

# Effect of auxiliary on the properties of SnO<sub>2</sub> nano-crystalline prepared via hydrothermal method

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**Abstract.** The study of dye-sensitized solar cells (DSSCs) based on nano-crystalline films of high band gap semiconductors is a progressive field of research that is being carried out by scientists in a wide range of laboratories. To improve the conversion efficiency of the DSSCs, the SnO<sub>2</sub> nano-rods photocurrent is prepared via the hydrothermal method, and characterized by XRD, FESEM, HRTEM and Absorption spectrum. Through analysis of the results, the conclusion is shown that the better SnO<sub>2</sub> nano-particles were prepared using the conditions that 0.05mol/L SnCl<sub>4</sub> concentration, the reaction time for 4 days, the molar ratio of salt and alkali for 1:4, a holding temperature of 200°C, and NaOH as auxiliary agent. The grain diameter of tin oxide is about 7 nanometers, and very uniform circular. SnO<sub>2</sub> nano-particles have been quite clear, a large number of crystalline phases have been formed, and crystalline phase is very complete. The absorbance in the visible light range shows the very weak absorbance property.

**Keywords:** dye sensitized solar cells; SnO<sub>2</sub>; hydrothermal method; auxiliary.

## 1 Introduction

Since initially reported by O'Regan and Grätzel in 1991, dye sensitized solar cells (DSSCs) have been considered as a credible alternative to the conventional silicon solar cells for their easy fabrication, low cost and high-energy conversion efficiency [1-2]. Ultrafine SnO<sub>2</sub> is a new material in solar cells and semiconductors and other fields have a lot of use [3-4]. The two most important parameters of the catalyst are active and selective catalysts prepared by the SnO<sub>2</sub>; these two parameters are very good. According to the research, SnO<sub>2</sub> surfactant higher than the large surface area; in addition SnO<sub>2</sub> structure more particularly, has a good adsorption. Want to get excellent performance of SnO<sub>2</sub> material prepared by first preparing SnO<sub>2</sub> ultra-fine powder so that SnO<sub>2</sub> maintain a high specific surface [5-6].

Hydrothermal synthesis in a closed container at high temperature and pressure and temperature of the high temperature and low pressure steam systems solubility generated by the low solubility of the final precipitated crystals programs. This method is compared with conventional methods, the dispersion of hydrothermal synthesis synthetic powder is better, and the degree of crystallinity is very good [7-8]. To overcome this problem researchers have come up with two basic approaches. The first is the formation of an energy barrier in between the semiconductor particles that allows the injection but avoids the recombination of electrons with holes in the dye electrolyte after relaxation. The

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passivation of the voids of the semiconductor film is the other method followed by researchers to reduce recombination channels.

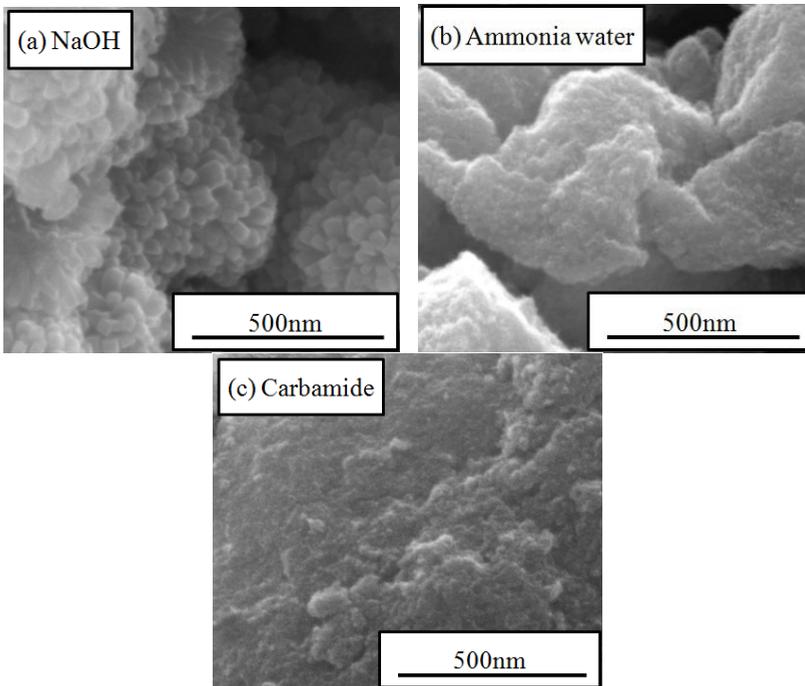
In this paper,  $\text{SnO}_2$  nano-crystalline were synthesized using a hydrothermal method by modifying auxiliary parameters, and  $\text{SnO}_2$  nano-crystalline were characterized by XRD, FESEM, HRTEM and absorption spectrum, which lay base for reaching the high conversion efficiency of the DSSCs.

## 2 Materials and experimental

Analytical-grade  $\text{SnCl}_4 \cdot 5\text{H}_2\text{O}$ , and  $\text{NaOH}$  were used, and  $\text{SnCl}_4 \cdot 5\text{H}_2\text{O}$ , and  $\text{NaOH}$  were prepared with certain molar concentration solution.  $\text{SnO}_2$  nano-crystalline were synthesized using a hydrothermal method by varied experimental parameters, such as the pH value, but the others parameters is certainly, such as the molar ratio of the precursors for 1mol/L, the process time for 8 days and the process temperature for  $200^\circ\text{C}$ , which may affect the properties of the  $\text{SnO}_2$  nano-crystalline. the properties of the  $\text{SnO}_2$  nano-crystalline were characterized via the following methods and intruments.

$\text{SnO}_2$  nano-crystalline phase analysis was identified by X-ray powder diffraction (XRD) (Model: D/Max-RB, Japan).  $\text{SnO}_2$  nano-crystalline microstructure analysis was performed by scanning electron microscopy (FESEM) (Model: Quante FEG 250, American) and high rang transmission electron microscope (HRTEM) (Model: JEM-2100UHR STEM/EDS, Japan).  $\text{SnO}_2$  nano-crystalline absorption spectrum analysis was performed by a UV-vis spectrophotometer (Model: UV-3600, Japan).

## 3 Results and discussion

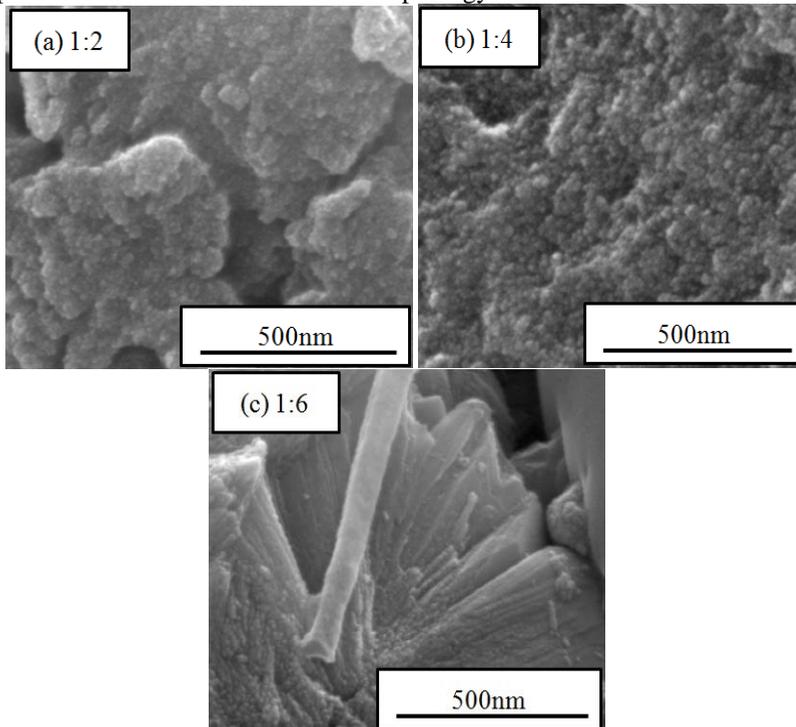


**Figure 1.** Microstructure of synthesized  $\text{SnO}_2$  nano-crystalline using different auxiliary kinds

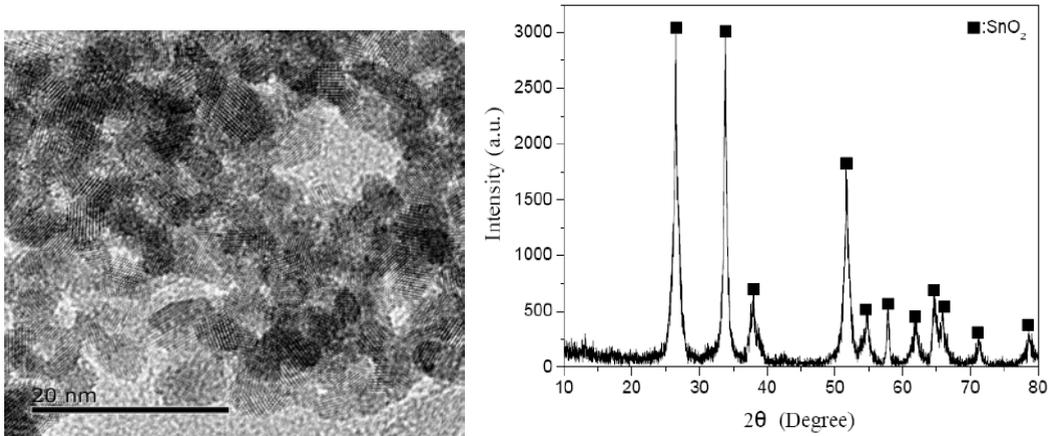
Fig.1 shows  $\text{SnO}_2$  nano-crystal is prepared using different adjuvants with the concentration of  $\text{SnCl}_4$  for 0.05mol/L, saline molar ratio of 1:4, 4 days incubation at  $200^\circ\text{C}$  environment, the size of prepared particles using  $\text{NaOH}$  as auxiliary is more large, uniform morphology than that of prepared particles using ammonia or carbamide, because  $\text{NaOH}$  is a strong alkali, it poses the large ionization degree, the number of moles of  $\text{NaOH}$  can be ionized the same amount of  $\text{OH}^-$ , while carbamide and ammonia are weak alkali, ionization  $\text{OH}^-$  is weak. When the adjuvant is  $\text{NaOH}$ , a reaction of salt and alkali is fuller,

more complete particle is formed, so the particle size is greater. The reaction of ammonia and urea is inadequate, which makes the grain size be smaller, so it shows powerful agglomeration and uneven topography. Whether an adjuvant is NaOH or ammonia and carbamide, the  $\text{SnO}_2$  particle distribution is more concentrated, the colors of  $\text{SnO}_2$  particles can also be seen mostly white using these three adjuvants, the reason is that the fine particles produces discharge effect under the SEM environment. Because the fine particles easily agglomerate to form many pores, therefore, it does not form a continuous conductive film, so that when the electrons hit the top down and therefore not easily lead to a discharge phenomenon.

Fig.2 shows in order to, the effects of different salt and alkali molar ratio on micrstructure of ultrafine powder prepared using NaOH as supplement aid,  $\text{SnCl}_4$  concentration for 0.05mol/L, and incubated two days at 200°C condition via field emission scanning electron microscope, it can be seen from the fig.2, when NaOH and  $\text{SnCl}_4$  ratio is 1: 4, the grain sizes obtained a greater and more uniform appearance. Since NaOH and  $\text{SnCl}_4$  ratio of 1: 4 was just the whole reaction is finished, the particle size is more stable, uniform morphology. When the saline molar ratio is 1: 2 inadequate response, the smaller the particle size of the obtained shape uneven appearance. When the molar ratio of alkali is 1: 6, since the base is excess, the reaction is stronger[9-10], and zinc oxide grains were multiplied, it drives the the  $\text{SnO}_2$  particle size to form non-uniform morphology.



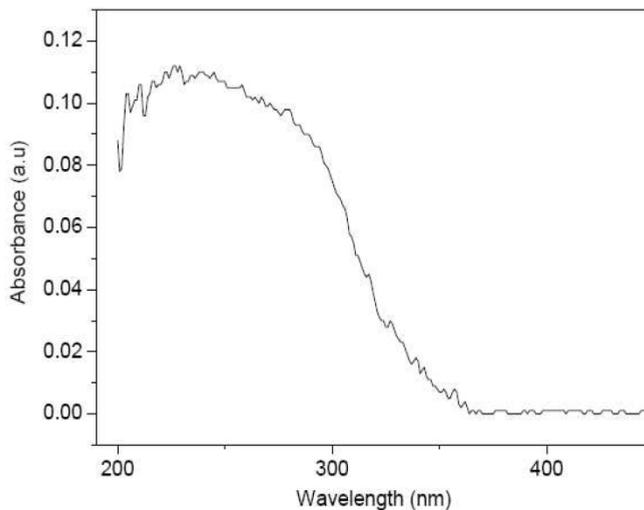
**Figure 2.** Microstructure of synthesized  $\text{SnO}_2$  nano-crystalline under different salt and alkali molar ratio



**Figure 3.** HRTEM and XRD of prepared SnO<sub>2</sub> nano crystalline

Fig.3 is the transmission electron microscopy images and X-ray diffraction phase analysis picture of synthetic SnO<sub>2</sub> using the conditions that 0.05mol/L SnCl<sub>4</sub> concentration, the reaction time for 4 days, the molar ratio of salt and alkali for 1: 4, a holding temperature of 200°C, and the NaOH as auxiliary agent. As can be seen from the figure, the grain diameter of tin oxide is about 7 nanometers, and very uniform circular.

From the Fig.3, we can see the image without miscellaneous XRD peaks, which indicates that the prepared SnO<sub>2</sub> nanometer powder is higher purity. Further, the peak intensity is high, which indicates that the content of prepared SnO<sub>2</sub> nanoparticles are more, the narrow width degree of powder peak described better degree of crystallinity. On the whole, the characteristic peaks of SnO<sub>2</sub> nanoparticles has been quite clear, a large number of crystalline phase has been formed, and crystalline phase is very complete.



**Figure 4.** The absorption spectrum of synthesized SnO<sub>2</sub> nano-crystalline

The absorption spectrum of synthesized SnO<sub>2</sub> nano-crystalline under salt and alkali molar ratio for 1:4 is shown in Fig.4, which indicates the absorbance of SnO<sub>2</sub> nano-crystalline shows the strong absorption in the ultraviolet ray range, however, the absorbance in the visible light range shows the very weak absorbance property. In the sunlight, ultraviolet energy is relatively higher, SnO<sub>2</sub> powder by sunlight absorption spectrum can be seen, the powder is more intense UV absorption, which use sunlight to convert into electricity is advantageous.

## 4 Conclusion

The study of dye-sensitized solar cells (DSSCs) based on nano-crystalline films of high band gap semiconductors is a progressive field of research that is being carried out by scientists in a wide range of laboratories. To improve the conversion efficiency of the DSSCs, the SnO<sub>2</sub> nanorods photocurrent is prepared via the hydrothermal method, and characterized by XRD, FESEM, HRTEM and Absorption spectrum. Though analysis the results, the conclusion is shown the better SnO<sub>2</sub> nanoparticles were prepared using the conditions that 0.05mol/L SnCl<sub>4</sub> concentration, the reaction time for 4 days, the molar ratio of salt and alkali for 1: 4, a holding temperature of 200°C, and the NaOH as auxiliary agent. The grain diameter of tin oxide is about 7 nanometers, and very uniform circular. SnO<sub>2</sub> nanoparticles has been quite clear, a large number of crystalline phase has been formed, and crystalline phase is very complete. The absorbance in the visible light range shows the very weak absorbance property.

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