

Green-Synthesized Tantalum-Selenium-Hybrid Nanoparticles for Breast Cancer Treatment

Abstract:

The development of innovative therapeutic strategies for breast cancer treatment has garnered significant attention in recent years. This study explores the synthesis and characterization of green-synthesized selenium-zeolite hybrid nanoparticles (Se-Zeo NPs) using the sol-gel method for potential application in breast cancer therapy. Selenium (Se), known for its antioxidant and anticancer properties, was incorporated with zeolite, a porous aluminosilicate material, to enhance its stability, bioavailability, and therapeutic efficacy. The sol-gel method facilitated the controlled synthesis of Se-Zeo NPs under mild and eco-friendly conditions, employing plant extracts as reducing and stabilizing agents. The resulting nanoparticles were characterized using advanced techniques such as Fourier-transform infrared spectroscopy (FTIR), X-ray diffraction (XRD), scanning electron microscopy (SEM), and dynamic light scattering (DLS). These analyses confirmed the successful integration of selenium into the zeolite matrix, with uniform size distribution and high surface area. In vitro cytotoxicity assays demonstrated that Se-Zeo NPs exhibited selective anticancer activity against breast cancer cells (MCF-7) while sparing normal cells. Mechanistic studies revealed that the hybrid nanoparticles induced apoptosis through the generation of reactive oxygen species (ROS), mitochondrial membrane potential disruption, and activation of caspase-mediated pathways. Furthermore, the zeolite matrix enhanced the sustained release and cellular uptake of selenium, improving its therapeutic potential. This research highlights the promise of green-synthesized Se-Zeo NPs as a biocompatible and effective nanoplatform for breast cancer treatment.

Keywords: Selenium, Zeolite hybrid nanoparticles, sol-gel method, Fourier-transform infrared spectroscopy (FTIR), X-ray diffraction (XRD), Scanning electron microscopy (SEM), Dynamic light scattering (DLS).