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pv magazine webinars

Components level testing vs PV panel testing

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Send them in via the Q&A tab. ☝️ We aim to answer as many as we can today!

You can also let us know of any tech problems there.

We are recording this webinar today. 🎥

We'll let you know by email where to find it and the slide deck, so you can re-watch it at your convenience. 👀 💡

PVEL Backsheet Durability Sequence vs Component-level HALT Testing

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AGENDA

- ***Overview (PV Module vs. Component Test Standards)***
- ***PVEL Backsheet Durability Sequence (BDS)***
- ***Silfab's Back-Contact PV Module (SIL-3xx BL)***
  - ***PVEL TOP Performer in 2021***
- ***Coveme standard PYE Backsheet Structure***
- ***PVEL BDS Test Summary***
- ***Component-level Backsheet Highly Accelerated Life Testing (HALT) and differences with PVEL BDS***
- ***Comparison of Results***
- ***Conclusion***

OVERVIEW (PV Module vs. Component Level Testing)

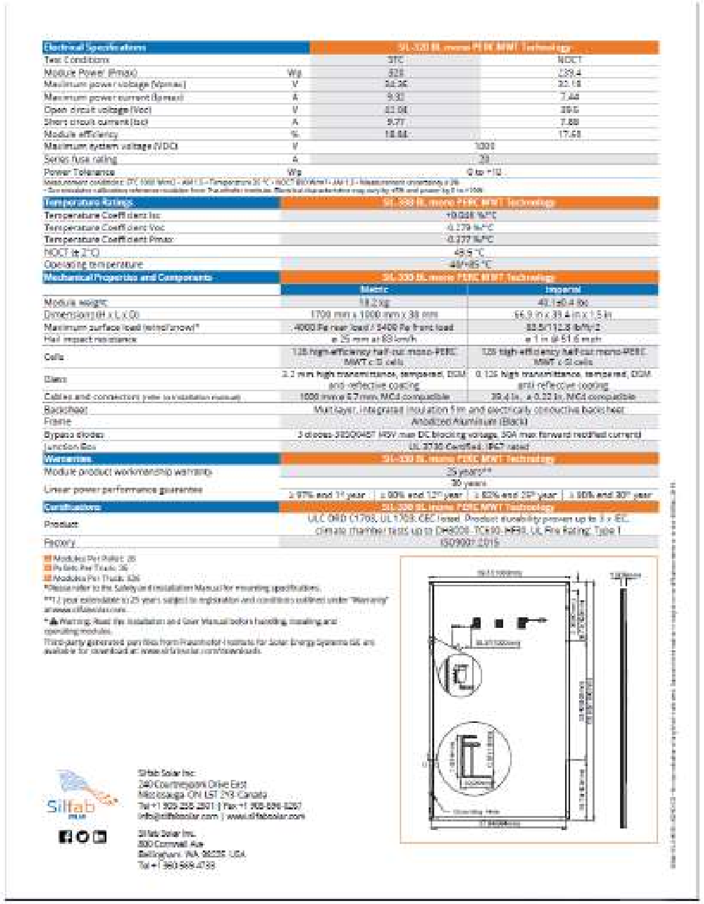
- Traditionally, Design Qualification and Safety Testing of PV Modules was limited to IEC 61215, IEC 61730, and UL 1703
- In 2022, IEC 61215 and IEC 61730 have significantly evolved in the latest 2nd editions (2021 and 2016 respectively) and UL has adopted 61730 as a mostly harmonized safety standard in North America
- It has been widely agreed within the PV industry that safety and design qualification according to 61215/61730 was not sufficient to ensure long-term reliability of PV modules
- As a result, an extended stress testing standard was developed at the module level titled IEC 63209: Photovoltaic modules - Extended-stress testing - Part 1: Modules (an attempt to standardize PVEL’s PQP and RETC’s PV Module Index Testing, among others)
- Understanding the limitations and inefficiency of PV module-level/end-product testing, a component level extended stress testing standard is currently being developed within the IEC (63209-2, Part 2 series)
    - Independently, conscientious component manufacturers have been doing their own versions of extended sequential and single component stress testing to help short-circuit the cycles of learning needed to successfully produce a PV module with sufficient durability for expected product lifetimes
- Furthermore, IEC 62788 PV component series (measurement procedures/accelerated weathering protocols) for encapsulants, frontsheets/backsheets, edge seals is already partially completed
    - Will eventually be referenced and required by 61215/61730 in order to even certify PV modules (not quite there yet…)

PVEL BDS Test

PV modules are subjected to 1000 hours of damp heat (following IEC 61215-2:2016 MQT 13), then the rear-side receives 65 kWh/m^2 of UV (UV65) irradiance at 150 W/m2, 80°C BPT (black plate temperature), followed by 50 cycles of thermal cycles (following IEC 61215-2:2016 MQT 11) and 10 cycles of humidity freeze (following IEC 61215-2:2016 MQT 12). The process of UV65, followed by 50 thermal cycles (TC50) and 10 cycles of humidity freeze (HF10) then repeats two more times for a total of three cycles. The final testing step is a UV exposure of 6.5 kWh/m^2 for photobleaching, which removes any minor discolorations that can be a result of the climate chamber testing and aren't observed in the field.

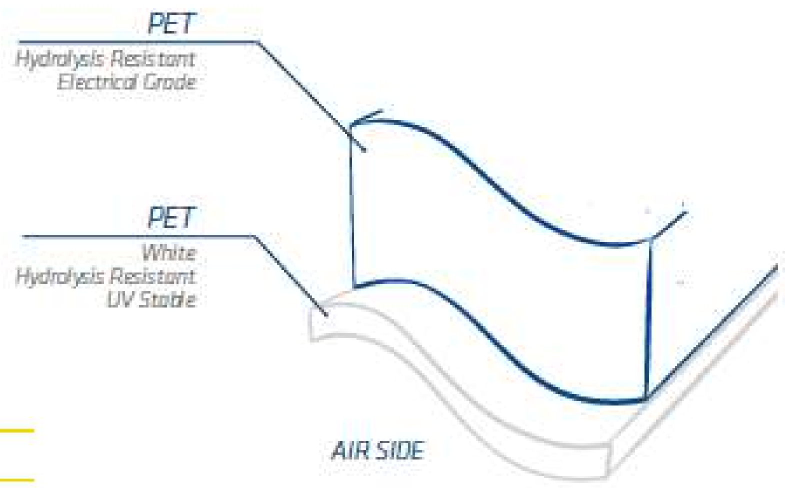
Silfab Back-Contact Elite Series (SIL-3xx BL) Module

PVEL 2021 PQP Scorecard Top Performer



Coveme Standard PYE Backsheet Outer Layer

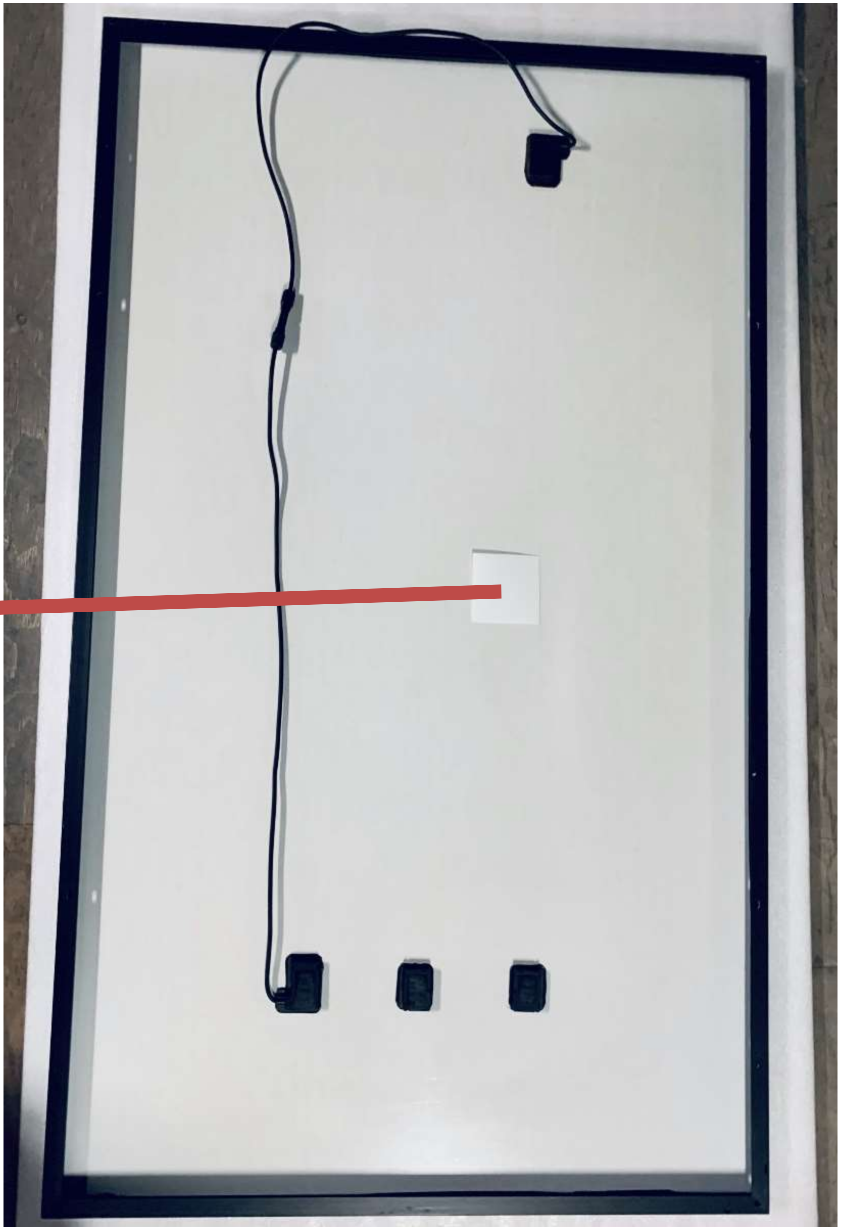
- White 50 µm outer layer (Mylar® SPV7W)
- 250 µm inner layer, hydrolysis resistant.



	Unit	Method	Typical values
PET thickness, air side, white	micron	caliper	50
PET thickness, inner layer, hazy	micron	caliper	250

PVEL BDS Test Summary

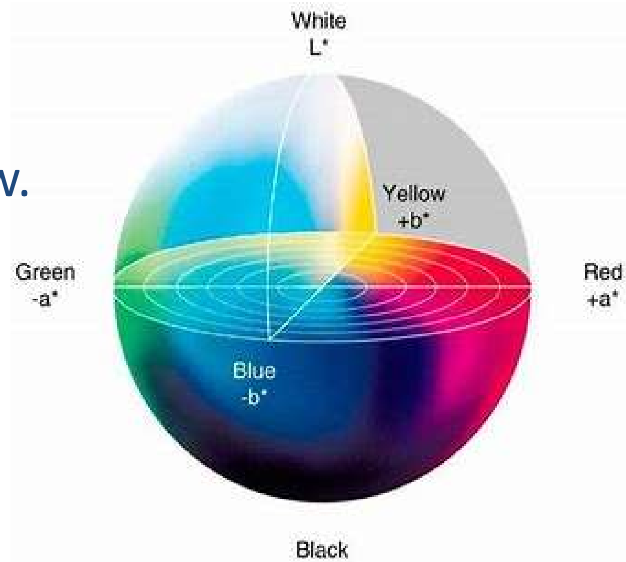
- Wet leakage test: PASS
- Visual inspection: PASS (no cracks)
- Color measurements: Very little variation: Delta E<5.



Colors

- Colors are measured with a Colorimeter that analyzes the color as a function of the amount of light reflected by a colored object at each wavelength.
- The values measured is then placed in a color space, CIE Lab is the most used.
- This is a three-dimensional space made by L*, a*, b*.

- ❑ **L*** represents the brightness
- ❑ **a*** represents the color variation from green to red
- ❑ **b*** represents the color variation between blue and yellow.

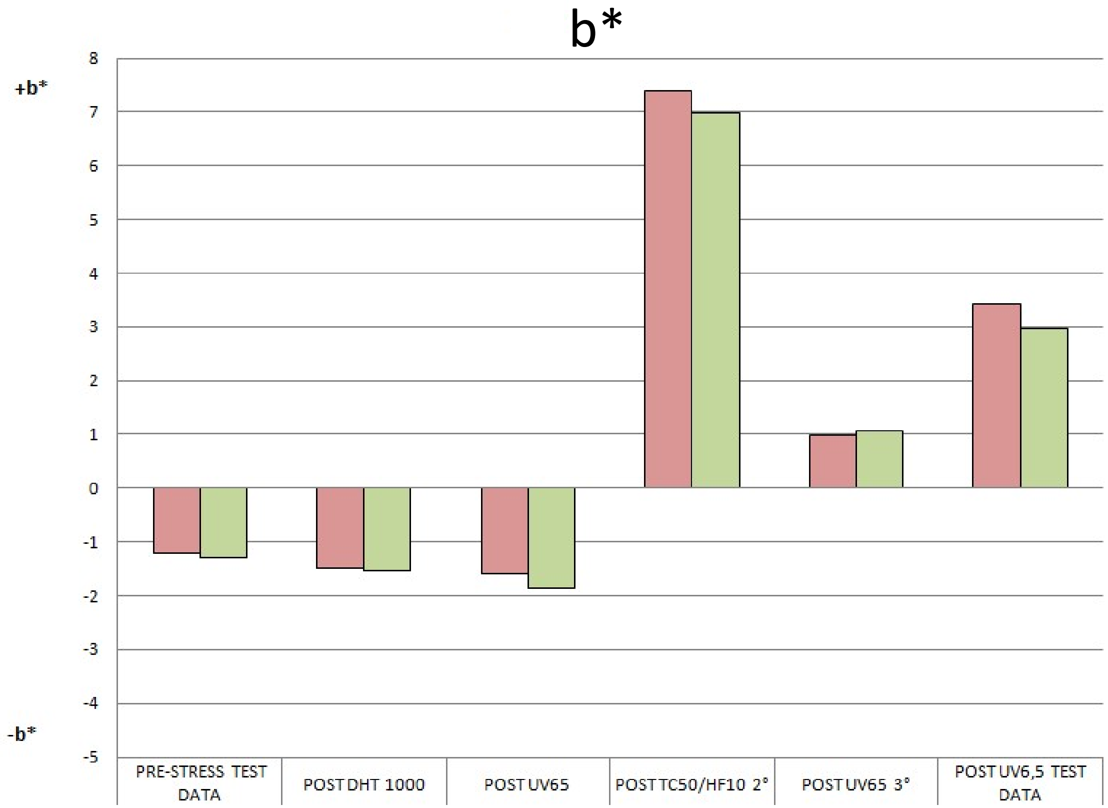


*b**

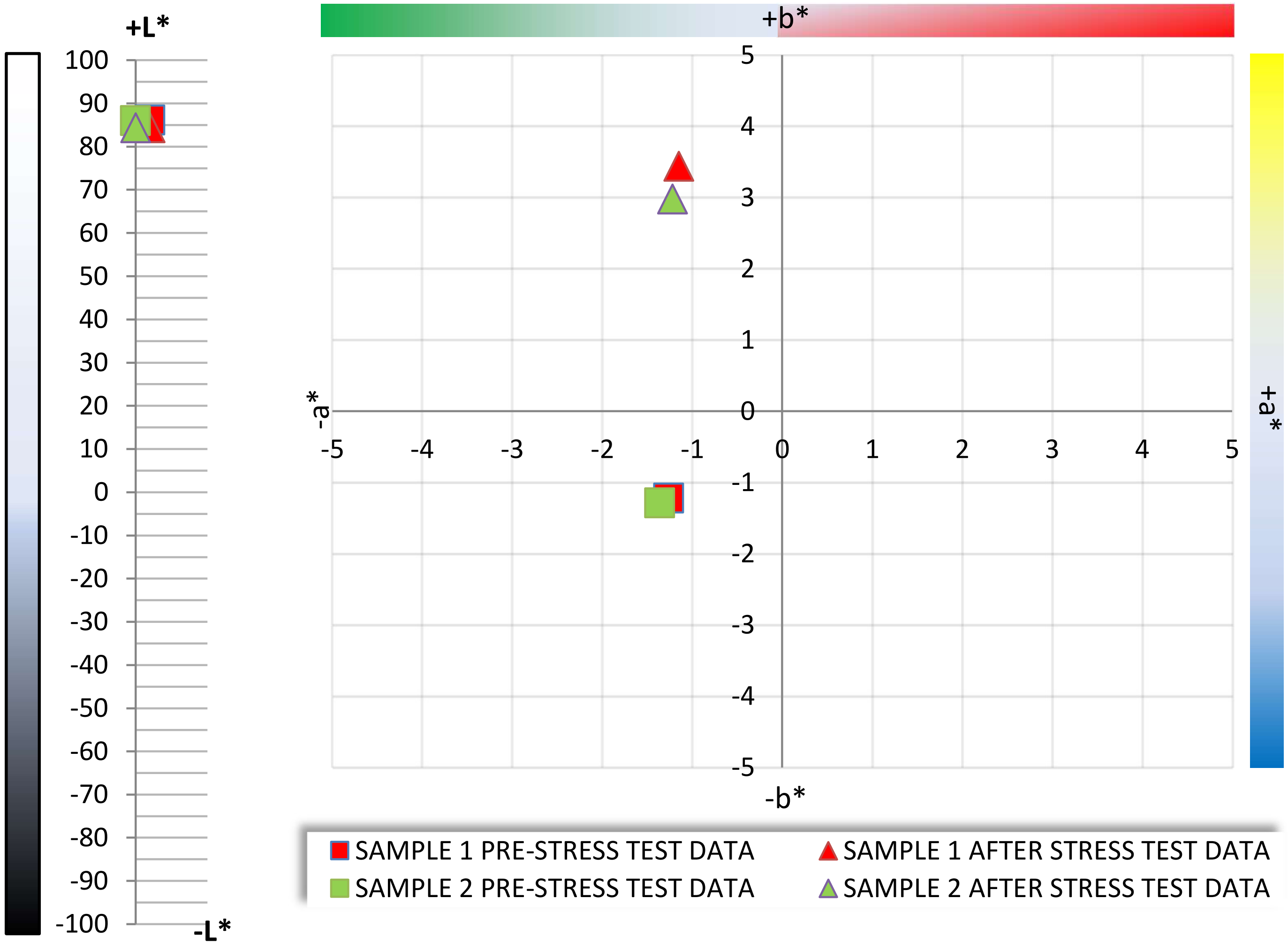
Key value to measure how much the color has changed after the sequenced test. A colorimeter with source A/10 ° spin (ASTM E308) is used.

SAMPLE 1	L*	a*	b*
PRE-STRESS TEST DATA	86,14	-1,26	-1,22
POST DHT 1000	97,76	-1,7	-1,49
POST UV65	86,01	-1,8	-1,6
POST TC50/HF10 2°	96,41	0,19	7,38
POST UV65 3°	85,45	-1,67	0,98
POST UV6,5 TEST DATA	84,38	-1,15	3,44

SAMPLE 2	L*	a*	b*
PRE-STRESS TEST DATA	85,99	-1,36	-1,29
POST DHT 1000	97,68	-1,74	-1,54
POST UV65	85,45	-1,92	-1,86
POST TC50/HF10 2°	96,98	0,06	6,98
POST UV65 3°	85,15	-1,65	1,08
POST UV6,5 TEST DATA	84,38	-1,22	2,98



Delta E



Delta E is the variation of color and it considers all coordinates L*, a*, b*.

The delta E between time 0 and after aging is <5!

	L*	a*	b*	ΔE
PRE-STRESS TEST DATA				
SAMPLE 1	86,14	-1,26	-1,22	
SAMPLE 2	85,99	-1,36	-1,29	
AFTER TEST DATA				
SAMPLE 1	84,38	-1,15	3,44	4.98
SAMPLE 2	84,38	-1,22	2,98	4.56

HALT Test for Backsheet by DuPont Teijin

Comparison of Tests

PVEL BDS

DH 1000
↓
UVA 65 kWh/m2
↓
TC 50 + HF 10
↓
UVA 65 kWh/m2
↓
TC 50 + HF 10
↓
UVA 65 kWh/m2
↓
TC 50 + HF 10
↓
UVA 6.5 kWh/m2

DuPont Teijin Backsheet Test

Component-level HALT

DH 1000
↓
UVX 65kWh/m2
↓
TC 200
↓
UVX 65kWh/m2
↓
TC 200
↓
UVX 65kWh/m2
↓
TC 200
↓
UVX 6kWh/m2

DH - 85°C / 85 % humidity

TC - 85°C to -40°C

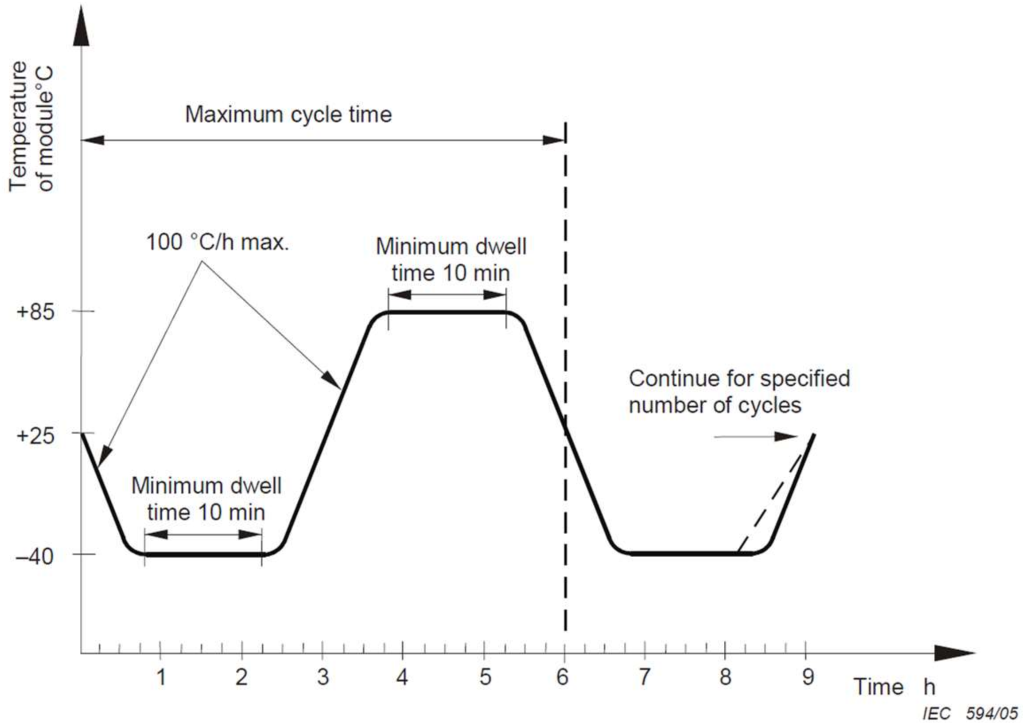
HF - 85°C / 85% humidity to -40°C

UVA – 150W/m2, 80°C BPT

UVX – 1.2kWhr/m2 (340nm), 90 °C BPT, 65 °C CAT, 20% RH

Thermal Cycling

The purpose of this test is to determine the ability of the PV module to withstand the effects (material fatigue, temperature stresses etc…) of repeated cycling between the minimum and maximum temperatures a module sees during it’s lifetime (85°C to -40°C).



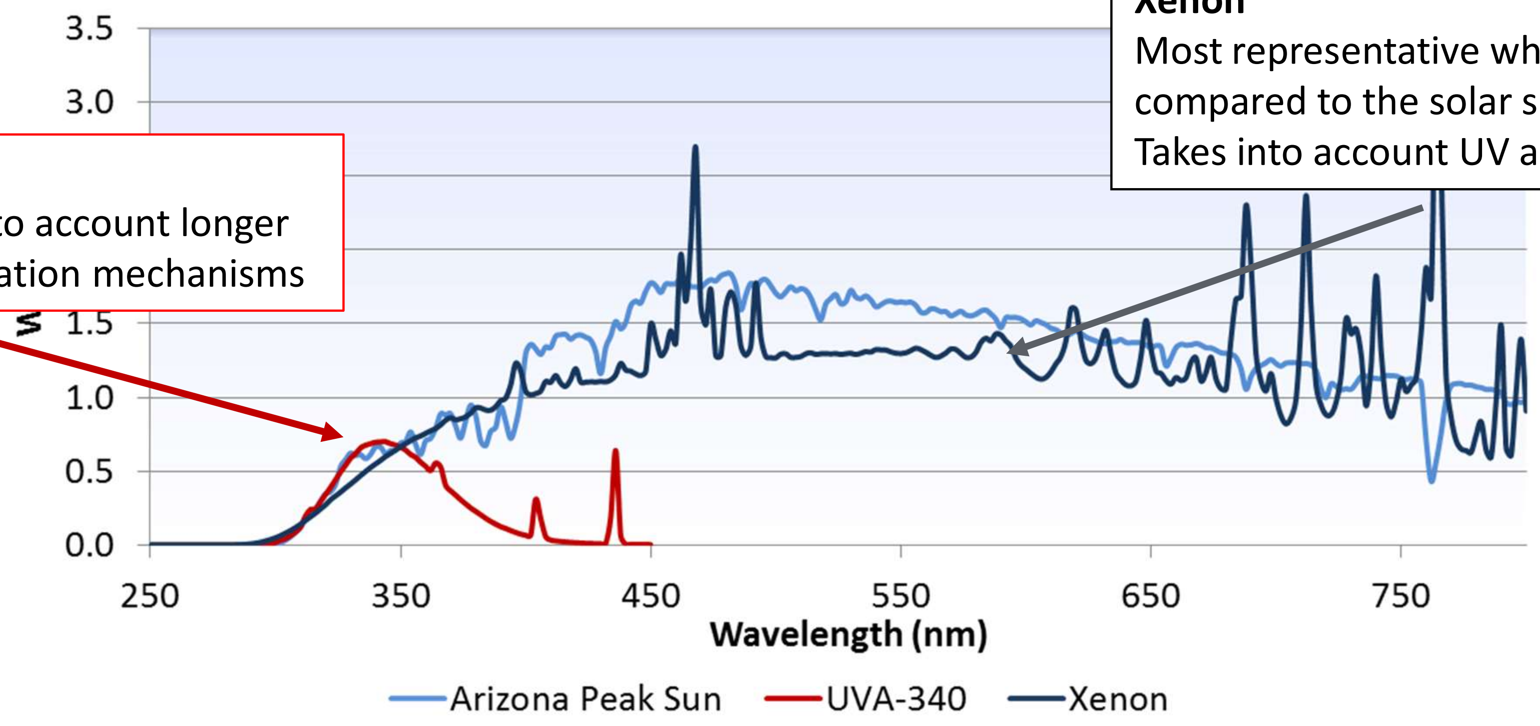
Humidity Freeze

- The humidity freeze test is designed to define the module's ability to endure the effects of high temperature/high humidity conditions, followed by a rapid freeze to -40C.

- The purpose of the test is to determine the ability of the PV module to withstand against humidity penetration and subsequent rapid freezing at extreme temperatures.

- The failure mechanism that can be induced by thermo-mechanical stress is that the PV modules may suffer from degradation processes originating from thermomechanical stresses induced to the interconnects (cyclic movement of cells) which cause loss of adhesion strength at interfaces and subsequent losses in the generated power and decrease in lifetime of the module.

Different Accelerated UV Testing



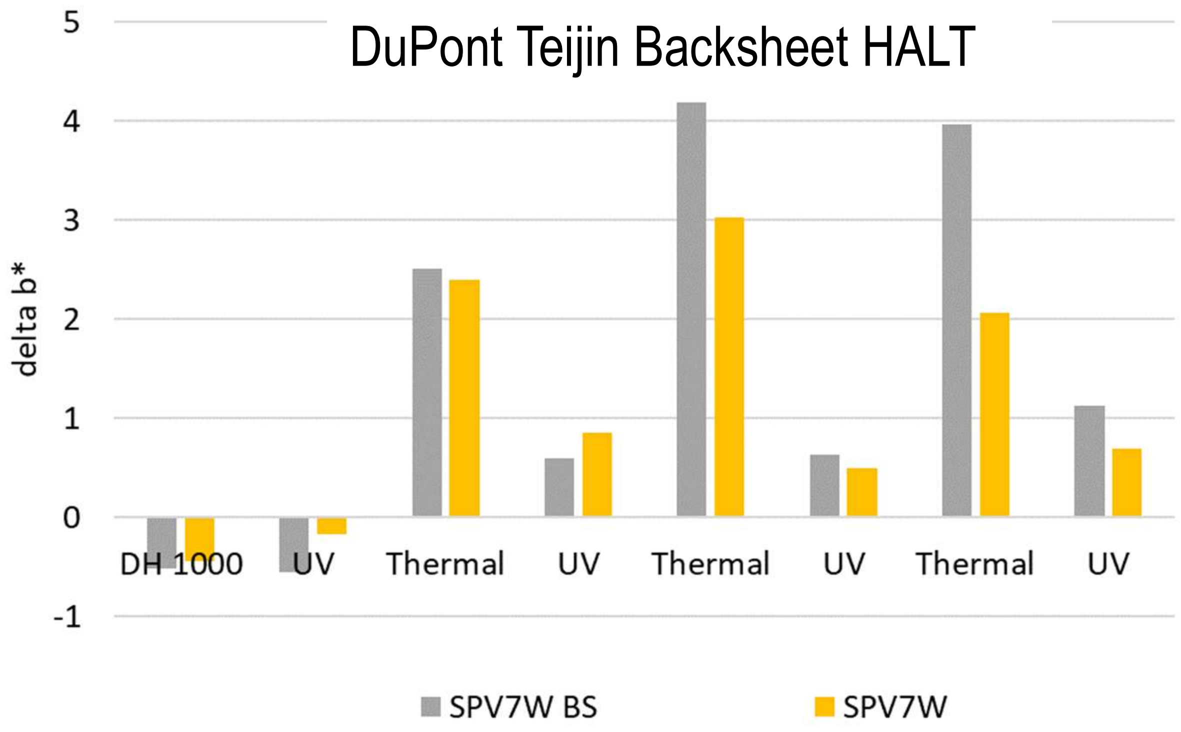
UVA 340 Lamp
Risk – not taking into account longer wavelength degradation mechanisms

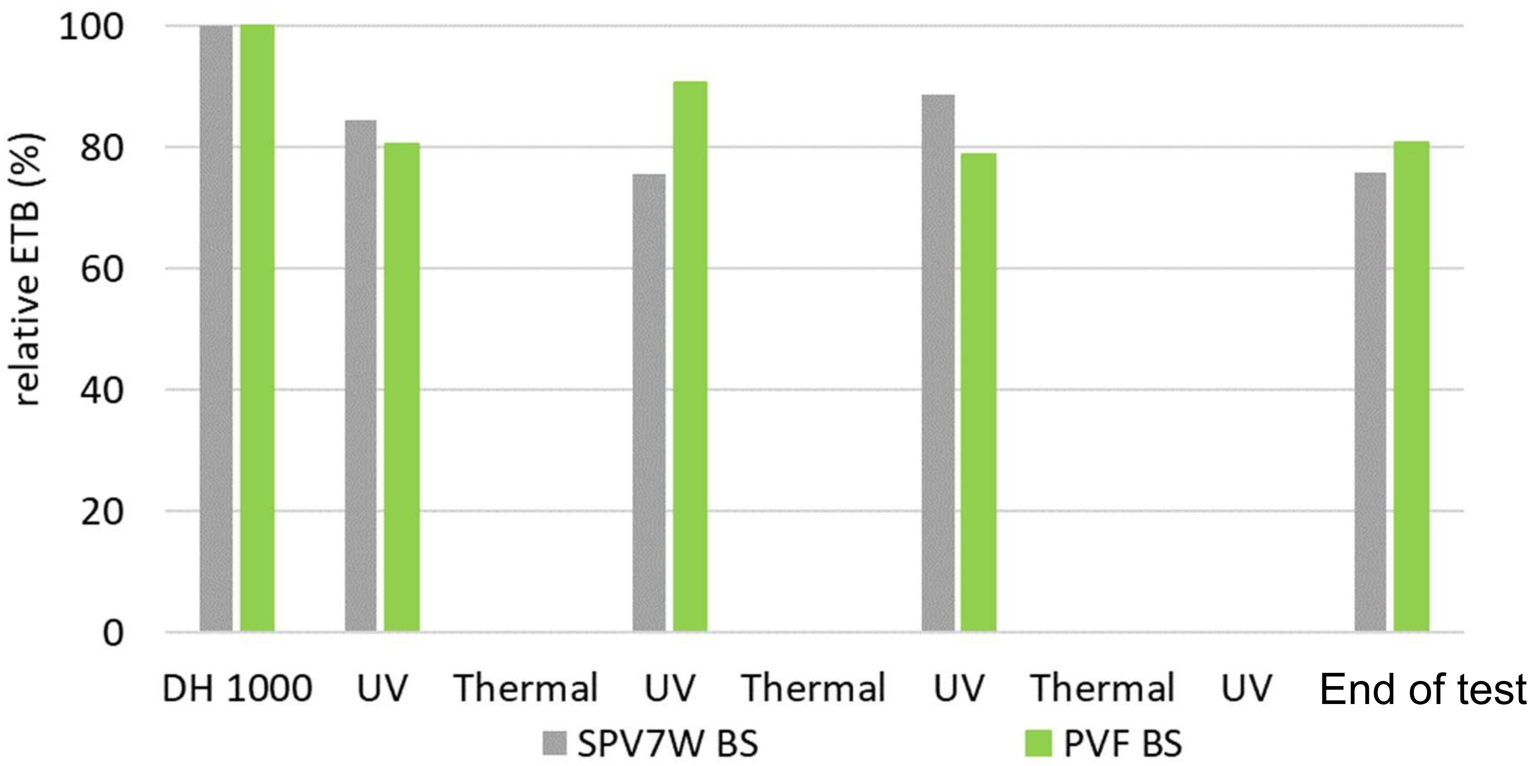
Xenon
Most representative when compared to the solar spectrum. Takes into account UV and visible.

DTF UV testing

DTF tested Mylar® SPV7W 50 micron film in two different ways:

- In a backsheet structure as per page 5
- As a PET film only (no inner layer and no EVA).





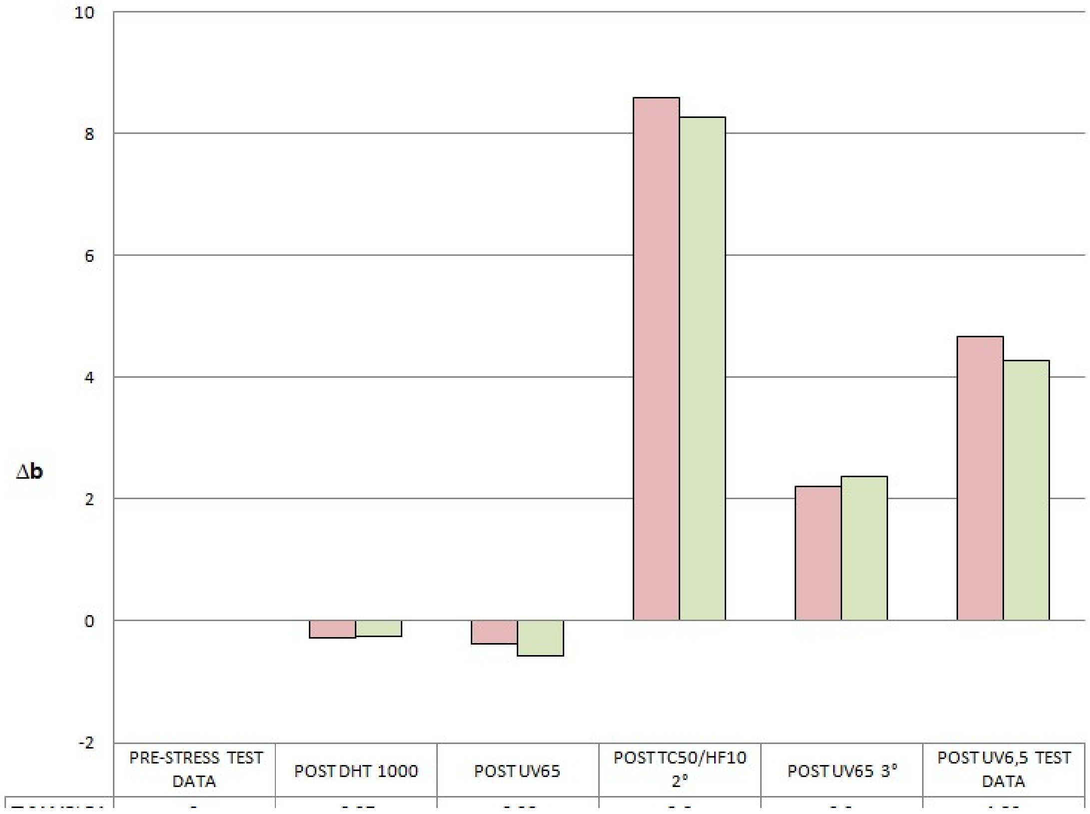
Fast HALT excellent retention of mechanical properties. PVEL test no cracks so again excellent retention of mechanical properties

PVL delta b*

Same data as slide 8 where we calculate delta b instead of b* alone. This is needed to compare data with DTF.*

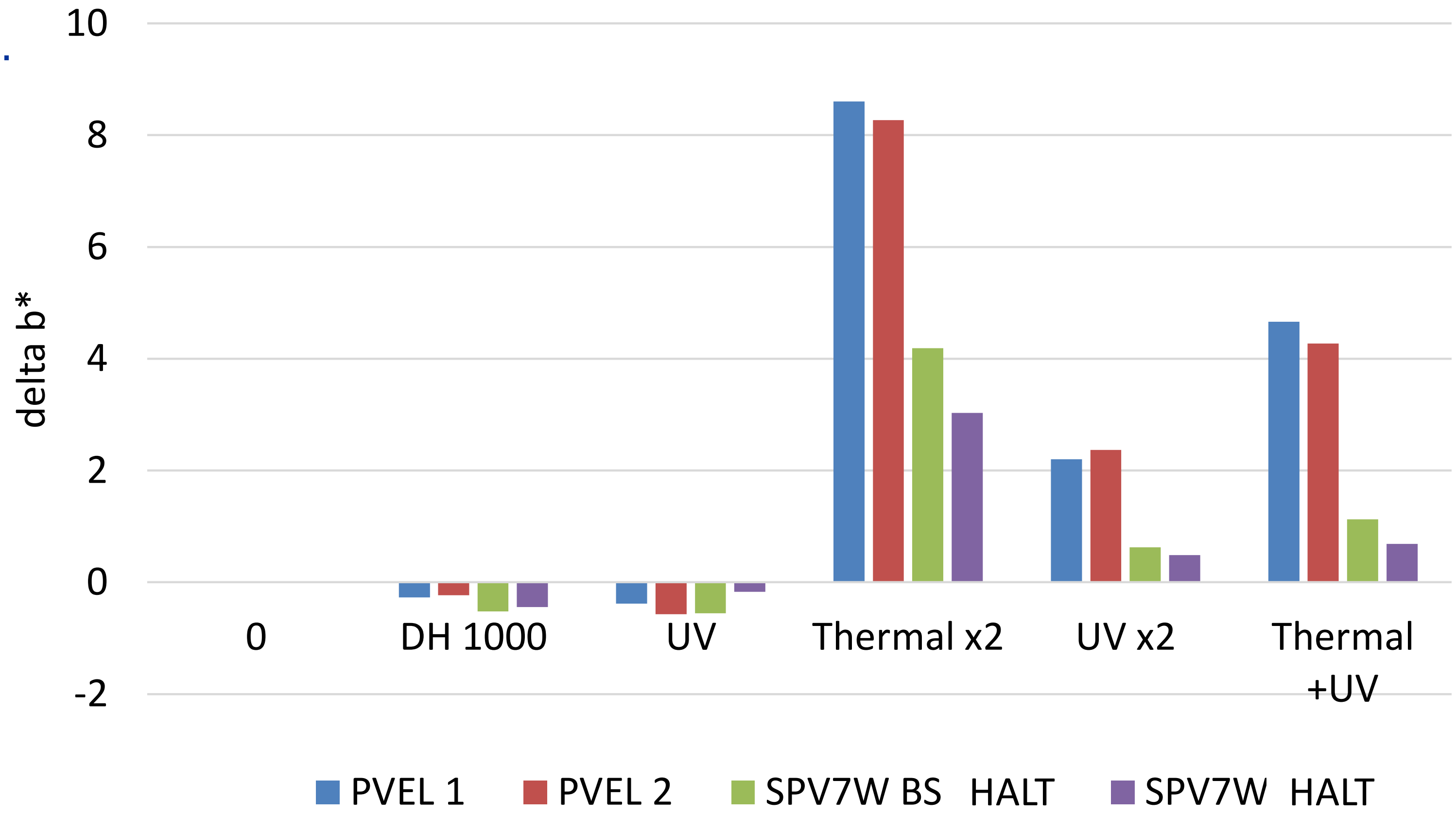
SAMPLE 1	L*	a*	b*
PRE-STRESS TEST DATA	86,14	-1,26	-1,22
	ΔL	Δa	Δb
POST DHT 1000	11,62	-0,44	-0,27
POST UV65	-0,13	-0,54	-0,38
POST TC50/HF10 2°	10,27	1,45	8,6
POST UV65 3°	-0,69	-0,41	2,2
POST UV6,5 TEST DATA	-1,76	0,11	4,66

SAMPLE 2	L*	a*	b*
PRE-STRESS TEST DATA	85,99	-1,36	-1,29
	ΔL	Δa	Δb
POST DHT 1000	11,69	-0,38	-0,25
POST UV65	-0,54	-0,56	-0,57
POST TC50/HF10 2°	10,99	1,42	8,27
POST UV65 3°	-0,84	-0,29	2,37
POST UV6,5 TEST DATA	-1,61	0,14	4,27



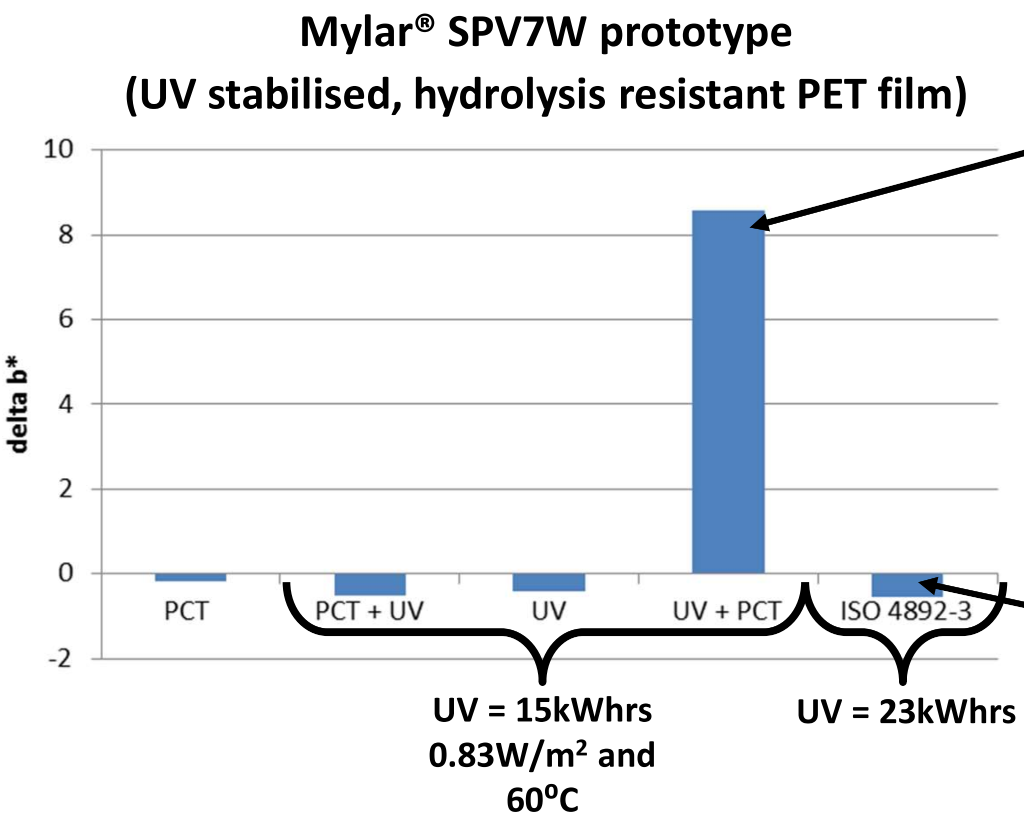
Comparing delta b data between the two tests*

- PVEL test made on PV Panel.
- DTF test made on Backsheet only and on Mylar® SPV7W film only!



UV followed by PCT?

PCT = 121^{o}C, 100% humidity



UV + Pressure Cooker Test (PCT)

- Yellowing from UV followed by ***high temperatures***
- Test accelerates reaction mechanisms that are ***unrealistic to real life scenarios***

Industrially recognised test method ISO 4892-3.

- 8 hours UV (9% UVB) at 0.76W/m^2, 60^{o}C followed by 4hrs condensation at 50^{o}C

UV followed by heat

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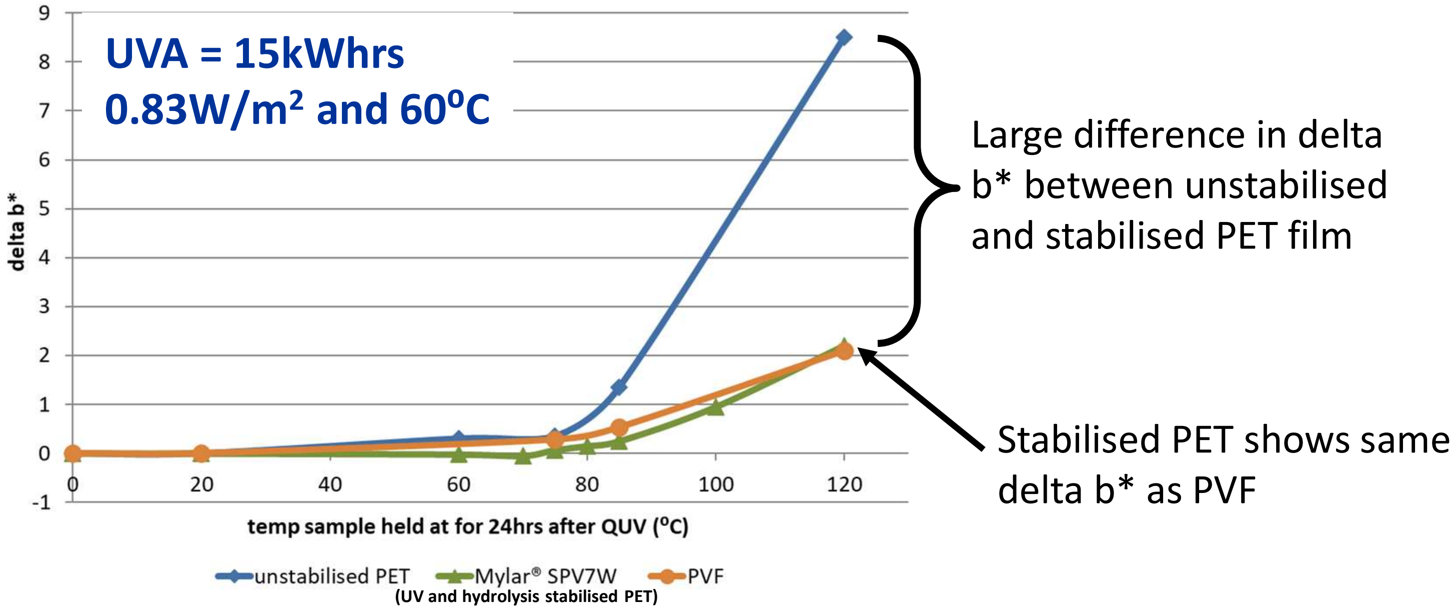

What is causing the yellowing in this test?

- Delta b* unaffected in all samples at temperatures below 80°C
- Tg of PET 78°C. So discoloration could be a factor of being above Tg, but PVF discolours about 80°C too
- Possible discolouration due to increased mobility above 80°C of radicals formed during UV radiation leading to thermo-oxidation

Observation

- ***Delta b* of previous slide (around 8) compares very well with PVEL delta b* on the panel (around 8).***
- ***In this case film and panel perform very similarly when heat and humidity follow UV.***

Conclusion

- ***Coveme PET Backsheet performed extremely well in both PVEL module level and component-level HALT tests, which are considered the current «gold standard» of PV backsheet reliability assessment. The color change is minimal in both cases.***
- ***HF in PVEL test may lead to greater yellowing due to combination of heat and humidity after UV.***
- ***The use of UVA rather than UVX could lead to different acceleration of photocatalytic degradation in TiO2 filled PET materials (mechanical degradation not always seen with UVA)***
- ***Bleaching of the film after Thermal and Humidity happens with both UVA and UVX.***
- ***Coupon testing of backsheets in UVX is important along side a more practice sequential testing of the full module in UVA (UVX already been implemented in component standard).***

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Q&A

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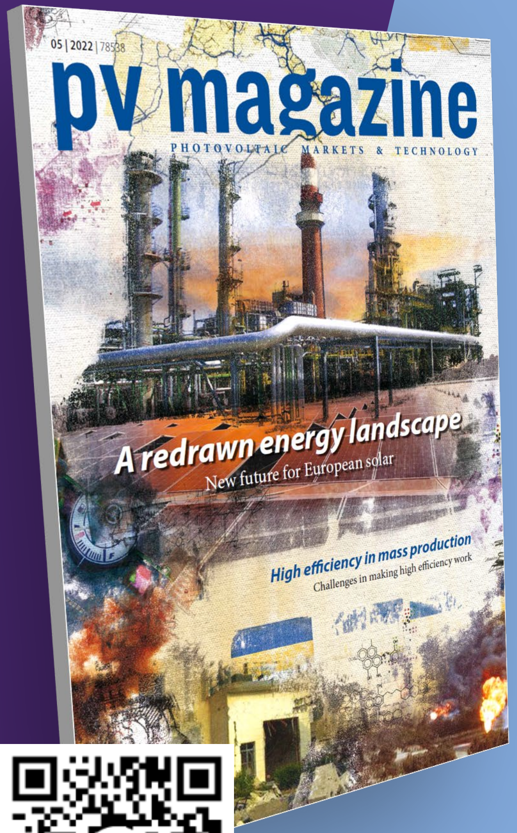

Photovoltaic water heater from Italy

by Emiliano Bellini

New photovoltaic in-roof system from Switzerland

by Sandra Enkhardt

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Tuesday, 21 June 2022
9:00 am – 10:00 am CEST, Berlin, Madrid
5:00 pm – 6:00 pm AEST, Sydney

Analyzing PV system safety and the promise of optimizers

Wednesday, 22 June 2022
5:00 pm – 6:00 pm CEST, Berlin, Madrid
11:00 am – 12:00 pm EDT, New York

Algorithms for solar tracker optimization under adverse conditions

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