# Green synthesized Ag/AgCl nanoparticles using Malva Sylvestris aqueous leaf extracts

Nanoparticles are molecular or atomic aggregations with a size range of 1-100 nm. Their physical and chemical properties are different from bulk materials with the same formula. They can be produced by chemical, physical and green methods; for instance, by polysaccharides, irradiation, poly oxometalates and biological methods. The advantages of green synthesis include cost-effectiveness, biodegradability and non-toxicity to the environment. Other advantages of green synthesis include the ability to control the size of the nanoparticles, sustaining biomolecules such as proteins and capacity for production in large quantities; furthermore, green synthesis is fast and simple and requires less time for production. A kind of green synthesis of nanoparticles is biosynthesis of them. In the biological method, plants, bacteria, viruses, yeasts, actinomycetes, fungi and algae are used for the synthesis of nanoparticles and the nanoparticle capping agents depend on the constitutions of the biological extract. Therefore scientists examine different biological extracts for synthesis of nanoparticles with specific properties.


Fig. 1. Biosyntheis and characterization of nanoparticles.

Silver nanoparticles are among the most widely-used nanoparticles due to their unique properties such as proper conduction, chemical stability, catalytic and antibacterial activities, ability to increase tumor temperature and use in medical imaging and drug delivery. Their physical, chemical, and optical properties are significantly linked to their shapes, sizes, compositions, and capping agents. Silver nanoparticles have different chemical forms such as Ag0, $Ag_2S$, silver oxide, silver phosphate and silver halide.

*Malva Sylvestris* is found in abundance in nature and used widely as a form of traditional medicine in Europe and Asia. It has mucilage-containing antioxidants that are used to reduce inflammation.

The leaves of this plant are rich in antioxidants such as phenols, flavonoids, carotenoids and tocopherols, which have a high reducing power.

In the present study, spherical Ag/AgCl nanoparticles with a size range of 10 to 50 nm in less than five minutes were biosynthesized. The synthesis was performed in a single step, in a low-cost and eco-friendly manner, from the aqueous extract of *Malva Sylvestris* leaves. The aqueous extract had a large amount of phenolic compounds and carbohydrates as reducing and capping agents. The nanoparticles also showed significant antibacterial and anti-biofilm activities against some multi drug resistant bacteria. They additionally showed antifungal activities on several Candida species. The highest concentration of Ag/AgCl-NPs (62.5 µg/ml) was required in order to inhibit *P. aeruginosa* B 52, *C. glabrata* and *C. parapsilosis* growth. The lowest concentration of Ag/AgCl-NPs (7.8125 µg/ml) inhibited the growth of *C. orthopsilosis, P. aeruginosa ATCC 27853* and *B. subtilis ATCC 6633*. A total of 125 µg/ml of Ag/AgCl-NPs was used to prevent *P. aeruginosa* B 52 biofilm growth. The concentration of 62.5 µg/ml Ag/AgCl-NPs also eradicated both *P. aeruginosa* 48 and *P. aeruginosa* B 52 biofilms. The results showed that $Hg^{2+}$ and $Pb^{2+}$ contaminants in water could be colorimetrically detected by these nanoparticles.

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## Publication

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