

Particle Size and Concentration Standards for Sub-100 nm Applications

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Fluid Measurement



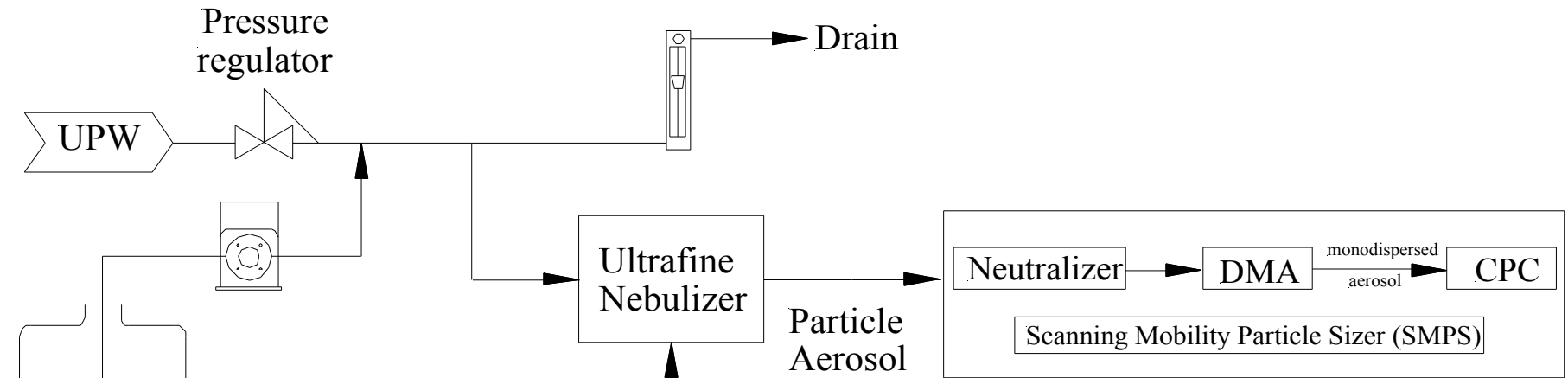
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Introduction

- Calibration of liquid optical particle counters ideally requires a polystyrene latex (PSL) standard with a known particle size distribution (particle diameter vs **concentration**).
- Measuring the PSD of colloidal suspensions below 200 nm has been difficult and has limited the availability of standards below this size.
- Using a newly developed liquid nanoparticle sizing system, PSD of PSL suspensions can be measured down to 5 nm allowing preparation of concentration standards below 100 nm.
- The testing of liquid filter retention can also benefit from a full understanding of the particle size distribution (PSD) of the challenge solution.

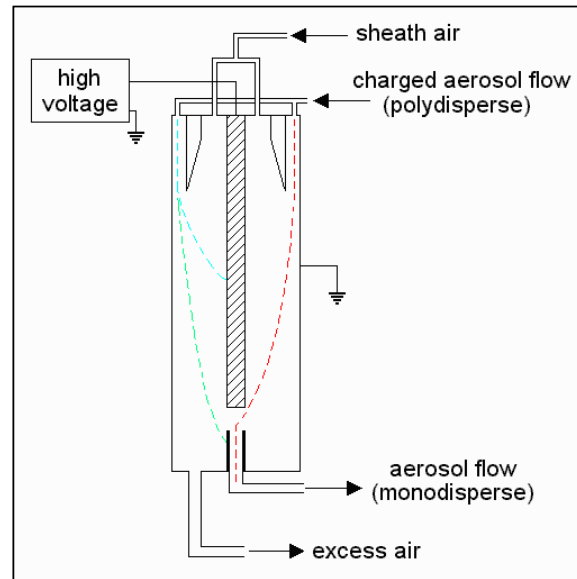


Schematic of the Liquid Nanoparticle Sizing System

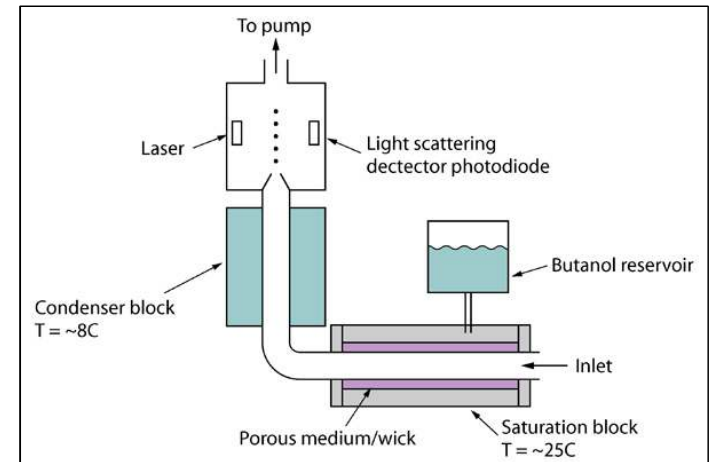


Nanoparticle suspension

Dynamic Mobility Analyzer (DMA)



Condensation Particle Counter (CPC)

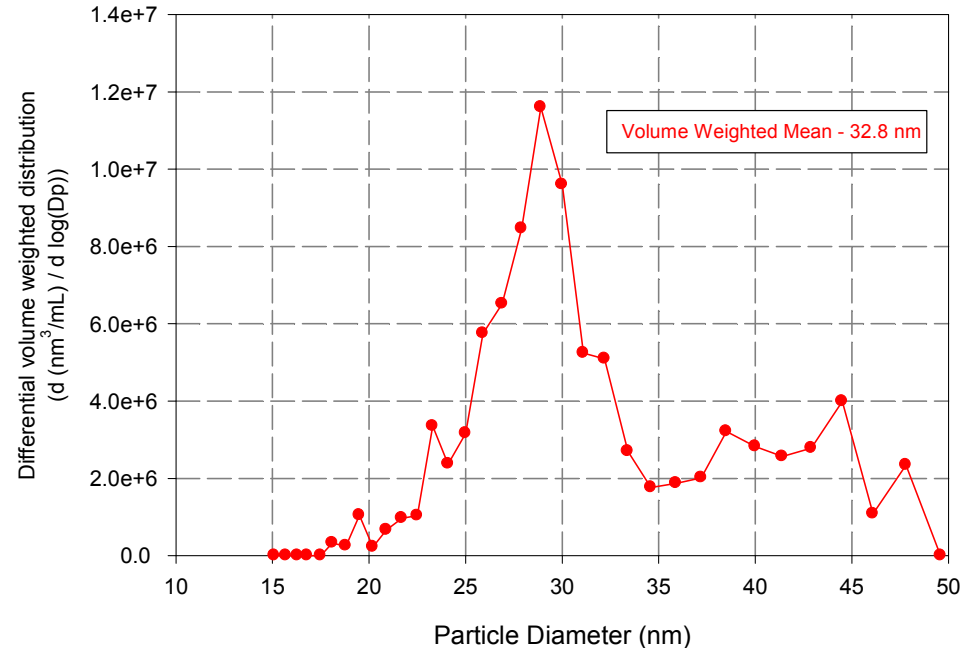
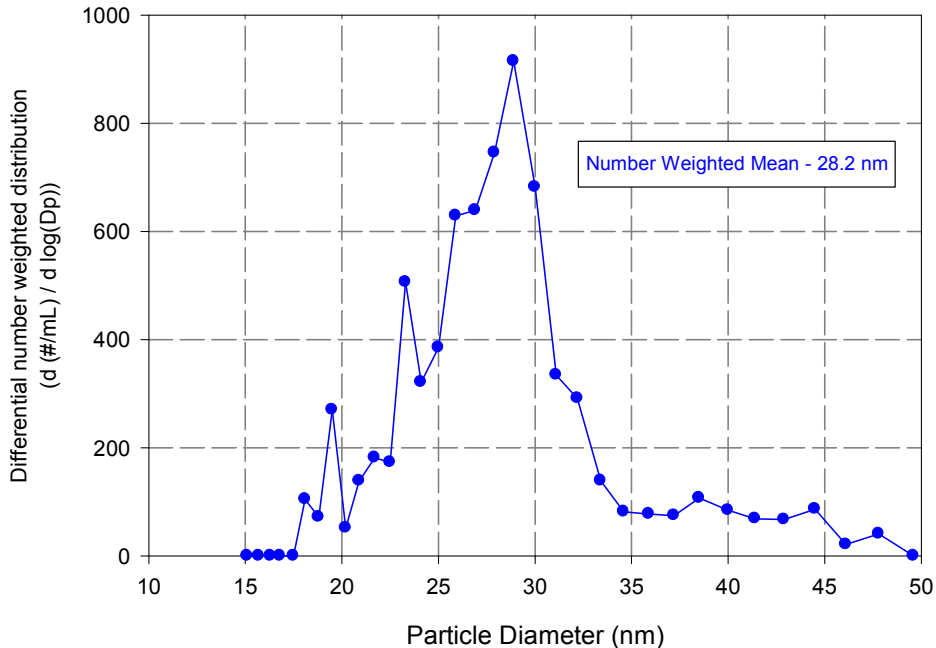


Liquid nanoparticle sizing system capabilities and benefits

- Broad operational range:
 - Single-particle quantitation from samples with particle concentrations at 2.0×10^8 - 1.0×10^{15} particles/mL.
 - Sizing range from 2.5 to 450 nm with 64 channels per decade resolution.
- Actual concentrations, not relative concentrations are measured.
- Shape of the particle size distribution is not assumed – able to resolve multi-modal distributions.
- Highly sensitive to small changes in the PSD.
- Technique is independent of the optical and density properties of the particles.
- Aerosol instrument (DMA) is used by NIST to size PSL reference materials.



NIST 30 nm gold analysis via liquid nanoparticle sizing

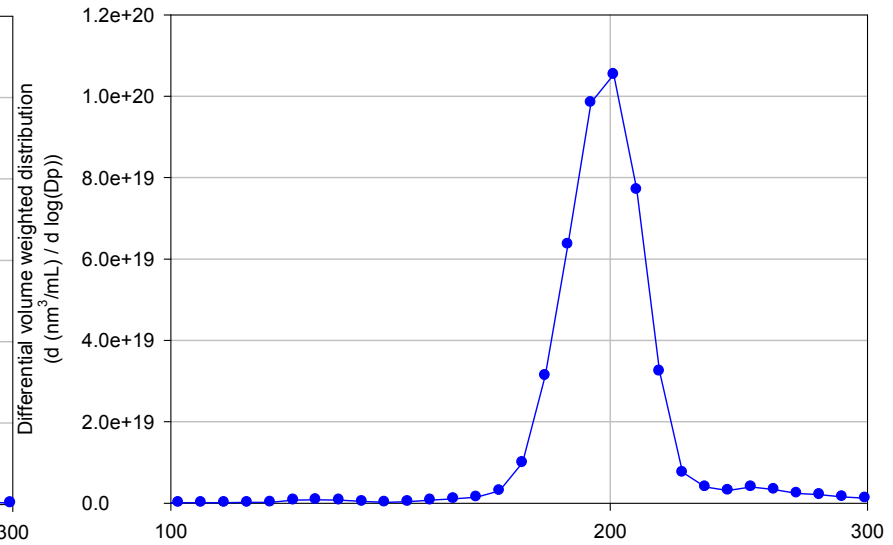
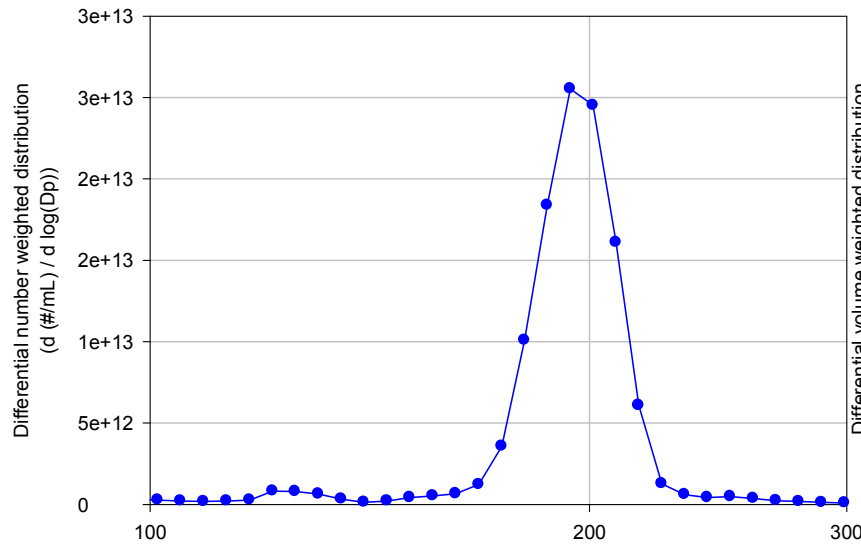


NIST Report of Investigation – Reference Material 8012 – 30 nm Gold Nanoparticles

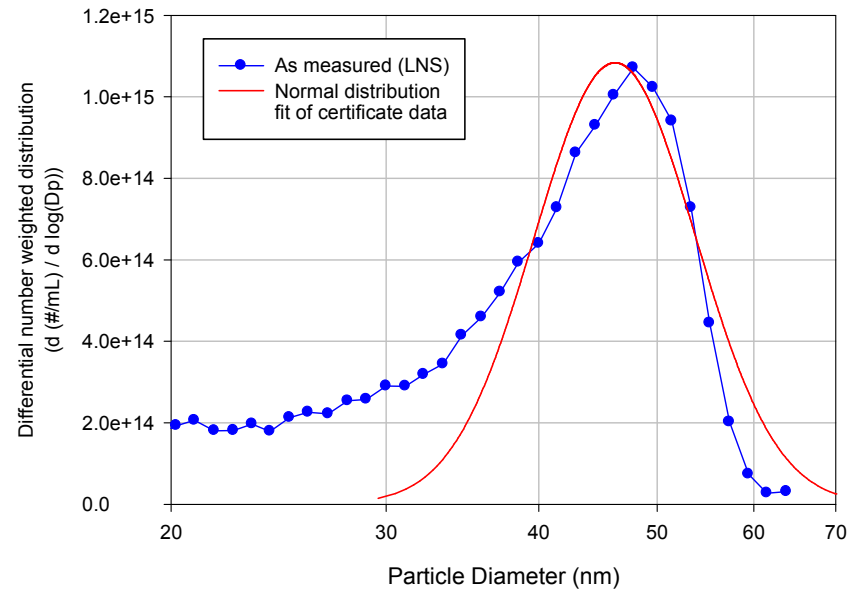
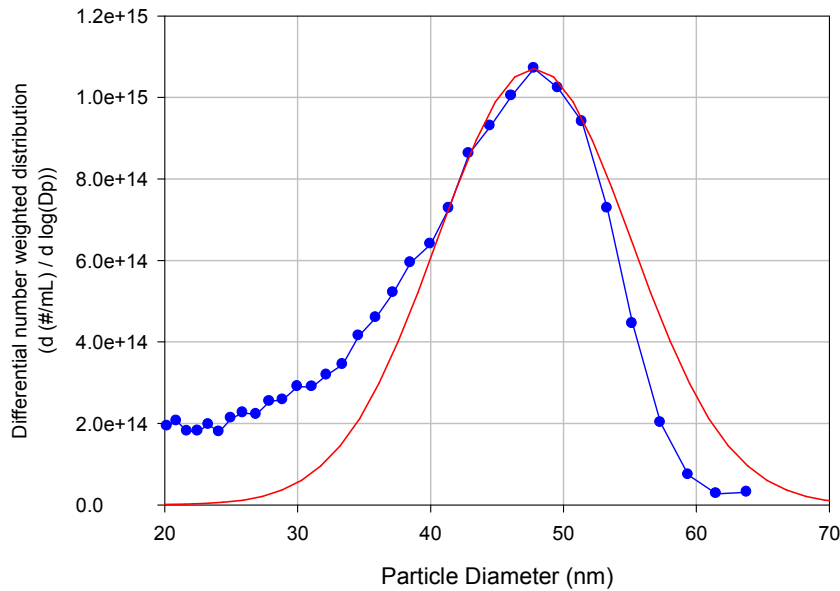
Technique	Analyte Form	Mean Particle Size (nm)		Expanded Uncertainty
Atomic Force Microscopy	dry, deposited on substrate	24.9	±	1.1
Scanning Electron microscopy	dry, deposited on substrate	26.9	±	0.1
Transmission Electron Microscopy	dry, deposited on substrate	27.6	±	2.1
Differential Mobility Analysis	dry, aerosol	28.4	±	1.1
Dynamic Light Scattering	liquid suspension			
173° scattering angle (back scattering)		28.6	±	0.9
90° scattering angle		26.5	±	3.6
Small-Angle X-Ray Scattering	liquid suspension	24.9	±	1.2

Particle size distribution of polystyrene latex

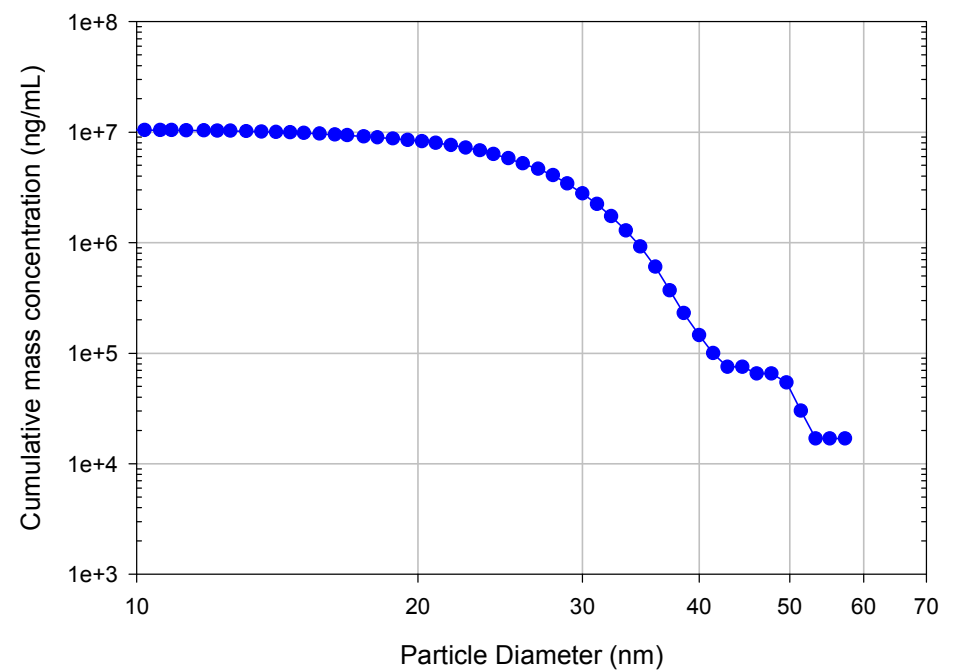
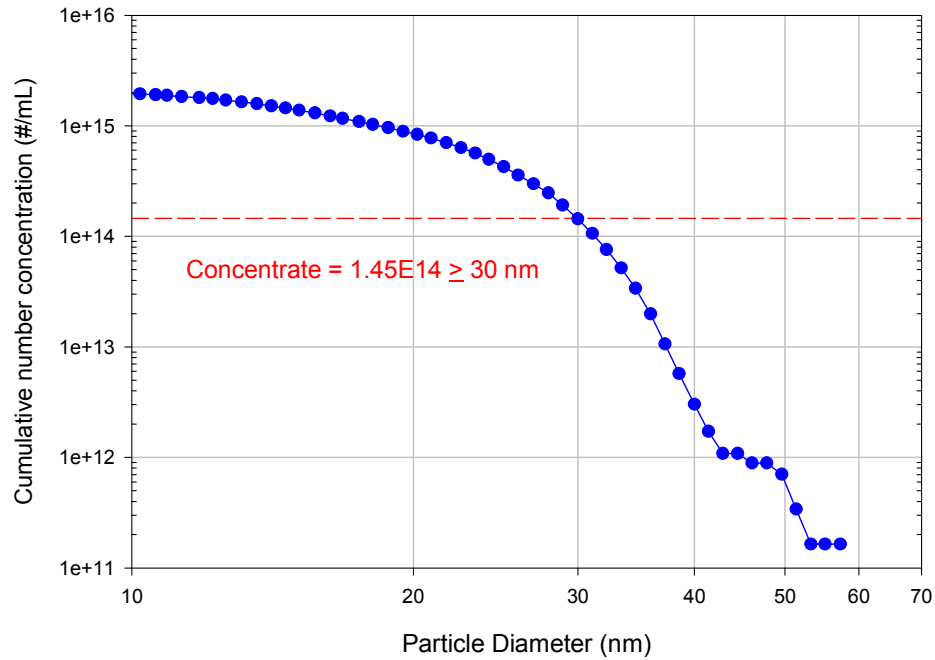
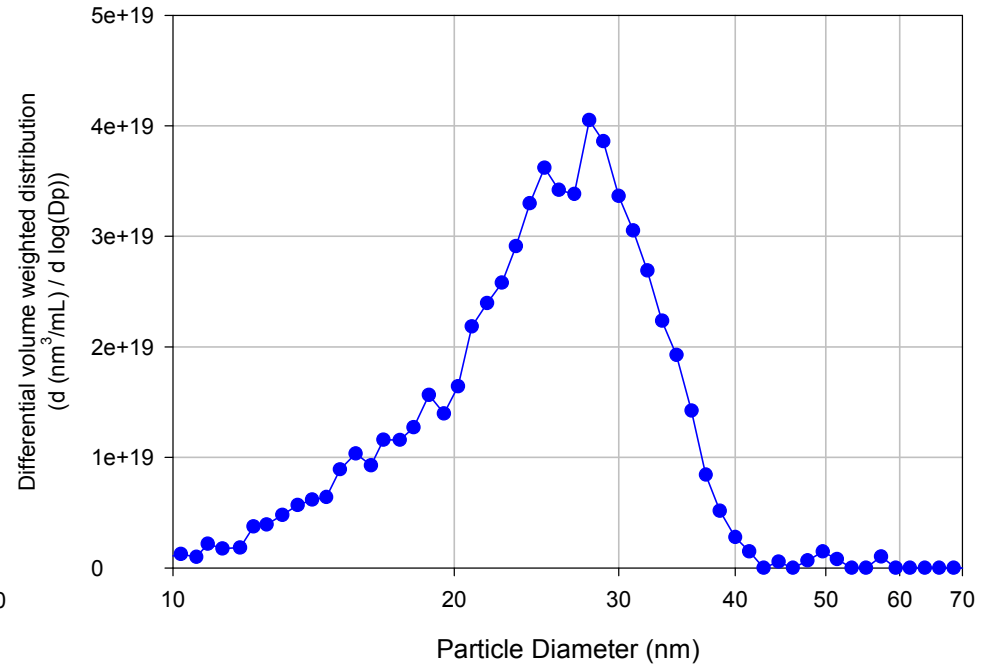
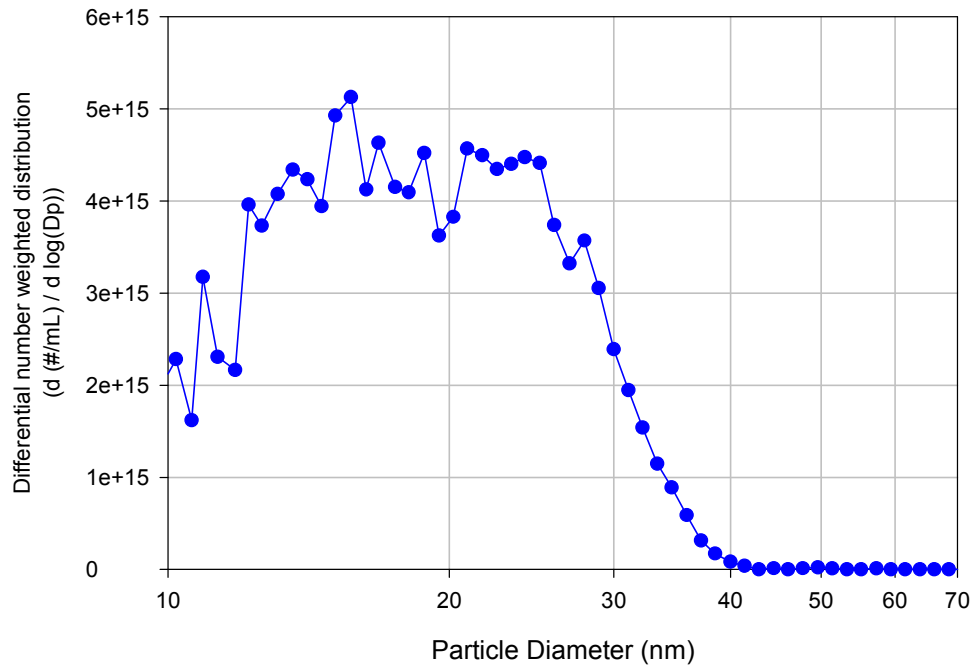
NIST Traceable 200 nm PSL
(Reported Size - 203 ± 5 nm)



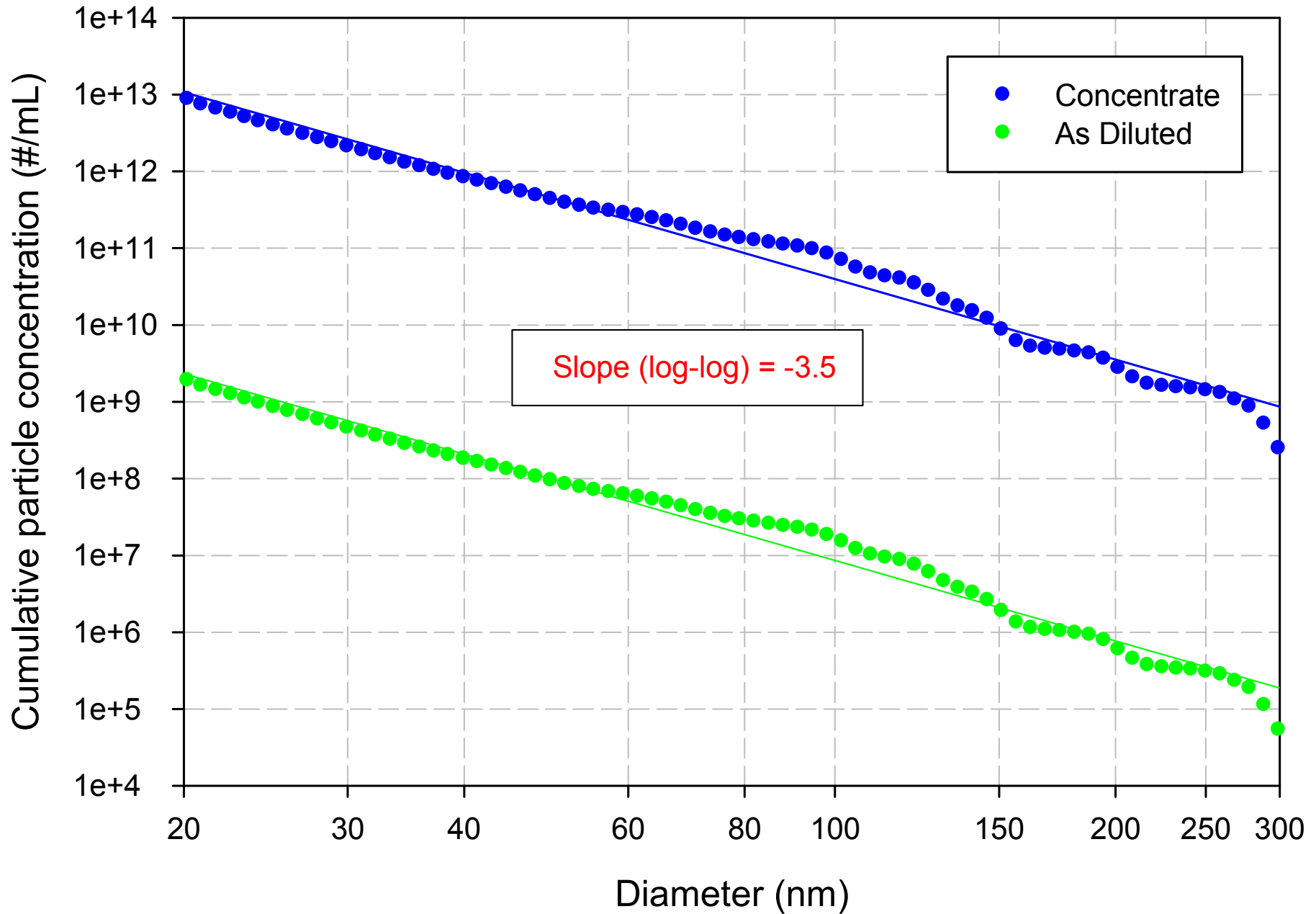
NIST Traceable 50 nm PSL
(Reported Size - 46 ± 2 nm)



NIST Traceable 30 nm PSL
(Reported Size - 30±1nm)

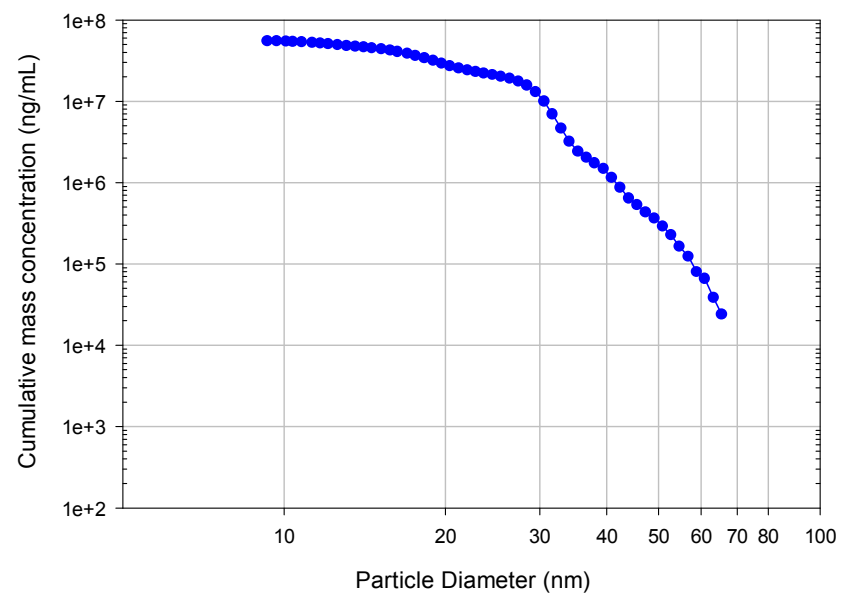
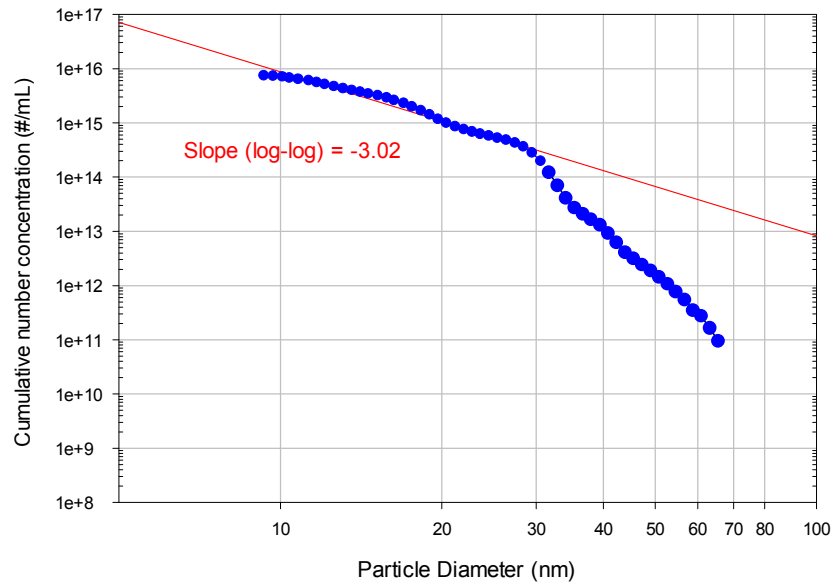
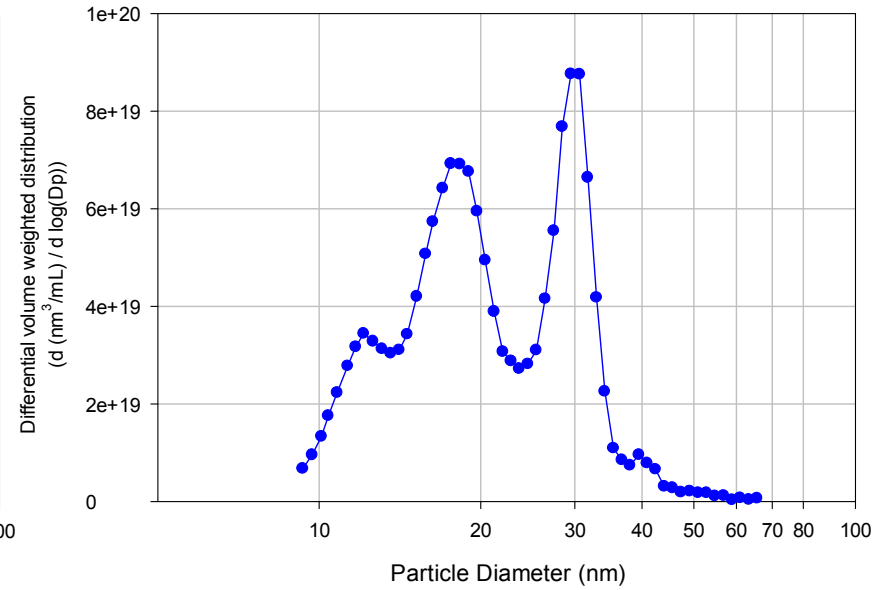
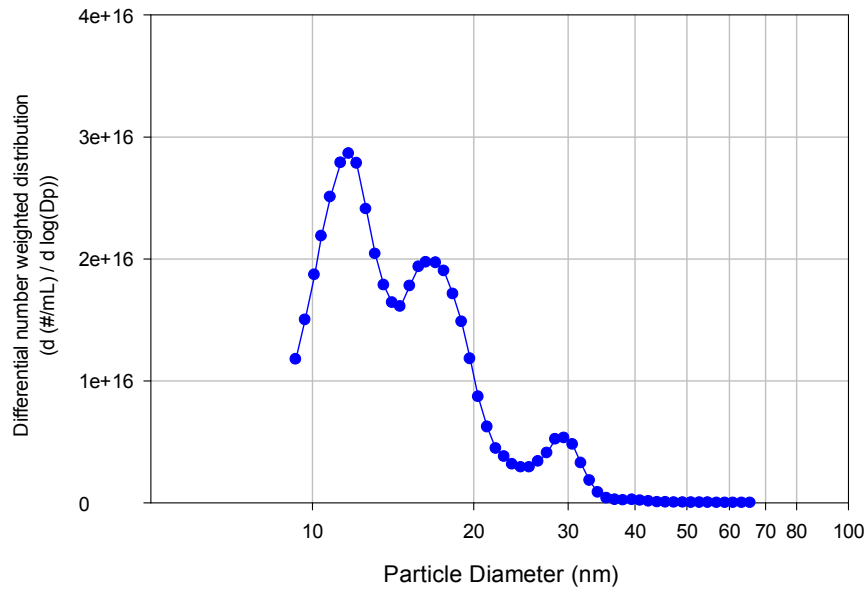


Poly-dispersed PSL challenge solution



Polydispersed Silica Challenge Solution

12, 18 and 28 nm colloidal silica



Available materials and sizes

- Polystyrene latex (NIST traceable)
 - 20, 30, 40, 50, 60, 70, 80, 100 nm
 - 20 to 125 poly
 - 20 to 300 poly
- Colloidal silica
 - 10, 20, 30, 50, 70, 100 nm
 - 10/20/30 nm poly-silica
- Custom materials and sizes less than 500nm as requested



Summary

- Technology is now available to measure the complete particle size distribution (size and concentration) of nanoparticles in liquids.
- The preparation of consistent PSL standards, with significant shelf life, has led to the development of a more accurate calibration for optical particle counters.
- The ability to accurately measure the particle size distribution of colloidal suspensions allows for preparation of non-PSL concentration standards for particles smaller than 100 nm.
- A unique polydispersed PSL standard, comprising a mixture of 16 different PSL sizes (a PSL “cocktail”), offers new opportunities for the characterization of sub-100 nm pore size filters.

