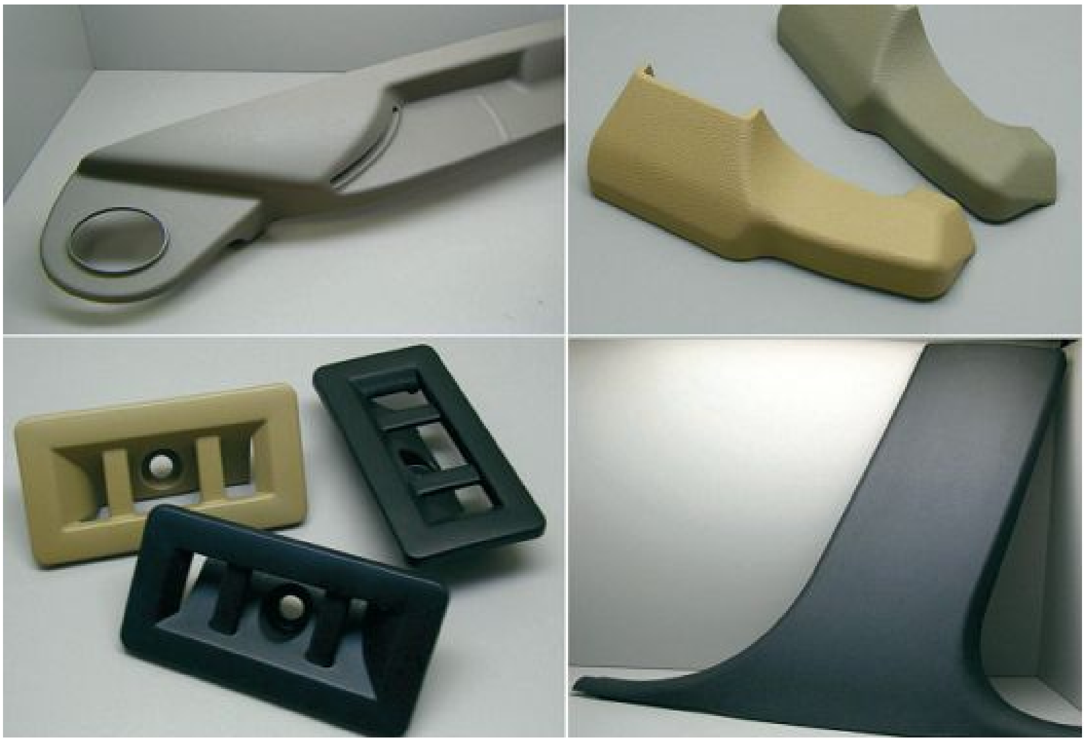

PP/PS Blends. Nano additives permit the manufacture of blends from polymers that were hitherto incompatible. A new PP/PS blend, for example, features excellent stability during processing thanks to the addition of specially processed nanoclays. Such blends have already proved themselves in the manufacture of moulded parts for vehicle interior fittings and trim.

Improved Compatibility

JOACHIM GROSSMANN
PETER PUTSCH

The market for blends produced from a variety of polymers has been manifesting an above-average growth since the beginning of the 1970s [1] and the trend is still upward. The decisive factors for the use of blends are their improved processing characteristics and/or improved functional properties, while often contributing to a reduction in the overall manufacturing costs of the end product as well. However, the choice of polymers that are suitable for the production of blends is limited, as most polymers are not readily compatible with one another [1].

Adopting an absolutely new approach, the firms of Süd-Chemie AG, Moosburg/Germany, and Putsch Kunststoffe GmbH, Nuremberg/Germany, have succeeded in producing a blend from polypropylene (PP) and polystyrene (PS). In this application, which has not been dealt with hitherto in relevant literature (c.f. [1 to 3], for example), nano additives are used for improving the compatibility of different polymers, thus preventing the process of separation that has often occurred in certain blends hitherto.

The starting points for this development were the increasingly stringent demands made by the automotive industry on the polymers used for vehicle interiors. Compared with PP or talc-filled PP, the new generation of materials was to display better scratch resistance and a uniformly matte surface with good tactile properties. Another requirement was the waiving of a subsequent paint finishing process as used in the case of interior parts made of acrylonitrile-butadiene-styrene copolymer (ABS) without any loss of tactile and visual appeal. Accompanied by countless practical trials, the three years' intensive development work jointly undertaken by these two companies ultimately led – in two stages – to the desired success.

Nano Additives Rendered Compatible with PP

In most cases, the starting material for the production of nano additives intended for the improvement of polymers is bentonite. This high-quality clay mineral consists of 60 to 95 % montmorillonite, a sil-

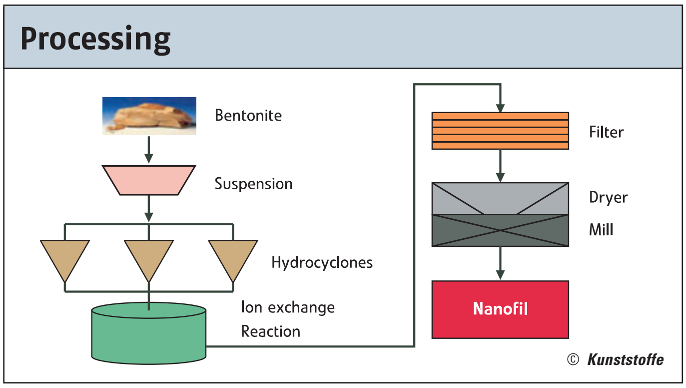

Fig. 1. Flow chart of the nano additive production process (source: Süd-Chemie)

icate mineral featuring a marked lamellar structure. In a chemical process (Fig. 1), the spaces between the silicate layers are increased to around 1.5 and 4 nm (intercalation) through the addition of 20 to 40 % water repellent, thus achieving good compatibility with hydrophobic polymers [3]. In their delaminated state, the type Nanofil nano additives thus obtained possess a pronounced platelet structure measuring 1 nm in thickness and 100 to 500 nm in diameter (by comparison: typical measurements with conventional lamellar fillers, such as kaolin and talc, are in the region of 500 nm in thickness and approx. 5000 nm in diameter).

By modifying and optimising the substances used in the intercalating process, Süd-Chemie has succeeded in developing a new generation of nano additives, for which patents have been applied for. One of these nano additives, type Nanofil SE 3000, can even be incorporated in polypropylene without the use of compatibilisers – and it is precisely this property which permits the manufacture of PP/PS blends. Because of its relatively high apparent density of 450 g/dm^3, this nano additive is suitable for use with conventional gravimetric feed systems. Special ancillary equipment such as stuffing units are not necessary. Moreover, the Nanofil products have an average particle size of 6 to 8 µm, which has proved to be particularly favourable when compounded in polymers for a diversity of applications [3].

Compounding with Adapted Parameters

For the manufacture of the newly developed blends from PP and PS, for which patents have likewise been applied, Putsch uses a co-rotating twin screw extruder (manufacturer: Leistritz Extrusionstechnik GmbH, Nuremberg). The starting materials for the compounding process – these are, for typical applications, 65 to 75 % PP, 15 to 25 % PS and 5 % Nanofil SE 3000 – are fed to the feed section of the twin screw extruder gravimetrically.

The extruder screws must ensure thorough dispersion of all components of the blend, and not least a complete distribution of the nano additives within the melt. For this process, which is termed exfoliation, the extruder screws are constructed from modular mixing and non-return sections which are optimised for medium to high shear. The processing parameters are fully adapted to the compounding requirements of the blend components.

After exfoliation, the Nanofil particles are almost totally separated into individual nano layers, each one completely surrounded by the polymer matrix. Not only is the resultant specific surface area of the nano additive extremely large – approximately 700 m^2/g – but the PS is finely and uniformly distributed within the PP matrix, as the TEM image (Fig. 2) shows. Within the blend, the exfoliated nano particles tend to gather at the interfaces between the polypropylene and the polystyrene. It is precisely this behaviour which, for reasons yet to be explained scientifically, seems to render PP and PS compatible.

Of these new PP/PS blends, Putsch currently produces three types – Elan XP 515, Elan XP 416 and Elan XP 422 – for industrial applications and on an industrial scale. They are distinguished primarily by their rigidity and their Izod low-temperature impact strength at -20 °C (Table 1). The compounds display excellent stability during processing and do not show any signs of delamination when subjected to mechanical stress. Compared with parts moulded in PP or talc-filled PP, parts moulded in these PP/PS blends

i Manufacturer

Süd-Chemie AG
Ostenriederstr. 15
D-85368 Moosburg
Germany
Phone +49 (0) 87 61/82-369
Fax +49 (0) 87 61/82-713
E-mail : plastic-additives@sud-chemie.com
www.sud-chemie.com

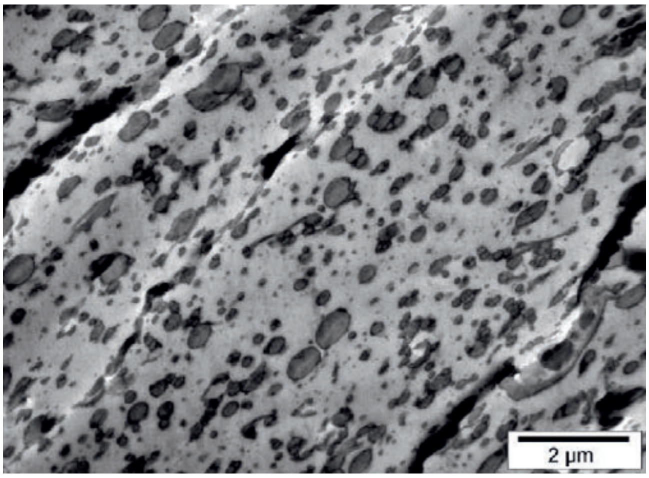

Fig. 2. This TEM image shows the fine, homogeneous distribution of the polystyrene components in the polypropylene matrix achievable with the nano additive for the PP/PS blend (source: University of Bayreuth/Germany)

Property		Elan XP 515	Elan XP 416	Elan XP 422
Density	g/cm^2	0.95	0.95	0.95
Melt flow index MFI 230 °C/2.16 kg	g/10min	10	10	10
Mechanical properties				
Tensile strength	MPa	20	27	26
Tear strength	MPa	18	17	17
Elongation at break	%	90	70	70
Modulus of elasticity in bending	MPa	1300	1600	1500
3.5 % flexural stress	%	45	48	46
Izod notched impact strength 23°C	kJ/m^2	15	7	10
–20°C	kJ/m^2	4.5	2.5	3
Thermal properties				
Heat ageing at 150°C	hrs	400	400	400
Vicat 5 kg	°C	72	78	76
Processing properties				
Melt temperature	°C	240 to 255	230 to 250	230 to 250
Mould temperature	°C	30 to 45	30 to 45	30 to 45
Shrinkage	%	0.9 to 1.1	0.9 to 1.1	0.9 to 1.1

Table 1. Characteristic properties of PP/PS blend

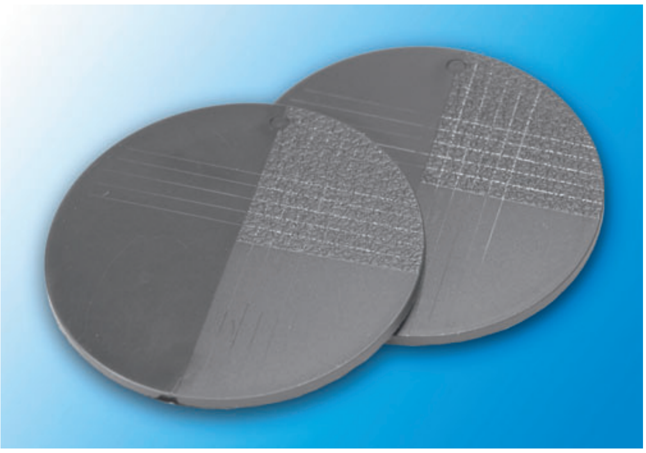

Fig. 3. In scratch resistance tests carried out under a pressure load of 5 N in accordance with VW standard PV 3952, parts manufactured from the nano additive showed only a negligible lightening in colour of ΔL = 0.3 (left) compared with ΔL = 3.2 in the case of PP-TV20 (right; photo: Putsch)

show a considerably better scratch resistance and a matte surface with good "feel appeal".

The Elan XP compounds are supplied ready for processing, i.e. they are heat and UV stabilised and already pigmented in the desired interior trim colours, with light colour shades being just as readily available as dark ones.

Injection Moulding like Polypropylene

Elan XP blends can be trouble-free processed on standard injection moulding machines. Processing parameters which result in high-quality, flawless parts when processing PP or talc-filled PP also produce the same results with Elan XP. Thus, when changing over to one of the PP/PS blends, little or no change needs to be made to the settings for the melt temperature, injection pressure, injection speed, holding pressure and holding pressure time. If the melt temperature indicated in Table 1 is also maintained in the hot runner, there is no likelihood of any separation of the blend components, even if the maximum shot volume is utilised only to a limited extent, that is to say, if the residence time is relatively long. For a particularly good surface finish, it is advisable to raise the mould temperature to between 40 and 45°C.

Elan XP blends display good flow characteristics and low-warpage properties, which means that even relatively large parts can be injection-moulded without any problems. As the shrinkage characteristics are the same as those of talc-filled PP, no alterations need to be made to existing moulds when changing over to a PP/PS blend. Compared with mineral-filled PP, Elan XP causes less wear in nozzles and on textured cavity surfaces. Given the correct part design and choice of injection points, no visible and/or strength-diminishing flow lines are likely.

As regards emission control requirements, Elan XP comes within the limits laid down by vehicle and original equipment manufacturers for vehicle interiors. In the odour evaluation all three types currently comply with category 3, and ongoing developments will ensure further improvement in the very near future.

Development Targets Reached

Thanks to close co-operation with automotive suppliers and OEMs during development, Elan XP is already being used in the manufacture of mass-produced parts. The results so far obtained have more than come up to expectations:

- In scratch resistance tests carried out under a pressure load of 5N ΔL = 0.3 (Fig. 3) compared with ΔL = 3.2 in the case of PP-TV20.
- Surface mattness was ascertained by means of gloss measurements taken under an angle of incidence of 60°. The readings obtained were, at 1.5 to 2, extremely low.

Moreover, the vehicle interior fixtures and trim display pleasant tactile properties.

As a means of improving upon the scratch resistance hitherto displayed by parts manufactured from mineral-filled PP, both Elan XP 416 (featuring the best scratch resistance) and Elan XP 422 (higher rigidity, higher Vicat softening point while retaining high scratch resistance) are the ideal solution. Supplied as a ready-to-use, pigmented and stabilised compound, Elan XP is virtually no more expensive in terms of price per kilogramme, but since it has an approximately 10 % lower density than a PP-TV 20, the costs per part are more favourable. Moreover, the proportion of parts that have to be rejected on account of scratches and/or undesirable glossiness is considerably reduced.

One of the future-oriented applications of Elan XP 515 is the substitution of unpainted PP/PS parts for painted ABS parts. As in such a case the entire painting process can be waived, the overall cost savings per part are considerable and may be as high as 50 % of the previous total production costs per part. As a partially crystalline polymer, however, Elan XP may display a higher degree of shrinkage than amorphous ABS, and it is therefore necessary to check in each individual case whether existing moulds can still be used. This will at least be possible in most cases where relatively small parts are produced, as the shrinkage difference is then negligible.

Among the first of the parts to be mass-produced in Elan XP 515 is a footwell heater vent (see title picture) for various Volkswagen and Audi models. It is precisely in this case that an unpainted PP/PS blend has served as a substitute for a painted ABS part, and the annual savings achieved by not having to paint the part are considerable – up to five digits in terms of Euros. The development of car seating trim in Elan XP is progressing well and an initial mass production run is scheduled for the middle of this year. ■

Manufacturer

Putsch Kunststoffe GmbH
Wiesbadener Str. 13
D-90427 Nürnberg
Germany
Phone +49 (0) 9 11/93626-0
Fax +49 (0) 9 11/306115
E-mail: peter@putsch.de
www.putsch.de

REFERENCES

1 Becker, G. W.; Braun, D. (eds.): Kunststoff-Handbuch, Vol. 3/2; Bottenbruch, L. (ed.): Technische Polymer-Blends. Hanser, Munich, Vienna 1993
2 Mülhaupt, R.: Nanomaterials: Opportunities and Risks. Kunststoffe plast europe 94 (2004) 8, pp. 76–88
3 Thermoplastische Kunststoff Nanocomposites. Publication by Süd-Chemie AG, Moosburg 2004

THE AUTHORS

DR. JOACHIM GROSSMANN, born in 1956, is Vice President Sales & Marketing of the Plastic Additives Division of Süd-Chemie AG, Moosburg/Germany.

PETER PUTSCH, born in 1960, is Managing Director of Putsch Kunststoffe GmbH, Nuremberg. His various areas of responsibility include Development and Application Technology.