Visualization of Various Biofluid Flow Phenomena using X-ray Micro-imaging Technique

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Abstract

A highly coherent x-ray beam provides phase-contrast images. The phase-contrast imaging method shows phase differences at boundaries between internal components of a test sample. To visualize the internal structures of opaque bio-samples with high spatial resolution, we established an x-ray micro-imaging technique in which synchrotron x-ray beam was used as a light source. The x-ray micro-imaging technique has been applied to several non-transparent biofluid flows for investigating the unrevealed transport phenomena in nature. For examples, sap flows in xylem vessels of vascular plants were quantitatively visualized to investigate the water-transport mechanism using the x-ray micro-imaging technique. The water-rise kinetics was evaluated by tracking the positional variation of waterfront meniscus or surface-treated gold nano-particles in xylem vessels from the x-ray images captured consecutively. In addition, the blood-sucking phenomena of a female mosquito were quantitatively visualized using x-ray imaging technique to conceive a new bio-mimetic technology. To measure velocity fields of biofluid flows quantitatively, we combined the x-ray micro-imaging technique and PIV velocity field measurement technique. Using the x-ray PIV technique, we could obtain the velocity field information of opaque blood flows with and without seeding artificial tracers. The x-ray micro-imaging technique was found to be very useful to get flow information of micro-scale biofluid flows and will play an important role in visualizing unknown bio-fluid flow phenomena, for which conventional methods have difficulties to overcome.

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