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RESEARCH ARTICLE

SYNTHESIS OF POTASSIUM DOPED FERRIC SULPHIDE NANOPARTICLES USING BIO-ASSISTED METHOD FOR AGRICULTURAL APPLICATIONS

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ABSTRACT

Potassium (K) doped ferric sulphide nanoparticles were prepared by a simple green synthesis (Bio-Assisted) method. Structural (XRD) studies confirm the formation of K-doped Ferric sulphide nanoparticles. The FESEM images show the agglomeration of nanoparticles that are mostly sponge like structure and spherical shape. The plant growth analysis revealed that potassium doped ferric sulphide nanoparticle could be used as plant growth promoter for high yield in agriculture.

Keywords: Green synthesis, Ferric sulphide, agglomeration, nanoparticles.

1. INTRODUCTION

The remarkable research interest in the field of nanotechnology has produced much reliable synthesis of nanomaterials over a different range of sizes and chemical composition as well. There are several improvements and modifications in the synthesis methods which provide a better control over the particle size, shape, and other characteristics of the nanoparticles (NPs). Nanoparticles having one of the dimension in the range of 1–100 nm act as a connection between both bulk materials and atomic or molecular structures [1]. They possess incredible and interesting properties due to their small sizes, large surface area with free dangling bonds and higher reactivity over their bulk cousins.

Synthesis and assembly strategies of nanoparticles has been mostly containing precursors from liquid, solid or gas phase; employ chemical or physical deposition approaches that rely on chemical reactivity or physical compaction to incorporate the nanostructure building blocks within the final material structure. The diversity of techniques can be classified in to top- down and bottom up approaches that are further classified into few categories namely, physical, chemical and bio - assisted methods. In general, chemical methods are composed of chemical species or molecules could increase the particle reactivity and toxicity that might harm human health and the environment owing to the composition ambiguity and lack of predictability [2, 3]. The particles prepared by green synthesis are completely different from physic - chemical approaches. Biological entities hold a huge potential for the production of NPs. Biogenic reduction of metal precursors to resultant NPs is eco-friendly [4], sustainable [5], free of chemical contamination [6], less expensive which can be used for mass production [7]. Therefore, biosynthesis or green synthesis can provide an environmentally benign, low - toxic, cost-effective and resourceful protocol to synthesize nanoparticles. Also, these methods are utilized in biological systems like bacteria, fungi, viruses, yeast, actinomycetes, plant extracts, etc. for the synthesis of metal and metal oxide nanoparticles [8].

The development of efficient green synthesis employed as natural reducing, capping and stabilizing agents without the use of toxic, costly chemicals and high energy consumption that attracted many researchers towards biological methods [9-11]. Speedy industrialization, urbanization and population explosion are resulting in deterioration of earth atmosphere and a huge amount of hazardous. Hence, this is a right time to learn about the natural resources which might lead to advancements in the synthesis processes of NPs. Therefore, green/biological synthesis of NPs is one of the possible alternatives to chemical and physical methods. Herein, the synthesis of K doped Ferric sulphide using a plant extract Simarouba glauca has been investigated for plant growth applications.

2. MATERIALS AND METHODS

2.1. Synthesis procedure of K-doped Ferric sulphide nanoparticles using plant extract:

Initially, Potassium doped Ferric sulphide nanoparticles were prepared by adding ferric chloride (99.99 % pure), Na2S (99.99 % pure) and KCl (99.9 % pure) to the plant extract *Simarouba glauca*. Then, *Simarouba glauca* leaves were

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washed and cleaned with double distilled water and dried with absorbent paper. Then, it was cut into tiny pieces with an ethanol sterilized knife, then the crushed leaves 20 g was dispensed in 100 ml of double distilled water and followed by heated for 1 hour at 80 °C. The prepared extract was filtered using Whatman filter paper. The filtrate was collected in a clean and dried conical flask by standard sterilized filtration method. Simultaneously, the primary solution was prepared by using 5 ml of plant extract which was added to 20 ml of deionized water. Then, the solution was stirred for 15 minutes using magnetic stirrer. Then, 1 mol % of ferric chloride was mixed with 40 ml of deionized water to the primary solution and stirred again for 15 minutes. Subsequently, Na_2S (1 mol %) was added to the primary solution and stirred about 15 minutes. Finally, 0.125 mol % of KCl dissolved with 40 ml of deionized water was added to the primary solution and constantly stirred for 1 hour to obtain homogenous mixture. The obtained solution was centrifuged and then dried in a hot air oven for 1 hour. The resultant powder was crushed well to obtain fine particles and it is shown in Fig.1.

The characterization of nanoparticles was analyzed by using X-ray diffraction (XRD) and field emission scanning electron microscopy (FESEM).

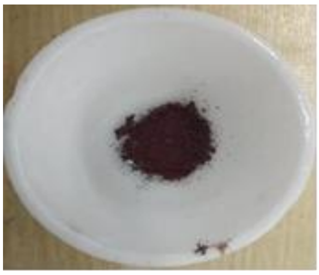

Fig. 1. As prepared Potassium doped Ferric sulphide nanoparticles

2.2. K doped Ferric sulphide nanoparticles in plant growth

The prepared k doped Ferric sulphide nanoparticles 1mg/ml was prepared as stock solution. In the present experiment was performed in lab scale level. Two glass plates were taken and the plate surfaces were covered with filter paper. Generally, the filter paper some contain some micro and macro nutrient to support plant growth. In this present study, the plant seed were inoculated in prepared glass plate. Totally, the experiment monitor upto five day, each day the experimental plant treated with water and k doped Ferric sulphide nanoparticles dissolved water (water contains prepared nanoparticles) 1.5 ml in morning and 1.5 ml in evening from stock solution. Finally, after 5th day the water treated and nanoparticles treated plant growth were measured (length of the shoot, length of the root, length of leaves and number of leaves).

3. RESULTS AND DISCUSSION

X-ray diffraction pattern were analyzed to understand the structural information of the prepared K-doped Fe2S3 nanoparticles. The Powder X-ray diffraction study was performed by Panalytical X-Pert Pro (Netherlands) X-ray diffractometer using Cu-Kα radiation source (λ=1.5406 Å) operated at 40 kV with the scan rate of 10°/min.

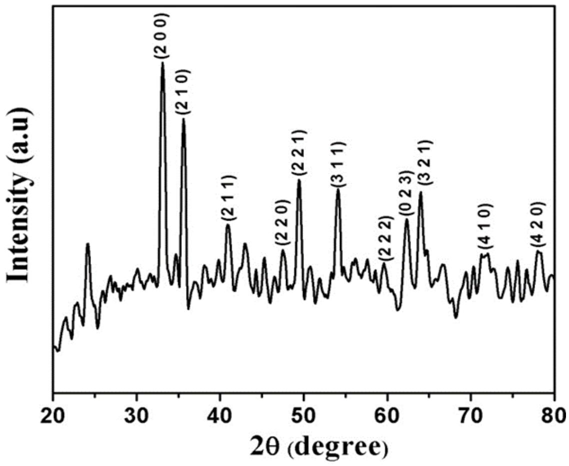

Fig. 2. XRD pattern of potassium doped Ferric sulphide nanoparticles

Figure 2 shows the powder XRD pattern of K-doped Fe2S3 nanoparticles prepared using Simarouba glauca leaf extract. All the peaks in diffraction pattern are in agreement with the standard JCPDS card data (Reference code 00-042-1340) which is corresponding to K: Fe2S3 in cubic geometry. The structural studies confirm the dominant peak position at 2θ values of 33.13°, 35.64° and 49.50° are respectively corresponding to (200), (210) and (221) orientation plane of prepared nanoparticles. The estimated average crystallite size of the prepared nanoparticles is found to be 7.01 nm.

The surface morphology of the prepared K-doped Ferric sulphide nanoparticles were analysed by field emission scanning electron microscopy using Quanta-200F model. Fig.3 (a,b) shows the morphology of K:doped Ferric sulphidennanoparticles that reveals the prepared nanoparticles are well agglomerated throughout the scanned image. The surface shows spongy and sphere shape nanoparticles.

3.1. Application of k doped Ferric sulphide nanoparticles in plant growth

Nanotechnology revolutionizes agriculture by enhancing the resource of plants to absorb nutrients. In the present work an attempt has been made to study the application of the prepared K doped ferric sulphide nanoparticle as a plant growth promoter [12]. After 5 days of observation in the prepared K-doped Ferric sulphide sample, a remarkable growth is observed in the nanoparticle applied sample as compared to that of reference sample. The biological parameter like shoot length, root length, leaf etc., are measured for both the sample. It is concluded that the sample with nanoparticle applied has remarkable increase in all the parameters in comparison to the reference sample.

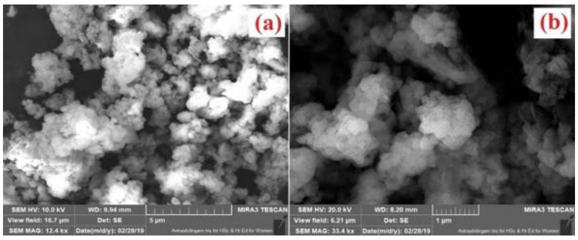

Fig. 3. SEM image a) Magnified at 124 times and b) Magnified at 334 times

Table1. Effect of nanoparticles in plant growth

Objectives	Plant grown in pure water	Plant grown using NPs
Length of the shoot	1.3 cm	3.5 cm
Length of the root	2.7 cm	4.6 cm
Length of leaves	No leaves	1.5 cm
Number of leaves	No leaves	2 No's

From the Table.1, it is clearly shows that the shoot length, root length, leaf length and number of leaves are differing from the reference sample (Fig. 4.a). On the other hand, observed seed growth is much more in nanoparticle treated samples (Fig. 4.b).

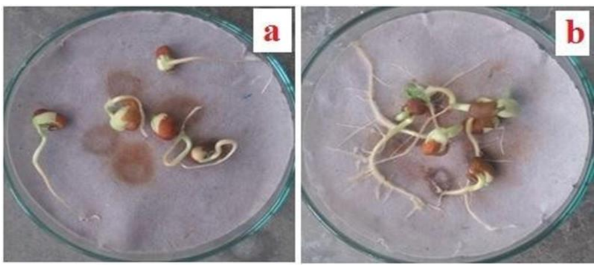

Fig. 4. (a) Reference samples, (b) K- doped ferric sulphide treated samples

4. CONCLUSION

Potassium doped ferric sulphide nanoparticles were prepared by simple Bio assisted co- precipitation (green synthesis) method. Structural study reveals the predominantly crystalline nature of the K-doped Ferric sulphide nanoparticles. The estimated average crystalline size is found to be 7.02 nm. The observed FESEM images show the agglomeration of nanoparticles and are sponge like structure. The plant growth studies revealed that K-doped Ferric sulphide nanoparticles could be used for high yield in agricultural production.

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