Characterisation of ultrafine particles from a waste-incinerator plant

Ultrafine particles emitted from a waste incinerator plant in Italy have been characterised in a recent study. The results suggest that a fabric filter was efficient at cleaning particulate matter from the exhaust gases. Data produced by the study could go on to be used by scientists studying the potential health impacts of ultrafine particles.

There are concerns about the impact of particles emissions from combustion processes on human health and the environment, including those from waste incinerator plants. Smaller particles that are able to penetrate deeply into the lungs represent a greater risk to health than larger particles. These are fine particles (PM$_{2.5}$) with a diameter of less than 2.5µm (micrometres) and ultrafine particles with a diameter of 100nm (nanometres) or less.

In this study the researchers characterised ultrafine particle emissions from a waste-to-energy incinerator plant in central Italy. The fuel for the plant is derived from municipal solid waste. The concentration, size, shape and chemical composition of the particles in the flue gas (exhaust gas) were determined before and after the flue gas passed through a fabric filter designed to reduce the amount of air pollutants reaching the atmosphere.

The average concentration of particles in the flue gas before it passed through the fabric filter was 2.4x10$^7$ particles per cubic centimetre (part. cm$^{-3}$), compared with 350 part. cm$^{-3}$ measured at the stack (chimney) after passing through the filter, implying that the filter was efficient at removing PM from the flue gases. The presence of a fabric filter itself was able to guarantee negligible concentration levels at the stack.

In addition, the concentration of particles measured at the stack was about 10 times less than the concentration of particles measured previously in the surrounding area, which is a rural location, i.e. the ultrafine particle concentration at the stack is lower than the typical background concentration.

The most frequent size of particles measured before the fabric filter was about 150nm, whereas the most frequent particle size at the stack was about 90nm. The results suggest that more than 99.99% of ultrafine particles were removed by the fabric filter.

Particles collected before the fabric filter were typically rounded, and were separate or clumped together in large aggregates (groups). In contrast, particles collected at the stack were a variety of shapes, such as in the form of thin, rectangular-shaped plates.

Chemical analysis of the particles for heavy metal content was carried out to understand the relative contribution of the different metals in the ultrafine particles. Absolute metal concentrations at the stack were low. The proportion of the heavy metals arsenic, cadmium and zinc in the total mass of particles decreased as the size of the particles increased.

In contrast, the proportion of the heavy metals cobalt, chromium, iron, antimony, scandium, samarium, thorium, europium and ytterbium in the total mass of particles increased as the size of the particles increased. The first group of metals have boiling points below 1200°C, which is in contrast to boiling points above 1200°C for the second group of metals. With a higher boiling point, the second group of metals are likely to remain as solids forming centres (condensation nuclei) around which larger-sized particles can form.


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