ESRF	**Experiment title:** Investigation of the mechanisms of inhaler dose release within commercial actuators using high speed phase contrast X-Ray imaging	**Experiment number**: ME1466
Beamline: ID19	**Date of experiment**: from: 13/09/2017 to: 14/09/2017	**Date of report**: 12/07/19
Shifts: 3	**Local contact(s)**: Alexander Rack, Margie Olbinado	*Received at ESRF:*

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Report:

We combined and synchronised High-Speed Phase Contrast X-Ray Imaging and Schlieren Imaging and carried out experiments on a number of commercial inhaler actuators and formulations at a range of flow rates in order to visualise and correlate the internal and external flow dynamics. The assistance and facilities were excellent, the experiments were successful and a very large dataset of high-speed video was acquired for subsequent analysis.

The work has been published in:
Pharm Res (2019) 36:120
https://doi.org/10.1007/s11095-019-2657-9

Poster Prize (biological applications) at:
The 32nd International Congress on High-Speed Imaging and Photonics (ICHSIP-32)

Pharm Res article abstract:

Purpose: The first pressurised metered dose inhaler (pMDI) was introduced in 1956. Even with excellent inhaler technique typically only 20% of the dose deposits in the lungs where needed. It is hoped that a better understanding of the initial plume formation and expansion during dose release can help improve modelling,

devices and ultimately transport to the lungs. We have used two high-speed imaging techniques to investigate the transient dose event.

Methods: Synchrotron phase-contrast X-Ray imaging is a technique that is sensitive to variations in the refractive index of materials in the X-ray region. Similarly, Schlieren imaging is an optical technique sensitive to the refractive index gradients which are often present in pMDI plumes due to gas density variations. We have combined and synchronised both techniques to investigate three commercial pMDIs actuators during dose release for various actuator/formulation combinations.

Results: We have observed temporal phases of propellant flowing in the orifice channel. At early times flash boiling takes place and drives gas emission, steep plume density gradients and liquid jets/droplets at the orifice. Evaporating liquid is present in the sump long after the dose is finished. Regional counter-flow is seen in plumes emitted into a mouth-throat geometry.

Conclusions: As the foamy liquid-vapour mixture is forced out of the sump and into the orifice the liquid walls of the bubbles break into fragments which are forced out of the sump and tend to form a liquid-gas flow in the orifice channel. The period of high density plume observed by the schlieren technique corresponds to flash-boiling-driven liquid exiting the orifice channel.