

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, respectively. Pt/Pd NPs showed IC₅₀ of 10.9 and 6.7 μ g/ml, respectively, and Pd NPs (IC₅₀ of 31 and 10.8 μ g/ml, respectively) and Pt NPs (IC₅₀ of 23 and 9.5 μ g/ml, respectively) to explore the possible anticancer and antioxidant mechanisms of the biogenic nanoparticles. Pt NPs, Pd NPs, and their mixture showed inhibitory activity against cysteine proteinase, which supports their high antitumor activity, but moderate antioxidant activity. In conclusion, Pd-Pt NPs mixture prepared using *harmala* seed alkaloid fraction showed potential as effective antineoplastic agents.

Nanomaterials 2021, April