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Composites of Polypyrrole, Reduced Graphene Oxide, and α-Manganese Dioxide with Ionic Liquid-Based Electrolyte for Dye-Sensitized Solar Cells

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Extended Abstract

Conventional fossil fuels are limited, emphasizing the need for renewable energy. Dye-sensitized solar cells (DSSCs) offer a cost-effective, environmentally friendly solution. However, the high cost of platinum counter electrodes and volatile liquid electrolytes limits their efficiency [1-2]. This study explores alternatives like conducting polymer composites and ionic liquids to enhance performance and stability of DSSC.

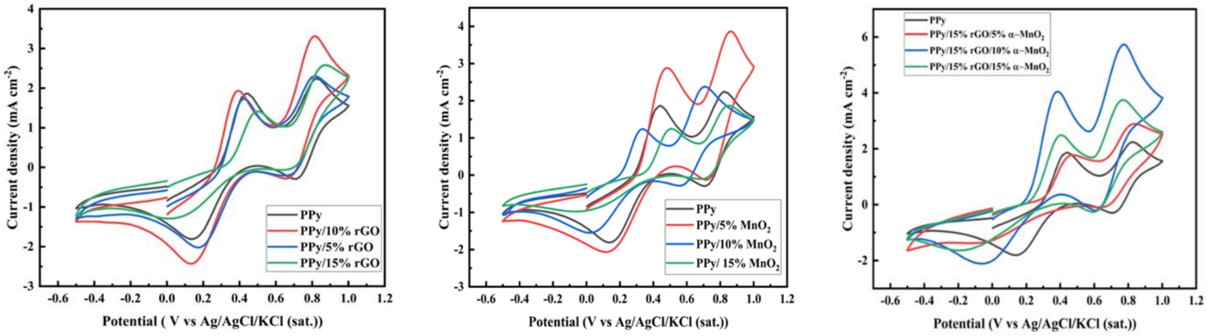
Polypyrrole (PPy), reduced graphene oxide (rGO), α-Manganese Dioxide (α-MnO2), polyvinylidene fluoride (PVDF), and 1-butyl-3-methylimidazolium tetrafluoroborate ([C4mim]BF4) were employed in the development of precursor materials and the polymer electrolyte, which incorporated an iodine-based redox mediator. The synthesis of PPy was accomplished through chemical polymerization, while rGO was generated using a modified Hummer's method, and α-MnO2 was produced via the hydrothermal approach.

Cyclic voltammetry (CV) and electrochemical impedance spectroscopy (EIS) were applied to investigate the electrochemical properties of PPy and its binary and ternary composites with different composition of α-MnO2 and rGO. According to cyclic voltammetric studies, the charge transfer kinetics of the PPy electrode with 5% α-MnO_2 and 10% rGO significantly increased. Also, the charge transfer kinetics of the ternary composite containing 15% rGO and 10% α-MnO_2 was improved, indicating its better performance as a counter electrode (CE) material in DSSCs. Fig. 1 illustrates the cyclic voltammograms of the composites of PPy with varying α-MnO_2 and rGO.

EIS measurements of the synthesized solid-state polymer electrolyte showed low bulk resistance of 25.17 Ω for the optimal composition, which enhanced the conductivity and stability of the electrolyte. Fig. 2 illustrates the EIS data showing the bulk resistance of the synthesized polymer electrolyte.

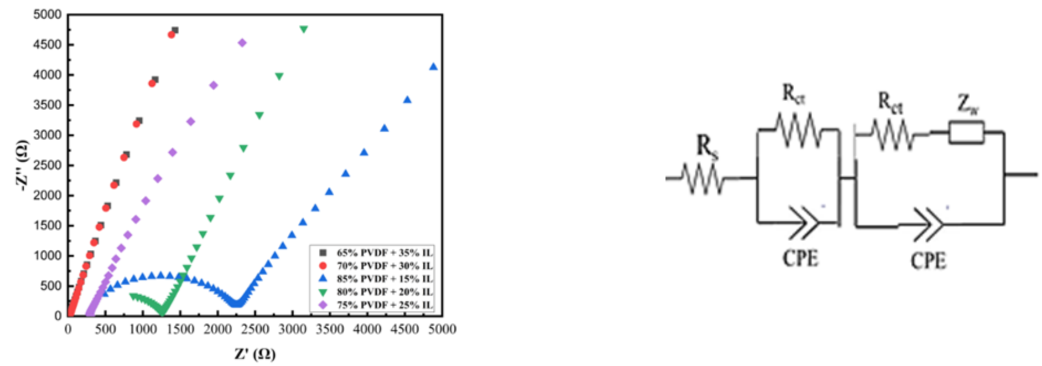
A cell was fabricated by using the standard techniques with the best performing materials, and the cell had been tested out under direct sunlight exposure which is illustrated in Fig. 3.

Huge variation in voltage indicates the successful preparation of the cell and the efficiency of the CE material with a solid-state polymer electrolyte. Further work is going on for performance testing of this fabricated solar cell.



(a) (b) (c)

Figure 1: (a,b) Cyclic voltammogram of the binary and (c) ternary composites of polypyrrole with varying the composition of α-MnO2 and rGO.



(a) (b)

Figure 2: Nyquist plot and equivalent Randles circuit for the synthesized solid-state polymer electrolyte.

References

[1].Zeng, W., Shu, L., Li, Q., Chen, S., Wang, F., and Tao, X. M., Fiber-Based Wearable Electronics: A Review of Materials, Fabrication, Devices, and Applications, Adv. Mater., 26, 5310-5336, 2014.

[2].Sharma, K., Sharma, V., Sharma, S.S., Dye-Sensitized Solar Cells: Fundamentals and Current Status, Nanoscale Res. Lett., 13, 1-46, 2018.

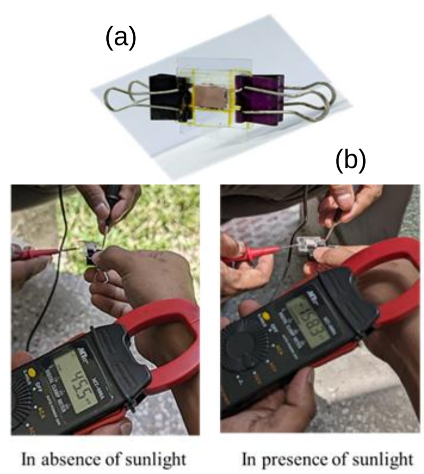


Figure 3: (a) Fabricated solar cells and (b) testing them in sunlight.