Magnetoplasmonic Nanocapsules as Wirelessly Controlled Nanotherapies

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Advanced nanobiomedical applications have been traditionally based on chemically synthesized single-phase inorganic or organic nanoparticles. Here, we present a novel type of structure especially suited for diverse biomedical uses: magnetoplasmonic nanodomes [1,2]. The nanodomes are composed of magnetoplasmonic semishells deposited onto 100-200 nm diameter polymer beads. The very high plasmonic absorption of the nanodomes in the near-infrared is used for very efficient local optical heating for cancer treatment [1]. The nanodomes exhibit a magnetic vortex configuration which, due to its vanishing remanent magnetization, results in virtually no dipolar interactions between particles, leading to an outstanding colloidal stability of the nanoparticles despite their size [1]. Importantly, their strong magnetic character allows remote manipulation to easily concentrate them in the site of action and regulate the level of photo-hyperthermia. Moreover, due to their asymmetric shape, the nanodomes exhibit strong optic and magnetic anisotropies. Thus, rotation of the nanodomes through alternating magnetic fields can be tracked optically using their different absorption depending on the orientation. Since the rotation of the nanoparticles depends strongly on the viscosity of the medium, which in turn depends on the temperature, the optical tracking of the rotation can be used to accurately determine the local temperature change around nanodomes [2], allowing in-situ tracking of the photo-hyperthermia treatments. The same nanodome concept can be extended to drug delivery, where the semishell allows for remote control of the nanocapsule, or MRI tracking of the beads [3]. This concept of magnetoplasmonic nanocapsules loaded with paclitaxel drug has enabled complete eradication of the tumors in vivo in mice by combining magnetic concentration and photothermal actuation, using a drug concentration between 200 and 500-fold lower than the therapeutic window of the free drug [3]. We have extended this nanocapsules concept to generate enhanced tunable synergistic nanotherapeutic actuation, for example, combining simultaneous photodynamic and photothermal therapies for enhanced antibiotic effects [4].

References

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