

UMPhST Târgu Mureș - Doctoral School
Abstract of the PhD thesis

Contributions to the biosynthesis, physicochemical characterization, and biological activity of certain metallic nanoparticles obtained using plant extract mediation.

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Nanotechnology is a branch of science that studies materials and processes at the nanometric scale (1–100 nm). The synthesis of metallic nanoparticles through traditional chemical methods often involves the use of reagents and reaction conditions that can be harmful to the environment and human health. In this context, their biosynthesis using plant extracts as reducing and stabilizing agents represents an eco-friendly and sustainable alternative. Plants utilize advanced biological mechanisms to capture metal ions from the environment. In this process, plant extracts rich in polyphenols, flavonoids, and anthocyanins play an essential role due to their chemical and biological properties. These compounds act as reducing and stabilizing agents, contributing to the formation and size control of nanoparticles. Unlike chemical and physical methods, biosynthesis using plant extracts requires lower energy consumption, involves lower costs, and allows for easy scale-up to industrial levels.

The main hypothesis of this thesis is based on the assumption that plant extracts obtained from the bark (rhytidome) of certain oak species (*Quercus dalechampii*, *Q. frainetto*, *Q. petraea*) can act as effective reducing and stabilizing agents in the biosynthesis of metallic nanoparticles, such as gold (AuNPs), silver (AgNPs), platinum (PtNPs), and palladium (PdNPs) nanoparticles. It is assumed that the biosynthesized metallic nanoparticles will exhibit not only distinct physicochemical properties but also relevant biological activities, such as antioxidant, antibacterial, antifungal, and specific cytotoxic effects, due to the compounds involved in nanoparticle formation.

Study 1. The primary objective of this PhD thesis was the biosynthesis and characterization of AgNPs using aqueous extracts from the three *Quercus* species. The polyphenols present in the extracts played a key role in reducing silver ions and stabilizing the formed particles. Following biosynthesis, a decrease in antioxidant activity was observed, attributed to the consumption of polyphenols during the reduction process. In terms of biological activity, the AgNPs exhibited strong antimicrobial effects against pathogenic bacteria such as *Staphylococcus aureus* and *Pseudomonas aeruginosa*, as well as significant antifungal activity against *Candida krusei*. However, these nanoparticles showed toxicity toward human cells at concentrations above 25 µg/mL, whereas the plant extracts were better tolerated, maintaining higher cell viability. These results indicate a promising therapeutic potential for AgNPs, but also highlight the need for careful monitoring of toxicity in the context of clinical use.

Study 2. The second objective of this PhD thesis was the biosynthesis and characterization of AuNPs using aqueous extracts from the three *Quercus* species. Polyphenols played a central role in reducing gold ions and preventing nanoparticle aggregation, a fact confirmed by FT-IR analysis, which revealed chemical interactions between the polyphenols and the surface of the AuNPs. The stability and size of the nanoparticles varied depending on the extract used. Biologically, the AuNPs exhibited lower antioxidant and antimicrobial activity compared to the plant extracts, but showed promising antifungal potential, particularly in the case of QD-AuNPs. Unlike the *Quercus* extracts, which exhibited cytotoxicity at high doses, the AuNPs were well tolerated by human cells, suggesting high biocompatibility and potential for biomedical applications. These findings support the possibility of process optimization to enhance therapeutic properties.

Study 3. The third objective of this PhD thesis was the biosynthesis and characterization of PtNPs using aqueous extracts from the three *Quercus* species. FT-IR and TEM analyses confirmed the spherical shape, uniform distribution, and chemical stability of the nanoparticles, with sizes ranging from 41 to 59 nm, depending on the *Quercus* species used. PtNPs exhibited the strongest antioxidant activity among all the nanoparticles studied, particularly those synthesized with *Q. petraea* extract (QP-PtNPs). In addition, they demonstrated enhanced antimicrobial activity against Gram-negative bacteria, especially *Escherichia coli*, as well as significant antifungal activity against *Candida krusei*. Cytotoxicity evaluations showed that PtNPs did not affect the viability of HaCaT cells even at high concentrations, in contrast to the plant extracts, making these nanoparticles promising candidates for dermatological applications due to their cellular safety profile.

Study 4. The fourth objective of this thesis was the biosynthesis and characterization of PdNPs using aqueous extracts from the three *Quercus* species. Physicochemical characterization revealed small particle sizes and a large interaction surface for the PdNPs; however, their antioxidant activity was limited due to a reduced content of active phenolic compounds in the final structure. Despite this, PdNPs exhibited selective antimicrobial activity, being particularly effective against *Staphylococcus aureus* and MRSA, as well as showing remarkable antifungal activity against *Candida krusei*, possibly mediated by the generation of reactive oxygen species (ROS). Additionally, the nanoparticles maintained high cellular viability even at elevated concentrations, unlike the *Quercus* extracts, which showed cytotoxicity at higher doses. These findings confirm the biocompatibility of PdNPs and suggest valuable therapeutic and catalytic potential.

The proposed topic clearly aligns with current trends in nanotechnology and biomedicine by developing sustainable methods for the biosynthesis of metallic nanoparticles that harness the natural bioactive compounds found in plants. The research has demonstrated that the nanoparticles obtained through this method possess valuable biological properties, such as antimicrobial, antifungal, and antioxidant activities, to varying degrees depending on the metal used and the nature of the plant extract.