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Visualization and quantification of freeze drying processes with neutron imaging

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Neutron radiography and tomography are very efficient imaging techniques that allow visualization and study in-situ the kinetics and major effects of primary freeze-drying. The methods complement the classical measurement techniques in freeze-drying that only indirectly obtain the relevant information based on the measurement of usually pressure and temperature. The main advantage of neutron imaging is the possibility to observe the drying process in-situ in a fully equipped set-up; this has never been presented before. It allows accurate track of the position of the sublimation front which is not possible with the classical tools. Based on this we could study for the first time the dependence of the local velocity of the sublimation front on the drying conditions. For example, we were able to visualize that the structure of the sublimation front basically depends on the particle size of the freeze drying product. Further experiments for a systematic study of the interrelation of particle size, solid content and drying conditions are already in preparation. They are necessary to identify the limits of freeze-drying regimes that depend on the process conditions. In the user meeting we will present the results from measurements at FRM-II and at PSI (Villigen/Switzerland). We will highlight the major outcomes and discuss the modifications required for future measurements.

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