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Preparation of yeast mediated semiconductor nanoparticles by *Candida albicans* and its bactericidal potential against *Salmonella typhi* and *Staphylococcus aureus*

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ABSTRACT

Biosynthesis of nanoparticles using microorganism is widely used in biological applications due to its eco-friendly nature and lower cost. The present study aimed to investigate the yeast, *Candida albicans* for the synthesis of nano cadmium sulfide is a semiconductor nanoparticle. The yeast synthesized nanoparticles tested for its spectroscopic and microscopic characters. The peak at 420 nm identified by UV-Vis spectrophotometer confirms the Cadmium sulfide (CdS) nanoparticles synthesis preliminarily. Further, the nanoparticles were characterized using X-ray diffraction assay, scanning electron microscope, and elemental dispersive analysis. Finally, the synthesized Cadmium sulfide (CdS) nanoparticles were tested for its antibacterial activity against disease-causing pathogens such as *Salmonella typhi* and *Staphylococcus aureus.* The maximum zone of inhibition shows 15mm at the concentration of 100µl of CdS nanoparticle. Thus a promising antibacterial activity of yeast mediated synthesized Cadmium sulfide (CdS) nanoparticles was described.

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INTRODUCTION

Nanobiotechnology has been boon for bioelectrochemistry in which microbes are used for the synthesis of nanoparticles. Cadmium sulfide has been expansively considered due to its budding technological applications in the field-effect transistors, solar cells, photovoltaics, light emitting diodes, photocatalysis, photoluminescence, an infrared photodetector, environmental sensors and biological sensors (Prasad and Jha 2010). Since Semiconductor nanocrystals have greatly concerned in both essential research as well as technical applications towards introducing advanced electronics and optical properties (Sanghi and Verma 2009). In Biological synthesis, the yeasts are more preferably exploited for the synthesis of semiconductor Cadmium sulfide nanoparticles, and it is well known as 'quantum semiconductor crystals' or 'semiconductor crystals' and also, yeast is considered a model microorganism for the study of bioprocesses (Zheng *et al.,* 2015). When there is an exposure of Cd+2 ions into the intracellular region of *Candida glabrata*, CdS quantum dots were formed (Pandian *et al.,* 2011). In recent era fungal strains are used in the biosynthesis of Cadmium sulfide

(CdS) nanoparticles due to the release of different enzymes fetch up their latent application, these enzymes are easy to handle in the laboratory (Andean *et al.,* 2011). Hence these nanoparticles are eco-friendly in nature which cinch to synthesis and attracted much attention among researcher groups. Furthermore, the nanometer-sized semiconductor with unique properties is composed of binary chalcogenides belonged to groups II-VI, such as CdS, PbS and ZnS, has been considerably explored in research nowadays (Mousavi *et al.,* 2012). In most of the yeast species studied, these molecules determine the mechanism for the formation of nanoparticles and stabilise the complexes (Breierova *et al.,* 2002). The capacity of yeast cell to change the absorbed metal ions into secondary or tertiary polymers which are non-toxic to the yeast cells. This is defined as the resistance (Dameron *et al.,* 2006). In the present study Cadmium sulfide (CdS) nanoparticles were synthesised using yeast cell and synthesized cadmium sulfide nanoparticles were (Cds) characterized and examined for its antibacterial activity against disease-causing pathogens such as *Salmonella typhi* and *Staphylococcus aureus.*

MATERIALS AND METHODS

Cadmium sulfate (CdSO4, 99.99% purity) and Sodium sulfide (Na2S, 98% purity) were obtained from Sigma Aldrich. Potato Dextrose Agar (PDA) was purchased from Himedia, and the microbial strain was given by the Department of Bioscience and Technology, VIT, Vellore. Deionized water used throughout the experiment was obtained from ultrapure water purification system. The strain was inoculated in PDA broth and incubated with 1mM of cadmium sulfate, followed by the addition of 1 mM sodium sulfite, at room temperature for 24 h. At the time interval of every 1 h, UV-Visible spectrum reading was taken to monitor the progress on the synthesis of yeast mediated CdS nanoparticles.

Characterisation of Cadmium sulfide (CdS) nanoparticles

The biosynthesis of Cadmium sulfide (CdS) nanoparticles in yeast cell culture were monitored by UV-visible spectrum between the range of 360 to 540 nm followed by XRD. The sample was made into powder form and given for SEM and EDX analysis for structural confirmation. For the synthesised Cadmium sulfide (CdS) nanoparticles antimicrobial activity was done.

RESULTS AND DISCUSSION

In this study, *Candida albicans* was used for the synthesis of Cadmium sulfide (CdS) nanoparticles. The strain was inoculated in PDA broth for 48 h and incubated with 1mM of cadmium chloride, followed by the addition of 1 mM sodium sulfide. At the time interval of every 1 h, the UV-Visible spectrum was taken to monitor the progress of the synthesis of yeast mediated Cadmium sulfide (CdS) nanoparticles.

By the reference of previous studies, yeast cells have the ability to enhance the cellular pool of glutathione and glutathione-like compounds called phytochelatins (Mehra and Winge 1991). In which the formation of metal thiolate complex neutralises the toxicity of heavy metal ions and traps inside the cell (Vido *et al.,* 2001). As a result sulfide anions are readily incorporated into cadmium glutathione complexes, resulting in the formation of nanocrystals (Dameron *et al.,* 1989b).

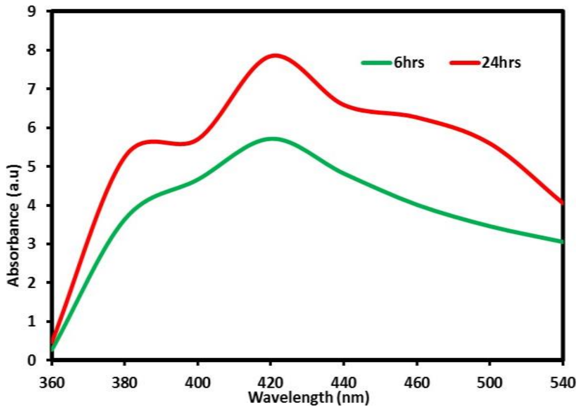

Figure 1: UV-vis spectrum of Cadmium sulfide (CdS) nanoparticles

The UV–visible absorption spectra result reveals a one-step procedure for the preparation of the Cadmium sulfide (CdS) nanoparticles NPs. The scale of wavelength was fixed between 360 and 540 nm, the surface Plasmon resonance (SPR) of the Cadmium sulfide (CdS) nanoparticles formed corresponded to 430 nm, and there was an increase in intensity at 24 h. It was observed that the reduction of ions starts from 6 h, and reaches saturation within 24 h of reaction. There were no significant variations in the intensity of SPR bands. This result indicates that the reaction is completed in 24 h.

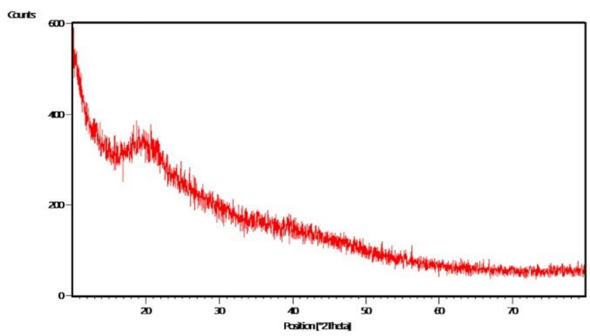

Figure 2: XRD spectrum of Cadmium sulfide (CdS) nanoparticles synthesised from C. albicans

The phase identification and crystalline structures of the nanoparticles were characterised by X-ray powder diffraction (Huan *et al.,* 2017). In the above figure, there is a single intense peak in the obtained spectrum of 2Θ in the XRD pattern which indicates the biologically synthesised Cadmium sulfide (CdS) nanoparticles. There was a gradual decrease in the spectrum which confirms the Cadmium sulfide (CdS) nanoparticles.

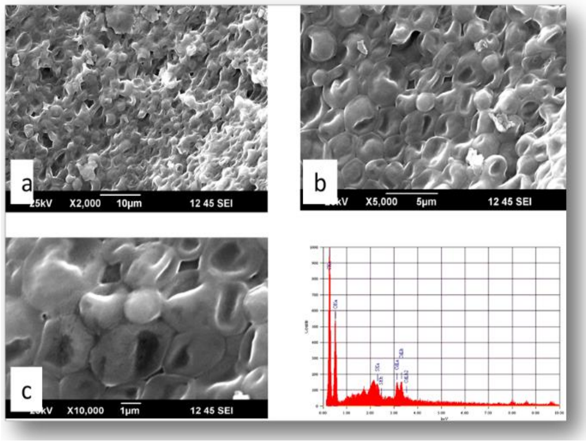

Figure 3: SEM and EDX analysis of Cadmium sulfide (CdS) nanoparticles

The morphology and distribution of the synthesised Cadmium sulfide (CdS) nanoparticles were examined by SEM analysis. SEM images of Cadmium sulfide (CdS) nanoparticles were viewed at different magnifications of X 2000, 5000, 10,000 (Fig. 3 a,b,c). The synthesised Cadmium sulfide (CdS) nanoparticles are mostly spherical in shape, and the size range 50 – 60 nm. The images confirmed the formation of semiconductor crystals with aggregates (Andean *et al.,* 2011).

The Energy Dispersive X-ray analysis (EDX) reveals a strong single peak as Cd and S which confirms the presence of Cadmium sulfide (CdS) nanoparticles. (Fig:3 d) These Semiconductor Cadmium sulfides (CdS) nanocrystals generally show a visual absorption peak approximately at 3.1keV due to the surface Plasmon resonance. The similar result could be observed with the biological synthesis of Cadmium sulfide (CdS) nanoparticles (Shaik Raziya, Bokka Durga 2016).

The antimicrobial activity of Cadmium sulfide (CdS) nanoparticles was investigated against two pathogenic bacteria, such as *Salmonella typi* and *Staphylococcus aureus.* As shown in (fig.4) the zone of inhibition (ZOI) was measured and expressed in millimetre (mm). The concentrations were of Cadmium sulfide nanoparticle various from 20µl, 40µl, 60 µL, 80 µL, and 100 µL. The standard antibiotic used for this study was streptomycin which is 10 µg/ml prepared in sterile water. This table shows the highest antimicrobial activity against *Salmonella typi* compared with *Staphylococcus aureus* when the concentration of nanoparticle gradually increases, the zone of inhibition also increases. The bacterial growth rate of *Staphylococcus aureus* was decreased while increasing the concentration of Cadmium sulfide nanoparticles. In the case of *Salmonella typhi* at the concentration of 60 µL, 80 µL, and 100 µL, the zone of inhibition was found to be 14.5, 15 and 16 mm in diameter, respectively. This was high in diameter than the standard antibiotic which was 12mm. Thus these significant results clearly demonstrate that the antibacterial activity was strong and good due to Cadmium sulfide (CdS) nanoparticles when coupled with the secondary metabolites of the yeast cell (Malarkodi *et al.,* 2013). Therefore, the antimicrobial activity of Cadmium sulfide (CdS) nanoparticles reveals be due to the less particle size; it might be able to penetrate the pores of the bacteria cell wall by enhancing the broad spectrum of antibacterial activity against the virulent bacteria (Kavitha *et al.,* 2018).

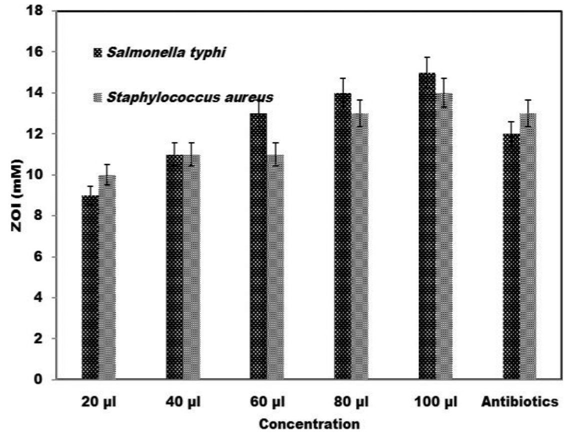

Figure 4: Antimicrobial activity of Cadmium sulfide (CdS) nanoparticles Nanoparticles against Salmonella typhi, and Staphylococcus aureus

CONCLUSION

In this study, eco-friendly synthesis of Cadmium sulfide (CdS) nanoparticles was carried out using *Candida albicans.* It clearly demonstrates that microbes play a vital role in controlling the size and shape of the nanoparticles. The morphological (SEM with EDS) and structural (XRD) including spectroscopic techniques UV-vis shows the stabilisation of Cadmium sulfide (CdS) nanoparticles. Applications of such eco-friendly nanoparticles in bactericidal, wound healing and other medical and electronic applications, makes this method potentially fetch up for the novel synthesis of other semiconductor materials. Further studies can be done for the exact mechanism of anti-microbial activity against virulent strains.

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