Nanoscopic Laser Induced Fluorescence for Concentration Measurement

Cuifang, Kuang; Guiren Wang
Department of Mechanical Engineering and Biomedical Engineering Program,
University of South Carolina, Columbia, SC, USA; guirenwang@sc.edu

Abstract

In fluid mixing study, measurement result of the unmixedness or segregation intensity strongly depends on the spatial resolution of the measuring technique. If it is space-resolved (i.e. the spatial resolution is smaller than a given space volume to be measured), the non-uniform concentration can be discerned in the volume. However, if the spatial resolution is larger or poor than the volume to be measured, any unmixedness or non-uniformity in concentration cannot be measured. In all mixing process, small scale scalar structures play a key role for ultimate molecular mixing. The small scalar scale can be in the range of nanoscale to microscale, i.e. 10 nm -100 μm. Therefore measuring technique for mixing measurement requires the spatial resolution of ~ 10 nm, if we want to study the fine scale structure for fundamental understanding of mixing mechanism.

Today, laser induced fluorescence (LIF) has become one of the most important techniques to measure concentration for mixing study. The spatial resolution of LIF is dictated by the diameter of the focused laser beam. Unfortunately the focused beam cannot be arbitrarily small and is limited by the classical Abbe's diffraction limit in physics. Based on this diffraction limit, the focused beam waist is about half of the wavelength of the visible light, i.e. ~ 250 nm for a blue laser beam of 488 nm. In reality due to imperfectness of optical path, such as alignment and aberration of lens, etc, the actual resolution is poorer than the theoretical limit. Any unmixedness within this spatial limit will not be detected.

In order to overcome the diffraction limit to increase the spatial resolution, a revolutionary technique, Stimulation Emission Depletion (STED), has recently been developed in nanobiophotonics. STED can significantly improve the spatial resolution. Our lab has recently developed a continuous wave (cw) laser STED system to enable a measurement with spatial resolution better 70 nm. In this presentation, we introduce this breakthrough technique and our lab's STED system, for future fluid mixing research.

In summary, the STED could provide a promising novel technique in exploring the mixing mechanism in nanoscale spatial resolution.

keywords: Stimulation Emission Depletion (STED), laser induced fluorescence (LIF), Abbe's diffraction limit, Nanoscopic Laser Induced Fluorescence, mixing measurement.

Contact Author's Information:

Guiren Wang
Department of Mechanical Engineering
& Biomedical Engineering Program
University of South Carolina
300 Main Street
Columbia, SC 29208, USA
Tel: (803) 777-8013
Email: guirenwang@sc.edu

Presenting Author's Information:

As above: Yes

Please specify whether you wish to be considered for an oral x□ or poster □ presentation.

Do you anticipate submitting a full paper to the special Mixing issue of the Canadian Journal of Chemical Engineering? Yes