Studying the causes of health effects of combustion-derived aerosols in the framework of the Virtual Helmholtz Institute HICE: First results on ship diesel and wood combustion aerosols

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The Virtual Helmholtz Institute HICE addresses the health effects of anthropogenic combustion processes. This is performed by means of a joint comprehensive characterization of the chemical & physical properties of the investigated combustion aerosols as well as the biological effects on cell cultures with high-end innovative methods. The data is jointly analyzed. Human alveolar basal epithelial cells (A549, BEAS2B etc.) are air-liquid interface exposed (ALI) to the diluted combustion aerosols (dilution 10-100x) and subsequently are toxicologically and molecular-biologically characterized. In addition to classical toxicological methods the RNA-transcription, protein expression and metabolite profile-changes are studied (transcriptomics, proteomics and metabolomics). By using stable isotope labeling technologies (^{13}C-glucose for metabolomics; ^{2}H-lysine for proteomics-SILAC) a very high sensitivity and accuracy for detection of molecular-biological effects is achieved at sub-tox.-effect dose levels. Aerosols from wood combustion and ship diesel engine (heavy/ light fuel oil) have been already investigated; other sources (car, truck) are currently studied. The main objectives of HICE are: i) a better understanding of the health effects mechanisms & early response effects as well as identification of health relevant parameters in aerosol, ii) investigation of the effects of organic compounds in gas/particles phase and elucidation of potential synergistic effects between gas phase compounds and particles, iii) studying the effects of the transition from fossil to bio fuels. Based on the "Karlsruhe exposure system" (KIT) a new mobile ALI exposition system was built (HICE-ALI). Furthermore, a mobile S2-biological laboratory was set up for the HICE-measurement campaigns. First experiments were performed at a wood combustion test facility (KIT) and at a research ship diesel engine which is operable with both, light and heavy fuel oil (L/HFO, U Rostock). The characterization of the aerosols includes a comprehensive chemical and physical profiling (GC-MS, LC-MS, FT-IR, ICP-MS, SMPS, AMS, ELPI, PTR, TEM). The ship diesel exhaust contains soot aggregates (Fig. 1), associated with organic and inorganic compounds. Furthermore two

Figure 1) Ship diesel soot (TEM microphotograph)

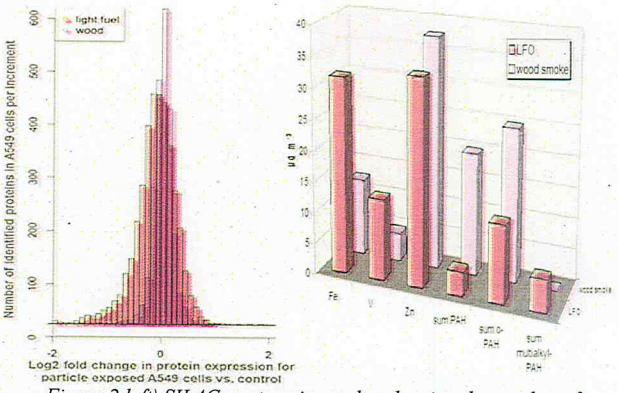

Figure 2 left) SILAC-proteomic results, showing the number of detected proteins as a function of the log2 fold change induced by wood and ship diesel PM. right) Chemical analysis of the PM.

innovative photo ionization mass spectrometers (SPI-MS and REMPI-TOFMS were applied for on-line detection of polycyclic aromatics (PAH) and other species in the exhaust gases, showing that partly high gas phase concentrations of health relevant compounds are observable. In Fig. 2(left) the effect of wood combustion and ship diesel PM on the protein expression of ALI-exposed A549 cells is depicted. Filtered aerosol (gas phase) is used as reference for the isotope labeling based method (SILAC). Therefore the effect of the wood combustion and shipping diesel PM can be directly compared. The ship diesel aerosol causes a broader distribution in the observed fold changes (log2), i.e. more proteins are significantly up- or down-regulated in case of shipping diesel aerosol-exposure. This corresponds to a stronger biological effect if compared to wood combustion aerosol exposure. First metabolic results support this finding. The chemical analysis results on the wood combustion and ship diesel PM (Fig.2, right) depict more PAH/oxidized PAH but less of some transition metals (V, Fe) in the wood combustion case. Interestingly, higher alkylated PAH are more abundant in shipping PM. The results suggest that PAH/Oxy-PAH may be less relevant for PM effects on A549 alveolar basal epithelial cells. The influence of transition metals and alkylated PAH needs to be further investigated.

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