Explosive composite based on nanoparticles and DNA could be an energy source for embedded microsystems

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A solid explosive with an energy density equivalent to that of nitroglycerine: this is the composite material produced by researchers at the Laboratoire d'Analyse et d'Architecture des Systemes (CNRS) in Toulouse, France, using an innovative production process that brings nanoparticles into contact with strands of DNA. These strands then "assemble" the various kinds of nanoparticles used. The released energy and ignition temperature of the new explosive are among the best ever described in the literature. The explosive could thus be used as an energy source to power embedded systems, both in space and in the environment. This innovative material is the subject of a paper published online in the journal *Advanced Functional Materials*.

Nanoparticles of aluminium and copper oxide make up the two basic ingredients of the composite material. Although the idea of coupling aluminium with copper oxide to produce energy is not new (they were once used to weld railway tracks), this is the first time that DNA strands have been used to assemble them. So why use DNA? Two complementary DNA strands (i.e. whose molecules are able to recognize each other) self-assemble into a double helix and then remain firmly bound together, just as they are in every cell of our body. The researchers made use of these 'sticky' properties. They separately grafted strands of DNA onto nanoscopic beads of aluminium and of copper oxide before mixing together the two types of nanoparticles coated with DNA strands. As a result, the complementary strands on each type of nanoparticle bind, turning the original aluminium and copper oxide powder into a compact, solid material which spontaneously ignites when heated to 410 °C (one of the lowest spontaneous ignition temperatures hitherto described in the literature).

In addition to its low ignition temperature, this composite also offers the advantage of having a high energy density, similar to nitroglycerine: for the same quantity of material, it produces considerably more heat than aluminium and copper oxide taken separately, where a significant part of the energy is not released. In contrast, by using nanoparticles, with their large active surfaces, the researchers were able to approach the maximum theoretical energy for this exothermic chemical reaction.

The high energy density of this composite makes it an ideal fuel for nanosatellites, which weigh a handful of kilograms and are increasingly used. Such satellites are too light to be equipped with a conventional propulsion system once in orbit. However, a few hundred grams of this composite would give them sufficient energy to adjust their trajectory and orientation.

The composite could also have a host of terrestrial applications: ignitors for gas in internal combustion engines or for fuel in aircraft and rocket nozzles, miniature detonators, on-site welding tools, etc. Once its heat is turned into electrical energy, the composite could also be used as a back-up source for microsystems (such as pollution detectors scattered through the environment).

More information: High Energy Al/CuO nanocomposites obtained by DNA-directed assembly. F. Séverac, et al, *Adv. Funct. Mater.*, online October 18 2011.

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