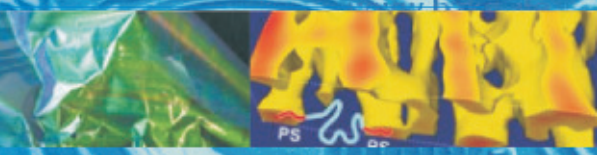
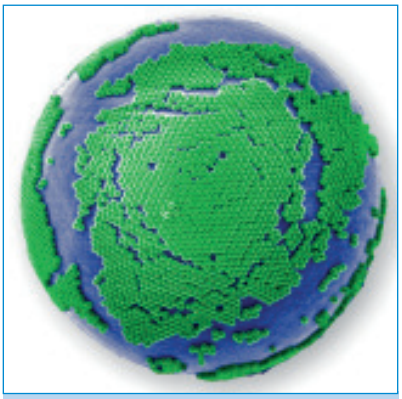


The Bayreuth Center for Colloids and Interfaces

Nanotechnology at the interface between research and application

The Bayreuth Center for Colloids and Interfaces (BZKG) is a central research institution of the University of Bayreuth, in which several research groups jointly combine their expertise and equipment. The aim of the BZKG is to connect fundamental research and industrial applications. The University Bayreuth with its research priorities in "Macromolecular and Colloid Research" as well as in "New Materials" offers a high level of competence in the areas of colloidal or interface-dominated systems and their applications in the biological or material sciences. Companies, especially small and medium sized ones, have with the BZKG a direct partner for research projects. These companies have not necessarily to be situated in the vicinity of Bayreuth but can be found across the entire Bavaria. The BZKG is not only enabling bilateral collaborations but also collaborative projects on the European level.

In the BZKG we study various types of colloidal objects, which span dimensions of few nanometers up to several micrometers. Therefore, our research compromises nanoparticles as well as the typical ingredients of paints. Other examples for colloidal systems are proteins or cosmetic formulations. Due to the dimensions of the colloidal objects it is possible to consider colloid science as a classical and ‚green' form of nanotechnology. The origins of colloid science can be traced back to the preparation of the first inks in the ancient Egypt or to the preparation of colloidal gold sols in China, more than thousand years ago. These examples illustrate an important aspect of colloid and macromolecule science: it has an inherent connection to real-life applications, which on one hand provides new impulses for the fundamental research and on the other hand leads to new products or procedures that can be readily applied.



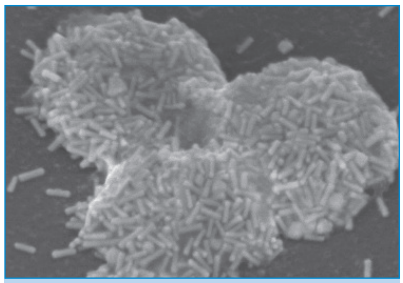
Monolayer of small 180nm polystyrene particles assembled on a 10 ìm particle ■

It is characteristic for colloidal systems that many of their properties are determined by the interface formed between particles and the aqueous phase and not by the bulk properties of dissolved objects. A simple example illustrates this point: In a glass of 0.2 liters that contains a 10% (w/w) colloidal suspension of latex particles with a diameter of 1 micrometer, the total surface area of the particles is equal to about is equal to about 60 m^2. In consequence, the properties of the interface determine how these colloids will behave together as colloidal suspension. For example, the surface forces are responsible for the stability of a colloidal particles suspension and thus determine how long it can be stored and under which conditions, e.g. in respect to the temperature, before the particles aggregate.

Interface science as discipline is dealing with the interfaces between phases in general, not only those between a colloidal particle and the adjacent solution. A representative example would be a water-based paint developed to color walls. This paint must be stable as colloidal suspension but it must also stick to the wall during (and after) the painting process (interface between two solids) as well as possess suitable drying properties (solid/gas interface). Thus, in interface science one studies the defined preparation of interfaces for specific applications, the purposive surface modification by suitable coatings as well as the development of sui-

table analytical techniques. The interfaces studied can be either of organic or inorganic origin. Typical organic interfaces might be formed for example by polymer materials. It represents great advantage of the University of Bayreuth that here colloid and interface science are represented by chairs from inorganic chemistry as well as macromolecular chemistry. The latter discipline studies primarily polymeric components and suitable additives. Besides, only by the combination of these two disciplines, it is possible to develop and to study so-called hybrid materials that have found applications as flame resistant materials as well as for gas tight barriers in packing or for optoelectronic devices. Furthermore, many other important processes in chemistry are dominated by interfaces, in particular catalysis. Another example, this time in material science, would be adhesion processes. Adhesion is not only important for the development of glues but also for the cleaning of surfaces. In addition, the structuring of surfaces on the scale of nanometers or micrometers becomes increasingly important in interface science. Typical examples are water-repellent surfaces whose design is based on the so-called "Lotus-effect". The portfolio of the BZKG is completed with the chairs from the engineering faculty that can provide expertise in polymer engineering or biomaterials.

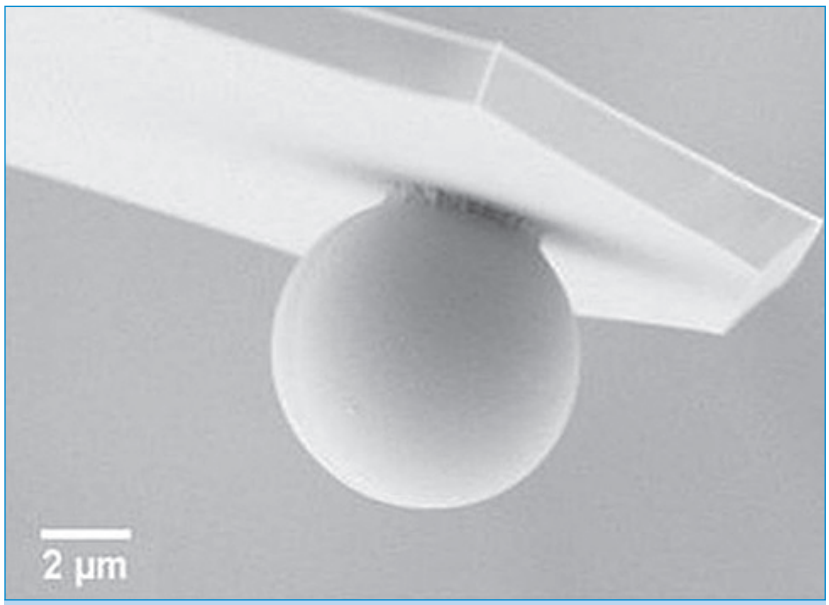
A comprehensive analytical characterization of colloidal or interface-based systems is a prerequisite in order to optimize their synthesis or applications in a rational manner. The BZKG provides also smaller companies the possibility to access a broad range of analytical techniques. It offers a number of well-known techniques, such as microscopy (scanning transmission microscopy, scanning electron microscopy, atomic force microscopy, and confocal laser scanning microscopy, etc.), light and X-ray scattering or electrokinetic methods. Additionally, more specialized techniques for characterization or synthesis are available, such as solid-state NMR, direct measurement of interaction forces, or innovative techniques for electrospinning. The research groups or key laboratories, respectively, maintain these analytical and preparative techniques. A comprehensive description of available techniques is given on website of the BZKG.



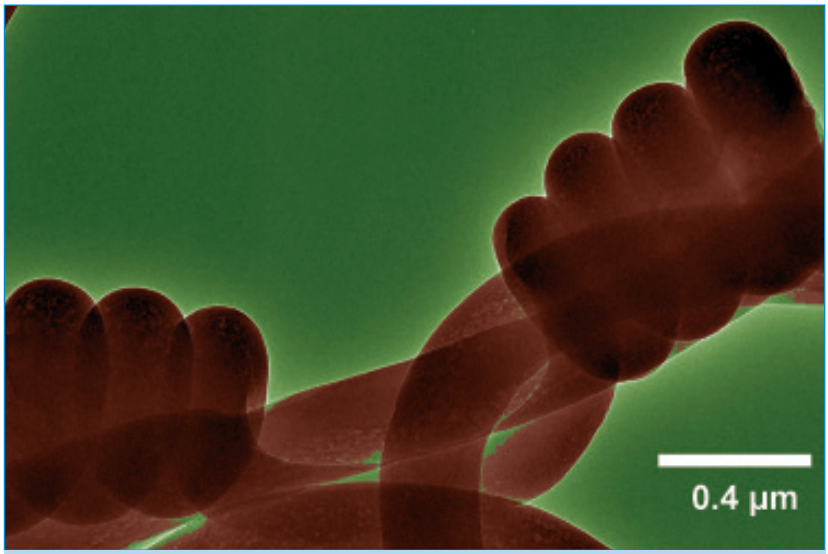
Scanning electron microscopy image of a copolymer micro-gel load by gold nanorods. (Prof. M. Karg) ■

A representative example of how the BZKG triggers synergetic effects in research are recent studies on nano-platelets: Thin sheets of phyllosilicates with highly defined properties, especially with respect to their charge and aspect ratio, have been synthesized at the chair of Inorganic Chemistry I. The mechanical properties of these platelets have been quantitatively evaluated at the chair of Physical Chemistry II with a newly developed method, which is based on the AFM and resembles tests known from the macroscopic world. In cooperation with the chair of Macromolecular Chemistry I and chair of Polymer Engineering these silicate platelets have been incorporated in a custom-designed polymer matrix in order to develop new hybrid-materials with unique properties such as optical transparency and gas impermeability.

The concept of merging different competencies available in the field of colloid and interface research at the University of Bayreuth for a specific project with one administrative contact, namely the BZKG, provides many advantages, especially for small and medium sized companies. These companies often lack of a specialized research department, here the BZKG offers a central point of contact in order to connect to the expertise of many research groups with competences in various fields. For example research groups from Inorganic and Macromolecular Chemistry as well as Engineering can jointly



By techniques like force spectroscopy with colloidal probes it is possible to determine interaction forces between microparticles and surfaces ■



These nanofibers have been prepared by coaxial electrospinning of soft and hard polymers. By choosing polymers with appropriate properties it possible to form "nano-springs" (Prof. S. Agarwal) ■

work together in a temporary fashion for a specific industry-related project, while the administrative framework is given by the BZKG. In this manner industry-related projects of various dimensions, ranging from small feasibility studies up to European collaborative research, can be administratively accompanied in a very flexible manner.

Historically, the BZKG developed from the association of five chairs at the University of Bayreuth. It was founded in July 2000 with the aim of bringing together the expertise in the various fields of colloids and interface research present in the various research groups. Prof. Dr. H. Hoffmann has been the founding director, who also significantly established and shaped the nearly 30-year old tradition of colloid and interface research at the University of Bayreuth. With the construction of a separate building, the BZKG provides also its own laboratory and office space. The support of the state of Bavaria has been essential, especially in the framework of the Bavarian HiTech-Initiative. These laboratories of the BZKG represent also the underlying idea and the spirit of this center: The open access not only to the expertise but also to the instrumental resources of all participating research groups. This principle has been followed for many years now and it represents also the basis for the Key-Lab-Structure as found today in the research priority area of "Macromolecular and Colloid Research" at the University of Bayreuth. Expensive and large instrumental equipment, such as electron microscopy are not only grouped in terms of laboratory facilities but also provided with central scientific support structure. This approach allows for an optimal scientific benefit for the users but also allows all research groups, especially those of young group leaders, a direct and non-bureaucratic access to these techniques for their projects. To date, the BZKG counts 16 members, which come from three different faculties and covers nearly the complete field of colloid and interface science. The large number of BZKG-members, which have to also contribute by membership fees to the infrastructure of the BZKG, demonstrates that this center is highly attractive, not only for collaboration partners from industry but also for the research groups at the University of Bayreuth. ■

The Bayreuth Center for Colloids and Interfaces (BZKG)

Bayreuther Zentrum für Kolloide und Grenzflächen (BZKG) an der Universität Bayreuth

Members: *16 chairs and research groups at the University of Bayreuth*

Founded: *July 2000*
(Former managing directors: Prof. Dr. H. Hoffmann 2000-2003 and Prof. Dr. M. Ballauff 2003-2009)

Managing Director:
Prof. Dr. Andreas Fery (Chair for Physical Chemistry II)
E-mail: andreas.fery@uni-bayreuth.de

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Further Information: *http://www.bzkg.de*
A comprehensive corporate brochure with detailed information regarding the participating research groups is available in pdf-format and can be downloaded from the webpage.

Core competencies of the participating research groups

Interfaces and Composites

Characterization and modification of surfaces and coatings	Prof. Fery – Physical Chemistry II
Gels, fibers, fleece on base of recombinant spider silk and silk proteins	Prof. Scheibel - Biomaterials
Preparation and characterization of microstructured surfaces	Prof. Fery - Physical Chemistry II
Hybridmaterials and nanocomposites	Prof. Müller – Universities Bayreuth & Mainz
Polymeradditive, nucleating agent, pigments – synthesis, characterization and processing	Prof. Schmidt - Macromolecular Chemistry I
Self-healing surfaces	Prof. Fery - Physical Chemistry II
Structuranalyzis in disordered or partially ordered materials – nucleation and growth, correlation of structure and properties in wrong-ordered materials	Prof. Senker - Inorganic Chemistry III
Synthesis of polymer systems of self-organizing nanostructures, analytics and characterization of complex polymer structures	Prof. Müller - Universities Bayreuth & Mainz
Ultrathin coatings on polymer basis	Prof. Fery - Physical Chemistry II
Intraction forces between particles or surfaces, adhesion in polymeric or inorganic systems	Prof. Papastavrou - Physical Chemistry II
Preparation and characterization of nanoporous capsuales and membranes	Prof. Förster - Physical Chemistry I
Synthesis of large area, high quality colloidal monolayers	Prof. Retsch - Juniorprofessur for Polymeric System
Distance-controlled assembly of nanoparticles in 2D and 3D	Prof. Karg - Juniorprofessur for Colloidal System
Preparation of functional polymer surfaces (antibacterial, superhydrophobe); and functional multikomponent nanofibers	Prof. Agarwal - Macromoleculare Chemistry II
Polymer nanofiber composites by electrospinning	Prof. Greiner - Macromoleculare Chemistry II
Funktional polymer/bacteria composites	

Particles and Colloids

„Chemical Tailoring“ of clays with multifunctional application, solid state chemical synthesis, structural analysis on the short and long range order transition	Prof. Breu - Inorganic Chemistry I
Dynamic transport phenomenae	Prof. Fischer – Experimental Physics V
Preparation and characterization of nanoporous capsuales and membranes	Prof. Fery - Physical Chemistry II
Catalysis with nanoparticles, Nanoparticle systems by molecular design	Prof. Kempe – Inorganic Chemistry II
Microparticles and capsuales on base of recombinant spider silk	Prof. Scheibel - Biomaterials
Interaction forces between particles or surfaces, adhesion in polymeric or inorganic systems	Prof. Papastavrou - Physical Chemistry II
Nanoparticles, micelles and vesicles for diagnostic and therapy	Prof. Förster – Physical Chemistry I
Synthesis of monodisperse latex particles and core-shell architectures	Prof. Retsch - Juniorprofessur for Polymeric Systems
Synthesis of inorganic/organic core-shell colloides	Prof. Karg - Juniorprofessur for Colloidale Systems
Nanopartikel composites by elektrospraying	Prof. Agarwal - Macromolecular Chemistry II
Responsive and biodegradable polymer-dispersions in water	Prof. Agarwal - Macromolecular Chemistry II
Polymer conjugated metal nanoparticle dispersions	Prof. Greiner - Macromolecular Chemistry II
Formulations for electrospinning	Prof. Greiner - Macromolecular Chemistry II
Colloid Science and their applications	Prof. em. Hoffmann - BAYCOLL
Molecular Switches	Prof. Weber - Inorganic Chemistry II