

Chemical Engineering Thesis Defense

Accelerated UV Testing and Characterization
of PV Modules with UV-cut and UV-pass EVA

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abstract

Encapsulant is a key packaging component of photovoltaic (PV) modules, which protects the solar cell from physical, environmental and electrical damages. Ethylene-vinyl acetate (EVA) is one of the major encapsulant materials used in the PV industry. This work focuses on indoor accelerated ultraviolet (UV) stress testing to investigate the EVA discoloration and delamination in PV modules by using various non-destructive characterization techniques, including current-voltage (IV) measurements, UV fluorescence (UVf), colorimetry and reflectance measurements. Mini-modules with glass/EVA/cell/EVA/backsheet construction were fabricated with two types of EVA, UV-cut EVA (UVC) and UV-pass EVA (UVP). The accelerated UV testing was performed in a UV chamber equipped with UV lights at an ambient temperature of 50°C, no humidity and total UV dosage of 400 kWh/m². The mini-modules were maintained at three different temperatures by placing different thickness of thermal insulation sheets over the backsheet. The backsheet and laminate edges were covered with aluminum tape to prevent oxygen diffusion into the module and hence the photobleaching reaction. The characterization results showed that UVC modules suffered from discoloration while UVP modules suffered from delamination. UVf imaging technique identify discoloration in the UVC modules when the discoloration is not visible to the naked eyes, whereas I_{sc} measurement is unable to measure the performance loss until the color becomes visibly darker. YI also provides the direct evidence of yellowing in encapsulant. The extent of degradation due to discoloration increases with the increase in module temperature. The I_{sc} loss is dictated by both the regions – discolored area (cell center) and non-discolored area (cell edges), whereas the YI is only determined at the discolored region. This led to the limited correlation between I_{sc} and YI in UVC modules. In case of UVP modules, UV radiation has caused an adverse impact on the interfacial adhesion between the EVA and solar cell, which was detected from UVf images and severe I_{sc} loss. No change in YI confirms that the reason for I_{sc} loss is not due to yellowing but the delamination. Further, the activation energy of encapsulant discoloration was estimated by using Arrhenius model on two types of data, % I_{sc} drop and ΔYI .

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