DEVELOPMENT AND TESTING OF A THERMOMECHANICAL PROCEDURE TO ASSESS THE DISASSEMBLY POTENTIAL OF A PHOTOVOLTAIC MODULE

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Abstract:

In this study, we present a method to assess the disassembly potential of photovoltaic (PV) modules by measuring the force required to separate their layers using two approaches: (a) peel-off tests on modules without cells and (b) delamination tests on single cell PV modules. Both tests are performed at different temperatures; the first measures the adhesion strength of the encapsulant with glass, while the delamination tests are performed using a knife. The research focuses on the performance of different encapsulants including Ethylene Vinyl Acetate (EVA), Thermoplastic Polyolefin (TPO) and Polyolefin Elastomer (POE), while also investigating the changes in adhesion strength after 1000 hours of exposure to damp heat (DH) conditions, 85 ºC and 85% RH. The results show that TPO has the lowest delamination strength, followed by EVA, with POE being the most resistant to delamination although significant decrease in their adhesion was observed above 60 °C. In addition, modules exposed to DH conditions showed lower adhesion than those not exposed to such conditions.

Keywords: Photovoltaic modules, recycling, circular economy, encapsulants, disassembly, delamination.

1. Background and motivation

- **PV waste challenge**: 78 million tonnes of waste by 2050 [1].
- Adopt **Design for Recycling (DfR) principles** [2] to support the transition to a **circular economy**.
- Develop a **recyclability index** [3] to assess the recycling potential of PV modules.
- We present an automated and quantifiable **thermomechanical method** to evaluate the **disassembly potential** of various PV technologies.

2. Methods

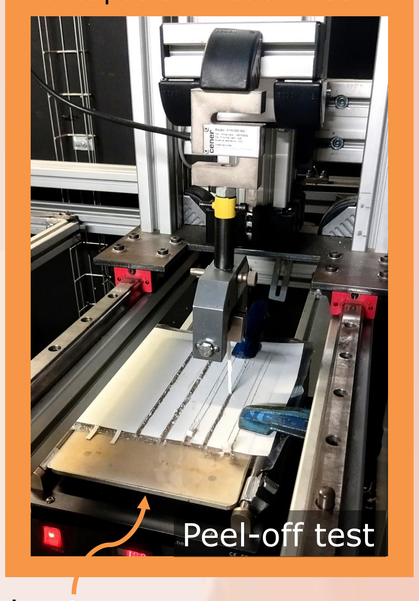
Measure the adhesion strength of the encapsulant to other layers at various temperatures using two different tests.

Peel-off and Delamination test

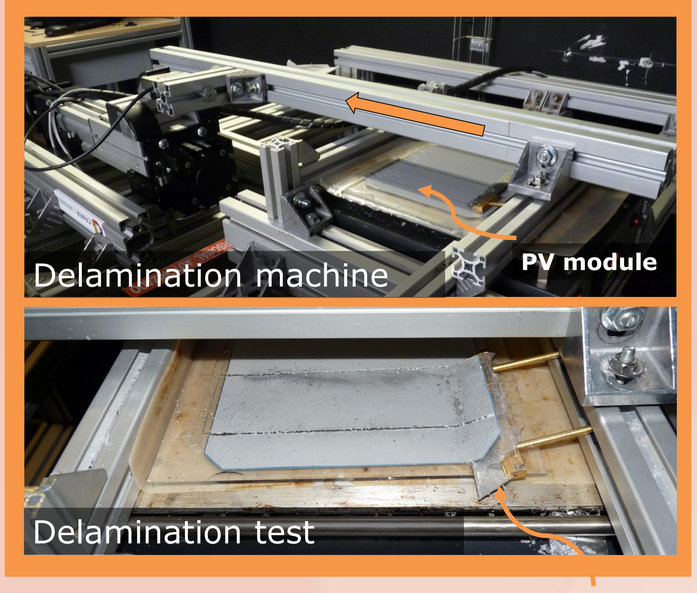
Encapsulants: EVA | TPO | POE

Conditions: No DH | 1000h DH

Peel off encapsulant+backsheet

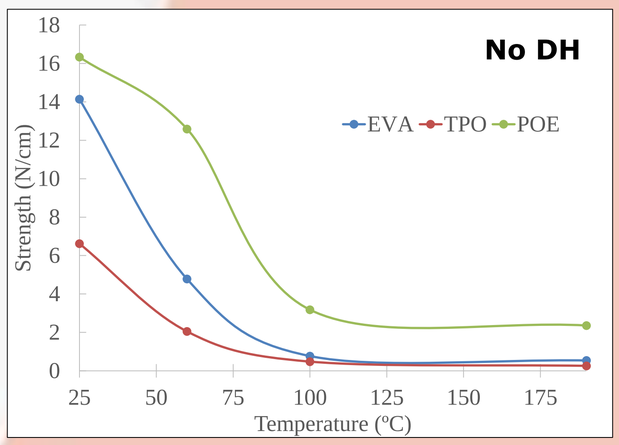


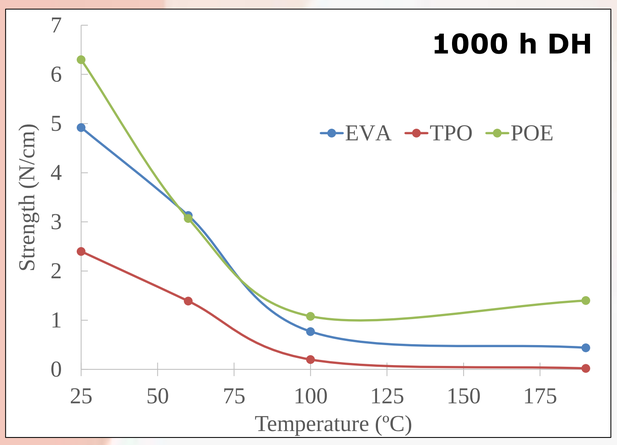
Encapsulant and cell mixture layers removal



3. Results and discussion: Peel-off

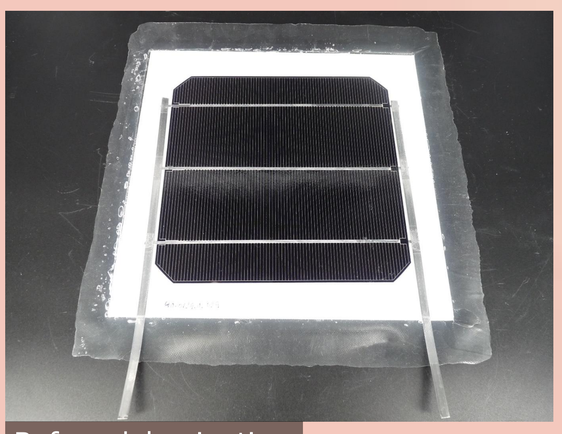
Temperatures: 25 ºC | 60ºC | 100 ºC | 190 ºC





- **TPO has the lowest adhesion** → EVA → POE
- Samples exposed to **DH conditions show reduced adhesion**.
- The **adhesion difference** ↓ **as test T** ↑, especially above 60°C.

4. Results and discussion: Delamination

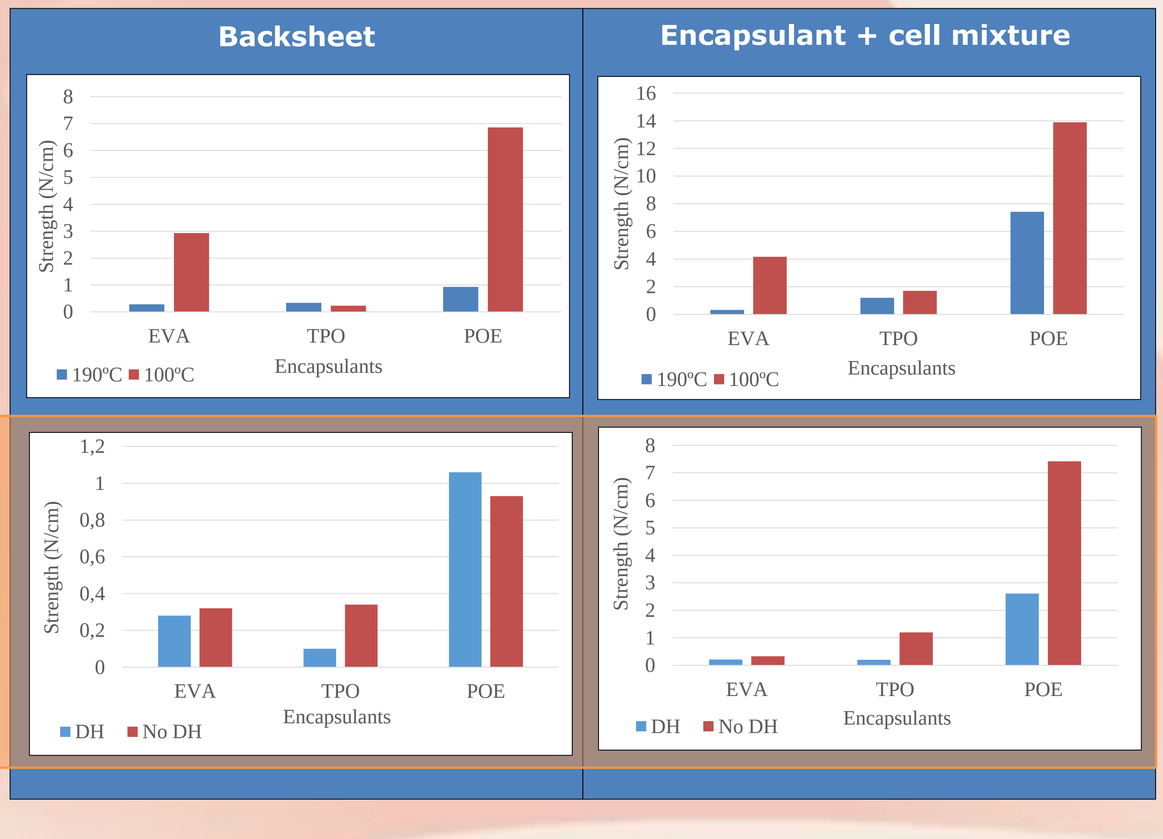


Before delamination

After delamination

These delaminations ⇒ Temperatures: 100 ºC | 190ºC

Conditions: No DH | 1000 h DH



- **DH** conditioned samples generally require a **lower delamination strength**.
- **Delamination strength: POE<EVA<TPO**.

5. Conclusions

- A new **automated and quantifiable method** has been developed to **assess the disassembly potential** of photovoltaic modules.
- Layer separation becomes **easier from 60 ºC onwards**.
- **TPO offers the easiest separation**, followed by EVA, with POE being the most difficult.
- **DH conditioned samples show a notable reduction** in encapsulant adhesion.

References

1. S. Weckend, A. Wade, y G. Heath, «End of Life Management: Solar Photovoltaic Panels», NREL/TP-6A20-73852, 1561525, ago. 2016.
2. J. Bilbao, G. Heath, A. Norgren, M. Lunardi, A. Carpenter and R. Corkish, «PV Module Design for Recycling Guidelines», NREL/TP-6A20-80984, 1832877, oct. 2021
3. D. Polverini, F. Alfieri, C. Spiliotopoulos, y A. Arcipowska, «Towards a recyclability index for photovoltaic modules: Methodology, challenges and policy implications», Progress in Photovoltaics: Research and Applications, 2024, 1-9

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