Comparison of Aerosolization Devices for Colloidal Particles

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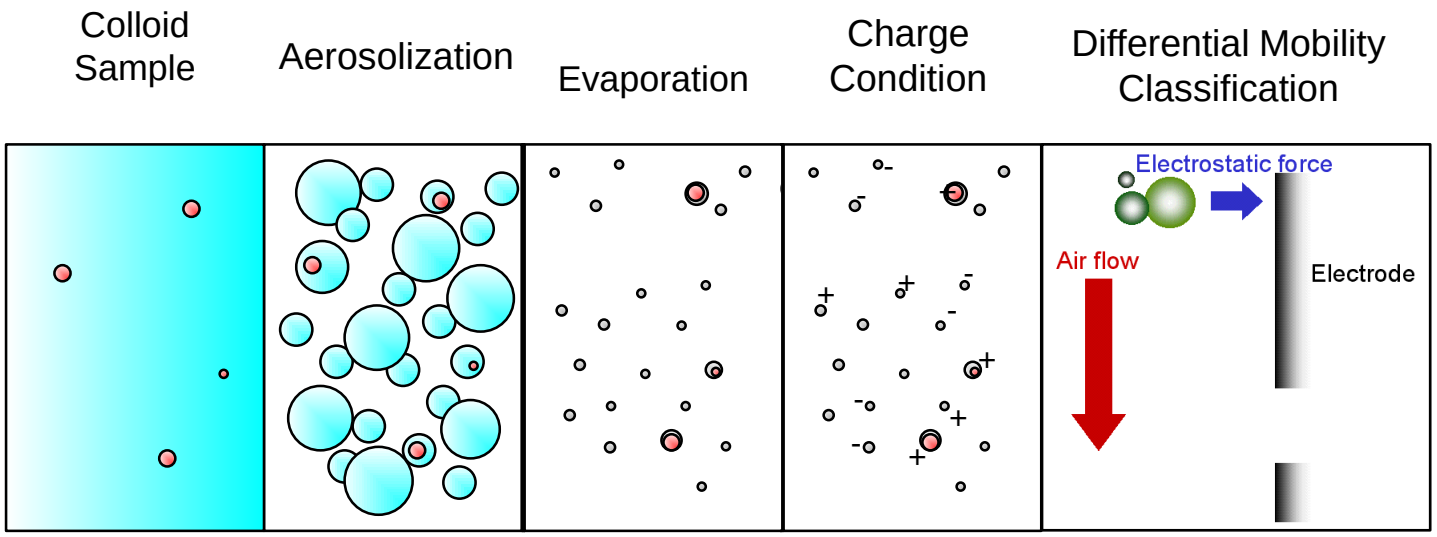
Why Aerosolize Colloidal Nanoparticles

- Colloidal nanoparticles in liquid phase are widely and frequently used in studies related to material science, chemistry, biology, and etc
- Many applications of these colloidal nanoparticles are strongly size dependent
- Challenges in analyzing colloidal nanoparticles in liquid phase or by offline electron microscopy
- Development of reliable high resolution, fast response, and lower size detection limit online sizing techniques is greatly in demand
- Electrical mobility classification methods used in aerosol measurements meet all above requirements

Colloid Aerosolization and Characterization



- Common Aerosolization Techniques
  - Pneumatic nebulization
  - Electrospray

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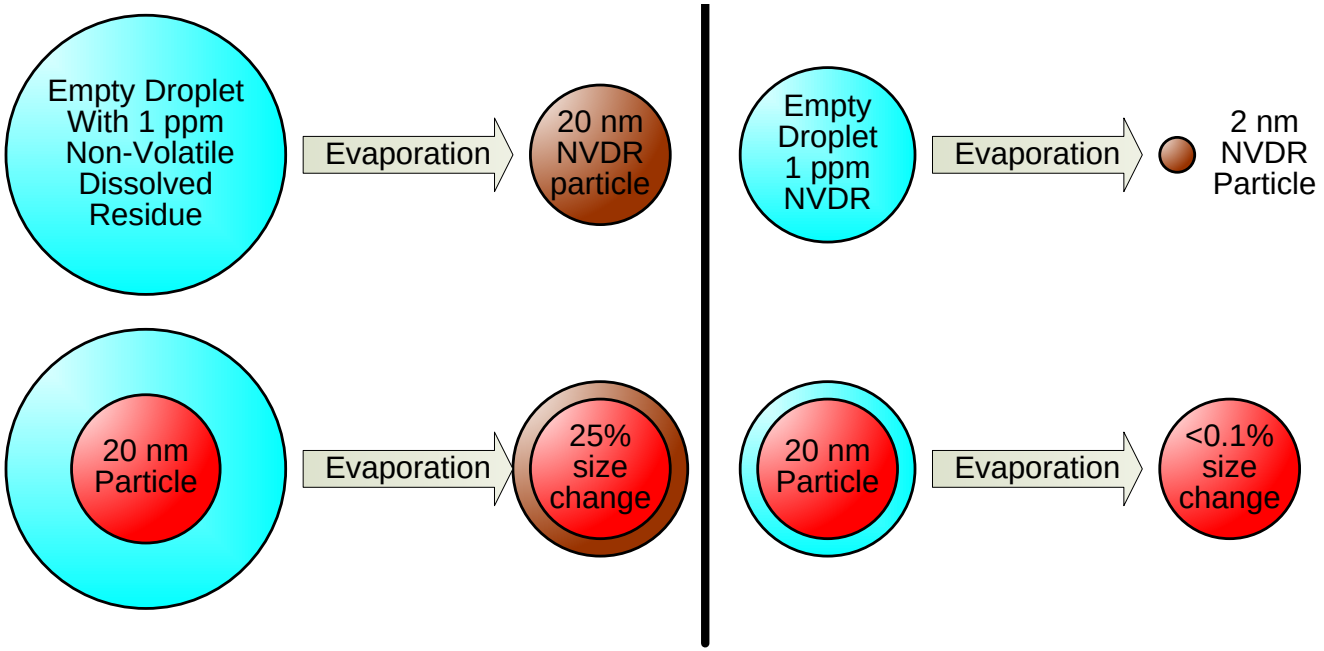
Droplet Size and Non-Volatile Residue



- Droplet-size-induced effects on nebulized particle size of precipitated non-volatile residue (PNVR)
  - PNVR aerosol particles created from “empty” droplets containing no colloid particle(s)
  - PNVR shells around colloid particles

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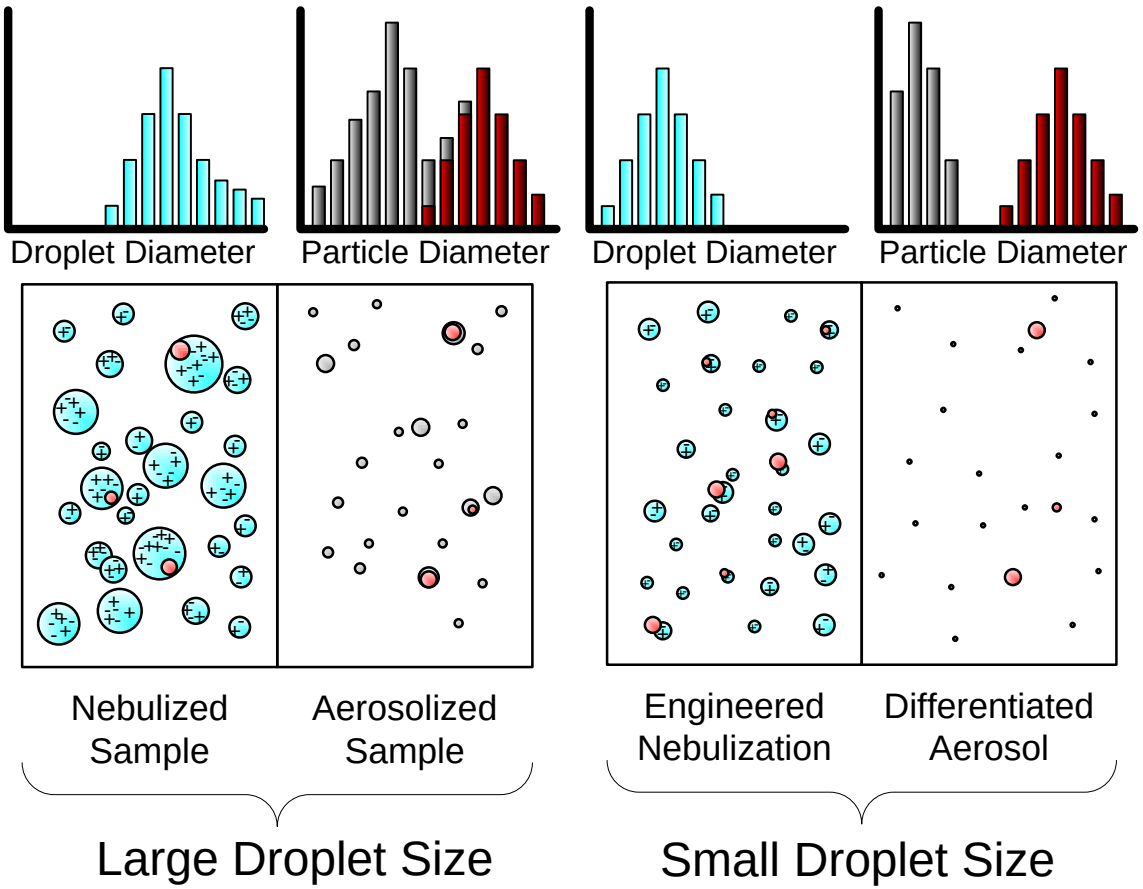
Differentiating DNVR and Liquid-Borne Particles



- Liquid-Borne Particles
- Dissolved NVR (DNVR)
- Precipitated NVR (PNVR)

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Experimental Plan

- Test both operation mechanisms
  - Pneumatic and electrospray
- Droplet size characterization
  - Sucrose solution
- Investigate particle differentiating capability
  - Particle size standard

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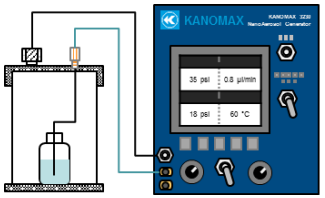
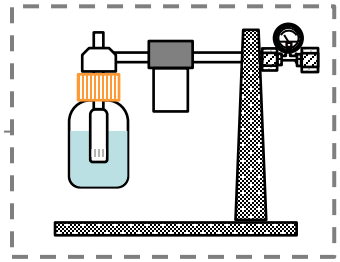
Experimental Setup

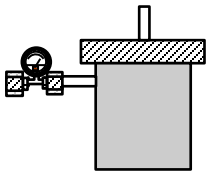
NanoAerosol Generator (Kanomax 3230)





Atomizer Aerosol Generator (TOPAS ATM 221)

Homemade Collison Atomizer (Stainless Steel)



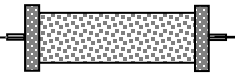
HEPA Filter

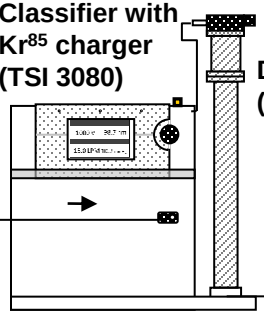
Electrostatic Classifier with Kr^{85} charger (TSI 3080)

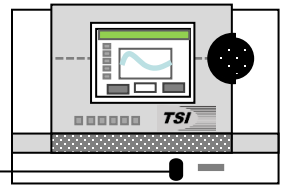
DMA (TSI 3081)

Ultrafine Condensation Particle Counter (TSI 3776)

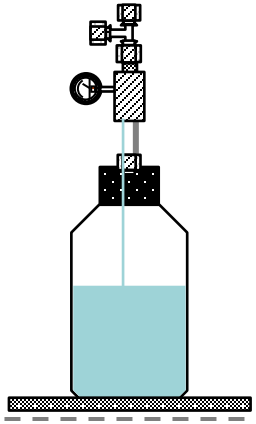
Diffusion Dryer

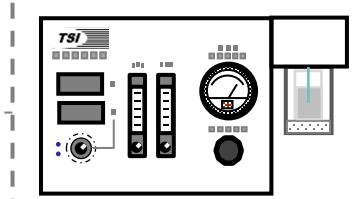




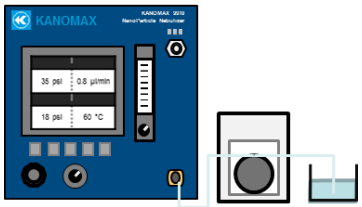


Aerosol Generator (TSI 3076)





Electrospray Aerosol Generator (TSI 3480)



NanoParticle Nebulizer (Kanomax 9110)

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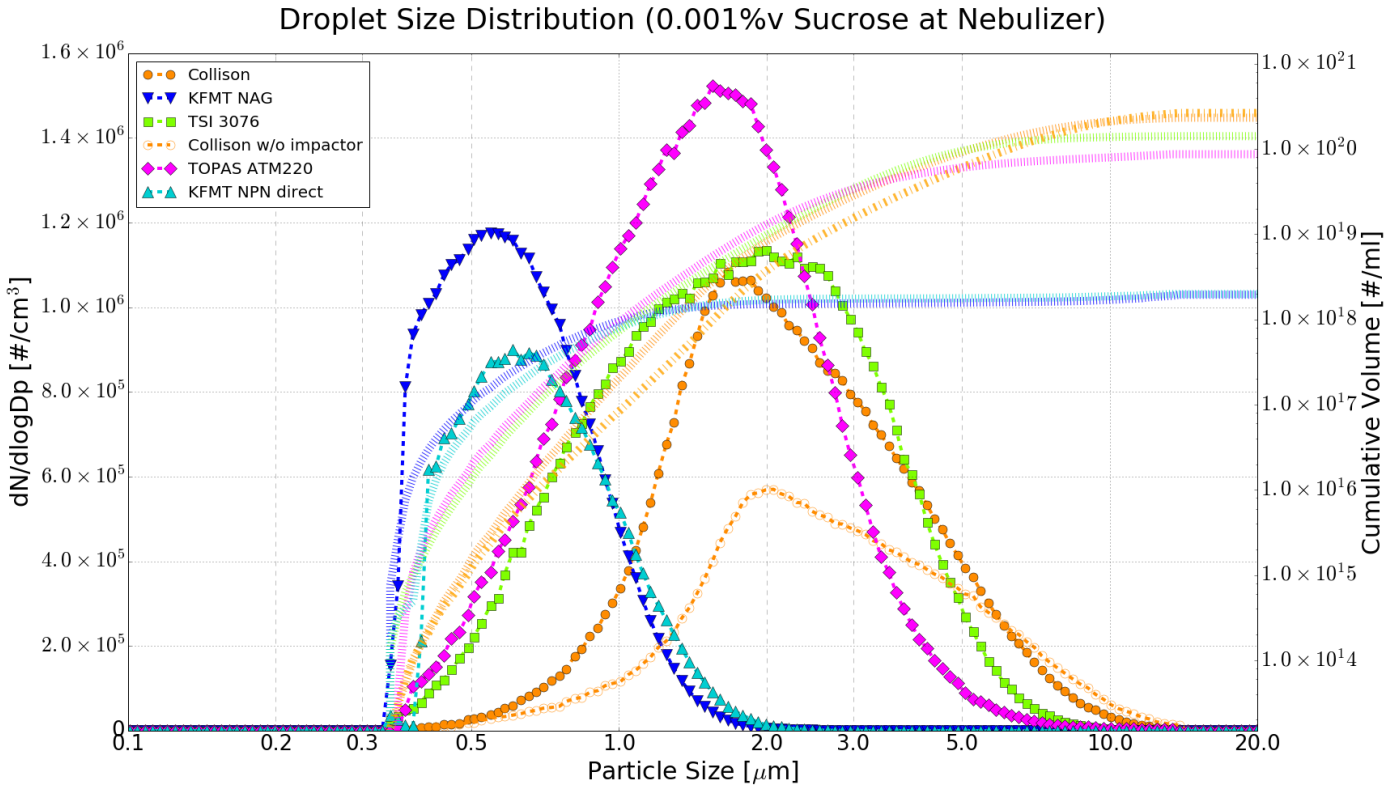
Droplet Size Distributions



PNVR Particle Size Distribution (PSD) is proportional to droplet PSD

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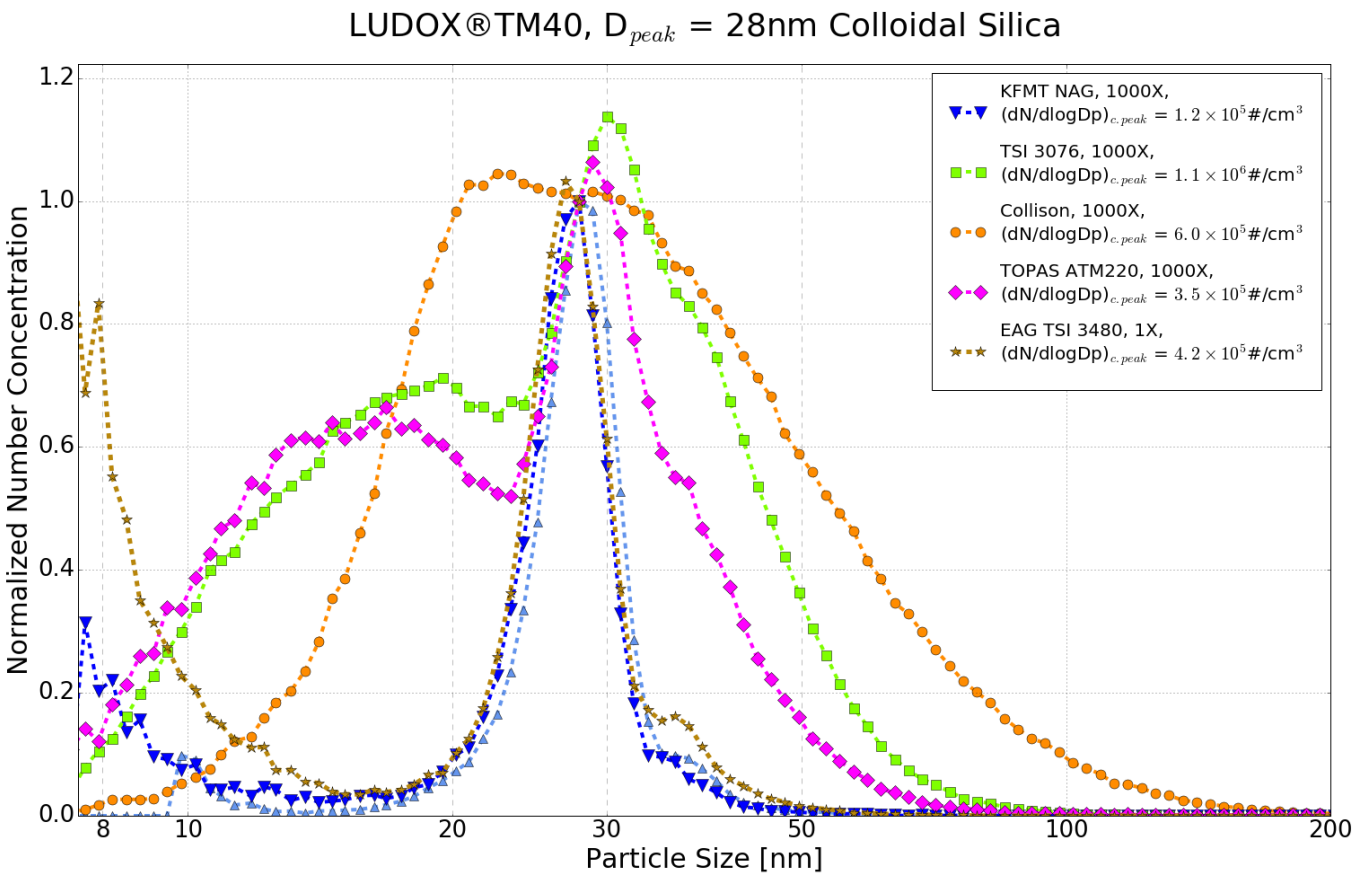
Aerosol Peak Differentiation



Controlling the droplet size distribution mitigates aerosolization induced artifacts

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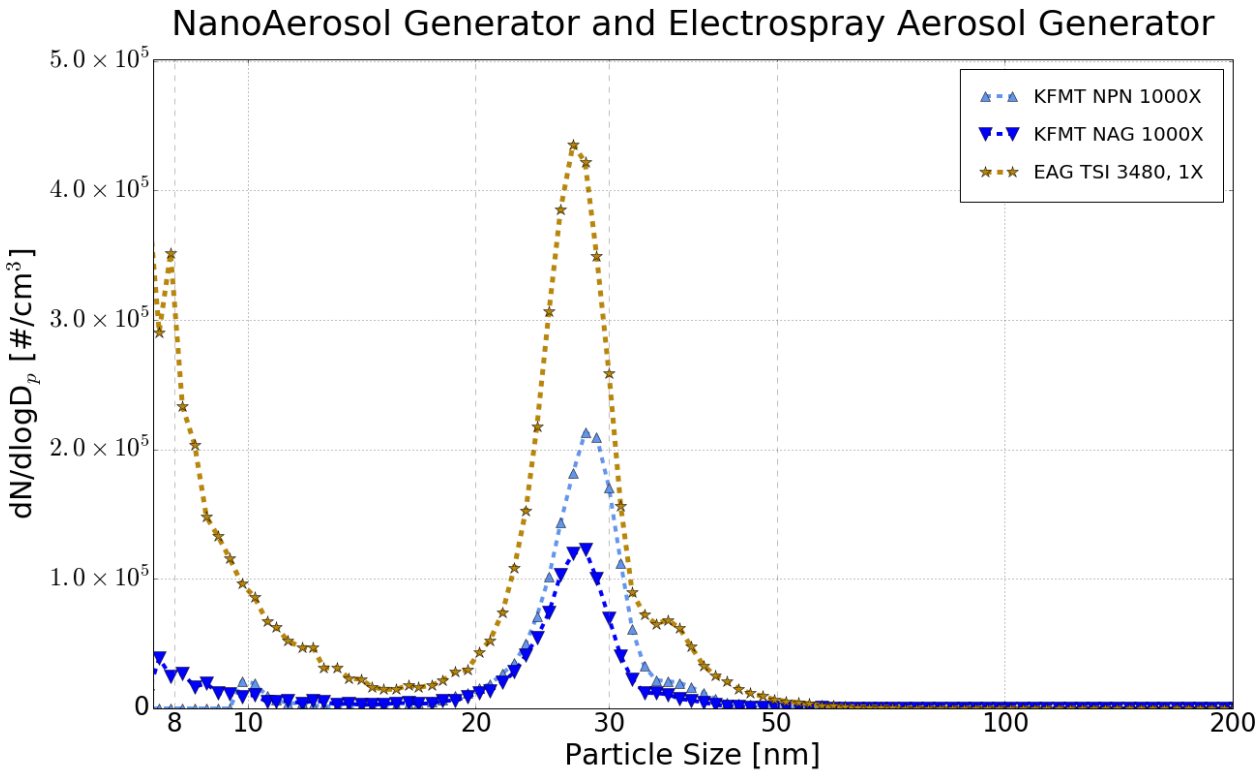
Aerosol Peak Differentiation

Volumetric Inspection Rate (VIR):

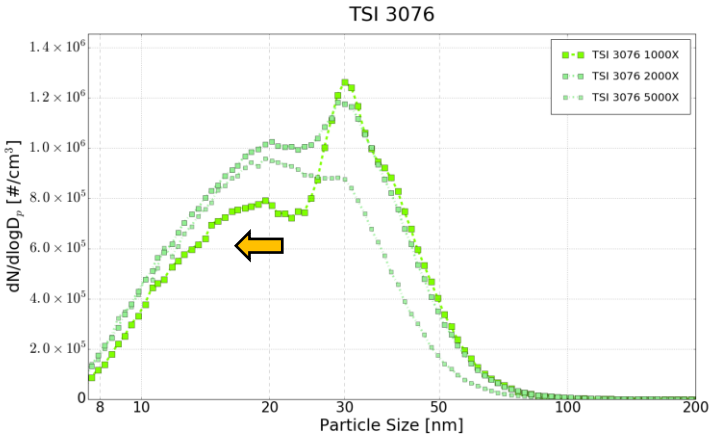
$$C_{W,Hydrosol} = \frac{C_{W,Aerosol} \times Q_{Aerosol}}{VIR}$$

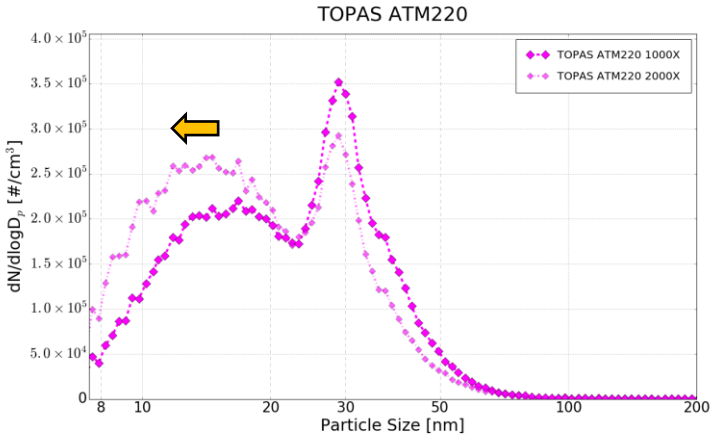
$$VIR = \frac{C_{Vol,Aerosol} Q_{Aerosol}}{C_{Vol,Hydrosol}\left(\frac{1}{DF}\right)}$$

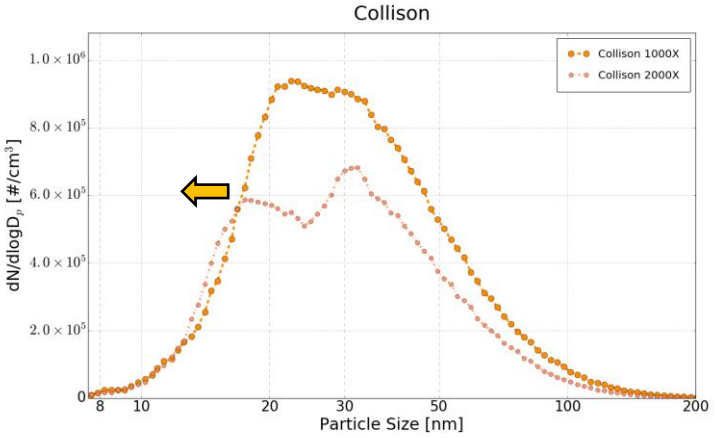


Generator	VIR (µL/min)
NPN	0.66
NAG	0.35
EAG	0.0017

Aerosol Peak Differentiation







Changes in colloid concentration mitigates aerosolization induced artifacts

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Conclusions

- Tandem aerosolization and electrical mobility classification methods well fit the application of colloidal nanoparticle size classification
- Droplet size distribution of an aerosolization device determines its capability in differentiating aerosol particle peaks.
- With a proper engineering design, pneumatic nebulizers are able to generate comparably small droplet size as electrospray aerosol generators

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Acknowledgement

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Thank You!

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