Tailored colour masterbatches for high-quality TPE tints

Applications and benefits of Caparol NEFA MB masterbatches for thermoplastic elastomers – part 2

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Dispersive and distributive mixing processes are major elements in the manufacture of thermoplastic masterbatches and compounds. Continuously working twin-screw extruders and kneader systems are mainly used for compounding. A crucial restriction of these mixing devices is the limited dwell time of the components to be mixed. Caparol Industrial Solutions GmbH is a company that has specialised in the manufacture of primarily liquid and paste-form pigment and additive concentrates. Discontinuously working mixing and dispersion machines, such as roller mills, bead mills or dissolvers are used in particular in the production of these concentrates.

This is where the compounds and masterbatches of the NEFA MB product group come into play. The combination of discontinuous mixers and twin-screw extruders can manufacture very highly filled, specialist products on the basis of special thermoplastic elastomers.

In the area of colour masterbatches, NEFA MB concentrates stand out because of their very high pigment fill levels. The manufacturing process employed makes the use of dispersion agents completely unnecessary. This can be an advantage for TPE tints in particular, since dispersion agents may lead to film formation on the component surface in some cases. Because of the colour intensity of the NEFA MB masterbatches, even TPEs with a strong colour of their own due to fillers, for example, can be tinted brilliantly with comparatively low quantities of masterbatches.

1 Introduction

A number of material properties have an important role to play in the development of TPE compounds. Not only the mechanical or rheological properties but also the thermal or chemical resistance of the materials are important factors for their design. The tinting of the TPEs may be necessary to ensure the products made from the material can be sold, but it tends to become subordinate as far as the development of the materials is concerned.

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One reason for this is that tinting using masterbatches is often only carried out when the materials are finally shaped. Also, the low additive volumes, which are typically in the range of 0.5 to 5 percent by weight, are usually not thought to have any significant influence on the physical properties defining the material.

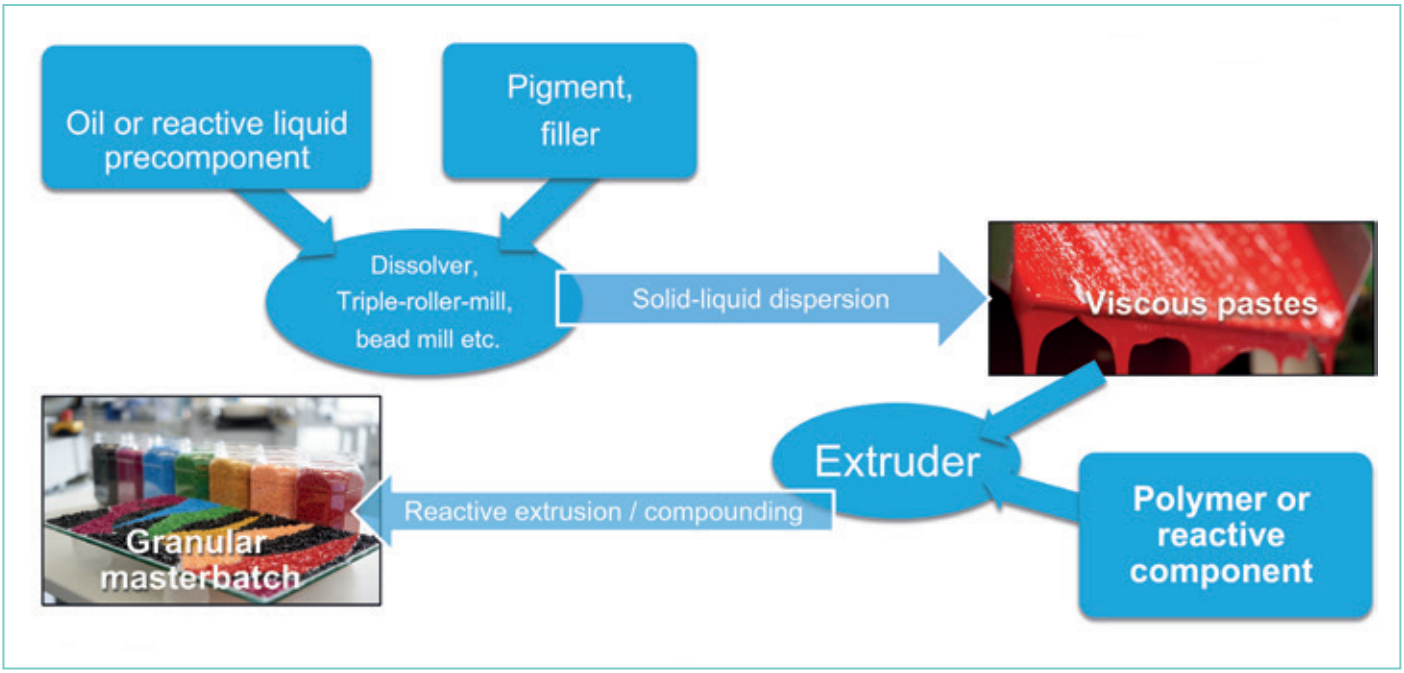
In addition, masterbatch systems are often used for TPE tinting that are also used for tinting classic thermoplastic materials. Masterbatches based on polyethylene or polypropylene are very commonly used for many TPE tints. Dispersion agents are generally used for manufacturing these masterbatches, so that the pigments can be sufficiently broken up, distributed and wet in the manufacturing process. Conventional thermoplastics that are not TPEs also have a clearly reduced macromolecular mobility at application temperature, however. This means that low-molecular substances, such as dispersion agents, are also transported on a very limited basis in conventional thermoplastics. This is different in the case of thermoplastic elastomers. Their properties are based on the principle that the macromolecules of the elastic phase in the application temperature range have a very high mobility. For this reason, dispersion agents, or other substances, migrate more easily out of the material. In the case of dispersion agents, this can lead to the undesired formation of surface deposits on the TPE component. Other impurities in pigments or fillers, such as sulfur, for example, may contribute to the formation of an unpleasant odour.

For TPE materials in particular, tinting with non-TPE-specific masterbatches can easily cause risks as a result of the circumstances described above.

2 Colour masterbatches specifically tailored for TPE materials

In this context, the masterbatches developed by Caparol Industrial Solutions GmbH are an interesting innovation to the existing portfolio of colour masterbatches for TPEs. The colour masterbatches in the product group NEFA MB F (NEFA stands for "Nerchauer Farben") are based on TPE-carrier sys-

Fig. 1: Process diagram for the production of NEFA MB F masterbatches



tems and can be tailored specifically for TPE applications. In an earlier article we have reported on carbon-black-based masterbatches and compounds produced by Caparol Industrial Solutions GmbH [1]. A multi-stage manufacturing technology at the interface of the paints and plastics industries was presented as the key to the compounds' special characteristics. Masterbatches in the NEFA MB F product group are also based on this manufacturing technology **(fig. 1).** In contrast to the classic colour masterbatch manufacture using twin-screw extruders or other continuously working dispersion systems, the NEFA MB colour masterbatches are manufactured using a two-stage process. The core process of masterbatch manufacture – the dispersion of the pigments – is carried out using solid-liquid mixing technologies that are well-established in the paints industry.

Fig. 2: Dissolver

Known examples of these technologies are dissolvers **(fig. 2),** triple-roller-mills or bead mills. The advantage of these mixing methods is the fact that the pigments can be dispersed in a liquid independently of the dwell time limitations of continuous processes. Unlike methods using twin-screw extruders, it is thus possible to work towards a particular dispersion goal for the pigment, e.g. a defined grain fineness, by varying the mixing time. This means that it is possible to distribute even difficult to disperse pigments finely in a liquid base, without using wetting and dispersion agents. A further advantage of this method has already been described in the first part of this publication. Because of the longer process times and the consequently better wetting of pigment surfaces, this process also allows the production of masterbatches with very high pigment loads. For example, filling levels of up to 80 percent by weight can be achieved with inorganic pigments and 50 percent by weight with organic pigments.

Irrespective of the first process step, the manufacture of NEFA MB F masterbatches also requires a compounding step, which is carried out in twin-screw extruders. The aim of this process step, however, is mainly the formation and homogenisation of a polymer matrix, and granulation, i.e. shaping of the products.

Fig. 3: Reaction equation for the production of polydimethylsiloxane-polyurea copolymers

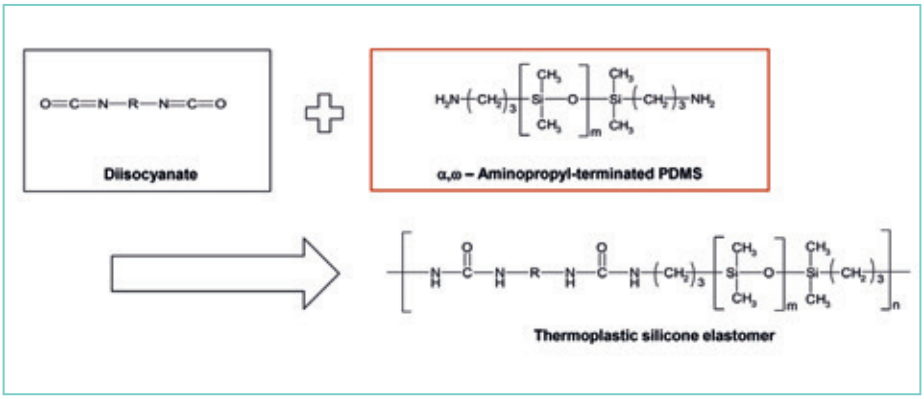
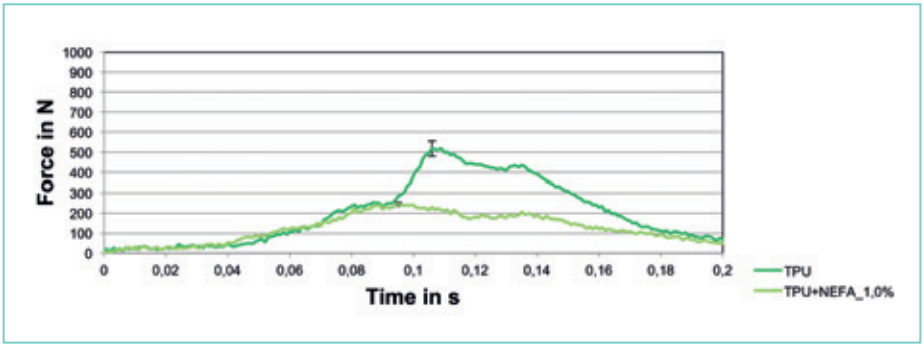


Fig. 4: Demoulding behaviour of TPU in the injection moulding process with NEFA MB A



In order for the procedure described for the production of masterbatches to be technologically feasible in first place, an adequate liquid preliminary stage of the polymer carrier system or a liquid recipe component is required in which the pigments can be integrated. Caparol Industrial Solutions GmbH works here with two different carrier polymer systems that both come from the spectrum of thermoplastic elastomers.

On the one hand, thermoplastic polydimethylsiloxane-polyurea copolymers (PDUC) are used as masterbatch carriers. On the other hand, styrene-ethylene-butylene-styrene block copolymers (SEBS) are used. In the case of the PDUCs, the pigments are integrated into reactive, liquid preliminary stages of the carrier polymers, the aminopropyl-terminated polydimethylsiloxane oils. The matrix and masterbatch formation is carried out through reactive extrusion, with the pigment paste being processed with a diisocyanate in the twin-screw extruder. The reaction equation for this is shown in **figure 3.** With the SEBS copolymers, use is made of their capacity to bind white oil in very large quantities as a softener. The polymer matrix is formed here through the compounding of the pigmented white oil paste together with other recipe constituents of conventional SEBS compounds. Both polymer systems have different, advantageous properties for the tinting of TPEs.

3 Silicone additive meets colour

PDUCs are thermoplastic copolymers based on urea hard segments and silicone soft segments with silicone contents of around 98 %. Because of the block-form chain structure of the PDUCs with quite varying polarities, these carrier systems are suitable for use through the full spectrum of TPE materials.

In addition to the described specific tinting advantages, there are also additional benefits for their use in TPE materials. PDUCs act as an effective processing aid during processing of the masterbatch by the customer. In this way, any processing torque arising during extrusion is clearly reduced by PDUC masterbatches. In the injection moulding process, the additives have a positive effect on both the injection process and on the demoulding of the finished components. In particular, the demoulding stage, which can sometimes be problematic with soft TPE materials, can be significantly improved by using NEFA MB F masterbatches. **Figure 4** shows the force progression of an ejector pin in the demoulding of a conical, cup-shaped component made from a TPU material with and without a PDUC-based masterbatch. The PDUC very clearly reduces the forces needed for demoulding and thus helps to improve demoulding.

The silicone-based carrier systems of the NEFA MB F masterbatches can also affect the material properties of various TPEs, especially the surface properties. The shine, surface quality or coefficient of friction of the surfaces of components can thus be improved by PDUC carrier systems. In addition, the additives have a very positive impact on the abrasion resistance of TPEs. The effect that an addition of 3 percent by weight of PDUC has on the abrasion resistance of two TPU materials is shown in **figure 5.** It can be seen that there is a considerable reduction in the abrasion measured, if PDUC carrier polymers are used to modify the TPUs.

Although the silicone-based carrier systems change specific material properties of TPEs even with the typical additive concentrations in the range of 0.5 to 3 percent by weight, the systems do not show any significant impact on the stress-strain behaviour or hardness of the modified TPEs.

4 Universal SEBS masterbatches for brilliant tints

The second masterbatch system, the SEBS-based colour concentrates, have no extra additive-enhancing effect in the tinting of TPE materials. However, because of the structure of the polymer carriers, the SEBS-based masterbatches can also be used without any problem throughout the range of TPE materials and are highly compatible. In addition to the advantages of the masterbatches already discussed, these systems can also be produced in very soft qualities despite the higher filling level. These systems are therefore very suitable in particular if a negative effect on the hardness as a result of

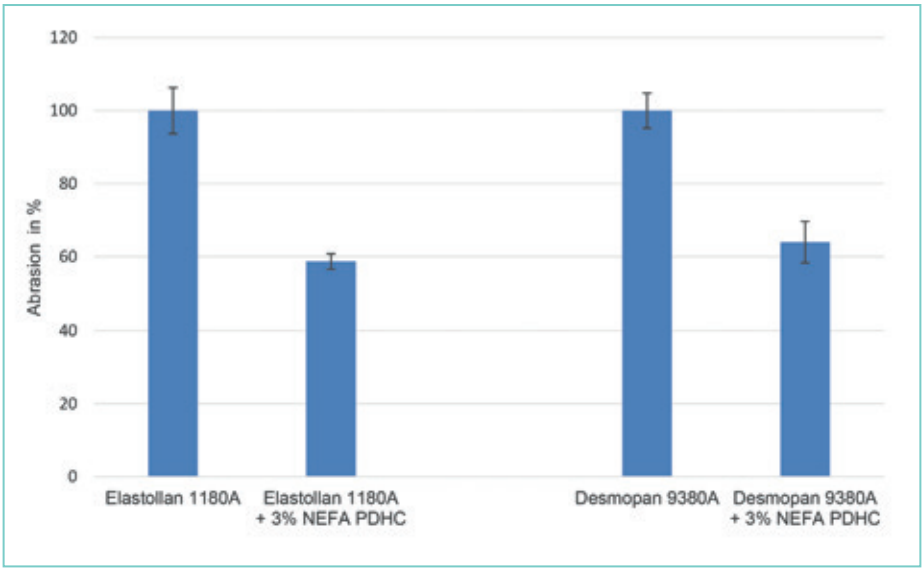
the masterbatch-addition is expected. Moreover and because of the broad raw material basis of SEBS compounds, it is possible to adjust these masterbatches in line with all customer-specific, regulatory requirements.

5 Summary

The tinting of TPE materials with conventional masterbatches can lead to problems. Low-molecular components of masterbatches, such as dispersion agents or impurities from raw materials migrate out of TPE materials much faster than from conventional thermoplastics and can thus have a negative impact on product properties.

Masterbatches produced by Caparol Industrial Solutions GmbH are products specially tailored to TPE materials which, because of the production process at the interface between the paint and plastics industries, do not require the use of any dispersion agent. The focus of the masterbatches is always the multi-stage manufacturing technology that makes particularly efficient filler dispersion and very high pigment loading possible.

Fig. 5: Influence of polydimethylsiloxane-polyurea copolymers on the abrasion resistance of TPU



These masterbatches are therefore particularly suited for the tinting and modification of TPE materials.

6 References

[1] M. Hübner, I. Scharr: Innovative, carbon black-filled compounds and masterbatches at the interface of the plastics and dye industries. Applications and benefits of Caparol NEFA MB masterbatches for thermoplastic elastomers – part 1. TPE Magazine, vol.12, November 2020, p. 200-203.