Hybrid functional nano-assemblies of fluorescent silver nanoclusters

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Combining atomically precise silver nanoclusters (AgNC) with nucleic acid (NA) nanotechnology provides large prospects for creating novel hybrid functional nanomaterials with unique properties. Nucleic acids can serve as both templates for silver nanocluster (AgNC) formation and building blocks for large nano-assemblies. Herein, we create various types of NA-AgNC hybrid nanomaterials which are more photostable, biocompatible and exhibit novel functional properties. The formation of AgNCs on single stranded cytosine rich DNA promotes unique optical properties defined by the sequences and conformation of the DNA templates. The size and shape of AgNCs are regulated by rationally designed and chemically synthesized short DNAs with different numbers of single-stranded cytosines embedded in secondary and tertiary DNA structures such as hairpin loops. Hairpin loops of various sizes (C6-C14) template similar size – Ag10 – nanoclusters while the optical properties of DNA-AgNCs are dictated by the loop size. We combine experimental and theoretical studies to understand the influence of cluster shape, loop conformation, and metal-to-ligand charge transfer on optical behavior of NA-AgNCs. Our observations point to the complexity of the electronic structure of the nanoclusters and the abundance of possibilities of de-excitation processes. This allows for fine-tuning of fluorescent properties of AgNCs. Furthermore, we demonstrate that tuning of the optical properties and red-ox stability of the AgNCs is possible by controlling the position of templating sequence within RNA-nanoring assemblies. These properties beget the use of DNA-AgNCs in a variety of nanophotonics and biosensing applications. We further apply the rational design of hybrid NA-AgNCs to create: 1) biosensors targeting specific sequences of micro RNA (mRNA-21) and heavy metals (Hg2+), 2) novel stable imaging probes active in near-IR portion of the spectrum, 3) effective anti-bacterial agents which are potent to combat multi-drug resistant bacteria.