Investigation of the Characteristics of Nanoparticles Emissions from the Small Diesel Engine

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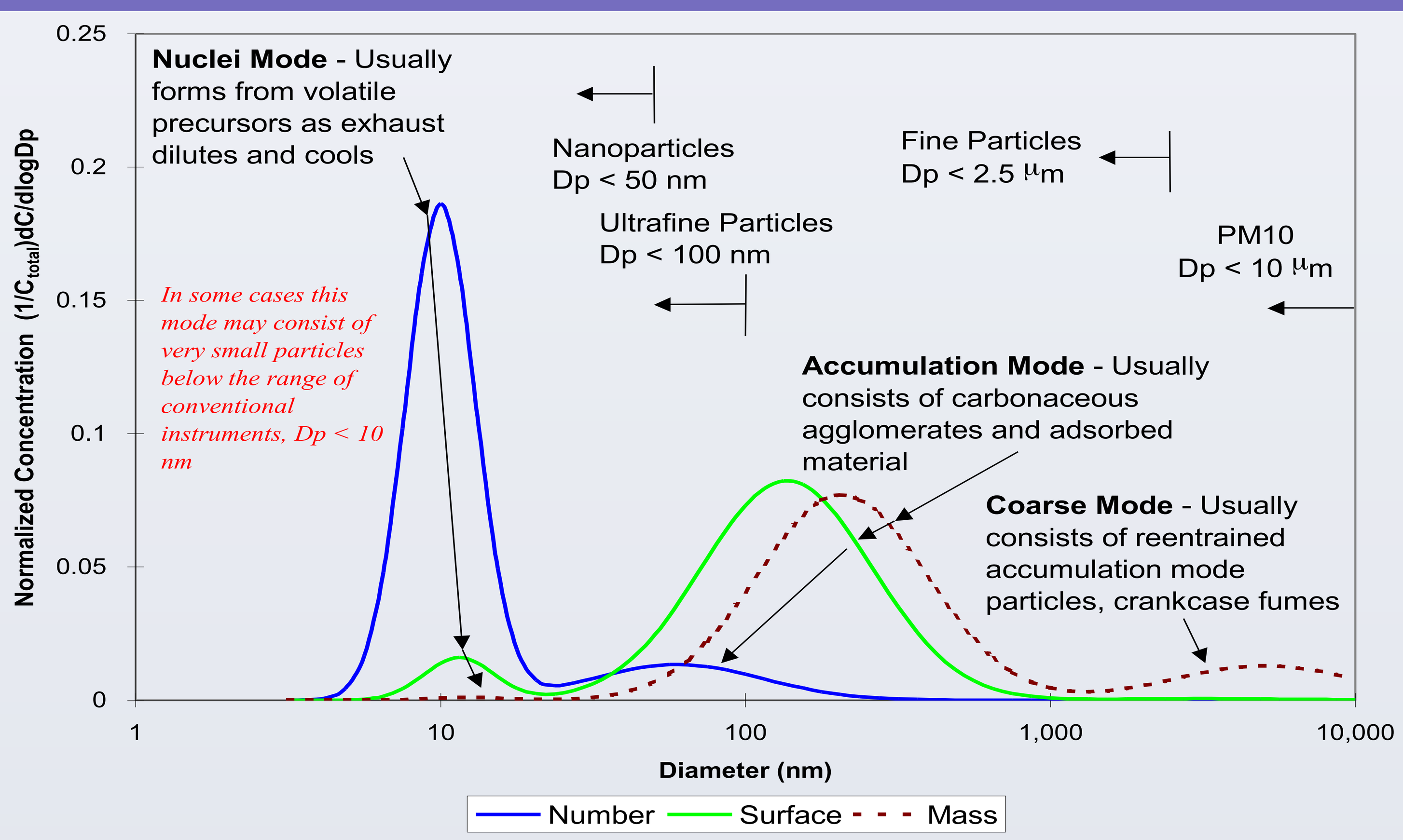
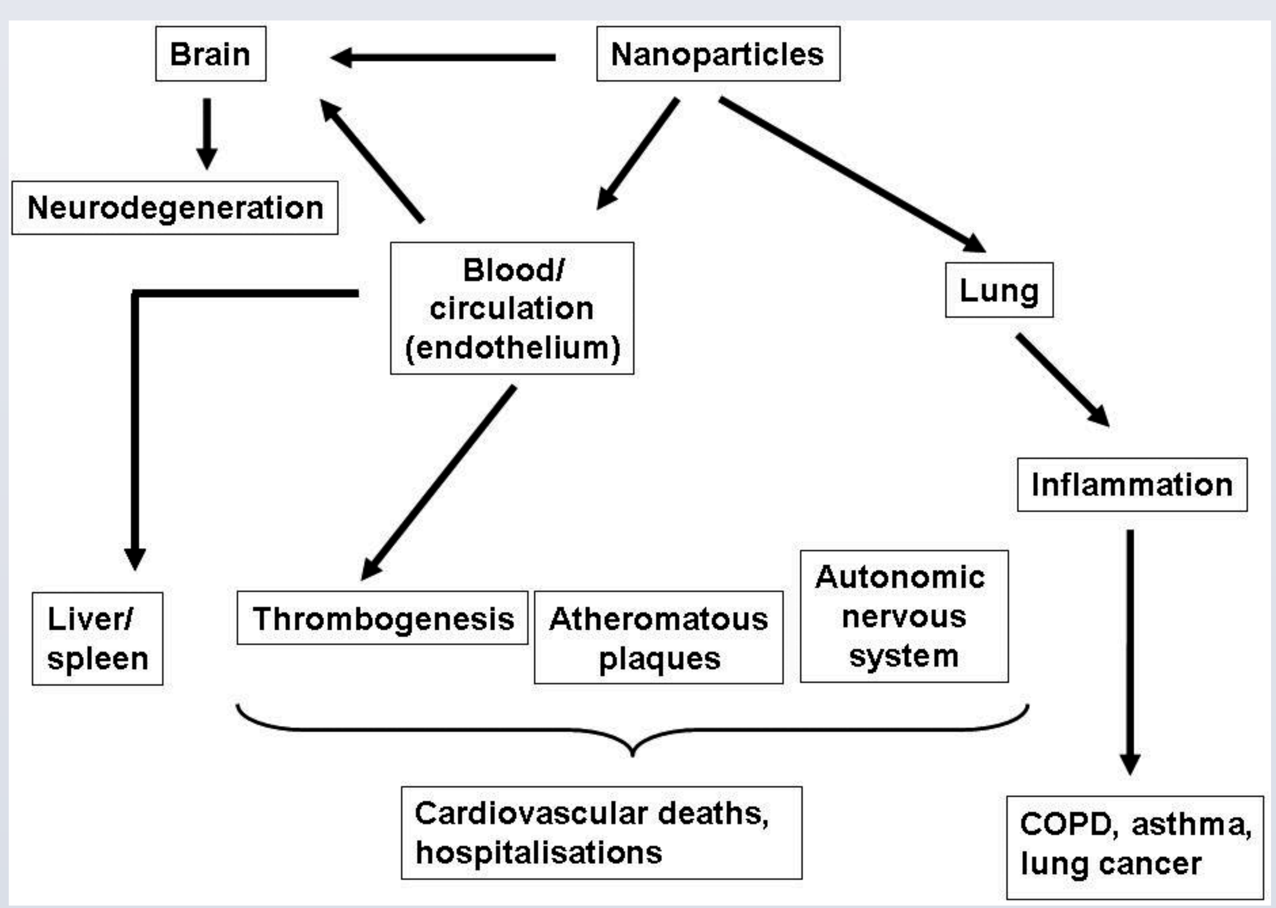
Abstract

The project focuses on acute environmental problem of nanoparticles emitted by Diesel engines. Studying morphology and characteristics of nanoparticles by using TEM (Transmission Electron Microscope) and the samples are collected in dilution tunnel with cascade impactor. These are advanced techniques applied for the study of Diesel engine exhaust emissions. Setting up the experiment and mastering samples' collection for TEM is seen as a major achievement of the project. Three different engine load conditions were studied: 0%, 40%, and 80%. Results reveal that, during idle operation, the particles take the form of liquid droplets in combination with a limited number of aggregates. However, upon application of a load, chain aggregates take the place of the droplets, displaying a 55 nm average primary particle size at varying loads. The application of load on the engine caused the exhaust temperature to rise, resulting in the gradual disappearance of round and irregular primary particle droplets due to volatile substance loss and non-volatile substance oxidation.

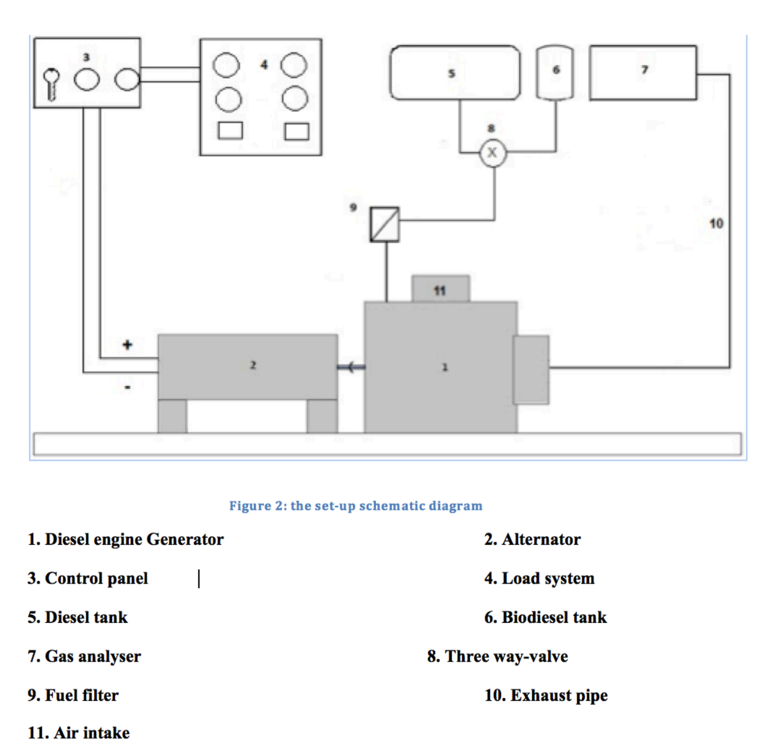
Medical Importance of nano-particles

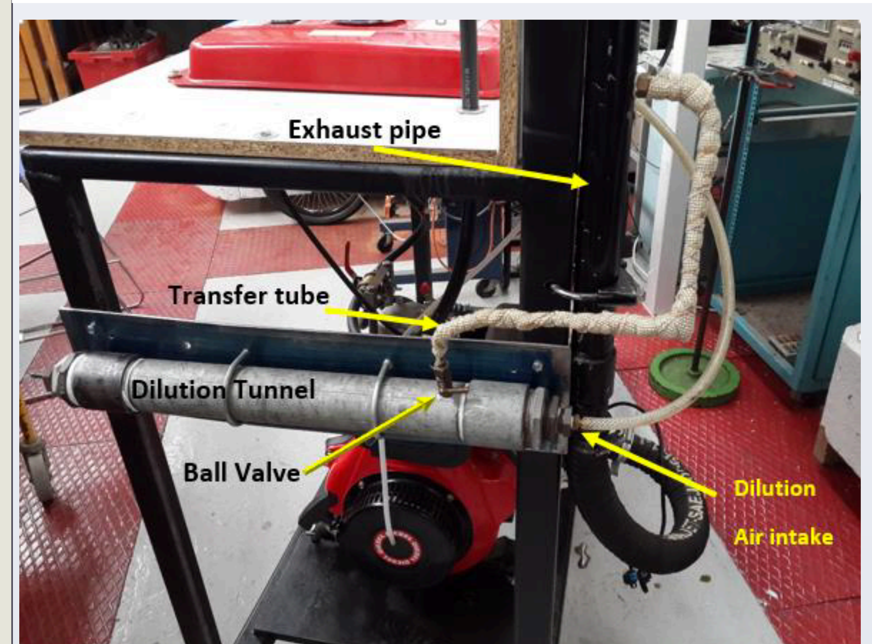


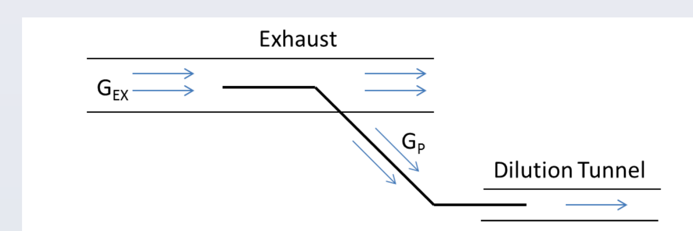


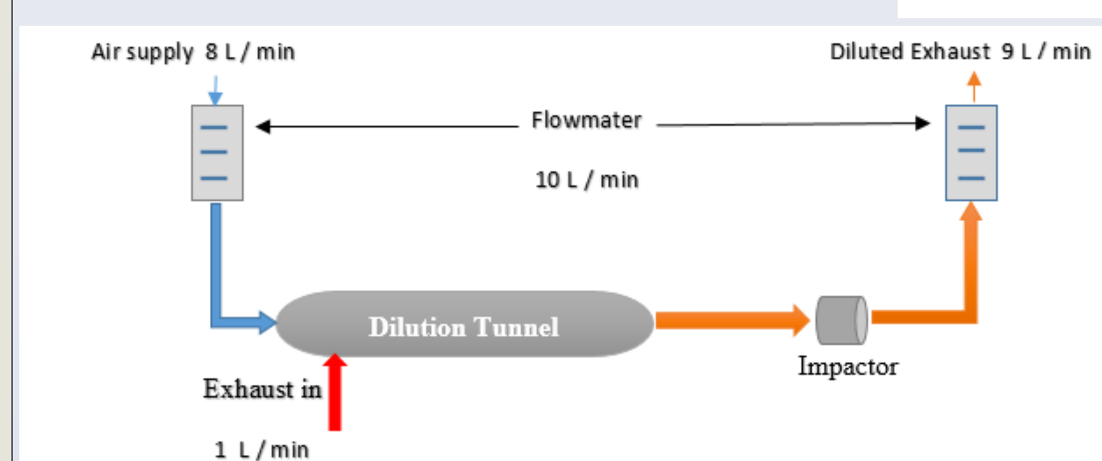
It was indicated by researches that both large (aggregates) as well as single sphere particles possess the capability of affection the deposition efficiency present in the lungs. Also the nanoparticles toxicity depends on the size, surface area and shape of the nanoparticles, rather than only on the size. Particles that are 1 nm size particles are deposited in the lungs upper regions. In the pharynx and the nose, and the bronchial tubes and windpipe, 5nm particles were deposited. The alveoli were the region where the 20nm nanoparticles were deposited. Irrespective of the routes that are taken, these particles can also reach the brain.

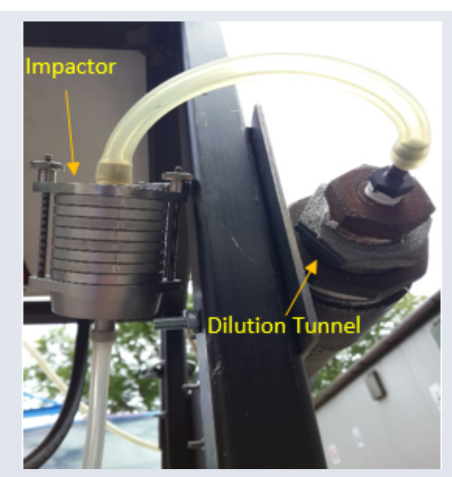
Experimental Methodology

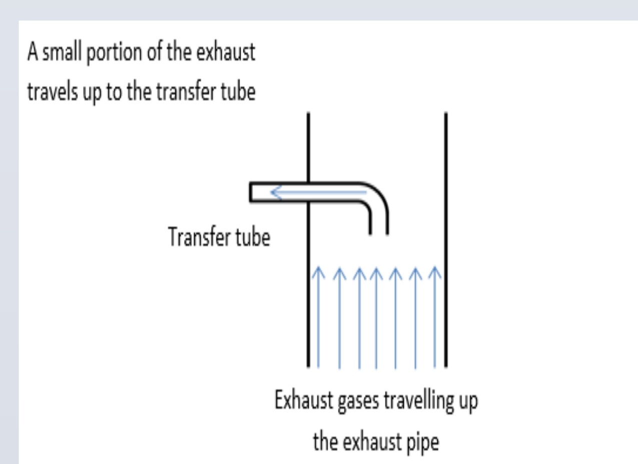


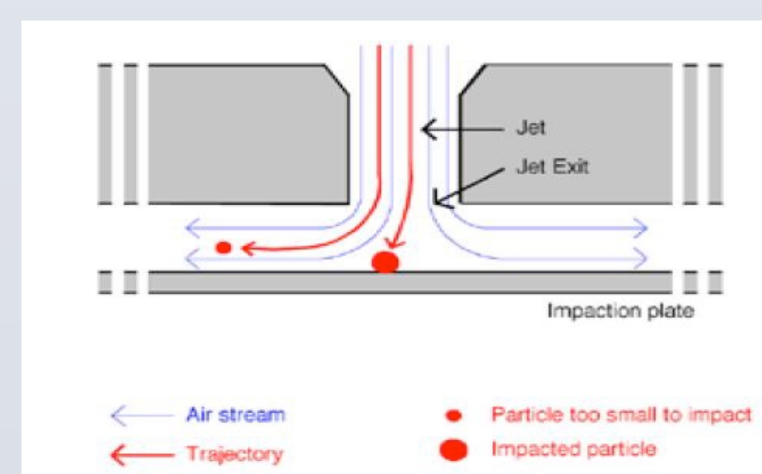










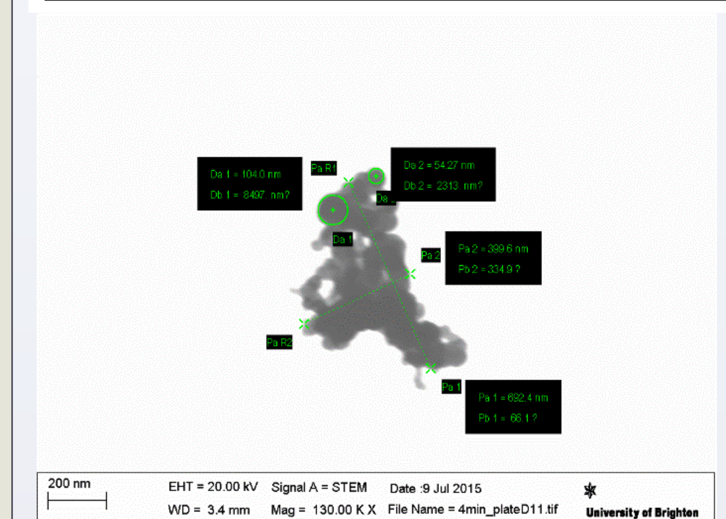


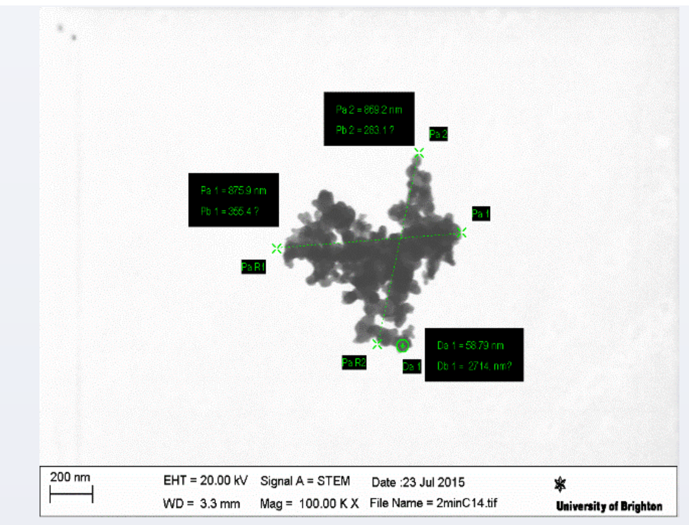
Experimental methodology is developed using a 5kW diesel engine generator set integrated with dilution tunnel and nanoparticles collection microgrid. Loading on engine was applied through electrical loading system: halogen floodlights 2000W and oil-filled radiator heater 2000W have been used to develop step load of 0.5kW. Dilution tunnel was integrated with the impactor in which copper microgrid was installed for the direct collection of the nanoparticles from the engines exhaust at a well defined dilution ratio.

Results and Discussion

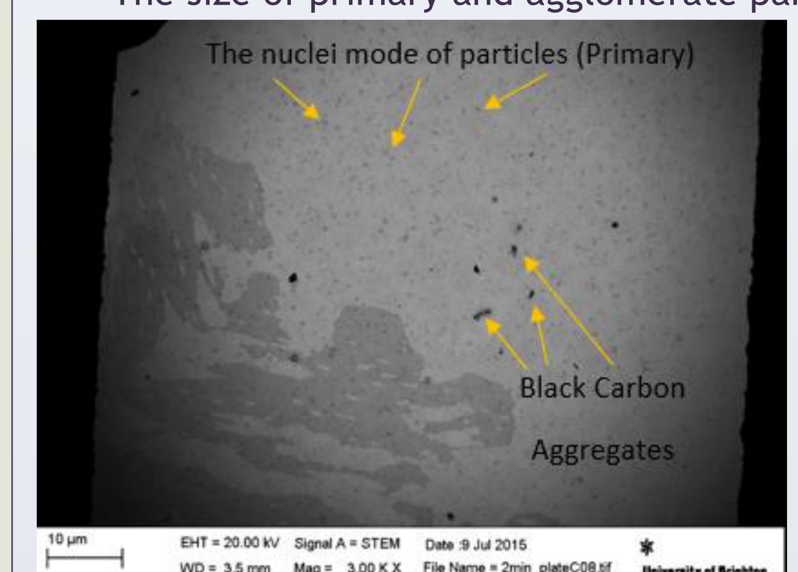
Test	Test period	Number of grids
0 % Load	Each test was repeated for different periods (1 minute, 2 minutes and 4 minutes)	Six TEM grids for each loading test that means two grids for each time
40 % Load		
80 % Load		

Conditions	0 % load			40 % load			80 % load		
Test Period	1 minute	2 min	3 min	1 min	2 min	3 min	1 min	2 min	3 min
Exhaust Temperature °C	75	85	110	105	125	150	168	192	233

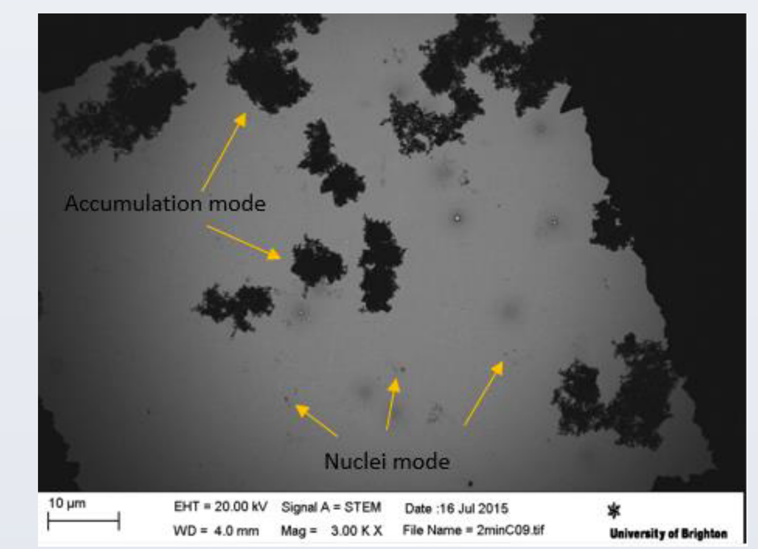




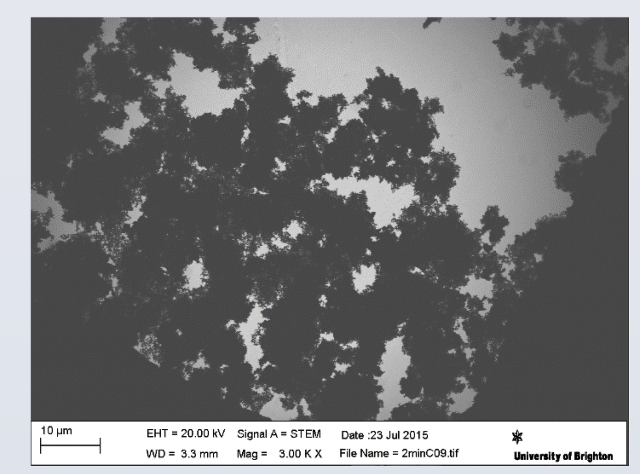
- The size of primary and agglomerate particles at 0% load (A) and at 40% load (B)



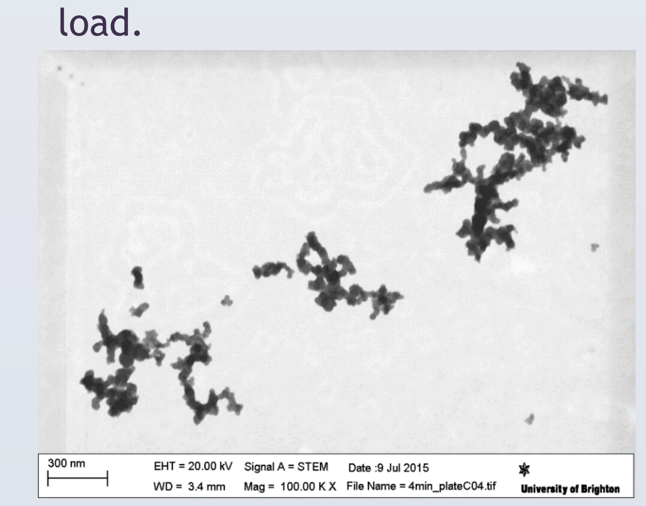
- The nuclei mode of particles at 0% load



- The nuclei and accumulation mode at 40% load.



- The accumulation mode of at 80% load



- Morphology of the aggregates studied

Conclusion

- A new experimental test procedure has been developed to generate, capture and analyse nanoparticles emitted from the diesel fuels .
- The morphology of nanoparticles and particles size show a linear relationship with the loads.
- In general, nucleation-mode particle concentration is more limited than accumulation-mode particle; the accumulation-mode particle concentration accounts for more than 85% of the overall amount of particle emitted.
- When the engine load is low, the premixed mode is the main mode of fuel burning, leaving extra time for the soot to oxidise, which leads to fewer particulates being formed.
- At higher engine load, a greater amount of particulates form due to the fact that more fuel is introduced in the combustion chamber and burned in the diffusion mode, leaving less time for soot to oxidise. The application of load on the engine caused the exhaust temperature to rise, resulting in the gradual disappearance of round and irregular primary particle droplets due to volatile substance loss and non-volatile substance oxidation.