Determination of the dimensionless extinction coefficient for soot generated by a PMMA flame

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Experimental soot concentration data in flames are useful for the validation of soot production and radiation models. Among the experimental methods available in order to determine soot volume fractions in fluid flows, Laser Induced Incandescence (LII) is a powerful method allowing to determine local soot volume fractions. Now, this technic is mature enough to be applied to more and more complex situations including in the field of fire studies, as in the present study. LII has been applied to the determination of soot volume fraction fields in the flame of a vertical PMMA slab. Indeed, during solid material combustion, the fuel pyrolysis is a key phenomenon, which depends on the heat transfer between the flame and the unburnt material [1]. So, as a source of radiation, soot particles play an important role in the solid material combustion.

An important step of the LII signal analysis is the calibration, in order to determine the relationship between the LII signal and the soot volume fraction [2]. The most-used approach for calibration consists in measuring the light extinction coefficient K_{ext}, which depends on soot volume fraction f_v. K_{ext} is also a function of soot particle morphology and of the optical index of the soot matter, which varies with the wavelength. But much of the optical index or K_{ext} data for soot have been determined from measurements in gaseous or liquid fueled flames but few for the solid combustion. Additionally, K_{ext} has been usually determined ex-situ for soot samples at ambient temperature [3]. Therefore one can wonder if the soot optical properties at standard or flame temperatures can be considered similar. The present work focuses on this question.

In this context, the spectral value of K_{ext} has been measured by using in-situ extinction measurements with a white laser beam (Leukos) crossing the flat flame of a PMMA slab. With the same experimental setup, K_{ext} is also determined in a gaseous fueled flame generated by a bronze porous burner and fed with a mixing of methane and ethylene. So the determined K_{ext} coefficients are relevant of the soot optical properties at high temperatures. In order to observe the influence of the soot temperature on the spectral variation of K_{ext}, it has been also determined by ex-situ measurements after sampling of soot in the flame [4]. This sampling has allowed additional measurements, the agglomerate soot particle size using a Scanning Mobility Particle Sizer (SMPS) and the mass concentration with a Tapered Element Oscillating Microbalance (TEOM).

The experimental results are analyzed to compare the spectral variations of K_{ext} in the 400-1100 nm range. Finally, different evaluations of the dimensionless extinction coefficient $K_e=K_{ext}/f_v$ are proposed corresponding to soot generated by gaseous or solid combustion at standard or flame temperatures. A quantitative comparison with the values found in the literature is presented.

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