New droplet-on-tape method assists biochemical research at X-ray lasers

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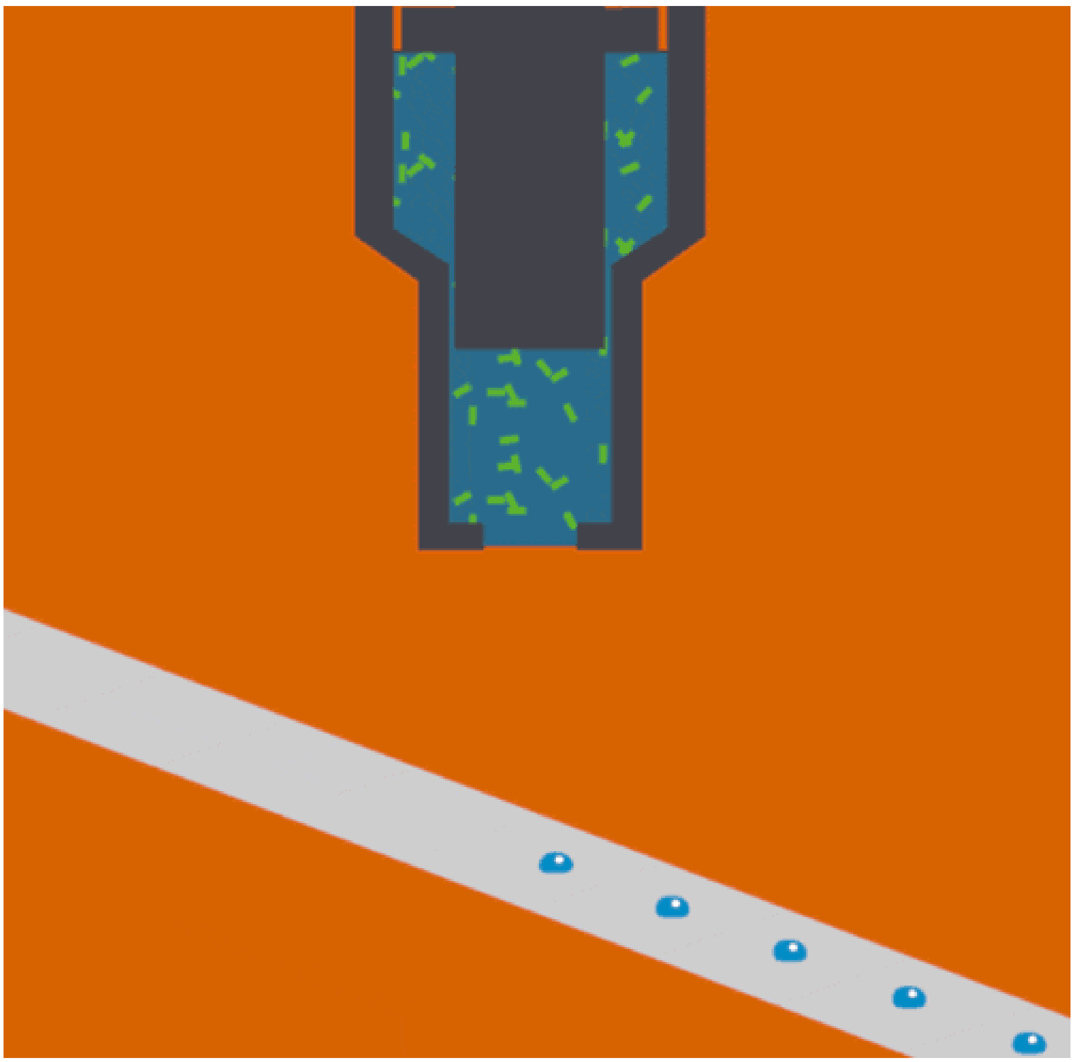


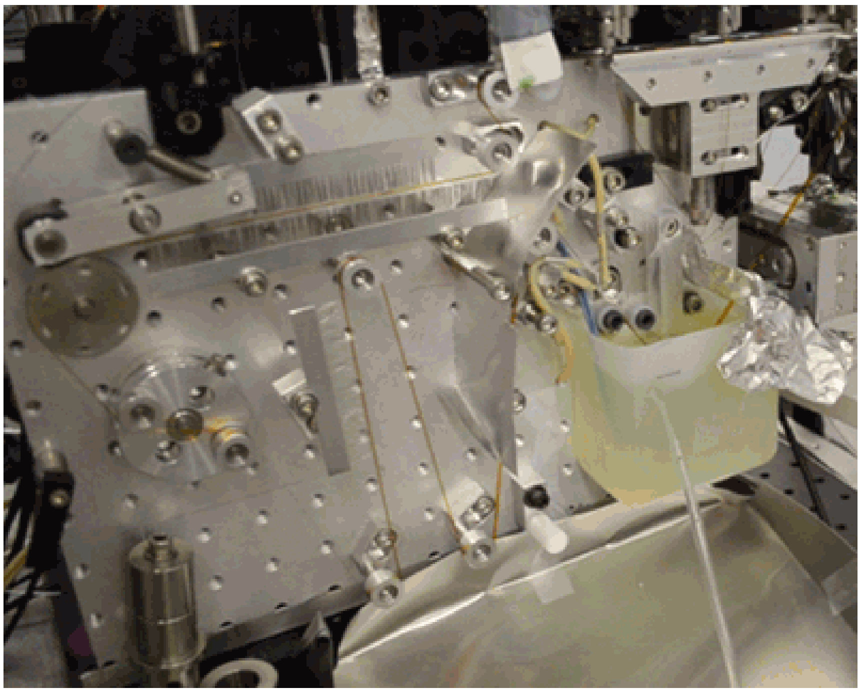
Acoustic droplet ejection allows scientists to deposit nanoliters of sample directly into the X-ray beam, considerably increasing the efficiency of sample consumption. A femtosecond pulse from an X-ray free-electron laser then intersects with a droplet that contains protein crystals. Credit: SLAC National

Biological samples studied with intense X-rays at free-electron lasers are destroyed within nanoseconds after they are exposed. Because of this, the samples need to be continually refreshed to allow the many images needed for an experiment to be obtained. Conventional methods use jets that supply a continuous stream of samples, but this can be very wasteful as the X-rays only interact with a tiny fraction of the injected material.

To help address this issue, scientists at the Department of Energy's Lawrence Berkeley National Laboratory, SLAC National Accelerator Laboratory, Brookhaven National Laboratory, and other institutes designed a new assembly-line system that rapidly replaces exposed samples by moving droplets along a miniature conveyor belt, timed to coincide with the arrival of the X-ray pulses. The droplet-on-tape system now allows the team to study the biochemical reactions in real-time from microseconds to seconds, revealing the stages of these complex reactions.

In their approach, protein solution or crystals are precisely deposited in tiny liquid drops, made as ultrasound waves push the liquid onto a moving tape. As the drops move forward, they are hit with pulses of visible light or treated with oxygen gas, which triggers different chemical reactions depending on the sample studied. This allows the study of processes such as photosynthesis, which determines how plants absorb light from the sun and convert it into useable energy.

Finally, powerful X-ray pulses from SLAC's X-ray laser, the Linac Coherent Light Source (LCLS), probe the drops. In this study published in Nature Methods, the X-ray light scattered from the sample onto two different detectors simultaneously, one for X-ray crystallography and the other for X-ray emission spectroscopy. These are two complementary methods that provide information about the geometric and electronic structure of the catalytic sites of the proteins and allowed them to watch with atomic precision how the protein structures changed during the reaction.



Droplet-on-tape conveyor belt system delivers samples at the Linac Coherent Light Source (LCLS). Credit: SLAC National Accelerator Laboratory

More information: Drop-on-demand sample delivery for studying biocatalysts in action at X-ray free-electron lasers. *Nature Methods* (2017) DOI: 10.1038/nmeth.4195

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