

Liquid Masterbatch Systems

Taking the Holistic View of Liquid Masterbatches as a Complete System

Liquid masterbatches are currently experiencing a renaissance, proving particularly popular for direct pigmenting of transparent polymer applications. These systems, which include dosing technology and monitoring software, can slash manufacturing costs by 10 to 40 % compared with conventional color masterbatches.

Previously, polymers were pigmented by admixing masterbatch powder directly to the polymer pellets or powder. Liquid adhesive was also incorporated to achieve better adhesion of the masterbatch powder on the polymer granulate and to reduce dusting. Subsequent progression to pigment pastes and liquid masterbatches was therefore not long in coming. Liquid masterbatches have to satisfy various requirements:

- They must be compatible with the polymer matrix of the polymer to be pigmented.
- The carrier system of the liquid masterbatches should provide optimum wetting of the pigment in order that the masterbatch may be loaded with sufficient pigment.
- To avoid sedimentation of high-density pigments in the liquid carrier mixture, the liquid masterbatch must have the right viscosity, yet still be readily pumpable.
- The organic carrier system of the liquid masterbatch must have sufficient heat stability to support processing of the polymer.
- Also, the liquid masterbatch system of the finished article pigmented with the liquid masterbatch must meet all the necessary regulations.

Structure and Use

As with conventional masterbatches, there are universal carrier systems available for liquid masterbatches with which various thermoplastics are pigmented. Generally, the different areas of application and processing require tailor-made liquid carrier systems with suitable tem-



PMMA panels colored with liquid masterbatch (figure: Polycasa)

perature profiles and special thermoplastics.

Usually, base colors or single-pigment colors (SPCs) are employed. In an SPC, a single, optimally loaded pigment is dispersed in the requisite base carrier. This affords a way of building up a modular system of single-pigment colors for each polymer range. In the second process step, these are used to blend liquid masterbatches of defined color.

Liquid masterbatches may be applied in different ways:

- Usually the manufacturer of the liquid carrier system creates ready-mixed, directly usable liquid masterbatches and delivers them straight to the converter.

- In certain circumstances, the end converter prepares the formulation in his own color-matching lab to suit the specific process. This formulation can then be commissioned from the manufacturer or even be mixed by the converter himself if he operates with a base color range.
- In rare cases, base colors in the manufacturing process are mixed and dosed online exactly as per formulation. This variant has not yet found widespread use due to the high technical complexity of achieving consistent color constancy.

In masterbatch production, the pigments are strongly sheared on the twin- »

Fig. 1. Production of liquid masterbatch

(figure: Clariant)



screw extruder and subjected to thermal stress; this is also true of additives. In contrast, producing the liquid carrier system in the dissolver followed by downstream grinding is much more gentle on the pigments and additives. Sensitive formulation ingredients benefit from compounding and application in liquid form, including

- effect pigments (higher gloss due to fewer damaged particles),
- daylight-fluorescent pigments (gentle process avoids spots) and
- sensitive additives.

When liquid carrier systems are used, the pigments are uniformly distributed in the carrier system (**Fig. 1**). Dosing the liquid masterbatch into the natural pellets causes the surface of each pellet to be wetted. By the time melting takes place in the processing section, the color is already distributed extremely homogeneously. Thus, “streak-free” coloring can be obtained even when extremely small amounts of the liquid carrier are added. The outcome is perfect through-coloring of transparent articles despite the fact that an extremely low amount of liquid masterbatch has been added (**Title figure; Fig. 2**). This can be seen particularly well in the market for coloring PET bottles (**Fig. 3**); liquid masterbatches are virtually used exclusively here now. The liquid masterbatch is added in amounts of 0.02 to 0.3%, with the exact figure depending on the hue.

From Color to System

The first liquid masterbatch systems often featured carrier systems that were very simple as regards wetting behavior for optimal

pigment loading. Similarly, the migration behavior of some liquid masterbatches in the finished articles was not always optimal. Handling often entailed the use of drum-mixing with polymer pellets and appropriate cleaning measures had to be employed for storage containers and mixers.

The intervening decades, however, have seen a number of new developments and modifications in this area. One concerns the automated use of liquid masterbatches, without the constant need for manual monitoring and support. Today the market offers a wide range of dosing systems with interfaces for integrating the processing machines. Thus, many problems with the processing of liquid masterbatches in the past have now been resolved and the masterbatches are easy to handle.

Although the use of liquid masterbatch may be advantageous in many ap-

plications – both financially and as regards processing technology – coloring with liquid masterbatch is met with hostility, especially in Europe. Nevertheless, the trend there is turning positive. Where it did not make sense to use liquid masterbatches a few years ago, the advantages mentioned earlier now make compelling arguments.

Clariant International Ltd., Pratteln, Switzerland, can look back on double-digit growth since launching its HiFormer system. This can be primarily attributed to the fact that Clariant has adopted a holistic approach to liquid masterbatches, with all components tailored to each other and to the application. This holistic view also factors in the local conditions pertaining at the customer, e.g. storage and transport conditions, processing machines and returns of contaminated packaging material.

The primary area of application for liquid masterbatches is in packaging and consumer goods. The advantages, as described above, lie in transparent and translucent hues. Cost savings of 10 to 40%, the exact figure depending on the application, are possible with liquid masterbatches compared with conventional masterbatches. Such savings are predicated on the use of a dosing pump of maximum precision.

Dosing Systems and Software

A key element of the HiFormer system is a rugged, easy-to-use dosing system that is used by the customer. It consists of

- hose pump (peristaltic pump),
- screw pump, and
- gear pump.



Fig. 2. Colored transparent plastic soundproofing panels (figure: Polycasa)

In the past, such dosing systems were mostly volumetric, but this type no longer meets customers' quality requirements. Therefore, for all new developments, the focus was and is placed on improving handling, dosing accuracy and monitoring capabilities.

Consider peristaltic pumps. Here, 6-way pump heads have been developed that significantly reduce the extent of characteristic peristaltic pump pulsation. As regards tube quality, Clariant conducted extensive tests on various combinations of pigment viscosities and hose materials. These were aimed at finding the optimal interaction between liquid masterbatch, pump and process over the entire dosing range. Peristaltic pumps are always recommended for frequent color changes.

Screw pumps which operate on the endless piston principle are to be found on the market. Their dosing geometry is such that each revolution always delivers a constant volume, even in the range of high counter-pressures, and to an accuracy of $\pm 1\%$ expressed in terms of the average delivery rate. Screw pumps are always recommended for tiny dosing amounts or infrequent color changes.

Gear pumps, widely known as melt pumps, can also be used for dosing liquid masterbatches. They offer high accuracy across the entire dosing range and can additionally be employed where space is at a premium.

Modern dosing systems offer the possibility of inputting product-related formulations which, having been input, can be retrieved for every new production run. Clariant has also tested and approved gravimetric-type dosing systems. These eliminate the need for time-consuming calibration of a volumetric system or repeated input of production-specific data. Of course, such systems also boast the necessary monitoring capabilities, e.g. reservoir fill-level and set/actual comparison of the set dosing amount with the amount actually dosed. Where the threshold of a given monitoring function is over- or under-exceeded, an alarm output is triggered, with which, for example, an error message on the machine can be activated. In addition, the system can be connected up to the company's own network via networking software. This enables pigment consumption to be tracked in real time and stock levels to be monitored.



Fig. 3. PET bottles colored with liquid masterbatch (figure: Clariant)

Different Ways of Processing Liquid Masterbatches

In addition to dosing, particular attention needs to be paid to the physical dosing point, i.e. the point in the process at which the liquid masterbatch is added. There are several technical approaches, of which only the most commonly employed will be addressed here.

The easy way to add liquid masterbatch to a process involving an injection molding machine is to use the feed zone. This simply entails bolting an adapter plate, which is supplied with the HiFormer system, between the hopper and the filling opening of the machine (**Fig. 4, top**). The adapter plate has a receptacle for an injection lance. This guarantees that the lance, which is connected to the dosing tube, is optimally positioned (in the center of the filling hole). Existing masterbatch dosing systems can therefore remain on the machine. This approach ensures that masterbatch pellets, too, can be processed in parallel.

In certain applications, the use of a pre-mixer in the feed zone is recommended to ensure that the process goes smoothly (**Fig. 4, center**). Connecting hoses are connected to the bucket and to the injection lance via self-closing valves. This guarantees that all components can be replaced without dripping during a bucket or color change.

Another possibility is to add the pigment in the transition section of the barrel. However, the acting high pressures and temperatures here render this a tech-

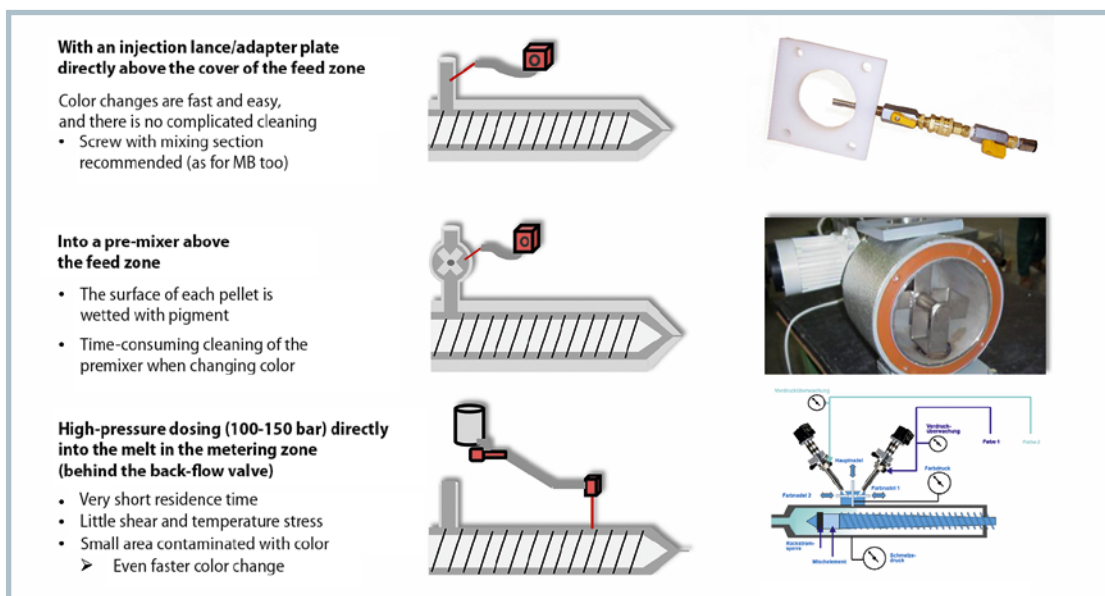
nically demanding solution, which must be tailored to the hardware of the machine. Solutions of this kind require collaboration with the relevant machine manufacturer. Sumitomo (SHI) Demag Plastics Machinery GmbH, Schwaig, Germany, has introduced one such system (**Fig. 4, bottom**), which allows the pigment to be added just before the nozzle in the dosing zone of the barrel of an injection molding machine. According to Sumitomo Demag, because the pigment is added very late to the plasticizing unit, scrap rates during a color change can be reduced and the color change can be realized in an extremely short time. As high-pressure dosing is needed, the carrier system for the liquid masterbatch must satisfy complex demands. In addition, the system allows up to five colors to be changed automatically during the production process without the intervention of the machine operator.

Tailored Carrier Systems

As manufacturing processes and polymers are constantly evolving and being optimized, there is a need to adapt carrier systems to market conditions. In view of the many available and newly developed machine systems on the market, it is essential for regular contact to be maintained with machine manufacturers. That is the only way to ensure that the pigment systems retain their functionality in all kinds of processes.

The carrier system must not adversely affect the process or the properties of »

Fig. 4. Addition points for liquid masterbatch on an injection molding machine: conventional dosing (top), with pre-mixer (center), development from Sumitomo Demag (bottom) (figure: Sumitomo Demag)



the end product in any way. New carrier systems were continually developed in the past as a way of ensuring this. Compatible solutions are offered for nearly all known polymers and polymer-manufacturing processes.

Today, makers of liquid masterbatches can avail of a carrier system portfolio that offers maximum compatibility with all standard thermoplastics. There have especially been major improvements in the case of high-viscosity melts, e.g. ABS, PC and PMMA, as regards processing, distribution and color brilliance, compared to previous carriers. To prevent

the number of carrier systems from multiplying into the future, a global development project has been launched, which aims to reduce the number of carriers.

Not only polymers and manufacturing processes, but also oils, the basic component of a liquid masterbatch, are constantly evolving. Such optimized oils can now help to optimize outdated formulations so that in the future fewer and fewer, but much more efficient carrier systems will be available for all polymers and applications.

So-called combi-batches – pigment batches containing specific additives such as UV stabilizers, blowing agents and lubricants – are available as standard products today. Here, too, developments are underway to make the full range of products that are available in pellet batches available in liquid systems as well.

One issue that arises with the use of liquid masterbatches is sedimentation, i.e. the settling of pigments or ingredients over time. As time passes, ingredients settle in the carrier liquid at a faster or slower rate. But that does not mean that the pigment can no longer be used. If sediment has formed after prolonged storage, the unopened bucket can be readied for use in a few minutes by means of an agitator, which is offered in the HiFormer system. Meanwhile work is ongoing on improving the additives in the carrier system so as to minimize settling and to increase the storage time.

Service for Customers

With the HiFormer system, packaging which is contaminated with liquid masterbatch, i.e. bucket and liner, and which has been fully emptied to the last drop, can be safely disposed of free of charge in an environmentally friendly manner through a waste management company. Since HiFormer pigments are not hazardous substances, no other specific measures regarding transportation and storage need be observed.

The processing of liquid masterbatches need not end with the ordering of new pigment. Clariant also offers support for new polymer products in the development phase – from selecting the correct color, e.g. the current fashionable color, to choosing between liquid masterbatch and pellet masterbatch through to selecting the appropriate dosing system.

It is naturally also important to offer instruction and training for converters. Machine operators, especially, need to be informed of the benefits and the vagaries of liquid coloring vis à vis masterbatch coloring.

Outlook

Given the relationships and developments described in this article, it is very likely that the use of liquid masterbatches in the area of self-coloring will gain in popularity in the future. Both the technical and the economic benefits will play a crucial role in the use of liquid masterbatches in many applications. ■

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Service

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