Dr František Štěpánek: creating microscopic chemical robots

František Štěpánek, a researcher from the Czech Republic specialising in particle technology, previously worked at Imperial College London and has now moved back to his home country to conduct his research through an ERC Starting Grant at the Institute of Chemical Technology, Prague.

research*eu focus: What are the fields covered by your project?

František Štěpánek: The research falls predominantly into the field of chemical engineering. However, the Chobotix project is interdisciplinary and also involves elements of physical chemistry, synthetic biology, cybernetics and materials science.

research*eu focus: What is the project about?

František Štěpánek: The aim of the project is to design and manufacture microscopic chemical robots. These can be defined as porous, internally structured particles a few microns in diameter, covered by a porous membrane able to regulate molecular transport into and out of the robot's interior that contains compartments carrying different kinds of molecules. These compartments will facilitate a predefined set of chemical reactions — e.g. 'neutralise' absorbed molecules or produce and release an active ingredient once the robot reaches its target destination. The robot's surface will be designed so as to recognise specific substrates that may be biological. Many aspects of the structure and function of chemical robots are inspired by those of single-cellular organisms.

Project title
Chemical processing by swarm robotics

Project acronym
Chobotix

Host institution
Institute of Chemical Technology, Prague, Czech Republic

ERC funding — Starting Grant
EUR 1 644 000

Project duration
60 months (starting 01/06/2008)

Project website
http://www.vscht.cz/chobotix

research*eu focus: What makes the project original, cutting-edge and pioneering?

František Štěpánek: The miniaturisation of robots based on mechanical principles is practical only up to a point. Micron- and submicron-sized entities operate in an environment ('colloidal domain') where interfacial forces dominate and objects are subjected to random Brownian motion. We believe that robots successfully operating at these length-scales should be based on chemical rather than mechanical principles. Such robots do not exist at the moment and their development will be unique and very challenging. If successfully implemented, they will open up many potential applications, including:

- targeted delivery of active ingredients (e.g. medicines);
- distributed sensing;
- distributed chemical processing (e.g. neutralisation of toxic spills in difficult-to-access environments);
- harvesting of valuable materials (e.g. precious metals) from dilute or non-conventional resources.

research*eu focus: When are first results expected?

František Štěpánek: The project is scheduled to last five years. We hope to have the first prototypes of chemical robots with basic functionality ready within approximately three years and then focus on their refinement for a few selected applications.

research*eu focus: What makes the project an interdisciplinary endeavour?

František Štěpánek: The complexity of the project makes it necessary to involve multiple disciplines, and in fact the research team is multidisciplinary. Apart from chemical engineering, input from physical chemistry is required during the manufacturing of the chemical robots' bodies (the synthesis of colloidal particles and their self-assembly). Materials science expertise is needed for the selection and modification of the materials from which the chemical robots will be composed. Concepts from both biology and cybernetics will be used when designing the robots' communication/signalling pathways, etc.

research*eu focus: What will now be possible for the project with this grant? What opportunities does the ERC funding offer to you?

František Štěpánek

František Štěpánek: The ERC grant makes it possible to dedicate significant resources towards a relatively risky project for five years, which would be difficult using piece-by-piece funding from multiple smaller grants. Along with other benefits such as the possibility to purchase state-of-the-art instruments, obtaining the ERC grant has helped attracting talented students and post-docs as well as establishing new scientific collaborations.

research*eu focus: Why is your projet project scientifically important and what scientific impact may it have?

František Štěpánek: Although chemical robots are non-living artificial objects, the research touches several fundamental questions related to the development of life. Is it possible to make artificial structures of similar complexity as living cells but based on a different chemistry (i.e. not using proteins as building blocks)? Under what conditions can initially identical individual entities undergo differentiation and a transition to multi-cellular structures?

research*eu focus: What other impact may the project have?

František Štěpánek: In the same way that industrial robots enabled the automation of manufacturing processes involving mechanical operations, chemical robots can bring significant changes to processes where the transformation or structuring of matter at the molecular and microscopic length-scale is involved. For example, entirely new classes of household and personal care products, pharmaceuticals, medical diagnostic devices, etc., may emerge.

For further information about the Chobotix project, please read page 22 of issue No 4 of the research*eu focus supplement entitled 'Measuring performance: The Czech Republic in the ERA'