



Size Determination of Latex Standards by Nanoparticle Tracking Analysis

The sizing of certified reference standards (fig. 1) provides a means for third parties to validate new equipment and techniques. Given that a sphere is the only shape which can be perfectly described by a single value (i.e. its radius), it removes ambiguity of results and represents an ideal object on which calibration should be performed.

Background

NanoSight instruments provide a unique ability to directly visualise and size nanoparticles in a liquid suspension. The visualisation of the particles allows **each particle to be simultaneously and individually sized**, overcoming inherent problems associated with techniques such as Photon Correlation Spectroscopy (PCS, or dynamic light scattering). The intensity of light scattered from a nanoparticle as a function of particle radius follows a power law and increases with the sixth power for a Rayleigh particle⁽¹⁾. Hence the **average** particle size produced by PCS (which measures total light scattered from an ensemble of particles) is heavily weighted to small numbers of large, perhaps contaminant, particles. Electron microscopy on the other hand requires time-consuming sample preparation and imaging and is only able to view a small area thus risking a non-representative analysis of the sample as a whole.

As can be seen in fig. 2 the NanoSight view can easily distinguish between particles by the amount of light they scatter. However particle sizing based on light scatter would require knowledge of the refractive index of the particles. The NanoSight technique calculates a sphere-equivalent hydrodynamic radius based on the **Brownian motion** of each individual particle tracked over multiple frames and

hence is totally independent of refractive index (fig. 3). The ability to track each particle individually allows better characterisation of poly-dispersed systems (fig. 4).

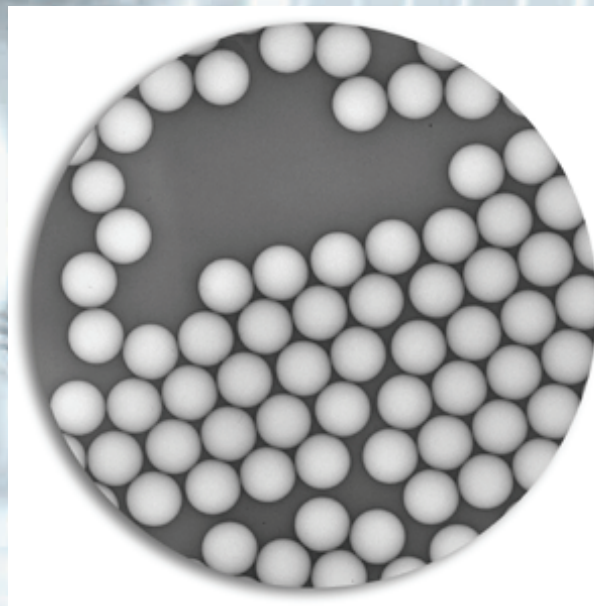


Figure 1: Sample SEM image of Duke Scientific⁽²⁾ calibration latex particles used throughout in the experiments described below.

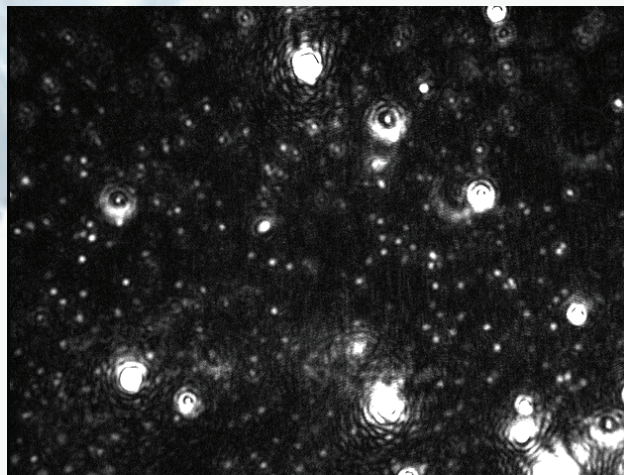


Figure 2: Image of 100nm and 400nm diameter latex calibration particles as seen by the NanoSight LM10 system.

Application Note



⁽¹⁾ C. F. Bohren, D. R. Hoffman, *Absorption and scattering of light by small particles*, (Wiley, New York, 1983)

⁽²⁾ Duke scientific website: <http://www.dukescientific.com/>

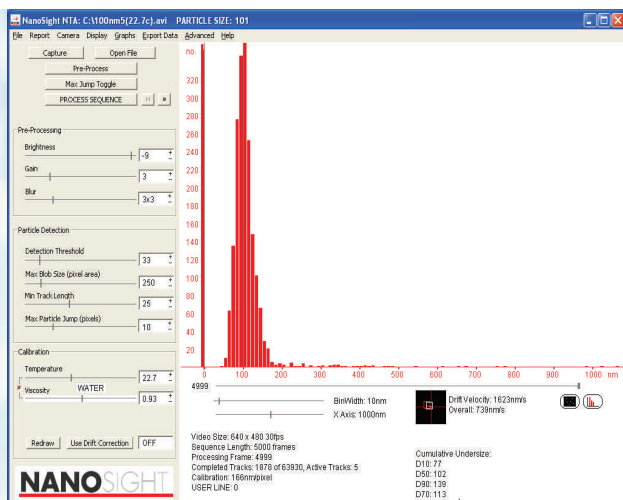


Figure 3. Typical distribution produced by NanoSight instruments. The above distribution is produced from 100nm calibration latex particles.

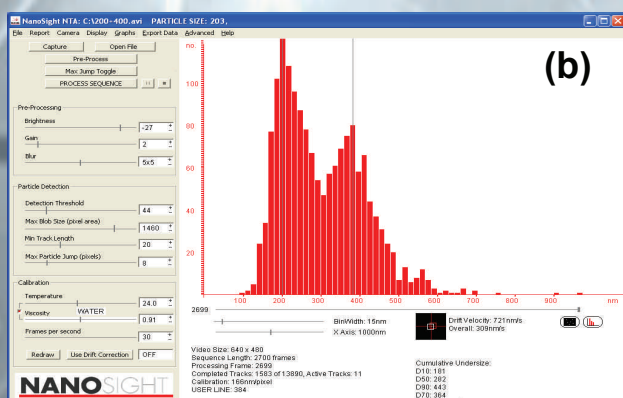
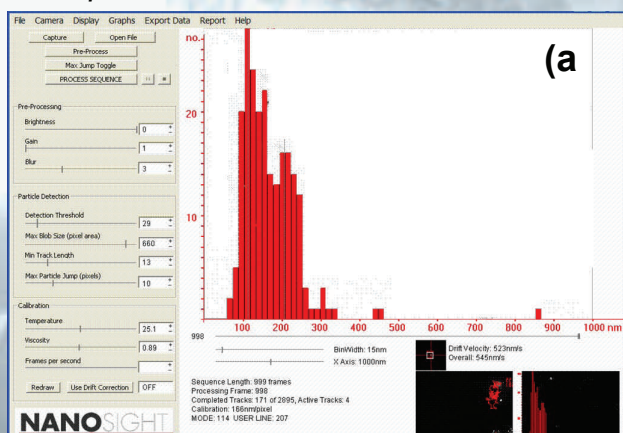


Figure 4. Particle size distributions for (a) a mix of 100 and 200nm latex particles and (b) a mix of 200 and 400nm latex particles.

Sample preparation

The only preparation required is dilution of the sample to between 10^6 and 10^9 particles/ml dependent on sample type and size. At this dilution individual particles can be seen moving under Brownian motion and therefore can be analysed. Optimum concentration is particle and solvent dependent.

Hydrodynamic Radius

The technique measures the hydrodynamic radius of a particle. This is the physical radius of particle, plus a small (typically few nm) Helmholtz layer of tightly bound water molecules. To minimise this effect the sample should be prepared in a 1mM salt solution. Due to this layer, the size measured in a water-based measurement will always be a few nanometers larger than measurements taken by TEM and quoted by the manufacturers of the latex standards (see Table 1).

Temperature Measurement

Correct temperature measurement is very important as an incorrect reading of sample temperature leads to an incorrectly calculated viscosity. A 1°C error in temperature reading gives approximately a 2.7% error in sizing for aqueous systems. Due to the small volume required in the NanoSight instrument ($<500\mu\text{l}$) the temperature equilibration takes only a few minutes and can be directly read during the analysis.

Key features

- Particles can be measured in their natural state (no drying/vacuum conditions required).
- Ability to size a sample with greater polydispersity due to the insensitivity of the technique to light scattering intensity.
- Small sample volume.
- Low cost of unit.
- Visualisation of individual particles without any pre-treatment such as labelling.



Size (nm)	Exp. No.	Mode (nm)	D10 (nm)	D50 (nm)	D90 (nm)	Average mode (nm)	Std (nm)
97±3	1	100	81	104	132		
97±3	2	99	78	101	131		
97±3	3	101	83	106	141		
97±3	4	100	80	103	146		
97±3	5	101	77	102	139	100.2	0.84
199±6	1	200	164	199	237		
199±6	2	200	166	203	246		
199±6	3	200	164	199	246		
199±6	4	202	170	202	242		
199±6	5	200	166	202	246	200.4	0.89
299±6	1	306	263	307	352		
299±6	2	299	265	306	351		
299±6	3	306	263	301	347		
299±6	4	304	267	310	361		
299±6	5	301	259	299	341	303.2	3.11
404±4	1	403	344	403	473		
404±4	2	396	351	404	464		
404±4	3	403	342	399	458		
404±4	4	398	356	410	479		
404±4	5	405	336	396	455	401	3.81

Table 1. Modal size and D10, D50 and D90 values for calibration latex spheres compared to the quoted values measured by TEM⁽²⁾ for a range of particle sizes.

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