Novel Experimental Method Indicates Proteins and Peptides are Protected from High Gas Temperatures during Spray Drying

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Purpose: Experiments on single suspended droplets have indicated that high temperatures in the liquid phase can occur during droplet drying in a hot gas stream [1]. It has been suggested that droplets heat up to similarly high temperatures during spray drying processes with a potentially detrimental effect on active pharmaceutical ingredients. This paper studies the temperature history of droplets under typical spray drying conditions for the production of respirable pharmaceutical powders.

Methods: A novel experimental method allows the direct measurement of evaporation rates of individual droplets traveling in a heated, laminar gas flow. Droplets were produced by a droplet-on-demand generator, injected into a gas environment that was representative of spray drying conditions, and their sizes were measured using laser light scattering at several points during the evaporation process. The experimental results are compared to a numerical model of the coupled heat and mass transfer process.

Results: The measured evaporation rates of pure water droplets subjected to gas temperatures between 25–150 ºC ranged from 1.31–10.26 $\mu m^2/ms$, which is within 4% of the rates predicted by the numerical results. Experiments with droplets containing pharmaceutical formulations show that, for a droplet size and formulation concentration range of practical interest, the evaporation rate is not significantly diminished by the presence of a shell on the surface. Consequently, the droplet temperature does not rise above the wet bulb temperature of a pure water droplet.

Conclusions: During spray drying of respirable particles, the liquid phase does not heat beyond the wet bulb temperature for most of the drying process. The active pharmaceutical ingredients are protected by evaporative cooling until the evaporation is nearly complete, and the proteins are already immobilized and protected in a glassy matrix.

1. Lin, J.-C. and J.W. Gentry, Aerosol Science and Technology, 2003. **37**: p. 15 - 32.