its hydrophobic cavities and releasing them with ATP-induced conformational motions.[1] GroEL (ca. 800 kDa) adopts a barrel-shaped structure, with height of 14.6 nm and outer/inner diameters of 13.7 nm/4.5 nm. We have previously used this biomolecular machine to form supramolecular structures[2] and demonstrated ATP-responsive guest release where GroEL mechanical motions alter the assembled structure morphology.[3]

Inspired by the self-assembled structures of metal organic frameworks (MOFs), we constructed analogous frameworks formed by AuNPs as nodes and GroEL as linkers. The use of DNA to link these components allowed for programming of the assembly. The real-time growth of clusters and manipulation thereof was tracked by dynamic light scattering. Distinct assembly pathways led to porous clusters having 1 or 3 GroEL units linking AuNPs, as characterized by cryoEM tomography. The porous clusters retained their ATPase activity and were able to load ultra-large macromolecular guests.



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