Transmission Electron Microscopy (TEM) & Nanoparticle Tracking Analysis (NTA) Case Study:
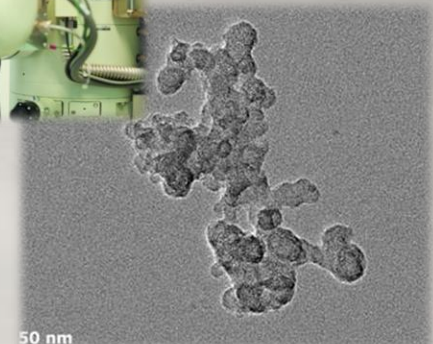
Soot-in-Oil Diagnostics

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Industrial Case Study

- A build-up of soot in engine oil reduces performance.

- Oil thickening increases viscosity, raising CO_2 emissions and fuel consumption.

- Increased engine wear occurs as anti-wear additive effectiveness is reduced.

- Level of wear depends upon the characteristics of the particles and agglomerates of soot.

The understanding of soot-in-oil characteristics and their impact is impeded by the limitations of experimental techniques for soot analysis

Industrial Case Study

- The size distribution and morphology of soot particles is critical.

- Influences oil properties and gives insight into particle formation and growth.

- Better characterisation should help develop strategies to combat engine wear.

**Novel strategy developed using the application of surface and interfacial analytics.**

- **Transmission Electron Microscopy (TEM)**

    - **Visualisation**

    - **Particle and feature sizing**

- **Nanoparticle Tracking Analysis (NTA)**

    - **'*In-situ*' particle size distribution**

**JEOL 2100F TEM at the Nottingham
Nanotechnology and Nanoscience Centre**

Industrial Case Study

- An electron microscopy technique with Ångstrom resolution.

- It uses the contrast in electron transmission as a beam passes through ultra-thin specimens to generate an image.
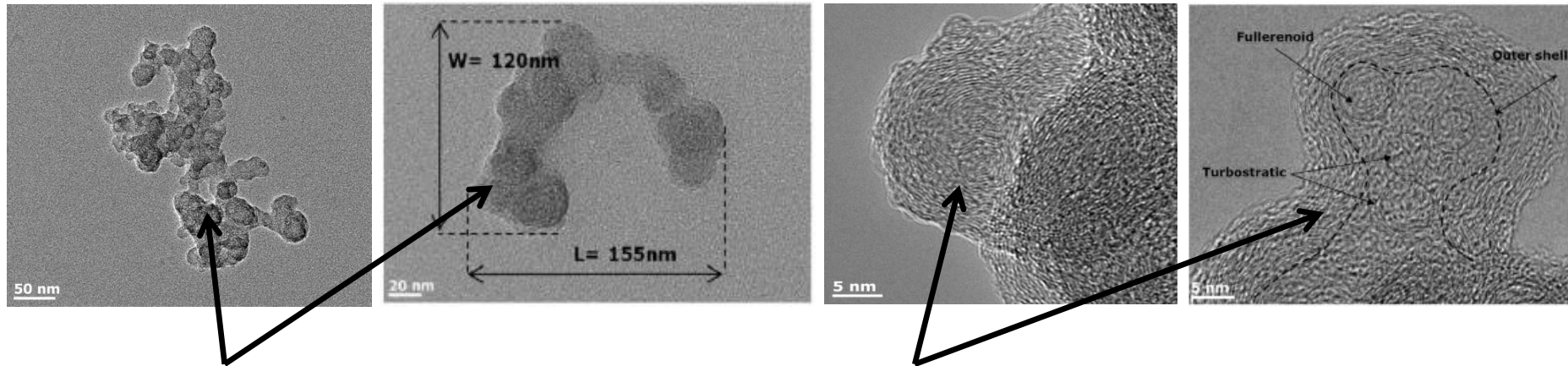
Particle sizing and morphology
Frequency, size distribution, structure etc. of nanometre structures

Structure of primary particles
High resolution (HRTEM) imaging identifies molecular structures e.g. inner core, graphitic layers, outer shell crystallites
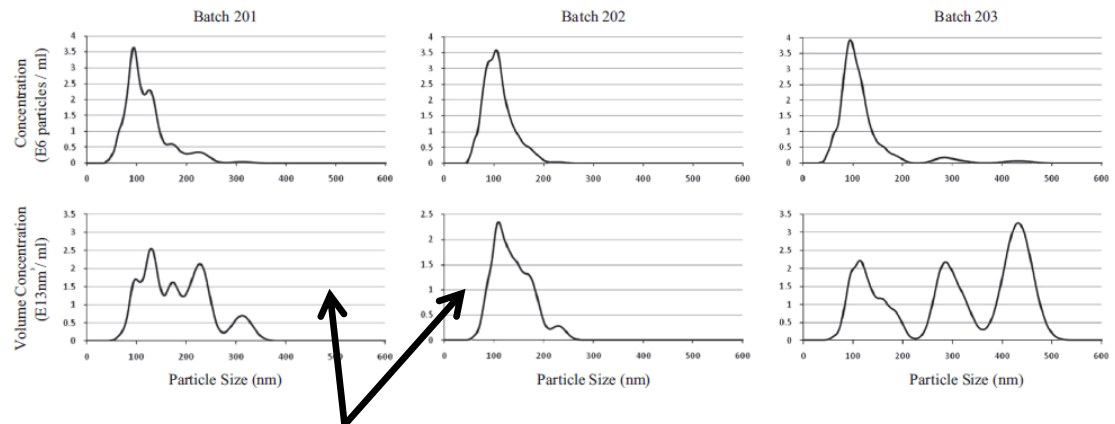
Industrial Case Study

- A technique used to size nanoparticles (10-2000 nm) and evaluate concentrations in liquid samples.

- A laser beam illuminates the particles, causing them to act as point scatterers, and an optical microscope with camera visualises and records the path of the particles under Brownian motion.

'In-situ' analysis
Nanosight LM14 at the NNNC

Nanoparticle size distributions and concentrations
Batch to batch comparisons of particle size frequencies, and concentration

Summary

- Soot-in-oil contamination reduces engine performance.

- Characterisation of size distribution and morphology of such contamination has been limited.

- TEM and NTA offer novel diagnostics of nanoparticulate soot-in-oil contamination.

- Soot particle size distributions, concentrations and structural assessments were recorded.

- Soot particle contamination of engine oil was better characterised, opening the door for the development of prophylactic strategies and screening processes.

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Industrial Case Study

For further information on how TEM, NTA or the lubricant analysis facilities at the Engine Research Group could help with your applications or systems please contact:

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A more detailed report of the work in this case study can be found in the following publication:

Application of nanoparticle tracking analysis platform for the measurement of soot-in-oil agglomerates from automotive engines. A. La Rocca, G. Di Liberto, P.J. Shayler, C.D.J. Parmenter, M.W. Fay. *Tribology International 70 (2014) 142–147*

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