SYBD 1: Magnetic Nanoparticles in Biomedical Diagnostics and Therapy

Time: Monday 15:00–17:30 Location: H1

Invited Talk SYBD 1.1 Mon 15:00 H1

Functionalization and Pharmaceutical Aspects of Magnetic Nanoparticles (Magnetic Carriers) — •Urs O. Häfeli — University of British Columbia, Faculty of Pharmaceutical Sciences, Vancouver, BC, Canada

This presentation will review the properties and applications of modern magnetic nanoparticles and microspheres for application as nanomedical agents, both for diagnosis and therapy of different diseases. Basic applications in biomedicine and industry, clinical applications, as well as open questions regarding risk and economy will be discussed.

Important features make nanoparticles and microspheres interesting for in vitro and in vivo applications: biocompatibility, biodegradability, transport capacity, surface functionalization with biological active molecules, binding of fluorescent and radioactive markers, increasing surface area with decreasing size, organ-specific targeting.

To further increase the particles efficiency, further work is necessary in the design of effective magnetic targeting systems, the coatings for optimized particles, the choice of targeting ligands, as well as the maximization of the particles* magnetic moment. Altogether, exciting in vivo applications are possible in magnetic guidance and controlled delivery of drugs, genetic material, and stem cells, in addition to their current use for the contrast enhancement in magnet resonance imaging and local hyperthermia treatment of cancer.

For additional information about the scientific field of magnetic particles, please check out www.magneticmicrosphere.com.

Invited Talk SYBD 1.2 Mon 15:30 H1

Fluid mechanical aspects of therapeutic application of suspensions of magnetic nanoparticles — •Stefan Odenbach — TU Dresden, Chair of Magnetofluiddynamics, Measuring and Automation Technology, Dresden, Germany

One of the promising approaches for the use of magnetic nanoparticles in cancer therapy is a technique called magnetic drug targeting. Here a chemotherapeutic agent is attached to the surfactant of the magnetic particles and a water based suspension of these drug carrying particles is injected into a supplying artery of the tumour. Using appropriate magnetic fields magnetic forces can be generated targeting the particles towards the tumour. As a result chemotherapy without side effects is envisaged.

Within the talk some of these aspects resulting from fluid mechanics will be highlighted and discussed. On the one hand we'll have a look on model experiments studying the targeting process for the magnetic fluid and its dependence on magnetic field configuration. The respective experiments presented will be accompanied by numerical simulations which are intended to provide a tool for future clinical applications allowing an optimal field control on the basis of angiographic data.

The second part of the talk will focus on magnetic field effects concerning the viscosity of ferrofluids for biomedical applications as well as on changes of the flow behaviour of blood with suspended magnetic particles in a field and will thus highlight investigations on fundamental fluid properties being important for experiments as well as simulations.

Invited Talk SYBD 1.3 Mon 16:00 H1

Magnetic Particle Imaging: A new Medical Imaging Modality — •Thorsten Buzug — Institute of Medical Engineering, University of Lübeck, Germany

Recently, magnetic particle imaging (MPI) has been introduced as a novel method for direct measurement of the spatial distribution of superparamagnetic iron oxide nanoparticles (SPIOs) that are used as tracer material. The SPIOs are subjected to a sinusoidally oscillating magnetic field and respond with a nonlinear change in magnetization. The acquired induction signal contains harmonics of the fundamental excitation frequency, which are subsequently used for determination of the spatial particle distribution and concentration. For spatial encoding a magnetic gradient field (the selection field) is superimposed onto the sinusoidal excitation field (the drive field) such that a field-free point (FFP) is established at a desired location within the field of view. Nanoparticles located near the FFP contribute to the signal generation, whereas particles that are far from the FFP are in saturation and cannot contribute. Image reconstruction from the measured induction signals can be seen as the solution for the corresponding inverse problem. In this talk, the state of the art in magnetic coil design for MPI is discussed. With a new symmetrical arrangement of coils, a field-free line can be produced that promises a significantly higher sensitivity compared with the standard arrangement for an FFP. Additionally, an alternative single-sided coil assembly is presented for the use in hand-held applications.

Invited Talk SYBD 1.4 Mon 16:30 H1

Superparamagnetic iron oxide nanoparticles for MR-visible mesh implants and novel drug targeting models — •Ioana Slabu[1,2], Anjali Roeth[3], Christiane Kuhl[4], Thomas Schmitz-Rode[1], and Martin Baumann[1] — [1]Applied Medical Engineering, Medical Faculty, Helmholtz Institute, RWTH Aachen University, Germany — [2]II. Physical Institute, RWTH Aachen University, Germany — [3]Department of Surgery, University Hospital, RWTH Aachen University, Germany — [4]Department of Radiology, University Hospital, RWTH Aachen University, Germany

Two major medical applications of superparamagnetic iron oxide (SPIO) nanoparticles are presented, exploiting their physical and magnetic properties to combine diagnostic and therapeutic functionalities. First, the concept and realization of a (magnetic resonance) MR-visible mesh implant is described which facilitates an accurate determination of complications after mesh implantation by means of MR imaging. The visual investigation of the implant helps to reduce the exposure of the patient to redundant surgery interventions. Second, magnetic drug targeting approaches based on numerical simulations for cancer therapies are developed. A new concept of placing an array of permanent magnets and coils inside hollow organs of the body very close to tumors is described. In this way, a stronger magnetic field and its higher gradient are achieved in the tumor. This allows a local accumulation of administrated SPIO nanoparticles with bounded drugs and enhances the efficiency of the therapy. First simulation results are already applied and validated in animal trials.

Invited Talk SYBD 1.5 Mon 17:00 H1

Magnetic measurement techniques assisting biomedical applications of magnetic nanoparticles — •Lutz Trahms — Physikalisch-Technische Bundesanstalt, Abbestr. 2-12, D-10587 Berlin, Germany

Due to their biocompatibiliy and their small size, magnetic nanoparticles (MNP) made of iron oxide can be guided to virtually every biological environment. MNP are susceptible to external magnetic fields and can be used, e.g., for drug transportation, heat generation or as contrast agents for MRI. All these applications require knowledge about the magnetic properties and, when applied in-vivo, quantitative knowledge about the spatial distribution in the living tissue. In this contribution, I will report on a number of magnetic measurement techniques that provide such information, i.e. in particular on conventional susceptibility measurements M(H), magnetorelaxometry, and magnetic particle spectroscopy. In addition, I will give examples how these analytical or spectroscopic techniques can be modified to obtain quantitative spatial information.