RATIONAL ENGINEERING OF MAGNETIC NANOARCHITECTURES FOR BIOMEDICAL APPLICATIONS

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Abstract: Magnetic nanoparticles differ markedly from bulk materials because their magnetic behavior is dominated by finite-size effects such as surface spin disorder and superparamagnetism, which become increasingly important as particle size decreases.[1] Magnetic nanoparticles have attracted considerable interest due to their potential applications in several fields, with particular relevance to biomedicine. In biomedical contexts, their superparamagnetic behavior at physiological temperature, high specific surface area, and ability to respond to AC and DC external magnetic fields enable targeted transport, controlled drug release, hyperthermia treatments, and enhanced imaging contrast.

To develop such applications, magnetic nano-architectures (MNAs) are typically engineered starting from a magnetic core that may feature complex structures (e.g., core/shell,[2] bi-magnetic nanocomposites[3,4] hollow nanostructures,[5] …), integrated with polymers,[6] mesostructured matrices,[7] bio-molecules,[8] or organic ligands. In general, the coating provides colloidal stability, biocompatibility, and functional anchoring sites, while the magnetic core ensures responsiveness to static and alternating magnetic fields, enabling magnetic targeting and hyperthermia-based therapies.

In this evolving landscape, this talk will propose a renewed vision of MNAs, in which the nanoscale arrangement of all phases and the magnetic features of the core are rationally engineered to achieve specific and optimized magnetic responses of the whole system. This concept emphasizes that magnetic functionality—whether static or dynamic—emerges not only from the intrinsic properties of the magnetic core but also from the way these are organized at the nanoscale. Indeed, interfacial effects, surface disorder, anisotropy gradients and interparticle interactions all contribute to defining the magnetic identity of the MNAs.

Key words: *magnetic nanoarchitectures; finite-size and surface effects; biomedical applications*

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