Design of (Thermo)Responsive Polymer-Grafted Nanoparticles for Biological Applications

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Nanoparticles grafted with polymers are used and developed for a multitude of biomedical and biotechnological applications (Figure 1), such as imaging contrast agents, hyperthermia treatment drug delivery, separation and purification [1,2]. Unique functions can be achieved for these applications by using nanoscale inorganic cores, such as nanoplasmonic metal cores or superparamagnetic oxide cores. However, the grafted polymer shell must prevent undesired colloidal interactions with biomolecules and cells that lead to aggregation and clearance to enable these functions in a biological environment; it also must promote desired specific biological interactions such as molecular and cellular targeting [1]. It is widely recognized that one of the best ways to achieve this is through grafting of the core particle with a dense brush of hydrophilic polymer, e.g. poly(ethylene glycol), which prevents protein and other biomolecules from binding to the particle and provides a scaffold for controlled functionalization with biofunctional ligands.

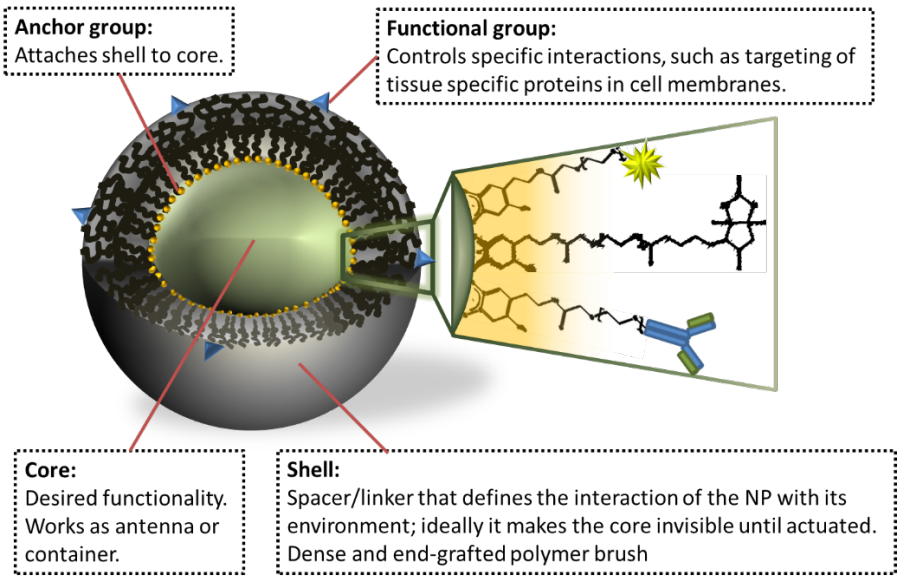

Figure 1. Schematic of nanoparticle grafted with functionalized polymer brush.

We will present our recent work on the design of monodisperse superparamagnetic iron oxide nanoparticles grafted with various sorts of polymer brushes. We will describe the influence of design parameters such as grafting [3,4], polymer chemistry [5–8], core size [5,9], molecular weight and polymer topology [10,11] on nanoparticle performance. In particular, we will present recent results on protein interactions with such particles and the influence of the particle core on the specific avidity of ligands for biomolecular targeting [9,12].

With increasing focus on multifunctional nanoparticles we have also studied how the morphology and topology of polymer shells influence the colloidal and polymer solvation transitions of nanoparticles grafted with thermoresponsive polymer shells. We provide insight into how the high curvature of nanoparticle-grafted polymer brushes decouple colloidal and free polymer transitions as well as how physiological conditions greatly change the transitions of next-generation thermoresponsive polymer coatings for biomedical applications such as poly(2-alkyl-2-oxazolines) [10,13,14].

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