Plastics Compounding Platform for Reliable and Dedicated Packaging Materials for PV Modules

H.-Y. Li, J. Escarré, G. Cattaneo, U. Fuerholz, C. Ballif, L.-E. Perret-Aebi

The compounding platform at CSEM has been expanded to better serve the needs for developing resistant and customized packaging materials for PV modules encapsulation. At the moment, cast film with width up to 20 cm can be extruded with capacity of 10 kg/h. Several ongoing projects have been benefitting from the platform and obtaining key R&D results. The expanded platform further strengthens the competitiveness of CSEM as a major R&D partner in the field of PV module technology.

The reliability of PV modules is critical for the further reduction of the levelized cost of PV electricity. A typical PV module mainly consists of front cover, stringed cells and back cover. For the structural integrity, those components are bonded with two layers of adhesive film, commonly referred as the encapsulant. These thin encapsulants, normally 0.4-0.5 mm thick, bare multiple important functionalities within the module, like the mechanical bonding, optical in-coupling, UV blocking, water/oxygen barrier, etc. Moreover, its stability under the combinational effects of light, heat and moisture has a significant impact on the reliability of the PV modules [1]. The mostly used encapsulant in the past decades has been based on poly (ethylene-vinyl acetate) (EVA). It has been observed that EVA encapsulants of various grades from different manufacturers exhibit distinct outdoor reliability. The composition of the EVA base resins used therein is often similar with 26-32% of Vinyl Acetate. The key factor causing the different reliability is the formulation. This is also true for the polyolefin (PO)-based encapsulant, which is considered as a major alternative to EVA.

Figure 1: The compounding platform in CSEM. a) Extruder; b) Flat film line; c) Compounder; d) Pelletizer.

In the past year, CSEM has expanded the infrastructure available in the plastics compounding platform, to meet the growing needs of various projects on performing and customized PV packaging materials. Now the platform includes mainly the following facilities (see Figure 1):

- Dr.COLLIN TEACH-LINE twin-screw compounder ZK 25 x 24 L/D. Its max. throughput is 4.0 kg/h.
- Dr.COLLIN lab strand pelletizer
- Dr.COLLIN single-screw extruder 25 mm Φ x 25 D, Type E 25E. Its max. throughput is 10 kg/h.
- Dr. COLLIN flat film line consists of Chill roll with width of 350 mm, 2 flat-film die slot with width of 200 mm, winder and tempering unit.
- Chemical analysis facility (e.g. DMDR, DSC, FTIR, GC/LC-MS, Raman, GPC, NMR,…), partly in collaboration with external partners
- Extensive accelerating lifetime testing facilities: climate chambers for damp heat, thermal cycling, humidity freeze, UV+ damp heat; UV chamber; Ovens; highly accelerated damp heat testing setup (high-pressure cooker test).

With the expanded infrastructure, the platform can extrude packaging foil of 0.1 to 2.5 mm thick with the maximum width of 20 cm and maximum throughput of 10 kg/h. The platform has been supporting a few projects (internal, industrial and CTI). The highlights of the R&D results are listed here:

- EVA and TPO-based encapsulant with red-shifted UV absorption have been developed. The cut-off wavelength can be adjusted from 350 to 400 nm. The conventional approach with cut off at 400 nm results in slight yellowing. With the innovative approach, the yellowness is reduced.
- A technique has been developed and tested extensively to fine-tune the viscoelastic properties of the EVA or PO base material during the module lamination cycle. This approach is shown to be capable of producing EVA/PO-based packaging materials with customized processabilities to meet the specific needs of the novel module design or module lamination process.
- Conventional white EVA reflects rather uniformly in the UV, visible and near IR. By adjusting the formulation, a white EVA encapsulant with improved transmittance in the NIR range has been developed.
- For a specific project, a PO-based packaging material with improved adhesion to the surface of metal and Si solar cell is developed. The adhesion to the studied surface is enhanced by at least 3 times compared to the reference solution.

Besides the highlights above, progress has been made on developing EVA/PO-based PV encapsulant with superior environmental reliability to the commercial competitors. This will serve as the base for the further development of customized packaging materials.

---

[1] H.-Y. Li, "Open the black box: understanding the encapsulation process of photovoltaic modules", Ph.D dissertation, EPFL (2013).