Evaluation of particle sizes of iron-oxide nano-particles in a low-pressure flame-synthesis reactor by simultaneous application of TiRe-LII and PMS

B. Tribalet, A. Faccinetto, T. Dreier, C. Schulz

Institute for Combustion and Gasdynamics (IVG), and Center for Nanointegration (CENIDE), University of Duisburg-Essen, 47048 Duisburg, Germany, ***thomas.dreier@uni-due.de***

Laser-induced incandescence (LII) has become a common method for in-situ analysis of particle size and visualization of particle volume fractions predominantly for soot diagnostics in a wide range of applications. Besides lower signal strength due to less strongly absorbing material and lower heat-up temperatures, one of the main challenges when applying LII to non-carbon nanoparticles is the poor data base of relevant particle thermophysical properties, e.g., heat conduction, accommodation coefficients, vaporization enthalpy and high-temperature chemistry for describing particle cooling due to convection, vaporization, and other effects. In the present work the measured laser-induced emission signals from flame-synthesized iron oxide (Fe_2O_3) nanoparticles were evaluated in terms of particle sizing by using a modified version of the TiRe-LII model developed by Kock et al. [1].

Iron oxide nanoparticles were synthesized in a rich, premixed H_2/O_2/Ar low-pressure (30 mbar) flat flame in a low-pressure flame reactor that was doped with ppm-levels of $Fe(CO)_5$ as precursor material. By moving the burner relative to the fixed measurement location (determined by either the laser beam or a sampling nozzle for the particle mass spectrometer (PMS), respectively) the particle residence time in the reactor can be varied. The particles were heated by a frequency-doubled Nd:YAG laser and time-resolved LII-signal traces were recorded perpendicular to the beam axis by a two-color detection unit equipped with narrow band-pass filters with center-wavelengths at 500 and 700 nm, respectively, in front of two high-speed photomultipliers with integrated amplifiers. Additional to the time-resolved measurements, LII signals were detected spectrally-resolved using a spectrometer with an intensified CCD camera. The PMS with a molecular-beam sampling system was attached to the burner chamber for simultaneous particle sizing.

To determine a phenomenological evaporation heat flux term in the energy balance, temperature decay curves obtained by two-color pyrometry were fitted through variation of a parameterized form of the particle evaporation term. With these evaporation parameters, LII-signal traces were evaluated in terms of particle size. The obtained size parameters were verified by corresponding PMS measurements for the same flame conditions. In addition, it was possible to calculate the energy accommodation coefficient α_T of the present particle material at several experimental conditions. Emission spectra taken right after laser heating did not vary significantly in shape as a function of laser fluence.

The combination of TiRe-LII and online molecular beam particle sampling with subsequent particle mass spectrometry in low-pressure flames is a promising approach for fundamental research on the characteristics of LII of various nanoparticle materials.

Preference: Poster Presentation

1. B. F. Kock, B. Tribalet, C. Schulz, and P. Roth, "Two-color time-resolved LII applied to soot particle sizing in the cylinder of a Diesel engine," Combust. & Flame **147**, 79–92 (2006).