Fraunhofer Testing Results

Goal of the SUMMIT project, which is part of the EU 7th Framework program, is to develop a novel photovoltaic module (PV-Module). The aim is to combine thin and frameless PV-laminates with a light and cost-efficient rack-system. The conventional metal frame will be replaced by thermoplastic composite solutions. With its long-standing experience in process and material development for thermoplastics, Fraunhofer ICT contributes its know-how for reaching the goal.
Due to environmental factors, testing and safety regulations, materials used in the PV-sector must fulfill a number of requirements. Examples are sufficient UV-, ozone and weather resistance as well as a high degree of flame-retardancy. An appropriate material selection is essential to fulfill the complex requirement profile. For this reason Fraunhofer ICT's main focus at the start of the project is on material selection and material characterization.
Based on first preliminary work long-fiber glass fiber reinforced polypropylene was chosen as base material. The material selection comprised three different PP-based long-fiber pellets, four different PP-based flame retardants, one PP-based color masterbatch as well as three ready-to-use short-fiber reinforced compounds. With the goal to determine possible effects of the different raw materials (long-fiber granulate, flame retardants and color masterbatches) on the mechanical characteristics (tensile, bending and charpy impact testing) and ignition resistance, seven material combinations were investigated. Together with the three short-fiber compounds a total number of ten material combinations were characterized.
The material characterization was mainly focused on determining the mechanical properties and the classification of the ignition resistance according to fire protection standard UL94. Furthermore, the impact of accelerated ageing (heat storage) on the mechanics and the ignition resistance was analyzed for an initial estimation of the long-time-behavior of the materials. Both the production of the injected molded standard specimens as well as the material testing were done at Fraunhofer ICT.

In the following the main results of the first material characterization are listed and explained in a brief summary:

Mechanical Properties:

The material parameters of the tensile, bending and charpy impact tests show that long-glass fiber reinforced PP composites are preferred for this application because the mechanical results for the seven material combinations based on different long-fiber pellets are significantly superior and show high potential to fulfill mechanical requirements. Depending on the testing procedure, the determined parameters show a relatively consistent property level. This allows the following conclusions:

- The tested long-fiber pellet materials show comparable mechanical properties.
- The various halogen-free flame retardants show no significant impact on the mechanical properties.
- No relation between the mechanical properties and the one color masterbatch used could be established.
- The three short-fiber compounds were found to be less suitable for the use in the PV-module design.

UL94 flammability tests:

The ignition resistance (UL94-classification) is significantly influenced by the material thickness. Therefore the UL94 flammability tests were conducted with different test specimens with a thickness of 1.6 mm and 3.0 mm.
The UL94 flammability tests lead to the conclusion that, although promising material variants were identified, further investigations and optimizations steps are required before a material recipe can be finalized for a thickness of 1,6 mm.
For the UL94 flammability tests of the thick specimens (3 mm) an improved fire behavior was observed for all material combinations. However, the UL94 "V0" classification, the best possible "vertical burning" classification according to UL94, were fulfilled by four material combinations. Figure 1 shows two examples for the UL94 flammability tests of the 3 mm thick test specimens for no classification (left) and for the "V0" classification (right). A comparison of both images clearly underlines the different effects of the various flame retardant additives.

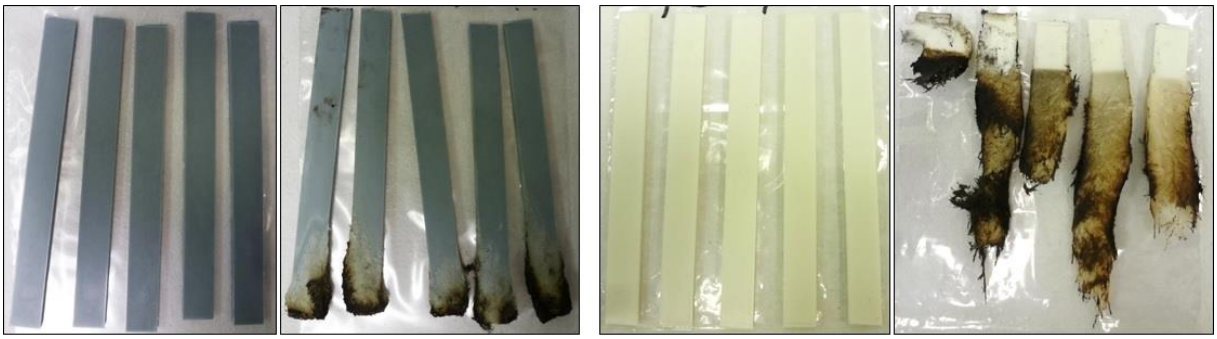

Figure 1: 3 mm thick test specimens before and after the UL94 testing, no classification (left) and "V0" classification (right)

With a specimen thickness of 3mm sufficient flame retardancy was achieved for a selection of the used flame retardants.

Heat storage (accelerated aging):

Figure 2 shows the tensile test specimens for the ten material combinations in an unaged state (Figure 2 left) and in an aged state (Figure 2 right). Accelerated thermal aging was performed for 1000 hours at 150°C. For all aged samples, a partially distinct color change can be observed, particularly for test specimen T7. According to the manufacturer of the flame retardant used in trial T7, the discoloration is due to the fact that the flame retardant already begins to react at 150 °C. The discoloration of the other samples is therefore also attributed to the use of flame retardants. Through the use of the color masterbatch in trial T6, the discoloration after the accelerated thermal aging step is not so clearly recognizable.

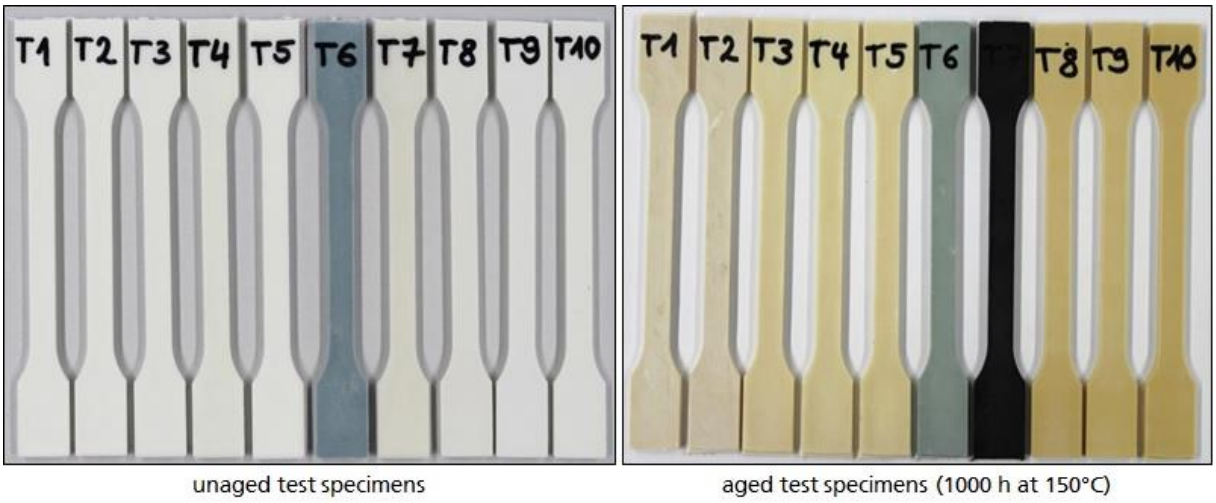

Figure 2: tensile test specimens in unaged (left) and aged state (right)

The accelerated thermal aging showed a minor influence on mechanical properties. Properties of aged specimens are mainly within the standard deviation of the unaged specimens' properties.
Based on the results of the flammability tests of aged specimens, the impact of thermal ageing on the ignition resistance depends on the used flame retardants. For one material combination the ageing resulted in a loss of the ignition resistance in accordance with UL94 "V0" classification. This underlines the necessity of aging tests to judge the long-term ignition resistance of the materials.

In conclusion, through this first material characterization it was possible to create a solid basis for further studies. Based on the previous results, the further investigations will primarily focus on the flame retardants' properties. Likewise, further investigations need to be performed in the field of material aging.