POTENTIAL PROBLEMS WITH ETHYLENE-VINYL ACETATE FOR PHOTOVOLTAIC PACKAGING

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Abstract

Photovoltaic (PV) devices are typically encapsulated using ethylene-vinyl acetate (EVA) to provide mechanical support, electrical isolation, optical coupling, and protection against environmental exposure. Under exposure to atmospheric water and/or ultraviolet radiation, EVA will decompose to produce acetic acid, lowering the pH and increasing the surface corrosion rates of embedded devices. Even though acetic acid is produced at a very slow rate it may not take much to catalyze reactions that lead to rapid module deterioration. Another consideration is that the glass transition of EVA, as measured using dynamic mechanical analysis, begins at temperatures of about -15°C. Temperatures lower than this can be reached for extended periods of time in some climates. Due to increased moduli below the glass transition temperature, a module may be more vulnerable to damage if a mechanical load is applied by snow or wind at low temperatures. Modules using EVA should not be rated for use at such low temperatures without additional low-temperature mechanical testing beyond the scope of UL 1703.

Materials and Methods

(1) EVA was obtained from a commercial source and was well formulated for use in photovoltaic applications.
(2) EVA acetic acid formation was evaluated by collecting the effused gases from the thermal decomposition of EVA using a heating apparatus and an ion chromatograph (IC) vial that contained a weighed amount of 4.8-M KOH. This collection solution was tested using IC analysis to determine the acetic acid formation rate.
(3) Aluminum mirrors were produced in the sputtering chamber of a Perkin-Elmer multichamber vacuum deposition system. The final Al thickness was approximately 800±25 Å.
(4) Dynamic mechanical analysis was performed on a TA Instruments Aerothermometer using a rectangular torsional testing fixture.
(5) A TA Instruments DSC Q1000 was used for differential scanning calorimetry (DSC).

EVA Decomposes to Produce Acetic Acid

Acetic acid has a pKa of 4.76 so it will tend to buffer solutions to pH~4.76 corresponding to a hydronium ion concentration of 1.74×10^-10 mol/L. As an order of magnitude estimate of the time necessary to reach pH~4.76, we extrapolated down to 27°C where EVA will produce 3.31×10^-10 mol/L acetic acid. Assume that the ratio of acetic acid to water in the polymer is the same as would be found for a solution in equilibrium with the polymer. This assumption provides a relationship between the chemical potential of the acetic acid in the polymer as compared to an aqueous solution. At 27°C EVA has at most 0.00223 10^-12 gAcid/gEVA/min and assume that the ratio of acetic acid to water is very detrimental.

Acetic acid, lowering the pH and increasing the surface corrosion rates of embedded devices. Even though acetic acid is produced at a very slow rate it may not take much to catalyze reactions that lead to rapid module deterioration.

EVA Produces Acidic Environments in Non-Breathable Packaging

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Alternative Encapsulants Reduce Rather than Accelerate Corrosion

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Conclusions

(1) During exposure to water and/or UV radiation EVA will decompose to produce acetic acid, thereby lowering the pH and generally increasing surface corrosion rates.
(2) Thin film PV technologies are more likely to be sensitive to acetic acid induced corrosion than are crystalline wafer based technologies.
(3) EVA goes through a Tg beginning at about -15°C, making its use at lower temperatures a significant concern.
(4) Without low temperature mechanical testing, a temperature rating of -15°C may be appropriate for modules constructed using EVA.