



For the radiator grill of the Audi A1 Sportback, a PP compound has been developed, which meets the robust requirements for exterior components (© LyondellBasell)

Like Modern Ship Figureheads

Polypropylene Replaces Acrylonitrile-Styrene-Acrylic Ester and UV-Resistant Paint for Exterior Applications

UV- and weathering-resistant components with a high-quality surface straight from the machine without post-finishing are in demand for automotive exterior applications. This combination of properties is only possible with targeted compound developments, as the example of a radiator grill demonstrates.

For a long time now, the radiator grill has ceased to serve just for protection against stones and road dirt or to cool the engine. Rather, the front radiator grill is the first thing to make an impression on modern motor vehicles and has thus become an esthetic decorative element like a ship figurehead. This exterior component must integrate air-intake, aerodynamic, protective, and esthetic functions and is therefore a prime candidate for the advanced use of plastics. Color, form, and function should, if possible, be achieved in one shot and the finished component

delivered straight from the machine without post-finishing steps.

To produce radiator grills for the Audi A1 Sportback model from automotive manufacturer Audi AG, Ingolstadt, Germany, alternative materials to the previously used plastics acrylonitrile-styrene-acrylic ester (ASA) or a blend of polycarbonate (PC) and polyethylene terephthalate (PC+PET) were sought (**Title figure**). The aim was to produce finished radiator grills straight from the injection mold. LyondellBasell, Frankfurt/Main, Germany, took on the project and developed a material

for radiator grills consisting of polypropylene with 20 % glass fiber reinforcement.

UV Protection without Post-Coating

The greatest challenge with components of this type is to combine sufficient UV stability of the uncoated plastic with high mechanical properties such as impact strength and elongation at break in the alternating climate test (Audi internal test specification). The approved material currently used, PC+PET, fulfills the specified mechanical criteria of the Audi test proto-

col but is not sufficiently UV-resistant. For this reason, additional painting of the component is required. This post-finishing step will be rendered unnecessary by the new development. The deteriorating appearance of the grained PC+PET variant with increasing service life will also be improved.

The following requirement profile was specified for the radiator grill material:

- Good surface quality,
- matt with high scratch and mar resistance in the basic version,
- balanced impact resistance/strength ratio,
- very good UV, weathering, and heat aging resistance,
- if possible, no visible weld lines, and good injection moldability.

On the basis of this profile, the polypropylene (PP) compound, Softell, from LyondellBasell was selected. Softell had already been used previously in a variety of serially produced interior applications such as door trim, covers, dashboards, etc. Since this material had not been used for exterior applications before, there was no information available on its weathering stability.

Combination of Requirements Fulfilled with Polypropylene

On the basis of this requirement profile, the grade Softell TKG2148P, a 20% glass fiber-reinforced PP compound, was developed in collaboration with Audi. This compound is based on a special copolymer produced by LyondellBasell's advanced Catalloy process. Catalloy polymers have a special polymer matrix that combines properties such as low gloss, soft-touch surface (for interior applications), and high impact strength at low temperatures (**Fig. 1**).

The PP compound based on this copolymer enables components with a matt finish to be produced. It also has very good mar and scratch resistance compared to PP/talc compounds. In addition, Softell TKG2148P exhibits lower warpage in sample plaques, which has been confirmed in tests on the radiator grill component.

This PP compound also shows balanced stiffness/toughness behavior. This is important for the application to prevent component fracture in a pendulum impact test conducted at low tempera-

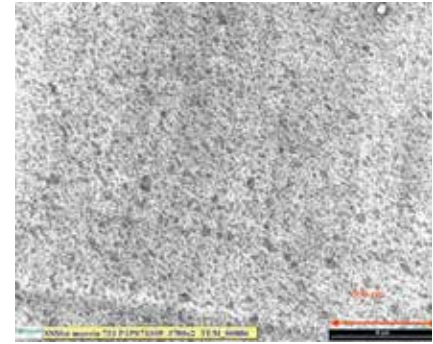
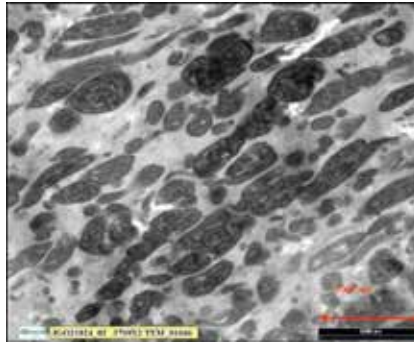


Fig. 1. A classic compound consisting of PP and impact modifier (left) and the Softell product with finely dispersed rubber (right) (© LyondellBasell)

ture on a vehicle-mounted component (Audi internal test method).

The requirement profile (mechanical properties) for the material being developed was agreed in consultation with Audi. **Table 1** shows the typical mechanical properties of Softell TKG2148P. In addition, the material was easyflow-modified for good processability to ensure smooth filling of the complex Audi A1 Sportback radiator grill. As a result, the molds can be of "simpler" design than for ASA. Unlike for ASA, intensive predrying of the material is not necessary. The material was stabilized against thermooxidative degradation in accordance with Audi specifications and colored in the required shade.

Trials in a Production Mold

The material was first compared with various other materials in an earlier production mold for the Audi A4 grill that had been used for models up to 2007. In the initial trials, encouraging component results were obtained with Softell TKG2148P

in terms of surface quality, warpage, and strength. The material's high scratch resistance in grained areas was also highly promising.

To test weathering resistance, specimens from the 2007 production mold were subjected to three cycles of standard tests PV3929 and PV3930. The results were positive and formed the basis for further tests. After weathering, PP glass fiber compounds normally show exposed glass fibers on the surface and severe graying. The tested specimens did not exhibit this, which can be attributed to the special polymer matrix in combination with the very effective UV stabilization. On the basis of the positive light aging test, Audi decided to build a near-production-quality prototype mold. This had to embody the future production mold design in order to provide as realistic results as possible.

Trial samples were produced in this mold from Softell and other plastics. The very high-quality appearance of the Softell samples impressed the Audi quality control team right from the out- »

Typical properties	Conditions	Result	Test standard
Melt index	230 °C, 2.16 kg	18 g/10 min	ISO 1133-1
Density	23 °C	1.06 g/cm ³	ISO 1183-1/A
Flexural strength	23 °C	2650 MPa	ISO 178/A1
Tensile modulus	23 °C	2550 MPa	ISO 527-1, -2
Tensile elongation at break	23 °C	12 %	ISO 527-1, -2
Charpy notched impact strength	23 °C	32 kJ/m ²	ISO 179-1/1eA
	-30 °C	9 kJ/m ²	ISO 179-1/1eA
Deflection under load, unannealed (0.45 MPa)		142 °C	ISO 75B-1, -2

Table 1. Property profile of the 20% glass fiber-reinforced PP compound, Softell TKG 2148P, which has been specially developed for Audi (© LyondellBasell)

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Service

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set. There were virtually no visible surface defects such as weld lines, etc. Further components were sent to specialist departments for testing, e.g. of mechanical properties. Tests included the long-term vibration/climatic test, alternating temperature test, and pendulum impact test.

The long-term vibration/climatic test simulates vibration of the vehicle front section over a defined, extended period of exposure to temperatures alternated at specified intervals between desert-like and North Pole extremes. Under such conditions, the bumper, including the radiator grill, must maintain its position within the tolerances. In the pendulum impact test, an impact is simulated with a defined ball and a given speed. Splintering of component parts is not permitted in this test and the vehicle should not be restricted in its function. These three tests, alongside various pull-off and other tests, are the most important and strictest tests for component release by technical development. The PP/glass fiber compound Softell TKG 2148P has successfully passed all the tests.

Conclusion

The Audi model committee (representatives from development, quality control, procurement, production, and project

management) therefore decided to use the material for subsequent serial production of an unpainted radiator grill. The knowledge obtained on mold design and the injection molding process was utilized for the subsequent serial production mold and shared with the supplier of the radiator grill. Through the intensive and close cooperation between Audi and the component and material suppliers, the project was successfully implemented in serial production.

Besides technical support from Audi and LyondellBasell, a material card for Softell TKG 2148P was prepared by LyondellBasell for CAE simulations. This was made available to serial suppliers and the Audi AG "Component Feasibility Influencing" ("Fertigungsgerechte Bauteilebeeinflussung") for evaluations (warping, rheology).

This successful development shows that with the PP/glass fiber compound Softell TKG 2148P, high-quality, unpainted radiator grills can be produced that meet the mechanical property requirements of Audi Quality Control. In addition, the system makes a contribution to sustainability, since it eliminates a previously necessary painting step. A further possible application could be the lower grill in the bumper of the Q8 vehicle. Other projects with Audi and tier 1 suppliers are in progress. ■