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Exploration of Diverse Properties And Gas Sensing Application of Transition Metal Doped Sno_2 Nanocomposites

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ABSTRACT

This manuscript unfolds the structural, surface and optical properties of the transition metal doped stannous oxide in comparison with pure stannous oxide. A simple sol-gel method is used to synthesize all the nanocomposites. It has immense contribution to gas sensing application by knowing its utmost need in current era. The transition metal doped nanocomposites have enhanced gas sensing efficiency than pure stannous oxide.

KEY WORDS: TRANSITION METAL, STANNOUS OXIDE, SOL-GEL, GAS SENSING, OPTICAL PROPERTIES

INTRODUCTION

Nanotechnology is multidisciplinary expanse of investigation and solicitations. It has diverse range of applications from medicine to environmental issues. It is defined as management of matter with at least one dimensional sized ranging from 1 to 100 nanometers. Nano composite is considered as one of significant part of nanotechnology owing to its surface morphology. Nano composites can be defined as multi component materials comprising multiple different (nongaseous) phase domains in which at least one type of phase domain is a continuous phase and in which at least one of the phases has at least one dimension of the order of nanometres. SnO_2 nanoparticles have gained special attention due to its shape and size persuading over properties. SnO2 is a n-type semiconductor having band gap value of 3.6 eV at 300k. It shows transparency in the visible region of the spectrum which enables it to perform in optoelectronic devices, conducive transparent electrodes, supporting system for catalysis, sensor and anti-reflection coatings.

The doping of transition metal in nano composite increases its electrochemical properties by showing better specific capacitance and charge/discharge which make them capable applicants as electrodes in super capacitors combining high energy density with high energy power delivery. The various transition metal doped nanocomposites are fabricated by using simple, cost effective sol-gel method. The transition metal doped SnO2 has extensive usage in gas sensor. Our atmosphere is full of toxic and unwanted gases due to rapid growth of industrialization. Environment can be polluted free by removal of all toxic gas exhausts from automobiles and industries. Gas sensor is the device used to detect varieties of contaminated gas present in air. The gas sensing applications of pure SnO_2 is less effective as compared to transition metal doped stannous oxide. So, doping of transition metal has played intense role in enhancing performance of gas sensor.

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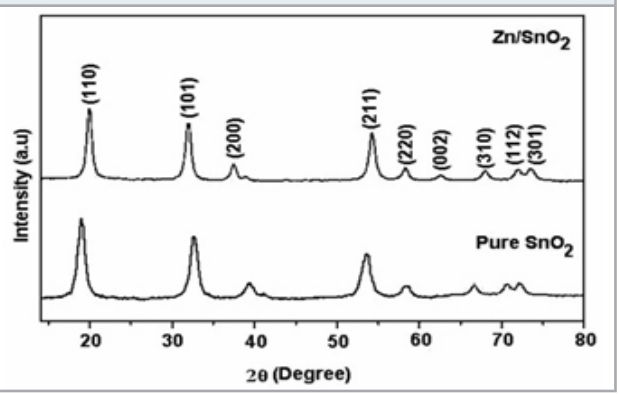
In this study ,the structural, surface morphological, optical properties of the pure SnO_2 and transitional metal doped SnO_2 is explained in systematic manner. The synthesized nanocomposites undergo characterization through different techniques such as XRD, SEM and UV-visible spectroscopy. The analytical study from characteristic spectra helps to outline structural, morphological and optical properties of prepared nanocomposites. The spectra data from X-Ray diffractometry reveals the size of nanocrystal.SEM study helps in figuring out shape of nanostructures by focusing at surface morphology. The interaction between high energy UV rays and nano composite depicts the amount of light absorbed by it and reveals the chemical behavior of prepared sample.

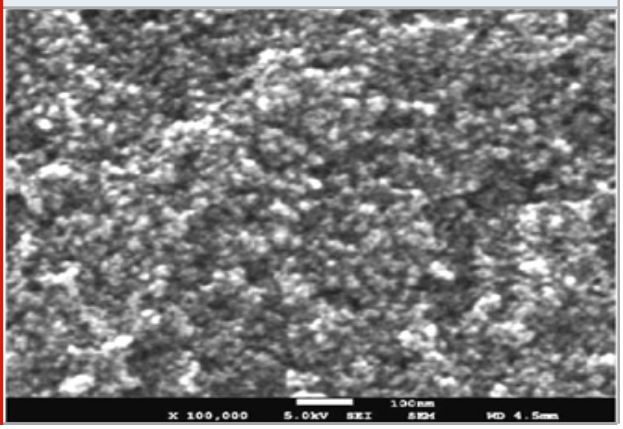
Structural properties: The structural studies of nanomaterial are achieved by considering results from XRD analysis. X-Ray Diffraction (XRD) technology is a non-destructive test procedure employed to investigate structure of nano crystalline materials. It give effort in finding out number of phase present in materials and to reveal information about its chemical composition. The average crystallite size of nanoparticle is obtained by using Scherer formula $D=0.9\lambda/\beta\cos\theta$, where λ depicts X-ray wavelength, θ is the Bragg diffraction angle and β is the FWHM peak performing at the diffraction angle θ. The different phase of SnO_2 is confirmed by all the diffractions peaks. It is noticed that increase in dopant concentration of transition metal in SnO_2 cause shift of peak to a greater angle. SnO_2 nano composite has smaller crystalline size in comparison to the transition metal doped SnO_2. This indicates that in latter case the generation of crystal defect around the dopant imbalance of charge arising from this defect alters the structure of nanomaterial. Some reported data suggested the minimum crystalline size of pure SnO_2 was smaller than transition metal doped SnO_2 which may be due to increase in concentration of dopant increase size of nano crystal and given Figure 1.

Figure 1: XRD characteristics spectra of pure SnO_2 and transition metal doped SnO_2



Surface properties: A scanning electron microscope scans a concentrated electron beam over a surface to generate an image. The electron beam inter mingle with the sample generating ample signals that reveal information about the surface morphology and composition. The transition metal doped SnO_2 nanoparticles is slightly agglomerated particles might be due to lower calcinations temperature. A typical image of SnO_2 nanoparticles given in Figure 2.

Figure 2: SEM image of transitional metal doped stannous oxide [23]



Optical properties: UV spectroscopy is used to determine optical properties of the nanomaterial. It is method employed for the quantitative analysis of the amount of light absorbed by the specified nanosample. It works on the principle of absorption of high energy UV light by molecule followed by electronic excitation which give a spectra. In case of transition metal doped SnO_2 nanocomposites it was noticed from the spectra that absorption edge shifts towards the higher wavelength side as it undergo red shift by increasing dopant concentration. Mostly, particle size decreases undergo decrease in maximum wavelength excitation absorption due to photo-generated electron-hole pairs.

Gas sensing application: The environmental pollution has become matter of concern in the current era. Health issues increases exponentially due to all non-toxic, hazardous gases present in the atmosphere is the main cause of air pollution. By keeping in mind above factor gas sensor has gained attention of research owing to its advantages comprising low cost, compact structure, long life span andsimple circuit. Transition metal doped nano composite has become hotspot in the area of gas sensor [6-9]. A gas sensor is an instrument which converts information of unknown gas into other electrical signals according to specific principles, combining detection principles, material science and processing technology. Though it is widely used in detecting harmful, toxic gases, it has demerits of low response, poor selectivity and high operation temperature. So to overcome above issues doping of transition metal is done by controlling particle size and morphology.

It has been found that doped stannous oxide has higher efficiency than pure stannous oxide. To have an eco-friendly environment, the detection of NO, nitrogen dioxide, ammonia, CO and formaldehyde has become necessary due to their noxious nature and allied threat to the ecology. These pollutants lead to the discrepancy

in atmosphere and global warming. The detection of nitrogen oxide and nitrogen dioxide are the source from ignition and automobiles has become gained huge concern as it is hazardous to flora and fauna species. CO is the tasteless, poisonous generally produced from ignition of fossil fuels and faulty working of apparatus has high toxic effect on the blood stream and nervous system [10]. It is widely used in power transformer in the form of dissolved gas helps in evaluating insulation performance.

So it has extreme significance in the environmental regulation and industrial usage. Ammonia is considered as irritating and corrosive gas whose low concentration cause severe irritation in skin and eyes and high concentration become root cause for caustic damage such as skin burning, eye damage etc. Formaldehyde in huge concentration in air cause throat infection, itching, redness, wheezing and dermatitis. Benzene is highly volatile and easily diffused to the atmosphere leading to create acute and chronic respiratory disease to flora as well as fauna species. Volatile organic compounds are organic substances with enhanced vapour pressure at ordinary conditions. These toxic chemicals have critical and long standing consequences on the health which comprises infection in eye, nose and throat, headaches and nausea. Tremendous researches are done for the development of enhanced sensitive, cost effective, portable sensor with low power intake. The doped nano sample having high surface to volume ratio and hollow structure is considered as model for gas molecule adsorption and storage.

CONCLUSION

This paper outline studies of various properties of transition metal doped stannous oxide in comparison with pure stannous oxide followed by the characteristic spectral interpretations. It has also application in the gas sensor made a revolution in research field. Gas sensing properties include effective nanostructure and morphology which is considered as main ingredient for excellent performances which can be achieved by adding dopant. By comparing it has been behold that transition metal doped stannous oxide has higher efficiency than pure stannous oxide.

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