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# Review Paper on Electronic and Ionic Behaviour of Mixed Conductors-Electron Conductors

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**ABSTRACT:** Mixed Conductors frequently exhibit both electronic and ionic conductivity. It plays an important role in many electrochemical applications. Co-precipitation method is simple, cheap, environment friendly method to prepare MIEC. The CN/SZ Nano catalyst displayed promising results and provided remarkably high biodiesel yield of 96.8%. since the surface of produced ions using this method Contains a great number of hydrophilic ligands. We are summarized the conclusions of different studied by varying synthesis methods, varying shape of Nano materials, changing doband, changing the sintering temperature We have done this review in characterized by X-ray diffraction (XRD), Fourier transform infrared (FTIR), scanning electron microscopy (SEM), Brunauer Emmett-Teller (BET), transmission electron microscopy (TEM), and isothermal calorimetry.

**KEY WORDS:** Mixed ion-electron conductors, Co-Precipitation, Metal oxide

## I. INTRODUCTION

Mixed ion-electron conductors (MIEC), are a single-phase material that has significant conduction ionically and electronically. Due to the mixed conduction, a formally neutral species can transport in a solid and therefore mass storage and redistribution are enabled. Mixed conductors are well known in conjugation with High temperature superconductivity and are able to capacitate rapid solid-state reactions. The substitution of non-magnetic ion through co-precipitation method alters its magnetic property from ferromagnetic to supermagnetic. This behavior has huge application in biomedical science.  $\beta$ -dicalcium silicate is used as a coating material with thermal insulation and corrosion resistant. It's responsible for progressive strength of the concrete. Hence it has the huge application in cement industries. The ultrasonic irradiated co-precipitation method has various industrial application for the controlled synthesis of nano-spinel ferrites

MIEC materials such as Strontium titanate ( $\text{SrTiO}_3$ ), Titanium dioxide ( $\text{TiO}_2$ ),  $(\text{La}, \text{Ba}, \text{Sr})(\text{Mn}, \text{Fe}, \text{Co})\text{O}_{3-d}$ ,  $\text{La}_2\text{CuO}_{4+d}$ , Cerium (IV) oxide ( $\text{CeO}_2$ ) tend to be nonstoichiometric oxides, many of which have perovskite structures with rare earth metals on the A-site and transition metals on the B-site. Substituting various ions into the lattice of such an oxide can result in increased electronic conductivity through the formation of holes and introduce ionic conductivity by developing oxygen vacancies. This mechanism is known as defect theory, which states that defects like these offer additional pathways that favor fast diffusion Other promising materials include those with pyrochlore, brownmillerite, Ruddlesden-Popper, and orthorhombic  $\text{K}_2\text{NiF}_4$ -type structures.

However, true (single-phase) MIECs that are compatible with other design parameters can be difficult to find, so many researchers have turned to heterogeneous MIEC materials (H-MIECs). An H-MIEC is a composite mixture of two phases: one for conducting ions, and another conducting electrons or holes. These materials are desirable for the ability to tune their properties for specific applications by adjusting concentration levels to achieve optimal electron and ion transport. Porous H-MIECs also incorporate a third phase in the form of pores, which allow the formation of triple phase boundaries (TPBs) between the three phases that provide high catalytic activity.



The co-precipitation method is broadly used for the synthesis of spinel ferrite nanoparticles due to its number of good points like it is time-consuming method, cost-effective, simple to do and reliable. The chemical co-precipitation method produces a homogenous powder with maximum yield and does not require any organic fuels like citric acid etc. MIECs like lanthanum strontium cobalt ferrite (LSCF) are frequently the subject of modern fuel cell research, as they enable the reduction reaction to occur over the entire cathode surface area instead of only at the cathode/electrolyte interface.

One of the most commonly used oxygen electrode(cathode)materials is the H-MIEC LSM-YSZ, consisting of lanthanum strontium manganite (LSM) infiltrated onto a  $Y_2O_3$ -doped  $ZrO_2$  scaffold. The LSM nanoparticles are deposited on the walls of the porous YSZ scaffold to provide an electronically conductive pathway and a high density of TPBs for the reduction reaction to occur. Compared to various methods we had chosen Co-precipitation method as it has many advantages such as lower cost, faster reaction speed, lower requirements on reaction equipment, better performance of the prepared powder, high activity and purity, and is a common method for preparing nano-sized powder. They are prepared by electrochemical method, Micro emulsion method, Reduction method and Co-precipitation method

## II.PREPARATION AND CHARACTERISATION OF MIXED ION ELECTRON CONDUCTORS

Yihang Dong et.al prepared / synthesized YZC Solid Solution by Co-precipitation method. Thermal analysis of the powder is tested by Thermogravimetric-differential Scanning Calorimetry (TG-DSC) technology. The calculation indicates that the residual weight gradually increased from 72.87% to 81.88% and the weight loss rate gradually increased from 27.07% to 18.10% with the increase of CeO<sub>2</sub> content. Crystal Structure is analyzed by X-ray diffraction (XRD). When the coordination number is equal to 8, the ionic radii are  $Zr^{4+} = 0.84 \text{ \AA}$ ,  $Y^{3+} = 1.03 \text{ \AA}$ ,  $Ce^{4+} = 0.97 \text{ \AA}$ ,  $Ce^{3+} = 1.14 \text{ \AA}$ . Lattice Constant is determined through Rietveld Refinement, Micro morphology is analyzed by SEM. Elements are quantitatively and qualitatively analyzed by energy dispersive spectrometer (EDS). The density and open porosity measured by Archimedes Method. The density shows a gradual increase and open porosity basically maintained at 0.12 with the increase of Ce doping. [1].

Nasir Amin et.al synthesized yttrium substituted Cadmium ferrites by Co-precipitation method. The effect of yttrium cations on structural, electrical and dielectric of yttrium substituted Cadmium ferrites was reported. The crystal structure was confirmed as spinel cubic structure by XRD. The XRD peaks appeared at  $2\theta = 29.02^\circ, 34.18^\circ, 51.39^\circ, 54.76^\circ$  corresponds to planes (220), (311), (422), (511), respectively and confirms the formation of spinel structure. EDS Confirmed the presence of all inserted elements. The DC resistivity was observed to be decreased with increase in yttrium Content which indicates that prepared samples exhibit Semiconductor nature. The Morphology is analyzed by SEM. Micro-graphs confirmed that most of the nanoparticles have size lower than 100 nm. FTIR results gave two absorption bands along with increasing behaviours of force constants, hence were good agreement with spinel ferrites. The effect of yttrium substitution on the optical band gap determined by UV-Vis spectroscopy. Band gap decreases from 3.6011-2.8153 eV for  $X = 0.00-0.500$  Dielectric constant & dielectric losses were in decreasing order, while AC conductivity revealed rising behaviour with increasing frequency Results showed the potential of yttrium doped Cd nanoferrites for applications in high frequency microwave absorbing devices[2]

Hamidreza Mohamed et.al Synthesized nanoparticles by co-precipitation method FT-IR spectra of magnetite exhibited strong bands in the low-frequency region (1000–500  $cm^{-1}$ ) due to the iron oxide skeleton. When PEG was bonded with iron oxide nanoparticles, some peaks overlapped or shifted. As it was observed in the IO-PEG spectrum, removing or weakening of some peaks (3200, 2090, 1,800,830  $cm^{-1}$ ) was indicative of the polymer coating. Crystal Structure is analyzed by X-ray diffraction (XRD) The morphology and size of the magnetite nanoparticles were investigated by TEM. The TEM images of synthesized nanoparticles showed that the nanoparticles had spherical structure and the size of them was under 10 nm. Biocompatibility of magnetite nanoparticles coated with PEG, PEGSiO<sub>2</sub>, and OA was demonstrated with MTT assay. The results from FT-IR, XRD spectra, and TEM images



showed well that magnetite nanoparticles were synthesized by co-precipitation and coated directly with biocompatible coatings investigated in this research [3].

A.C.B.Jesus et.al studied the synthesis and magnetic properties of Fe<sub>3</sub>O<sub>4</sub> nanoparticles by Co-precipitation method. Thermogravimetric analysis (TGA) were performed in TA Instrument, Universal Analysis 2000. The measurements were collected using a platinum sample holder in argon flow from 20 to 800° C at rate of 10°C/min. TEM images shows that Fe<sub>3</sub>O<sub>4</sub> nanoparticles are spherical like with sizes varying from 3 to 5 nm. The XRD and TEM data shows that the magnetic diameter estimated by XRD analysis is slightly smaller than those estimated using TEM images. The analyze Zero Field Cooled and Field Cooled (ZFC–FC) allows us to estimate the average diameter of Fe<sub>3</sub>O<sub>4</sub> nanoparticles. It is also used to evaluate the effective anisotropy constants [4].

Deepali D. Andhare et.al studied the Effect of Zn doping on structural, magnetic and optical properties of Cobalt ferrite nanoparticles. Cobalt zinc ferrite nanoparticles were prepared by Chemical Co-precipitation method. XRD analysis revealed the single phase cubic structure of Co-Zn ferrite nanoparticles. The crystallite size increases with increase Zn substitution in prepared sample were observed from the XRD study. Structural parameters such as lattice constant & X-ray density increase with increasing Zinc concentration. It is evident from JCPDS value that angles corresponding to zinc ferrite (values of  $2\theta$  35.27, 62.225, 56.671) are lower than cobalt ferrite (values of  $2\theta$  35.437, 30.084, 62.585, 56.973). The formation of ferrite phase was confirmed by FTIR Spectra. The FTIR spectra of prepared Co–Zn nanoparticles were carried out in the range of 400–2000 cm<sup>-1</sup>. The SEM images shows the agglomeration of spherical grains due to the difference in the magnetic nature of the sample. The morphology of prepared Co<sub>1-x</sub>Zn<sub>x</sub>Fe<sub>2</sub>O<sub>4</sub> (x 0, 0.3, 0.5, 0.7, 1) nanoparticles was observed by scanning electron microscopy (SEM). EDX Spectra shows the formation of Cobalt Zinc ferrite, U-Vis spectroscopy shows variation of energy band gap with increasing Zinc concentration in Cobalt ferrite. A spectrometer in the photon wavelength range 200–800 nm. The substitution of Zn in Cobalt ferrite reduces its hardness and alters the magnetic property from ferromagnetic to Super paramagnetic which has a huge application in biomedical science. The study shows with increasing substitution of Zn<sup>2+</sup> Cobalt ferrite, the magnetic properties goes on decreasing [5].

Zhuangfeisu et.al synthesized nano  $\beta$ -Ca<sub>2</sub>SiO<sub>4</sub> powder ( $\beta$ -dicalcium Silicate ceramics) by Co-precipitation method. Nanosizing of  $\beta$ -C<sub>2</sub>S is an important method to improve hydration activity and also an important biomedical and electronic material. Strong characteristic peaks of  $\beta$ -C<sub>2</sub>S crystallites were observed in the XRD patterns of all the samples annealed at temperatures equal or higher than 700 C. The improvement of hydration activity provides a large imagination space for its future application. High purity nano sized  $\beta$ -C<sub>2</sub>S particles were prepared at Sintering temperature with low relative crystallinity high specific surface area, low f-caO content, nanoparticle size. The Crystal Size, relative crystallinity f-Cao Content, Specific surface area was analyzed by SEM and TEM [6].

S. Thambidurai et.al synthesized Zinc oxide-Cobalt oxide nanocomposites by a simple Co-precipitation method. The Structure and Crystallinity were examined through X-ray diffraction (XRD). The diffraction peaks found at  $2\theta$  values of 31.86, 34.52, 36.35, 47.64, 56.71, 62.98, 66.48, 68.07 and 69.17 can be assigned to (1 0 0), (0 0 2), (1 0 1), (1 0 2), (1 1 0), (1 0 3), (2 0 0), (1 1 2) and (2 0 1) diffraction plans, respectively of the hexagonal wurtzite structured ZnO. The presence of visible light responsive CO<sub>3</sub>O<sub>4</sub> absorption and induced red shift in reduced band gap energy. The nitrogen adsorption desorption isotherm disclosed a relatively high specific surface area of ZnO CO<sub>3</sub>O<sub>4</sub> nanocomposites when compared to pure ZnO nanoparticle [7]

S. Asha et.al nano particles synthesized by chemical co-precipitation method. XRD pattern of PbWO<sub>4</sub> NPs synthesized through the co-precipitation process No impurity peaks can be detected, demonstrating the formation of the pure PbWO<sub>4</sub> phase. elemental profile of the PbWO<sub>4</sub> NPs. It displays optical absorption signals at 2.5, 10.5, 12.6 and 14.8 keV due to Pb; 1.8, 7.4, 9.8 and 11.6 keV due to the W; and 0.5 keV due to O confirm the formation of PbWO<sub>4</sub>. the UV–vis absorption spectrum of the PbWO<sub>4</sub> NPs. The sharp absorption peak at 281 nm, which is allocated to the binding exciton placed above the conduction band's lower line. The PbWO<sub>4</sub> luminescence characteristics are sensitive to their structure depending on structural deficiency SEM and TEM images are utilized for characterizing the morphology with PbWO<sub>4</sub> NPs [8]



Yuandong et.al synthesized nano spinel ferrites by chemical co-precipitation method. The structure analysis of XRD shows the formation of pure nano spinel ferrites without any impurity. The crystallite sizes were less than 40nm and the lattice constant with volume has been identified as  $a = 5.4512 \text{ \AA}$  and  $V = 358.87 \text{ \AA}$ . The TEM showed ferrite particle as polygonal. They exhibit FTIR stretching bands at about  $410 \text{ cm}^{-1}$ . They had absorption peak in  $581 - 584 \text{ cm}^{-1}$ . The highest value of magnetic momentum was  $2.37 \mu\text{B}$  at room temperature. It is used as effective photocatalyst for Waste water treatment [9]

A.Sanchez-Martinez et.al XRD patterns are well defined three main peaks at  $27.4^\circ$ ,  $45.5^\circ$  and  $53.8^\circ$ . The presence of peaks associated to confirm the formation of a composed photocatalyst. Crystallite sizes of 5 nm and 6 nm for ZnSe and ZnSe:Se were obtained, respectively. These values are comparable with those reported in the literature. The X-ray diffraction (XRD) analysis indicated the formation of a zinc blende-type ZnSe which has a crystallite size of  $\sim 6 \text{ nm}$ . The photocatalytic activity of ZnSe and ZnSe:Se NP's was assessed by the  $\text{H}_2$  production and RhB degradation under UV irradiation traces of elemental Se act as co-catalyst to avoid the recombination of charge carriers. It is used as a alternative for Wastewater treatment contaminated by organic compounds.[10].

### III. CONCLUSION

The preparation of Nano-ferrite through ultrasonic assisted Co-precipitation method gave uniform particle size distribution and excellent performance. At lower temperature, The ultrasound had a positive effect on improving the magnetic properties. It has a huge potential for Industrial applications. Co-precipitation method is broadly used for the synthesis of spinel ferrite Nanoparticles as it is time consuming, cost effective, reliable & simple to do. It also produces a homogeneous powder with maximum yield and does not require any organic fuels like citric acid etc. It also proved that the increasing substitution of  $\text{Zn}^{2+}$  in cobalt ferrite magnetic properties goes on decreasing

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