Chemical and physical characteristaion of ship engine combustion aerosols in combination with in vitro exposure of human lung cells

Thorsten Streibel1, Sebastian Oeder2, Tamara Kanashova3, Olli Sippula4, Sean C. Sapcariu5, Johannes Passig1, Jeroen Buters2, Ralf Zimmermann1

1 Joint Mass Spectrometry Centre, University of Rostock and Helmholtz Zentrum München, Dr.-Lorenz-Weg 1, 18059 Rostock, Germany, thorsten.streibel@uni-rostock.de

2 Center of Allergy and Environment (ZAUM), Biedersteiner Strasse 29, 80802 München, Germany

3 Max-Delbrück-Centrum für Molekulare Medizin, Robert-Rössle-Strasse 10, 13125 Berlin-Buch, Germany

4 University of Eastern Finland, Yliopistonranta 1, 70211 kuopio, Finland

5 University of Luxembourg, 7 Avenue des Hauts Fourneaux, 4362 Belval, Luxembourg

Gaseous organic trace compounds and particulate matter emitted with the exhaust from ships constitute a significant contribution to the anthropogenic environmental burden, especially for coastal regions worldwide. To provide a molecular link between the chemical and physical characteristics of ship emission aerosols and the cellular responses they evoke and to identify potentially harmful fractions in shipping emission aerosols, emissions from a one-cylinder ship diesel research engine have been investigated. In parallel, through an air-liquid interface exposure system human lung cells were exposed under realistic *in vitro* conditions.

Two different fuels, diesel distillate (DF) and heavy fuel oil (HFO) have been used. Filtered exhaust gas was monitored online by mass spectrometrical methods. In addition, particulate matter from the exhaust was sampled on quartz filters and subsequently investigated by thermal desorption coupled to gas chraomatography and mass spectrometry systems.

Gaseous PAH patterns of diesel fuel are dominated by alkylated naphthalenes, when the fuel is switched to heavy fuel oil, alkylated phenanthrenes become prevalent. The PAH content of heavy fuel oil particles is also shifted to higher molecular species, and even at a desorption temperature of 580 °C decomposition products of large aromatic structures are still visible. Similar patterns as in the emissions are observed in the pure fuels, giving rise to the assumption that PAH are mainly carried over to the exhaust as unburnt fuel content. HFO emissions in general contained higher amounts of toxic compounds and were higher in particle mass. Emitted particles from HFO combustion were generally smaller and contained heavy metal cores, wheras DF particles showed the typical soot-aggregate structure. Consequently, DF emission had higher overall concentrations of elemental carbon (“soot”).

The chemical analyses of the exhaust aerosols were combined with omics-profiling including isotope labelling methods to characterise lung cell responses. Despite a lower content of known toxic compounds, combustion particles from the DF influenced several essential pathways of lung cell metabolism stronger than particles from the unrefined fuel HFO. This might be attributable to the higher soot content of DF emissions (OEDER et al. 2015).

Reference:

S. Oeder et al., Particulate Matter from both Heavy Fuel Oil and Diesel Fuel Shipping Emissions show Strong Biological Effects on Human Lung Cells at Realistic and Comparable in vitro Exposure Conditions, PLOS ONE 2015, in press