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Emerging Spinel Ferrite Nanoparticles 2021: Mini Review

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ABSTRACT

In this review, we have focused on the recent happenings in the spinel ferrite nanoparticles flashed by many researchers in the year 2021. The current developments in cobalt ferrite, nickel ferrite, copper ferrite, and zinc ferrites have been reviewed. The impact of their mixed-metal combinations with Co^{2+}, Cu^{2+}, Mg^{2+}, Cr^{2+}, Cd^{2+}, Mn^{2+}, etc. divalent ions has been studied by some researchers. The spinel ferrite nanoparticles are obtained mainly by several simple, cheap and cost-effective synthesis methods. Various characterizations techniques like XRD, AFM, SEM, HR-TEM, FTIR, UV-Vis, spectroscopy, Raman, VSM, were employed for the determination of their physical and chemical properties. The diverse applications of these magnetic nanoparticles have been addressed in various fields viz. science research, technology, medical, agriculture, biotechnology, etc.; since the decades to the present day.

Keywords: Spinel ferrite; Synthesis methods; Characterization techniques; Applications of ferrites.

I.INTRODUCTION

Ferrites are the 'iron oxide' formed of Fe_2O_3 and FeO as their main component,; belong to the $Fd_{3m}O^h_7$ space group with a general formula of AB_2O_4 [1]; constituting the ceramic bodies possessing the ferri-magnetic properties. These properties can be tuned by addition of dopent in these materials. They are specialized with a cubic closed–pack arrangement of 'oxygen ions'with the equally distributed ions of at tetrahedral (A)-site and octahedral [B]-sites in the lattice structure [2]. They possesses tunable structural, increamental electrical, good catalytic activity, and dynamic magnetic properties etc. M.I.A. Abdel Maksoud et.al has reported the results obtained from the structural and optical characterizations performed, and suggested the possible applicability in the catalysis applications [3]. S Rather et.al has studied the different physical properties of Al^{3+}-doped nanostructured spinel nickel ferrites [4].

Kebede K. Kefeni Bhekie B. Mamba and Titus A.M. Msagati [5] have reported the inevitable application of spinel ferrite in water and waste water treatment. They took the effort todictate the functionalizing the water surface with non-toxic chemicals provided with the opportunity for the future generation in solving the problems related to water treatments. Henrik Lyder Andersen et.al [6] has prepared magnetic spinel ferrite (MFe2O4) via simple, green, and scalable hydrothermal synthesis and studied the crystalline and magneticstructure-property relationship in spinel ferrite nanoparticles. Y. Slimani et. al [7] has prepared $Ni_{0.4}Cu_{0.2}Zn_{0.4}Fe_{2-x}Eu_xO_4$ (x = 0.00 – 0.10) nanoparticles were synthesized via ultrasonic irradiation. They have discussed the superparamagnetic property at RT and soft ferromagnetic nature below T_B. Also, dielectric and electrical properties were discussed in detail. Raghvendra Singh Yadav et.al [8] has studied the impact of sonochemical Synthesis of $MnFe_2O_4$ single-phase spinel ferrite structure nanoparticles. Tuyet Nhung Pham, Tran Quang Huy, and Anh-Tuan Le[9] have reported the uses of spinel ferrite-based hybrid architectures for lithium-ion battery, environmental monitoring, and biomedical applications.

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Mohammad Azam Ansari, Abdülhadi Baykal, Sara Asiri & Suriya Rehman[10] has prepared the chromium-substituted copper ferrite nanoparticles by coprecipitation method, and reported the enhances in their antibacterial property. It has been proposed for the coating of medical devices to prevent microbial biofilm growth, magnetically drug delivery systems, ointments, cosmetics, creams and lotions for topical application. K.Elayakumar et.al [11] has studied the rare earth element Ce^{3+} doped $CuFe_2O_4$ NPs prepared by the simple sol-gel route and used the XRD and SEM along with EDX studies to the spinel phase formation. In their studies, they reported the enhanced antibacterial efficiency against Staphylococcus aureus and Klebsiella pneumonia. Sumithra Y Srinivasan et.al [12] has studied the applications of cobalt ferrite nanoparticles in the biomedical nanotechnology, biotechnology and bioengineering. Meenakshi Dhiman et.al [13] have reported the synthesis of $Mg_{0.9}Mn_{0.1}Sc_xFe_{(2-x)}O_4$ via the sol-gel method and studied the magnetic properties suitable for biomedical applications.

Among the various methods, some of the good popular synthesis methods are the ceramic method [14], wet-chemical method [15], micro-emulsion method [16], hydrothermal method [17], spray pyrolysis technique, a salt-melt technique [18], auto-clave method [19] etc. Diverse methodologies were deployed for the synthesis and characterization of these magnetic materials that can be assisted for novel applications. The ferrite materials have maintained their leadership in industrial, research, biomedical applications due to their renowned semiconducting behavior in comparison to the other competent materials [20]. As the T.H. Mubarak, O.A Mahmood, and W A Shatti studied the iron-nickel particles used as a contrast medium in an MRI Machine [21]. These ferrites have commonly used in numerous applications such as MRI [22], recording media [23] such as cassettes and CDs, the magnetic stripes in electronic cards, and Rfid magnetic sheet used for digital transactions [24]. The modern applications of ferrites included biomedical drug delivery [25], medical appliances, biological implants in the biological structure, nanorobotic applications, and complex algorithmic technologies in various modern research and development [26]. R.Suresh et.al has studied the wastewaster treatment applications of spinel ferrite [27]. Yutao Peng et.al studied the pollution-controlling applications of the ferrite in his literature and exposed future recommendations regarding the water treatments [28]. Ferrites also fascinated the world with numerous applications like magnetic fluids [29], micro and nanoelectronic chips used in mobile and computer technologies, gas sensing devices [30], microwave communication [31], transformers, transducers [32], nano-electronic switches, electric motors and dynamos [33],magnetic resonance imaging[34], catalyst [35], antenna rod [3, 36], transformer core [37], memory chip [38], microwave devices [39] sensor [40] etc.. To meet this application pyramid adynamic desired product could be continuously designed over the various traditional and newmodern synthesis techniques. **Figure 1** depicts the Major applications of ferrite in diverse fields.

A) SYNTHESIS METHODS FOR FERRITE PREPARATION

Among the various methods, some of the good popular synthesis methods are the ceramic method [14], wet-chemical method [15], micro-emulsion method [41], a hydrothermal method [17], auto-clave method [19], spray pyrolysis technique, a salt-melt technique [18], etc. **Figure 2** depicts the various synthesis methods adopted by many researcher all over the world.

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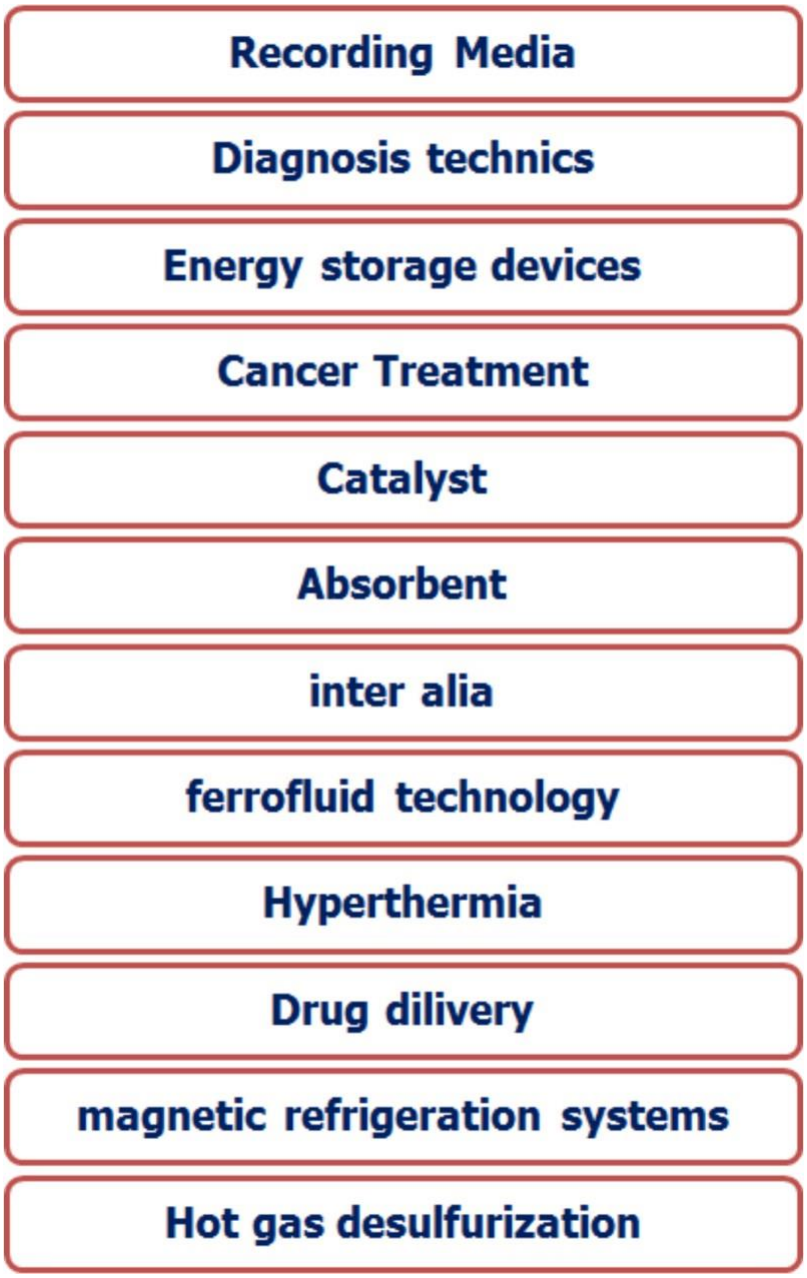

Figure 1:Shows Major applications of ferrite in the diverse fields

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B) VARIOUS CHARACTERIZATION TECHNIQUES

The thermal stability and sintering temperature of the spinel ferrite be characterized by using Thermo-gravimetric and differential thermal analysis (TG-DTA). The structural properties can be investigated to confirm phase purity of prepared spinel ferrite spinel ferrites by X-ray diffraction (XRD) technique at room

temperature. Using the XRD data, lattice constant, crystallite size, X-ray density, porosity, grain size and other structural parameters can be obtained. The thickness of the spinel ferrite can be evaluated by using weight difference method or surface profiler. The Fourier transform infrared (FTIR) spectroscopy can be

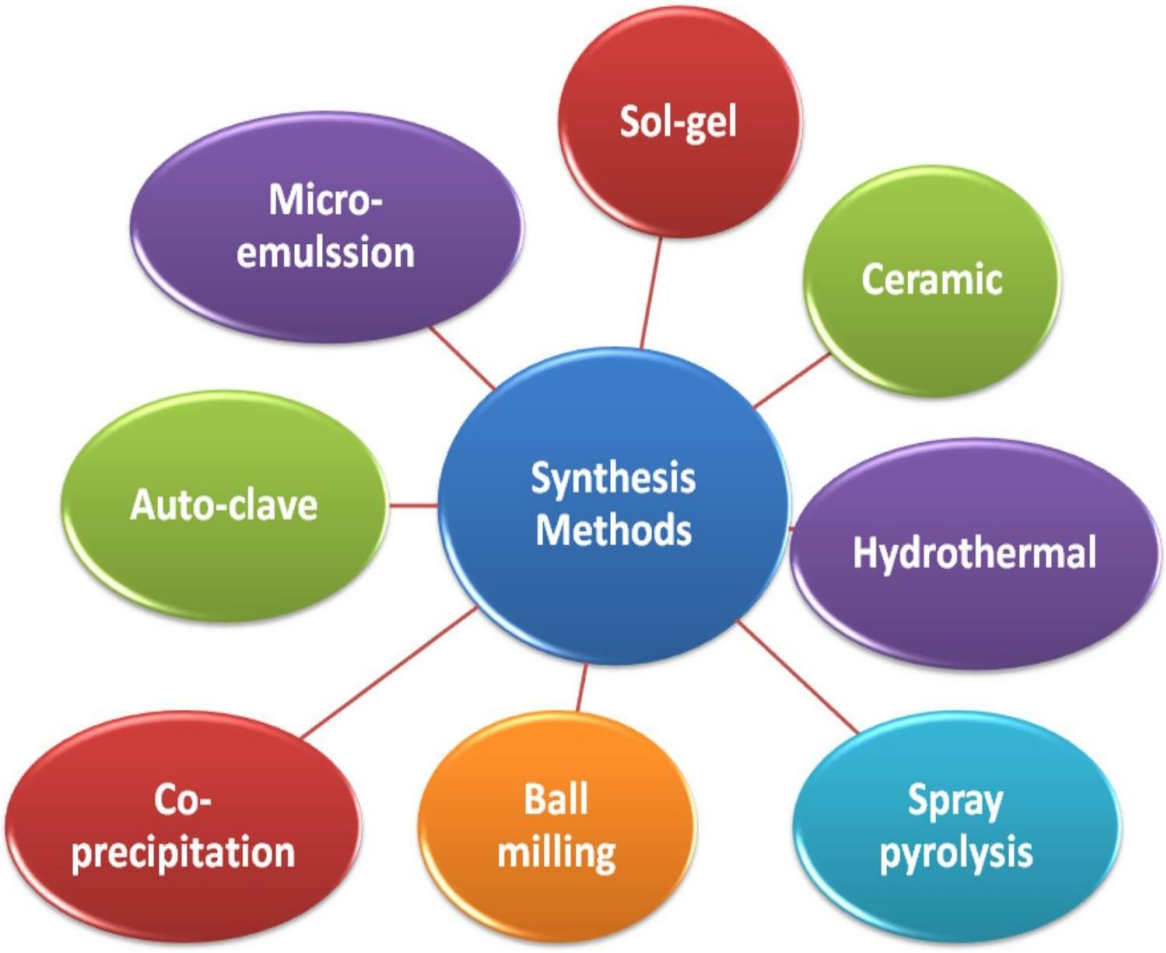

Figure 2: Shows Synthesis methods adopted worldwide for the preparation of ferrite

employed to confirm the spinel structure formation of the pure and deposited spinel ferrite spinel ferrites. The surface morphological studies can be carried out using SEM; also the grain size can be evaluated by SEM images. The elemental composition of the deposited spinel ferrite can be verified by EDAX studies. The microstructure, average roughness etc of the prepared spinel ferrites spinel ferrites can be studied by using AFM. The optical properties of the prepared spinel ferrites can be studied by using UV-Visible spectroscopy technique. The magnetic properties as magnetization using VSM at room temperature can be carried out. The obtained M-H plots can be used to obtain various magnetic parameters such as saturation magnetization, remanence magnetization, coercivity and magneton number.

II.SUMMARY

We have served the recent literature relevant to the synthesis, characterization and various physical properties of spinel ferrites. In this report we have noticed the importance of these 'iron oxides' termed to be ferrite in the various fields viz. Biomedical, industrial, home appliances, space technology, medical diagnosis, catalysts, transformers, transducers and so on. We believe this review can be beneficial for the overall study of magnetic nanoparticles as well, which can help the future developments of ferrite industries in the modern era.

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