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A Review: Ferrites Nanoparticles (FNPs) Synthesis via Sol-Gel Auto Combustion Synthesis

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Abstract: *Ferrite nanoparticles have a large interest due to their wide range of applications in biomedical, industrial electronic devices, and wastewater treatment. This review is focused on the synthesis of ferrite nanoparticles via sol-gel auto combustion. Ferrites have complex spinel structure. They are magnetic in nature. Their magnetic nature makes them useful for several wide applications in electrical and medical application such as targeted drug delivery, magnetic hyperthermia etc. Sol-gel auto-combustion synthesis is widely used for the synthesis ferrite nanoparticles because sol-gel synthesis is a very versatile route of synthesis. The important feature of the sol-gel auto-combustion technique is that the heat required to trigger the reaction is supplied by the reaction itself instead of coming from external agent or source.*

Keywords: Ferrite nanoparticles, Biomedical Applications,Magnetic Hyperthermia etc

I. INTRODUCTION

Magnetic nanoparticles (MNPs) have attracted a great deal ofattention due to their promising applications in biomedicine, as catalysts and in magnetic data storage[1] Synthesis of magnetic cobalt ferrite nanoparticles with controlled morphology, monodispersity and composition: the influence of solvent, surfactant, reductant and synthetic conditions]. The ferromagnetic materials, ferrites are magnetic ceramics consisting of iron oxide and metal oxides finds potential applications for making many devices such as permanent magnets, memory storage devices, micro-wave devices and for the telecommunication equipment purpose. Theimportance of ferrites lies in the fact that they possess wide range of electrical and magnetic properties. The high electrical resistivity, low eddy current and dielectric loss, high saturation magnetization, high permeability, high Curie temperature etc. are the remarkable electrical and magnetic features of ferrites [2]Ferrite nanoparticles (FNPs) belong to a broad group of magnetic nanoparticles (MNPs) and have received a considerable amount of attention due to their wide applications in various fields, which ranges from biomedical to industrial. [3]

Applications of ferrites

FNPs are very useful materials due to their dielectric, electric, magnetic, optical, and chemical properties. The use of ferrite nanoparticles in applications such as biomedical devices, electronic devices, and in wastewater treatment [4] etc.

Biomedical Applications of FNPs:

Now a days FNPs have been widely used for various biomedical applications because of their biocompatible nature towards the human body. Magnetic nanoparticles have opportunities in biomedical applications in the investigation of cancer treatment and infectious disease through enhancing (MRI) Magnetic resonance imaging, magnetichyperthermia, drug delivery, etc. Magnetic Resonance Imaging (MRI): MRI helps to diagnose and treat medical problems. MRI uses very strong magnets, radio waves with a computer to make detailed pictures inside the body.

Magnetic Hyperthermia In Cancer Therapy: In Magnetic Hyperthermia therapy used along with magnetic nanoparticles to kill the tumour by hitting it without damaging thetissue. Heat is created by radiofrequency, ultrasound energy, microwave, or by using magnetichyperthermia.

*Drug Delivery:*Ability to carry an adequate drug concentration and directly release it to the organ to be treated because of this targeted drug delivery has emerged as an astonishing medication methodology for direct treatment of the infected body organ, and it avoids the side effects caused to other healthy organs of human body [5]

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Sol-gel auto- combustion

Various synthesis methods have been employed to obtain FNPs with superior electric and dielectric properties. Thesesynthesis methods includes co-precipitation [6], hydrothermal synthesis [7]sol–gel auto-combustion [8], reverse micelles [9] and micro-emulsion [10] etc. Among these methods sol-gel auto-combustion is a promising technique which offers to be significant in saving time and energy over the traditional methods [11]. The sol-gel method is simple, involving a very fast chemical and exothermic reaction to form the material [12]. Amongst these chemical methods, the sol–gel auto-combustion technique is one of the most reliable, convenient and effective method, involving a low reaction temperature (80–100 °C) and a rapid turn-around time for powder synthesis. It is a one-step process producing a voluminous fluffy fine powder and is based on formation of sol then gel and combustion in a heated solution containing salts of the desired metals mixed with an appropriate fuel. The effectiveness and production of highquality fine powder (nanometer dimension) depends on the preparation condition and preparative parameters such as nature of fuel, fuel/metal nitrate ratio, pH and annealing temperature [13]. Further, the properties of the obtained powder like the heat generated during combustion (enthalpy) and the flame temperature generated during auto combustion. All these parameters depend on the nature of the fuel. Since the fuels differ in their complexing ability, reducing power and the evolved gas content, the selection of a suitable fuel becomes very important for achieving the desired properties in the final product. The important feature of the sol-gel auto-combustion technique is that the heat required to trigger the reaction is supplied by the reaction itself instead of coming from external agent or source. Figure 1 shows the schematic diagram of sol-gel method.

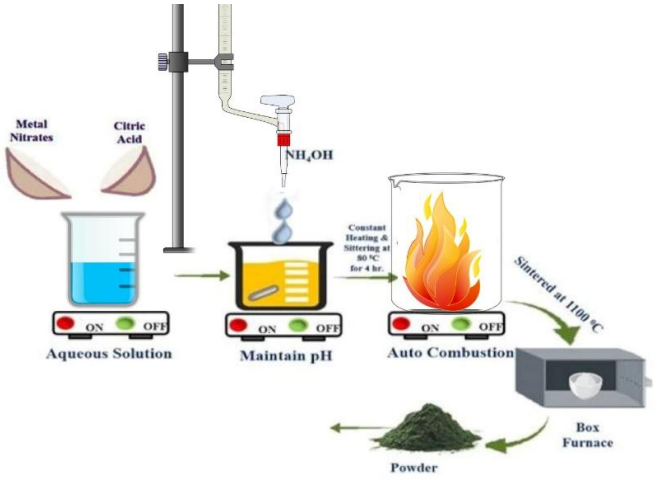

Figure 1.Schematic diagram of sol-gel processing.

Commonly used organic compounds as fuels in sol-gel auto combustion synthesis are citric acid ($C_6H_8O_7$), dextrose ($C_6H_{12}O_6$), sucrose ($C_{12}H_{22}O_{11}$), urea (CH_4N_2O), glycine ($C_2H_5NO_2$) etc. It has been assumed that urea, glycine and citric acid make strong complexes with metal cations in the solution. These fuels achieve two purposes: during combustion forms CO_2, H_2O and liberate heat in exothermic process and the forms complexes with metal ions simplifying homogeneous mixing of the cations in solution. Since nitrogen itself does not participate in the redox reaction it is thought that it is released as a gaseous substance increasing the porosity of the obtained materials. The intensity of the combustion reaction is also dependent on the type of fuel [13].

Summary

Ferrite nanomaterials can be used for several electronic and medical applications. Several methods have been adopted to synthesize ferrite nanomaterials but Sol-gel auto combustion synthesis extensively used because it does not require very sophisticated infrastructure of the laboratory.

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