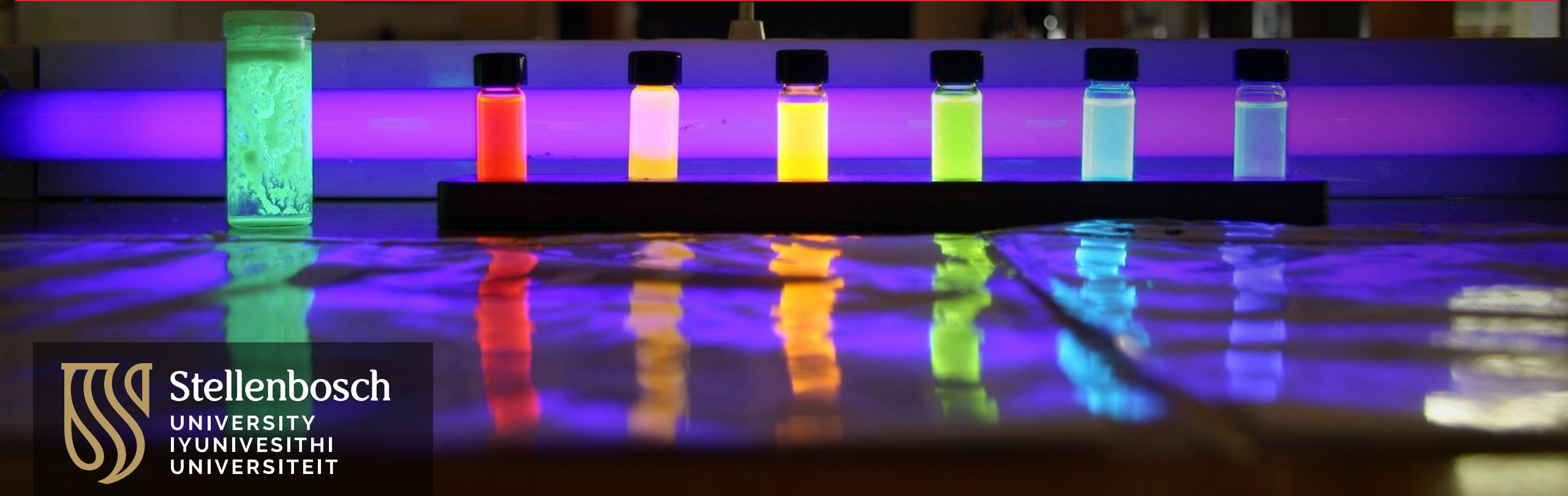


# Solution phase photodegradation studies of PCDTBT

Kelsey Everts

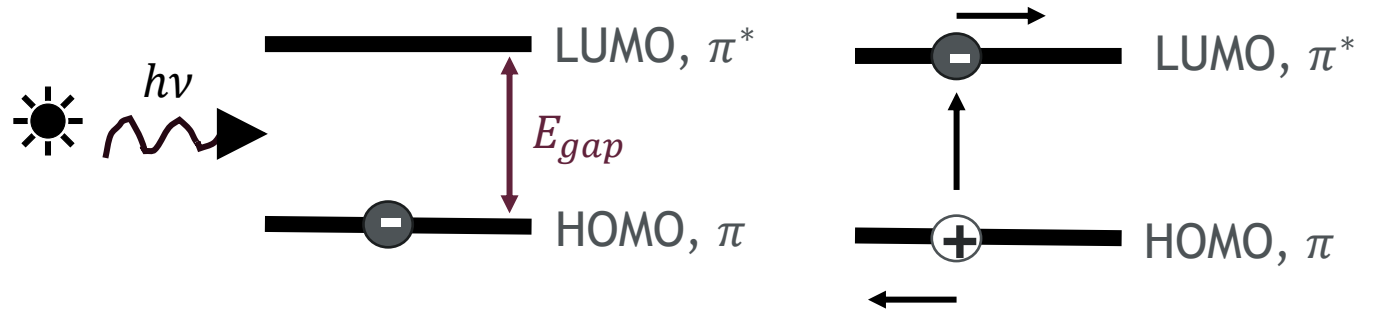
Supervisor: Dr G Bosman

SAIP 2023



Stellenbosch  
UNIVERSITY  
IYUNIVESITHI  
UNIVERSITEIT

# Solar cells



## Silicon

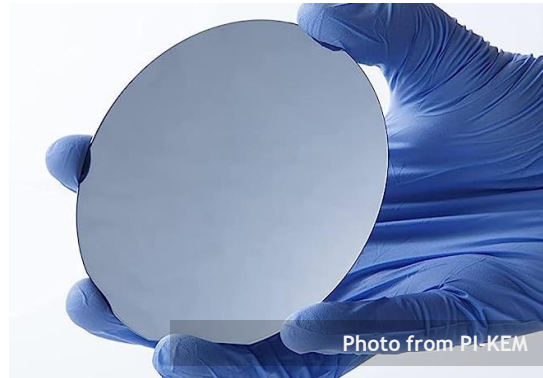
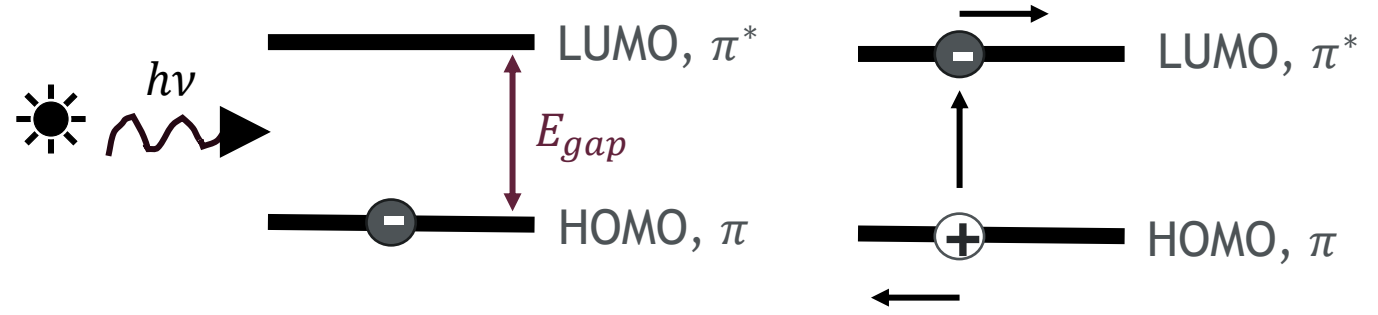


Photo from [insert ref]

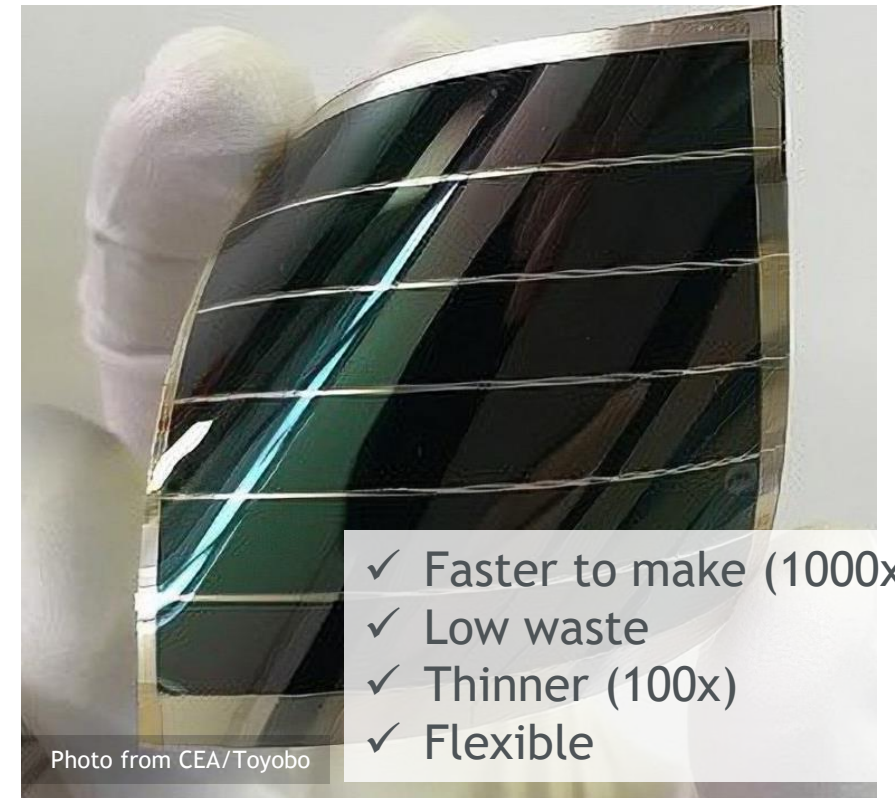
# Solar cells



## Silicon



## Organic

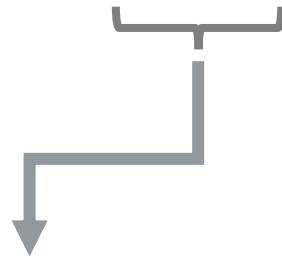


# Well then why isn't organic solar here yet?

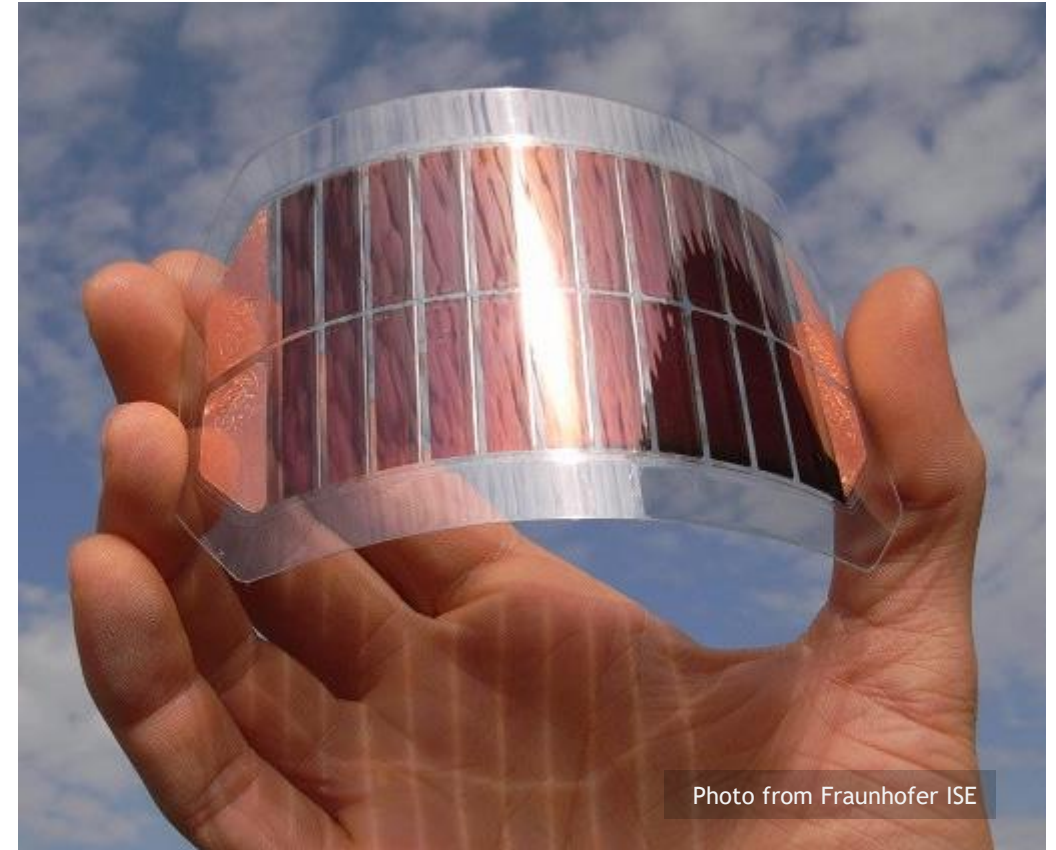
## Stability issues

Organic 10 years vs Silicon 25 years

Oxygen, water, **light**

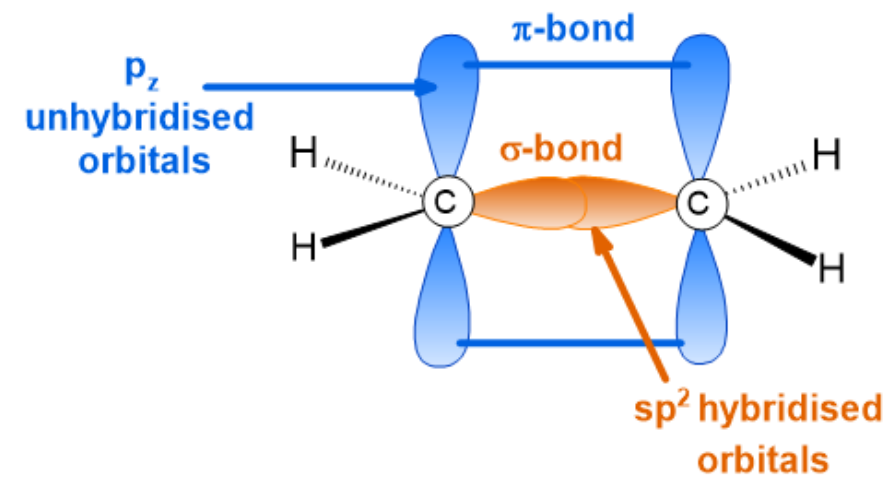
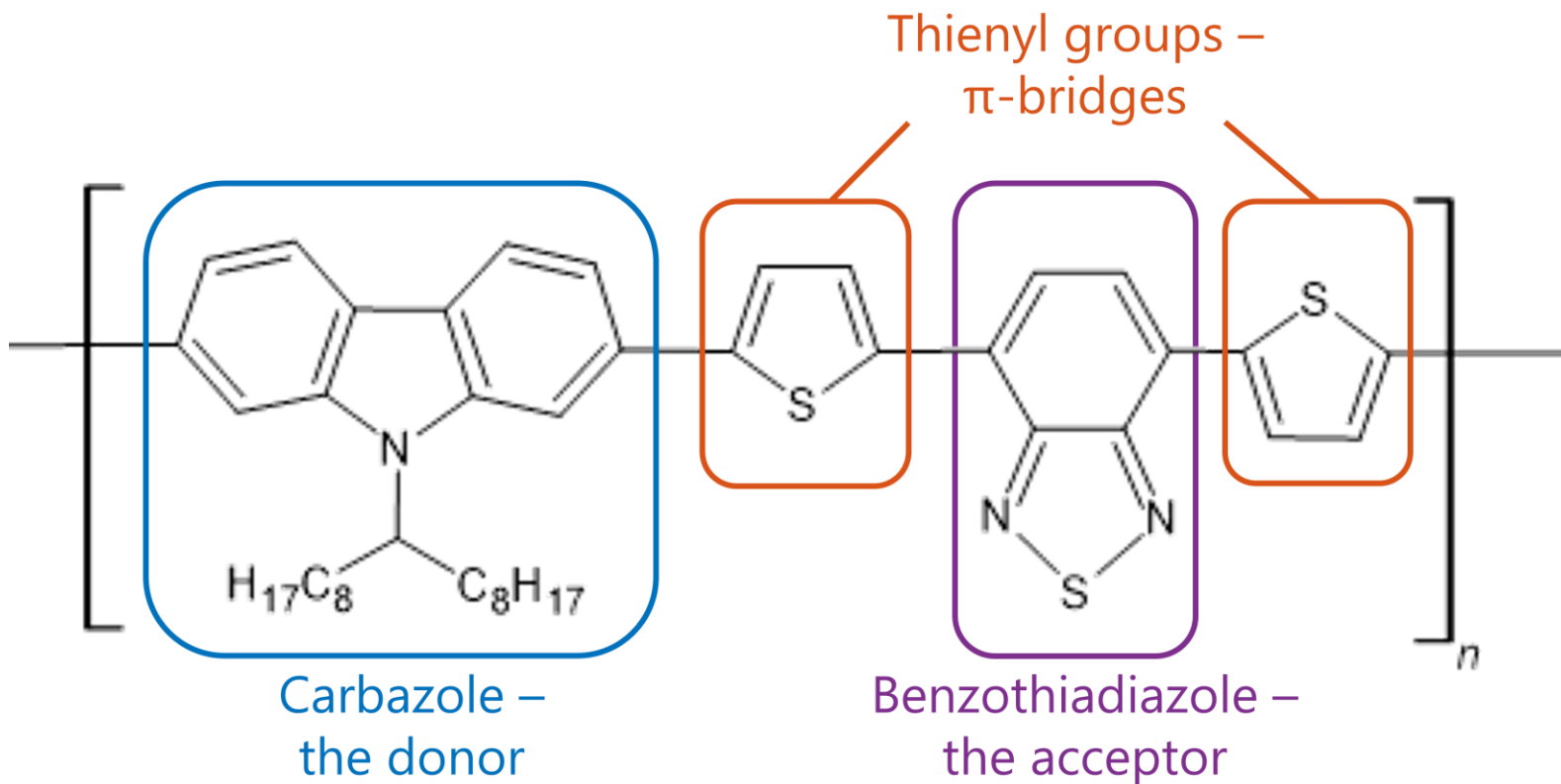


Light induced degradation

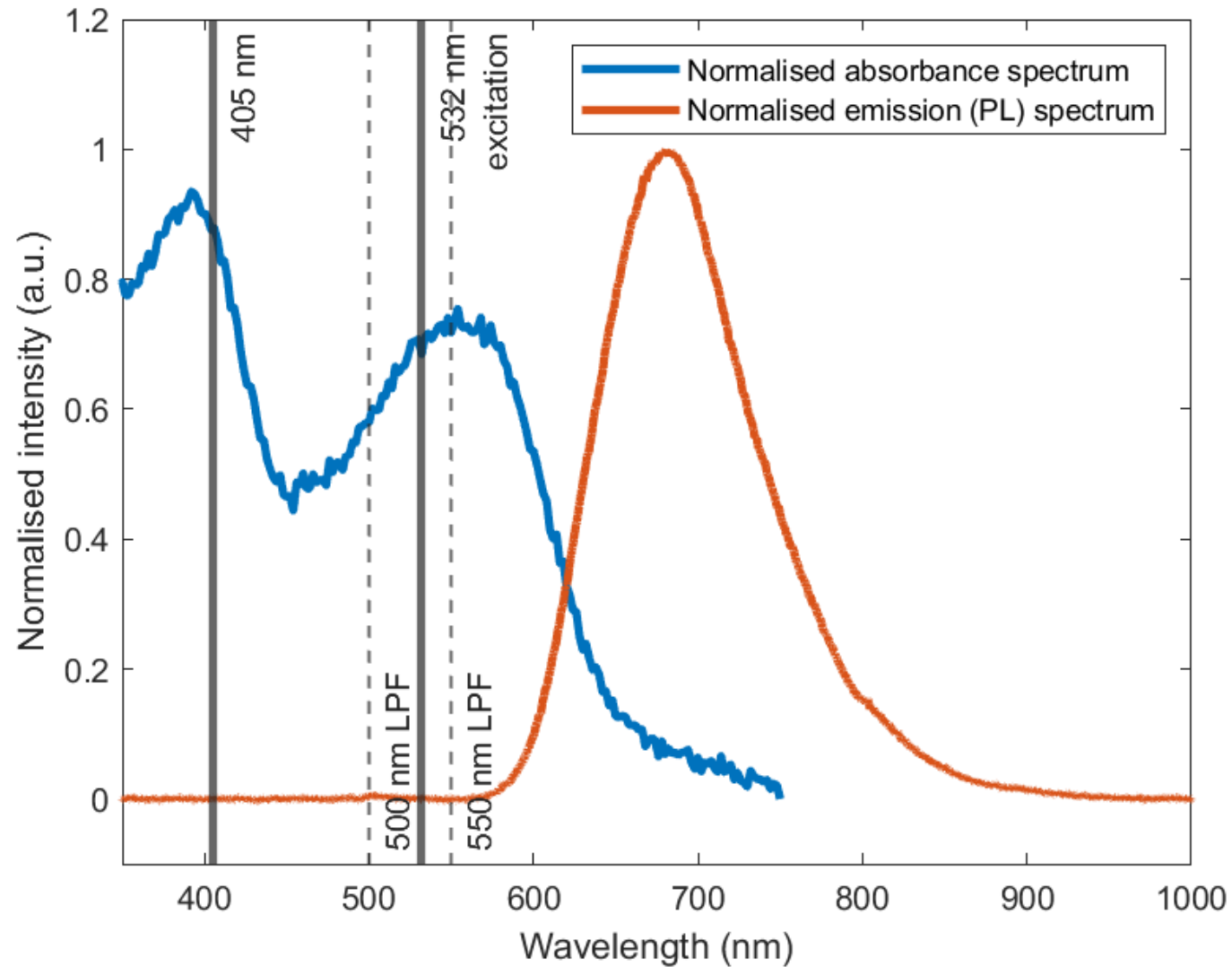


# Our polymer - PCDTBT

Poly[N-9'-heptadecanyl-2,7-carbazole-alt-5,5-(4',7'-di-2-thienyl-2',1',3'-benzothiadiazole)]



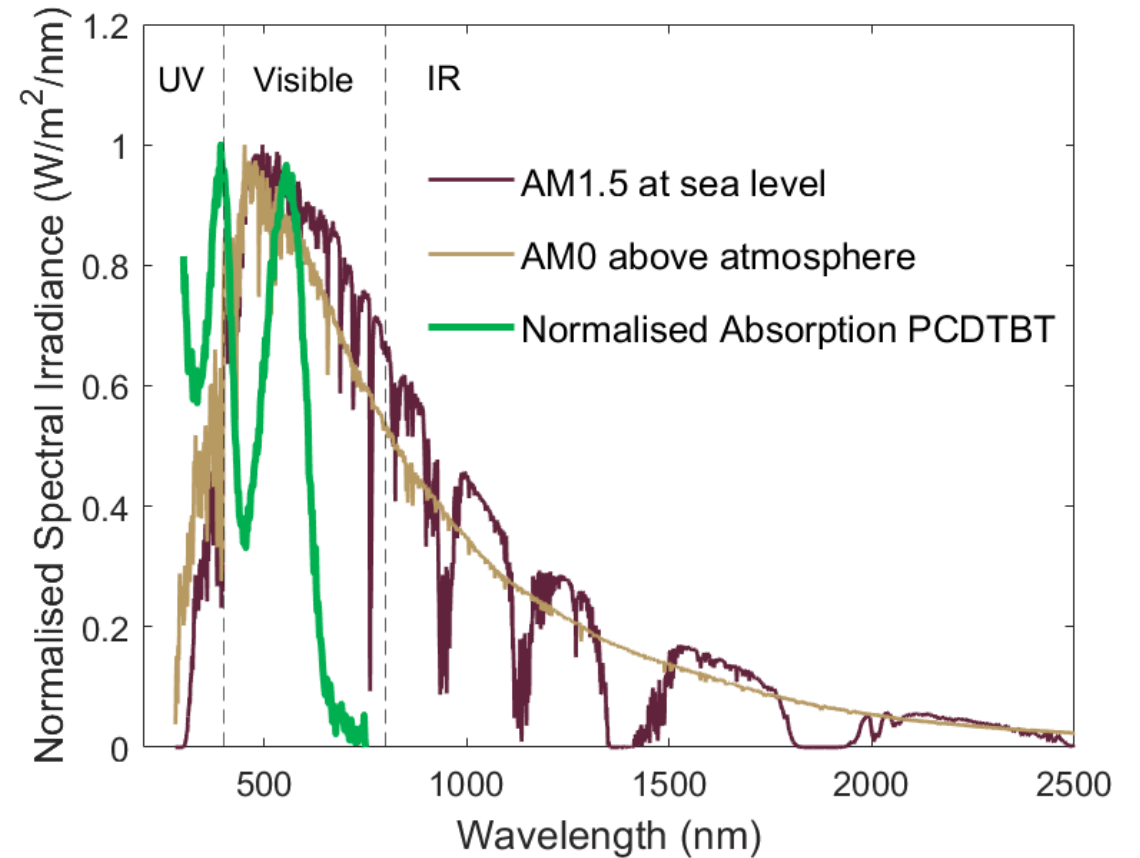
# Steady state absorption of a fresh solution sample



Stokes shift: 289nm and 140nm  
Allows use of emission LP filters

# Is the solar spectrum ideal? No

Spectrally too broad



From NREL Reference Solar Spectral Irradiance ASTM G-173-03 tables

# Why build a tool for photodegradation?

Solar Simulator

Spectrofluorometer

Long term degradation



$\lambda$  selectivity



High intensity

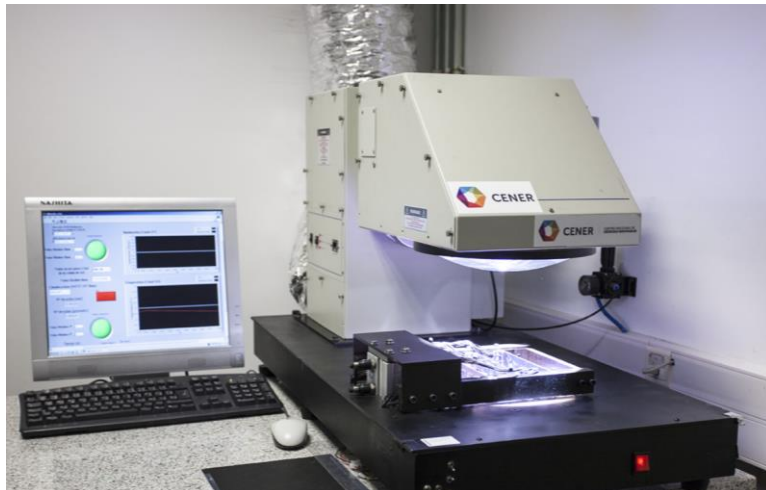


Photo from National Renewable Energy Centre (CENER) - Spain



Photo from Edinburgh Instruments



# Why build a tool for photodegradation?

Solar Simulator

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High intensity

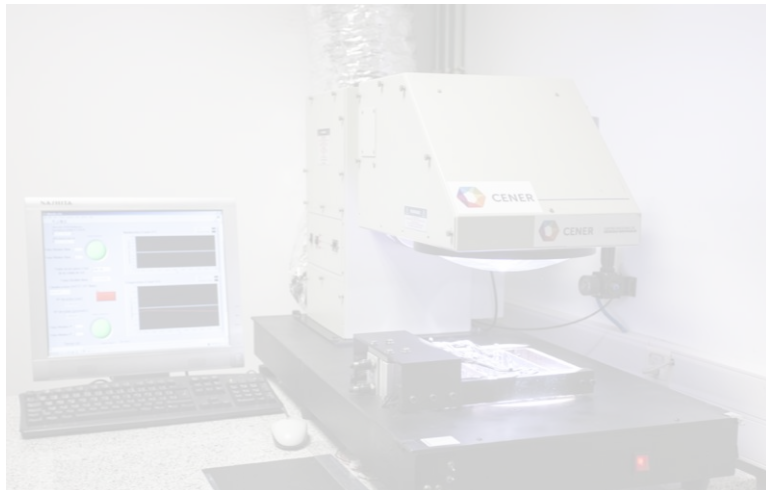


Photo from National Renewable Energy Centre (CENER) - Spain



Photo from Edinburgh Instruments

# Why build a tool for photodegradation?

Galey, C., & Park, H. (2019). Intermediate states during photodegradation in MEH-PPV solutions and thin films. *AIP Advances*, 9(10).

	Solar Simulator	Spectrofluorometer	Custom setup
Long term degradation	✓	✗	✓
$\lambda$ selectivity	✗	✓	✓
High intensity	✗	✗	✓

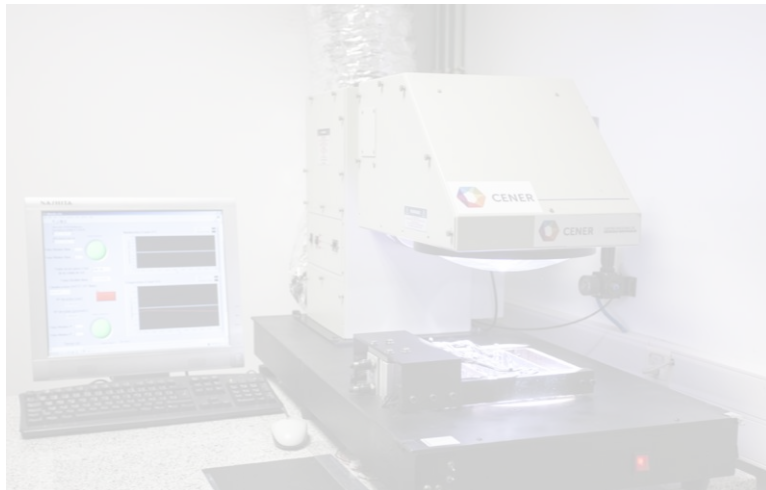
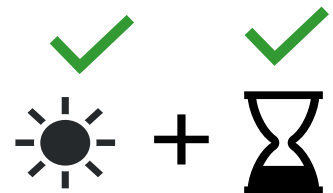


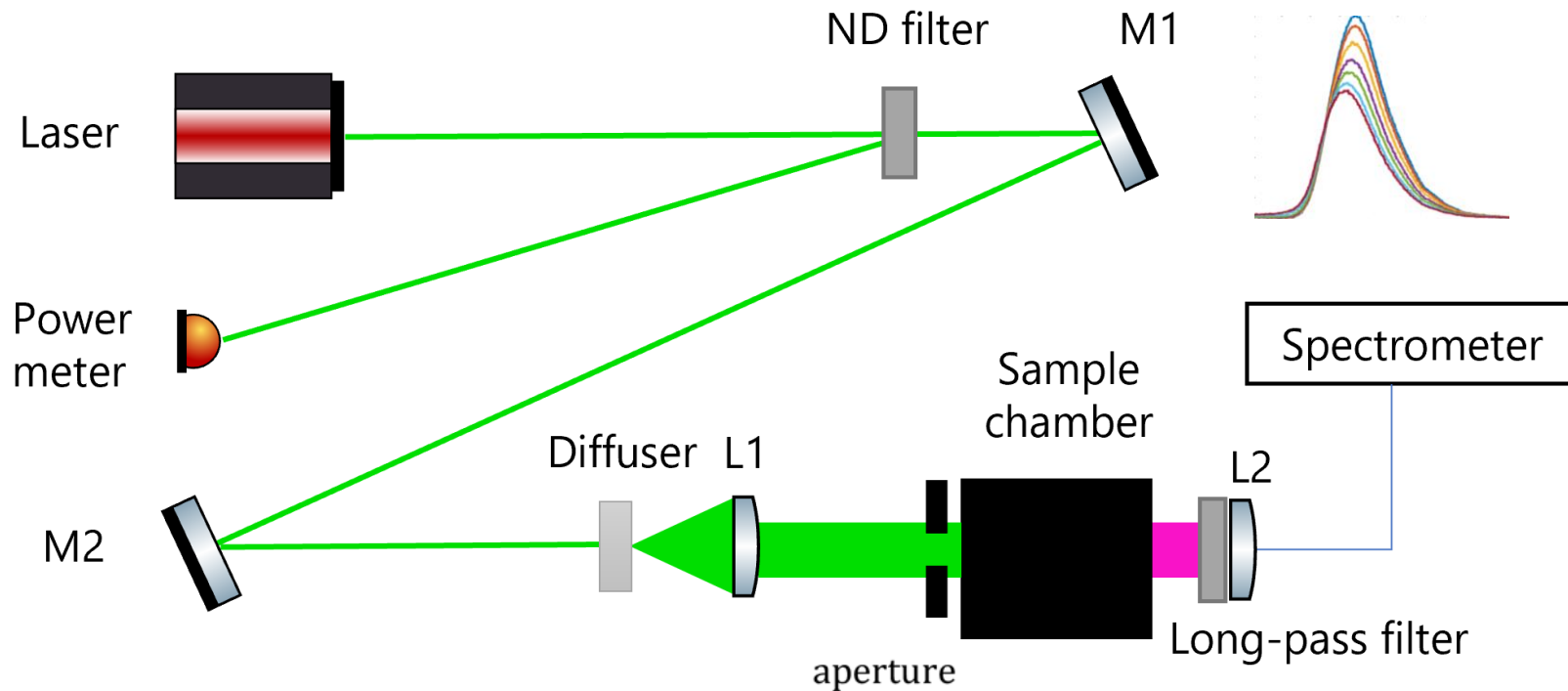
Photo from National Renewable Energy Centre (CENER) - Spain



Photo from Edinburgh Instruments

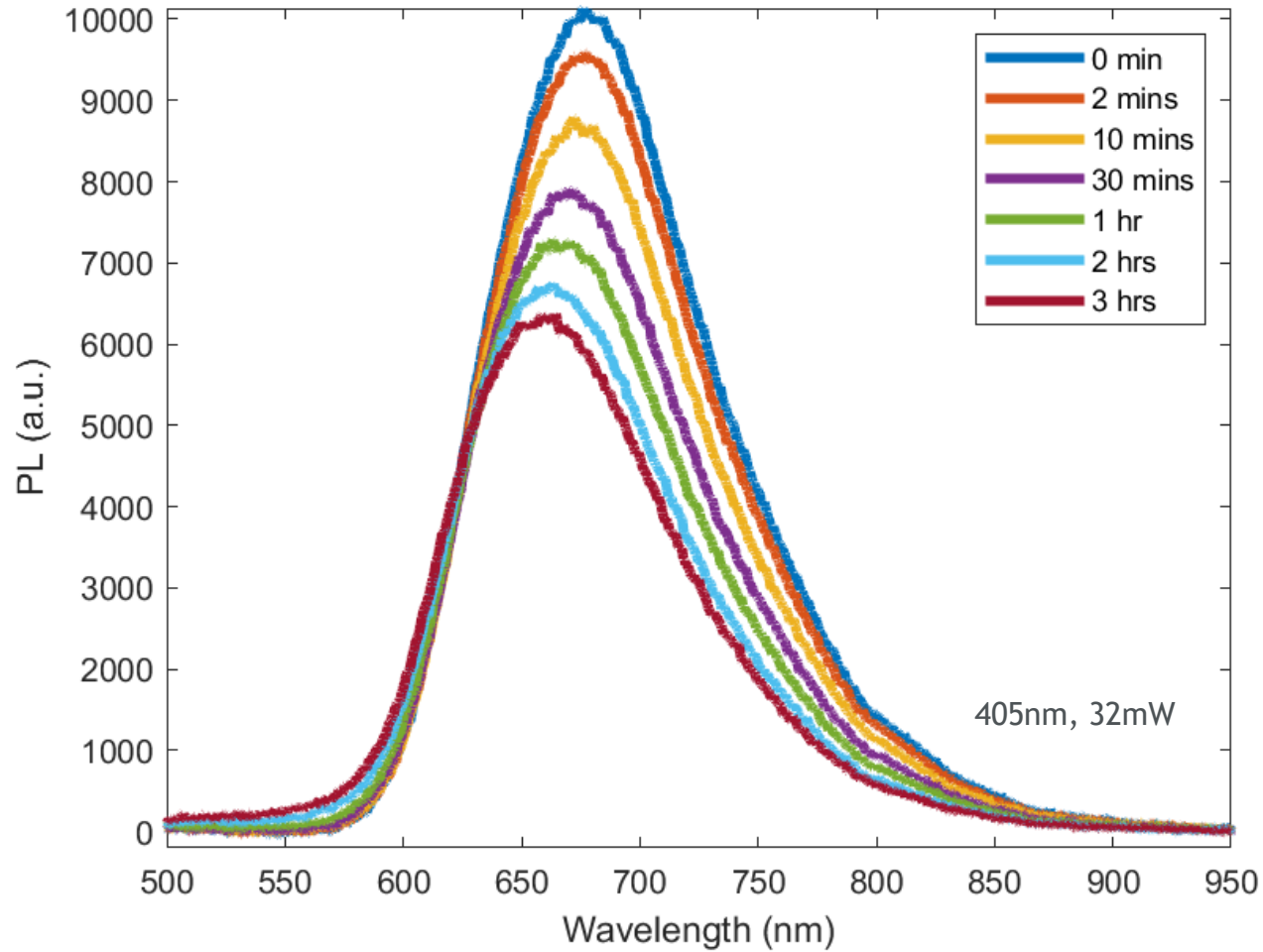


# Our custom spectroscopic tool



$\lambda$ (nm)	405nm, 532nm
High Intensity	$70 \pm 0.13$ mW, (400 suns at 532nm)
Spatial uniformity	$\frac{\sigma}{p_{av}} < 7\%$
Slow degradation	milliseconds-days

# Photoluminescence results



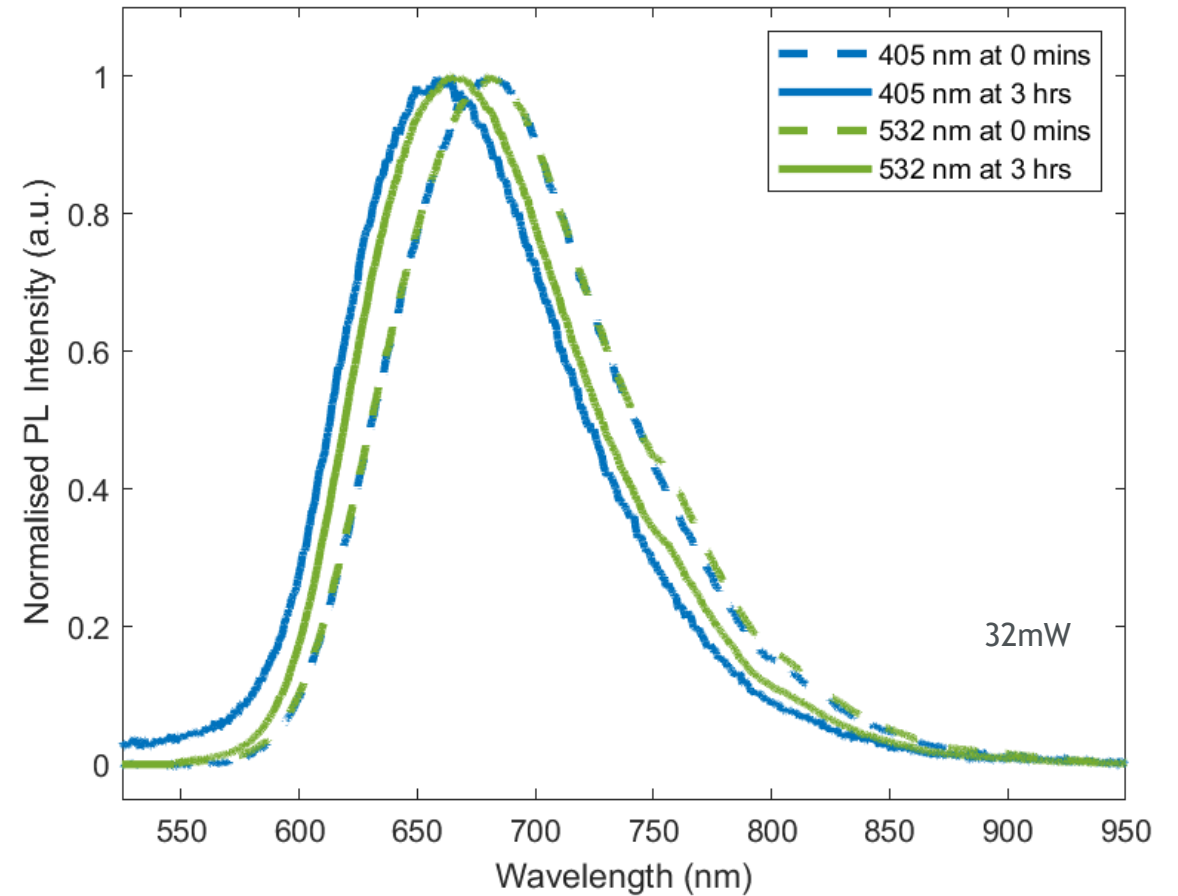
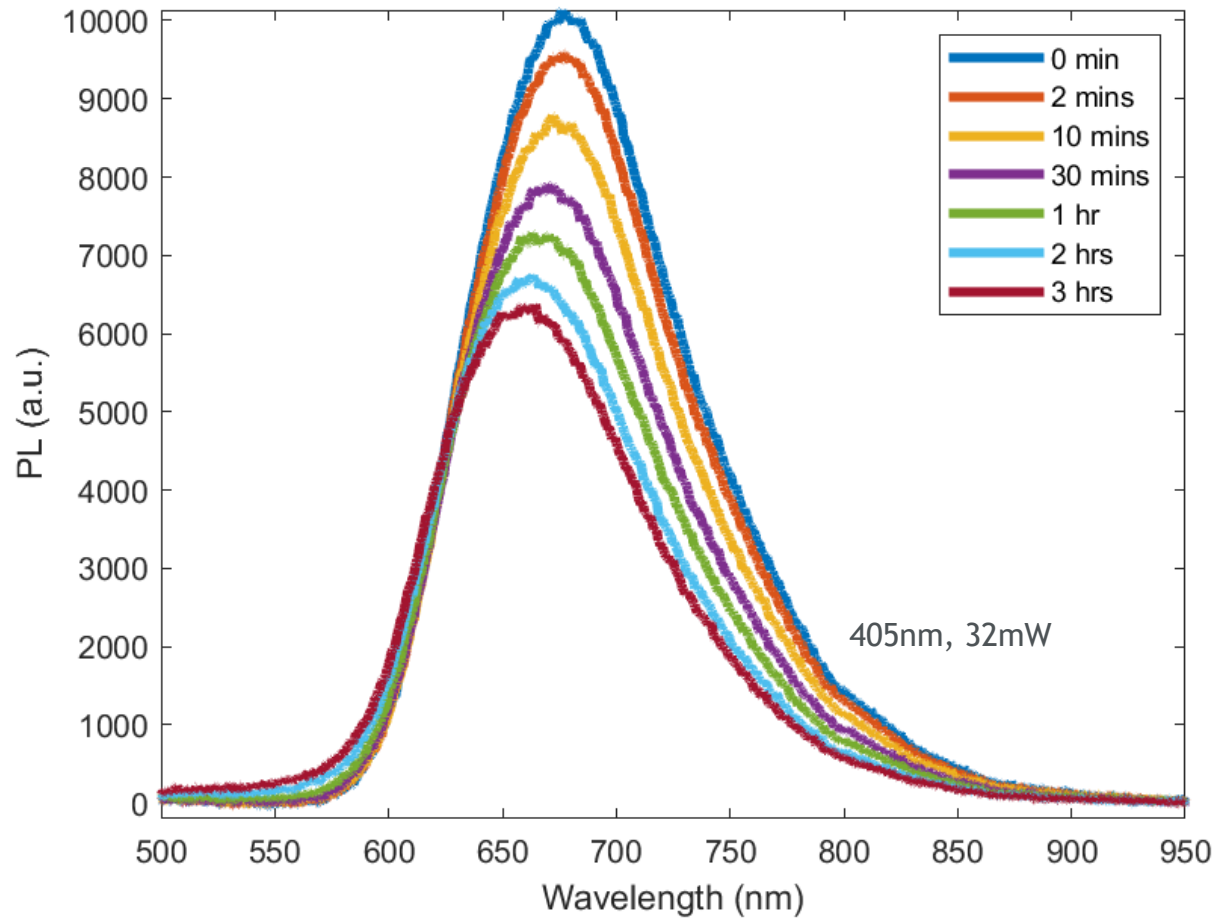
Hypsochromic (blue) shift

Spectral profile

Intensity decay

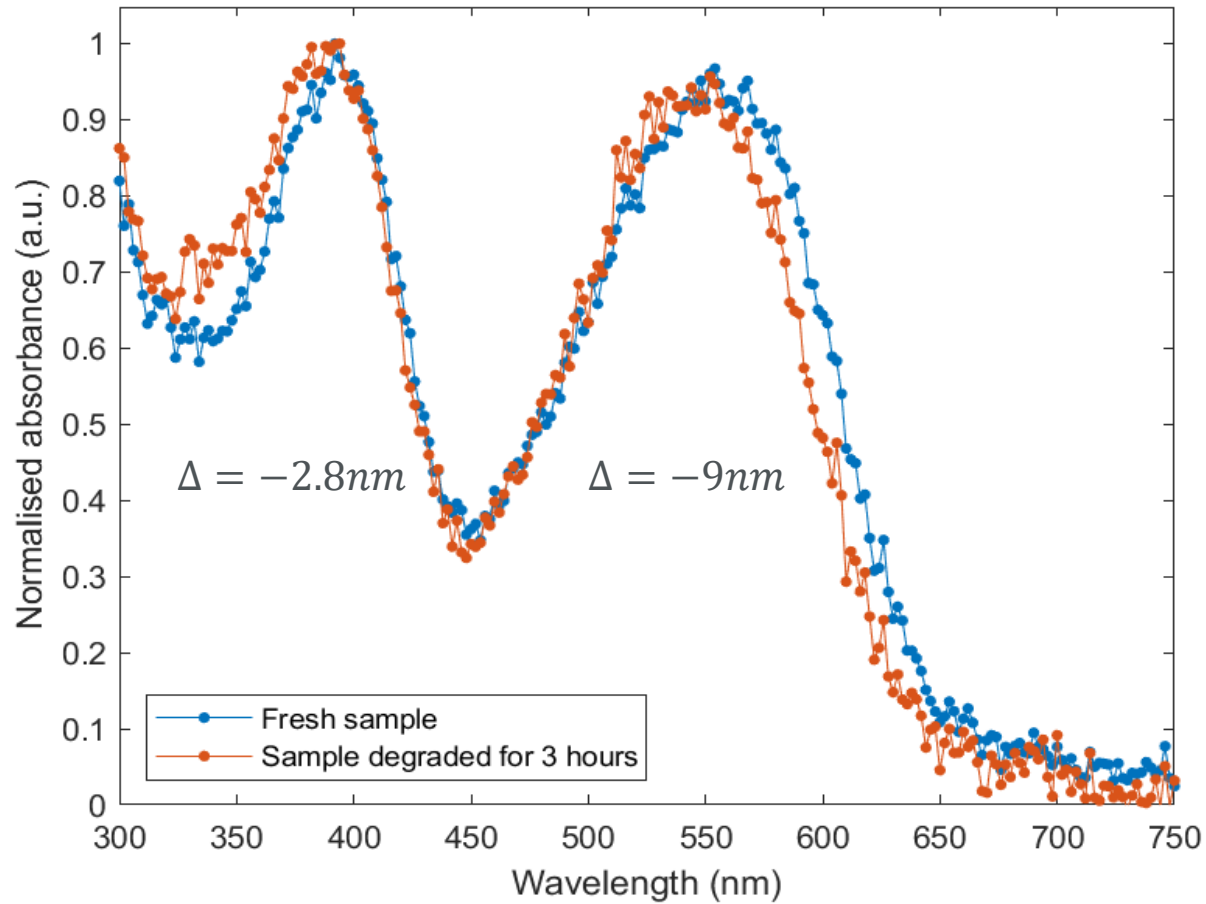
# Chain scission - blue shift

$$E_n \propto \frac{1}{L^2}$$



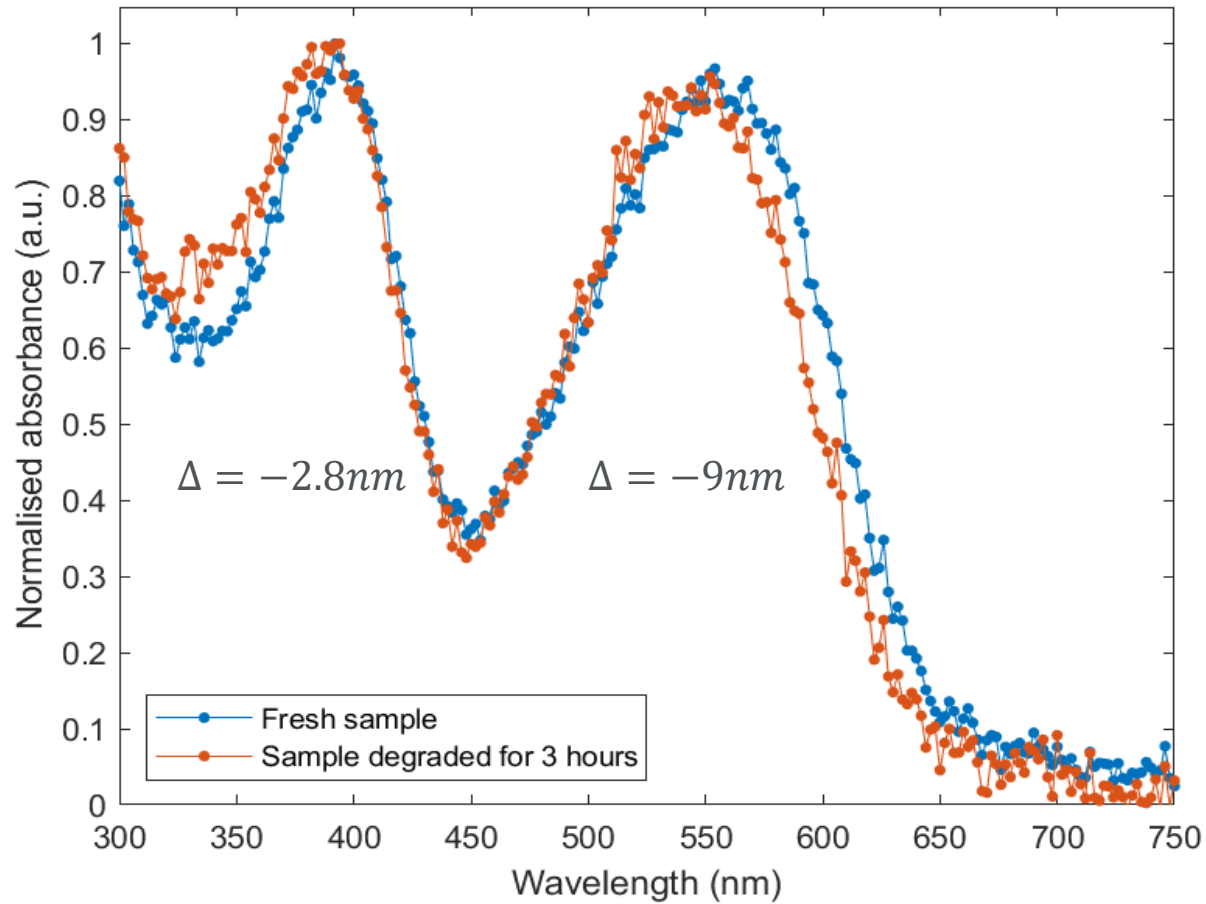
# Confirmation of chain scission

## Steady state absorption

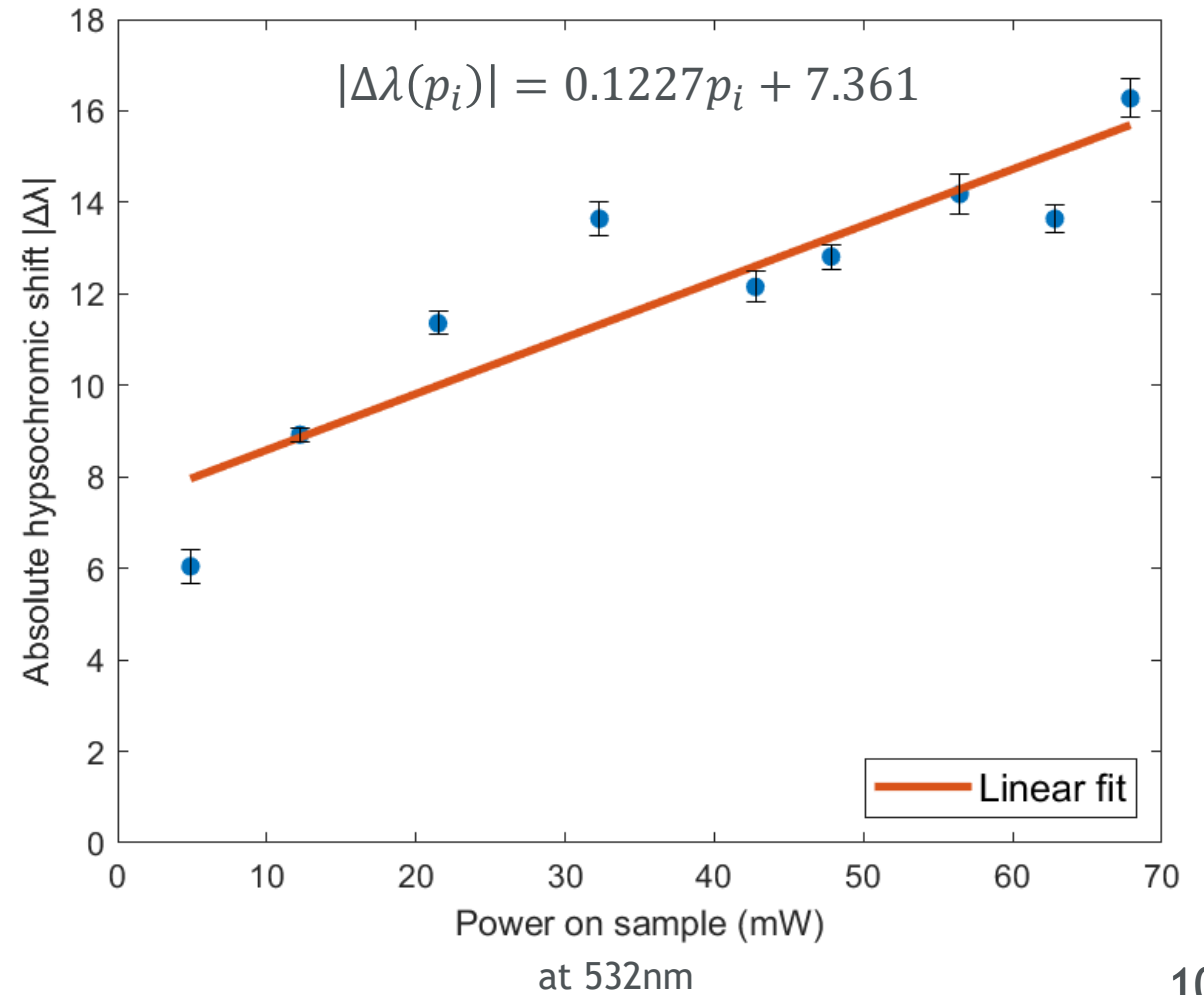


# Confirmation of chain scission

## Steady state absorption

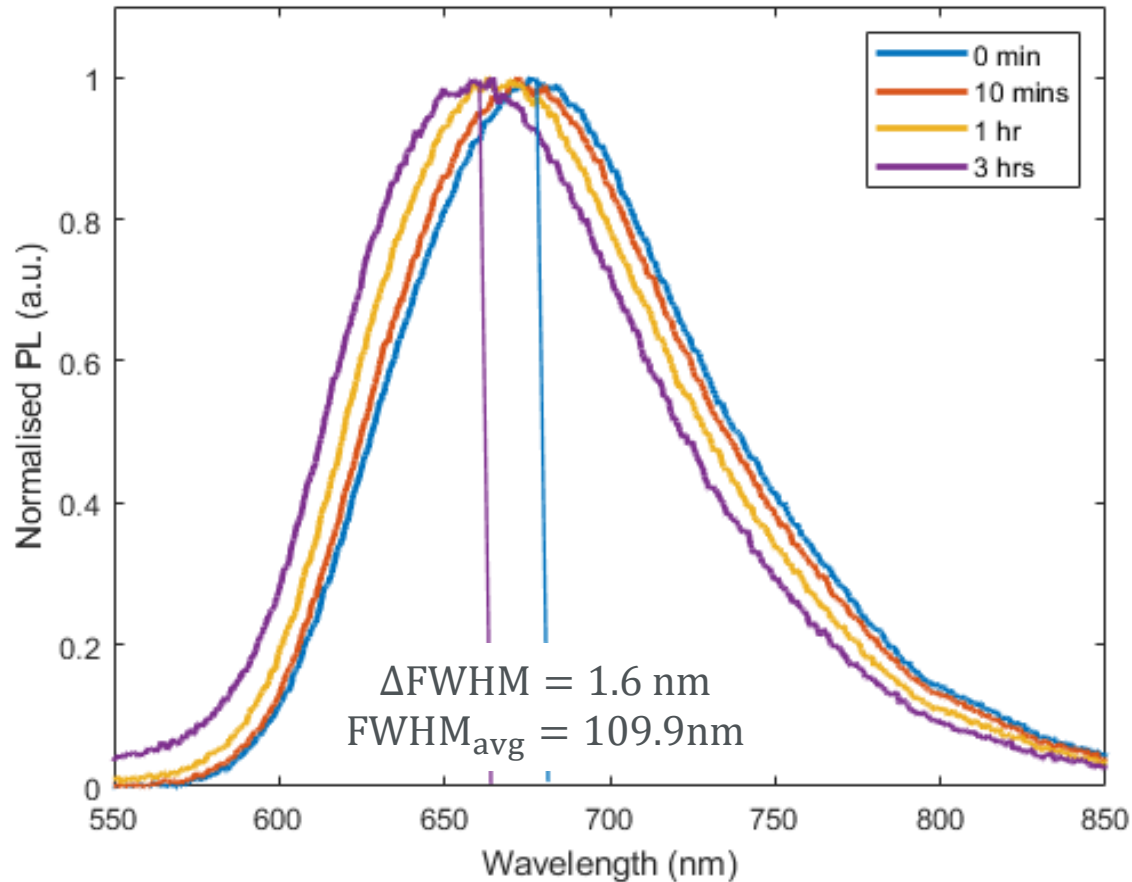


## Different incident intensities

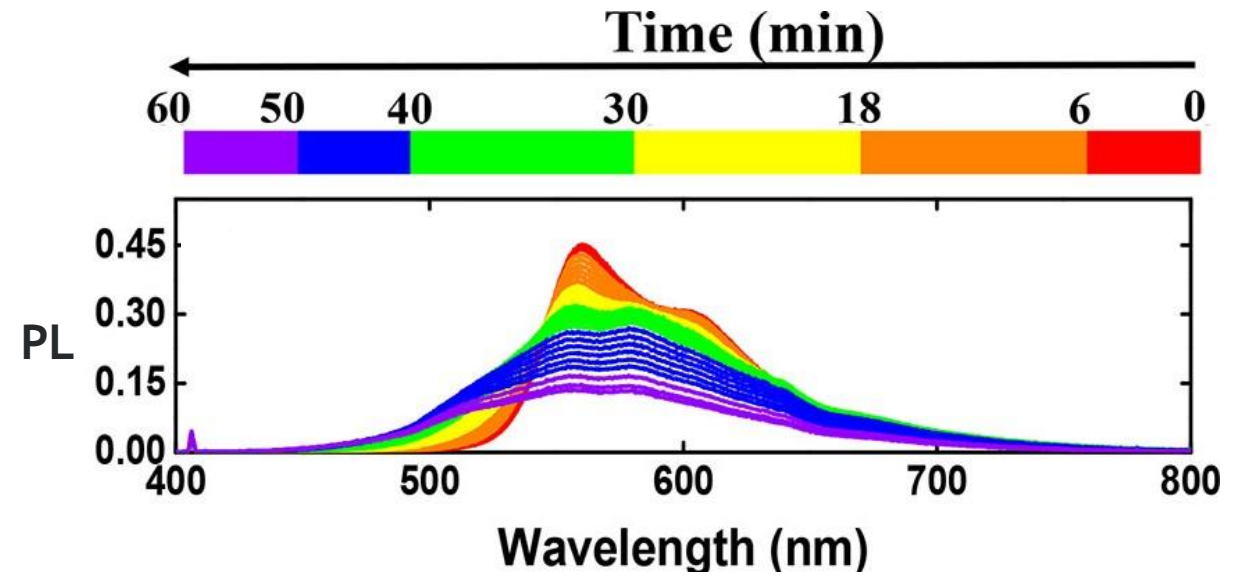


# Spectral profile

PCDTBT - 3 hours



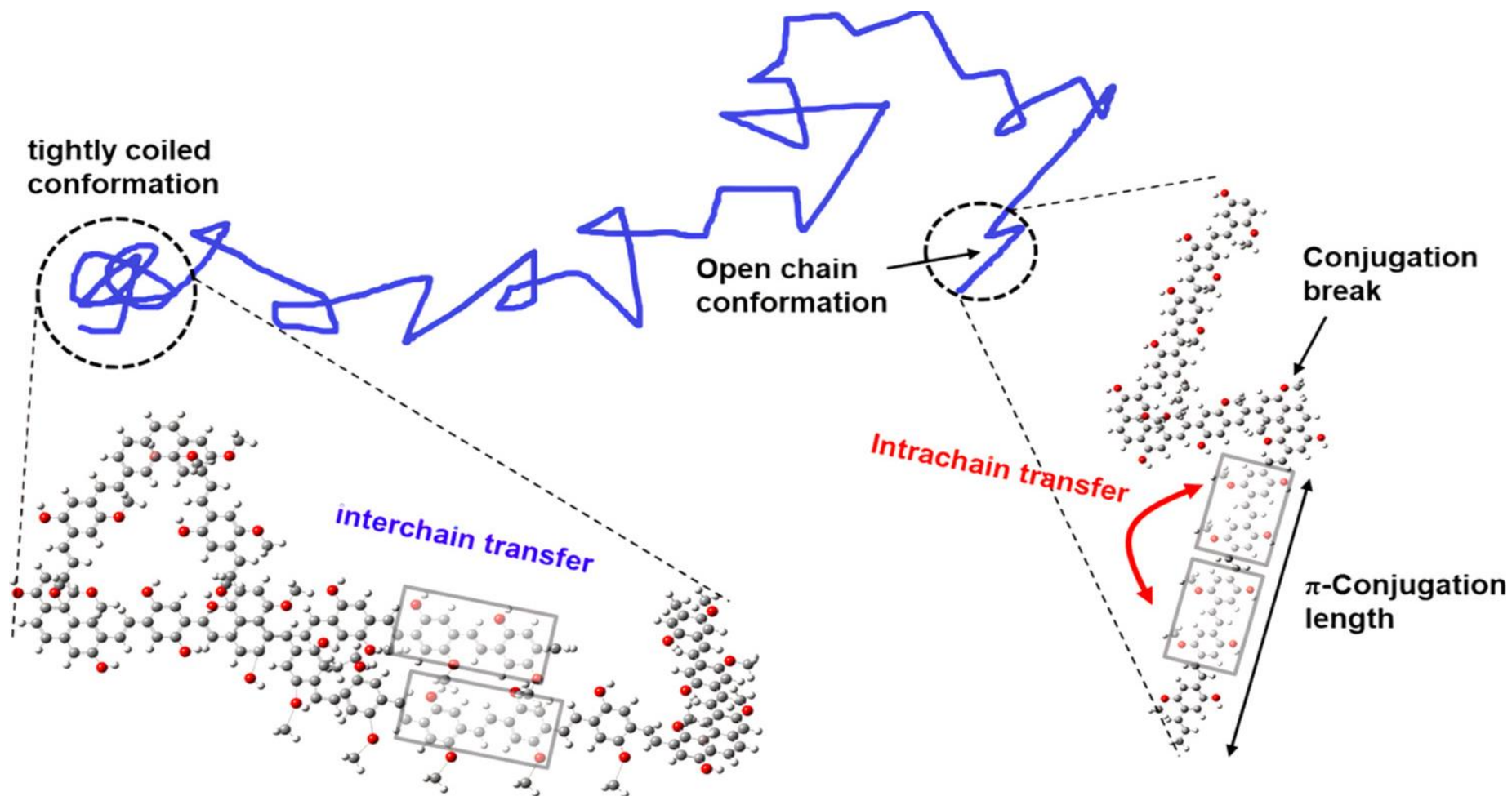
MEH-PPV - 60 minutes



Raicoski, M. L., & Vivas, M. G. (2021). Photobleaching Kinetics of MEH-PPV in Solution: The Role of Conformational Disorder. *Journal of Physical Chemistry B*, 125(34), 9887-9894.

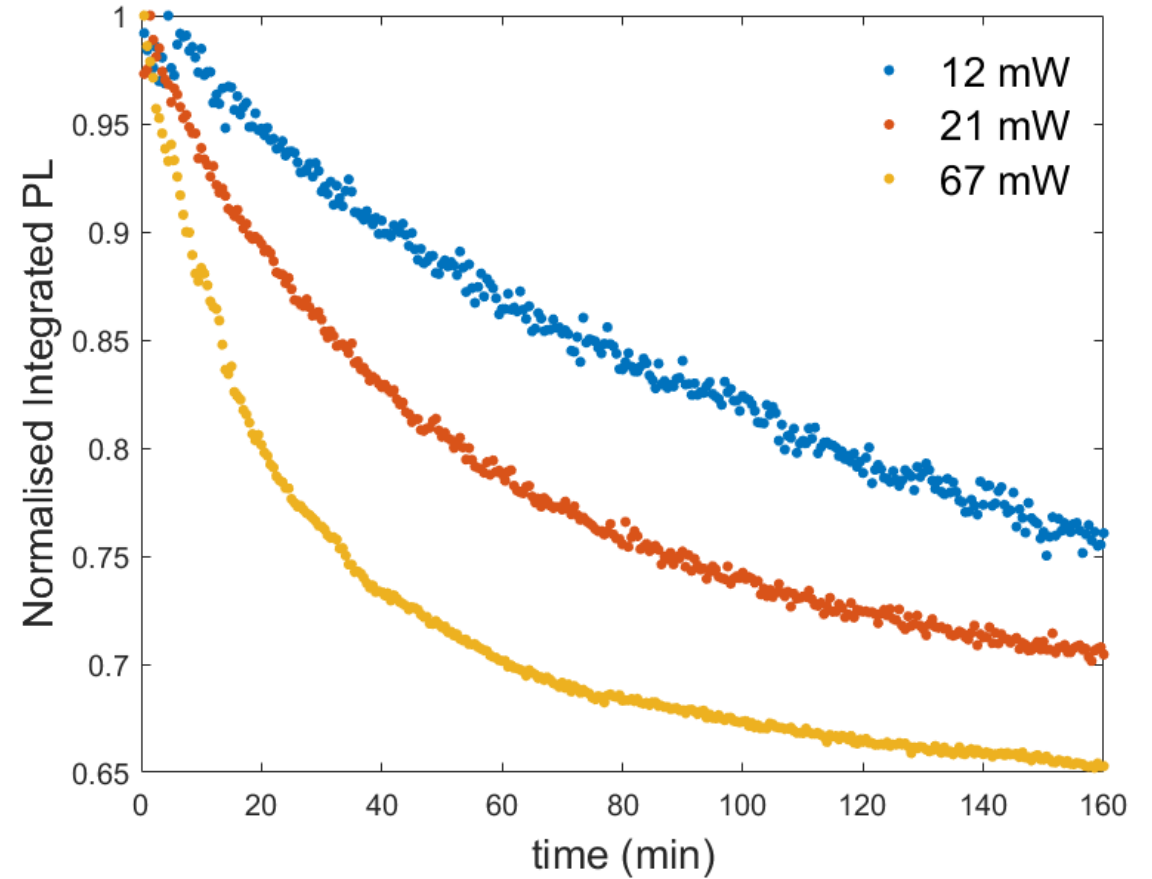
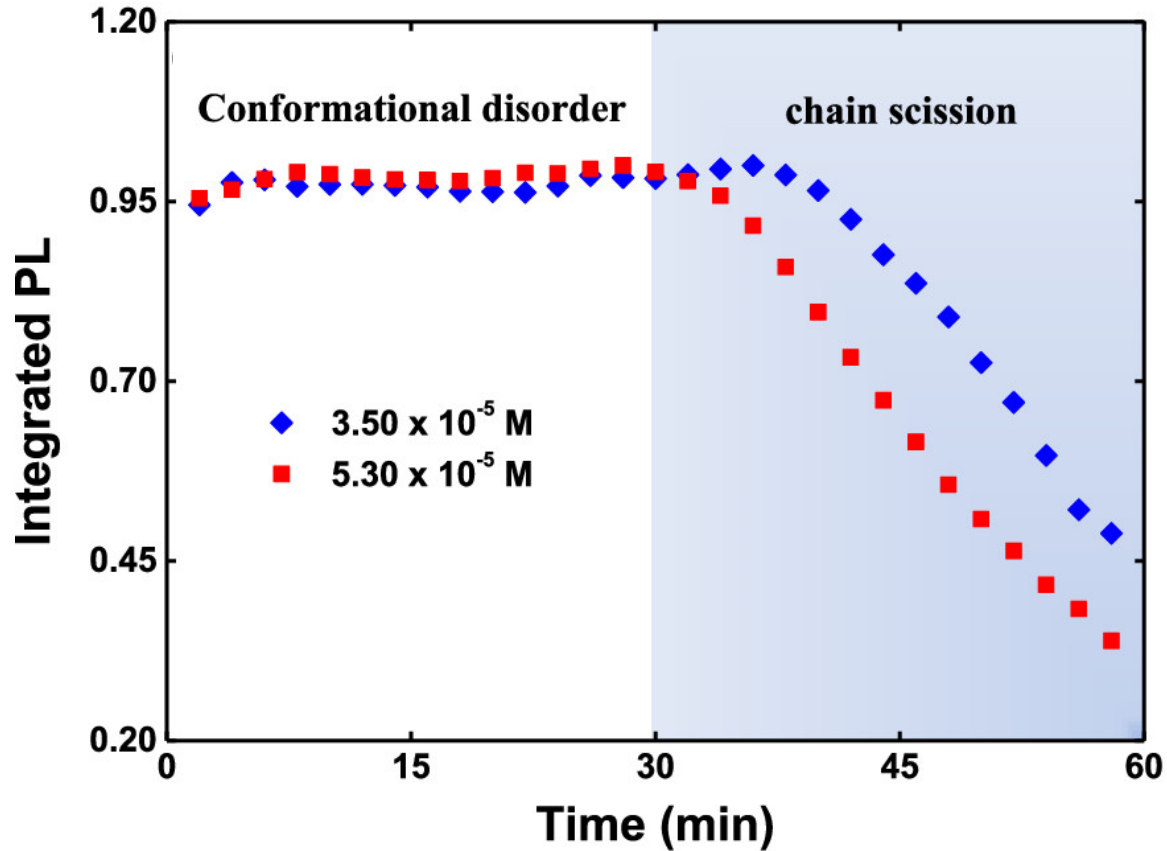


# Conformation also matters



Raicoski, M. L., & Vivas, M. G. (2021). Photobleaching Kinetics of MEH-PPV in Solution: The Role of Conformational Disorder. *Journal of Physical Chemistry B*, 125(34), 9887-9894.

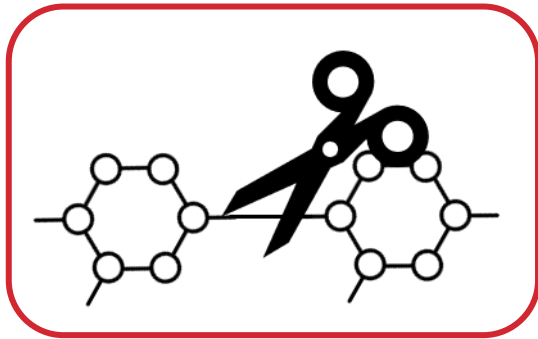
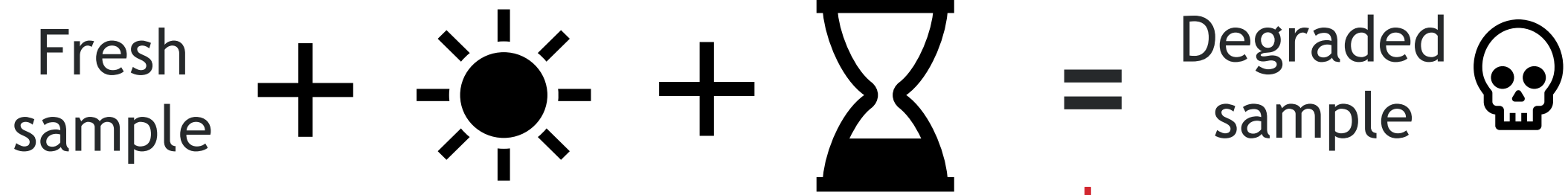
# Integrated photoluminescence



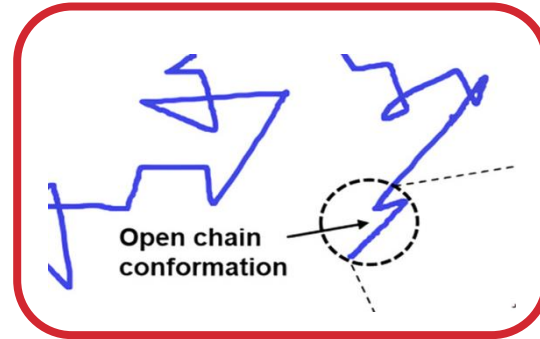
Raicoski, M. L., & Vivas, M. G. (2021). Photobleaching Kinetics of MEH-PPV in Solution: The Role of Conformational Disorder. *Journal of Physical Chemistry B*, 125(34), 9887-9894.

532nm excitation

# The Problem - solution phase photodegradation of PCDTBT

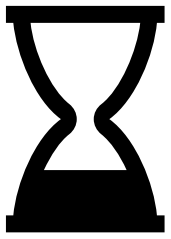


Chain Scission

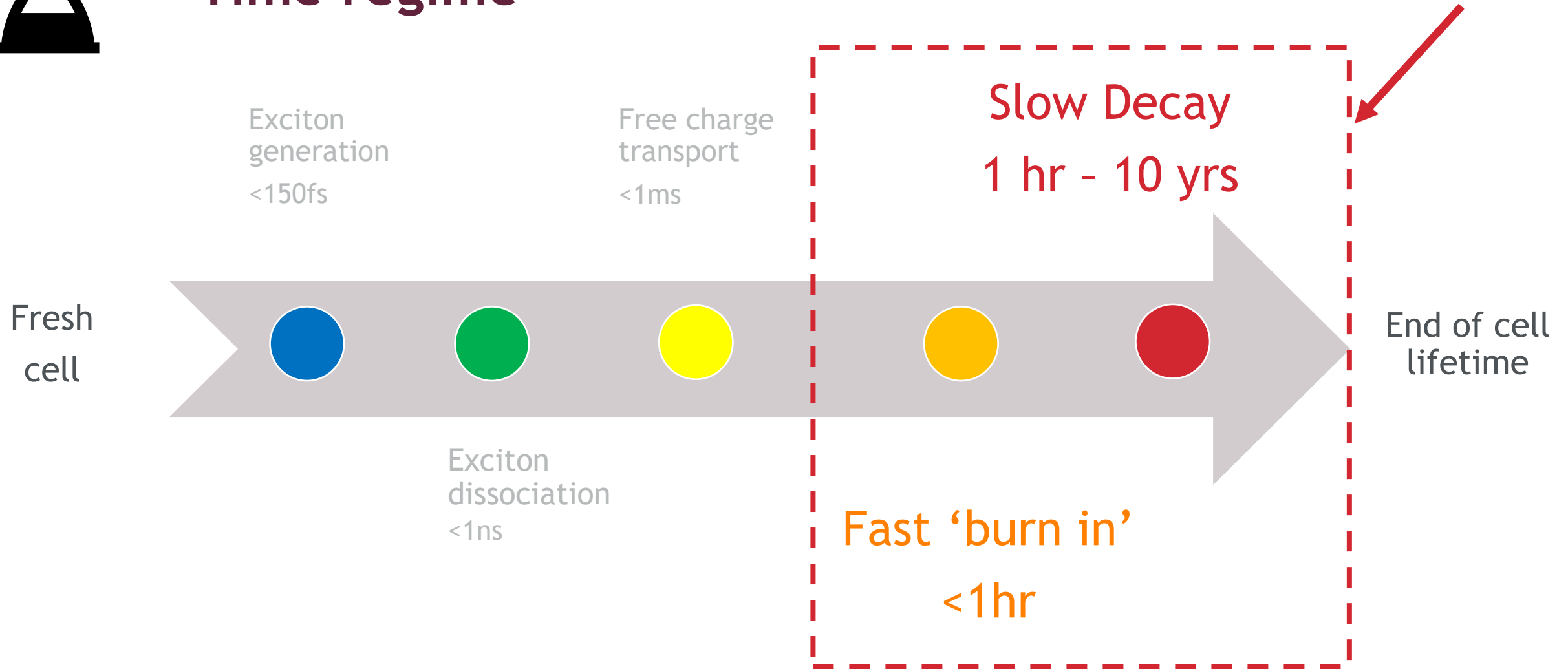


Conformation

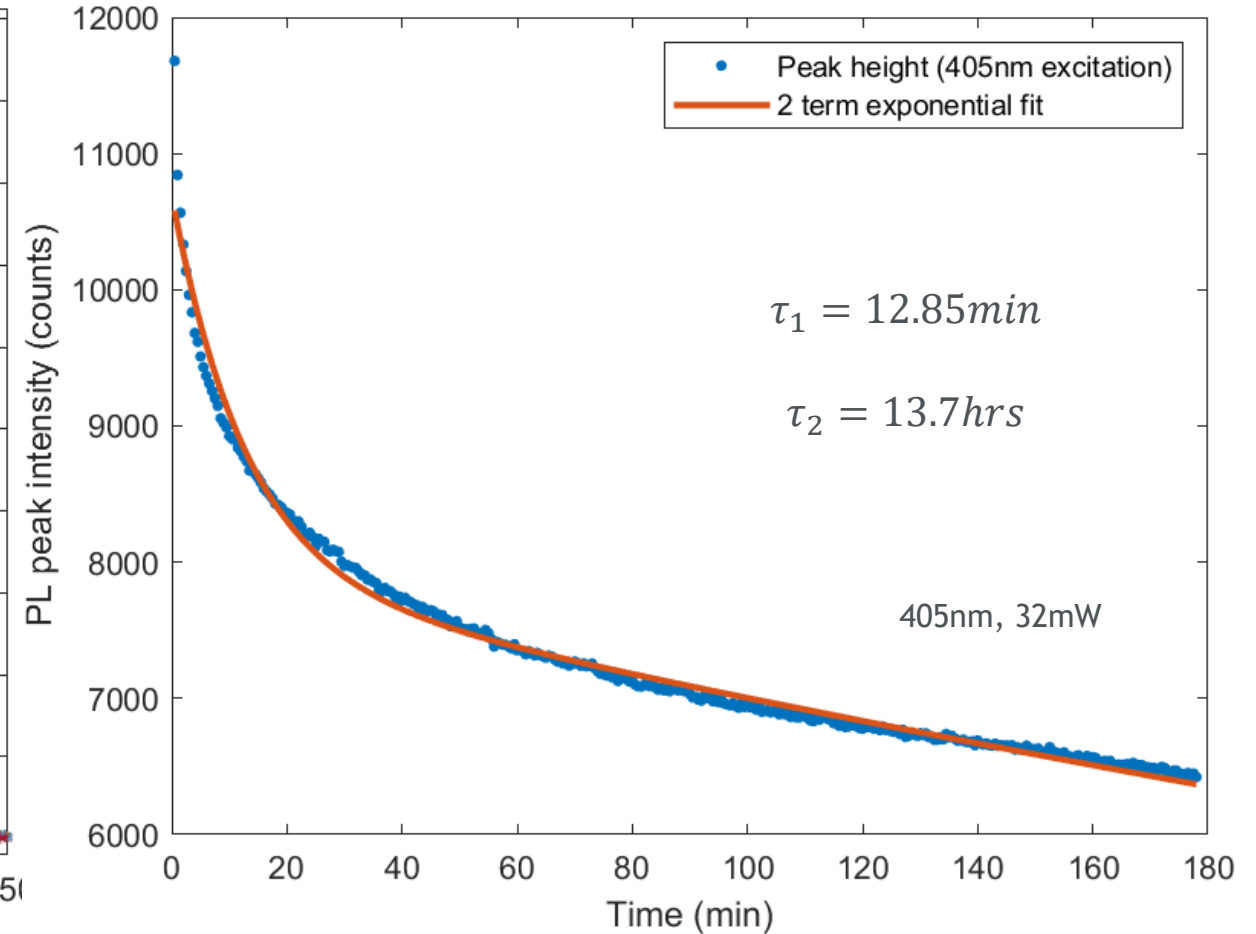
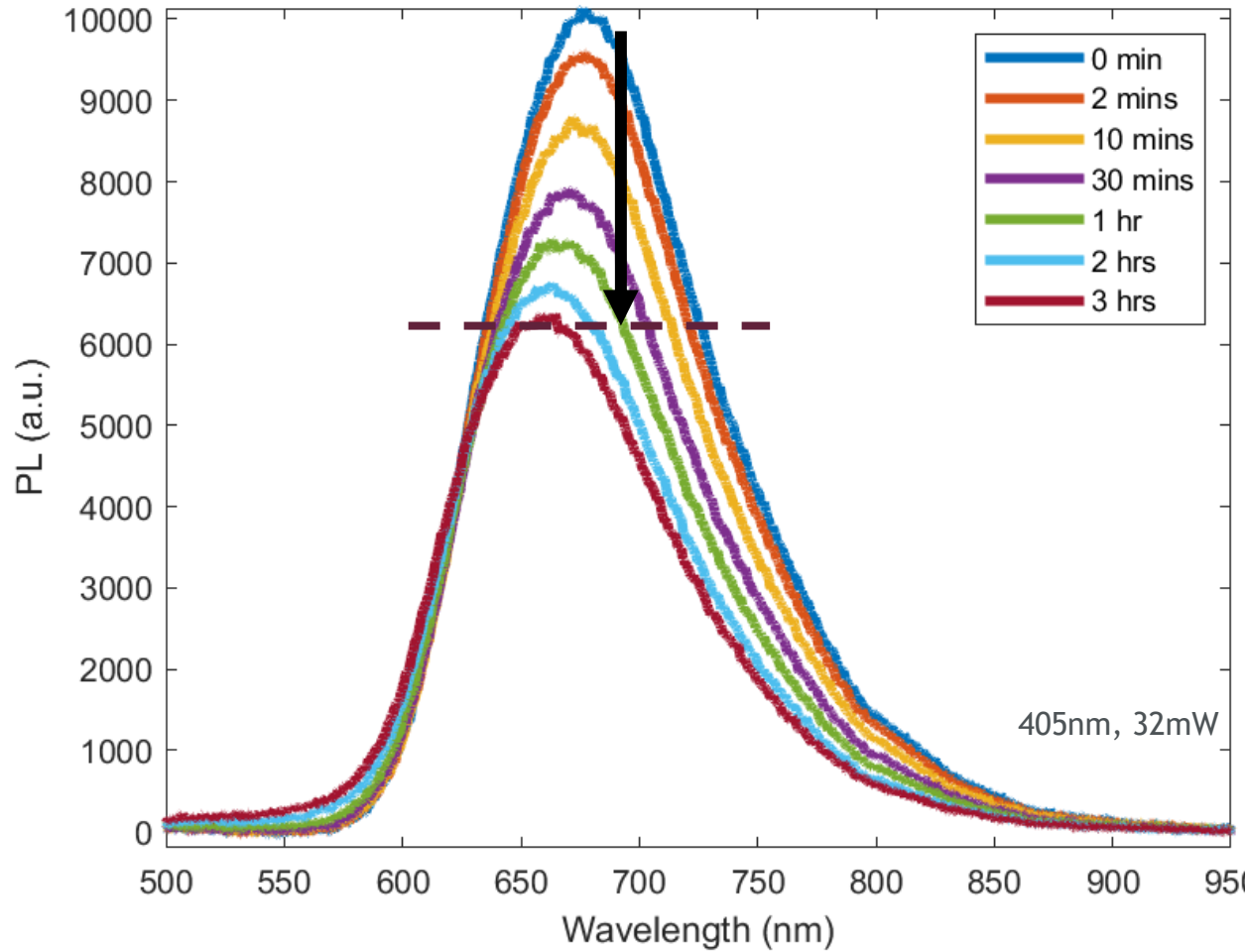


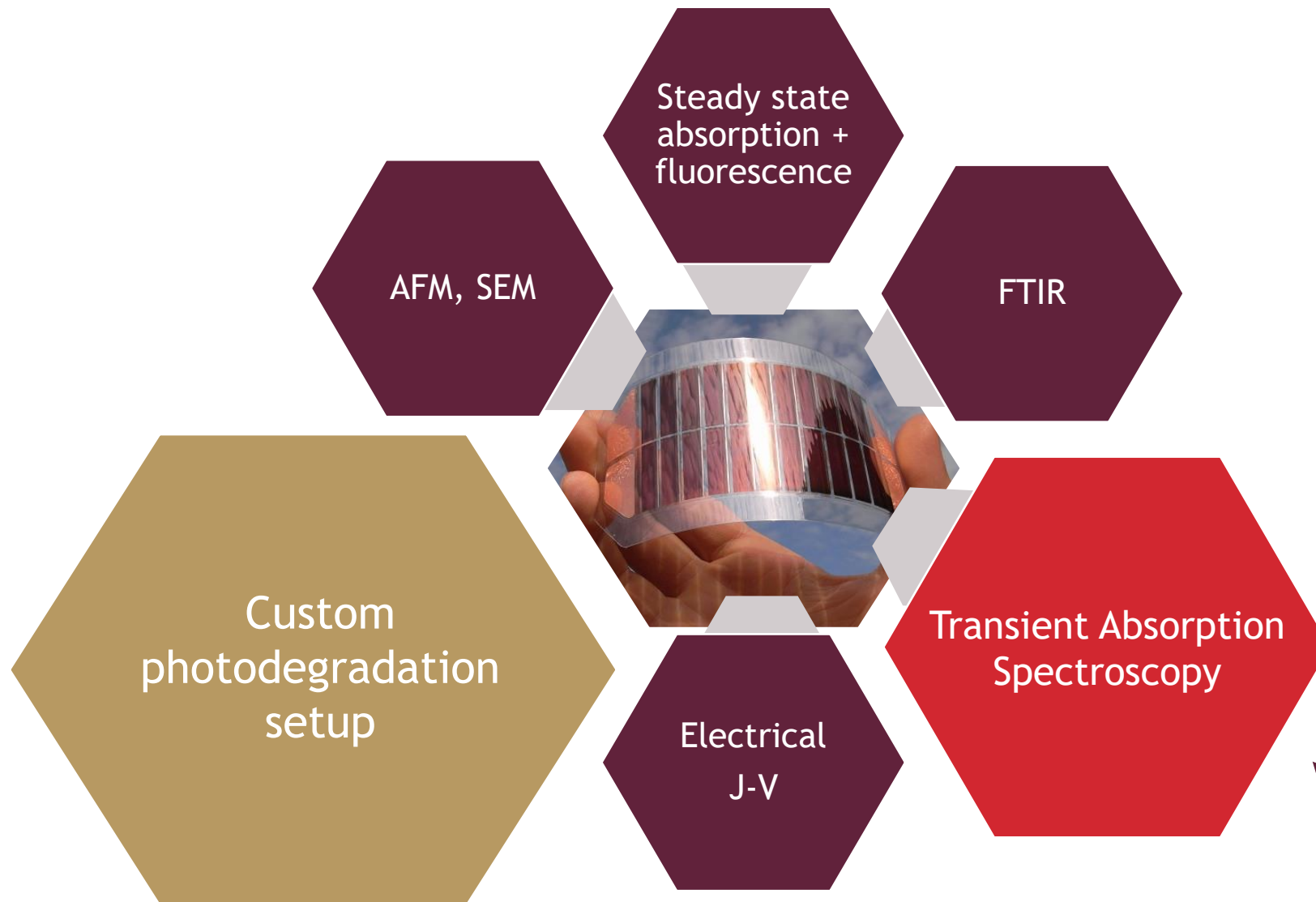


# Time regime



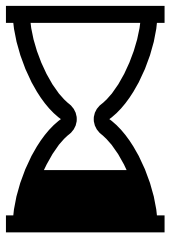
# Fluorescence intensity decay - a sign of photodegradation



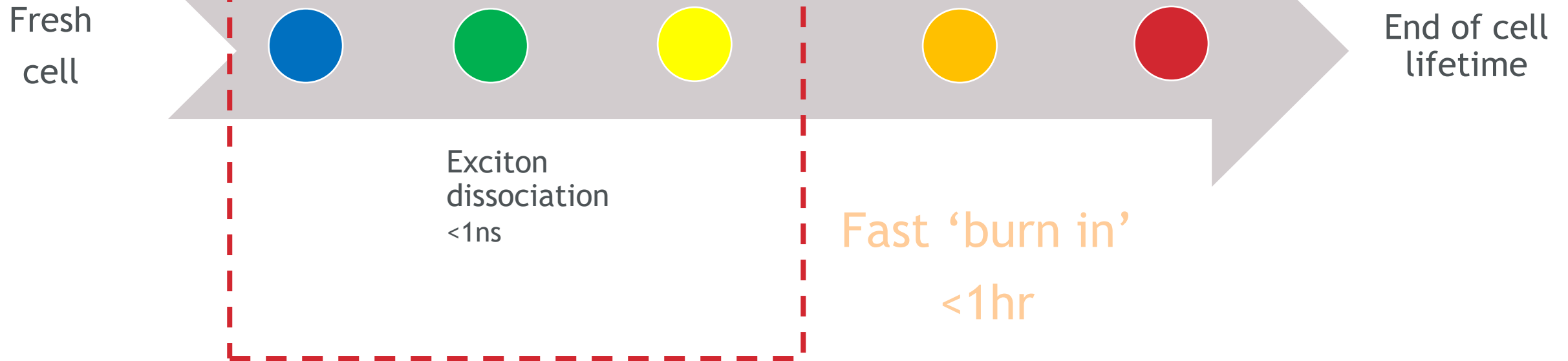


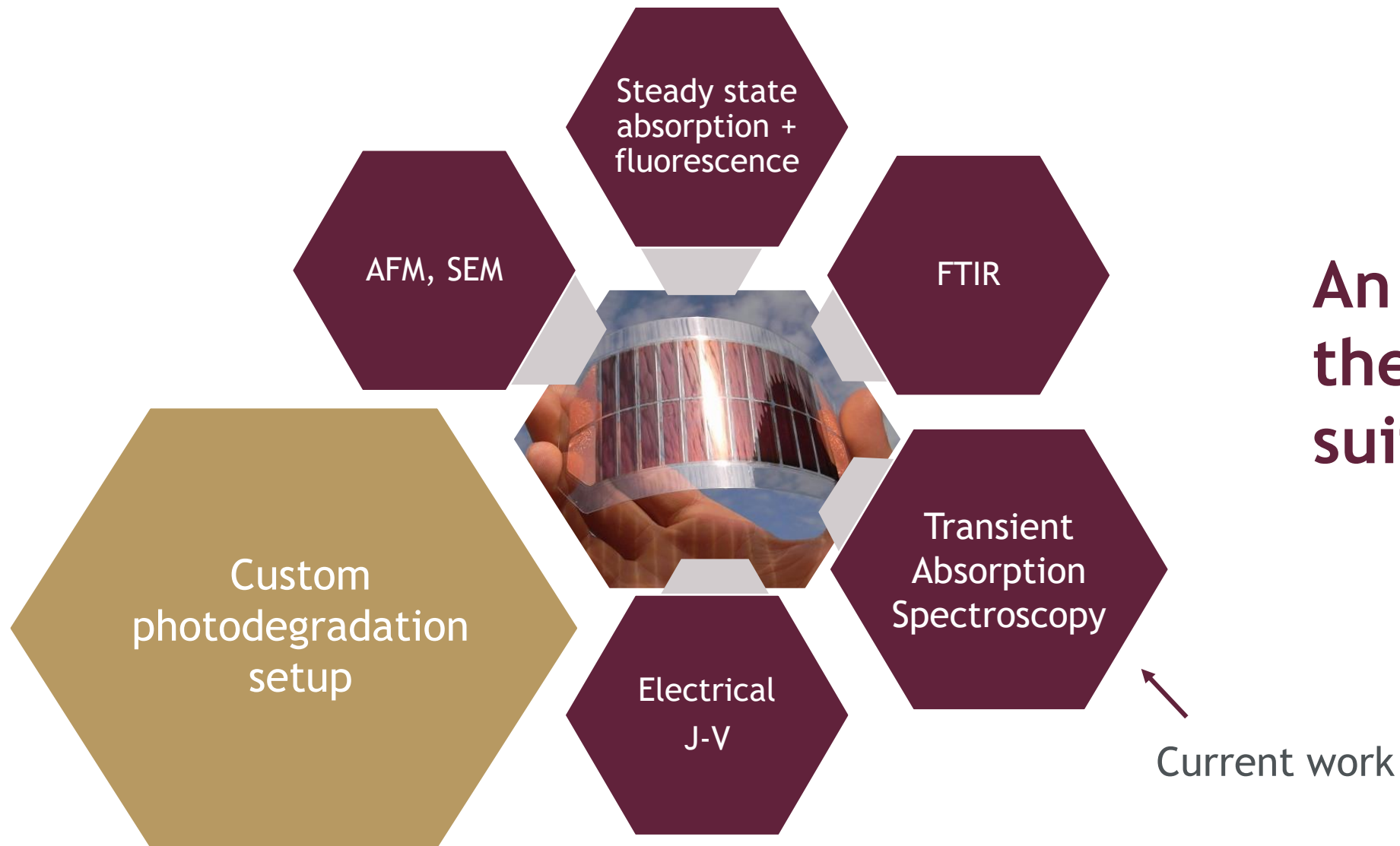
**An addition to the testing suite.**

What's next?  
<1ns events



# Time regime





**An addition to the testing suite.**