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Synthesis and characterization of nanocrystalline $CdFe_2O_4$ and its antibacterial activity against *Escherichia coli*

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ABSTRACT

Nanocrystalline $CdFe_2O_4$ of were synthesized by sol-gel citrate method. Structural properties, antimicrobial activity were investigated. An assay shows the broad spectrum antimicrobial activity of nanoparticles against Gram negative pathogenic strain. The existence of $CdFe_2O_4$ structure of ferrite was confirmed by X-Ray diffraction (XRD) and Fourier Transform infrared (FTIR). Result indicated that nanosized particles greatly influence the antimicrobial activity of the sample

Keywords: $CdFe_2O_4$ nanoparticles, antimicrobial activity, FTIR, XRD

INTRODUCTION

The emergence of infectious diseases in general poses a serious threat to public health worldwide, especially with the emergence of antibiotic-resistant bacterial strains. Generally, both Gram-positive and Gram-negative bacterial strains are thought to present a major public health problem. Over the years, antibiotics have been used to control infections resulting from both community and hospital environments [1–3]. Current advances in the field of nanobiotechnology, particularly the ability to prepare metal oxide nanomaterials of specific size and shape, are likely to lead to the development of new antibacterial agents. The functional activities of nanoparticles are influenced largely by the particle size. Therefore, nanoparticles have received great attention due to their unique physical, chemical, and effective biological properties in various fields, including medicine. The Properties of nanoparticles can easily be altered by reducing or changing their size, especially when the manipulations are done at the nanometer scale [4–7]. In addition, nanoparticles with smaller particle size have been reported to show good antimicrobial activity [8]. Antimicrobial activity of nanoparticles has largely been studied with human pathogenic bacteria such as *Escherichia coli* [12-13]. Bactericidal activity of such nanoparticles in part depends on (1) size, (2) stability, and (3) concentration in the growth medium. While growing in medium amended with nanoparticles, the bacterial population growth can be inhibited by specific nanoparticle interactions [7]. Nano-structured materials are attracting a great deal of attention because of their potential for achieving specific processes and selectivity, especially in biological and pharmaceutical applications [9-11].

In recent years, nanotechnology has been flourishing. The development of Nano materials is a foundation for the development of nanotechnology. Nanobiotechnology is highly interdisciplinary by nature and requires close collaboration between biologists, physical scientists and engineers [25] Nanotechnology is mainly concerned with synthesis of nanoparticles of variable sizes, shapes, chemical compositions and controlled dispersity and their potential use for human benefit [26] Nanoparticles exhibit completely new or improved properties based on specific

characteristics such as size, distribution and morphology. As specific surface area of nanoparticles is increased, their biological effectiveness can increase in surface energy. Nano materials refer to materials with special properties, whose geometric dimension reaches Nano scale. Among Nano- materials, great importance has been attached to Nano oxide [14-16]. Nano-structured materials are attracting a great deal of attention because of their potential for achieving specific processes and selectivity, specially in biological and pharmaceutical applications [17-19]. In recent years, nanotechnology has been flourishing the development of Nano materialsis a foundation for the development of nanotechnology. Nano materials refer to materials with special properties, whose geometric dimension reaches Nano scale. Among Nano-materials, great importance has been attached to Nano oxide [14-16]. .Nano-structured materials are attracting a great deal of attention because of their potential for achieving specific processes and selectivity, specially in biological and pharmaceutical applications [17-19]. The aim of this paper is to explain theoretically the reason of nano- $CdFe_2O_4$ formation when using the sol-gel process that gives a single phase at both lower sintering temperatures [20]. This study aimed to investigate the potent long lasting antibacterial activity of nano- $CdFe_2O_4$ toward the gram-negative bacterium *E. coli,* synthesized via sol-gel citrate method.

MATERIALS AND METHODS

All chemicals and solvents were analytical grade and purchased from commercial sources.

Synthesis of $CdFe_2O_4$ nanoparticles

The $CdFe_2O_4$ nanoparticles prepared by using sol-gel citrate method. The stiochiometry mixture of Cadmium nitrate, Ferric nitrate magnetically stirred with citric acid and ethanol at 80° C for 3hrs to get homogeneous and transferrent solution. The solution was further heated at about 130° for 12 hrs in pressure vessel to form the gel precursor. The prepared product was subjected to 3hrs heat treatment at 350°C in muffle furnance and then milled to a fine powder. The dried powder then calcinated in range of 350°-650°C in order to improve the crystalinity of material

Method for antimicrobial activity

Bacterial susceptibility to nanoparticles

To examine the susceptibility of E. coli to nano $CdFe_2O_4$, three estimation methods were used. Bacterial growth in the presence of nano $CdFe_2O_4$ in liquid medium. In the first method, the bacteria were grown in nutrient broth (NB). To start the growth, 2 mL of the overnight-cultured E. coli stock was added to 100 mL NB, containing 0.12% glucose with and without 0.5 and 1% nano $CdFe_2O_4$, separately. The bacteria were aerobically cultured at 30ºC for 24 hours. Optical density (OD) measurements were taken at 600 nm to monitor the bacterial concentration.

Bacterial killing in the presence of nano $CdFe_2O_4$ in liquid medium

In the second method, the culture solution was centrifuged and the cells were washed and re-suspended in distilled water, reaching a final concentration of 6.3 log CFU/ml in each of the sample flasks and incubated at 4ºC. The final concentration of the E.coli suspensions was made in 100 ml distilled water. Different amounts of nano $CdFe_2O_4$ (0.5 and 0.1%) were then separately added to the bacterial suspensions to keep in contact with the bacterial cells and shaken at 40°C for 48 hours. Optical density (OD) was measured to obtain the results. Aliquots of 0.1 ml of the growth mixtures (water +bacterial cells + nanoparticles) were sampled every two hour. The number of resulting bacterial cells was noted after every two hours of incubation. Bacterial number was determined by measuring the optical density (OD) at 600 nm. The OD values were converted into the E. coli concentration as log CFU/ml **[24].**

Bactericidal effect of nano $CdFe_2O_4$ on E.coli by well diffusion method

In the third method bacteria were grown on nutrient agar plates. Approximately 105 CFU were applied to the plates. Different concentration of $CdFe_2O_4$ nanoparticles (, 0.5% and 1%) were added to the disc. The plats were incubated at 300° C for 4 hours.

RESULTS AND DISCUSSION

Morphological analysis

1. XRD

X-Ray diffraction pattern shows in Fig 1. (X-pert, PRO XRD System, Punjab) reveals crystalline nature of sample.

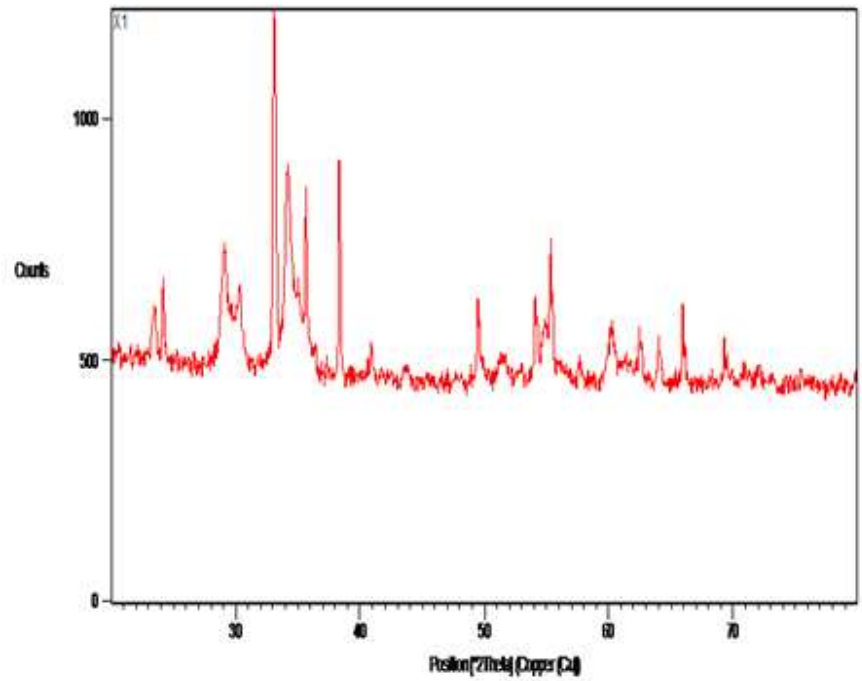

Fig 1.XRD pattern for $CdFe_2O_4$ Calcinated at 550°C

The average crystalline size was 30nm obtained from FWHM of peak corresponding to 2Θ calculated by Debye – Scherrer formula which is given by, L = k λ / β CosΘ Where, L is the average size of crystal, K= 0.9 particle diameter, the λ (0.154 A°) is wavelength of X-Ray, β is full width at half maximum (FWHM) of the diffraction peak and 2Θ is the diffraction angle of diffraction. FWHM is calculated by warren's formula $B^2 = (Bm^2 – Bs^2)$ where Bm is full width at half maximum of the sample and Bs the full width at half maximum of standard quartz.

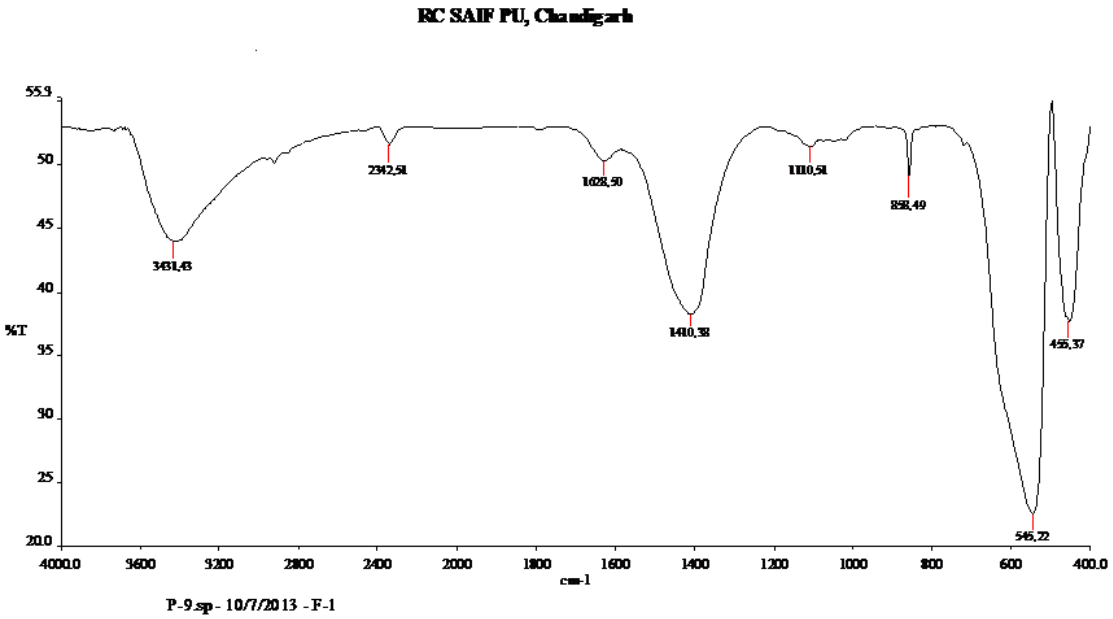

Fig 2. FTIR spectrum of $CdFe_2O_4$ nanoparticle calcinated at 550°C

2. FTIR

FTIR spectra were recorded in range of 400-4000 cm^{-1} **Fig 2**. Shows the FTIR spectra of $CdFe_2O_4$ sample calcinated at 550°C.It is observed that most intense band of spectrum, splitted in 1410cm-1 and 455cm^{-1}, due to stretching of Cd-O-Fe bond of tetrahedral building units forming the structure. The wide absorption in the high energy region of spectrum, centered at 3431cm^{-1}, resulting from –OH stretching is associated to the vibration of water molecule coordinated to ferrite structure that is a broad band at 3431cm^{-1} that assigned to absorbtion of H_2O from the atmosphere or OH group of alcohol. Very small band at 2342cm^{-1} is due to adsorbed or atmospheric CO_2. The characteristics small band at 1628cm^{-1} is assigned to both asymmetric and symmetric C-O respectively. Two small peaks at 455 and 545cm^{-1} that are characteristics of poorly crystalline α-Fe_2O_3.

Antimicrobial properties

During the recent analysis the antibacterial activities of different concentrations of nano- $CdFe_2O_4$ were investigated to find out the best concentration that can have the most effective antibacterial property against the E. coli culture. Good growth inhibition results were observed when the bacterial cells were incubated with $CdFe_2O_4$ nanoparticles during the liquid cultures.

Effect of nano $CdFe_2O_4$ on the growth of E. coli in liquid medium

In the first study, we investigated the effect of different concentrations of nanoparticles in liquid culture of E. coli. The optical density of the medium was investigated as the number of bacteria after contact with the nanoparticles. Fig. 3 shows the effect of different concentrations of nano-$CdFe_2O_4$ on the growth of E. coli. **Fig. 3**.

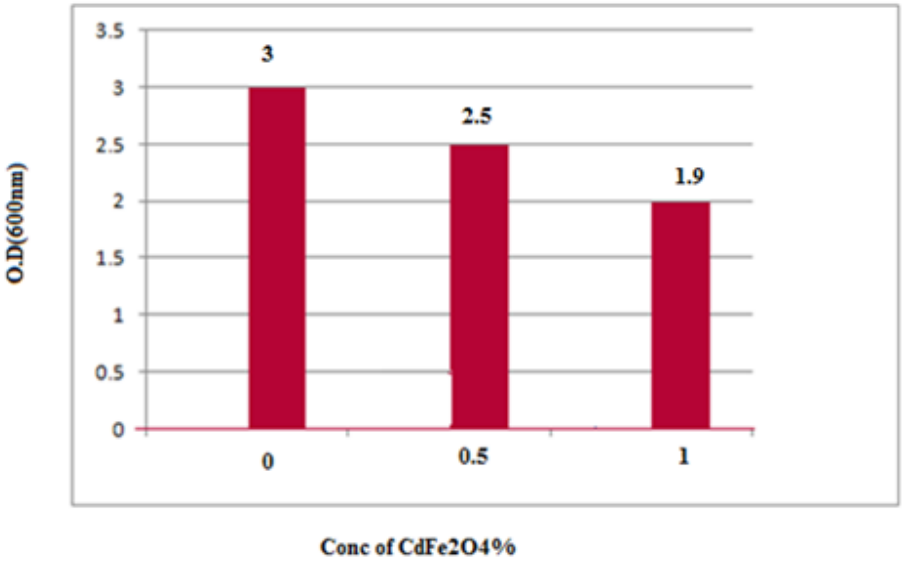

Fig 3. E.Coli concentration dependence upon different concentration of $CdFe_2O_4$ in culture medium

As demonstrated in this figure, 0.5% nano-$CdFe_2O_4$ did not have antibacterial effect while, 1% nano-$CdFe_2O_4$ was highly efficient in inhibiting the E.coli growth as compared to control group. This figure shows that the presence of 0.5% nano-$CdFe_2O_4$ caused a 0.5 times decrease and 1% nano $CdFe_2O_4$ caused a 0.6 times decrease in the optical density of bacterial cultures as compared to control experiment.

Bactericidal effect of nano $CdFe_2O_4$ on E.coli in liquid medium

The second study, estimation of the number of viable E. coli cells in contact with 1% $CdFe_2O_4$ was carried out in water at 4ºC for different contact time intervals. Our result showed the reduction of E. coli cells, upon the addition of 1% nano $CdFe_2O_4$ to the bacterial culture. Fig. 4 represents the number of viable E. coli cells in contact with 1% $CdFe_2O_4$, suspended in water at 4 ºC for different contact times. After the E. coli were suspended in water along with 1% nano $CdFe_2O_4$, it showed complete bacterial killing after 36 hours of their contact with 1% nano-$CdFe_2O_4$. Fig. 4 shows that administration of nano $CdFe_2O_4$ to the bacterial cultures killed most of the bacteria in 2 days. These results demonstrate that nano $CdFe_2O_4$ have a high antibacterial efficiency against E. coli.

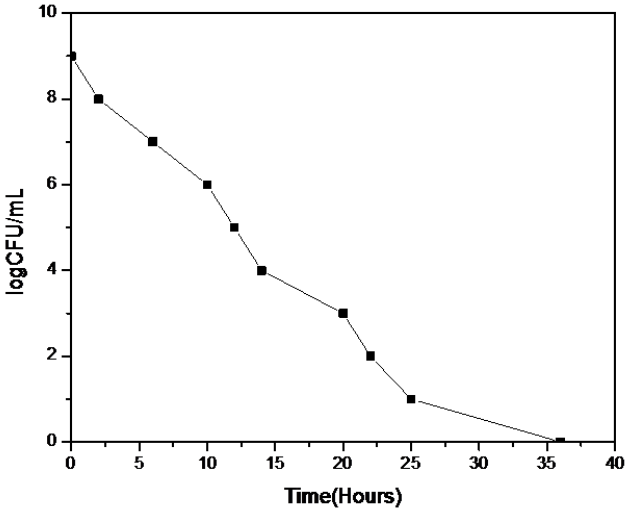

Fig. 4: Killing kinetics of 1% $CdFe_2O_4$ on the E. coli culture

Bactericidal effect of nano $CdFe_2O_4$ on E.coli by Disc diffusion method

Our data of third study, Disc diffusion method is in accordance with the above two estimation methods. After 4 hours the plates were visualized. Fig. 5 shows that the zone of inhibition was absent, 12 mm, 15mm around 0.5% and 1% $CdFe_2O_4$ nanoparticle well, respectively.

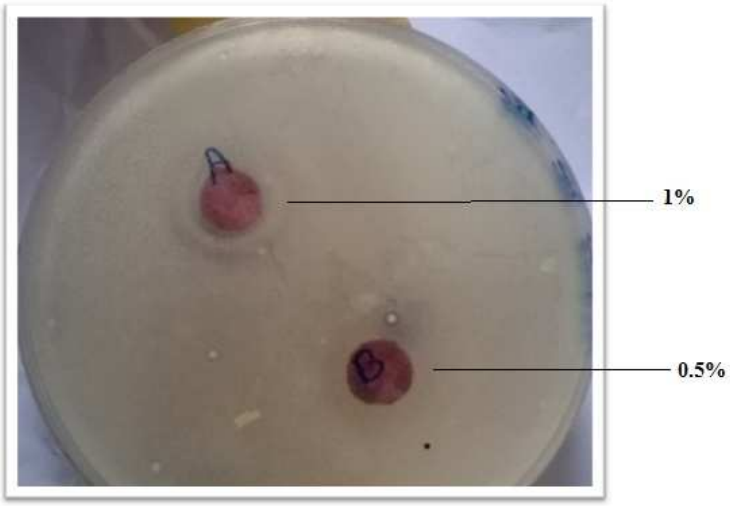

Fig 5. Bactericidal effect of nano $CdFe_2O_4$ on E.coli by Disc diffusion method

The present data demonstrate that a formation made with the biologically stabilized nano $CdFe_2O_4$ can be useful in the treatment of infectious disease caused by E. coli. Our data is in accordance with the previous studies, dealing with the antibacterial effects of nanomaterials [21-23]. The above data demonstrate that $CdFe_2O_4$ nanoparticles can be useful in the treatment of infectious diseases caused by *E.coli*.

CONCLUSION

It is concluded that the $CdFe_2O_4$ nanoparticles shows effective antibacterial activity towards the gram negative bacterium *E.coli*. Offered versatile and attractive approach for uniform nanoparticle formation since they provide good control over particle shape and size. Nanosized particles greatly influence the antimicrobial activity of the sample This technique has its own advantage and is subjected to wider use in preparing nanoparticles.

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REFERENCES

[1] N Engl J Med. F Lowy, *Journal of Clinical Investigation*, **(1998);** 339: 520–532.
[2] Malaw Med J. Komolafe, *Medical Journal*, (**2003**); 15: 63–67.
[3] PM. Hawkey, *Journal of Antimicrobial Chemotherapy*, **(2008)**; 62 Suppl 1:i1–i9.
[4] K Lewis, AM Klibanov, *Journal of Chemical and Biological Engineering*, **(2005)**; 23:343–348.
[5] NL Rosi, CA Mirkin, *Journal of Material Science* (**2005);** 105:1547–1562.
[6] **A** Azam, AS Ahmed, M Oves, MS Khan, A Memic, *International Journal of Nanomedicine*, **(2012);** 7:3527–3535.
[7] KR Raghupati, RT Koodali, AC Manna. *International Journal of Nanomedicine* **(2011**) ; 27:4020–4028.
[8] O Mahapatra, M Bhagat, C Gopalakrishnan, KD Arunachalam, *J Exp Nanosci* (**2008) ;** 3:185–193.
[9] Wu, X., Liu, H., Liu, J., Haley, KN., Treadway, J.A., Larson, J.P., Ge, N., Peale, F. and Bruchez, M.P., *Journal of Nat. Biotechno*l (**2003)** 21: 41-46.
[10] J.D Fortner, ., D.Y Lyon., C.M Sayes , A.M Boyd, J.C., Falkner., E.M., Hotze, L. B Alemany, Y. J Tao, K. D Ausman, , V. L. Colvin, and Hughes**,** *Journal Of Environmental Science* **(2005)** 4307-4316.
[11] P Li, J Li, C Wu, Q Wu and J.Li, *Journal of Nanotechnology***,** (**2005)** 1912-1917.
[12] JP Ruparelia, AK Chatterjee, SP Duttagupta, S Mukherji, *Journal of Acta Biomater* (**2008)**; 4:707–716.
[13] M Heinlaan, A Ivask, I Blinova, HC Dubourguier, A Kahru *Journal of Chemosphere***.** (**2008);** 71:1308–1316.
[14] Xu GC, ET al. Chemical Industry press, *Nanocomposite*. Beijing: **(2002).**
[15] Cermenati L, Dondi. DL. Maurizio Fagnoni and Angelo Albini. *Journal of Tetrahedron*. **(2003);** 59: 6409-6414.
[16] Liu JP, et al**.** China Textile Press, Nanotechnology in textile Science. Beijing: **(2003).**
[17] Wu X, Liu H, Liu J, haley KN, Treadway JA, Larson JP, et al *Journal of Biotechnol*, **(2003); 21(1):41-6.**
[18] Fortner JD, Lyon DY, Sayes CM, Boyd AM,Falkner JC, Hotze EM Alemany et al *Journal of Environ Sci Technol*, **(2005)**; 39(11): 4307-16.
[19] M. A. Gabal, A. A. El-Bellihi, and S. S. Ata-Allah, *Journal of Materials Chemistry* (**2003)** part II, vol.81, no. 1, pp. 84–92**.**
[20] Y. Sharma, N. Sharma, G. V. S. Rao, and B.V. R.Chowdari, *Bulletin of Materials Science*, (**2009)** vol. 32, no. 3, pp. 295–304**.**
[21] Clement, J.L. and Jarrett, P.S. *Journal of Material Based Drugs* (**1994)** 1; 467-482.
[22] H Zhang, and G Chen, *Journal of Environ Sci Technol*, **(2009)** 43; 2905-2910.
[23] G. Cook, and J.W. Costerton, *Int. Journal of Antimicrob Agents*, **(2003)** 107; 6269-6275.
[24] I Sondi, and B Salopek-Sondi, *Journal of Colloid Interface Sci*, **(2004)** 275; 177-182.
[25] M Singh, S. Manikandan and A.K. Kumaraguru, **2011**. *Nanoparticles: Res. J. Nanosci. Nanotechno*l., 1: 1-11.
[26] Elumalai, EK. Prasad, T.N.V.K.V. Hemachandran, J. Viviyan, S. Therasa, Thirumalai, T. David, *Journal of Pharm. Sci. & Res*. Vol.2 (9), 549-554.