International Solvay Institutes
Brussels

# 2013 International Solvay Chair in Chemistry

## Professor Egbert W. Meijer

(Institute for Complex Molecular Systems, Laboratory of Macromolecular and Organic Chemistry & Laboratory of Chemical Biology, Eindhoven University of Technology, the Netherlands)

## Inaugural Lecture

Tuesday 26 November 2013 at 4:00 pm in the Solvay room

# Why we cannot make life

"The origin of life on earth" is without doubt one of the most intriguing scientific topics, while the wish to create life in a laboratory is amongst its most difficult challenges. The enormous progress in science and technology over the past decades has provided many deep insights into the miraculous composition and functioning of living systems. Today, on the one hand, we can clone sheep, grow organs from stem cells, while cells, plants, animals and bacteria have been genetically modified. On the other hand, the synthesis of small and large molecules has become so sophisticated that almost every molecule that exists on earth can now also be made in a laboratory, including long strands of DNA, proteins and complex drugs that can cure diseases. These many insights, however, also show the complexity of the molecular biology of living cells. As a result, the astonishment about how life could ever have originated has further increased. The lecture will illustrate the greatest challenges that are encountered while seeking to understand the origin of life, including an explanation of why it will take a very, very long time before a living cell can be made in a laboratory out of its individual components. Special attention will be paid to the self-organization of complex supra-molecular systems as a critical step in the building process.

# Lecture 1

Thursday 28 November at 2:00 pm in the Solvay room

## Mastering complexity: non-covalent synthesis of functional supramolecular systems

The intriguing prospects of molecular electronics, nanotechnology, biomaterials, and the aim to close the gap between synthetic and biological molecular systems are important ingredients to study the cooperative action of molecules in the self-assembly towards functional supramolecular systems. The design and synthesis of well-defined supramolecular architectures requires a balanced choice between covalent synthesis and the self-assembly of the fragments prepared. The current self-assembly processes are primarily controlled by solvent, temperature or concentration. For synthetic chemists, the non-covalent synthesis of these supramolecular architectures is regarded as one of the most challenging objectives in science: How far can we push chemical self-assembly and can we get control over the kinetic instabilities of the non-covalent architectures made? How can we go from self-assembly to self-organization? Where the number of different components is increasing the complexity of the system is increasing as well. Mastering this complexity is a prerequisite to achieve the challenges in creating functional systems. In the lecture we illustrate our approach using a number of examples out of our own laboratories, with the aim to come to new strategies for multi-step non-covalent synthesis of functional supramolecular systems.

***E.W. "Bert" Meijer*** *is Distinguished University Professor in the Molecular Sciences, Professor of Organic Chemistry at the Eindhoven University of Technology and scientific director of the Institute for Complex Molecular Systems. After receiving his PhD degree at the University of Groningen, he worked for 10 years in industry (Philips and DSM). In 1991 he was appointed in Eindhoven, while in the meantime he has held part-time positions in Nijmegen and Santa Barbara, CA. Bert Meijer is a member of many editorial advisory boards, including Advanced Materials, Angewandte Chemie, and the Journal of the American Chemical Society. Bert Meijer has received a number of awards, including the 1999 Silver Medal of the Macro UK group, the Spinoza Award in 2001, the ACS Award for Polymer Chemistry in 2006, the AkzoNobel Science Award 2010, the International Award of the Society of Polymer Science Japan in 2011, and the Cope Scholar Award of the ACS in 2012. He is a member of a number of academies and societies, including the Royal Netherlands Academy of Science.*

# Lecture 2

Tuesday 29 April 2014 at 4:00 pm in the Solvay Room

## About supramolecular assemblies of π-conjugated oligomers and polymers; chirality as a muse

Chemical self-assembly is an important tool in constructing functional nanoscopic materials. Knowledge about the presence and stability of multiple local supramolecular minima or substates in these synthetic self-assembled systems is crucial in order to drive the assembly towards the desired thermodynamic minimum. Both the existence and the factors that influence the formation of these substates have, however, barely been investigated. In the presentation, we show that the chemical self-assembly of chiral π-conjugated oligomers, sexithiophenes and oligo(phenylenevinylenes) operates via a nucleation – elongation pathway and hence is highly cooperative. As a result the solvent plays an essential role in the chemical self-assembly and strong evidence is found that the alkane solvents are co-organized with the oligomeric stack. These results are also of crucial importance for the discussion whether the chemical self-assembly creates the thermodynamically determined product or that is possible to form kinetically trapped structures as well. We will show that the self-assembly is strongly influenced by external stimuli. Impurities levels as low as 0.1% can direct the assembly, while only with cooling rates as low as 1 K/hr the assembly process occurs close to or under thermodynamic equilibrium. Multiple supramolecular substates have been probed, while stepwise cooling shows that annealing at different stages of the self-assembly influences the assembly process in different ways and indicates the changing energy landscape.

# Lecture 3

Friday 23 May 2014 at 2:00 pm in FORUM D

## Folding of single-chain macromolecules; towards synthetic enzymes

The folding of proteins as well as the self-assembly of proteins into fibrillar and beta-amyloidal structures is the results of specific secondary interactions within a polymer chain or between polymer chains. The diversity in protein structures and the complexity of the processes involved make studies to folding and assembly of proteins challenging research objectives. In the lecture, a number of simple artificial structures will be introduced that are studied in great detail for their self-assembly processes in both organic solvents and water. In a particular example, meta-stable folded single-chain macromolecules will be used as a catalyst. An attempt will be made to elucidate the differences and similarities between these simple artificial structures and complex proteins to arrive at a few general statements on folding and assembly of (macro)molecules. Both kinetic and thermodynamic studies will be used to show some remarkable similarities in behavior of artificial structures in organic solvents and proteins in water.

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