CYPRUS UNIVERSITY OF TECHNOLOGY
Faculty of Engineering

MASTER THESIS

ENCAPSULATION FOR ORGANIC PHOTOVOLTAICS

Chatzipapa Antri

Limassol [2016]

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Department of Mechanical Engineering and Material Science
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Especially i would like to thank the supervisors of my thesis Dr Pano Keivanidi and Dr Stelio Chouli for their continued guidance. Furthermore, i would like to thank Dr Vasileio Drakonaki for his help in the experimental procedure of my thesis.

Abstract

In the beginning of this project work, a study was made on normal structures of Organic Photovoltaics (OPV) cells (bulk heterojunction). The next step was to examine the lifetime of Organic Photovoltaics and to find ways to increase it. The study became more specific, shifting the examination to Indoor Accelerated Lifetime. Following all these steps it was decided that in order to extend the lifetime in organic photovoltaics an encapsulation was necessary to help the process.

So, it was decided to apply an encapsulation on an OPV cell with a bulk heterojunction structure, with the use of zeo, ossila and dymax3089. The final goal was to achieve an extended lifetime for Organic Photoltaics, i.e. live further without the yield of PCE drops below 80%.

Due to several malfunctions, during the experimental process, three types of glues were encapsulated, zeo, ossila and dymach.. The comparisons were made among ossila - dymax 3089 and ossila-zeo.

The results showed that ossila is able to extend the lifetime of organic photovoltaics 21 times more than dymax 3089 is, thus, undoubtedly ossila is much better than the dymax 3089. Comparing ossila with zeo, zeo increases the lifetime of organic photovoltaic six times more than ossila does. So, according to the measurements of the specific study, it can be resulted that if an organic photovoltaic is encapsulated with zeo eraser then its lifetime will be extended more than with an encapsulation of ossila and dymax 3089. However, it still needs further research, for instance, to use more kinds of glues to have more accurate results.

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Terms and abbreviations:

Al: Aluminium

ITO: Indium Tin Oxide

OPV: Organic Photovoltaic

PEDOT: Poly(3,4-ethylenedioxythiophene)-poly(styrenesulfonate)

PCBM: [6,6]-Phenyl C60 butyric acid methyl ester

PSS: Poly(sodium 4-styrenesulfonate)

P3HT: Poly(3-hexylthiophene-2,5-diyl)

CHAPTER 1. INTRODUCTION

The tremendous growth occurred over the past century created the need for large amounts of energy. Due to the fact that the production of energy derived from fossil fuels, there was a major need for renewable energy sources such as solar, water and wind which are environmentally friendly. Based on numerous calculations, 174 petawatts of solar energy reaching the earth are left unused. For the above reasons, to start the construction and expansion of photovoltaics.

The first phase (first generation photovoltaic) started with ‘inorganic photovoltaic’ and it is a crystalline or polycrystalline silicon which consists of an interface of silicon doped with positive (p-type) and negative (n-type) semiconductors. The production of the photovoltaic is quite expensive and additionally had a short lifetime. For these reasons, scientists wanted to find out alternative materials for the production of photovoltaics.

The need for production at reduced cost gave rise to the second generation known as ‘thin-film technology’. Thin-film technology is created by depositing a thin layer of photon active material on the glass or on a flexible substrate, including metal sheets which typically use amorphous silicon (a-Si), copper indium gallium diselenide (CIGS), or candmium diselenide (CdTe) as a semiconductor. Some questions remain unanswered and they are related with the heritage of toxic materials in terms of construction and lifetime.

Subsequently, the third generation of photovoltaics is developed, named ‘organic photovoltaics’. The production is based on organic electronic material solutions. The operation of photovoltaics is very simple: there is an active region (active layer) consisting of a mixture of an acceptor and an electron donor. Because of the semiconductor excitation, the photons (from the sun) created the excitons i.e electrons stimulated and switched from the valence band to the conduction band and the hole which left behind by the positively d electron when stimulated. At the interfaces of electron donor and acceptor, exciton is disintegrated and electrons are collected creating current flow. The organic photovoltaics comparing with the inorganic are cheaper, lighter, elastically and the processing to create is easy at room temperature. Despite the advantages of organic photovoltaics, there are also some parameters which need to be considered and they are related with the cost, the performance and the lifetime. Cost and performance are already known, but the present study will examine the effects of lifetime.

1.1 Object and targets of thesis

The main object of this master thesis is the encapsulation of organic photovoltaic's with bulk heterojunction structure with glues which existed in the laboratory(ossila, dymax 3089 and ossila-zeo), in order to increase the lifetime. This means there is maintenance of efficiency over 80% of the initial measured value.

CHAPTER 2. ORGANIC PHOTOVOLTAICS, LIFETIME AND ENCAPSULATION

2.1 Organic photovoltaics:

Organic photovoltaics' manufucture is cheap allowing mass production which is harmless to the environment. Also, organic photovoltaics have high coefficient of optical absorption leading to the absorption of a big part of solar energy but it also provides the possibility of producing a very thin photovoltaic module. Nevertheless, their flexible quality makes them to be able to be fitted and to be placed on elastic substrates thus there are great print speeds leading to higher production and smaller payback time cost of the device.

The main principle of electronic structure is based on n-conjugated electrons i.e the rotation plain and double bond between carbons. The single bond includes p-bond and the double bonds and containing p-bond, and n-bond. The n-electrons have greater degree of mobility than the p-electrons. The n-electrons have two basic terms depending on the state where they are located. The first is called LUMO or conduction band. In that case, there aren't any electrons (empty) whereas when n-electrons are full of electrons they are called HOMO or valence band. The energy gap between the organic photovoltaic or otherwise between the valence band(HOMO) and the conduction band (LUMO) is between 1 to 4 ev (Figure 1).

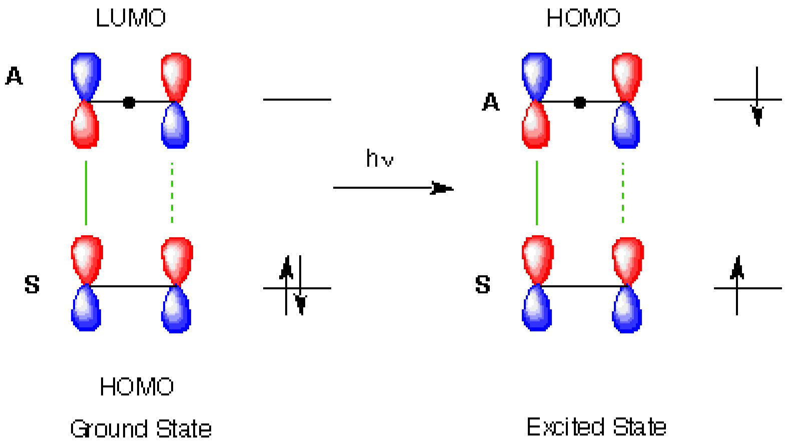


Image 1: HOMO LUMO

2.2 Bulk Heterojunction:

According to Yu (et. al.,1995), Organic Bulk Heterojunction is a material which is anywhere within a distance of only a few nanometres and it can meet interface donor / electron acceptor everywhere. The original structure is composed by a mixture of poly [2-methoxy-5 (2-ethyl-hexyloxy) -1,4-phenulene vinylene), MEH-PPV as the electron donor and electron acceptor cyanoPPV like. The principle of this structure is based on the idea of using two materials that have different affinities and electro ionization potentials. The Bulk Heterojunction due to mixing donor / electron acceptor in a layer results in larger interfaces cleavage excitons, thus, there is a potential of greater thickness of the photoactive region and greater absorption of photons. Interfacial donor / receiver are stronger dynamically so there is a greater breakdown of excitons. Subsequently, there is a collection of electrons from the material with the greatest affinity electrophoresis and a collection of holes from the material with the lower ionization potential.

When the sunlight falls (photons) on the device, it is absorbed by the solar panel from the photosensitive layer. Then, there is an excitation of electrons resulting to the creation of exciton. The photons are cleaved and the electrons pass through the polymer donor and the electron acceptor. The above separation occurs due to the interfacial difference of LUMO of the polymer donor and electron acceptor, respectively. So, there is a division into holes and electrons which now have a longer life which allows them to reach the electrodes and to be collected. In addition, there is less chance of exciton recombination [13].

2.3 Normal Structure of organic photovoltaic:

A typical organic photovoltaic structure has been chosen for the purpose of this thesis. The bulk heterojunction is chosen mainly for the following reasons [13]:

- Regarding research, there is evidence that it is the structure with the higher efficiency.

- Due to donor / electron acceptor mixing in a layer, a photo-active area of higher thickness is created providing a higher photon absorption.

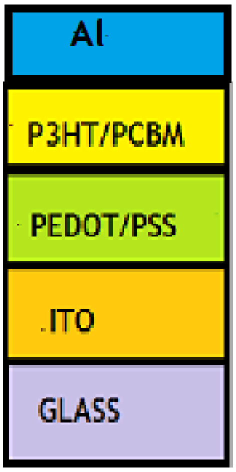


Image 2: Final Bulk Heterojunction structure

The typical structure of a bulk heterojunction photovoltaic (Image 2) consists of the following substrates:

Glass (GLASS):

Insulator is the substrate of the device. Its transparent allows light to pass. The glass must have full permeability in order to not block light and also to be cheap and an insulator (Image 3).

Image 3: Glass

ITO (Indium Tin Oxide):

It is one of the two electrodes (cathode) (together with PEDOT / PSS) and its role is to collect the electron holes. It is one of the most popular materials used as a cathode electron because of its transparency, which allows the light to pass through, and it's also easy to be found in the market. The ITO must have the corresponding energy levels and conductivity for passing light (Image 4).

Image 4: ITO

PEDOT / PSS:

It is the electrode of cathode (with ITO) and it is responsible for the collection of holes. The PEDOT blocks electrons, because the ITO collects holes and electrons, and it also ports the surface. The PEDOT must have permeability. The PSS provides transparency (Image 5).

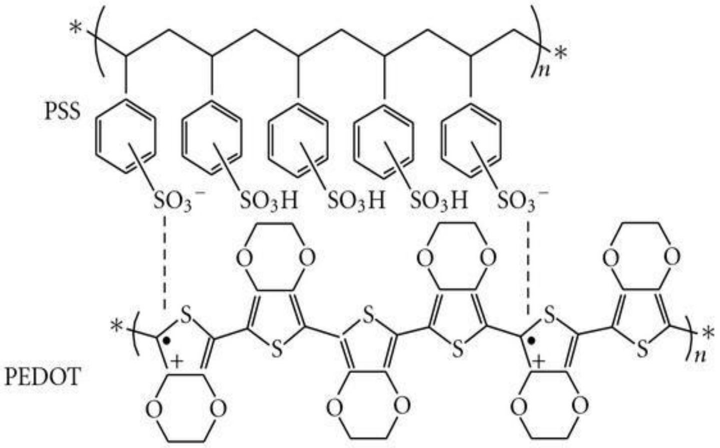


Image 5: PEDOT / PSS

P3HT / PCBM:

The P3HT is a good electron donor and PCBM is a good electron acceptor (Figure 15). Thus, placing the two semi-conducting polymers together, one gives the electrons and the other collects them, resulting in an easier and faster exciton disintegration. The PCBM (phenyl C61 - butyric acid methyl ester) has HOMO 6.1 - 6.8 eV, LUMO 3.7 - 4.1 eV and electric mobility ^{10} -3 cm / Vs. The P3HT has power agility $^{0.2}$ -3 cm / Vs, the HOMO is between 4.9 and 5.2 eV and the LUMO between 2.9 and 3.3 eV.

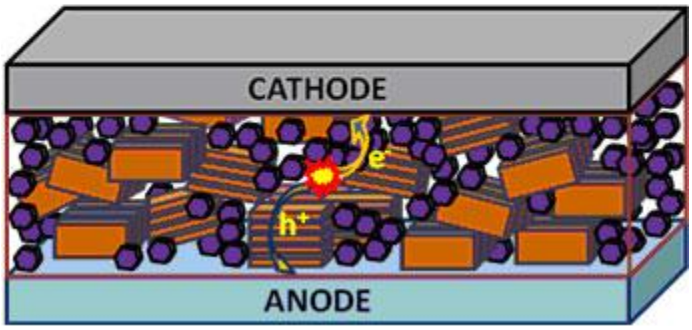


Image 6 : P3HT as anode and PCBM as cathode

Al:
The Al is the second electrode (anode electrode) and a good electrons acceptor. For this reason, it functions as anode and electron collector.

2.4 Lifetime

Recently, it has been observed that organic photovoltaics (OPVs) have noted a significant progress, especially in the aspect of their performance which marked a noteworthy increase, i.e. from 4% performance to 8.3% in 5 years and with the 10% to be easily achievable[7]. This achievement gave a good opportunity for a future commercialization of OPV. Many large steps have been made in order to extend the lifetime of OPV devices by using structures based on P3HT/fullerene BHJs. These structures showed that lifetime could be increased to 5000h when the encapsulation was made with a glass on glass. However, the stability of organic photovoltaics remains an important issue which must be resolved in order to move on a mass production of organic photovoltaics. This review deals, mainly, with the basic processes of degradation of organic photovoltaic. Recent methods attempted to increase the stability of the device and the lifetime. One of the most effective measures that can be taken in order to increase the lifetime of organic photovoltaics is the encapsulation, which protects them from atmospheric degradation. Effective encapsulation is essential for the long-term performance of the device, but it is equally important for the commercialization of organic photovoltaic. To achieve a balance between the maximum protection of the device and the low cost of encapsulation, various encapsulation techniques have been used for the analysis in current thesis focusing on the cost effectiveness and the overall suitability for commercial applications[7,14,15,16]. The power conversion efficiency of organic photovoltaic (OPV) cells has increased from 4–5% in 2005 to 7.4% and 8.3% in 2010. The goal of a 10% single junction OPV device seems attainable making the commercialization of OPV more realistic. With advances made on the efficiency front, the lifetime and reliability of OPV devices has come into focus. To date there has been considerable work done in understanding and quantifying the lifetime and degradation of bulk heterojunction solar cells (BHJs) based on poly (para –phenylene vinylene) (PPV) and poly(3-hexylthiophene) (P3HT) polymers. A comparison of OPV lifetime experimental results across different research groups has posed challenges due to the lack of standardized testing and reporting procedures; however, great strides were made in this regard during the most recent International Summit on OPV Stability (ISOS-3). Modules based on P3HT/fullerene BHJs have shown lifetimes of 5000 h when state-of-the-art encapsulation with a glass-on-glass architecture is used. Assuming negligible degradation in the dark and 5.5 h of one-sun intensity per day, 365 days per year, this translates into an operating lifetime approaching three years. More recently P3HT/PCBM devices utilizing an inverted architecture have been shown to retain more than 50% of their initial efficiency after 4700 h of continuous exposure to one-sun intensity at elevated temperatures and have exhibited a long shelf-life when stored in the dark in ambient conditions [5].

2.5 Indoor Protocols

- Environment:

In dark
Ambient: % Relative Humidity and Temperature
Controlled Environment: Room Temperature, Dry Oven (65^oC, $85\,^oC$), monitor % Relative Humidity with data logger.

- Test Protocol:

1. Remove from oven and cool in Room Temperature
2. Place under 1 sun solar simulator (report temperature)
3. JV slots/data: sweep until stable (+/-3% efficiency or <5 minutes)

- Testing interval: not specified, recommend weekly or 100hrs.

Environment for Accelerated Testing

- Temperature and % Relative Humidity
- Voltage bias.
- Data Reported:

Efficiency (PCE)
Isc
Voc
FF
JV Data
[1,12]

2.6 Encapsulation

OPVS had a great attention due to their advantages such as the easy fabrication, the low cost, and the light weight. However, the stability still remains one of the major concerns in this type of photovoltaics. When the illumination passes through the photoactive layer, photochemical reactions are taking place. This is one of the main reasons for losses so devices need to be protected from water and oxygen. There are three categories of OPVS research, the effort to increase efficiency, the roll to roll technique of deposition and the long time stability of devices. After several attempts, the efficiency of 6.4% in single layer and 10.7 % for tandem had been achieved. (Apart from roll to roll method is also one of the main topics where we can reduce the cost by using a simple process). There are plenty of articles dealing with stability and lifetime. The research of stability can be divided in the modifying device structure and the introduction of a new encapsulation method. The best encapsulation process was in 2007 where the PCE falls to 6% after 6145 hours[5]. Unfortunately, this method is rather complicated because it uses atomic layer deposition technique and this is quite costly compared to the solution process. In order to overcome these problems, a new method of encapsulation is practicing during this period. The specific encapsulation uses a solution processing UV epoxy which is a drop casting together with spin coated ZnO as buffer layer to avoid any damages from the encapsulation solution. The devices which are made with the new encapsulation technique, degrade only 20.5 % after two weeks of ambient storage. In this study, reverse structure of OPVS is used, in order to improve stability and compatibility with roll to roll method.. ITO coated (10-15 Ω cm $^{-1}$), 40 nmm of ZnO with spin coated (1500 rpm, 25s, annealing 300 ^{o}C 15'), P3HT/PC$_{71}$BM (ration 1:0.6, coated and annealing at 150 ^{o}C) PEDOT/PSS (0.5 wt % of PTE,1500 rpm 25s and annealing at 120 ^{o}C 20'-100nm). It is obvious that the annealing process is able to improve the PCE of OPVS. Also, the use of ZnO as buffer layer is made by using spin coating at the top of solar cell (700 rpm 25s, annealing 120^{o}C 20'). In addition, the encapsulation UV resin solution has beeb dropped o to ZnO and later annealed at 120^{o}C 20' and this process was repeated for five times giving around 400nm thickness of encapsulation layer [7,8,17].

CHAPTER 3. EXPERIMENTAL PROCEDURE

3.1 Fabrication

The general experimental procedure for a normal structure in organic photovoltaics, comprises the following steps:

1. Clean the glass substrate (15mm x 15mm):

1.1 Put acetone to clean any dirt and certain organic residues can be left on the glass (eg somebody got in his hands without wearing gloves).

1.2 Put isopropanol (IPA) in order to purify the acetone was used in the previous purification step.

1.3 Pneumatic order to remove any residues of paper that had been used for cleaning the glass in the previous two stages. Also compressed air helps to remove dust and any other impurities from the glass substrate can be derived from the atmosphere of the workshop.

2. Position the glass substrate in doctor blading.

3. Deposition 35 ml PEDOT / PSS in:

Temperature: 50 ° C

Speed: 30 mm / s

Height: 2 mm

4. Position the substrate in hot plate for Annealing for 30 minutes at 140 ° C.

5. Design and sample control in the microscope.

6. Surface Thickness measurement by a profilometer

7. Position the glass substrate in doctor blading.

8. Deposition 35 ml P3HT / PCBM in:

Temperature: 75 ° C

Speed: 15 mm / s

Height: 2 mm

9. Study and sample control in the microscope.

10. Surface Thickness measurement by a profilometer.

11. Position the substrate in sublimation device for installation Al.

3.2 Encapsulation process

1. Glue encapsulation placement
2. Exposure to UV light at 120 ° C
3. Placing in the hot plates at 85 ° C for 15 minutes

3.3 Lifetime Characterization

1. Position in the solar simulator at Pin = 100mev
2. Take measurement for FF, Voc , Jsc and PCE
3. Position the Photoelectrical System for Photo mapping.

3.3.1 Humidity

- In the first experiment the OPVS were placed in the oven on 85 % RH.
- In the second experiment the OPVS were placed on 85 % RH.
- In the third experiment the OPVS were placed on 85 % RH.
- In the fourth experiment the OPVS were placed on 85 % RH.

3.3.2 Damp Heat

- In the first experiment the OPVS were placed on 65 ° C.
- In the second experiment the OPVS were placed on 65 ° C.
- In the third experiment the OPVS were placed on 65 ° C.
- In the fourth experiment the OPVS were placed on 30 ° C.

3.3 Lifetime Characterizations

PCE: power conversion efficiency

PCE = n

$$n = \frac{\mathrm{Jsc} * \mathrm{Voc} * \mathrm{FF}}{\mathrm{Pin}}$$

The performance of organic photovoltaic depends on: Voc, the Jsc, the FF and Pin.

Voc: Voltage open circuit

The Voc exists due to the fact that there is a difference in energy caused by several materials in the layers of the device. So the Voc is created by the dissociated exciton. Voc depends on the materials that have been screened in order to create organic photovoltaics. If Voc is low, it means that there is a reconnection of charges, or there are high energy levels. If this is the fact, the existing materials must be replaced by materials with different energy levels.

Jsc: Short Circuit Current Density

The Jsc is created when the loads start moving. The Jsc depends on the mobility and separating ability of the excitons. So if the s remain stable and they do not move, the Jsc cannot exist. In addition to this, if the amount of disintegration of excitons is low, then the Jsc is also low.

FF: Fill Factor

Fill Factor is the factor which shows the wastages of organic photovoltaic. For instance, if there is wastage of loads, the FF will be low. On the contrary, if a large number of charges are gathered, the FF will be high. The number of s which are gathered each time is correlated with the speed of the mobility of charges (mobility of charges). The faster they move, the greater number of s will therefore be gathered resulting to high FF.

Pin: incident solar power.

The Pin is the incident solar radiation. The radiation which is sent to the solar stimulator in labs is equal with 100 mW/cm^2.

3.3.1 Humidity

Exposure to extreme conditions of humidity have been proved to act negatively on the performance of organic photovoltaic (OPV), due to the fact that the distortion is on the electrodes of the device instead of the active layer. Normal and inverted OPV devices have been studied, in order to identify the main degradation mechanisms under extreme humidity conditions. Reverse engineering can be a useful technique for the detection of the main degradation mechanisms of the anode electrode, in normal or inverted organic photovoltaics (OPVs). By using reverse engineering methods, the main degradation mechanism of inverted OPVs can be presented under accelerated humidity, due to the PEDOT: PSS (cathode electrode). The OPVs are rapidly degraded due to the sensitivity of the metals which are usually used for the anode, and this leads to oxidation ratio of the absorption of oxygen molecules. The degradation of the electrode anode leads to the formation of metal oxides preventing the electrical conductivity and the collection of s since the work function of the metal oxide has a smaller work function of the metal [20]. Some metals such as Al, Ca and Ag are usually used as electrodes in OPV devices because of their high work function.

The two main metal electrode degradation mechanisms are the oxidation, and the chemical interaction with polymers. Furthermore, when the PEDOT: PSS (cathode electrode) absorbs water, a permanent structural modification of the layers of the device is being promoted because of the hygroscopic nature of PEDOT reducing the conductivity which consequently leads to the reduction in the life of the device. Moreover, it has been observed that the acidity of PEDOT: PSS can cause etching of indium in ITO (Indium tin oxide), releasing indium ions, which then are diffused throughout the device [15,16,18.]

3.3.2 Degradation

It has been proved that the exposure to moisture has negative effects on the lifetime of the organic photovoltaic due to the deterioration of the electrodes of the device and not because of the active layer. Environmental lifetime factors, such as water, oxygen, high temperature and exposure to light are responsible for the stability of OPVs. Specifically, metals react very quickly with the oxygen, which is usually used for the anode electrode, oxidation occurs when oxygen molecules are absorbed. The degradation of the metal electrode forms thin insulating oxide barriers which block the electrical conductivity and the collection of carriers. Some metals such as AL, Ca and Ag are commonly used as electrodes in OPV devices because of their high work function. It is notable that the two main metal electrode degradation mechanisms are commonly recognized. These mechanisms are the oxidation and the chemical interaction in the active layer. The degradation caused by the oxidation at the electrode / polymer interface may result to the formation of an oxide layer at the top of the metal surface, and in the metal / polymer interface. This oxide layer prevents the electrode selectivity, thereby reducing the device performance. For Ag electrodes, it has been observed that the electrode is being oxidized and that the separating layer of the silver oxide is being created as time goes by. In addition, the oxidation is much slower compared to the Al electrodes. Moreover, Poly

(3,4-ethylenedioxythiophene) polysterene sul-fonate (PEDOT: PSS) which is essential for the collection of holes in the normal structure of OPV, is extremely sensitive to moisture and oxygen. The negative effects of air on the electrical properties of the material show that when the layer of PEDOT: PSS absorbs water, a permanent modification is being promoted to the structure of the device networks due to the hygroscopic nature of PEDOT For this reason, conductivity is being reduced causing also a reduction to the lifetime of the device. In addition to that, the layer of PEDOT: PSS can affect the degradation of the active layer. It has also been reported that the PEDOT: PSS can induce degradation of the P3HT: PCBM (poly (3-hexylthiophene): (phenylc61 - butyric acid methylester) as evidenced by the reduction of absorption and the formation of aggregates in the active layer. To sum up, it has been observed that the exposure of the devices to water causes the loss of PEDOT: PSS conductivity. Nevertheless, the acidity of the PEDOT: PSS affects ITO, causing the loss of conductivity over time [2,3,6,9,11,12,19,21].

CHAPTER 4. EXPERIMENTAL APPARATUS

4.1 Solar Simulator

Description :

Certified to IEC 60904-9 2007 Edition, JIS C 8912, and ASTM E 927-05 standards, these large area sources use a xenon lamp and proprietary filter to meet, efficiently and reliably, Class ABA performance parameters without compromising the 1 sun output power. The result is a cost-effective system designed for laboratory and/or production environments– all backed by our global service and support network.

Image 7: Solar Simulator

Complete line of Class ABA products from 2x2" to 8x8" output beam sizes

Factory certified CW systems per IEC 60904-9 2007 Edition, JIS C 8912, and ASTM E 927-05

Long-lived, highly reliable instruments designed specifically for laboratory and/or production environments

Temperature sensors and interlocks ensure operator safety

Convenient user features simplify operation[15]

4.2 Photo-Current Mapping

Photoelectrical System for examination of defects and aging effects of organic light emitting diodes (OLEDs) and organic and anorganic solar cells.(PCT1)

Image 8 : Photoelectrical System for examination of defects and aging effects of organic light emitting diodes (OLEDs) and organic and anorganic solar cells.(PCT1)

The PCT1 system created in order to investigate both the aging and the defects of OLEDs and organic and inorganic cells.

In this way, the samples are illuminated in a complete scalable laser light. The mapping system makes the development of current and voltage in each designated dot.

Based on the above conclusions can be drawn about consistency and strength of the material.

The PCT1 system has many advantages; It checks with very high resolution , made a detailed analysis of boundary defects , the software is user friendly for both the test and analysis the experimental process is fast.

- Description of components-Terminology

PCT1 -Test system consist of the following components:
Client PC with monitor und software
Power Unit(s) for electrical power-supply
Control Unit(s) for controlling the electronic measurement equipment
PCT1- measuring device.

- Client PC

The Personal Computer (in the following characterized as PC) is necessary for execution the delivered software "Phocus“.

- Control Unit

The Control Unit contains the electronic measurement and regulation of the test systems and is in fact the central unit of the test system.

- Power Unit

Power Unit is the power supply of the test system.

- Sample holder /sample drawer

The device for holding the sample(s) consists of the sample drawer and the sample holder.
The sample drawer contains 5 optical sensors (LEDs) for the exact positioning laser to sample. The sample holder optional can be manufactured by Botest Systems GmbH to customers’ requirements (cost relevant). The samples can be inlayed very easy and fast in the sample holder.

- The job of the sample holder is:

Intake of the samples
Contacting the devices
Creation of defined test conditions

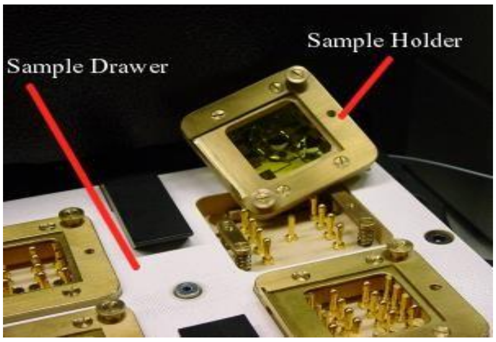


Image 9 : Illustration: example for sample drawer and sample holder[10].

4.3 Profilometer

A profilometer is a device used to measure the surface roughness. There are two types of profilometers: the one which is used with contact and the other which is contactless. Most of these devices use the measurement of the vertical difference between the high and the low point of a surface in nanometers. This measurement can easily show the difference in objects which seem or have the same sense of touch on the surface without any direct measurement. The profilometer is a common gauge used in many sectors but it is mainly used as measurement of the roughness of road surfaces.

A profilometer with contact uses the technology which is very similar to that of a turntable. A stylus with a diamond tip is running on a sample of a material. The stylus records the variation of the surface in a waveform and sends the information back to a computer. This computer is able to process the wave and to form directly the surface depending on the stylus movement[13].

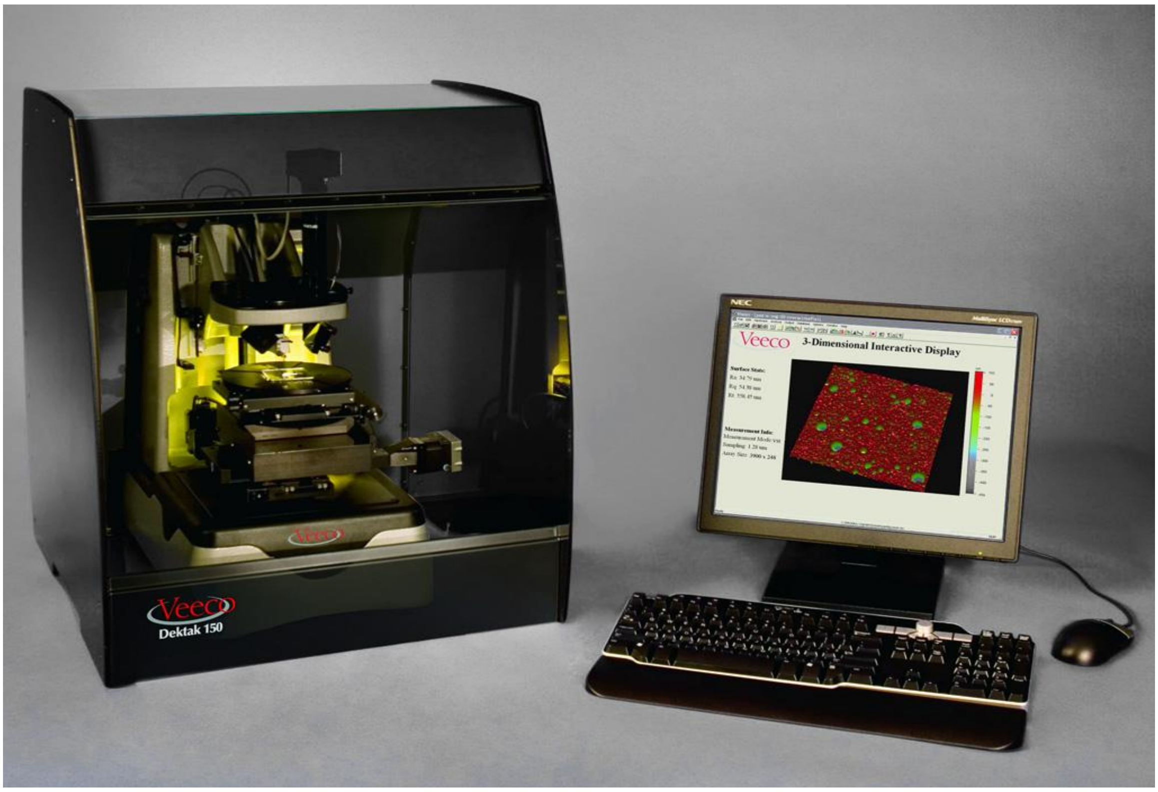


Image 10 : Profilometer

CHAPTER 5 . RESULTS AND DISCUSSIONS

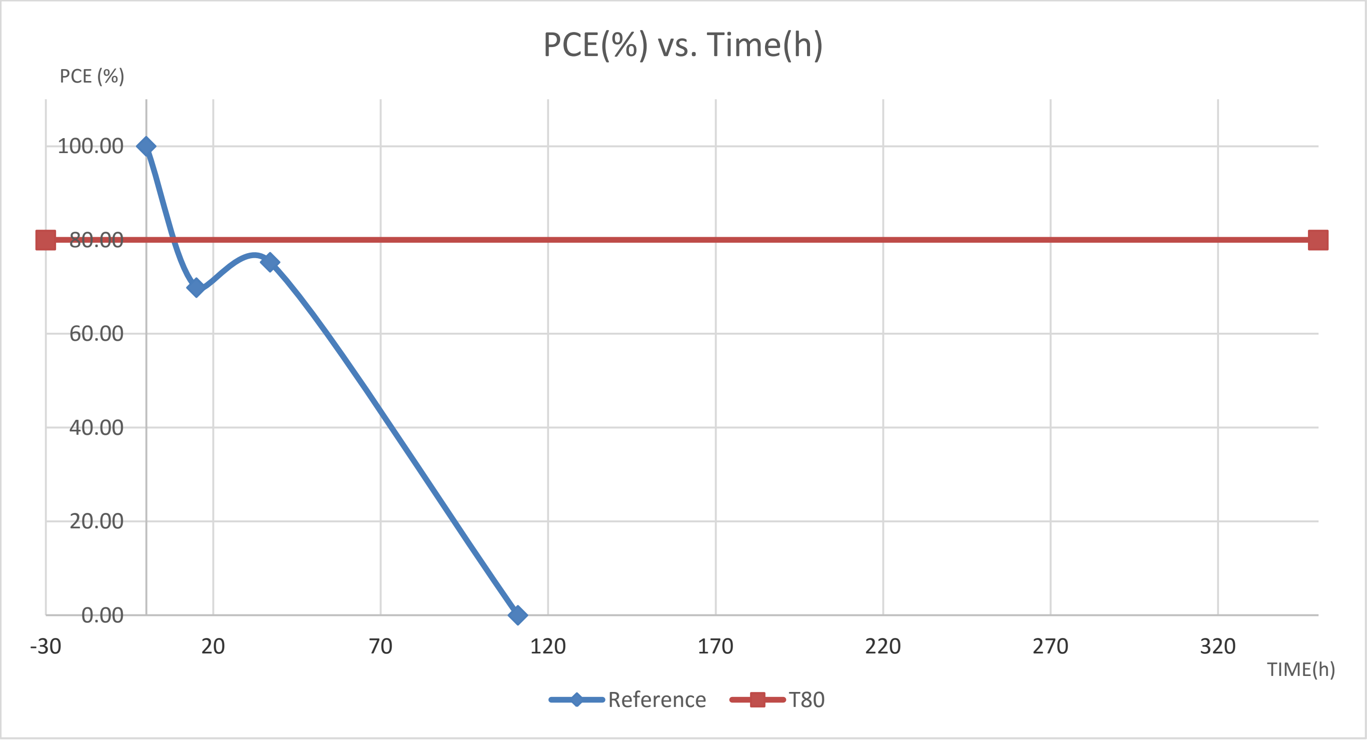
5.1 GRAPHS ANALYSE

Experiment 1:

OSSILA and DYMAX

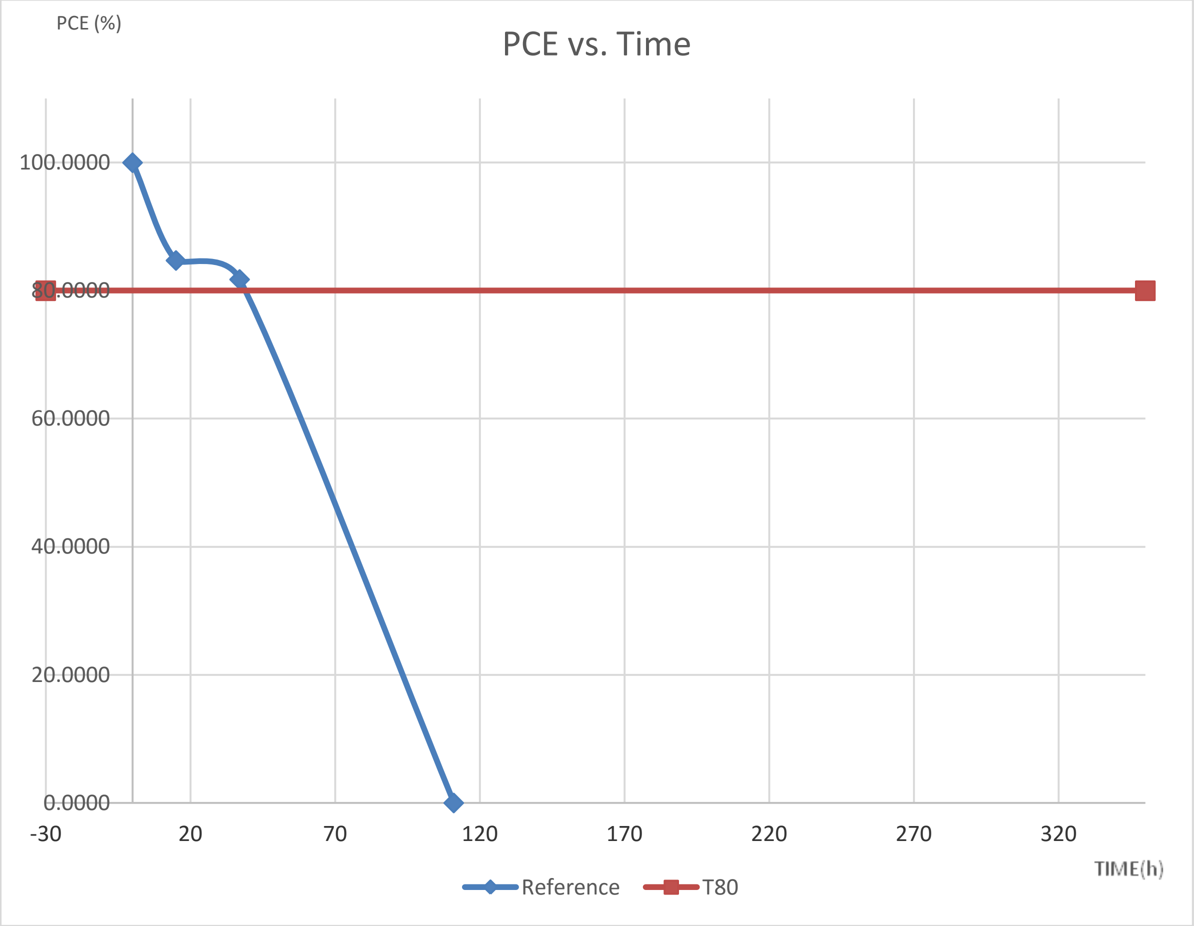
PCE Vs TIME

PCE: power conversion efficiency



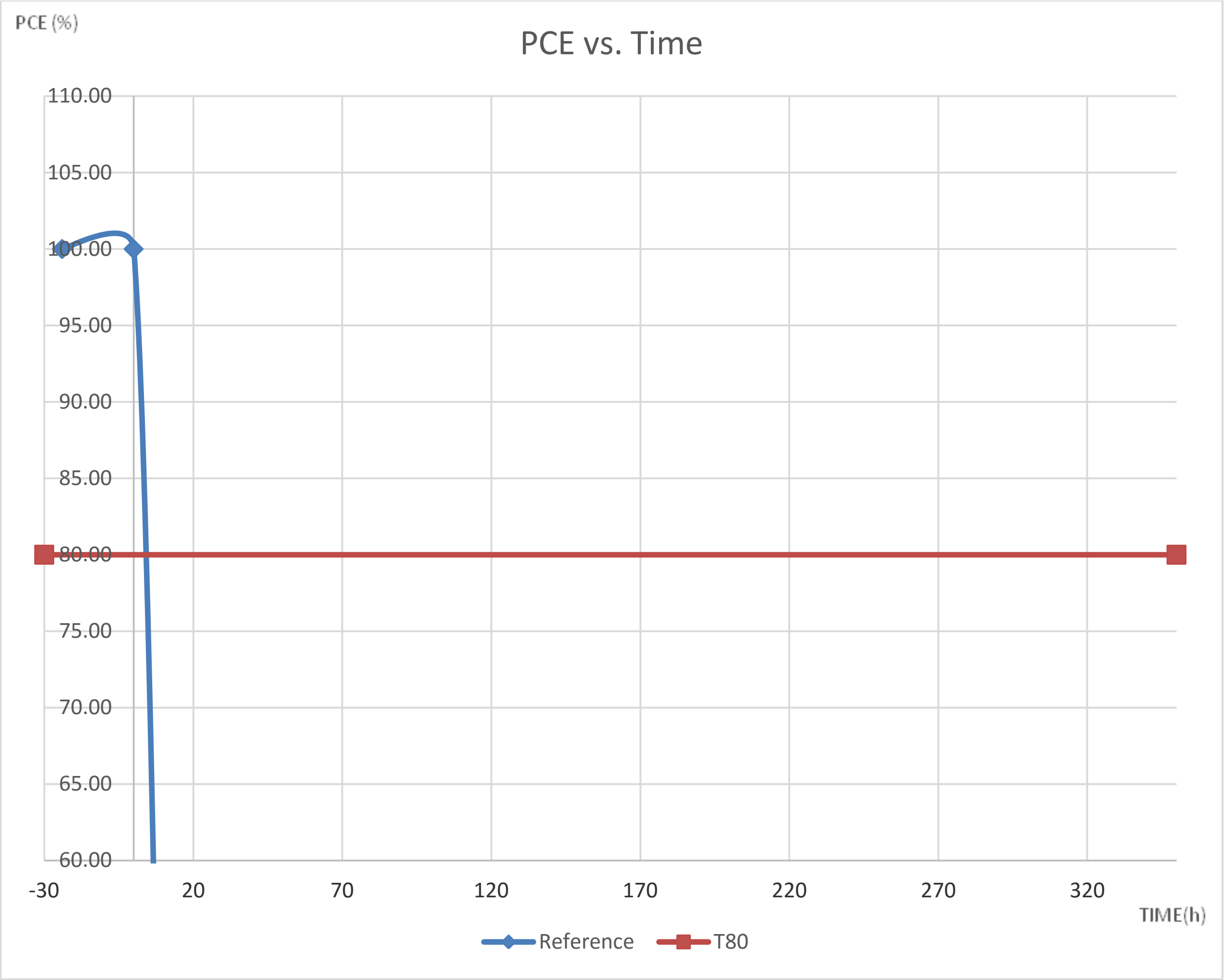
Graph 1:Experiment 1: OSSILA AVERAGE PCE Vs TIME

As it can be seen from the above graph, the average efficiency of the organic photovoltaic wherein became ossila encapsulation compared with the lifetime within a time of 111 hours. As can be seen the performance falls below 80% during the first 8 hours. In addition to the first 15 hours we can see an average yield of about 69.86% at 37 hours then the yield rises to 75.27% and ending at 0% to 111 hours.



Graph 2: Experiment 1: OSSILA MAX PCE Vs TIME

In the above graph we can see the maximum efficiency of the organic photovoltaic wherein became ossila encapsulation compared with the lifetime within a time of 111 hours. The graph shows the performance falls below 80% during the first 11 hours. Also in the first 15 hours, the average yield is 84.72% in the 37 hours and then the yield rises to 81.75% ending at 0% to 111 hours.

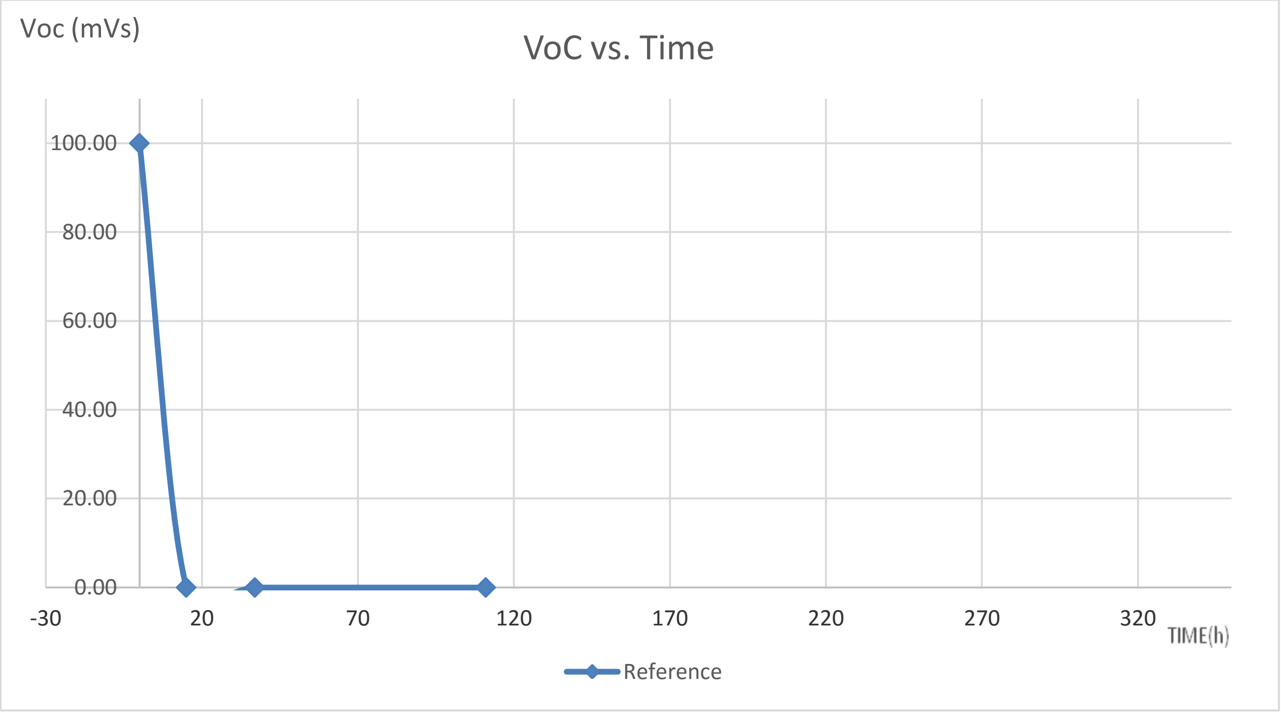


Graph 3: Experiment 1: DYMAX MAX PCE Vs TIME

The graph shows the average efficiency of the organic photovoltaic wherein became dymax encapsulation compared with the lifetime within a time of 7 hours. As we can see the performance falls below 80% during the first 5 hours. In addition, in the first 7 hours there is a high decrease reaching 0 % implying that the devices are completely useless.

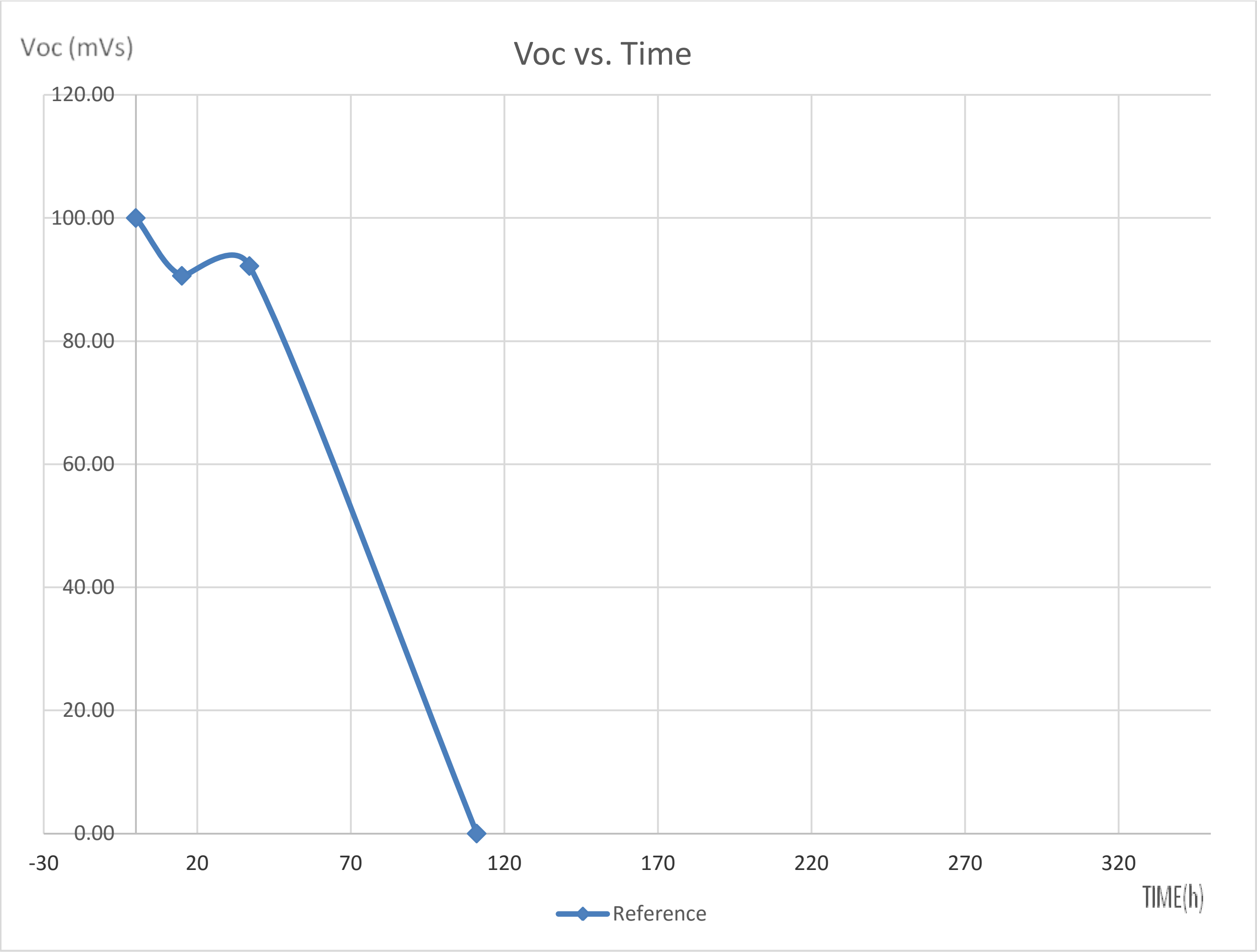
Voc Vs Time

Voc: Voltage open circuit



Graph 4:Experiment 1: DYMAX AVERAGE Voc Vs TIME

The graph shows the average Voc of the organic photovoltaic with dymax encapsulation compared with the lifetime of 111 hours. As it can be seen the Voc falls to 0 % in the first 18 hours.

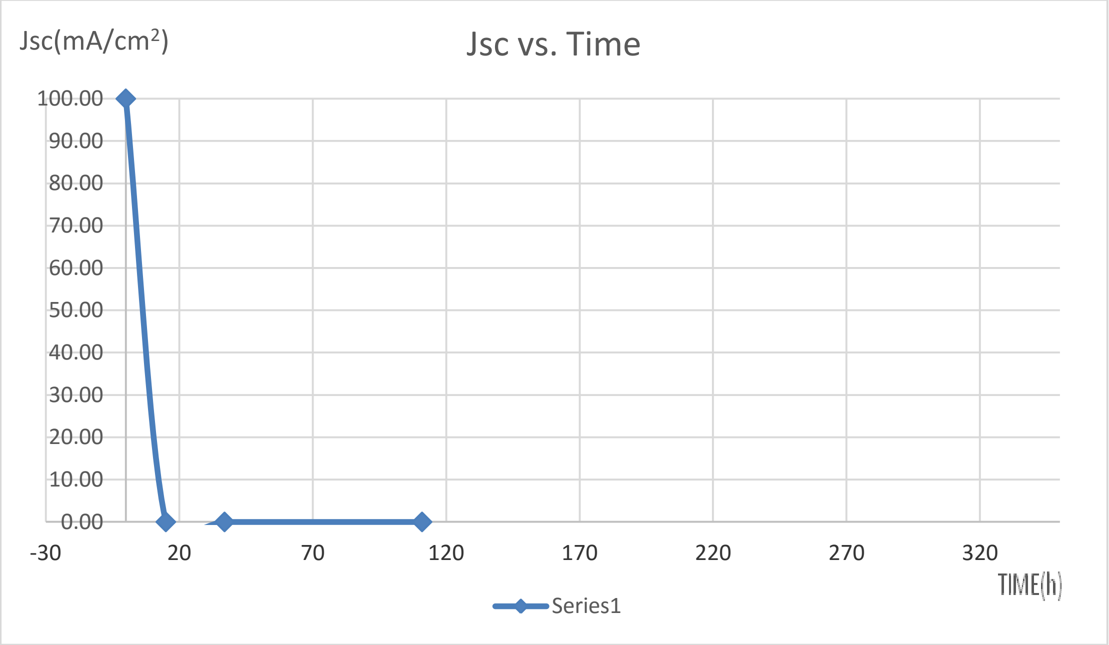


Graph 5: Experiment 1: OSSILA AVERAGE Voc Vs TIME

Here, the average Voc of the organic photovoltaic with ossila encapsulation is compared with the lifetime of 111 hours. The graph shows that Voc falls to 90.61 % in the first 15 hours. In addition, the next measurement shows Voc to have a slight increase, reaching 92.2 % during the 37 hours.

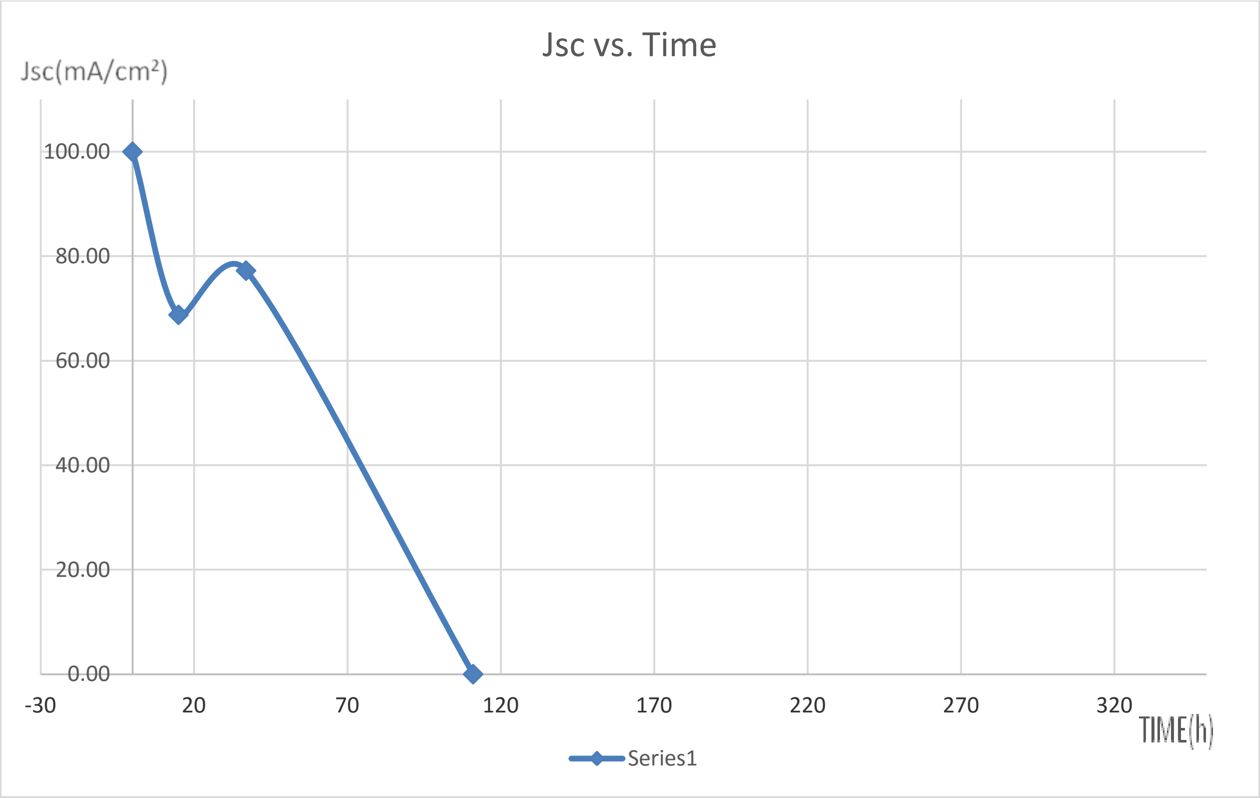
Jsc Vs Time

Jsc: Short Circuit Current Density



Graph 6: Experiment 1: DYMAX AVERAGE Jsc Vs TIME

The above graph illustrates the average Jsc of the organic photovoltaic with dymax encapsulation compared with the lifetime of 111 hours. Jsc decrease to 80 % in the first 5 hours. In the end, the Jsc results to 32.55 % in 112 hours.

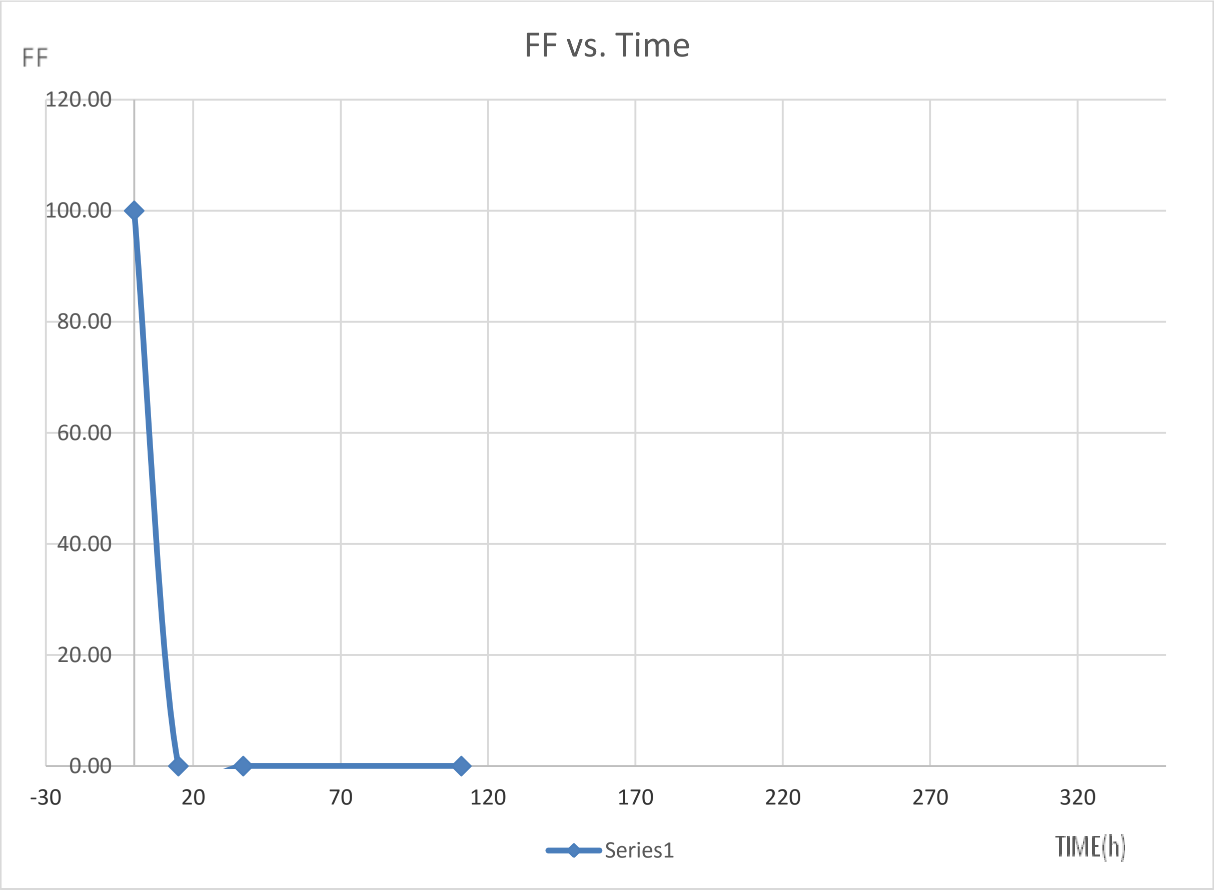


Graph 7: Experiment 1: OSSILA AVERAGE Jsc Vs TIME

The above graph illustrates the average Jsc of the organic photovoltaic with ossila encapsulation compared with the lifetime of 111 hours. Jsc decreases to 68.79% in the first 15 hours. In addition, in the next measurement, Jsc increases to 77.24% in 37 hours resulting to 0% in 111 hours.

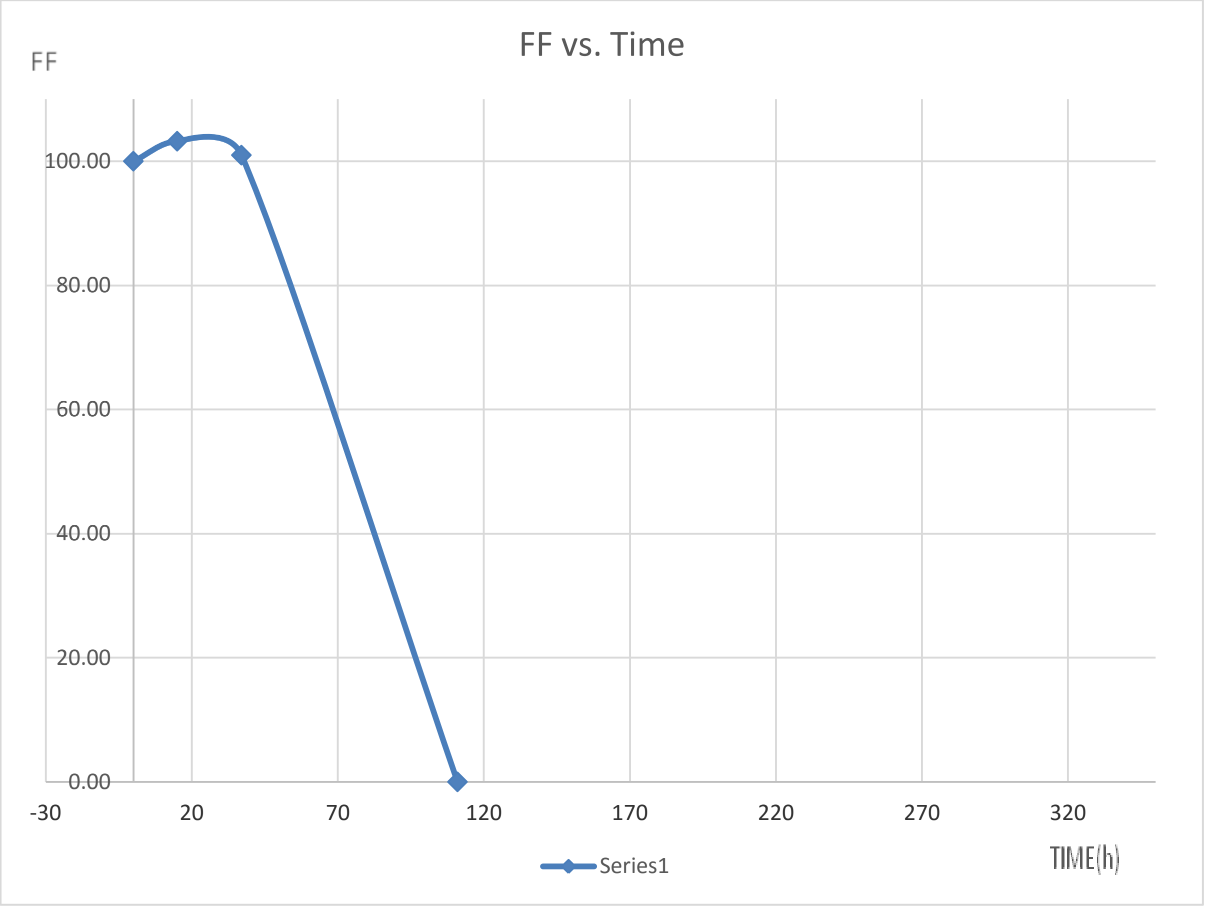
FF Vs Time

FF : Fill Factor



Graph 8: Experiment 1: DYMAX AVERAGE FF Vs TIME

The above graph shows the average FF of the organic photovoltaic with dymax encapsulation compared with the lifetime of 111 hours. The graph shows that FF falls down to 80 % in the first 3 hours and it reaches 0 % in the first 18 hours.



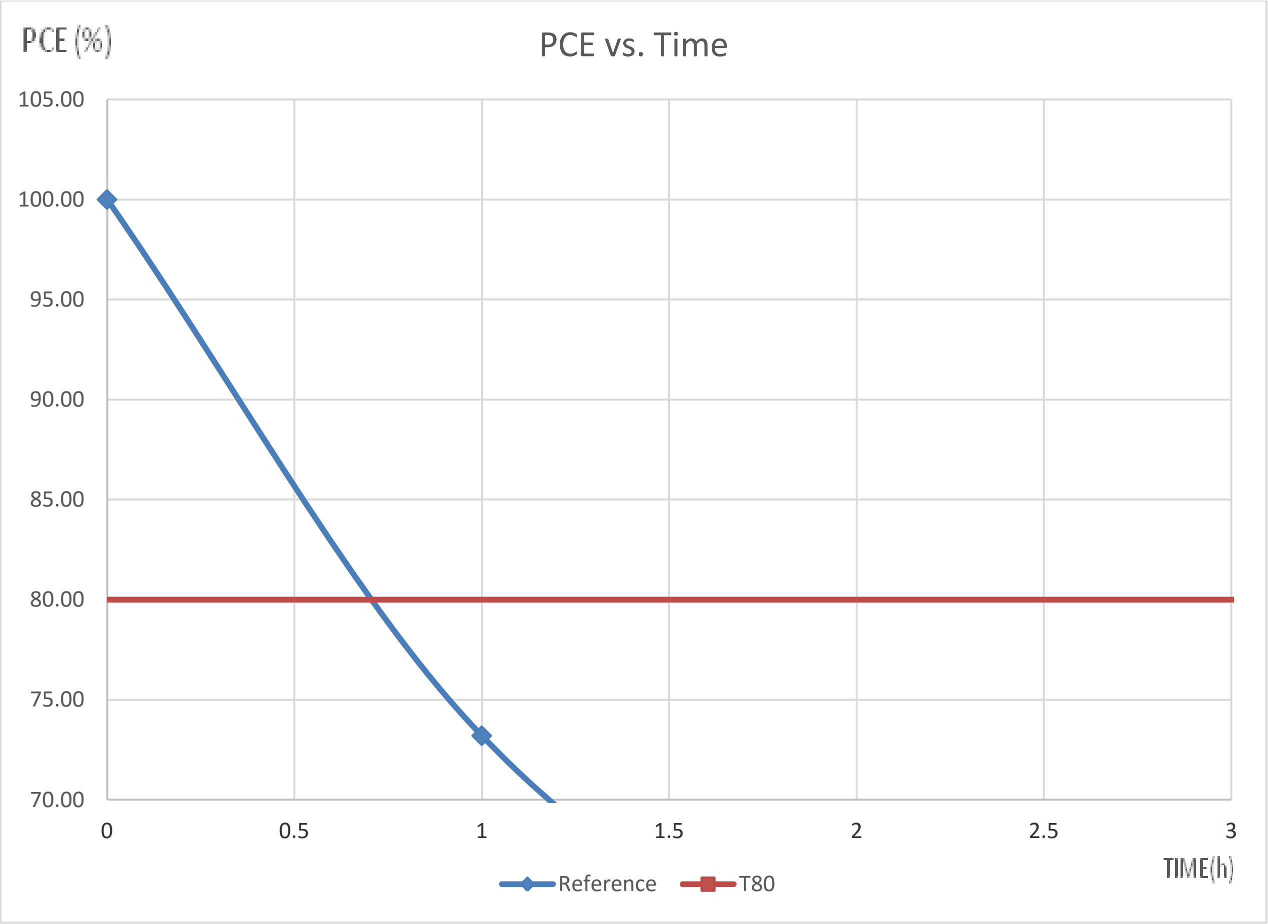
Graph 9: Experiment 1: OSSILA AVERAGE FF Vs TIME

The above graph illustrates the average FF of the organic photovoltaic with ossila encapsulation compared with the lifetime of 111 hours. The graph shows FF resulting to 103.22 % in the first 15 hours. In addition, FF decreases to 100.98% in 37 hours resulting to 0% in the time period of 111 hours.

Experiment 2:

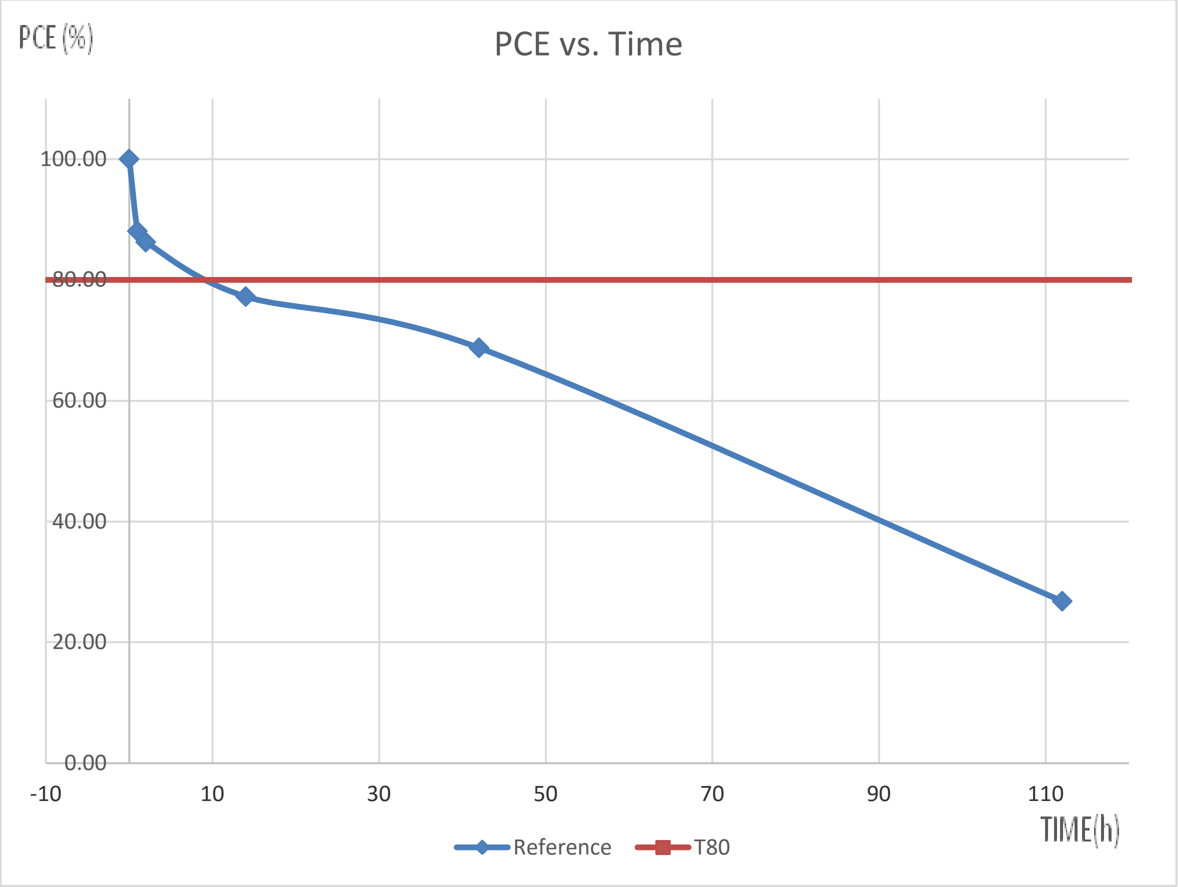
OSSILA and DYMAX

PCE Vs TIME



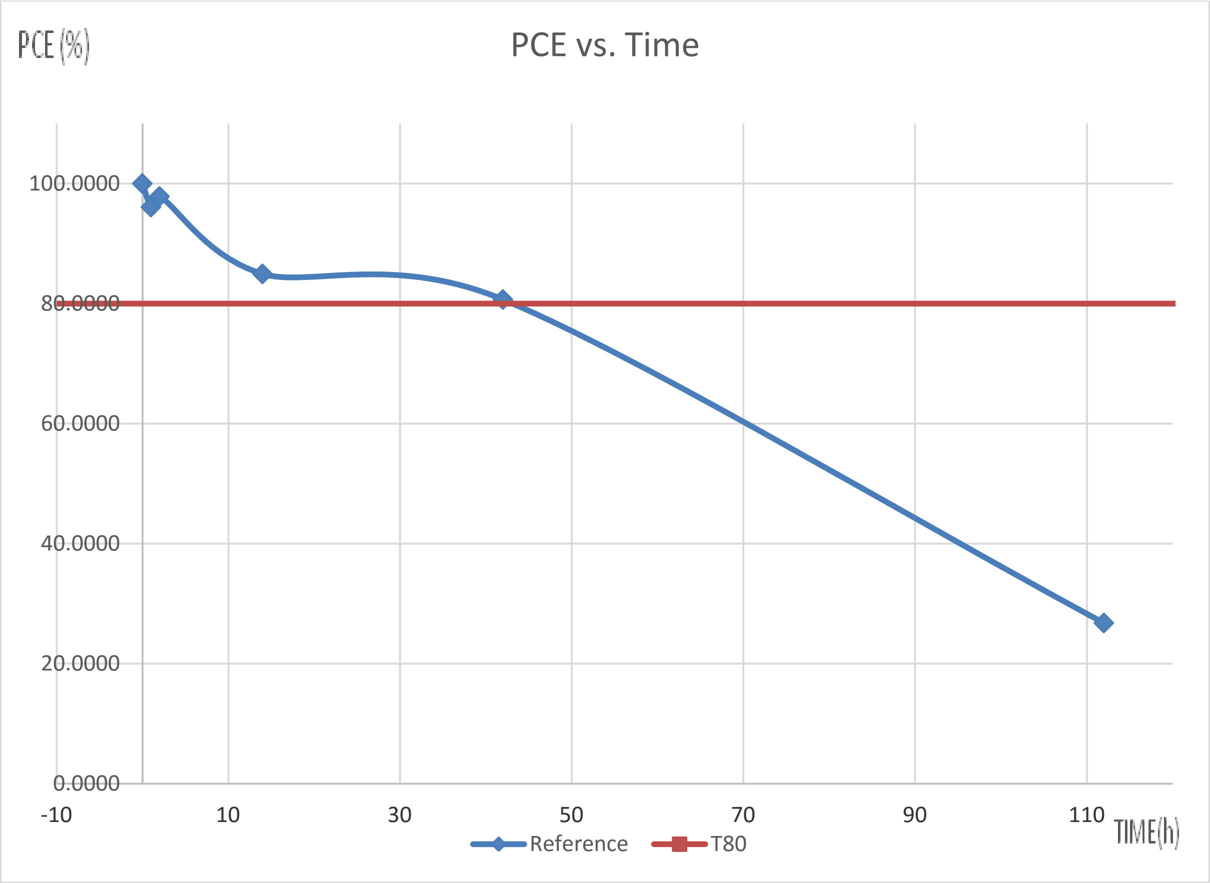
Graph 10: Experiment 2: DYMAX AVERAGE PCE Vs TIME

The graph shows the average efficiency of the organic photovoltaic with dymax encapsulation compared with the lifetime of 3 hours. As it can be seen, the performance falls to 80% during the first 40 minutes, to 73.2 % in an hour, and to 61.42 % in 2 hours, resulting to 0% in 14 hours.



Graph 11: Experiment 2: OSSILA AVERAGE PCE Vs TIME

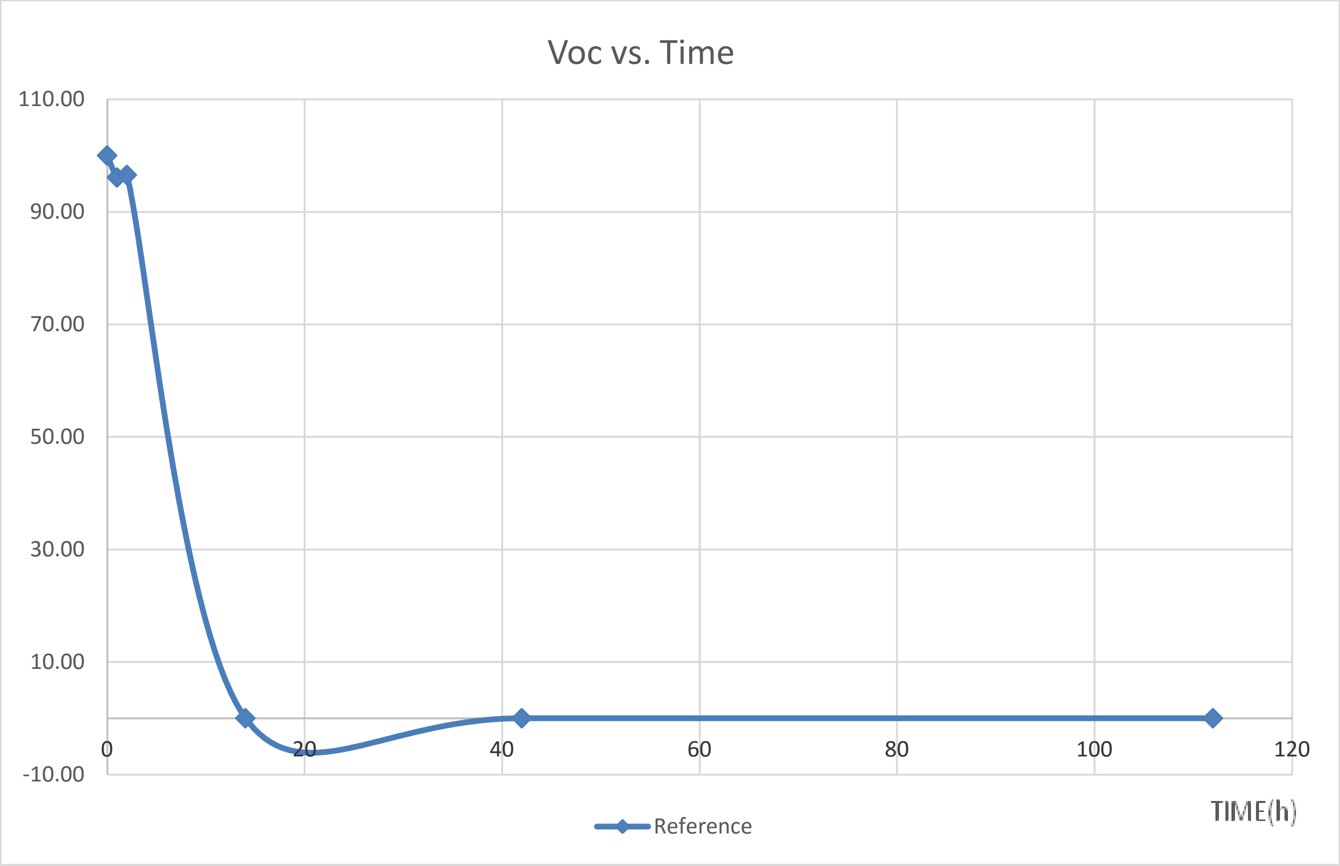
This graph presents the average efficiency of the organic photovoltaic with ossila encapsulation compared with the lifetime of 112 hours. Moreover, the performance falls to 80% during the first 9 hours. In addition, in the first 14 hours, thr average yield is 77.24% ending at 26.8% in 112 hours.



Graph 12: Experiment 2: OSSILA MAX PCE Vs TIME

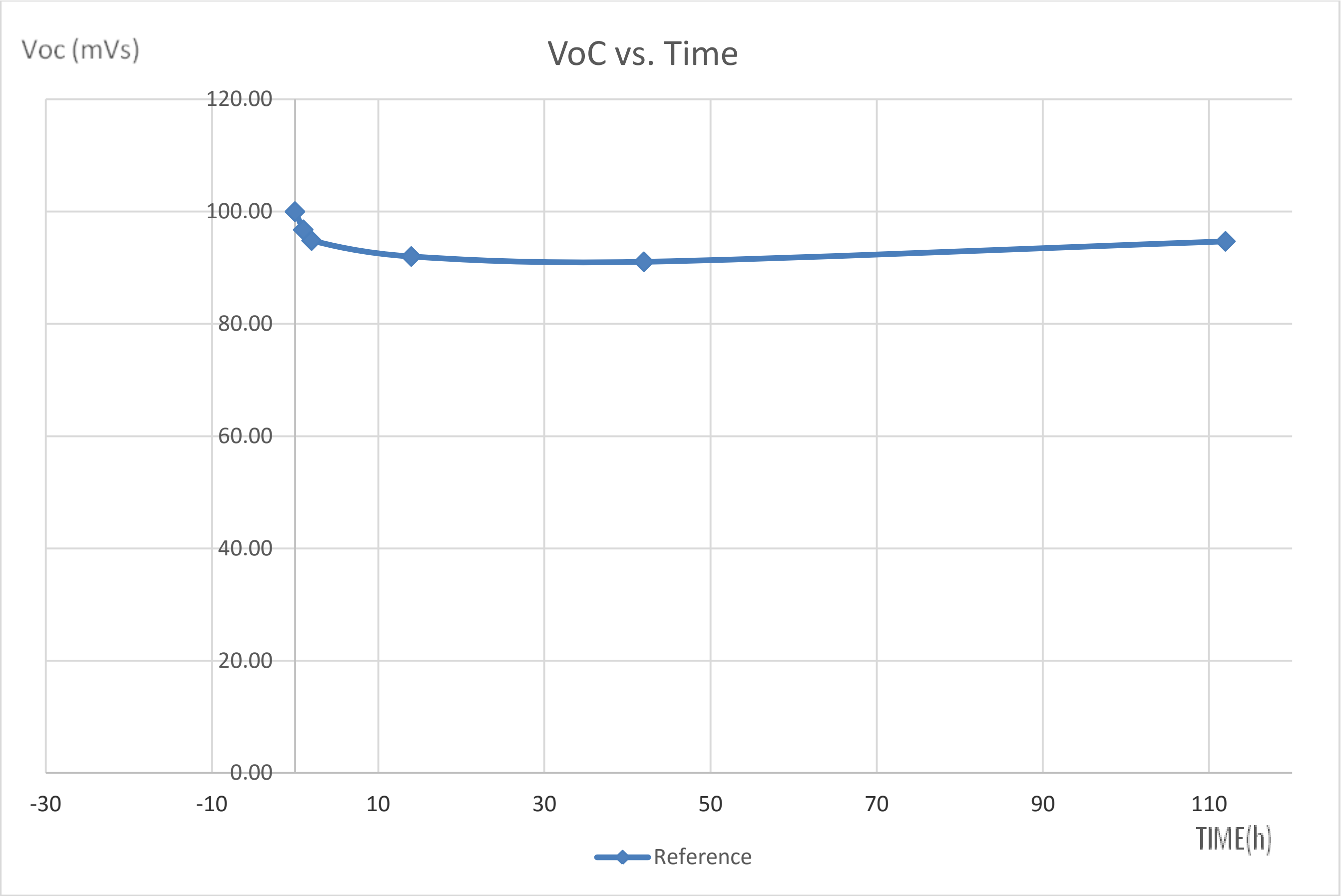
The above graph illustrates the maximum efficiency of the organic photovoltaic with ossila encapsulation compared with the lifetime of 112 hours. The graph shows the performance falling to 80% during the first 42 hours. Also, in the first 14 hours, the average yield is 77.23% ending to 26.79 % in 112 hours.

Voc Vs Time



Graph 13: Experiment 2: DYMAX AVERAGE Voc Vs TIME

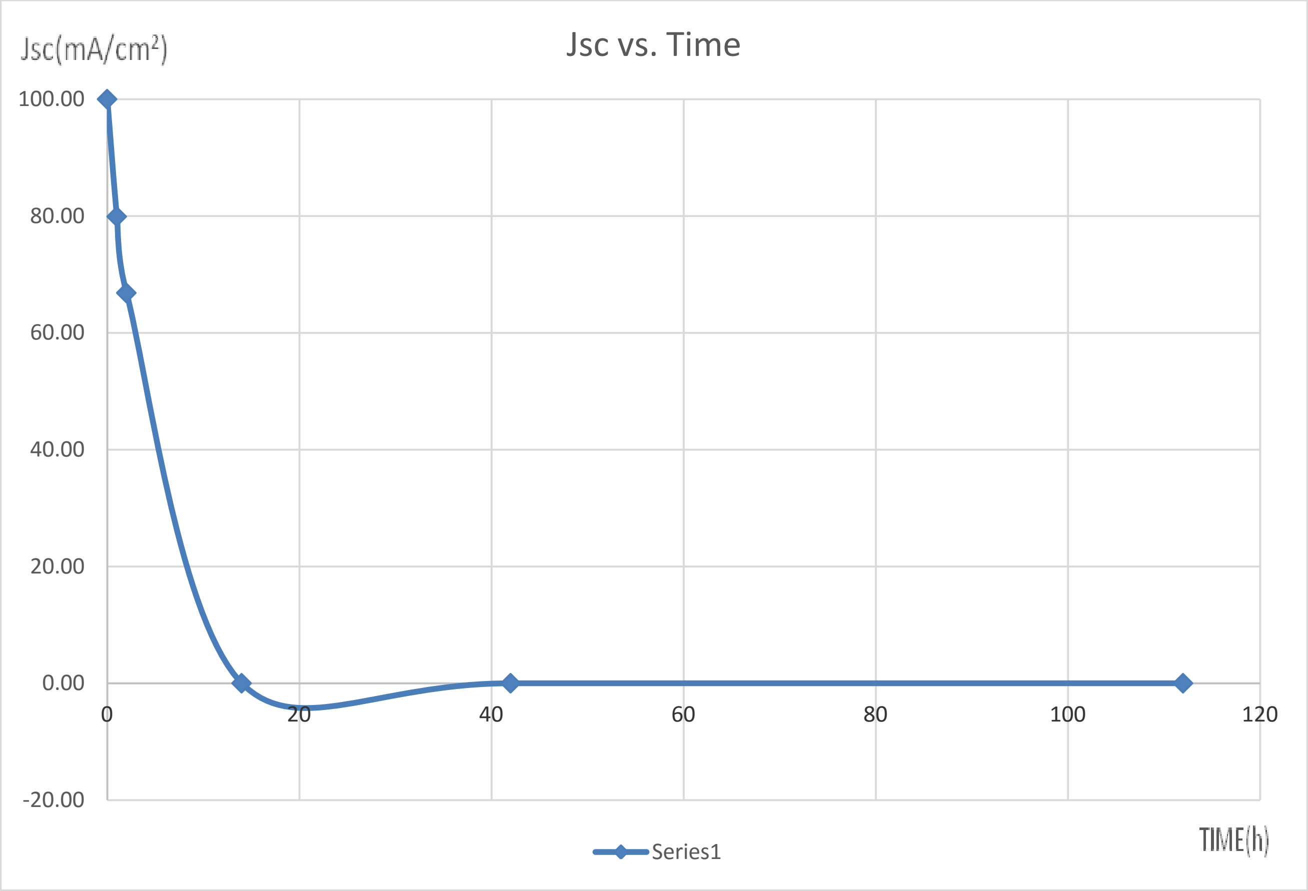
The graph illustrates the average Voc of the organic photovoltaic with dymax encapsulation compared with the lifetime of 112 hours. As it can be seen, Voc remains stable to 80% in the first 2 hours and then it falls to 0 % in 14 hours.



Graph 14: Experiment 2: OSSILA AVERAGE Voc Vs TIME

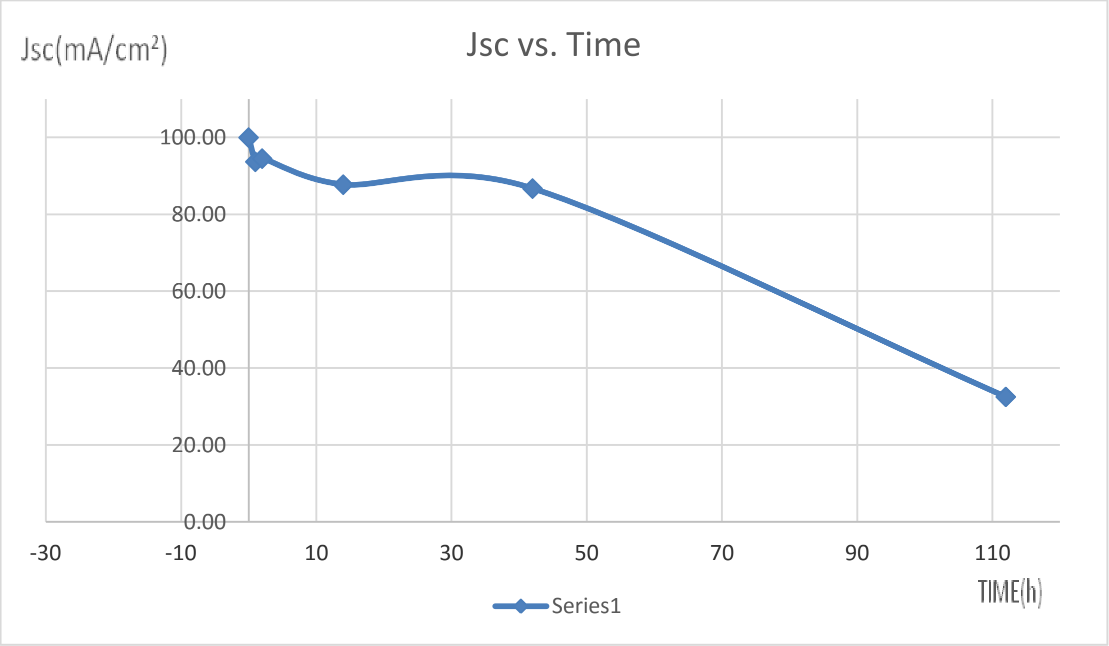
The above graph shows the average Voc of the organic photovoltaic with ossila encapsulation compared with the lifetime of 112 hours. The graph illustrates Voc to fall to 92 % in the first 14 hours. In addition, in the last measurement Voc remains high resulting to 94.69 %.

Jsc Vs Time



Graph 15: Experiment 2: DYMAX AVERAGE Jsc Vs TIME

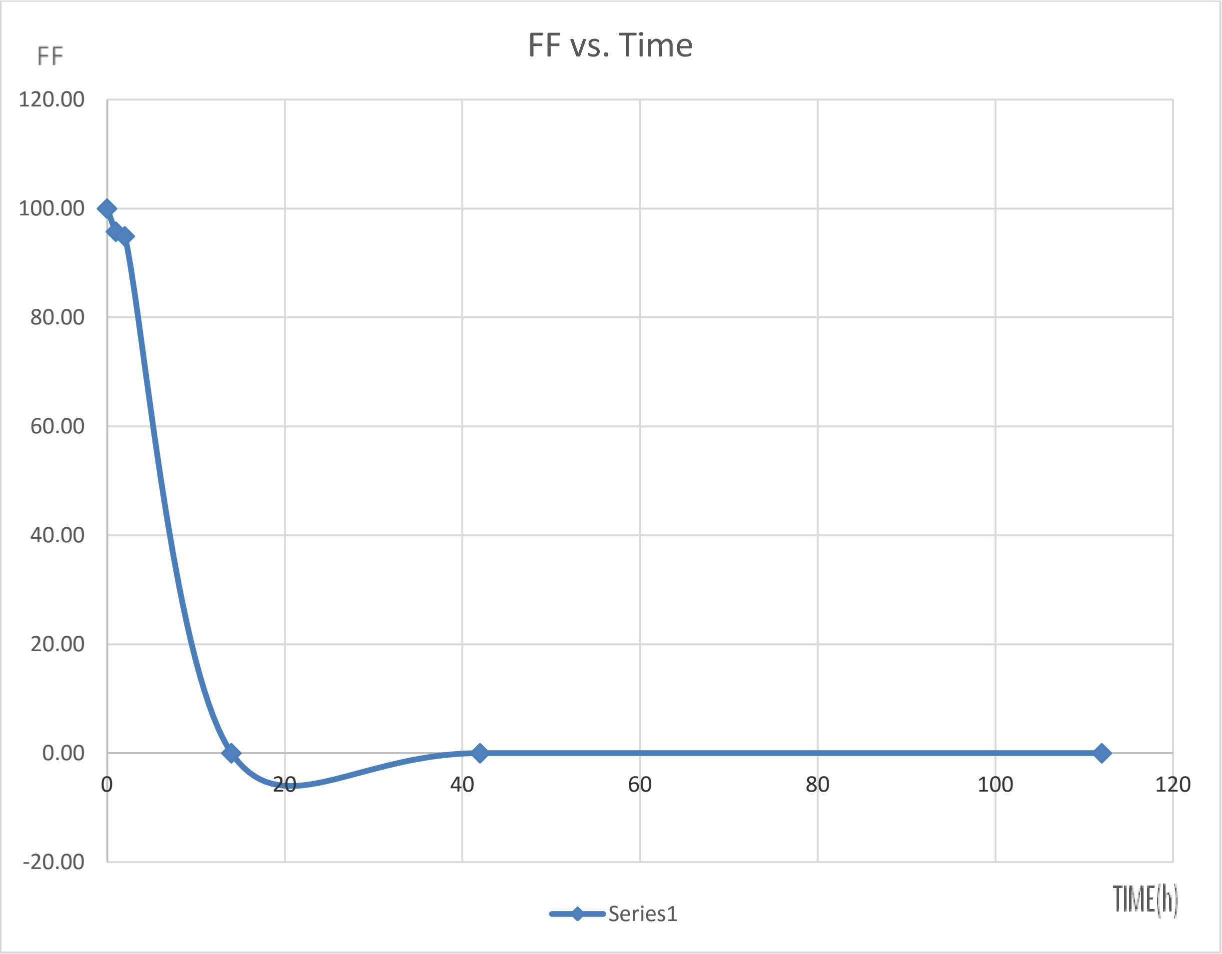
The above graph illustrates the average Jsc of organic photovoltaic with dymax encapsulation compared with the lifetime within a time of 112 hours. The graph shows that Jsc falls to 80 % in the first 40 minutes. In addition, Jsc falls to 0 % in the first 14 hours.



Graph 16: Experiment 2: OSSILA AVERAGE Jsc Vs TIME

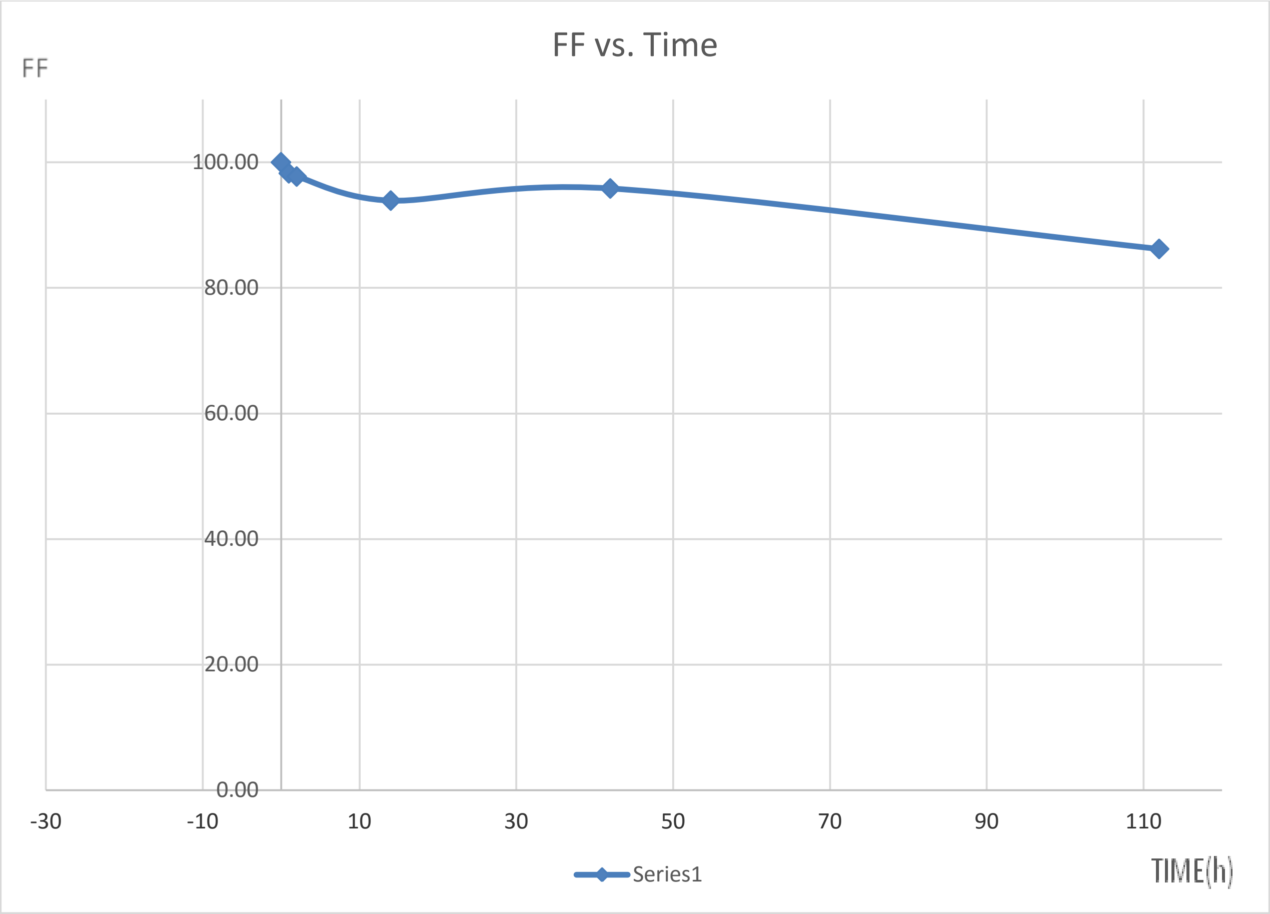
The above graph shows the average Jsc of organic photovoltaic with ossila encapsulation compared with the lifetime of 112 hours. Moreover, the graph illustrates Jsc decreasing to 68.79% in the first 15 hours. In addition, in the next measurement, it can be observed that Jsc decreases to 77.24 % in the 37 hours resulting to 0% in the 111 hours.

FF Vs Time



Graph 17: Experiment 2: DYMAX AVERAGE FF Vs TIME

Here, the average FF of the organic photovoltaic with dymax encapsulation is compared with the lifetime of 112 hours. In addition, the graph shows FF to remain at 90 % in the first 2 hours, remarking a fall to 0 % after 14 hours.



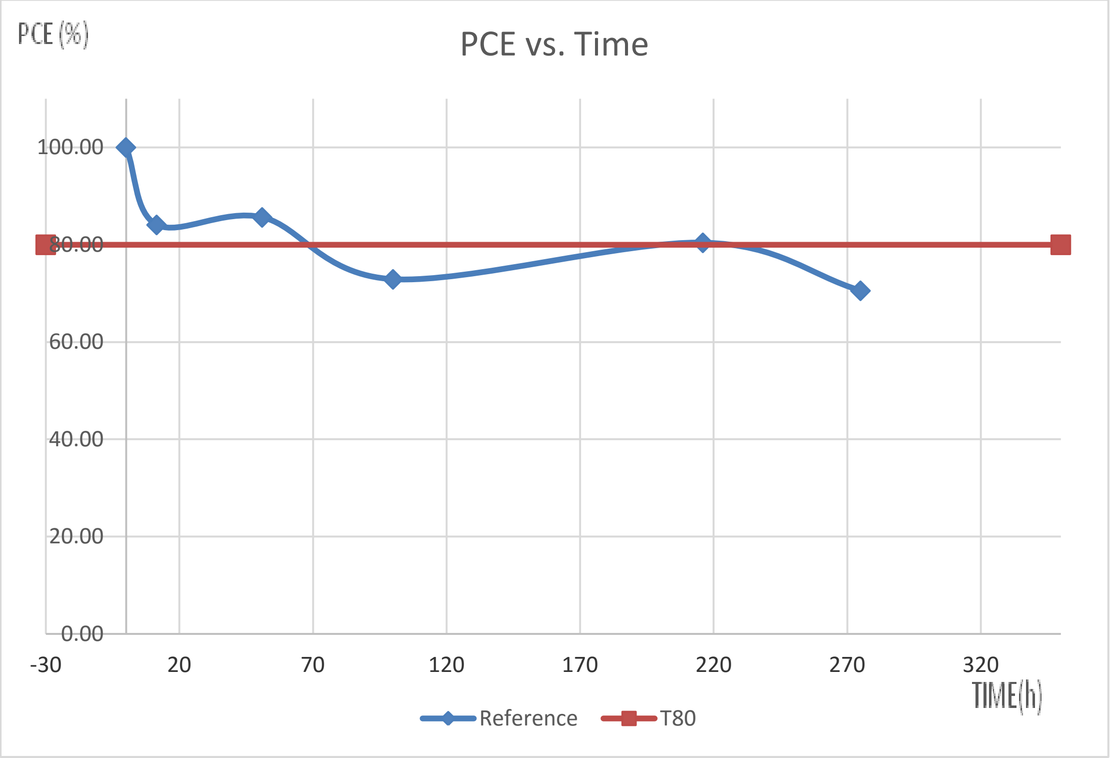
Graph 18: Experiment 2: OSSILA AVERAGE FF Vs TIME

The above graph illustrates the average FF of organic photovoltaic with ossila encapsulation compared with a lifetime of 111 hours. Also, the graph shows FF to fall to 97.73 % in the first 2 hours. In addition, the next measurement, in the time period of 42 hours, presents FF to fall to 95.83% resulting to 86.21% in 112 hours.

Experiment 3:

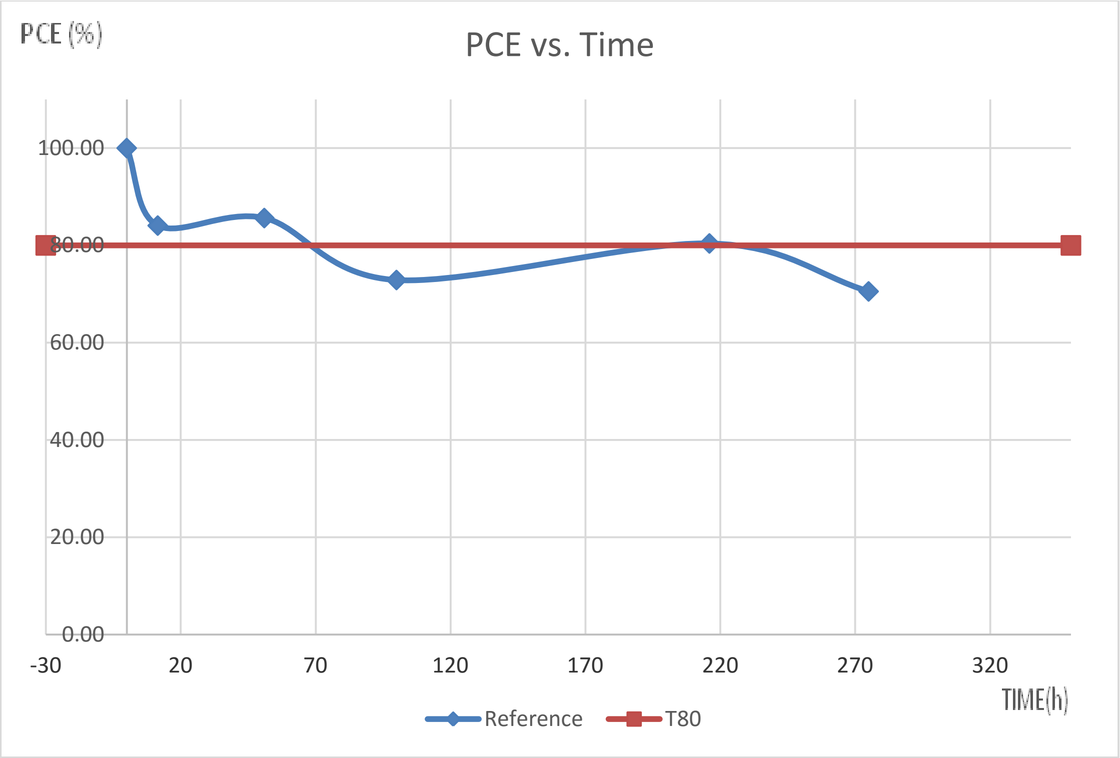
OSSILA and ZEO

PCE Vs TIME



Graph 19: Experiment 3: OSSILA AVERAGE PCE Vs TIME

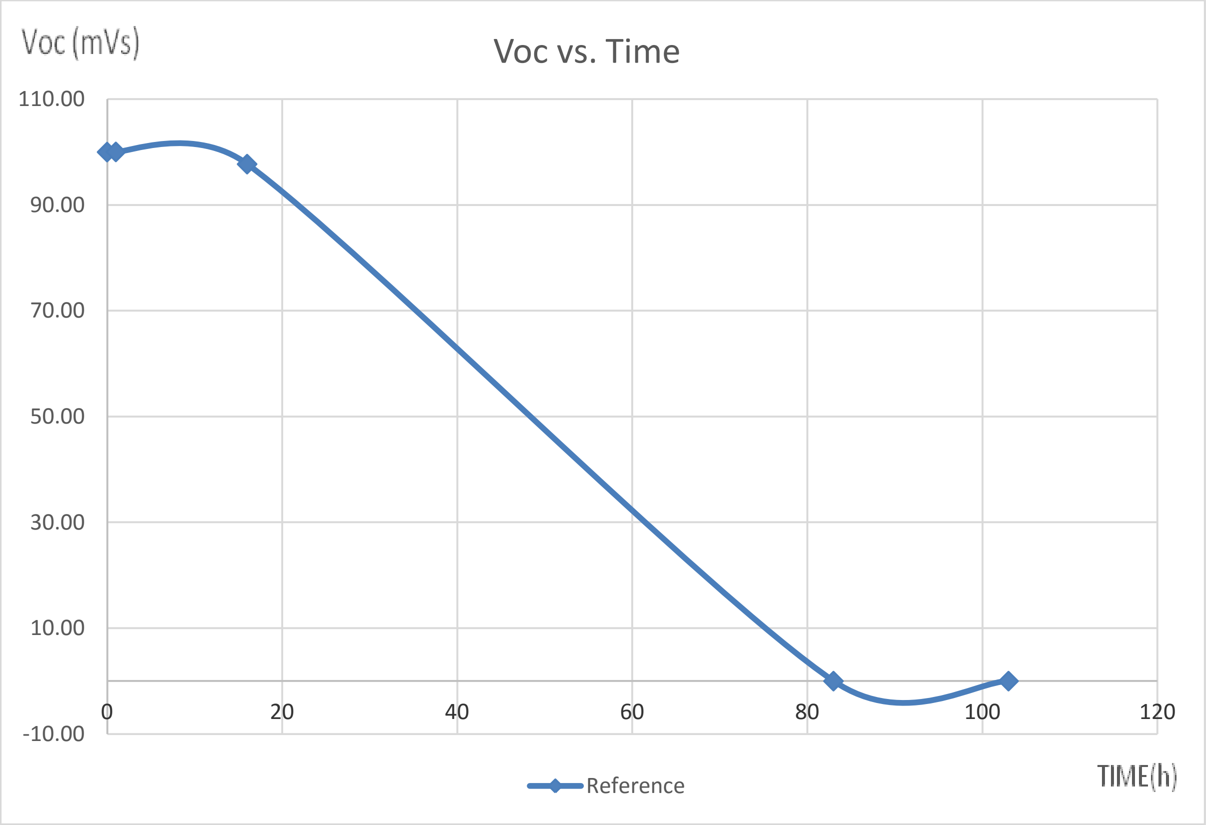
The above graph depicts the average efficiency of the organic photovoltaic with ossila encapsulation compared with the lifetime of 275 hours. The graph shows something very important, that the performance remain up to 80%, during the first 38 hours.



Graph 20: Experiment 3: ZEO AVERAGE PCE Vs TIME

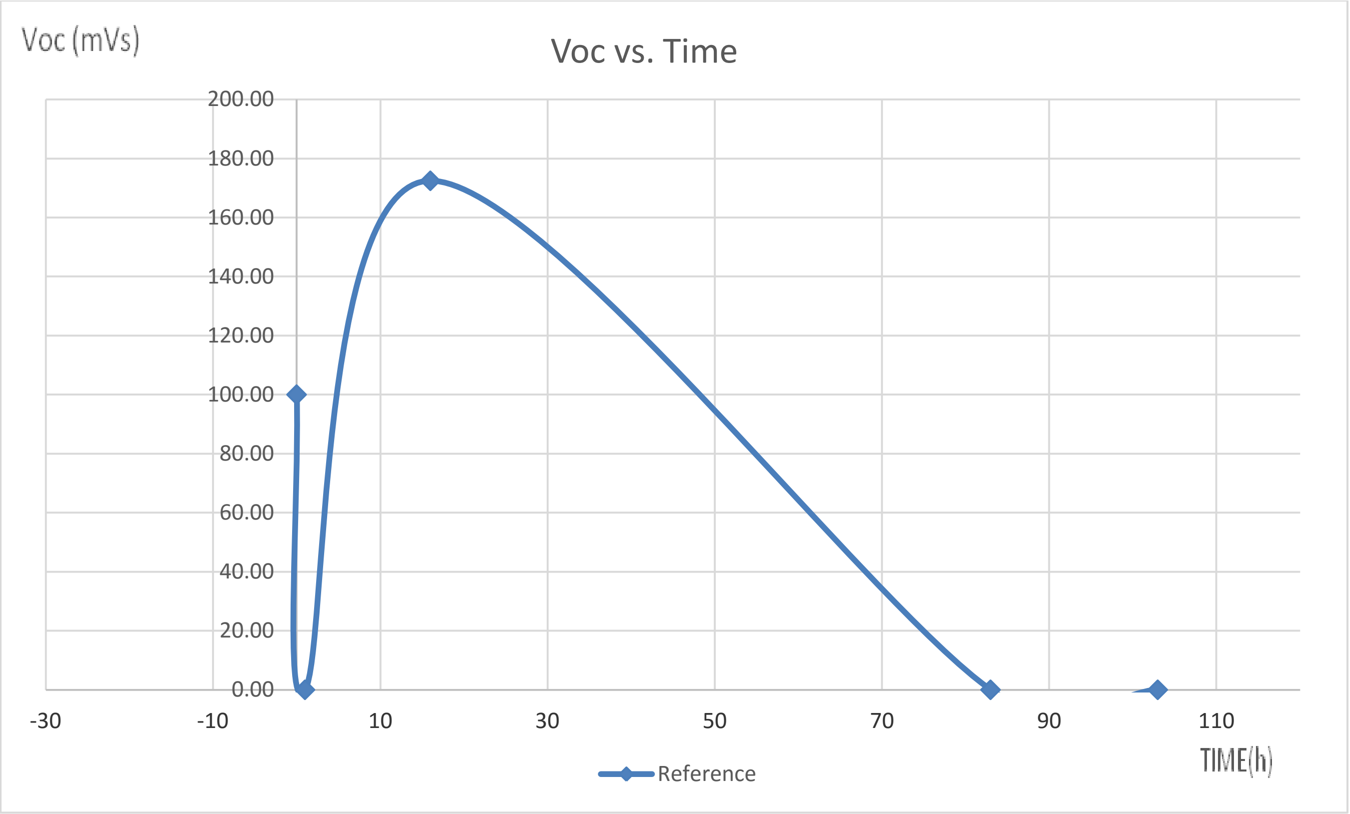
The above graph illustrates the average efficiency of the organic photovoltaic with zeo encapsulation compared with the lifetime within a time of 275 hours. The graph shows something very important, that the performance remains up to 80% and to 80.4% during the 216 hours. Also, at the end of the measurement the performance is still high with 70.54% in 275 hours.

Voc Vs Time



Graph 21: Experiment 3: ZEO AVERAGE Voc Vs TIME

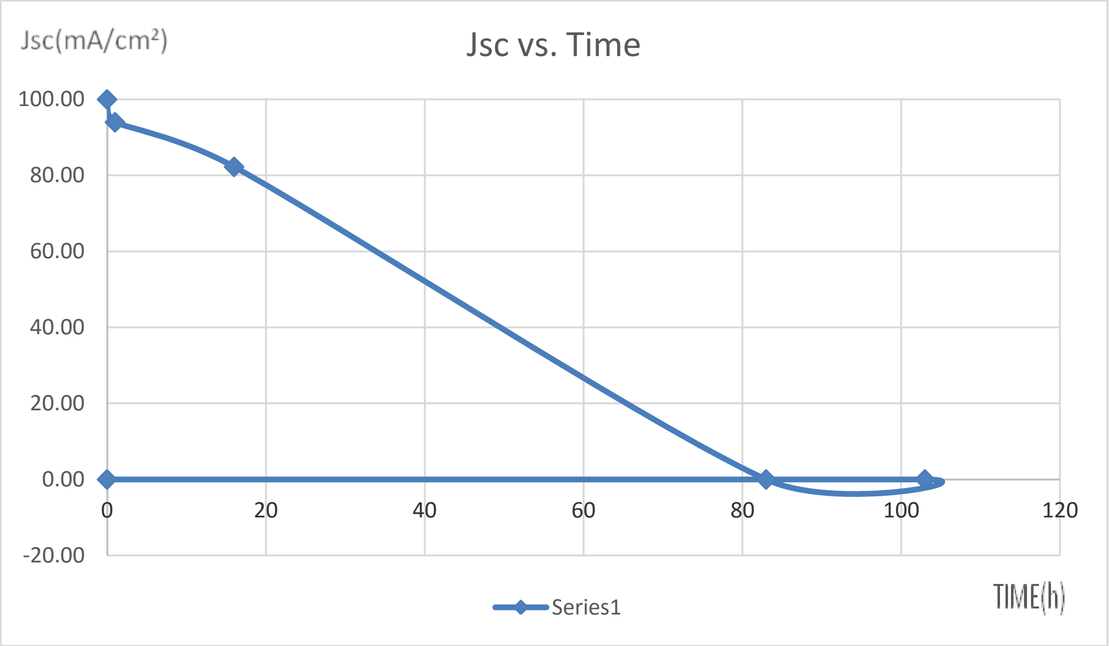
The graph shows the average Voc of the organic photovoltaic with zeo encapsulation compared with the lifetime within a time of 103 hours. As it can be noticed, Voc remains to 97.72 % in the first 16 hours and decreasing to 0 % in 83 hours.



Graph 22: Experiment 3: OSSILA AVERAGE Voc Vs TIME

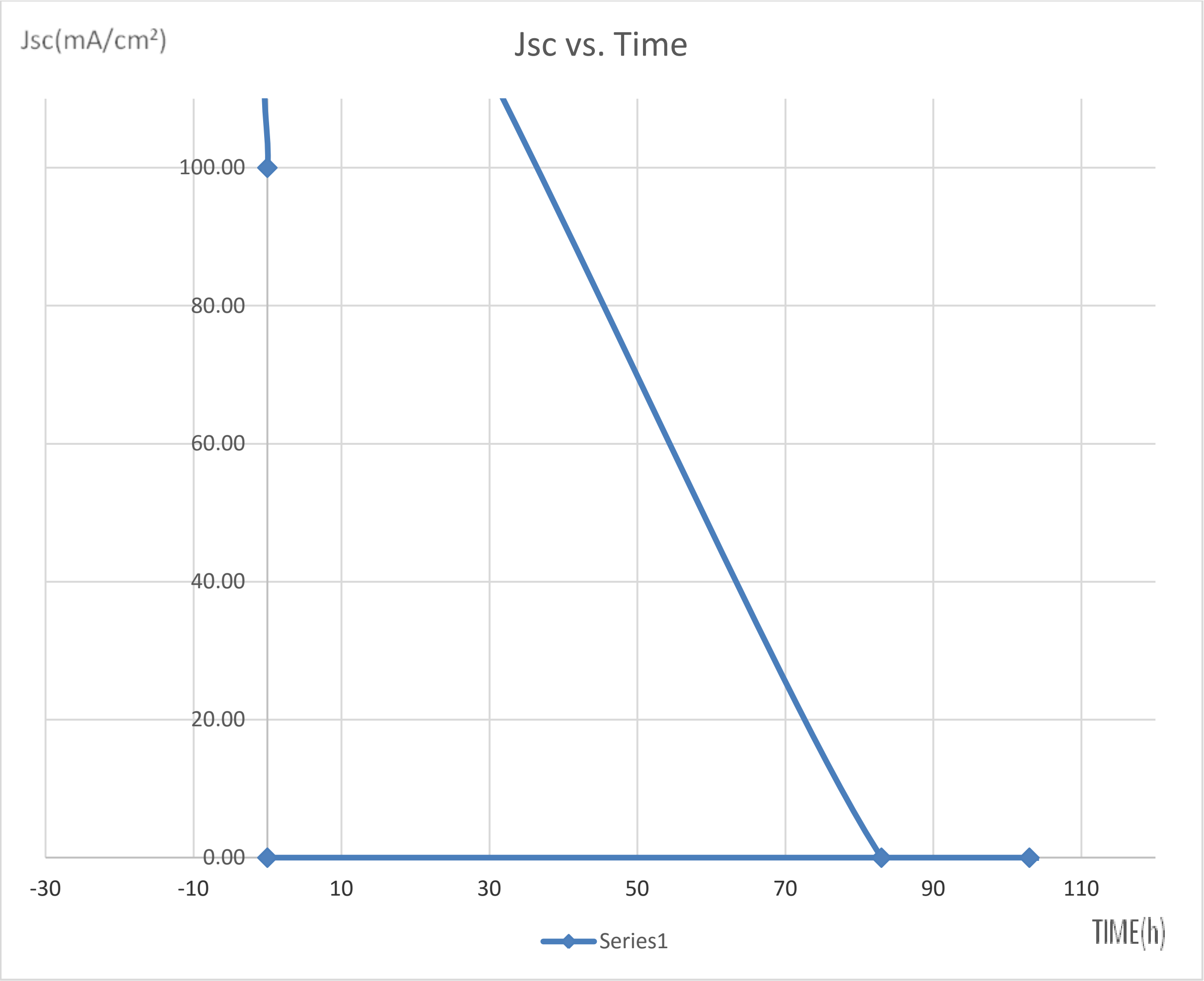
The above graph illustrates the average Voc of the organic photovoltaic with ossila encapsulation compared with the lifetime of 103 hours. The graph shows Voc rising to 172.44% in the first 16 hours. In the next measurement in the time period of 83 hours, Voc decreases to 0 %.

Jsc Vs Time



Graph 23: Experiment 3: ZEO AVERAGE Jsc Vs TIME

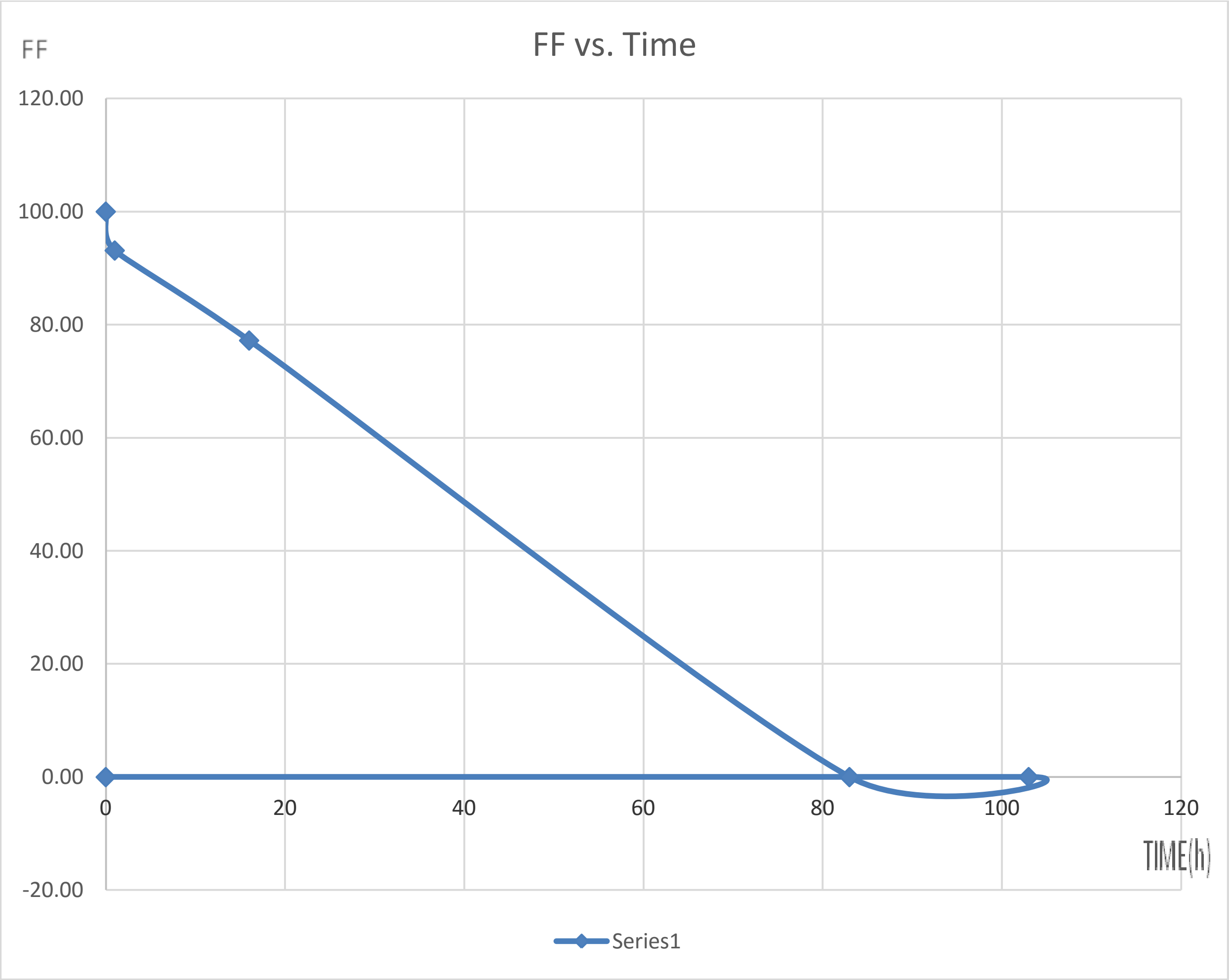
As we can see from the above graph, illustrates the average Jsc of the organic photovoltaic wherein became zeo encapsulation compared with the lifetime within a time of 103 hours. The graph shows the Jsc remains up to 80%, to 82.4 % in the first 16 hours. In the end the Jsc fall down to 0 % in 103 hours.



Graph 24: Experiment 3: OSSILA AVERAGE Jsc Vs TIME

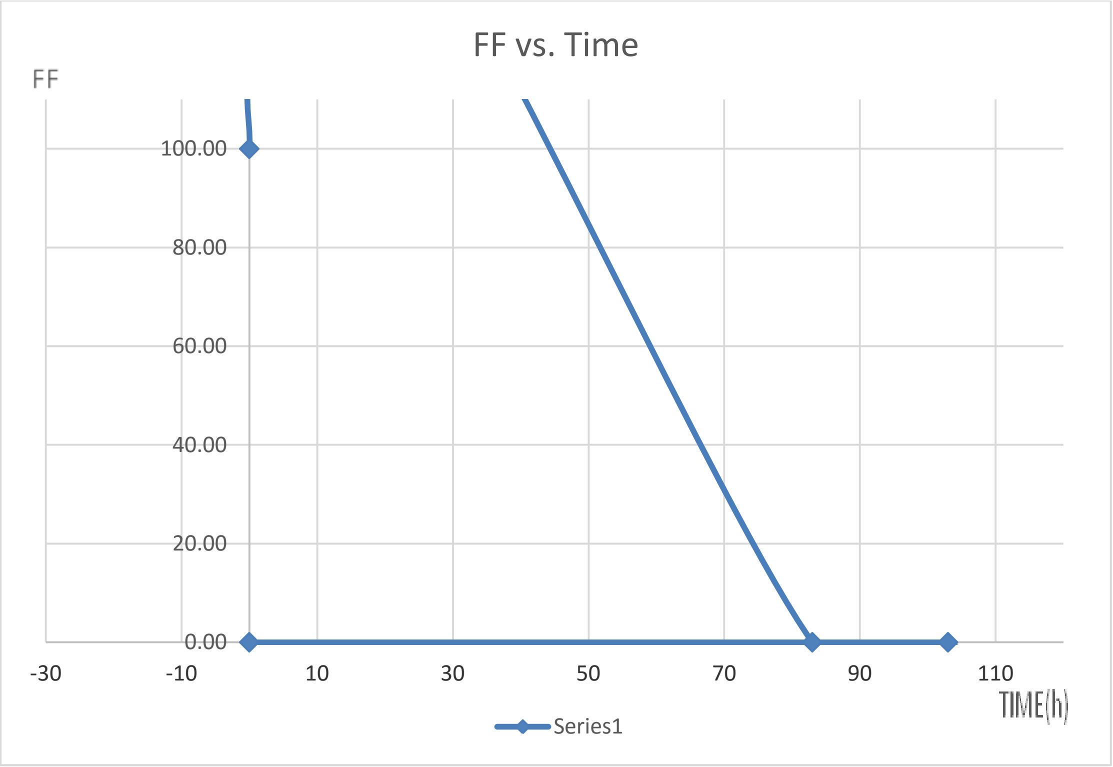
The above graph illustrates the average Jsc of the organic photovoltaic wherein became ossila encapsulation compared with the lifetime within a time of 103 hours. In addition the graph shows the Jsc raising up to 140.46% in the first 16 hours. In the last measurement of 103 hours we observe a reduce to 0%.

FF Vs Time



Graph 25: Experiment 3: ZEO AVERAGE FF Vs TIME

From the above graph we can see the average FF of the organic photovoltaic wherein became zeo encapsulation compared with the lifetime within a time of 103 hours. Also the graph shows the FF remains up to 93.13 % in the first hour, resulting falling down to 0 % after 83 hours.



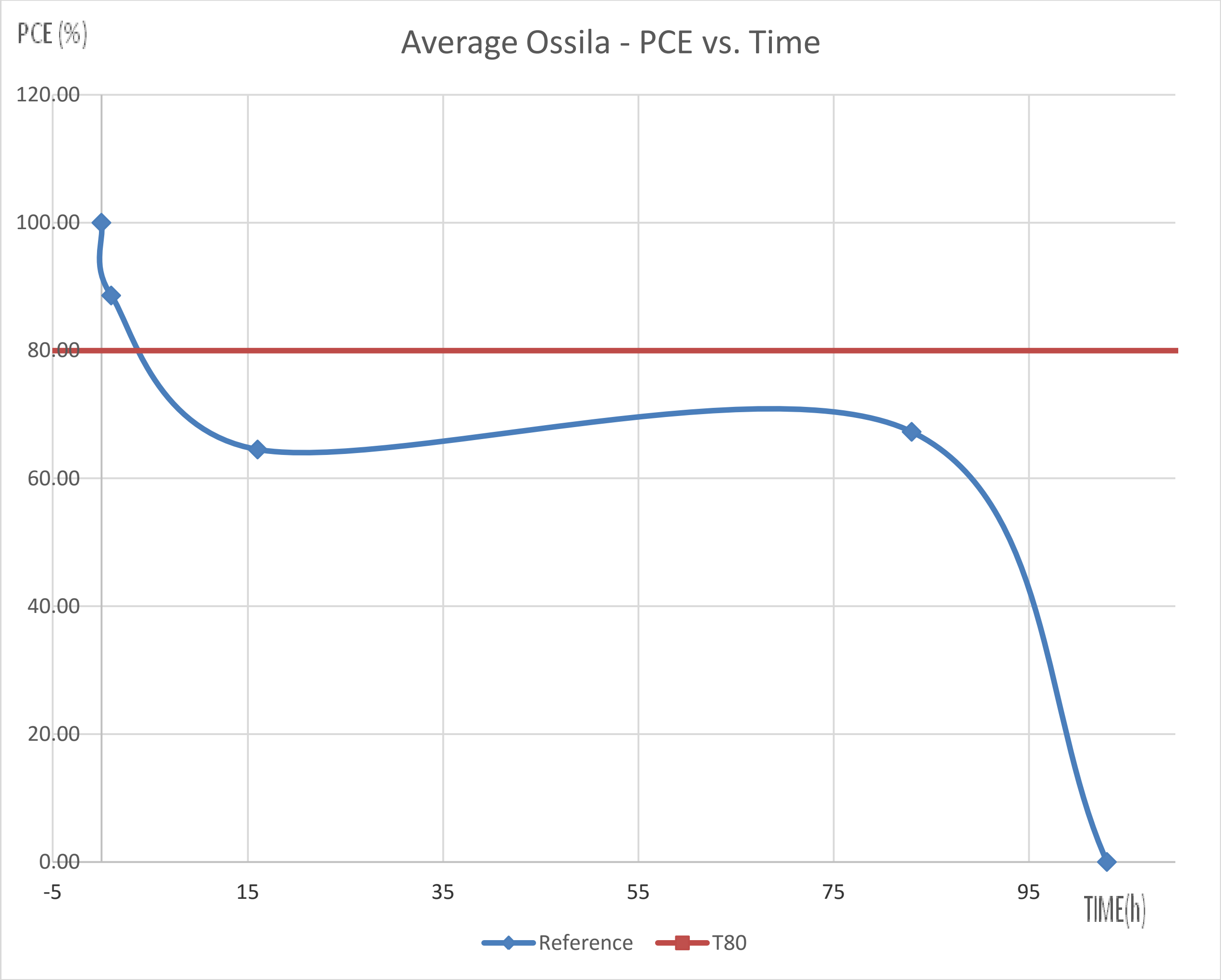
Graph 26: Experiment 3:OSSILA AVERAGE FF Vs TIME

The above graph shows the average FF of the organic photovoltaic with ossila encapsulation compared with the lifetime of 103 hours. In addition, the graph illustrates the FF rising up to 168.08 % in the first 16 hours. In the end of the measurements, it results to 0 % in 103 hours.

Experiment 4:

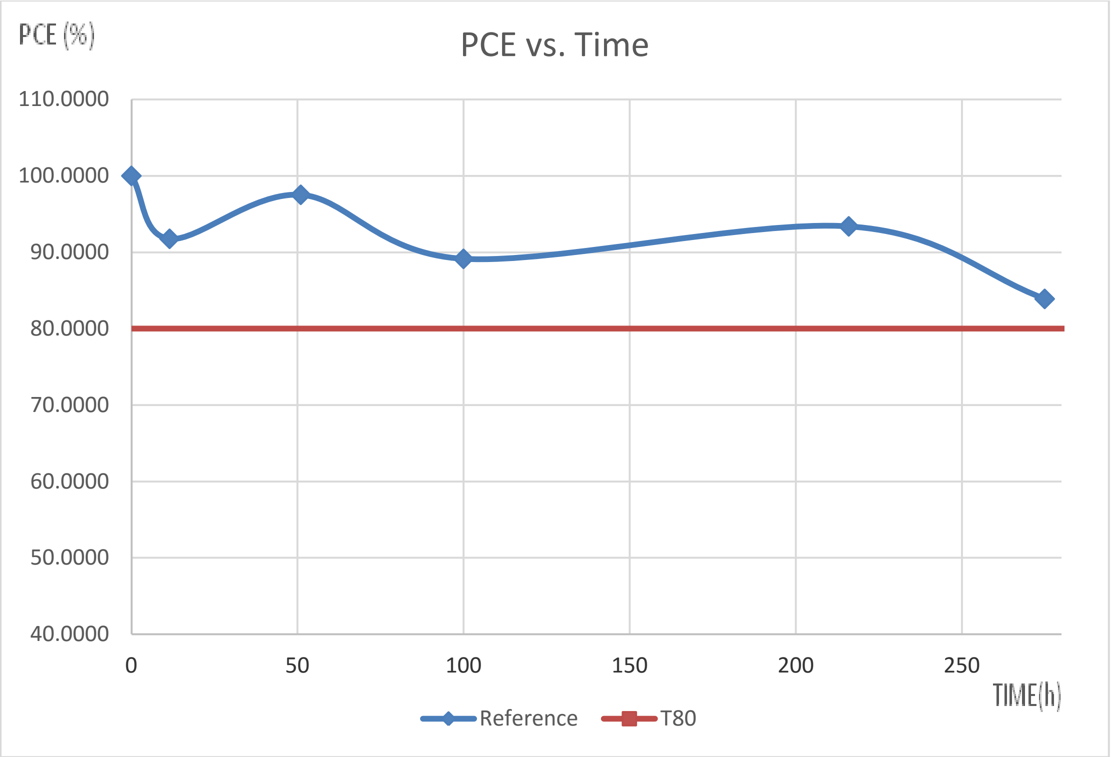
OSSILA and DYMAX

PCE Vs TIME



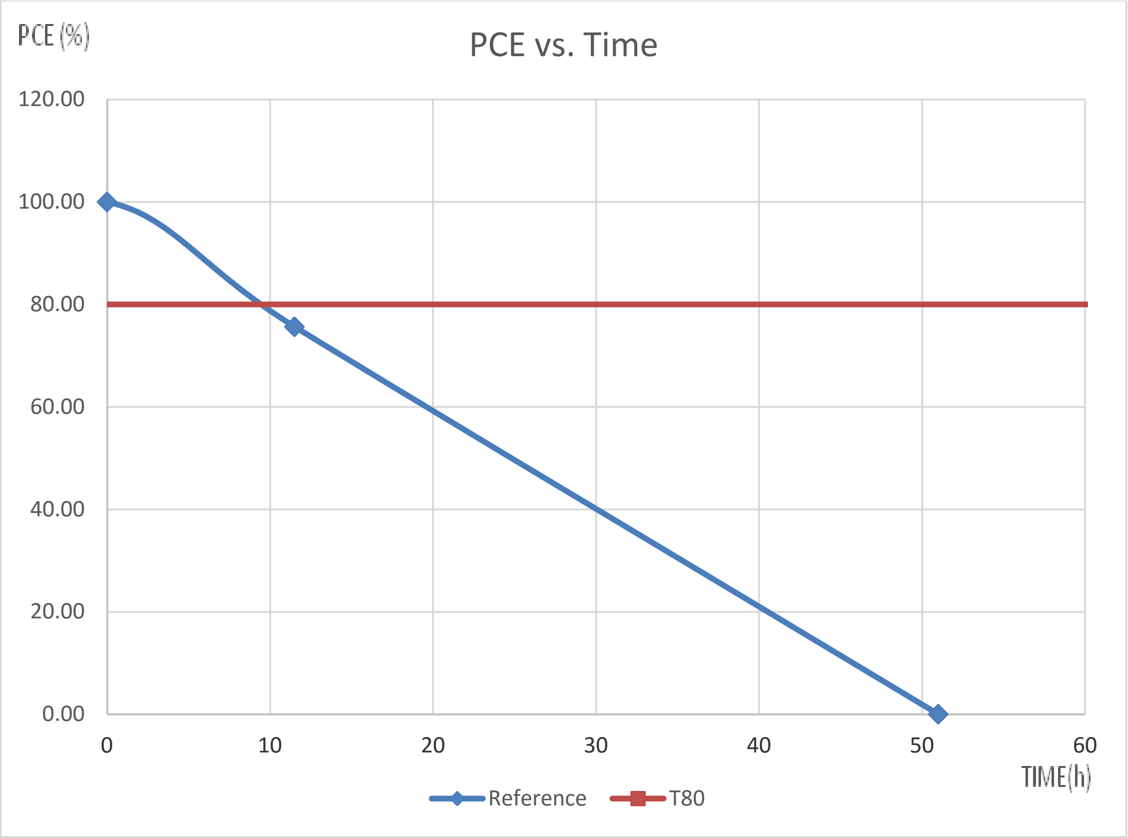
Graph 27: Experiment 4: OSSILA AVERAGE PCE Vs TIME

The above graph shows the average efficiency of the organic photovoltaic with ossila encapsulation compared with the lifetime of 103 hours. Another important thing is that the performance falls below 80% during the first 5 hours. In addition, during the 83 hours, an average yield of about 67.29% can be noticed ending at 0% in 103 hours.



Graph 28: Experiment 4: OSSILA MAX PCE Vs TIME

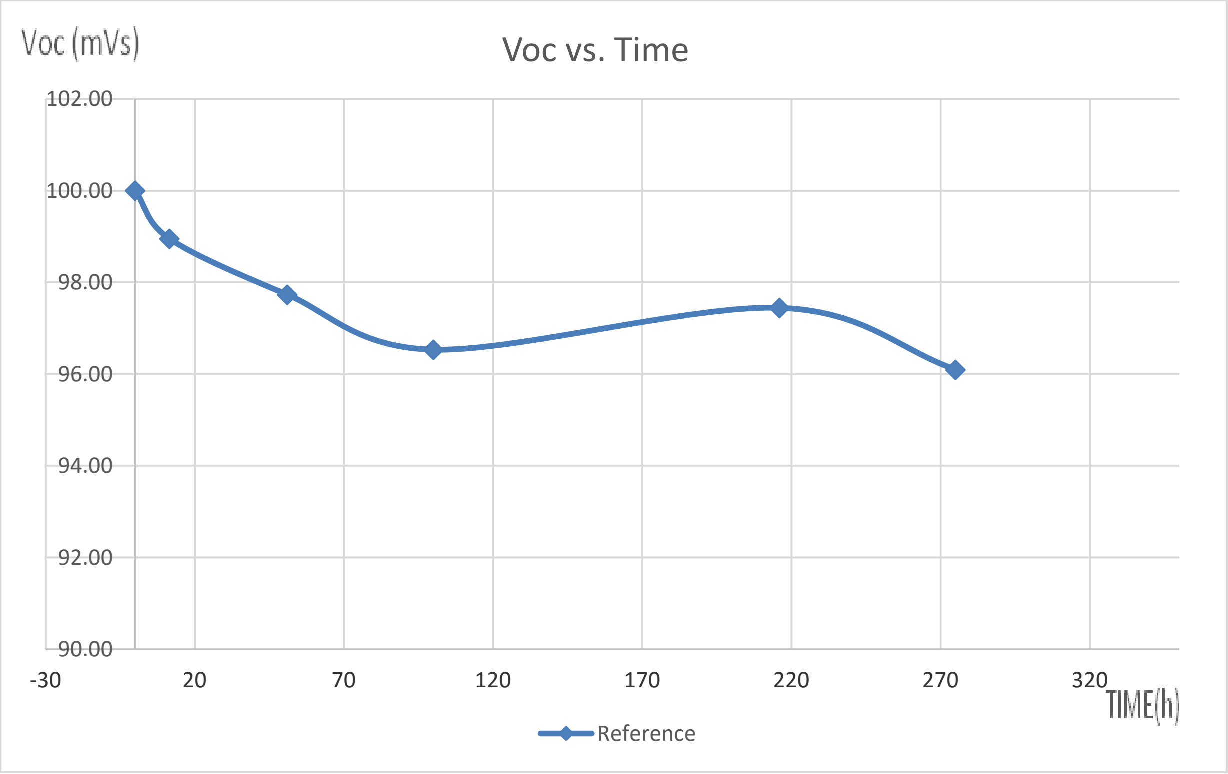
The above graph presents the maximum efficiency of the organic photovoltaic with ossila encapsulation compared with the lifetime of 275 hours. In addition, the graph shows that the performance still remains up to 80% marking a slight increase to 85.52% during the first 51 hours. Also, in the first 216 hours, the average yield is 80.4% ending at 70.54% in 275 hours.



Graph 29: Experiment 4: DYMAX MAX PCE Vs TIME

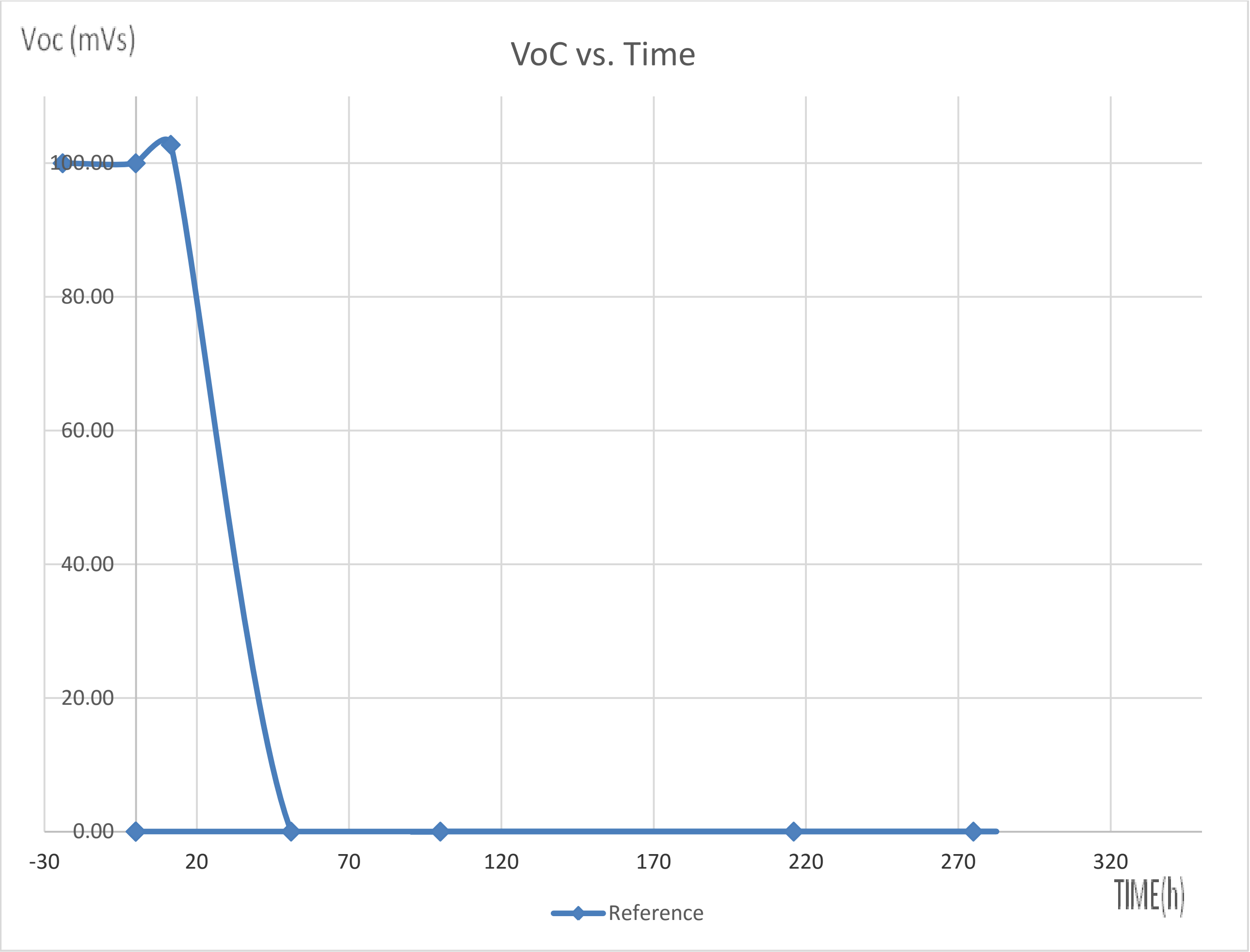
The above graph illustrates the maximum efficiency of the organic photovoltaic with dymax encapsulation compared with the lifetime of 275 hours. In addition, it seems that the performance decreases from 80 % to 75.63 %, during the first 11.5 hours.

Voc Vs Time



Graph 30: Experiment 4: OSSILA AVERAGE Voc Vs TIME

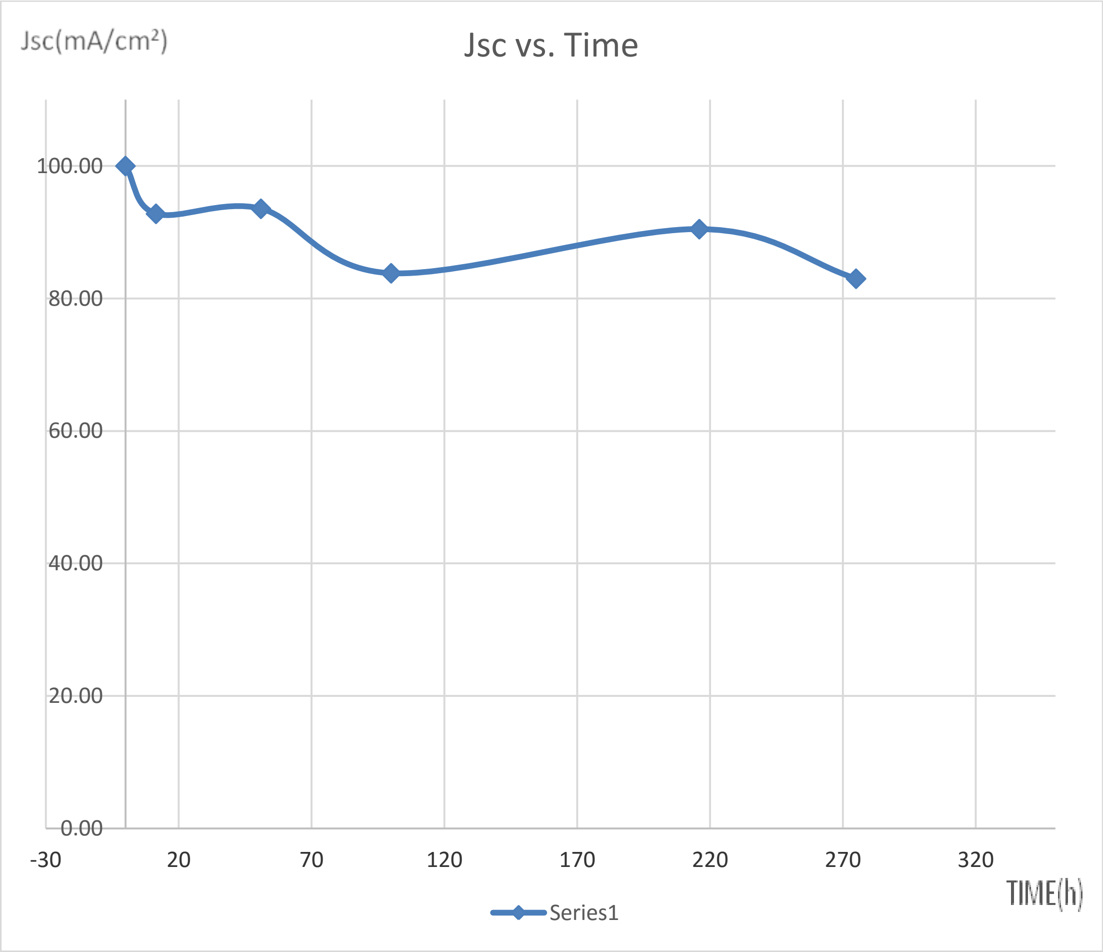
As it can be seen from above, the graph illustrates the average Voc of the organic photovoltaic with ossila encapsulation compared with the lifetime of 275 hours. Moreover, it shows that Voc remarks a high increase reaching the 102.75% during the first 11.5 hours. In addition, the next measurement shows that Voc falls to 0% during the 51 hours.



Graph 31: Experiment 4: DYMAX AVERAGE Voc Vs TIME

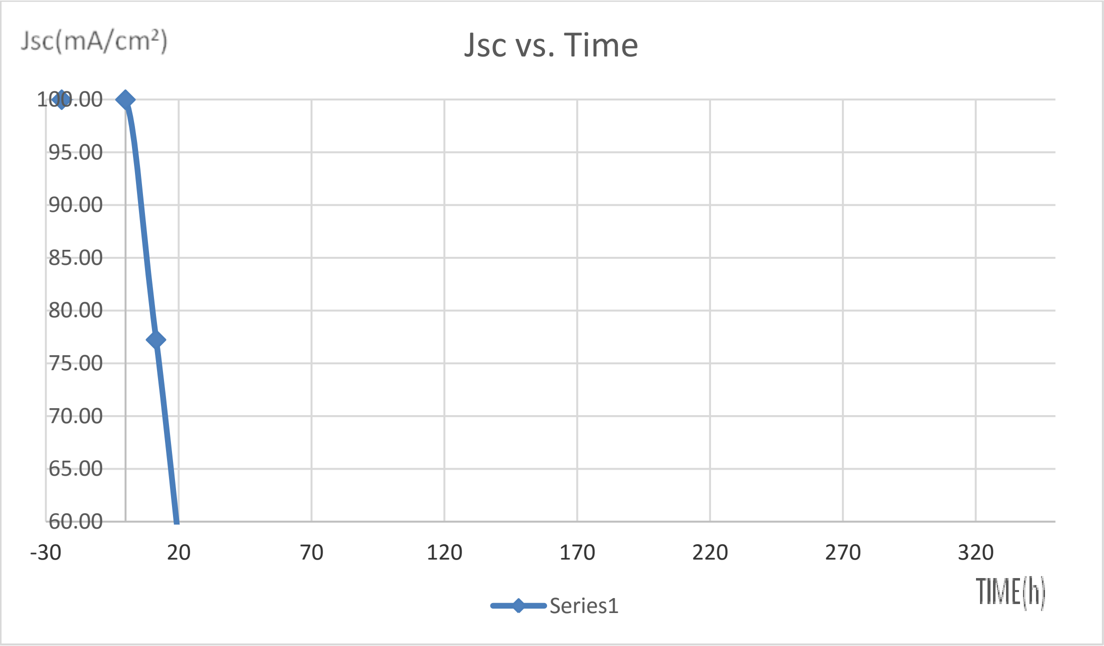
The graph illustrates the average Voc of organic photovoltaic with dymax encapsulation compared with the lifetime of 275 hours. As it can be seen, Voc falls to 0 % in the first 51 hours.

Jsc Vs Time



Graph 32: Experiment 4: OSSILA AVERAGE Jsc Vs TIME

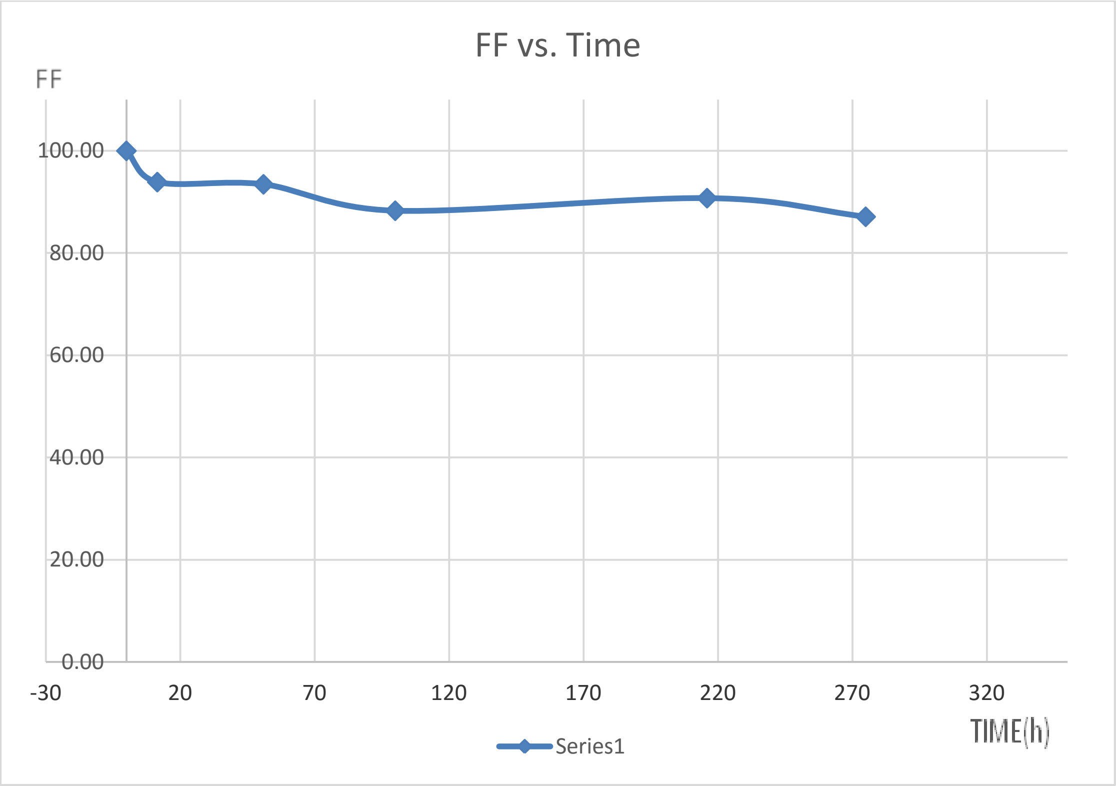
The above graph illustrates the average Jsc of the organic photovoltaic with ossila encapsulation compared with the lifetime of 275 hours. Also, the graph presents Jsc falling down to 83.81 % during 100 hours. In the last measurement, it can be observed that Jsc decreases slightly ending with 82.99% during 275 hours.



Graph 33: Experiment 4: DYMAX AVERAGE Jsc Vs TIME

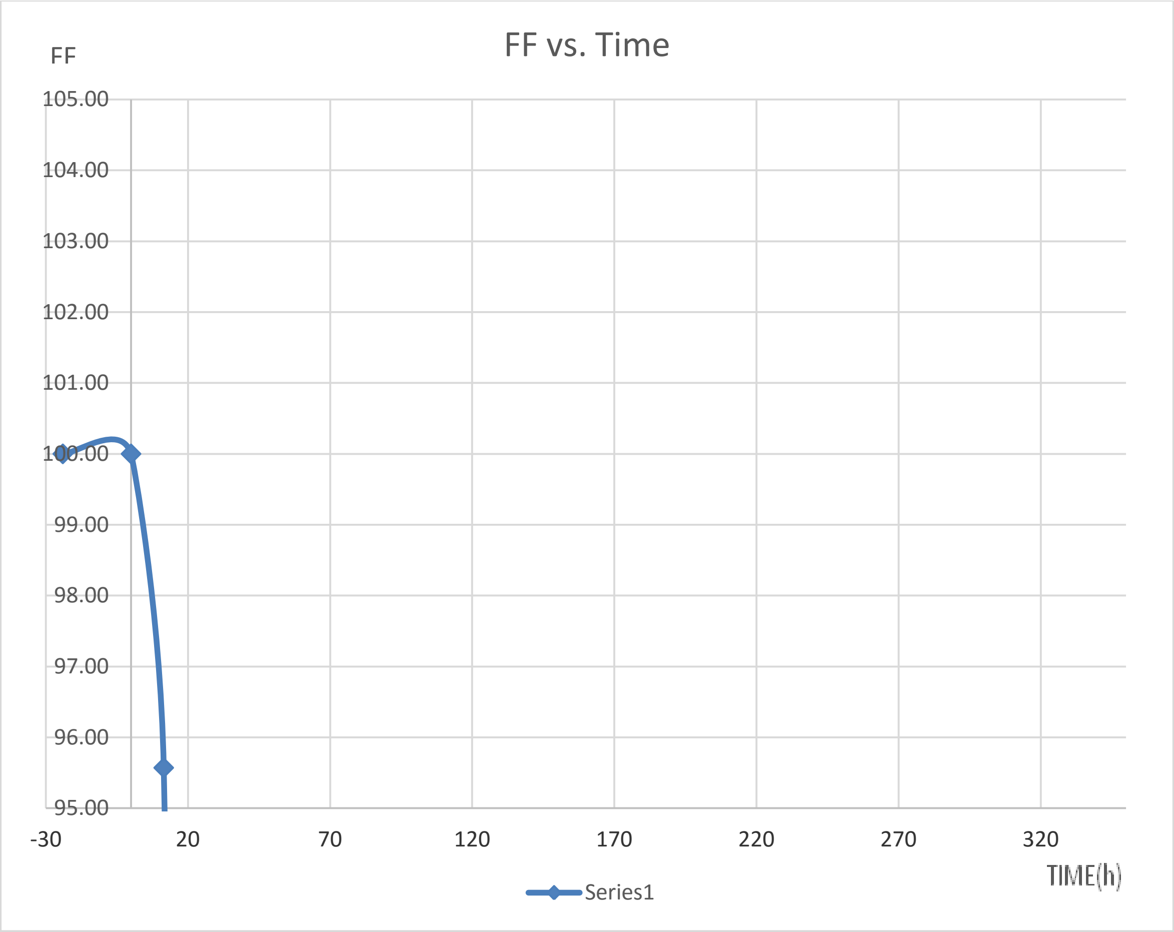
The above graph illustrates the average Jsc of the organic photovoltaic with dymax encapsulation compared with the lifetime of 275 hours. In addition, the graph shows that Jsc falls down to 80 % in the first 11.5 hours resulting to 0 % in 275 hours.

FF Vs Time



Graph 34: Experiment 4: OSSILA AVERAGE FF Vs TIME

The above graph shows the average FF of the organic photovoltaic with ossila encapsulation compared with the lifetime of 275 hours. Also, the graph shows that FF decreases to 88.29 % in the first 100 hours. In the end of the measurements, results show that FF ends with 87.1% in 275 hours.



Graph 35: Experiment 4: DYMAX AVERAGE FF Vs TIME

The above graph shows the average FF of the organic photovoltaic with dymax encapsulation compared with the lifetime of 275 hours. Here, FF falls down to 80 %, resulting to 0 % in the first 51 hours.

5.2 Photocurrent Mapping

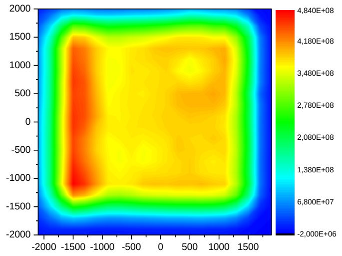
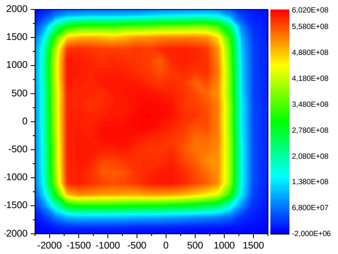
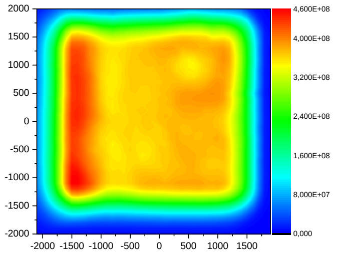
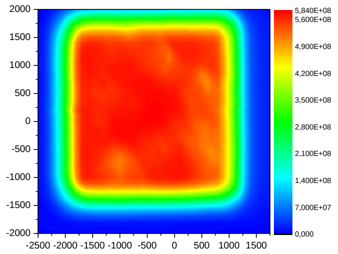
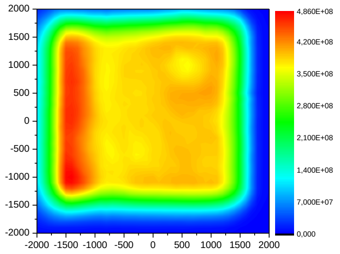
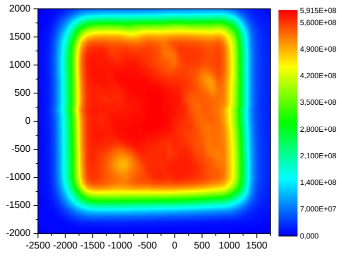
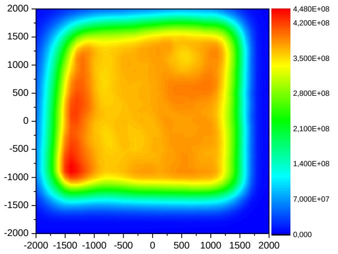
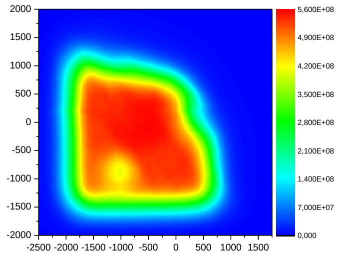
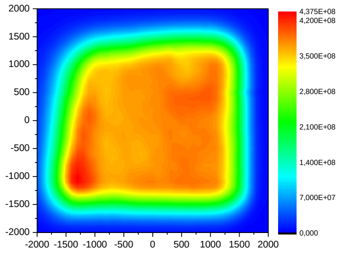
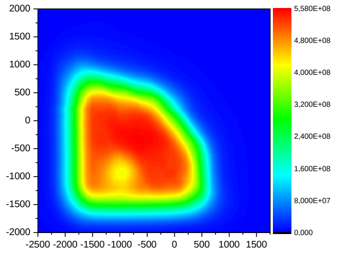
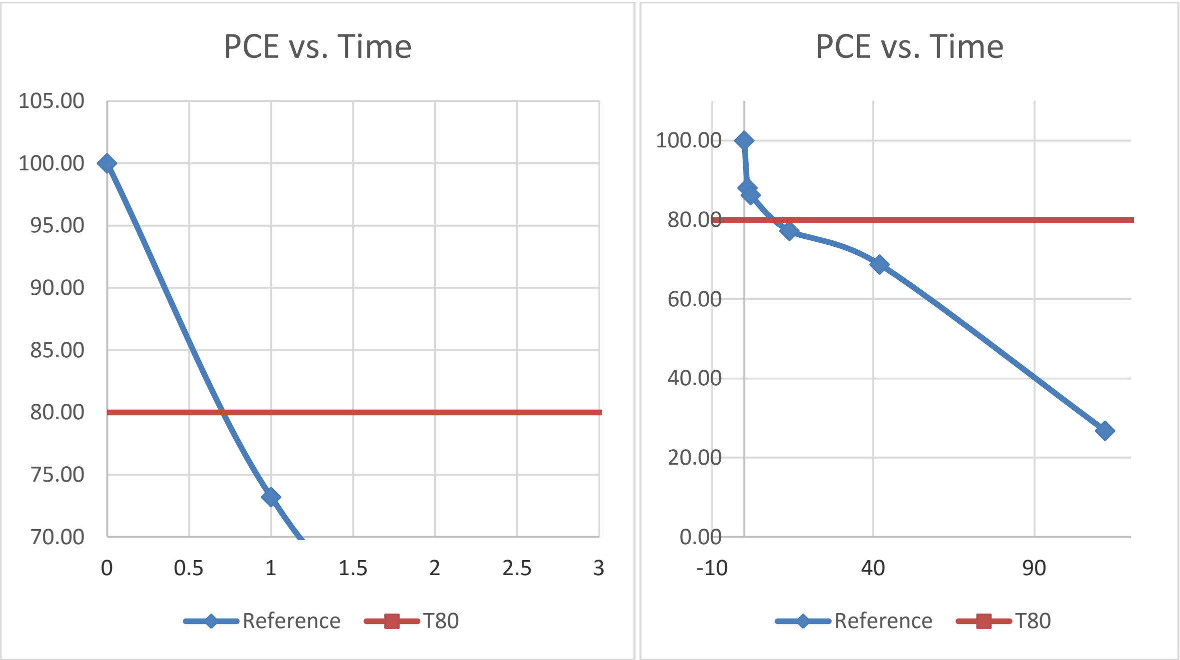
Encapsulation	**ZEOGLUE**	**OSSILA System**
Photocurrent Mapping after fabrication		
Photocurrent Mapping after 1h at Damp Heat (65°C, RH=85%)		
Photocurrent Mapping after 16h at Damp Heat (65°C, RH=85%)		
Photocurrent Mapping after 83h at Damp Heat (65°C, RH=85%)		
Photocurrent Mapping after 103h at Damp Heat (65°C, RH=85%)		

Image 11: Ossila and Zeo photocurrent mapping.

The above image depicts the pictures (Zeo to the left and Ossila to the right) which are taken from the photocurrent mapping. In the first 16 hours, the degradation is almost the same for both glues. After 83 and 103 hours respectively, the degradation of Ossila electrode is larger than Zeo's. This is a result of the influx of moisture in the devices with Ossila encapsulation, implying that Zeo is responsible for the protection of the devices from moisture.

5.3 Results

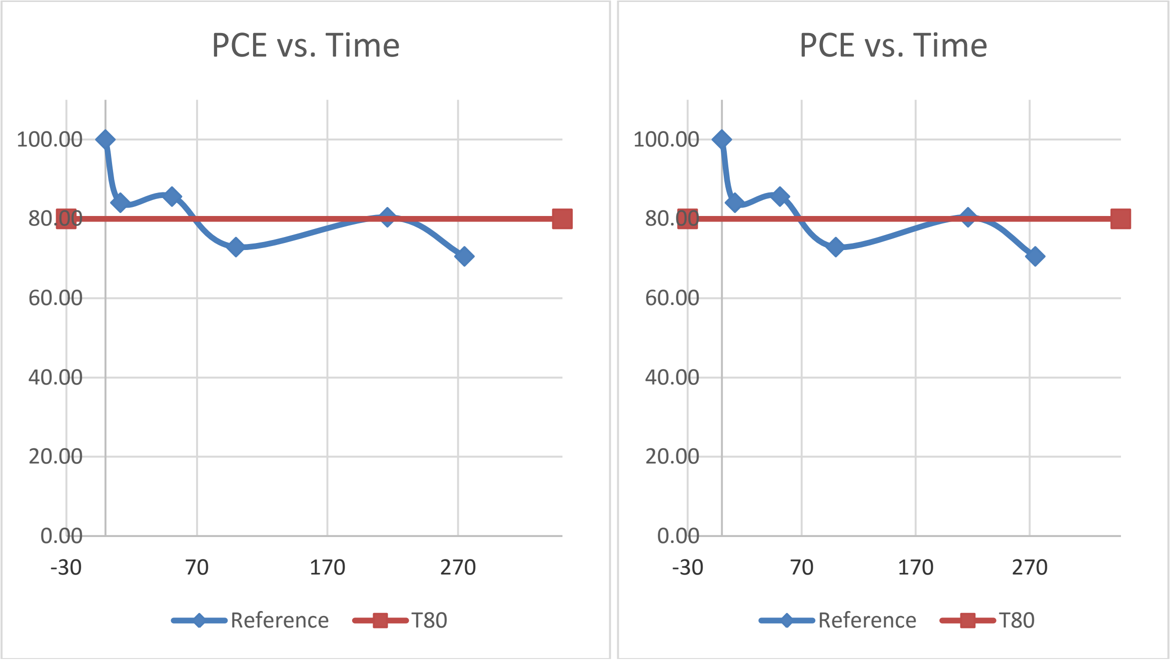
Compare Ossila Vs Dymax 3089



Graph 37 : DYMAX Vs OSSILA AVERAGE PCE Vs TIME

The graph shows the average efficiency of the organic photovoltaic with dymax and ossila encapsulation compared with the lifetime of 112 hours. It can be notices that the performance of dymax decreases to 80% during the first 40 minutes compares with ossila decreases in the first 14 hours. This fact implies that ossila's lifetime is 21 times more than dymax's.

Compare Ossila and Zeo



Graph 37: OSSILA Vs ZEO AVERAGE PCE Vs TIME

The above graph illustrates the average efficiency of the organic photovoltaic with ossila and zeo encapsulation compared with the lifetime of 275 hours. The graph shows something very important, which is related with the performance of zeo. Zeo remains stable to 80%, to 80.4% during the first 216 hours instead of ossila which remains stable during the first 38 hours. This means that zeo's lifetime is 6 times more than ossila's.

Ossila

Hours	$< \frac{Voc}{Voc_{initial}} >$	$< \frac{Jsc}{Jsc_{initial}} >$	$< \frac{FF}{FF_{initial}} >$	$< \frac{PCE}{PCE_{initial}} >$
1	0.9960	0.9370	0.9160	0.8660
16	0.9772	0.8025	0.7705	0.8710
83				0.6635

Zeo

Hours	$< \frac{Voc}{Voc_{initial}} >$	$< \frac{Jsc}{Jsc_{initial}} >$	$< \frac{FF}{FF_{initial}} >$	$< \frac{PCE}{PCE_{initial}} >$
1	0.9853	0.9553	0.9872	0.8420
16	0.9914	0.7226	1.0200	0.7330
83				0.7270

The above charts show the average value relative to the initial of V_{oc}, $J_{SC,}$ FF and PCE in relation with the hours that were in the oven. Based on the first analysis, it is obvious that zeo extends more the lifetime of Organic Photovoltaics compared with ossila and dymax. Since the power conversion efficiency (PCE) depends on Voc, Jsc and FF, then a detailed analysis must be done in order to find out which factor is responsible for the increase of lifetime.

Voc: The average Voc ratio of ossila in the first hour is 0.9960, falling down to 0.9772 in 16 hours and for zeo is 0.9853 and 0.9914 respectively. The results show that the Voc of zeo remains almost the same from the beginning whereas the Voc of ossila remarks a slight decrease.

Jsc: The average Jsc ratio relative to the initial of ossila is 0.9370 in an hour and 0.8025 in 16 hours whereas the average drop of zeo is 0.9553 in an hour and 0.7226 in 16 hours. Results show that the Jsc of ossila remains higher than the Jsc of zeo.

FF: The average FF rati relative to the initial of ossila is 0.9160 in an hour and 0.7705 in 16 hours where the average drop of zeo is 0.9872 in an hour and 1.0200 in 16 hours. So results indicate that the FF of zeo remains stable from the beginning comparing the values of FF of ossila that remarks a high drop.

Comparing the above factors, it can be assumed that the main difference deals with the values. In zeo the FF is stable from the beginning ending with a slight increase whereas in ossila the FF seems to have a continuous decrease. The FF shows the loss of the charges. In other words, if the charges are moving fast, they can be extracted whereas if the charges are moving slowly, they will be able to get recombined. The assumption that the use of ZEO favors efficient charge extraction implies that both PEDOT: PSS and Al electrodes of the ZEO-based devices are well-protected by moisture. This is because:

1) There is no degradation of PEDOT/PSS layer. There is no water adsorption in PEDOT/PSS. It is known that PEDOT is hygroscopic (has a hygroscopic nature) [21], so if there was any hydration in PEDOT: PSS, the PEDOT would have adsorbed it, decreasing the PH and transforming it into acid [21]. With low PH, ITO can be damaged resulting to the decrease of conductivity and holes would not be able to have interface in order to be collected [9,11,12,].

2) There is no oxidation at the anode electrode (Al). To be more precise, due to the fact that metals react with oxygen very quickly, there is an oxidation caused by the adsorption of oxygen molecules [21]. The degradation of metal electrode creates thin barriers of oxide interrupting electric conductance and collection of carriers of charges. Metals such as Al, usually serve as electrodes in OPV devices because of their quality to have high work function (Φ=4.29ev) [20]. The basic mechanism of degradation of the metal electrode is well-known as the oxidation in the active layer. The degradation caused by oxidation may create a layer of oxide at the top of the metal layer (Al_2O_3) as well as the interface of metal with active layer [19]. The layer of oxidation has lower work function (Φ=3.9ev) and since it is insulator, it eliminates the collection of charges and thus reduces the performance [18].

To sum up, the attempt of this study was find out ways of increasing photovoltaics lifetime because photovoltaic's lifetime is an important parameter which needs improvement in relation with the inorganics. Experiments were made by using a basic structure of bulk heterojunction based on the method of the encapsulation. The encapsulation was made with the use of 3 types of glues which were found in the lab. The experimental procedure begun with the comparison of ossila with dymax 3089 and then with the comparison of ossila with zeo because ossila has been proved to be better than zeo. After the comparison of ossila with zeo, zeo was found to be better than ossila because it increased the lifetime 6 times more than ossila did. Through the study of different parameters which are responsible for the performance, it has been observed that the main difference is related with FF affects electrodes and as a result there was no degradation to the electrodes . For the above reasons, there were two implications: The first implication is that the anode electrode is protected from water inflow and the second one is that the cathode electrode is protected from humidity inflow and as a result they cannot be damaged but they are able to increase their lifetime. In further studies, more types of glues could be used in different structures of photovoltaic's which could be able to increase the lifetime of photovoltaic's.

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7. APPENDIX

7.1 Measures Tables

Experiment 1:

OSSILA and DYMAX

First measurements (after fabrication) :

Table 1: Experiment 1, ossila first measurement, device 1.

DEVICE 1 OSSILA	Voc(mVs)	Jsc(mA/cm^2)	FF(%)	PCE(%)
1	489.000	100.100	31.600	1.560
2	477.000	10.120	35.800	1.730
3	498.000	9.250	32.000	1.480
4	475.000	9.220	33.000	1.440
Average	484.750	32.170	33.100	1.550

Table 2: Experiment 1, ossila first measurement, device 2.

DEVICE 2 OSSILA	Voc(mVs)	Jsc(mA/cm^2)	FF(%)	PCE(%)
1	540.000	9.620	42.700	2.220
2	559.000	9.510	50.740	2.690
3	565.000	9.340	51.590	2.720
4	559.000	9.690	51.140	2.770
Average	555.750	9.540	49.040	2.600

Table 3: Experiment 1, dymax first measurement, device 3.

DEVICE 3 DYMAX	Voc(mVs)	Jsc(mA/cm^2)	FF(%)	PCE(%)
1	553.000	9.330	47.000	2.430
2	525.000	9.100	40.900	1.950
3				
4	534.000	8.340	45.100	2.100
Average	539.000	8.9233	9.215	2.190

Table 4: Experiment 1, dymax first measurement, device 4.

DEVICE 4 DYMAX	Voc(mVs)	Jsc(mA/cm^2)	FF(%)	PCE(%)
1	546.000	10.100	42.300	2.330
2	543.000	10.250	44.600	2.490
3	514.000	9.700	42.400	2.120
4	553.000	9.930	48.000	2.630
Average	539.000	10.000	44.330	2.390

Second measurements (15 Hours in 65 °C/RH 85%) :

Table 5: Experiment 1, ossila second measurement, device 1.

DEVICE 1 OSSILA	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1	456.000	0.933	3.400	0.030	33.800	1.070	0.480	0.310
2	425.000	0.891	8.970	0.890	36.700	1.030	1.410	0.820
3	447.000	0.898	8.350	0.900	32.800	1.030	1.220	0.820
4	429.000	0.903	8.560	0.930	33.300	1.010	1.220	0.850
Average	439.250	90.61	7.320	68.790	34.150	103.220	1.080	69.860

Table 6: Experiment 1, ossila second measurement, device 2.

DEVICE 2 OSSILA	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Average	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 7: Experiment 1, dymax second measurement, device 3.

DEVICE 3 DYMAX	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Average	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 8: Experiment 1, dymax second measurement, device 4.

DEVICE 4 DYMAX	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Average	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Third measurement (37 Hours in 65 °C/RH 85%) :

Table 9: Experiment 1, ossila third measurement, device 1.

DEVICE 1 OSSILA	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	438.000	0.918	7.100	0.700	36.500	1.020	1.190	0.690
3	461.000	0.926	7.800	0.840	32.000	1.000	1.210	0.820
4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Average	449.500	92.20	7.450	77.240	34.250	100.980	1.200	75.270

Table 10: Experiment 1, ossila third measurement, device 2.

DEVICE 2 OSSILA	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Average	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 11: Experiment 1, dymax third measurement, device 3.

DEVICE 3 DYMAX	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Average	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 12: Experiment 1, dymax third measurement, device 4.

DEVICE 4 DYMAX	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Average	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Fourth measurement (111 Hours in 65 °C/RH 85%) :

Table 13: Experiment 1, ossila fourth measurement, device 1.

DEVICE 1 OSSILA	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Average	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 14: Experiment 1, ossila fourth measurement, device 2.

DEVICE 2 OSSILA	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Average	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 15: Experiment 1, dymax fourth measurement, device 3.

DEVICE 3 DYMAX	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Average	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 16: Experiment 1, dymax fourth measurement, device 4.

DEVICE 4 DYMAX	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Average	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Experiment 2:

OSSILA and DYMAX

First measurements (after fabrication) :

Table 17: Experiment 2, dymax first measurement, device 1.

DEVICE 1 DYMAX	Voc(mVs)	Jsc(mA/cm^2)	FF(%)	PCE(%)
1	480.000	9.770	33.100	1.550
2	471.000	8.600	28.400	1.150
3	483.000	8.950	29.800	1.300
4	474.000	8.440	30.750	1.230
Average	477.000	8.940	30.510	1.310

Table 18: Experiment 2, dymax first measurement, device 2.

DEVICE 2 DYMAX	Voc(mVs)	Jsc(mA/cm^2)	FF(%)	PCE(%)
1	461.000	9.400	32.000	1.380
2	462.000	9.130	30.100	1.270
3	445.000	9.100	34.000	1.380
4	442.000	8.890	31.000	1.210
Average	452.500	9.130	31.775	1.310

Table 19: Experiment 2, ossila first measurement, device 3.

DEVICE 3 OSSILA	Voc(mVs)	Jsc(mA/cm^2)	FF(%)	PCE(%)
1				
2				
3	517.000	9.240	37.750	1.800
4	410.000	9.000	31.270	1.400
Average	463.500	9.120	34.510	1.600

Table 20: Experiment 2, ossila first measurement, device 4.

DEVICE 4 OSSILA	Voc(mVs)	Jsc(mA/cm^2)	FF(%)	PCE(%)
1	478.000	10.380	35.460	1.760
2	463.000	10.020	32.750	1.520
3				
4	490.000	8.990	31.350	1.380
Average	477.000	9.800	33.190	1.550

Table 21: Experiment 2, ossila first measurement, device 5.

DEVICE 5 OSSILA	Voc(mVs)	Jsc(mA/cm^2)	FF(%)	PCE(%)
1	502.000	9.400	34.100	1.610
2	457.000	9.990	35.200	1.680
3	528.000	9.450	37.300	1.860
4	536.000	10.180	40.250	2.200
Average	505.750	9.760	36.710	1.840

Table 22: Experiment 2, ossila first measurement, device 6.

DEVICE 6 OSSILA	Voc(mVs)	Jsc(mA/cm^2)	FF(%)	PCE(%)
1	471.000	10.170	31.900	1.530
2	490.000	10.340	34.800	1.760
3	482.000	9.550	30.500	1.400
4	469.000	9.500	28.700	1.230
Average	478.000	9.890	31.480	1.480

Second measurements (1 Hours in 65 °C/RH 85%) :

Table 23: Experiment 2, dymax second measurement, device 1.

DEVICE 1 DYMAX	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1	449.000	0.935	7.950	0.810	30.300	0.920	1.080	0.700
2	449.000	0.953	8.340	0.970	27.760	0.980	1.040	0.900
3	465.000	0.963	8.610	0.960	28.800	0.970	1.150	0.880
4	453.000	0.956	7.440	0.880	27.300	0.890	0.920	0.750
Average	454.000	95.180	8.090	90.680	28.540	93.680	1.050	80.840

Table 24: Experiment 2, dymax second measurement, device 2.

DEVICE 2 DYMAX	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1	443.000	0.961	6.100	0.650	31.900	1.000	0.860	0.620
2	451.000	0.976	4.600	0.500	30.200	1.000	0.630	0.500
3	434.000	0.975	5.970	0.660	31.700	0.930	0.820	0.590
4	428.000	0.968	8.500	0.960	30.400	0.980	1.100	0.910
Average	439.000	0.970	6.293	0.691	31.050	0.978	0.853	0.656

Table 25: Experiment 2, ossila second measurement, device 3.

DEVICE 3 OSSILA	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1								
2								
3	500.000	0.967	8.800	0.950	34.100	0.900	1.500	0.830
4	425.000	1.037	8.820	0.980	30.400	0.970	1.200	0.860
Average	462.500	100.19	8.810	96.620	32.250	93.770	1.350	84.520

Table 26: Experiment 2, ossila second measurement, device 4.

DEVICE 4 OSSILA	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1	455.000	0.952	10.200	0.980	35.400	1.000	1.640	0.930
2	440.000	0.950	9.820	0.980	32.400	0.990	1.400	0.920
3								
4	468.000	0.9550	8.790	0.980	31.000	0.990	1.280	0.930
Average	454.333	95.240	9.600	98.020	32.930	99.220	1.440	92.720

Table 27: Experiment 2, ossila second measurement, device 5.

DEVICE 5 OSSILA	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1	506.000	1.008	5.100	0.540	32.200	0.940	0.840	0.520
2	453.000	0.991	9.050	0.910	35.300	1.000	1.450	0.860
3	504.000	0.955	9.270	0.980	36.500	0.980	1.710	0.920
4	513.000	0.957	9.900	0.970	40.500	1.010	2.030	0.920
Average	494.000	97.770	8.330	85.050	36.130	98.300	1.510	80.670

Table 28: Experiment 2, ossila second measurement, device 6.

DEVICE 6 OSSILA	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1	456.000	0.968	9.980	0.980	32.250	1.010	1.470	0.960
2	465.000	0.949	10.170	0.980	34.500	0.990	1.630	0.930
3	456.000	0.946	9.300	0.970	30.400	1.000	1.290	0.920
4	443.000	0.945	9.200	0.970	28.400	0.990	1.160	0.940
Average	455.000	95.190	9.660	97.680	31.390	99.720	1.390	93.790

Third measurement (2 Hours in 65 °C/RH 85%) :

Table 29: Experiment 2, dymax third measurement, device 1.

DEVICE 1 DYMAX	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1	446.000	0.929	6.520	0.670	31.300	0.950	0.910	0.590
2	446.000	0.947	7.600	0.880	28.100	0.990	0.950	0.830
3	467.000	0.967	7.700	0.860	29.200	0.980	1.050	0.810
4	456.000	0.962	6.100	0.720	27.100	0.880	0.760	0.620
Average	453.750	95.120	6.980	78.350	28.930	94.910	0.920	70.970

Table 30: Experiment 2, dymax third measurement, device 2.

DEVICE 2 DYMAX	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1	460.000	0.998	3.170	0.340	28.760	0.900	0.420	0.300
2	445.000	0.963	4.800	0.530	31.100	1.030	0.660	0.520
3	439.000	0.987	4.600	0.510	30.500	0.900	0.620	0.450
4	429.000	0.971	7.500	0.840	30.000	0.970	0.970	0.800
Average	443.250	0.980	5.018	0.553	30.090	0.949	0.668	0.519

Table 31: Experiment 2, ossila third measurement, device 3.

DEVICE 3 OSSILA	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1								
2								
3	488.000	0.944	8.330	0.900	31.600	0.840	1.290	0.720
4	415.000	1.012	8.880	0.990	34.200	1.090	1.370	0.980
Average	451.500	97.810	8.610	94.410	32.900	96.540	1.330	84.760

Table 32: Experiment 2, ossila third measurement, device 4.

DEVICE 4 OSSILA	Voc (mVs)	$\frac{Voc}{Voc_{initia}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initia}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1	446.000	0.933	10.150	0.980	35.100	0.990	1.590	0.900
2	434.000	0.937	9.020	0.900	30.900	0.940	1.210	0.800
3								
4								
Average	440.000	93.520	9.590	93.900	33.000	96.670	1.400	84.970

Table 33: Experiment 2, ossila third measurement, device 5.

DEVICE 5 OSSILA	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1								
2	444.000	0.972	8.800	0.880	34.600	0.980	1.350	0.800
3	496.000	0.939	9.240	0.980	36.000	0.970	1.630	0.880
4	508.000	0.948	9.800	0.960	40.450	1.000	2.010	0.910
Average	482.667	95.290	9.280	94.040	37.020	98.440	1.660	86.450

Table 34: Experiment 2, ossila third measurement, device 6.

DEVICE 6 OSSILA	Voc (mVs)	$\frac{Voc}{Voc_{initia}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{init}}$	FF(%)	$\frac{FF}{FF_{initia}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1	445.000	0.945	9.800	0.960	31.800	1.000	1.390	0.910
2	455.000	0.929	10.000	0.970	34.300	0.990	1.560	0.890
3	446.000	0.925	8.930	0.940	29.700	0.970	1.180	0.840
4								
Average	448.667	93.290	9.580	95.530	31.930	98.540	1.380	87.920

Fourth measurement (14 Hours in 65 °C/RH 85%) :

Table 35: Experiment 2, dymax fourth measurement, device 1.

DEVICE 1 DYMAX	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1	0.000	0.000	0.00	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.00	0.000	0.000	0.000	0.000	0.000
3	0.000	0.000	0.00	0.000	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Average	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 36: Experiment 2, dymax fourth measurement, device 2.

DEVICE 2 DYMAX	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Average	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 37: Experiment 2, ossila fourth measurement, device 3.

DEVICE 3 OSSILA	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1								
2								
3	476.000	0.9210	8.320	0.900	32.600	0.860	1.290	0.720
4								
Average	476.000	92.070	8.320	90.040	32.600	86.360	1.290	71.670

Table 38: Experiment 2, ossila fourth measurement, device 4.

DEVICE 4 OSSILA	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1	438.000	0.916	9.680	0.930	33.900	0.960	1.440	0.820
2								
3								
4								
Average	438.000	91.630	9.680	93.260	33.900	95.600	1.440	81.820

Table 39: Experiment 2, ossila fourth measurement, device 5.

DEVICE 5 OSSILA	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1								
2								
3	487.000	0.922	8.990	0.950	36.100	0.970	1.580	0.850
4	510.000	0.951	8.380	0.820	39.500	0.980	1.690	0.770
Average	498.500	93.69	8.690	88.730	37.800	97.460	1.640	80.880

Table 40: Experiment 2, ossila fourth measurement, device 6.

DEVICE 6 OSSILA	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1	434.000	0.921	8.420	0.830	28.700	0.900	1.050	0.690
2	435.000	0.888	8.580	0.830	33.600	0.970	1.400	0.800
3								
4								
Average	434.500	90.460	8.500	82.890	31.150	93.260	1.230	74.090

Fifth measurement (42 Hours in 65 °C/RH 85%) :

Table 41: Experiment 2, dymax fifth measurement, device 1.

DEVICE 1 DYMAX	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Average	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 42: Experiment 2, dymax fifth measurement, device 2.

DEVICE 2 DYMAX	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Average	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 43: Experiment 2, ossila fifth measurement, device 3.

DEVICE 3 OSSILA	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Average	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 44: Experiment 2, ossila fifth measurement, device 4.

DEVICE 4 OSSILA	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1	438.000	0.916	9.100	0.880	35.700	1.010	1.420	0.810
2								
3								
4								
Average	438.000	0.916	9.100	0.880	35.700	1.010	1.420	0.810

Table 45: Experiment 2, ossila fifth measurement, device 5.

DEVICE 5 OSSILA	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1								
2								
3	481.000	0.911	9.100	0.960	35.100	0.940	1.410	0.760
4	489.000	0.912	8.340	0.820	38.900	0.970	0.990	0.450
Average	485.000	91.160	8.720	89.110	37.000	95.370	1.200	60.400

Table 46: Experiment 2, ossila fifth measurement, device 6.

DEVICE 6 OSSILA	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1	433.000	0.919	8.380	0.820	30.000	0.940	1.090	0.710
2	438.000	0.894	8.830	0.850	32.600	0.940	1.250	0.710
3								
4								
Average	435.500	90.660	8.610	83.900	31.300	93.860	1.170	71.130

Sixth measurement (112 Hours in 65 °C/RH 85%) :

Table 47: Experiment 2, dymax sixth measurement, device 1.

DEVICE 1 DYMAX	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Average	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 48: Experiment 2, dymax sixth measurement, device 2.

DEVICE 2 DYMAX	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Average	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 49: Experiment 2, ossila sixth measurement, device 3.

DEVICE 3 OSSILA	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Average	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 50: Experiment 2, ossila sixth measurement, device 4.

DEVICE 4 OSSILA	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Average	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 51: Experiment 2, ossila sixth measurement, device 5.

DEVICE 5 OSSILA	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Average	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 52: Experiment 2, ossila sixth measurement, device 6.

DEVICE 6 OSSILA	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1	446.000	0.947	3.310	0.330	27.500	0.860	0.410	0.270
2								
3								
4								
Average	446.000	0.946	3.310	32.550	27.500	86.210	0.410	26.800

Experiment 3:

OSSILA and ZEO

First measurements (after fabrication) :

Table 53: Experiment 3, ossila first measurement, device 1.

DEVICE 1 OSSILA	Voc(mVs)	Jsc(mA/cm^2)	FF(%)	PCE(%)
1		9.770	33.100	1.550
2	580.000	8.600	28.400	1.150
3	580.000	8.950	29.800	1.300
4	560.000	8.440	30.750	1.230
Average	573.333	8.940	30.510	1.310

Table 54: Experiment 3, ossila first measurement, device 2.

DEVICE 2 OSSILA	Voc(mVs)	Jsc(mA/cm^2)	FF(%)	PCE(%)
1				
2				
3	580.000	7.660	44.200	1.980
4	560.000	7.680	40.800	1.770
Average	570.000	7.670	42.500	1.875

Table 55: Experiment 3, ossila first measurement, device 3.

DEVICE 3 OSSILA	Voc(mVs)	Jsc(mA/cm^2)	FF(%)	PCE(%)
1	600.000	9.890	52.100	3.110
2	600.000	9.710	56.900	3.340
3	580.000	9.590	54.700	3.060
4	580.000	9.430	50.800	2.800
Average	590.000	9.660	53.630	3.080

Table 56: Experiment 3, zeo first measurement, device 4.

DEVICE 4 ZEO	Voc(mVs)	Jsc(mA/cm^2)	FF(%)	PCE(%)
1	580.000	9.070	31.500	1.670
2	580.000	9.440	37.500	2.070
3	560.000	9.090	35.300	1.810
4	580.000	8.810	28.000	1.390
Average	575.000	9.100	33.080	1.740

Table 57: Experiment 3, zeo first measurement, device 5.

DEVICE 5 ZEO	Voc(mVs)	Jsc(mA/cm^2)	FF(%)	PCE(%)
1	580.000	9.950	35.600	2.070
2	560.000	9.650	33.400	1.820
3	560.000	10.060	39.400	2.240
4	560.000	10.080	39.500	2.250
Average	565.000	9.940	36.980	2.100

Table 58: Experiment 3, zeo first measurement, device 6.

DEVICE 6 ZEO	Voc(mVs)	Jsc(mA/cm^2)	FF(%)	PCE(%)
1	580.000	7.650	39.500	1.760
2	560.000	7.680	38.900	1.690
3	560.000	7.280	41.800	1.720
4	560.000	7.350	43.700	1.810
Average	565.000	7.490	40.980	1.750

Second measurements (1 Hours in 65 °C/RH 85%) :

Table 59: Experiment 3, ossila second measurement, device 1.

DEVICE 1 OSSILA	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1	580.000	1.000	9.360	0.930	44.500	0.900	2.430	0.840
2	580.000	1.000	9.460	0.940	46.500	0.920	2.570	0.870
3	580.000	1.036	9.330	0.950	43.600	1.020	2.370	1.000
4	580.000	1.190	9.380	0.940	44.870	0.946	2.460	0.901
Average	580.000	1.000	9.360	0.930	44.500	0.900	2.430	0.840

Table 60: Experiment 3, ossila second measurement, device 2.

DEVICE 2 OSSILA	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1								
2								
3	580.000	1.000	7.220	0.940	41.200	0.930	1.740	0.880
4	560.000	1.000	7.300	0.950	38.600	0.950	1.590	0.900
Average	570.000	1.000	7.260	0.947	39.900	0.939	1.665	0.889

Table 61: Experiment 3, ossila second measurement, device 3.

DEVICE 3 OSSILA	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1								
2	580.000	0.967	9.060	0.930	48.800	0.860	2.660	0.800
3	580.000	1.000	9.030	0.940	51.200	0.940	2.790	0.910
4	580.000	1.000	8.790	0.930	47.700	0.940	2.530	0.900
Average	580.000	0.988	8.960	0.935	49.230	0.9109	2.660	0.870

Table 62: Experiment 3, zeo second measurement, device 4.

DEVICE 4 ZEO	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1	560.000	0.966	8.650	0.950	32.500	1.030	1.640	0.980
2	580.000	1.000	8.700	0.920	32.800	0.870	1.400	0.680
3	560.000	1.000	8.660	0.950	35.300	1.000		0.000
4	560.000	0.966	8.350	0.950	28.100	1.000	1.280	0.920
Average	565.000	0.982	8.590	0.944	32.180	0.978	1.440	0.645

Table 63: Experiment 3, zeo second measurement, device 5.

DEVICE 5 ZEO	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1	560.000	0.966	9.490	0.950	35.300	0.990	1.890	0.910
2	560.000	1.000	9.240	0.960	32.500	0.970	1.690	0.930
3	560.000	1.000	9.620	0.960	39.300	1.000	2.130	0.950
4	560.000	1.000	9.540	0.950	39.100	0.990	2.100	0.930
Average	560.000	0.991	9.470	0.954	36.550	0.988	1.950	0.9315

Table 64: Experiment 3, zeo second measurement, device 6.

DEVICE 6 ZEO	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1	560.000	0.966	7.560	0.990	41.000	1.040	1.750	0.990
2	560.000	1.000	7.460	0.970	40.100	1.030	1.690	1.000
3	540.000	0.964	6.960	0.960	38.000	0.910	1.440	0.840
4	560.000	1.000	7.040	0.960	44.000	1.010	1.750	0.970
Average	555.000	0.983	7.260	0.968	40.780	0.9962	1.660	0.950

Third measurement (16 Hours in 65 °C/RH 85%) :

Table 65: Experiment 3, ossila third measurement, device 1.

DEVICE 1 OSSILA	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1								
2	560.000	0.966	6.270	0.620	28.100	0.570	0.990	0.340
3	560.000	0.966	8.590	0.860	36.100	0.710	1.750	0.590
4	560.000	1.000	7.310	0.740	28.700	0.670	1.180	0.500
Average	560.000	0.977	7.390	0.740	30.970	0.651	1.310	0.476

Table 66: Experiment 3, ossila third measurement, device 2.

DEVICE 2 OSSILA	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1								
2								
3								
4								
Average								

Table 67: Experiment 3, ossila third measurement, device 3.

DEVICE 3 OSSILA	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1								
2	580.000	0.967	8.820	0.910	50.600	0.890	2.610	0.780
3	580.000	1.000	8.800	0.920	48.500	0.890	2.490	0.810
4	560.000	0.966	8.370	0.890	45.900	0.900	2.170	0.780
Average	573.333	0.977	8.660	0.904	48.330	0.893	2.420	0.790

Table 68: Experiment 3, zeo third measurement, device 4.

DEVICE 4 ZEO	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1								
2								
3								
4								
Average								

Table 69: Experiment 3, zeo third measurement, device 5.

DEVICE 5 ZEO	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1	560.000	0.966	5.560	0.560	35.000	0.980	1.100	0.530
2	560.000	1.000	9.230	0.960	33.900	1.010	1.770	0.970
3	560.000	1.000	8.620	0.860	40.600	1.030	1.980	0.880
4	560.000	1.000	5.370	0.530	40.100	1.020	1.220	0.540
Average	560.000	0.991	7.200	72.620	37.400	1.020	1.520	0.733

Table 70: Experiment 3, zeo third measurement, device 6.

DEVICE 6 ZEO	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1								
2								
3								
4								
Average								

Fourth measurement (83 Hours in 65 °C/RH 85%) :

Table 71: Experiment 3, ossila fourth measurement, device 1.

DEVICE 1 OSSILA	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1								
2							2.300	0.790
3							1.840	0.620
4							1.710	0.720
Average							1.950	0.712

Table 72: Experiment 3, ossila fourth measurement, device 2.

DEVICE 2 OSSILA	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1								
2								
3								
4								
Average								

Table 73: Experiment 3, ossila fourth measurement, device 3.

DEVICE 3 OSSILA	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1								
2							1.990	0.600
3							1.950	0.640
4								
Average							1.970	0.616

Table 74: Experiment 3, zeo fourth measurement, device 4.

DEVICE 4 ZEO	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1							1.400	0.840
2								
3							0.930	0.510
4							0.450	0.320
Average							1.400	0.840

Table 75: Experiment 3, zeo fourth measurement, device 5.

DEVICE 5 ZEO	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1								
2							1.130	0.620
3							0.560	0.250
4								
Average							0.850	0.435

Table 76: Experiment 3, zeo fourth measurement, device 6.

DEVICE 6 ZEO	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1							1.490	0.850
2							1.640	0.970
3							1.550	0.900
4								
Average							1.560	0.906

Fifth measurement (103 Hours in 65 °C/RH 85%) :

Table 77: Experiment 3, ossila fifth measurement, device 1.

DEVICE 1 OSSILA	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1								
2							2.000	0.690
3							1.490	0.500
4							1.380	0.580
Average							1.620	59.040

Table 78: Experiment 3, ossila fifth measurement, device 2.

DEVICE 2 OSSILA	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1								
2								
3								
4								
Average								

Table 79: Experiment 3, ossila fifth measurement, device 3.

DEVICE 3 OSSILA	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1							1.550	0.500
2							1.840	0.550
3							1.580	0.520
4								
Average							1.660	52.190

Table 80: Experiment 3, zeo fifth measurement, device 4.

DEVICE 4 ZEO	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1							0.76	0.46
2							0.91	0.44
3							0.36	0.20
4							0.30	0.22
Average							0.58	32.74

Table 81: Experiment 3, zeo fifth measurement, device 5.

DEVICE 5 ZEO	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1								
2								
3							0.340	0.150
4								
Average							0.340	15.180

Table 82: Experiment 3, zeo fifth measurement, device 6.

DEVICE 6 ZEO	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1							1.480	0.840
2							1.590	0.940
3							1.450	0.840
4							1.020	0.560
Average							1.390	79.710

Experiment 4:

OSSILA and DYMAX

First measurements (after fabrication) :

Table 83: Experiment 4, ossila first measurement, device 1.

DEVICE 1 OSSILA	Voc(mVs)	Jsc(mA/cm^2)	FF(%)	PCE(%)
1	488.000	9.380	34.700	1.590
2	483.000	8.740	33.900	1.430
3	479.000	9.110	35.100	1.530
4	493.000	8.700	30.000	1.270
Average	485.7500	8.980	33.430	1.460

Table 84: Experiment 4, ossila first measurement, device 2.

DEVICE 2 OSSILA	Voc(mVs)	Jsc(mA/cm^2)	FF(%)	PCE(%)
1	508.000	8.600	32.000	1.400
2	487.000	8.900	33.900	1.470
3				
4	560.000	9.960	48.000	2.670
Average	518.333	9.150	37.970	1.850

Table 85: Experiment 4, dymax first measurement, device 3.

DEVICE 3 DYMAX	Voc(mVs)	Jsc(mA/cm^2)	FF(%)	PCE(%)
1				
2	514.000	7.360	43.100	1.630
3	535.000	10.100	41.100	2.220
4	551.000	10.100	46.500	2.590
Average	524.500	9.187	8.730	1.925

Table 86: Experiment 4, dymax first measurement, device 4.

DEVICE 4 DYMAX	Voc(mVs)	Jsc(mA/cm^2)	FF(%)	PCE(%)
1	497.000	8.280	35.500	1.460
2	500.000	8.350	36.400	1.520
3	507.000	8.860	35.700	1.610
4	506.000	8.840	37.200	1.670
Average	502.500	8.580	36.200	1.570

Second measurements (11.5 Hours in 30 °C/RH 85%) :

Table 87: Experiment 4, ossila second measurement, device 1.

DEVICE 1 OSSILA	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1	473.000	0.969	8.410	0.900	31.230	0.900	1.240	0.780
2	473.000	0.979	7.400	0.850	31.100	0.920	1.090	0.760
3	468.000	0.977	8.340	0.920	33.100	0.940	1.290	0.840
4		0.000		0.000		0.000		0.000
Average	471.333	73.140	8.050	66.470	31.810	69.010	1.21	59.630

Table 88: Experiment 4, ossila second measurement, device 2.

DEVICE 2 OSSILA	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1	491.000	1.000	8.000	1.000	31.000	1.000	1.210	0.860
2	483.000	0.992	8.400	0.940	32.000	0.940	1.290	0.880
3								
4	571.000	1.020	9.610	0.960	44.600	0.930	2.450	0.920
Average	515.000	100.380	8.670	96.960	35.870	95.770	1.650	88.650

Table 89: Experiment 4, dymax second measurement, device 3.

DEVICE 3 DYMAX	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1								
2	520.000	1.012	6.360	0.860	41.000	0.950	1.360	0.830
3	540.000	1.009	8.500	0.840	40.800	0.990	1.870	0.840
4	567.000	1.029	7.960	0.790	42.000	0.900	1.890	0.730
Average	530.000	1.017	7.430	0.831	40.900	0.949	1.615	0.802

Table 90: Experiment 4, dymax second measurement, device 4.

DEVICE 4 DYMAX	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1	505.000	1.016	6.760	0.820	34.100	0.960	1.170	0.800
2	510.000	1.020	6.900	0.830	34.600	0.950	1.210	0.800
3	532.000	1.049	5.020	0.570	34.700	0.970	0.930	0.580
4	535.000	1.057	6.220	0.700	35.700	0.960	1.190	0.710
Average	520.500	103.570	6.230	72.820	34.780	96.070	1.130	72.190

Third measurement (51 Hours in 30 °C/RH 85%) :

Table 91: Experiment 4, ossila third measurement, device 1.

DEVICE 1 OSSILA	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1	464.000	0.951	8.410	0.900	31.600	0.910	1.230	0.770
2	468.000	0.969	7.520	0.860	31.600	0.930	1.110	0.780
3	463.000	0.967	8.510	0.930	33.150	0.940	1.310	0.860
4		0.000		0.000		0.000		0.000
Average	465.000	72.160	8.150	67.280	32.120	69.680	1.220	60.150

Table 92: Experiment 4, ossila third measurement, device 2.

DEVICE 2 OSSILA	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1	484.000	0.986	8.100	1.010	30.300	0.980	1.180	0.980
2	476.000	0.977	8.360	0.940	31.600	0.930	1.260	0.860
3								
4	568.000	1.014	9.660	0.970	43.700	0.910	2.400	0.900
Average	509.333	99.250	8.710	97.390	35.200	94.000	1.610	91.040

Table 93: Experiment 4, dymax third measurement, device 3.

DEVICE 3 DYMAX	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1								
2								
3								
4								
Average								

Table 94: Experiment 4, dymax third measurement, device 4.

DEVICE 4 DYMAX	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1								
2								
3								
4								
Average								

Fourth measurement (100 Hours in 30 °C/RH 85%) :

Table 95: Experiment 4, ossila fourth measurement, device 1.

DEVICE 1 OSSILA	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1	462.000	0.947	8.400	0.900	31.000	0.890	1.200	0.750
2	464.000	0.961	5.550	0.640	27.600	0.810	0.790	0.550
3	455.000	0.950	8.460	0.930	33.000	0.940	1.270	0.830
4		0.000		0.000		0.000		0.000
Average	460.333	71.430	7.470	61.480	30.530	66.190	1.090	53.430

Table 96: Experiment 4, ossila fourth measurement, device 2.

DEVICE 2 OSSILA	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1	478.000	0.974	7.200	0.900	28.650	0.920	0.990	0.810
2	468.000	0.961	6.200	0.700	27.600	0.810	0.780	0.530
3								
4	560.000	1.000	9.690	0.970	43.740	0.910	2.380	0.890
Average	502.000	97.820	7.700	85.650	33.330	88.320	1.380	74.530

Table 97: Experiment 4, dymax fourth measurement, device 3.

DEVICE 3 DYMAX	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1								
2								
3								
4								
Average								

Table 98: Experiment 4, dymax fourth measurement, device 4.

DEVICE 4 DYMAX	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1								
2								
3								
4								
Average								

Fifth measurement (216 Hours in 30 °C/RH 85%) :

Table 99: Experiment 4, ossila fifth measurement, device 1.

DEVICE 1 OSSILA	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1		0.000		0.000		0.00		0.000
2	460.000	0.952	6.180	0.710	29.400	0.870	0.840	0.590
3	463.000	0.967	8.440	0.930	32.300	0.920	1.260	0.820
4		0.000		0.000		0.00		0.000
Average	461.500	47.970	7.31	40.840	30.850	44.690	1.050	35.270

Table 100: Experiment 4, ossila fifth measurement, device 2.

DEVICE 2 OSSILA	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1	479.000	0.976	7.950	0.990	29.700	0.960	1.130	0.930
2	470.000	0.965	8.200	0.920	30.800	0.910	1.180	0.800
3								
4	567.000	1.013	9.710	0.970	42.400	0.880	2.330	0.870
Average	505.333	98.44	8.620	96.330	34.300	91.670	1.550	86.980

Table 101: Experiment 4, dymax fifth measurement, device 3.

DEVICE 3 DYMAX	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1								
2								
3								
4								
Average								

Table 102: Experiment 4, dymax fifth measurement, device 4.

DEVICE 4 DYMAX	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1								
2								
3								
4								
Average								

Sixth measurement (275 Hours in 30 °C/RH 85%) :

Table 101: Experiment 4, ossila sixth measurement, device 1.

DEVICE 1 OSSILA	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1		0.000		0.000		0.000		0.000
2	455.000	0.942	4.700	0.540	27.200	0.800	0.590	0.410
3	450.000	0.939	8.340	0.920	31.800	0.910	1.200	0.780
4		0.000		0.000		0.000		0.000
Average	452.500	47.040	6.520	36.330	29.500	42.710	0.890	29.840

Table 102: Experiment 4, ossila sixth measurement, device 2.

DEVICE 2 OSSILA	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1		0.000		0.000		0.000		0.000
2	466.000	0.957	8.050	0.900	30.900	0.910	1.160	0.790
3								
4	563.000	1.005	9.580	0.960	41.500	0.860	2.240	0.840
Average	514.500	65.410	8.820	62.210	36.200	59.200	1.700	54.270

Table 103: Experiment 4, dymax sixth measurement, device 3.

DEVICE 3 DYMAX	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1								
2								
3								
4								
Average								

Table 104: Experiment 4, dymax sixth measurement, device 4.

DEVICE 4 DYMAX	Voc (mVs)	$\frac{Voc}{Voc_{initial}}$	Jsc (mA/cm^2)	$\frac{Jsc}{Jsc_{initial}}$	FF(%)	$\frac{FF}{FF_{initial}}$	PCE (%)	$\frac{PCE}{PCE_{initial}}$
1								
2								
3								
4								
Average								