Portable Nano-Particle Emission Measurement System

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Publishable Executive Summary

This report concerns the analysis of the surface chemistry of deposited particulate matter in the context of generic single-cylinder test engine particle emissions. This deliverable responds to one of the main objectives of the PEMS4Nano project, specifically: to provide a fundamental understanding of particle formation, composition, size distribution and transport and their impact on the measurement procedure. Reliable particle characterisation must be established in order to develop robust and reproducible measurement technology.

WP2 concerns "Measurement Technology", with Task 2.3 being devoted to "Particle Losses" and Task 2.4 to the "Evolution of Particle Ensemble with Simulation". A validation of the experimental techniques used to perform surface chemical analysis of particulate matter is key to responding to these tasks. The development of a particle loss model – required to calculate an accurate particle concentration – depends on a fundamental understanding of the particle chemistry (Task 2.3.1). The first step towards determining the role of the dilution ratio, temperature, etc on the particle agglomeration behaviour and related losses is to have a reliable and reproducible measurement of the particles produced by the generic single cylinder test engine (Task 2.3.2). This data will be integrated into particle loss models and in particular is required to develop and validate a detailed population balance model (DPBM, Task 2.4.2) in the model guided application.

Analytical techniques at **ULL** and **HORJY** are perfectly adapted to determining the surface chemical composition of particulate matter collected during the development of measurement technology on the generic single cylinder test engine at **BOSCH**. Two complementary mass spectroscopic techniques are available at **ULL**: Laser desorption Laser ionisation Mass Spectrometry (L2MS), developed in-house at **ULL**, and the commercially-available Secondary Ion Mass Spectrometry (SIMS). These techniques allow the analysis of the surface chemical composition of deposited particulate material by volatilisation and ionisation of surface molecules, which are distinguished and identified according to their mass using Time of Flight Mass Spectrometry (ToF-MS). The mass spectrometry techniques available at **ULL** are especially well adapted to the identification of hydrocarbon species (including polycyclic aromatic hydrocarbons (PAHs) and substituted hydrocarbons), metal species (from the fuel, lubricating oil, or engine wear), and sulfur-containing species (very important for modelling particle growth mechanisms).

In this deliverable, we present an analysis of the surface chemical composition of deposited particulate samples provided by **BOSCH** as summarised in Figure 0-1. We were able to identify **hydrocarbon families** (including those attributed specifically to lubricant oil), **metals** and **sulfur-bearing species** using the two mass spectrometric techniques L2MS and SIMS.

Measurement technology for determination of surface chemistry has been developed and optimised by M15. We have validated the robustness and reliability of the techniques L2MS, SIMS and AFM-Raman/TERS for the surface chemical analysis of particulate matter. By additional L2MS analysis of samples of the oil and gasoline used in the generic single cylinder test engine, we were able to verify the source of chemical species identified in the samples.

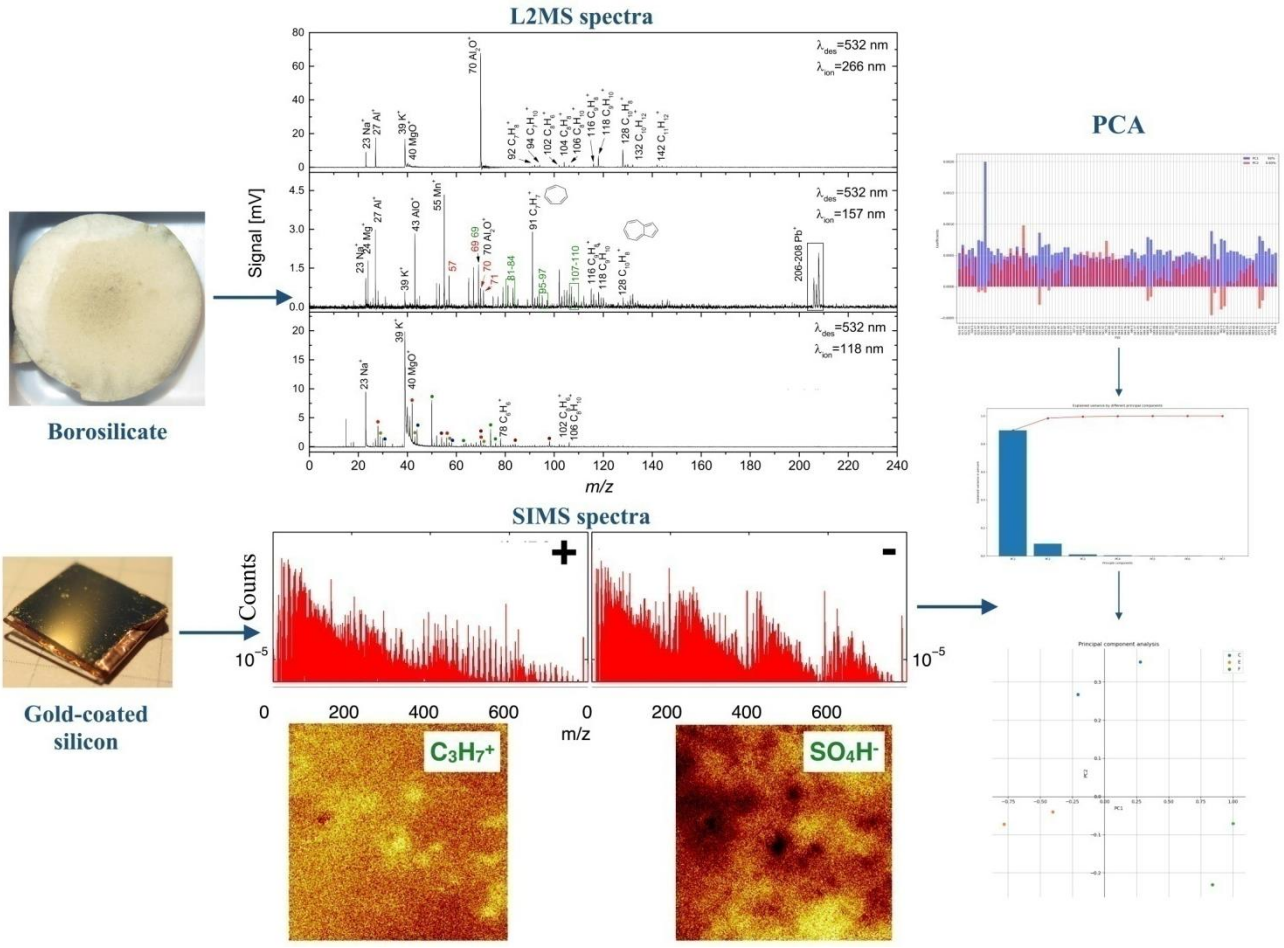

Figure 0-1 Overview of surface chemistry characterisation

Initial analysis of samples provided by **BOSCH** has revealed certain modifications of the measurement strategy that must be made in order to discriminate particles (see **D3.1**). Technical risks identified in **D1.1**, such as damage during sampling/transport and lack of deposited particulate matter on the substrates, have already been addressed by a revisiting of the sampling methodology and joint measurement campaigns involving **ULL/BOSCH/HORJY**, supported by **TSI** (M14, M18).

Despite the relatively low surface coverages on the samples, using appropriate analysis techniques (L2MS with a sensitivity in the range of the sub-femtomole per laser pulse, SIMS and post processing with PCA) we could provide a highly detailed surface chemical characterisation of deposited particulate samples.

These analyses provide essential chemical composition data (especially concerning **adsorbed hydrocarbons** (**soluble organic fraction**), **aromatics**, **metals** (**ash**) and **sulfur-bearing species**) for future integration into, and validation of, the detailed population balance model being developed in parallel by **CMCL** as a core component of the **model guided application**.

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Project partners:

#	Type	Partner	Partner Full Name
1	IND	HORIBA	Horiba Europe GmbH
2	IND	Bosch	Robert Bosch GmbH
3	IND/SME	CMCL	Computational Modelling Cambridge Limited
4	IND	TSI	TSI GmbH
5	HE	UCAM	The Chancellor, Masters and scholars of the University of Cambridge
6	HE	ULL	Université des Sciences et Technologies De Lille – Lille I
7	IND	IDIADA	Idiada Automotive Technologie SA
8	IND	HORJY	Horiba Jobin Yvon S.A.S.
9	IND/SME	UNR	Uniresearch BV

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