

Supplementary information

Alginate Extracted from *Azotobacter chroococcum* Loaded in Selenium Nanoparticles: Insight on Characterization, Antifungal and Anticancer Activities

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Nanoparticle characterization

FT-IR

The functional groups of As/Se-NPs, and Alg-Se-NCMs were inspected using a Fourier transform infrared spectrometer (FT-IR), Thermo Fisher Nicolet IS10, (Waltham, MA, USA) spectrometer; the FT-IR spectrum ranged between 400 and 4000 cm^{-1} at a resolution 4 cm^{-1} . The nanoparticles were incorporated with KBr Pellets to determine the active groups.

Transmission Electron Microscopy (TEM)

The shape and size of biosynthesized As/Se-NPs, and Alg-Se-NCMs were assessed using TEM (JEOL JSM-6510/v, Tokyo, Japan). A drop of bio-fabricated nanoparticle solution was put on the carbon-coated copper grids and kept overnight under vacuum desiccation. The carbon-coated copper grids were then loaded onto a specimen holder.

XRD Analysis

The crystallite As/Se-NPs, and Alg-Se-NCMs was evaluated using X-ray powder diffraction (XRD) (PAN Analytical X-Pert PRO, spectris plc, Almelo, The Netherlands). The nanoparticles size was inspected using Scherrer's equation. Crystal size $L = \lambda k / c \beta \theta$, where $\lambda = 0.1540 \text{ nm}$, k is the constant factor of 0.91, θ = diffraction angle in radians, and β = full width at half maximum (FWHM).

Energy-Dispersive Spectroscopy

A field emission scanning electron microscope equipped with energy-dispersive spectroscopy (EDS) (JEOL JSM-6510/v, Tokyo, Japan) was used to investigate the surface morphology and element

contents of As/Se-NPs, and Alg-Se-NCMs. Nanoparticle solutions were centrifuged for 20 min at 10,000 rpm and drop-coated onto a thin glass film. The samples were then examined using scanning electron microscope compositional analysis, and the conformation of the presence of elemental selenium was carried out through energy-dispersive X-ray spectroscopy.

Zeta Potential

The zeta potential of the As/Se-NPs, and Alg-Se-NCMs solution provided details of the stabilization of the nanoparticles (Malvern zeta size nano-Zs90, Malvern, PA, USA).

Differential Scanning Calorimetry (DSC) and Thermogravimetric Analysis (TGA)

The thermal properties of As/Se-NPs, and Alg-Se-NCMs were studied by DSC and TGA. About 6mg sample was used to determine thermal analysis using TGA (TGA-50H Thermogravimetric analyzer). The sample was scanned at a flow rate of 40 mL/min over a temperature of 800 °C. The DSC technique is used to investigate the sample changes with temperature or time changes. The DSC thermogram behavior was investigated up to 400 °C.