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Bio-approach for the green synthesis of silver nanoparticles

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The conventional methods of the nanoparticles synthesis most often include the utilization of toxic precursors and utilize environmentally unacceptable species (e.g. organic solvents, etc.). Therefore, green approaches for the nanoparticles synthesis are sought. One of the options is to use eco-friendly materials, e.g. plant extracts or a biocompatible waste to facilitate the formation of the nanoparticles. Moreover, these materials can serve as capping agents and cover the surface of the nanoparticles, which could be beneficial in their future utilization. Another option is to use a different method of the synthesis. As an example, the solid-state synthesis without the presence the toxic solvents can be mentioned.

In this study, the silver nanoparticles were prepared using two eco-friendly biomaterials, concretely the extract of the plant *Origanum vulgare* L. and the eggshell membrane. Both these substances contain characteristic groups, which possess the ability to reduce silver from its ionic form into the elemental form, thus causing the formation of the Ag nanoparticles. Two different methods were used in the present study, namely the classical solution-based synthesis and the mechanochemical solid-state one. The prepared nanoparticles were characterized by X-ray diffraction, Fourier-transform infrared spectroscopy, scanning electron microscopy and UV-Vis spectroscopy. The results obtained for the Ag nanoparticles prepared by the two methods are compared in the paper. In general, it can be concluded that the nanoparticles can be formed in quite a short time and in most cases, only the reducing agent and the precursor of silver (AgNO_3) are necessary. Also the successful capping of the Ag nanoparticles with the used biocompatible species was observed. These observations emphasize the green character of the reported synthesis.