ABSTRACT

Synthesis and modifications of biocompatible materials having potential therapeutic properties against pathogenic infections and carcinogenic cells.

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Nanomaterials have emerged as an indispensable option in therapeutic and biomedical applications in recent years. The two major challenges in the medical field, antibiotic resistance and the malignancy of tumors are undergoing exponential escalation globally. Our study involves the development of nano-sized materials having dual therapeutic properties. Fabrication of these nanoparticles involves polymer or fluorescence materials, along with unconventional drug integration. In the pursuit of methods that are cost-effective and environmentally conscious, naturally abundant polymers and natural extracts have been harnessed for the synthesis of these nanoparticles. The green synthesis method has been pursued to generate nano-sized materials, which are considered for developing an efficient therapeutic system specific to the targeted cell with less toxicity.

Here we reported some nanoscale materials like Hydroxyapatite, Zinc Oxide, Silver, herbo-metallic medicine, and Zinc Sulfide, that are biocompatible with human normal cell lines and have potential activities against pathogenic bacterial strains and cancer cells. We have used synthetic vehicles like hydroxyapatite and natural polymers like gum acacia for capping the biomimetic nanoparticles to enhance their biocompatibility and feasibility. In addition, we used antibiotics and different therapeutics to target the specific cell and used fluorescence material for bioimaging.

Along with synthesis we have also observed and analyzed the physical characterizations of the materials and done different in vitro biological characterizations. These functionalized nanomaterials are thoroughly characterized by employing Field Emission Scanning Electron Microscopy (FESEM), Transmission Electron Microscopy (TEM), Powder X-Ray Diffraction (XRD), Thermogravimetric analysis (TGA), Fourier-Transform Infrared Spectroscopy (FTIR), Ultraviolet-Visible Spectroscopy (UV-Vis) and Dynamic light scattering (DLS) techniques etc.

To establish the efficacy of these functionalized antibacterial agents we have performed methods like minimum inhibitory concentration (MIC), minimum bactericidal concentration (MBC), agar well diffusion method, evaluation of intracellular reactive oxygen species (ROS) generation, bacterial cell survivability assay, etc. To evaluate the biocompatible properties of our nanomaterials we have performed cytotoxicity assay.
To assess the effectivity of functionalized anticancer nanoparticles we performed methods like MTT assay and estimation of Intracellular ROS generations by DCFDA method. We observed the comparative targeted delivery of the nanomaterials depending on pH.

To understand the mechanism of the therapeutics apoptotic cell quantification was done by Annexin V-FITC staining. The mitochondrial membrane potential was examined with the help of JC1 staining. The intracellular GSH (Glutathione) and NADPH levels were evaluated using sensing luminescence GSH-Glo™. Glutathione Assay kit (Promega) for GSH measurement and Amplite™ Fluorometric NADPH Assay kit (Advancing Assay & Test technologies [AAT] Bioquest, USA) for NADPH was used. Mitochondrial ROS measurement was estimated with the help of MitoSOX™ and nuclear morphology was examined with the help of DAPI staining (these later experiments were performed for Gum acacia capped Zinc oxide nanoparticles and herbo-metallic drug only).

So, our research is focused on the synthesis of therapeutic materials, their modifications, and their effective delivery against pathogenic infections and cancer cells. Our research has a comprehensive and dynamic approach. We followed meticulous synthesis procedures where we encapsulate nanomaterials with natural therapeutics and modified their properties for strategic development for precise targeting. With cutting-edge techniques and a profound commitment to advancing biomedical science, our endeavors stand poised to reshape the landscape of medical interventions, offering new hope in the battle against pathogenic infections and the relentless progression of cancer.

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