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Preparation of Magnetic Iron Oxide Nanoparticles by the Modified Wet Chemical Method

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Abstract

In the embattled drug delivery, intravenous injection is given to patient followed by a magnetic field gradient over the fraction where drug is needed to be delivered as well as also in many medical applications requires iron oxide nanoparticles be discrete and magnetic. But rusting of these Nanoparticles after synthesis, decreases their efficiency in most of the applications and limits the uses of these particles. So here in this article we have modified the chemical method used for the synthesis of NPs. We have synthesized Iron Oxide Nanoparticles having average particle size Average ~100 nm with Magnetic Property from the Modified Wet Chemical Method which also solves the problem of rusting of iron particles. Modifying Wet Chemical Method, we have tried to solve the oxidation problem and at the same time giving advantage of developing magnetic property in nanoparticles. The method is easy to use and involves less time than any other magnetic nanoparticles preparation methods. Also the particles prepared by our method tend to have better magnetic properties and hence can be used in various applications with higher efficiency.

Keywords: Magnetic Properties, Iron Oxide, Rusting, Clean Surface NPs, Modified Wet Chemical Method.

INTRODUCTION

Iron, with the atomic weight 55.845 ± 0.002 amu and atomic number 26 is known to be the most pervasive transition metals and the fourth most abundant element in the Earth's crust [1]. It is the structural backbone of our modern Frame of World and therefore it is ironic that in the field of Nanotechnology, iron has been somewhat neglected due to problems which are faced during the preparation of Iron Nanoparticles. This is unfortunate, but is understandable [2]. Iron's reactivity is important in many applications but becomes a big problem in case of rusting. As it has long been known that finely ground iron is pyrophoric, iron nanoparticle research has fallen behind in this area. Iron nanoparticles have historically been difficult to properly analyze and inconvenient for practical applications due to iron's strong reactivity to moisture. However, iron has many advantages at the nanoscale, including powerful magnetic characteristics [3].

Rusting of Iron Nanoparticles just after their preparation decreases its efficiency in most of the applications and limits the uses of particles. Most of the recent advances in the synthesis of high-quality nanoparticles have used highly pure organometallic precursor and precisely controlled inert conditions such as purified high-grade reagents and freeze-thaw technique and thus makes it tedious for the users at initial level. An easy and economic

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synthesis would be desirable for clinical and industrial applications. Modified Wet Chemical Method helps at this point, it just requires some basic chemicals and instruments and most importantly requires less time [4–5].

The advantage of using iron oxide nanoparticles over iron counts on the chemical stability of iron oxide over pure metal nanoparticles. Iron oxide nanoparticles have attracted a lot of attention due to their fundamental properties, which are brought about by their abundant polymorphism, multivalent oxidation states, and mutual polymorphous changes in nanophase, as well as their magnetic properties, which again lead to a variety of applications. [6].

Clinical application requires that iron oxide nanoparticles be discrete and magnetic, various methods of preparation have been studied and applied to make the Iron Nanoparticles magnetic but most of them uses various reagents and precise conditions, so easy and simple method is needed and highly desirable [7–8].

Magnetic nanoparticles in general are of great interest today, and iron is among the most useful magnetic materials [9–10]. They are excluded from this table because this ferromagnetism is only in narrow, cryogenic temperature regions [11–16].

MATERIALS AND METHOD

Nanoparticles were prepared by the modified wet chemical method. In this method, particles were prepared in three steps. In first step, 0.1 M solution of Ferric Chloride Heptahydrate was prepared in water by continuous stirring for 15 minutes. In next step, 0.5 M solution of Sodium Chloride was prepared in water by continuous stirring for 15 minutes. Finally, both the above solution were added drop by drop in 10 ml water with continuous stirring and vigorous heating on magnetic stirrer followed by stirring for 15 minutes and heating for 10 minutes simultaneously. Particles prepared in this way were found to be magnetic in nature and a black colour solution was formed which declares the presence of Fe^{+2} ion, (It is well known that Fe $^{+2}$ ion has black colour) instead of Fe^{+3} ion which is green in colour [17–18].

RESULTS AND DISCUSSION

Particles so prepared by the modified wet chemical method were in nanometer range and were highly magnetic in nature. Particles were so magnetic that they got stick to the magnetic bead as soon as the stirring of the solution is stopped. Particles were characterized by different methods like DLS (Figure 1), SEM (Figure 2), UV spectroscopy (Figure 3 & 4), PL spectroscopy (Figure 5). DLS results have proved that the average particle size of the magnetic nanoparticles prepared by the Modified Wet Chemical Methods is 210 nm.

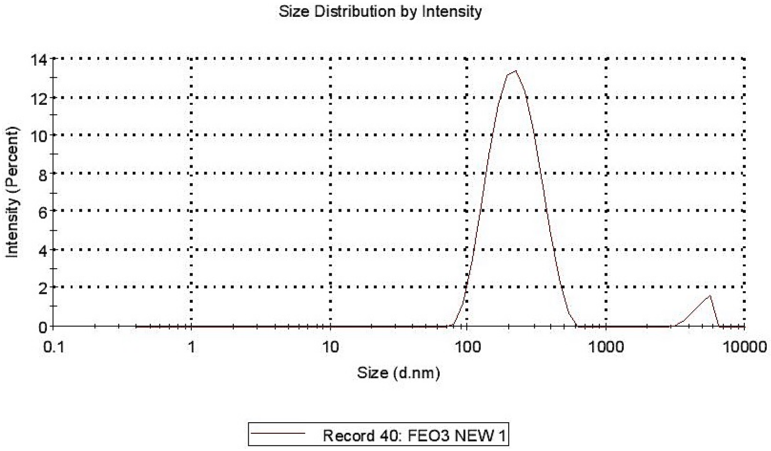

Figure 1. Size distribution by intensity of particles (Average particle size of the magnetic nanoparticles prepared by the Modified Wet Chemical Methods is 210 nm)

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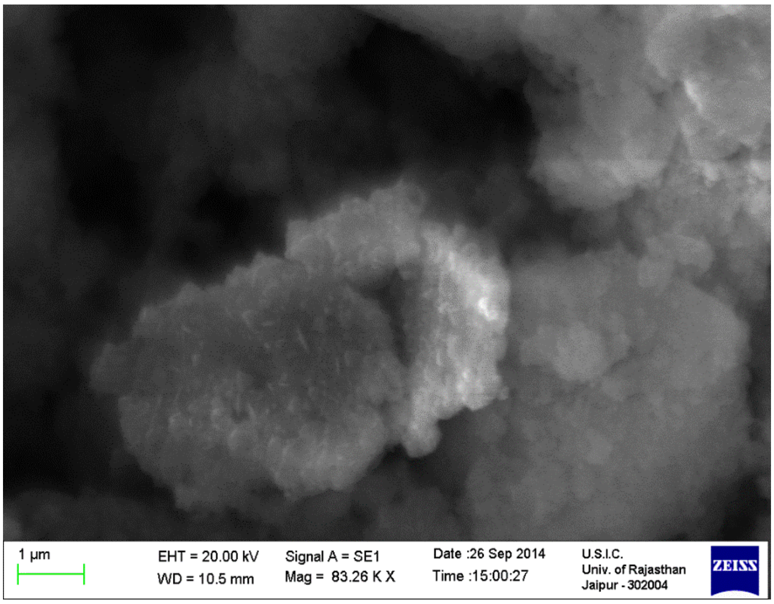

Figure 2. SEM image of iron oxide nanoparticles.

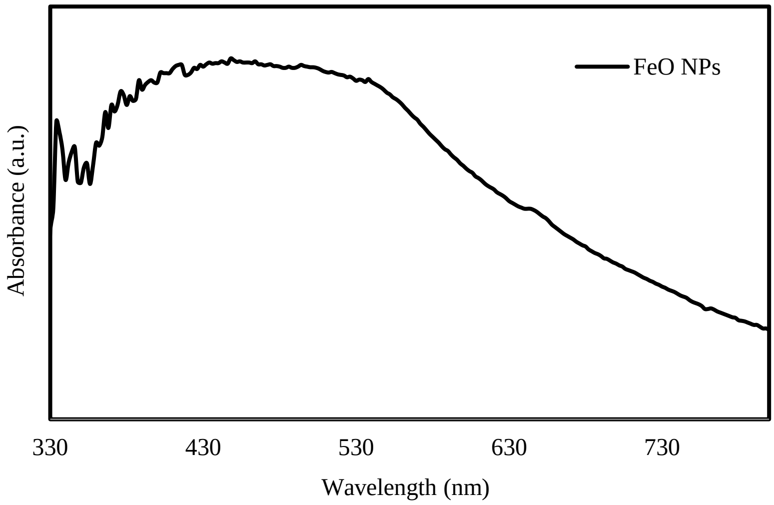

Figure 3. UV-Vis absorption spectrum of iron oxide NPs.

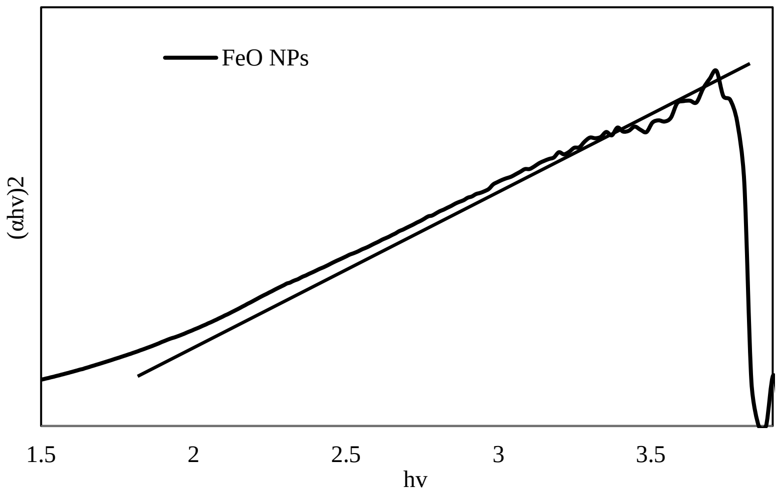

Figure 4. UV-Vis absorption edge of iron oxide NPs.

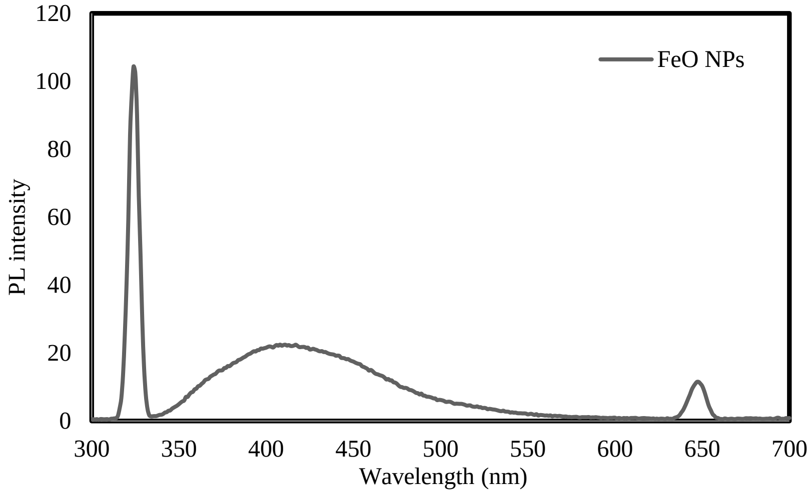

Figure 5. PL spectra of vacuum dried powder of iron oxide nanoparticles.

Nanoparticles retains many chemical and physical properties because of their small size and in case of iron nanoparticles with the above mentioned properties two terms appears in mind, first is ‘RUST’ for which we need not to worry at all with the modified method & second is ‘MAGNETISM’ which is the easiest to develop and hence can be used in many applications [18–22].

Nanoparticles have high surface-to-volume ratio with high amount of free surface energy and by joining the term ‘IRON’ before nanoparticles, we get magnetic property with high surface to volume ratio which can be manipulated in many ways for the better of technology.

The very important thing about the magnetic properties of magnetic nanoparticles (IRON) is that they can exhibit the lowest (zero) coercivity or highest coercivity observed in a material, depending upon size, so here we can alter COERCIVITY (which is the measurement of magnetic hardness) as required.

The coercivity of small particles is zero but increases with increasing size, and reaches a maximum in the size range of tens on nanometres, then declines, and approaches bulk coercivity. Complete Hysteresis Loop depends on Coercivity, altering Coercivity directly means altering Hysteresis Loop so in short, we can say that through Iron nanoparticles we can get complete command over Soft and Hard Magnetic Materials which are having a wide range of applications like constructing a electromagnet or permanent memory or a permanent magnet.

Magnetic Iron Oxide Nanoparticles are of great use in targeted drug delivery, MRI enhancement and Hyperthermia treatment. A mixture of CO and H_2 gas is passed over a catalyst to synthesize hydrocarbons in Fischer-Tropsch synthesis method, here the catalyst used should be a metal belonging to group VIII, which makes Iron a suitable choice as it is inexpensive, but commercially only bulk iron is used in this process. Instead of BULK If Iron Nanoparticles are used as a catalyst, then one can get better results. For Clinical use Iron Oxide is preferred over Iron because of its biocompatibility.

In directed drug delivery, intravenous injection is given to patient followed by a magnetic field gradient over the part where drug is needed to be delivered. Hyperthermia as a medical treatment relies upon locally heating tissue to greater than 315 K for approximately 30 min to destroy the tissue, particularly tumors. The heating of magnetic particles has been investigated for decades as a possible approach to selectively heating cancerous tumors.

SUMMARY & CONCLUSION

Modifying Wet Chemical Method, we have tried to solve the oxidation problem and at the same time giving advantage of developing magnetic property in nanoparticles. In the near future we can hope that

Magnetic Iron nanoparticles will be studied, developed and applied just like bulk Iron which will help in flourishment and blossoming of Technology, and hence for humanity. 220 nm average particle diameters was obtained by DLS analysis for Iron Oxide Nanoparticles. Same facts were also obtained in SEM analysis where particle size is ranging from 200–250 nm. This analysis shows no agglomeration in particles even synthesized without using any capping/stabilizing agents. UV-V is absorption band edges (SPR) were observed at 418 nm for Ag NPs. Here demonstrated synthesis method was extremely simple, cheaper and fast for synthesis of NPs without production of toxic and flammable byproducts.

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