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On the Nature of Ferrite Nanoparticles

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Abstract: Ferrite nanoparticles had acquired considerable research interest due to their applications, such as magnetic separation of labeled cells, therapeutic drug, hyperthermia treatment for cancer, contrast enhancement agent for magnetic resonance imaging. In order to decide the nanoparticle for a particular application, their nature can be modified or altered with their stochiometric compositions. Generally, properties of ferrite nanoparticles are as a result of cations present and the balance existing between cations of tetrahedral and octahedral sites.
Keywords: Ferrite, magnetic nanofluid, magnetization, hyperthermia.

I. INTRODUCTION

Ferrite nanoparticles of different sizes and properties can be prepared by various techniques such as co-precipitation[1], ball milling[2], micro emulsion[3], sol-gel[4], and thermal decomposition[5]. Ferrite nanoparticles after appropriate surface modification can be dispersed in various polar or non-polar carrier liquids[6] to prepare magnetic nanofluid. Surface modification may be done with surfactants such as sodium oleate, polyvinyl alcohol, tetramethyl ammonium hydroxide, carboxy methyl dextran, citric acid, lauric acid, myristic acid, etc.,

Composition of tetrahedral and octahedral site of ferrite alters the general properties like magnetic property, curie temperature, thermal conductivity, electrical conductivity and resistivity, dielectric constant. Different types of magnetic nanoparticles include MFe_2O_4 (M = Fe, Ni, Co, Mn, Mg, Zn, Cu) [7].

II. CHEMICAL COMPOSITION

Cation distribution among tetrahedral and octahedral site of ferrites reflect magnetic property and other properties also. Magnetic moments of all the cations present in tetrahedral site are oriented anti parallel to that of the cations of octahedral site. Therefore, the distribution of cations over these tetrahedral and octahedral sites and their exchange interaction decides the properties of ferrites. Also, size and shape effect cannot be excluded.

A. Zinc Effect

Zinc ferrite shows paramagnetic behavior as bulk material due to its normal spinel structure, in which zinc ions are incorporated in tetrahedral site. When zinc ferrite is prepared in form of nanoparticles, it becomes ferromagnetic due to partial migration of zinc to octahedral site[8]. The substitution of non magnetic zinc ion in a ferrite (which has preferential tetrahedral site occupancy) results in the reduction of exchange interaction between tetrahedral and octahedral sub lattices. The extent of properties especially magnetic property can be tailored by substituting relevant cations in tetrahedral and octahedral lattices.

B. Iron Effect

Magnetite and maghemite with a diameter of 5 – 20nm have attracted much attention[9]. Magnetite nanoparticles are of good research interest because of their non-toxic nature, which makes it biocompatible. Stable aqueous magnetic fluids can be conveniently prepared using magnetite nanoparticles for biomedical applications. This essentially needs appropriate surface modification. In order to tune the properties, diamagnetic zinc can also be incorporated to appropriate level, which might make it suitable for particular application with modified properties.

C. Manganese Ferrite

Manganese ferrite and Manganese Zinc ferrite are potentially used in hyperthermia application and as contrast agent in Magnetic Resonance Imaging[10]. The properties of manganese zinc ferrite can be adjusted according to the needs by varying the stochiometric composition. Nature of the cations present displays different properties, without neglecting the magneto crystalline and shape anisotropies. Rather than manganese ferrite, properties of ferrite depends on the negative exchange interaction existing between the cations occupied in tetrahedral and octahedral sites. Any variation of cationic composition may alter the exchange interaction and thus properties.

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D. Nickel Ferrite

Among all spinel ferrites nickel and nickel zinc ferrite are useful due to their high electromagnetic performance, moderate saturation magnetization, hysteresis and good chemical stability. The cost of production of ferrites depend on the method that can be adopted. Also, nickel zinc ferrite found their applications in biomedicine[11]. It is being reported by several researchers that nano ferrites are soft magnetic materials with narrow hysteresis, and thus high permeability.

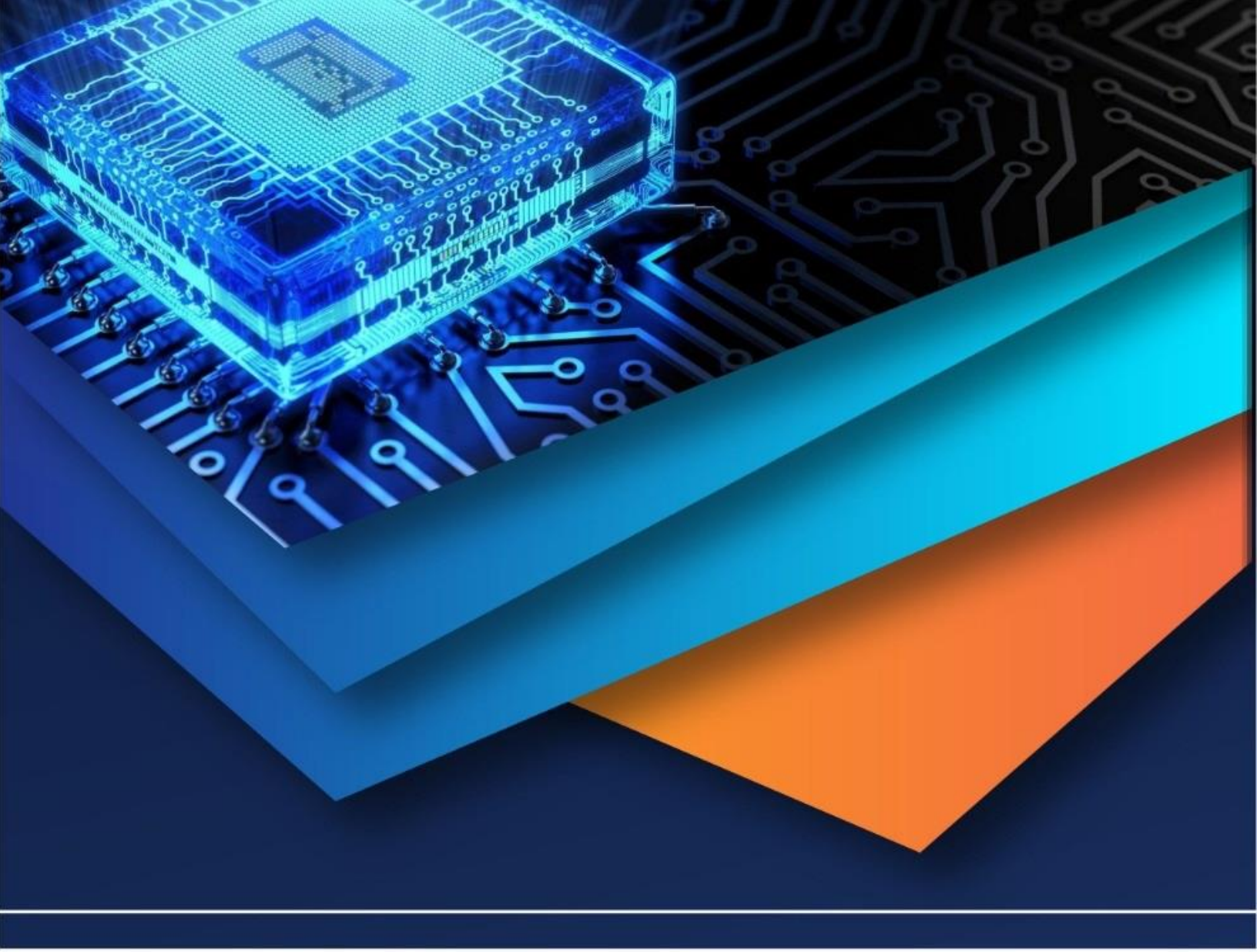
III. CONCLUSION

This paper attempts to give summary and literature survey on ferrites which after surface modification, used in biomedicine. In hyperthermia application the goal is the higher value of heat generation by a stable fluid in a lower exposure time. So based on which heat generation mechanism we want, a suitable selection of magnetic core, surfactant layer and carrier liquid can influence the promising applications.

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