Fluorescence-Doped Particles for Simultaneous Temperature and Velocity Imaging

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Abstract

In this project, we are developing, characterizing and implementing micron-sized particles for measurements in wind tunnel that have additional capability beyond the state of the art. Particles are routinely used in wind tunnels as flow tracers, and for laser Doppler velocimetry (LDV) and particle image velocimetry (PIV) measurements of velocity. However, there are several applications where conventional particles do not work well, for example, close to solid surfaces or near air/water interfaces. To address these shortcomings, as well as enable novel fluid flow characterization techniques, we have researched production and characterization of multifunctional polystyrene latex microparticles, PSLs. With the new approach, we are doping the particles with fluorescent dyes to provide: temperature sensitivity, pressure sensitivity, spectral separation of the emitted fluorescence from the laser source (providing improved signal-to-noise ratio and rejection of spurious scatter) and response to other environmental factors. An example of PSL multifunctionality is PSLs doped with fluorescein derivatives, which allows temperature and velocity to be measured simultaneously either at a point (LDV) or in a plane (PIV). Ideally, the doped particles should be non-toxic allowing for their use in NASA's large scale wind tunnels.

Progress has been made in several aspects of the project: 1) Several batches of particles were synthesized incorporating a variety of commercially available dyes including rhodamine B, fluorescein 27, Kiton red, tetraphenyl porphyrin, and other compounds. 2) The influence of dye incorporation on PSL particle size and distribution has allowed generation of dye-doped PSLs with characteristics amenable to customer use, i.e., particle size distributions of target particle diameter ±15%. 3) Research uncovered complex behavior between a fluorophore of interest, fluorescein 27, and ambient moisture levels of central importance for use in wind tunnel experiments. 4) Changes in fluorescent properties for other dye materials incorporated into the PSL have been uncovered. This potentially will enable tuning of fluorescent properties of the dye-doped PSLs for specific experimental conditions. The developing library of dye-doped PSLs could be utilized in a variety of experiments including two phase flow systems, single phase-multiple source flow mixing behavior, etc. Customers (external as well as NASA internal) have been identified and sample particles are being provided for an array of research efforts spanning from aerodynamic characterization experiments to novel heart valve replacement architectures.