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Research Article

Preparation of Magnetic Nanoparticles by Novel arc discharge method and its Applications

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Abstract

This review shows the preparation of magnetic nanoparticles and its applications by using novel arc discharge method. Nanotechnology has contributed to the practical development in a variety of engineering biomaterials and renewable energy resources over the last decade. At present ferrite nanoparticles and oxide nanoparticles are the most employed one. Compared to the other techniques for the synthesis of Fe3O4, this novel arc discharge method has many advantages such as simpler operation, cheaper experimental precursor and high productive capacity.

Keywords: *Nanoparticles, Novel arc discharge, Applications*

1. Introduction

Nanoscience is one of the most important researches in modern science. Nanotechnology is beginning to allow scientists, engineers, chemists, and physicians to work at the molecular and cellular levels to produce important advances in the life sciences and healthcare. The use of nanoparticle [NP] materials offers major advantages due to their unique size and physicochemical properties (Bychko, *et al*, 2005) Among nanomaterials magnetic nanoparticles are of keen interest to researchers owing to their praise worthy magnetic properties. Magnetic nanoparticles have a wide range of applications, including magnetic fluids recording, catalysis, biotechnology/ biomedicine, material sciences, photo catalysis, electrochemical and bioeletrochemical sensing, microwave absorption, magnetic resonance imaging [MRI], medical diagnosis, data storage, environmental remediation and, as an electrode, for supercapictors and lithium ion batteries (LIB)(Rashad, *et al* , 2012). While talking of, various magnetic nanoparticles, magnetite (Fe3O4) has been used for a several wide number of applications due to its superparamagnetic properties but one property of being sensitive to oxidation and agglomeration, has lemmatized its use. The solution to this problem is, to protect the magnetic nanoparticles by various types of coatings. These shells not only protect the magnetic nanoparticles, but, also provide a new platform for further functionalization that enhances the properties of the magnetic nanoparticles. Nowadays, a lot of novel binary and ternary magnetic nano composites have been synthesized with various core shell structure including grapheme, carbon nanotube, conducting polymer, metal oxide and other inorganic materials as coating on magnetic nanoparticles (Dumestre, *et al*, 2002).

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2. Synthesis

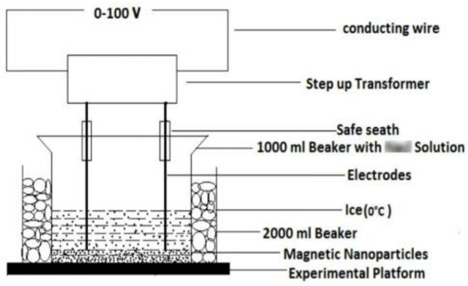

Fig.1 The experimental apparatus for the preparation of Fe3O4 by the novel arc discharge method.

The experimental apparatus used is illustrated in fig.1. A 50hz alternating power supply was supplied to LiCl solution in a 1000ml beaker [1 mole^{-1} LiCl]. Stainless steel rods(ER310) were used as electrodes distance between them being 3cm. Both electrodes were fixed and placed in the electrolyte. Voltage was adjusted using variac, varied from 15-50 volts. After setting the required voltage note down the ammeter and voltmeter readings for a given time period. These electrodes were melted during the arc discharge due to the strong exothermic reaction. The black magnetic precipitates are appeared in the electrolyte and these are separated by using the filter paper. The above precipitate is washed with distilled water and absolute alcohol for 2 times. This precipitate is heated in a furnace between the temperature 50 to 150 degrees. The Nanopowder obtained after heating is tested by powder XRD test.

3. Applications

3.1. Recent Advances in the biomedical applications of magnetic nanostructures

Recently magnetic nanoparticles have been used for a wide number of applications, For example in industry, as magnetic inks for bank cheques and jet printing, high density magnetic data storage devices, magnetic information storage, xerography, catalysis, magnetic refrigeration, electronics (recording media) as photo catalyst for organic dye removal, for water splitting, gas sensors, as an electrode in Li-ion batteries in biomedical application and sewage treatment applications. Because of the nano size of magnetic nanoparticles they can be attached to cell or they can be transported through the cell by introducing within the cell and can even directly enter into the blood stream. Biomedical applications are imposed to strict requirements on the particles (physical, chemical and pharmacological) properties, including chemical composition, size, granulometric uniformity, homogeneous crystal structure, magnetic properties, surface area and structure, adsorption properties, biocompatibility, hardness and flexibility, solubility, low toxicity and non-allergic affect. Numerous properties that offer abundant attractive possibilities to magnetic nanoparticles in biomedical field are their comparable sizes to those of a virus (20–500 nm), a protein (5–50 nm) or a gene (2 nm wide and 10–100 nm long) their superior magnetic properties and their large surface area that make them nontoxic, biocompatible and better suitable for biological system. In this chapter, we will only present the review of few applications of magnetic nanoparticles in biotechnology and energy applications

3.2. Industrial applications

Magnetic iron oxides are commonly used as synthetic pigments in ceramics, paints, and porcelain. Magnetic encapsulates may find very important uses in many areas of life and also in various branches of industry. Such materials are interesting from both points of the fundamental study of materials science as well as their applications. Hematite and magnetite have been applied as catalysts for a number of important reactions, such as the preparation of NH_3, the desulfurization of natural gas, and the high-temperature water-gas shift reaction. Other reactions include the Fishere-Tropsch synthesis for hydrocarbons, the dehydrogenation of ethylbenzene to styrene, the oxidation of alcohols, and the large-scale synthesis of butadiene.

3.3. Environmental applications

A similarly important property of nanoscale iron particles is their huge flexibility for *in situ* applications. Modified iron nanoparticles, such as catalyzed and supported nanoparticles, have been synthesized to further enhance their speed and efficiency of remediation. In spite of some still unresolved uncertainties associated with the application of iron nanoparticles, this material is being accepted as a versatile tool for the remediation of different types of contaminants in groundwater, soil, and air on both the experimental and field scales. In recent years, other MNPs have been investigated for the removal of organic and inorganic pollutants.

3.3.1. Organic pollutants

There are a few articles about the removal of high concentrations of organic compounds which are mostly related to the removal of dyes. The MNPs have a high capacity in the removal of high concentrations of organic compounds. Dyes are present in the wastewater streams of many industrial sectors such as in dyeing, textile factories, tanneries, and in the paint industry. Therefore, the replacement of MNPs with an expensive or low efficient adsorbent for treatment of textile effluent can be a good platform which needs more detailed investigations.

3.3.2. Inorganic pollutants

A very important aspect in metal toxin removal is the preparation of functionalized sorbents for affinity or selective removal of hazardous metal ions from complicated matrices. MNPs are used as sorbents for the removal of metal ions. Thus, MNPs show a high capacity and efficiency in the removal of different metal ions due to their high surface area with respect to micron-sized sorbents. These findings can be used to design an appropriate adsorption treatment plan for the removal and recovery of metal ions from wastewaters (Singamanen, *et al*, 2011).

3.4. Magnetic nanoparticles for Energy storage applications

Nowadays there is an urgent requirement to develop green and more efficient sources of energy. Most commonly used facile sources of energy are Li-ion batteries, fuel cell, supercapictors and hydrogen production cell. Lithium ion batteries that possess high charge and discharge ability, high energy density and high power capacity are the most efficient cost effective and attractive source of energy for power application and electric vehicles. These batteries have long been considered to be one of the most promising power sources for popular mobile devices, such as mobile phones, notebooks. Magnetic nanoparticles also find application in this field. Fe3O4 is one of the promising materials that have been used as anode for lithium ions batteries (Teymourian , *et al* , 2013).

Conclusions

1) Magnetic nanoparticles play an important role in the rapidly developing branches of science specializing in the study of objects (existing in nature or, more often, artificially produced) with Nano-sized structural blocks.
2) Magnetic Nanoparticles display the phenomenon of super paramagnetic. Targeting of drugs by Nanoparticles is intend to reduce drug wastage frequency of drug administration side effects providing prolonged, sustained, drug delivery to desired targeted organ [Ece simsek and Mehmet akif kilc].
3) Even though the extensive use of magnetic nanoparticles (especially for biological applications and nanomaterials containing them is delayed by the difficulty of producing materials with a narrow size distribution of particles and stable reproducible characteristics and the high cost of their large-scale production, such nanoparticles are used more and more often in the everyday practice. In our opinion, it is time for extensive search for the ways of practical use magnetic nanoparticle.

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