Nanobiotechnology

The term nanotechnology is known by well over 50% of Germans, especially since the lotus effect hit the headlines in the late 1990s. Around the turn of the millennium, "bio" was inserted between "nano" and "technology", and "nanobiotechnology" has since taken up more and more room in the headlines as well as requiring major financial investment. From 2000-2010, the German Federal Ministry of Education and Research (BMBF) invested a total of 60 million euros into the development of nanobiotechnology and in 2010 published the Action Plan Nanotechnology 2015, outlining the strategy for further responsible development, innovation and public dialogue for the period 2010-2015. So what is nanobiotechnology, what is the difference between nanotechnology and nanobiotechnology, and where and what nanobiotechnological research is being carried out in Germany, and more particularly in Baden-Württemberg, and which applications is it aimed at?

Nanoparticles that are introduced into the body for therapeutic reasons need to be taken up by specific cell types. The question as to how the human body's own molecules can bind to nanoparticles is one of the key issues that state-of-the-art nanobiotechnology seeks to answer. Proteins (cyan) can enclose a nanoparticle (green) that is able to bind on the cell membrane to receptors (blue), for example, in the same way as free protein. Further information about this topic can be found in the article "Nanoparticles: researchers to map protein corona" on the right.
© Center for Functional Nanostructures

There are huge expectations for the tiny nanoparticles because nanotechnology is regarded as a key technology of our time and a door opener for the future. Key technologies provide the basis and prerequisites for further technological developments, have huge competitive potential, create value in research and industry and are able to sustainably change economy and society.

Nanobiotechnology is a branch of nanotechnology and it brings together research on biological and non-biological systems, and on living and non-living biosystems. It is an interdisciplinary science where chemists, physicists, biologists, medical doctors and engineers work together. In scientific terms, nanoparticles are not just defined by their size (particles less than 100 nanometres in size; one nanometre is one millionth of a millimetre), but also by their specific chemical and physical characteristics. For example, the chemical reactivity of a nanoparticle changes in relation to the particle's high surface area to volume ratio.

Nanotechnology miniaturises biological processes

In principle, three aspects turn nanotechnology into nanobiotechnology: to be at the nano-size in at least two dimensions is crucial for the functioning of the application, at least one bio-component must be part of the application and there must be the potential to create the functional units or control or steering on the nanoscale. Nanobiotechnology investigates and uses the transfer between "bio" and "nano" in either direction: from "bio" to nano" (bio2nano) and vice versa (nano2bio). Bio2nano refers to the use of biological principles and materials to create new devices and systems integrated from the nanoscale, for example in the fields of information, communication, energy and environment.

In contrast, nano2bio applies nanotechnology to biological processes in order to miniaturise, control or support them, for example for producing biofunctional surfaces. Biofunctional surfaces are surfaces that have been treated using nanotechnological methods so that they promote or prevent the growth of cells, for example on stents, which must not clog. Nanoparticles also play a role in drug delivery systems where they are used as vehicles for delivering medical substances to specific locations in the human body.

As described in an article by Wolf G. Kroner, physicists and chemists are mainly interested in the capability of DNA to organize itself. Individual chemical constituents are repeatedly and reliably assembled into the same two- and three-dimensional structures. DNA is able to detect sequence errors and repair them. DNA generates its own functionality. It is possible to imitate biological structures and processes and thus generate other things than "life" – electronic data storage devices, circuits or processors that are smaller and more effective than previous ones. It is possible to use enzymes for simulating the growth of metallic nanoparticles. The coupling of anorganic particles to DNA creates functionalities for applications beyond biology – applications that are not found in nature.

Anti-inflammatory dialysis membranes and intracranial implants – state-of-the-art nanotechnology applications

Area where the blood enters the dialyser. The individual hollow fibres are embedded in polyurethane potting material.

© Gambro Dialysatoren GmbH

Gambro Dialysatoren GmbH, a global medical technology company, develops and manufactures products and therapies for kidney and liver dialysis and other extracorporal therapies for the treatment of patients with acute and chronic diseases. Gambro is currently involved in a project that aims to investigate and produce a new generation of highly selective dialysis membranes to improve the treatment of inflammation in patients undergoing chronic dialysis. The innovative dialysis membranes consist of a bundle of hollow fibre membranes. The blood is separated into plasma and platelets in the major channels; while sensitive blood cells remain in the blood compatible main channel, the blood plasma enters the porous, nanoscale part of the hollow fibre by way of tight pores. The blood flows along a bioactive surface with selective absorber molecules that quickly capture specific toxic substances from the blood plasma. The nanopores are being equipped with functional groups using a dry plasma-chemical procedure followed by a wet chemical treatment during which bioactive molecules are attached to the nanopores. The project commenced in September 2011 and is supported by the German Federal Ministry of Education and Research (BMBF) with funds totalling 2.1 million euros for a period of three years.

The INCRIMP – intracranial implant project – is funded by the BMBF and led by inomed Medizintechnik GmbH in Emmendingen (the project also involves MCS GmbH, Retina Implant AG, Plasma Electronic, the NMI Natural and Medical Sciences Institute at the University of Tübingen in Reutlingen and the University Hospital of Tübingen, all based in Baden-Württemberg). The project is aimed at the development of components and a prototype intracranial implant for diagnostic and therapeutic application in neurology and neurosurgery, e.g. for the diagnosis and therapy of epilepsy. In order to avoid the use of medicines, which are frequently associated with severe adverse drug effects, current therapeutic approaches aim to suppress the spread of epileptic activity through the targeted microstimulation of cerebral structures. However, the microelectrodes most frequently used for this purpose neither have the required long-term stability nor do they have adequate biocompatibility. The data are currently transferred by way of cables that run through the scalp, which is however associated with the risk of infection. INCRIMP is focused on developing an innovative system based on microsystems and nanotechnology that can be fully implanted into the skull and does not require energy and signals to be transferred through wires. The researchers hope that the new system will enable the safe electrophysiological and neurochemical long-term (more than 30 days) monitoring of patients and the targeted electrical stimulation of brain function at the same time as reducing the risk of complications that might arise as a result of cable connections in the scalp.

The Konstanz-based company Orthobion is developing osseo-integrative titanium and calciumphosphate coatings for (medical) plastics materials used for spinal implants. The advantages of implants with nanoscale surface properties is that the osseo-integrative coating adheres more stably to the implant and the implants themselves have a higher BIC factor (BIC = bone-implant contact), which means that the bone cells adhere better to the implant.

Nanobiotechnology in Germany

Around 1,800 institutions (as of January 2011) in Germany are focused on nanotechnology, including higher education institutions, research institutions and others (including networks, public authorities and associations), as well as 960 companies. Eleven German nanotechnology competence centres (CCNano) bring together partners from science, industry and the financial world. The number of players involved in nanobiotechnology differs considerably from one German state to another: the three top positions are held by North Rhine-Westphalia, Bavaria and Baden-Württemberg. Around 340 of the 960 companies deal with nanobiotechnology as a sub-area of nanotechnology; the majority of companies are active in more than just one field. In the field of basic research, German research institutions and universities focus mainly on the application of nanotechnology as well as on the effects nanoparticles have on human beings and the environment.

Nanobiotechnology in Baden-Württemberg

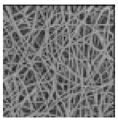
In Baden-Württemberg, nanobiotechnological research is pooled in the Functional Nanostructures (CFN) competence network, a platform that brings together researchers from a broad range of different disciplines and different research institutions in Baden-Württemberg. The question arises as to whether the understanding of functional nanostructures is really so important that a specific competence network needed to be established for dealing with these issues. The crucial factors were two particular developments: on the one hand, scientific progress in the field of nanostructuring, nanomeasurement technology, -analytics and -materials enables new products, processes and technologies to be developed for industrial application, including car varnish, catalysts, high-performance materials, medical devices, data storage devices, etc. On the other hand, progress made in other key technologies (e.g. artificial intelligence, medical technology) depends to an increasing extent on the knowledge and control of functional structures on the nanometre scale.

Dossier

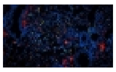
26-Mar-2012
Anja Böhme
© BIOPRO Baden-Württemberg GmbH

Other dossier articles

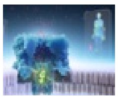
06.02.2025
Targeted, virus-free gene therapy for the eye using degradable nanopropellers



23.10.2024
Wound monitoring using sensory nanofibres



09.11.2023
Inhalation of nanocarriers for antibiotics against resistant tuberculosis pathogens



25.11.2021
nanodiagBW: using nanopores to create completely new diagnostic possibilities