Doctoral Dissertation
Doctoral Program in Bioengineering and Medical-Surgical Sciences
(32nd Cycle)

Magneto-plasmonic nanoparticles for photothermal therapy

Cristina Multari

Supervisors
Prof. Enrica Vernè
Prof. Marta Miola, Co-Supervisor

Politecnico di Torino

Summary

The activities performed during the present PhD thesis were mainly focused on the synthesis, optimization process and characterization of magneto-plasmonic nanoparticles (MPNPs) composed by a magnetic core (SPIONs) and an external gold or silver nanoparticles decoration (Au and Ag NPs respectively), that could be used as advanced system in magneto-photothermal therapy and diagnosis of cancer.

The aim was to produce these MPNPs-Au/Ag with the innovative use of tannic acid (TA), an organic compound with antioxidant, antiviral, anti-inflammatory, and anticarcinogenic properties, maintaining the peculiar characteristics of both nanomaterials. This allowed to generate a hybrid nanosystem that could act as drug delivery system and contrast agent for magnetic resonance (directly reaching the tumor site), while concurrently allowing photothermal therapy.

In particular, the MPNPs-Au/Ag were synthetized through two different route:

- In the first route the nanoplatforms were synthetized through a simple co-precipitation method in which the citric acid was used as stabilizing agent and APTES as functionalizantion to immobilize the TA reduced Au NPs or Ag NPs.
- In the second routes, the efforts were devoted to improve the preparation of MPNPs-Au/Ag usying the TA as reducing and stabilizing agent, avoiding the use of any other reagents. This allow to obtain the nanoplatforms through a new, simple and green synthesis method.

For both synthesis routes, the correct formations of MPNPs-Au/Ag were detected by physical, chemical and morphological characterization methods demonstrating the good dispersion and the correct grafting of metal nanoparticles on SPIONs surface. Then, the magneto-plasmonic properties were detected with magnetic and optical characterization which confirm their ability to maintain the peculiar properties of both nanomaterials.

Moreover, the ability of the as-synthetized MPNPs-Au/Ag to produce heat, was studied by irradiating the samples with a laser light, confirming the capability of the metal NPs to generate heating in the surrounding fluid and therefore to be potentially used for photothermal therapy.

A cytotoxicity study was also performed to preliminary asses the biocompatibility of the NPs and to establish the MPNPs concentration that would not damage the healthy cells. For this purpose, the effect of MPNPs-Au/Ag were detected both on healthy and cancer cells.

Finally, in order to analyze the efficacy of MPNPs in contact with healthy and cancer cells, a green laser source was used to evaluate the ability of Au NPs to convert absorbed light into thermal energy. Cell tests confirmed that MPNPs-Au causes an important damage of cancer cells, if exposed to laser light; while is not resulting dangerous in normal cells. This indicate that the MPNPs-Au allows to convert the light received into heating which can destroy cancer cells, due to their high heat sensitivity.

In conclusion, the synergy and the combined effect of SPIONs and metal NPs allows us to maintain the possibility of precisely driving the MPNPs to a specific tumour site using an external magnetic field, due to their superparamagnetic response, and to produce heat by converting the light received from laser irradiation into thermal energy, due to the Au NPs' decoration.

Thus, these hybrid nanoplatforms have great potential for use in photothermal therapy in cancer.