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Antimicrobial Activity of Bio and Chemical Synthesized Cadmium Sulfide Nanoparticles

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ABSTRACT

Background: The green synthesis of cadmium sulfide (CdS) nanoparticles has been regarded as the most promising technique for their prospective applications in biological system. **Aim of the work:** In this study isolation of different bacterial strains from stool samples of healthy volunteer, selection of the most efficient bacterial strains able to reduce cadmium sulfide metal into nanoparticles. Characterization of biosynthesized metal nanoparticles by standard analytical methods. Mediating the biosynthesized cadmium sulfide nanoparticles in medical applications in comparison to those produced by chemical methods. **Materials and methods:** Extracellular *Escherichia coli* E-30 and *Klebsiella pneumonia*e K-6 isolated from stool samples were the strains used for biosynthesis. Cadmium sulfide nanoparticles were also produced by wet chemical method. The characterizations of cadmium sulfide nanoparticles were done by using UV-Visible Spectroscopy, Transmission electron microscopy (TEM), energy dispersive x-ray (EDX) and Fourier transform infrared spectroscopy (FT-IR). **Results**: *Escherichia coli* E-30 has shown to be efficient in synthesizing cadmium sulfide nanoparticles where CdS nanoparticles were with average size ranging from 3.2 to 44.9 nm while average size of CdS nanoparticle was synthesized by *Klebsiella pneumoniae* K-6 ranging from 8.5 to 44.9 nm. While cadmium sulfide nanoparticles synthesized by wet chemical method, ranging from 8.77 to 16.50 nm. Biosynthesized cadmium sulfide nanoparticles by *Escherichia coli* E-30 showed highest antimicrobial activity on *Aspergillus fumigatus*, *Geotricum candidum*, *Bacillus subtilis*, *Staphylococcus aureus* and *Escherichia coli* than chemical synthesized of CdS nanoparticles. **Conclusion**: *Escherichia coli* and *Klebsiella pneumoniae* isolated from stool samples had the ability to produce cadmium sulfide nanoparticles. This kind of microorganisms can be used for synthesis of nanoparticles and heavy metal absorption for detoxification of environment.

Keywords: biosynthesis cadmium sulfide nanoparticles, *Escherichia coli* and *Klebsiella pneumoniae*, wet chemical synthesis cadmium sulfide, antimicrobial activity.

INTRODUCTION

Nanotechnology is the creation, manipulation and use of materials at the nanometer size scale (1 to 100 nm). At this size scale there are significant differences in many material properties that are normally not seen in the same materials at larger scales. Although nanoscale materials can be produced using a variety of traditional physical and chemical processes, it is now possible to biologically synthesize materials via environment-friendly green chemistry based techniques [1, 2]. The microorganisms have the ability to produce nanoparticles either extracellular or intracellular depending on the type of organism used [3, 4]. The biosynthesis mechanism of semiconductor nanoparticles involves the reduction of inorganic metals in the solution which is facilitated by the enzyme sulphate reductase present in most of the bacterial species [4, 5]. In the intracellular production of nanoparticles the transport of ions takes place into the cell which utilizes the intracellular enzymes for the production, whereas in extra cellular production of nanoparticles the metal ions and enzymes are trapped on the cell surface to produce nanoparticles [6, 7]. The decrease in the size of nanoparticle provides more surface to volume ratio which increase the chance of Cd^{+2} exposure to the bacterial cells. Nanoscale materials have emerged up as novel antimicrobial agents owing to their high surface area to volume ratio and its unique chemical and physical properties [8]. There are reports on antimicrobial activity of nanoparticles such as Ag, Au, MgO, CuO, Cd, Al, TiO2, etc. which are effective against different drug resistant

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bacterial, viral and fungal strains [9]. CdS has been studied due to its potential technological applications in environmental sensors and biological sensors [10]. In the past few decades, a variety of wet chemical methods have been used to prepare CdS nanoparticles such as chemical precipitation method [11], solvothermal method [12], micro-emulsion [13] and hydrothermal method [14].

AIM OF THE WORK

In this study isolation of different bacterial strains from stool samples of healthy volunteer, selection of the most efficient bacterial strains able to reduce cadmium sulfide metal into nanoparticles. Characterization of biosynthesized metal nanoparticles by standard analytical methods. Mediating the biosynthesized cadmium sulfide nanoparticles in medical applications in comparison to those produced by chemical methods.

MATERIALS AND METHODS

Isolation and identification of bacteria

Sixty two stool samples were taken in sterile plastic cups and cultured directly on Mac Conky and C.L.E.D agar plates (about 1 h after collection), the inoculum on the plates was streaked out for discrete colonies with a sterile wire, then incubated at 37°C for 24 hours. Growing bacteria were isolated and identified by studying morphological and biochemical characteristics, including Gram stain, catalase test, indole production, methyl red test, oxidase test, hydrogen sulphide production, citrate test, culture on bile esculin and fermentation of lactose, glucose, maltose, sucrose, and mannitol [15, 16].

Molecular identification of bacterial isolates

Bacterial isolates were further identified via 16S rRNA cataloging DNA was extracted from bacterial cultures by using protocol of GeneJet genomic DNA purification Kit (Thermo K0721). 16S rRNA gene was amplified for each isolate by PCR by using Maxima hot start PCR Master Mix (Thermo K105). The forward primer: 5'-AGA GTT TGA TCC TGG CTC AG-3' and the reverse primer: 3'-GGT TAC CTT GTT ACG ACT T-5'. The DNA fragment was gel purified using Gene JET™ PCR Purification Kit (Thermo K0701) [17, 18].

Screening of cultures for Cadmium Sulfide Nanoparticles biosynthesis

Extracellular synthesis of Cadmium Sulfide Nanoparticles

Bacterial strain used for the synthesis of cadmium sulfide nanoparticles were *Escherichia coli*, and *Klebsiella* sp, were grown on LB broth at 37ºC for 24h. Culture was prepared by transferring one loop of bacteria into 3 ml nutrient broth and grown for 24h at 37°C at 150 rpm on rotary shaker. The culture was further enriched by transferring 1 ml of culture into 50 ml nutrient broth and grown for 24h at 37°C at 150 rpm. The culture broth was centrifuged at 8000 rpm for 20 minutes and the supernatant was collected for further studies. The synthesis of cadmium sulfide nanoparticles involves the reaction between cadmium chloride and sodium sulfide under the influence of bacterial supernatant. $CdCl_2+Na_2S \rightarrow CdS+2NaCl$. 0.25 M concentration of cadmium chloride and sodium sulfide was used for the reaction to synthesize CdS. Four different ratios of cadmium chloride and sodium sulfide ranging 1:1, 2:1, 3:1 and 4:1 respectively was taken to check the effect of cadmium chloride on nanoparticle formation. A volume of 5, 6.6, 7.5 and 8 ml of cadmium chloride and 5, 3.3, 2.5 and 2 ml of sodium sulfide corresponding to ratio 1:1, 2:1, 3:1 and 4:1 were added in different screw cap tubes and allowed to react. This reaction produced an orange-yellow color of cadmium sulfide suspension to which equal volume of supernatant was added to each of the tubes and mixed thoroughly. The mixture was kept in water bath at 60°C for about 10-20 minutes until there was fluffy orange yellow deposition seen at the bottom, indicating the formation of nanoparticles. The suspension was left to cool and incubated at room temperature overnight. Following day, the solution was observed for coalescent orange yellow clusters deposited at the bottom of the tube [19].

Purification of Nanoparticles:

The sodium chloride formed from the reaction of cadmium chloride and sodium sulfide was removed without disturbing the CdS nanoparticle precipitate. The precipitate was washed with acetone and water to remove if any contaminants present and dried in hot air oven at 45° - 50°C.

Wet Chemical Synthesis of Cadmium Sulfide Nanoparticles:

CdS was prepared by stirring 1 mM of cadmium chloride with 5 mM sodium citrate along with addition of 1 mM of sodium sulfide. The precipitate was washed with double distilled water twice and dried at 60 °C in air [20].

Characterization of Cadmium sulfide Nanoparticles

UV-visible spectra were obtained using a Shimadzu, U.V-1650-PC spectrophotometer. The formation of CdS NPs was monitored by UV–vis spectra of the reaction mixture from 200 to 700 nm. Furthermore, morphological analysis and particle size distribution of the nanoparticles were carried out using Transmission Electron Microscope (TEM, JEOL-JEM 1010). EDX is used for the analysis of elemental composition of the CdS NPs. Finally FT-IR analysis was done using FT/IR NICOLET 6700.

Antimicrobial Activity of Cadmium Sulfide Nanoparticles:

The antimicrobial activity of samples was determined using agar well diffusion method [21]. All the compounds were tested *in vitro* for their antibacterial activity against *Bacillus subtilis, Streptococcus pneumonia, Staphylococcus aureus* and *Staphylococcus epidermidis* (Gram Positive bacteria), *Pseudomonas aeruginosa, Escherichia coli, Proteus mirabilis* and *Klebsiella pneumoniae* (Gram Negative bacteria) using nutrient agar medium. Antifungal activity was carried out against *Aspergillus niger, Aspergillus fumigatus, Geotricum candidum* and *Candida albicans* using Sabouraud`s dextrose agar medium. Ampicillin, Gentamicine and Amphotricine B were used as standard drugs for Gram positive, Gram negative and antifungal activity respectively. The compounds were tested at a concentration of 5 mg/ml against both bacterial and fungal strains. The sterilized media was poured onto the sterilized Petri dishes (20 ml, each petri dish) and allowed to solidify. Wells of 6 mm diameter were made in the solidified media with the help of sterile borer. A sterile swab was used to evenly distribute microbial suspension over the surface of solidified media and solutions of the tested samples were added to each well with the help of micropipette. The plates were incubated at 37°C for 24h in case of antibacterial activity and 48h at 25°C for antifungal activity. This experiment was carried out in triplicate and zones of inhibition were measured in mm. scale.

The study was approved by the Ethics Board of Banha University.

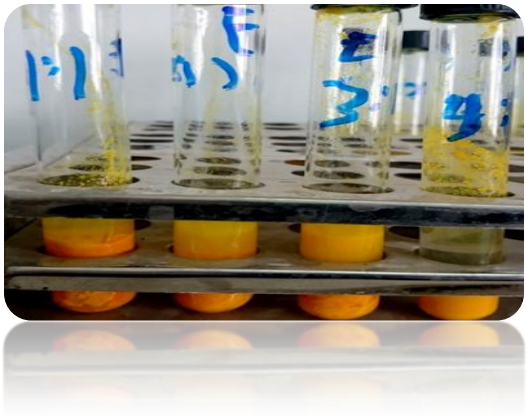
Statistical Analysis

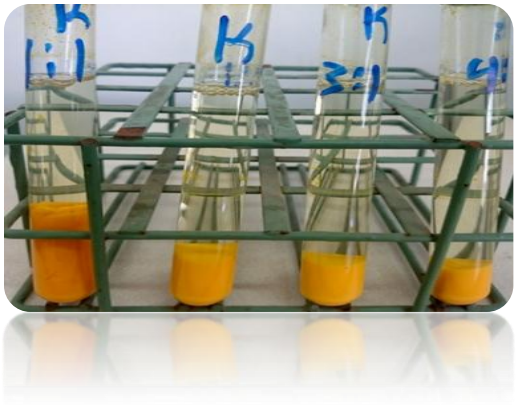
The data were coded, entered and processed on computer using *SPSS* (version 18) [22]. The results were represented in tabular and diagrammatic forms then interpreted. Mean, standard deviation, range, frequency, and percentage were use as descriptive statistics. Chi-Square test X^2 was used to test the association variables for categorical data. Student's t-test was used to assess the statistical significance of the difference between two population means in a study involving independent samples. ANOVA (F test) for normally quantitative variables, to compare between more than two groups, and Post Hoc test (LSD) for pairwise comparisons.

RESULTS

Screening of *Escherichia coli* and *Klebsiella* sp for biosynthesis of cadmium sulfide nanoparticles.

The obtained bacterial isolates were identified by Gram stain and Conventional biochemical tests into *E. coil* (31 isolates) and *Klebsiella* sp (19 isolates). 50 bacterial isolates were obtained from stool samples of healthy volenteer. These bacterial isolates 31 *Escherichia coli* and 19 *Klebsiella* sp were screened for cadmium sulfide nanoparticles synthesis. 5 bacterial isolates (3 *Escherichia coli* and 2 *Klebsiella* sp) were found to synthesize cadmium sulfide nanoparticles **Fig. (1).**





(A): *Escherichia coli* **(B): *Klebsiella sp***

Fig. (1): Biosynthesis of cadmium sulfide nanoparticles by bacteria (*Escherichia coli* and *Klebsiella* sp).

Production of Cadmium Sulfide Nanoparticles by Chemical methods:

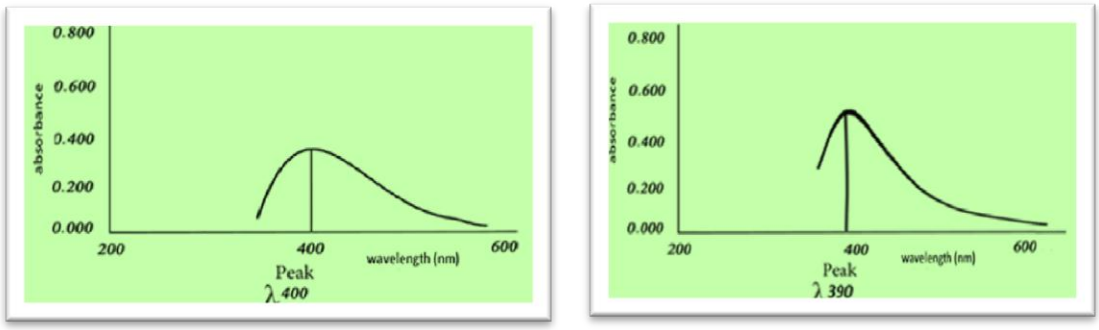
The CdS nanoparticles obtained showed color variation from transparent to bright yellow and after the completion of reaction this turned to reddish orange **Fig. (2) and (3)**.

Fig. (2): The synthesized CdS nanoparticles obtained as such in suspension form.

Fig. (3): The synthesized CdS nanoparticles obtained after washing and drying.

Characterization of CdS Nanoparticles

The cadmium sulfide nanoparticles synthesized by 3 Escherichia coli and 2 Klebsiella sp were analyzed using UV-vis spectrophotometer. Strong and broad peak between 350-400 nm after 24 h of incubation period was obtained by Escherichia coli E-30 and Klebsiella sp K-6 respectively, **Fig. (4) (A and B)**. While CdS synthesized by wet chemical method, shows UV-vis absorption spectra at 430 nm **Fig. (5).**



(B)

Fig. (4): UV- visible absorption spectrum of CdS nanoparticles produced by (A) *Escherichia coli* E-30 and (B) *Klebsiella* sp K-6.

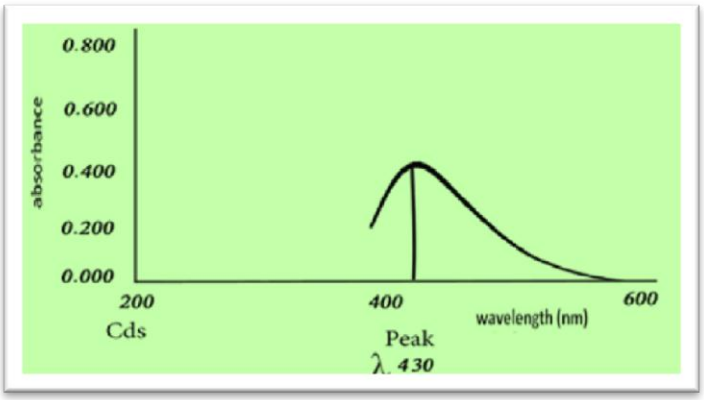


Fig. (5): UV-visible absorption spectrum of CdS nanoparticles produced by wet chemical method.

TEM analysis is performed to examine the size and shape of the biosynthesized cadmium sulfide nanoparticles using *Escherichia coli* and *Klebsiella* sp. The cadmium sulfide nanoparticles were fairly uniform in size, spherical in shape, and with average diameter ranging from 3.2 to 44.9 nm for bacterial isolate E-30 and for bacterial isolate K – 6 ranging from5.7 to 26.3 nm **Fig. (6)**. Electron microscopy analysis allowed to confirm visually the observed stability of the obtained colloidal solution. Size of CdS nanoparticles synthesis using wet chemical method were ranged from 8.77 to 16.50 nm **Fig. (7)**.

E-30

K-6

Fig. (6): TEM photograph of Cadmium Sulfide nanoparticles synthesized using *Escherichia coli* E-30 and *Klebsiella* sp K-6.

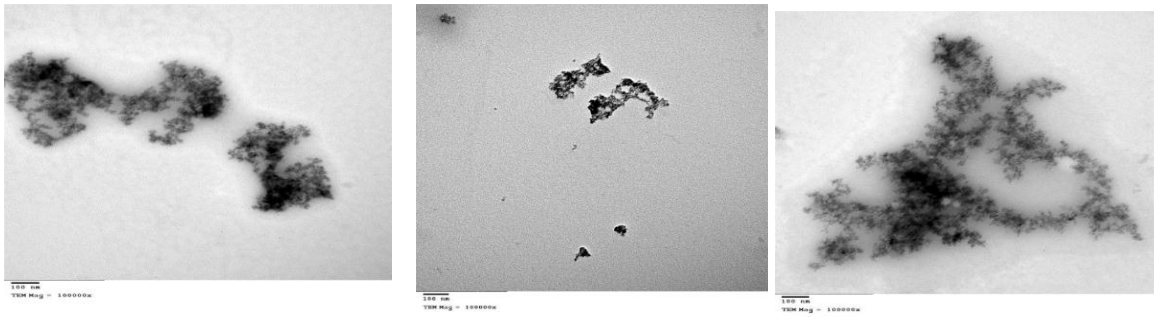


Fig. (7): TEM photograph of Cadmium Sulfide nanoparticle synthesized by wet chemical method.

The elements present in the samples were analyzed by EDX, the results showed percentage of Cd and S nanoparticles synthesis by *Escherichia coli* E-30 were 52.57% and 32.23% respectively, and percentage of Cd and S nanoparticles synthesis by *Klebsiella* sp K-6 were 38.35% and 36.78% respectively **Fig. (8) and Fig. (9).** The elements present in the samples were analyzed by EDX, the results showed strong signals of Cd and S indicating the nanoparticles were made of Cadmium sulfide metals, percentage of Cd and S nanoparticles synthesis by wet chemical method 65.12% and 18.41 respectively **Fig. (10)**.

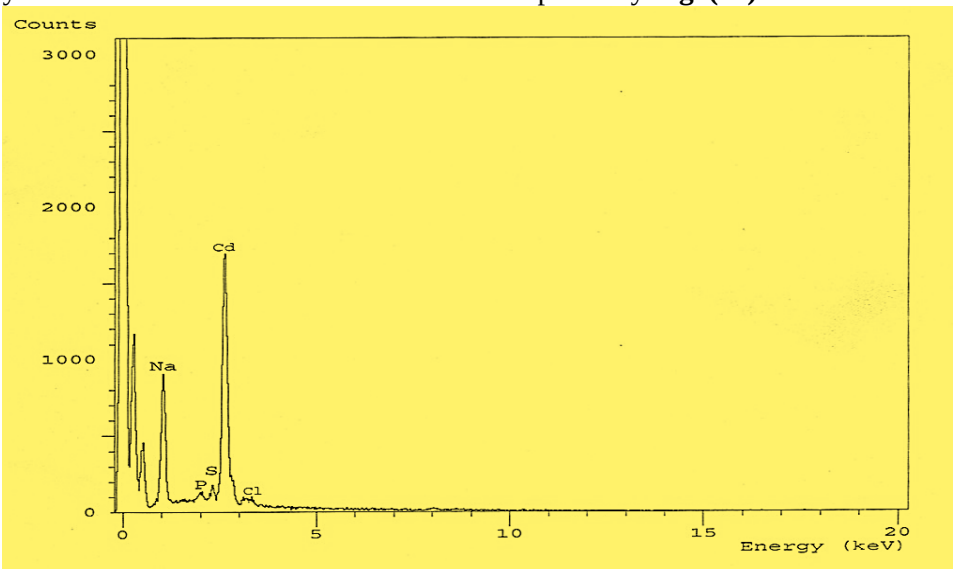


Fig. (8): EDX analysis of biosynthesized CdS nanoparticles using *Escherichia coli* E - 30, showing strong signal for Cd and S nanoparticles.

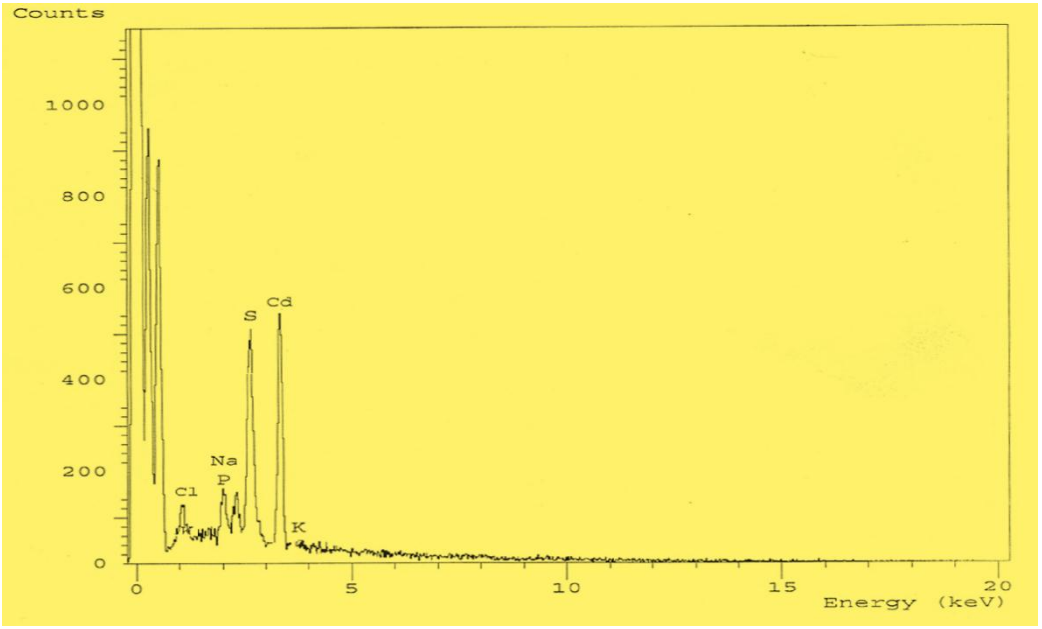


Fig. (9): EDX analysis of biosynthesized CdS nanoparticles using *Klebsiella sp* K - 6, showing strong signal for Cd and S nanoparticles.

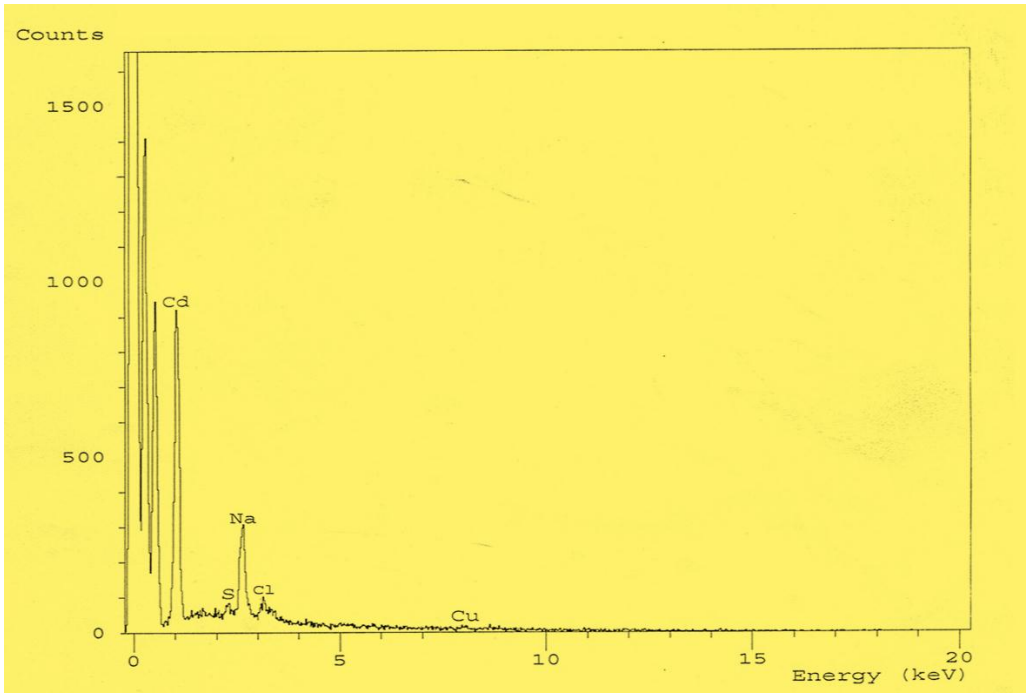


Fig. (10): EDX analysis of synthesis CdSNPs using wet chemical method, showing strong signal for Cd and S nanoparticles.

The FTIR spectra of CdS nanoparticles biosynthesized by *Escherichia coli* E-30, the peaks occurring at 3446.9 (OH group), 3397.4 (NH group), 2361.8 (-CH group), 2121.5 (C≡C bond), 1645 (amide 1), 1540.4 (C=C) and 1460.1(-CH) cm^{-1} **Fig. (11)**. FTIR spectra of CdS nanoparticles

biosynthesized by *Klebsiella* sp K-6, the peaks occurring at 3502.9 and 3298.9 (OH group), 2121.7 (C≡C bond), 1659.3 (amide 1), 1552.0 (amide 11), 1455.1(-CH group) and 1230.5 (C-O bond) cm^{-1} **Fig. (12)**. **Fig. (13)** show the peaks obtained by all the synthesized CdS nanoparticles. The peak in the range of 3578.3-3235.4cm^{-1} assigned to stretching vibration of hydroxyl group with strong hydrogen bond. Two strong peaks at 2945.1 and 2910.0 cm^{-1} are the characteristic bands of the asymmetric and symmetric aliphatic C–H stretching vibration respectively. The characteristic infrared peak of C═C appeared at 1650.0 cm^{-1}.The two peaks observed at 1462.1 and 1391.9 cm^{-1} assigned as CH2 bending vibration and the deformation vibration of $C–CH_3$ respectively. The infrared absorption peak at 1141.4 cm^{-1} was assigned as C–C and C–O–C stretching vibrations.

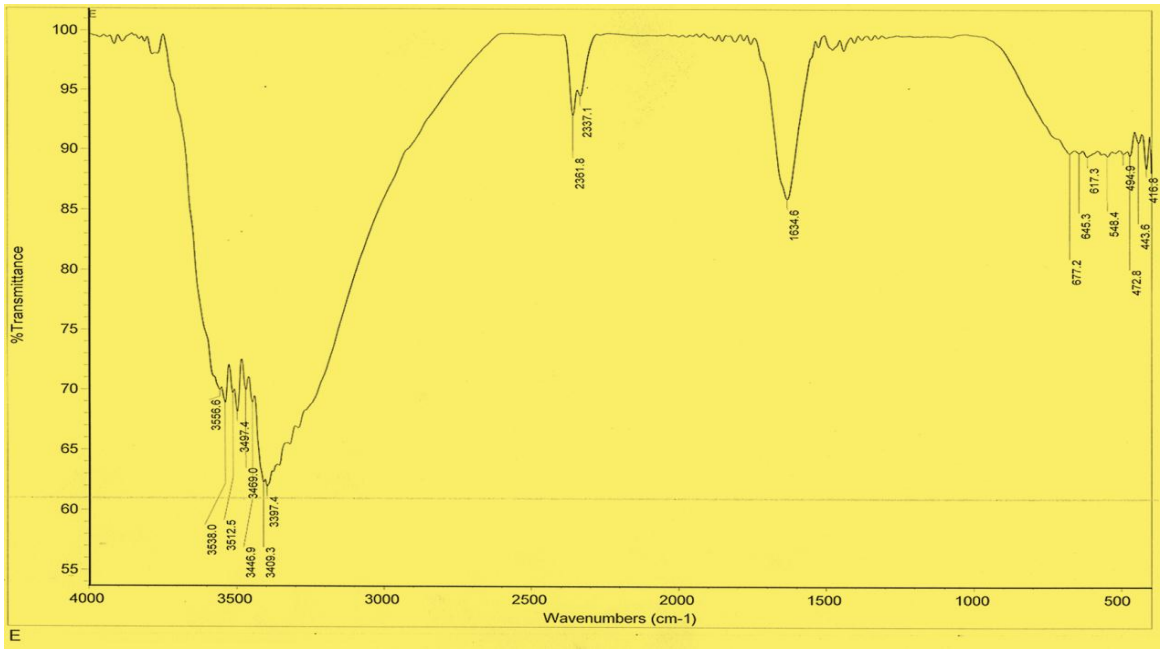


Fig. (11): FTIR spectrum of CdS nanoparticles generated by *Escherichia coli* E-30.

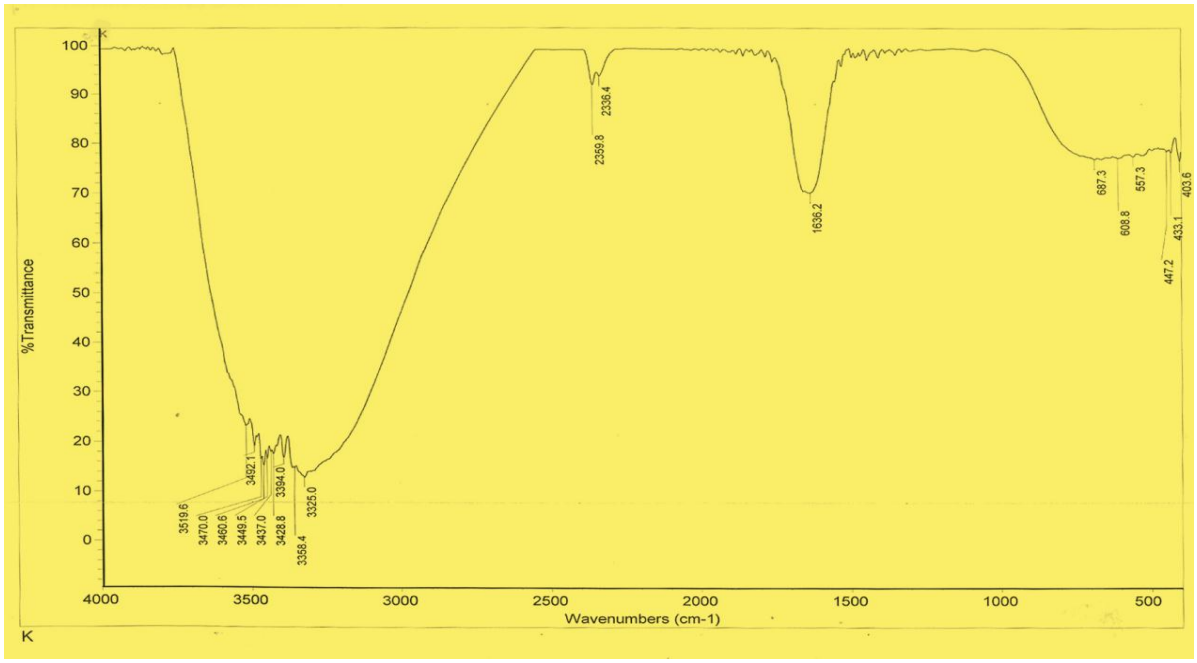


Fig. (12): FTIR spectrum of CdS nanoparticles generated by *Klebsiella* sp K-30.

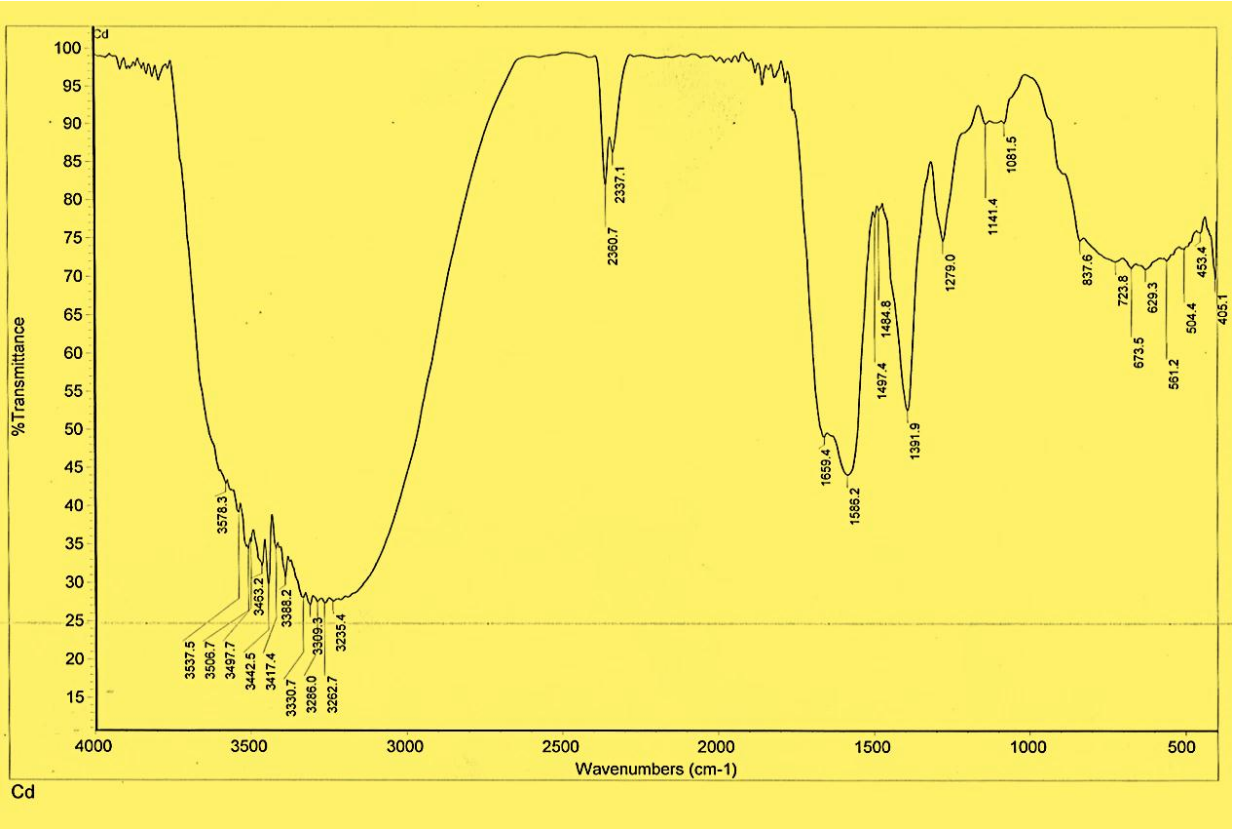


Fig. (13): FTIR spectrum of cadmium sulfide nanoparticles generated by wet chemical method.

16s rRNA identification of the isolates E – 30 and K – 6 and phylogenetic tree:

The selected strains were identified by 16S rRNA gene sequence analysis to ascertain their taxonomic positions. The isolate E – 30 showed 96% similarity with *Escherichia coli* strain NBRC 102203 16S ribosomal RNA and isolate K – 6 showed 99% similarity with *Klebsiella pneumoniae* strain DSM 30104 16S ribosomal RNA **Fig. (14) and Fig. (15).**

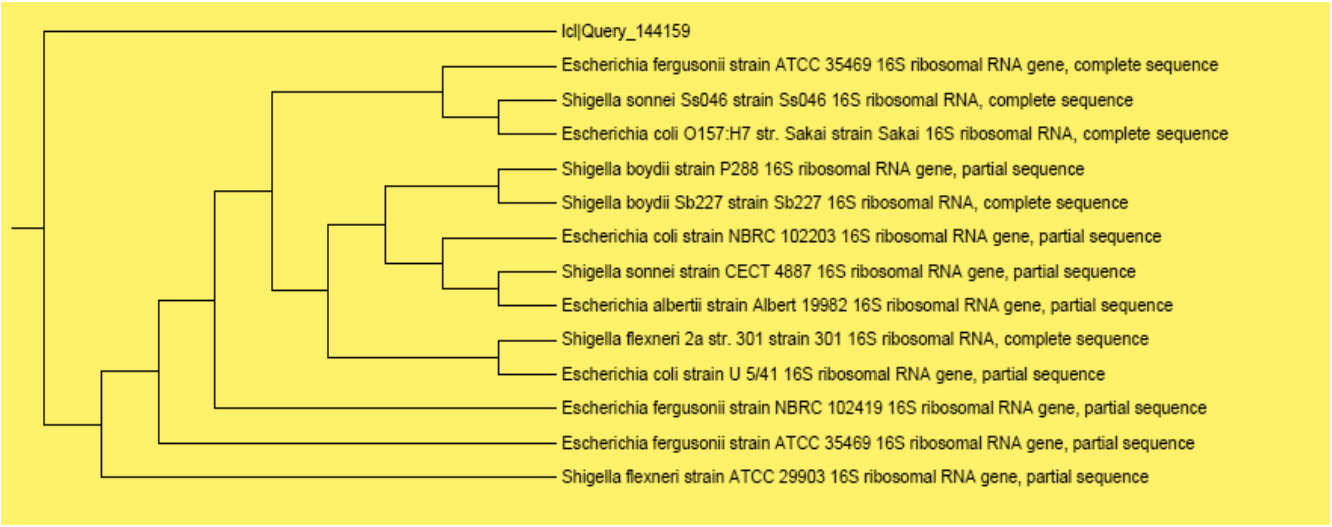


Fig. (14): Neighbor-joining tree based on 16S rRNA sequences, showing the phylogenetic relationship between the selected strain E-30 and their representative species from NCBI database.

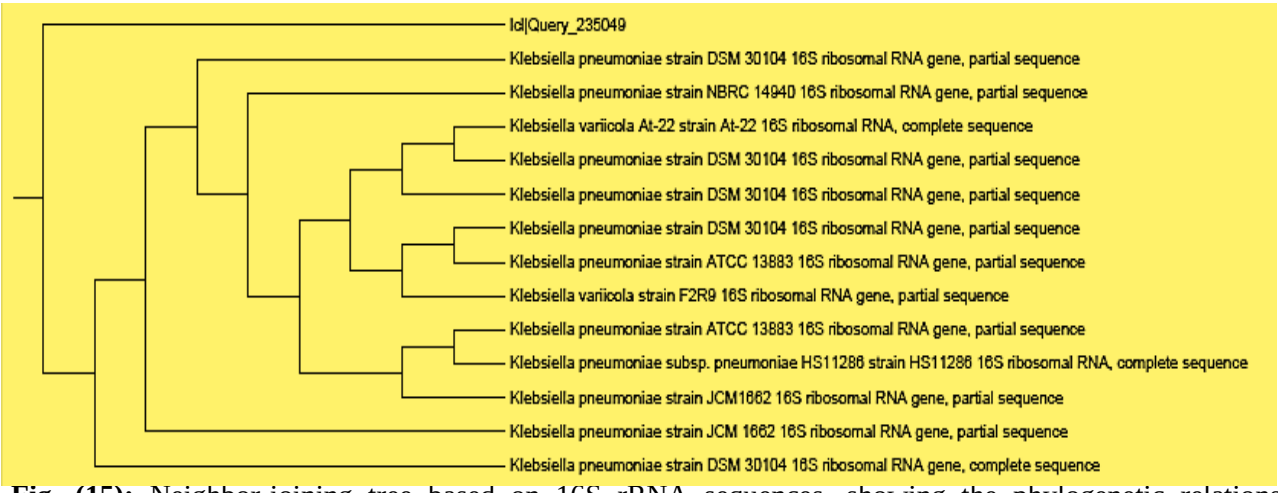


Fig. (15): Neighbor-joining tree based on 16S rRNA sequences, showing the phylogenetic relationship between the selected strain K-6 and their representative species from NCBI database.

Antimicrobial Activity of Cadmium Sulfide Nanoparticles:

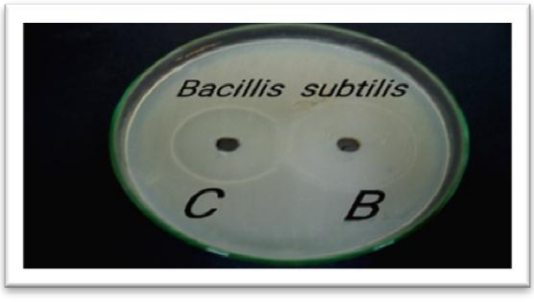
The antimicrobial activity of the CdS nanoparticles were investigated against environmental and clinically pathogenic microorganisms *Aspergillus fumigatus, Aspergillus niger, Geotricum candidum, and Candida albicans* (antifungal activity), *Bacillus subtilis, Streptococcus pneumoniae, Staphylococcus aureus and Staphylococcus epidermidis* (Gram positive bacteria) and *Pseudomonas aeruginosa, Escherichia coli, Proteus mirabilis* and *Klebsiella pneumoniae* (Gram negative bacteria). A concentration of 5 mg/ml CdS nanoparticles showed highest inhibition on most strains. CdS nanoparticles synthesized by bacteria had the maximum zone of inhibition against *Bacillus subtilis* (23.4±0.58), *Staphylococcus aureus* (22.1±0.72), *Pseudomonas aeruginosa* (21.4±0.63), *Escherichia coli* (17.3±1.2), *Geotricum candidum* (17.3±1.2), *Aspergillus fumigatus* (17.3±0.63) and *Aspergillus niger* (14.7±0.58). CdS nanoparticles synthesized by chemical method showed the maximum zone of inhibition against *Pseudomonas aeruginosa* (21.3±1.2), *Bacillus subtilis* (18.3±1.2), *Staphylococcus aureus* (17.3±0.63), *Aspergillus fumigatus* (16.3±0.58), *Escherichia coli* (15.6±0.72), *Geotricum candidum* (15.6±0.63) and *Aspergillus niger* (13.6±1.2). **Table (1) and Fig. (16),** showed comparative the results of zone of inhibition between CdS nanoparticles synthesized by bacteria and chemical method. Biosynthesis of CdS nanoparticles synthesized showed highest inhibition on most strains than chemical synthesis of CdS nanoparticles. And showed the highest inhibition was seen in gram positive bacteria followed by gram negative bacteria.

DISCUSSION

The synthesis of gold nanoparticles was carried out by two bacterial strains E-30 and K-6. Phylogenic analysis of the 16s rRNA sequence data showed that, the strain E-30 belonged to *Escherichia coli* and the strain K-6 belonged to *Klebsilla pneumoniae*, where the isolate E – 30 showed 96% similarity with *Escherichia coli* strain NBRC 102203 16S ribosomal RNA and the isolate K – 6 showed 99% similarity with *Klebsiella pneumoniae* strain DSM 30104 16S ribosomal RNA. The qualitative analysis of cadmium sulfide nanoparticles were carried out based on the visual observation of color formation. The reaction between cadmium chloride and sodium sulfide was reduced to cadmium sulfide nanoparticles under the influence of enzyme sulfate reductase. The formation of coalescent orange-yellow clusters at the bottom of the tube indicated the formation of nanoparticles [23, 4, 24]. In this study UV-vis spectroscopy for CdSNPs production by *Escherichia coli* E-30 and *Klebsilla pneumoniae* K-6 reveals a strong absorption peaks at 400 and 390 nm, respectively.

Table (1): Comparison between Antimicrobial activity of CdS nanoparticles against environment and clinically pathogenic microorganisms (C-chemical, B-bacterial and NA-No Activity).

Tested microorganisms	sample		tandard ntibiotics
	Chemical synthesis of Cadmium sulfide(C)	Biosynthesis of Cadmium sulfide (B)	
Fungi	**Mean of Zones Inhibition (mm)**		**Amphotericin**
***Aspergillus fumigatus* (RCMB 02568)**	16.3±0.58	17.3±0.63	23.7±0.58
***Aspergillus niger* (RCMB 02542)**	13.6±1.2	14.7±0.58	22.4±1.2
***Geotricum candidum* (RCMB 05097)**	15.6±0.63	17.1±1.2	28.7±0.63
***Candida albicans* (RCMB 05036)**	NA	NA	25.4±1.2
Gram Positive Bacteria			**Ampicillin**
***Streptococcus pneumoniae* (RCMB O l0010)**	NA	NA	23.8±0.63
***Bacillus subtilis* (RCMB 010067)**	18.3±1.2	23.4±0.58	32.4±0.72
***Staphylococcus aureus* (RCMB 000106)**	17.3±0.63	22.1±0.72	26.2±1.2
***Staphylococcus epidermidis* (RCM B 010024)**	NA	NA	20.3±1.2
Gram Negative Bacteria			**Gentamicin**
***Pseudomonas aeruginosa* (RCMB 010045)**	21.3±1.2	21.4±0.63	23.4±0.63
***Escherichia coli* (RCMB 010052)**	15.6±0.72	17.3±1.2	26.3±0.58
***Proteus mirabilis* (RCMB 01002 54 -2)**	NA	NA	22.3±1.2
***KIebsiella pneumoniae* (RCMB 01002 23-5)**	NA	NA	25.2±0.63



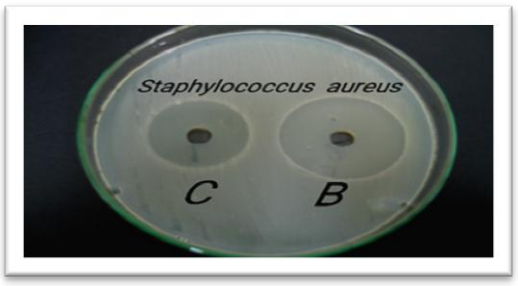


Fig. (16): Antibacterial activity of bio and chemical synthesis of CdS nanoparticles against different microorganisms *Bacillus subtilis*, *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Escherichia coli*, *Geotricum candidum*, *Aspergillus fumigatus* and *Aspergillus niger*. (C), Chemical synthesis of CdSNPs; (B), Biosynthesis of CdSNPs.

El-Shanshoury *et al.* [25] have demonstrated that, ultraviolet (UV)–visible spectroscopy study revealed the build-up of absorption bands at 419.5, 381.5 and 362.5 nm for *E. coli* ATCC 8739, *B. subtilis* ATCC 6633 and *L. acidophilus* DSMZ 20079T, respectively for assisted synthesis of CdS nanoparticles. UV–Visible spectroscopy test revealed that the surface Plasmon resonance for *Enterobacteriaceae* assisted synthesis of CdS nanoparticles is at the range of 300-600 nm. The maximum absorption was at 400-450 nm in UV-Visible spectroscopy [4]. In our study, showed that heavy absorption of visible light at 430 nm for cadmium sulfide nanoparticles formation by wet chemical method using UV-vis Spectroscopy. Our results were in the line with **Seoudi *et al.*** [26], who reported that, the UV–Visible spectra of the CdS nanoparticles were synthesized by chemical exhibited an absorption peak at 450 nm. Biosynthesis of cadmium sulfide nanoparticles, showed distribution of size, the best bacterial isolate *Escherichia coli*, E - 30 with average diameter ranging from 3.2 to 9.6 nm, and *Klebsiella pneumonia* K-6 ranging from5.7 to 26.3 nm. **El-Shanshoury *et al.*** [25], reported that TEM was performed to ascertain the formation of CdS nanoparticles, and few aggregates having the size of 2.5 to 5.5 nm were found. While images of chemical CdS nanoparticles show particles size range from 8.77 to 16.50 nm. **Kozhevnikova *et al.*** [27], who

observed that electron micrograph of particles of the disperse phase of chemical CdS nanoparticles are seen of the size 10-100 nm. EDX spectrum was showed strong signals of Cd and S indicating the nanoparticles were made of cadmium sulfide metals. The biosynthesis of CdS nanoparticles using the bacteria of Enterobacteriaceae, EDX spectrum was recorded strong signals showed the presence of Cd and S [4]. Our results showed strong signals of Cd and S indicating the nanoparticles were made of chemical Cadmium sulfide metals. **Qutub [28],** who observed that EDX spectra of the chemical synthesis of CdS NP reveals the presence Cd (51.5%) and S (48.5%) strong peaks and presence of other peaks. The FTIR spectra of CdS nanoparticles biosynthesized by *Escherichia coli* E-30, the peaks occurring at 3446.9, 3397.4, 2361.8, 2121.5, 1645, 1540.4 and 1460.1 cm-1. While *Klebsiella pneumonia* K-6, the peaks occurring at 3502.9, 3298.9, 2121, 1659.3, 1552.0, 1455.1 and 1230.5 cm-1. This is in agreement with **Tripathi *et al.* [29],** who found that (FTIR) provides the evidence for the presence of proteins as possible biomolecules responsible for the stabilization of the synthesized CdS nanoparticles. In the present work, the FTIR spectra show the peaks obtained by all the chemical synthesized CdS nanoparticles. The peak in the range of 3578.3-3235.4(OH group), 2945.1 and 2910.0 (C-H), 1650 (C=C), 1462.1 (CH2), 1391.9 (C-CH3) and 1141.4 (C-C and C-O-C) cm−1. The infrared spectral data confirmed that the -OH group used as a coordinated site to aggregate the cadmium ions and different uniform sizes of CdS nanoparticles were formed at this site by releasing of S^{-2} ions [26]. The efficiency of antimicrobial activity also depends on the size of the nanoparticles. Smaller nanoparticles have more surface atoms which gives them a larger surface area for interaction with the bacterial cell. It has also been shown that smaller nanoparticles have larger fractions of atoms on low coordination and high energy sites like corners, edges and steps which makes them more active than larger particles [30]. Biosynthesis of CdS nanoparticles synthesized showed highest inhibition on most strains than chemical synthesis of CdS nanoparticles. **Shivashankarappa *et al.* [19]**, who observed that, biosynthesis of CdS nanoparticles showed the highest antimicrobial activity was seen in the order of *Pseudomonas aeruginosa* (26.5±0.70) followed by *Bacillus licheniformis* (23.5±0.70), *Bacillus cereus* (22±0.01), *E coli* (19.1±0.14) and *Staphylococcus aureus* (18.25±0.35).

CONCLUSION

Escherichia coli and *Klebsiella pneumoniae* isolated from stool samples had the ability to produce cadmium sulfide nanoparticles. They had been confirmed with UV, XRD, TEM and FTIR. And the nanoparticles has potential antibacterial activity against clinical and environmental isolates. This is an inexpensive procdure and ecofriendly process to produce this nanoparticles. Hence, this kind of microorganisms can be used for synthesis of nanoparticles and heavy metal absorption for detoxification of environment.

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