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ANTI BACTERIAL STUDY OF CADMIUM SUBSTITUTED NICKEL FERRITE NANO PARTICLES

K Rafeekali, E M Muhammed

Research department of physics, Maharajas college, Eranakulam, Kerala, India

rafeekali4u@gmail.com, 9447404221

Abstract- Nanoparticles of cadmium substituted nickel ferrite were synthesized with step increment x, $NiFe_{2-x}Cd_xO_4$ (x=0, 0.03, 0.06, 0.09, 0.12) by sol-gel technique. This work explored the antimicrobial properties of synthesized cadmium doped nickel ferrite nanoparticles against microorganism *Escherichia coli* (*E. coli*) using solid agar plates and liquid broth medium. It is found that antibacterial effect is maximum at x=0.03. The variation of antibacterial effect was studied as a function of cadmium concentration x.

Keywords: Rare earth ions, doping, mixed ferrites sol gel, micro organisms, anti bacterial effect

1. Introduction

Nanocrystalline ferrites have been the focus of intense research for more than a decade due to their unusual structural, magnetic and electrical properties. Several physical and chemical methods are available for the synthesis of ferrite nanoparticles. The sol-gel technique allows good control over stoichiometry and produce nanoparticles with small size and narrow size distribution . Hence this method is selected for the synthesis of nickel ferrite nanoparticles. nickel ferrite is an important magnetic material and is characterized by its high coercivity, moderate saturation magnetization and very high magneto-crystalline anisotropy. These properties along with their physical and chemical stability make them suitable for several technological applications. The application of magnetic nanoparticles as antimicrobial agents is gaining importance due to the fact that they can be easily manipulated by anexternal magnetic field. The iron oxide nanoparticles have been synthesized and tested for various applications in medicine such as magnetic hyperthermia, targeted drug delivery and bactericides. Among the different ferrites, nickel ferrite has special magnetic and physical properties which lead to its wide applications in medicine. The biomedical and clinical applications of cadmium nanoparticles are well established in the literature. Further, they have a broad spectrum of antibacterial activity against several pathogens. Hence they are incorporated into various matrices to extend their utility in biomedical applications. The addition of cadmium to nickel ferrite will provide a new composite material with good magnetic behaviour and enhanced antimicrobial activity. The confluence of magnetic and antibacterial properties can make this material important for applications in biomedicine.

2 Experimental

2.1 Synthesis

Nanoparticles of cadmium substituted nickel ferrite were synthesized with step increment **$NiFe_{2-x}Cd_xO_4$ (x=0, 0.03, 0.06, 0.09, 0.12)** by sol-gel technique. Stoichiometric ratio of nickel nitrate,cadmium nitrate and ferric nitrate (AR grade MERCK) were dissolved in minimum amount of ethylene glycol using a magnetic stirrer. The solution was heated at333K until a wet gel of the metal nitrate was obtained. Further heating of thegel at 473K resulted in the self ignition and finally produces a highly voluminous and fluffy powder. The obtained powder was ground well using an agate mortar. These synthesized powders were labelled with different x values

2.2 Antibacterial Study

This work explored the antimicrobial properties of synthesized cadmium doped nickel ferrite nanoparticles against microorganism *Escherichia coli* (*E. coli*) using solid agar plates and liquid broth medium, from the Pathology Laboratory of St. Albert's College, Ernakulam. These cultures were then sub cultured into nutrient broth according to the standard protocols for sub culturing and allowed to grow in an incubator at 313K for 24 hours and used for further experiments.

3. Results and discussions

In this work, the antibacterial efficacy of cadmium substituted nickel ferrite nanoparticles was analyzed against various microbes using liquid broth and plate based growth studies. The minimum inhibitory concentration in the present study was observed to be 1mg/ml. The optical density and viable count measurements of the bacterial strains in the culture media were examined as a function of cadmium content and these results are depicted in Figure 1.

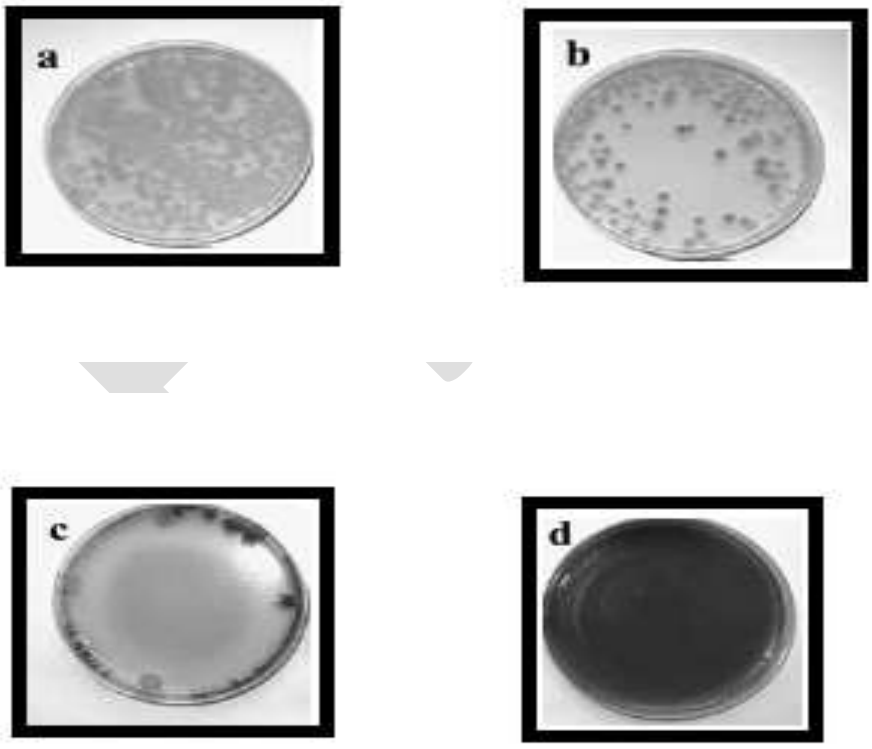

Figure.1. E. coli **treated with cadmium substituted nickel ferrite nano particle with cadmium concentration (a) x=0.03 (b) x=0.06 (c) x=0.09 (d) x=0.12**

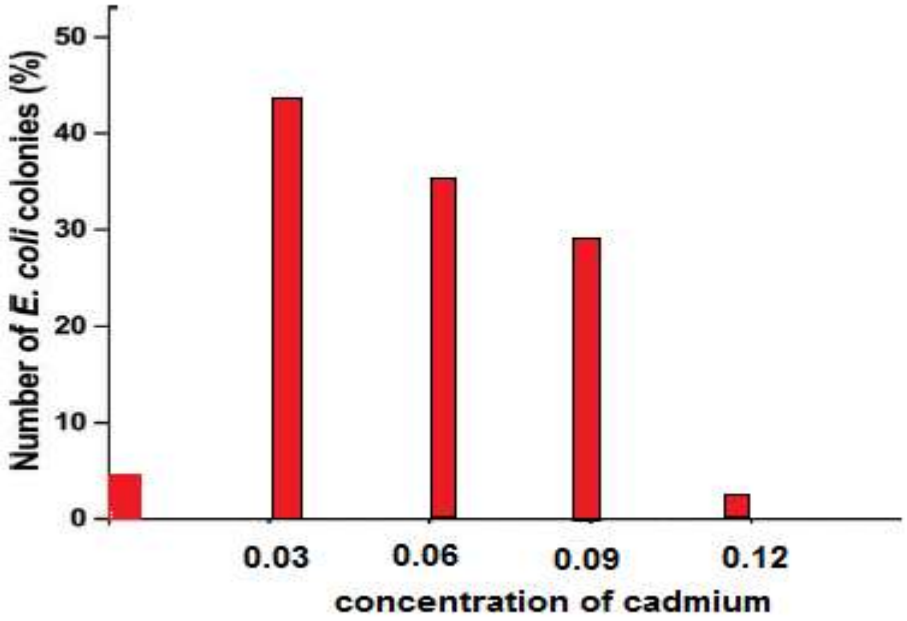

Fig.2.Growth rate of E.Coli graphically

From the OD measurements, it was observed that the antibacterial activity increased with increase in cadmium concentration of x=0.03. However, when the cadmium content exceeds above x=0.03, a stimulatory effect in the bacterial growth was observed. The small size allows the nanoparticles to cross the cell wall of the bacteria disrupting the cell membrane and leading to cell death. Also the degree of dispersion of nanoparticles in water plays an important role in the antibacterial mechanism and it increases with decrease in particle size. Therefore, the improved antibacterial properties of the samples with smaller cadmium content can be attributed to the large surface to volume ratio which provides them better contact with the bacterial cell. Three different stages of growth are observed in all cases and these are called lag phase, log phase and stationary phase.

4. Conclusions

Cadmium substituted nickel ferrite nanoparticles, $\mathbf{NiFe_{2-x}Cd_xO_4}$ have been successfully synthesized by sol-gel technique. The antibacterial efficacy was tested against gram negative andgram positive bacterial strains and the results show an enhancement in the activity with the addition of cadmium into nickel ferrite. However for higher concentrations of cadmium ion, a decline in the antibacterial behaviour isobserved. The improvement in the biocidal activity is attributed to the increase in the surface to volume ratio of the nanoparticles which enhances the contact area with the microbes. Thus the silver substituted cobalt ferrite nanoparticles with good magnetic and antibacterial properties can offer great promises in biomedical and pharmaceutical applications.

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