**‘Synthesis, Characterization and investigation of some Mixed Metal Oxide and their Bio-Medical Applications’**

A synopsis submitted to



Punyashlok Ahilyadevi Holkar Solapur University, Solapur

**For the Degree of Philosophy**

**In**

**Chemistry**

Under the faculty of Science

By

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1. **Title of the proposed Research Work:**

‘Synthesis, characterization and investigation of some mixed metal oxides and their biomedical applications’

1. **Introduction:**

Metal oxides have been used for various applications as they have remarkable properties like catalytic, electro-optic, electromechanical, ferroelectric, and wave density charging behavior. Due to their distinctive physicochemical properties, a good deal of research has also been directed toward utilizing metal oxide materials in biomedical applications.Some metal oxides can interact with the surfaces of a carrier to develop oxides’ monolayer structures for drug delivery. Magnetic metal oxide nanoparticles (NPs) are of great interest in medical research because they can be manipulated with an external magnetic field.Some metal oxide NPs can kill cancer cells at low dose and remain nontoxic to normal cells . Recent discoveries have opened a new boundary for biomedical applications of metal oxide NPs in retinopathy, biological sensors, and cancer treatment. [1-5]

Metal oxides at nanoscale play a vital role in the biomedical field. ZnO NPs, has excellent ultraviolet (UV)-absorbing properties and transparency for visible light, making these NPs excellent sunscreen agents. Other properties, such as their antibacterial and anticancer activities, have also been explored, which result from their ability to induce the generation of ROS.

Similarly like Zinc oxide various other oxides can be implemented in biomedical applications like Titanium oxide, Iron oxide, etc. [7,8]

**5)** **Research Work:**

The present work is designed to synthesize some mixed metal oxides by some novel routes such as sol-gel,auto-combustion, wet chemical synthesis, precipitation and microwave assisted method. Characterization of synthesized compounds will be carried out by modern analytical techniques such as XRD, particle size analysis, pore volumes, BET surface area, thermogravimetric analysis (TGA), differential thermal analysis (DTA), FT-IR spectroscopy, SEM (scanning electron microscope), TEM (transmission electron microscope), XPS (X-ray fluorescence spectroscopy),Photoluminescence, UV.DRS, diffused reflectance spectroscopy and Mössbauer spectroscopy to investigate their properties.

**6) Choice of the topic and Significance of the Research Work:**

The development of new nanomaterials with high biomedical performance and low toxicity is essential to obtain more efficient therapy and precise diagnostic tools and devices. Scientists often face issues of balancing between positive therapeutic effects of metal oxide nanoparticles and their toxic side effects. In this review, considering metal oxide nanoparticles as important technological and biomedical materials, it provides a comprehensive review of research on metal oxide nanoparticles, their nanoscale physicochemical properties, defining specific applications in the various fields of nanomedicine.

**7) Brief Review of Literature:**

Over the past few decades, nanotechnology has emerged as a promising technique for various biomedical applications. Among the nanomaterials currently available, metal NPs have been explored as standalone biomedical agents as well as novel carriers for the delivery of therapeutic agents for a variety of disorders.[8]

The US Food and Drug Administration (FDA) has recognized bulk ZnO as a generally recognized as safe (GRAS) substance, and ZnO NPs larger than 100 nm are considered to be relatively biocompatible, which supports their use for drug delivery.[9]

Kumar et al. [6] synthesized ZnO NPs of 64 nm using the precipitation method by the reaction of zinc sulfate and sodium hydroxide in a molar ratio of 1:2. The NPs obtained were very pure, as revealed by X-ray diffraction analysis.

N. Sanpo .et al had develop novel multifunctional magnetic iron-based nanoparticles that also exhibit antibacterial properties to fulfill the requirements of a drug delivery

system so that the antibiotic concentration could be minimized.For this purpose, we have synthesized transition metal-substituted cobalt ferrite nanoparticles (Co0.5X0.5Fe2O4 with X = Cu, Zn, Mn and Ni) by the sol–gel process using citric acid (CA) as the chelating agent.[4]

Hayat et al. [7] synthesized 25-nm ZnO NPs using a modified sol–gel method and successfully utilized them for the photocatalytic oxidation of phenol

Today the use of metal oxides has reached an internationally recognized standard. For example, zirconium dioxide (zirconia, ZrO2) biomaterials must be prepared in accordance with the international standard of reference ISO 13356 (zirconia). These international standards specify the requirements and corresponding test methods for biocompatible metal oxide materials for medical uses.

Our preliminary investigation using mixed-metal oxides containing transition metals for oxidation reactions indicated that structural properties of mixed metal oxides show a good correlation with catalytic performance [6,7]. Many researchers have successfully synthesized the fine particles. A modern trend in the research of nanosized particles in various branches of science allows one to assert that in the 21st century both science and technology will deal with nanosized objects. The most fundamental problem of modern chemistry is to reveal the peculiarities of the effect of the particle size on its physicochemical properties and reactivity.

**8) Statement of the problem:**

An important aspect which we must consider for the safe and effective use of metal oxides in biomedical applications is toxicity. The other important consideration for metal oxides being used for implants is their chemical inertness. Iron oxide (Fe₂O₃), zinc oxide (ZnO), titanium oxide (TiO₂) are the most commonly used metal oxides in biomedical applications. The NP of these metal oxides can be synthesized and modified with appropriate functional groups that allow them to bind with drugs, antibodies, and ligands of interest. The functionalization of metal oxides can be facilitated by noncovalent interactions (coordination or hydrogen bonding) between the ligands and the surface metal ions or hydroxyl groups

There are several challenges in the production of metal oxides, among those are difficulty in scale up and high cost of production. For metal oxide NPs to be used as drug carriers, it is a big challenge to determine their drug-loading capacity. This is because part of the drugs is released before reaching the target cells due to unstable interaction between the drug molecules and the metal oxide NPs. The bioavailability and biocompatibility of metal oxides are important to avoid agglomeration in physiological condition and remain intact in the tissue for enough time to elicit a desired response. Taken together, these considerations are important for creating a useful metal oxide material in biomedical applications

**9) Objectives of the study:**

Mixed metal oxide nanoparticles, containing Ni, Ti, Zn, CO, Cu are versatile platforms for biomedical applications and therapeutic intervention.

Their use in medical applications, commonly referred to as ‘nanomedicine’, seeks to deliver a new set of tools, devices and therapies for treatment of human disease. Mixed metal oxide NPs possess some advantages such as high stability, simple preparation processes, easy engineering to the desired size, shape and porosity, no swelling variations, easy incorporation into hydrophobic and hydrophilic systems and easy functionalization by various molecules due to the negative charge of the surface, that make them a promising tool for biomedical application.

Synthesis of various mixed metal oxide systems by various chemical methods such as sol-gel,citrate gel, mechanochemical process, co-precipitation, hydrothermal, and microwave assisted methods will be undertaken.The prepared materials will be investigated by various characterization techniques.

**10) Hypothesis:**

* The metal oxides can be modified by reducing them to the nanoscale.so as to enhance various physiological properties which can be implemented in biomedical applications.
* The synthesized materials can be used for drug delivery in the human body.
* They can be used as effective medicine for cancer treatment
* The materials can be also used as wound healing and antimicrobial agents
* They may be also useful as photocatalysts in degradation of organic dyes, gas sensing materials, and catalysts in various reactions.

**11) Methodology (experimental/theoretical work):**

* Initially, metal oxides will be synthesized using some novel routes like sol-gel method,co- precipitation, hydrothermal, and microwave assisted methods which gives a good yields.
* Once the materials are prepared by its suitable method, synthesized metal oxides nanoparticles will be characterized by advanced analytical techniques such as XRD, BET, surface area, pore volume, TGA, DTA, EDS, FT-IR, SEM, TEM, PEL, UV-DRS, Raman, Mössbauer and XPS etc.
* Attempts will be made to test them on biological tissues under study.

**12) Time schedule of proposed research work:**

* **First Year**

In this first phase, extensive literature surveys will be carried out at various universities, national research laboratories, and from Internet media. Along with this, transition metal doped mixed metal oxides will be synthesized by novel routes like sol-gel method, citrate gel, auto combustion, or microwave-assisted methods.

* **Second year:**

In the second phase, we intend to utilize the materials for different physico-chemical characterization using various techniques mentioned earlier which will enable us to study selectivity of certain compounds in applications.

* **Third year:**

In this phase, after characterization, the compounds will be deployed for biomedical applications of commercial importance. The efficiency and utility of the materials will also be evaluated. From the comparison of results, conclusions will be drawn about the most suitable material for its applications. The work carried out will be presented at various national as well as international conferences / workshops / symposia / seminars, etc. The said research work will also be considered for publications in scopus indexed peer reviewed national and international journals.

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Research Student Research Guide