Designing molecules capable of self-assembling into functional nano-objects and materials is a complex challenge. We spoke to Professor Nicolas Giuseppone of the SELFCHEM project about driving forces behind efforts to design smart self-assembled systems with specific new functionalities.
**Self-organisation**

The project is investigating the duplication of chemical information, its transfer and conversion, and the transport of physical information to improve the understanding of the basis of self-organisation. While all natural systems self-organise, it is not currently known whether they self-organise with common rules. "If we can understand this, we will then be able to design smarter materials. For instance, we would like to construct complex systems starting from very simple building blocks because they will be able to use the external energy to improve their organisation while dissipating this energy," says Professor Giuseppone. Self-organisation is an emerging property in itself, and Professor Giuseppone believes it could also give rise to new functional properties in materials science. "For any kind of functional material, you can expect to switch on and off – or modulate – its properties by recombination and self-organisation processes," he says. "But life has proven to go further and to create new ‘bio’ functions from scratch during the evolutionary process. Chemistry can in principle create an unlimited diversity of molecules and self-assemblies."

From here there is no limit to new systems that could potentially be created in terms of structures. However, researchers first need to understand the basis of self-organisation in greater detail. "Living systems always keep the majority of their constituents when making copies of themselves, although they can alter part of their genes, which generates new proteins and metabolites which can improve their ability to adapt to their environment," explains Professor Giuseppone. "This diversity helps living systems explore new and more efficient phenotypes. This can be seen the same way at the molecular and supramolecular levels, where libraries of components can be generated until one fits better to its environment. The use of reversibility in generating this diversity is a key element, because reversibility of self-assemblies in general provides systems with new functionalities such as error-checking and self-healing properties which are necessary for adaptation."

**Hierarchical organisation**

The hierarchical organisation in systems chemistry is also key to these targeted functionalities. Several layers of structures and dynamics are involved in networks, with each playing a major role in the system as a whole. "Self-assemblies can be seen as molecules linked by supramolecular bonds. These products can all communicate with each other, crossing the different length scales and affecting different levels of the system. “An event
At a glance

Full Project Title
SELFCHEM

Project Objectives
The objectives of the SelfChem project are oriented towards a better understanding of complex systems, self-organisation, and emergence of order from chaos. It aims at understanding multi-component chemical systems, how the circulation of information can be the driving force for the formation of functional self-assembled nano-structures and reaction networks.

Contact Details
Project Coordinator, Professor Nicolas Giuseppone
Faculty of Chemistry, University of Strasbourg, SAMS Research Group - icFRC, Institut Charles Sadron
23 rue du Loess, BP84047
67034 Strasbourg Cedex 2
France
T: +33(0)3 88 41 41 66
F: +33(0)3 88 41 40 99
E: giuseppone@unistra.fr
W: www-ics.u-strasbg.fr/sams


Synthesising nanowire
Using these fundamental principles, the Giuseppone group has shown that it is possible to synthesize a new class of nanowires, which conducts electricity with extraordinary efficiency, by simply placing its building blocks in an electric field, for example. Moreover, this selected supramolecular structure is spontaneously self-organised exactly between the electrode at a scale of 100 nm, demonstrating that it is possible to obtain the right material for the right function, at the right moment and at the right place. “By conferring such properties on these kinds of systems, chemists will change their way of thinking, going from directed synthesis to self-construction. In other words, the objective is to let the system explore the energetic landscape itself, to find the combination best suited for a given purpose," explains Professor Giuseppone. The project has established links with the commercial sector, and while the project's work is still at an early stage, Professor Giuseppone believes their research could be relevant to several areas of industry. “Long term benefits could be expected in the domains of self-healing materials and self-repairing devices, smart drug carriers and nanotechnologies to precisely control bottom-up fabrication,” he says.

In addition to sensing their environment, smart systems should be able to adapt to it, possibly by changing their constitution in order to become more efficient under specific conditions or to multitask.

Project Coordinator
Professor Nicolas Giuseppone is deputy director of the Institute Charles Sadron. He became Full Professor of Chemistry in 2007 at the University of Strasbourg, after which he created the SAMS research group at the ICS. His current research interests focus on Supramolecular Chemistry and Systems Chemistry, more specifically for their implementation in soft-matter science.