Characterization of Nearly Transparent Films for Use in Soiling Experiments

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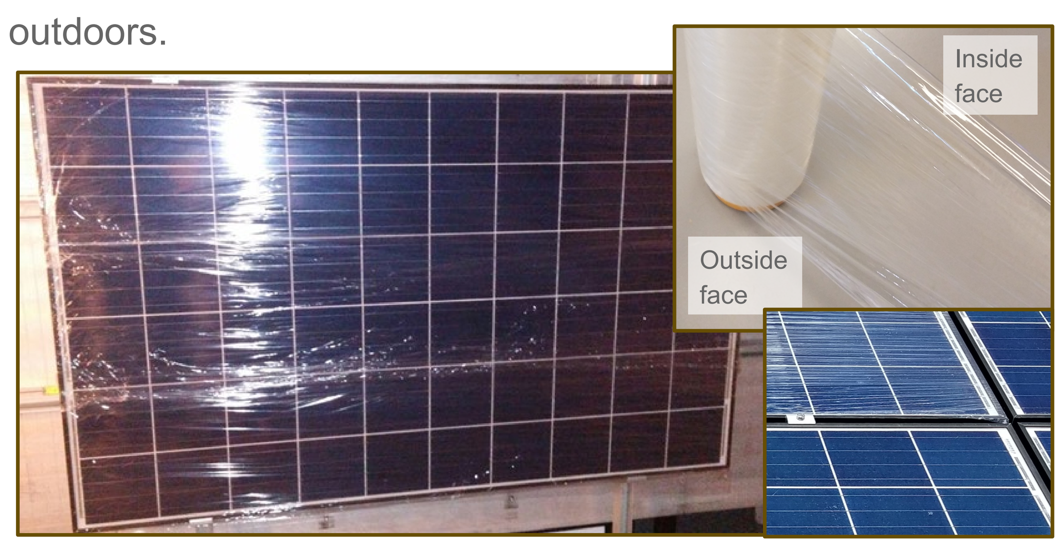
Introduction / Abstract

As the photovoltaics industry matures, the methods for monitoring and responding to power loss events is also maturing. For researchers to develop advanced algorithms to detect and notify plant owners of actual failures, and potential failures, reliable methods need to be developed to emulate field failures. This work discusses the characterization of two nearly transparent films for their potential use in PV modules soiling experiments. The objective of the work is to develop well characterized methods for inducing power loss due to soiling such that data sets can be generated and used to develop advanced algorithms for power loss detection, root cause analysis, and prognostic notifications.

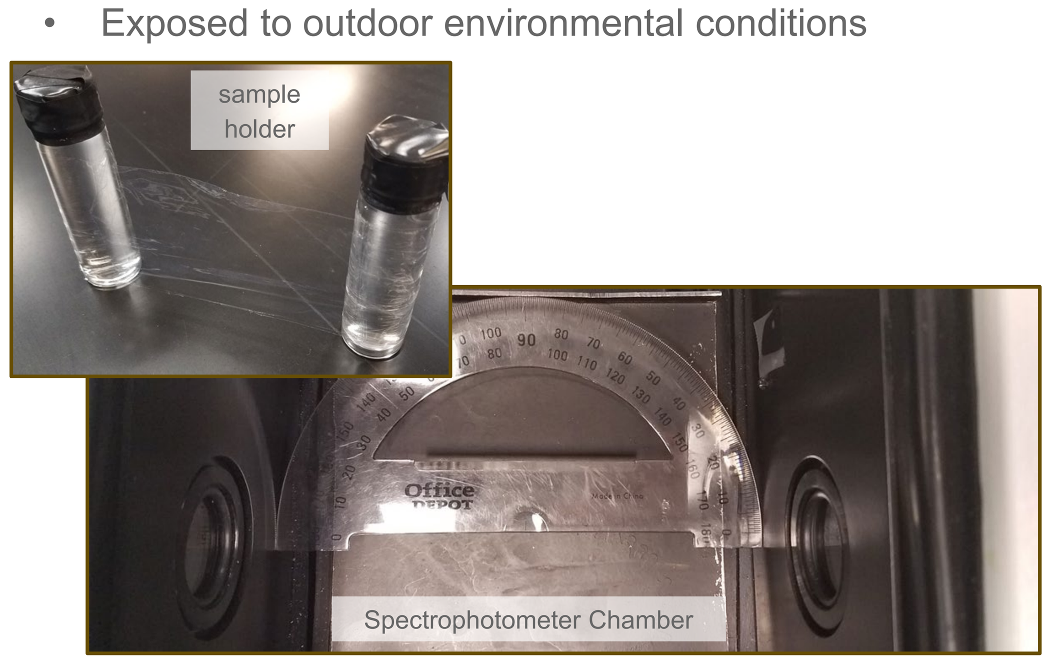
Goal: Characterize a linear low-density polyethylene film's optical transmission properties and its impact on PV module performance when covering a module's surface.

Methodology

- The linear low-density polyethylene film was tested to determine its influence on PV module performance when the material covered the front of a module both indoors and outdoors.



- The optical property, percent transmission (%T), was characterized for two film thicknesses, 39 μm and 65 μm.
  - Wavelength range 225 nm to 800 nm
  - Incident angles (IA) ±60° from normal
  - Exposed to outdoor environmental conditions



Experimental Results

- In this work, the Sinton FMT 350 was used for indoor flash testing to determine the PV performance of a module both uncovered and covered with a single and a double layer of the polymer film

One layer
- 7.7 % drop in Isc
  - 9.39 A to 8.67 A
- 8.1 % Power loss
  - 272 W to 250 W

Two layers
- 15.0 % drop in Isc
  - 9.39 A to 7.98 A
- 15.4 % Power loss
  - 272 W to 230 W

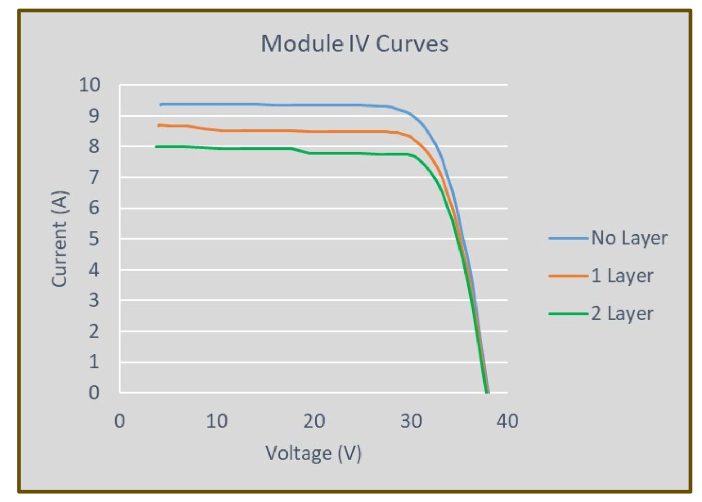


Figure 1. I-V curve from test module uncovered, single layer and double layer of polymer film

- The Shimadzu UV-2401PC IV-VIS recording spectrophotometer was used measure the percent transmission of the polymer film
  - 39 μm and 65 μm were tested
  - Outside face and Inside face were tested
  - Two exposures to outdoor conditions (UV:295 nm to 385 nm band kWh/m^2) were tested
    - 1st Exposure, September, 2018
      - 1.53 kWh/m2 (7 days, Cocoa, FL)
    - 2nd Exposure, September+, 2018
      - 4.65 kWh/m2 (33 days, Cocoa, FL)

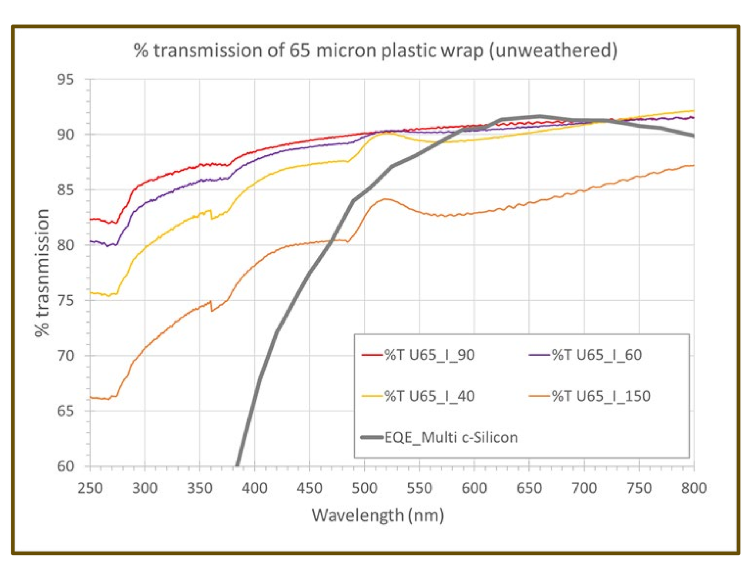


Figure 2. %T of 65 μm film, inside face, at different incident angles [90° = normal]

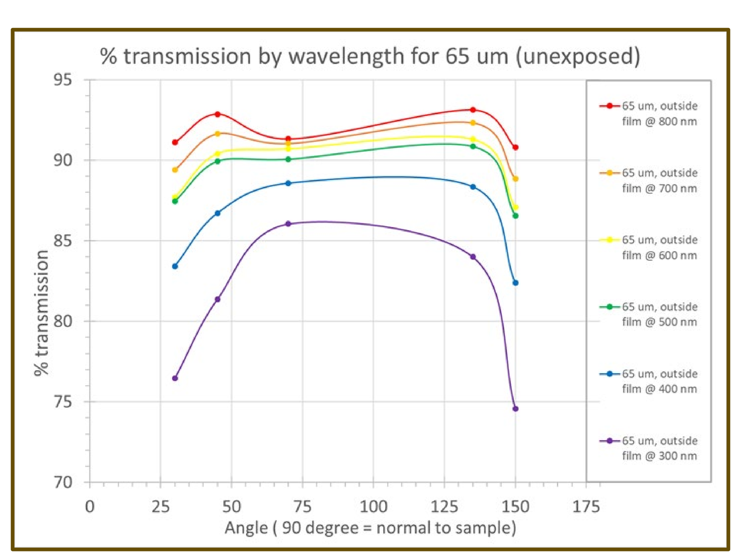


Figure 3. %T of 65 μm film, outside face, by incident angle (x-axis), and wavelength (family of curves)

Key Findings
- 65 μm slightly higher %T
- 65 μm less standing waves
- Outside face slightly higher %T prior to outdoor exposure
- Used Inside face for ease of application
- %T falls off < 400 nm
- %T falls of with outdoor exposure
  - No change after 1.53 kWh/m^2
  - % T is 4% less after 4.65 kWh/m^2

Experimental Results (cont.)

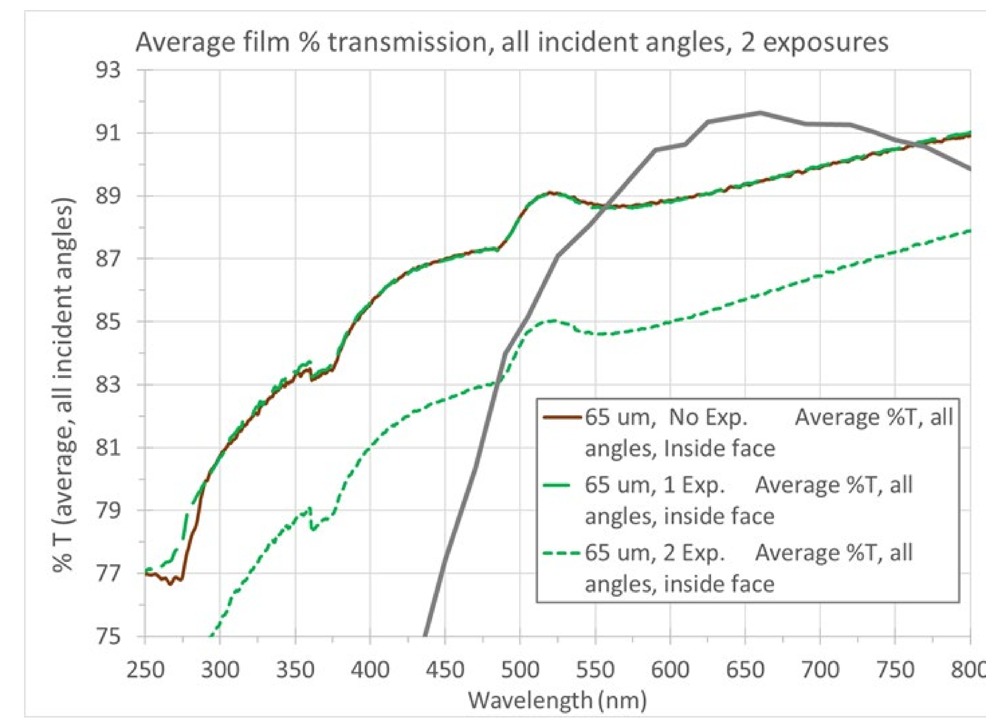


Figure 4. Average % T across all incident angles of films at different outdoor exposures.

- The outdoor field test of a grid tied PV system used the Pordis in situ I-V tracer to compare string and module parameters against standard modules and one module covered with the polymer film.

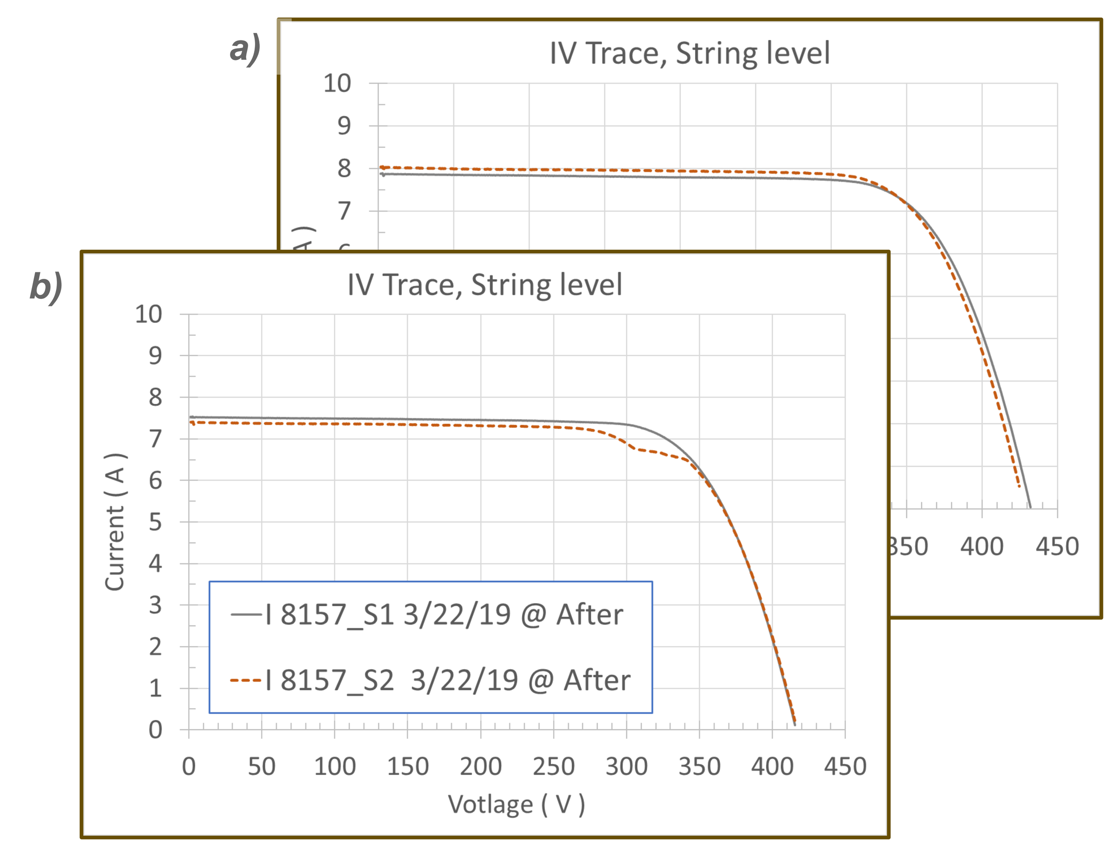


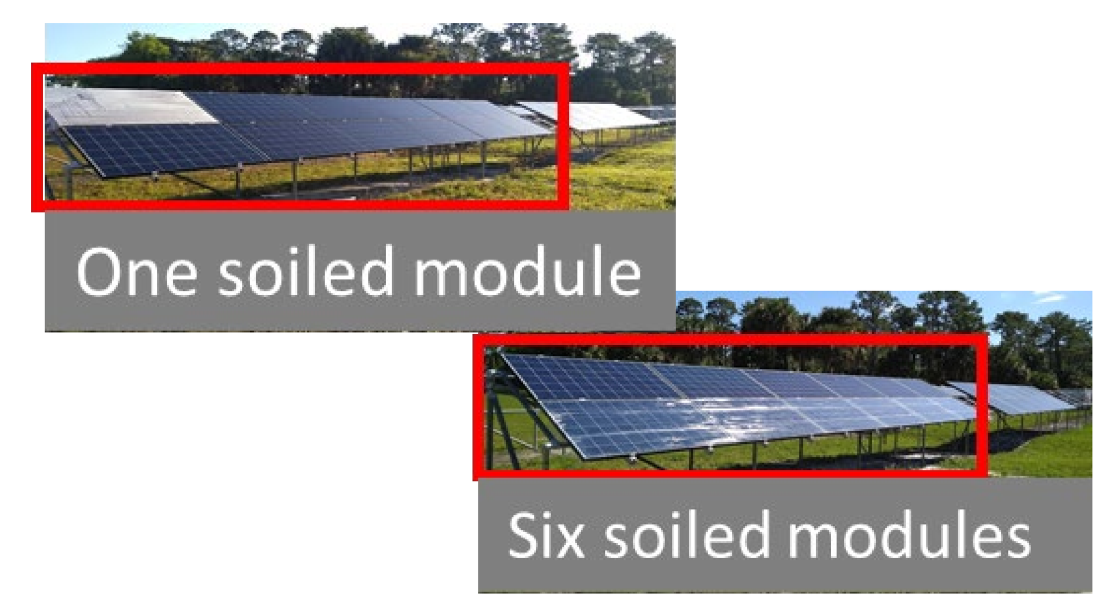
Figure 5. a) Strings 1 and 2 before module covered., b) Strings 1 and 2 after one module in String 2 was covered with film

Discussion

- A linear low-density polyethylene film was characterized to determine its effect on PV performance when the material covered a module. The characterization was done using and indoor solar simulator and outdoors in a grid-tie PV system with in situ I-V tracing capability.
- The polymer's reflective nature, observed in the image of the full module to the left, led to characterization of the films optical properties. Specifically investigating the % transmission over a wide range of incident angles. In addition the films susceptibility to degradation due to outdoor exposure was also tested.
- The results of the investigation indicates the film could be used to emulate soiling when accounting for time of day (IA) and duration the film was tested in the field (UV degradation).

Conclusions

- This work presented a study to determine if a linear low-density polyethylene film could be used to emulate soiling of PV modules.
- The results show that PV performance of PV modules decreased by ~ 8% when a module is covered with the film.
- The flexibility of the material makes is a cheap, fast, simple method to 'soil' any number of modules in a string or system. [1,500 linear feet = $18]
- The material can be used to generate data sets for developing advanced algorithms for power loss detection. However, due to the %T drop when the sun's incident angle > 40° , the data sets should be screened appropriately when used.
- The material's %T drops by 4% over a relatively short time period (30 days). This provides an opportunity to test power loss detection algorithms over brief time sequences while being exposed to a wide range of environmental conditions.
- The outdoor test of the material in a PV system produces the characteristic step in an I-V curve that indicates soiling.



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