STUDY ON EFFECT OF DUAL-LAYER POLYVINYLIDENE FLUORIDE NANOFIBER MEMBRANE TOWARDS QUASI-SOLID STATE DYE-SENSITIZED SOLAR CELL'S CHARACTERISTICS

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Abstract

Dye-sensitized solar cell (DSSC) is one instance of third-generation photovoltaic cell that is capable to be manufactured without sophisticated machineries. Adaptation of polymer-based electrolytes in dye-sensitized solar cells' fabrication have contributed benefits in enhancing the DSSCs' performance. Polymer nanofiber membrane-based material was utilized in the fabrication of DSSCs to function as quasi-solid electrolyte. The impact of Polyvinylidene Fluoride (PVDF) membranes with varied pore sizes and layers of DSSCs' structures and their photovoltaic characteristics are investigated in this paper. The implementation of 0.45µm/0.1µm-pore sized dual-layer PVDF nanofiber membrane as quasi-solid electrolyte in DSSC's structure has shown good improvement in enhancing short circuit current density, fill factor and efficiency with the values of 3.0716µA/cm^2, 56.84% and 0.000539%, compared to the 0.1µm-pore sized single layer PVDF nanofiber membrane' structure with 2.0957µA/cm^2, 46.18% and 0.000337%, respectively.

1 Introduction

Recent growth in the world's largest population and a rise in consumer habits are two of the critical factors of today's rising energy demand and electricity usage. Fossil fuel is mainly used to heat, power, and fuel vehicles[1]. As energy is essential to human existence, there can utilize numerous alternatives to fossil fuels. Renewable energy is one example. It is believed that renewable energy, such as solar energy, can be defined as energy produced by the sun. Solar power may be the most viable choice in the future for various reasons[2]. First, solar energy is the most abundant renewable energy source, and the sun emits it at a rate of 3.8x10^{23}kW, of which the earth captures around 1.8x10^{14}kW[3]. Solar energy reaches the earth in several forms, including light and heat. Second, it is a potential source of energy on the planet since it is non-exhaustible and has greater output efficiency than other energy sources. In addition, scientists have prioritized the development of photovoltaic devices that can convert light into electricity[4].

The dye-sensitized solar cells (DSSCs), one of the emerging photovoltaic cells, were invented by O'Regan and Gratzel in 1991[5]. Due to its economic cost, ease of manufacture, and relatively high-power conversion efficiency, especially at low light intensities, DSSCs have attracted considerable interest. Transparent conducting oxide on a glass substrate, a semiconductor photoanode, a ruthenium-based dye, a redox electrolyte solution, and a counter electrode are the standard components of DSSCs[6]. Recent advances have been made in each component of DSSCs to achieve excellent performance, such as a platinum-free counter electrode, metal-free organic dyes, flexible DSSCs instead of glass substrate, and solid-state and quasi-solid electrolytes [7]. Unfortunately, the usage of liquid electrolytes has resulted in complications for DSSCs due to crucial concerns that continue to affect them. Liquid electrolyte disadvantages include leakage, liquid volatility, and dye desorption[8].

Many studies have improved durability and stability by replacing the liquid electrolyte used in DSSCs with a solid-state or quasi-solid electrolyte. Utilizing quasi-solid electrolytes formed from a polymer nanofiber membrane in a solution electrolyte is a new improvement for DSSCs electrolytes. These semi-solid electrolytes with a structured network of polymer nanofibers display ionic conductivity values comparable to those of a liquid electrolyte while maintaining a semi-solid structure, thereby decreasing solvent evaporation and leakage and providing mechanical stability[9]. In addition, the excellent contact between the photoanode and counter electrode is a feature of the quasi-solid state. Even though this electrolyte is less efficient than its counterpart, the efficiency can still be increased by incorporating various additions. The additives can be added for multiple purposes, including improving the thermal, mechanical, or electrical properties of a quasi-solid, enhancing charge carrier movement, and modifying the parameters of DSSCs [7].

This study utilized the polymer nanofiber membrane constructed from Polyvinylidene Fluoride (PVDF) because of its low glass transition temperature, high solubility for organic