FUNCTIONALIZED MAGNETIC NANO PARTICLES - PLANT GROWTH PROMOTER AND FERTILIZER

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Introduction:

Iron-based magnetic nanoparticles (MNPs) have been studied extensively for the past few decades. They have been applied in various applications, particularly in the biomedical sector. Due to their excellent physical and chemical properties, they have also been used widely in the agricultural sector. MNPs can be synthesized inexpensively and applied in large scale agricultural activities. This paper highlights the applications of iron-based MNPs in the agricultural sector mainly as antimicrobial agents, plant growth promoters, site-targeted delivery agents, nanosensors, detection and remediation for pesticide residue. These aspects have to be well-understood before MNPs can be fully implemented effectively this pin the agricultural sector. Lastly, a hybrid nanomaterial, which is consisted of iron and other transition metal nanoparticles (TMNPs), is proposed. This hybrid nanomaterial is expected to overcome the shortcomings of iron-based MNPs. The lack of professional guidance and poor land management resulted nutrient loss in soils significantly which in turn reduces the quality and quantity of food. Although Fe is usually rich in soils, they are mainly fixed by soil particles. This is because majority of Fe content are unable to act as the nutrient source for plant. It is reported that 30–35% of the soils in the world are Fe-limiting for plant growth. The iron oxide NPs can be developed as a Fe-fertilizer to enhance the agricultural development, particularly in Fe-limiting soils that restrict the physiological development of plants. Besides, iron oxide NPs have the potential to act as a plant growth promoter for processes such as respiration, photosynthesis, enzymes activation, lignin formation, nitrogen reduction and fixation, and ribonucleic acid (RNA) synthesis. In addition, MNPs have higher surface energies compared to the conventional bulk fertilizers, which generate changes in its physicochemical, electrical, and optical properties, as well as reactivity in the agriculture application. These unique characteristics allow MNPs to be a nano additive in the controlled release of fertilizers. This significantly reduces the loss of fertilizer due to leaching, fixation, or volatilization in soils. As a result, lesser MNPs formulated fertilizer is required to satisfy the plant's need, which in turn reducing the ecological impact.

Objectives:

The occurrence and development of new pathogenic races is a continuing problem, and the use of chemicals to control pests is expensive and not always enactive. In recent years, the use of nanomaterials has been considered as an alternative solution to control plant pathogens.

Agricultural practices usually include the systematic application of a wide array of active compounds at variable dosages and frequencies, which represent a wide range of selective regimes.

- Synthesis of metal oxide nano particles by Green method.
- Understand the material behavior through the various characterizations like, XRD and FTIR.
- Select seeds and coat with nano particles and monitor the growth.

Methodology:

Glycyrrhiza glabra plant stem medically certified by KLE Ayurveda Medical College. Belagaum, India, Ferric chloride (FeCl3 purchased from Sigma Aldrich). All aqueous solutions were prepared in double distilled water.

Preparation of extract

Thoroughly wash the procured roots with distilled water to remove dust and impurities. This ensures that the extract is free from contaminants. Finely chop 20 grams of the washed roots. The chopping process increases the surface area, facilitating efficient extraction. Add the finely chopped roots to 100 ml of deionized water and heat the mixture to 90°C and maintain this temperature for 45 minutes. This process helps in extracting compounds from the roots into the water. After heating, allow the mixture to cool to room temperature. This step is crucial to avoid potential degradation of heat-sensitive compounds. Separate the extract from the solid plant material by filtration. Use Whatman filter paper no.4. This process removes any remaining solid particles, yielding a clear liquid extract. The pH of the extract should be measured. The extract should be kept in freezer for further use.

Synthesis of Fe2O3 nanoparticles

5ml of the extract is added to the 20ml of 0.1M FeCl3 / Fe (NO3)2 / Fe (NO3)3 solution heated at 700C for 10 minutes with constant stirring. The formation of the nanoparticles will be indicated by change in the color of the solution either to dark / dark brown color. The as prepared nanoparticles were centrifuged and washed with DI water several times to remove impurities and then dried for further studies.

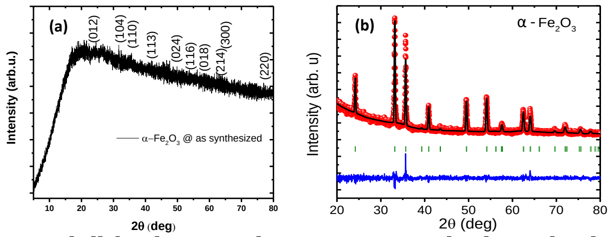

Figure 1. (a) As synthesized α – Fe2O3 nanoparticles and (b) shows the RT annealed and Rietveld refined XRD pattern of α – Fe2O3 nanoparticles

Figure 1 (a and b) depicts the X-ray diffraction (XRD) patterns of as synthesized and annealed α – Fe2O3 powder to determine the structure and symmetry. Fig. 1(a) shows the low intense diffraction peaks with high broadening, after the careful analysis, small humps are noticed and it is well matching with the α – Fe2O3 phase (JCPDS-ICDD card number 89-0596). For deeper insightful information of the structure, we annealed the as synthesized powder at 300 0C for 5 hours. After the successful annealing we measured the XRD pattern, it shows a clear peaks with rhombohedral structure with centered hexagonal structure (R-3c space group) (JCPDS-ICDD card number 89-0596) [42]. The annealed XRD pattern shows the selected main characteristic peaks at different 2θ values of 24.1°, 33.2°, 35.6°, 49.5° and 54.1° corresponding to the hkl planes (0 1 2), (1 0 4), (1 1 0), (1 1 3) and (0 2 4) respectively. Rietveld refinement carried out to obtain atomic level structural information, by using Full Prof software. From the Fig 1. (b) it confirms the there is no any additional reflections or impurities. This method, plant extract and synthesis conditions can effectively employed for the synthesis of high purity α-Fe2O3 nanoparticles. Obtained structural parameters are a = 5.0355 (6), b = 5.0355 (6), c = 13.7499 (4) Å. The particle size and macrostrain were estimated by Debye Scherer formula and obtained values are 40.75 nm and 0.82 nm.

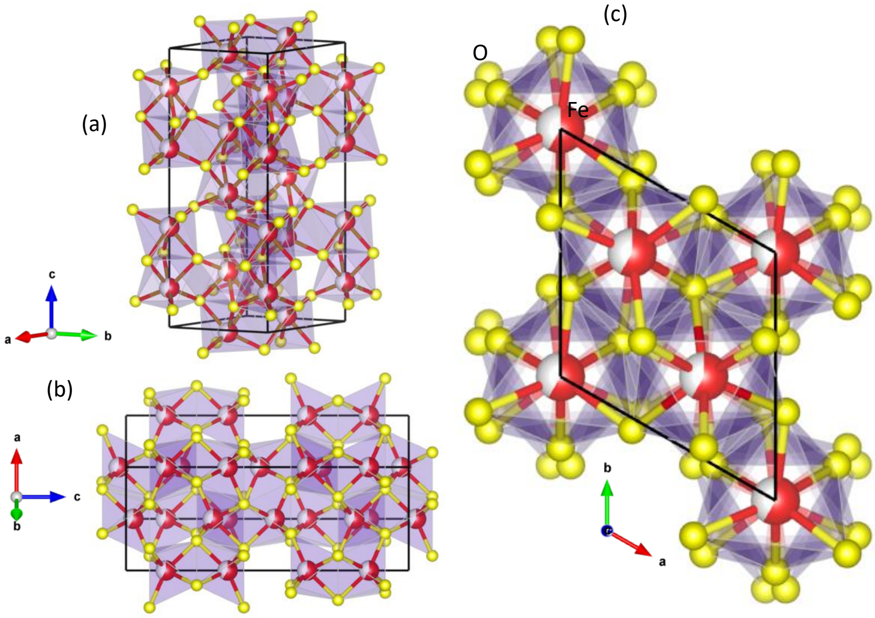

Figure 2. Polyhedral structure of α – Fe2O3 at different directions along (a) a , (b) b and (c) c axis

Figure 2 shows the arrangement of Fe (red color) and O (yellow color) in distorted Hexagonal structure. In generally α-Fe2O3 hematite crystallizes in a corundum structure and well characterized by a slightly distorted hexagonal close-packed oxide-ion lattice where 2/3 of the octahedral sites are occupied by Fe3+ ions with non-degenerated energy levels on metal d-electrons due to a ligand field splitting originating from Fe-O hybridization (Figure 2) (de Groot et al., 1989). Oxygen ions that are located parallel to (0001) plane levels, are separated by an iron double layer, yielding a tacking sequence of O3-Fe-Fe repeat units.

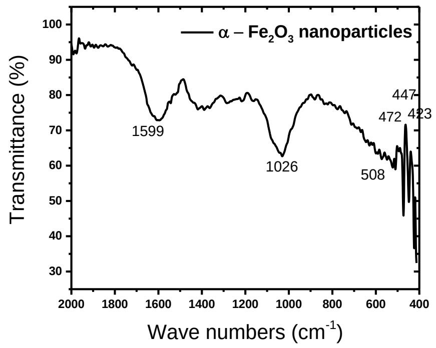

Figure 3. FTIR spectra of α – Fe2O3 nanoparticles of infrared absorption properties through the stretching and bending vibrations

Fig 3 shows that FTIR spectra of α – Fe2O3 nanoparticles of infrared absorption properties through the stretching and bending vibrations. From the data we have noticed 6 prominent peaks which corroborates the stretching and bending vibrations of α – Fe2O3 nanoparticles. The band at 423, 447, 472 and 508 cm-1 are indicating the presence of Fe–O stretching vibration modes. This clearly confirms the synthesized nanoparticles are α – Fe2O3 nanoparticles and it is well corroborated with XRD data in fig. 1. The absorption peak is noticed around 1026 and 1599 cm-1, these modes can be dispensed to the stretching and bending vibration of OH groups of H2O molecules [*, 2,24,25]. Slight difference in the modes in presented data and reported data is due to the different morphology and synthesis conditions.

Conclusion:

We have successfully synthesized the α – Fe2O3 nanoparticles by green method. XRD shows the formation of single phase without any other impurities. FTIR shows the stretching and bending moments of Fe and O. Further plant based studies are under progress.

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