Analysis of sub-micrometric particulate emitted by different types of internal combustion engines: a Raman Micro-spectroscopy study

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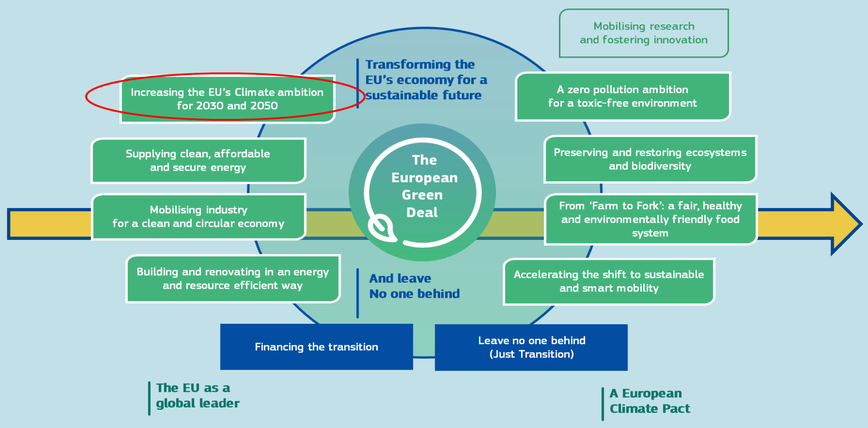
Project Background

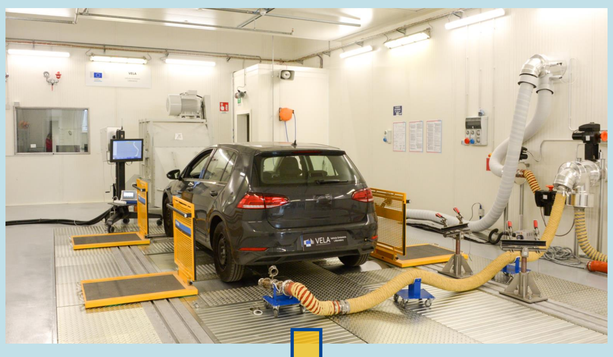
The present research belongs to a broader project dealing with **Market Surveillance of vehicle emissions** in the European Union, introduced in its essential lines in **European Commission Regulation 858 (2018)**. It is part of the Decarbonized, Smart and Safe Mobility Portfolio of the **European Commission's Joint Research Centre** (EC JRC).

REGULATION (EU) 2018/858 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL
of 30 May 2018
on the approval and market surveillance of motor vehicles and their trailers, and of systems, components and separate technical units intended for such vehicles, amending Regulations (EC) No 715/2007 and (EC) No 595/2009 and repealing Directive 2007/46/EC
(Text with EEA relevance)

►B COMMISSION REGULATION (EU) 2017/1151
of 1 June 2017
supplementing Regulation (EC) No 715/2007 of the European Parliament and of the Council on type-approval of motor vehicles with respect to emissions from light passenger and commercial vehicles (Euro 5 and Euro 6) and on access to vehicle repair and maintenance information, amending Directive 2007/46/EC of the European Parliament and of the Council, Commission Regulation (EC) No 692/2008 and Commission Regulation (EU) No 1230/2012 and repealing Commission Regulation (EC) No 692/2008
(Text with EEA relevance)
(OJ L 175, 7.7.2017, p. 1)

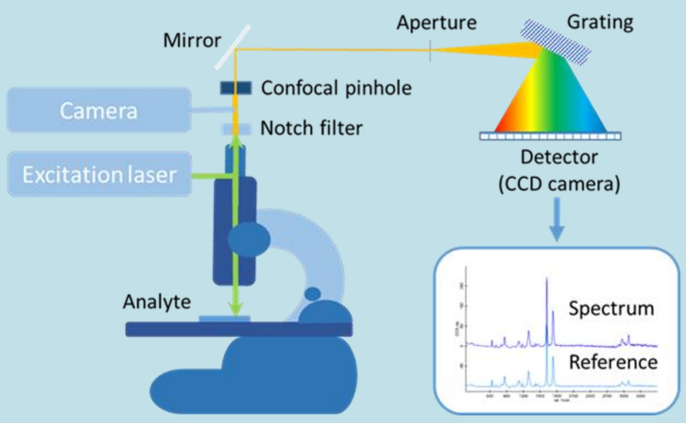


Methodologies

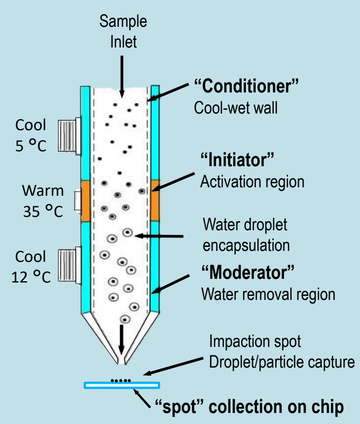


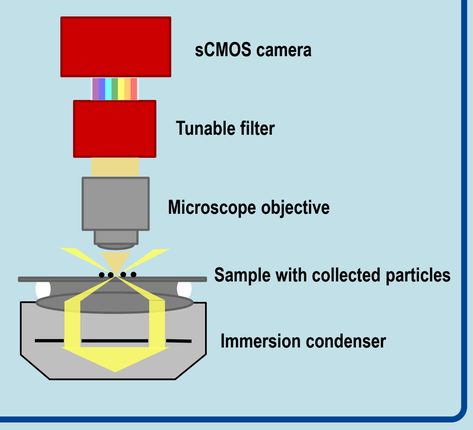
Vehicle emission tests are carried out in the **Vehicle Emission Laboratories (VELA)** of the European Commission's Joint Research Centre. The present research is focused on the development of an efficient and accurate approach for the physicochemical and morphological characterization, by means of **optical microscopy and Raman spectroscopy**, of **particulate samples** collected at the exhaust of internal-combustion engine vehicles. The study examines Raman spectra of micro, sub-micro, and ultrafine particles emitted by both light-duty and heavy-duty vehicles, **with samples collected according to the European Commission Regulation 1151 (2017).**
Vehicle emission tests are carried out under standardized type-approval conditions and also under extended driving conditions, in which the driving style, ambient temperature and altitude are significantly varied. In this way one can check if **the different testing conditions have any significant effect on the nature of the emitted particulate on a micrometric and sub-micrometric scale.**

RAMAN



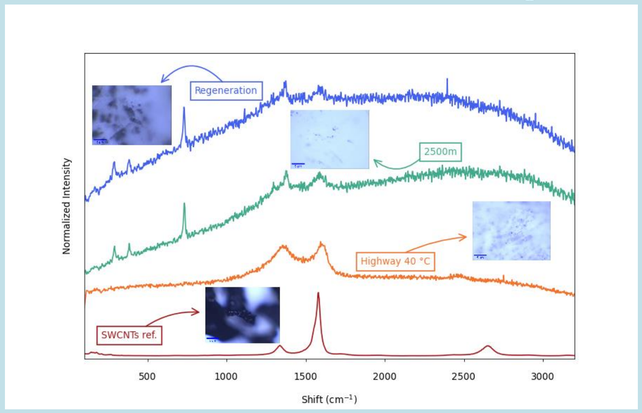
HSEDF on Single Particles

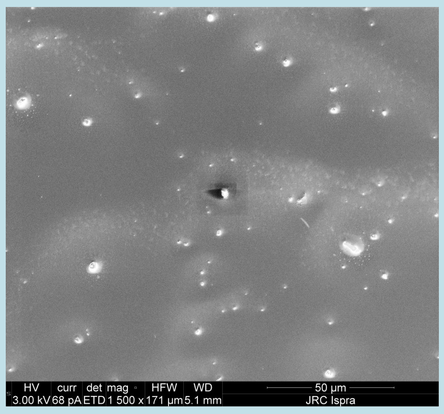


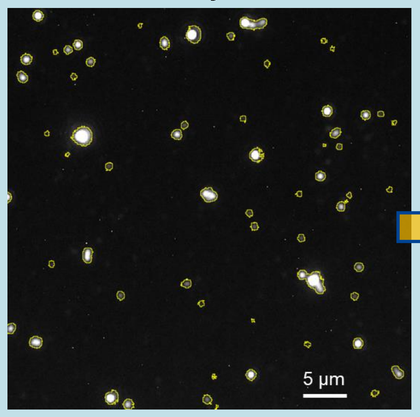


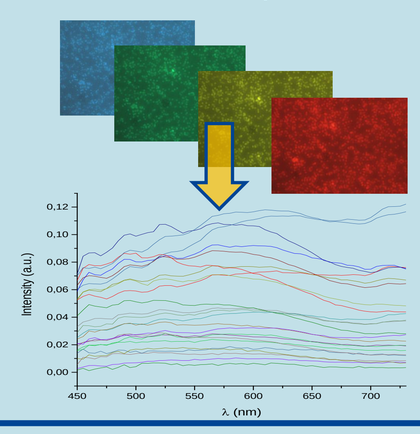
Preliminary results

Raman spectroscopy can identify various forms of carbon in the samples, particularly defective graphene rings in most cases, indicating its **effectiveness in characterizing particulate matter deposited on filters**, according to the procedure indicated in EC Regulation 1151 (2017), **without any further sample preparation.** This approach, combined with numerous tests on different vehicles, allows for the development of a large database for statistical analysis. The current research is also addressing a correlative study using **Hyper-Spectral Enhanced Dark Field (HSEDF) microscopy and SEM/EDX analysis**, exploiting the **Mie scattering** effect in **sub-microscopic single particles** collected by means of a **condensation aerosol collector**. This study permits to measure the refractive index of single nanoparticles and, in combination with the EDX elemental analysis, to obtain insights on their material composition.









Future perspective

Long-term goals of exhaust particulate analysis include determining a **comprehensive approach** for the observation of chemical species formed in **exhaust particulate under specific driving conditions and characterizing their behaviour under various circumstances**. The possible formation of carbon nanotubes or sulphur-containing compounds will be studied in particulate matter produced by internal-combustion engine vehicles driven under various testing conditions. Possibly, also **particulate matter produced by brakes and tyres** will be investigated. The impact of these species on air quality, the environment, and human health will be assessed in future studies.

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