Paper 12.1

Quantitative imaging of large-scale structures and molecular mixing in gaseous free shear flows

T. R. Meyer,[*] G. F. King,[**] G. C. Martin,[*] R. P. Lucht,[†] F. R. Schauer,[‡] and J. C. Dutton[*]

[*]University of Illinois, Urbana, IL 61801, USA

[**]3M Corporation, St. Paul, MN 55144, USA

[†]Texas A&M University, College Station, TX 77843, USA

[‡]Air Force Research Laboratory, Wright-Patterson AFB, OH 45433, USA

ABSTRACT

Previous investigations have demonstrated that it is possible to obtain quantitative images of subresolution molecular mixing in free shear flows using chemically reactive tracer species. The advantage of such techniques over highly-resolved measurements is their ability to obtain molecular mixing data over the entire flowfield, and as such, to study the effects of large-scale motions on molecular mixing. In gaseous flows, this has been accomplished using simultaneous cold-chemistry (nitric oxide) and passive scalar (acetone) planar laser-induced fluorescence. The current work summarizes the theoretical and experimental bases for this technique, discusses the unique advantages of using simultaneous tracers, and analyzes various sources of error and uncertainty that can degrade quantitative accuracy. Such errors can result from the use of nitric oxide quenching corrections, differential diffusion of tracer species, and finite imaging spatial resolution. Results from experimental measurements are presented in conjunction with a direct numerical simulation of species transport in a driven axisymmetric jet.