Drying kinetics and packing of particles of silica-water nanofluid droplets dried in an acoustic levitator

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Abstract

In many industrial applications such as ceramics, food products, detergents and pharmaceuticals, the spray drying process is used to produce powders with different characteristics. Drying models predicting the drying kinetics of single droplets can be used to relate the final powder properties (such as the final grain diameter, mean porosity, compacity, morphology, microstructure, etc.), with the spray dryer design and process parameters.

The drying models available can be classified in different categories. Drying models based on reaction engineering approach (REA) have been found promising due to its simplicity and high accuracy at different drying conditions. However, the model applicability is limited by the range of materials whose drying behavior has already been experimentally studied.

In this work single droplets of silica-water nanofluids (Aerosil 200) were dried in an acoustic levitator under different experimental conditions of initial solid mass load (0.02 w/w < Y_S < 0.20 w/w), *pH* value (2 < *pH* < 10), salt concentration (0 M < *[NaCl]* < 0.05 M), air temperature (80ºC < *T* < 120ºC), and initial droplet volume (0.3 µl < V_0 < 0.8 µl). The drying curves (*X*=f(t)) were experimentally obtained for each test conducted and the REA model was used to model the experimental data. To do this, correlations for the activation energy were obtained for this system at different drying conditions. These correlations enlarge the database existent which only contains activation energies for materials used in the food industry. Theoretical curves show a good agreement with the experimental data.

For each experiment the critical moisture content was obtained experimentally and theoretically from the drying curves, showing a good agreement. The final grain diameter can be related with the critical moisture content by means of a mathematical equation. The results obtained were compared with those resulting from the image processing of the videos recorded for each experimental test. The theoretical results show a good agreement with the experimental ones.

Finally, the packing of particles inside the droplet has been checked to be constant for a particular system and equal to the random close packing. The packing fraction in independent on the solid content, the drying temperature, the *pH* of the suspension, the salt content and the initial droplet volume. This packing can be obtained from the modelling of the viscosity data to the Quemada equation. For nanoparticles the value of the packing fraction is lower than for hard microparticles due to the presence of cohesive forces that difficult the movement and rearrangement of particles.

The final diameter and the packing fraction were used to calculate the shell length and the degree of hollowness of the grains. Experimental and theoretical results for the shell length and the ratio shell length/grain diameter show a good agreement.

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