Chemical Engineering Thesis Defense

Comparison of Encapsulant Degradation between Glass/Backsheet and Glass/Glass Field-aged Photovoltaic Modules

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abstract

EVA degradation is a matter of concern from a durability point of view. This work focuses on studying the EVA encapsulant degradation in glass/backsheet and glass/glass field-aged PV modules and eventually comparing them. Three field-aged modules (two glass/backsheet and one glass/glass modules) from three different manufacturers with EVA encapsulant were considered and EVA was extracted from the edges and the centers of a few cells selected and the non-cell region from each module based on the visual and UV Fluorescence (UVF) images. Characterization techniques such as I-V measurements, Colorimetry, Different Scanning Calorimetry (DSC), Thermogravimetric Analysis (TGA), Raman spectroscopy and Fourier Transform Infrared Spectroscopy (FTIR) were performed on EVA samples. UVF images gave the discoloration area in EVA. The intensity of the encapsulant discoloration (EVA browning) was quantified using colorimetric measurements. Module performance parameters like Isc and Pmax degradation rates were calculated from I-V measurements. Physical properties such as the degree of crystallinity, vinyl acetate content and degree of crosslinking were calculated from the DSC, TGA, and Raman measurements, respectively. Presence of polyenes responsible for the browning of EVA encapsulant was detected in FTIR spectra. The results obtained from the characterization techniques confirm that when EVA undergoes degradation due to long periods of exposure to UV radiation and high temperature, crosslinking in EVA increases beyond 90% which causes a decrease in the degree of crystallinity of EVA. Hence, there is an increase in vinyl acetate content. FTIR showed the presence of polyene functional groups in degraded EVA, thereby confirming the occurrence of Norrish II reaction. However, photobleaching occurs in glass/backsheet modules due to a presence of breathable backsheet whereas no photobleaching occurs in glass/glass modules because they are hermetically sealed. But, the yellowness index of EVA in glass/glass module (non-cell > cell edges > cell centers) is higher than that in glass/backsheet modules (cell centers > cell edges > non-cell). Also, the Isc and Pmax degradation rates are higher for glass/glass modules than glass/backsheet modules. Hence, eventhough EVA performs well in glass/backsheet modules, EVA is not an ideal choice of encapsulant for glass/glass modules.

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