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Review: Metal Disulphide used as Counter Electrode for Dye Sensitized Solar Cell

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Abstract—*Dye sensitized solar cell is the alternative of the silicon solar cell. It is a third generation solar cell. Dye sensitized solar cell consists of several components photo anode which act as electron transporting layer, a dye, electrolyte and counter electrode. Counter electrode collects electrons from external circuit and promotes regeneration of $I_3^-$from I^- .Counter electrode should have high electrochemical activity and low charge transfer resistance. Past few year, platinum is used as counter electrode in dye sensitized solar cell, it's too expensive and scarce, so we need to explore other low cost effective platinum free counter electrodes and those materials which have high surface to volume ratio . The metal disulphide used as counter electrodes are NiS_2, MoS_2, WS_2, TiS_2, SnS_2, etc. In this paper we have discuss the morphology, electrochemical property and synthesis of metal disulphide materials for counter electrode.*

Keywords*: DSSCs, counter electrodes.*

Introduction

Energy crises is the main issue in the twenty first century .Combustion of nonrenewable sources of energy such as petroleum, coal, natural gas increase day by day causes pollution that causes several environmental problems e.g water resources pollution, frequently occurring fog haze, green house effect and so on . Due to these causes society is moving towards the use of infinite energy resources such as geothermal, wind, solar and hydrothermal which offers clean and sustainable environment[1].Disadvantage of these resources is they cannot utilize continuously and completely, they totally depends upon the natural conditions[2].Thus, we need to apply sustainable and clean energy development strategies which involve major technology changes such as replacement of various fossil fuel, efficiency enhancement in energy production, energy saving on demands .In this regard various technology is required to convert off peak electricity into different form energy storage during on periods[3] .To strike balance between the needs and demands and the environmental issues, to investigate in clean and sustainable energy in solar energy, particular in solar cell, is needed to attendant in green energy future. Solar cell play a essential role in our daily life.

Silicon has been used for fabrication of solar cell. Silicon solar cell is expensive in comparison of Dye Sensitized solar cell .Advantages of Dye sensitized solar cell over silicon solar cell are flexible, light weight, low toxic and it gives good performance in diverse light condition. DSSC consists of photoanode (TiO_2, ZnO, SnO_2), having thickness of several micron which grown on the conducting substrate, a sensitizer (dye), electrolyte (e.g I_3^-, I) and counter electrode(NiS_2, MoS_2, WS_2, TiS_2, Pt) [4].Platinum is generally used as counter electrode in solar cell, but it is a scarce metal and its mass production is too expensive . for fabrication of conventional platinum counter electrode heat treatment is required which exclude the flexible solar cell[5].So we require a platinum free counter electrode, which have cost effective, high conductivity, large surface area and flexibility to fabricate any type of substrate[6] .So researcher strongly moves towards new class of materials, transition metal sulphides such as NiS_2, MoS_2, WS_2, TiS_2, SnS_2 have been investigate to fabricate to platinum free counter electrode for DSSC. Counter electrode acts catalysts, it play an important role in DSSC which helps in reduction I_3^- ions to I^- in redox electrolyte for dye regeneration [7].

For the past few years metal sulphide acts as prominent candidates for counter electrode in DSSC because metal sulphides have high electrochemical activity, high conductivity, and unique morphology . Metal sulphide have low charge transfer resistance, faster ions transport, long cycle stability unique morphology such hollow sphere, nanorod, nanoprism, nanodisk and so on .transition metal sulphides have large surface area, which is good for electrochemical activity Due to their small size of metal sulphide it can provide more electro catalytic sites for charge transfer [8]Due to these properties metal sulphides excellent for fabrication of counter electrode for DSSC .In this paper, we have studied electrochemical study, synthesis and morphology of the metal sulphides

2 Importance of counter electrode

Counter electrode is the crucial component in Dye Sensitized Solar cell. In DSSC counter electrode has three main functions (a) Its acts as catalyst for reduction of I_3^- and I^-, which are intermediate between dye after inoculation of electron, (b) its collects electron from external circuits and load to the electrolyte, (c) Counter electrode behave like a mirror, it reflects the unabsorbed light back to the cell and improve the efficiency of solar cell[9].

3 Materials for counter electrode

3.1 Nickel Sulphide(NiS_2)

NiS_2 is the important phase of nickel sulphide .Nickel Sulphides occurs in many phases such as Ni_3S_2, Ni_7S_6, Ni_3S_4, Ni_9S_8 [10] . Nickel sulphide has two prominent phase α-NiS and β-NiS, low temperature phase rhombohedral millerties and high temperature phase hexagonal . There are several method for the synthesis of nickel sulphide such as hydrothermal method, microemulsion method, sol gel .co-precipitation method. It has excellent optical, electrical and electrochemical properties .Nickel disulphide have unique morphology such as nanorod, nanoprism, nanowhisker[11].Nickel sulphide has low charge transfer resistance, high conductivity, long cyclic stability, faster ions transport .Nickel sulphide shows excellent electrochemical behavior .Nickel sulphide has high cyclic stability (1000), at 350 cycle capacitance remains maintained [12].

3.2 Molybdenum disulfide(MoS_2)

Molybdenum Disulphide is the most typical transition metal disulphide .Molybdenum disulphide is the most stable existing semiconductor .They have several method for synthesis such as chemical vapour deposition, Solvothermal, thin film etc. Molybdenum disulphide has high carrier mobility and diffusion length. This made up Mo layer is sandwich between the two S layers It has high electrochemical activity [13], good mobility, large optical ($\sim 10^7 m^{-1}$) in the visible range [14].

3.3 Tungsten(WS_2)

Tungsten Disulphide has a band gap (1.3ev-2.2ev) in the range of photovoltaic .It has tuneable electronic properties by doping with other molecule and atoms .Due to incident photon it absorb maximum light which enhance the efficiency of solar cell .It also exhibits outstanding transport carrier and high carrier mobility. The maximum efficiency 23.26% has been obtained with J_{sc} of 33.49mA/cm^2 and V_{oc} of 0.843V as silicon solar cell [15].

3.4 Titanium Disulphide(TiS_2)

Titanium Disulphide has excellent thermoelectric property, it has unique morphology such as nanorod, nanotubes, nanodisks etc it has large surface area which is good for electrochemical activity .It acts like catalyst for redox I_3/I^- in solar cell [13]

3.5 Tin Disulphide(SnS_2)

Tin Disulphide is a direct band gap semiconductor material. Optical and electrical property can be vary by doping using suitable dopants like Chlorine, Silver etc .It has unique morphology such as nanocrystal, nanowire, nanosheets, and excellent electrochemical activity, which is good for counter electrode in Dye Sensitized solar[16] .

4. Different methods for preparation of Counter electrode

There are several methods for preparation of counter electrode such as thermal decomposition method, hydrothermal method, Solvothermal method, chemical vapour deposition .Particle size, morphology and surface area depends upon the preparation technique small particle size and large surface area promotes excellent electrochemical activity which is good for solar cell efficiency [17]

4.1 Hydrothermal method

Hydrothermal method is used for the synthesis of transition metal disulphide for specific size and shape .In hydrothermal method water is used as solvent at high temperature and pressure,

Using this method we have controlled the structure and size of the particle by varing temperature, pressure, reactant ratio and reaction time

4.2 Solvothermal method

Solvothermal method is similar to hydrothermal method, In this method we use non –aqueous

Solution .the crystallization and growth has been controlled by temperature, reaction time and concentration of the precursors.

4.3 Thermal decomposition

Thermal decomposition technique is a chemical decomposition technique caused by heat .The reaction is usually endothermic because heat is produced by breaking of chemical bond .It is usually a simple and easy technique .Porous Structure is obtained using this technique which is good for electrochemical activity

5. Conclusion

In this paper, we have summarized the morphology, electrochemical activity of transition metal disulphides. We concluded that transition metal disulphide better than platinum for counter electrode in Dye Sensitized Solar Cell.

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