Highly Accelerated UV Aging of Organic Luminescent Materials

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Abstract

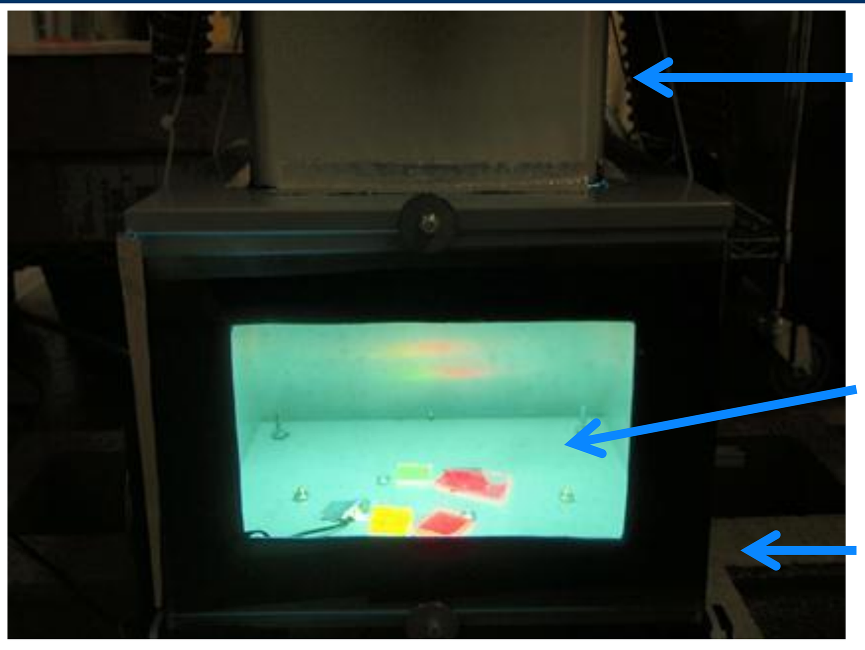
Organic luminescent materials are being developed for application to solar modules but have a history of degradation under full sun illumination. A highly accelerated UV test has been developed to screen luminescent materials and determine accleration parameters. Active water cooling is used to control temperature under exposure to high intensity UV light. Samples are encapsulated in a glass/organic/glass packaged and then submerged in a water bath with temperature controlled between 20 – 60ºC. The improved cooling allows up to 50 suns of equivalent UVA radiation be applied to the samples with no heating and a linear dependence of degradation rate on intensity. Some luminescent materials show no degradation after the equivalent of 20 years of UV light.

Application of Luminescent Materials for Solar

1) Downconversion of blue light to region of high EQE
- **CdS layer in CIGS and CdTe absorbs photons with λ<500nm**
- **Luminescent materials: Absorb <500nm → Emit >600nm**
- **Up to 10% improvement in efficiency demonstrated in CdTe**

2) Luminescent Solar Concentrators
- **Absorb → emit into waveguide for collection in PV cell**

Test Chamber



High intensity UV lamp
Metal Halide D: Broad UV spectrum
250 mW/cm^2 of UVA
(Sun ~ 5mW/cm2)

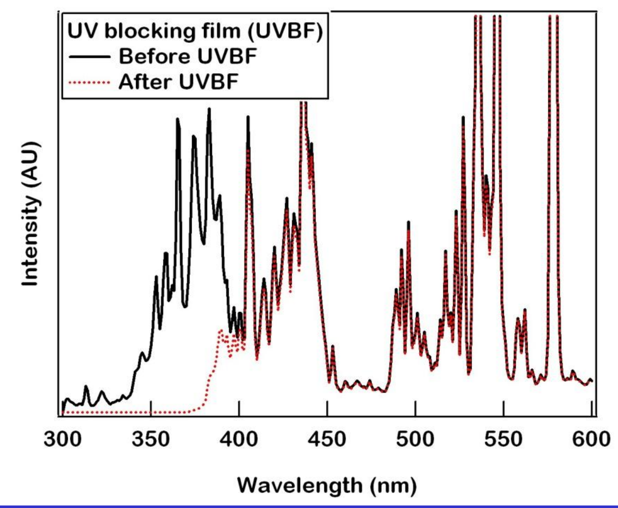
Water Bath
Samples submerged

Circulator (20-60ºC)

Water is transparent to UV and maintains accurate temperature

Test Methodology

Control Spectrum: UV blocking films
Replace UV blocking film daily

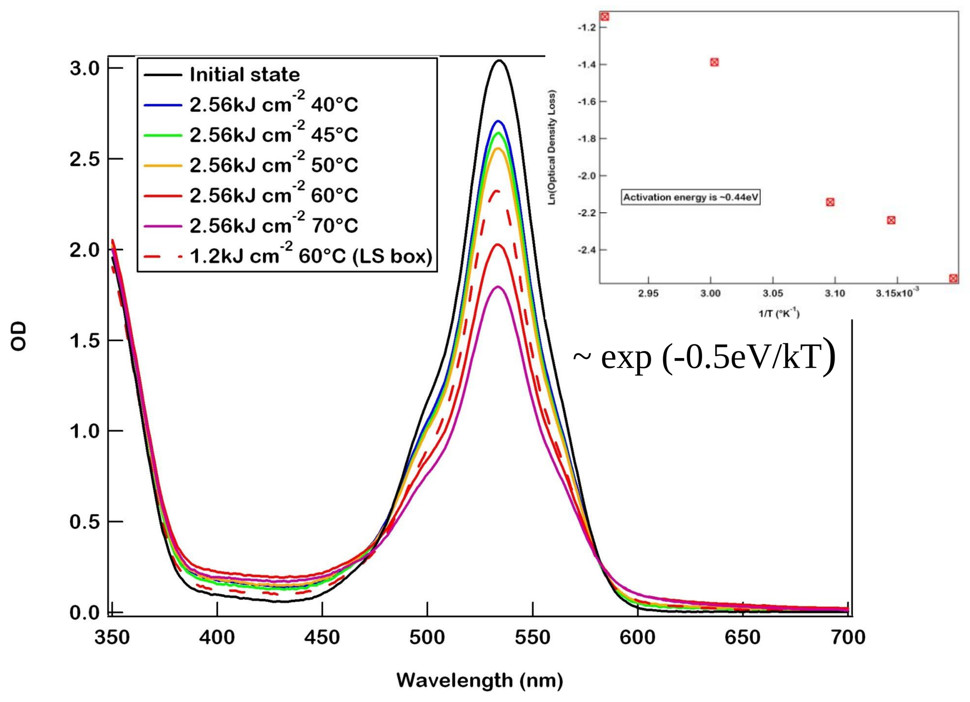


Controlled degradation

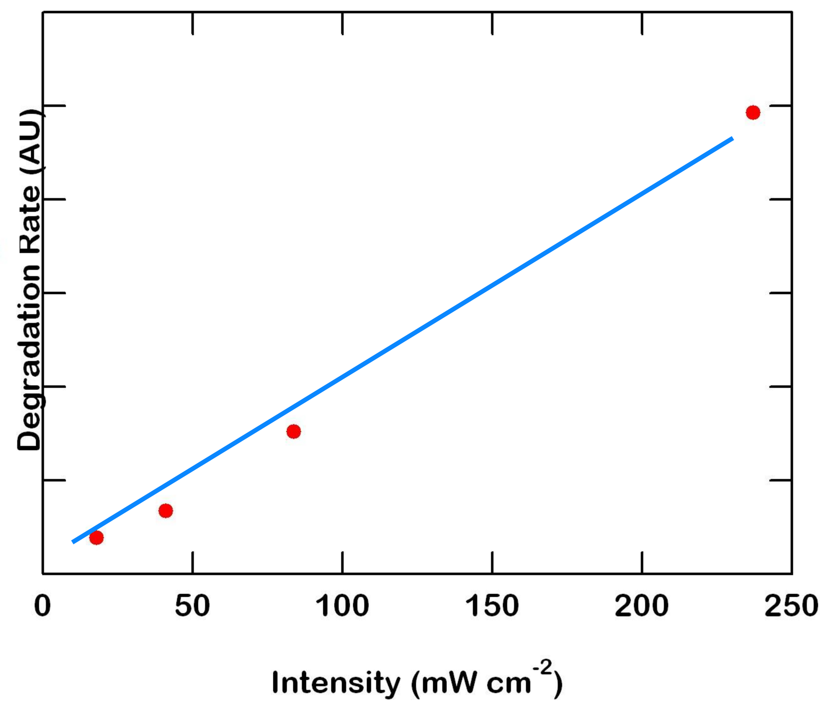
Measure Degradation vs. UV cutoff and Temperature

Select Results on Old Generation Dyes

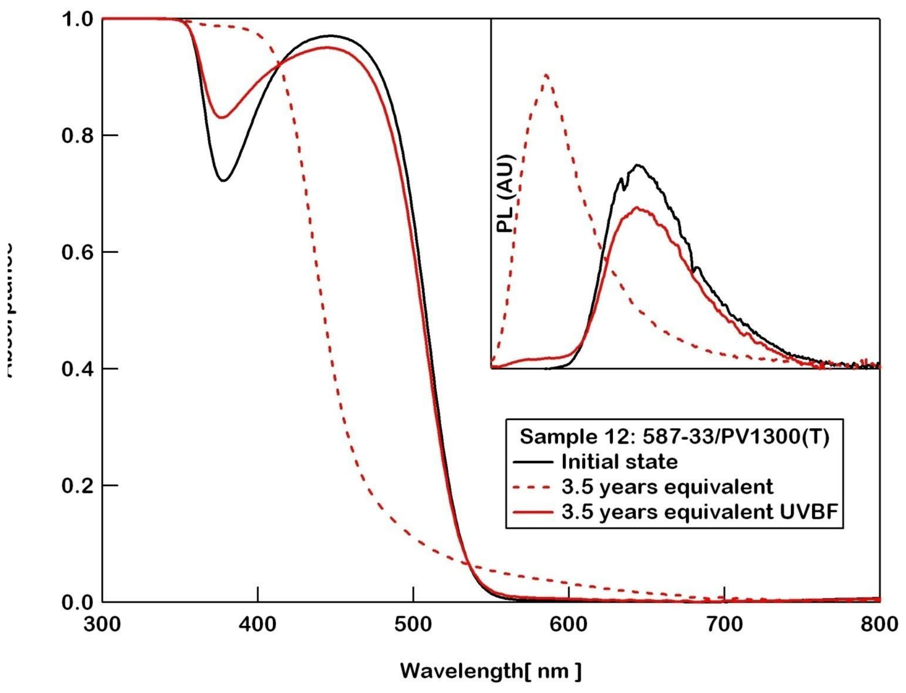
Temperature Dependence Arrhenius



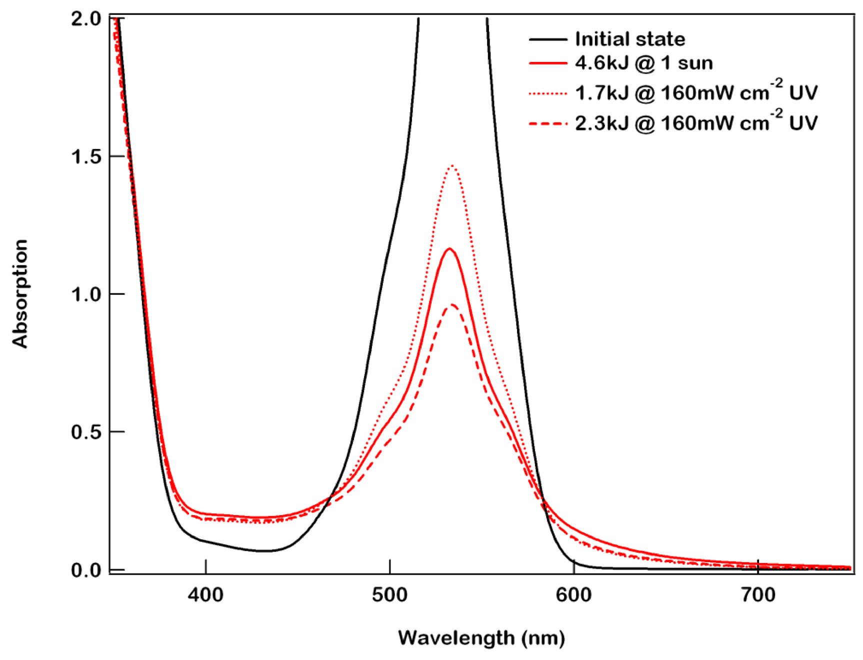
Degradation rate: linear with intensity



Absorption and photoluminescence degradation can be different



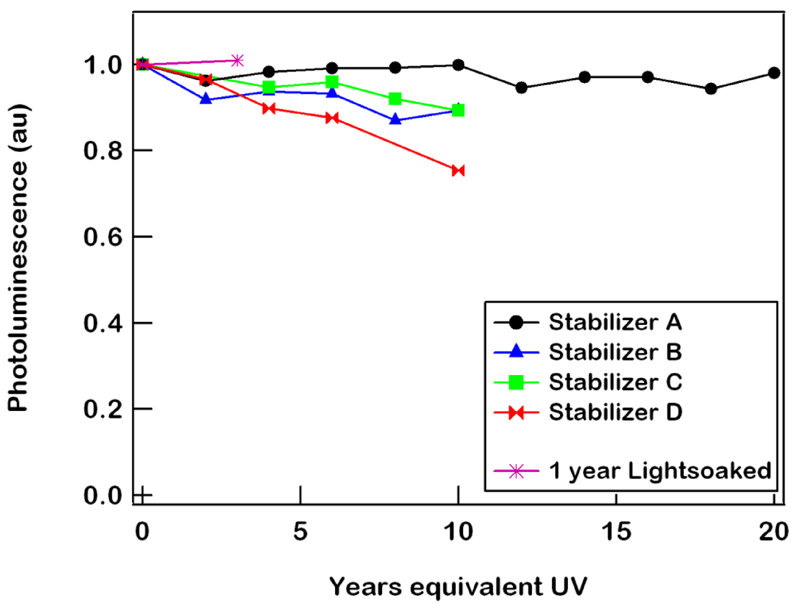
Reasonable correlation to lifetime under 1 sun

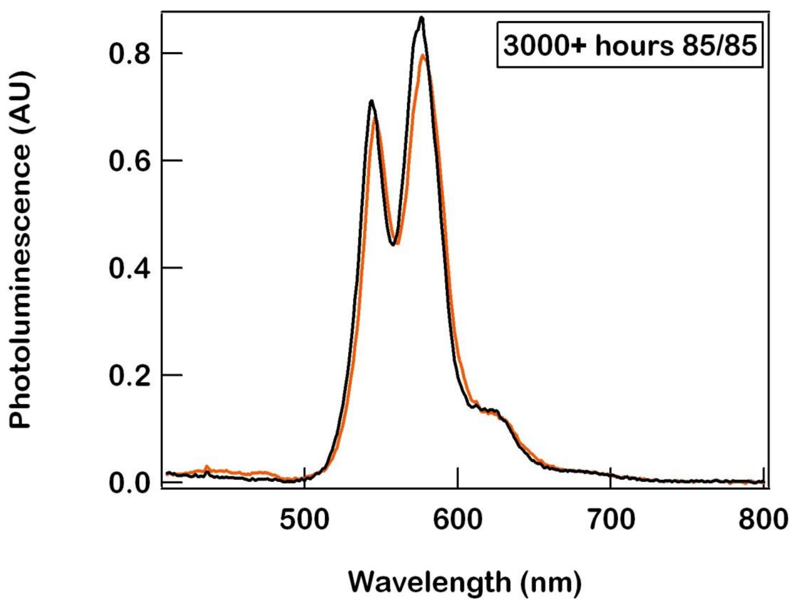


Accurate temperature control + UV cutoff control + high intensity = Quantitative acceleration parameters

Example of Stable Luminescent Material

Stable Dyes: 20 years equivalent of UV with no degradation
1) **Dye with high intrinsic stability**
2) **Proper host (PMMA vs. PVB vs. EVA)**
3) **Proper stabilization of host**





Stability of Current Generation Luminescent Materials

1) Luminescent materials can withstand >10 years equivalent UV

Differences in testing of Luminescent materials vs. polymers
1) **Luminescent materials are very dilute (<1%) in host matrix**
   → low capture cross section
2) **Luminescent materials have short excited state lifetime**
   → Short time for photo-oxidation to occur

New methodology: water cooling + very high intensity UV light
Avoid excessive heating of samples from high intensity light
Improved temperature control → improved extrapolations

Used for testing sealed PV encapsulants (CIGS and CdTe)

Water cooling can be applied to cooling front face glass