CRYSTALLINE VS. AMORPHOUS: PREDICTING AND CONTROLLING PARTICLE FORMATION IN RAPIDLY EVAPORATING AEROSOL MICRODROPLETS

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The drying of droplets in the aerosol phase to form solid microparticles is of fundamental importance to a range of industries, particularly spray-drying wherein powdered products for pharmaceuticals, food and cosmetics are produced from rapidly drying an aerosolised feed solution. The resulting particle size, morphology and degree of crystallinity, whilst crucial for the desired product, can be very sensitive to the drying process, and hence to the processing conditions. In this work we are studying the propensity for crystallisation in a rapidly evaporating droplet, to understand what governs crystallisation or amorphous particle formation in a spray-dryer.

Using an Electrodynamic Balance (EDB) we levitate a single liquid droplet (radius ~ 25 µm) and collect the elastic light scattering pattern from a 532 nm laser that illuminates the droplet. Using the scattering phase function and the geometric optics approximation we can calculate the droplet radius throughout the drying process and distinguish between crystallisation and the formation of an amorphous particle.[1] We can thus measure the drying kinetics and propensity to crystallise for droplets containing a range of components (inorganic, organic or mixtures, e.g. $NaNO_3$, KNO_3, NaCl, lactose, sucrose) in different drying conditions. Using SEM imaging analysis, we can relate the final dry-particle morphology to the evaporation kinetics. By the addition of co-components to the initial droplet solution we can induce, prevent or delay crystallisation in an evaporating droplet of an aqueous inorganic salt (see Fig. 1). We thus present a step closer to ultimately predicting and controlling product morphology and degree of crystallinity in the products of spray-drying processes.

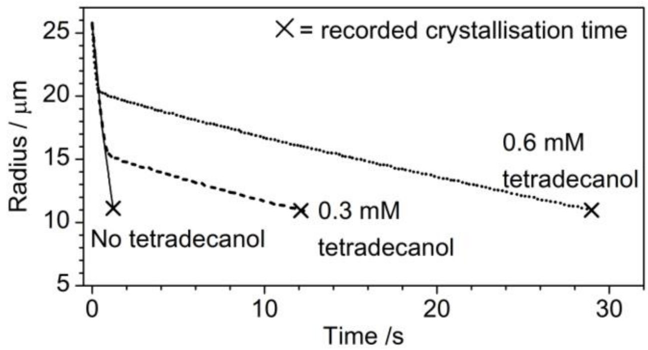

Figure 1: An example of a technique to delay crystallisation in a salt solution droplet in the EDB. A droplet containing NaCl (10% wt/wt), ethanol (45%) and water (45%) evaporates and crystallises at ~ 11 µm but with increasing amounts of a small addition of surface-active alcohol which reduces the evaporation rate, we delay the crystallisation time.

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REFERENCES:

1. Gregson, F. K. A., Robinson, J. F., Miles, R. E. H., Royall C. P., and Reid, J. P., Drying Kinetics of Salt Solution Droplets: Water Evaporation Rates and Crystallization, *J. Phys. Chem. B*, **2018**, *123*, 266.