Experimental investigation of residence time, granulation liquid and granule size distributions in twin-screw granulation.

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Purpose:

Twin-screw granulation is a promising technique for the continuous production of pharmaceutical solid dosage forms. In a short period, solid-liquid mixing must be achieved by arrangement of transport and kneading elements to produce granules with a particle size distribution appropriate for tableting. The residence time distribution and the solid-liquid mixing governed by field conditions in twin-screw granulators thus contain interesting information about mixing and different granulation rate processes such as aggregation and breakage.

Method:

In this study, near infrared chemical imaging (NIR-CI) was used to characterize the impact of process (feed-rate, liquid-to-solid ratio and screw speed) and equipment parameters (number of kneading discs and stagger-angle) on the residence time, the granulation liquid-powder mixing and the resulting granule size distributions during twin-screw granulation. Residence time and axial mixing information was extracted from tracer maps and the solid-liquid mixing was measured from the moisture maps, obtained by monitoring the granules at the granulator outlet using NIR-CI. Granule size distribution was measured by sieving.

Results:

The screw speed most dominantly influences the mean residence time, which decreases with increasing screw speed. Even though the feed-rate, liquid-to-solid ratio, number of kneading discs and stagger angle are less influencing factors on their own, they interact with other parameters (such as screw speed), hence significantly influencing the residence time. The level of axial mixing indicated by mean-centered variance of residence time was most influenced by

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the screw speed. A high axial mixing and low residence time obtained at high screw speed reduced the oversized (>1400 μm) and increased the fine (<150 μm) fractions. The material throughput has no significant effect upon axial mixing, but it dominantly controls the solid-liquid mixing. More variations in granulation liquid distribution were observed at a low throughput condition. However, a better solid-liquid mixing at high throughputs yielded more oversized particles.

Conclusion:

The results from this experimental study improved our understanding of the granulation time, the back-mixing and the solid-liquid mixing responsible for the granulation yield after twin-screw granulation. Furthermore, the residence time and particle size results are crucial for physical twin-screw granulation modelling and optimization of the process.

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