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SONS NEWS

The newsletter of the EUROCORES Programme in Self-Organised NanoStructures (SONS) ••• December 2004

Contents

Welcome to *SONS News*, the newsletter of the EUROCORES Programme in Self-Organised NanoStructures (SONS)[1]. This programme is an initiative of the European Science Foundation[2] and its Member Organisations which aims to create and build up the European knowledge base that will lead to fundamental science breakthroughs and enable promising future applications of SONS. It is widely recognised that accomplishment of this goal requires a truly multinational interdisciplinary approach in Europe.

To achieve these aims, a first phase of SONS was launched. This has resulted in the selection and launch of 16 Collaborative Research Projects (CRPs) that are bringing together the best scientists and expertise available in Europe. The topics addressed by these CRPs cover the field of molecular self-assembly in connection with the mechanisms, functions and fabrication of SONS. Among the investigated phenomena and methods are nanostructuring, hierarchical self-assembly, molecular positioning and manipulation, theoretical simulation of self-assembly, opto-electronic characterisation, etc.

In quantitative terms, the first call of SONS involves 23 funding organisations and funds 16 CRPs consisting of 82 research groups from 12 different countries with a total programme budget of 12 million euros. CRPs funded in the first call will generally run for 3-4 years and it is anticipated that a second call will be made in 2005 to cover the last 3 years of the programme.

Research funding started between late 2003 and early 2004. In May 2004, the networking phase of SONS was launched with the first general SONS meeting in Strasbourg. Since then, the first SONS networking activity – a workshop on optical tweezers – has been held and two more workshops, on single-molecule transport and surface nanopatterning, are planned for spring-summer of 2005. And we have recently issued a call for new proposals for networking activities. You will find all the details in this issue.

SONS News also intends to incorporate the view of the SONS science community represented in the 16 CRPs. Therefore, each issue will include contributions from SONS researchers. This series starts here with articles written by the partners of project SONS-AMPHI (*Higher levels of self-assembly of ionic amphiphilic copolymers: strategies based on multiple molecular interactions*) and project FUN-SMARTs (*Assembly and manipulation of functional supramolecular nano-architectures at surfaces*).

We hope you will enjoy reading *SONS news*, and we take the opportunity to wish all SONS researchers a fruitful and rewarding journey in the amazing field of SONS.

1. SONS is a EUROCORES (EUROpean Science Foundation COllaborative RESearch) Programme. The EUROCORES Scheme is an innovative funding instrument aimed to create the critical mass necessary for scientific excellence in Europe. For more information: www.esf.org/eurocores
2. The European Science Foundation is a non-governmental organisation whose mission is to promote high quality science at a European level. It acts as a catalyst for the development of science by bringing together leading scientists and funding agencies to debate, plan and implement pan-European initiatives. For more information: www.esf.org

SONS networking activities

First SONS workshop held in Scotland

The first SONS workshop was held 9 to 11 September 2004 in Greenock, near Glasgow in Scotland, UK.
The workshop, about optical tweezers and their applications, was organised by Dag Hanstorp, Project Leader of SPANAS, with the collaboration of Kishan Dholakia, Project Leader of NOMSAN. It brought together 26 scientists from the Collaborative Projects SPANAS and NOMSAM and invited external experts in the field.
This workshop successfully opened the networking phase of SONS and will be the first of a series of fruitful scientific events in the field of SONS, some of which are already scheduled (see Upcoming events).

Upcoming events

- Workshop on Transport through Single-Molecules, 9-12 March 2005, Leiden (The Netherlands). Organised by: Jan M. van Ruitenbeek (SASMEC)
- Workshop on Surface Nanopatterning, June 2005, Pisa (Italy). Organised by: Alessandro Fortunelli (SSA-TMN)
- SONS Scientific Committee Meeting, 30 May 2005, Strasbourg.

New call for networking proposals

After the approval of the first batch of SONS networking activities, a new call for **proposals for networking activities** to be held in 2005 was announced.
All Project Leaders and Principal Investigators of SONS Collaborative Research Projects were invited to submit their proposals **before 15 November 2005.** Applicants will be notified of the results by end December 2004. For further information, contact **sons@esf.org** or see **www.esf.org/sons**.

New decision body of SONS Scientific Committee: the Executive Group

As decided at the Scientific Committee meeting in May 2004 (see NEWS on the first conference of SONS in this Newsletter), an Executive Group (EG) has been created to constitute the decision-making body of the Scientific Committee. Essentially, the EG will act on behalf of the Scientific Committee in providing the ESF with advice and recommendation on day-to-day decisions concerning scientific activities. The EG is formed by six Project Leaders who will rotate on an annual basis. The membership for the first term is as follows:

- Dholakia, Kishan (NOMSAN)
- Faul, Charl (SISAM)
- Fortunelli, Alessandro (SSA-TMN)
- Kapon, Eli (SALDSON)
- Reiter, Günter (SONS-AMPHI)
- Ruben, Mario (FUN-SMARTs)

Election of members for the next term will take place at the next annual Scientific Committee meeting (Strasbourg, 30 May 2005).

First SONS conference in Strasbourg

The first SONS event took place on 24 and 25 May in Strasbourg, in conjunction with the European Materials Research Society (E-MRS) Spring Meeting 2004.

The first day (24 May) was devoted to the general SONS meeting, which brought together 70 scientists from the 16 Collaborative Research Projects (CRPs) of the EUROCORES Programme SONS. The Collaborative Research teams had the opportunity to present their projects and discuss common research interests and potential joint activities with other teams.

The working structure and management mechanisms of the EUROCORES Programme SONS were presented by the ESF, paying particular attention to the support of programme networking activities involving several CRPs. Within the EUROCORES scheme, research work and networking within projects is funded at the national level by the funding agencies, whereas programme coordination and interproject networking is managed by the ESF and funded by the EU Sixth Framework Programme.

The Scientific Committee meeting was held on 25 May. This committee is formed by the Project Leaders as representatives, with the EUROCORES Programme Coordinator (from the ESF) as Secretary and Convenor. It is a scientific advisory committee which provides the ESF with advice and recommendations on the networking activities and the scientific coordination of the programme.

Among the major decisions taken by the committee was the creation of an Executive Group, and the setting-up of a mechanism for selection and approval of programme networking activities. The scientific reporting requirements and procedures were also discussed and agreed.

In summary, this two-day conference provided all SONS participants with the opportunity to get to know each other's work, share and learn from experience and jointly discuss future activities within the programme.

The next SONS Scientific Committee meeting will take place on 30 May 2005.

The second SONS general science conference will be held in 2006.

SONS Collaborative Research Projects

Internal meetings

As part of their joint work, the Collaborative Research Projects have held or are planning to hold the following internal meetings*:

BIONICS
Kick-off meeting,
18 November 2003,
Mainz, Germany
Progress meeting,
3 September 2004,
Bologna, Italy

SONS-AMPHI
Internal meeting,
24 November 2004,
Berlin, Germany

NANO-SMAP
Kick-off meeting,
3 May 2004,
Copenhagen, Denmark
Progress meeting,
25 October 2004,
Utrecht, Netherlands

NETSOMA
Consortium meeting,
17 September 2004,
Zürich, Switzerland
Next meeting in
December 2004

NOMSAN
Kick-off meeting,
28-29 March 2003,
StAndrews, UK
Technical meeting,
6-9 November 2003,
Barcelona, Spain
Extended working visit,
11-17 January 2004,
St Andrews, UK
Major technical meeting,
17-18 January 2005,
Barcelona

MOL-VIC
First internal meeting,
30 January 2004,
San Sebastian, Spain

AMPHI
Intra-project meeting,
1-2 November 2004,
Prague, Czech Republic

SISAM
Internal meeting
(combined with
a workshop on
self-assembly held at
the MPI), 8-9 January
2004, Golm, Germany.
Internal planning and discussion meeting,
30 September-1 October
2004, Groningen,
Netherlands

SSA-TMN
Internal meeting,
15 October 2004,
Pisa, Italy

SPENSA
Internal meeting,
27-28 October 2004,
CEA Saclay, France

SPANAS
Internal meeting,
26-27 February 2004,
Göteborg, Sweden

NANOSYN
Internal meeting
(workshop),
12-14 November 2004,
Basel, Switzerland.

*Note that CRP internal meetings are not open to non-partners, except by express invitation.

Welcome

We are pleased to welcome the following researchers who have joined a Collaborative Research Project under SONS support:

FUN-SMARTs

Aarhus University
Dr Carsten Busse started on
1 December 2003

ICMAB Barcelona
Jordi Gómez-Segura
(PhD student) started on
1 December 2003

ICMAB Barcelona
Nuria Crivillers (PhD student)
started on 1 December 2003

ICMAB Barcelona
Dr Nans Roques started on
1 December 2003

ISMN Bologna
Cristiano Albonetti
(PhD student) started on
1 September 2003

ISMN Bologna
Jean Crispin Kengne
(PhD student) started on
1 January 2004

EPF Lausanne
Dr Stéphane Pons started on
1 October 2003

MPI Stuttgart:
Stephan Rauschenbach
(PhD student) from 1 February
to 30 April 2004

MPI Stuttgart
Sebastian Stepanow
(PhD student) started on
1 May 2004

University of Trieste
Alessio Comisso (PhD student)
started on 1 August 2003

University of Twente
Dr Saxena Anubhan started on
1 November 2004

Forschungszentrum Karlsruhe
Dr Chandru Rajadurai started
on 14 December 2003

BIONICS

Ayman, Al-Hussaini
(PhD student) from 15 February
to 14 July 2004

Jang, Yong-Jun
(PhD student) from 15 February
to 14 October 2004

Jung, Sung-Hyun
(PhD student) from 1 April
2004 to 31 March 2005

NANO-SMAP

Chalmers University
Dr Duncan Sutherland
started on 1 January 2004
(50% time)

Chalmers University
Hossein Agheli (PhD student)
started on 1 January 2004
(50% time)

Dresden University
of Technology
Prof. Dr Hans-Jürgen Adler,
Institute for Macromolecular
Chemistry and Textile
Chemistry (not funded
by SONS)

Dresden University
of Technology
Mandy Gnauck (PhD student)
started on 1 October 2004

ETH Zurich:
Dr Michelle Grandin started on
15 January 2004 (50% time)

ETH Zurich
Thomas Blättler (PhD student)
started on 1 April 2004

Utrecht University
Dr Andrew Campbell, started
on 1 April 2004 (50% time)

NETSOMA

University of Cambridge
Shlomy Goffri (PhD student)
started on 1 October 2003

Technical University
of Eindhoven
Dr **Chris Radano** started on
1 October 2004

Technical University
of Eindhoven
Dr **Steve Dudek** started on
1 October 2004

Riso National Laboratory
Dr **Dag W. Breiby** started on
1 January 2004.

ETH Zuerich
Dr Natalie Stutzmann
started on 1 January 2004

NOMSAN

St Andrews Group
Dr Veneranda Garces-Chavez
from January 2004
to December 2006,

St Andrews Group
Daniel Rhodes (Aug 2004-
Dec 2006), he is just finishing
his PhD and then will be
a postdoc on the grant.

ICFO-Institut de Ciències
Fotòniques
Dr Iain Cormack from 23 June
2003 to 31 May 2004

ICFO-Institut de Ciències
Fotòniques
Giovanni Volpe (PhD student),
started on 1 October 2004

MOL-VIC

Miguel Ruiz-Osés
(Ph D student) started on
1 June 2004.

SASMEC

University of Madrid
Dr Roel Smit started on
1 May 2004, Technical
University of Denmark

Dr Magnus Paulsson started on
1 February 2004
University of Leiden

Dr Annemarie from 1
September 2003 to 31 August
2004, University of Leiden

Dr Alex Yanson started on
1 September 2004

SISAM

University of Groningen
Dr Evgeny Polushkin started in
September 2003

University of Potsdam
Danielle Franke (PhD student)
started in September 2003

University of Potsdam
Dr Zhixiang Wei started in
August 2003

University of Helsinki
Dr Nicole Volk from September
2003 until 31 July 2004

University of Helsinki
Dr Robin Ras started in August
2004

SSA -TMN

IPCF-CNR (Pisa
G. Barcaro (PhD student)
started on 1 January 2004

INFM (Genoa)
Dr F. Mita started on
9 September 2004

INFM (Genoa)
short collaborations: **Stephane Olivier** (September 2004)

SPENSA

University of Bath
Dr Ben O'Driscoll started on
23 February 2004.

NANOSYN

University of Bern
Xavier Guegano (PhD student)
started on 1 May 2004

University of Basel
Roman Huber (PhD student)
started on 1 of February 2004

University of Basel
Laetitia Bernard
(second PhD Student) will start
on 1 January 2005

Universidad Complutense,
Madrid
Francesco Giacalone
(postdoctoral): if everything
is alright with the application
(hopefully that is expected),
the starting date is 1 October
2004.

University of Durham
Dr Igor F. Perepichka started
on 1 February 2004.

Odense University
Dr Hemant Gopee
started on 1 December 2003

Assembly and Manipulation of Functional Supramolecular Nano-Architectures on surfaces

The FUN-SMARTs

The function of a material depends both on the nature of its constituents and their mutual interactions and arrangement. The controlled fabrication, manipulation and implementation of nanosize functional chemical entities into complex molecular architectures provide a wide range of potential applications with great value for science and technology. The properties of such nanostructured materials follow a bottom-up scale change from the nano- to the macrolevel with increasing structural and functional integration. The supramolecular self-organisation approach enables a high degree of structural organisation within the nanoregime. Noncovalent bonds mediate the controlled assembly and hierarchical growth of instructed, fully integrated and connected operational systems. Thus an impressive variety of structural motifs employing various self-assembly protocols has been designed, e.g., helicates, catenates, grids, cages, dendrimers, rosettes, chains, ladders, rotaxanes etc. (see Figure 1).

The construction of functional architectures employing complex molecules at substrates is a demanding task. It requires the integration of expertise in complementary areas of science, i.e., **supramolecular chemistry** dealing with functional self-organising systems, modern **organic and inorganic synthesis strategies** for the design of complex species with functional groups and metal ions at desired positions, and **scanning probe techniques** to characterise or manipulate molecules with atomic precision. Moreover, high quality **model simulations** are decisive for the correct understanding of the nature of molecular interactions, recognition and self-assembly.

Thus synergetic interdisciplinary collaborations between scientists from these areas are mandatory to master the fabrication of novel functional architectures in the nanometer regime exploiting suitable self-assembly protocols. Under the coordination of **Mario Ruben** from the **Institute of Nanotechnology** in Karlsruhe, Germany, the FUN-SMARTs network is the arena for high-level collaboration of eight European chemistry and physics groups. By joining eight different research groups providing expertise in supramolecular chemistry, nanoscale physical science and computer-based simulation we plan to set up an interdisciplinary European joint venture concentrating

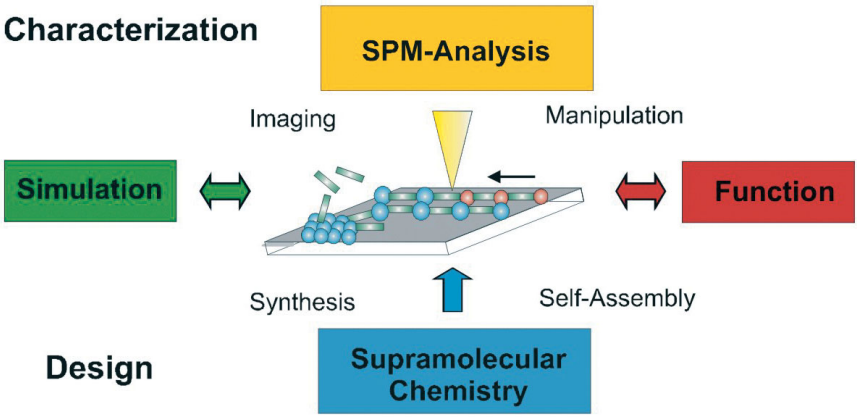
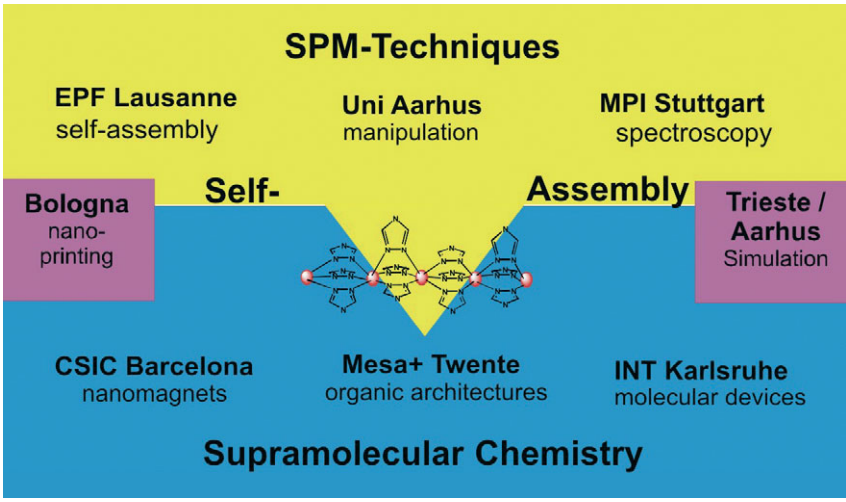


Figure 1



Scientific composition of the FUN-SMARTs consortium.

on the development of new concepts for directed self-assembly of functional nano-architectures. Financially, the FUN-SMARTs project comprises a global budget of about 1.46 million euros supplied by eight national science agencies within the organisational frame of the European Science Foundation. The main focus of the project will be addressed to the nanoscopic understanding and the steering of self-assembly processes employing functional molecular building blocks at well-defined surfaces. First, the ordering behaviour and stability of appropriately synthesised functional molecules with well-defined functions will be studied. Furthermore, the FUN-SMARTs project will pursue the idea of a full modular construction of functional architectures out of organic species and adsorbed atoms. In order to place the supramolecular

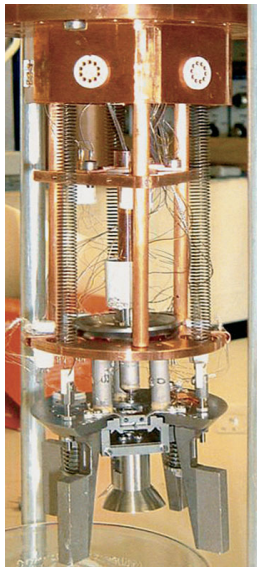
Project

nanoarchitectures in higher-level structures we will employ nanoprinting techniques. The envisaged functionalities deal mainly with the handling of molecular magnetism on the nanoscale and with the investigation of new concepts for molecular motors. During all stages of the project, modelling experiments of the associated theoretical groups will contribute to the understanding of the obtained results and guide the development of refined self-assembly protocols.

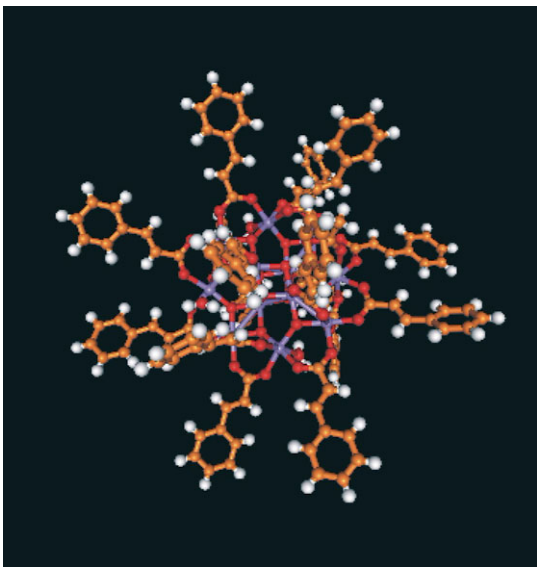
A particularly interesting group of functional molecular entities with potential use in self-assembly are magnetic complexes. These compounds can be subdivided by the underlying magnetic phenomenon into three classes of compounds: (1) high spin systems; (2) spin crossover systems; and (3) valence tautomeric compounds. The first class gains its interest by magnetic exchange interactions between spin bearing centres rendering a resulting molecule with a large spin ground state and a high magnetic anisotropic barrier. The second class of magnetic compounds relies on the phenomenon of electronic spin state crossover in certain transition metal, especially iron, complexes. Highly ordered molecular architectures consisting of magnetically active building blocks could be designed by strict application of self-assembly techniques. A third class of magnetic compounds is based on valence tautomerism. The compounds of these classes have two magnetically and optically different molecule states which can be interconverted by external stimuli.

In the long term, the gained insights in supramolecular self-assembly will contribute to the fabrication of novel functional nanoscale architectures and their integration in the higher hierarchical level. System parameters such as temperature, light, photon irradiation, pressure, electric potential, tunnel current, or chemical reactivity are envisaged as possible triggers of future nanoscopic devices and engines.

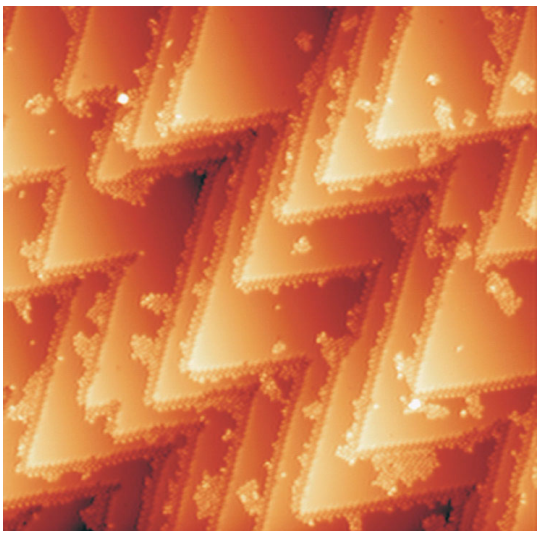
→ For further information:
www.esf.org/sons
sons@esf.org



The main working tool within the nanoregime: Self-constructed STM set-up in the group of Prof. J.V. Barth (EPF Lausanne).



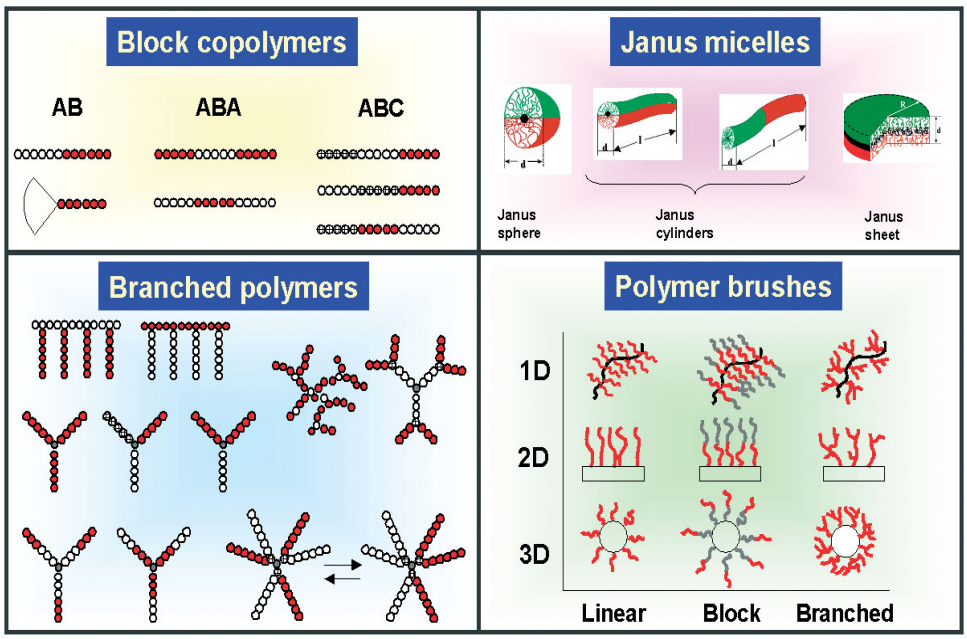
Perspective molecule for molecular magnetic print boards: Single crystal X-ray structure of a magnetically active Mn12 molecule (Group Prof. Veciana, Institut de Ciencia de Materials de Barcelona).



High-resolution STM image of a molecular assembly on a Cu(100) surface (Group Prof. Kern, MPI-FKF Stuttgart).

Higher Levels of Self-Assembly of Strategies Based on Multiple Molecular Interactions

The assembly of amphiphilic molecules in aqueous environment is one of the basic ways for self-organisation on macro- and super-molecular levels 'invented' by nature. The spontaneous formation of self-assembled structures, so beautifully exemplified by the living cell, is the outcome of a delicate balance between a limited number of attractive and repulsive forces, each one with its characteristic strength and range: electrostatic, hydrogen-bonding, solvent-mediated (solvophobic/solvophilic), metal-coordination, etc. In combination with proper chemical architecture, nature manages to produce not only structures of astounding complexity, but also with almost any functionality one can think of.



New polymeric architectures with polyelectrolyte segments.

Ionic Amphiphilic Copolymers:

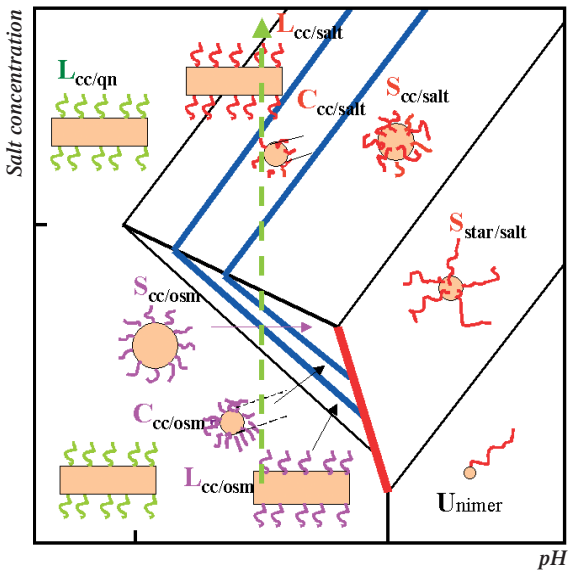


Diagram of aggregation states for diblock-polyelectrolytes with pH-sensitive (acidic) ionic blocks.

Blue lines denote sphere-to-cylinder and cylinder-to-lamella transitions in crew-cut micelles

Because of environmental concerns, water-based formulations and technologies have recently acquired a point of major importance for many technological processes. Self-assembled nanoaggregates based on amphiphilic copolymers find important biomedical applications as, for example, drug delivery systems and are used for tailoring the biocompatibility of artificial surfaces in biomaterial engineering and diagnostics (e.g. implants, biosensors). They are also important in food industry (e.g., as emulsifiers and foam-makers). Many water-based industrial formulations (such as personal and home care products, agrochemicals, etc.) include amphiphilic copolymers that aggregate and co-assemble with hydrophobic or/and small amphiphilic molecules (surfactants).

Modern synthetic chemistry enables the creation of macromolecules of almost arbitrary architectural complexity incorporating building blocks of different chemical natures in well-controlled positions. Some examples are shown in the figures below.

However, structural and functional properties of the final materials are most often determined by interactions between individual macromolecules and their ability for self-assembly into inter- and super-molecular nanoaggregates.

The thermodynamic (and kinetic) paths of the self-organisation, governed by multiple types of interactions, are pre-determined by the macromolecular architecture (on the stage of synthesis), but can also be influenced by external conditions. The real progress in our understanding of fundamental aspects of the behaviour of complex macromolecular systems and in the rational design of the new functional materials is possible only by applying a multidisciplinary approach and bringing together chemistry and physics, experiment and theory. For example, theory enables us to predict how, by varying control parameters such as salt concentration and/or pH, one can affect structure and morphology of aggregates formed by diblock-polyelectrolytes with pH-sensitive ionic blocks in aqueous solutions (see figure to the left). The self-assembly of non-ionic di- and tri-block copolymers at nanometric length scales has been extensively explored and the nanostructures they form, both in the presence and absence of organic solvents, have been amply studied. We are convinced that in order to get beyond the most elementary forms of self-organisation systems, a combination of ***independently tuneable*** forces, including long-range electrostatic forces, is needed. Water-based systems offer a unique possibility to enlarge the spectrum of the interactions involved. A strategy based on multiple interactions offers the best perspectives, particularly if it is combined with advanced, creative polymer chemistry which enables us to introduce additional degrees of freedom (additional dimension) in the macromolecular design, that is the topological complexity. The ultimate goal of this project is to create and understand systems that can self-assemble in a hierarchical way, that is, systems made up of molecules that could self-assemble in such a way that the particles formed self-assemble again into a superstructure, which then has the ability to undergo another assembly process, et seq.. We aim to explore possible approaches and the project should be seen as the first step in this challenging direction. It is our goal to obtain highly responsive (smart) systems capable of switching the aggregation state and supermolecular organisation as a response to variation of the external conditions. Furthermore, strong electrostatic interactions involved may lead to formation of regular arrays (patterned structures) in solution or at interfaces. The resulting nanostructured surfaces are expected to have tuneable or stimuli-responsive properties (e.g., wettability, friction, and bio-adhesion). Some of these structures may serve as molecular resolution templates or data storage materials.

→ For further information: www.esf.org/sons
sons@esf.org

The SONS-AMPHI network combines: (1) advanced techniques for the synthesis of macromolecules that can lead to multiple levels of self-association; (2) a wide range of complementary experimental techniques capable of obtaining proofs and insights into the hierarchical self-assembly processes; and (3) an appropriate theoretical programme to understand the reasons and mechanisms for multiple levels of organisation.

The Funding Agencies participating in the EUROCORES Programme SONS are:

Austria - Fonds zur Förderung der Wissenschaftlichen Forschung (FWF)
Belgium - Fonds National de la Recherche Scientifique (FNRS)
Belgium - Fonds voor Wetenschappelijk Onderzoek - Vlaanderen (FWO)
Czech Republic - Grantovà agentura Českè republiky
Denmark - Statens Naturvidenskabelige Forskningsråd (SNF)
Finland - Suomen Akatemia/Finlands Akademi
France - Commissariat à l'Énergie Atomique/Direction des Sciences de la Matière (CEA)
Germany - Deutsche Forschungsgemeinschaft (DFG)
Hungary - Hungarian Scientific Research Fund (OTKA)
Hungary - Magyar Tudomanyos Akademia
Ireland - Enterprise Ireland
Italy - Consiglio Nazionale delle Ricerche (CNR)
The Netherlands - Nederlandse Organisatie voor Wetenschappelijk Onderzoek (NWO)
Norway - The Research Council of Norway
Poland - Polska Akademia Nauk (PAN)
Portugal - Fundação para e Ciência e a Tecnologia (FCT)
Slovakia - Slovak Academy of Sciences
Spain - Consejo Superior de Investigaciones Cientificas (CSIC)
Spain - Oficina de Ciencia y Tecnologia (OCYT)
Sweden - Vetenskapsrådet
Switzerland - The Swiss National Science Foundation for the promotion of scientific research
Turkey - Scientific and Technical Research Council of Turkey (TÜBITAK)
United Kingdom - Engineering and Physical Sciences Research Council (EPSRC)

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EUROCORES Programme SONS is a European Science Foundation (ESF) initiative partially supported by the European Commission Sixth Framework Programme, under Contract N° ERAS-CT-2003-980409.

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EUROPEAN SCIENCE FOUNDATION **CO**LLABORATIVE **RES**EARCH