



**MICROTHENE®F:
POWDERS FOR SMC/BMC
APPLICATIONS**



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BULK AND SHEET MOLDING COMPOUNDS

Bulk molding compounds (BMC) and sheet molding compounds (SMC) are fiber-reinforced polyester (FRP) composites that can be molded into parts for applications in the automotive, appliance, electrical and construction industries.

MICROTHENE F POWDERS AS LOW PROFILE ADDITIVES

Microthene F powders are used as low profile additives (LPA) in SMC and BMC compounds to improve surface smoothness and control shrinkage resulting from molding the finished part. Microthene F powders also improve the dispersion of pigments throughout the compounds, yielding more uniform color in the end product.

LPA can be divided into Class A-finish LPA and non-Class A-finish LPA; the second category includes Microthene F powders. Class A finishes are similar to those required for automotive body panels. Class A-finish LPA must also reduce shrinkage to less than 0.5 mils/inch.

Other than automotive body panels, relatively few applications require a Class A finish. Microthene F powders not only yield a highly acceptable finish for most applications, they can also reduce shrinkage in the end product to approximately one mil per inch. Microthene F powders are also a low cost alternative to other low profile additives.

In any BMC or SMC application, the LPA, such as a Microthene F powder, is a very small portion of the total weight of the compound.

RAW MATERIALS IN SMC/BMC APPLICATIONS

Thermoset composite raw materials can be divided into four categories: thermosetting polymers, fiber reinforcements, fillers and additives.

Thermosetting Polymers

About 75 percent of all the resins used in composites are polyesters. Unsaturated polyesters are produced by the condensation polymerization of dicarboxylic acids, glycols and anhydrides of dicarboxylic acids. The resulting polymer is dissolved in a reactive monomer, typically styrene, which lowers the overall viscosity of the product. This decreased viscosity also makes the polyester easier to process.

After the polymer is dissolved in the monomer, the mixture is heated, causing the monomer to react with the polyester. The reaction changes the liquid mixture to a solid. Essentially, the components of the mixture crosslink producing a very stable material. This process is called "curing." By varying the components of the original polyester resin, the physical properties of the final product can be changed.

Fiber Reinforcements

Fibrous reinforcements are added to the polyester to increase the impact strength of the end product. The most common reinforcement used for BMC and SMC is glass fiber because it is cost effective and results in a cured end product with high impact strength. In a BMC, the glass fiber is approximately 20 percent by weight and the fibers are normally 0.25 in. to 0.5 in. long. In an SMC, the glass fiber content is 30 percent to 60 percent by weight and the fibers vary in length from 0.75 in. to 3.0 in.

Fillers

Inorganic fillers, usually 40 percent to 70 percent of the end product by weight, are used in BMC and SMC to further change the physical properties of the end product. The two most common fillers used in BMC and SMC are calcium carbonate and Kaolin clay. The addition of fillers lowers the cost, reduces the amount of fiber reinforcement needed and makes the part more flame retardant. Fillers can also improve the physical properties, improve crack resistance and offer better rheological control of the resin.

Additives and Modifiers

Between one percent and five percent of the weight of a BMC consists of additives and modifiers, including low profile additives such as Microthene F powders. Additives can include initiators (T-butyl perbenzoate), release agents (calcium stearate), pigments (TiO₂, carbon black, iron oxides), thickeners (MgO, CaO, MgOH₂, CaOH₂) tougheners (conjugated dienes, elastomers) and low profile additives.

PROCESSING BMC AND SMC

BMC and SMC, although similar in composition, are processed differently. However, in both cases, production of a molded part from BMC or SMC is a two-part process: blending of the resin mix and compression molding of the final part.

With BMC materials, the polyester resin and additives are first blended to form a resin mix. Filler is then added. Next, the mixing speed is decreased in the "pre-mix" to incorporate the glass fibers thoroughly without breakage. The resulting material is a thick paste with the consistency of wet clay. If the material is to be concentrated further, thickening agents are added at this time. The BMC is now ready to be compression molded. A predetermined amount of BMC is placed in a mold consisting of matched dies. The mold is closed at a pressure of 350 psi to 2,000 psi and kept at a temperature of 250° to 350°C (480° to 662°F). Generally, the material is molded for one second for every mil of thickness in the finished part; however, actual operating conditions vary and are regarded as proprietary information throughout the industry.

The blending of SMC materials is very similar, except the inert filler is added gradually throughout the mixing operation instead of all at one time. SMC has the consistency of a liquid paste or pancake batter. The SMC is then transferred to an impregnator where the paste is compressed into two sheets. Fiberglass roving or mat is then laid on one sheet. The other sheet is then laid over the roving to create a three-layer sandwich structure. This composite structure is further compressed in compaction belts.

The final compacted SMC is cut to appropriate lengths for its final molding application. These sheets are then stored until the proper viscosity for molding is reached.

From this point, the SMC molding process is similar to that of BMC. The sheet is placed between matched dies that are compressed and cured under the same general conditions as BMC.

HOW LPA WORKS

Microthene F powders are used as LPA in BMC and SMC. LPA both reduces shrinkage and improve the surface appearance of a finished product made from BMC or SMC. Generally, LPA works in the following way.

At room temperature, the BMC or SMC premix consists of two phases, a thermoset phase and a thermoplastic phase. The thermoset phase is mainly unsaturated polyester, styrene, additives, fillers and a small amount of LPA. Most of the premix is in the thermoset phase, also called the continuous phase. The thermoplastic phase consists of mostly LPA, a small amount of unsaturated polyester, styrene, fillers and additives. This phase is present in 10-micron to 100-micron microglobules and is referred to as the dispersed phase.

As the premix is heated to 120°C:

- The crosslinking reaction begins in the continuous phase.
- Styrene monomer and the thermoplastic LPA expand thermally to counteract shrinkage from polymerization.
- The small amount of unsaturated material in the dispersed phase crosslinks to form micron-sized beads in chains throughout the dispersed phase.

On further heating to 140°C, the styrene continues to be consumed until it no longer acts, along with the LPA, to compensate for the polymerization shrinkage. Strain develops at the continuous phase/dispersed phase interface.

At 150°C, strain continues to increase, initiating stress cracking at the dispersed phase/continuous phase interface. The stress cracks propagate through the weak polymer bead network of the dispersed phase. This stress cracking relieves the increased strain at the interface and prevents catastrophic cracking in the part.

Upon cooling, thermal contractions introduce more strain on the part. The strain is relieved by further stress cracking in the dispersed phase, thus reducing shrinkage.

The just-described mechanism helps address the LPA function in relation to the processing variables, polymerization shrinkage and thermal contraction [1]. Surface smoothness improves with decreased mold shrinkage [2]. The addition of LPA reduces polymerization shrinkage but does little for thermal contraction or mold shrinkage. LPA with more solubility in the continuous phase produce smaller microglobules in the dispersed phase than less soluble LPA. Thermal shrinkage decreases in compounds with smaller microglobules of thermoplastic LPA due in part to the increased surface area.

ADVANTAGES OF MICROTHENE F POWDERS

Microthene F powders are insoluble in polyester and their microglobules are relatively large (100 microns). This size indicates, based on the process described above, that polymerization shrinkage is controlled in BMC and SMC containing Microthene F powders but thermal shrinkage continues relatively uninhibited.

Although some surface imperfections might also be expected in the final product because of this relatively large amount of thermal shrinkage, products made from BMC and SMC containing Microthene F powders are extremely smooth. The polyethylene in the Microthene F powders “blooms” to the surface and coats imperfections yielding an excellent finish. Blooming occurs as the premix melts before extensive crosslinking takes place.

Products made from BMC and SMC containing Microthene F powders shrink to a limited extent. However, molds can be designed to compensate for this shrinkage and still yield an acceptable part.

Products made from BMC and SMC containing Microthene F powders are “glossier” than similar products made with different LPA. This gloss results from the polyethylene migrating to the surface.

Additionally, processability improves when Microthene F powder is used as LPA. As the BMC premix passes through the extruder on its way to injection molding, the Microthene F powders in the premix help lubricate the compound making it easier to process.

Mold release agents may not be needed in the formulation. The end product slips out of the mold easily because the polyethylene blooms to the surface. Improperly formulated premixes can leave a sticky residue on the mold that has been analyzed as polyethylene.

Microthene F powders are easily colored and absorb pigments much better than the SMC or BMC composite matrix. This quality allows the molder to produce a homogeneously colored part without priming and painting.

Excellent surface smoothness and shrinkage reduction, the ability to absorb color and relatively low cost are the main advantages of using Microthene F powders as LPA in BMC and SMC formulations. For further information or assistance in product selection, contact your Equistar Performance Products sales representative.

REFERENCES

- [1] Pattison, V.A., et. al., "Mechanism of Low Profile Behaviour in Unsaturated Polyester Systems," *J. Appl. Polym. Sci.*, 18, 2763 (1974).
- [2] Atkins, K.E., et. al., "Advances in SMC/BMC Compounding: New Low Profile Additives for High Filler Compositions," 47th SPI Composites Conference, 1E, 1992.



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