

## ***DNA-directed assembly of Al and CuO nanoparticles for energetic applications***

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Nanothermite materials today consist in heterogeneous mixtures of metallic fuels and inorganic oxidizers with nanoscale dimensions. This very active field of research is driven by the potential of developing multi-functional energetic systems with enhanced capabilities. In this context, Al/CuO is interesting because of its high potential energy, tunable reactivity, its ability to produce gas at high temperatures as well as its compatibility with MEMS technologies to produce nanoenergetic devices at low costs. It has been now demonstrated that the reactivity of such Al/CuO nanocomposites is significantly enhanced but depends on the organization, density, and dimensions of particles, which largely influence their combustion kinetics and overall thermal properties. Typically, nanocomposite materials are processed in hexane solutions using ultrasonication of nanopowders to disperse agglomerates and increase mixing intimacy but this can form undispersed agglomerates of segregated particles during drying which may lead to inhomogeneity and a wider dispersion in combustion kinetics. To overcome this issue, a bottom-up approach through DNA-directed Al and CuO nanoparticles self-assembly is a good way to design and engineer nanocomposite materials with controlled composition and excellent homogeneity.

In this contribution, we present an optimization procedure starting with the choice of the DNA sequence, with the assembly protocol relying also on optimized procedures to disperse and sort metallic and metal oxide nanopowders with an average diameter of 150 nm in an aqueous solution. We also characterize specific DNA surface modification processes for Al and CuO. The specificity of the grafting is ensured by the grafting of the protein Streptavidin on both nanoparticles surfaces before bonding of the biotin-functionalized DNA.

The grafting density of Streptavidin and DNA on the surface of Al and CuO nanoparticles is determined and optimized as a function of salt concentration, oligonucleotide length, and nature of the spacer by a fluorescence method. For CuO nanoparticles, we obtain a grafting density for Streptavidin and DNA of  $9.7 \times 10^{11}$  proteins/cm<sup>2</sup> and 350 pmol.cm<sup>-2</sup>, respectively. For Al nanoparticles, the grafting density for Streptavidin and DNA is  $7.2 \times 10^{11}$  proteins/cm<sup>2</sup> and 100 pmol.cm<sup>-2</sup>, respectively. The nature of the mechanisms driving self-assembly is investigated using several characterization techniques (Zeta Potential measurements, particle size analysis using DLS and electron microscopy). We observe that the aggregation kinetics greatly depends on the length of ssDNA strands design. DSC measurements are finally presented to quantify the energetic performances of the resulting thermite composite.