Nanoparticles for Theragnostic Applications

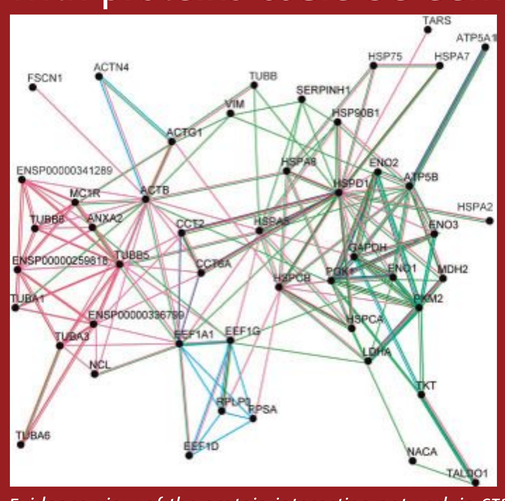
Margarethe Hofmann-Amtenbrink, MatSearch Consulting Hofmann, Pully Switzerland
Heinrich Hofmann, Swiss Federal Institute for Technology, Powder Technology Laboratory, Lausanne Switzerland

Introduction

Iron oxide nanoparticles (SPION) are promising candidates for various biomedical applications. Ranging from 7 to 20 nm in size, unique magnetic properties appear, such as superparamagnetism. Special inorganic or organic coatings and biological functionalization make these nanoparticles biocompatible, so they are of great interest for many categories of applications comprising separation, diagnosis and therapy.

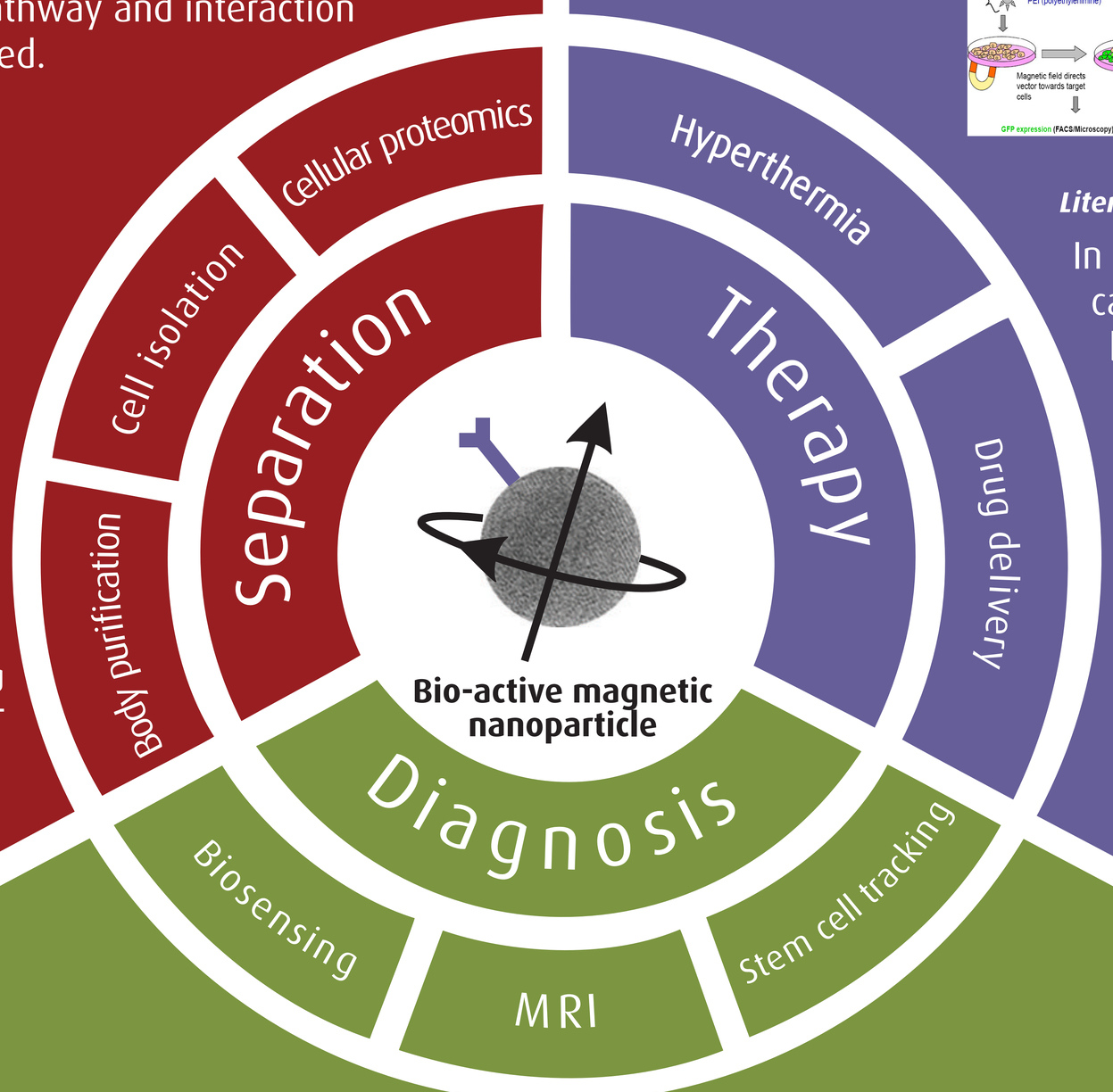
Separation:

Cell and DNA separation is well established to be done by SPION beads of several hundred nanometers. However, in the fields of system biology, drug identification etc. it is of great interest to target and separate specific organelles and proteins from the cells and their compartments and depict intracellular interaction within the living systems. To achieve magnetic separation of proteins and organelles from a cell, the appropriate choice of coating materials and subsequent coupling to a biological compound is needed. Functionalized SPIONs recovered by using a magnetic column could be targeted to mitochondria. By coupling this tool to mass spectrometry, the complex intracellular pathway and interaction with proteins could be demonstrated.



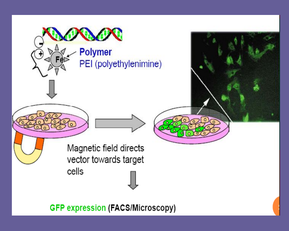
Evidence view of the protein interaction network in STRING. Different line colors represent the types of evidence for the association. Green: neighborhood, red: homology, blue: co-occurrence, brown: co-expression, magenta: experiments, light blue: databases, and light green: text mining.

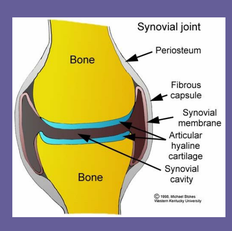
Partners:
EPFL, Lausanne, CH Institute of Bioengineering and Institute of Chemical Sciences and Engineering, Microsystems Laboratory, Proteomics Core Facility, School of Life Sciences.
Vanderbilt University Nashville, TN, USA: Department of Biomedical Engineering.
Literature:
J. Salaklang et al., Angew. Chem. Int. Ed. 2008, 47, 7857 –7860



Drug and Gene Therapy, Hyperthermia

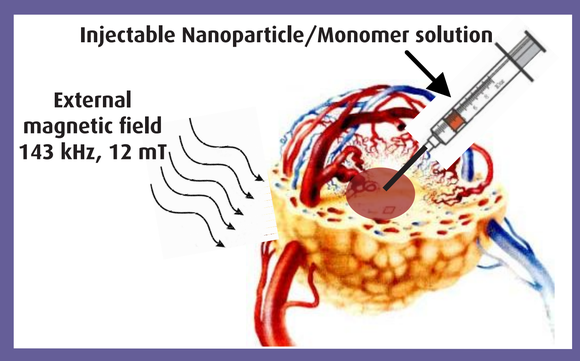
Nanotechnology-based products are significantly affecting the drug delivery sector, which is looking for safer and more personalized drug development. Similar to other nanosized carriers, SPIONs are used in drug targeting and non-viral gene delivery. This requires strong interaction with various cell compartments. Non-viral gene delivery of plasmids and novel DNA fragments (PCR products) coupled to PEI-coated SPIONs, using e.g. pulsating magnetic fields, has shown a significantly increased transfection efficiency being 40 times higher than in cells not exposed to the magnetic field.





Partners: University of Zurich, Zurich, CH
Literature: S. Kamau et al., Nucleic Acids Research

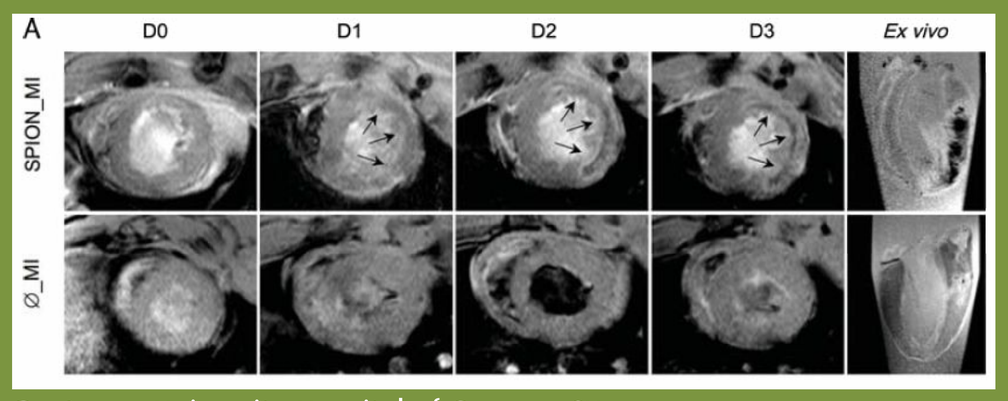
In addition, SPIONs can be used in cancer therapy because of their capability to heat up. Injectable formulations were developed, forming gels which entrap magnetic particles in a tumor.



Partners:
University of Geneva, CH
ANTIA Therapeutics AG, Bern, CH

Diagnosis

Inflammatory cells like monocytes/macrophages are involved in numerous pathologies, including myocardial Infarction (MI). FDA-approved for clinical use, iron oxide nanoparticles are potent contrast agents for magnetic resonance imaging (MRI), which is sensitive enough to detect iron-loaded cells in a living animal as well as in humans. It could be demonstrated that monocytes/macrophages can be loaded in vivo by a simple i.v. injection of iron-oxide nanoparticles, and then be tracked by MRI in the very same rodent model with excellent precision.



Partners: University Hospital of Geneva, CH
Literature: X. Montet et al., European Heart Journal, 2009

Results presented on this poster have been gained by the EU project «Magnanomed» funded in the framework of FP5, by research projects funded by the Swiss National Foundation (SNF) and by funding from the Swiss Commission of Technology and Innovation (CTI) and the ESM Foundation. Based on all these projects funded for about 10 years, a new FP7 project «NanoDiaRA» (Grant agreement NMP4-LA-2009-228929) could be launched with 15 partners. NanoDiaRA started in February 2010 and will be active until 2014.
Partners: Europäische Akademie zur Erforschung von Folgen wissenschaftlich-technischer Entwicklungen, Germany (Coordinator); MatSearch Consulting Hofmann, Switzerland (Scientific Coordination); Ecole Polytechnique Fédérale de Lausanne, Switzerland; Lund University, Department of Experimental Medical Science, Sweden; Charité - Universitätsmedizin Berlin, Germany; University of Tartu, Estonia; Universiteit Nijmegen, Stichting Katholieke Universiteit, The Netherlands; Paracelsus Medizinische Privatuniversität Salzburg – Privatstiftung, Austria; Université de Genève , Switzerland; University of Fribourg, Switzerland; CSEM Centre Suisse d'Electronique et de Microtechnique SA, Switzerland; Merck Serono SA, Switzerland; AnaMar AB, Sweden; Merck Chimie – Estapor Microspheres Division, France; Arrayon Biotechnology, Switzerland.