Magneto and photoresponsive hybrid nanoplatforms for drug delivery and nanomedecine applications

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The design of magneto and photoresponsive hybrid nanoplatforms has become a great challenge in the field of nanomedecine[1,2]. Among the different starting materials needed for the realization of such multifunctional theranostic nanoplatforms, carbon-based materials and magnetic nanoparticles are suitable remotely wave-responsive materials respectively with near infra-red (NIR) light and magnetic field. **Carbon based materials** such as graphene, carbon nanotubes or carbon black nanospheres are able to induce a local heating under NIR laser stimuli. **Magnetic nanoparticles** (**MNPs**) are one of the most investigated ones, being able to act as negative contrast agents (CAs) for Magnetic Resonance Imaging (MRI) by shortening the transversal relaxation time T_2 of protons of water,[3] and as heat mediators (HMs) for Magnetic Hyperthermia (MH), based on the energy losses generated in MNPs upon fast magnetization reversal when exposed to an alternating magnetic field (AMF) and this local heating can be beneficial for various medical applications.[3] Such an approach constitutes currently a new area of therapeutic application displaying a rapid expansion today, especially in anticancer treatment[4] but also may be of interest in the fields of biomaterials or tissue engineering. However, regarding their use in a physiological media, these both type of inorganic NPs need to be functionalized with a suitable surface state to ensure colloidal stability, biocompatibility and drug loading/release properties. To face these latter issues, **mesoporous silica (**MS) as shell coatings of these two nanoheaters are particularly choice materials. Indeed MS are stable, easily chemically modified and has a high drug delivery (DD) capability thanks to its important pore volume [5]

Since several years, at IPCMS, Strasbourg, we have developed a deep expertise in the synthesis of a range of various MS nanostructures having well-controlled pore size (from 2.5 to 15 nm) that were used for various design of stimuli responsive NPs. In a first work, such MS NPs were used as original sacrificial templates for the preparation of drug releasing protein capsules or nanoparticles[6–8]. In another work, large pore stellate silica grafted with quantum dots and coated with polysaccharides were also used as hybrid fluorescent nanoplatforms and were assessed in zebra fish models.[9] Silica was also coated around activable inorganic nanoparticles such as magnetic NPs or carbon materials. Hence, MS shells were recently deposited at the surface of iron oxide NPs for simultaneous enzyme sensitive drug release and MRI applications.[10] They were also coated around carbon-based materials and in coll. with Dr S.Harlepp (INSERM U1109) the remote controlled and pulsatile drug release

under application of NIR light laser was achieved in vitro in aqueous solutions[11,12] At least, recently, we coated large pores stellate mesoporous silica with around magnetic cores and achieved the grafting of small quantum dots and proteins coatings within these pores. Such magnetic luminescent nanocomposites were shown useful for bimodal fluorescence /MRI imaging and magnetic hyperthermia and were investigated with cells in coll. with Dr M. Tasso (Univ La Plata, Argentina) (F. Perton et al. submitted).

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