NANOPARTICLES FOR BIOMEDICAL APPLICATION

Heinrich HOFMANN
Ecole Polytechnique Fédéral Lausanne
Institute of Materials, Powder Technology Laboratory
Switzerland
Heinrich.hofmann@epfl.ch

Quantum-dots and other nanosized particles with unique physical have a large impact on some important development in different medical areas like diagnostic tools (magnetic resonance imaging, MRI), in in-vitro and in-vivo detection and analysis of biomolecules, development of nonviral vectors for gene therapy, as transport vehicles for DNA, protein, drugs or cells and finally in different therapeutic tools for cancer treatment. Beside the unique physical properties induced by size ore quantum effects of the nanoparticles, the size of the particles which is with 2 to 30 nm comparable to the size of biological building blocs (protein, DNA) allows to investigate the cellular machinery without too much interfere the biological mechanisms or to interact directly with these biological unit. Understanding of biological processes on the nanoscale level is one of the strong driving forces behind development of nanotechnology. Out of the impressive number of size-dependant physical properties available for practical use of nanoparticles, optical and magnetic effects are the most interesting for biological applications. In this presentation, the use of such particles as analytical tool, as transport vehicle and for cancer treatment will be presented
In order to interact with biological target, a biological or molecular coating which acts as a bioactive and selective interface should be attached to the nanoparticles. Examples of such coatings may include antibodies, biopolymers like collagen, or monolayers of molecules that make the nanoparticles biocompatible and colloidal stable in a biological environment. The approaches used in constructing nanoparticles for biomedical and/or biotechnological application are shown schematically in Figure 1. The inorganic core of the nanosized particles allows the user to apply different external fields so that specific nano effects can be used for there detection or active therapeutic tasks For example, using gold as core material, surface plasmon resonance and their changes is used in biosensors, semiconducting core materials (ZnS, CdSe) are useful for photoluminescent effects used in biosensors or finally superparamagnetic iron oxide particles are used for imaging and drug delivery using the strong saturation magnetisation of these nanoparticles. Because the physical properties depend strongly from the size of the particles, it is evident that the size as well as the size distribution of the core particles has to be controlled carefully during the synthesis. The protective layer which gives to the particles the necessary biocompatibility is mostly consisting of biocompatible or biodegradable polymers or silica. Beside the biocompatibility, the protective layer has also to lead to a colloidal stability of the particles in water or even more important in blood or body liquid. The development of such layers is still challenging because the physical properties of the core material will be also influenced by the coating. Finally, linkers (long chain polymers) with functional groups like thiol, amino or carboxylic groups or proteins which allow a site specific binding at the cell membrane or even the translocation penetration of the particles through the membrane, (endocythosis) have to attach to the protective layer. The range of the used biomolecules is as large as the range of potential application and depends strongly from the applications, the biomolecules in contact as well as the type of cell which has to be treated. Some examples will be given in the talk describing the application of the particles.

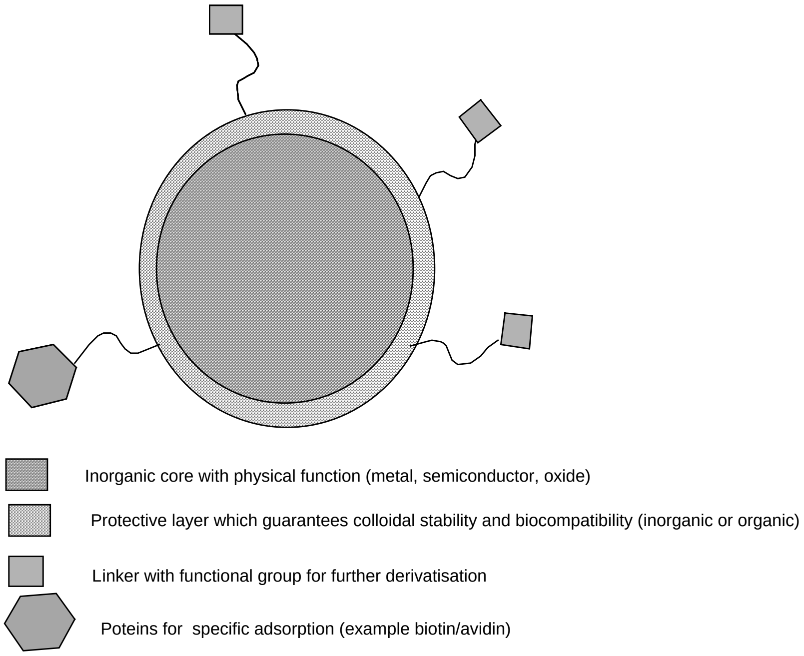

Figure 1: Typical configuration used for nanoparticles for biomedical application.

Beside single particles beads, nanoparticles embedded in a biocompatible matrix are also used. Such particles can show several functions at the some time like superparamagnetic properties useful for transport in a gradient of a magnetic field and photoluminescence for tracking or local treatment of diseases. Such multifunctional particles are mainly used for biosensors or for separation tasks. In-vivo applications are difficult because the size of the beads is very often several 100 nm and therefore to large for translocation, but still small enough for transport tasks in blood vessels.

Finally, it needs to be addressed whether certain nanoparticles have adverse health effects.