Interactions of USPIO with the Biological Microenvironment,

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Interactions of nanoparticles with the biological environment determine both their biomedical promises and their safety profile. The bio-nano-interface is where nanoparticles engineered by chemists meet biological components such as blood proteins and cells which determine their biological fate. In turn, the biological activity impacts the chemical and physical properties of nanoparticles, changing to some extent their physical response until complete degradation. The purpose of this lecture is to outline the different aspects of bio-nano-interactions and examine the consequences that may concern molecular and cellular imaging using superparamagnetic iron oxide nanoparticles (USPIO).

1) We will first describe the interactions of iron-oxide nanoparticles with cells in vitro. The way to control cellular uptake of nanoparticles, e.g. by tuning the chemistry of nanoparticle surface, will be described. In vitro cell labelling is widely used for MRI tracking of cell migration after the cells have been injected in vivo. The behaviour of the labelled cells in vivo will be discussed.

2) The second part will highlight the importance of interactions of USPIO with blood plasma after their direct administration in the circulation. The pharmacokinetic profile of USPIO is determined by early interactions with plasma proteins influencing both the surface state and the local organization of nanoparticles. Thereby what cells “see and process” is no longer the initially-engineered nanoparticles, but biomolecule/nanoparticle complexes which are formed in vivo. The biodistribution, targeting and long term fate of nanoparticles are tightly governed by their biological identity acquired in vivo.

3) In the third part, we will tackle the issue of the long term biotransformation and biodegradation of USPIO. We will emphasize the role of intracellular confinement of nanoparticles and detail the implication of iron metabolism in achieving nanoparticle transformation, while minimizing toxicity.

4) Finally, we will investigate the impact of the biological microenvironment on the NP magnetic properties. We will show how the uptake and transformation of USPIO by cells affect their superparamagnetic behaviour and NMR relaxivities, and analyse the repercussions of biological environment on short and long term cell detection by MRI.

References

- C. Wilhelm, F. Gazeau, Universal cell labelling using anionic magnetic nanoparticles
- M. Lévy *et al.*, Long term in vivo biotransformation of iron-oxide nanoparticles
- M. Lévy M *et al.*, Nanomagnetism reveals the intracellular clustering of nanoparticles in the organism
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