



ChemTech

## International Journal of ChemTech Research

CODEN (USA): IJCRGG, ISSN: 0974-4290, ISSN(Online):2455-9555  
Vol.13 No.03, pp 203-209, 2020

# Synthesis, Characterization and Antimicrobial Studies of SnO<sub>2</sub> Nanoparticles

Sumathi .P<sup>1\*</sup>

<sup>1</sup>Department of Chemistry, Gobi Arts & Science College, Erode, Tamilnadu, India

**Abstract :** This study was involved to synthesize and investigate the antimicrobial properties of highly pure nanocrystalline SnO<sub>2</sub> by simple chemical method. In the nanorods, SnO<sub>2</sub> nanoparticles, with a size of about 74 nm, the SnO<sub>2</sub> nanoparticles were maximum antibacterial activity against both bacterial and fungal with the zone of inhibition for Klebsiella pneumoniae, Staphylococcus aureus, Salmonella typhi and Ascerpergillus Flavus, Ascerpergillus Niger from 25µg/ml and 100 µg/ml respectively. SnO<sub>2</sub> nanoparticles showed good activity against both Gram-negative and Gram-positive bacteria confirming these as future broad spectrum antibacterial a cost effective way and to study its antimicrobial properties. We observed an effective antibacterial and antifungal activity of the SnO<sub>2</sub> nanoparticle against bacteria and fungi. The results showed that SnO<sub>2</sub> nanoparticles enhanced the good antibacterial activity.

**Keywords :** SnO<sub>2</sub> Nanoparticles, Klebsiella pneumoniae, Staphylococcus aureus, Salmonella typhi.

## 1. Introduction

Nanochemistry is the science of tools, technologies and methodologies for chemical synthesis, analysis and biochemical diagnostics performed in nanolitre to femtolitre domains. It is the use of synthetic chemistry to make nanoscale building blocks of desired shape, size, composition, surface structure, charge and functionality. Nanotechnology is leading to the production of many types of nanoparticles such as metal, metal oxide, doped and un-doped metal and metal oxide etc. The antibacterial studies of the doped and un-doped SnO<sub>2</sub> nanoparticles are also being studied [1]. The conductivity and optical properties of SnO<sub>2</sub> are largely dependent on the particle size and shape of the nanocrystallites [2-5]. Because of its excellent optical, electrochemical, and catalytic properties it is being used in many practical applications such as solid-state sensors, solar cells, Li-batteries and optoelectronic devices. Large band gap semiconductors, such as TiO<sub>2</sub>, SnO<sub>2</sub>, SiO<sub>2</sub> and ZnO are suitable photocatalytic materials [6-7]. Tin(IV) oxide plays a very important role in the field of gas sensing and

Sumathi .P et al/International Journal of ChemTech Research, 2020,13(3): 203-209.

DOI= <http://dx.doi.org/10.20902/IJCTR.2019.130317>

catalysis and as a transparent conducting oxide [8]. The activities of nanoparticles are directly dependent on the bacterial strain i.e., Gram positive and Gram-negative because they have differences in their cell wall. More recently, researchers have produced nano-sized wires and tubes. Nanowires have remarkable optical, electronic and magnetic properties, so they will prove useful in storing computer data. Carbon nanotubes may lead to new building materials, being much stronger and higher than steel. Metal oxide nanoparticles shows a great demand in the chemical, electronic and pharmaceutical industries [9-11]. Different methods have been adopted to synthesize nanoparticles like sol gel method [12-13] hydrothermal method, deposition-precipitation method. Antimicrobial properties have been demonstrated for metallic nanoparticles, metal oxide powders and nanoparticles [14]. The antibacterial property makes it desirable in hospital, Pharmaceutical and food industries where there is need for hygienic situation [15].

The present investigation synthesized nano-sized SnO<sub>2</sub> by novel simple chemical method and study their antibacterial and antifungal activities against *Klebsiella pneumonia* (Gram negative bacteria), *Staphylococcus aureus*, *Salmonella typhi* (Gram positive bacteria) and *Aspergillus Flavus*, *Aspergillus Niger* (Fungai) as a model by two methods.

## 2. Experiments

### 2.1 Antimicrobial studies

The in-built SnO<sub>2</sub> systems have increased biological potency, more so with the system having smaller rings. On this basis, the synthesized SnO<sub>2</sub> powder was evaluated for their in-vitro antibacterial and antifungal activities. The evaluations were carried out using "Agar plate technique" for both antibacterial and antifungal activity. Glasswares used in the present investigation were thoroughly washed with deionised water and dried.

For culturing bacteria, Nutrient agar medium and for fungi, Muller Hinton agar medium were used. Both the bacterial and fungal cultures were inoculated in nutrient booth and Muller Hinton agar booth respectively and incubated for overnight. Stock solution was prepared next day. 1 mg of each different sample was dissolved in 1.0 ml of DMSO.

### 2.2 Preparation of nutrient agar medium

Table-1 Nutrient agar was mainly used for the isolation of bacteria in pure culture.

### 2.3 Sterilization

The above media were sterilized in an autoclave at 151 bs for 15 min. After sterilization, the medias were poured into sterile petri dish each of 35 ml. The sterile cotton swab was dipped into the nutrient and Muller Hinton agar media over night for bacteria and fungi culture respectively. The excess inoculation was removed by pressing the swab against the inner wall of the culture tube. Petri dishes were sterilized in a hot air oven at 160°C for 3 hrs.

### 2.4 Preparation of media

The compositions of media were weighed separately and dissolve in approximate amount of water. After the sterilization, the media was allowed to cool for sometimes and at bearable heat, the media was poured into the Petri dishes aseptically. The depth of the medium should be approximately kept as 4mm. After solidification, the dishes were dried for 30 min in an incubator to remove excess moisture from the surface.

### 2.5 Inoculation

#### 2.5.1 Preparation of Inoculum

Only clinical isolates were used for the sensitivity test. The bacteria culture was maintained in nutrient agar slants. 48 hrs old culture was used as source of inoculum. The fungal isolates were maintained in Muller Hinton agar agar slants. Spores were collected from 5 days old culture and used as source of inoculum.

### 2.5.2 Method of Inoculation

A loop full of bacterial culture was suspended in 10ml of sterile distilled water. 0.5ml of this was pipetted out in to sterile Petri dishes over which 20ml of nutrient agar medium was poured and mixed thoroughly. The entire agar plates were swabbed horizontally, vertically and outer edge of the plate to ensure heavy growth over the entire surface. All the culture plates were allowed to dry for about five min in the prepared agar media plates. The well was prepared with equal distance in the size of 4 mm. The prepared well was filled with different concentration of various samples using sterile pipettes. All the plates were incubated for 24 hours at 37°C. Then the presence of zone of inhibition could be measured on the plates.

20ml of Muller Hinton agar medium was poured into sterile Petri dishes and allowed to solidify. A loop full of fungal spores were suspended in 10ml of sterile distilled water. A loop of this suspension was placed in the centre of Petri dishes. The agar surface of the plate was looped in 3 directions by turning the plate 60° angle between each looping. The lid of the petri dishes was closed and kept at room temperature for 5-10 minutes to dry. The inoculum confluent growth was desirable for accurate results.

### 2.5.3 Incubation

The inoculated petri dishes were incubated at 27°C for a period of 2 days in the case of bacteria and 5 days in the case of fungi.

### 2.5.4 Micro organisms used

The following clinical pathogens were used to check the antibacterial activity of synthesized SnO<sub>2</sub>.

- ❖ **Gram negative bacteria**
  - Klebsiella pneumoniae
- ❖ **Gram positive bacteria**
  - Staphylococcus aureus
  - Salmonell Typhi
- ❖ **Fungi**
  - Ascerpergillus Niger
  - Ascerpergillus Flavus

### 2.5.5 Preparation of synthesized SnO<sub>2</sub> sample disc

The disc preparation technique followed for both antibacterial and antifungal activity of a SnO<sub>2</sub> sample was same. The SnO<sub>2</sub> is insoluble in water but soluble in con HCl. Exactly 0.1mg of dried powder sample was individually weighed. Then the stock was prepared by dissolving it in con HCl and used to study antibacterial and antifungal sensitivity.

### 2.5.6 Application of Antibiotic discs

The antibiotic disc was removed from their respective vials with the help of a sterilized forceps and carefully placed in the petri dishes, at least 22-24mm away from the edge. The antibiotic disc served as positive control, sterile distilled water disc served as negative control and prepared SnO<sub>2</sub> discs were placed at a considerable amount of distance to place on the media overlapping at the zone. Then the disc was pressed gently on the surface of the medium. The petri dishes were allowed to stand at room temperature for 30 minutes or refrigerated at 15 min for prediffusion.

### 2.5.7 Incubation

The plates were incubated at 37°C for about 20 hrs for antibacterial activity and at 27° for about 20hrs for antifungal activity.

### 2.5.8 Reading the results

The zone of inhibition of each antibiotic was measured at the end of incubation period. The zones were measured from the discs showing complete inhibition and diameters of the zones were recorded to the nearest millimeter.

**Table-1 Nutrient agar was mainly used for the isolation of bacteria in pure culture.**

Ingredients	Gm/1000ml
Peptone	5.0 gm
Beef extract	3.0 gm
NaCl	5.0 gm
Yeast extract	2.0 gm
Agar	15.0 gm
Distilled water	1000 ml
pH	6.8 ± 0.2

**PH (at 25°C) = 7.3 ± 0.2**

**Table-2 Composition of Muller Hinton agar**

Ingredients	Concentration gms/litre
Beej injusion	300.00
Casein acid hydrolysate	17.50
Starch	1.50
Agar	17.00

## 3. Results and Discussion

### 3.1 Antimicrobial study

Table 3 presents the antimicrobial activity of SnO<sub>2</sub>. From the table, it can be seen that, the nanocrystalline SnO<sub>2</sub> inhibits effectively the growth of staphylococcus aureus bacteria than Klebsiella pneumoniae and it poorly inhibits the growth of Salmonella typhi bacteria in almost all concentrations of SnO<sub>2</sub>. As the concentration of micro-organism increases, the growth of bacteria also increases. From the Fig 1, it can be concluded that, the synthesized SnO<sub>2</sub> powder has strong antibacterial activity towards staphylococcus aureus. The order of antibacterial activity of SnO<sub>2</sub> on growth of the three bacteria are staphylococcus aureus > Klebsiella pneumoniae > Salmonella typhi. Table 4 gives the antifungal activity of SnO<sub>2</sub>. From the table it can be seen that, the synthesized SnO<sub>2</sub> has very good antifungal activity towards Ascerpergillus Flavus and Ascerpergillus Niger in all concentrations of SnO<sub>2</sub> from 25 µg/ml and 100 µg/ml. It has comparable antifungal activity on growth of both fungi shown Fig 2.

**Table-3: Antibacterial activity of SnO<sub>2</sub>**

Micro organism	Growth in			
	25µl SnO <sub>2</sub>	50µl SnO <sub>2</sub>	75 µl SnO <sub>2</sub>	100 µl SnO <sub>2</sub>
Staphylococcus aureus	15 mm	16 mm	18 mm	20 mm
Klebsiella pneumoniae	16 mm	18 mm	17 mm	21 mm
Salmonella typhi	15 mm	17 mm	19 mm	20 mm



**Fig.1 Antibacterial activity of SnO<sub>2</sub>**

**Table-4: Antifungal activity of SnO<sub>2</sub>**

Micro Organism	Growth in			
	25µl SnO <sub>2</sub>	50µl SnO <sub>2</sub>	75 µl SnO <sub>2</sub>	100 µl SnO <sub>2</sub>
Ascerpergillus Flavus	8 mm	10 mm	12 mm	15 mm
Ascerpergillus Niger	8 mm	9 mm	12 mm	14 mm



**Fig.2 Antifungal activity of SnO<sub>2</sub>**

The relative antibacterial activity of SnO<sub>2</sub> suspensions of particles with size 74 nm toward *Klebsiella pneumoniae*, *Staphylococcus aureus*, *Salmonella typhi* was studied qualitatively in aqueous Nutrient broth by disk diffusion. A standard testing protocol was employed that is applicable to inorganic metal oxides. The antifungal activity of SnO<sub>2</sub> suspensions of particles with size 74 nm towards *Ascerpergillus Flavus*, *Ascerpergillus Niger* was studied qualitatively in aqueous Muller Hinton agar broth.

The ability of the antimicrobial agent to rupture bacterial cells is tested by the disk diffusion method and the results are given in table 4. The presence of an inhibition zone clearly indicate that the mechanism of the biocidal action of SnO<sub>2</sub> involves disrupting the membrane. The high rate of generation of surface oxygen species from SnO<sub>2</sub> leads to the death of the bacteria. SnO<sub>2</sub> suspensions was incubated with *Klebsiella pneumoniae*, *Staphylococcus aureus*, *Salmonella typhi* in aqueous Nutrient broth. Bacterial growth was studied by visually inspecting the nutrient broth for turbidity. If the material being tested does not kill but instead inhibits the growth of bacteria (Bacteriostatic agent), the bacteria will grow when it is removed from the

solution containing the material, and colonies will be observed upon plating an aliquot. If the material being tested is bactericidal, the absence of bacterial colonies will be observed upon plating. To establish whether the suspensions were bacteriostatic or bactericidal, 25  $\mu$  lit, 50  $\mu$  lit, 75  $\mu$  lit, 100  $\mu$  lit aliquots were taken from the incubated Nutrient broth, each containing SnO<sub>2</sub> Klebsiella pneumoniae, Staphylococcus aureus, Salmonella typhi and were plated on Nutrient agar plates and incubated for 18-20 h.

SnO<sub>2</sub> suspension with a concentration in the range of 25-100  $\mu$ l effectively inhibits the bacterial growth. No significant antibacterial activity was observed at concentrations less than 10  $\mu$ l. The SnO<sub>2</sub> suspension with 74nm particles is more effective. This can be explained on the basis of the oxygen species released on the surface of SnO<sub>2</sub>, which cause fatal damage to microorganisms. Highly reactive species such as OH, H<sub>2</sub>O<sub>2</sub> and O<sub>2</sub><sup>2-</sup> were formed. The generated H<sub>2</sub>O<sub>2</sub> can penetrate the cell membrane and kill the bacteria. Since, the hydroxyl radicals and superoxides are negatively charged particles, they cannot penetrate into the cell membrane and must remain in direct contact with the outer surface of the bacteria; however, H<sub>2</sub>O<sub>2</sub> can penetrate into the cell.

The detailed mechanism for the activity of SnO<sub>2</sub> is still under debate. One possible explanation of the antibacterial effect of SnO<sub>2</sub> is based on the abrasive surface texture of SnO<sub>2</sub>. SnO<sub>2</sub> nanoparticles have been found to be abrasive due to surface defects. Although metals and metal oxides are known to be toxic at relatively high concentrations, they are not expected to be toxic at low concentrations. No colonies were observed at this PH. This indicates that a pH in the range of 6-8 does not affect the growth of the bacteria, irrespective of the metal ions present.

## Conclusion

Antimicrobial activity of the SnO<sub>2</sub> nanoparticle has been studied against three bacteria namely Staphylococcus aureus, Klebsiella pneumonia and Salmonella typhi, and two fungi Aspergillus flavus, Aspergillus niger. SnO<sub>2</sub> suspension with a concentration in the range of 25-100  $\mu$ l effectively inhibits the bacterial and fungi growth. From the antimicrobial studies it can be concluded that, SnO<sub>2</sub> nanoparticle have strong antibacterial activity and antifungal activity.

## References:

1. Fang LM, Zu X T, Li ZJ, Zhu S, Liu CM, Wang LM, Gao F, Microstructure and luminescence properties of Co-doped SnO<sub>2</sub> nanoparticles synthesized by hydrothermal method, J Mater Sci: Mater Electron, 19, (2008), 868–874.
2. Jae-Ryoung Kim, Hwangyou Oh, Hye Mi So, Ju-Jin Kim, Jinhee Kim, Cheol Jin Lee and Seung Chul Lyu, Schottky diodes based on a single GaN nanowire, Nanotechnology, 13 (2002), 701-701.
3. Liu. Y, Zheng C, Wang W, Yin C and Wang G, Synthesis and Characterization of Rutile SnO<sub>2</sub> Nanorods ,Adv. Mater, 13 (2001) 1883.
4. Daniel M. Lyons, Kevin M. Ryan, Michael A. Morris, Justin D. Holmes, Tailoring the Optical Properties of Silicon Nanowire Arrays through Strain, Nano. Lett., 2(8) (2002) 811-816.
5. Charles R. Martin, Membrane-Based Synthesis of Nanomaterials, Chem. Mater, 8 (1996) 1739-1746.
6. Matthias Batzill, Ulrike Diebold, The surface and materials science of tin oxide, Prog. Surf. Sci., 79 (2005) 47-154.
7. Author links open overlay panel RishuKatwala, HarpreetKaur, GauravSharma, Mu.Naushad, DeepakPathania, Electrochemical synthesized copper oxide nanoparticles for enhanced photocatalytic and antimicrobial activity, Journal of Industrial and Engineering Chemistry, 31,(2015), 173-184.
8. Kennedy M K, Kruis F E, Fissan H, Mehta B R, Stappert S and Dumpich G, Tailored nanoparticle films from monosized tin oxide nanocrystals: Particle synthesis, film formation, and size-dependent gas-sensing properties, J. Appl. Phys, 93 (2003) 551.
9. Ming Su, Shuyou Li and Vinayak P. Dravid, Miniaturized Chemical Multiplexed Sensor Array, J. Am. Chem. Soc. (2003) 9930-9931.
10. Edson R. Leite, Ingrid T. Weber, Elson Longo, and Jose A. Varela, A New Method to Control Particle Size and Particle Size Distribution of SnO<sub>2</sub> Nanoparticles for Gas Sensor Applications, Adv. Mater,12 (2000) 965.

11. Mehran Alavia, Naser Karimia, Iraj Salimikiab, “phytosynthesis of zinc oxide nanoparticles and its antibacterial, antiquorum sensing, antimotility, and antioxidant capacities against multidrug resistant bacteria” *Journal of Industrial and Engineering Chemistry*, Vol.72, 2019, 457-473.
12. Feng Gu, Shu Fen Wang, Meng Kai Lu<sup>1</sup>, Guang Jun Zhou, Dong Xu, and Duo Rong Yuan, Photoluminescence Properties of SnO<sub>2</sub> Nanoparticles Synthesized by Sol-Gel Method, *J. Phys. Chem. B*, 108 (2004) 8119-8123.
13. Luhua Jiang, Gongquan Sun, Zhenhua Zhou, Shiguo Sun, Qi Wang, Shiyu Yan, Huanqiao Li, Juan Tian, Junsong Guo, Bing Zhou and Qin Xin, Size-Controllable Synthesis of Monodispersed SnO<sub>2</sub> Nanoparticles and Application in Electrocatalysts, *J. Phys. Chem. B*, 109, (2005) 8774-8778.
14. Maestre D, Cremades A, and Piqueras J, Cathodoluminescence of defects in sintered tin oxide, *J. Appl. Phys.*, 95 (2004) 3027.
15. Kanagasubbulakshmi S and Kadirvelu K, Green Synthesis of Iron Oxide Nanoparticles using *Lagenaria Siceraria* and Evaluation of its Antimicrobial Activity, *Defence Life Science Journal*, Vol. 2, No. 4, 2017, 422-427.

\*\*\*\*\*