Encapsulant Materials Manufacturing Research

Springborn Materials Science Corporation is participating in Phase 3A of PVMaT.

PVMaT is a 5-year, cost-shared partnership between the U.S. Department of Energy and the U.S. PV industry to improve the worldwide competitiveness of U.S. commercial PV manufacturing.

PVMaT Fact Sheet

Photovoltaic Manufacturing Technology

Springborn Laboratories

Goals

The goals of Springborn Laboratories under the PVMaT Phase 3A Project are to (1) pursue the advanced development of a PV module encapsulation sheet, (2) reformulate the presently used elastomer based on ethylene vinyl acetate (EVA), and (3) reformulate, as needed, alternative elastomer-based encapsulants that more effectively resist discoloration and degradation when exposed to high temperature and ultraviolet (UV) solar radiation in the field.

Yellowing or browning of some EVA-based encapsulants has occurred at several installations worldwide, where both temperature and UV radiation are comparatively high. This deterioration, though not widespread, concerns many PV module manufacturers, utilities, and other end-users. A successful end of this multi-year development program will result in enhanced encapsulation systems, which will permit module lifetimes of 20 to 30 years, even under the extreme high temperature and sunlight conditions similar to those of the southwestern United States. Improved and stabilized PV module encapsulant sheets, whether based on EVA or an alternative polymer, will have processing and laminating properties similar to the present A9918P or 15295P grades. Optical properties and price will also be comparable.

Technology

EVA and other polymers serve as encapsulants in PV modules to bond and protect the structures that comprise the modules. Springborn is a primary supplier of the polymer encapsulants used in PV manufacturing. In field experience under conditions of high temperature and intense sunlight, certain EVA formulations have yellowed. Springborn is researching the mechanisms of yellowing and methods to combat this effect.

Scope of the Program

Under Phase 3A of PVMaT, Springborn is addressing five primary areas:

- A literature search and study of case histories in the field to better understand the yellowing process
- A comparative study of accelerated UV aging to better define the factors contributing to EVA yellowing
- Analytical studies to define the chemical mechanisms of discoloration
- Reformulating the EVA encapsulation system, formulating alternative elastomer-based encapsulant systems as needed, and producing pilot-scale test quantities of improved materials
- Field-testing improved encapsulation systems in full-sized modules at Arizona Public Service's STAR facility in Tempe, Arizona.

In this development program, Springborn has teamed with Global Photovoltaic Specialists, Inc.; Photocomm, Inc.; Siemens Solar Industries; Solarex Corporation; Solec International, Inc.; United Solar Systems Corporation; Utility Power Group, Inc.; ASE Americas, Inc.; AstroPower Inc.; the Institute of Materials Science at the University of Connecticut; Arizona State University; and Arizona Public Service Company.

Results

During the second year of the contract, a study of encapsulant composition and its effect on aging mechanisms indicated that

- Standard-cure A9918P laminated between low-iron glass yellowed significantly after 17 weeks in a xenon-arc Weather-Ometer (W-O).
- For laminates prepared using A9918P with no Lupersol™ 101 crosslinker, and exposed in the W-O for 10 weeks, yellowness was reduced by two-thirds, implicating Lupersol™ 101 in the discoloration process.

- Other W-O studies using A9918P with various combinations of additives provided strong evidence that discoloration arises primarily from stabilizers and their interaction with Lupersol™ 101 rather than from EVA resin itself.

Instrumental analysis also suggests that additive interactions are a key step in the yellowing mechanism. Development work during Phase 3 has focused mainly on interrupting this step and has yielded three stabilization strategies.

New EVA-based encapsulants— three "standard-cure" (X9903P, X9923P, and X9933P) and one "fast-cure" type (X15303P).

After 40 weeks in the W-O, laminates of these four types with Starphire™, a low-iron glass highly transparent to UV-B light, had Yellowness Indexes of only 2.0 to 4.9. Color does not become visible until a Yellowness Index of about 10.

For added protection, a cerium-oxide-containing glass superstrate, either Solatex II™ or Solarphire™ can be used. Glass should contain sufficient cerium oxide to provide a lower-end cutoff of light transmission of about 325 nanometers.

These new grades use the same EVA as in A9918P and 15295P, laminate and cure under the same conditions as A9918P and 15295P, and are comparable in cost.

Cerium-oxide-containing glass— especially with "fast-cure" 15295P. After 30 weeks in the W-O, samples with cerium-containing glass had a Yellowness Index of 5.2, undetectable color by eye, and after 1 year, a 13 Index. But after the same exposure, 15295P samples with Starphire™ glass had an Index of 87. Also, 82 weeks (19 months) of EMMA (Equatorial Mount with Mirrors for Acceleration) outdoor exposure in Phoenix resulted in almost no color for samples with cerium glass, versus a 7.2 Index with Solite™ glass and 37.1 when combined with A9918P. Yellowness Indexes of 30 to 80 visually range from medium yellow to dark brown.

Tefzel™ cover film in place of glass— After 60 weeks of W-O exposure, a Tefzel/A9918P/glass laminate had a Yellowness Index of 2.0, which is undetectable by eye, whereas 82 weeks (19 months) of EMMA gave no measurable yellowing.

These new materials are now being fabricated into modules and "mini-modules" for additional testing.

Company Profile

Springborn Laboratories, Inc., along with its wholly owned subsidiaries, provides services to more than 6000 sponsors worldwide. These services include high-quality contract materials research, development, and engineering; specialty manufacturing of polymeric materials and components, including PV encapsulants; testing and inspecting for the qualification of materials; and quality assurance testing of electrical components, textiles, and apparel.

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