Synthesis and characterization of nanoparticles and their bio-catalytic applications

ABSTRACT

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Abstract

In summary, different shapes and sizes Pd nanoparticles, like 8-10 nm edge length truncated octahedron/fivefold twinned pentagonal rods and 17-20 nm edge length hexagonal/trigonal plates have been prepared in aqueous solution phase by reducing K_2PdCl_4 with ascorbic acid in the presence of surfactant PEG via sonochemical method at room temperature. XRD study revealed particles growth took place anisotropically at both temperatures. FTIR and SERS studies revealed adsorption of AA and PEG at NP's surface. The particle's size distribution graph indicates formation of particles having wide size distribution while the zeta potential value -13 mV indicated that the particle's surface is negatively charged and hence stable. The truncated octahedron/fivefold twinned pentagonal rods shaped Pd NPs, formed at room temperature while thermally stable and kinetically controlled hexagonal/trigonal plate-like Pd NPs have been evolved at a higher temperature 65 °C. The obtained Pd NPs has a high surface area and narrow pore size distribution. The computationally calculated binding energy indicates this Pd cluster is an effective drug against cancer cells. The lowest binding energy is with 2ITY complex. Molecular Docking gives the best and stable conformations of the ligand with proteins in the receptor active pocket. Biochemically, the effect of PD NPs on A-549 human lung cancer cells exhibited that cytotoxicity is dependent on the dose of NPs. The results described here indicate much potential for use of these NPs in biomedical applications as described in third chapter.

Synthesis of PEG-coated and L-ascorbic acid stabilized mesoporous α-Fe_2O_3 NPs (LAA@IONP-PEG) has been achieved in the sonochemical assisted method using aqueous solution mixture of complex $K_3[FeCl_6]$, PEG and L-ascorbic acid.

LAA@IONP-PEG have been evolved in varieties of shapes and size as revealed in TEM, FESEM, EDX, UV-visible, FTIR, XRD and BET studies. Initially formed metastable β-FeOOH transformed into a stable α-Fe_2O_3 phase during the reaction at 37 °C. The anti-cancer study of LAA@IONP-PEG against renal carcinoma HEK-293 human embryonic kidney cell lines study suggests that high surface area with a large number of active sites mesoporous α-Fe_2O_3 nanoparticles are well suited anti-cancer agent and serve as promising candidate for treatment of renal carcinoma HEK-293 human embryonic kidney cell lines. Docking study has confirmed the anti-proliferative action of NPs through binding affinity with renal carcinoma molecular targets. The synthesized NPs show a synergistic effect with Axitinib as an anti-cancer drug effective against renal carcinoma cell lines. Cytotoxicity and IC_{50} analysis led to detailed changes in the enzyme structure. The nanoparticles sample may be a good antioxidant agent during the cancerous condition of a cell. The results from the experimental and theoretic studies served as a valuable anti-cancer tool against renal carcinoma drug therapy in future as described in fourth chapter.

LAA@Cu_2O-PEG nanopolyhedra has been via sonochemical assisted method using aqueous solution mixture of complex $K_3[FeCl_6]$, PEG and L-ascorbic acid at a temperature 37°C. LAA@Cu_2O-PEG has been evolved polyhedral. The anti-cancer study of LAA@Cu_2O-PEG against renal carcinoma HEK-293 human embryonic kidney cell lines study suggests that high surface area with a large number of active sites nanopolydera are well suited anti-cancer agent and serve as promising candidate for treatment of renal carcinoma HEK-293 human embryonic kidney cell lines. Docking study has confirmed the anti-proliferative action of NPs through binding affinity with renal carcinoma molecular targets. The synthesized NPs show a synergistic effect with Axitinib as an anti-cancer drug effective against renal

carcinoma cell lines. Cytotoxicity and IC_{50} analysis led to detailed changes in the enzyme structure. The nanoparticles sample may be a good antioxidant agent during the cancerous condition of a cell. The results from the experimental and theoretic studies served as a valuable anti-cancer tool against renal carcinoma drug therapy in future as described in fifth chapter.

Sonochemical method for synthesis of nickel nanoparticles was analysed via UV-visible absorption spectroscopy shows λ_{max} value due to the quantum confinement of Ni NPs. The XRD analysis shows that the Ni NPs are highly crystalline with face centred cubic (fcc) structure. EDAX data confirms the presence of prepared Ni NPs. The FTIR and Raman spectra confirm the formation of PEG grafted and L-ascorbic acid coated Ni NPs and presence of fundamental phonon peaks. Morphological studies using the SEM, FESEM and TEM analysis shows cube shaped nickel nanoparticles. BET results show formation high surface area mesoporous Ni NPs. The prepared Ni NPs are shown effective cytotoxicity against MCF-7 breast cancer cell lines. The results were supported by morphological analysis of treated and controlled cells. The normal and regular morphological pattern is observed in untreated cells and irregular cell morphology is seen in cells treated with Ni NPs. This study has proposed the best and simple protocol to synthesize Ni NPs with an effective anticarcinomas activity against MCF-7 breast cancer cell lines as shown in sixth chapter.

LAA-PEG@Ag-Au NCs have been successfully synthesized by using the simple sonochemical method. A comparative study of their characterization and pharmacognostic properties has been estimated. Our finding makes another proof that the stability of AA-PEG@Ag-AuNCs increased coating of L-Ascorbic acid. Further, it also seems that the L-Ascorbic acid-coated LAA-PEG@Ag-Au NCs are effective

against lung carcinomas A-549 Lung cancer cell lines as the MTT cytotoxicity analysis has shown a decrease in cell viability with an increase in drug concentration. The increased cell ROS, glutathione and MMP shows that the nanocomposites are to be effective for the A-549 Lung cancer cell lines and the best drugs for the future perspectives. Thus our present study proved that L-Ascorbic acid loaded LAA-PEG@Ag-Au NCs, may lead to a greater impact in the carcinomas clinical area as targeted drug delivery besides recommending it for lung cancer in particular. Therefore it is concluded that LAA-PEG@Ag-Au NCs possess the versatility to overcome some of the challenging impediments in the treatment of carcinomas as shown in seventh chapter.

Scope and Further Research

In the present work an inorganic nanoparticle/nanocomposite of various metal salts has been synthesized, however shape and size distribution of the materials may also modify to alter the responsiveness of the prepared nanoparticles. Hence an effort may be used to different type of growth of materials to made optimisation of various nanostructure.

To risen the value of effectiveness of nanoparticles against diagnosis, number of suraface modifications has been performed via capping with organic polymers like polyaniline, polydodecylether (Brij-58) etc.

To explore surface modifications of nanostructures with different morphology against analysis like anticarcinomas, pathogenic and virological responses.