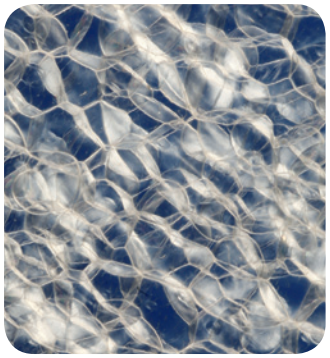
Scientific Forum 2010

Von Nylon zu Nanomaterialien

Die Zukunft der Polymere

Messe Basel, Halle 1 – Saal Luzern (1. Stock)



21. September
Schülertag

22. – 23. September
Scientific Conference

24. September
Berufstag
für Studenten

SCG
Schweizerische Chemische Gesellschaft

SSC
Société Suisse de Chimie

SCS
Swiss Chemical Society

Dienstag, 21. September 2010 | Schülertag

Tagespartner
Verein Schweizerischer Naturwissenschafts-lehrerinnen und -lehrer

Polymere im täglichen Leben

9:30	Begrüssung Prof. Peter Kündig, SCG-Präsident
9:40	«Polymere für Knochen und Bildschirme: Was kleinste Partikel aus Plastik machen können ...» Prof. Wendelin Stark, ETH Zürich
10:05	«Medizinische Polymere – von Schläuchen und neuen Organen» Dr. Katharina Maniura, Empa
10:30	Live-Vorführung von Experimenten
10:50	Pause
11:20	Vorstellung von Maturaarbeiten Steve Clerc, Neuchâtel, «Les cordes dynamiques d'escalade: sécurité réelle ou psychologique?» Andreas Frutiger, Hilterfingen: «Fixierung und Reduktion von atmosphärischem CO_2 mit Wasserstoff zu kurzkettigen Kohlenwasserstoffen»
11:50	Diskussion: «Alles Plastik, oder was?» Prof. Wendelin Stark, ETH Zürich Dr. Katharina Maniura, Empa Dr. Urs Klemm, Konsumentenforum Fragen aus dem Publikum Gesprächsleitung: Helen Issler
12:30	Imbiss (gratis)

Nachmittag: Besuch der Messe ILMAC, mit Wettbewerb (gratis, fakultativ)

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Wednesday, 22 September 2010 | Scientific Conference

Materials and Analytics

9:30	Welcome Peter Kündig, SCS President
9:35	«Macromolecular Engineering for Functional Nanostructured Materials» Krzysztof Matyjaszewski, Carnegie Mellon University, USA
10:15	«Mass Spectrometry of Polymers with Special Emphasis on MALDI» Steffen Weidner, Bundesanstalt für Materialforschung und -prüfung, Germany
10:50	Coffee Break
11:20	«Novel Photoinitiators and Photopolymers for Applications in Electronics» Tobias Hintermann, BASF Schweiz
11:55	«Functional Nanomaterials: From Nanotoxicology to Medical and Industrial Applications» Wendelin Stark, ETH Zurich
12:30	End of Conference Day One

Chairman: Georg Fráter, Swiss Chemical Society

Thursday, 23 September 2010 | Scientific Conference

Biological and Medical Applications

9:30	Welcome Paul Gilgen, President of the Organising Committee
9:35	«Biofunctional Processing and 3D Bioplotting of Biomaterials» Rolf Mülhaupt, University of Freiburg, Germany
10:15	«Delivery of Anticancer Agents by Liposomes: Nanomedicine in Action» Alberto A. Gabizon, Shaare Zedek Medical Center and Hebrew University, Israel
10:50	Coffee Break
11:20	«Biopolymers – Simply Natural!» Linda Thöny-Meyer, Empa St. Gallen
11:55	«Synthetic Biomembranes» Wolfgang Meier, University of Basel
12:30	End of Conference Day Two

Chairman: Jürgen Vogt, Swiss Chemical Society

Der Eintritt ist für alle Veranstaltungen kostenlos.
Free admission, no registration.

Anmeldung von Gruppen erwünscht (weber@scg.ch).

Das Scientific Forum ist Partner der ILMAC und Teil der Basel Life Sciences Week 2010.

Weitere Veranstalter sind MipTec, BioValley und das Friedrich Miescher Institut.

www.basellifesciencesweek.ch
www.scg.ch

Freitag, 24. September 2010 | Berufstag

Berufsbilder und Firmenporträts aus der Polymerbranche

9:30	Begrüssung Paul Gilgen, Präsident der ILMAC-Fachkommission der SCG
9:40	Einführung Jean-Nicolas Aebischer, Hochschule für Technik und Architektur Freiburg
9:50	Philip Nising, Sulzer Chemtech
10:10	Martin Vollmer, Clariant International
10:30	Bettina Steinmann, 3D Systems
10:50	Pause
11:20	Christian Quellet, Givaudan Schweiz
11:40	Konrad Grob, Kantonales Labor Zürich
12:00	Thorsten Klein, Postnova Analytics
12:30	Ende des Programms

Moderator: Jean-Nicolas Aebischer, Hochschule für Technik und Architektur Freiburg

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Wednesday, 22 September 2010

Materials and Analytics

Macromolecular Engineering for Functional Nanostructured Materials

Krzysztof Matyjaszewski

Center for Macromolecular Engineering, Department of Chemistry, Carnegie Mellon University, USA

Copper-based ATRP (atom transfer radical polymerization) catalytic systems with polydentate nitrogen ligands belong to the most efficient controlled/living radical polymerization systems.[1,2] Recently, by applying new initiating/catalytic systems, Cu level in ATRP was reduced to a few ppm.[3]

ATRP of acrylates, methacrylates, styrenes, acrylamides, acrylonitrile and many other vinyl monomers provides polymers with molecular weights in a large range $200<M_n<20{,}000{,}000$ and with low polydispersities. Polymers can be formed quantitatively in bulk, in solution and in dispersed media. Block, graft, star, hyperbranched, gradient and periodic copolymers, molecular brushes and various hybrid materials as well as bioconjugates have been prepared.[2] The (co)polymers made by CRP have many potential applications as components of advanced materials such as coatings, elastomers, adhesives, surfactants, dispersants, lubricants, additives, but also as specialty materials in biomedical and electronic areas and will affect the market of ~$20 billion/year. Examples of design, synthesis, characterization and applications of nanostructured multicomponent polymeric materials prepared *via* CRP will be presented.[4]

[1] 'Handbook of Radical Polymerization', Eds. K. Matyjaszewski, T. P. Davis, Wiley, Hoboken, **2002**.
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Krzysztof Matyjaszewski (PhD, 1976 Polish Academy of Sciences) is J. C. Warner University Professor of Natural Sciences and director of Center for Macromolecular Engineering at Carnegie Mellon University. His main research interests include controlled/living radical polymerization, catalysis, environmental chemistry, and synthesis of advanced materials for optoelectronic and biomedical applications. He has co-authored over 600 publications, including 14 books and over 30 US and 100 international patents. His first paper and review on ATRP have been cited more than 2000 times each and his citation record (>37,000) ranked among top 10 scientists in all fields of chemistry worldwide in 2004–2010. Matyjaszewski is a member of Polish Academy of Sciences and US National Academy of Engineering. He received honorary degrees from University of Ghent, Belgium (2002), Russian Academy of Sciences (2006), Lodz Polytechnic, Poland (2007), University of Athens, Greece (2008) and l'Institut Polytechnique, Toulouse, France (2010). He developed atom transfer radical polymerization (ATRP), which has been commercialized in US, Europe and in Japan. Over 40 companies have been members of ATRP and CRP Consortia at CMU with ten signed commercial licenses.

Mass Spectrometry of Polymers with Special Emphasis on MALDI

Steffen M. Weidner

Federal Institute for Materials Research and Testing (BAM), Berlin, Germany

Since its introduction soft ionization methods like MALDI- and ESI-TOF mass spectrometry have become indispensable tools for polymer characterization. For the first time molecular masses, mass distributions and chemical functionalities could be simultaneously obtained. Thus, MALDI and ESI-TOF MS are especially advantageous for the control of polymerizations, the determination of polymer modifications and in the analysis of degradation products. The combination with different separation methods will be presented, which can be useful to overcome drawbacks of mass spectrometry, and to achieve a characterization of even complex polymer and copolymer systems. Several examples of a comprehensive LC-MALDI analysis of several important classes of polymers (*e.g.* polyamides, polyesters, EO-PO copolymers) will be presented, demonstrating the potential of this coupling.

Steffen Michael Weidner received his PhD in Macromolecular Chemistry at the Technical University Berlin in 1996. Since March 2000, he is head of the working group 'Analysis of Polymers' at the Bundesanstalt für Materialforschung und -prüfung (BAM), the German Federal Institute for Materials Research and Testing in Berlin. He is a leading expert in using Matrix-assisted Laser Desorption/Ionization (MALDI) technology for analysis and characterization of polymers. He is the author of a high number of scientific papers and book chapters and member of the German and the American Society for Mass Spectrometry.

Novel Photoinitiators and Photopolymers for Applications in Electronics

Tobias Hintermann

Performance Chemicals Research
BASF Schweiz AG, Basel, Switzerland

The electronic industry is an extremely fast developing and highly innovative sector of today's industry. Because of high competitiveness, it is driven by the constant demand for new devices

with better performance (smaller size, reduced weight, improved energy efficiency) and new applications. The design of new devices is accompanied by a strong need for reduction of production costs for older generations. The first trend is facilitated by miniaturization of electronic components such as transistors and microchips, and the development of new technologies (*e.g.* OLED and e-paper displays, batteries with higher energy density). On the other hand costs can be lowered by an increase in production efficiency through improved processes, increased substrate size, and reduced size of components.

Fast cure on demand is advantageous to many manufacturing processes in the electronic industry. Examples of applications are the encapsulation and sealing of sensitive electronic components, displays and solar cells, adhesives for lamination and assembly of electronic parts and devices, and curing of dielectrics and insulating layers in printed electronics. Optical micro-lithography processes are of particular importance because they permit a fast and precise production of two- and three-dimensional structures by applying patterning techniques to photosensitive layers, using image-wise exposure in connection with layer-wise build-up technology to create electronic functionalities. Some of the most important application fields for micro-photolithography in the electronic industry are in the manufacturing of display panels (thin film transistors, color filter, black matrix, photo-spacers, insulating layers), semiconductors (*i.e.* integrated circuits, microprocessors, DRAM and flash memory), and microelectromechanical systems (MEMS).

Advancements in optical micro-lithography tools, processes and particularly photosensitive materials are critical for the continued advancement of microelectronic devices. Today, ArF-excimer laser nano-lithography generates precise patterns with a resolution of <40 nm with chemically amplified photoresists comprising highly optimized photo acid generator (PAG) as photoactive component. In the last few years BASF has developed a series of Irgacure® PAGs for different lithographic requirements and exposure wavelengths; i-line (365 nm), KrF (248 nm), ArF (193 nm). Today's ArF PAG technology can be extended to meet the demand of future EUV (13.5 nm) lithography.

Significant progress of the manufacturing technology for liquid crystal displays was enabled by BASF's innovative photoinitiator Irgacure® OXE02. This extremely sensitive photoinitiator is used to pattern an environmentally friendly organic resin black matrix (RBM) which separates the red, blue, and green sub-pixels to provide improved contrast in LCD-TVs. The new technology allowed the replacement of the formerly used environmentally problematic chromium metal in this application, and at the same time improves the manufacturing process by eliminating numerous technical issues potentially arising through the use of the traditional method.

Tobias Hintermann received his PhD from ETH Zürich and then moved to Harvard University for a postdoc before joining Ciba SC in 2000. In 2003 he moved to the Ciba research center for electronic materials in Amagasaki, Japan, working on several topics related to microelectronics. Returning to Basel he became head of the photoinitiators research group in the Research Center for Polymerization & Curing Agents in 2008, and after integration of Ciba into BASF he is now part of BASF Performance Chemicals Research, Basel. His current interest spans the field of photoinitiators, photoacid generators, and photolatent catalysts. He is the author of more than 30 scientific papers and patents.

Functional Nanomaterials: From Nanotoxicology to Medical and Industrial Applications

Wendelin J. Stark

Functional Materials Laboratory,
ETH Zürich, Switzerland

The properties of nanoparticles are between solids and small molecules. We may even compare them in parts with polymers, where an arrangement of monomers determines the polymer's fate. In a particle, the 'monomers' are clustered differently (amorphous or crystalline). Visionary concepts have spread from a fundamental understanding of small particles. But novel and rather down-to-earth applications are available already today: Especially magnetic nanoparticles show the way for the accelerated transfection of vectors into cells[1] or *in vivo* extraction of noxious compounds.[2] Artificial muscles or improved materials for implants comprising nanoparticulate materials might be implemented.[3] Amorphous calcium phosphates and bioactive nanoglass are under preclinical investigation for bone healing or to fight osteoporosis as toothpaste-like injectable bone cement, which hardens within minutes inside a living organism.[4] Nano-silver is well-known for its antimicrobial properties and consequently will be found in even more industrial products than already today.[5]

Nanoparticles interact with cells in unprecedented ways which affect public perception and may result in product risks (*e.g.* Trojan-horse type toxin uptake).[6] Unraveling non-traditional mechanisms, however, may result in improved or even completely new medical treatment concepts, considering that the wealth of pharmaceuticals available today has largely been fueled by such understanding of molecules within biological systems. In fact, the majority of broadly used medications have been originally identified on the basis of a toxic effect. These and other implementations of nanomaterials in medical and technical applications will be presented.

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[6] L. K. Limbach, P. Wick, P. Manser, R. N. Grass, A. Bruinink, W. J. Stark, *Environ. Sci. & Techn.* **2007**, *41*, 4158.

Wendelin J. Stark (1976) received his Master in Chemistry in 2000 followed by a PhD in Mechanical Engineering in 2002 from ETH Zurich. He founded the Functional Materials Laboratory at the Department of Chemistry and Applied Biosciences at ETH Zürich in 2004. Application-oriented research at the interface of chemistry with material science and medicine has resulted in several commercialized products and two implant materials currently undergoing preclinical investigations. Since 2004, seven PhDs were finished with an average duration of three years. Since 2007, he has published about 15–20 research articles per year in top peer-reviewed journals and is currently author of about 100 papers

and 16 patents as well as numerous (over 150) reviewed proceedings and presentations at leading conferences in chemical and medical engineering. The Functional Materials Laboratory has acquired prominent industrial partners with a long-term commitment, and currently assists a product development in a Global-100 company. A European Fortune-200 company is currently implementing a process developed in Professor Stark's laboratories. In 2007, a spin-off company (Turbobeads) was founded out of his laboratory to commercialize magnetic molecule tags and accelerated medical diagnostics. In summer 2008, a second spin-off company (Nanograde) has been launched from Professor Stark's research group.

Thursday, 23 September 2010

Biological and Medical Applications

Biofunctional Processing and 3D Bioplotting of Biomaterials

Rolf Mülhaupt

Freiburg Materials Research Center (FMF), University of Freiburg, Freiburg, Germany

Biofunctional processing of biomaterials represents an important challenge in regenerative medicine with applications ranging from tissue repair and drug release to organ printing. The ultimate goal is to import data from computer tomography or X-ray into computer assisted design (CAD) in order to design and fabricate biofunctional tissue meeting the special demands of individual patients. The majority of conventional polymer processing technologies such as molding and casting fail to process bioactive components because they require either high temperatures or rather toxic resins. The computer-guided mold-free layer-by-layer fabrication, known as Rapid Prototyping (RP), and originally developed for concept modelling in automotive industry, offers attractive opportunities for biofunctional processing. Selective laser sintering and stereolithography are used to fabricate implants and hearing aids, but do not tolerate bioactive components. Today 3D inkjet printing and 3D bioplotting™ have been developed to process aqueous systems containing cells and biopolymers. The 3D printing inks require very low viscosity. Thermoreversible gels were employed as printing inks for cell printing. In contrast, the 3D Bioplotting process, developed at the Freiburg Materials Research Center in close collaboration with EnvisionTec and Prof. Dr. R. Schmelzeisen at the University Hospital, is extraordinarily versatile with respect to the choice of materials, and can process solutions, pastes, melts, dispersions exhibiting low and very high viscosities. Strands and microdots are dispensed *via* a 3D movable nozzle. A wide range of polymer solutions (PLA, PE, collagen, cellulose), cements, and also reactive resins (PUR, silicones, acrylics, fibrinogen) can be processed. In contrast to many other technologies, no temporary support structures are required. Plotting in liquid media and matching the densities of the materials and the plotting medium enables buoyancy compensation of gravity. Soldification involves either physical crosslinking by cooling below glass and melting temperature, and also chemical crosslinking by means of ionomer formation and other chemical reactions. Reactive plotting (fibrin, alginates) afforded fabrication of structured hydrogel scaffolds. Multiple-3D dispensing enables fabrication of hybrid materials with 3D positioning of components. In a recent advance hydrogel precursors were modified to enable 3D plotting of osteoblast cell suspensions which form functional tissue. The 3D scaffolds can also be equipped with other biological functions such as controlled drug release. Ceramic and hydrogel scaffolds have been used *in vivo* for bone repair.

Rolf Mülhaupt is professor of macromolecular chemistry and director of the Freiburg Materials Research Center at the University of Freiburg, Germany. He studied chemistry in Freiburg and received his PhD in 1981 at ETH Zürich. After industrial research at Du Pont in Wilmington/Delaware (1981–1985) and Ciba in Marly/CH (1985–1989), he joined the University of Freiburg in 1989. His research includes polymer chemistry, catalysis, multiphase polymers, nanocomposites, functional processing, and specialty polymers and additives. He received the Piero Pino gold medal of the Italian Chemical Society (2004) and the Hermann Staudinger Prize of the German Chemical Society (2009). Since 2000 he has been a member of the Heidelberg Academy of Sciences.

Delivery of Anticancer Agents by Liposomes: Nanomedicine in Action

Alberto A. Gabizon

Shaare Zedek Medical Center and Hebrew University-School of Medicine, Jerusalem, Israel

Despite the advent of new molecular targeted therapies for cancer, most of the currently used anti-tumor agents have problematic toxicities compromising efficacy, and often resulting in life-threatening events. Liposomes can provide effective control of the release rate and of the tissue distribution of many of these agents. These pharmacokinetic changes often have a major pharmacodynamic impact with attenuation of toxic effects and protection of sensitive tissues from dangerous and unwanted drug exposure. Polyethylene-glycol (PEG) coating of liposomes results in inhibition of liposome uptake by the reticulo-endothelial system and significant prolongation of liposome residence time in the blood stream. A hallmark of these long-circulating liposomal drug carriers is their enhanced accumulation in tumors. The mechanism underlying this passive targeting effect is the phenomenon known as enhanced permeability and retention (EPR) which has been described in a broad variety of experimental tumor types, and appears also to be a relevant phenomenon in human cancer. Developments in drug loading technology have improved the efficiency and stability of drug entrapment in liposomes, particularly with regard to anthracyclines, vinca alkaloids, and camptothecin analogs. An example of a liposome formulation with demonstrated clinical added value is PEGylated liposomal doxorubicin, which has demonstrated clinically a favorable safety profile with an impressive reduction in cardiac toxicity and proven efficacy against various malignancies and can be considered as the first anti-cancer nanomedicine approved for clinical use. In summary, liposome-based systems offer a vast array of potential applications in the delivery of cancer chemotherapeutic agents which may result in a substantial improvement of the therapeutic index. Although liposomal doxorubicin has already found a place in routine clinical use, the potential of liposomal drug delivery remains so far under-exploited.

Alberto (Abraham) Gabizon (born 1951 in Tetuan, Morocco), received his medical degree at the School of Medicine in Granada, Spain, and his doctorate (PhD) in Cell Biology from the Weizmann Institute of Science in Rehovot, Israel. He completed his residency in Oncology at the Hadassah Medical Center in Jerusalem, and obtained the Israeli board certification in Radiation and Medical Oncology in 1985. Between 1985–1988, he spent three years on a research fellowship at the Cancer Research Institute of the University of California in San Francisco, where he helped to develop a new generation of long-circulating liposomes known as Stealth liposomes which have greatly improved stability and selective accumulation in tumors. Dr. Gabizon returned to Israel in 1989 as Senior Staff Physician and Investigator at the Sharet Institute of Oncology of Hadassah Medical Center where he continued his research and clinical activity until 2001. In 2002, Dr. Gabizon was appointed Chairman of the Oncology Institute at Shaare Zedek Medical Center, and Professor of Oncology at the Hebrew University-Faculty of Medicine in Jerusalem, his current appointment. Dr. Gabizon has received the Spanish National Prize of Medical Graduation (1975), the Career Research Award (1989) and Professorship Award (2008) of the Israel Cancer Research Fund, the Hebrew University Kaye Innovation Award (1997) for the invention 'Liposomal Doxorubicin for Cancer Treatment', and most recently the Alec Bangham Life Time Achievement Award of the International Liposome Research Society. Dr. Gabizon's research contribution placed a central role in the development of PEGylated liposomal doxorubicin (known as Doxil or Caelyx), a unique anticancer formulation extensively used in the clinic with important pharmacologic and safety advantages over conventional chemotherapy. Dr. Gabizon is active in the medical oncology field in early clinical trials, and in preclinical pharmacology research with special emphasis on applications of liposomes in drug delivery, targeting of drugs, and experimental cancer therapy, and has published around 120 original articles and specialized book chapters. Dr. Gabizon is a resident of Jerusalem, married and father of four children.

Biopolymers – Simply Natural?!

Linda Thöny-Meyer

Empa
Laboratory for Biomaterials, St. Gallen, Switzerland

The term biomaterial is often used explicitly in the context of medical applications, where biodegradability and biocompatibility play a critical role. In this presentation I will discuss examples of various classes of biopolymers with applications that are not exclusively related to a use in the body, *i.e.* for medical purposes. Such biopolymers span several families of substances, including polysaccharides, polyester, polyphenols, polynucleotides, and polypeptides. The huge reservoir of Nature's biopolymers with remarkable characteristics can be expanded by man-made technologies, leading to novel combinations of polymers or their building blocks in bio-derived polymers.

The sector of industrial ('white') biotechnology includes the production and engineering of biopolymers. At Empa we focus not only on the engineering of biomaterials for special applications but also on synthesis and production of novel biomaterials. Cellulose makes up 50% of the cell wall of plant cells where it provides stability and keeps the plants in shape. The Empa wood laboratory explores the production and application of nano-cellulose. By physical treatment natural cellulose fibers are broken down into nanofibrils which form networks of polymers with high surface area, which are rich in hydrophilic groups. The advantages of such nanofibrils in materials are their high stability, transparency, good barrier functions and their reactivity allowing chemical modification.

In the laboratory for biomaterials we change the characteristics of biopolymers in new combinations with additives in order to obtain material characteristics for special purposes, *e.g.* degradable materials in fields of textiles, packaging, agriculture and medicine. We also use biotechnology to produce polyesters and polypeptides from bacteria. Bacterial strains are engineered such that waste materials can be used for the production of cell mass. By applying special fermentation conditions we obtain high cell densities and improve yields. In addition we develop environmentally friendly procedures to isolate polyhydroxyalkanoate bioplastics in medical grade. The obtained material is used for medical but also biological applications. Enzymes involved in synthesis, degradation or conversion of biopolymers are cloned, produced and engineered in our laboratory. An example is tyrosinase, the key enzyme of melanin biosynthesis, which has further applications such as protein immobilization.

Biopolymers comprise polymeric materials that are either bio-based, *i.e.* made by natural processes from natural sources, or that can be degraded by natural processes. In times when petrochemical resources become more limited, or are regarded ecologically problematic, these sustainable materials are expected to become more and more important and economically competitive.

Linda Thöny-Meyer has been the head of the Laboratory for Biomaterials at Empa since 2006. She performs R&D in the field of biopolymers and biocatalysis. She graduated 1988 at ETH Zürich with honors. After postdoctoral activities at Stanford University she habilitated in 1997 and became an assistant professor for Molecular Microbiology at the Institute of Microbiology, ETH Zürich. 2004–2006 she worked as a patent attorney for E. Blum & Co in Zürich. For her research contributions she obtained several awards including the title of an honorary doctor from Lund University, Faculty of Sciences, where she also served in the Scientific Advisory Board.

Synthetic Biomembranes

Wolfgang Meier and Nico Bruns

Department of Chemistry of the University of Basel
Basel, Switzerland

Similar to conventional lipids, suitable amphiphilic block copolymers may self-assemble in aqueous media to membrane-like superstructures. The physical properties of these membranes can be controlled to a large degree via the chemical constitution,

the molecular weight and the hydrophilic-to-hydrophobic block length ratio of these polymers. Compared to conventional low molar mass building blocks (*e.g.* lipids), membranes based on macromolecular self-assembly not only have the advantage of superior stability and toughness, but in addition offer numerous possibilities of tailoring physical, chemical and biological properties since many functions can be implemented simultaneously in one single macromolecule.

Moreover, other well-defined functions such as recognition, cooperativity, regulation, replication, and catalysis can be introduced by combining these superstructures with suitable functional groups from nature, *e.g.* by incorporation of integral membrane proteins into the biomimetic membranes. Recently, we used this concept to prepare polymer nanoreactors by encapsulating water-soluble enzymes inside the aqueous compartments of block copolymer vesicles. Channel proteins were used to selectively control the exchange of substrates and products with the environment. Immobilized polymer nanoreactors were used as chemically and mechanically stable, nanometer-sized compartments to follow folding/unfolding of single proteins and to monitor enzymatic reactions down to a single nanoreactor scale. Model reactions were used to demonstrate the potential of these structures for biosensing and the local production of bioactive compounds. In addition, these nanoreactors can be targeted to predefined cells. After cellular uptake, they retain their function over extended times inside the living cells, thus acting as a sort of artificial organelle. This opens new ways for controlled drug delivery and intracellular sensing.

Wolfgang Meier studied Chemistry at the University of Freiburg and received his PhD degree in Macromolecular Chemistry in 1992. In 1996 he was appointed as lecturer in Physical Chemistry at the University of Basel where he received his 'Habilitation' in 1998. In 2001 he was appointed as professor at the International University of Bremen and since 2003 he is Professor of Chemistry at the University of Basel. He received several awards (Ruzicka-Prize, 2001; Hermann-Staudinger-Prize, 2006) for his research.
His main research interests are in the field of hierarchical self-assembly of functional polymers, and polymer-protein hybrid materials.

Nico Bruns is currently a 'Habilitand' (research group leader) at the Department of Chemistry at the University of Basel. He studied Chemistry at the Universities of Freiburg and Edinburgh. He received his PhD in Macromolecular Chemistry in 2007. He then spent one and a half years as a postdoctoral researcher at the University of California, Berkeley, after which he came to Basel to establish his own line of research and his own research group. He received a scholarship from the German National Academic Foundation (Studienstiftung des deutschen Volkes), a Marie Curie Intra European Fellowship, as well as several awards, *e.g.* the Pfizer-Research Award for Young Scientists. His research interests include cage-like proteins as nanoreactors and functional nano-devices. He is also investigating polymer-protein hybrid materials and amphiphilic copolymer systems.