Nanomaterials: from syntheses to applications and evaluation of their possible toxicity risks

Carmen-Mihaela TÎLMACIU

Institut Charles Gerhardt Montpellier, UMR 5253 CNRS-UM2, Montpellier, France
e-mail: carmen-mihaela.tilmaciu@univ-montp2.fr

Herein, the first part of my presentation illustrates the work carried out during my thesis at *CIRIMAT - Toulouse*, within the framework of the Marie Curie Research Training Network CARBIO (http://www.carbio.eu). This project aimed at exploiting the potential of multi-functional single- and double-walled carbon nanotubes for biomedical applications, with a focus on anti-tumor treatment, *hyperthermia*, (secondment at *IFW Dresden - Germany*) and on *MRI* (collaboration with the *University of Enschede - The Netherlands* and with the *Hospital of Purpan - Toulouse*).
CNT were synthesised by catalytic chemical vapour deposition, using a MgO-based catalyst, which was reduced at 1000˚C in a mixture of H_2 and CH_4, containing 18 mol % of CH_4. The selectivity towards DWNT was *ca.* 80% **[1]**. After purification, they were filled with magnetic nanowires from *iron precursors* (FeI_2, $FeCl_2$ and $FeCp_2$) **[2]**, as well as from *cobalt precursors* (CoI_2), in the *melted phase*.
Filling *in solution* with chloroquine diphosphate salt, an antimalarian drug, was also successfully achieved **[3]**. Luciferase assay, MTT toxicity test, as well as HRTEM, EDX and elemental analysis were performed, in order to prove the filling and to quantify the percentage of the drug in the sample (secondment at the *University of Surrey - England*).

Then, during my first postdoctoral research performed at *ENSIC, LRGP - Nancy*, I worked on the synthesis and surface functionalization of ZnO Quantum Dots (QDs) **[4]** to render them hydrodispersible and to evaluate their cytotoxicity by surface chemistry-dependent reactive oxygen species (ROS) generation. Indeed, ZnO is one of the most promising II-IV semiconductor, (free of extremely toxic class A elements, such as Cd, Pb and Hg), that nowadays has gone through a sort of renaissance, because of its wide bandgap (3.37 eV at room temperature), which renders it a challenging material for photonic applications in the UV, blue and visible spectral range.
A sol-gel route was used to synthesize poly(ethyleneglycol)-capped blue or yellow-emitting ZnO QDs. After ligand exchange with fatty acids or amines, the obtained nanocrystals were further silanized to make them hydrodispersible. The ROS generation from QDs was found to be dependent on the surface chemistry of the both considered materials.

The last part of my presentation will be related to my current post-doctoral research at *ICG - Montpellier*, where we propose to graft a self-assembled phosphonate monolayer functionalized by silver thiolate species on titanium surface, in order to evaluate their antibacterial potential on inorganic biomaterials **[5,6]**. A combination of FTIR, water contact angle measurements and XPS spectroscopy was used to characterize the phosphonate monolayer. Besides, *in vitro* tests on *E. coli* ATCC25922 and *S. epidermidis* ATCC 12228 showed a strong decrease of the bacterial adhesion (>99.9% reduction of viable adherent bacteria) and of biofilm formation compared to the bare substrates before and after the sterilization process. Based on these results, *in vivo* tests of tolerance on mice are also in progress. Hence, the approach presented here should apply to all the metallic or ceramics biomaterials used nowadays in orthopedic applications, as a promising solution against the nosocomial implant related infections affecting patients undergoing orthopedic surgery.

[1] E. Flahaut *et al*., *Chem. Commun*., **2003**, 1442.
[2] C.-M. Tîlmaciu *et al., Chem. Commun*., **2009**, 6664.
[3] V. Sanz *et al*., *Carbon,* **2011**, 49, 5348.
[4] A. Aboulaich *et al*., *Nanotech.,* **2012**, 23, 335101.
[5] J. Amalric *et al., J. Mater. Chem.*, **2009**, 19, 141.
[6] G. Guerrero *et al., Pathol. Biol.,* **2009**, 57, 36.