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Green synthesis of metal oxide nanoparticles using plant extract, its structural and optical properties and application

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Abstract:*The nanoparticles being the most utilized invention of nanoscience and technology,which is used in many aspects of science and medicine. These remarkable utilization of particles is due to their diverse properties at nanolevel. The chemical and physical approach to formation of nanoparticles are toxic to surroundings also leading to less efficient usage of them in medical perspective. In this article green synthesis of cobalt ferrite nanoparticles is done by sol-gel auto combustion using Caralluma Tuberculata extract as reducing agent, iron nitrate and cobalt nitrate as precursor salts. Cobalt ferrite nanoparticles are used in many aspects for certain properties such as antimicrobial activities the synthesized particles were characterized using different techniques such as UV Spectroscopy, SEM, FTIR, XRD,EDX. The antibacterial activity of cobalt ferrite nanoparticles is performed which shows remarkable results by increasing the inhibition zone for both E coli and Staphylococcus bacteria.*

Keywords:*Green synthesis, Metal oxide nanoparticles,Antimicrobial,Nanoparticles.*

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I. INTRODUCTION

The conventional approach to synthesis of nanoparticles are hazardous and not ecofriendly making these nanoparticles not far effective for biomedical application as they have high toxicity due to precursors from which they are made. Using organic substances as reducing agent leads to nontoxic formation of nanoparticles. Thus making these synthesized particle more effective in field which they are used [1]. ZnO green synthesized from Agathosma betulina extract were spherical and 15nm in size [2]. ZnO nanoparticles synthesized from *Pisumsativum* (green peas) peels show very impressive photocatalytic and antifungal activities[3].

Silver NPs synthesized by Mimosa pudica Gaertn as reducing agent were used for anti-parasiticactivities against malaria. The most effective mortality rate was observed for A,subpictus and against the larvae of C-quinquefasciatus [4]. Ag particles synthesized from beetroot extract shows that as the amount of extract increased the particle size formed decreases moreover these particles also showed effective inhibitory results for both gram negative and positive bacteria [5]. Ag NPs synthesized from Eucalyptus chamaniana are stable and can be used for promyelocytic leukemia [6].Moreover, Ag nanoparticles have wide range of application such as to overcome water toxicity, antimicrobial properties of them are remarkable in the sense Ag NPs has made a great change in applied medicine [7].

Caralluma Tuberculata plant which grows in several parts of the world. In several researches its Anti-inflammatory properties are investigated. This plant also shows antibacterial properties and is also utilized as cytotoxic phytotoxic agent [8].

Ferrite materials are ferromagnetic materials that are mostly made of ferric oxide (Fe_2O_3)[9]. Cobalt ferrite nanoparticles are a type of Nano-scale magnetic material that consists of cobalt (Co) and iron (Fe) atoms arranged in a crystal lattice structure. These nanoparticles have attracted significant attention due to their unique properties and potential applications in various fields. They also possess a high coercivity, meaning they require a relatively large amount of magnetic field to demagnetize. This property makes them suitable for high-density magnetic data storage [10]. Cobalt ferrite nanoparticles can also be utilized in environmental remediation. They have been studied for their potential in removing pollutants and heavy metals from contaminated water and soils. cobalt ferrite nanoparticles have shown promise in biomedical applications. Researchers have been exploring their use in targeted drug delivery systems, where the nanoparticles can be functionalized with specific drugs and directed to specific sites within the body[11].By raising the calcination temperature magnetization is also increased in case of Nickel ferrite nanoparticles [12].

II. METHOD AND METHODOLOGY

Synthesis of Co_2Fe_3 Nanoparticles is done by sol gel auto combustion method. The plant of Caralluma tuberculata dried and was grinded in powder form as shown in figure 1 (a). The extract of plant was made in deionized water 6 samples of extracts were made on basis of temperature40°C,50°C,60°C,70°C, 80°C, 90°C. BY adding folin's reagent in each solution and performing their UV it was found that at 60^{o}C the highest absorbance is shown. So, all other plant extract were made on this temperature. To synthesize cobalt ferrite nanoparticles Cobalt Nitrate and Iron Nitrate are used as precursor salts in 1:2 ratio.In 5ml deionized water 1g of Cobalt nitrate and 2g of Iron nitrate are added and stirred on magnetic stirrer for 15mins as the salts get completely dissolved in water in this ratio large amount of salt solution is made.In each 25ml of salt solution 5mg of extract solution is added and stirred on magnetic stirrer at different temperature for 15minutes. After this the cluster of particle will form at the bottom of beaker. Highest NPs are formed at 80^{o}C so all the particles will be formed at this temperature. Three types of solution on the basis of extract concentration are made.In first sample 25mg of extract is added in 50ml of salt solution. In second sample 50ml of extract solution is added in 50ml of salt solution while in sample three 100ml extract solution is added in 50ml of salt solution. The ash black powder of cobalt ferrite nanoparticles are formed (figure 1-b) from three types of concentration of extract.

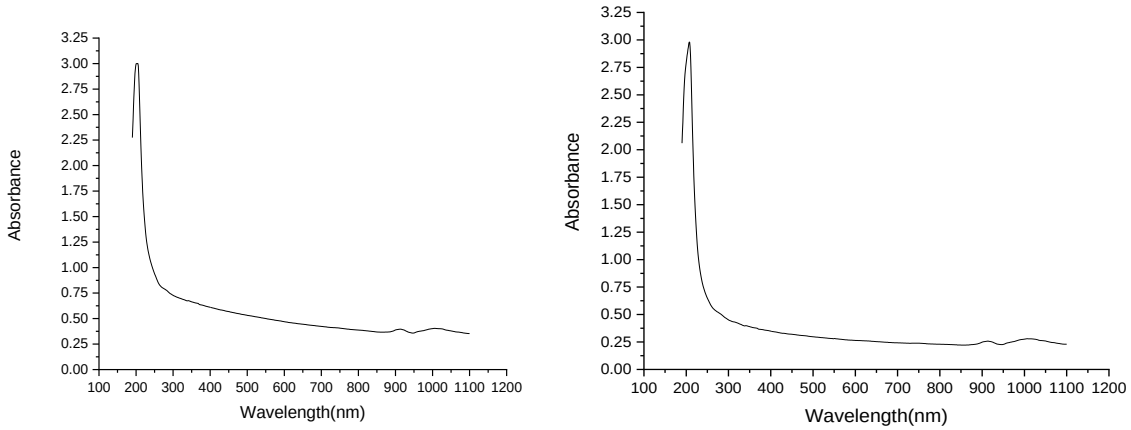
Figure 1: (a) Powder form of Carraluma Tuberculata (b) Cobalt Ferrite NPs

III. Results and Discussion

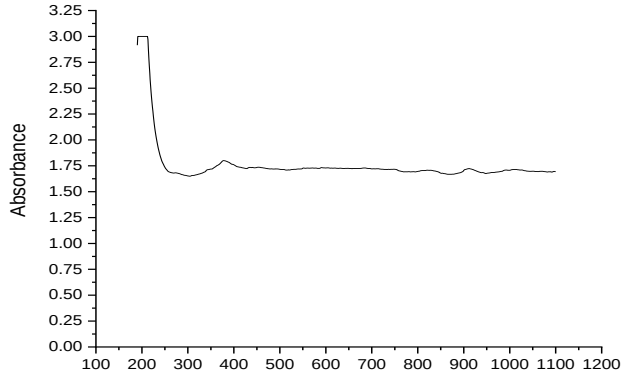
The NPs of cobalt ferrite formed by green synthesis of caralluma tuberculata extract as reducing agent were characterized through various techniques to confirm their presence and specific properties and application.

UV – Spectroscopy

UV visible spectroscopy of cobaltferrite nanoparticles is done .It shows the optical properties of synthesized nanoparticles the absorbance range was taken from 100nm to 1200nm . UV of all three samples of nanoparticles made on the basis of different extract concentration taken . The highest peaks was observed between 200 to 250nm for sample S1(figure 2(a)). The absorbance range for second sample (S2) is from 100 to 1200nm highest peak is observed between 200 to 230nm(figure 2(b)). Third Sample (S3) shows slightly different absorbance then other two samples S1 and S2. This change may be due to high concentration of plant extract (100ml) in S3(figure 2(c)).



(a) *(b)*

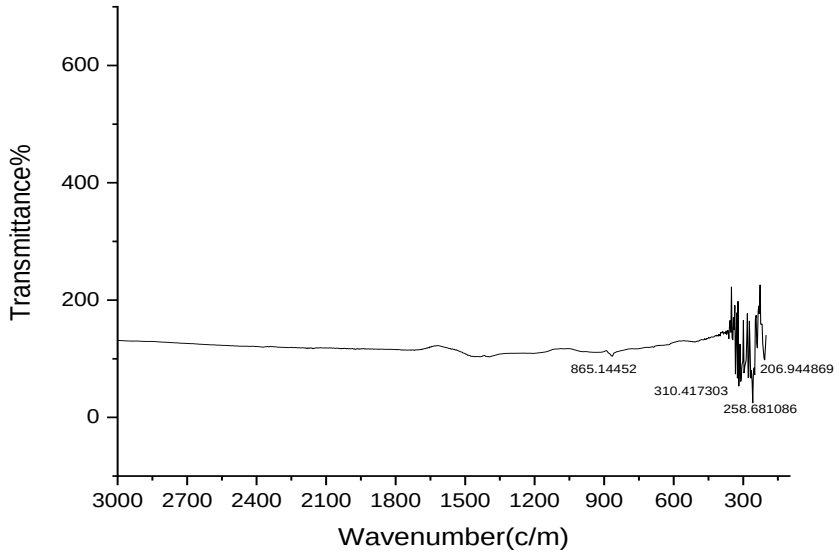


(c)

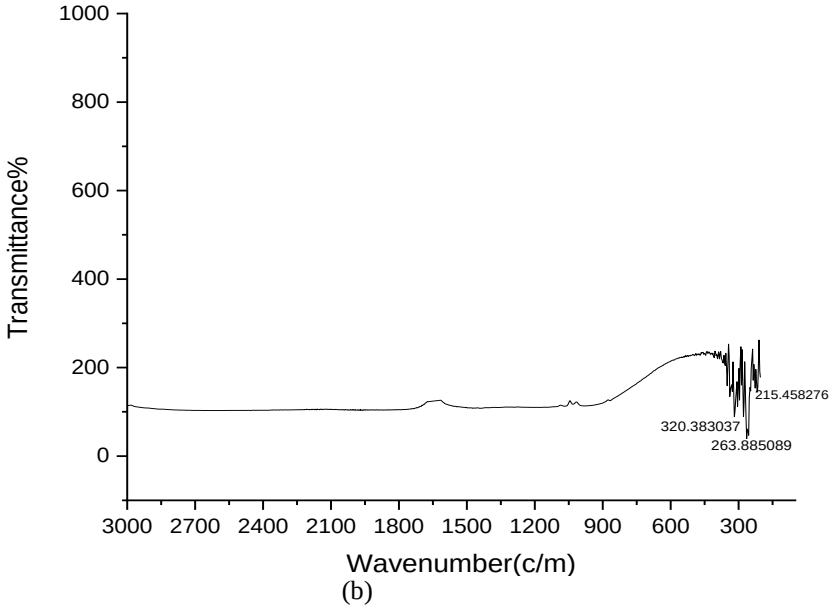
Figure 2: (a) UV of S1(b) UV of S2 (c) UV of S3

FTIR

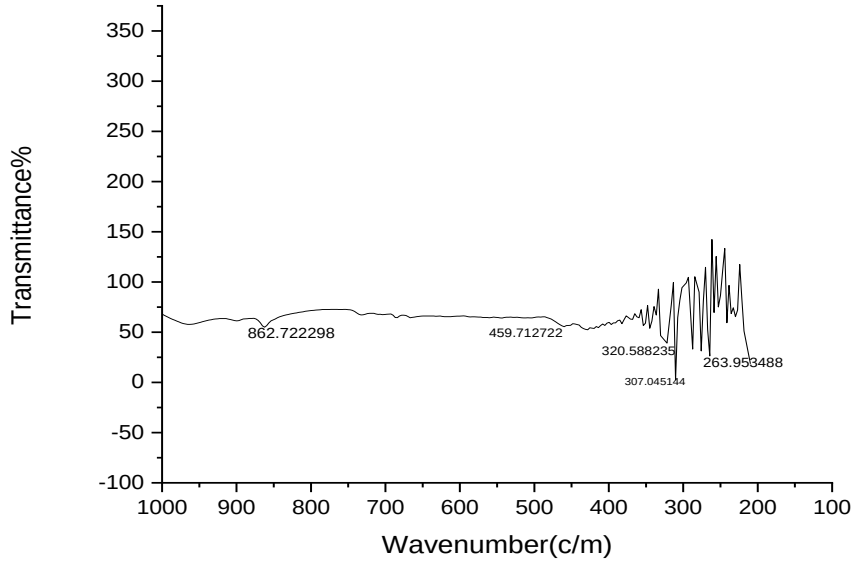
To identify the presence of different phenolic groups in all three samples Fourier transform infrared spectroscopy is done. Which shows the stretching and bending for various phenolic groups present in samples. For S1 different peaks are seen at 865.15cm^{-1}, 310.42cm^{-1} ,258.68,206.945cm-1(as shown in figure 3(a)). For sample S2 for which extract concentration is 50ml the peaks are seen at 320.5cm^{-1},263.8cm^{-1},215.45cm^{-1} and others(as shown in figure 3(b)).For S3 for which extract concentration is 100ml the FTIR bending peaks are seen at 863.7cm^{-1},459.7 cm^{-1},320.58cm^{-1},307.04cm^{-1},263.95cm^{-1}(as shown in figure 3(c)).



(a)



(b)



(c)

Figure 3: (a) FTIR of S1(b) FTIR of S2 (c) FTIR of S3

XRD

X-Ray Diffraction technique is used to confirm the crystalline or amorphous nature of formed nanoparticles for crystalline nature distinct peaks are observed, while for amorphous nature no specific peaks are seen. At 400 t0 600^{O}C then discrete peaks appeared on XRD graph. The combined XRD graph of all samples for crystalline cobalt ferrite is given as in figure 4.

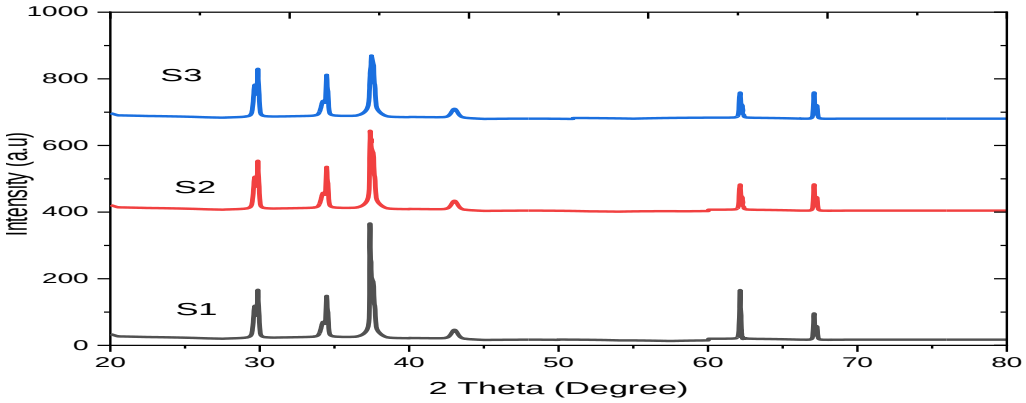
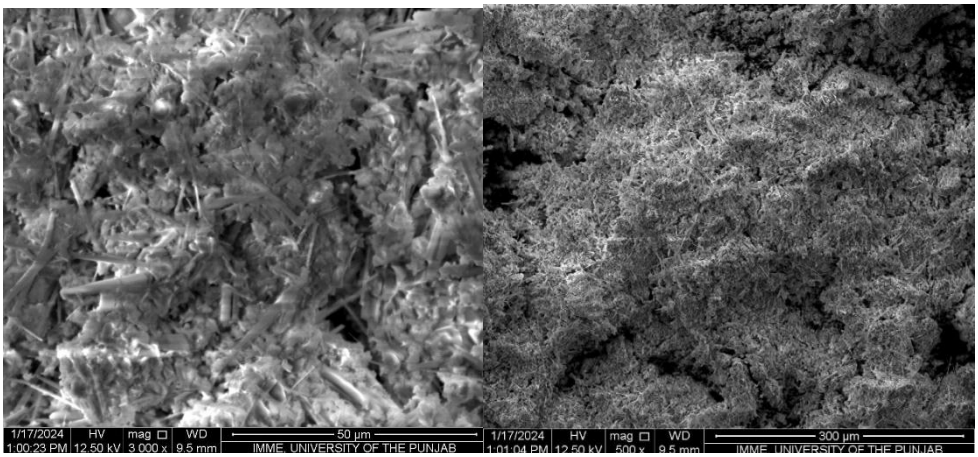


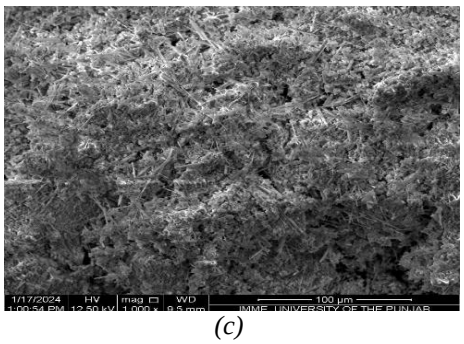
Figure 4: XRD off S1,S2,S3

SEM

Scanning electron microscopy is used to study the morphology of synthesized nanoparticles. The SEM image show agglomerates of cobalt ferrite nanoparticles. The size of observed nanoparticles is different between 70 to 120 nm. The SEM images are given belowin figure 5.



(a) *(b)*



(c)

Figure 5: (a) SEM image at 50um (b) SEM image at 300um (c) SEM image at 100um

EDX

EDX of the sample shows that it contains mainly oxygen, cobalt, ferrite small amount of other elements are also observed. The highest peak was observed for oxygen second highest peak is for Fe (iron), third highest peak is of cobalt such as shown in figure 6.

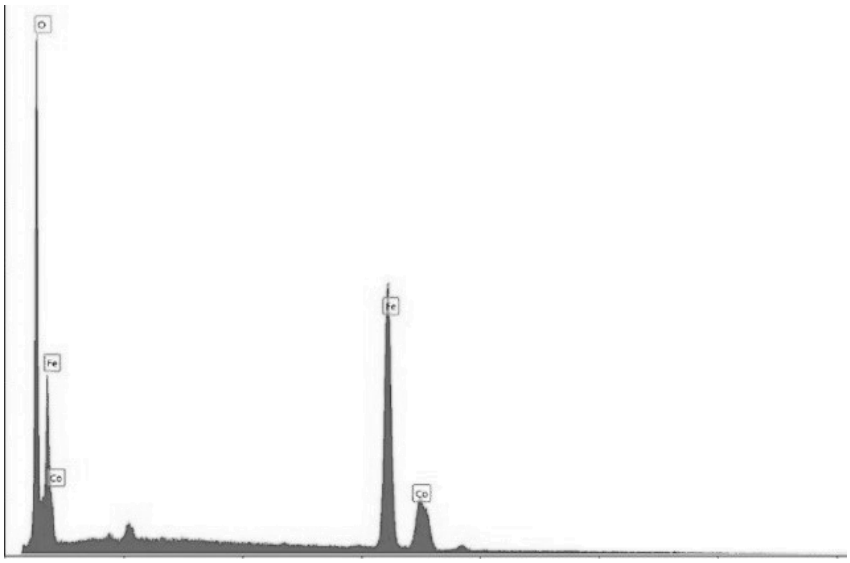


Figure 6: (a) EDX of Cobalt ferrite NPs

Antibacterial Activity

The antibacterial activity of cobalt ferrite nanoparticles of all three samples is tested against both gram negative and gram positive bacteria such that the inhibition zone increases(shown in figure 7). This was performed in presence of ciprofloxacin which is an effective antibiotic for various diseases. The result shown were remarkable it shows that the effect of ciprofloxacin increased 34 % in inhibition of E Coli bacteria and 28% in Staphylococcus aureus.

Figure 7: Antibacterial activity of Cobalt ferrite

VI. Conclusion

In this research green synthesis of cobaltferrite nanoparticles is done by using Carallumma tuberculata plant as reducing agent .Three different samples of nanoparticles are made on basis of concentration of plant extract. All three types of samples are characterized using XRD,FTIR,SEM,EDX,UV. The antimicrobial property of particles is tested by using them on E.Coli and Staphylococcus bacteria. Antibacterial experiment responded with effective results thus confirming that they can be used for biological purposes. Moreover, the expenses on the synthesis were very minute making it reasonable for everyone no waste chemicals are exhaled in air either and yield of particles is also high.

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