Nanoparticle Tracking Analysis (NTA) for Time-resolved, reproducible Nanoparticle Characterisation under Environmentally Relevant Conditions

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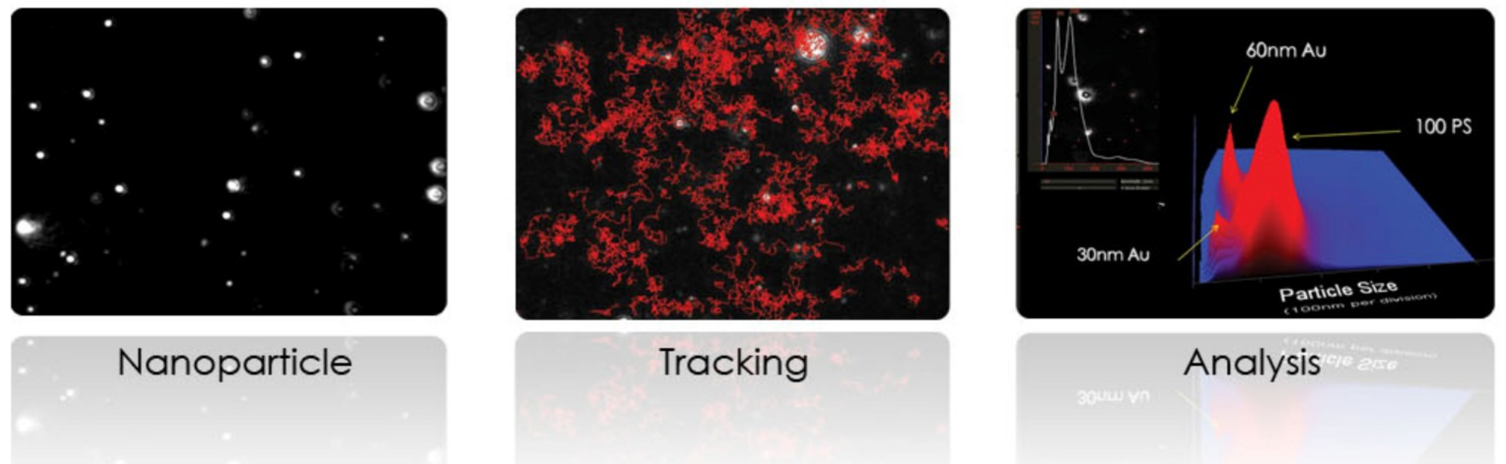
Nanoparticle Tracking Analysis

Introduction

With ever-increasing amounts of nanomaterials being commercially produced and utilised, there exists a need to determine the lifecycle and fate of these materials, with an understandable focus on potentially toxic effects [1].

Analysis by Nanoparticle Tracking Analysis (NTA) allows simultaneous measurements of particle size distribution, concentration, surface charge, and fluorescence, and as such provides detailed information on nanomaterial characteristics throughout the lifecycle [2].

This robust technique provides a useful tool in time-resolved analysis of particle behaviour relevant to lifecycle testing and understanding the fate and behaviour of nanomaterial in biological and ecologically relevant media.



Technique

- A laser diode (635nm, 532nm, 488nm or 405nm) is used to pass a finely focussed beam through a sample chamber containing nanomaterial in liquid
- The light scattered by individual particles is collected using optical microscopy components, allowing a direct visualisation of them moving under Brownian motion
- A video file of this movement is captured and the NTA software tracks the movement of each particle on an individual basis.

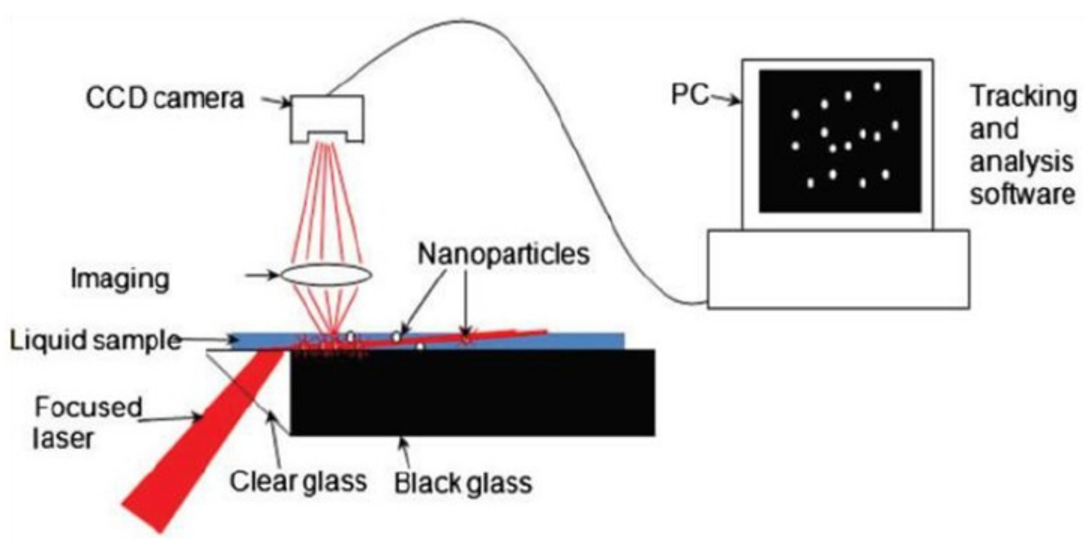
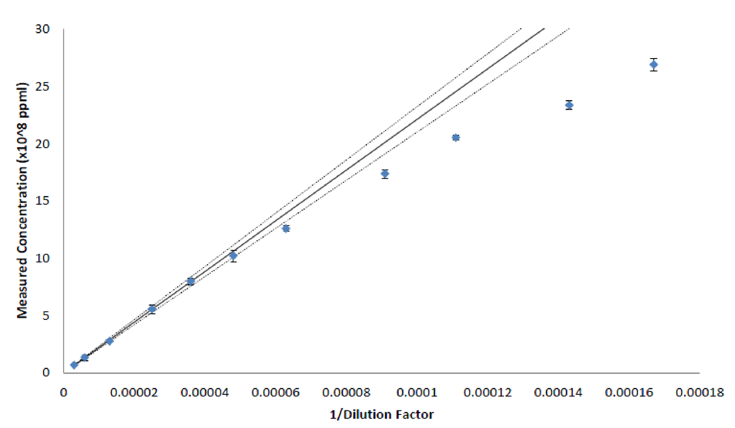


Figure 1. Schematic of NTA equipment

The particle-by-particle approach of NTA allows accurate measurement of particle concentration within a liquid suspension (particles per mL).



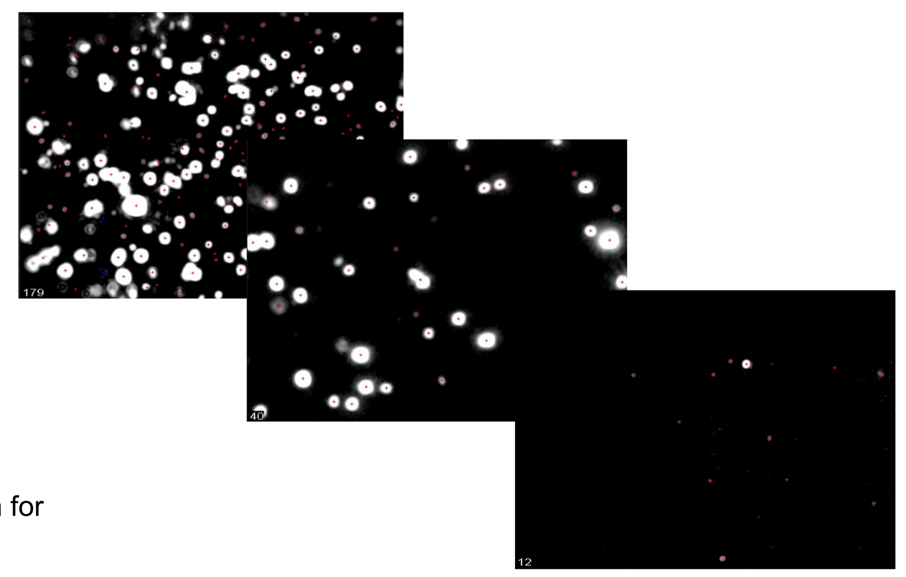


Figure 2. Sample dilution against NTA measured concentration for 100nm standard particles

Reproducibility of NTA

A key challenge in the field of nanoparticle (NP) analysis is in producing reliable and reproducible characterisation data for nanomaterials. As part of the QNano project NTA is currently undergoing a round robin Interlaboratoy Comparison (ILC) to validate the technique.

- 12 laboratories involved
- Looked at a range of particle sizes, materials, mixes and medias/solvents to determine sizing ability and resolution by NTA over 6 ILC rounds [3]
- Improvements of protocol between rounds resulted in improved repeatability and reproducibility
- 7th round was undertake to look at concentration measurements using NTA

Results

RR4

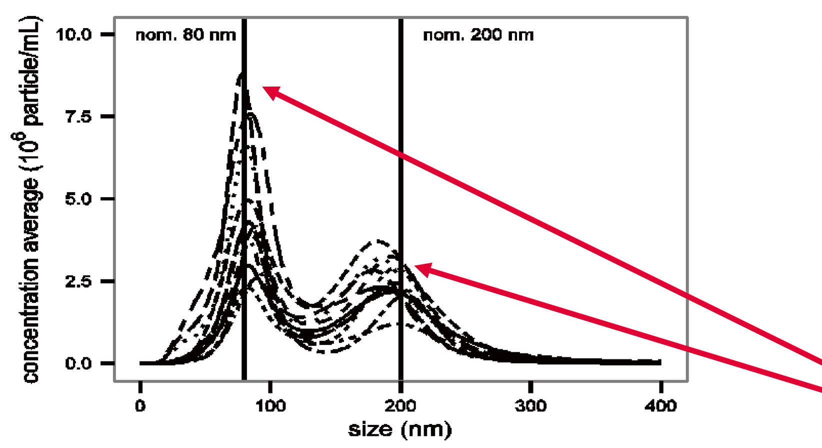


Figure 3. Results from 12 participating laboratories for sample PSL Mix Peak2

		RR1	RR2	RR3	RR4	RR5
		Mode	Mode	Mode	Mode	Mode
	Nominal Size (nm)	%CV	%CV	%CV	%CV	%CV
Gold	30	54.81	10.46			
Carboxylate PSL	100	33.29	9.30			
Amino PSL	100	31.20	15.87			
Silica	100	34.54	10.00			
PSL	100			3.46		
Gold	60			5.07		
Gold	80			4.12		
PSL	100				3.12	
PSL (in Ham's F10 Media)	100				3.65	
PSL (in Ham's F10 Media + BSA)	100				4.69	
Gold Mix Peak1	80				5.47	
PSL Mix Peak2	200				5.16	
PSL	200					3.52
Gold	30					10.94
Gold (in 10% glycerol)	30					9.07
PSL	600					6.01
Average		38.46	11.41	4.21	4.42	7.38

Table 1. Round Robin sample results summary

RR6

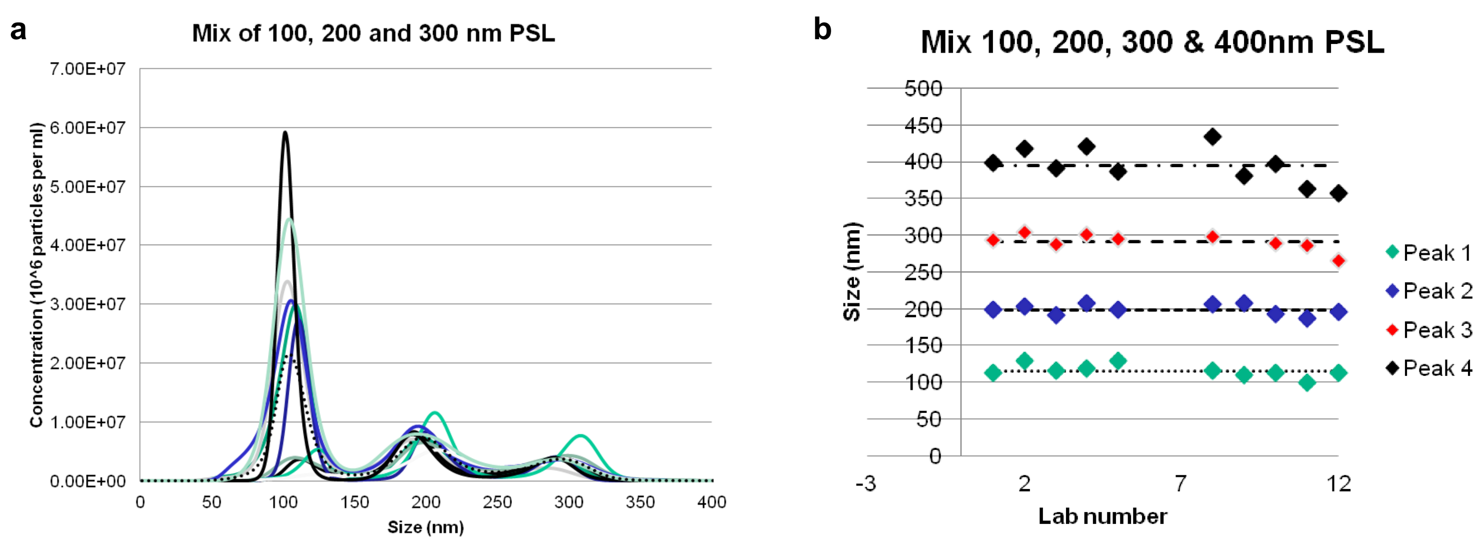


Figure 4. Results from 12 participating laboratories for (a) trimodal; and (b) further multipeak samples from RR6

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Time-resolved and Environmentally Realistic Conditions

The importance of characterising particles in relevant media has high importance in environmental and toxicological studies. Whilst PSD and behaviour of particles is easily determined in laboratory grade water, the behaviour may differ from particles in more relevant media due to factors such as ionic strength, temperature, and the presence or absence of biomolecules and natural organic matter.

As part of the NanoMILE project PSD for a selection of particle types and sizes in three different media were determined.

MNM	Size	Source	Stock concentration	NanoSight dilution factor
Cerium (IV) Oxide (precipitated, uncoated) NM-212	Primary crystal size **33 nm**	JRC	10mg/mL	10,000x
Ag nanoparticles (spherical, citrate stabilised)	**100 nm**	Sigma-Aldrich	0.02 mg/mL	10x
NIST TiO2 (CRM 1898) mixed-phase (anatase and rutile)	~ **70nm** primary particle (in water)	NIST	10mg/mL	1,000x

Table 2. Particles tested in media/ particles tested for experimental design

Results

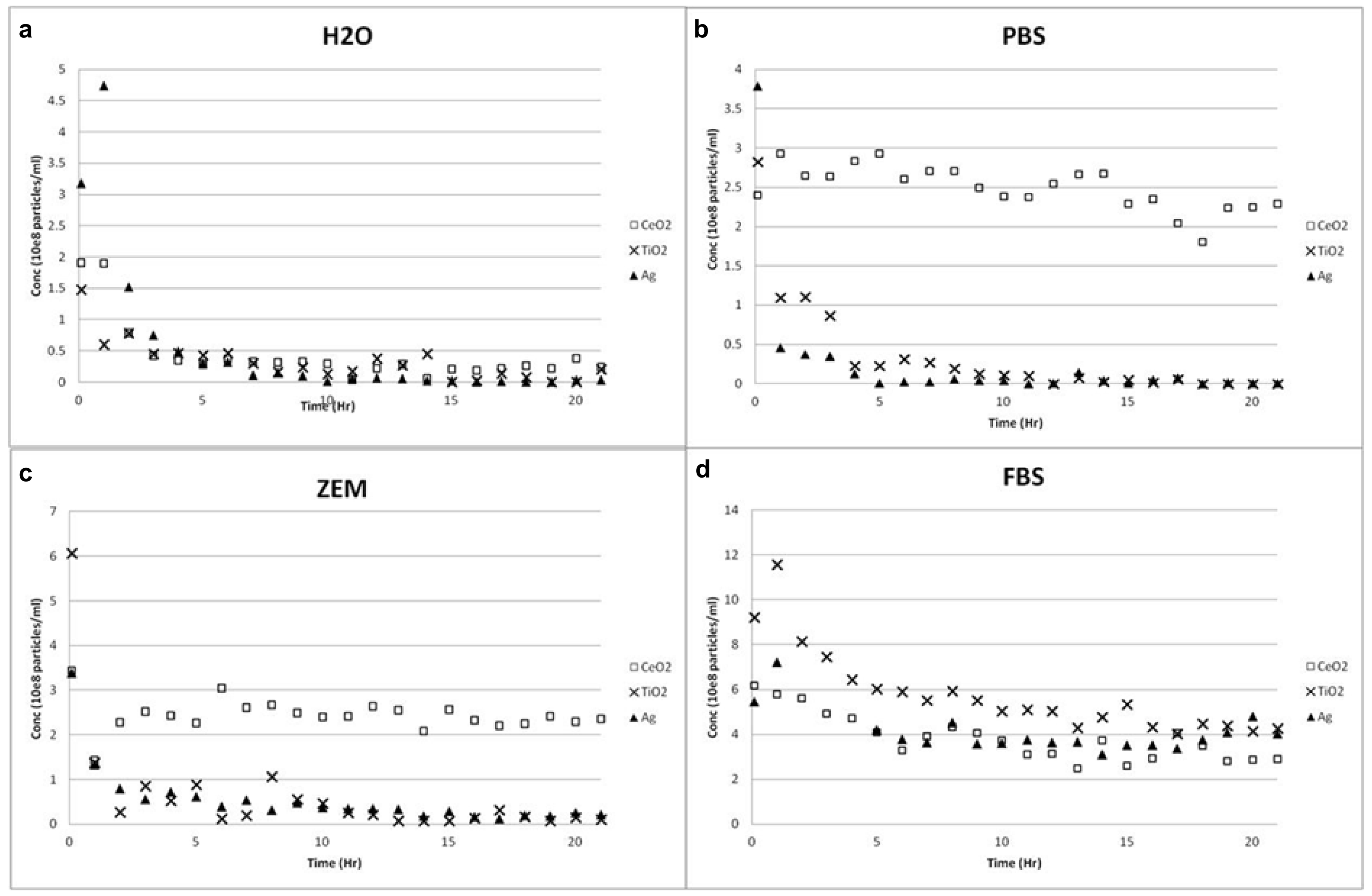

Figure 8. Concentration values of selected particle types in (a) deionised water; (b) PBS; (c) Zebrafish Embryo Media (ZEM); and (d) Foetal Bovine Serum (FBS) over a 21 hour period

Conclusion

- NTA forms an innovative and robust tool in characterising nanomaterial behaviour in a range of media
- The NTA Round Robin has developed protocols and SOP's exhibiting proven increases in repeatability and reproducibility of particle size measurements throughout the entire NanoSight instrument range independent of operator
- The technique lends itself to time-resolved analysis and can be used with a range of media relevant to understanding the behaviour of nanomaterial in both biological and ecologically relevant media

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References

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[3] Hole P, Sillence K, Hannell C, et al. 2013. Interlaboratory comparison of size measurements on nanoparticles using nanoparticle tracking analysis (NTA). Journal of Nanoparticle Research 12: 1-12