

## ABSTRACT

Cationic gold nanoparticles (GNPs) represent innovative materials promising for treating severe diseases, including cancer. Due to the unique physical properties of colloidal gold, GNPs have been shown to function as theranostics agents, allowing the diagnosis and treatment of the pathological area simultaneously. In addition, a cationic surface charge of GNPs provides extensive nanoparticle-cell interactions. However, despite the great potential in clinical medicine, various types of GNPs have contradictory results, and the studies dealing with the biological and therapeutic properties of cationic GNPs are inconsistent.

This doctoral thesis summarizes the current state of knowledge about the biological properties and medical applications of GNPs focusing specifically on positively charged GNPs. A overview of plasmonic photothermal therapy (PPTT) as a cancer treatment strategy is included. Using a step-by-step research approach, our results then characterize the therapeutic potential of GNPs with a specific shape of nanorods (GNRs) and surface modification with quaternary ammonium salt (QAS). At first, the elementary factors participating in the interaction of cationic GNRs with cells, their transmembrane and intracellular transport, and long-term persistence in cells were described. Subsequently, the safety of cationic GNRs was evaluated using cell cultures, venous blood, and mouse model. The organ distribution of GNRs after intravenous administration was investigated as well. In order to eliminate the health risk of PPTT, new types of cationic GNRs coated by hydrophilic ligands were further rationally designed and prepared. The role of the chemical structure of surface ligands on the resulting properties of GNRs was discussed. Finally, the photothermal effect of cationic GNRs was successfully demonstrated in 2D and 3D cell cultures and on subcutaneous tumor-bearing mice.

In conclusion, the results of the thesis revealed that excellent cellular uptake, high photothermal conversion efficiency, and negligible toxicity make cationic GNRs modified by QAS an optimal tool for PPTT of both malignant and benign tumors. These findings also broaden the basic knowledge about GNPs, which are essential for the successful development of therapeutic and diagnostic technologies at the nanoscale.

**Keywords:** Gold nanoparticles, nanorods, quaternary ammonium salts, cellular uptake, toxicity, biodistribution, plasmonic photothermal therapy