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Sol-Gel mediated facile synthesis of Zinc-Oxide nanoaggregates, their characterization and antibacterial activity

Vinay Sharma
Centre for Converging Technologies,University of Rajasthan, Jaipur, Rajasthan

Abstract : *Zinc oxide nanoparticles have been known for their strong antimicrobial properties since a long time. I have synthesized ZnO nanoaggregates using the environment friendly Sol-Gel method. The particles thus prepared were characterized by various technique like UV vis spectrophotometer, X-ray diffraction and Scanning Electron Microscopy. These techniques confirmed the presence of ZnO nanoparticles in form of aggregates. Finally , the antibacterial nature of ZnO nanoaggregates was performed on E.coli MTCC 40 strain of gram negative bacteria using Disk diffusion method.*

Keywords – *antibacterial nature, disk diffusion method, E.coli MTCC40, Sol-Gel method, nanoaggregates*

I. Introduction

Nanotechnology is the science of production, manipulation and use of materials at subatomic level to produce novel products and processes[1]. At this particular range various optical, biological, magnetic, physical and chemical properties of particles get changed drastically. Nanotechnology has tremendous applications in diagnostic devices, drug delivery, tissue engineering, environmental chemistry, water filtration, producing eco-friendly energy production systems, quantum computers etc. Due to high surface to volume ratio, nanoparticles have emerged as novel antibacterial agents[2]. The considerable antimicrobial activities of various nanoparticles, such as silver nanoparticles, ZnO, MgO, TiO2 and SiO2, and their selective toxicity to biological systems suggests a potential application as therapeutics, diagnostics, surgical devices and nanomedicine-based antimicrobial agents[3]. In the present study i have tried to synthesize ZnO nanoaggregates by using an economic and eco-friendly Sol-Gel method. This method has been proved very useful for production of metal oxides[4]. After synthesis, the particles were characterized by UV- vis spectrophotometer, X-ray diffractometer and SEM. For antibacterial activity demonstration, E.coli MTCC 40 strain of gram negative bacteria was used and disk diffusion method[5] was employed for it. I have divided the study in three sections, Synthesis of ZnO nanoaggregates, Characterization and Antibacterial activity.

II. Experimental

2.1 Chemicals and apparatus.

The chemicals used for the synthesis were Zinc acetate 5.487g in 50ml dd water, Oxalic acid 1.096g in 50ml dd water. A magnetic stirrer cum heater was to carry out hydrolysis of precursors. An electric furnace upto temperature tolerence of 1000^0C was used. Double distilled deionised MQ water was used.

2.2 Synthesis of ZnO nanoaggregates.

Zinc acetate 5.487g was weighed and mixed well in 50ml dd water with the help of stirrer for 1 hour. In another beaker oxalic acid 1.096g was weighed and mixed well in dd water for ½ hour. The oxalic acid solution was then mixed in Zinc acetate solution dropwise with continous stirring for 3 hours. The resultant white colored solution was then washed with dd water several times to free off the acetate ions. It was then centrifuged at 5000rpm for 20 minutes.The resulting white gel precipitate was then heated at 87^0C for 5hrs.Finally, it was put in pre-calibrated electric furnace at 600^0C for 2 hrs.ZnO nanoparticles were thus obtained in white powder form. Fig.1 shows the resultant gel after 87^0C heating.

Fig.1 Heating at 87^0C

2.3 Characterization.

For characterization of above formed ZnO sample three different techniques were used i.e , SHIMAZDU UV-1800 uv vis spectrophotometer, X'PERT POWDER x ray diffractometer and Scanning electron microscope.

2.4 Antibacterial activity.

Prepared stock of gram negative bacteria E.coli MTCC40 was taken and its inoculum was streaked onto NA plate. By using 10x dilution and streaking, single colony of bacterium was picked up by sterilized inoculating loop.The whole work was performed in laminar flow hood. Pure line culture of E.coli MTCC40 was thus obtained. Briefly Nutrient Agar(NA) medium was used to cultivate bacteria.Fresh overnight cultures of inoculum(100µl) of E.coli bacteria was onto NA plates. Paper disks of 5mm diameter were cut and autoclaved.Some of disks were dipped into standard vancomycin antibiotic(10µg/litre), some into standard erythromycin antibiotic(10µg/litre), some into distilled water and some into nanoparticle solution(containing 50mg/litre ZnO nanoparticles) **.** These disks were placed on the surface of agar using flame sterilized forceps.

III. Results And Discussion

3.1 Synthesis result

After heating at 600^0C, the resultant is obtained in white powder form. It is shown in Fig.2.

Fig.2. ZnO nanoaggregates

3.2 Characterization results

Fig.3. shows the UV vis absorption spectra of thus obtained ZnO nanoaggregates. A typical exciton peak at 368nm is observed in the absorption spectrum. By comparing the result with standard UV absorption of bulk ZnO (at 380nm), it is evident that absorption peak shifts towards lower wavelength i.e. blue shift. This shift in the absorption edge is due to quantum size effect [6].

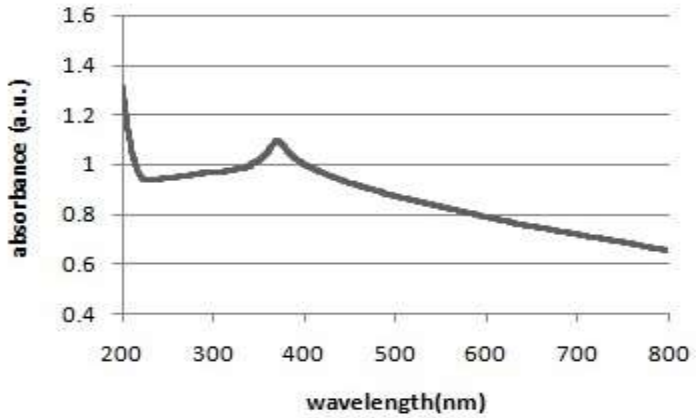

Fig.3. UV vis absorption spectrum of ZnO nanoaggregates.

Fig.4. shows the XRD pattern of ZnO nanoaggregates. The source of radiation was CuKα with λ=1.54$A^{0.}$All the diffraction data are in good aggreement with JCPDS files no.36-1451. However, in my results the XRD peaks are narrow showing that the particle size is more. This could be due to self aggregation of ZnO particles. The sharpness of peaks are showing that particles have good crystallinity.

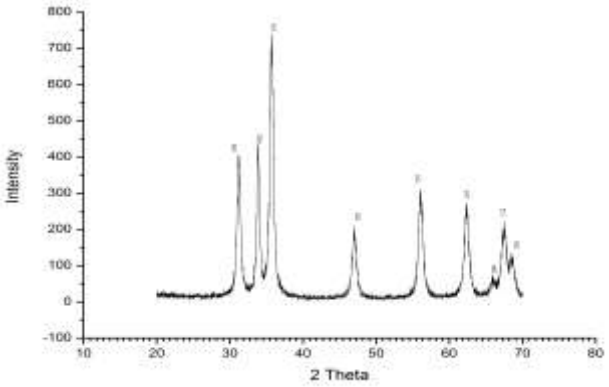

Fig.4 XRD pattern of ZnO nanoaggregates.

Fig.5 shows the Scanning Electron Microscope (SEM) image of as prepared sample. This SEM image clearly shows that the particles have been aggregated with dimension of each aggregate being ~ 2µm.It thus justifies that ZnO nanoaggregates have been formed.

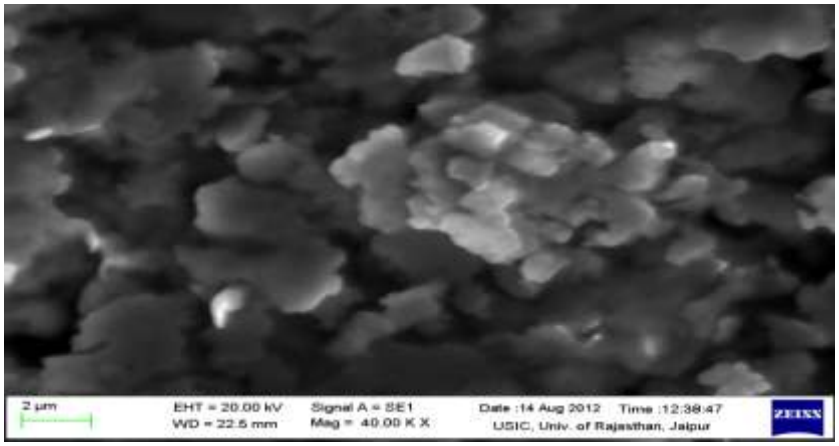

Fig.5 SEM image of ZnO nanoaggregates.

3.3 Antibacterial activity results

Fig.6 shows the antibacterial activity result of ZnO nanoaggregates. It is clearly visible that the zone of inhibition is highest for ZnO nanoaggregates indicated by(1). For erythromycin zone of inhibition indicated by(2), is lesser than ZnO nanoaggregates. (3) and (4) represents the activity of vancomycin and dd water respectively. Therefore, with gram negative E.coli MTCC40 strain, ZnO nanoaggregates were found to be the most effective, followed by erythromycin and vancomycin respectively.

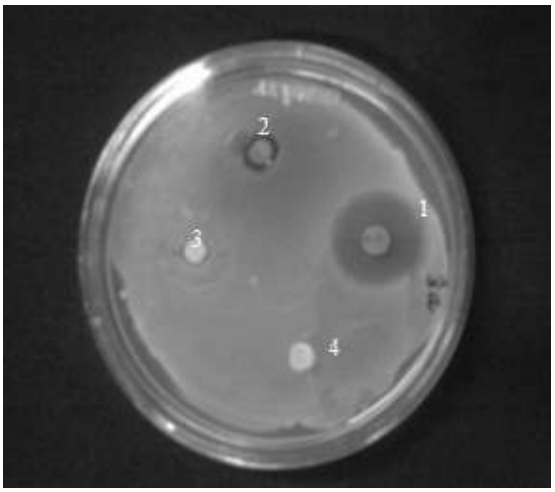

Fig.6 Antibacterial activity : (1) ZnO nanoaggregates > (2) Erytromycin > (3)Vancomycin > (4) dd Water

IV. Conclusion

In the present work i have reported the synthesis of ZnO nanoaggregates by a facile,eco-friendly and economic Sol-Gel method. UV vis absorption spectra clearly shows a blue shift which justifies the quantum confinement effect, hence lowering of dimensions. XRD pattern shows that the ZnO nanoaggregates have good crystallinity. SEM image clearly confirms the morphology of ZnO nanoaggregates.This aggregation could be due to high temperature(600^0C) heating.In the end of the study, antibacterial activity reveals that ZnO nanoaggregates are good at decreasing the bacterial growth.They are much effective than the traditionally used antibiotics.

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