Influence of Encapsulant – Backsheet Combinations on PV Module Degradation Modes.

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INTRODUCTION AND MOTIVATION

Degradation and failure of photovoltaic (PV) modules can be attributed and explained by the mass transport properties (diffusion and permeation) of small molecules through and within the components of the modules, e.g. backsheet and encapsulant. These properties are highly related to the intrinsic structure and composition of the polymeric matrices, as well to the chemical nature of the molecules being transported in and out the PV module. A PV module it is not only subjected to the transport of molecules, but also to heat and energy exchange with the environment, yielding in degradation processes. An optimal combination of backsheet-encapsulant can limit the transport phenomena, thus degradation modes. Ultimately, finding a backshet-encapsulant combination that yields in an improved lifetime and reliability of the PV module.

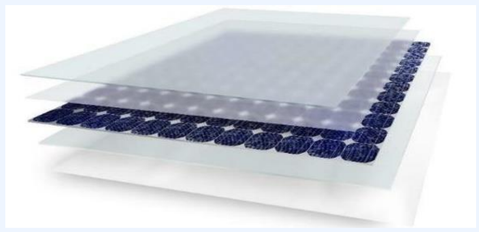

Figure 1. Elements of a PV module.

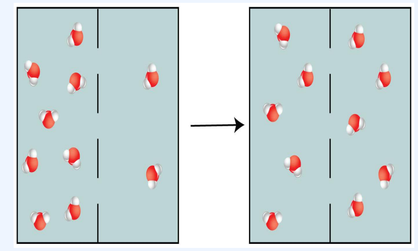

Figure 2. Transport of molecules.

EXPERIMENTAL

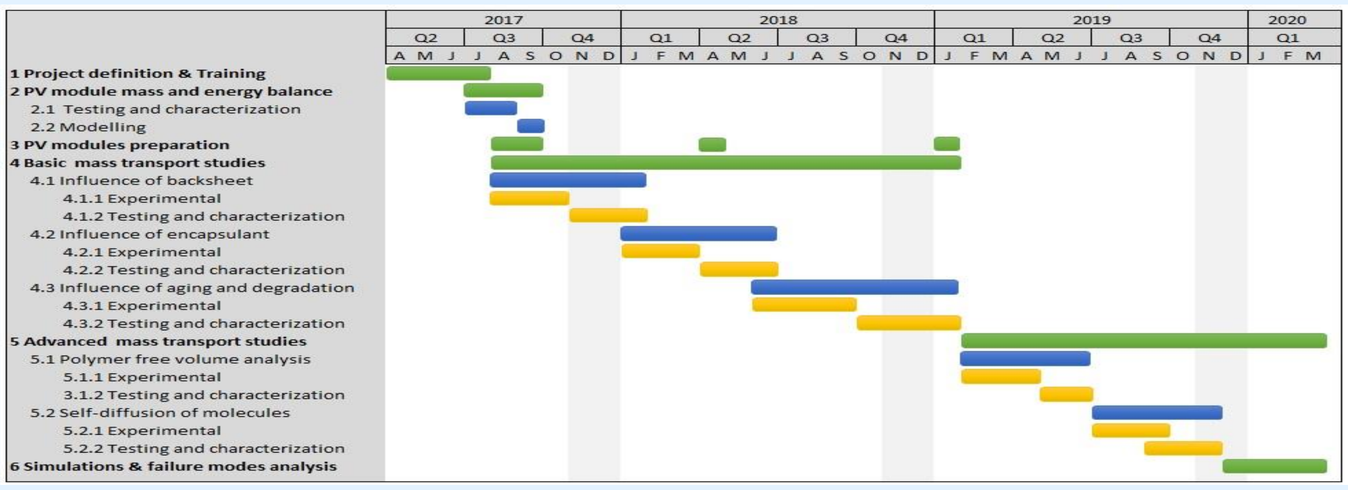

Figure 3. Work plan for (SOLARTRAIN) POS10.

What it's true, is that every mass transport study in a PV module starts with a mass and energy balance. This is, the mathematical depiction of the energy and material flow in and out (and through) the components of a PV module. For this particular task, and to have an accurate depiction of the system, thermal characterization of the materials in a PV module is needed; also as a measure of ageing.
Mass transport studies in a PV module are not new, several studies related with the permeation of water, oxygen and acetic acid. Nevertheless, permeation and diffusion experiment are still relevant since new materials are continuously being developed for solar applications: Heat capacities, thermal conductivities.
The relevance of mass transport studies can be further increased, by determining climate specific mass transport parameters, and the transport of certain molecules like salt and ammonia .

SIMULATION

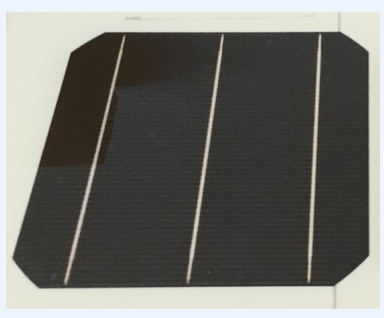

Figure 4. Laminated PV module.

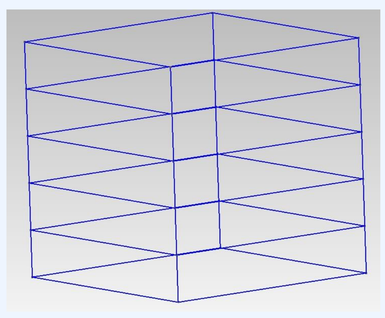

Figure 5. Layered PV model construction.

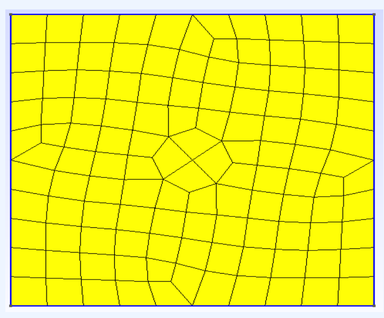

Figure 6. Mesh for finite elemental analysis.

Nowadays, simulations it's a fundamental part of material degradation and failure mode analysis, due to it's ability to predict results. With this tool, concentrations of different chemical species can be determined at certain interfaces or at different position on the components of the module.
With the right model, climate specific (arid, continental, alpine, marine, country side)thermal loads) can be simulated). Also, the effect of steady or non-steady state conditions for mass transport studies. A focal point of this study is the test of diffusion-reaction modes for different chemical species transported or generated in a PV module. Another aspect of simulation is the use of finite elemental analysis to make a complex problem into a smaller one.

EXPECTED RESULTS

- Climate specific mass transport parameters for arid, continental, alpine, marine, country side, coupled with environmental factors.
- Optimal backsheet–encapsulant combinations, that yields in the lowest water and oxygen permeation rates, but improves the lifetime and reliability of the PV module.
- Clear correlations between backsheet – encapsulant crystallinity, crosslinking degree, thickness, free volume with permeation rates and diffusion coefficients.
- New methods for the determination of mass transport parameters, by following the increasing (or decreasing) of specific peaks in the Raman spectrum, specially the carbonyl peak.

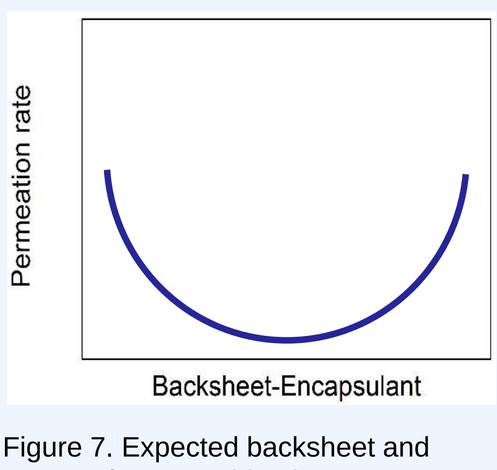

Figure 7. Expected backsheet and encapsulant combinations sermeation rates

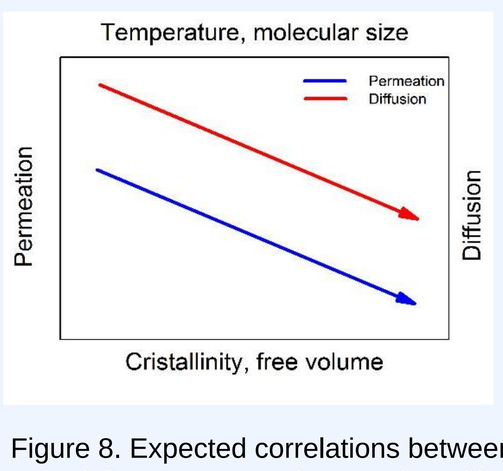

Figure 8. Expected correlations between material's structure and properties with mass transport parameters.

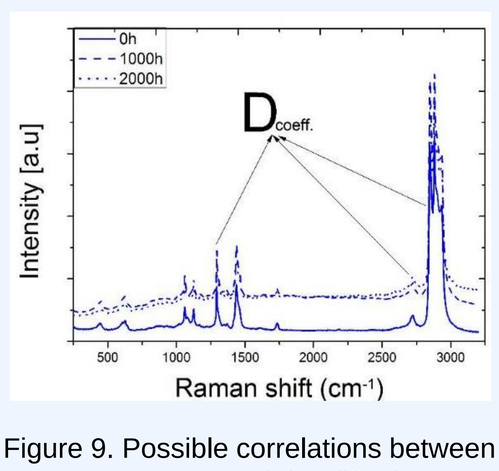

Figure 9. Possible correlations between Raman spectrum and the diffusion coefficient.

OBJECTIVES

- To obtain detailed understanding of the material and energy flows in and out of a PV module under operating conditions with respect to encapsulant – backsheet combinations.
- To establish correlations between material structure, permeation behavior and PV module degradation modes.
- To investigate factors affecting the permeation behavior in the course of PV module degradation.

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