The Sticking and Crystallisation of Amorphous Lactose

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ABSTRACT

Amorphous lactose has been identified as being one of the major factors in causing stickiness and caking problems when producing and storing dairy powders. Amorphous lactose becomes sticky when its glass transition temperature is exceeded. Above the glass transition temperature it changes to a state where it is a very viscous liquid, and it can flow and build bridges between particles, causing them to become stuck together. Stickiness in amorphous substances depends on the viscosity of the substance, which is a function of how far above the glass transition temperature the actual temperature of the powder is. This work details investigations into the rate and extent of sticking in amorphous lactose, at different temperatures above the glass transition temperature, to find what conditions should be avoided when processing and storing powders containing amorphous lactose.

Methods for predicting the glass transition temperature of amorphous lactose as a function of water activity and moisture content were identified. The glass transition temperature of pure amorphous lactose can be estimated from the moisture content, but in a commercial dairy powder the presence of other components makes this a very difficult exercise. It was concluded that the best way to estimate the glass transition temperature was from a water activity measurement, using a third order model fitted to the available glass transition temperature data.

It was found that the sticking behaviour of amorphous lactose depends on how far above the glass transition temperature it is, irrespective of the temperature and humidity conditions required to achieve this. From investigations into the rate of sticking of amorphous lactose it was found that 25°C above the glass transition temperature amorphous lactose becomes very sticky instantaneously. As such, moisture and temperature conditions that cause the glass transition temperature to be exceeded by this amount should be avoided in all regimes of powder processing. It is also recommended that for processing operations where particle contact times are of the order of a few seconds to a few minutes, the temperature should not be allowed to exceed the glass transition temperature by more than 10°C in order to avoid possible stickiness problems. For long-term storage, powders containing amorphous lactose should be kept in conditions below the glass transition temperature.

Crystallisation of amorphous lactose is recognised as contributing to caking problems, through moisture release and solidification of amorphous bridges. A model for amorphous lactose crystallisation has been confirmed by newly published data. Further crystallisation data is still required at low humidities and high temperatures, but the current model can be used to predict crystallisation rates with reasonable confidence.

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