Design and evaluation of a Selective Particle Size Sampler (SPS)

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Abstract

The objective of this study is the design, construction and evaluation of a Selective Particle Size (SPS) sampler able to provide continuous delivery of diesel soot particles of specific size ranges. The design of the sampler combines principles of aerosol transport phenomena and separation technologies. Particles smaller than a given size are removed from the exhaust by diffusional deposition, while removal of particles above a given size is achieved by low pressure inertial impaction. The main implementation of the developed sampler is the exposure of biological samples such as cell and tissue cultures to the selected particles.
By applying the SPS sampler to diesel exhaust it is possible to obtain two widely separated size distributions for biological exposure studies. Since the SPS sampler provides a size distribution of small particles with 60 nm mean diameter as well as a size distribution of large particles with 150 nm, size-depended toxicological and DNA alternation studies can be made.
Additionally, it is promising to combine the two described separation principles – inertial impaction and diffusional deposition - in order to obtain distributions with smaller geometric standard deviation able to simulate a monodispersed aerosol sample.

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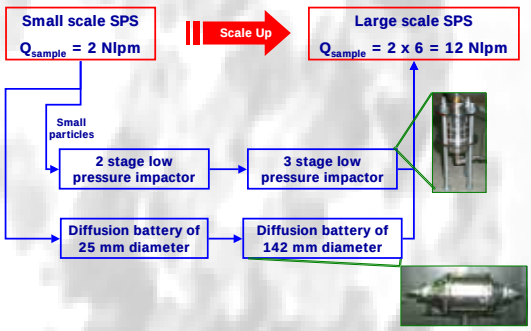
MOTIVATION

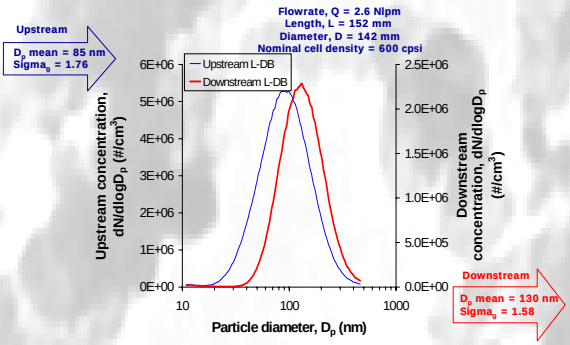
The objective of this study is the scale-up of a Selective Particle Size (SPS) sampler (Ref. 1), in order to increase the sample flowrate to 12 Nlpm from the initial 2 Nlpm design. This device termed "Large SPS" (L-SPS) is able to deliver a continuous stream of diesel soot particles of specific size ranges for further studies. The design of the sampler combines principles of aerosol transport phenomena and separation technologies. Particles smaller than a given size are removed from the sample stream by diffusional deposition in a Diffusion Battery, (DB), while removal of particles above a given size is achieved by Low Pressure Inertial Impaction, (LPII). The main implementation of the developed sampler is the exposure of biological samples such as cell and tissue cultures to particles of selected sizes in order to study the size-specific biological impact of diesel particles.

EXPERIMENTAL



DIFFUSIONAL DEPOSITION – Selection of Large Particles

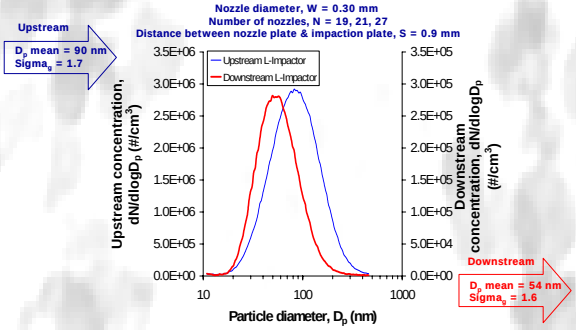
The Diffusion Battery (DB) scale up could have been effected by increasing parameters such as length, cell density and diameter of the monolithic structure used. The increase of the first two parameters was not investigated due to lack of space (in the longitudinal direction) and the possibility of DB channel clogging, respectively. Therefore, the scale-up was achieved by increasing the DB diameter to 142 mm from the initial 25 mm. A "flow-through" honeycomb with a nominal cell density of 600 cells/in^2 (cpsi) and length 152 mm was finally employed as a DB.



LOW PRESSURE INERTIAL IMPACTION – Selection of Small Particles

- The scale-up of the Low Pressure Inertial Impactor (LPII) was focused on increasing both the number of impaction stages and the number of nozzles. After several tests and considerations of the critical Stokes number, the scale-up was achieved, using a 3-stage inertial impactor with the following characteristics.

Impaction stage	Number of nozzles (-)	Nozzle diameter, W (mm)	Distance between nozzle plate & impaction plate, S (mm)
1st	19	0.3	0.9
2nd	21	0.3	0.9
3rd	27	0.3	0.9



IN VITRO LUNG TOXICITY ASSESSMENT ON POLARIZED SINGLE CELL TYPE CULTURE SYSTEM

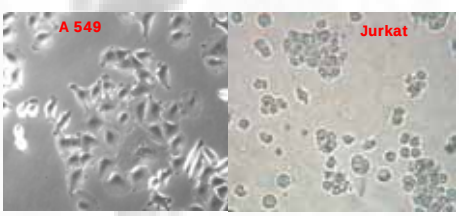
Applying the SPS sampler to diesel exhaust it is possible to obtain two widely separated size distributions for biological exposure studies. Since the SPS sampler provides a size distribution of small particles with 54 nm mean diameter as well as a size distribution of large particles with 130 nm, size-depended toxicological and DNA alternation studies can be made.

Additionally, it is promising to combine the two described separation principles – inertial impaction and diffusional deposition - in order to obtain distributions with smaller geometric standard deviation in order to simulate a monodisperse aerosol sample.

Exposed Cell Lines

The cell lines that were exposed to diesel engine exhaust were:

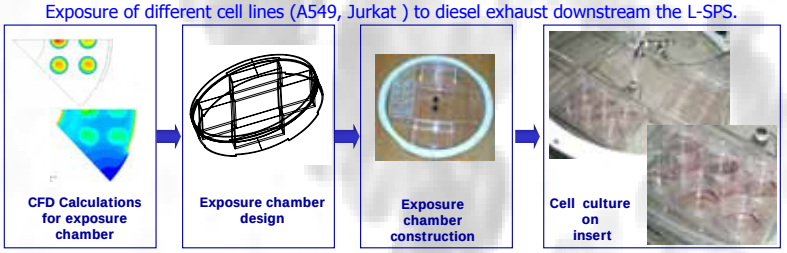
- A549 nFKB, IL8 (Lung epithelial cells,adherent to surfaces)
- JURKAT INFγ, IL4 (Blood cells, grow in suspension, sensitive to fungi contamination)



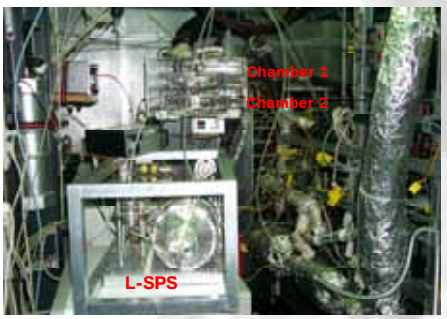
Cell Lines Exposure to Diesel Exhaust

All cell lines were exposed employing a specially in-house designed and constructed *in vitro* Exposure Chamber.

Exposure of different cell lines (A549, Jurkat) to diesel exhaust downstream the L-SPS.



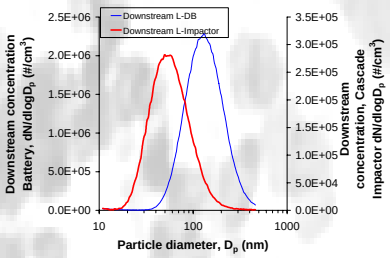
Experimental Set up



CONCLUSIONS

Applying the L-SPS sampler to diesel exhaust it is possible to obtain two widely separated size distributions for biological exposure studies.

Additionally, it is promising to combine the two described separation principles – inertial impaction and diffusional deposition - in order to obtain distributions with smaller geometric standard deviation able to simulate a monodispersed aerosol sample.



REFERENCES: 1. Design and evaluation of a selective particle size sampler for continuous delivery of different size ranges of diesel exhaust particles for health effect studies, Dimitrios Boudouris, Eleni Papaioannou, Penelope K. Baltzopoulou and Athanasios G. Konstandopoulos, *Aerosol & Particle Technology Laboratory, CERTH/CPERI, P.O. Box 361, Thermi Thessaloniki 57 001, Greece*

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