(Intra)cellular therapies using magnetic and/or plasmonic nanoparticles : from thermal cancer treatments to tissue engineering and biotransformations.

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With the advent of nanotechnology in the field of medicine, new strategies have emerged to overcome some of the limitations of current cell therapies tools.
In cancer therapy, thermal treatments with magnetic or plasmonic nanoparticles provide noninvasive means of heating cells at therapeutic levels. While the ultimate target for nanoparticle-mediated thermal therapies is the cancer cell, heating performance was rarely evaluated intracellularly. In the attempt to bridge this gap, we provided thermal measurements mediated by magnetic [1] or plasmonic [2] nanoparticles inside cancer cells, in vitro or in vivo in the tumor environment. The ultimate goal of thermal cancer therapies is to improve the treatment efficacy and combat the tumour from within. We proposed combined nanotherapeutic concepts [3-5] based on magnetothermal, photothermal, and photodynamic therapies which led to complete cancer cell destruction in vitro and complete tumor ablation in vivo.
While magnetic nanoparticles are increasingly used as clinical agents for imaging and therapy, their use as a tool for tissue engineering opens up challenging perspectives that have rarely been explored. Our strategy has been to take advantage of magnetic nanoparticles internalization to create thick, organized, purely cellular 3D tissue structures [6,7], that can be stimulated on demand [8,9].
The use of nanoparticles for cancer cell therapies or tissue engineering raise more general issues of nanoparticles biosafety, once internalized in cells. Yet the nanoparticles long-term tissular fate is poorly documented. We have developed magneto-thermal techniques to follow the fate of magnetic and plasmonic nanoparticles and their assimilation within a living tissue [10,11].

References

[1] Di Corato, Espinosa, Lartigue, Tharaud, Chat, Pellegrino, Ménager, Gazeau, Wilhelm. Biomaterials 24, 6400 (2014) [2] Espinosa, Silva, Sánchez-Iglesias, Grzelczak, Péchoux, Desboeufs, Liz-Marzán, Wilhelm. Adv HealthCare Mat, 5, 1040 (2016) [3] Di Corato, Béalle, Kolosnjaj-Tabi, Espinosa, Clément, Silva, Ménager, Wilhelm. ACS Nano, 9, 2904 (2015) [4] Espinosa, Bugnet, Radtke, Neveu, Botton, Wilhelm, Abou-Hassan. Nanoscale, 7, 18872 (2015) [5] Espinosa, Di Corato, Kolosnjaj-Tabi, Flaud, Pellegrino, Wilhelm. ACS Nano, 10, 2436 (2016) [6] Fayol, Frasca, Le Visage, Gazeau, Luciani, Wilhelm. Advanced Materials. 25, 2611 (2013) [7] Fayol D, Du V, Reffay M, Luciani, Bacri J-C, Gay C, Wilhelm. Integrative Biology, 7, 170 (2015) [8] Mazuel, Reffay M, Du V, Bacri J-C, Rieu J-P, Wilhelm. Phys Rev Lett, 114, 098105 (2015) [9] Du V, Luciani, Richard S, Mary G, Mazuel, Reffay M, Menasché P, Agbulut O, Wilhelm. Nature Comm, In revision [10] Mazuel, Espinosa, Luciani, Reffay M, Le Borgne R, Motte, Desboeufs, Michel, Pellegrino, Lalatonne, Wilhelm. ACS Nano, 10, 7627 (2016) [11] Mazuel, Espinosa, Radtke, Bugnet, Neveu, Lalatonne, Botton, Abou-Hassan, Wilhelm. Adv Funct Mat, 10.1002/adfm.201605997 (2017)

Figures

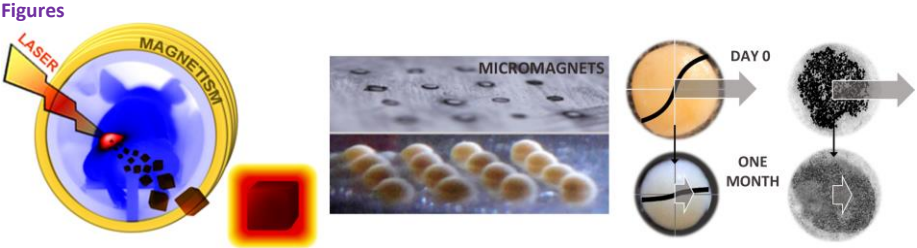

Figure 1: Magneto-photo-thermal approach in cancer therapy (left), magnetic tissue engineering (middle), and magnetic monitoring of tissular nanodegradation (right).