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Characterization of Phyto fabricated Sulfur Nanoparticles Synthesized by *Aloe vera* leaves Extract via Herbal Method

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Abstract

This research explores the eco-friendly synthesis of sulfur nanoparticles through an herbal method utilizing Aloe vera leaves extract. The utilization of natural extracts for nanoparticle synthesis aligns with sustainable practices. The study focuses on optimizing the synthesis conditions and provides a detailed structural characterization of the resulting sulfur nanoparticles. Techniques such as X-ray Diffraction (XRD) and Fourier Transform Infrared Spectroscopy (FTIR) employed to analyze the crystalline structure, morphology, elemental composition, and surface properties of the nanoparticles. The findings contribute to the understanding of green synthesis methods and offer insights into potential applications in catalysis, sensors, and medicine. This research underscores the importance of sustainable approaches in nanomaterial synthesis using herbal resources.

Keywords: SNPs; Sulphur Nanoparticles; Green Synthesis

1. Introduction

Nanotechnology has emerged as a revolutionary field with profound implications across various scientific disciplines and industrial sectors.*(1)* Among the plethora of nanomaterials, sulfur nanoparticles have garnered significant interest due to their unique properties and potential applications in fields such as catalysis, energy storage, and biomedicine. However, the methods employed for nanoparticle synthesis are often associated with environmental concerns and resource-intensive processes.(2,3)

In the pursuit of sustainable and ecofriendly alternatives researchers are turning towards green synthesis methods that utilize natural resources and biowastes.(4) Orange peels, a common agricultural byproduct rich in bioactive compounds, present an intriguing source for nanoparticle synthesis.(5) This research delves into the synthesis of sulfur nanoparticles via an herbal method using Aloe vera leaves extract. The integration of herbal techniques not only aligns with the principles of green chemistry but also offers a cost-effective and scalable approach for nanoparticle production.(6,7)

The overarching objective of this study is to investigate the structural characteristics of sulfur nanoparticles synthesized through this innovative method. Understanding the morphology, crystalline structure, and surface properties of these nanoparticles is crucial for unlocking their full potential in diverse applications.(8) By focusing on the structural

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characterization, this research aims to contribute to the growing body of knowledge on green synthesis methods and advance the understanding of sulfur nanoparticles as a promising nanomaterial.(9) This introduction sets the stage for exploring the synthesis of sulfur nanoparticles using via an herbal method and emphasizes the significance of structural characterization in unlocking the full potential of these nanoparticles in various applications.(10) The non-metal sulfur (S) in the scales of bulk, micro and nano, has a wide range of applications in different industrial activities such as in fertilizers, sulfuric acid production, plastics, enamels, pulp and paper industries, antimicrobial agents, gun powders and in different other industries(5,11)

The objective of this research is to explore the feasibility of phytofabricating sulphur nanoparticles using Aloe vera leaves extract and to characterize their structural properties. The characterization techniques, including X-ray diffraction (XRD) and Fourier Transform Infrared Spectroscopy (FTIR, will be employed to gain insights into the crystalline structure, morphology, surface functionalization, and optical properties of the synthesized sulphur nanoparticles.(3)

2. Experimental Section

The synthesis and characterization of sulphur nanoparticles phytofabricated via green synthesis using Aloe vera leaves extract involve a series of experimental techniques. The following outlines the key methods employed in this study.

2.1. Collection and Preparation of Aloe vera leaves Extract

Waste Aloe vera leaves are collected from medicinal Garden of G.S.Tompe College, Chandur Bazar and thoroughly washed to remove impurities.

The peels are finely chopped or ground to increase the surface area for efficient extraction.

The peels extract is obtained by heating the crushed peels material with water and filtering the resulting solution as Aloe vera leaves extract.

2.2. Green Synthesis of Sulphur Nanoparticles

Sulphur nanoparticle synthesis is initiated by combining the Aloe vera leaves extract with sodium thiosulphate as sulphur precursor

The reaction mixture is then subjected to heating for 2 hours to facilitate the formation of sulphur nanoparticles by the bioactive compounds present in the Aloe vera leaves extract.

The synthesis process is closely monitored to ensure the desired nanoparticle formation.(13)

2.3. Structural Characterization of Synthesized SNPs

The synthesized SNP sample is subjected to FTIR spectroscopy to analyze the functional groups and biomolecules involved in the stabilization and capping of the sulphur nanoparticles.

Further, X-ray diffraction study of Synthesized SNPs was carried out to determine crystal structure, phase purity, and crystalline size of the nanoparticles.

3. Result and Discussion

3.1. Fourier Transform Infrared spectroscopy (FTIR)

In the present study FTIR Spectra of SNPs synthesized by using aloe vera peels shows characteristic bands at 3419.94, 2928.07, indicates characteristic bands of O-H andN-H groups, , band at 2928.07 represent C-H stretching. Band at 1642.46 indicates carboxylic groups of aloe vera. The band at 1536.37cm-1 are due to C=C stretching of peel extract. The stretching frequency at 1135.16, 1011.71, 841.00 indicates C-O, C-N, C-C stretching respectively. The FTIR spectrum of synthesized sulphur nanoparticles

shows all characteristic peaks of S-S stretching frequencies over the range 2348.43_2109.25 cm-1. FTIR spectra of SNPs shows a new linkage of sulphur nanoparticles in which aloe vera extract can bind to sulphur nanoparticles through C=O,

N-H, O-H linkages present in amino acid residues of extracts. Thus, these can act as stabilizer surfactant and dispersing or capping agent for synthesized sulphur nanoparticlesand prevent agglomeration of sulphur nanoparticles.

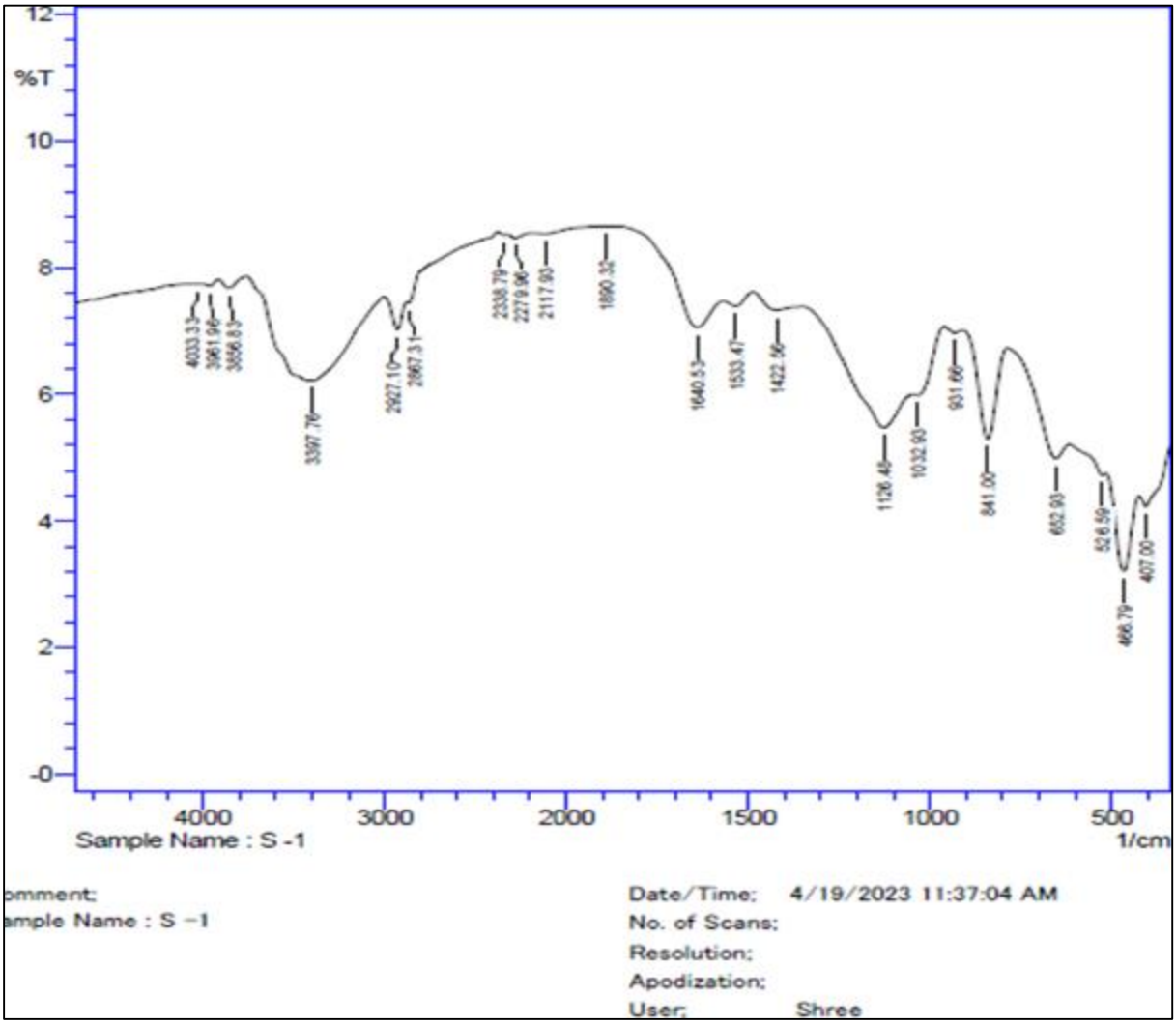

Figure 1 FTIR spectra of SNPs synthesized by using Aloe vera leaves extract

3.2. XRD Spectra

The XRD is commonly used extensive technique for characterization of nanoparticles provides information regarding the crystalline structure, nature of the phase, lattice parameters and crystalline grain size. The latter parameter is estimated by using Scherrer equation (stated earlier) using the broadening of the most intense peak of an XRD measurement for a specific sample. The nanoparticles are commonly analyzed in powder form after drying. The composition of the particles can be determined by comparing the position and intensity of the peaks with the reference patterns available from the international center for diffraction data (ICDD). X-ray diffraction (XRD) analysis of nanoparticles synthesized using plant extract is a rather new implementation of the technique to analysis the characteristic of synthesized nanoparticles.

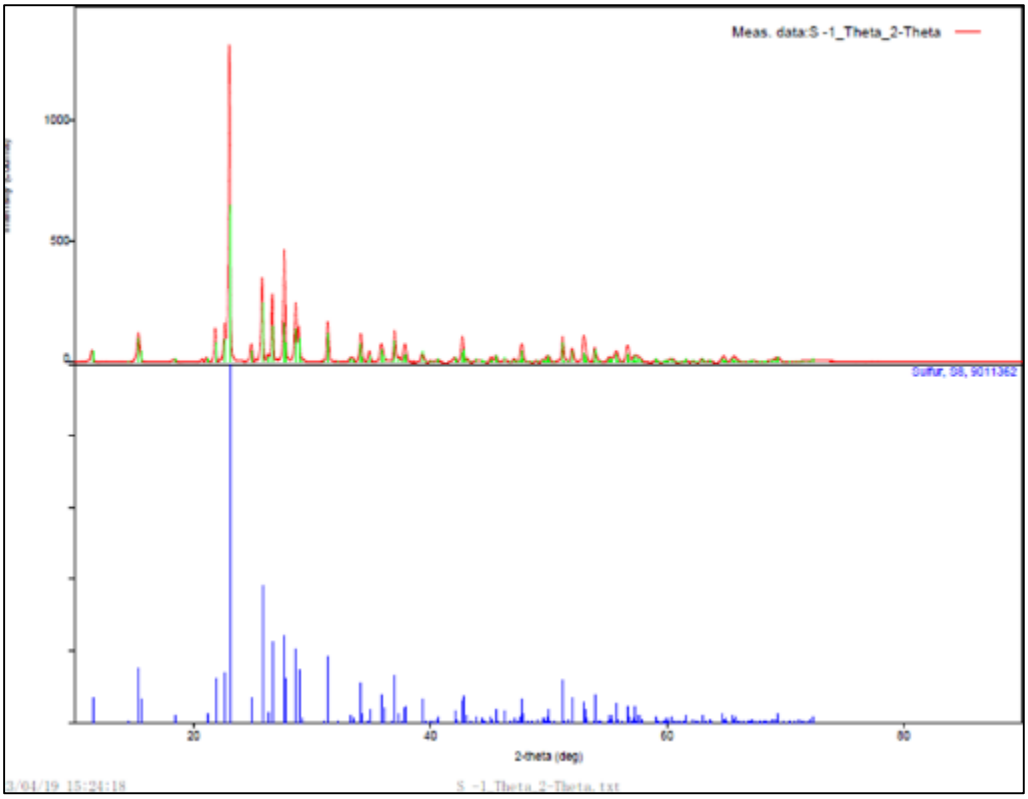

Figure 2 XRD Analysis of SNPs synthesized by using *Aloe vera* leaves extract

The XRD analysis is done to analyse the structure and crystalline size of synthesized nanoparticles. The 2θ peaks at 23.07, 25.83, 27.70, are attributed to thecrystal planes of sulphur at 2 2 2, 3 1 1, 2 0 6 respectively. The positions and intensitiesof the diffraction peaks are in good agreement with the literature values for monoclinic phase sulphur. The particle size of the sample can be calculated using Scherrer's relationship:

$$D = 0.9\lambda/(B\cos\theta)$$

The obtained results showed that as prepared monoclinic SNPs with average crystallite size about 20 nm.

4. Conclusion

In this study, a novel, simple and environmentally benign synthesis method for the preparation of sulfur nanoparticles from sodium thiosulphate in the presence orange peel extract was developed. It is an easy, cost-effective and doesn't involve harmful and toxic chemicals. The biomolecules and phytochemicals present in the Aloe vera leaves not only reduce the sulphur ions and also stabilize the sulphur NPs. The particle size of sulfur nanoparticles can be controlled from 10 nm to 100 nm by adjusting the reaction parameters including the initial sodium thiosulphate concentration and the quantity of fruits extract. The synthesized SNPs were characterized by XRD, FT-IR. The obtained results showed that as prepared monoclinic SNPs with average crystallite size about 20 nm. The explored ecofriendly, highly efficient SNPs synthesized using orange fruit peel extract are expected to have more extensive applications in biomedical and agricultural fields**.**

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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