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SYNTHESIS OF ACRYLIC ACID-BASED ZINC OXIDE NANOCOMPOSITE WITH ANTICANCER APPLICATION

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ABSTRACT

The zinc oxide nanoparticles were synthesized using *Brassia actinophylla* (*B. actinophylla*)flower extract. The ZnO nanoparticles were introduced into TDA hydrogel (T-tartaric acid, D-diethylene glycol, A-acrylic acid) to form the TDA-ZnO nanocomposite. The UV-peak was observed at 280 nm and the FT-IR peak was obtained at 685 cm^{-1}confirming the presence of nanoparticles in the hydrogel. The nanoparticle's size was confirmed by TEM and SEM analysis. The anticancer activity of polymer nanocomposites was performed against the A549 lung cancer cell line and the results have been recorded and compared.

Keywords: Nanoparticles, Hydrogel, Polymer Composite, Antibacterial Activity, Characterization, Plant Extract.

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INTRODUCTION

There are physical and chemical methods to synthesize nanoparticles, currently biological systems and microbes are being used more frequently to create metal nanoparticles due to their easier manufacturing and more environmentally friendly process. The materials of the 1-100nm range were highly focused by the researchers in the nanotechnology field. The nanosized materials found tremendous applications in material science and engineering. Due to their change in properties based on size and shape used in catalysis, medicinal drug delivery, and energy storage devices.[1]Metal oxides damage the cell wall structure of bacteria during the experimental process. The bacterial cell wall constitutes peptidoglycan (PG), gram-positivebacteria cell wall thickness is 20-50 nm, and Gram-negative bacterias possess less thickness.[2]The antimicrobial effects of NiO NPs produced with *Croton macrostachyus* plant leaf extract were tested against the selected bacterial strains and resulted in appreciable biological activity.[3,4]The graphene-based nanomaterials were applied to the cell membrane of bacteria which leads to cell death by diffusing into cell walls. Copper oxide nanoparticles introduced in cellulose material improved the antibacterial activity so the composite material was suggested for use in packaging and paper coatings. Due to the extensive antibacterial activity gold gold-based nanocomposites found applications in the food industry and medical field.[5]Metal oxides were used in biosensors for the detection of cancerous cells. Since it has a smaller size and, a high surface area to volume ratio, biocompatibility easily comes into contact with cancer cells and destroys them.Tartaric acid (TA) is found in several fruits.[6]The toughness and tensile strength of TA-based nanofillers are superior to polypropylene and also economical and eco-friendly.

The TA/ZnO composite with the appropriate ratio improves hydrophilicity and photocatalytic activity than the separate TA and ZnO. Polyethylene glycol-based hydrogels are temperature responsive so it is used in drug delivery applications. Diol improves the elastic modulus and toughness when it is introduced into graphene oxide. The presence of diol in IAD(I-itaconic acid, A-acrylic acid, D-diol) improves the biological activities like antibacterial and antifungal activities also it is responsible for the pH sensitivity of the hydrogel.[7] The present study aimed for the synthesis of TDA (T-Tartaric acid, D-Diol, A-Acrylic

acid) based TDA/ZnO polymer nanocomposites, and the anticancer activity was tested against the A549 lung cancer cell line.

EXPERIMENTAL

Green Synthesis of Zinc Oxide Nanoparticles (ZnO NPs)

The ZnO NPs were prepared by solution combustion method using *B. actinophylla* flower extract as a fuel. In order to synthesize nanoparticles, 0.1 g of dried crude aqueous extract and a stoichiometric amount of zinc nitrate hexahydrate were constantly stirred for 10 minutes to get a homogeneous mixture and heated at 400±10ºC for 5 minutes. At the end, the sample was taken out from the muffle furnace. The synthesized white-colored ZnO nanoparticle was stored in an airtight container for further analysis.[7]

Synthesis of TDA-ZnO Polymer Nanocomposite

The metal oxide nanoparticles (ZnO) synthesized using *B. actinophylla* flower extract were introduced into TDA hydrogel for the polymer nanocomposites TDA-ZnO synthesis. During the synthesis, 0.2 g of green synthesized NPs obtained from *B. actinophylla* flower extract were added into TDA hydrogel with constant stirring at 160 ºC for 4 hours. ZnO NPs were added to TDA hydrogel to synthesize white color TDA-ZnO polymer nanocomposites. Finally, the polymer nanocomposite was washed with de-ionized water, and dried at lukewarm conditions for 48 hours.

RESULTS AND DISCUSSION

UV-Visible Analysis

Figure-1a shows UV-peak of TDA-ZnO polymer nanocomposites, the ZnO NPs dispersion was controlled in the TDA hydrogel, so that the peak was observed at 280 nm.[8]

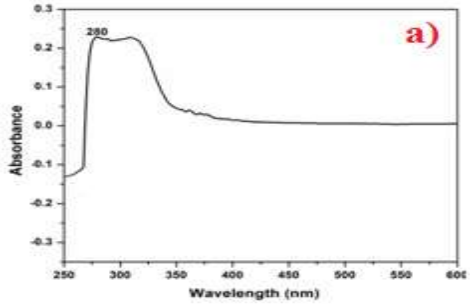

Fig.-1a: UV-Vis Spectrum Polymer Nanocomposites TDA- ZnO

FT-IR Analysis

The FT-IR peak of TDA-ZnO is shown in Fig.-2. The OH stretching peak was obtained at 3447 cm^{-1} indicating the presence of tartaric acid. The –CH stretching peak, acrylic acid ester bond C=O obtained at 2951 cm^{-1}, 2353 $cm^{-1,}$ and 1732 cm^{-1}. The –C-O stretching bond of the diethylene glycol peak was observed at 1261 cm^{-1}. The stretching vibration of NPs was observed at 685cm^{-1}.[9]

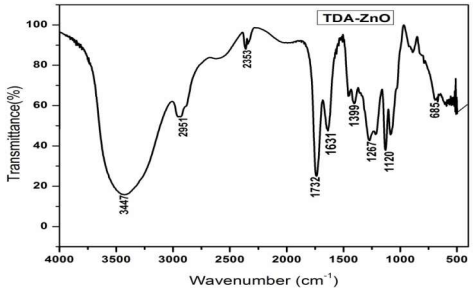

Fig.-2: FT-IR Spectrum Polymer Nanocomposites TDA- ZnO

SEM Analysis

Figure-3a, b SEM images of TDA-ZnO polymer nanocomposite. The white dots found in the images are ZnO NPs, they are nicely deposited in TDA hydrogel. There is a good cohesion force found between the hydrogel and nanoparticles.[10] The nanoparticle's interaction with the TDA hydrogel was effective, which led to proper polymer nanocomposite encapsulation. We are unable to measure the exact size of nanoparticles in the hydrogel because the analysis was done with the hard surface of the nanocomposite.

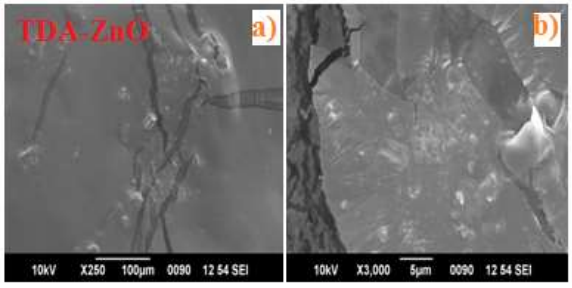

Fig.-3: SEM images of Polymer Nanocomposite TDA-ZnO (a,b)

EDX Analysis

The atomic percentages of elements present in TDA-ZnO polymer nanocomposite were found to be carbon 44.93%, oxygen 52.82%, and zinc 2.25% (Fig.-4a).The amount of carbon present in the EDX spectrum represents the carbon level in TDA hydrogel, metal oxide formation confirmed with the presence of oxygen (oxygen(O), zinc (Zn). The percentage of nanoparticles dispersed on the surface of TDA hydrogel is very low, which prevents nanoparticle aggregation in the polymer composite.[11]

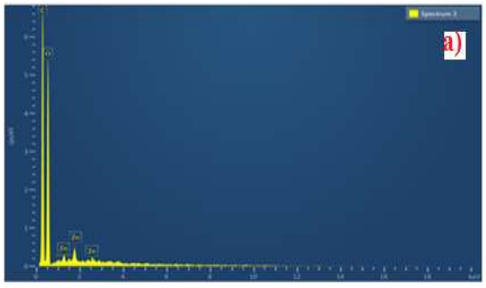

Fig.-4a: EDAX Spectrum of Polymer Nanocomposite TDA-ZnO

TEM Analysis

The spherical shape of the ZnO NPs of size between 28 to 36 nm is dispersed on the TDA-ZnO nanocomposite (Fig.-5a to d).

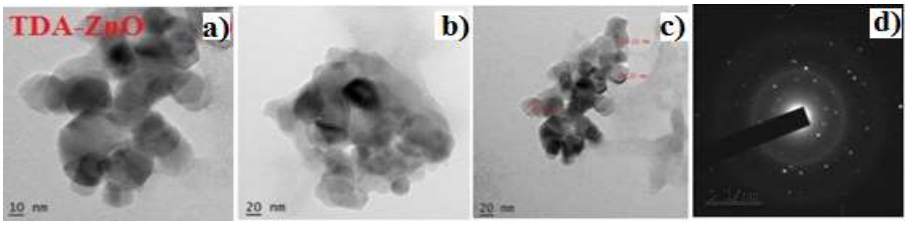

Fig.-5: TEM images of Polymer Nanocomposites TDA-ZnO (a,b,c,d)

Anticancer Activity

The biomedical importance of TDA hydrogel and green synthesized metal oxide nanoparticles incorporated polymer nanocomposites TDA-ZnO have been assessed by MTT assay of in vitro cytotoxicity study against lung cancer cell line (A549).The analysis was performed with five different (5, 25, 50, 75,100 µg) concentrations and the result has been compared with the control for all the polymer nanocomposites. At 5µg/mL concentration, ZnO NPs bound TDA-ZnO polymer nanocomposite cytotoxicity was 47% and cell viability was 63%, for the same polymer nanocomposite anticancer property was increased at 100µg/mL and it showed 81% cytotoxicity and 19% cell viability (Fig.-6a). The anticancer activity of TDA-ZnO polymer nanocomposite was higher than other nanocomposites. The fluorescent pictures of highly active TDA-ZnO polymer nanocomposite are shown with five different concentrations (5, 50, 75, 100 µg/mL). The IC_{50} values of TDA-ZnO NPs (52.6 µg/mL).The ZnO NPs generate more ROS (Reactive oxygen species) on the A549 cell line due to which the cytotoxicity of TDA-ZnO polymer nanocomposite was found to be high at a higher concentration 100µg/mL.[12]

CONCLUSION

TDA-ZnO polymer nanocomposite was prepared by adding green synthesized ZnO NPs into TDA hydrogel. The UV and FT-IR characterizations confirm the presence of nanoparticles in the hydrogel. The

anticancer activity of TDA-ZnO polymer nanocomposite was higher than other nanocomposites against the A549 lung cancer cell line.

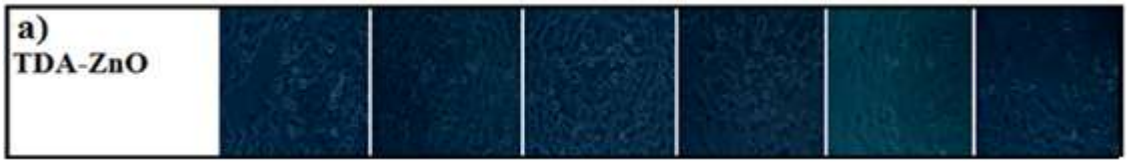

Fig.-6a: Cytotoxicity Analysis of TDA-ZnO

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CONFLICT OF INTERESTS

The authors declare that there is no conflict of interest.

AUTHOR CONTRIBUTIONS

All the authors contributed significantly to this manuscript, participated in reviewing/editing, and approved the final draft for publication.The research profile of the authors can be verified from their ORCID IDs, given below:

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