ABSTRACT **Index No. 169/16/Phys./25**

THESIS TITLE: Structural, microstructural, magnetic and hyperfine characterization of some Zn-based nano and microstructured ferrite systems with application potential

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The present thesis depicts the study of structural, microstructural, optical, magnetic and hyperfine properties of $Co_{0.5}Zn_{0.5}Fe_2O_4$, $Co_{0.8}Zn_{0.2}Fe_2O_4$, $ZnFe_2O_4$ nanoparticles and microsphere and further explores the application possibilities of these samples as magnetic memory, catalyst, supercapacitor and photocatalyst.

The application potential of nanosized ferrite systems in the field of magnetic recording media can be severely affected by the occurrence of unstable spontaneous magnetization at room temperature owing to their superparamagnetic character and lowering of magnetization due to surface spin canting. Overcoming superparamagnetism by improvement of anisotropy energy and countering the effect of spin canting by modifying the cation redistribution constructively are supposed to be as the solutions of above-mentioned problem. On the other hand, nanosized spinel ferrites show superparamagnetism at room temperature, display moderate magnetization and become agglomerated. This sternly hampers their application in biomedical field. Thus, efforts have been made to synthesize submicronsized superparamagnetic ferrites with higher saturation magnetization and lower tendency of agglomeration through formation of hierarchical self-assembled and monodispersed solid and hollow microspheres of ferrites composed of superparamagnetic nanoparticles.

In the context, the role of mechanical activation in tuning the magnetization, blocking temperature and cation distribution for nanosized $Co_{0.5}Zn_{0.5}Fe_2O_4$ have been examined. The present study shows that the mechanical milling is capable of uplifting the magnetization, magnetic ordering and ordering temperature of the nanosized $Co_{0.5}Zn_{0.5}Fe_2O_4$ synthesized by coprecipitation followed by ball milling. This modified synthesis route has been utilized to increase the magnetization and to prevent the spontaneous thermal flipping of magnetization vector of superparamagnetic nanoparticles by enhancing their anisotropy energy through incorporation of mechanical strain among the lattice planes of the sample.

The morphology-dependent magnetic properties of solid and hollow $ZnFe_2O_4$ microspheres synthesized by simple solvothermal technique have also been studied. It has been found that the solid microspheres are formed by self-assembly of nanoparticles and display

superparamagnetic character predominantly along with collective magnetic excitations at room temperature. The hollow microspheres display Verway transition due to the cation vacancy in them. The occurrence of cation vacancy has been verified from XPS and Mössbauer spectroscopic study.

The possible application of nanosized $Co_{0.5}Zn_{0.5}Fe_2O_4$ as dc magnetic memory has been explored. The electrochemical performance of the nanosized $Co_{0.5}Zn_{0.5}Fe_2O_4$ synthesized by hydrothermal method has been studied.

Nanosized $Co_{0.8}Zn_{0.2}Fe_2O_4$ samples have been prepared by coprecipitation method followed by high energy ball milling and subsequent thermal treatment. This modified synthesis route plays a pivotal role in shaping the magnetic and hyperfine properties of the samples. It has been shown that the complex interplay of particle size, cation redistribution, interparticle interactions, surface spin disorder and strain induced anisotropy result in arousal of exchange bias in these single-phase nanoparticles. The samples display excellent catalytic activity in the multicomponent reaction for the synthesis of coumarin-3-carboxamide.

The magnetic and hyperfine properties of self-assembled $Co_{0.5}Zn_{0.5}Fe_2O_4$ microspheres composed of superparamagnetic nanoparticles have been studied. It has been found that the sample is ferrimagnetic in nature, migration of iron ions has occurred from [B] to (A) sites causing cation redistribution and spin canting is present on the particle surface. The sample acts as an efficient catalyst in the degradation of Congo Red dye in dark conditions. It also displays very high photodegradation efficiency under both visible and UV light conditions. The present thesis has been written on the basis of following publications in all of which the candidate is first author:

[1] *Journal of Magnetism and Magnetic Materials*, 487 (2019) 165303-1 – 165303-11.

[2] *Physica B: Condensed Matter*, 583 (2020) 412015-1 – 412015-12.

[3] *Proceedings of DAE SSPS* (2021) 198-199.

[4] *Materials Today Communications* (Under Review).

[5] *Physica B: Condensed Matter* (Under Review).

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