međunarodni znanstveno-stručni skup
Ružičkini dani
DANAS ZNANOST – SUTRA INDUSTRIJA
18. – 20. rujna 2024. | Vukovar, Hrvatska

GREEN SYNTHESIS OF SILVER NANOPARTICLES BY USING KNOPPER GALL *Andricus quercuscalicis EXTRACTS*

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Knopper galls develop as a chemically induced distortion of growing acorns on pedunculate oak (*Quercus robur* L.) trees, caused by gall wasps of the genus *Andricus quercuscalicis* (Fig. 1.). Galls develop on all parts of plants [1] during feeding or after laying eggs and developing larvae in the plant tissue (cecidiogenesis). Plant hormones such as auxin and cytokinin are involved in cecidiogenesis, but also influence the production of tannins which accumulate in high concentrations in galls. Tannins have strong reducing properties, making them suitable for green synthesis of silver nanoparticles (AgNPs). AgNPs have a wide range of applications, including antibacterial, antiviral, anticancer, and antileishmanial activity, as well as for biochemical detection and catalysis, wastewater treatment and medicine [2]. In this work, green synthesis of silver nanoparticles was conducted using tannin-rich extracts of Knopper galls and aqueous solution of $AgNO_3$.

Figure 1. *Andricus quercuscalicis*

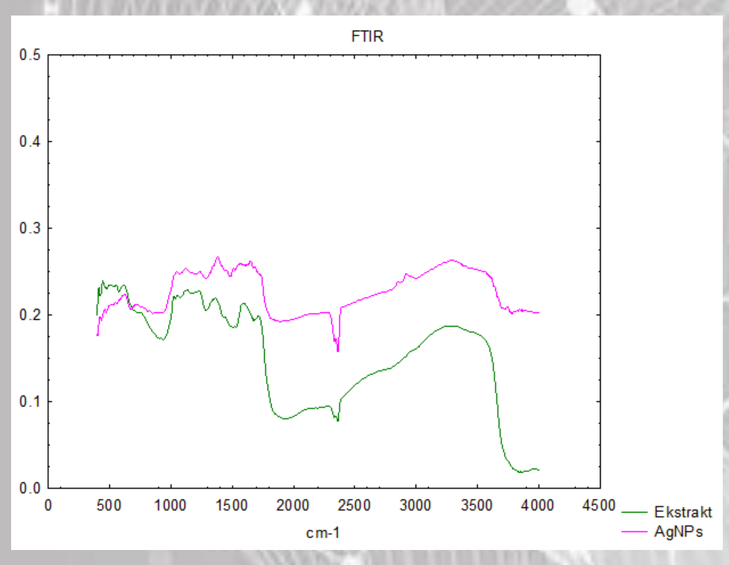

Figure 2. FT-IR spectra of AgNPs synthesized via *Andricus quercuscalicis* extract

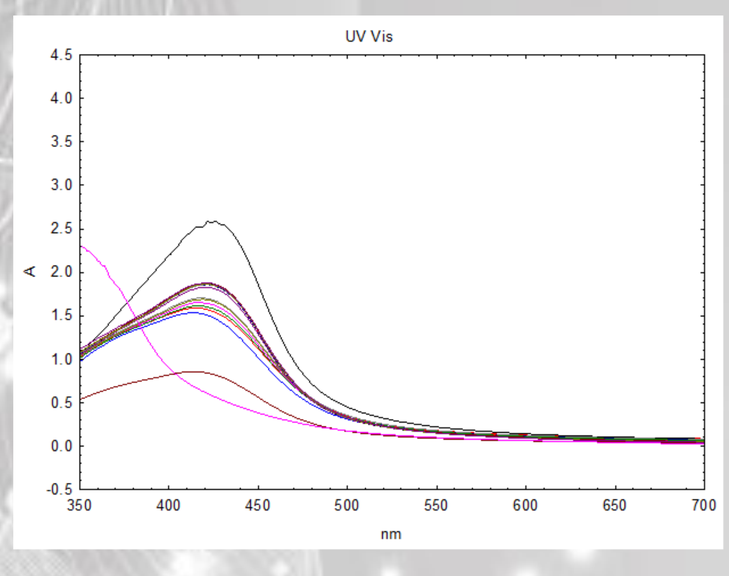

Figure 3. UV Vis spectra of AgNPs synthesized via *Andricus quercuscalicis* extract

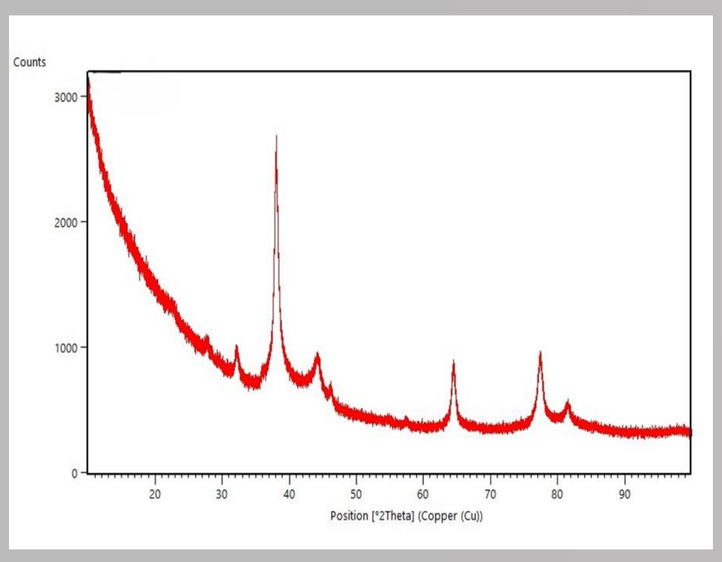

Figure 4. PXRD pattern of AgNPs synthesized via *Andricus quercuscalicis* extract

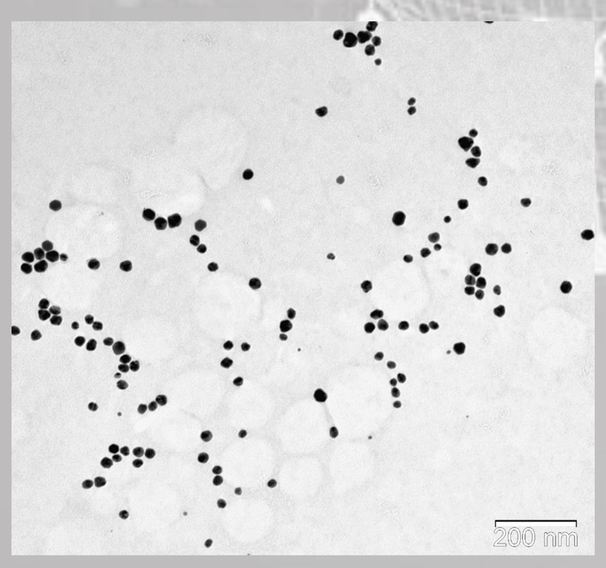

Figure 5. TEM micrographs of AgNPs synthesized via *Andricus quercuscalicis* extract

Synthesized silver nanoparticles were characterized using FT-IR analysis (Fig. 2.), UV-visible spectrophotometry (Fig. 3), powder X-ray diffraction – PXRD (Fig. 4.) and TEM (Fig. 5.). The results of the characterization of the synthesized nanoparticles indicate the successful synthesis using Knopper galls extract as a reducing agent, with UV-Vis absorption peak at 413 nm. The crystalite diameter of AgNPs was estimated to be 27 nm, using the Scherrer equation, consistent with TEM analysis.

The results of FT-IR analysis show which biomolecules are responsible for a successful synthesis of nanoparticles. The results of PXRD clearly illustrated that silver nanoparticles synthesized are crystalline in nature. The silver nanoparticles synthesized using Knopper Gall extracts exhibited significant antibacterial activity with minimum inhibitory concentrations (MIC) of 8.35 mg mL^{-1} against *Bacillus subtilis* and 4.17 mg mL^{-1} against *Staphylococcus aureus*, while showing no inhibitory activity against *Escherichia coli* and *Pseudomonas aeruginosa*. The developed synthesis method is simple, fast, and environmentally friendly since there were no waste of chemical by-products.

[1] E. Kwast, Nat.Croat. 21(2012) 223.
[2] A. Periasamy, S. C.B. Gopinath, H. Shik Yun, C-G. Lee, Journal of Molecular Structure 1177 (2019) 302.