

Towards a stable mass and number generator of Ag fractal soot-like particles for repeatable calibration

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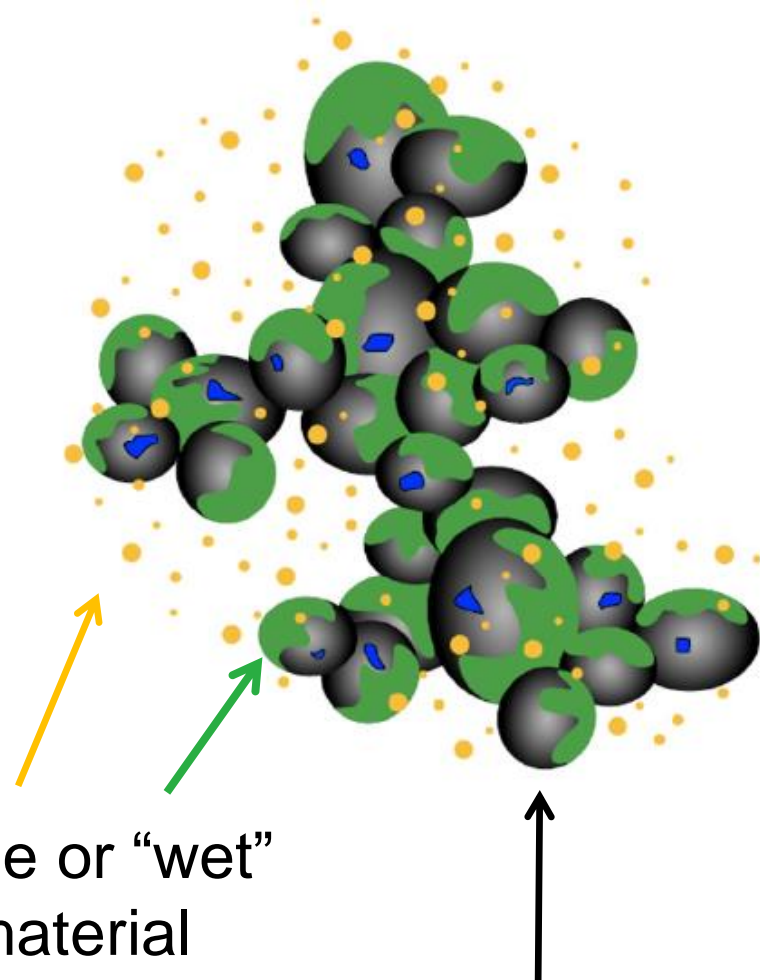
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Germany

Catalytic Instruments GmbH & CO.KG specializes in the production of innovative aerosol instruments and services based on “catalytic stripper” technology

- Need for silver particle generation
- Standard methods for silver particle generation
- Characteristics of silver particles
 - Aggregate
 - Spherical
- Design of new silver particle generator
- Results
- Catalytic stripper

Solid Particle Aerosol Source

- Particle size and morphology governs transport and line losses in sampling systems.
 - Losses independent of chemistry
- Fractal-like aggregates are common components of automotive exhaust.
- Solid particles do not undergo phase-change during sampling, heating and dilution.
- Silver particles are commonly used aerosol sources
 - Known chemistry
 - Known morphology
 - Known phase



Semi-volatile or “wet”
particles / material

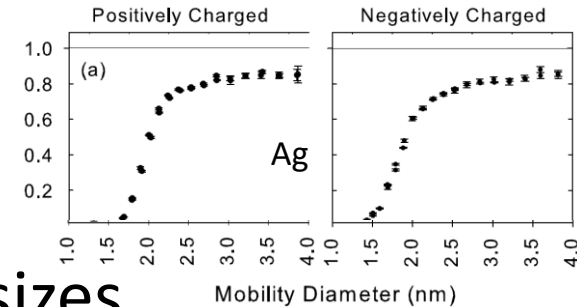
Solid or non-volatile particles

Ag Particles are Common Test Aerosols

- Ag allows easy generation of <20 nm particles

Effect of Working Fluid on Sub-2 nm Particle Detection with a Laminar Flow Ultrafine Condensation Particle Counter

Kenjiro Iida, Mark R. Stolzenburg, and Peter H. McMurry
Particle Technology Laboratory, University of Minnesota, Minneapolis, Minnesota, USA



- Ag is easily spans orders of magnitude in sizes



Engine Exhaust Solid Sub-23 nm Particles: II. Feasibility Study for Particle Number Measurement Systems

Barouch Giechaskiel and Giorgio Martini
Joint Research Centre

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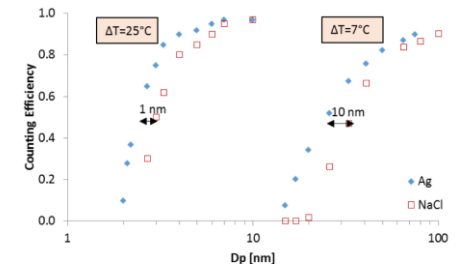
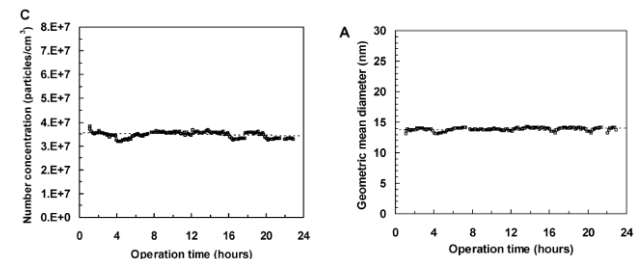


Figure 2. Counting efficiencies of PNCs with different temperature differences between saturator and condenser (from [7] and [8]).

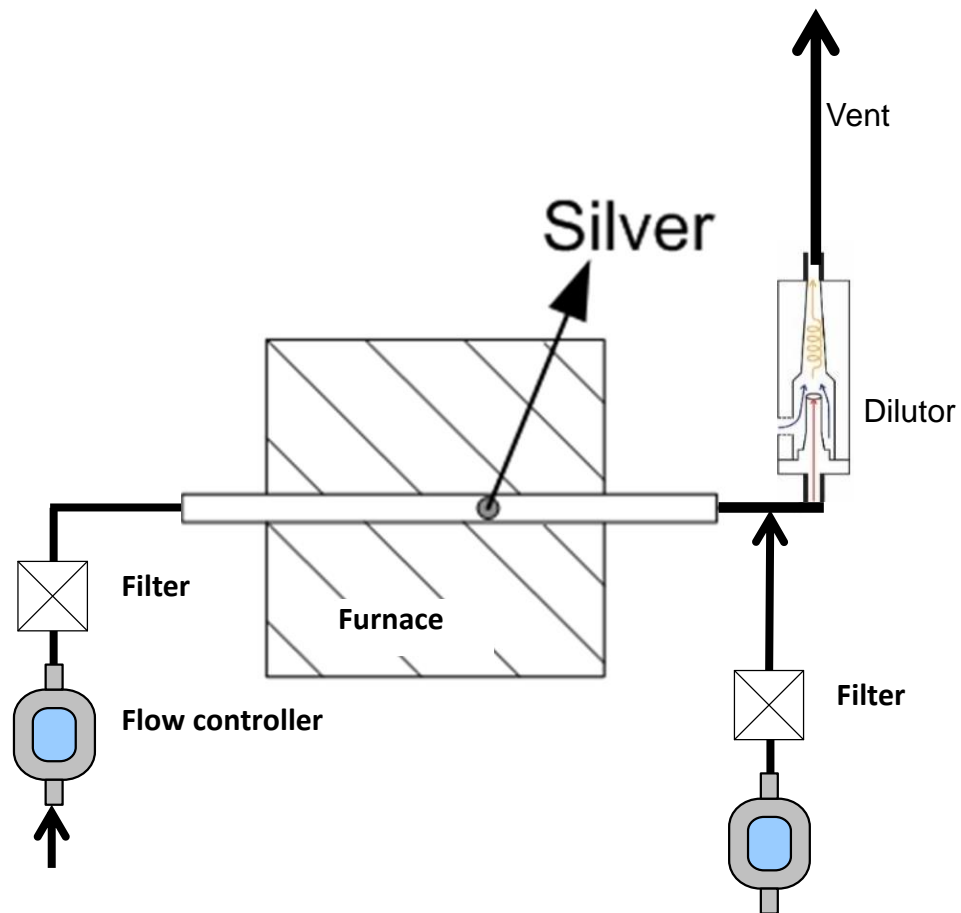
- Ag generation systems have long term stability

Long-Term Stability Characteristics of Metal Nanoparticle Generator Using Small Ceramic Heater for Inhalation Toxicity Studies

Jun Ho Ji, Jae Hee Jung, Il Je Yu & Sang Soo Kim

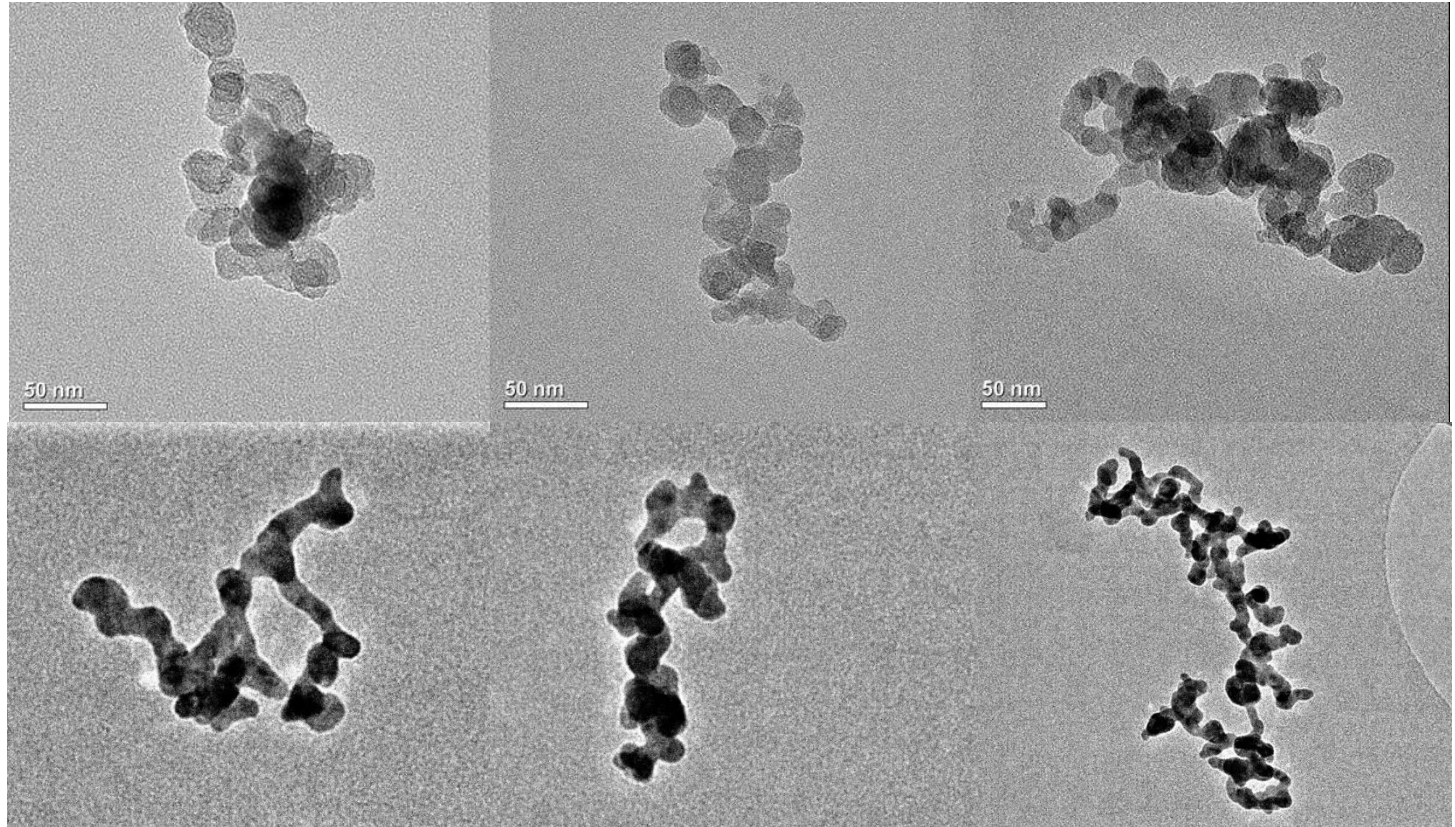


Standard Method for Silver Particle Generation



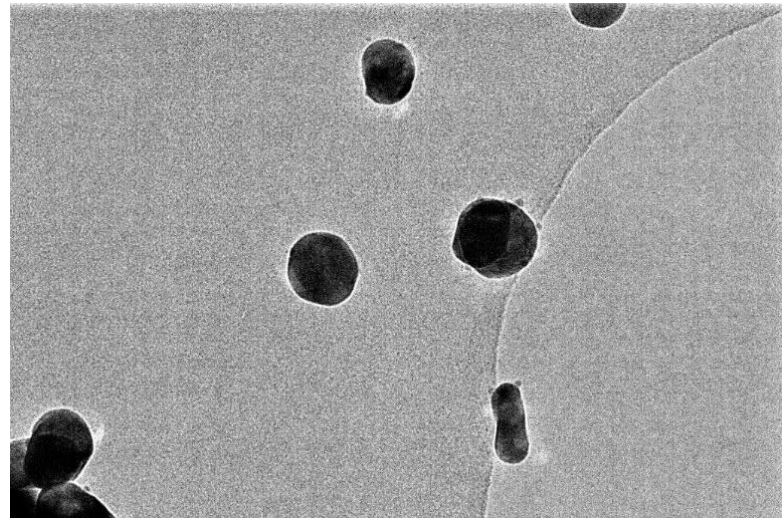
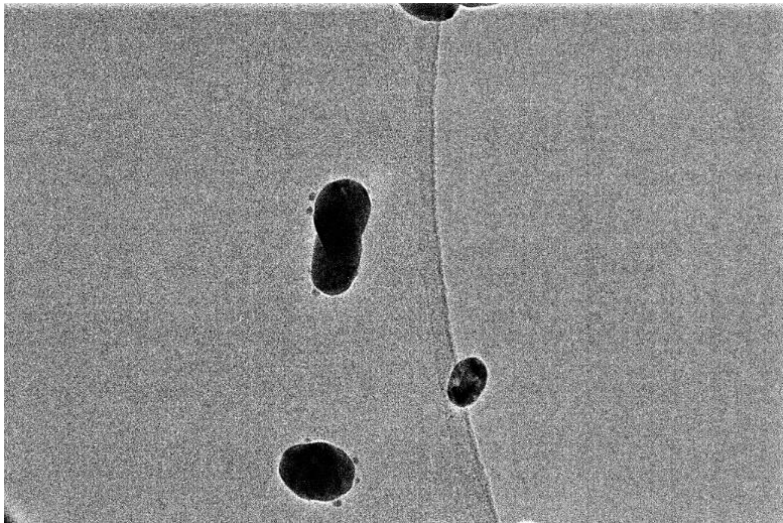
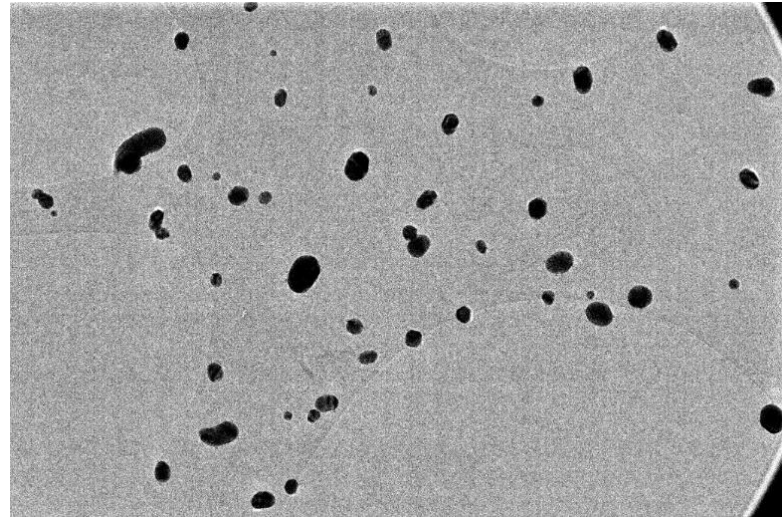
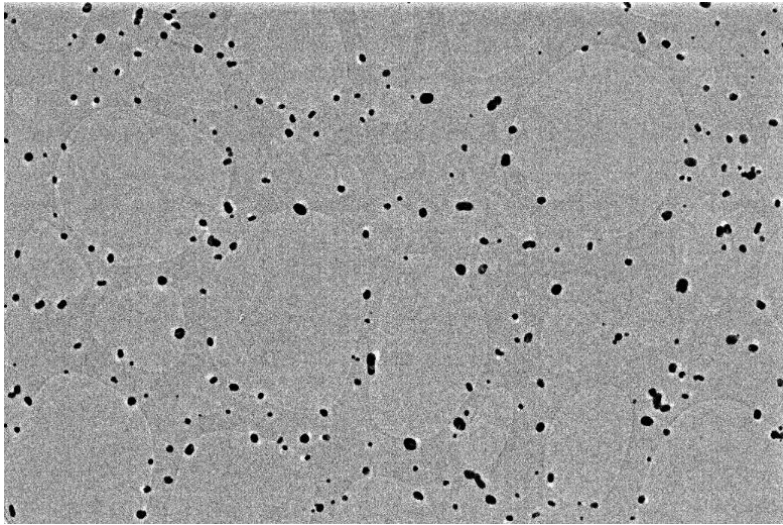
Silver and Diesel Soot Aggregates have Similar Morphology

**Diesel
soot**

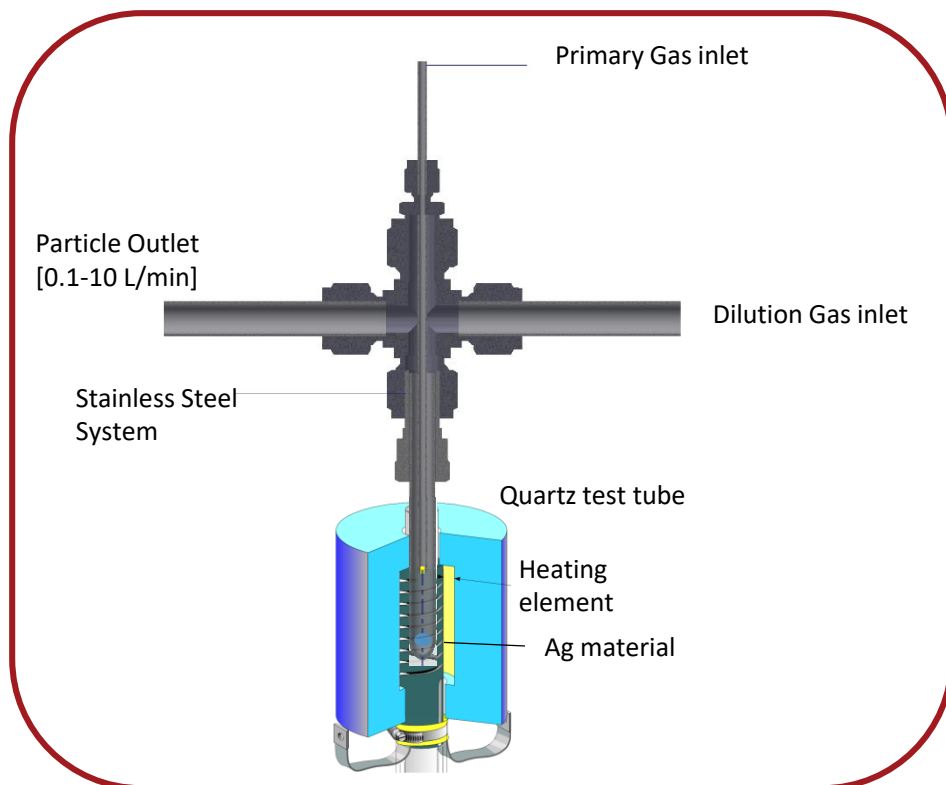


**Silver
particles**

Sintered Silver Particles are Spherical



Schematic of Model SPG01*

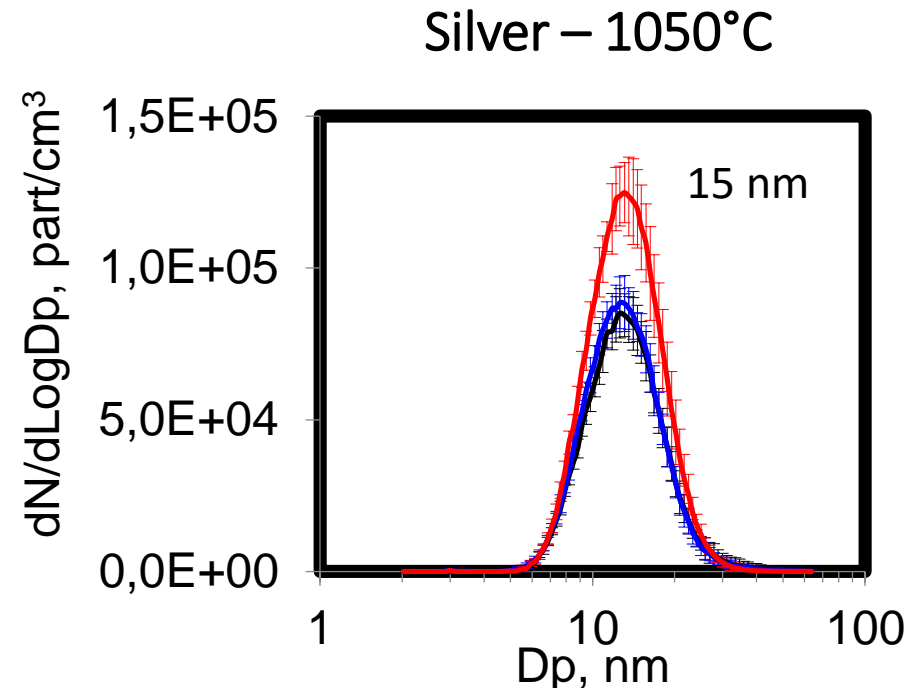
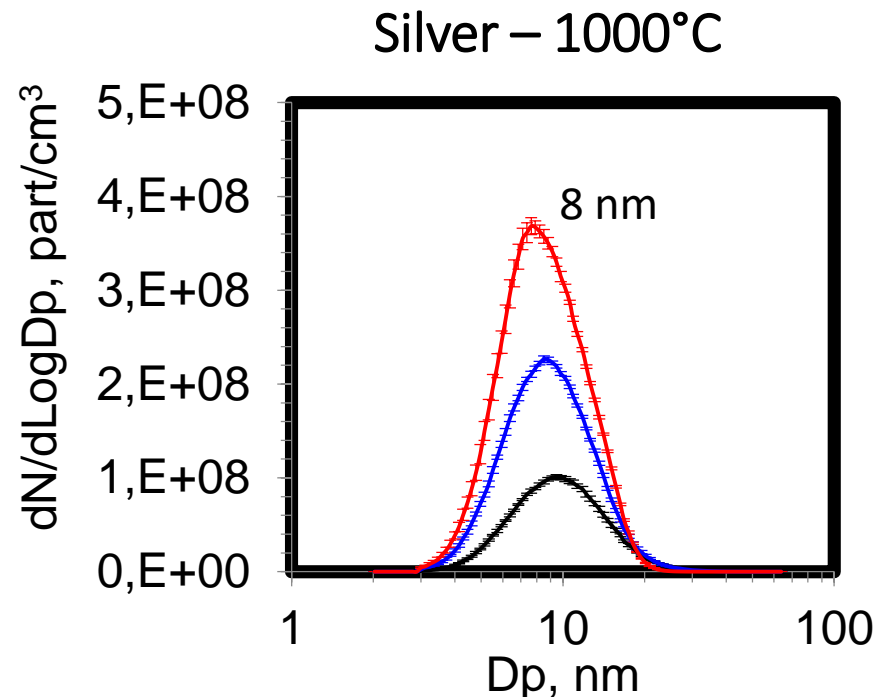


- **First commercial** inert-gas condensation device
- Robust design
- Precise temperature control
- Repeatable operation
- Optional – downstream Sintering Furnace

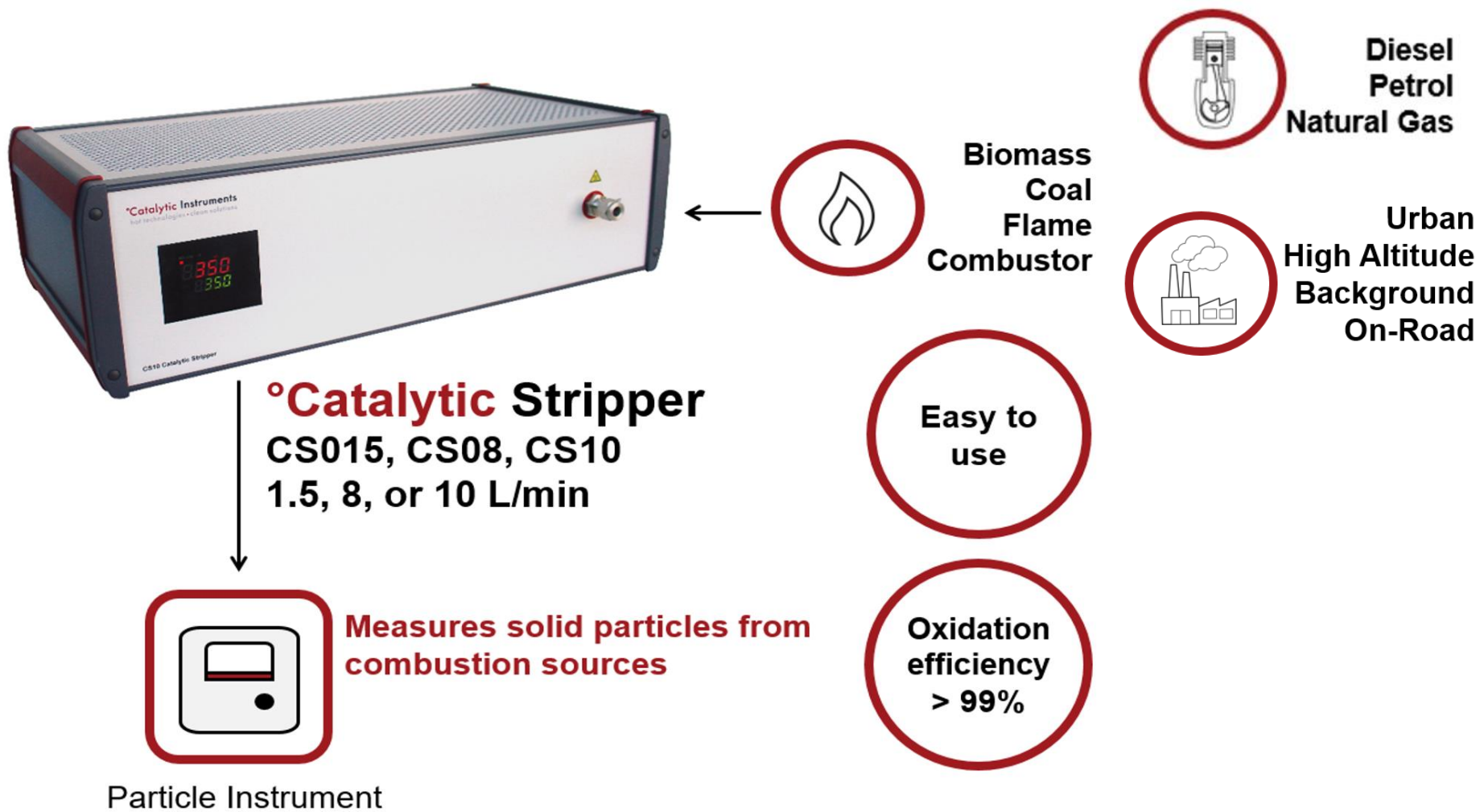
*Patent pending

Benefits of Silver Particle Generator (SPG01)

- Silver size changed by operating temperature
- Silver concentration changed by dilution without changing size
- Orders of magnitude in concentration possible – 10^4 to 10^8



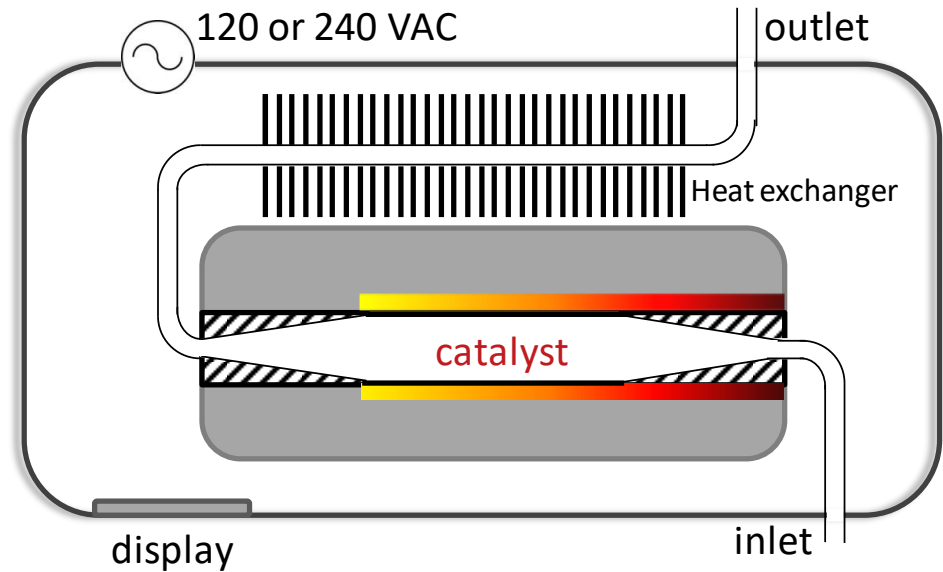
Catalytic Stripper for Solid Particle Measurements



Catalytic stripper design

Typical CS design characteristics

- Ceramic monolith
- Alumina washcoat
- Known precious metal coating
- Catalyst formulation tolerant to sulfur poisoning
- Constant operating temperature of 350°C
- Flowrate 0.3 to 25 L/min or more
- Predictable solid particle loss characteristics



Catalytic Stripper — a more robust solution

- Evaporation Tube (ET) alone has been shown to **not remove** all volatile components in some cases^{1,2}
- The ET may even *generate* solid particles under certain conditions²

→ The Catalytic Stripper (CS) is a robust solution to the requirement of **solid** particle measurement

- The CS complies with current PMP regulation directly (i.e. > 99.99% removal of challenge aerosol at 50nm)
 - simply a more robust ET in the VPR system, with catalytic membranes for higher volatile removal efficiency

¹Amanatidis, S., Ntziachristos, L., Karjalainen, P., Saukko, E., Simonen, P., Kuittinen, N., ... R Onkk O B, T. (2018). AS&T Comparative performance of a thermal denuder and a catalytic stripper in sampling laboratory and marine exhaust aerosols. <https://doi.org/10.1080/02786826.2017.1422236>

²Swanson, Jacob and David Kittelson, 2010. Evaluation of thermal denuder and catalytic stripper methods for solid particle measurements, Journal of Aerosol Science, Volume 41, Issue 12, Pages 1113-1122.

CS removal of **all** volatile components <23nm

- High number of *volatile* sub-23nm aerosol passing through ET in a VPR system... none through CS

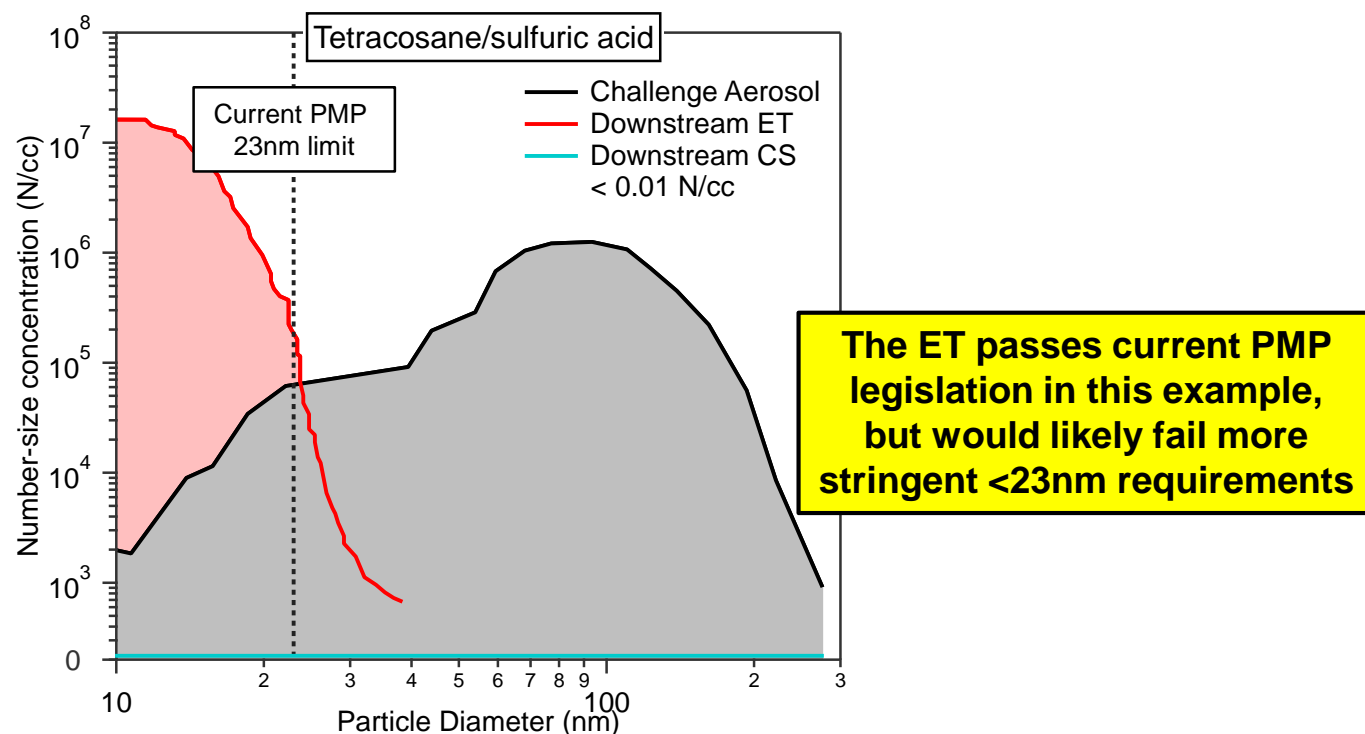


Figure adapted from: Swanson, Jacob and David Kittelson, 2010. Evaluation of thermal denuder and catalytic stripper methods for solid particle measurements, Journal of Aerosol Science, Volume 41, Issue 12, Pages 1113-1122.

A tougher volatile challenge...

- High number of *volatile* sub-23nm aerosol passing through ET in a VPR system... none through CS

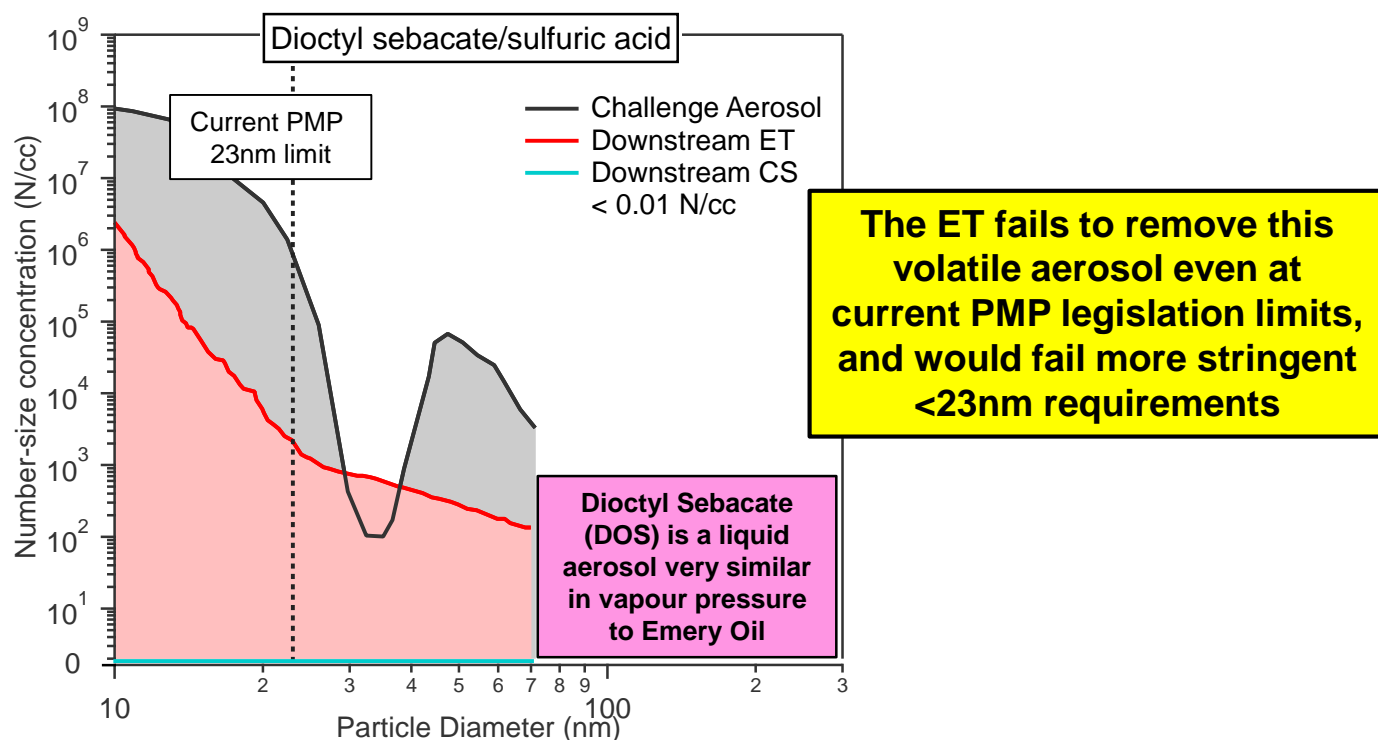


Figure adapted from: Swanson, Jacob and David Kittelson, 2010. Evaluation of thermal denuder and catalytic stripper methods for solid particle measurements, Journal of Aerosol Science, Volume 41, Issue 12, Pages 1113-1122.

Catalytic Stripper — a more robust solution

- Repeatabile and robust performance
- Exceeds 23nm legislated performance
 - ✓ Tetracontane
 - ✓ Emery Oil (proxy)
 - ready for 10nm PMP legislation & harmonized CPC calibration
- CS requirements are customizable
 - ✓ flow rates
 - ✓ oxidation efficiency vs penetration profile
- Available as catalytic core or benchtop device
- Low power consumption (nominal 40W; max < 210 W during warm up)

