Application note | LR76

Extruders

Encapsulation of flavors and ingredients

Authors

Matthias Jährling and Dirk Hauch

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Introduction

Flavors are sensitive and expensive additives used in different industries such as pharmaceutical, chemical, cosmetic, and food. Over the last decades, these flavors and active ingredients have been encapsulated in a polymeric matrix for various purposes such as protection against oxidation, loss of flavor, taste masking, controlled release, or better product handling.

Possible matrix polymers include starch, different sugars, cellulose derivatives, lipids, proteins, and special rubbers. The largest shares have of course starch and sugars. The traditional method of encapsulating flavors is based on a batch process, but it can be improved upon with twin-screw melt extrusion.

Traditional processing

The polymers are molten with the addition of water. Then the flavors or active ingredients are added and mixed by vigorous kneading. Depending on the formulation, excess water may need to be removed under vacuum. Thereafter, the melt is cast as a plate and cooled down.

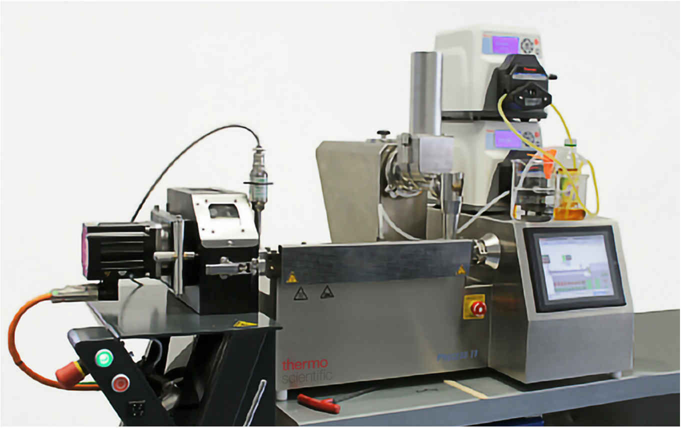

Figure 1: The Thermo Scientific Process 11 “Hygienic” Parallel Twin-Screw Extruder.

This process is very cumbersome and time-consuming. Also, the required material amount is not flexible because it is predetermined by the size of the batch mixer.

Another popular traditional method for encapsulation of flavors is spray drying. A drawback of this complex, continuous process is the loss of flavors and active ingredients due to high process temperatures. The materials may oxidize, may have a shorter shelf life, and explosion protection measures may even have to be taken for some materials. The high energy consumption for drying in this process also makes it less favorable from an economic standpoint.

Encapsulation using twin-screw melt extrusion

Polymers are frequently processed with extruders, so it is an obvious choice to extend this technology for the encapsulation of flavors. The flexible combination of dispersive and distributive mixing in a twin-screw extruder is perfectly suitable for the continuous encapsulation of flavors.

The twin-screw extruder allows the temperature to be changed throughout the barrel zones, and it has a modular screw design to induce only the amount of shear and thermal energy needed for the process of encapsulation. This prevents unwanted degradation of the sensitive materials.

In the feeding section of the extruder (see Figure 2; material flows from right to left) the polymer matrix material is metered and conveyed into the first mixing zone. Due to the heat and shearing, the polymer is transformed into a homogenous melt. In a secondary feed zone, the flavor is added using a liquid feeding pump.

In a further mixing zone, the flavor is now dispersed and evenly distributed into the polymer matrix. At the end of the extruder, the sample pressure is built up to press the compound through a die and shaped into many small strands which are then directly cut into fine pellets by the rotating knife of a face-cut pelletizer. Another option is to extrude the melt directly onto chill-rolls which freeze it down and shape the material into flakes.

The Thermo Scientific™ Process 11 “Hygienic” Extruder is the ideal instrument for testing the encapsulation process on a laboratory scale, because it combines the advantages of a compact bench-top extruder, with the full functionality of a production setup. Its modular design enables the optimal adjustment of the extruder barrel and screws to match the application and product needs. All product contact parts are made from stainless, hygienic-grade steel.

As food products are often cleaned with water-based detergents, the high-grade steel provides an advantage over regular extruders which are normally used in polymer processes.

Testing equipment

- **Extrusion system:** Process 11 “Hygienic” Extruder
- **Cooling circulator:** Polar Series Accel 500 LC Recirculating Chillers
- **Feeder for premix:** Gravimetric MiniTwin MT0 for Process 11 Extruder
- **Feeder for liquid:** Masterflex® P/S Pump Systems
- **Downstream system:** Face-cut pelletizer

For encapsulation of a flavor in a sugar matrix, the Process 11 “Hygienic” equipment setup was designed in a way that the sugar was metered into the cooled, first feeding zone of the extruder, with a gravimetric twin-screw feeder. The sugar was then conveyed by the extruder screw, into the first mixing zone. There the sugar was molten due to the shear and heat generated by the kneading elements. These kneading elements were followed by conveying screw elements. In a co-rotating twin-screw extruder the conveying elements are not totally filled and the melt is not pressurized. As a result the extruder could be opened again and the flavor was added to the molten sugar by the Masterflex P/S peristaltic pump.

Conveying screw elements then transported the mixture into two subsequent mixing sections, where the flavor was dispersed and evenly distributed in the sugar matrix. At the end of the extruder the pressure was built up, and the final compound was pressed through the die head, into the face-cut pelletizer. Designing the final product Figure 3 shows the final product, collected after cooling in the cyclone of the face-cut pelletizer.

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Once the process is developed on the extruder, it is very simple to exchange of the downstream accessories to obtain differently shaped material. Figure 4 shows flakes produced from the same process using a chill-roll (see Figure 5) instead of the face-cut pelletizer. The molten material leaving the extruder is compressed and cooled down between two temperature-controlled rolls and formed into a thin sheet. The cooled sheet is then broken down into flakes by a kibbler device at the end of the chill-roll.

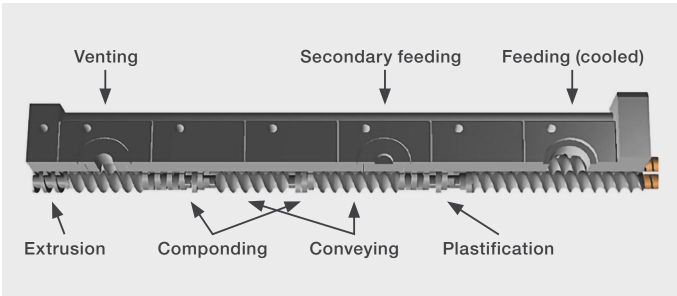

Figure 2: Schematic of a twin-screw extrusion.

Figure 3: Encapsulated flavor — pelletized.

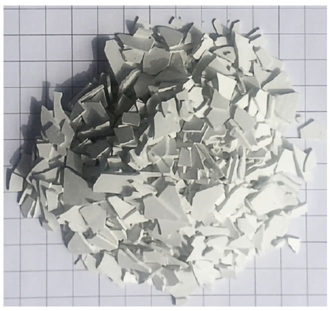

Figure 4: Encapsulated flavor — flaked.

Conclusion

Using twin screw extruders for encapsulation of flavors and ingredients into a sugar or polymeric matrix offers several advantages over traditional processes. The extruder is a continuous working instrument by nature, so the amount of end-product is determined by run time and does not require adaptation via different-sized production equipment as traditional batch operation does. Compared to the energy-hungry process of spray-drying, extrusion has milder process conditions and reduces the risk of product denaturation. Finally, the choice of downstream equipment (face-cut pelletizing or chill-roll) can help produce application-specific end-products as required.

Figure 5: Chill-roll with kibble.

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