A BIOGENIC APPROACH FOR IRON OXIDE NANOPARTICLES: COCONUT WATER AS A SUSTAINABLE PRECURSOR

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ABSTRACT

This study reports the green synthesis of Fe_2O_3 nanoparticles using coconut water as a natural reducing and stabilizing agent. X-ray diffraction (XRD) analysis confirms the formation of a highly crystalline cubic iron oxide structure with a crystallite size of 6 nm. Fourier-transform infrared (FTIR) spectroscopy identifies functional groups from coconut water that enhance nanoparticle stability. These Fe_2O_3 nanoparticles exhibit promising properties for photocatalytic degradation of pollutants, antibacterial coatings, and solar energy applications. The eco-friendly synthesis method highlights the potential of Fe_2O_3 nanoparticles for sustainable and multifunctional applications in environmental and biomedical fields.

KEYWORDS: Fe_2O_3Nanoparticles, Coconut water, Green Synthesis, XRD, FTIR, Biomedical fields

INTRODUCTION

Iron oxide nanoparticles (IONPs) exhibit distinctive properties such as superparamagnetic, large surface-to-volume ratio, and tunable morphology, making them valuable in biomedicine, environmental remediation, and catalysis. Among these, Fe_2O_3 nanoparticles are favored for their biocompatibility, chemical stability, and cost-effectiveness. Conventional synthesis routes—co-precipitation, sol–gel, and thermal decomposition—often require toxic reagents and high energy input, raising environmental concerns. Green synthesis methods offer sustainable alternatives, using biological extracts rich in natural biomolecules as reducing, capping, and stabilizing agents. Coconut water, derived from Cocos nucifera, contains sugars, amino acids, vitamins, minerals, and phenolics, enabling it to function as a multifunctional medium for nanoparticle formation. Its use minimizes environmental toxicity while potentially enhancing nanoparticle stability and functionality. This study focuses on the eco-friendly synthesis of Fe_2O_3 nanoparticles using coconut water, aiming to develop a simple, low-cost, and scalable method aligned with green chemistry principles for potential biomedical and environmental applications. [1-10]

MATERIALS AND METHODS

10ml of coconut water was taken from the matured coconut and get filtered**.** 1M of ferric chloride is mixed with 100ml of distilled water and 90ml of this solution was used.10ml of coconut water was mixed with 90ml of ferric chloride solution and get stirred. Sodium Hydroxide solution was added to adjust the pH of the solution. The solution was allowed to settled down and form a precipitate**.** Water was drained out from the precipitate and the nanoparticles were washed for several times with ethanol and distilled water. It was heated in hot air oven at 100˚C for 4 hours and get powdered using Mortar and Pestel.It was then calcinated at 500˚C in Muffle Furnace and get powdered using Mortar and Pestel**.** The synthesized nanoparticles were characterized by XRD and FTIR.

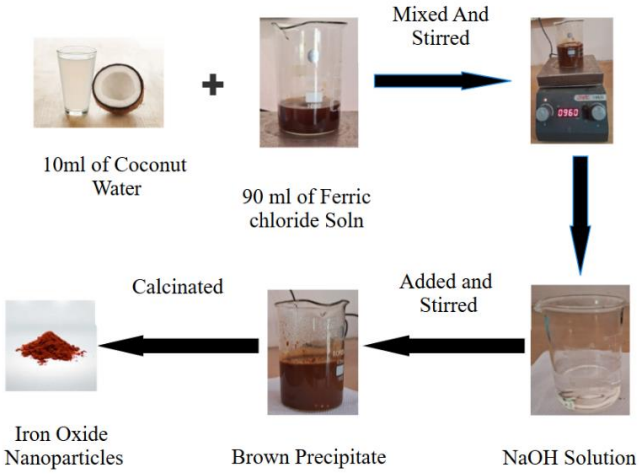

Fig 1. Flow chart for synthesizing Fe_2O_3 nanoparticles

RESULT & DISCUSSION

XRD was employed to analyze the crystalline phase of Fe_2O_3 nanoparticles. Fig 2 shows the X-ray diffraction patterns of Iron Oxide (Fe_2O_3). The primary peaks at 45.82˚, 54.41˚, 62.76˚can be indexed to the cubic structure of metal Iron oxide. The parameters agree well with the JCPDS card #19-9629 with any impurity peaks.[1]The average crystalline size of the Fe_2O_3nanoparticles is found to be 5.9 nm.

Sample	FWHM	2 theta ˚	d-spacing A˚	Crystalline Size	Average Crystalline size
	1.8893	11.19	7.9018	0.7	
	0.1181	32.01	2.7960	12.2	

Fe_2O_3	0.2362	33.54	2.6715	6.1	5.9 nm
	0.1968	36.06	2.4906	7.4	
	0.2362	45.82	1.9803	6.4	
	0.2362	54.41	1.6862	6.6	
	0.2362	62.76	1.4805	6.9	
	0.3149	64.40	1.4466	5.2	
	0.4723	66.44	1.4070	3.5	
	0.3936	75.67	1.2567	4.5	

Table 1. Structural Parameters of Fe_2O_3 nanoparticles

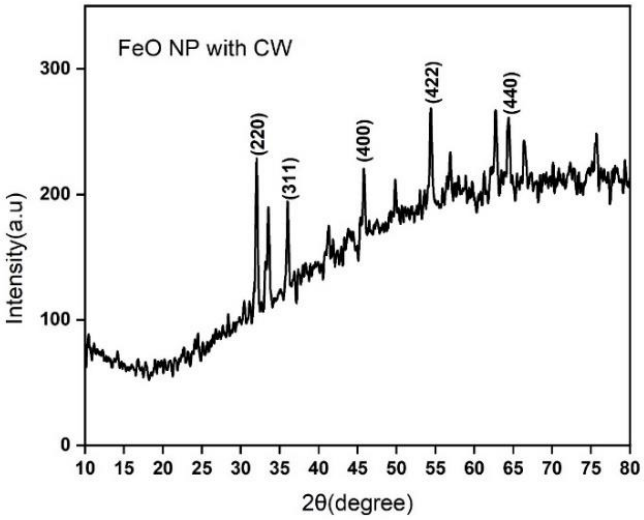

Fig 2. XRD pattern of Fe_2O_3

Figure 3 shows the FTIR spectrum of Iron Oxide taken between the range of 450 – 4000cm^{-1}. The broad absorption band centered at 725.23 cm^{-1} corresponds to the stretching mode of the hydroxyls of the absorbed water. Very weak bending vibrations of water molecule appeared at 3657.90 cm^{-1}. Strong band position at 455.20 cm^{-1} may be attributed to the stretching mode of the Fe-O.

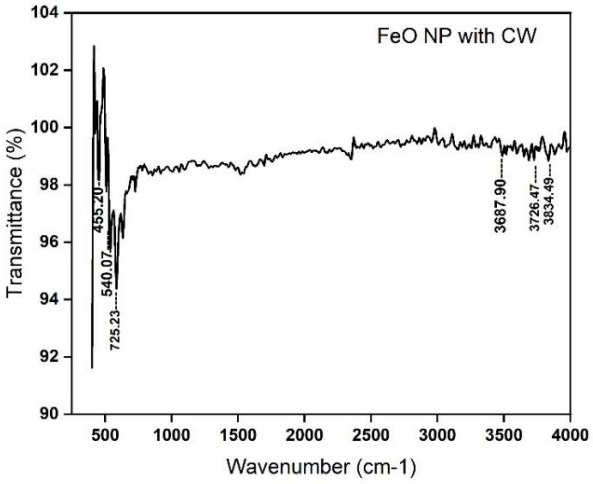

Fig 3.FT-IR Analysis of Fe_2O_3

CONCLUSION

Fe_2O_3 nanoparticles was synthesized using coconut water as a sustainable precursor. XRD confirms the crystalline nature of Fe_2O_3 nanoparticles with a crystallite size of 6 nm. FTIR spectroscopy identifies the functional groups present, indicating interactions between Fe_2O_3 and bioactive compounds from coconut water, which may enhance stability and surface properties. It is effective for environmental applications such as wastewater treatment and degradation of organic pollutants under visible light. The biofunctional properties from coconut water enhance their potential for antibacterial coatings, drug delivery, and biosensing. Their optical properties make them suitable for solar energy conversion, sensors, and magnetic applications.

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