Non-IPA Production of DEHS Nanoparticles for Evaluating PTFE Filter

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- Methods to reduce particle size
- Neutralization of DEHS particles
- Conclusion

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Introduction

- Polytetrafluoroethylene (PTFE) membrane filtration media, which exhibit high efficiency and low pressure drop, have been widely used in air filtration products. (Galka and Saxena 2009)
- For PTFE membrane and other nanofiber filters, the Most Penetration Particle Size (MPPS) is typically between 0.07 to 0.1 micron.
- According to EN 1822-5-2009, when using a polydisperse aerosol to test filter element, it's required that the median diameter D_M should be +/-50% of MPPS.

Galka N, Saxena A. High efficiency air filtration: The growing impact of membranes. Filtration & Separation. 2009 Aug 31;46(4):22-5.
EN 1822-5-2009, High efficiency air filters (EPA, HEPA and ULPA). Determining the efficiency of filter elements.

Introduction

- In EN 1822, possible aerosol substances include: DEHS, PAO and Paraffin oil.
- To achieve smaller particle sizes, one method is to dilute the DEHS using highly volatile solvent, e.g. Isopropyl Alcohol (IPA).
- Issues of using IPA:
  - Particles may get highly charged
  - Stability of particle size distribution
  - Flammability
  - IPA intoxication (Zaman, et al. 2002)

Zaman F, Pervez A, Abreo K. Isopropyl alcohol intoxication: a diagnostic challenge. American Journal of Kidney Diseases. 2002 Sep 30;40(3):e12-1.

Objective

Goal:

- Generate particles with count median diameter (CMD) of 70-100 nm using 100% DEHS.
- Particle concentration is high enough to provide statistically meaningful results for high efficiency filters such as E12 or higher.

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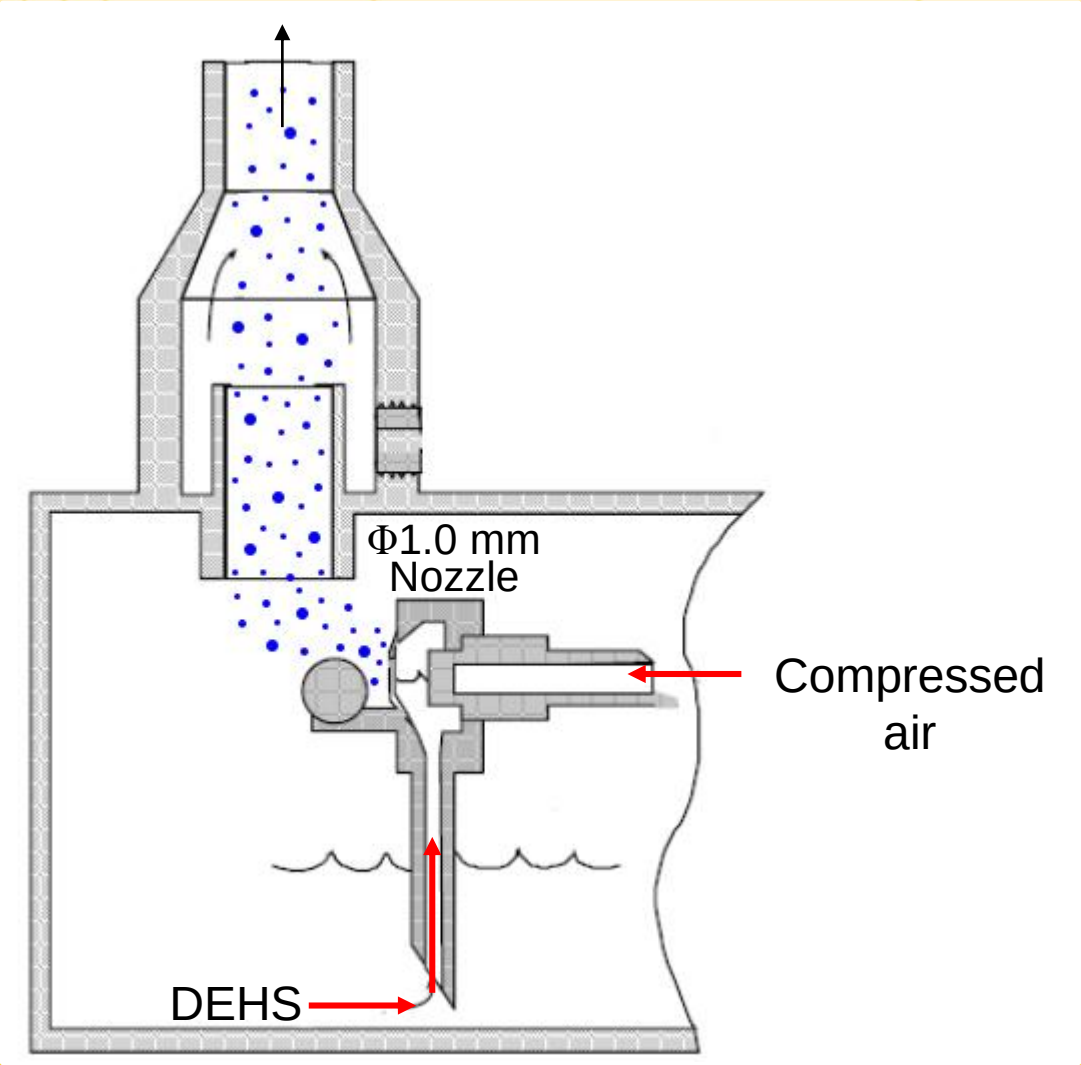
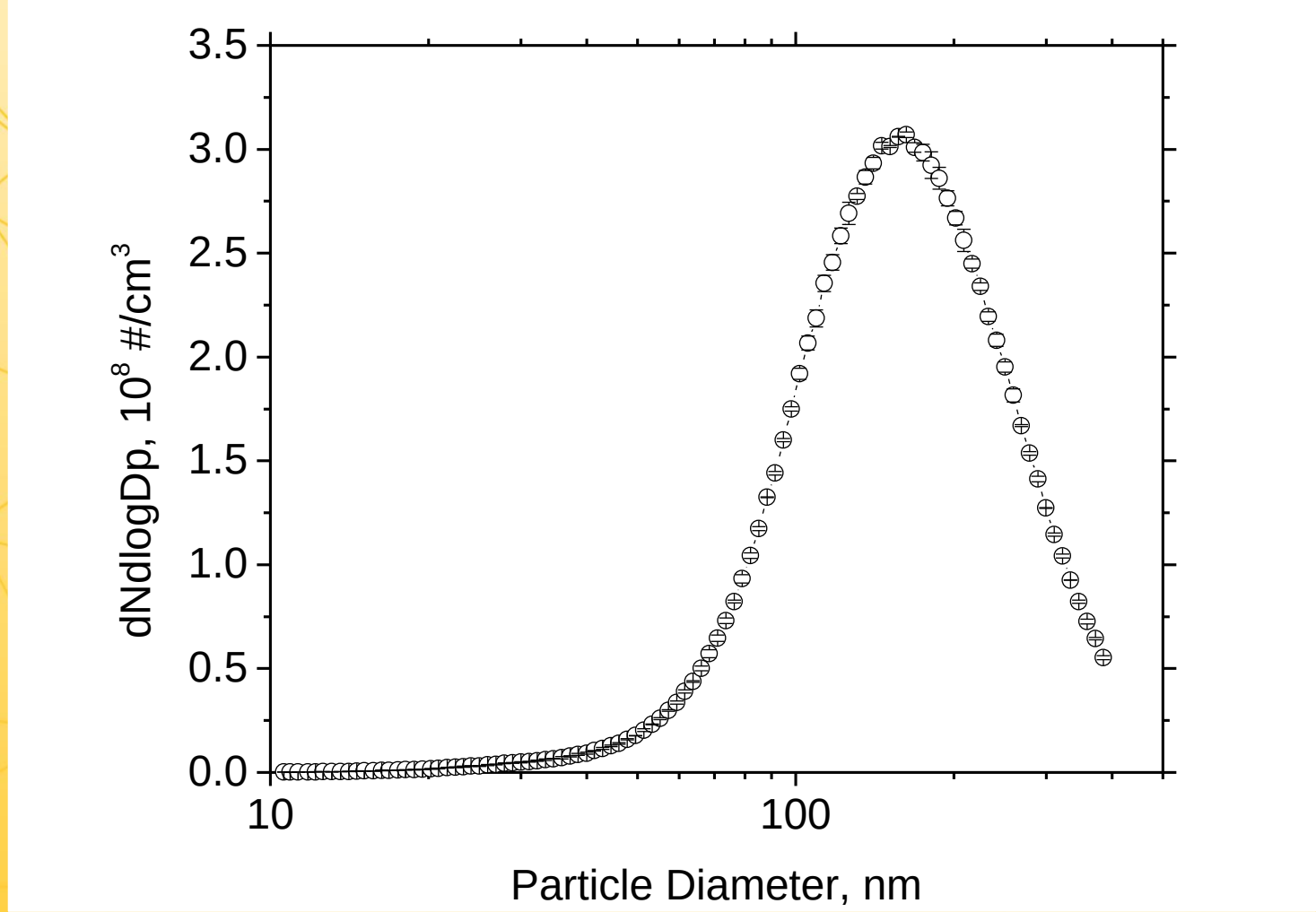
Six-jet atomizer (TSI 9306)



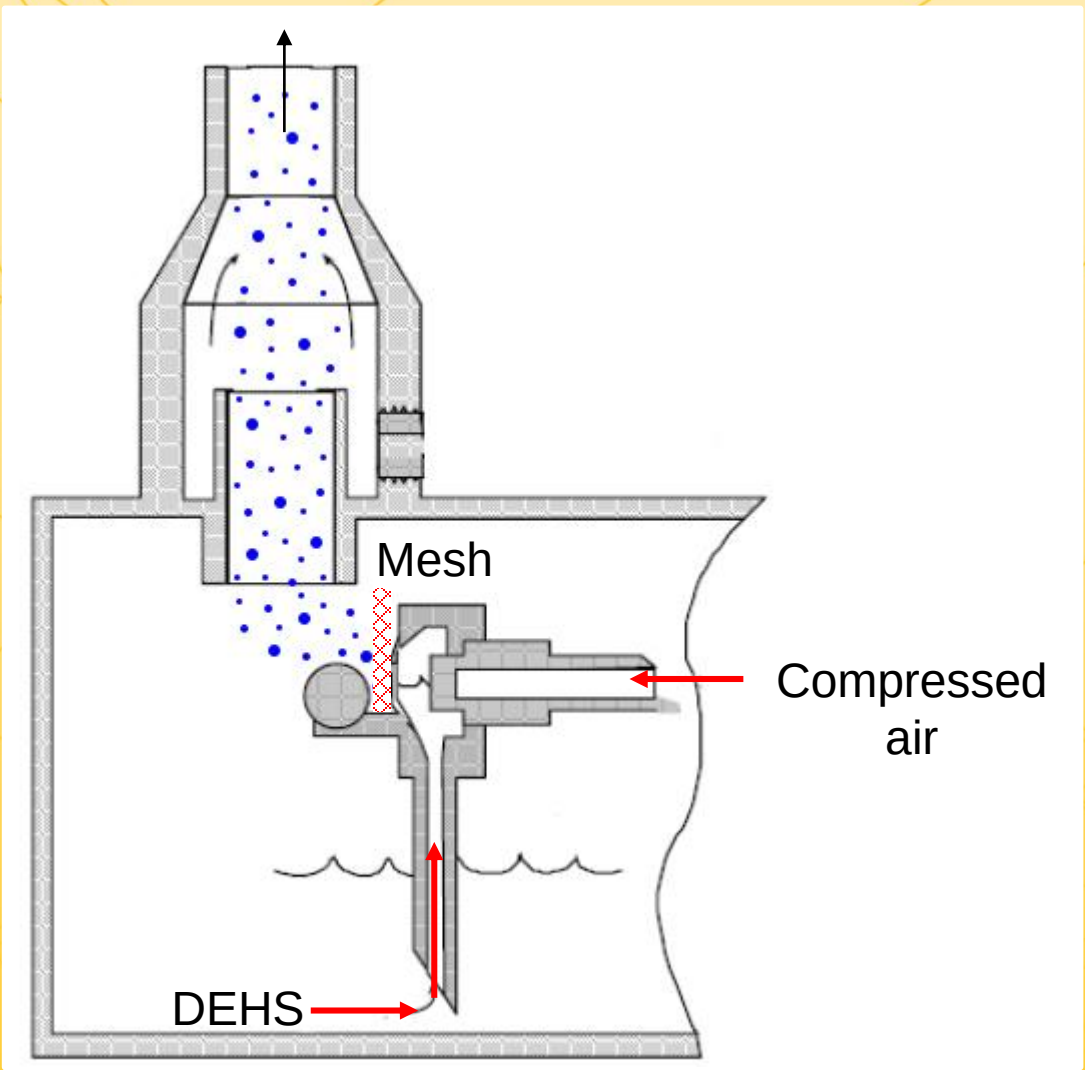
- 1 jet on
- 100% DEHS
- Compressed air: 80 psi, 14 L/min

Particle size distribution of original atomizer



	Count Media Diameter (CMD), nm	< 100 nm Total number Concentration, 10^8 #/cm^3
Original	160.6±0.4	0.289

Methods to reduce particle size



Method 1

- ❑ Smaller nozzle

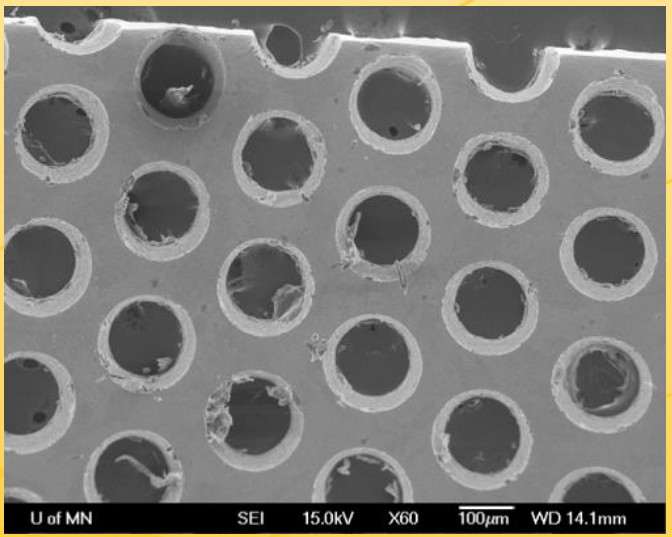
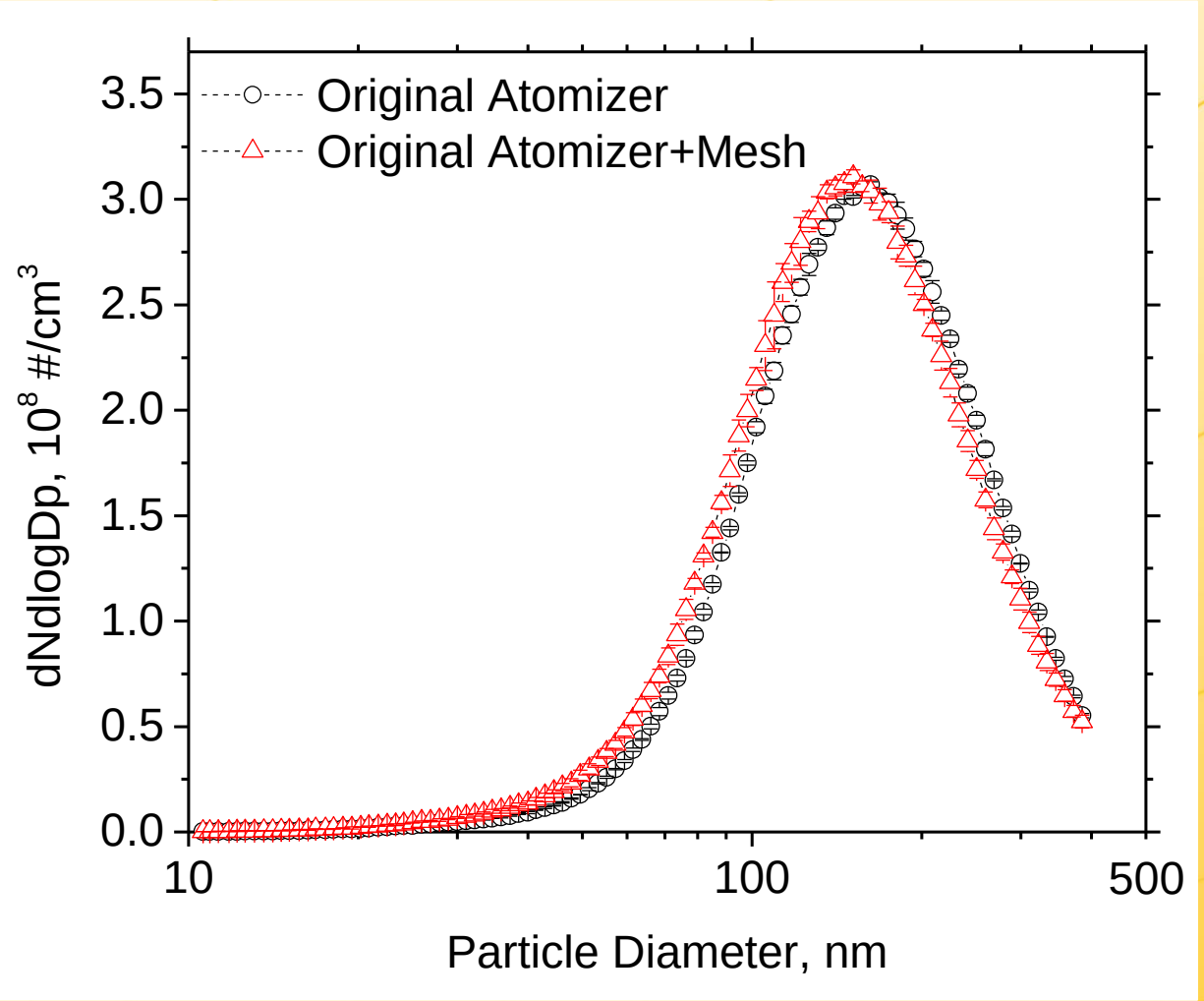


Photo Chemical Etched Mesh

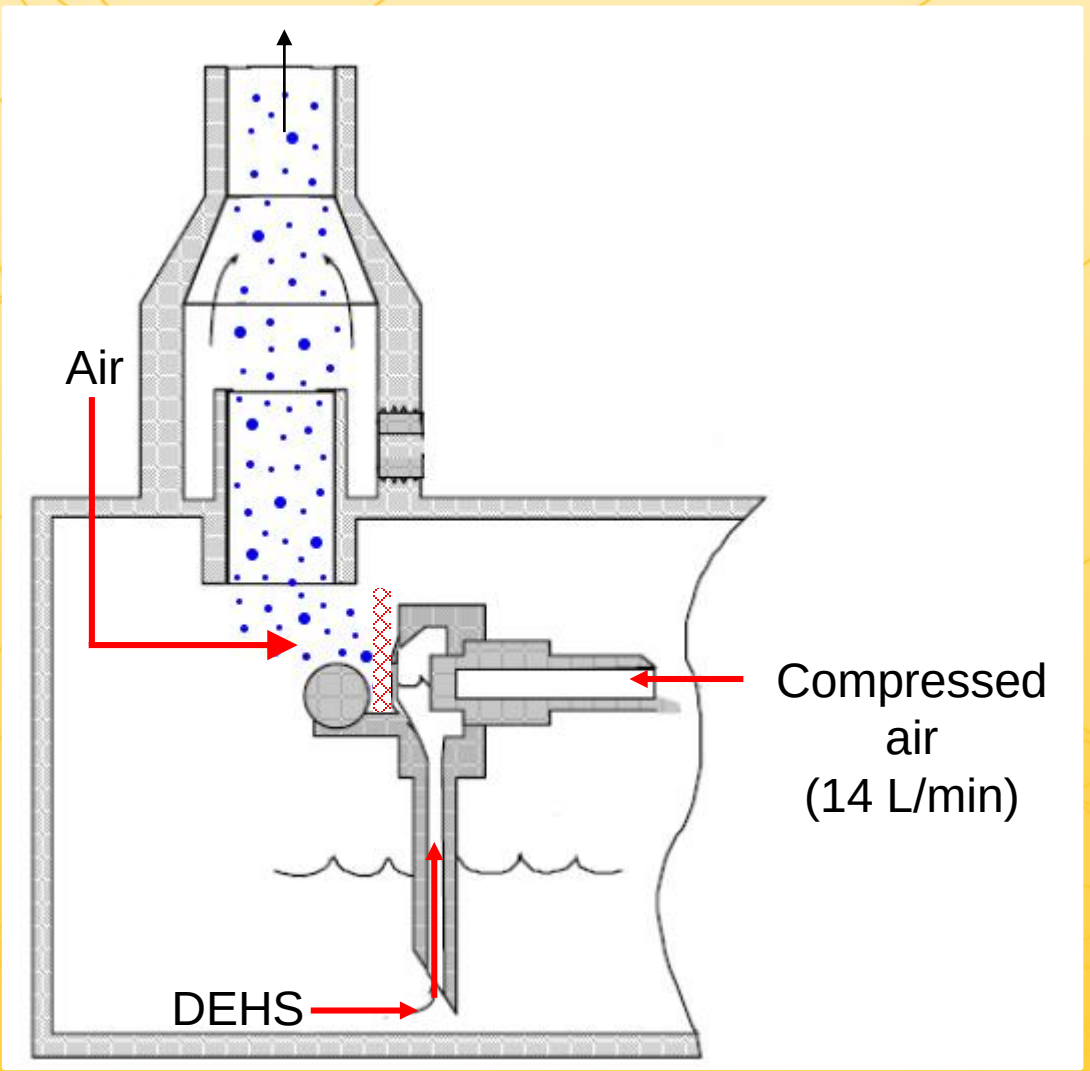
- Pore size: 150 µm

Effect of mesh on CMD and particle concentration



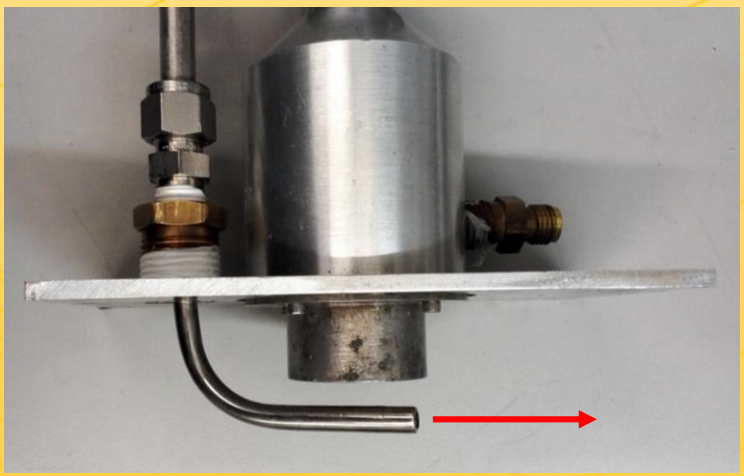
	Count Media Diameter (CMD), nm	< 100 nm Total number Concentration, 10^8 #/cm^3
Original	160.6±0.4	0.289±0.003
Original + Mesh	151.1±0.4	0.329±0.012

Methods to reduce particle size



Method 2

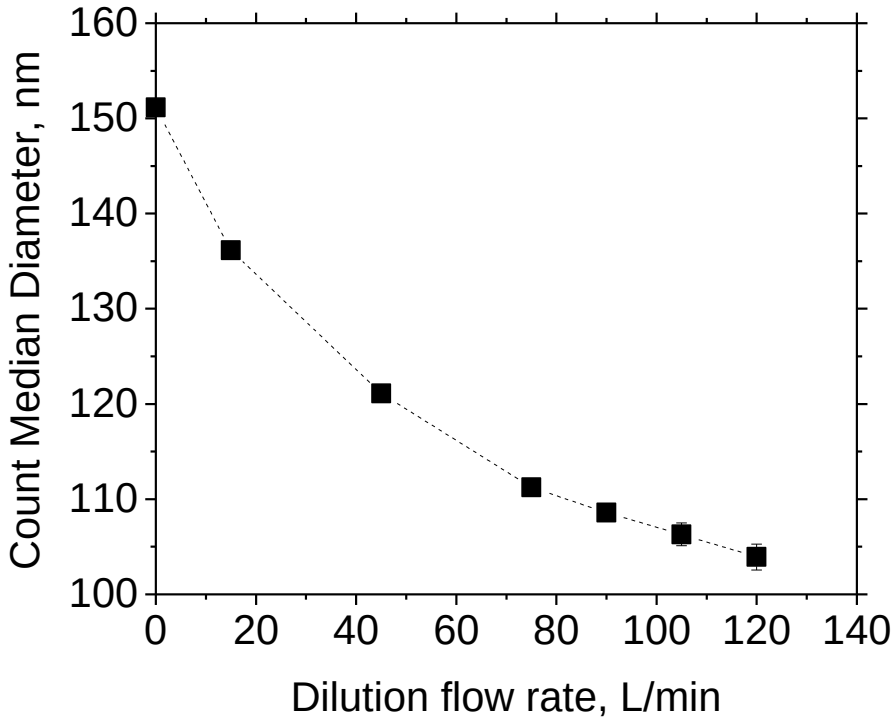
- Quick dilution to reduce coagulation

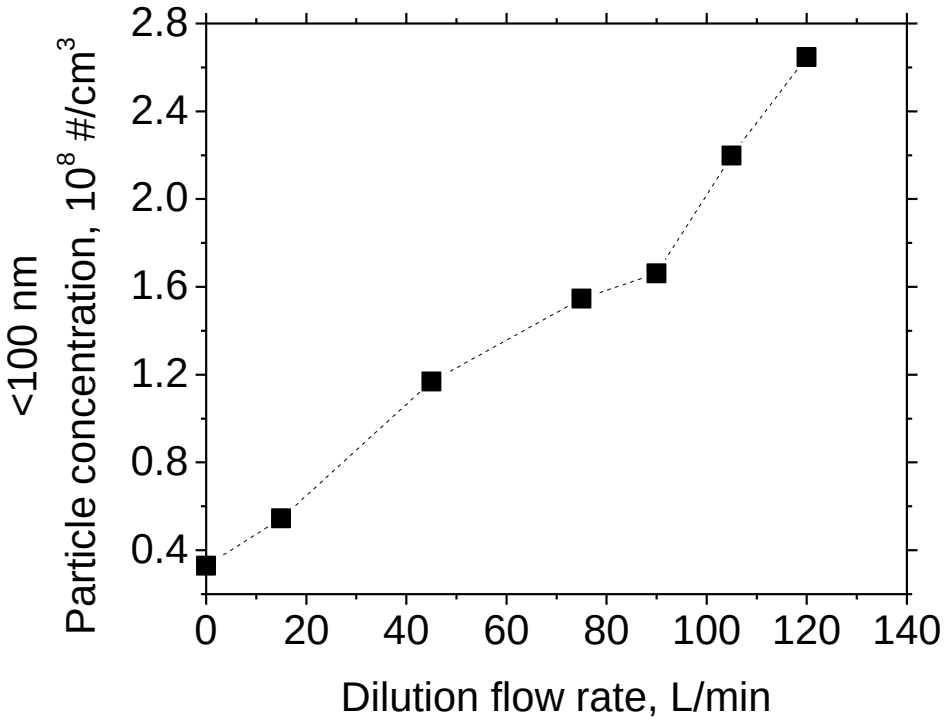


Quick dilution tube

Effect of dilution flow rate on CMD and particle concentration

- With mesh





- Higher dilution flow rate leads to smaller Count Median Diameter (CMD) and higher <100 nm particle concentration.

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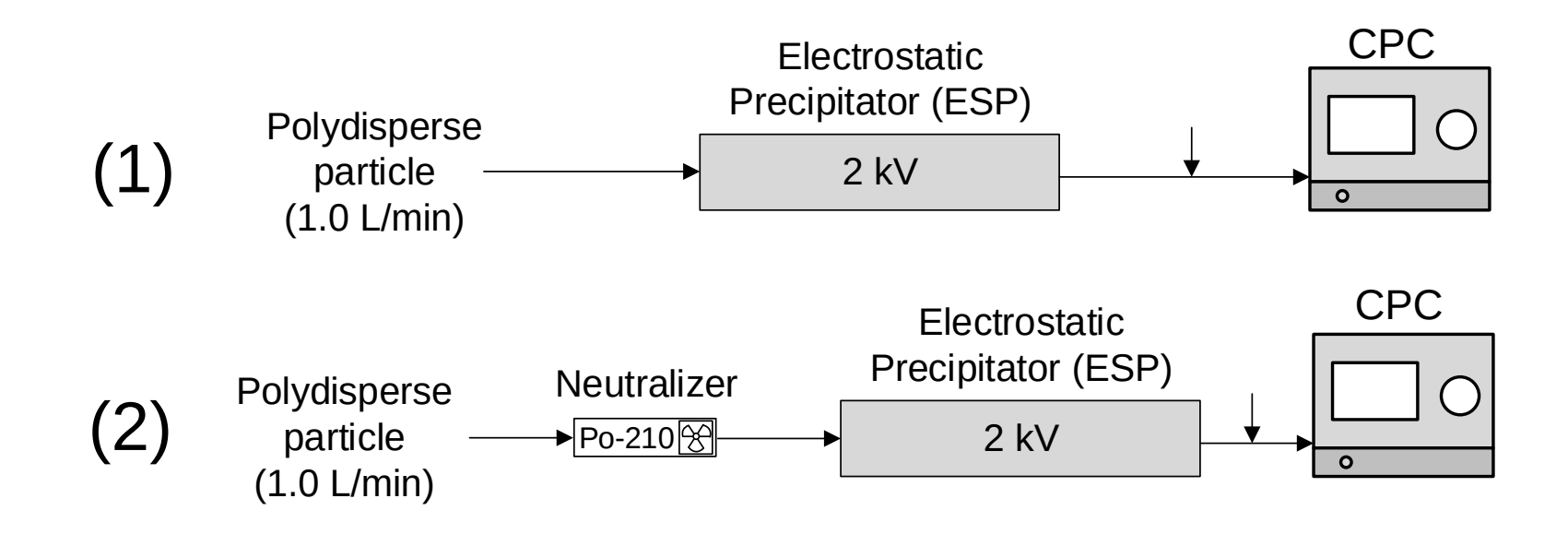
Experimental method

Percentage of charged particles in polydisperse particle



C_{total}: particle number concentration measured by CPC when ESP is **OFF**.

$C_{neutral}$: particle number concentration measured by CPC when ESP is **ON**.

Percentage of charged particles = $1 - C_{neutral}/C_{total}$

Percentage of charged particles in polydisperse DEHS particle

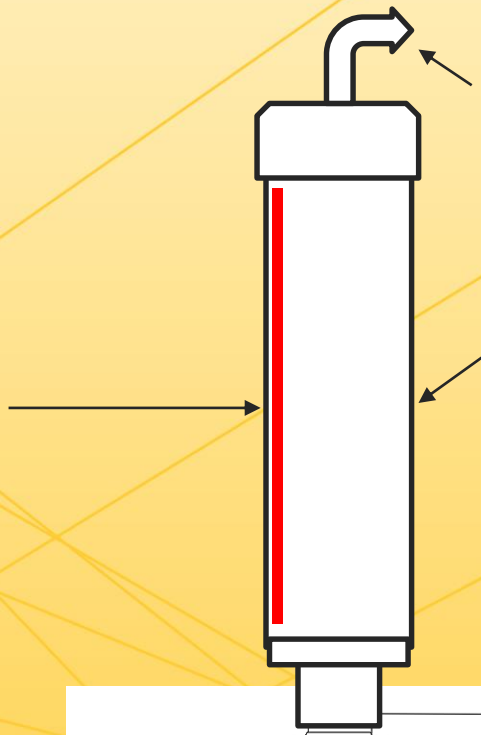
- 100% DEHS

	Percentage of charged particles	Std
No neutralization	2.4%	0.6%

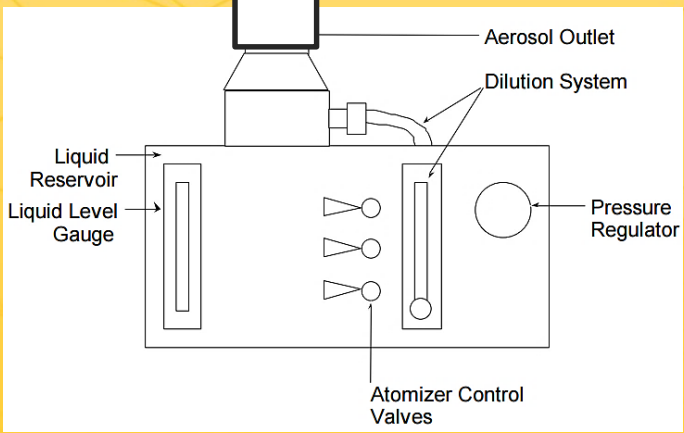
Most of particles generated by pure DEHS are neutral.

Home-made neutralizer

4 x Po-210 Strips

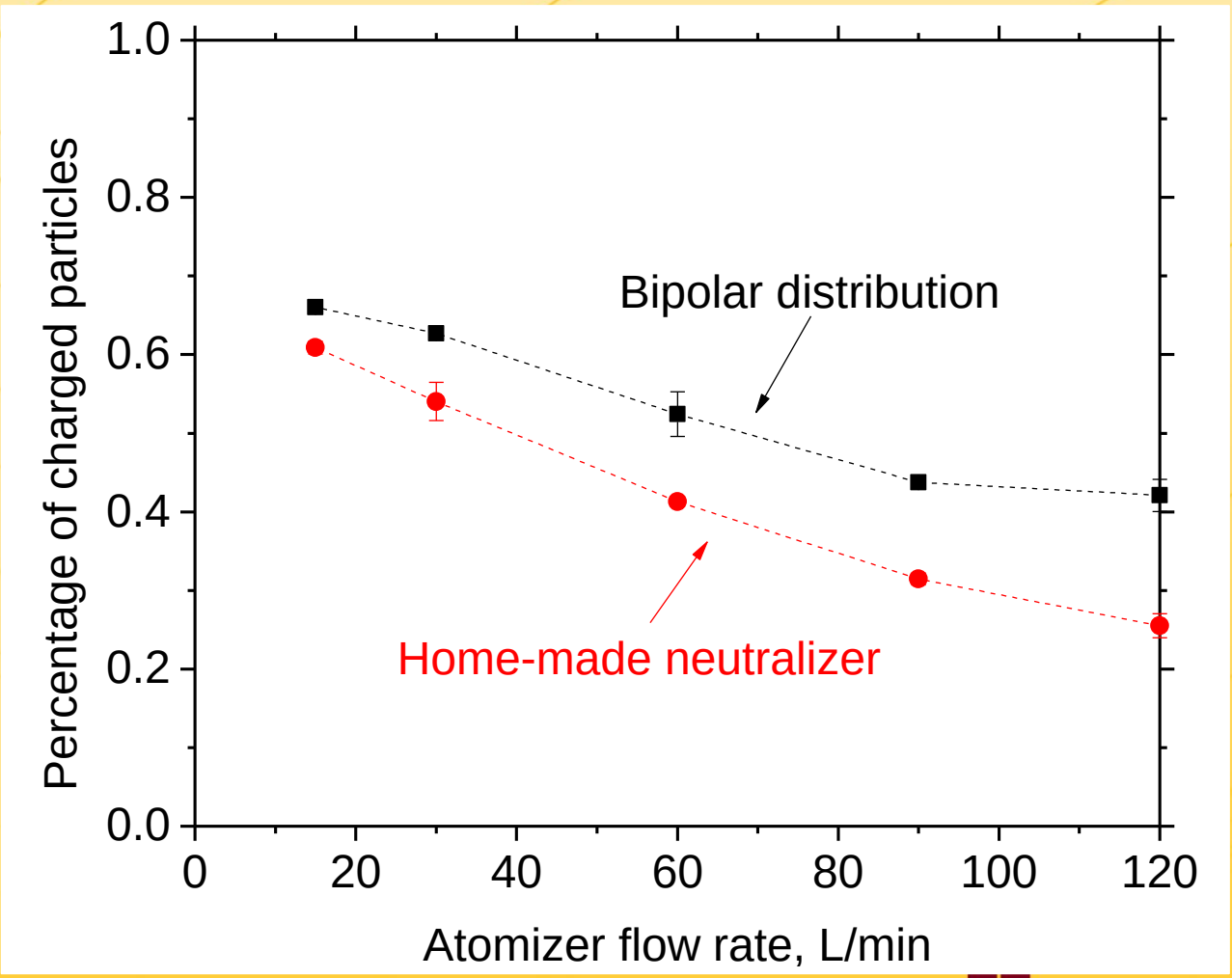


2” PVC Pipe, 14 in. Length



Result and discussion

Effectiveness of home-made neutralizer



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Conclusion

- Mesh and quick dilution were applied to atomizer, which reduce count median diameter (CMD) of 100% DEHS from 160 nm to 100 nm.
- Higher dilution flow rate leads to higher <100 nm particle concentration.
- Most of particles generated by pure DEHS are neutral.

Future work

- Optimize the design to further reduce CMD.
- Neutralization evaluation for high flow rate atomizer.