	Experiment title: A SAXS Study of the Effects of Soot Reducing Additives on Particle Size Distributions in Flames	**Experiment number**: SC-1950
Beamline: ID02	**Date of experiment**: from: 21/06/2006 to: 25/06/2006	**Date of report**: 14/02/2007
Shifts: 12	**Local contact(s)**: Dr. M. Sztucki, Dr. T. Narayanan	*Received at ESRF:*

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Report:

In previous experiments (SC 1284, SC1540), we have investigated the particle size distribution in an ethylene diffusion flame using Small Angle X-Ray Scattering (SAXS), first on the beamline ID09 but subsequently using the pinhole camera on ID02. These results have been published [1,2]

In this round of experiments, our goal has been to study the effect of soot particle sizes when known soot reducing additives are added to a flame. Experiments have been performed using an ethylene diffusion flame with and without the addition of ferrocene in the vapour phase. Ferrocene $(C_5H_5)_2$ Fe, is believed [3] to operate catalytically by decomposing in the flame and being oxidized to form iron oxide particles that serve as nucleation sites. The carbon soot grows on the particle and the intimate contact between the carbon and the oxide leads very efficiently to reactions of the type:

$$FeO + C \rightarrow Fe + CO$$
$$Fe_3O_4 + 2C \rightarrow 3Fe + 2CO_2$$

in which the carbon is oxidised and the iron oxide reduced to the metal. The iron metal is then re-oxidised in the flame so that the process can re-cycle. SAXS experiments were performed with different concentrations of added ferrocene but in fact no noticeable change in particle size was observed. This is strange given the mechanism just described. We intend to continue this study by adding ferrocene to a methane flame and looking for a measurable particle size distribution. Experiments were performed during this run just with a

pure methane flame but no soot particles were detectable. The goal of the next experiment will be then to see if indeed adding ferrocene does produce particles and if so what size. We shall await these measurements before proceeding to publication of this work.

Other additives were used in this round including alkali and alkaline-earth salts dissolved in water. These were then aspirated into the fuel line using a regulated air supply so that we had a premixed flame rather than a diffusion flame. It was found that alkaline-earth salts ($CaCl_2$ and $BaCl_2$) had no detectable effect on the particle size distribution with respect to just plain water addition, though CsCl and to a lesser extent, KCl, led to smaller particles. In fact the largest change in the particle size distribution came from the addition of water aspirated into the flame and a paper is in preparation on this subject. The role of water in combustion (extinguishment and soot reduction) is obviously of great practical interest though studies have been remarkably few.

A modelling approach was taken in the reduction of the experimental data and it was found that excellent agreement could be obtained by using a Debye-Bueche function [3] for the form factor and a Teixeira type fractal equation [4] for the structure factor.

An example of this fitting procedure for the diffusion flame at a height above the burner of 13.75 mm is shown in figure 1.

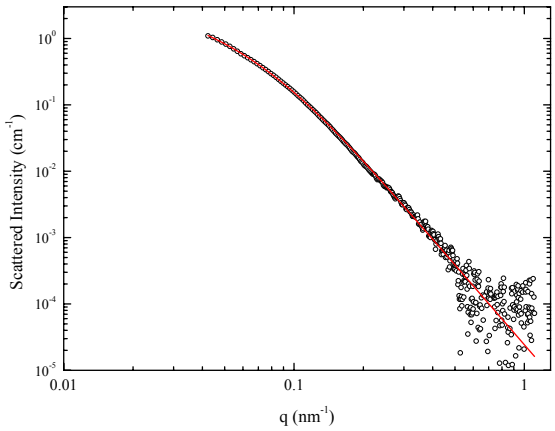

Fig. 1: X-ray scattered intensity vs q for an ethylene diffusion flame at a Height above the Burner (HAB) of 13.75 mm. The blue line is the fitting function as described in the text.

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