Assembly of nano-machines mimics human muscle

October 23 2012

For the first time, an assembly of thousands of nano-machines capable of producing a coordinated contraction movement extending up to around ten micrometers, like the movements of muscular fibers, has been synthesized by a CNRS team from the Institut Charles Sadron. This innovative work, headed by Nicolas Giuseppone, professor at the Université de Strasbourg, and involving researchers from the Laboratoire de Matière et Systèmes Complexes (CNRS/Université Paris Diderot), provides an experimental validation of a biomimetic approach that has been conceptualized for some years in the field of nanosciences.

This discovery opens up perspectives for a multitude of applications in robotics, in nanotechnology for the storage of information, in the medical field for the synthesis of artificial muscles or in the design of other materials incorporating nano-machines (endowed with novel mechanical properties). This work has been published in the on-line version of the journal Angewandte Chemie International Edition.

Nature manufactures numerous machines known as "molecular". Highly complex assemblies of proteins, they are involved in essential functions of living beings such as the transport of ions, the synthesis of ATP (the "energy molecule"), and cell division. Our muscles are thus controlled by the coordinated movement of these thousands of protein nano-machines, which only function individually over distances of the order of a nanometer. However, when combined in their thousands, such nano-machines amplify this telescopic movement until they reach our scale and do so in a perfectly coordinated manner. Even though synthetic

chemists have made dazzling progress over the last few years in the manufacture of artificial nano-machines (the mechanical properties of which are of increasing interest for research and industry), the coordination of several of these machines in space and in time hitherto remained an unresolved problem.

Not anymore: for the first time, Giuseppone's team has succeeded in synthesizing long polymer chains incorporating, via supramolecular bonds (1), thousands of nano-machines each capable of producing linear telescopic motion of around one nanometer. Under the influence of pH, their simultaneous movements allow the whole polymer chain to contract or extend over about 10 micrometers, thereby amplifying the movement by a factor of 10,000, along the same principles as those used by muscular tissues. Precise measurements of this experimental feat have been performed in collaboration with the team led by Eric Buhler, a physicist specialized in radiation scattering at the Laboratoire Matière et Systèmes Complexes (CNRS/Université Paris Diderot).

These results, obtained using a biomimetic approach, could lead to numerous applications for the design of artificial muscles, micro-robots or the development of new materials incorporating nano-machines endowed with novel multi-scale mechanical properties.

More information: *Angew. Chem. Int. Ed.* On line on the 18/10/2012
DOI: 10.1002/ange.201206571

Provided by CNRS