

Effect of auxiliary on the properties of SnO₂ 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 SnO₂ nano rods 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 SnO₂ nano particles were prepared using the conditions that 0.05mol/L SnCl₄ 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. SnO₂ nano particles 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.

Keywords: dye sensitized solar cells; SnO₂; hydrothermal method; auxiliary.

1 Introduction

Since initially reported by O' Regan and Gratzel 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 SnO₂ is 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 is active and selective catalysts prepared by the SnO₂ these two parameters are very good. According to the research, SnO₂ surfactant higher than the large surface area; in addition SnO₂ structure more particularly, has a good adsorption. Want to get excellent performance of SnO₂ material prepared by first preparing SnO₂ ultra-fine powder so that SnO₂ 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 upwith two basic approaches. The firstthe 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 orelectrolyte 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, SnO_2 nano-crystalline were synthesized using a hydrothermal method by modifying auxiliary parameters, and 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 NaOH were used, and $\text{SnCl}_4 \cdot 5\text{H}_2\text{O}$, and NaOH were prepared with certain molar concentration solution. 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°C , which may affect the properties of the SnO_2 nano-crystalline. the properties of the SnO_2 nano-crystalline were characterized via the following methods and intruments.

SnO_2 nano-crystalline phase analysis was identified by X-ray powder diffraction (XRD) (Model: D/Max-RB, Japan). 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). SnO_2 nano-crystalline absorption spectrum analysis was performed by a UV-vis spectrophotometer (Model: UV-3600, Japan).

3 Results and discussion

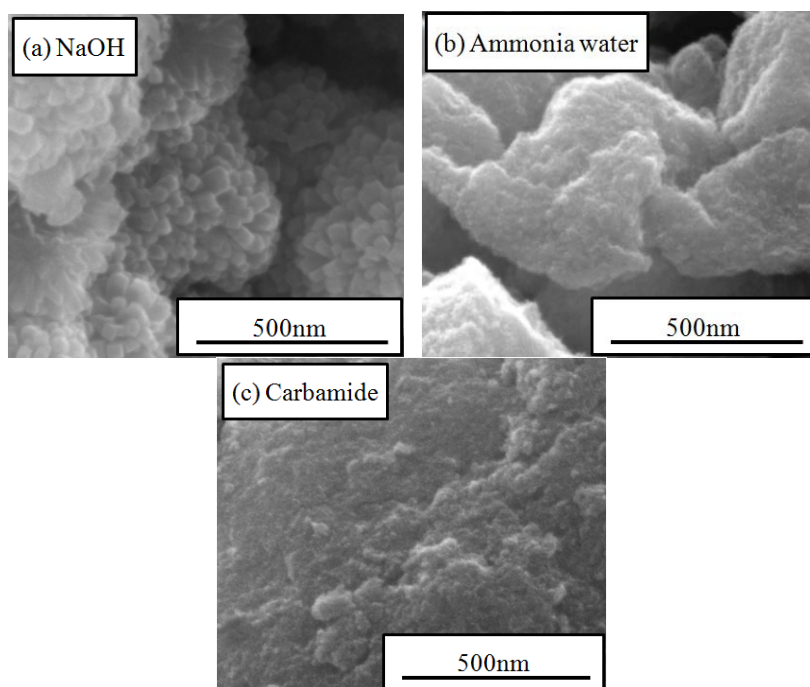


Figure 1. Microstructure of synthesized SnO_2 nano-crystalline using different auxiliary kinds

Fig.1 shows SnO_2 nano-crystal is prepared using different adjuvants with the concentration of SnCl_4 for 0.05mol/L, saline molar ratio of 1:4, 4 days incubation at 200°C environment, the size of prepared particles using NaOH as auxiliary is more large, uniform morphology than that of prepared particles using ammonia or carbamide, because NaOH is a strong alkali, it poses the large ionization degree, the number of moles of NaOH can be ionized the same amount of OH^- , while carbamide and ammonia are weak alkali, ionization OH^- is weak. When the adjuvant is 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 SnO_2 particle distribution is more concentrated, the colors of 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 microstructure of ultrafine powder prepared using NaOH as supplement aid, 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 SnCl_4 ratio is 1: 4, the grain sizes obtained a greater and more uniform appearance. Since NaOH and 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 SnO_2 particle size to form non-uniform morphology.

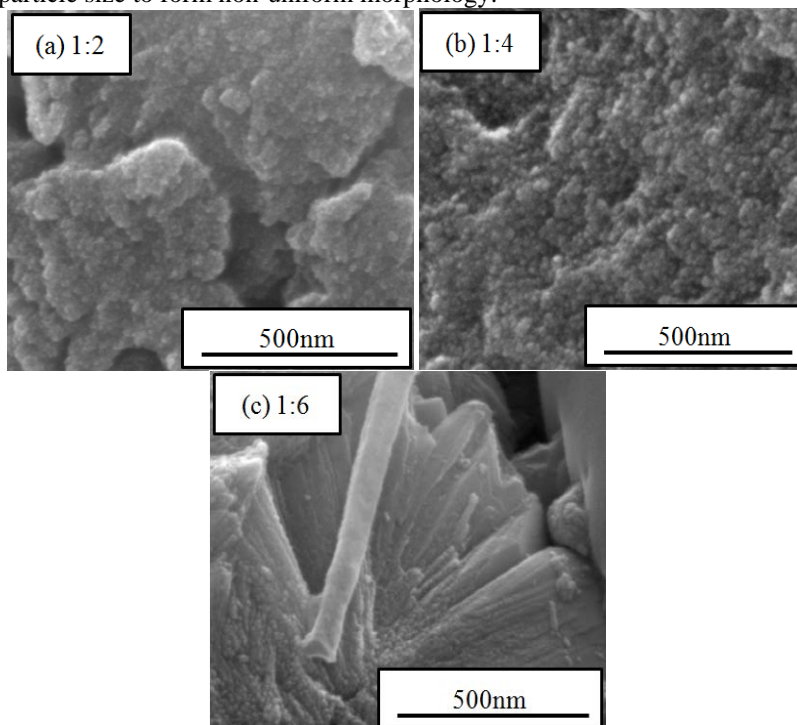


Figure 2. Microstructure of synthesized SnO_2 nano-crystalline under different salt and alkali molar ratio

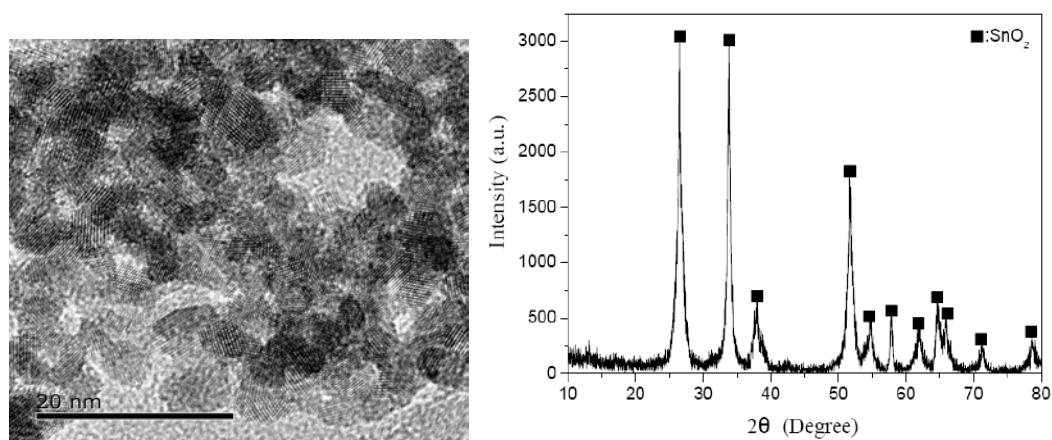


Figure 3. HRTEM and XRD of prepared SnO_2 nano crystalline

Fig.3 is the transmission electron microscopy images and X-ray diffraction phase analysis picture of synthetic SnO_2 using the conditions that 0.05mol/L SnCl_4 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_2 nanometer powder is higher purity. Further, the peak intensity is high, which indicates that the content of prepared SnO_2 nanoparticles are more, the narrow width degree of powder peak described better degree of crystallinity. On the whole, the characteristic peaks of SnO_2 nanoparticles has been quite clear, a large number of crystalline phase has been formed, and crystalline phase is very complete.

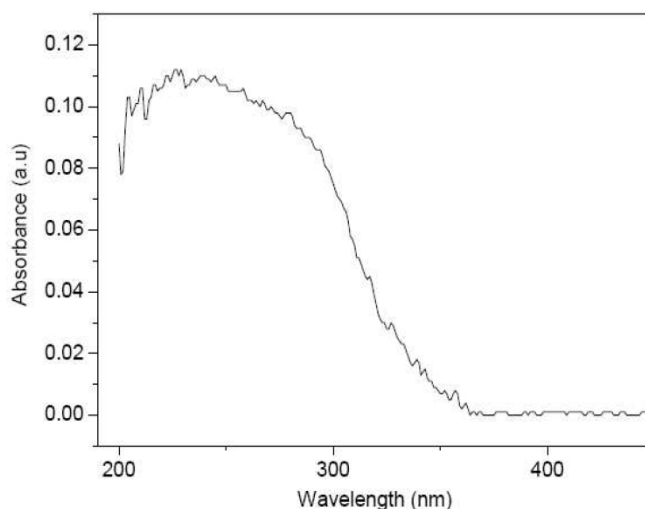


Figure 4. The absorption spectrum of synthesized SnO_2 nano-crystalline

The absorption spectrum of synthesized SnO_2 nano-crystalline under salt and alkali molar ratio for 1:4 is shown in Fig.4, which indicates the absorbance of SnO_2 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_2 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_2 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_2 nanoparticles were prepared using the conditions that 0.05mol/L SnCl_4 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_2 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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