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Application of a Different Morphology of Inorganic Compound in the New Energy Generation

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New energy is also known as non-conventional energy. Part of the renewable energy utilization technology has made considerable development, and play an important role around the world. The technology of biomass, solar, wind, hydroelectric power, geothermal energy and so on has been widely applied. For each forms energy, the morphology of the materials is quite important. Based on the overview of existing published papers, the compound can be used to improve the efficiency of the new energy power generation due to its complex nature. In addition, the performance of the material will change when the size is small enough. Therefore, both the two advantages can be used in the efficiency improving in the new energy field. In the paper, a new method to improve the performance of the new energy generation efficiency has been proposed with compound morphology. According to the experimental results and analysis, the method can be used in the performance improving in the new energy field. The results show the validity of the method and it can also be used in other fields to improve performance.

1. Introduction

New energy is also known as non-conventional energy. It refers to the variety forms of energy outside traditional energy sources, which including solar (Novacheck and Johnson (2015), Zirnhelt and Richman, (2015)), geothermal energy (Stauffacher, Muggli, Scolobig, et al, (2015)), wind energy (Ritter, Shen, Cabrera, (2015)), (Bilir, Imir, Devrim, et al, (2015)), ocean energy (Rusu and Onea (2016)), biomass and nuclear fusion energy (Ryzhkov (2015)), etc. Part of the renewable energy utilization technology has made considerable development, and play an important role around the world. The technology of biomass, solar, wind, hydroelectric power, geothermal energy and so on has been widely applied. In variety forms of the new energy, solar cell is an important way to generate the power.

The solar cell (Khezami, Megbel, Jemai, et al, (2015)), which is based on the photoelectric effect, is a main method to converting the light energy to electrical power. There are two kinds of the solar cell: organic type and inorganic type. In actual application, the research work often combines the advantages of the two types semiconductors.

For both of the two kinds of solar cell, the structure of the materials is quite important to affect the performance. For the inorganic materials, both pure substances and compound are discovered as the material in the solar cell (Han, Leo, Kim, etal (2014)). The various elements are from the third main group and fifth main group in the periodic table of the elements. For the organic materials, the research on the compound of inorganic crystals quantum dots and organic semiconductor has been greatly developed (Lee, Issam, Belmahi (2009), Beecher, Yang, Palmer (2014)). Organic semiconductors can be divided into three classes: organic, polymer and a donor acceptor complexes (Kollender, Gasiorowski, Sariciftci, (2014), Umeyama, Imahori, (2014), Patil Hemlata(2014)). For both types of semiconductor materials, the application is often appeared in the form of compound.

Based on the existing research work, the compound materials are usually adopted to improve the performance of solar cell. Meanwhile, the size scale is also becomes a hot point to study. When the material is in quantum level, the performance will be greatly changed, which can be used to help improving the performance of the solar cell. For various compounds, PbS is a semiconductor compound in IV-VI columns in

the element periodic table (Reich, Chen T, Efros, (2013)). Its characteristics of narrow band gap and larger exciton Bohr radius are quite useful to improve the efficiency of the solar cell.
For the preparation of the solar cell, the preparation of the PbS quantum dots is quite important. For the industry use, the cost of the preparation process should be cheap, and the production should has great performance. In order to improve the performance of the new energy power generation efficiency, a compound of PbS quantum dots has been prepared to improve the performance of the solar cell.

2. PbS quantum dot preparation

PbS is a semiconductor compound in IV-VI columns in the element periodic table (Yanyan Gao(2012)). It has the narrower band gap and larger exciton Bohr radius. This material has potential applications in light-emitting diodes, single electron transistor, field effect transistors, solar cells and thermoelectric materials.
Compared with physical method, quantum dots detector prepared by chemical solution can combine the advantages of high performance and low cost (Kovalenko Maksym V(2010), Shiohara Amane(2010), Morris-Cohen Adam J(2010), Kachoosangi Roohollah Torabi(2008),and Chatteriee Dev K(2008)). It can control the quantum dot size according to the amount of solvent, reaction temperature, reaction time and other parameters to adjust the material band effectively.
In recent years, there has been a lot of reports for the synthesis of PbS quantum dots with different morphology by variety of methods (,Khiew PS (2003), Sun Bing(2013), Zhou GJ(2006), Zhongbiao Zhao(2013)): PbS nanocrystals with square shape are prepared by the unit precursor decomposition and solution backflow; PbS nano crystal is prepared through the combination of the surface active agent and a polymer substrate; PbS nanowires and nanoplates can be obtained through polymer assisted thermal method; Multi legged PbS nano crystal rod can be obtained according to the thermal decomposition of molecular precursor; through the method of aqueous phase, nanocrystalline PbS with eight symmetrical arms along the 111 surface has already been prepared; dendritic PbS nanocrystals, as a kind of interesting supramolecular structure has the potential applications due to its special morphology and properties.
Direct PbS preparation method has been used in the research work. Preparation of precursor of benzoic acid lead is prepared according to the method in the reference (Zhang, Lee, Vittal, et al), (2006)], which is modified. In this paper, benzoic acid and lead acetate were dissolved in anhydrous alcohol, and the concentrations of the two reactants were diluted. A magnetic force mixer was used to stir the lead acetate solution, and then a loop mixer was inserted into the liquid level of lead acetate solution to leak the benzoic acid when it was stirring. The whole process will be realized at the condition of 55 ℃. The loop mixer is shown in Figure.1.

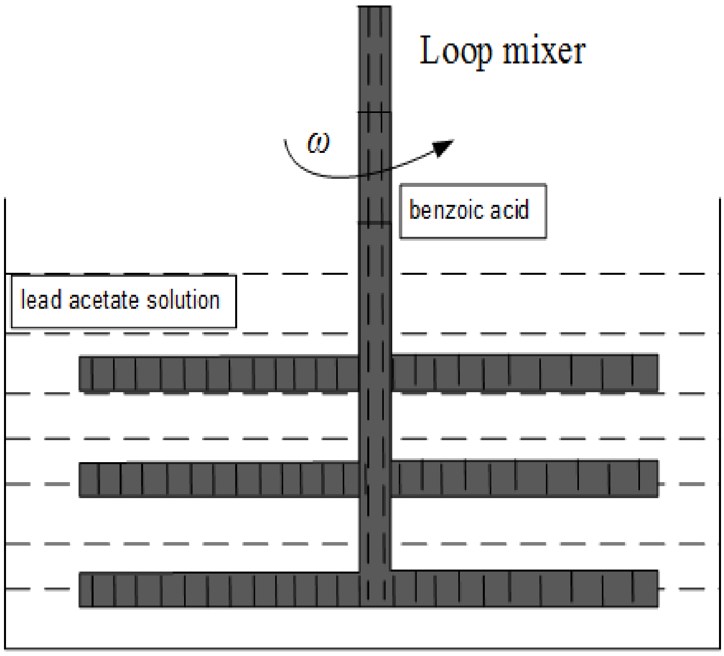

Figure 1: Schematic view of mixing process of benzoic acid and lead acetate

The synthesis of PbS quantum dots is based on the PbS quantum dot technology proposed by Zhang (Zhang, Lee, Vittal, et al, (2006)). The PbS quantum dot is obtained by improving its method. Under the condition of 60 ℃ and slow stirring speed, the morphology of PbS quantun dots are controlled by adjusting the physical conditions of the reaction, such as introducing reaction solvent and reaction additive, controlling reaction time, and so on. The reaction solvent is to make the reaction in liquid phase, and slow mixing can help to make the reaction more uniform. In the process of the experiment, the temperature of the reaction solution and the rotating speed of the circulation agitator are especially controlled.
The X ray diffraction analysis result of Pbs quantum dots shows the diffraction peaks at 26.10, 29.90, 43, 50.70, 62.90, 53.20, 71.1 and 79. Compared with the standard card, the corresponding growth orientation was (111), (200), (220), (311), (222), (400), (420) and (422). It can be proved that the PbS quantum dots are obtained. Average diameter of the quantum dots can be calculated by the Debye-Scherer equation according to the average diffraction peak of half peak width:

$$D = \frac{a\lambda}{\beta \cos\theta}$$

Where, D is the average diameter of the quantum dots; a is the geometrical factor, a=1.0; λ is the wavelength of X ray, and its value is 1.54178; β is the half peak width; θ is the diffraction angle. Then, the average diameter of the quantum dots obtained is 5.1nm.

3. The preparation of the solar cell

From the viewpoint of thermodynamics, it is easy to inject the photoelectron of the quantum dot to the conduction band level of nanocrystalline thin film SnO_2, which makes the photoelectric conversion performance of PbS quantum dot sensitized SnO_2 nanocrystalline thin film solar cell much better. In this paper, SnO_2 nanocrystalline thin film was sensitized by PbS quantum dot to improve the photoelectric conversion performance.
In these steps, SnO_2 colloid will be prepared as following steps:
1) The SnO_2 nano powder (35-50nm) was applied to the ultrasonic apparatus, and the container of the ultrasonic instrument was closed after injecting certain amount of acetone solution. The SnO_2 solution can be obtained after 2.5h with the ultrasonic and stirring action.
2) In the process of volatilizing of the acetone, the SnO_2 colloid will become viscous. In the mixing process, some Triton (TritonX-100, the composition of $C_{34}H_{62}O$) should be added by a certain amount. The SnO_2 colloid obtained will be coated on the FTO conductive glass.
3) In the high temperature environment of 550℃, 45min is needed to provide. Then, SnO_2 was sintered in different constant temperature environments, and the porous film was obtained.
The battery assembly process is listed as the following:
1) PbS quantum dot solution was prepared when it is soluted in a certain amount of 20mL toluene. The solution is dark. The FTO coated with SnO_2 film was prepared by drying 30min to remove the moisture content in the porous.
2) The production of step 1 will be placed in the MPA and acetonitrile mixed solution, where the percentage of the MPA 20%.
3) Connect the SnO_2 nanocrystalline thin films to the carboxyl group at one end of MPA.
4) Connect the PbS quantum dot sensitized agent and the molecular connector.
5) After 48h of immersion, the PbS sensitized SnO_2 nanocrystalline thin film was taken out. It can be seen that the positive and negative sides of the glass are both become dark, which means that the PbS quantum dots have been chemically adsorbed on SnO_2 nanocrystalline films.
Then, SnO_2 sensitized by the quantum dot should be washed several times by alcohol. When the film was dried, it can be used to test the performance.

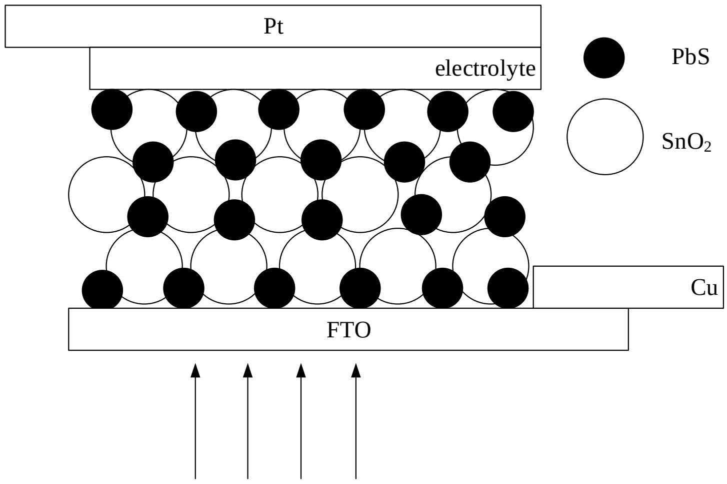

Figure 2: Assembly of the solar battery

4. Experiment and analysis

The injection process of the excited electrons can be deduced by the effect of SnO_2 nanoparticles on the fluorescence spectra of PbS quantum dots. Effect of SnO_2 nanoparticles on the fluorescence spectra of Pbs quantum dots is shown in Figure.3.

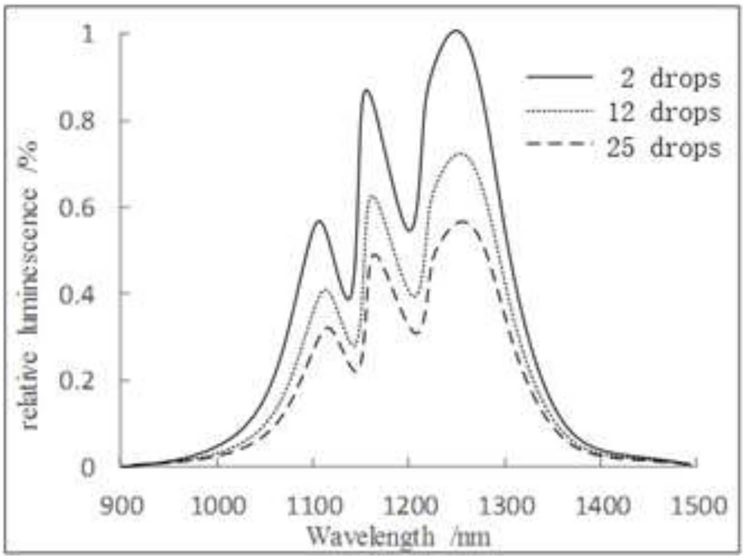

Figure 3: Effect of different drops of SnO2 nanoparticle on the luminescence of PbS quantun dots

In the toluene solution of PbS quantum dot, the peak intensity of PbS quantun dots is decreased when SnO_2 nanoparticles are injected. This means the fluorescence quenching. With the increase of the number of SnO_2, the fluorescence peak intensity decreased.

Figure 4 shows the *I-V* curve quantum dot sensitized solar cell. It can be seen that the open circuit voltage Voc=120mV and the short-circuit current is 0.38mA/cm^2. The fill factor is 0.203, while the photoelectric conversion efficiency is 0.0063%. The fill factor is relative low, and the main reason may be that the electronic transmission ability of SnO_2 nano crystal thin film is poor, which increase the inner battery resistances. The main reason of the low open circuit voltage is the redox potential of the electrolyte close to the SnO_2 conduction band level. It can be increased according to the electrolyte with suitable redox potential.

The reason of low short circuit photocurrent is that the poor connection between quantum dots and nano crystalline thin films, which affects the injection kinetics of the photo generated electrons. Therefore, based on the analysis of SnO_2 nanocrystalline thin film solar cell sensitized by PbS quantum dots, the photoelectric conversion efficiency of solar cells can be improved by structure adjustion, composition and process.

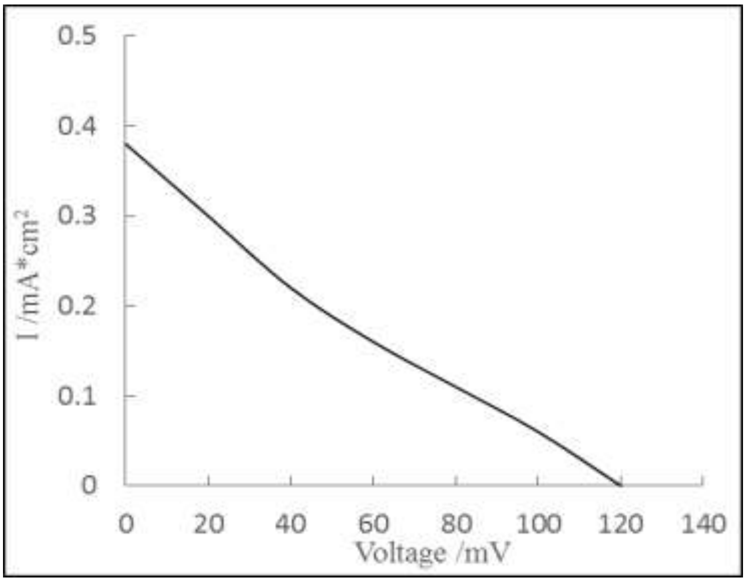

Figure 4: The I-V curve of SnO2 sensitized by PbS quantum dot

5. Conclusions

New energy is also known as non-conventional energy. It refers to the variety forms of energy outside traditional energy sources, which including solar, geothermal energy, wind energy, ocean energy, biomass and nuclear fusion energy, etc. Part of the renewable energy utilization technology has made considerable development, and play an important role around the world. The technology of biomass, solar, wind, hydroelectric power, geothermal energy and so on has been widely applied. In variety forms of the new energy, solar cell is an important way to generate the power.

In order to increase the efficiency of the in organic solar cell, a compound of PbS quatum has been prepared and applied to the solarcell. The experiment gives some results:

(1) In the toluene solution of PbS quantum dot, the peak intensity of PbS quantum dots will be decreased when SnO_2 nanoparticles are injected;

(2) The open circuit voltage and short-circuit current have some extent improvement.

(3) The fill factor is relative low due to the poor electronic transmission ability of SnO_2 nano crystal thin film, and the main reason of the low open circuit voltage is the redox potential of the electrolyte close to the SnO_2 conduction band level, and the reason of low short circuit photocurrent is that the poor connection between quantum dots and nano crystalline thin films.

The experiment shows the validity of the preparation method of the PbS quantum dots and SnO_2 solar cell.

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