

Green Synthesis of Platinum and Palladium Nanoparticles Using *Peganum harmala* L. Seed Alkaloids: Biological and Computational Studies

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Abstract

This study reports a facile and eco-friendly method for the green synthesis of platinum and palladium nanoparticles (Pt NPs and Pd NPs) using *Peganum harmala* seed alkaloid fraction. The ζ -potential of the synthesized Pt NPs, Pd NPs and Pt/Pd NPs were -11.2 ± 0.5 , -9.7 ± 0.4 , and -12.7 ± 2.1 mV; respectively. Transmission electron microscopy (TEM) revealed the formation of spherical-shaped nanoparticles with smooth margins. The mean diameters of the synthesized Pt NPs, Pd NPs, and Pt/Pd NPs were determined using TEM analysis and were found to be 20.3 ± 1.9 , 22.5 ± 5.7 , and 33.5 ± 5.4 nm, respectively. The nanoparticles' bioreduction was confirmed by ultraviolet-visible (UV-vis) spectroscopy, X-ray diffraction (XRD) and Fourier transform infrared (FTIR) spectroscopy, and their organic contents were determined by thermal gravimetric analysis (TGA). The Pt/Pd NPs mixture showed more pronounced antioxidant activity of 843.0 ± 60 μ g Trolox equivalent (TE)/mg NPs compared to the individual Pt NPs (277.3 ± 13.5) and Pd NPs (167.6 ± 4.8) μ g TE/mg NPs. Pt/Pd NPs exhibited significant cytotoxic activities against lung cancer (A549) and breast adenocarcinoma (MCF-7) cells, IC₅₀ of 8.8 and 3.6 μ g/ml for Pt/Pd NPs and Pd NPs, respectively. Pt/Pd NPs (IC₅₀ of 10.9 and 6.7 μ g/ml) and Pd NPs (IC₅₀ of 31 and 10.8 μ g/ml) showed moderate antioxidant activity. In conclusion, Pd-Pt NPs mixture prepared using *harmala* seed alkaloid fraction showed potential as effective antineoplastic agents.

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