IFPRI Project Abstract

Spray Drying Kinetics and Morphology

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Project Objective:

The aim of the project is to investigate the influence of rheological properties of spray solutions on morphological properties of particles during spray drying. The developed mathematical relationships are also to take into account the kinetics of drying the particles inside the drying chamber.

Approach:

The goals of the project will be achieved through the following steps:
- detailed rheological tests of water solutions of the selected substance will be performed in a wide range of concentrations and temperatures;
- tests of the co-current spray drying process of the tested solutions (for selected process conditions) will be carried out in order to obtain powders for morphological tests;
- the drop drying kinetics will be carried out in a specially designed and constructed column, in which the monodisperse chain of drops will be dried by the free fall method;
- relationships between rheological properties of solutions, drying kinetics and process parameters, and particle morphology will be determined using neural networks.

Recent Results:

The task of determining the rheological properties of the selected material, which is maltodextrin DE12, has been completed.

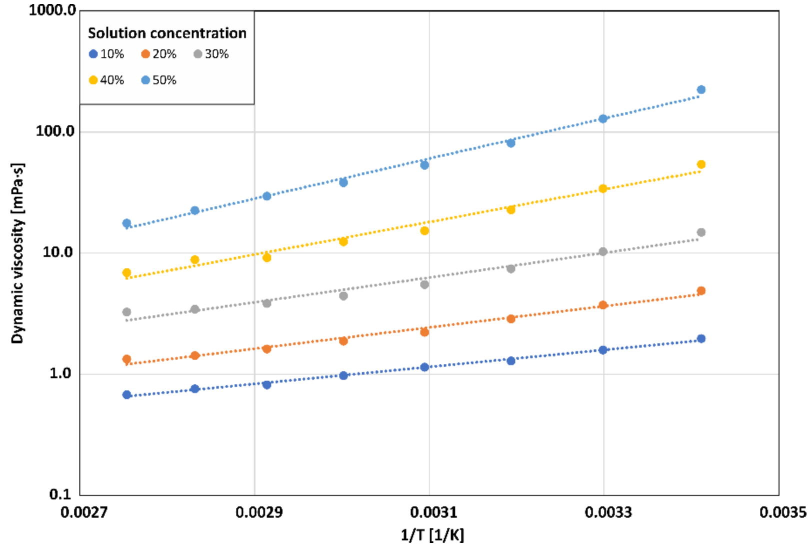
Viscosity measurements:
Rheological measurements were made with the Physica MR 301 rotational rheometer manufactured by Anton Paar. The measurements were carried out in the temperature range of 20-90 °C using a dedicated system of CC27-SN32556 coaxial cylinders used for rheological tests of low-viscosity media. The flow and the viscosity curves were determined in the range of shear rate from 1 to 500 s^{-1}.
On the basis of the flow curves made in the ordered range of temperatures and concentrations, the tested solutions showed Newtonian properties, and the value of dynamic viscosity was determined as the average value in the considered range of shear rate.

For all tested concentrations, a typical negative temperature dependence of the change in viscosity was observed, which was described by the two-parameter Andrade exponential model:

$$\eta = A \cdot \exp\left(\frac{B}{T}\right) \qquad (1)$$

where:

η -dynamic viscosity	[mPa · s]
A -pre-exponential parameter	[mPa · s]
B -temperature parameter	[K]
T -temperature	[K]



Dependence of viscosity on reciprocal of temperature for aqueous maltodextrin solutions.

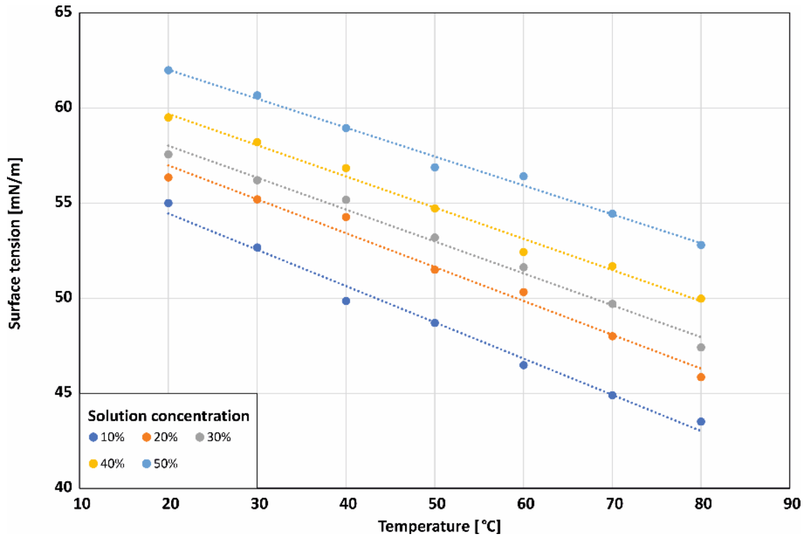
In the tested range of concentrations (10-50 %) and temperatures (20-90 °C), the change in viscosity can be described by equation (1), in which the value of coefficients A and B can be determined on the basis of equations (2) and (3), in which the weight concentration of mlatodextrin ($c_{s,0}$) is the independent variable:

$$A = -0.0002 \cdot c_{s,0} + 0.009 \qquad (2)$$

$$B = 54.702 \cdot c_{s,0} + 939.46 \qquad (3)$$

<u>Measurement of surface tension:</u>

Surface tension measurements were made with the K100 KRÜSS tensiometer using the ring method (Du Noüy) in the temperature range of 20-80 °C.



Dependence of surface tension on temperature for aqueous maltodextrin solutions

For all tested concentrations, a typical negative temperature dependence of the change in surface tension was observed (Figure 3), which was described by a linear relationship (equation 4).

$$\sigma = c \cdot T + d \quad (4)$$

Summing up, in the tested range of concentrations (10-50 %) and temperatures (20-80 °C), the value of surface tension (mN/m) can be described by the equation (4), in which the value of the coefficients a and b can be determined on the basis of equations (5) and (6), in which the independent variable is the weight concentration of maltodextrin ($c_{s,0}$):

$$a = 0.0009 \cdot c_{s,0} - 0.1978 \quad (5)$$
$$b = 0.1601 \cdot c_{s,0} + 56.838 \quad (6)$$

Measurements of the surface tension were not carried out at the temperature of 90 °C due to the too high probability of solvent evaporation due to the large free surface of the liquid in a dedicated, factory measuring vessel. High temperature and large contact surface with air lead to local concentration of the solution, which could lead to measurement errors related to the change of concentration.
In addition, in the case of tests carried out at high temperatures over concentrated solutions (40 and 50 % by weight), the formation of a film layer on the surface was observed, the existence of which would additionally disturb the correctness of the measurement.

Next Steps:

In the next year of the project, the following will be performed:
- reconfiguration of the drying installation to a co-current system,
- spray drying tests in accordance with the design plan,
- the beginning of the construction of a column for measuring the drying kinetics of a single drop.