

## Chapter 6

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***Conclusion and Future Scope***



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## 6.1. Conclusion

Dye sensitized solar cell (DSSC) is an emerging third generation photovoltaic device. Easy fabrication, significant photoconversion efficiency and inexpensiveness has made DSSCs very popular among the scientific research communities across the globe. The solvent (in the electrolyte) provides a suitable medium for the redox couple to carry out efficiently the electrochemical charge transfer and charge diffusion processes to generate electric current from the cell. The leakage and evaporation of the volatile solvents used in DSSCs affect its long-term stability. The stability of a DSSC can be improved by replacing the liquid electrolyte with a polymer gel electrolyte (PGE).

DSSCs fabricated using PGEs comprising poly(methyl methacrylate) (PMMA) host incorporated with various additives like polyaniline nanotube (PAniNT), carbon black (CB) and carbon dots (CD) were found to be highly efficient. Furthermore, low-cost carbon based catalyst with high surface area and catalytic activity like PAniNT/reduced graphene oxide aerogel (PAniNT/rGOA) was used as a Pt-free counter electrode to make the device more cost-effective. In order to achieve the above results, synthesis and characterization of various components of a DSSC (i.e., PGEs based on PMMA host with different additives and carbon based counter electrode material) were conducted in detail. The influence of different additives in PGE (PAniNT, CB and CD) on the device parameters were studied and optimized. The electrical and electrochemical behaviors of the DSSCs prepared using different PGEs were investigated under simulated sunlight mimicking 1 Sun illumination. The device performance of the DSSCs fabricated with PAniNT/rGOA counter electrode was also evaluated and optimized.

The important outcome of our study is summarized as follows:

- 1. A Highly Stable and Efficient Quasi-Solid-State Dye Sensitized Solar Cell Based on Poly(methyl methacrylate)/Polyaniline Nanotube Gel Electrolyte**
  - 1.1 A novel PGE based on PMMA and PAniNT blend was successfully synthesized.
  - 1.2 The highest efficiency of 5.11% was obtained with the DSSC fabricated with PGE (containing 0.30 wt% PAniNT) under irradiation of 100 mW cm<sup>-2</sup> and AM 1.5 simulated sunlight.
  - 1.3 The addition of PAniNT in the PMMA polymer matrix improved the magnitude of  $J_{SC}$  by increasing the ionic conductivity of the gel electrolyte.
  - 1.4 The DSSC fabricated with polymer gel electrolyte with 0.30 wt% PAniNT retained 47.6% of the  $J_{SC}$  value after 1000 h of testing exhibiting significant long-term stability.

**2. A Highly Stable and Efficient Quasi-Solid-State Dye Sensitized Solar Cell Based on Poly(methyl methacrylate)/Carbon Black Polymer Gel Electrolyte with Improved Open-Circuit Voltage**

- 2.1 A novel PGE based on PMMA and CB blend was successfully synthesized.
- 2.2 The optimized DSSC with 0.57 wt% CB in the PMMA matrix exhibited the highest photoconversion efficiency of 5.52% under irradiation of 100 mW cm<sup>-2</sup> simulated sunlight.
- 2.3 PMMA enhanced the magnitude of  $V_{OC}$  of the DSSC by restricting the movement of Li<sup>+</sup> ions in the polymer matrix while CB improved the  $J_{SC}$  value by increasing the ionic conductivity of the PGE.
- 2.4 The DSSC employing PGE with 0.57 wt% CB exhibited significant long-term stability by retaining 83% of the initial  $J_{SC}$  value after 1000 h of testing.

**3. Effect of Photoluminescent Carbon Dots on the Efficiency of Dye Sensitized Solar Cell with Poly(methyl methacrylate) Based Polymer Gel Electrolyte**

- 3.1 A highly efficient and stable DSSC was fabricated with PMMA and CDs based PGE.
- 3.2 The optimized DSSC with 0.14 w/v % CDs exhibited photoconversion efficiency of 6.05%.
- 3.3 CDs enhanced the efficiency of the device by complementing the visible sunlight absorption region of the dye molecules.
- 3.4 The quasi solid state DSSC fabricated with 0.14 w/v% CDs exhibited a significant long-term stability with 96.7% retention of the initial  $J_{SC}$  value after 1000 h of testing.

**4. Polyaniline Nanotube/Reduced Graphene Oxide Aerogel as Efficient Counter Electrode for Quasi-Solid-State Dye Sensitized Solar Cells**

- 4.1 A graphene based PANiNT/rGO aerogel was successfully synthesized by incorporating PANiNT in rGOA.
- 4.2 The DSSC fabricated with PANiNT/rGOA as the counter electrode employing PGE exhibited the highest photoconversion efficiency of 5.47%.
- 4.3 rGOA acted as a high surface area support for PANiNTs, which played the role of electro-catalyst for triiodide reduction.

5. We have reported three different polyelectrolytes, PMMA/PANiNT, PMMA/CB and PMMA/CD. PMMA/CD based DSSC showed the highest conversion efficiency of 6.05%.

## 6.2. Future scope

DSSCs are one of the most promising third generation photovoltaic devices. The availability of raw materials, easy fabrication technique and cost-effectiveness of a DSSC makes it a possible competitor with the conventional silicon solar cells. Significant improvements have been made to different components of a DSSC to increase the photoconversion efficiency and long-term stability for their commercialization. However, in comparison to the conventional silicon cells the efficiency of DSSCs is low. There are still many challenges associated with DSSCs to make them viable for practical use and marketing.

The future scopes on the basis of the present research studies are:

1. Fabrication of flexible quasi-solid-state DSSCs employing the prepared PGEs (PMMA/PAniNT, PMMA/CB and PMMA/CD based PGEs).
2. Preparation of polymer gel electrolytes with other polymer hosts like polyethylene oxide, polyacrylic acid, polyethylene glycol or low molecular organic gelators.