A resistive soot sensor for mass quantification through a correlation between conductance and soot mass loading

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Introduction

In a nuclear facility, it is important to assess the consequences of particle emissions during a fire on containment devices, such as HEPA filters. Therefore, the prediction of aerosol quantities that may clog these filters is essential. The final objective of this work is to quantify the deposit of soot particles on the walls of a fire room using a resistive soot sensor. Most of the existing particle sensors are based on the electrical properties of soot. The response of the resistive sensor corresponds to a measurement of conductance between two electrodes on which the electrical connections are established by soot bridges formation. However, no relevant correlation exists between soot mass loadings and conductance. The aim of this paper is to propose such a correlation.

Methods

For this purpose, a two-step approach was considered.

The first step consisted in quantifying the deposited masses of soot, produced by a mini-CAST burner, on resistive sensors using a thermo-optical analyser. These sensors have been developed in a previous study (Grondin et al., 2016).

The experimental setup used for soot generation and characterisation is shown schematically in Figure 1.

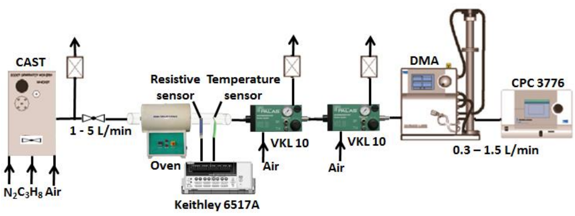

Figure 1: Experimental setup used for soot deposition.

The resistive sensor was placed downstream an oven, with the sensing side parallel to the stream direction. A K-type thermocouple was placed near the sensor to record the gas temperature (185°C). The sensor signal was monitored continuously (Figure 2) by applying a 10 V (dc) on the interdigitated electrodes while measuring the soot size distribution and concentration with DMA and CPC analysers.

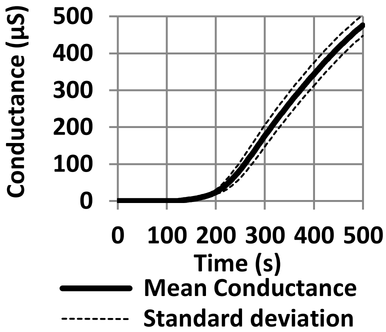

Figure 2: Conductance measurement during soot deposition experiment under 10 V of polarization

After the soot deposition experiment, the sensor was introduced in the Organic Carbon/Elemental Carbon (OC/EC) analyser for mass quantification.

A correlation between deposited mass and conductance curve was then established. This correlation is specific for soot produced by the mini-CAST burner. Indeed, such a correlation curve strongly depends on soot particles nature and specifically on their intrinsic conductivity.

The second step consisted in measuring the conductivity for soot presenting different production conditions and physicochemical properties. Intrinsic conductivity of soot pellets was then determined using a four wire conductance measurement method (Marinho et al., 2012). Comparison between intrinsic conductivity of mini-CAST soot and realistic fires particles will be used for extending the correlation curves obtained in the first step to specific soot produced in a “nuclear facility fire” context.

Conclusions

We studied the response of the resistive sensor as a function of time under controlled temperature, flow rate and soot size distribution. Correlation with deposited mass was established after the OC/EC analysis. Besides, we determined experimentally the conductivity of different soot particles. The results of the correlations will be presented and discussed to open the way to further investigation on the link between bridges conductivity and deposited mass.

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