Residence time distribution is a key instrument to study and optimize the degree of dispersion. It is a function of axial mixing and exposure time. Screw speed is suspected to have a minor impact on the degree of dispersion.

A further advantage of using the QIR is the fixed boundaries of QIR—i.e., mean bulk mixing and QIR. A measuring flow to take a flow from each material at the exit place which is useful for an extraction process. The data shown but the QIR an extraction process is based on 1/2 to achieve an acceptable mixing.

Results

Even if the dye is introduced as sharp signal (equally a point), it is widely distributed in the extracted polymer strand. That distribution in the axial direction disperses the residence time distribution of the particles within the extruder. The mean residence time is inside the screw setup, mostly influenced by the feed rate. In figure 1, the boundary versus the line is displayed. With increased flow rate, the residence time in the extruder changes. With the feed rate a wide residence time distribution is observed with a very broad mean with the increase of the flow rate.

Material and Methods

For this approach Kollidon® Va 15 is used as a co-rotating twin-screw compound. Plastics Extruder Thermo Fisher, different extrusion processes including different screw configuration. Many twin-screw or screw type and screw setup and processing temperature leading to residence time dispersion are measured to find the most accurate residence time and the most accurate formula that expresses the specific material's expansion profile was measured.

Material Kollidon® Va 15 is used as a polymer carrier. It is a poly-p-vinylpyrrolidone-vinyl pyrrolidone copolymer (BASF SE, Ludwigshafen, Germany).

Hot Melt Extrusion Process

A Plastics Extrusion process (Thermo Fisher Scientific, Karlshorfe, Germany) is used to conduct the experiments. It is a co-rotating twin screw extruder with a diameter and length of 41.4 mm. Different parameters were used. The process parameters are shown in Table 1.

Measurement of the residence time

The pigment is added as a tracer to the hopper of the feeding section at a given time point. In the table, the tracer concentration is given as the time over the time as tracer intensity with a coefficient every 0.5 s (see figure 1).

Calculation of mean residence time

Mean residence time describes the percentage that a particle enters the extruder at T=0 with the flow rate. It is calculated with the following equation:

\[ \bar{t} = \frac{1}{\rho} \int_0^\infty t \cdot \rho(t) \, dt \]

Calculation of variance

Variance describes the degree of dispersion and is calculated as:

\[ \sigma^2 = \frac{1}{\rho} \int_0^\infty (t - \bar{t})^2 \cdot \rho(t) \, dt \]

The variance is often used as a measure for the axial mixing process in the extruder. But as the equation for calculation of variance includes as term (t-\bar{t})^2, it always appears opposite to the mentioned exponential ratio to reduce the variance. The variance is not absolute and is decided because of that to use the inter-quartile range as measure of axial mixing instead. The inter-quartile range (IQR) is calculated as the total mean intensity at 75 percentiles and 25 percentiles from the exit age distribution (\bar{t} = \frac{Q_3 - Q_1}{2})

Conclusion

Residence time distribution is a key instrument to study and optimize mixing behavior. Mean residence time is a measure of mixing history. Long residence time means large mixing history. Inter-quartile range is preferred over variance as parameter for measuring axial mixing. The mean residence time is influenced by feed rate and is a weaker parameter. Higher feed rate leads to shorter residence time. Residue of dispersion is a function of axial mixing history (residence time) and hence influenced by feed rate and screw geometry.

Outlook

• Screw speed is suspected to have a major impact on the degree of dispersion and the mixing behavior of polyurethane.
• Further studies need to be conducted to determine the impact on active pharmaceutical ingredient.
• Study to impact the balance between the degree of dispersion and the degradation profile of active.

Acknowledgements

This work was performed in collaboration with the BASF in the concept. The authors are working closely with BASF, as well as European Journal of Pharmaceutics and Biopharmaceutics, 2007

References


The following equation gives the flow rates highest for standard conveying parameters in a screw

\[ D = \frac{n \cdot 100}{100 - \frac{D_{max}}{D}} \]

In which D is the screw diameter in the screw, D, the distance between the extruder hopper, L the length of the extruder section, the number of flights per screw to and l, the number of flights in the extruder. The extensional viscosity of the extrusion process is considered to be 1000 Pa.s.

Installing decisive parameters to achieve molecular dispersion via hot melt extrusion

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Introduction

Hot melt extrusion is a process which can be used for a wide range of polymers. It can be used for formulation analysis as well as solid state release formulations and for several applications, like tablets, lotions or organogels.

With the hot melt extrusion process a drug is emulsified in a polymeric carrier and is extruded via a screw to be pharmaceutically achieved. This solid dispersion set after the drug is dispersed into the polymer in the capillary or annular-screw or even extrusion dies. When the drug is dispersed into the polymer, the drug is subjected to a flow induced to increase the biodegradation.

During the hot melt extrusion process the active pharmaceutical ingredient (API) and the excipients are fed into the extruder. All components will be sheared, plasticized, dispersed and finally compressed by stress. Even through a shear.

The purpose of this work was to measure the impact of residence time parameters on dispersion and development quality characterized by the various residence time \( t_{\text{res}} \) and inter-quartile range (IQR). (The slicing time can be also used to avoid out of specification). The (D) is a high dispersion mixing in needed to achieve a solid, but extrusion. A higher velocity of the fluid is transferred into a solid by influencing thermal and mechanical energy. For a given configuration, mixing parameters of time to shear results in an increase in melt temperature as well. It may lead to degradation but also in higher dispersion. The screw configuration is used to find the optimal dispersion with minimizing the risk of degradation.