**Synthesis and Characterization of Superparamagnetic Iron Oxide Nanoparticles for Water Purification Applications**

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**ABSTRACT**

Nanotechnology and nanoscience is emerging field of research. This field has a wide sphere in almost every field from environment to medicine. Nanotechnology is known for its water softening applications as well. Heavy metals have caused serious threat in the environment therefore in this study we will discuss about the synthesis of SPIONS (Super Paramagnetic Iron Oxide Nanoparticles) by co-precipitation method and discuss their applications in removing heavy metals from water. SPIONS synthesized were coated with chitosan and the nanocomposites thus formed can be used to treat water for removing heavy metals. The nanoparticles formed were characterized by TEM (transmission electron microscopy), EDS (Energy Dispersive X-Ray Spectroscopy), FTIR (Fourier transform infrared spectroscopy).

**KEYWORDS-** chitosan, heavy metals,SPIONS.

1. **INTRODUCTION**

Super paramagnetic iron oxide nanoparticles (SPIONS) synthesis, their characterization and further water purification applications will be discussed in this study. Scientists in different parts of world have synthesised and worked with SPIONS and have reported them to be non toxic and non reactive to human beings. [1, 2]. Apart from their biomedical uses, SPIONS have also been reported for waste water treatment. India is suffering from water contamination crisis on a large scale. Punjab and adjoining regions known for good agricultural lands are suffering from the problem of presence of heavy metals in ground water [3, 4, 5]. Therefore, this study is done for the purpose of solving this problem so that this method can be applied in treating civic and ground water [6, 7].

Nanotechnology is one of the fastest growing areas of research in the world today. This term nanotech means the creation and structuring of materials which has one dimension in the nanometer range (1 nm =10^-9 m).This range provides high surface to volume ratio which allows the nanoparticles to functionalise with different ligands, coating materials and become significant tools with lots of applications in biomedical and pharmaceutical industry [8,9].

Nanoparticles are popular these days because they exhibit significant and unusual properties in comparison to conventional polycrystalline particles. These can be modified according to their biological, physical and chemical properties of nanosize constructed materials into different shapes like bucky balls, nanowires, nanoparticles, thin films and nanocomposites according to the study.

2. **Synthesis of SPIONs**

Co-precipitation Method

2.1 Experimental

**Starting material**

Iron chloride, Iron Nitrate, Sodium hydroxide, potassium iodide, chitosan, glacial acetic acid and ammonia solution all were purchased from Himalya Scientific House, Chandigarh.

2.2 Synthesis

18g of anhydrous FeCl₃ was dissolved in 150ml distilled water to prepare an aqueous solution X. 5g of potassium iodide was dissolved in 50ml distilled water to prepare a solution called Y. Solution X and Y were mixed, stirred and left for an hour. The precipitates of iodine were filtered out, washed with distilled water
and dried. The washing was then added to filtrate and whole volume of filtrate was hydrolysed using ammonia solution, which was added drop by drop with continuous stirring until complete precipitation of black magnetite was achieved. The set up was left to settle, filtered and washed for further use [2].

2.3. Coating

SPIONS prepared by co-precipitation method were coated with Chitosan and the nanocomposites formed can be directly used for conducting the adsorption experiment for removing heavy metals Cr (III), Cu (II), Cr (VI) directly from water [3].

A weight % of chitosan was dissolved in 1 volume % of glacial acetic acid. The chitosan solution was allowed to stir for 18 hours then 0.05g of SPIONS were added to chitosan and stirred further for 6 hours to get a chitosan magnetite nanocomposite. This can be further used for removing heavy metals from water.

![Figure-1 Fe-Chitosan Nanocomposite](image)

3. RESULTS

3.1 FTIR

![Figure-2](image)
FTIR was analysed for ferric nanoparticles. The strong absorption band at 609 cm\(^{-1}\) (Fig-2) is assigned to the vibrations of Fe-O bond, which confirms the formation of Fe\(_3\)O\(_4\) nanoparticles. The wave number at 1406.25 is for C=O stretching vibrations\[4,10\]. The adsorption at 3051.24 cm\(^{-1}\), 3137.21 cm\(^{-1}\), corresponds to overlapping and stretching vibrations of aromatic hydrogen and NH groups.

3.2 EDS
The EDS high intensity peaks in (Fig-3) show the iron concentration and formation of Fe\(_3\)O\(_4\). The Cu signals were from Cu grid.

3.3 TEM

TEM image (Fig-4) of synthesized magnetite indicates presence of nanocubes and nanorods.
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The high resolution image of single iron oxide cubes (in Fig-5) shows lattice fringes with an inter fringe distance of 0.257nm.

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5. CONCLUSION

Magnetism is a unique physical property of SPIONS that independently helps in water purification by modifying the physical properties of contaminated water. SPIONS can be used for industrial scale as well as civic wastewater treatment, due to their low cost, strong adsorption capacity, easy separation and enhanced stability [8, 9]. Contamination of water with toxic metal ions (Hg(II), Cr(III), Cr(VI), Ni(II), Co(II), Cu(II), Cd(II), Ag(I), As(V) and As(III)) is becoming a severe environmental and public health problem. In order to achieve environmental detoxification, various techniques like adsorption, ion exchange, reverse osmosis, electrochemical treatments and membrane filtration, processes are extensively used. Among these, adsorption is a conventional technique to remove toxic metal ions and bacterial pathogens from water [5, 6, 7]. The field of nanotechnology is very diverse and has high potential. The recent developments in use of iron oxide nanoparticles as an in situ in waste water treatment may have certain limitations. The study of the fate of nanoparticles in the environment and its impact on health may have some concern. However, coating with suitable materials like silica, chitosan may solve the issues of harmful effect on health.

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