



Green Synthesis of Iron Oxide Nanoparticles Using *Lantana Camara* Extract

F. Shaibh^{1,2}, Adel G.E. Abbady¹, Moustafa M³, Alaa Hassan Said^{1,2}

¹Electronics and Nano Devices lab, Faculty of Science, South Valley University, Qena, Egypt.

²Physics Department, Faculty of Science Qena, South Valley University, Qena, Egypt.

³Physics Department, Faculty of Science, Minia University, Minia, Egypt.

ABSTRACT

Iron oxide nanoparticles (IONPs) are a talent material in a variety of everyday applications due to its multifunctional properties. Its attractive candidate in the biomedical field due to its low toxicity and biocompatibility, antibacterial, antifungal, anticancer and magnetic characteristics. Its utilized in different application such as magnetic separation, targeted drug administration, magnetic resonance imaging (MRI), magnetic fluid hyperthermia, thermoablation, and biosensing. Physical, chemical, and environmentally biogenic methods have been applied to synthesis IONPs. Green methods is favorable compared with physical and chemical synthesis, due to its low cost, enhanced biocompatibility, and eco-friendliness. In this work, *lantana camara* extract was used for green synthesis of IONPs. The synthesized IONPs were characterized by X-ray diffraction (XRD), and Fourier transform infra-red (FTIR) spectroscopy. The obtained results revealed that *lantana camara* extract can be used as a reducing agent for synthesis of IONPs.

Keywords: Green synthesis, Iron Oxide, X-ray diffraction (XRD), and Fourier transform infra-red (FTIR) spectroscopy.

1. Introduction

In recent years, magnetite iron oxide nanoparticles Fe_3O_4 (IONPs) have garnered interest due to its unique properties, include superparamagnetism, low toxicity, high biocompatibility, antibacterial, antifungal, and anticancer properties. Moreover, the high ability of electrons transfer, high surface energy, large surface area, and high absorption. [1]. It became a good candidate for many applications such as, magnetic scaffolds [2], data storage [3], biomedicine [4], [5], magnetic resonance imaging [6], [7], cell labelling [8], cell therapy [9], gene delivery [10], [11], drug delivery [12], hyperthermia [1][13], therapeutic application [14], bioimaging [15], and environmental water treatment remediation [16]–[18]. Different methods had been reported for synthesis of IONPs including co-precipitation [19], sol–gel method [20], energy milling [21], ultrasonic assisted impregnation [22], microemulsion [23], sonochemical [24], gamma irradiation [25], solvothermal [26], hydrothermal [27], and green method [28].

The green synthesis of nanoparticles offers new possibilities, such as functionalization with biomolecules, which can enhance the bioactivity of nanoparticles in biomedical applications. In addition, green synthesis methods are deemed simple, clean, eco-friendly, and inexpensive. In the green synthesis of NPs, the reduction of metals can be accomplished with the aid of biomolecules, which function as both a reducing and capping agent. Several sources of biomolecules, including plant extract, bacteria, fungi, algae, virus, and yeast, were investigated for NPs synthesis. The plant-based synthesis of NPs is the simplest, quickest, and most scalable technique. A metal salt is created with plant extract, and the reaction is complete in minutes to a couple of hours at room temperature. This is not a difficult technique [29].

In this work, Fe_3O_4 NPs were synthesized using *Lantana Camara* extract. The physical properties of the prepared sample were examined X-ray diffraction (XRD), and Fourier transform infra-red (FTIR) spectroscopy.

2. Materials and Methods

2.1 Materials

The following chemicals were used in this study were used without further purification. Sigma-Alorich, Lot #MKBJ3856V, 0.05% Iron(II) Sulfate Heptahydrate. Sodium hydroxide (NaOH).

2.2 Preparation of plant extract

2.2.1 Lantana Camara leaves extract

Fresh *Lantana camara* leaves were harvested, carefully rinsed with tap water and distilled water to eliminate dust particles and sun-dried to remove any leftover moisture. 3 g of powdered dried leaves were combined with 100 mL of deionized water and cooked for 30 minutes at 80 °C. The produced mixture was cooled, filtered with Whatman paper number 1, collected, and kept at 4 °C for future use.

2.3 Preparation of Iron Oxide nanoparticles (Fe₃O₄NPs)

Iron Sulfate Heptahydrate (FeSO₄·7H₂O) was used as a precursor for iron during the coprecipitation-based production of IONPs. Briefly, 1.81 g of iron sulphate heptahydrate was dissolved in 100 mL of deionized water and agitated at 1100 RPM for 30 minutes at 60 °C. The reducing agent, 10 mL of plant extract, was added to the iron solution while it was being stirred for 30 minutes. The pH of the solution was adjusted to 12 by adding the appropriate amount of sodium hydroxide. The produced solution was allowed to completely precipitate and then washed many times with a 2:1 ethanol: distillate water (V/V) solution and dried at 100 °C.

2.4 Characterization of green synthesized IONPs

The X'Pert PRO-PAN analytical diffractometer was used to take the X-ray diffraction (XRD) readings at 40 kV and 30 mA, using Cu-K α radiation ($\lambda=1.54056 \text{ \AA}$). FTIR spectral analysis utilizing the KBr disc technique to determine the functional groups of the researched samples using FTIR Model 6100, Jasco-Japan, with a resolution of 4.00 cm⁻¹ and a wave number range of 4000 to 400 cm⁻¹.

3. Results and Discussion

3.1. Characterization of iron oxide nanoparticles

Figure 1 represent XRD pattern of green IONPs, the successful formation of IONPs was confirmed by the presence of all its characteristic peaks without any structural changes. The peaks at 2θ values (30°, 35°, 43°, 53°, 60 and 62°) correspond to the planes of (202), (311), (400), (422), (511) and (404) of *L. camara* mediated iron oxide nanoparticles. The obtained result with a complete agreement with card No. (COD 9007644) [30] and with the reported results for IONPS [30].

The FT-IR spectrum was used to identify the functional groups of green IONPs in wave number range of 4000-400 cm⁻¹. The fingerprint vibration band for Fe-O stretching vibration, which observed at ~ 544, the bending vibrational band at 1616 cm⁻¹ and stretching vibration band at 3300 cm⁻¹ which corresponding the water as moisture, figure 2. The presence of the characteristic function groups of IONPs confirmed the reduction of iron salt and the formation IONPs using *L. Camara* plant extract [31].

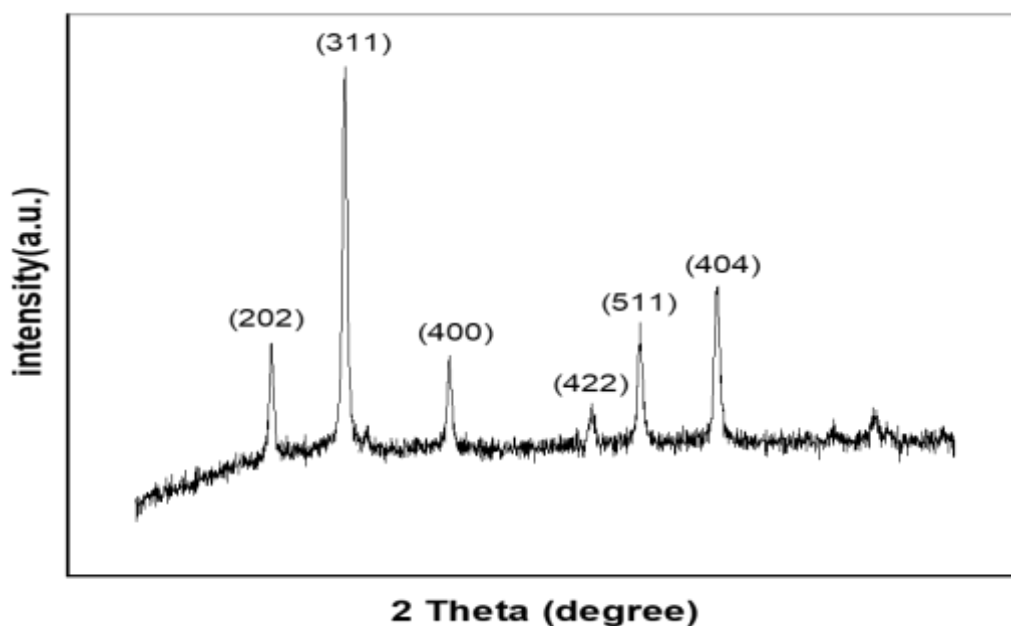


Fig.1 XRD patterns of green IONPs with *L. Camara* extract

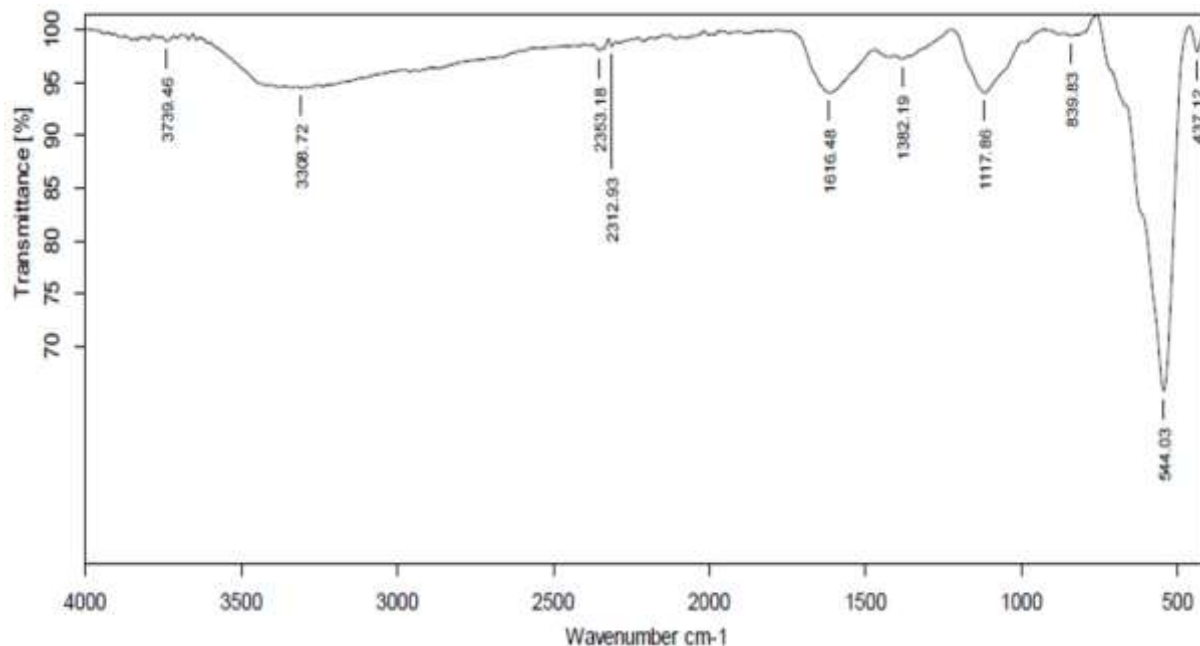


Figure (2) FTIR spectra of green IONPs with *L. Camara* extract.

4. Conclusion

Iron oxide NPs can be synthesized in a straightforward, cost-effective, and environmentally friendly manner. Iron oxide nanoparticles were successfully synthesized from *Lantana Camara* extract without structural changes.

References

- [1]. R. Rahmawati *et al.*, "Synthesis of Magnetite (Fe₃O₄) Nanoparticles from Iron sands by Coprecipitation-Ultrasonic Irradiation Methods," *J. Mater. Environ. Sci.*, vol. 9, no. 1, pp. 155–160, 2018, doi: 10.26872/jmes.2018.9.1.19.
- [2]. R. Rahmawati *et al.*, "Optimization of Frequency and Stirring Rate for Synthesis of Magnetite (Fe₃O₄) Nanoparticles by Using Coprecipitation- Ultrasonic Irradiation Methods," in *Procedia Engineering*, 2017, vol. 170, pp. 55–59. doi: 10.1016/j.proeng.2017.03.010.
- [3]. . Liao, H. Zhang, and C. Lai, "Magnetic Nanomaterials for Data Storage 14 . 1 Introduction : Magnetic Data Storage and its Requirements on Magnetic Nanomaterials," pp. 439–471, 2017.
- [4]. T. J. Brunner *et al.*, "In vitro cytotoxicity of oxide nanoparticles: Comparison to asbestos, silica, and the effect of particle solubility," *Environ. Sci. Technol.*, vol. 40, no. 14, pp. 4374–4381, Jul. 2006, doi: 10.1021/es052069i.
- [5]. A. Ito, M. Shinkai, H. Honda, and T. Kobayashi, "Medical application of functionalized magnetic nanoparticles," *J. Biosci. Bioeng.*, vol. 100, no. 1, pp. 1–11, 2005, doi: 10.1263/jbb.100.1.
- [6]. O. Veisoh, J. W. Gunn, and M. Zhang, "Design and fabrication of magnetic nanoparticles for targeted drug delivery and imaging," *Advanced Drug Delivery Reviews*, vol. 62, no. 3. pp. 284–304, Mar. 08, 2010. doi: 10.1016/j.addr.2009.11.002.
- [7]. M. Serhan *et al.*, "Total iron measurement in human serum with a smartphone," in *AIChE Annual Meeting, Conference Proceedings*, 2019, vol. 2019-November. doi: 10.1039/x0xx00000x.
- [8]. C. Wilhelm and F. Gazeau, "Universal cell labelling with anionic magnetic nanoparticles," *Biomaterials*, vol. 29, no. 22, pp. 3161–3174, Aug. 2008, doi: 10.1016/j.biomaterials.2008.04.016.
- [9]. S. I. Jenkins, H. H. P. Yiu, M. J. Rosseinsky, and D. M. Chari, "Magnetic nanoparticles for oligodendrocyte precursor cell transplantation therapies: progress and challenges," *Mol. Cell. Ther.*, vol. 2, no. 1, p. 23, 2014, doi: 10.1186/2052-8426-2-23.
- [10]. R. Rahmawati *et al.*, "Optimization of Frequency and Stirring Rate for Synthesis of Magnetite (Fe₃O₄) Nanoparticles by Using Coprecipitation- Ultrasonic Irradiation Methods," *Procedia Eng.*, vol. 170, pp. 55–59, 2017, doi: 10.1016/j.proeng.2017.03.010.
- [11]. D. Ebert and M. E. Greenberg, "基因的改变 NIH Public Access," *Bone*, vol. 23, no. 1, pp. 237–337, 2013, doi: 10.1002/sml.201100825.N-Alkyl-PEI.

- [12]. S. Singh, H. Chawla, A. Chandra, and S. Garg, "Magnetic hybrid nanoparticles for drug delivery," *Magn. Nanoparticle-Based Hybrid Mater. Fundam. Appl.*, vol. 2, no. 3, pp. 319–342, 2021, doi: 10.1016/B978-0-12-823688-8.00034-X.
- [13]. X. L. Liu *et al.*, "Optimization of surface coating on Fe₃O₄ nanoparticles for high performance magnetic hyperthermia agents," *J. Mater. Chem.*, vol. 22, no. 17, pp. 8235–8244, 2012, doi: 10.1039/c2jm30472d.
- [14]. K. Cheng and S. Sun, "Recent advances in syntheses and therapeutic applications of multifunctional porous hollow nanoparticles," *Nano Today*, vol. 5, no. 3, pp. 183–196, 2010, doi: 10.1016/j.nantod.2010.04.002.
- [15]. N. A. Frey, S. Peng, K. Cheng, and S. Sun, "Magnetic nanoparticles: Synthesis, functionalization, and applications in bioimaging and magnetic energy storage," *Chem. Soc. Rev.*, vol. 38, no. 9, pp. 2532–2542, 2009, doi: 10.1039/b815548h.
- [16]. M. Takafuji, S. Ide, H. Ihara, and Z. Xu, "Preparation of poly(1-vinylimidazole)-grafted magnetic nanoparticles and their application for removal of metal ions," *Chem. Mater.*, vol. 16, no. 10, pp. 1977–1983, 2004, doi: 10.1021/cm030334y.
- [17]. W. Yantasee *et al.*, "Removal of heavy metals from aqueous systems with thiol functionalized superparamagnetic nanoparticles," *Environ. Sci. Technol.*, vol. 41, no. 14, pp. 5114–5119, 2007, doi: 10.1021/es0705238.
- [18]. J. Dong, Z. Xu, and S. M. Kuznicki, "Mercury removal from flue gases by novel regenerable magnetic nanocomposite sorbents," *Environ. Sci. Technol.*, vol. 43, no. 9, pp. 3266–3271, 2009, doi: 10.1021/es803306n.
- [19]. F. Chen, S. Xie, J. Zhang, and R. Liu, "Synthesis of spherical Fe₃O₄ magnetic nanoparticles by co-precipitation in choline chloride/urea deep eutectic solvent," *Mater. Lett.*, vol. 112, pp. 177–179, 2013, doi: 10.1016/j.matlet.2013.09.022.
- [20]. Z. I. Takai, M. K. Mustafa, S. Asman, and K. A. Sekak, "Preparation and characterization of magnetite (Fe₃O₄) nanoparticles by sol-gel method," *Int. J. Nanoelectron. Mater.*, vol. 12, no. 1, pp. 37–46, 2019.
- [21]. B. A. Bolto, "Magnetic particle technology for wastewater treatment," *Waste Manag.*, vol. 10, no. 1, pp. 11–21, 1990, doi: 10.1016/0956-053X(90)90065-S.
- [22]. N. Yang, S. Zhu, D. Zhang, and S. Xu, "Synthesis and properties of magnetic Fe₃O₄-activated carbon nanocomposite particles for dye removal," *Mater. Lett.*, vol. 62, no. 4–5, pp. 645–647, 2008, doi: 10.1016/j.matlet.2007.06.049.
- [23]. T. Lu, J. Wang, J. Yin, A. Wang, X. Wang, and T. Zhang, "Surfactant effects on the microstructures of Fe₃O₄ nanoparticles synthesized by microemulsion method," *Colloids Surfaces A Physicochem. Eng. Asp.*, vol. 436, pp. 675–683, 2013, doi: 10.1016/j.colsurfa.2013.08.004.
- [24]. S. Wu *et al.*, "Fe₃O₄ magnetic nanoparticles synthesis from tailings by ultrasonic chemical co-precipitation," *Mater. Lett.*, vol. 65, no. 12, pp. 1882–1884, 2011, doi: 10.1016/j.matlet.2011.03.065.
- [25]. A. Abedini, A. R. Daud, M. A. A. Hamid, and N. K. Othman, "Radiolytic formation of Fe₃O₄ nanoparticles: Influence of radiation dose on structure and magnetic properties," *PLoS One*, vol. 9, no. 3, 2014, doi: 10.1371/journal.pone.0090055.
- [26]. C. Li, Y. Wei, A. Liivat, Y. Zhu, and J. Zhu, "Microwave-solvothermal synthesis of Fe₃O₄ magnetic nanoparticles," *Mater. Lett.*, vol. 107, pp. 23–26, 2013, doi: 10.1016/j.matlet.2013.05.117.
- [27]. H. Yan, J. Zhang, C. You, Z. Song, B. Yu, and Y. Shen, "Influences of different synthesis conditions on properties of Fe₃O₄ nanoparticles," *Mater. Chem. Phys.*, vol. 113, no. 1, pp. 46–52, 2009, doi: 10.1016/j.matchemphys.2008.06.036.
- [28]. H. Shi *et al.*, "Green synthesis of Fe₃O₄ nanoparticles with controlled morphologies using urease and their application in dye adsorption," *Dalt. Trans.*, vol. 43, no. 33, pp. 12474–12479, 2014, doi: 10.1039/c4dt01161a.
- [29]. A. Gour and N. K. Jain, "Advances in green synthesis of nanoparticles," *Artif. Cells, Nanomedicine Biotechnol.*, vol. 47, no. 1, pp. 844–851, 2019, doi: 10.1080/21691401.2019.1577878.
- [30]. H. Wasly, "X-RAY ANALYSIS FOR DETERMINATION THE CRYSTALLITE SIZE AND LATTICE STRAIN IN ZnO NANOPARTICLES," *J. Al-Azhar Univ. Eng. Sect.*, vol. 13, no. 49, pp. 1312–1320, 2018, doi: 10.21608/aej.2018.18943.
- [31]. P. Rajiv, B. Bavadharani, M. N. Kumar, and P. Vanathi, "Synthesis and characterization of biogenic iron oxide nanoparticles using green chemistry approach and evaluating their biological activities," *Biocatal. Agric. Biotechnol.*, vol. 12, no. June, pp. 45–49, 2017, doi: 10.1016/j.bcab.2017.08.015.