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A STUDY ON CHARACTERIZATION OF STANNATE NANO STRUCTURES

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ABSTRACT

Zinc stannate is a compound made up of two different types of oxides that may be distinguished from one another by their crystalline structures and zinc to stannous element ratios: both Zn_2SnO_4 and $ZnSnO_3$ Binary semiconducting oxides (II-VI and IV-VI oxides), such as ZnO, TiO_2, and SnO_2, have attracted a lot of attention as zero- and one-dimensional nanostructures. This is because these oxides possess some incredibly distinctive qualities and have the potential to be utilised in a wide range of applications, including photocatalysis solar cells and gas sensors. However, there is a pressing need for semiconductors that have been carefully developed to better fit the characteristics of emerging materials due to the active research being done in nanotechnology. As a result, interest in ternary oxide semiconductors (II-IV-VI oxides) of the form AII 2B IVO4 has increased. Examples include cadmium stannate (Cd_2SnO_4), also known as cadmium tin oxide (CTO), and zinc stannate (Zn_2SnO_4), also known as zinc tin oxide. Another illustration is germanium (ZTO). Zn_2SnO_4, which is renowned for having high electrical conductivity, high electron mobility, and appealing optical properties, can be used in a wide range of applications, including negative electrode materials for Li-ion batteries, photocatalysts for the degradation of organic pollutants, and sensors for the detection of humidity and various combustible gases.

KEYWORDS: STANNATE, NANO, STRUCTURES

INTRODUCTION

Zn_2SnO_4 can be employed in various applications thanks to these characteristics. Complex ternary oxides, such Zn_2SnO_4, are more chemically stable than binary oxides, which makes them suitable for applications involving very hostile conditions. Zn_2SnO_4 has been shown to be efficient as a flame retardant as well as a smoke suppressor. Since the sizes and shapes of nanostructures can affect their electrical and optical properties, it is crucial to retain control over these variables. Currently, there is significant research towards the construction of more complex structures using nanoscale building pieces. Even while the technique for converting micromaterials into nanostructures has advanced significantly over the past ten years, the procedure is still rather expensive and requires specialised equipment. The creation of complex structures is still a challenging challenge for researchers. The process of self-organization offers a productive way to create these structures. Many different growth techniques have been used to create nanostructures with a wide range of materials and morphologies, such as wires, rods, tubes, belts, tetrapods, flowers, dendrites, ribbons, and so on.

At temperatures higher than 600 degrees Celsius, zinc stannate typically goes through a transformation that changes it from a metastable form ($ZnSnO_3$) into the stable zinc Orth stannate (Zn_2SnO_4) when it is crystallised by means of a solid-state reaction during the process of crystallization. Temperatures in the range of 300–500 degrees Celsius are necessary for the completion of this transformation. It is challenging to produce a pure Zn_2SnO_4 phase using high-temperature synthesis methods like thermal evaporation. A $ZnSnO_3$, Zn_2SnO_4, and SnO_2 mixed phase is frequently the end product. The structure of hostable Zn_2SnO_4 is that of a cubic spinel, whereas the structure of the metastable $ZnSnO_3$ is that of a face-centered perovskite. Figure 1, which can be found over here, illustrates the atomic structures of zinc stannate.

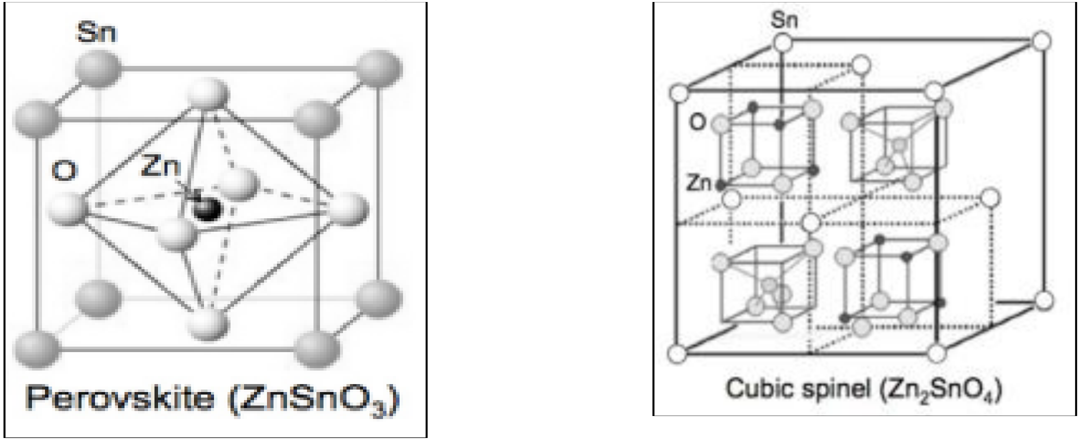

Figure 1. Zinc stannate has two different crystal structures: perovskite for zinc metastannate ($ZnSnO_3$) and cubic spinel for zinc orthostannate (Zn_2SnO_4)

REVIEW LITERATURE:

Farshad Beshkar (2017) In the course of this study, $ZnSnO_3$ nanostructures were fabricated by applying the Pechini technique in conjunction with an innovative gelling agent. Herein we applied dien and Tepa as gelling agent. Maleic acid, benzoic acid, and trimesic acid were used as additional hydrolysis agents. Trimesic acid was also used. In addition, the influence of this gelling agent and hydrolysis agent on the size of the end products was investigated, and the $ZnSnO_3$ nanostructures that were produced were utilised in an effort to eradicate acid brown 14 when they were subjected to UV radiation. After being illuminated for two hours, $ZnSnO_3$ nanostructures have a significant level of photocatalytic activity, which enables them to eliminate around 92% of acid brown 14 from a solution. The XRD, SEM, EDX, DRS, FT-IR, and TEM techniques were utilised so that the newly formed nanostructures could be characterised as they were being produced.

Joydeep Dutta (2018) over the course of the previous ten years, nanostructured binary semiconducting metal oxides have received a great deal of interest due to the distinctive properties that they possess. Due to these characteristics, they are suitable for a wide variety of different applications. There has been a visible increase in interest in ternary complex oxides over the past few years. This can be linked to the pursuit of further strengthening the physical and chemical features. Zinc stannate, which is also referred to as zinc tin oxide (ZTO), is a member of the family of ternary oxides that is recognised for having properties that are stable under harsh conditions, possessing a greater electron mobility in comparison to its binary analogues, and exhibiting a variety of optical properties that are unique to themselves. Because of this, the component is ideal for usage in a wide range of applications, including as photocatalysts, solar cells, and sensors. The hydrothermal method is an especially promising green process since it can be executed at lower temperatures. The creation of ZTO nanostructures may be accomplished in a variety of methods, and this particular method is only one of them. In this work, we present a synopsis of the conditions that led to the formation of diverse ZTO nanostructures by employing the hydrothermal method. These nanostructures were created using the hydrothermal method. In addition, we investigate a few of the potential uses of this technology that have been outlined in the study that has been published.

Sabeena Shoukat (2019) the sol-gel synthesis method was used to construct the nanostructure of zinc stannate, and after that, its physicochemical, adsorption, and photocatalytic characteristics were studied. By utilising the N2 adsorption-desorption approach, the Brunauer–Emmett–Teller (BET) and Barrett, Joyner and Halenda (BJH) procedures were utilised in order to compute the specific surface area (S). Both the SBET and the SBJH were found to have a specific surface area of 105 and 138 m2 g1, respectively, despite having pores with an average size of 2.5 nanometers. After undergoing diffraction examination, it was found that the crystallites had a cubic shape and measured an average of 31.74 nanometers in size. Transmission electron microscopy (TEM) and scanning electron microscopy (SEM) were used to analyse the morphology of the particles. Based on the findings of the TEM analysis, the average particle size was found to be 21.6 nm. After having the band gap measured from the diffuse reflectance spectra, the value of 3.36 eV was discovered to be the band gap. The percentage composition of the sample, as well as its purity, was determined with the assistance of energy dispersive X-ray spectroscopy (EDX). The surface functional moieties of the sample were analysed by using a technique known as Fourier transform infrared (FTIR) spectroscopy. The batch approach was utilised for the purpose of analysing the adsorption of Cr (VI) ions. The solution underwent a wide variety of adjustments with regard to the initial electrolyte content as well as the pH and temperature of the medium.

Subhadeep Paul (2019) this study details the production of nano-zinc stannate as well as its application as a one-of-a-kind finishing agent that can perform many functions on cotton fabric. The author was responsible for conducting all of the necessary research. Nano-zinc stannate was synthesised using the co-precipitation technique. The nanostructures that were produced as a consequence were characterised using scanning electron microscopy, transmission electron microscopy, and X-ray diffraction in order to explore their shape and microstructure. According to the findings, the crystal structure of the nanostructures was hexagonal with a cubic core in their centre. The nano-zinc stannate that was synthesised was then applied to cotton fabric, and after that, the multifunctional efficacies of the treated fabric, such as its resistance to UV radiation, its antibacterial property, its capacity to clean itself, and its thermal stability, were evaluated. The zinc stannate-treated cotton fabric that was as-synthesized displayed considerably greater levels of self-cleaning, antibacterial property, and flame-resistant action in contrast to the nano-zinc stannate-treated cotton fabric that was annealed. It was found that the UV protection factor of the treated (annealed zinc stannate-treated) fabric increased to more than 45 after it had been treated with annealed zinc stannate. Annealed zinc stannate treatment. In addition, it was found that the treated cloth had a bacterial resistance that was greater than ninety percent against both Gram-positive and Gram-negative bacteria. In terms of thermal kinetics, the zinc stannate-treated cloth that was as-synthesized reported a 39% reduction in the peak heat release rate when compared to the cotton fabric that had not been treated in any way. In addition to this, the treated fabric displayed catalysed pyrolysis activity and a larger quantity of char mass production at higher temperatures. This formation was 30–40% higher than what was observed in the cotton used as a reference.

A.S.H. Makhlouf (2019) Stannate chemical conversion coatings were put to the outside of AZ91D so that it would be more resistant to corrosion. While the stannate-coated samples were submerged in 3.5% NaCl, gas samples were collected and electrochemical measurements were taken in order to evaluate the pitting auto-repairing capabilities of the samples. According to the measurements that were carried out on the uncoated alloy, it possesses a polarisation resistance (Rp) that comes in at 3.1 x 103 cm^2 overall. When the stannate coating was applied to alloys, the Rp value increased by a factor of four or five after the coating was applied. The rate of hydrogen evolution was similarly lowered for specimens that had been coated with stannate, which shows that the stannate functions as a barrier to limit chloride attack and, as a consequence, lessens the susceptibility to corrosion.

Characterization of $ZnSnO_3$ Nanostructures

Nanostructured zinc stannate has been successfully synthesised by following the technical procedure that was described earlier. After that, cutting-edge technological instruments were utilised in order to conduct a battery of tests on nano zinc stannate, the purpose of which was to ascertain the substance's morphology, chemical composition, crystal structure, and particle size.

The term "nanoscience" refers to the study of fundamental principles underlying molecules and structures with at least one dimension roughly ranging between 1 and 100 nanometers. In contrast to bulk materials, whose physical properties are unaffected by their dimensions, the sizes of nanoparticles frequently dictate their chemical and physical properties. Nanoparticles can be defined as particles with dimensions on the nanoscale. Nanomaterials are distinguished from traditional materials by the vastly increased surface area to volume ratio that characterises them. This property, which is also the factor that is responsible for the myriad of changes that are brought about in the properties of the materials, is the defining characteristic of nanomaterials. Therefore, the properties of materials will typically undergo transformations as their sizes approach the nanoscale and as the percentage of atoms on the surface of a material begins to become significant. This is because the nanoscale represents an order of magnitude smaller than the microscale. When compared to the total number of atoms that are found in the bulk of the material, the percentage of atoms that are found at the surface of bulk materials with dimensions greater than one micrometre (or micron) is negligible. This is because the bulk of the material contains a greater number of atoms.

According to the number of dimensions that are present in the nanomaterial's constituent building blocks, nanomaterials can be divided into the following primary categories: zero-dimensional (D), one-dimensional (D), two-dimensional (D), and three-dimensional (D) nanomaterials.

Materials in which all of their dimensions are able to be measured at the nanoscale or on a smaller scale. Nanomaterials with zero dimensions can take many forms, including nanocluster materials and nano dispersion materials. Nanoparticles are contained in these distinct types of materials, which prevents them from interacting with one another.

The one dimension that cannot be measured on a scale as small as a nanometer. One-dimensional nanomaterials can take a variety of forms, including nanofibers, which are also referred to as nanorods, and nanotubular materials. Nanofibers can be as short as 100 nanometers or as long as tens of microns, depending on the application.

Examples of three-dimensional nanomaterials include powders, materials that are fibrous, structures that have multiple layers, and structures that are polycrystalline. These structures are comprised of 0D, 1D, and 2D structural parts, all of which are in close proximity to one another and combine to form interfaces. There are many different kinds of three-dimensional nanostructured materials, but one of the most significant types is a compact or consolidated (bulk) polycrystal containing nano size grains. The volume of this particular kind of polycrystal is completely occupied by the nanograins; furthermore, the free surfaces of the grains are virtually nonexistent, and the structure consists solely of grain interfaces. The formation of such interfaces and the "disappearance" of the nanoparticle (nanograin) surface is the fundamental difference between three-dimensional compact nanomaterials and nanocrystalline powders with varying degrees of agglomeration that consist of particles of the same size as the compact nanostructured materials. This difference is the fundamental difference between these two types of nanomaterials.

The "disappearance" of the nanoparticle surface, also known as the nanograin, is the term used to describe this phenomenon.

Within a size range that exists between the dimensions on an atomic scale and the typical dimensions that characterise bulk material, condensed matter shows certain noteworthy particular qualities that may be markedly different from the physical properties of bulk materials. Between the atomic scale and the typical dimensions used to characterise bulk materials lies this size range. There may be many more of these odd qualities hiding in plain sight, even if we are already aware of a number of them. It is possible to trace the origins of several of the physical characteristics of nanomaterials. These consist of high percentage of surface atoms, (ii) a high surface energy, (iii) spatial confinement, and (iv) a lower level of imperfection. The examples that follow are only a few of many others:

(1) Because nanomaterials have a disproportionately high number of surface atoms in comparison to their total number of atoms, it is possible for these materials to have a significantly lower melting point or temperature at which the phase transition occurs, as well as appreciably reduced lattice constants. This is because nanomaterials contain a disproportionately high number of surface atoms in comparison to their total number of atoms.

(2) The mechanical properties of nanoparticles have the potential to attain the theoretical strength, which is one or two orders of magnitude higher than the mechanical properties of single crystals in their bulk form. This is a possibility for the mechanical properties of nanomaterials. The mechanical properties of materials have a tendency to improve when the scale at which they are used is reduced. The primary explanation for the improvement in the material's mechanical strength is due to the decreased possibility of faults occurring in the product.

(3) In some circumstances, the optical characteristics of bulk crystals and nanomaterials can differ from one another in ways that are notably noticeable. For example, when the band gap of a semiconductor nanoparticle widens, the peak of the particle's optical absorption shifts to wavelengths that are progressively shorter. It is possible for the colour of metallic nanoparticles to change depending on their sizes due to surface plasmon resonance.

CONCLUSION

Nanoscience and nanotechnology are still in the early stages of development. To have a long-term impact on technology and research, these materials' fundamental principles and basic theoretical frameworks must be grasped. X-ray diffraction, UV-visible spectroscopy, scanning electron microscopy, and atomic force microscopy are great instruments for observing material characteristics that have been changed at the atomic/molecular or macromolecule scale utilising a bottom-up or top-down method. Nanostructures can be used to enhance technological innovation through their creation and discovery. Bringing this technology to market also requires developing fresh theories that can anticipate and explain nanoscale phenomena and synthesising the material.

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