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Electrical Characteristics and Efficiency of Organic Solar Cells with (P3HT: ICBA) Active Layer at Ambient

By

Nader Ahmed Khalil Adawi

Supervisors

Prof. Abdel-Karim Daud
Department of Engineering
Palestine Polytechnic University

Dr. Jamal Ghabboun
Physics department
Bethlehem University

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The undersigned hereby certify that they have read, examined and recommended to the Deanship of Graduate Studies and Scientific Research at Palestine Polytechnic University and the Faculty of Science at Al-Qdus University the approval of a thesis entitled:

Electrical Characteristics and Efficiency of Organic Solar Cells with (P3HT: ICBA) Active Layer at Ambient

Submitted by

Nader Ahmed Khalil Adawi

In partial fulfillment of the requirements for the degree of Master in Renewable Energy & Sustainability.

Graduate Advisory Committee:

Prof. Abdel-Karim Daud
(Supervisor), Palestine Polytechnic University.
Signature:——————————— Date:———————

Dr. Jamal Ghabboun
(Co-supervisor), Bethlehem University.
Signature:——————————— Date:———————

Dr. Husain Al-Samamra
(Internal committee member), Al-Quds University.
Signature:——————————— Date:———————

Dr. Ishaq Musa
(External committee member), Palestine Technical University-Kadoorie.
Signature:——————————— Date:———————

Thesis Approved by:

Name: Dr. Murad Abu Sbeih	Name: Dr.Wadie Sultan
Dean of Graduate Studies & Scientific Research	Dean of Faculty of Graduate Studies
Palestine Polytechnic University	Al-Quds University
Signature:……...……	Signature:……...……
Date:…..……...……	Date:…..……...……..

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By **Nader Ahmed Khalil Adawi**

ABSTRACT

Organic solar cells become one of the highly active research fields in Material Science for renewable energy. Organic photovoltaic systems hold the promise for a cost-effective, lightweight solar energy conversion platform, which could benefit from simple processing of the active layer. Using organic materials such as polymers and fullerene derivatives show great potential being electron donors and acceptors. A combination of narrow band donor polymer and one of the fullerene derivatives provide a possible solution for the production of efficient organic solar cells. One of the best organic active layer is the combination of Poly(3-hexylthiophene-2,5-diyl) with 1',1'',4',4''-tetrahydro-di[1,4] methanonaphthaleno [5,6] fullerene-C60 (P3HT:ICBA). High holes mobility in conjunction with good solubility and partial air stability make regio-regular P3HT electron donor, a reference material of choice for both fundamental and applied research in organic solar cells. Polymers fullerene ICBA organic solar cells are effective acceptors because of their high electron affinity and ability to transport charge effectively.

Simulation of molecular properties of the P3HT and ICBA were carried out to confirm appropriateness of HOMO-LUMO levels with the energy levels of other electrodes used in the solar cell to facilitate charge mobility through junctions of the device. A GAUSSIAN software package was used for the purpose of simulation.

Spin coating was used to deposit the P3HT:ICBA layer on a ITO substrate. Aluminuim electrodes were vapor deposited under vacuum, at different stages with a thermal evaporator and a Keithley set-up was used for Current-Voltage (IV) measurements at ambient.

The success of this research is measured by effectively building and test the cells under ambient with the available modest facilities, while the efficiency is better appreciated through using a glove box with inert gas. Samples were prepared with different P3HT:ICBA blend

ratios. While the maximum efficiency known for the best organic cells is 10% the maximum achieved efficiency in this research is 0.89% for 1:1 (P3HT:ICBA) blend ratio. IV curves were made for the cells with illumination 100 mW/cm^2 at 25 ºC. Solar cell parameters were extracted using Matlab to build our organic solar cell. Moreover, the extracted parameters were used for modeling in Matlab and got the IV and Power-Voltage PV curves at different irradiation.

الخصائص الكهربائية وكفاءة الخلايا الشمسية العضوية باستخدام (P3HT:ICBA) كطبقة فعالة في البيئة المحيطة

نادر أحمد خليل عدوي

ملخص

أصبحت الخلايا الشمسية العضوية واحدة من أهم مجالات البحث النشطة في علوم المواد و الطاقة المتجددة. إن الأنظمة الكهروضوئية العضوية تعمل على تحويل الطاقة الشمسية إلى طاقة كهربائية بسعر مناسب و وزن خفيف ، والتي يمكن أن نستفيد منها من خلال عمليات بسيطة للطبقة الفعالة. إن استخدام المواد العضوية مثل البوليمرات ومشتقات الفوليرين يدل على وجود إمكانات كبيرة لكونها من الجهات المانحة للإلكترون والمستقبلات. مزيج من البوليمر و مشتقات الفوليرين ذو فجوة طاقة ضيقة يوفر حلاً ممكن لإنتاج خلايا شمسية عضوية ذات كفاءة جيدة. واحدة من أفضل الطبقات النشطة العضوية هي مزيج من بوليمر(P3HT) والفوليرين(ICBA)-(P3HT: ICBA) ذو الإمكانية العالية لتشكل الثقوب "القطب الموجب" والذوبان في المذيبات العضوية و استقراره في الهواء يجعل من البوليمر"P3HT" مانح جيد ، وهو مادة مرجعية مفضلة في البحوث الأساسية والتطبيقية في الخلايا الشمسية العضوية. وتعتبر الفوليرين "ICBA" من المستجيبات الفعالة بسبب جذبها العالي للالكترونات وقدرتها على نقل الشحنة بشكل فعال.

تم إجراء محاكاة للخصائص الجزيئية لـ P3HT و ICBA لتأكيد ملاءمة مستويات الطاقة HOMO-LUMO مع مستويات الطاقة للأقطاب الأخرى المستخدمة في الخلية الشمسية لتسهيل حركة الالكترونات من خلال الطبقات المختلفة للخلية الشمسية. تم استخدام حزمة برنامج GAUSSIAN لغرض محاكاة مستويات الطاقة للمادة العضوية.

تم استخدام الحركة الدورانية لوضع الطبقة الفعالة P3HT: ICBA على ITO. تم ترسيب الأقطاب الكهربائية من الالمنيوم تحت فراغ في مراحل مختلفة باستخدام مبخر حراري ، وتم استخدام مجموعة Keithley لقياسات الجهد و التيار(IV) في جو المختبر.

يتمثل نجاحنا في هذا البحث من خلال بناء واختبار الخلايا تحت المحيط بفاعلية مع المعدات و الادوات المتاحة ، بينما يتم قياس الكفاءة بشكل أفضل من خلال استخدام صندوق القفازات مع غاز خامل. تم تحضير العينات بنسب مختلفة من (P3HT: ICBA). أفضل كفاءة للخلايا الشمسية العضوية وصلت إلى حوالي 10 ٪ الحد الأقصى للكفاءة الذي حققناه في هذا البحث هو 0.89٪ لنسبة مزيج 1:1 (P3HT: ICBA). تم عمل القياسات الخاصة بالمنحنيات (IV) للخلايا على شدة أشعاع 100 ملي واط / سم^2 عند درجة حرارة 25 درجة مئوية ، ثم تم استخراج المتغيرات الخاصة لخلايانا الشمسية العضوية باستخدام برنامج ماتلاب. علاوة على ذلك ، تم استخدام المتغيرات المستخرجة لعمل نموذج للخلية الشمسية العضوية في برنامج ماتلاب وتم الحصول على منحنيات IV و PV عند اشعاعات مختلفة.

DECLARATION

I declare that the Master Thesis entitled **"Electrical Characteristics and Efficiency of Organic Solar Cells with (P3HT: ICBA) Active Layer at Ambient"** is my own original work, and herby certify that unless stated, all work contained within this thesis is my own independent research and has not been submitted for the award of any other degree at any institution, except where due acknowledgement is made in the text.

Nader Ahmed Khalil Adawi

Signature:———————————— Date:————————————

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Student Name: Nader Ahmed Khalil Adawi

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DEDICATION

To my family, especially, to my father, to my mother, the reason of what I become and reached today.

To my brothers.

To my sister.

To my sweetie.

Thank you for your support

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