Soot oxidation and thermal stability of nanoparticles in flames, a SAXS approach

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The amount and the composition of nanoparticles released during combustion processes are important research topics due to their environmental and health impact. We can distinguish nanoparticles produced during the combustion processes (soot particles) from nanoparticles released during waste incineration or fires involving materials containing manufactured nanoparticles.
In the first case, soot oxidation is a key phenomenon enabling the quantity of nanoparticles produced during combustion processes (automobile, aircraft and marine ship engine emissions) to be reduced. Many in-situ studies of the size and morphology of soot particles under real flame conditions have been performed but to our knowledge, none has allowed the separate roles played by oxidation and surface growth, to be distinguished.

Concerning the release of embedded nanoparticles, which are more and more encountered in many materials, there is a lack of knowledge of the physico-chemical behaviour of NPs in reactive and high temperature conditions. As an example, recent findings obtained at KIT (Lang, et al., 2015)have demonstrated that CeO2 nanoparticles are not stable in flames while the melting temperature of these materials is significantly higher than those observed in incineration and combustion processes.

The aim of the present experiment is to study using SAXS the fate of generated upstream soot (Mini CAST 5201, (Moore, et al., 2014; Yon, et al., 2015)) and metal oxides (Ce02, Al203, TiO2, WO3) injected into a well characterized flame. Nanoparticles and additives were injected inside a premixed non-sooting flat flame burner (McKenna) and the size distribution of soot produced in the flame was investigated using SAXS (SWING beamline at SOLEIL). The main experimental originality of this bottom-up approach is the control of the injected particles in the flame that permits, for example soot oxidation to be studied, separating the oxidation process from soot formation.

Figure 1 presents an example of results obtained regarding the soot oxidation process. The fate of the soot primary particle size during oxidation at different heights above the burner (different residence time in the flame) is represented. We observe a clear decrease of the modal diameter and, more surprisingly, an increase of the geometric standard deviation.

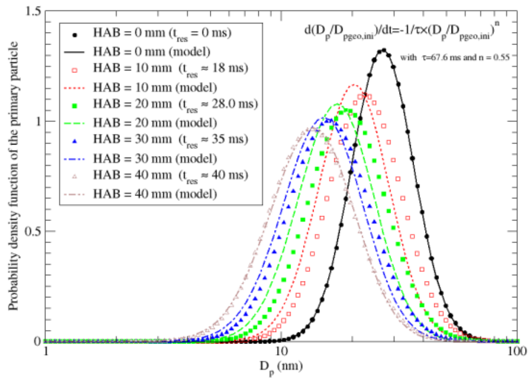

Figure 1. Impact of the oxidation process on the soot primary particle size distribution.

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