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Study of the effect of soot aggregation on thermal radiation: application of DDA on 3D combustion soot obtained by SEM tomography.

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Morphology and radiative properties of soot is of interest to many researchers working on environmental aerosol and combustion diagnostics. In this study, different than previous researches, the thermal radiative properties of combustion soot are obtained for a real 3D complex shape of soot aggregate.

Due to the limitations and uncertainties arising from in-situ measurements in combustion flames for a dispersed group of aggregates, ex-situ observations under microscopy of samples collected inside the flame are often referred to in the literature [1]. There exist studies considering the 3D geometry of aerosol samples obtained by TEM tomography [2], the fractal definition and numerical generation or the 2D image analysis of emitted soot [1,3]. In our previous work [4], a preliminary SEM tomography was successfully applied for the very first time on a soot aggregate sampled directly from a combustion flame. This aggregate was extracted from a laboratory scale rich propane-air flame, and the 3D shape of the soot was obtained by applying a tomographic reconstruction technique based on the high-resolution SEM images. This tomographic reconstruction is much richer in terms of information than the classical 2D analysis technique for complex morphology description.

The reconstructed 3D geometry of soot is discretized and then submitted to our DDA code, formerly tested and applied on test geometries and numerical aggregates [5], in order to evaluate the soot radiative properties. In between other methods such as T-Matrix and GMM, DDA was retained for its ease of applicability on random geometries.

Finally the DDA results on the absorption and scattering from the real 3D soot are compared to our previous results [6] on numerically generated fractals. The effect of the real agglomerated geometry is studied for different volume concentrations. The compatibilities and the discrepancies between the real soot and the numerical fractal aggregate will be presented in terms of the thermal radiative properties and their subsequent effect on the radiative heat flux within a fuel-rich combustion chamber.

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