Atmospheric Behaviour of Ultrafine Particles Arising from Road Traffic
Supervisor: Prof. Roy M. Harrison & Prof. Rob MacKenzie Contact: r.m.harrison@bham.ac.uk

Abstract

Airborne particles are a well recognised cause of increased morbidity and mortality in the general population. While the precise influences of particle size and chemical composition upon toxicity have yet to be fully elucidated, there has been a great deal of interest in the ultrafine fraction of less than 100 nanometres diameter which show high toxicity per unit mass. By far the greatest abundance of ultrafine particles in the urban atmosphere arises from emissions from road traffic and particularly from diesel engines, and recent work in our group has provided clear evidence that such particles are semi-volatile and that they progressively evaporate as they travel away from the source of emission. However, current knowledge of their chemical composition and rate of evaporation is very weak and this project aims to provide the necessary fundamental information to allow better prediction of their behaviour. This will involve sampling particles from test engines, analysis of chemical composition, alongside field experiments in which the evolution of the ultrafine particle fraction will be observed using advanced aerosol instrumentation. This will be complemented by theoretical studies and numerical modelling of particle behaviour.

Project Outline. Airborne particles are a topic of international interest because of their adverse effects on human health. In this context there has been particular attention paid to the ultrafine or nanoparticle fraction of less than 100 nanometres diameter because of its high toxicity per unit mass. There has been considerable concern over manufactured nanoparticles but currently the main source of nanoparticles in the urban atmosphere is from those present in the emissions from road vehicles. Our recent work has shown that these are made up of two different types of particle, one of which referred to as the nucleation mode is semi-volatile, i.e., it slowly evaporates as it moves into cleaner air. Recent work from the United States has suggested that the semi-volatile compounds associated with such particles not only desorb into the vapour phase but are subsequently oxidised to form less volatile compounds which recondense onto the solid particles. These processes cause not only an increase in mass (because of the oxidation process) but also lead to pollution by secondary organic compounds at great distances from the source regions. However, much of this work is theoretical in nature and requires an experimental underpinning which is the primary aim of this project.

The purpose of the project is to gain an improved and more quantitative understanding of the composition of semi-volatile nucleation particles from diesel exhaust, their behaviour in the atmosphere and consequences for regional air quality. Associated with this are specific objectives to sample and characterise particles from engine exhaust in the laboratory to measure their concentrations and their evolution as they age in the atmosphere and to determine the vapour phase products arising from them.

The initial work will require sampling of diluted engine exhaust using the University's advanced engine test bed facilities. Size-fractionated samples will be collected using Micro-Orifice Uniform Deposit Impactors, and after thermal desorption will be analysed by gas chromatography/ mass spectrometry using state-of-the-art instrumentation.

Electron microscopy will also be used to investigate possible solid cores to the primarily semi-volatile liquid particles. Methods will also be developed to collect the vapour phase components both in the engine laboratory and in the field on absorption tubes which will be analysed by GCMS. Field experiments will also be conducted using the measurement of size distributions by Scanning Mobility Particle Sizers in order to determine the evolution of particle size distributions downwind from an automotive source and the extent to which vapour phase compounds are released. The final part of the programme will involve designing a theoretical description of the particle evolution process and collaborating in numerical model simulations of the atmospheric processes.

Applicants should apply via
http://www.birmingham.ac.uk/postgraduate/courses/research/gees/environmental-health-risk-mgt.aspx
where they should click on 'Apply now' and choose the option 'PhD in Department of Division of Environmental Health and Risk Management' and give the PhD title in the 'Funding details' section of the online application.