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3D-Printed Microfluidic Device Featuring Electronically Triggered Droplet Generation and Injection for Serial Crystallography

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Background

Serial femtosecond crystallography (SFX) with recent advances in X-ray free electron lasers (XFELs) is a revolutionary technique for determining the structure of macromolecules at ambient temperature. It has enabled the study of large membrane protein complexes at atomic resolution and their reaction dynamics, previously considered impossible by traditional crystallographic methods. In SFX experiment with XFELs, each crystal hit by the XFEL is destroyed, requiring the sample to be replenished between X-ray pulses by continuous injection of crystal suspension. Large amounts of sample are required to collect a complete X-ray diffraction dataset since sample delivered in the path of the X-ray beam during its "off time" is wasted. In some cases, up to 1 gram of protein is required while wasted protein can be as high as 99% of the prepared sample. Addressing these challenges would therefore improve the efficiency and cost effectiveness of SFX with XFELs.

Invention Description

Researchers at Arizona State University have developed a 3D-printed microfluidic device for generation and manipulation of water-in-oil droplets by electrical triggering for injection into an X-ray beam path. Droplets of aqueous crystal suspension are generated in the device's T-junction and are coaxially focused into a jet by helium gas in the nozzle. Electrodes at the T-junction allow for electrical control of droplet generation frequency, from 10 Hz to 120 Hz. Through pulsing of sample droplets using this monolithic hybrid device, significantly less sample will be consumed in SFX with XFEL experiments.

Potential Applications

- Serial femtosecond crystallography (SFX) with X-ray free electron lasers (XFEL)
- Protein structure analysis

Benefits and Advantages

- Controlled injection results in reduced sample volume consumption
- Compatible with current XFEL environments both in vacuum and ambient atmospheres

Laboratory Homepage of Professor Alexandra Ros