Investigations on the removal of volatile components from diesel exhaust

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Fine and especially ultrafine particles are considered to be harmful for human health (Oberdörster, 1995). As diesel-powered vehicles are a significant source for particles in this size range, it is important to limit and consequently reduce the emissions caused by their exhaust. Unfortunately, the well-tried attempt to confine the emissions based on the mass sampled on a filter turned out to be ineffective for fine particles and low particle concentrations (Matter, 1999). For this reason a new limit which is based on the particle number, was established within the European Union in 2011 (EU 566/2011).

Additionally to the number limit a new measurement procedure was introduced. It suggests the quantification of the particles with a condensation nucleus counter (CNC). It furthermore instructs a removal of volatile particles from the exhaust gas before quantification of the solid residue (figure 1). One crucial point of this measurement procedure is that the volatiles have to be removed completely from the exhaust gas to ensure reproducible and accurate results.

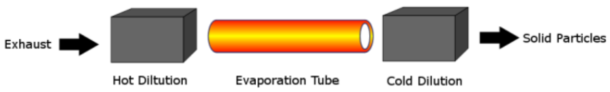

Figure 1. Scheme of the evaporation tube.

Subject of our research is to investigate different apparatus applied for the separation of volatile particles from exhaust gas in terms of their removal efficiency and capacity. To simplify the investigations, a model aerosol is used to mimic real exhaust gas. It consists of spark discharge soot coated with n-hexadecane respectively sulphuric acid particles suspended in dry particle free air.

At present there are three volatile particle remover types (VPR) known in literature: evaporation tube, thermodenuder and catalytic stripper (Giechaskiel, 2011). Our investigations started with the evaporation tube (ET). Within this device the exhaust is heated (evaporation of the volatiles) and consequently diluted (prevent recondensation).

To examine the removal efficiency, soot particles of different size were coated with a 1-nm layer of hexadecane and subsequently heated in the ET (figure 2). It can be seen that the counting efficiency of a CPC is increasing if a coating is present on the particle. This means that incomplete removal leads to changes in the detected particle number. After removal of the volatile component the counting efficiency is again on the same level as uncoated soot (soot reference). Thus it can be said that a complete removal of n-hexadecane is possible with the evaporation tube.

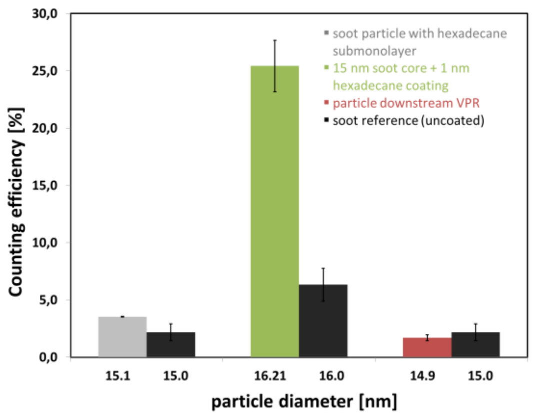

Figure 2. CPC counting efficiency of spark discharge soot (uncoated, coated with n-hexadecane and thermally treated).

Further experiments are conducted considering volatile exhaust components which are not as easy to remove as n-hexadecane. Catalytic stripper and thermal denuder are investigated in an analogous manner.

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