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Studies on nano-fluids based on Electrochemically Deposited Tin Nanoparticles

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ABSTRACT

In the present work, we have prepared Tin nanoparticles by using electro-deposition method. The structural, optical and morphological properties of the prepared Tin (Sn) nanoparticles were characterized by using XRD, UV-Visible Spectroscopy and scanning electron microscopy, respectively. The XRD spectra reveal that the prepared Sn nanoparticle shows crystalline and cubic structure. In present investigation, we also studied the effect of the different parameters such as temperature, applied potential, time, stirring rate on electrical properties of the Sn nanoparticles. The present work also investigated the effect of Sn nanoparticles on electrical conductivity of base fluid (DDW) by using different sources. The electrical properties of the base fluid get altered on the dispersion of nanoparticles. The effect of illumination under different source on electrical conductivity of the Sn nanoparticle with base fluid was also discussed.

Keywords: Nanotechnology, Nanoparticles, electro-deposition, electrical conductivity, Tin etc.

INTRODUCTION

Nanoparticles are of great scientific interest as they are effectively a bridge between bulk materials and atomic or molecular structures. The properties of many conventional materials change when formed from nanoparticles. This is typically because nanoparticles have a greater surface area per weight than larger particles which causes them to be more reactive to some other molecules. There are many advantages of nanoparticles in medical field, in cosmetics, in industries, in biomedical, textiles, electronics, health care, food agriculture, etc.[1-4]. There are so many methods for preparation of metal nanoparticles such as spry pyrolysis method, CVD, PVD, ball milling method, colloidal method, electrodeposition method, etc [5].In the experiment we have prepared metal nanoparticles. So, a solid material which is typically hard, shiny, malleable, fusible, and ductile, with good electrical and thermal conductivity (e.g. iron, gold, silver, and aluminum) is the metal & nanoparticles of such material is the metal nanoparticle [6]. Nanoparticles often possess unexpected optical properties as they are small enough to confine their electrons and produce quantum effects. Absorption of solar radiation is much higher in materials composed of nanoparticles than it is in thin films of continuous sheets of material. Tin has significantly higher electrical conductivity compared to silicon (10^{-7} Ω·m versus 2×10^{3} Ω·m). It has high volumetric density and a maximum theoretical capacity upon lithiation (994 mAh/g) that also exceeds that of graphite [7]. There are several methods for preparation of metal nanoparticles such as are, spry pyrolysis method, CVD, PVD, ball milling method, colloidal method, electrodeposition method, etc. [8-9]. From these methods we have used electrodeposition method which is cheap and easy. Here we have synthesized copper nanoparticles from this method by applying certain potential difference with constant current supply and at the room temperature. The preparation of the nanoparticle can possible at room temperature in the laboratory by using electrodeposition method. The structural and morphological characterization of film has been carried out by X- ray diffraction (XRD) and Scanning electron microscopy (SEM) respectively and their optical and compositional properties have been studied by UV-vis-NIR spectrophotometer.

In the present work we successfully synthesized the Sn nanoparticles by using electrodeposition method and study its conducting as well other characteristics by using characterization technique. The prepared tin nano particles shows various properties. Tin nanoparticles shows maximum absorbance of UV light. Therefore it is applicable in sunscreen lotions, cosmetics, sunglasses, etc. to protect the human organs from harmful UV rays [10-11].

METHODOLOGY

1. Electrodeposition technique: In the present synthesis of Sn nanoparticles, 0.1 M $SnCl_2$ (1.13 gm) solution used as a cationic precursor. This solution added in the 50 ml ethanol in beaker. Stir the solution (180 rpm) properly on magnetic stirrer and add 20 drops of 50 % diluted HCl. The voltage given to the electrodes should be 3 V and 4.5 V. The pH of the electrolyte is one. The deposition time is 10 minute. The synthesized Sn nanoparticles dispersed in ethanol by ultrasonication and then kept at room temperature (27 °C) for 3 months to determine their stability. The X-ray diffraction studies of Sn nanoparticles was carried out using X ray diffractometer (Bruker D8), Scanning electron microscope (JEOL JSM-6360) was used for the surface morphological study. The optical absorption spectra were recorded in the range 300-1200 nm at room temperature by JASCO spectrophotometer. The electrical conductivity of Sn nanoparticles in aqueous solution also measured.

Fig 1. Electro-deposition Setup in the laboratory

2. Measurement of electrical conductivity:

The electrical conductivity of any fluid is a measure of its ability to carry an electric current. The electrical conductivity can be expressed as mhos (Reciprocal of ohms) or as siemens. In most fluids, the conductivity is very low, so millisiemens or microsiemens are used as units for conductivity. Chemical composition of fluid determines its conductivity. Since the charge on ions in solution facilitates the conductance of electrical current, the conductivity of a solution is proportional to its ion concentration and their mobility [12-13]. The ions in water act as electrolytes and conduct the electricity.

Most conductivity measurements are made in aqueous solutions, and the ions responsible for the conductivity come from electrolytes dissolved in the water. Although water itself is not an electrolyte, it does have a very small conductivity, implying that at least some ions are present. The ions are hydrogen and hydroxide, and they originate from the dissociation of molecular water. The nano-fluids used in experiment were prepared using a two-step method. First, an appropriate amount of Sn nanoparticles has been weighed with the analytical balance and then mixed with water make conducting aqueous solution. . Then, samples were stirred for 30 min using magnetic stirrer. The electrical conductivity found to be a significant dependence on the dispersed particles and its concentration. Thus, the second step of preparation of samples was sonication in ultrasonic bath in order to break up the agglomerates remaining after the mechanical stirring. The time for sonication was 20 min. An ultrasound that we used has a power of about 350 W, and is equipped in ultra-wave generators with frequency about 34 kHz.

RESULTS AND DISCUSSION

1. Structural Analysis:

The crystallographic analysis was done by utilizing XRD. XRD analysis of the prepared sample of Tin nanoparticles was taken for the range of 10 to 80 degrees as shown in Fig.2 The XRD study reveal that the synthesized sample shows high crystallinity level and tetragonal structure. The tetragonal Sn phase structure (JCPDS Card No. 04- 0673, space group: I41/amd, 141) is evidenced by the peaks appearing at 2θ = 30.07°, 31.58°, 43.96°, 45.06°, 54.97°, 62.19°, 63.84° and 73.40°, corresponds to (200), (101), (220), (211), (301), (112), (321) and (411) respectively. The peak broadening suggested that a synthesized Sn particle shows nanocrystalline nature.

X (2Θ)	Y (Intensity)	hkl (miller indices)	D
30.0744559	307.023031	(200)	0.2968
31.5819015	144.697185	(101)	0.2829
43.9721993	119.050327	(220)	0.2056
45.0687285	178.163207	(211)	0.2009
54.9793814	93.5598521	(301)	0.1668
62.1958763	135.157805	(112)	0.1490
63.8476518	96.3745512	(321)	0.1456
73.4054983	133.906739	(411)	0.1288

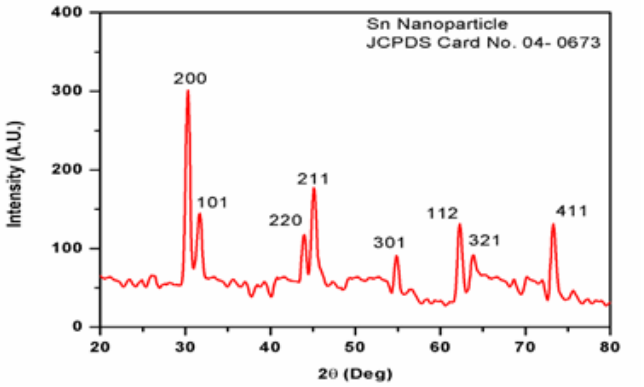

Fig 2. XRD spectra of synthesized Sn nanoparticles.

2. Optical Analysis: The optical analysis of the synthesized nanoparticle was carried out by using UV-Visible spectroscopy in the range of wavelength 300-800 nm. In the optical spectra, the prominent peak is appeared at 250nm, so we can conclude that Sn nanoparticles absorb light of wavelength of 250 nm.

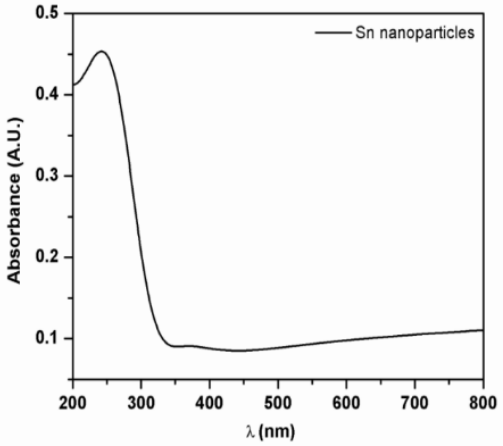

Fig 3: The UV visible spectrogram of synthesized Sn nanoparticles

Since the 250nm wavelength lies between 100 nm to 400 nm that is in ultra-violet region, Sn nanoparticles absorbs UV light. The position and shape of the absorption peaks are dependent on the particle morphology, dielectric functions of the metal and the surrounding medium as well as surface-absorbed species.

3. Microstructural Properties:

Surface morphology of Sn nanoparticles was characterized using scanning electron microscope. Fig. 3 shows SEM micrographs of Sn nanoparticles. It is observed that the image showed micrometer-sized randomly distributed crystal aggregates, in the range of 0.2–2 μm. The higher magnification imaging (Fig. 3 b) revealed that the irregular shaped nanocrystal are agglomerated and formed big size crystal.

4. **Electrical conductivity:** In the present study the electrical conductivity was measured using electrical conductivity meter. The fluid is subjected to illumination under different illuminating source in order to observe the effect of electromagnetic radiations on the electrical conductivity of prepared sample. The results are shown below as a effect of change in distance between illuminating source and sample.

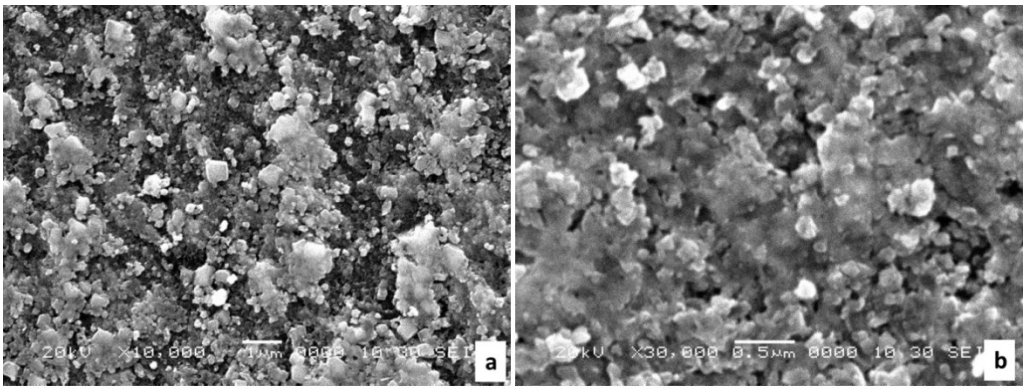

Fig 4: SEM images of electro-deposited Sn nanoparticles prepared at 3V potential

1) In tungsten lamp:

Distance (cm)	Sn(3V)	Sn(4.5)
10	119.3	123.0
20	119.0	122.2
30	118.3	121.7
40	118.8	121.5
50	118.1	121.9

2) In sodium lamp

Distance (cm)	Electrical conductivity(μS) Sn(3V)	Sn(4.5)
10	191.2	0.712×10^{-3}
20	197.1	0.728×10^{-3}
30	196.6	0.734×10^{-3}
40	197.3	0.737×10^{-3}
50	196.6	$0.742 \quad 10^{-3}$

3) In IR lamp

Distance (cm)	Sn(3V)	Sn(4.5)
10	194.2	0.709×10^{-3}
20	196.8	0.727×10^{-3}
30	196.4	0.741×10^{-3}
40	196.6	0.789×10^{-3}
50	196.9	0.801×10^{-3}

4) In Sunlight

Distance (cm)	Electrical conductivity(μS) Sn(3V)	Sn(4.5)
10	0.998	0.999
20	0.998	0.999
30	0.999	0.999
40	0.998	0.999
50	0.999	0.999

From the results, it is observed that the electrical conductivity for Sn nanoparticles prepared at 3V potential is more as compare to that prepared at 4.5V. This may be due to smaller and uniform particle size of Sn nanoparticles. It is also observed that the electrical conductivity gradually decreases as the distance between illuminating source and sample increases, due to decrease in intensity of

electromagnetic radiations. Under illumination with sunlight the sample shows more electrical conductivity. Electrical conductivity measured with illumination under monochromatic source is less as compare to white light source. The huge enhancement in electrical conductivity was observed for Sn nanoparticles suspended in double distill water as a fluid. The significant electrical conductivity enhancement is caused, among others, by creating a double electrical layer around nanoparticles and creating conduction paths in higher concentrations of nanoparticles in base fluid. The polarisation current density is found and applied electric field being known, the electrical conductivity of polarised particles in the aqueous medium. The polarisation process is quantified by the effective dielectric constants.

CONCLUSION

This study reports the synthesis of Sn nanoparticles by using electro deposition method. The preparation method used is quite cheaper & beneficial. From the XRD result, the synthesized Sn nanoparticle shows tetragonal and nanocrystalline structure. The UV spectra reveal that the Sn nanoparticles shows maximum absorption in the ultraviolet region of the spectra. Sn nanoparticles can be used in cosmetics (sunscreen lotion), sunglasses, etc to protect human skin from the harmful UV rays. The synthesized Sn NPs has more electrical conductivity in sunlight. Therefore these NPs has future application in solar cells which will be very beneficial. Nano tin dispersed in lubricating oil can be obtained specific performance of multi-purpose oil additives. That means can be used in lubricants. Also can be used in metal electric padding, conductive slurry. The huge enhancement in electrical conductivity was observed for Sn nanoparticles suspended in double distill water as a fluid.

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Conflicts of interest: The authors stated that no conflicts of interest.

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