Green synthesis of gold and silver nanoparticles from Cannabis sativa (industrial hemp) and their capacity for biofilm inhibition

Background: Cannabis sativa (hemp) is a source of various biologically active compounds, for instance, cannabinoids, terpenes and phenolic compounds, which exhibit antibacterial, antifungal, anti-inflammatory and anticancer properties. With the purpose of expanding the auxiliary application of C. sativa in the field of bio-nanotechnology, we explored the plant for green and efficient synthesis of gold nanoparticles (AuNPs) and silver nanoparticles (AgNPs). Methods and results: The nanoparticles were synthesized by utilizing an aqueous extract of C. sativa stem separated into two different fractions (cortex and core [xylem part]) without any additional reducing, stabilizing and capping agents. In the synthesis of AuNPs using the cortex enriched in bast fibers, fiber-AuNPs (F-AuNPs) were achieved. When using the core part of the stem, which is enriched with phenolic compounds such as alkaloids and cannabinoids, core-AuNPs (C-AuNPs) and core-AgNPs (C-AgNPs) were formed. Synthesized nanoparticles were characterized by UV-visible analysis, transmission electron microscopy, atomic force microscopy, dynamic light scattering, Fourier transform infrared, and matrix-assisted laser desorption/ionization time-of-flight. In addition, the stable nature of nanoparticles has been shown by thermogravimetric analysis and inductively coupled plasma mass spectrometry (ICP-MS). Finally, the AgNPs were explored for the inhibition of Pseudomonas aeruginosa and Escherichia coli biofilms. Conclusion: The synthesized nanoparticles were crystalline with an average diameter between 12 and 18 nm for F-AuNPs and C-AuNPs and in the range of 20-40 nm for C-AgNPs. ICP-MS analysis revealed concentrations of synthesized nanoparticles as 0.7, 4.5 and 3.6 mg/mL for F-AuNPs, C-AuNPs and C-AgNPs, respectively. Fourier transform infrared spectroscopy revealed the presence of flavonoids, cannabinoids, terpenes and phenols on the nanoparticle surface, which could be responsible for reducing the salts to nanoparticles and further stabilizing them. In addition, the stable nature of synthesized nanoparticles has been shown by thermogravimetric analysis and ICP-MS. Finally, the AgNPs were explored for the inhibition of P. aeruginosa and E. coli biofilms. The nanoparticles exhibited minimum inhibitory concentration values of 6.25 and 5 μg/mL and minimum bactericidal concentration values of 12.5 and 25 μg/mL against P. aeruginosa and E. coli, respectively.

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