411c Gas Entrainment Measurement in Spray Flames for Particle Synthesis

Martin C. Heine, Lutz Mädler, Rainer Jossen, and Sotiris E. Pratsinis

Using Phase Doppler Anemometry the scale of turbulence and the spray dilution by entrainment are investigated during nanoparticle synthesis by flame spray pyrolysis (FSP). Ethanol and a solution of 0.5 M zirconium-propoxide in ethanol are dispersed and combusted using an external-mixing gas-assisted atomizer resulting in ZrO_2 particles of 11.3 nm at a production rate of 100 g/h. Droplet size distributions of the solid cone spray are measured and related to standard correlations of spray atomization. Air entrainment and the radial spread of the expanding jet are determined from the gas velocities in horizontal planes across the spray cone at different heights above the nozzle. The isotropy of the turbulence is investigated using measured axial and radial velocity fluctuations. The turbulent flow is characterized by the integral time and Kolmogorov scales as well as the average shear rates acting on droplets and particles. The flow structure of these spray flames is of major importance as it determines species transport and mixing, flame quenching by air entrainment, and subsequently the particle residence time at elevated temperatures that determines the all-important product particle size, polydispersity, morphology and crystallinity.