ABSTRACT

Nanotechnology commended novel development in science to specify innovative inventions by manipulating substances at nano-scale. Due to limitations with conventional chemical fabrication protocols, latest techniques still being followed for nanomaterials. Among the physicochemical approach, biogenic synthesis in term of precursor (plant extract), the nucleation process was investigated. Green synthesis had been considered cheap, eco-friendly, efficient and acted as both reducing and capping agents. This present study is on the scrutiny of *Aloe Barbadensis* leaves extract for efficiency to fabricate iron oxide, zinc oxide and copper oxides nanoparticles. Furthermore, the scope and applications of MO-NPs in the industrial and biomedical precinct has been reported. Metal oxides exhibited novel properties in the sorption process, anticancer drug loading, nano food packaging, antimicrobial activity due to mechanical strength, enhance surface to volume ratio. This study presents coverage of different MO-NPs application in distinct fields. The morphology and nature of the above-fabricated MO-NPs were investigated by modernized characterization techniques like X-ray diffraction (XRD), UV–visible spectroscopy, scanning electron microscopy (SEM), Fourier transforms infrared (FTIR) and spectrometry transmission electron microscopy (TEM). The XRD analyzed the average size of for SC: C-1, Z-1and F-1 metal oxides samples, SEM images described tetrahedral, rhombohedral and hexagonal shape of copper oxide, iron oxide and zinc oxide nanoparticles. FT-IR analysis confirmed the alcoholic, phenolic and proteins groups responsible for the biogenic reduction.

The present study aims to explore the adsorption of two azo dyes Congo red and malachite green from aqueous solutions by low-cost adsorbent three MO-NPs sample codes (SC:C-1, Z-1and F-1)under various experimental conditions. The contact time effect, pH influence, concentration of azo dyes, and adsorbent dose were studied. The kinetic and equilibrium isotherm experimental data were applied to investigate the mechanism of pseudo-first-order (PFO), pseudo-second-order (PSO), Elovich model, Langmuir equilibrium isotherm and Freundlich isotherms. The graphical results imply that both azo dyes adsorption nicely followed the pseudo-second-order kinetic model with high-correlation coefficients ($r^2 \approx 0.991$), Langmuir isotherm and Elovich model

at 318 K, however, pseudo-first-order model and Freundlich isotherm non-fitted to experimental data. The maximum percentage removal of azo dyes MG and CR at 318 K were observed 90% and 92% by SC: Z-1(AV). The results of the present study substantiate that MO-NPs are promising adsorbents for the adsorption of the azo dye Congo red and Malachite green.

The MO-NPs iron oxides, copper oxides and zinc oxides had been applied extensively for antibacterial and antifungal activity by using agar well diffusion method adding 0.9% saline solution. In this study, three biogenically synthesized MO-NPs by especially Oral infectious pathogens Bacterial strains (Escherichia coli, Bacillus Subtilis, Bacillus Licheniformis, Klebsiella pneumonia) and fungal strains (*Aspergillus Niger, Candida albicans)* were used as test microorganisms. The effect of particle size and concentration of nano metal oxides (2.5 µg/mL, 5µg/mL, and 10µg/mL) were studied by different parameters like zone of inhibition (ZOI), minimum inhibitory concentration (MIC) and minimum bacterial concentration (MBC) and performed in nutrient agar and broth. The zone of inhibition of zinc oxide nanoparticles at a concentration of 10 µg/mL was calculated after 24hours about 27 mm, 23 mm, 24 mm, 21.2 mm and 20.5 mm for test microorganisms. The results proved that inhibition zones are effectively increased with time. The iron oxide nanoparticles exhibited the lowest zone of inhibition 18 mm, 14.6 mm, 13.5 mm, 12.8 mm and 11.7mm and copper oxide nanoparticles demonstrated intermediate zone of inhibitions 20mm, 18mm, 17.5mm, 17.8mm, 15.2 mm and 14.5mm. The results demonstrated that among the transition metal oxides zinc oxide being least particle sized and highest concentration enhanced the antimicrobial activity for all bacterial and fungal strain applied with the highest concentration of 10µg/mL.

Zinc oxide nanoparticles and silica gel dressing in wound healing found non-irritant and healing ability. In conclusion, here we reported an eco-friendly, feasible and short time preparation of zinc oxide nanoparticles and silica gel enhanced wound skin elasticity, no inflammation, blood clotting and positive effect on skin repairing. The silica gel and nano zinc dressing showed controlled degradation, blood clotting, activation of platelets and swelling as compared to control samples. The graphical representation of percentage wound closure on mice skin was 95% recovered by SG/ZnO-NPs dressing, 76% with ZnO-NPs bare and 61% in control samples.

For environmental sustainability and safety degradable PLA (polylactic acid), polymers were synthesized by adding ZnO-NPs as filler for increasing the shelf life of

fruits in nano food packaging. Grapes (*Vitis vinifera)* changes their texture and taste within a short time of storage by normal packaging materials, the storage life of fruits could be enhanced by nanomaterials for well adheration of nano metal oxide ZnO-NPs / PLA (polylactic acid) films, which act as antibacterial and oxygen scavenging agent. Recent work demonstrated that nano zinc oxide metal-based polymers.

Emerging drug delivery strategies hold promise to treat triple-negative breast cancer with reduced toxicity and enhanced efficacy. Green synthesis based metal oxide nano formulation drug delivery system modifies bio distribution and pharmacokinetics of encapsulated chemotherapeutic drugs, exposing the neoplastic tissue against the enhanced concentration of the drug released and reduced exposure to normal tissue. This pragmatic study aims to develop zinc oxide nanoparticles (ZnO-NPs) by green synthesis using aloe vera (*Aloe barbadensis*) leaf extract (ALE) to evaluate in vitro anti-tumour cytotoxic activity of naked and surface functionalized ALE-ZnO-NPs and their drug loading capacity against doxorubicin (DOX) and gemcitabine (GEM). Morphological, optical and structural properties of ALE-ZnO-NPs were characterized by scanning electron microscopy (SEM), energy dispersion X-ray diffraction (EDX), UV-Vis spectrophotometry, Fourier-transform infrared analysis (FTIR) and X-ray diffraction (XRD). The ALE-ZnO-NPs was hexagonal with an average particle size of 10-20 nm with an absorption peak at 325 nm. Weight and atomic percentage of zinc (50.58% and 28.13) and oxygen (26.71% and 60.71%) as determined by EDX and FTIR peak at 3420 m^{-1} confirmed synthesis of zinc oxides particles at the nanoscale. Drug loading efficiency (LE) and loading capacity (LC) of naked and PEGylated ALE-ZnO-NPs was analyzed. DOX showed superior LE 65 % (650 mg/g) and LC 32% (320 mg/g) against GEM LE 30.5% (30mg/g) and LC 16.25 % (162 mg/g) on ALE-ZnO-NPs. Similar pattern of trend was observed in case of PEG-ALE-ZnO-NPs, where DOX had amplified LE 68% (680mg/g) and LC 35% (350)mg/g in contrast to GEM with 35% (350mg/g) and 19% (190mg/g) respectively. Therefore, we chose DOX encapsulated nanoparticles along with naked ones to check their in vitro antiproliferative potential against triple-negative breast cancer cell line (MDA-MB-231) through MTT assay. The ALE-ZnO-NPs and DOX-ALE-ZnO-NPs exhibited anti proliferative activity but DOX-PEG-ALE-ZnO-NPs proved potent combination nano formulation among all with less than 50% cell viability at 80ug/ml and 120ug/ml concentration.