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Time resolved measurements of medical inhaler sprays at the Advanced Photon Source

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In the search for new and improved medical inhaler devices for the treatment of asthma and other pulmonary diseases, pharmaceutical device makers must understand how small changes in drug properties and the design of the delivery device can affect the properties of the micron-size droplets these devices produce. The scientific challenge underlying this effort is that dense liquid sprays present a very challenging measurement environment. The density of gas-liquid interfaces inside the spray scatters visible light so effectively that the spray becomes opaque. The time and length scales present in these sprays are typically on the order of microseconds and microns. As a result, the laser based techniques which the industry has relied on for decades are no longer able to deliver all the answers to the challenges they currently face. At the Advanced Photon Source at Argonne National Laboratory in Illinois USA, researchers from Monash University are working with beamline scientists from Argonne's Time Resolved Research group (Sectors 7-BM and 9-ID) to use synchrotron radiation to address these challenges. X-rays are not scattered as strongly as visible light by the droplet field, allowing us to probe inside the dense regions near and inside the inhaler nozzle where laser diagnostics cannot. This allows us to see in great detail for the first time the complex fluid mechanics that occur in these devices. A range of techniques have been applied. Time resolved X-ray radiography provides a quantifiable density distribution in the spray. Time resolved X-ray fluorescence spectroscopy allows us to track the drug concentration independent of any other chemicals in the formulation throughout the spray, as many common inhaled drugs contain tracer elements such as bromine. Ultra-fast X-ray phase contrast imaging also reveals the qualitative structure of the liquid-gas interfaces in the device itself. Most recently, ultra small angle X-ray scattering has allowed us to make average composition measurements of the droplets in flight, in the dense region of the spray where the droplet size is ultimately determined. The insights gained through these measurements will enable the development of more physically robust models which can then be used in the development of new devices. The research also aims to address some major open questions about the physics of how droplets form in medical inhaler sprays. This work is supported by the Australian Research Council and Chiesi Limited through the DECRA and Linkage Project schemes. Travel to the APS for Monash Researchers was made possible through an International Synchrotron Access Program grant from ANSTO and the Australian Synchrotron.

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