A new experimental device for the thermophoretic velocity measurements of nanoparticle soot aggregates

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During the last decades, several studies shows that nano-particles suspended in a gas with non-uniform temperature might migrate from the hot to the cold region of their surrounding gas. This motion is due to a thermophoretic force that results from the gas molecules differential bombardment on the particle surface. This phenomenon is called thermophoresis, and it appears to be a promising technique to capture nano-particles such as soot aggregates in order to prevent their harmful impact on the environment and public health. However, most of the studies were conducted with spherical particles. Indeed, due to the complex morphology of non-spherical particles such as soot aggregates, there are limited studies handling the effect of thermophoresis on this kind of particles. Mackowski (2006) proposed a numerical study showing that the thermophoretic velocity of an aggregated particle is governed by the primary particles number, those results have been experimentally confirmed by Brugière *et al*., (2013). Suzuki *et al*. (2009) have concluded experimentally that the thermophoretic velocity is governed by the primary particle size.

The main objective of this work is then to find which parameters are involved in the thermophoretic migration of non-spherical nanoparticles, this by conducting an experimental study based on the so-called penetration method. Indeed, many studies demonstrated the interest of this method, where deposition rates on a cold wall are obtained by measurement of the particles concentrations upstream and downstream of the test section. For that, we've sized and developed a new experimental tri thermal axial flow precipitator composed with two 50cm length concentric tubes, where the aerosol flows through the 1mm annular space between the two tubes. The thermal gradient is obtained by cooling the inside tube and heating the outside one. For cold and hot temperatures respectively equal to 278 and 333K, our sizing model predicted that 50% of particles will be captured by the precipitator, this with a Reynolds number equal to 77. A device calibration with polystyrene latex spheres (PSL) is being performed.

We use in this experiment soot particles produced by a propane diffusion flame (MiniCAST) generator. The MiniCAST generates soot particles with a wide range of electrical mobility diameter ($20 < d_m < 200$nm). A characterisation of these particles has been conducted for different operating conditions of the soot generator, this in order to obtain morphological parameters such as the fractal dimensions (D_f), the primary particles diameters (d_{pp}) and their number (n_{pp}). These parameters are obtained from transmission electron microscopy (TEM) images, where particles are collected by filtration on TEM grid. We also used a centrifugal particle masse analyser (CPMA) in order to obtain the particles masse (m). Table 1 present the characterisation results of five MiniCAST setting points that will be used with the thermophoretic precipitator:

Table 1. MiniCAST soot particles morphological parameters.

Pt	d_m (nm)	D_f	d_{pp} (nm)	n_{pp}	m (fg*)
1	139	1.50	22.80	47	0.785
2	123	1.66	22.73	61	0.509
3	105	1.70	19.41	75	0.314
4	86	1.55	15.16	68	0.169
5	67	1.54	14.51	47	0.092

* fg : Femtogram (10^{-18}kg)

In this study, we will present results showing the effect of the fractal dimension and the primary particles diameters on the thermophoretic velocity.

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