ABSTRACT

Energy, one of the fundamental requirements for society's progress, cannot be created or destroyed; it can only be changed into one form or another. The world's need for energy is growing every day as a result of population growth and ongoing industrialization. Traditionally, fossil fuels like coal, petroleum, and natural gas are used to generate electricity. However, these fuels will eventually run out in addition to devastatingly polluting the environment and posing significant difficulties for earth's living creatures. In order to meet our ever-increasing energy needs, it is necessary to find some unstoppable energy sources that can supplement traditional energy supplies and take their place in the future. The use of renewable energy sources that are free from the issues related to the use of fossil fuels has therefore received attention. Some of the possibilities available to us are solar, wind, tidal waves, geothermal, and biomass.

Although conventional Silicon-based photovoltaic technologies are promising, the expensive cost of these cells makes them uncompetitive with current power generating methods. Contrarily, dye-sensitized solar cells (DSSCs) are a non-traditional photovoltaic technology that has garnered much interest due to its promising conversion efficiencies, low cost, non-toxic, and recyclable components, and adaptability for a wide range of end-user goods. Though many other DSSCs have been studied, the majority of them have not yet gained commercial popularity due to problems with low conversion efficiency, production costs, and lower stability and durability. The main objective of this thesis is to investigate on the different components of DSSC with an aim to optimize its performance in terms of environment-friendly nature, cost-effectiveness, better durability and improved light to electron conversion efficiency. This thesis is broadly organized into seven chapters. The favorable results from this thesis will lead to the following mentioned outcome.

Chapter 1 addresses the world's present energy scenario and an overview of the necessity of renewable energy sources. This chapter also includes a brief discussion about different types of photovoltaic devices available. Furthermore, a basic introduction to DSSC, its construction and role of its different components is also discussed in this chapter. Besides this, the working principle of DSSCs is also described.

Chapter 2 describes the basic theory and detailed description about different experimental techniques viz. X-ray diffraction analysis (XRD), Scanning electron microscopy (SEM), Energy-dispersive X-ray spectroscopy (EDS) study, UV-VIS spectroscopy and Raman spectroscopy used for characterizing the materials of the different components of DSSCs. In addition, the principles of Current-Voltage (I-V) and electrochemical impedance spectroscopy measurement along with the detail description of critical parameters determining the device performance, have also been discussed in this chapter.

Chapter 3 illustrates a comparative evaluation of optical, electrical and electrochemical properties of DSSCs fabricated using vertically aligned ZnO nanorods synthesized using low-cost Sol-Gel spin coating technique on ITO coated glass substrate and ZnO nanopowder and their application in the fabrication of natural dye-based Dye Sensitized Solar Cells. Natural dyes extracted from pomegranate and turmeric are used as sensitizers. Electrochemical impedance spectroscopy (EIS) was employed for a detail investigation of the charge carrier recombination properties and the charge transfer mechanism at different interfaces of the devices.

Chapter 4 contains an investigation on the impact of surface modification via sol-gel spin coating of ZnO nanoparticles on the performance of WO_3 photoanode-based DSSCs by varying the concentration of ZnO precursor solution. The semiconducting material WO_3 was chosen in search of a photoanode material for DSSC alternative to TiO_2. However, the performance of pure WO_3 based DSSC was found to be extremely poor despite having several advantageous properties. To improve the photovoltaic performance of the cell, the WO_3 surface was coated with varying concentrations of the ZnO precursor solution. It was observed that the concentration of the precursor solution of ZnO highly controls the photovoltaic performance of the DSSC.

Chapter 5 depicts the role of optimum concentration of chenodeoxycholic acid (CDCA) as anti-dye-aggregation material in improving the DSSC performance based on rose bengal dye. Aside from this, the effect of a very thin and compact ZnO blocking layer was also investigated to reduce the charge recombination and hence to improve the performance of dye sensitized solar cells.

Chapter 6 focuses on the use of gel electrolyte in DSSC instead of liquid electrolyte. The leakage problems of liquid electrolyte, electrode corrosion, photo-degradation of attached dyes, and solvent volatility restrict the long-term performance of DSSCs based on liquid electrolyte. To overcome these limitations, gel electrolyte has been used as the volatility of organic solvents can be decreased and leakage can be prevented by gel-type electrolytes. Gel electrolyte-based DSSCs have been fabricated with ethyl cellulose (EC) as gelation material in the conventional liquid electrolyte containing LiI and I_2 as a redox couple in acetonitrile solvent to enhance the stability of the cells. Both TiO_2 and ZnO were used as photoanode materials for different types of DSSCs. Photovoltaic performance, including their stability behavior over a certain period of time were also evaluated.

Chapter 7 summarizes the essential findings and conclusions arising from the present work.