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Synthesis and Characterization of Multi Metal Oxide Nanocomposite (ZnO-SrO-MgO) and Its Applications

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ABSTRACT

Nanotechnology used widely due its smaller in size and massive application in all field of science. Metal oxide nanoparticles are a significant class of nanomaterials with numerous uses in both science and technology. A heterogeneous, versatile multi metal oxid ZnO-SrO-MgO has been prepared by chemical co-precipitation method. Synthesis can achieve selected surface structure, phase, shape and size of metal oxide nanoparticles, resulting in a set of desired attributes. The synthesized multi metal oxide nanoparticles were characterized by various instrumental techniques. The synthesized multi metal oxide materials beautifully present in nano meter level as 94 nm identified through SEM analysis. Absorption spectra from UV confirmed the multi metal oxide from its corresponding peaks. XRD peaks with plane obtained in the range it's confirmed the presence nanoparticles. Multi metal oxide exhibits good antifungal and antimicrobial activity

1. INTRODUCTION

Nano science and materials plays vital roles in all branches of science and technology. A nanocomposites is formed by two or more materials, at least one of which is a nanomaterial, which have diverse physical and chemical characteristics. Nano composite materials are intended to have qualities that outperform, sometimes dramatically, the sum of their individual parts. Nanocomposite applied in many areas especially in clinical care, therapeutic and diagnostics, recent days Nano robots involves to heal tissues related issues in our body. Nanomaterials has several application viz., energy storage, fuel cells, adjustable resonant devices, sensing, catalysis, molecular computing and nanomedicince. Because of the high surface-to-volume ratio, surface imperfections, and quantum effect, nanomaterials have different optical, electrical, magnetic, and catalytic capabilities than bulk counterparts. Metal oxides have an intrinsic charge separation capability that distinguishes them from metals. Metal oxide nanoparticle synthesis can be improved to achieve desired or targeted features. Because of its applications in electronics, optics, energy storage, and catalysis, progress in manufacturing nanoparticles of metal oxide has been tremendous.As a result of its ease of adoption by the host, Nano particles are widely employed in a variety of disciplines [1]. Food, biomedical, electro analysis, energy storage, wastewater treatment, automotive, and other sectors have all made use of nanocomposites. This thorough overview covers the chemistry, architectures, advanced applications, and latest advancements in bio renewable nanocomposites [2-7].

Multi metal oxide nanoparticles are exceedingly strong; they have good capabilities for carrying both thermal and electrical energy, and as a result, they have a wide range of uses. Composites with a Better Structure: When saturated with thermoset resins, MMO in woven or non-woven textiles or resin-infused bucky-paper form have demonstrated considerable increase in the strength and stiffness of composite constructions, for example, aerospace, golf club shafts, and structural laminates applications. In the sphere of medicine, a biosensor is being developed that will allow yeast infections to be identified faster than the existing approach. Metal oxide nanoparticles perform admirably as adsorbents, catalysts, and catalytic supports. It has also been postulated that they are appropriate for a wide range of remediation applications. This has already been demonstrated for materials including MgO, CaO, and SrO. Mixed metal oxides are widely employed in a variety of usage, and so many articles in the literature are devoted to mixed metal oxides and their prospective applications.The coprecipitation step entails the precipitate of metals in the form of alkali from a salts precursor using a base in a solution. The controlled release of anions and cations aids in the regulation of nucleation and particle growth kinetics, which aids in the formation of monodispersed nanoparticles.

2. EXPERIMENTAL

2.1 Materials

For this synthesis, Magnesium Sulphate, Zinc Chloride, Strontium Nitrate and Sodium Carbonate materials were purchased from Sigma-Aldrich and De ionized water used for the entire synthesis.

2.2 Measurements

MMO were characterized using the following instruments viz., UV–Visible spectral analysis was performed on a JASCO, V- 600 Diffuse Reflectance spectrophotometer. FTIR measurements of samples prepared as KBr disks were performed on a Thermo Scientific Nicolet iS5 FTIR spectrometer. XRD Measurements carried out using a Gonio radius 240 with Cu (λ= 1.54060 Å) in the range of 10 and 80 degree. FE-SEM investigation done through a high performance TESCAN MIRA3. The Atomic force microscopy study by the Nano surf easy 2 scan BT02218 is profilometer – a sharp cantilever tip interacts with the sample surface sensing the local forces between the molecules of the tip and sample surface.

3. SYNTHESIS MULTI METAL OXIDE NANOPARTICLES

Magnesium Sulphate, Zinc Chloride, Strontium Nitrate and Sodium Carbonate solutions prepared 0.1N using distilled water. The co-precipitation of carbonates is applied in the manufacture of MgO-SrO-ZnO multi metal oxide nanoparticles. For this preparation metal salt solution viz., $ZnCl_2$, $MgSO_4 7H2O$, and $Sr(NO_3)_2$ solutions in a beaker as 1:1:1 ratio, the mixture stirred at room temperature for five minutes. The 1M Na_2CO_3 solution added slow and steadily to the mixture until precipitation complete. After 5 hours string, ensured the formation of products, then precipitates centrifuged. The residues washed deionized water several times and dried at 220ºC in an oven. The dried powdered mixture crushed using mortar – pestle, after it was calcinated in muffle furnace at 900ºC for 4 h and finally powdered MgO – SrO - ZnO [8]. The carbonates converts as oxides while process of calcinations and reaction given below

$$Zn^{2+} + 2Cl^{-} + (2Na^{+} + CO_3^{2-}) \rightarrow ZnCO_3 + NaCl \quad \text{----------} (1)$$

$$(Mg^{2+} + SO^{4}-) + (2Na + CO_3^{2-}) \rightarrow MgCO_3 + NaSO_4 \quad \text{----------} (2)$$

$$Sr(NO_3)^2 + (2Na + CO_3^{2-}) \rightarrow SrCO_3 + NaNO_3 \quad \text{------------} (3)$$

4. RESULTS AND DISCUSSION

4.1. UV-Visbile spectroscopy

The formation of mutlimetal oxide MgO-SrO-ZnO nanocomposites confirmed in UV-Vis absorption spectra (JASCO 650 Spectrophotometer). The characteristic absorption band between 200-250 nm which helps in the confirmation of strontium oxide nanoparticle [9]. Also we are able to confirm that a curve obtained near 320nm confirms the presence of ZnO nanoparticles [10]. The MgO nanoparticle can be confirmed by the presence of a peak at 280 nm-300nm [11]. Also we can ensure the presence of MgO and ZnO in the mixture by noting down the graph obtained absorbance between 0.3- 1.3 [8]. The UV spectra analysis confirms the presence of the MgO-SrO-ZnO but shows an increased intensities, which will enhance their characteristic activities in Fig. 1.

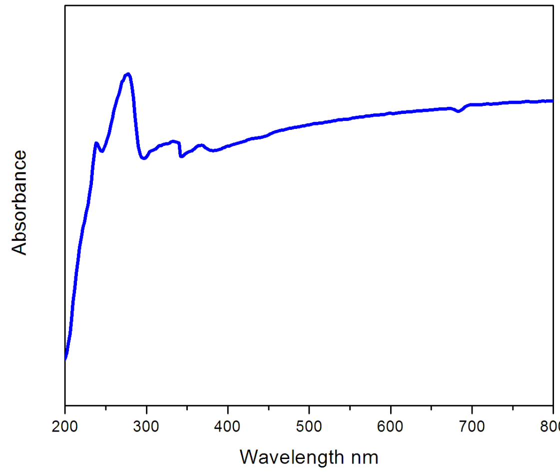

Figure 1. UltraViolet - Visible spectrum of MgO –SrO -ZnO nanocomposites

4.2. FTIR Analysis

The FTIR spectrum of MgO-SrO-ZnO nano composite is shown in Fig. 2. Stretching and bending vibrations of H_2O absorbed from the environment are ascribed to the bands found at 3454.51 cm-1 and 1628 cm-1, respectively, for MgO-SrO-ZnO [8]. The asymmetric stretching vibration of Sr-O is responsible for the significant wide absorption peak at around 1384 cm^{-1}. Sharp absorption bands at 956 and 642 cm^{-1} can be ascribed to Sr-O out of plane bending vibration [11]. At 610 cm1, the stretching mode of the Zn-O bond occurred. Peaks detected between 900 and 400 cm^{-1} indicate the development of metal oxide bonding. The signal at 642 cm^{-1} indicates the creation of a Mg-O bond [11, 14]. OH may be ascribed to the sharp absorption bands at 1384.03 cm^{-1}, 1628.32 cm^{-1}, and 3454.51 cm^{-1} can be assigned to O-H bending and C-O is stretching vibrations [14]. The FTIR analyses helps us to confirm the multi metal oxides formed [8]

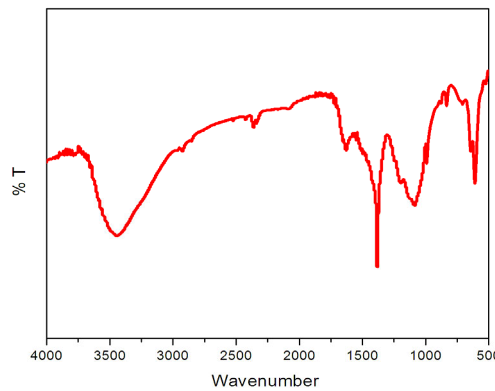

Figure 2. FTIR analysis of MgO-SrO-ZnO nanocomposites

4.3. XRD Analysis

The XRD diffraction examined using XPERT instrument. The X-ray diffraction provides a comprehensive examination of the planes of the nanoparticle, resulting in a combination of multi metal oxide shown in Fig 2. The Scherrer equation for identifying of crystalline size of nanoparticles using the following equation.

$$D = \frac{0.89\,\lambda}{\beta \cos\theta} \quad (5)$$

where λ is the wavelength of the X-ray, θ is the Bragg diffraction angle and β is the FWHM. The planes of the produced multi metal oxide are computed using XRD diffraction, and the planes so discovered are (111),(300),(210), and (311) [8]. The signal found in the two theta range of 40-50 indicates that MgO is generated in the combination [9]. The existence of ZnO nanoparticles is confirmed by the XRD peak found in between 30-40 [8]. The existence of strontium oxide nanoparticles is further confirmed by the peak 30-40 [10].

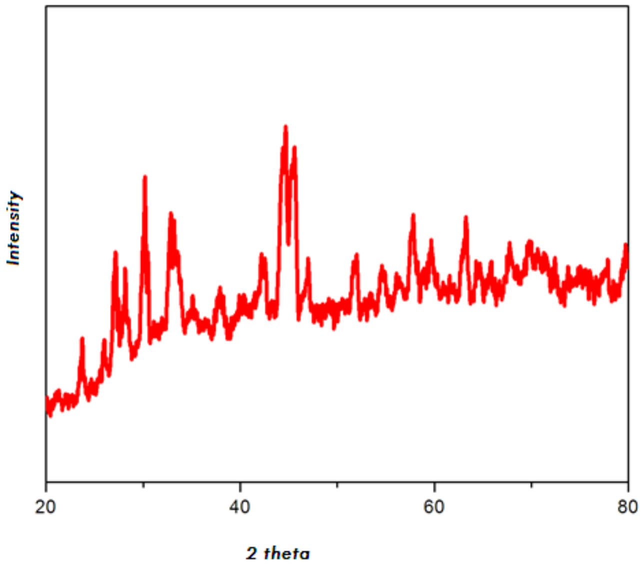

Figure 3. XRDanalysis of MgO-SrO-ZnO nanocomposites

4.4. FESEM Analysis

Generally, FESEM provides a good view of the surface structure of the nanoparticles with high resolution. The FESEM analysis to identify the particle size and morphology of the synthesized multi metal oxides. FESEM images of MgO-SrO-ZnO Nano composites at various magnifications have been captured and confirmed the formation of MgO-SrO-ZnO multimodal oxide nanoparticles. The FESEM investigation revealed the distinctive textures and morphology of MgO-SrO-ZnO, as illustrated in Fig. 4. The homogeneous sized particles with a slightly crystalline shape found and particle size is 94.29 nm in range.

4.5. AFM analysis

AFM technique is the one of the best tool for measuring nano sized materials. This method analysis the particles surface using Tip, it so high-pitched that as it is moved across something, the tip can feel the shape by measuring the forces between the atoms on the tip and the atoms on the object.

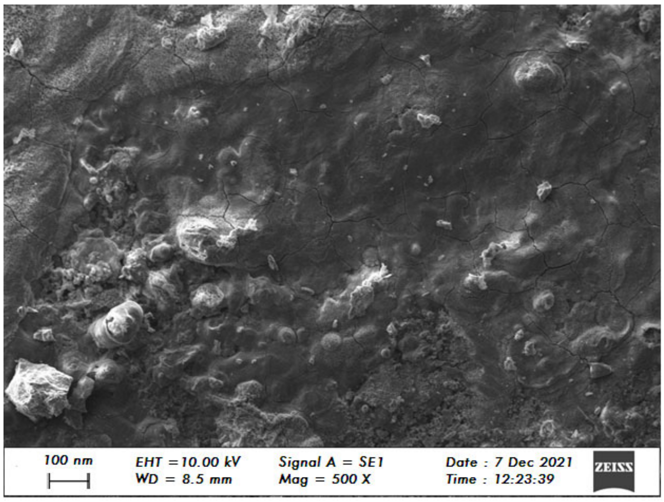

Figure 4. FESEM analysis of MgO-SrO-ZnO nanocomposites

AFM topographical images of mixed metal oxide nano particles in Fig.5. The average length particle 90 to 110nm. It may be due to the Metal bindings or over sitting of each together and cubic morphology.

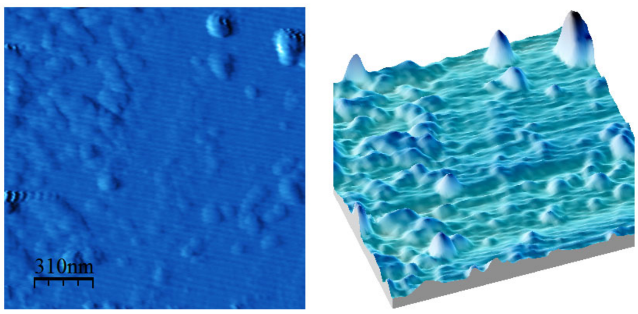

Figure 5. Effect of MgO-SrO-ZnO against *Candida albicans*

4.6. Anti-Fungal Activity of Multi Metal

4.6.1 Oxide nanocomposites

The anti-fungal activity carried out by agar well diffusion method. The prepared nanocomposites was allowed to diffuse out into the medium and interact in a plate freshly seeded with the test organisms. The resulting zones of inhibition will be uniformly circular as there will be a confluent lawn of growth. The diameter of zone of inhibition can be measured in millimeters. Candida albicans, Potato dextrose agar medium, Amphotericin B antimycotic solution was used. Petri plates containing 20ml potato dextrose agar medium were seeded with 24hr culture of fungal strain Candida albicans. Wells were cut and different concentration of MgO-SrO-ZnO (500 µg/ml, 250 µg/ml, 100 µg/ml and 50 µg/ml) was added. The plates were then incubated at 37°C for 24 hours. The anti-fungal activity was assayed by measuring the diameter of the inhibition zone formed around the wells. Amphotericin B was used as a positive control. The values were calculated using Graph Pad Prism 6.0 software (USA).

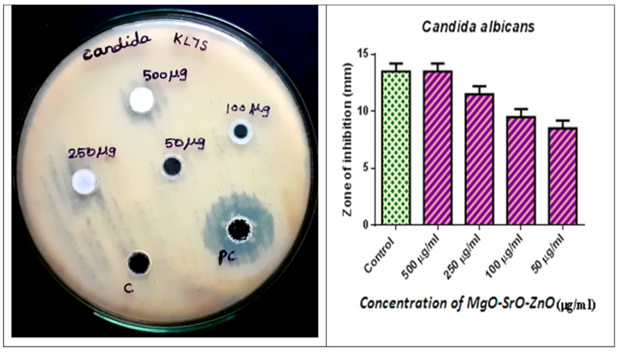

Figure 6. Effect of MgO-SrO-ZnO against *Candida albicans*

Table 1. Mean ± SD of zone of inhibition obtained by MgO-SrO-ZnO Nanocomposites against the pathogens Candida albicans

Name of the test organism	Name of the test sample	Zone of inhibition (mm) Mean ± SD				
		500 µg/ml	250 µg/ml	100 µg/ml	50 µg/ml	Control (Ab)
Candida albicans	KL7S (MgO-SrO-ZnO)	13.5 ±1.5	11.5 ±0.5	9.5± 0.8	8.5 ±0.5	13.5± 0.5

5. CONCLUSIONS

MgO-SrO-ZnO multi metal oxide was synthesized successfully. X - ray diffraction spectroscopy confirmed the presence of metal oxide nanoparticle and identified the planes. The Ultraviolet spectroscopy results reveals the formation of multi metal oxides through their absorption. The Infrared spectroscopy helps us to confirm the structural elucidation of the nanoparticles and the various stretching and bending vibrations of SrO is observed. It also shows the fact of presence of other metal oxide bonds in it. The FESEM illustrations of Multi Metal Oxides surface and shape of the nanoparticle and reveals the size of the nanoparticles as 94 nm. AFM nanoparticles for MMO within the MMO. The metal oxide NPs has good Antifungal character from the application studies.

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