“Hard” and “soft” nanoobjects asymmetrically tied together by DNA

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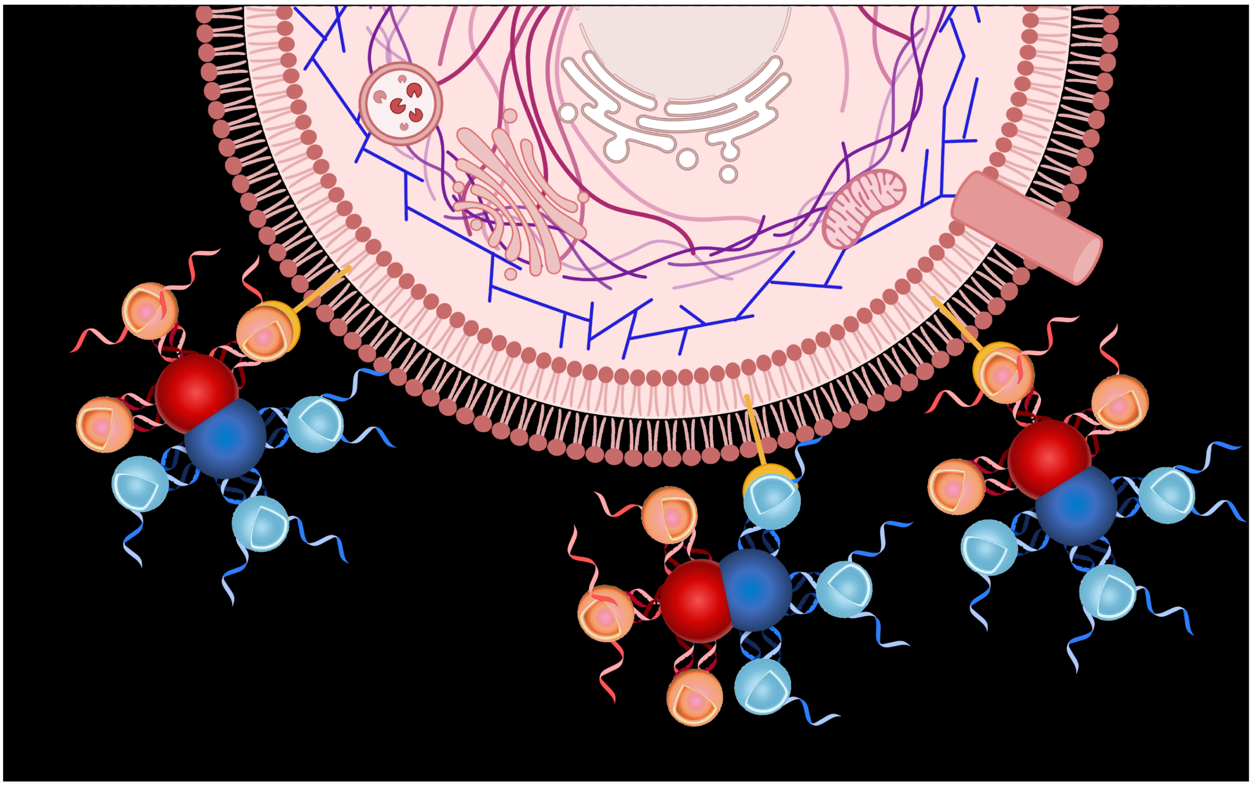
Researchers at the University of Basel have developed a strategy for the controlled self-organization of disparate nanoobjects into hybrid clusters as a new type of material at nano-scale. These clusters uniquely combine “hard” asymmetric nanoparticles, named Janus nanoparticles, with “soft” vesicles by using DNA as linkers. The “hard” Janus nanoparticles direct the self-organisation of the clusters whilst the “soft” vesicles serve for loading of desired cargos promoting bio-applications. The results have been published in the journal *Nano Today*.



Self-organization is an important strategy to produce systems with emergent properties and functionalities in fields such as chemistry, electronics and technology. Hybrid materials are of particular interest because they combine properties not encountered in a single class of material. However, the self-organization of strongly differing nanoobjects, such as mechanically robust “hard” nanoparticles and fragile “soft” vesicles has remained a big challenge.

A research team led by Prof. Cornelia Palivan from the NCCR Molecular Systems Engineering and the Department of Chemistry at the University of Basel introduced a modular strategy to assembly dissimilar nanocomponents into hybrid “hard-soft” clusters. The “hard” components are Janus nanoparticles (JNPs), dumbbell-shaped asymmetric particles that possess two chemically

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distinct lobes. The “soft” components are vesicles, consisting of a liquid-filled interior surrounded by a thin shell of synthetic copolymer. The spatially separated distinct lobes of JNPs were leveraged for the attachment of vesicles.

DNA ties nanoobjects together

The researchers used the power and selectivity of double DNA helix formation to direct the attachment of vesicles to the asymmetric lobes of JNPs. A single DNA strand (ssDNA) can pair up and form the double DNA helix only with its complementary strand, which contains a matching sequence of opposed base pairs. The lobes of the JNPs were decorated with one type of ssDNA strand each, leveraging the chemically distinct nature of the two lobes. The complementary ssDNA strands were attached to the vesicles. By simply mixing JNPs and two different types of vesicles, the ssDNA strands “zipped” together, and induced the formation of hybrid clusters. Crucially, the thin vesicles shells were resilient enough and remained intact.

Platform for various biomedical applications

Vesicles with sizes in the nanometer range can transport and protect a variety of cargo, such as drugs, enzymes or imaging agents. By attaching two differently loaded vesicles to one JNP, even usually incompatible cargoes can be brought into proximity without mixing. Together with a specific interaction with cells and the lack of toxicity, such hybrid clusters enable various combined actions by controlled localisation and the integration of different sensitive compounds.

“These hard-soft clusters provide a versatile platform of controlled self-organised nanoobjects with dissimilar properties that takes advantage of the properties and functionality of both components”, says Cornelia Palivan. “I believe our strategy will enable advanced medical applications, as for example theranostics, where both imaging agents and therapeutic compounds should be brought together, or different drugs/enzymes need to be delivered simultaneously for cocktail treatments in nanomedicine”.

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Reference

Voichita Mihali, Michal Skowicki, Daniel Messmer and Cornelia G. Palivan “Clusters of polymersomes and Janus nanoparticles hierarchically self-organized and controlled by DNA hybridization” *Nano Today* **2023**, https://doi.org/10.1016/j.nantod.2022.101741

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