ETH zürich

High-throughput generation of aircraft-like soot

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PTL Particle Technology Laboratory

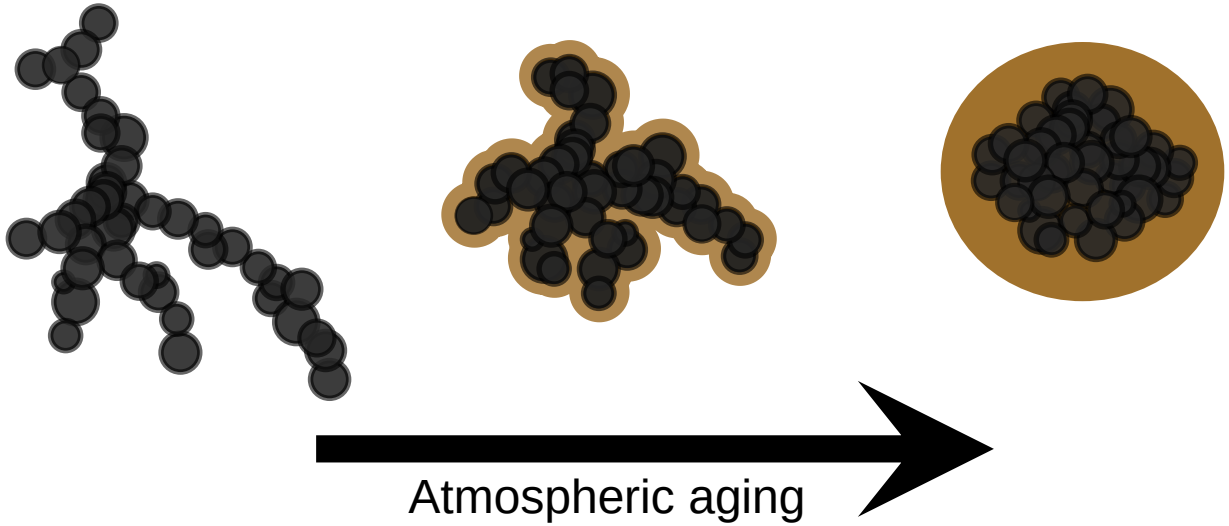
FNSNF
Fonds national suisse
Schweizerischer Nationalfonds
Fondo nazionale svizzero
Swiss National Science Foundation

Motivation

Ultrafine (< 100 nm) particle air pollution [1]

Specific surface area, *SSA*, is one of the most important metrics for quantifying toxicity [2]

SSA [3] and pore size distributions [4] determine rate of atmospheric aging



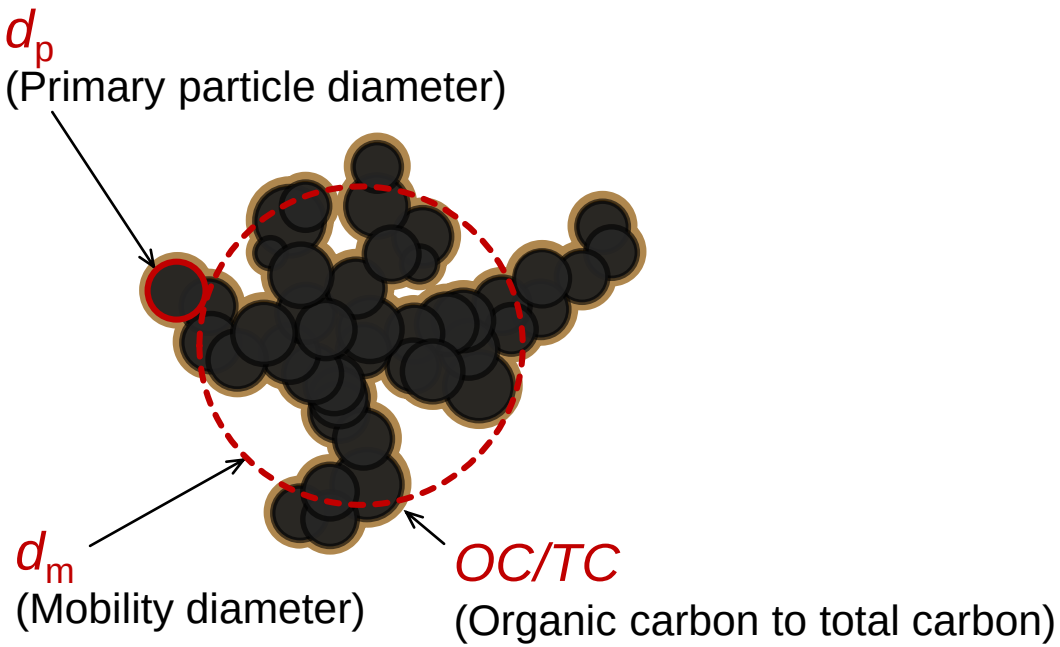
***SSA* measurement requires 10s of mg of soot!**

[1] D. Westerdahl, S.A. Fruin, P.L. Fine, C. Sioutas (2008) *Atmos. Environ.* 42, 3143–3155.
[2] O. Schmid, T. Stoeger (2016) *J. Aerosol. Sci.* 99, 133 – 143.
[3] C. Marcolli, F. Mahrt, B. Kärcher (2021) *Atmos. Chem. Phys.* 21, (10) 7791 – 843.
[4] R. Zhang, A.F. Khalizov, J. Pagles, D. Zhang, H. Xue, P.H. McMurry (2008) *Proc. Natl. Acad. Sci. USA.* 105, (30) 10291 – 10296.

Soot Commercial Soot Generator

This work, enclosed spray flames:

MiniCAST:

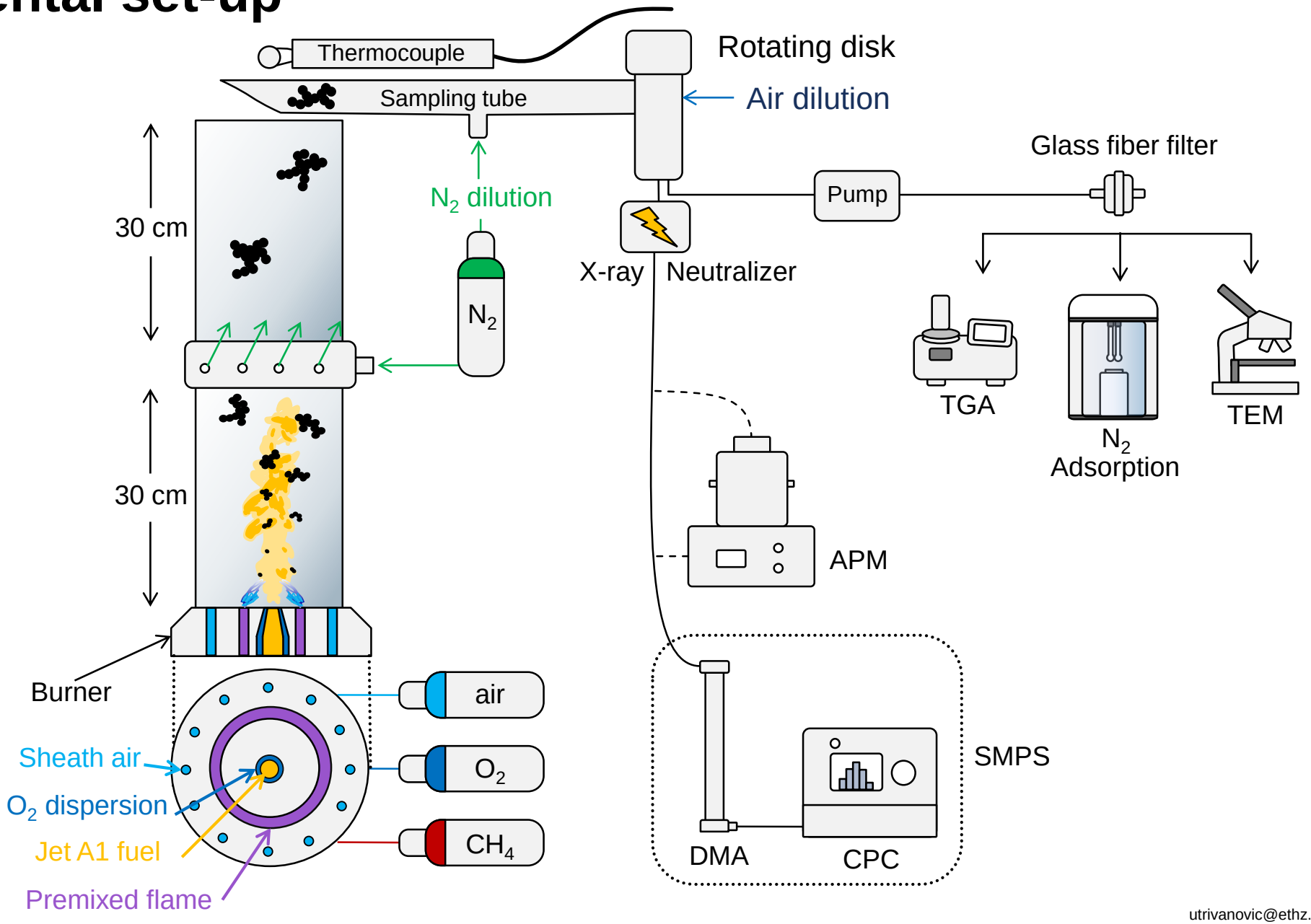


Cannot produce high-thrust aircraft soot (OC/TC too high or d_m too large)

Aircraft-like with high throughput

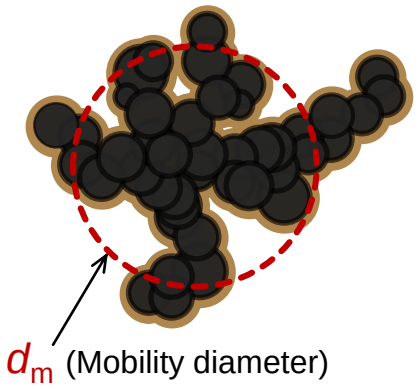
[1] U. Trivanovic, G.A. Kelesidis, S.E. Pratsinis (2022) *Aerosol Sci. Technol.* In Press, doi: 10.1080/02786826.2022.2070055

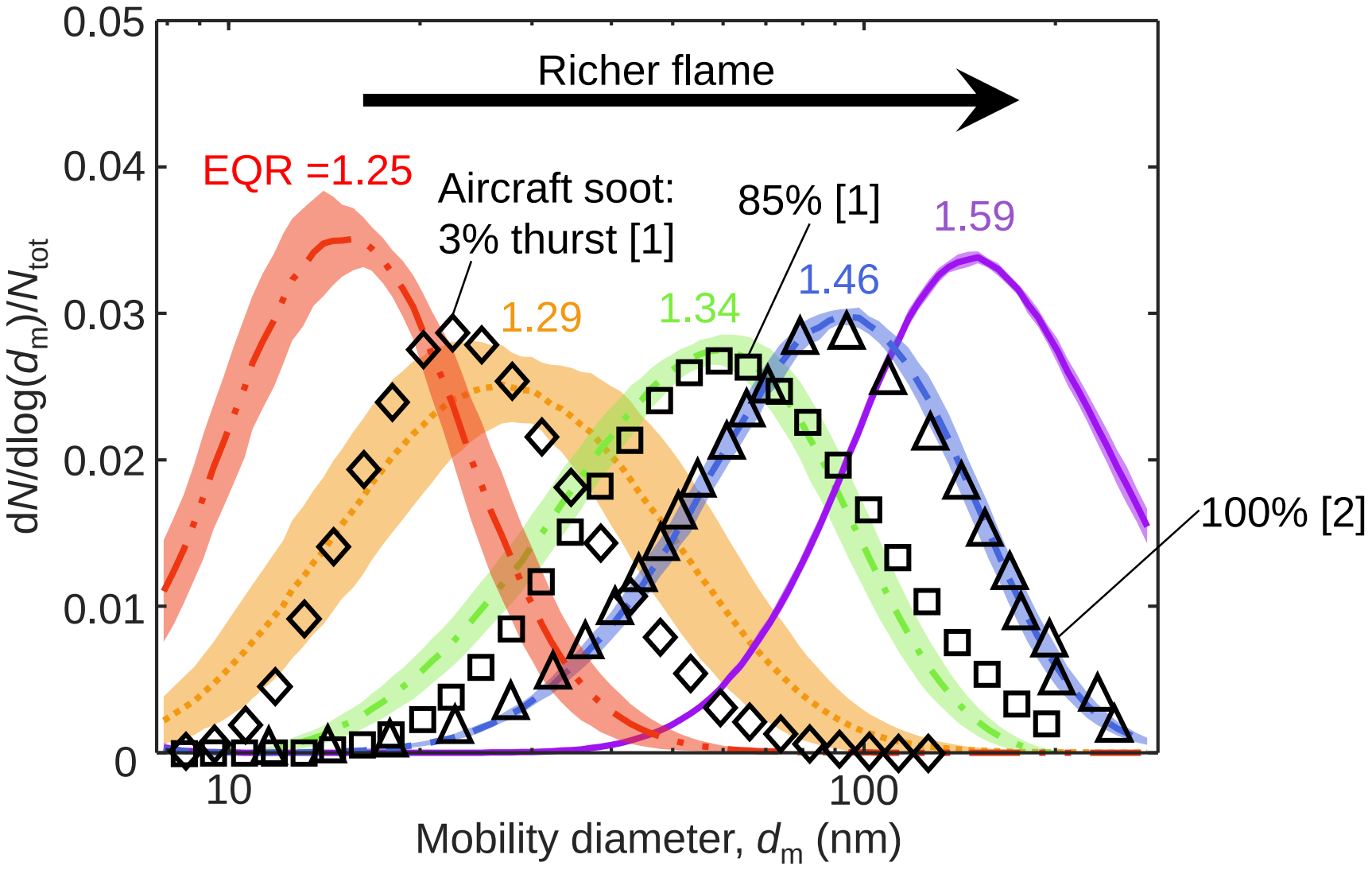
Experimental set-up



U. Trivanovic, G.A. Kelesidis, S.E. Pratsinis (2022) *Aerosol Sci. Technol.* In Press, doi: 10.1080/02786826.2022.2070055

Mobility size distributions

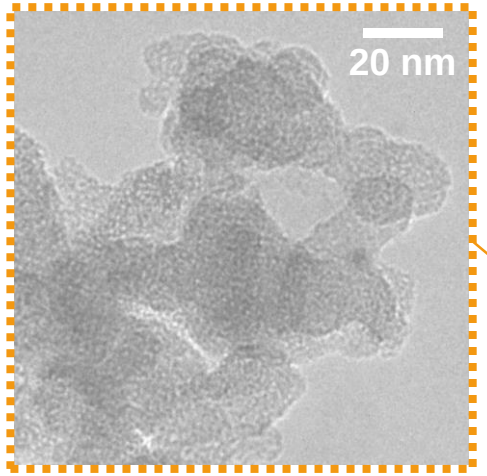




[1] M. Abegglen, L. Durdina, B.T. Brem, J. Wang, T. Rindlisbacher, J.C. Corbin, U. Lohmann, B. Sierau (2015) *J. Aerosol Sci.* 88, 135 – 147.
[2] D. Delhaye, F.-X. Ouf, D. Ferry, I.K. Ortega, O. Penanhoat, S. Peillon, F. Salm, X. Vancassel, C. Focsa, C. Irimiea, et al. (2017) *J. Aerosol Sci.* 105, 48 – 63.

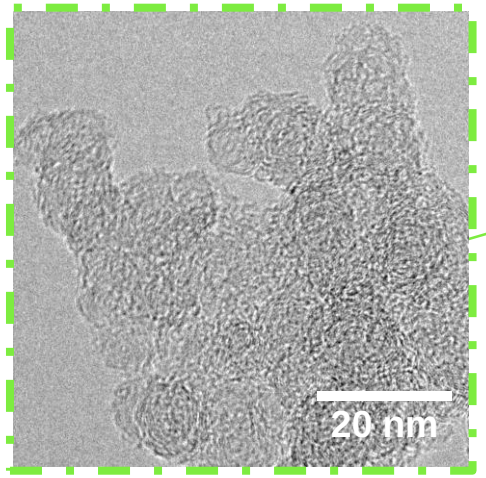
Dynamics of soot d_m and d_p

EQR = 1.29

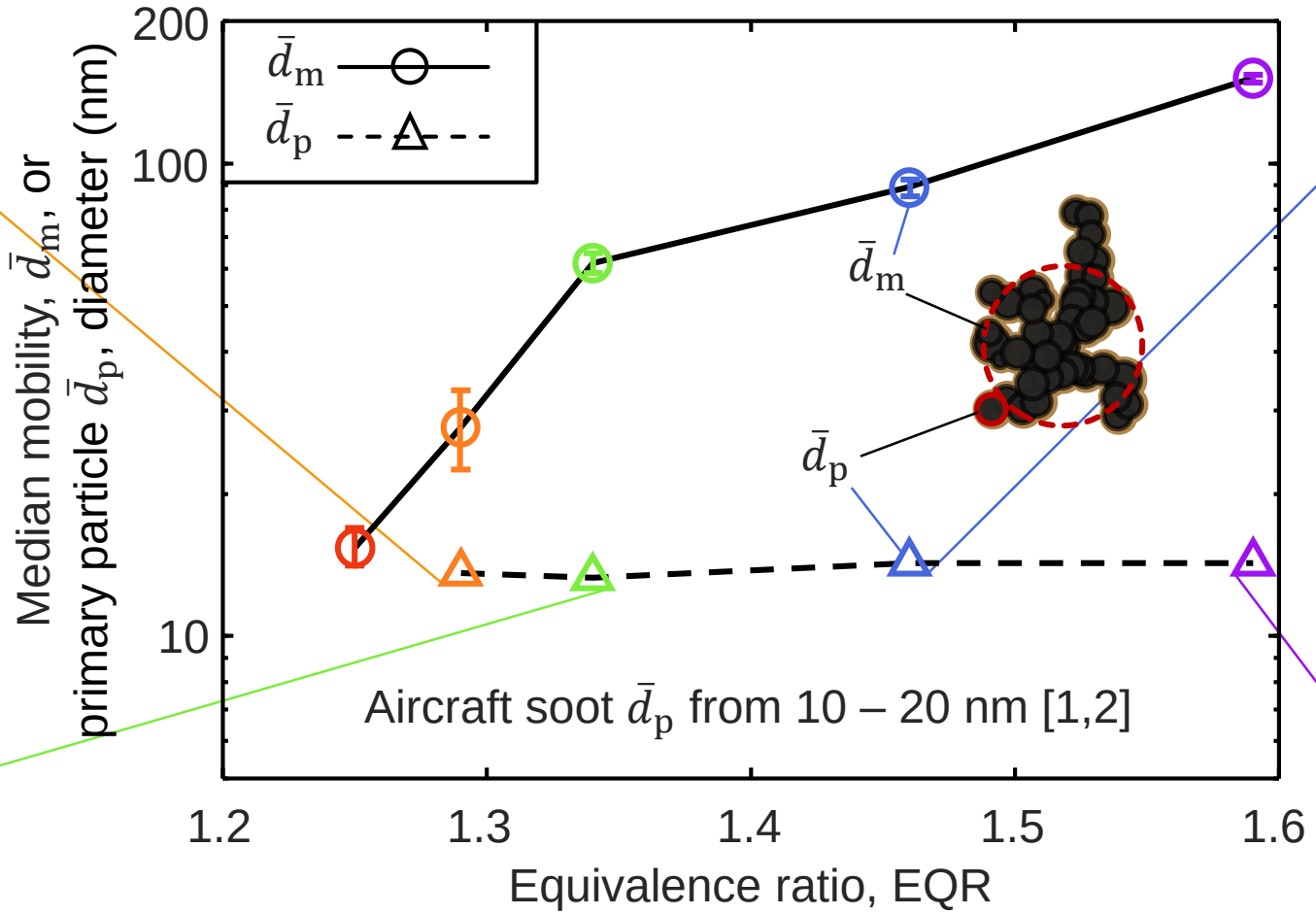


$\bar{d}_p$ = 13.6

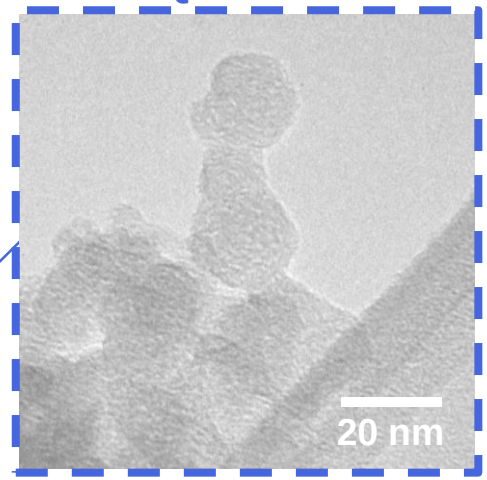
EQR = 1.34



$\bar{d}_p$ = 13.5

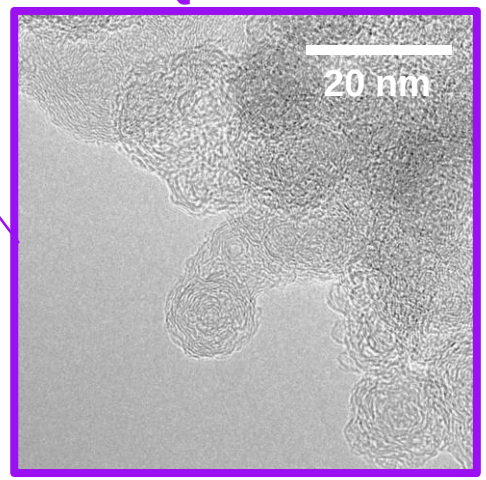


EQR = 1.46



$\bar{d}_p$ = 14.1

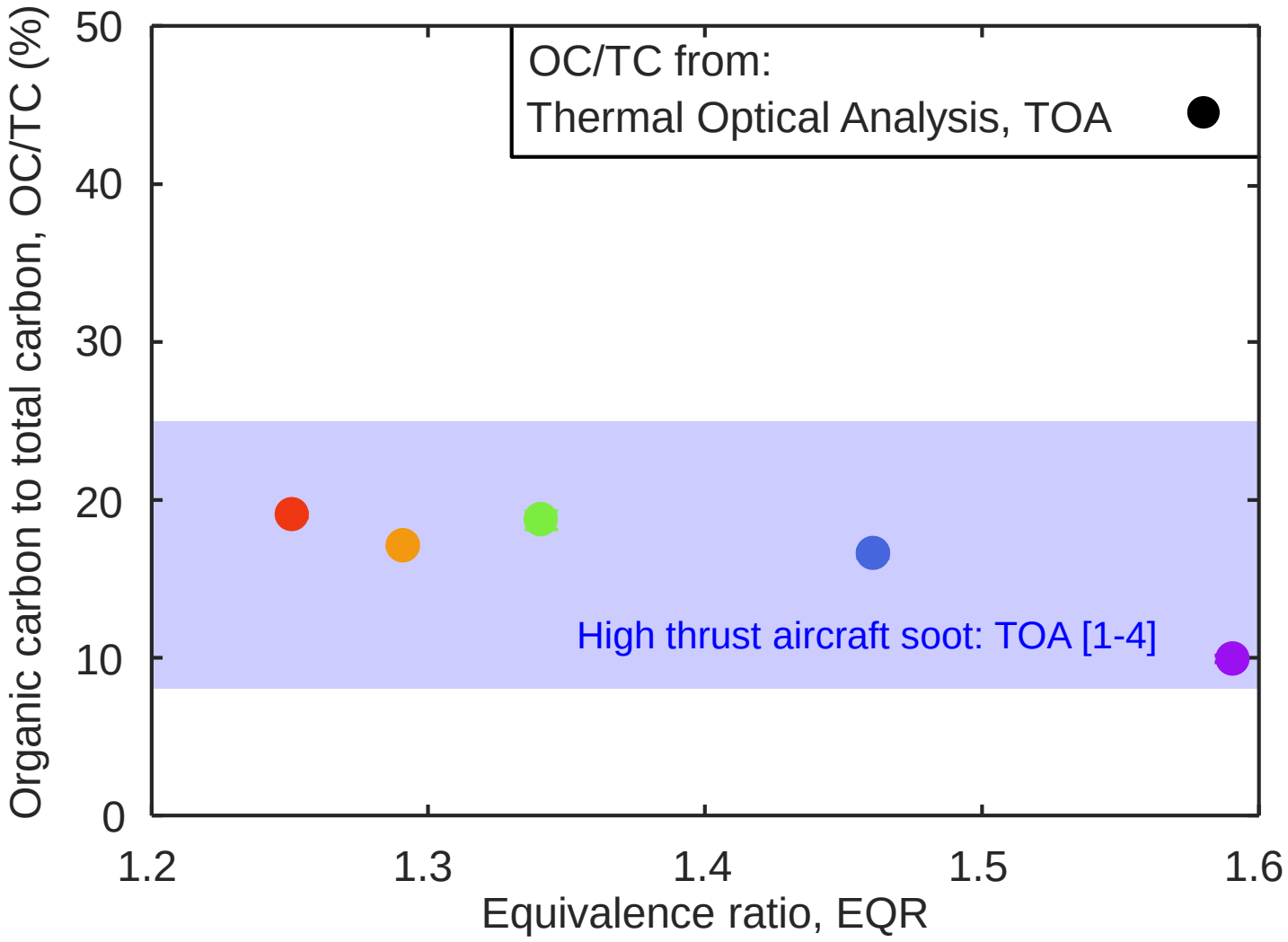
EQR = 1.59



$\bar{d}_p$ = 14.3

[1] A.M. Boies, M.E.J. Stettler, J.J. Swanson, T.J. Johnson, J.S. Olfert, M. Johnson, M.L. Eggersdorfer, T. Rindlisbacher, et al. (2015) *Aerosol Sci. Technol. 49*, 842 – 855.
[2] A. Liati, B.T. Brem, L. Durdina, M. Vögtli, Y.A.R. Dasilva, P.D. Eggenschwiler, J. Wang (2014) *Environ. Sci. Technol. 48*, 10975 – 10983.

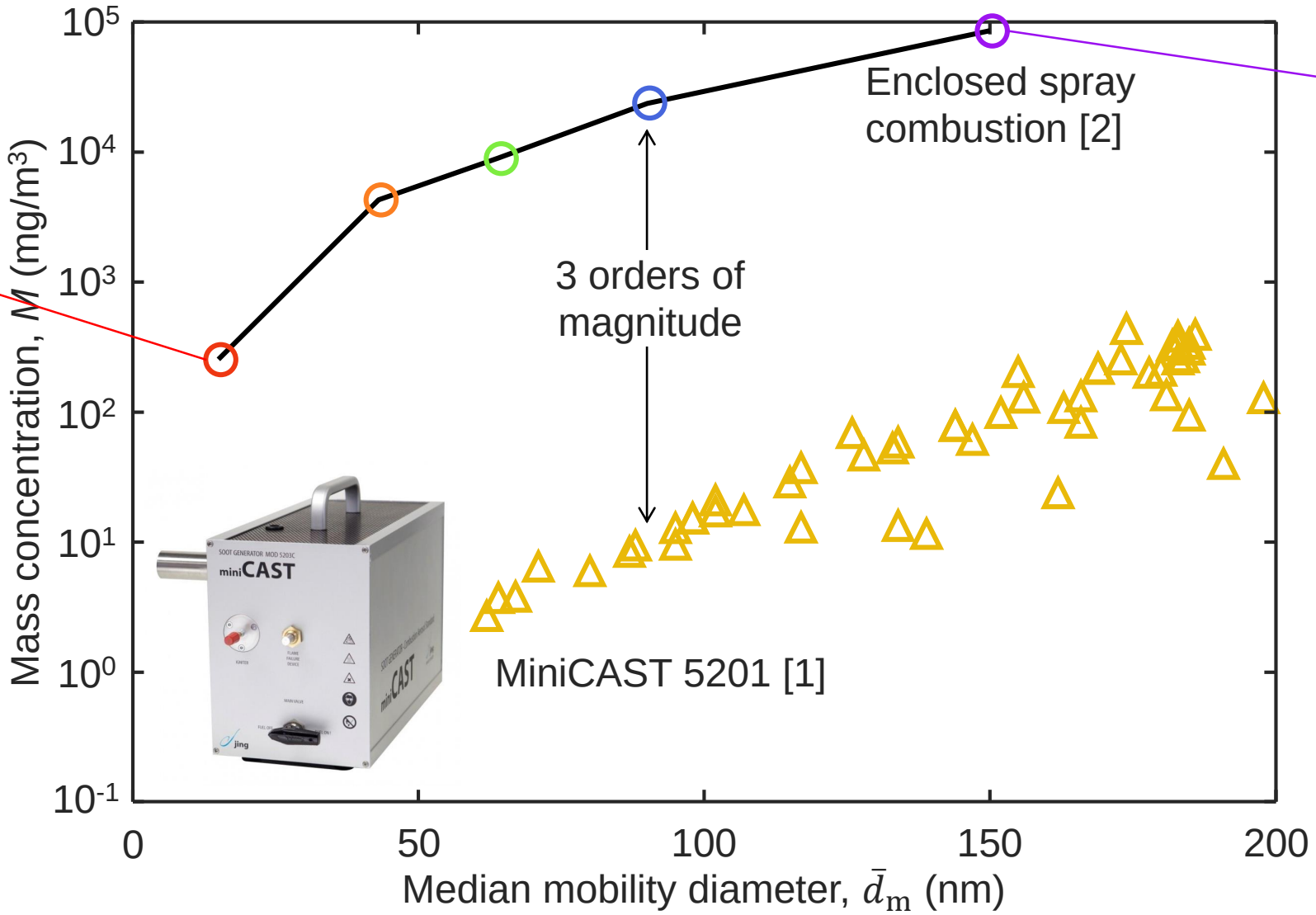
Organic carbon total carbon ratio



[1] F. Cavalli, M. Viana, K.E. Yttri, J. Genberg, J.-P. Putaud (2010) *Atmos. Meas. Tech*. 3, 79 – 89.
[2] D. Delhaye, F.X. Ouf, D. Ferry, I.K. Ortega, O. Penanhoat, S. Peillon, F. Salm, X. Vancassel, C. Focsa, C. Irimiea, et al. (2017) *J. Aerosol Sci. 105*, 48 – 63.
[3] M. Elser, B.T. Brem, L. Durdina, D. Schönenberger, F. Siegerist, A. Fischer & J. Wang (2019) *Atmos. Chem. Phys.* 19, 6809 – 6820.
[4] I. Marhaba, D. Ferry, C. Laffon, T.Z. Regier, F.X. Ouf, P. Parent (2019) *Combust. Flame* 204, 278 – 289.

Mass concentration

0.3 mg/min

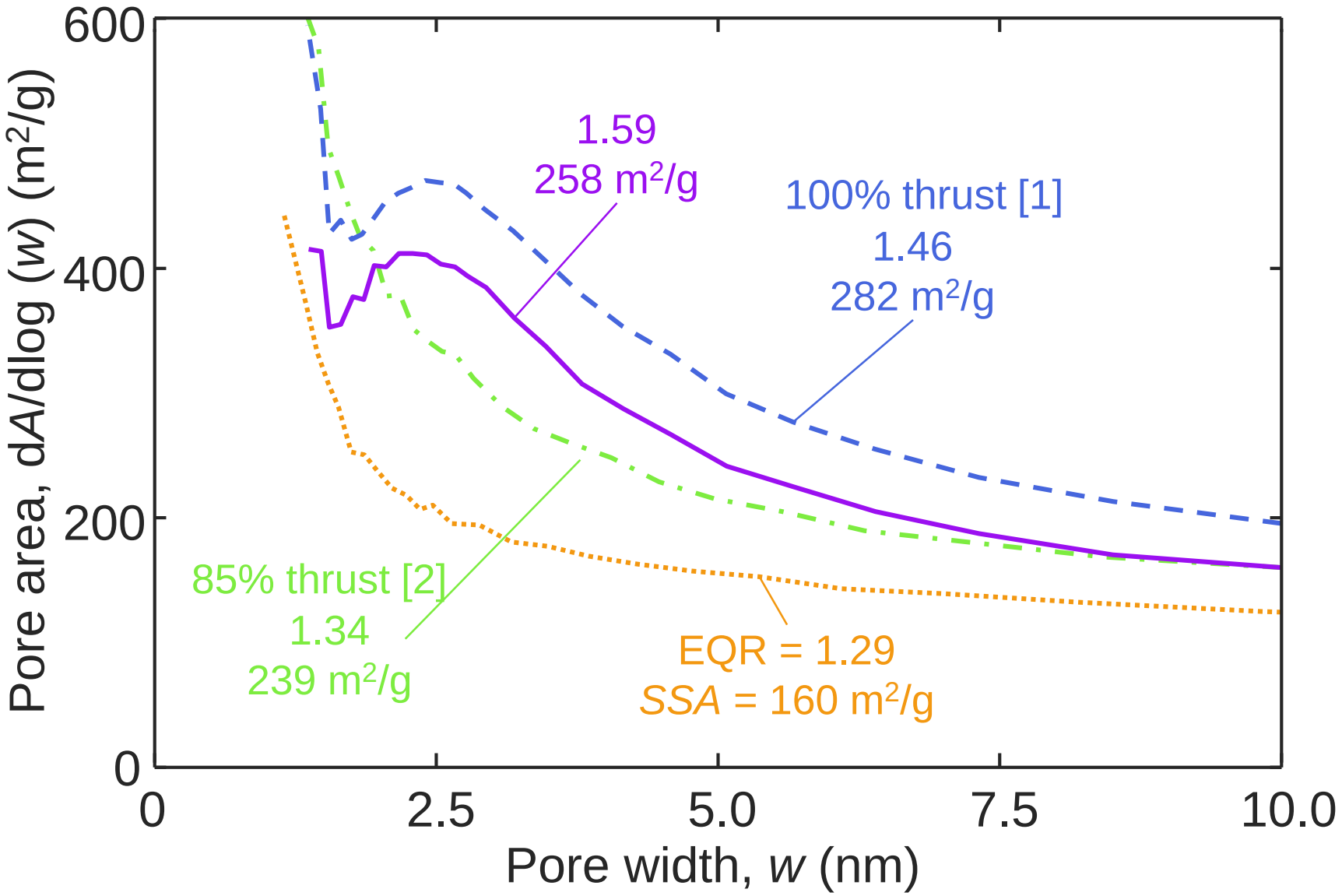


[2]

18 mg/min

[1] M. Ess & K. Vasilatou (2019) *Aerosol Sci. Technol.* 53, 29 – 44.
[2] U. Trivanovic, G.A. Kelesidis, S.E. Pratsinis (2022) *Aerosol Sci. Technol.* In Press, doi: 10.1080/02786826.2022.2070055

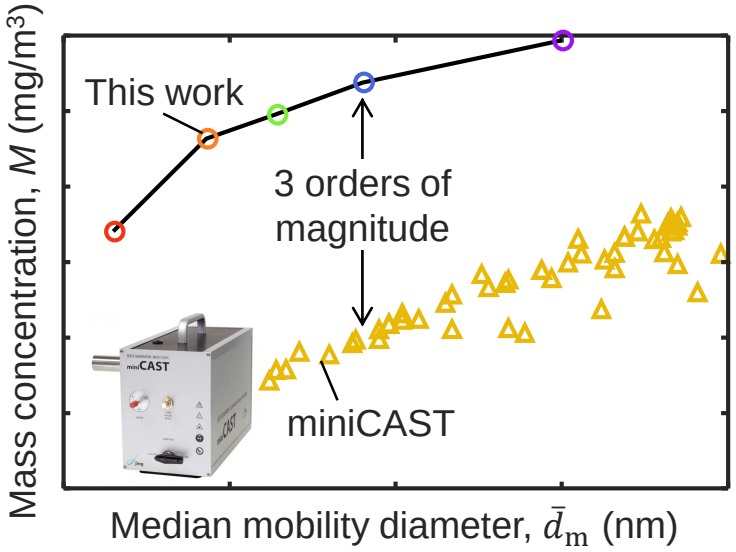
Pore size distributions

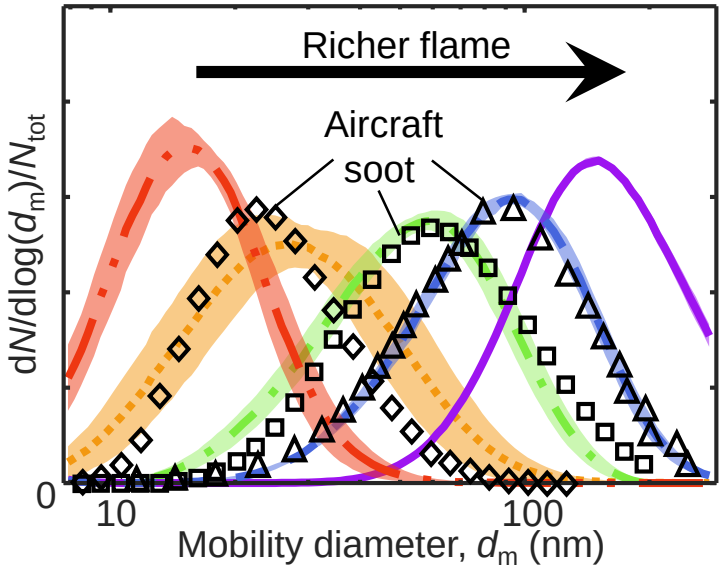


[1] D. Delhaye, F.-X. Ouf, D. Ferry, I.K. Ortega, O. Penanhoat, S. Peillon, F. Salm, X. Vancassel, C. Focsa, C. Irimiea, et al. (2017) *J. Aerosol Sci.* 105, 48 – 63.
[2] M. Abegglen, L. Durdina, B.T. Brem, J. Wang, T. Rindlisbacher, J.C. Corbin, U. Lohmann, B. Sierau (2015) *J. Aerosol Sci.* 88, 135 – 147.

Conclusions

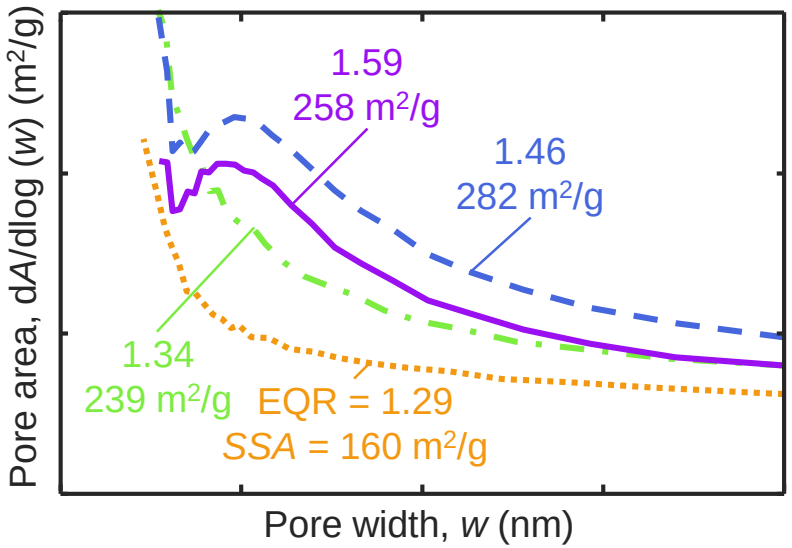
- Aircraft-like soot is generated here by enclosed spray combustion by varying EQR





- The present reactor can produce up to 3 orders of magnitude larger mass concentrations than existing generators

- Aircraft soot is primarily non-porous but at take-off (100% thrust) there may be an increase in porosity.



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Thank you for listening