Analysis of P3HT Photodegradation

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Renewable Energy

https://youtu.be/h9VPWxa3HPo

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Introduction

Earth's energy consumption:
400 EJ/YEAR
Energy from the Sun:
10,800 EJ/DAY
Earth receives more energy than required!

From 2001 to 2050, increases expected in
World population:
From 6.1 to 9.4 billion people
Economic growth:
From $7,500 to $15,000 per capita GDP
Global energy demand will increase!

PV

Solar energy is harnessed primarily using photovoltaics (PVs)
The most established PVs are silica-based which are expensive and lack flexibility!
Organic photovoltaics (OPVs) are being researched and developed to pave the way to a new era of photovoltaics

OPV

Advantages:
Low fabrication cost
Light weight allowing larger surface area
Chemical flexibility for improving properties

Challenges & Proposed solutions
Environmental instability – Requires encapsulation
Lower efficiency – Improved with chemical flexibility

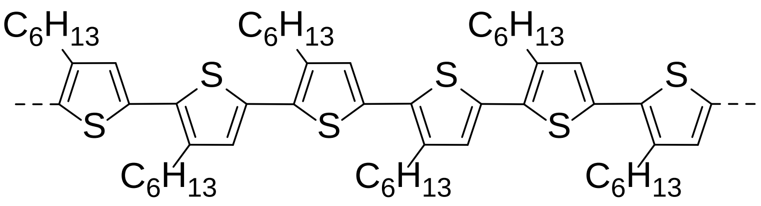
Reference 1

Objective

Poly (3-hexylthiophene-2, 5-diyl) (P3HT) is an organic semi-conductive conjugated polymer that shows promise in being used as OPVs.

Drawback of P3HT:
Degrades quickly on exposure to moisture or ultra-violet radiation through photo-oxidation causing polymer fragmentation, and ultimately reduced efficiency and operational lifetime.

The primary objective of this project was to examine the photodegradation of P3HT using an accelerated aging test using concentrated light.



Solar Cells | Fluorescence Imaging | Lasers | Photodynamic Therapy | LEDs | Photoacoustic Imaging | Spintronics

Figure 1: P3HT chemical structure (top) and its uses (bottom)

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Reference 2

Methods

1. Sample Preparation

Sample films were created using the drop-cast technique where various amounts of the solid polymer were dissolved in chloroform determined by the concentration required.

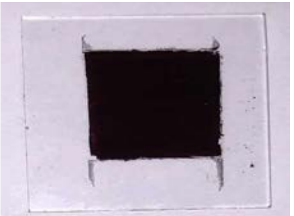

Figure 2: P3HT film on slide

2. Aging Experiment

The films created on the slides were placed under the xenon lamp for up to 120 hours in a dark environment at ambient temperature. The films were aged for light intensities of 1 and 3.7 suns, where light intensity was controlled by varying the height of the platform the cell was placed on.

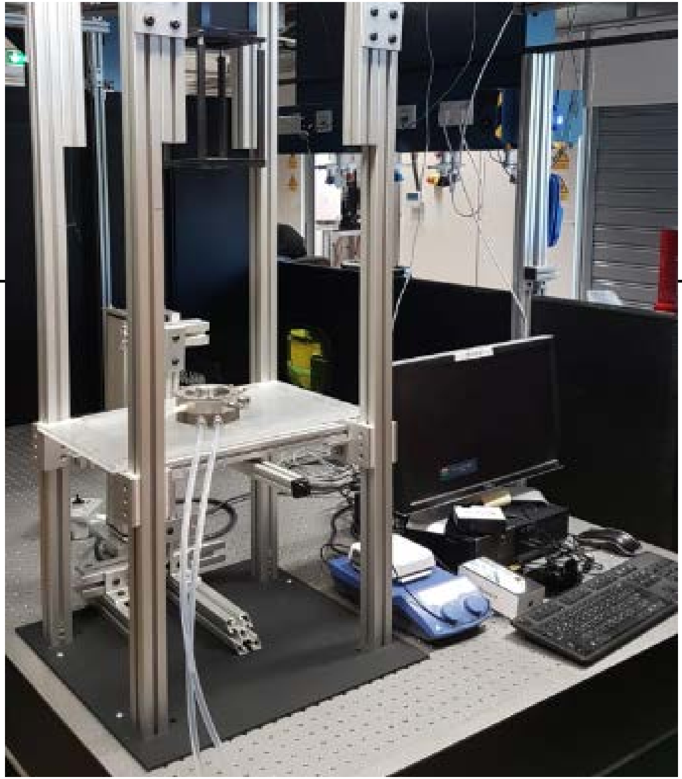

Figure 3: Experimental setup with xenon lamp and solar cell

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Methods

3. Characterization

An ultraviolet-visible (UV-VIS) spectrometer was connected to the solar cell to record absorbance values at regular intervals, and the light intensity was measured by a pyranometer. The absorbance values at different wavelengths were collected roughly every 12 hours by the spectrometer.

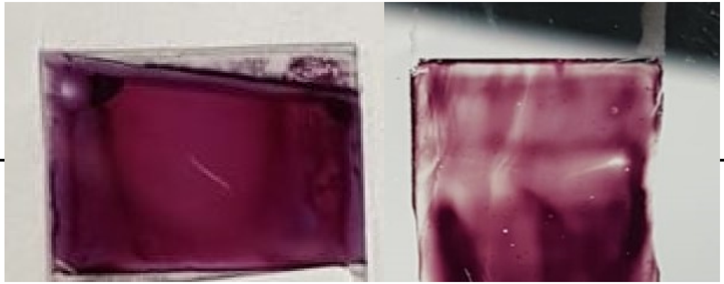

Figure 4: Before (left) and after (right) aging

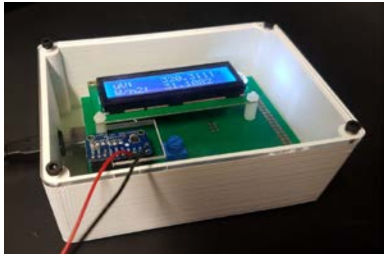

Figure 5: Arduino setup to take pyranometer readings

4. Result Analysis

The UV-VIS spectrums collected were then used to quantify the photodegradation rate of the polymer.

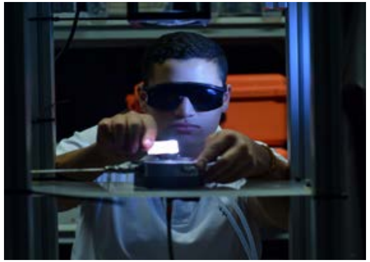

Figure 6: Removing film sample from the solar cell

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Results

Atomic force microscopy (AFM) images of the drop-casted and spin-coated polymer films indicate a significantly ***smoother surface on the drop-casted film on a micro scale showing it had, on average, a lower roughness value than the spin coated films.***

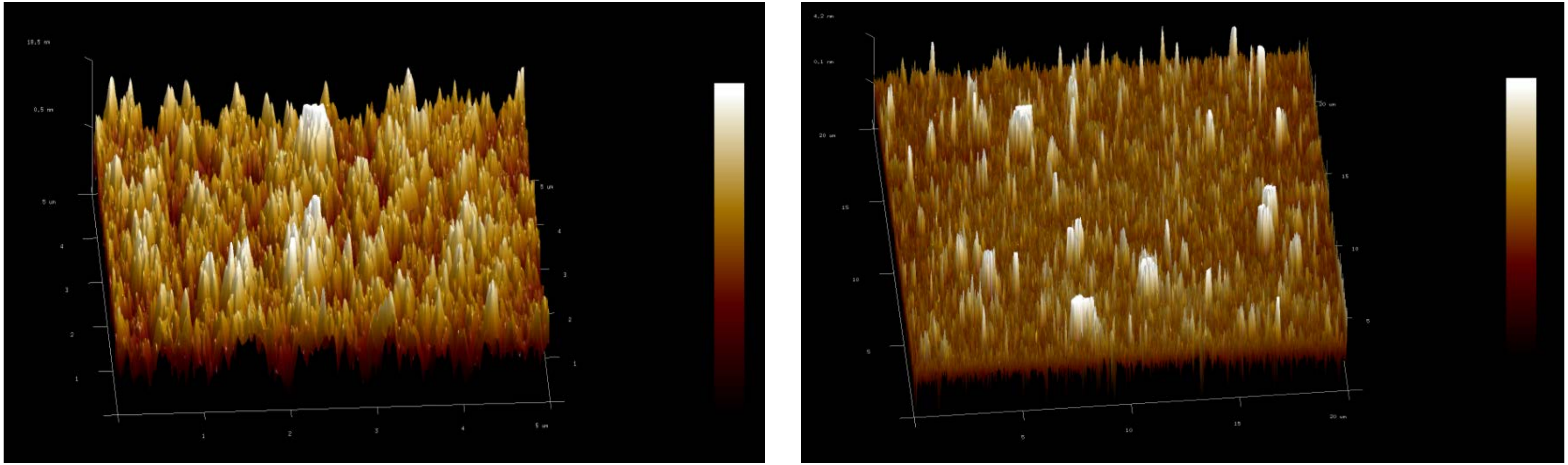

Figure 7: AFM images of the drop-casted (left) and spin-coated (right) film samples

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Results

The two graphs below indicate that with an ***increase in light intensity, the absorbance of the polymer films increases at a given wavelength***.

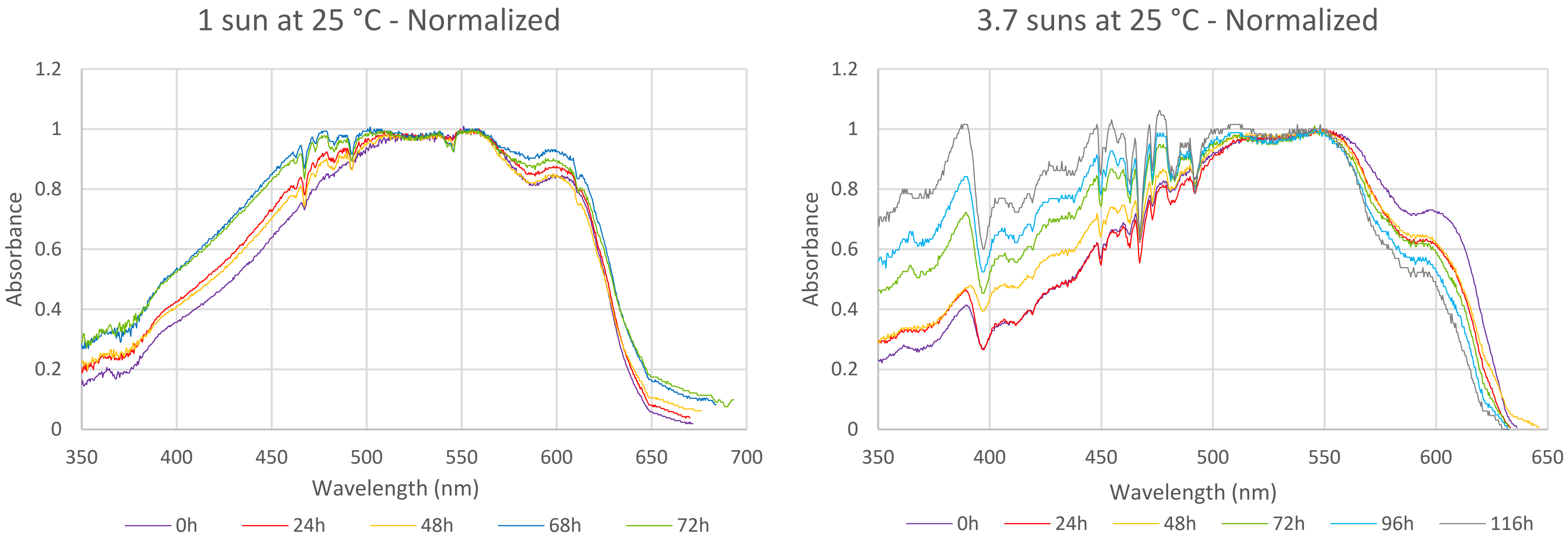

Figure 8: Normalized graphs of the aging experiments exposed to 1 sun (left) and 3.7 suns (right)

Results

The graph below which is plots the photodegradation rate (area under the normalized curve) as a function of solar energy dosage, which is simply the product of the light intensity and duration of exposure, gives an approximate relation between them as

Photodegradation rate = -0.0029 x Dosage + 0.9775

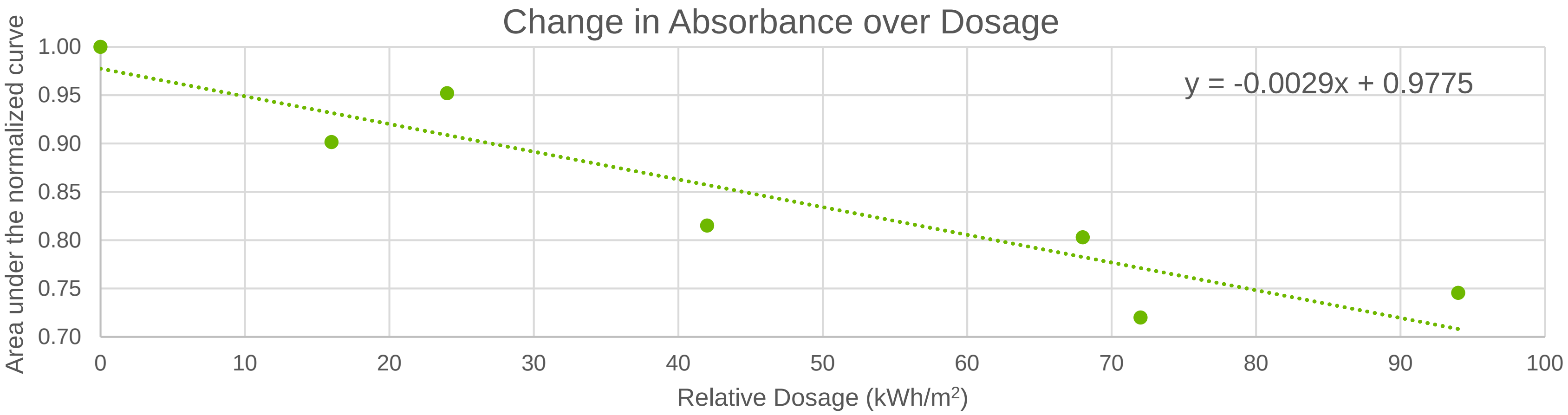

Figure 9: Area under the normalized curve for 1 sun plotted as a function of dosage

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Conclusions

The strongest absorption at a given light intensity occurs at specific wavelength regardless of the exposure period, however the total absorption of the film decreases with increase of the exposure period.

There exists a linear correlation between the dosage and photodegradation of the P3HT films, and using the equation obtained it can be estimated that a film with an area of about 1 cm^2 will take almost a month to lose it's initial absorption capacity.

There is a clear potential for P3HT to be utilized for solar applications and its performance can be enhanced by coupling it with other compounds that can inhibit or slow the degradation rates.

Future work

1.

Analyze aged films to understand changes in morphology due to photodegradation with a scanning electron microscope.

2.

Perform accelerated aging test for P3HT using a High Flux Solar Simulator (HFSS) instead of a xenon lamp.

3.

Assess economic potential of P3HT films with respect to its production, photodegradation, and maintenance.

Figure 10: HFSS setup interior (left) and exterior (right) at Texas A&M University at Qatar

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References

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1. Madogni VI, Kounouhéwa B, Akpo A, Agbomahéna M, Hounkpatin SA, Awanou CN. Comparison of degradation mechanisms in organic photovoltaic devices upon exposure to a temperate and a subequatorial climate. *Chem Phys Lett*. 2015. doi:10.1016/j.cplett.2015.09.023

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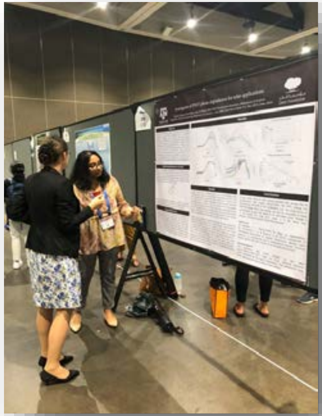

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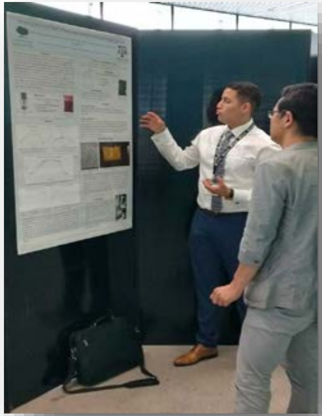

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From left to right: Dr. Konstantinos Kakosimos, Dr. Mohammed Al-Hashimi, Taha Kubbar and the Sustainable Energy and Clean Air Research lab (SECAReLab) team