Supplemental Information for

Design and validation of an air-liquid interface (ALI) exposure device based on thermophoresis

Mika Ihalainen1, Pasi Jalava1, Tuukka Ihantola1, Stefanie Kasurinen1, Oskari Uski1, Olli Sippula1, Anni Hartikainen1, Jarkko Tissari1, Kari Kuuspalo1, Anna Lähde1, Maija-Riitta Hirvonen1, Jorma Jokiniemi1

1 Department of Environmental and Biological Sciences, University of Eastern Finland, P.O. Box 1627, Kuopio FI-70211, Finland

**Analytical solution for deposition rate**

A flow between two plates of different temperatures was considered, and the velocity profile between the plates can be approximated as plane Poiseuille flow (Panton, 2005)

 (S1)

where *Q* is the flow rate, *b* is the channel width, *a* is the height of the channel, and *z* is the position coordinate perpendicular to air flow. The velocity of the particle in the x-direction is presumed to follow the velocity of the gas as described in Eq. S1. In the z-direction, the particle experiences thermophoretic and gravitational forces, which affect the particle at the opposite direction and yield

 (S2)

If a particle is released at the inlet location *z0* at *t =* 0, the coordinates of the particle can be described as

 (S3)

, (S4)

where . The particle deposits as the; thus, by solving the Eq. S4 and setting , the x-coordinate *xdep* for deposition of particle released at *z0* can be obtained

 (S5)

The maximum *xdep* will be reached when *z0 =* 0

 (S6)

Next, we consider a region between (z0+dz) and (z0). The area of this region is *dA = bdz,* and the aerosol particles per second flow through is

 (S7)

where *c* is the concentration of aerosol and *vx(z0)* is described in Eq. S1. The particles released from the considered region are deposited between *xdep(z0+dz)* and *xdep(z0)*. This allows us to write the deposition area

 (S8)

By combining the Eq.s S5 and S8, the deposition rate on the cold plate is

 (S9)

This shows that the deposition rate obtained analytically depends only on the *vz* velocity and aerosol concentration and not on location *z0* leading to even deposition at range of *x =* [0, *xdep,max*].



Figure S1. Thermophoretic, gravitational and diffusion velocity magnitudes of spherical soot particles inside thermocollector.

**Estimated effect of diffusion on particle deposition**

The diffusion velocity inside the aerosol channel of the thermocollector was estimated with the following equations (Gormley and Kennedy 1949)

 (S10)

 (S11)

 (S12)

 (S13)

where *D* is diffusion coefficient, *v* is velocity of the flow, *L* is length of the channel and *d* is diameter of the channel. The deposition velocities of the thermophoresis, gravitation and diffusion are compared in Fig S1. The diffusion was estimated to be as effective deposition mechanism as the thermophoresis for 10 nm particles but for 20 nm particles the effect of diffusion is substantially smaller on overall deposition. Therefore it is suggested that the lower particle size limit for the thermocollector should be approximately 20 nm. In future, the effect of diffusion in thermocollector should be considered in a more detailed manner. This would increase the predicted deposition rate accuracy for the particles close to the lower particle size limit.

 References:

Gormley, P, and M Kennedy. 1949. “Denuder Principle and Equation.” *Proc. R. Ir. Acad. A* 52: 163–69.

Panton, Ronald L. n.d. “Incompressible Flow, 2005.” John Wiley & Sons, New Jersey.