Influence of Spin-Coating Speed and Mixing Ratio on Polymer-Fullerene Films

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Abstract

Due to increasing environmental concerns and depletion of nonrenewable resources, different forms of renewable energy must be studied. Organic polymer-based solar cells are a very popular and promising form of renewable energy; however, they are still relatively new and not as well studied in comparison to traditional silicon solar cells. For that reason, the main focus of this project was to gain knowledge on how polymer-based solar cells could be enhanced by improving different variables and elements of the cell. The solar cell studied was made by mixing P3HT Poly(3-hexylthiophene-2,5-diyl) with PCBM (Phenyl-C61-butyric acid methyl ester) and spin coating the solution onto a glass substrate. By varying the ratio of P3HT:PCBM as well as using different spin coating speeds, the impact on the absorbance of the cell was studied.

Introduction

Organic polymer-based solar cells, although still relatively new, have progressed greatly. Despite the limited knowledge about these solar cells, their low costs, easy production, and improving efficiencies have proven that they are worth studying and, ultimately, optimizing. In a study done with a mixed solution of P3HT Poly(3-hexylthiophene-2,5-diyl) and PCBM (Phenyl-C61-butyric acid methyl ester) bulk-heterojunction solar cells had shown efficiencies reaching 8.13%

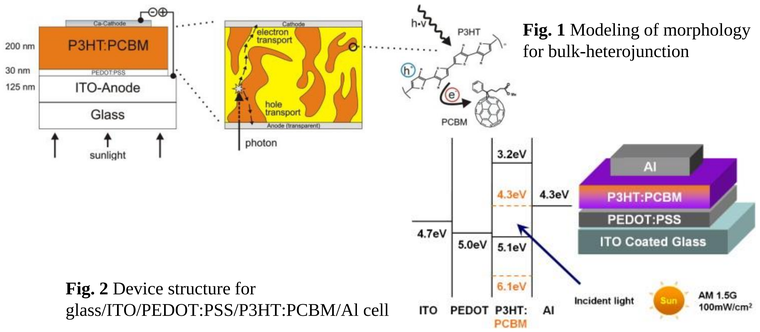

Fig. 1 Modeling of morphology for bulk-heterojunction

Fig. 2 Device structure for glass/ITO/PEDOT:PSS/P3HT:PCBM/Al cell

The pi-conjugated conductive polymer P3HT layer acts as the p-type active layer and the fullerene PCBM layer is used as the n-type active layer. Although the cell is promising, it performs lower than the traditional silicon solar cells. The purpose of this research is to discover the ideal mixing ratio and spin-coating speed for the P3HT:PCBM solution. By varying these, the absorbance of the polymer solution can be increased, and therefore the overall efficiency of the cell can be improved.

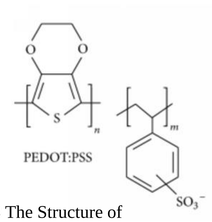

Fig. 3 The Structure of PEDOT:PSS

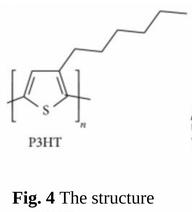

Fig. 4 The structure of P3HT

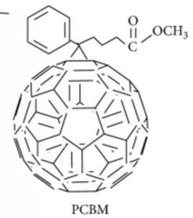

Fig. 5 The structure of PCBM

Experimental Details

To improve the efficiency of P3HT:PCBM solar cells, various parameters were varied to discover how they might influence the overall performance of the solar cell. The first parameter varied was the ratio of P3HT:PCBM. Three different ratios were tested, they were 1:1, 1:0.8, and 0.8:1. Next, the ratio was kept the same and the spin coating speed was varied between 1000, 1500, 2000, 2500 and 3000 RPM. Other variables studied include the inclusion of filtered or unfiltered PEDOT, additional layers of polymer being spin coated and the amount of time the solution was left stirring.

Results

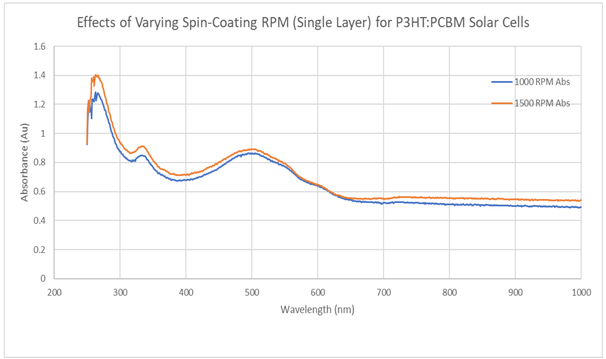

Fig. 6 The optimal spin-coating speed to yield the highest absorbance was determined

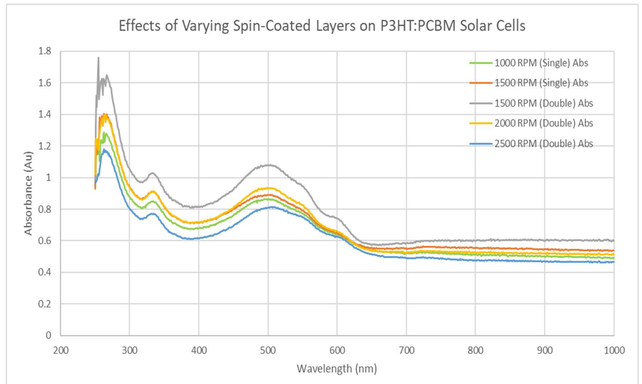

Fig. 7 After finding the right spin-coating speed, the addition of an extra layer was tested to see if the absorbance would improve further.

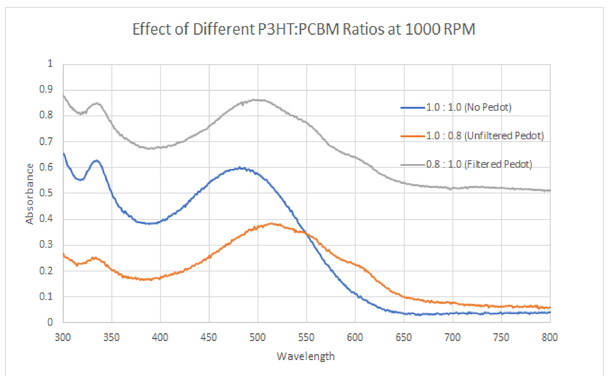

Fig. 8 Once the best spin-coating parameters were determined, the ratios of P3HT:PCBM were varied.

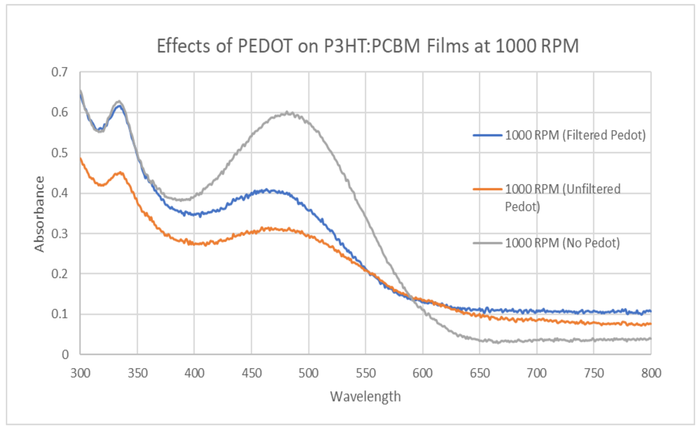

Fig. 9 As the other variables were studied, it was found that the presence of PEDOT affected the overall absorbance. The absorbance also changed depending on whether the PEDOT was filtered or unfiltered.

Discussion & Conclusion

By varying different paraments different conclusions were able to be drawn out from the data. First, the data was able to demonstrate that the best speed to spin coat at is 1500 RPM. The reason being is because this speed is fast enough to spread the polymer all over the glass slide but not too fast so that it spreads too thinly. Through further testing, the effects of applying PEDOT onto the original solution of P3HT:PCBM was observed. PEDOT would increase the absorbance at wavelengths of 650-800 nm. Filtering and not filtering PEDOT also played a role on the outcome of the absorbance of the solar cell, as the filtered PEDOT would be able to achieve a better absorbance. This is due to the fact that filtering PEDOT decreases the chances of large particles to be drawn out of the solution and therefore a better more even spread is able to create. However, the results show that using PEDOT seems to reduce the peak of P3HT. Multiple layers were also spin coated; however, this reduced the absorbance rather than increase it as predicted. It may be due to the fact that spin coating another layer would push off some of the previous layer instead of adding to it. Finally, through repetition the best mixing time was determined to be a total of 65 hours. Although a lot of conclusions were made, there are still multiple parameters left to be tested and explained such as why PEDOT affects the peak of P3HT.

References

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