ENGINEERING OF ZnO NANOPARTICLES FOR VARIOUS BIOMEDICAL APPLICATIONS

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ABSTRACT

Zinc oxide, owing to its multiple characteristics like the ease of synthesis, tunable optical and other physiochemical characteristics, and ability to be decorated with desired functional groups, is a desirable and popularly used material in varying biomedical applications. The thesis explores methods for engineering numerous properties of zinc oxide nanoparticle along with their distribution for intended biomedical applications.

The work focuses on developing a facile wet-chemical method to tune the band gap of ZnO crystals. Lowering of band gap due to introduction of additional defects has helped the particles to fluoresce at an excitation of 488 nm, mitigating the ill-effects of UV light incurred in bioimaging. The presence of interstitial defects has ensured fluorescence in biological media helping the particles to serve their purpose as bioimaging agents. Upon exposure to human dermal fibroblasts, the ZnO_{20T} particles (ZnO synthesized with 20% v/v Tween 80) internalized, while the excellent biocompatibility of the particles has been explained by the altered conduction band. Finally, the particles are seen to retain their native antibacterial property.

Secondly, the obtained ZnO_{20T} nanoparticles have been functionalized with Poly-l-lysine (PLL) to ensure higher fluorescent intensity by resisting fluorescent quenching. This ensures long-term monitoring of cell-nanoparticle interaction compared to existing literatures which report the same only up to 6 h. When exposed, ZnO_T_PLL particles (PLL coated ZnO_{20T} nanoparticles) demonstrate differential toxicity towards breast cancer MCF-7 cells while being biocompatible towards healthy L929 cells, thus justifying their applicability as

anticancer agents. Internalization of the ZnO_T_PLL nanoparticles are governed by pseudo-first order kinetics which has been monitored using laser scanning confocal microscope (LSCM). Further, LSCM helps in determining the reactive oxygen species generation in MCF-7 cells over the course of time. The proposed framework proves to be an effective method for investigating nanoparticle-cell interaction and evaluation of therapeutic efficiency

Lastly, ZnO_{20T} nanoparticles have been uniformly distributed in Polycaprolactone (PCL) matrix by tailoring the applied voltage in electrospinning while fabrication. Along with nanoparticle distribution, the modulation of voltage has been found to have a profound effect on other microstructural properties and zinc ion release, resulting in conspicuous ramifications on the cell proliferation capabilities of the mats. Further, excellent in-vivo biocompatibility of the optimized ZP_{22} mats (ZnO_{20T}/PCL mats fabricated at 22 kV) accompanied by re-epithelization and dermal regeneration capabilities show its prospective application in non-invasive wound healing applications.

Keywords: Band Gap, Cytocompatibility, 3D imaging, Therapeutic agent, Electrospinning, Cell-proliferation.