Bettersize
BETTER PARTICLE SIZE SOLUTIONS

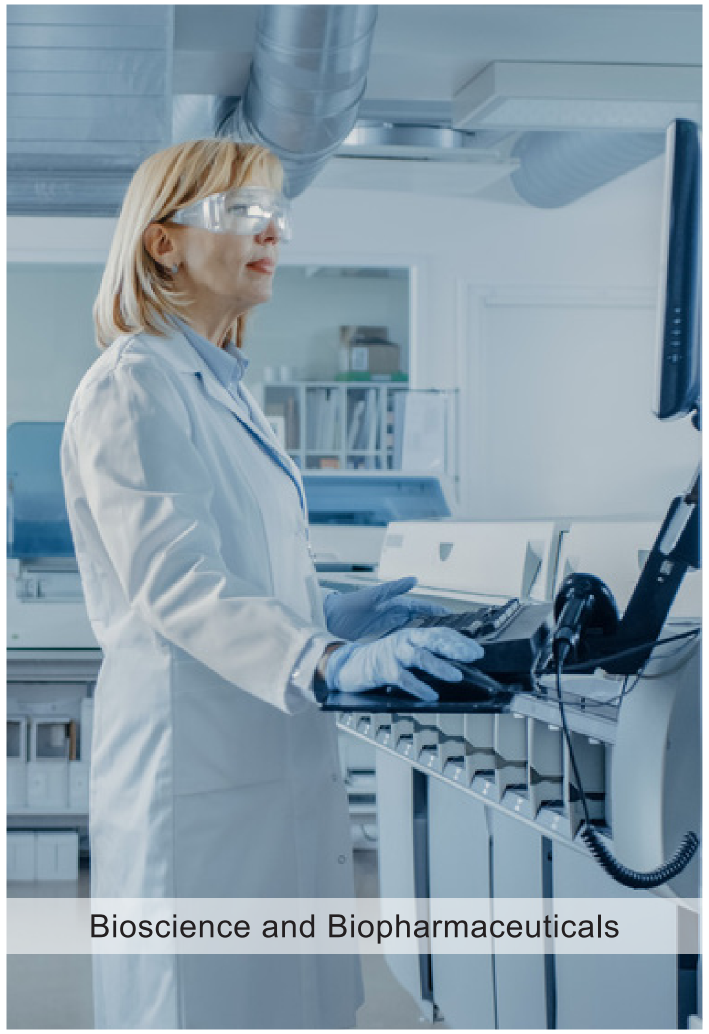
BeNano 90 Zeta

Be the Nanoparticle Expert You Need

PARTICLE SIZE

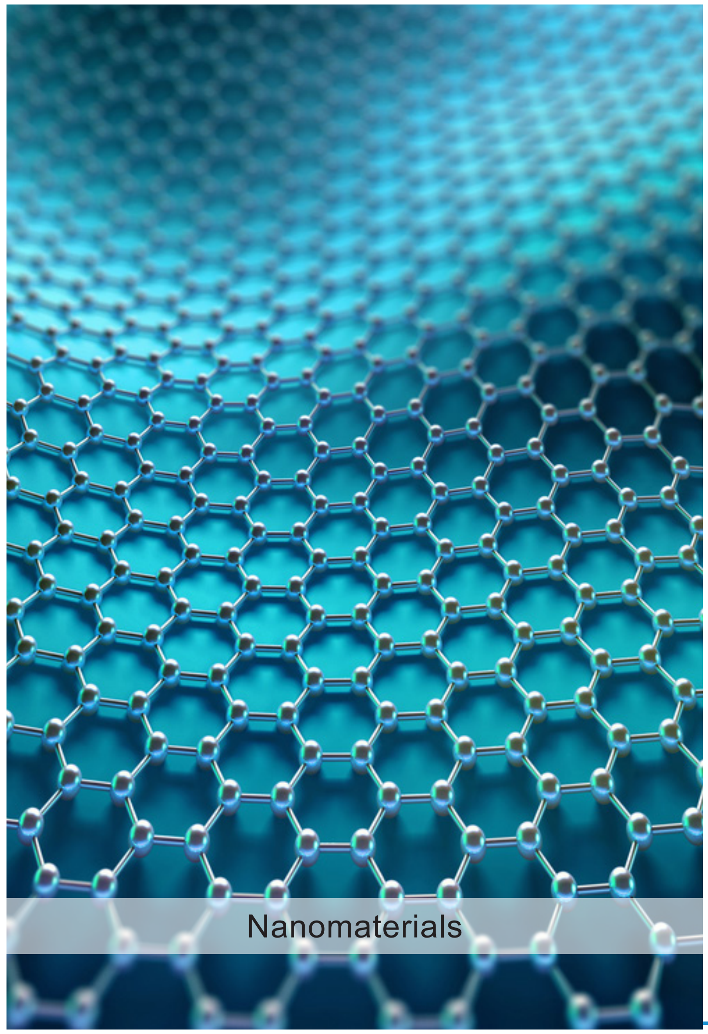
ZETA POTENTIAL

MOLECULAR WEIGHT



Bioscience and Biopharmaceuticals

Food and Beverage



Nanomaterials

Consumer Products

Be the Nanoparticle Expert You Need

The BeNano 90 Zeta is the latest generation of nanoparticle size and zeta potential analyzer designed by Bettersize Instruments Ltd. Dynamic light scattering (DLS), electrophoretic light scattering (ELS) and static light scattering (SLS) are integrated in the system to provide accurate measurements on particle size, zeta potential and molecular weight. The BeNano 90 Zeta is widely applied in academic and manufacturing processes of various fields including but not limited to: chemical engineering, pharmaceuticals, food and beverage, inks and pigments, and life science.

"An excellent and robust device for nano-characterization with DLS, SLS, ELS techniques that provide not only particle size analysis but also reproducible zeta potential results."

China Agricultural University

NANOPARTICLE SIZE AND ZETA POTENTIAL ANALYZER

Features and Benefits

High-Performance Hardware

- **Solid-State Laser**

  High-power semiconductor laser with high beam quality and long service life

- **APD**

  High sensitivity for low concentration or weak scattering sample

- **Temperature Control System**

  Wide temperature range (-10~110℃) suitable for more applications

- **Rapid Measurement Capability**

  Fast operations and editable results

- **Intelligent Intensity Adjustment**

  Intelligent adjustment of the intensity according to the signal-noise ratio

- **Sensitive Optical Fiber Detection System**

  Effectively increase signal-noise ratios due to high sensitivity of the optical system

- **Highly Stable Optical Design**

  Provides highly repeatable results with no routine maintenance required

Research Level Software

- **Standard Operating Procedure (SOP)**

  Ensures the completeness and accuracy of parameters

- **Phase Analysis Light Scattering**

  Measurement of low electrophoretic mobility and zeta potential

- **Intelligent Algorithm of Result Evaluation**

  Intelligent evaluation and processing of signal quality to eliminate the effect of random events

- **Versatile Calculation Modes**

  Various built-in calculation modes to cover multiple scientific research and application fields

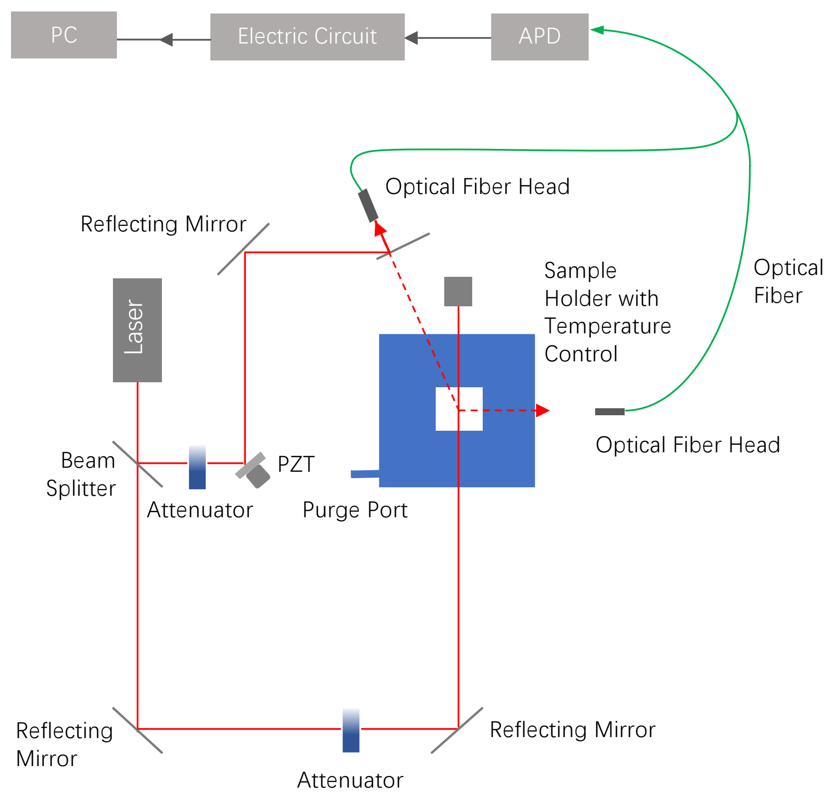
Versatile Accessories

- **Capillary Sizing Cell**

  Sample volume down to 3-5 μL and higher measurement accuracy for large particles

- **Disposable Folded Capillary Cell**

  Excellent repeatability of zeta potential measurements and avoid cross-contamination



Optical Layout of the BeNano 90 Zeta

Measurement Parameters

- Hydrodynamic diameter D_H
- Polydispersity index PdI
- Diffusion coefficient D
- Interaction parameter k_D
- Molecular weight
- Solution viscosity
- Intensity, volume, surface area and number distribution
- Zeta potential and its frequency distribution

Particle Size Measured by DLS

Zeta Potential Measured by ELS

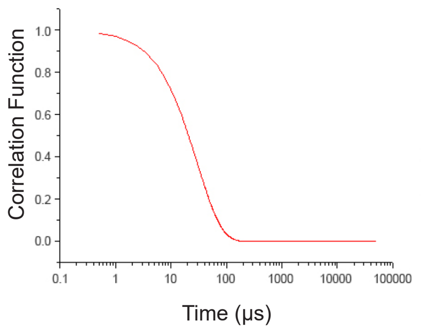
Molecular Weight Measured by SLS

DYNAMIC LIGHT SCATTERING (DLS)

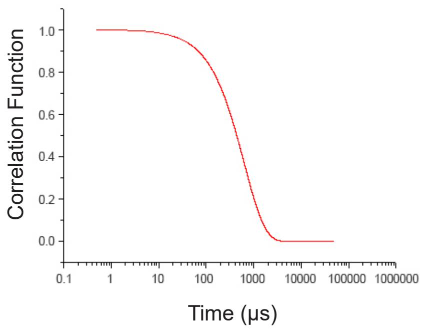
Dynamic light scattering (DLS), also known as photon correlation spectroscopy (PCS) or quasi-elastic light scattering (QELS), is a technology used to detect the fluctuations of the scattering intensities caused by the Brownian motion of particles. In the dispersant, smaller particles move faster, while larger particles move slower.

An avalanche photodiode (APD) detector aligned at 90°collects the scattering intensities of the particles and records them with time. The time-dependent fluctuation is converted into a correlation function using the correlator. By applying a mathematic algorithm, the diffusion coefficient D is thereby obtained. The hydrodynamic diameter D_H and its distribution are calculated through the Stokes-Einstein equation:

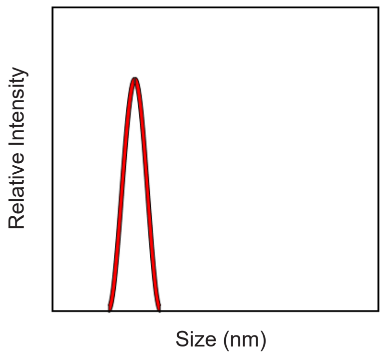
$$D = \frac{k_B T}{3\pi\eta D_H}$$



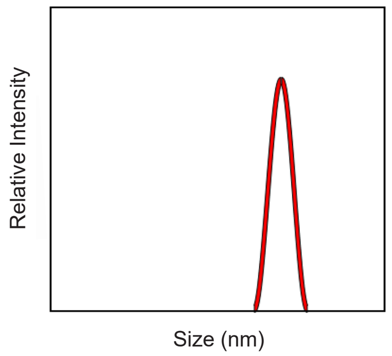
The Correlation Function of Small Particles



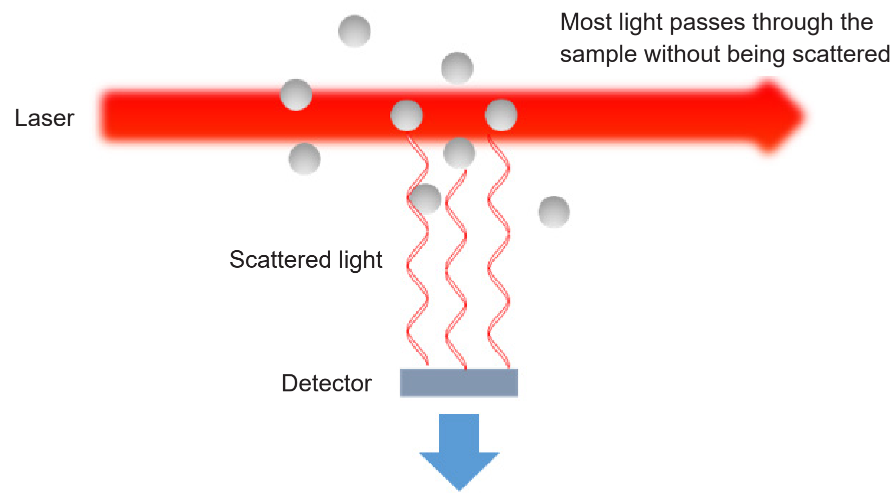
The Correlation Function of Large Particles

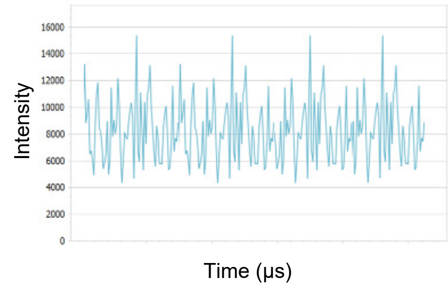


Particle Size Distribution of Small Particles

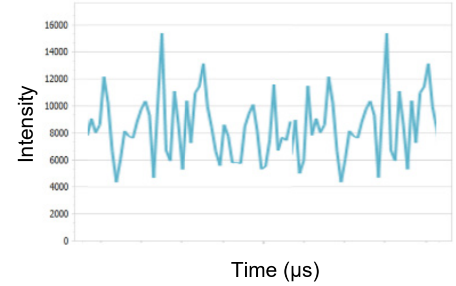


Particle Size Distribution of Large Particles





Scattering of Small Particles

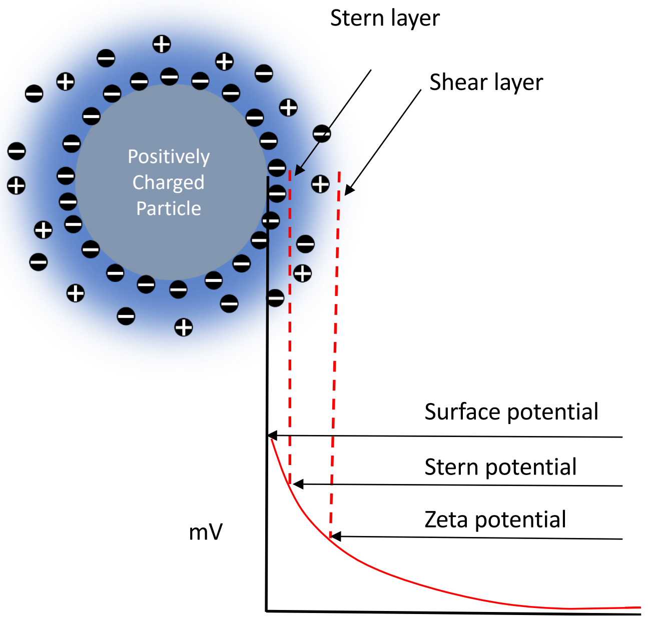


Scattering of Large Particles

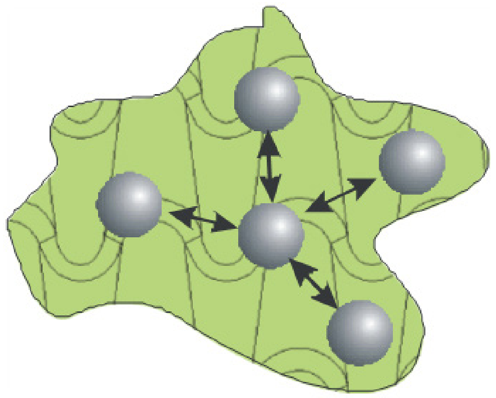
Applications

- Particle size and distribution of polymers, colloids, self-assembling system, biomacromolecules, proteins, peptides, antigens, antibodies, nano metal/non-metal particles
- Studies on the polymerization process and reaction mechanisms
- Studies on kinetics of self-assembly and other processes of polymerization and depolymerization of macromolecules
- Research on thermal-sensitive systems, for example, PNIPAm

ELECTROPHORETIC LIGHT SCATTERING (ELS)



Potential Distribution at Particle Surface

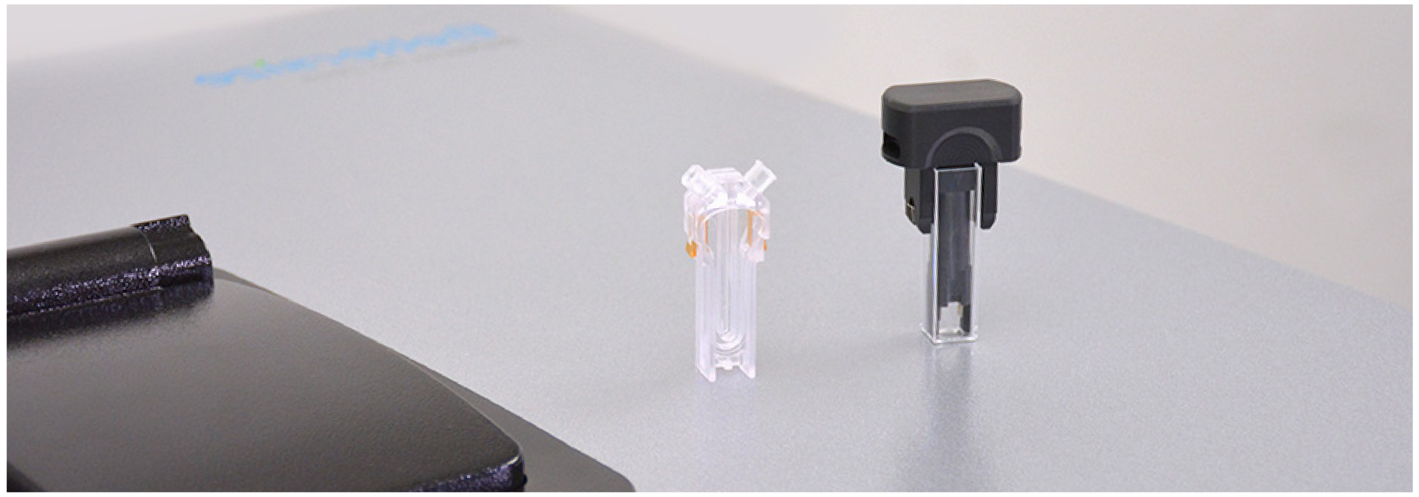


Intermolecular Forces Between Particles

Particles usually carry charges on the surface in aqueous systems, surrounded by counter-ions that form a firmly inner Stern layer and an outer shear layer. Zeta potential is the electrical potential at the interface of the shear layer. A suspension system with higher zeta potential tends to be more stable and less likely to form aggregates.

Electrophoretic light scattering (ELS) is a technology for measuring electrophoretic mobility via Doppler shifts of the scattered light. When an incident light illuminates dispersed particles that are subjected to an applied electric field, the frequency of the particles' scattered light will be different from the incident light due to the Doppler effect. The frequency shift is measured and converted to provide the electrophoretic mobility and hence the zeta potential of a sample by Henry's equation:

$$\mu = \frac{2\varepsilon_r \varepsilon_0 \zeta}{3\eta} f(\kappa\alpha)$$



Applications

- Zeta potential, electrophoretic mobility, and their distributions of suspension systems such as macromolecules, colloids, emulsions, coal-water slurries, proteins, antigens, antibodies and nano metal/non-metal particles
- Industries include, but are not limited to, chemicals, chemical engineering, biology, food and beverage, pharmaceuticals, water treatment, environmental protection, abrasive and paints
- Monitoring and controlling product stability
- Stability research and control of the suspension system
- Studies on the surface electrical properties and surface modifications

PHASE ANALYSIS LIGHT SCATTERING (PALS)

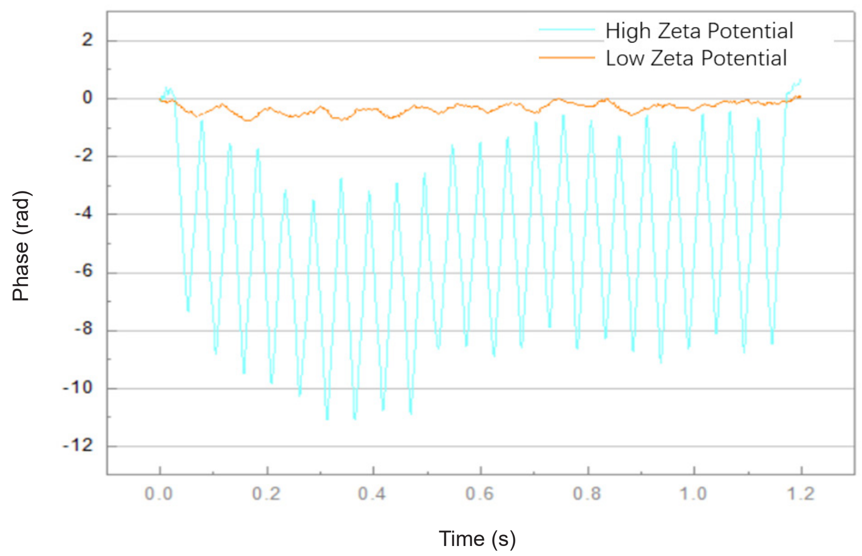
The traditional ELS converts the correlated scattering signals into frequency distribution and then calculates the frequency shift Δf of the scattered light, compared with the reference light. Phase analysis light scattering (PALS), an advanced technology based on the traditional ELS technology, has been further developed by Bettersize Instruments Ltd. to measure zeta potential and its distribution of a sample.

By analyzing the phase information Φ of the original scattered signal, PALS obtains the frequency information of that light. The phase shift dΦ/dt with time is proportional to the frequency shift Δf.

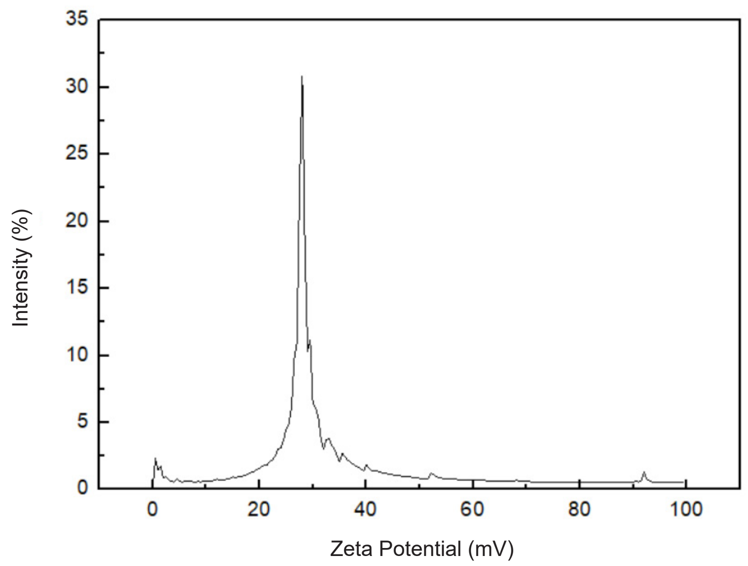
PALS technology can suppress the influence of the Brownian motion of particles on the results, thereby providing higher statistical accuracy. In various applications, PALS can effectively measure the zeta potential of particles whose charge approaches the isoelectric point, for instance, particles with very slow electrophoretic mobility at a high salt concentration.

"We are operating BeNano 90 Zeta to investigate the characteristics of our nanoparticles (size and molecular weight). Our Ph.D. researchers can bounce right in and analyze their samples with just one click."

Guizhou University



Phase Plot of PALS



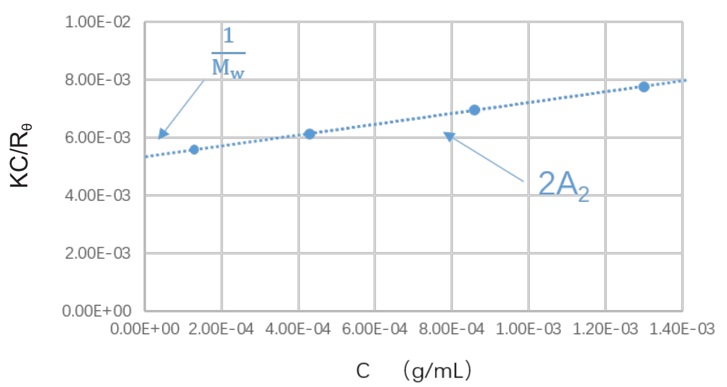
Zeta Potential Distribution

STATIC LIGHT SCATTERING (SLS)

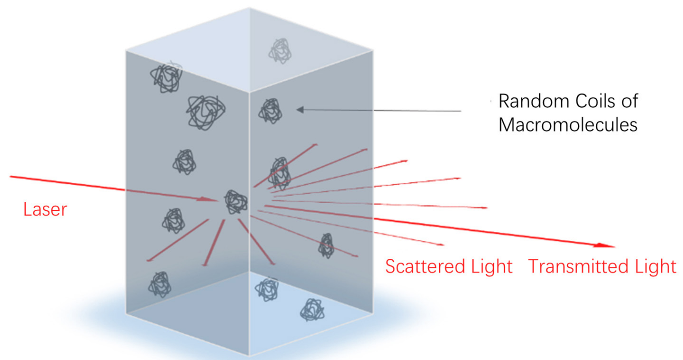
Static light scattering (SLS) is a technology that measures the scattering intensities, weight-average molecular weight (Mw) and second virial coefficient (A_2) of the sample through Rayleigh equation:

$$\frac{KC}{R_\theta} = \frac{1}{M_w} + 2A_2C$$

where C is the sample concentration, θ is the detection angle, R_θ is the Rayleigh ratio used to characterize the intensity ratio between the scattered light and the incident light at the angle of θ, Mw is the sample's weight-average molecular weight, A_2 is the second virial coefficient, and K is a constant related to $(dn/dc)^2$.



Debye Plot



Scattered Light of Macromolecules

"BeNano 90 Zeta delivers incredible outcomes for the analysis of nanoparticles such as particle size and zeta potential of our drug samples. This is the most utilized and valued analyzer in our laboratory."

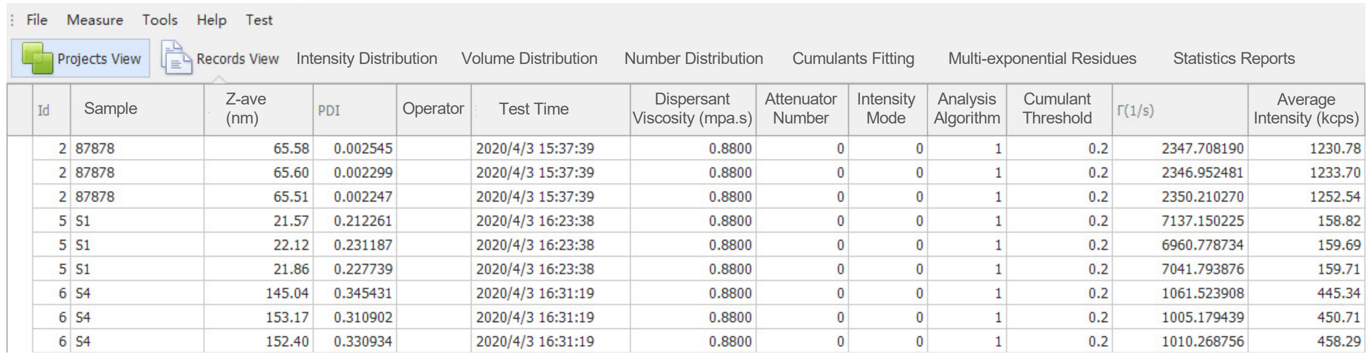
Hunan Anxin Biological Co., Ltd.

During molecular weight measurements, scattering intensities of the sample at different concentrations are detected. By using the scattering intensity and Rayleigh ratio of a known standard (such as toluene), the Rayleigh ratios of samples at different concentrations are computed and plotted into a Debye plot. The molecular weight and the second virial coefficient are then obtained through the intercept and slope from the linear fitting of the Debye plot.

Applications

- Chemical engineering: characterization of polymers, micelles and supermolecules
- Petroleum engineering: characterization of macromolecule additives and oil-displacing surfactants
- Life science: characterization of proteins, polypeptides, and polysaccharides
- Pharmaceuticals: research on aggregation and stability of drugs
- Conformation of supermolecules, research on self-assembling aggregates

A RESEARCH LEVEL SOFTWARE

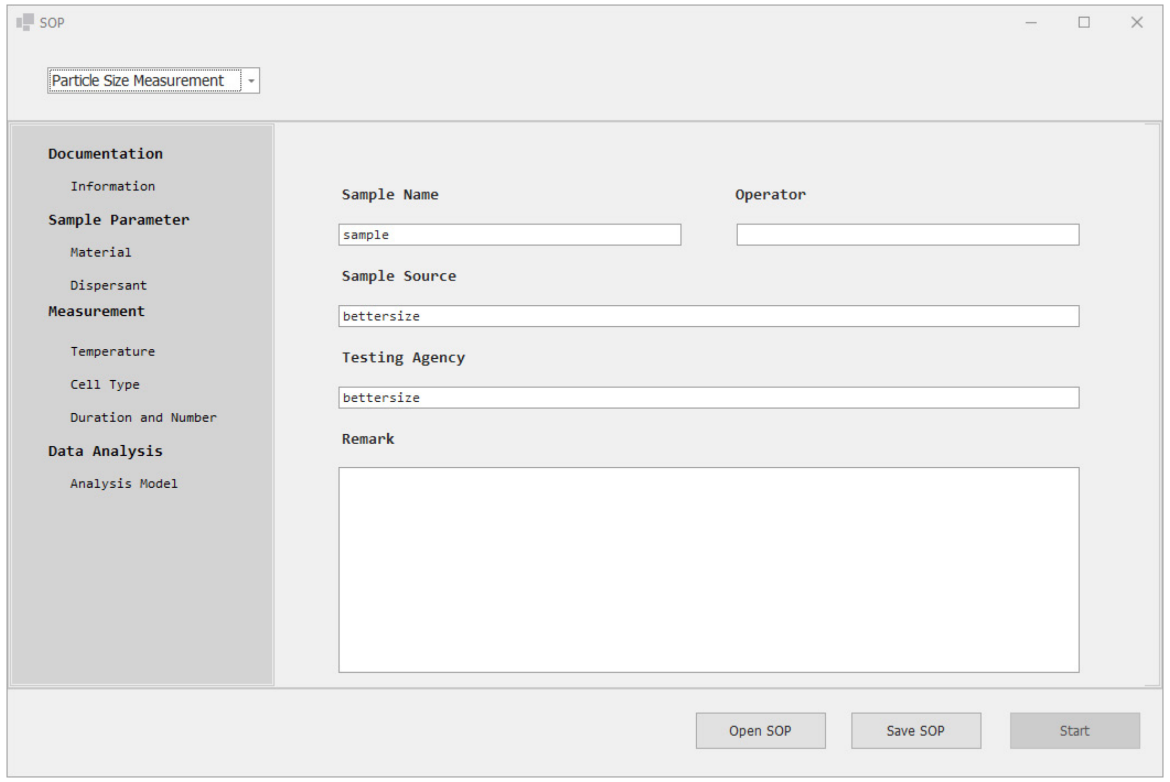


Id	Sample	Z-ave (nm)	PDI	Operator	Test Time	Dispersant Viscosity (mpa.s)	Attenuator Number	Intensity Mode	Analysis Algorithm	Cumulant Threshold	Γ(1/s)	Average Intensity (kcps)
2	87878	65.58	0.002545		2020/4/3 15:37:39	0.8800	0	0	1	0.2	2347.708190	1230.78
2	87878	65.60	0.002299		2020/4/3 15:37:39	0.8800	0	0	1	0.2	2346.952481	1233.70
2	87878	65.51	0.002247		2020/4/3 15:37:39	0.8800	0	0	1	0.2	2350.210270	1252.54
5	S1	21.57	0.212261		2020/4/3 16:23:38	0.8800	0	0	1	0.2	7137.150225	158.82
5	S1	22.12	0.231187		2020/4/3 16:23:38	0.8800	0	0	1	0.2	6960.778734	159.69
5	S1	21.86	0.227739		2020/4/3 16:23:38	0.8800	0	0	1	0.2	7041.793876	159.71
6	S4	145.04	0.345431		2020/4/3 16:31:19	0.8800	0	0	1	0.2	1061.523908	445.34
6	S4	153.17	0.310902		2020/4/3 16:31:19	0.8800	0	0	1	0.2	1005.179439	450.71
6	S4	152.40	0.330934		2020/4/3 16:31:19	0.8800	0	0	1	0.2	1010.268756	458.29

BeNano software comes with user-friendly interface, results previews, and various types of report pages.

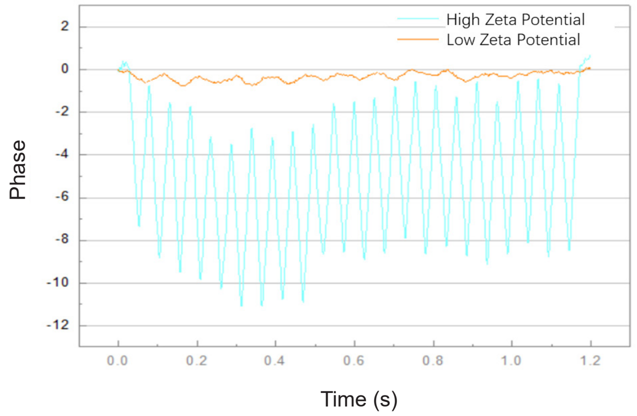
Features

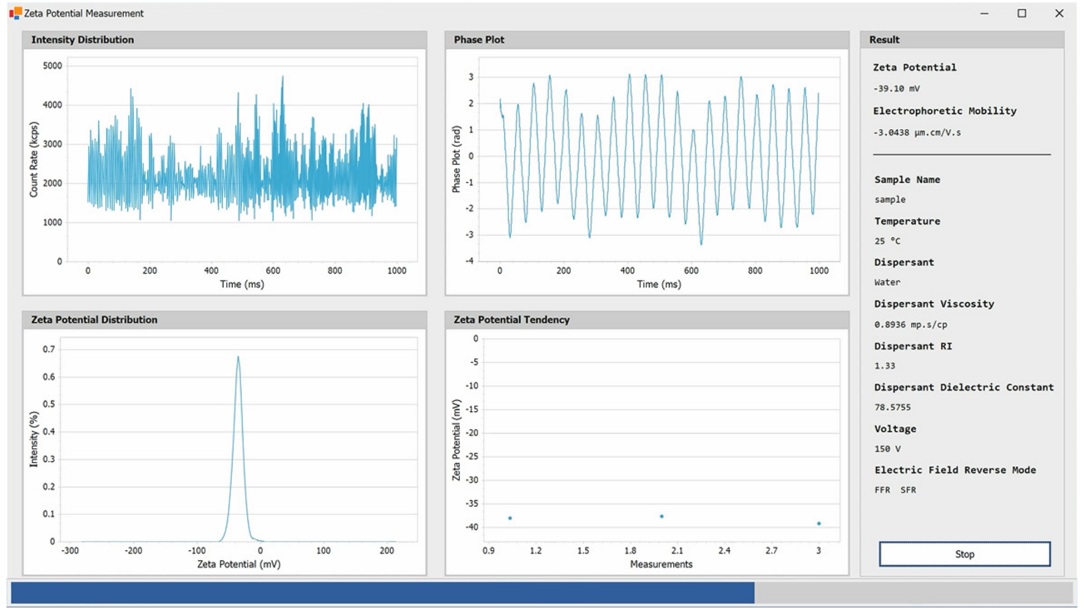
- Standard Operating Procedure (SOP) ensures the completeness and accuracy of parameters during measurements
- Measurement interface shows real-time information and results of various types
- Results and Statistics – automatic calculations of mean and standard deviation
- Statistics and Overlay – compares results from multiple runs
- Over 100 parameters available, 100% covering the needs for research, QA, QC, and production
- Life-long upgrades provided free of charge



Electrophoretic Light Scattering

- Phase Analysis Light Scattering
- Zeta potential and its distribution are available
- Analysis model
  - Smoluchowski
  - Hückel
  - Customized





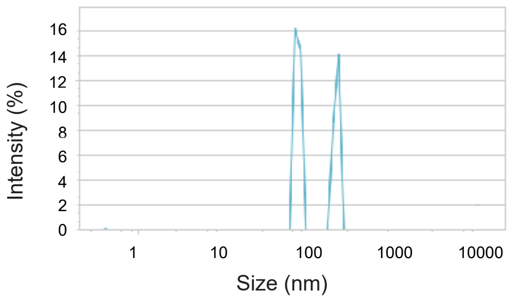
Dynamic Light Scattering

- Intelligent selection and deletion of poor-quality data
- Results of Z-ave particle size, PdI, particle size distribution, diffusion coefficient are available
- Analysis model
  - Cumulants
  - Universal
  - CONTIN

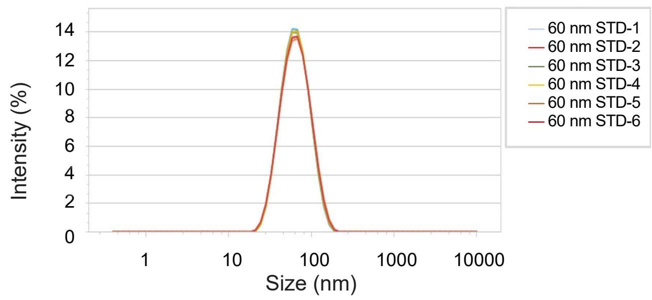
Powerful Statistics and Analyzing Tools

- Display the real-time results in the measurement page
- Mean, standard deviation, and relative standard deviation information available
- Able to reanalyze and re-edit historical data
- More detailed information displayed in the "Statistics and Overlay" page
- Capable of batch-processing multiple results

APPLICATIONS – DYNAMIC LIGHT SCATTERING



Particle size distribution of a 60 nm and a 200 nm polystyrene latex miture



Particle size distribution of a 60 nm polystyrene latex

	Z-ave Size
Average	63.59
Standard Deviation	0.55
Relative Standard Deviation	0.86%

Resolution

The resolution of the DLS technology depends on the algorithm. Usually for two narrowly sized-distributed components with size difference of over 3:1, the algorithm discerns two individual peaks by adjusting the resolution to a higher level. The BeNano 90 Zeta provides several algorithms with different resolutions to meet the high-resolution requirements of different applications. The figure on the upper left is the result of a 60 nm and a 200 nm latex mixture.

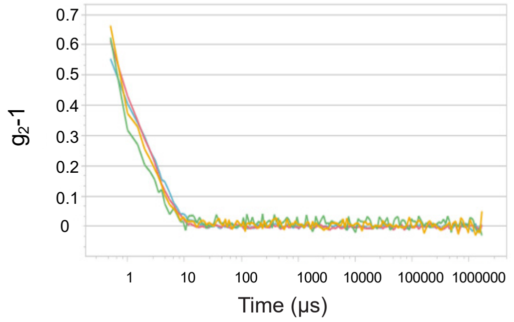
Repeatability

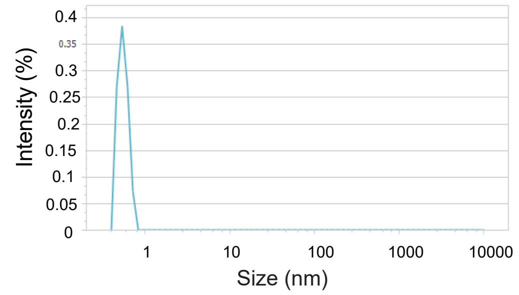
The BeNano 90 Zeta optical system is robust and stable. It has an automatic intensity adjustment and intelligent signal judgment system to ensure high stability and repeatability of the measurements. The figure on the upper right shows the measurement repeatability of the 60 nm polystyrene latex. As shown, the system provides excellent repeatability with a relative standard deviation less than 1%.

For Small Particles

The BeNano 90 Zeta is equipped with a 50 mW solid-state laser, a high-sensitivity APD detector and single-mode fibers, which provides unprecedented sensitivity and accurate measurement for extremely small particles with fast diffusion speeds.

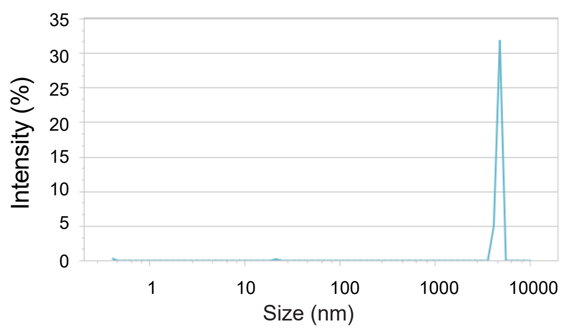
Even for molecules smaller than 1 nm such as vitamin B1 (as shown below), under very diluted conditions of 5% wt, the BeNano 90 Zeta can effectively detect its scattering intensity and fast decay signals to obtain the particle size and size distribution.



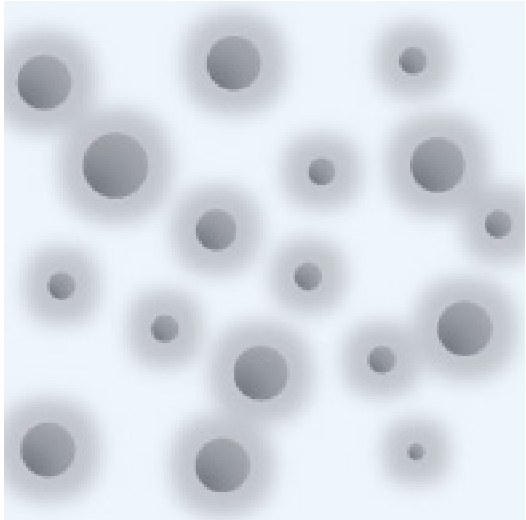


For Large Particles

Large particles diffuse slowly and are likely to sediment. Applying DLS technology for large particles requires the intelligent adjustment of the scattering intensity and ensures enough correlation time for the slow decay. The highly effective detection system of the BeNano 90 Zeta can offer enough correlation time providing accurate calculation of slow decay signals. The figure below is the measurement result of a 5 μm polystyrene latex.

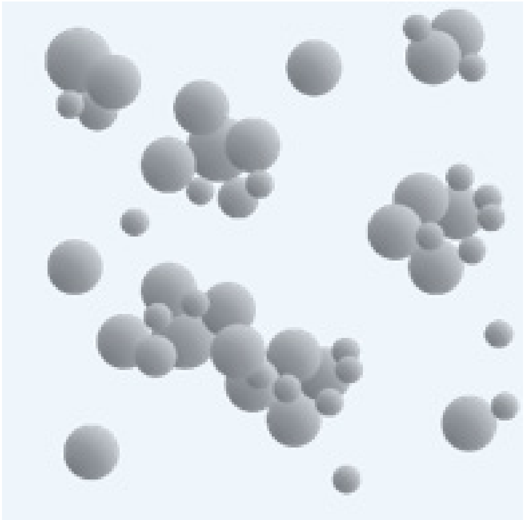


Particle Stability



High Zeta Potential

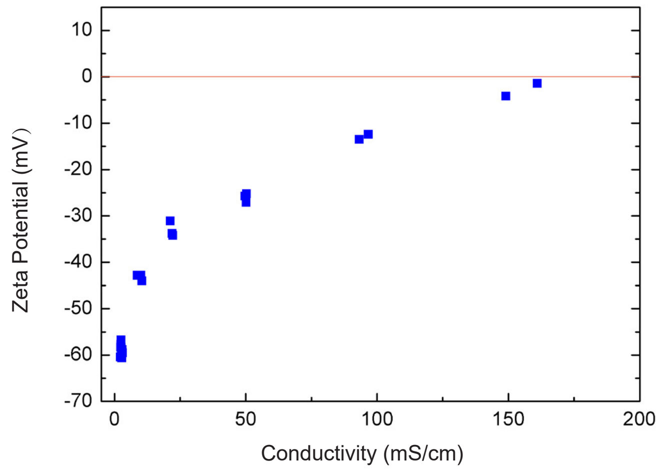
- High repulsion force of particles
- Stable particle system

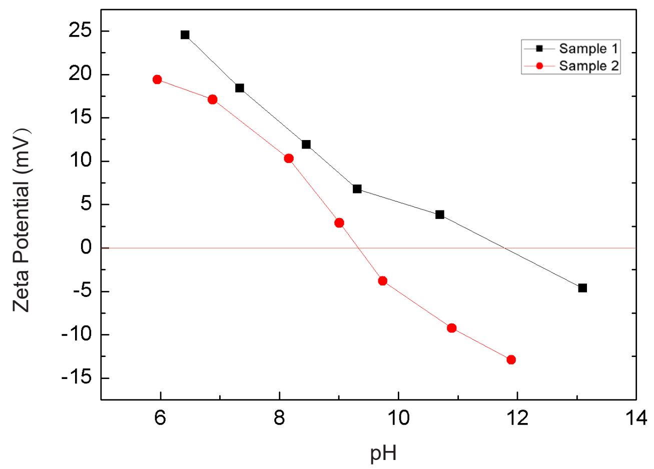


Low or Zero Zeta Potential

- Flocculation, aggregation, sedimentation
- Unstable particle system

Zeta potential is a key indicator of the stability of the particle system. With a high zeta potential, the repulsive force between particles is strong and the system tends to be stable. Alternatively, with a low zeta potential, the repulsive force between particles is weak, the particles are easy to agglomerate or flocculate, and the system stability is poor. The main factors affecting zeta potential include the dispersant pH, ionic strength (salt concentration) and the concentration of small molecule additives.

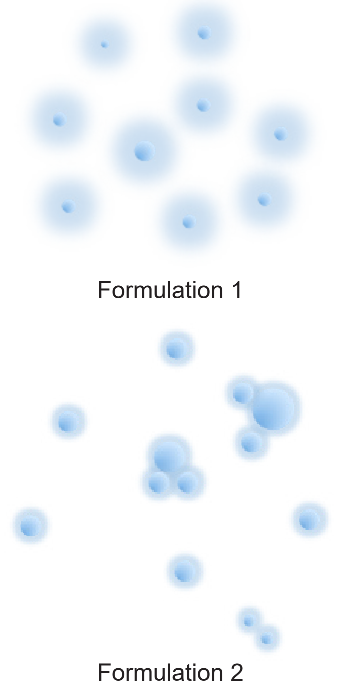




> The pH of the dispersant is one of the important factors affecting the zeta potential of the particles. Usually, at a lower pH the particles tend to be more positively charged, and at a higher pH they tend to be more negatively charged. It should be noted that even particles with the same chemical composition may have different zeta potentials under the same dispersant environment, if the sample source is different.

The ionic strength of the dispersant is also one of the important factors affecting the zeta potential of the particles. In general, a higher ionic strength will result in a stronger shielding effect, meaning the absolute value of the particle's zeta potential is closer to zero, and a smaller electrophoretic mobility of the particle in the electric field. It should be noted that some ions can be specifically adsorbed on the surface of the particles, which will additionally increase the amount of charge distributed on the surface of the particles.

APPLICATIONS – PARTICLE INTERACTIONS



Light scattering technology can provide information of intermolecular forces and stability of a given colloidal particles suspension system. Specifically, the second virial coefficient A_2 (B_{22}) and interaction parameter k_D can be determined by a concentration-dependent SLS measurement and DLS measurement, respectively. Besides, the zeta potential of the particles can be obtained by an ELS measurement.

Using quantifiable parameters such as A_2, zeta potential, and k_D, users can access accurate and comparable information regarding the intermolecular forces of the particles.

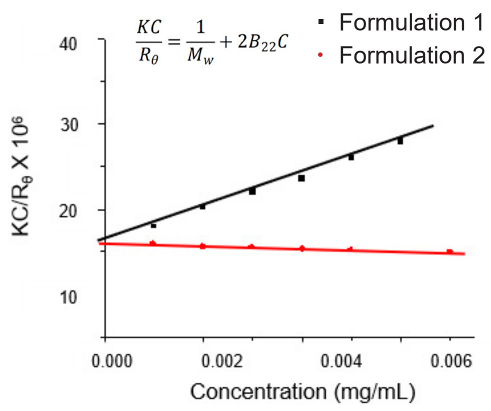
Using quantifiable parameters such as A_2, zeta potential, and kD, users can access accurate and comparable information regarding the intermolecular forces of the particles.

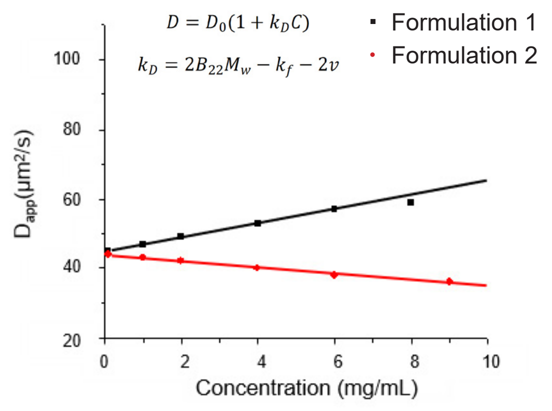
Protein Suspensions and Formulations

The stability of a protein suspension depends on the functional groups of the protein and the solution environment. By changing the components of the solution environment, a relatively stable protein formulation with fewer protein aggregates and good thermal stability could be obtained. Examining the intermolecular forces between proteins in a formulation through light scattering technology enables stability determination.

The second virial coefficient A_2 (B_{22}) is calculated by analyzing the scattering intensity dependence on suspensions concentration in a static light scattering measurement. Typically, a larger B_{22} corresponds to a higher stability, while a negative value of B_{22} indicates a low stability system that is more likely to form aggregates.

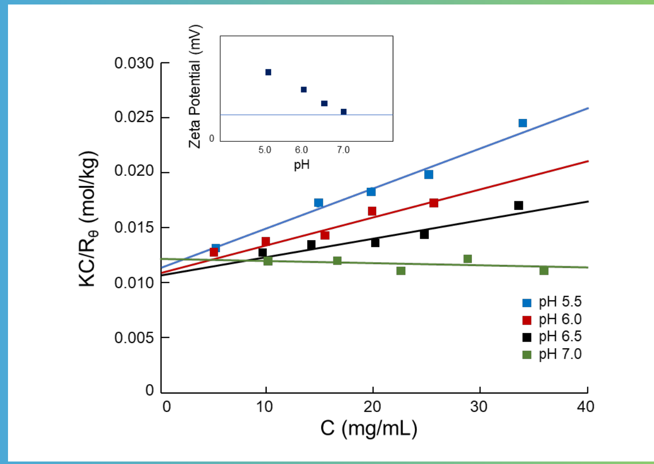
Another widely accepted technology, especially by the pharmaceutical industry, is to use dynamic light scattering to measure the diffusion coefficient of the suspension. The dependence of diffusion coefficient on the concentration may derive the DLS interaction parameter k_D. Similar to B_{22}, a larger k_D suggests higher stability of a protein formulation.





Protein Suspensions and Environmental pH

One of the surface characteristics of protein is that it exhibits different intermolecular forces, electric potential, and charge density properties in environments with different pH values. By using static light scattering (SLS), the dependence of scattering intensities of proteins on the suspension concentrations is investigated in different pH environments. A Debye plot is constructed by plotting and linearly fitting the scattering intensities versus the concentration profiles of the suspensions. The slope of the linear fitting equation is used to calculate the second virial coefficient B_{22}. As shown below, when the environmental pH is 5.5, the protein solution has a steep slope and hence a high B_{22}, which suggests stronger intermolecular force and higher stability in the suspension system. As the pH values increase, the values of B_{22} decrease, which means the stability of the protein solution declines with pH increase. From the upper left of the figure, it can be observed that the zeta potentials also decrease as the pH values increase from 5.5 to 7, which agrees with the B_{22} result.



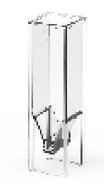
ACCESSORIES

Particle Size Measurement

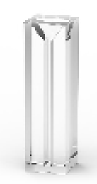
Type	Description	Material	Sample Volume	Temperature Range
Disposable PS Cuvette	Commonly used sample cell for aqueous samples	PS	1 – 1.5 mL	-10 – 70°C
Glass Cuvette (square opening)	Commonly used sample cell for aqueous and organic samples	Glass	1 – 1.5 mL	-10 – 110°C
Glass Cuvette (round opening)	Commonly used sample cell for aqueous and organic samples with better sealing performance	Glass	1 – 1.5 mL	-10 – 110°C
Disposable Micro-volume Cuvette	For aqueous samples with micro volume required	PMMA	40 – 70 µL	-10 – 70°C
Micro-volume Glass Cuvette	For aqueous samples with micro volume required	Glass	25 – 50 µL	-10 – 110°C
Capillary Sizing Cell	For aqueous and organic samples with ultra-micro volume required	Glass	3 – 5 µL	-10 – 70°C

Disposable PS Cuvette (square opening)

Glass Cuvette (round opening)



Disposable Micro-volume Cuvette

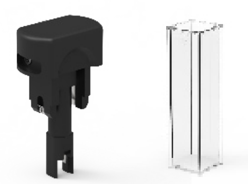


Micro-volume Glass Cuvette

Capillary Sizing Cell Kit

Zeta Potential Measurement

Type	Description	Material	Sample Volume	Temperature Range
Dip Cell	For aqueous and organic samples	PEEK, Platinum	1 – 1.5 mL	-10 – 100°C
Folded Capillary Cell	For aqueous samples	PC	0.75 mL	-10 – 90°C

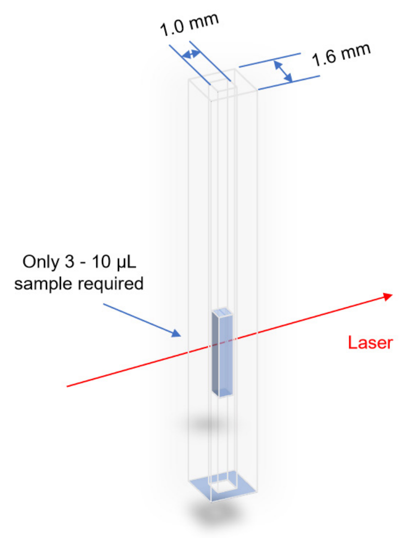


Dip Cell Kit

Folded Capillary Cell

Capillary Sizing Cell

- Ease of use - just dip the sample and test
- Low cost and disposable compared to low volume quartz cell
- Extremely low sample volume required (3-5 µL)
- Avoid large particle sedimentation and allow for larger particle measurement up to 15 µm
- Smaller inner diameter of the capillary allows for a more uniform temperature field, avoiding the effect of turbulence or convection on the signal caused by the temperature field of the sample
- Shorter optical path (0.5 mm) - lower multiple light scattering effects



Disposable Folded Capillary Cell

- 5 cm electrode distance to avoid heating the sample, and provide a more uniform electric field
- Avoid cross-contamination
- Suitable for high-polarity particle systems
- Optical path of 4 mm, capable of measuring samples with a maximum concentration of 40% w/v
- High-tech but disposable item with a low usage cost

Functions	BeNano 90 Zeta	BeNano 90	BeNano Zeta
Particle Size Measurement			
Size Range (D_H)	0.3 nm – 15 um*	0.3 nm – 15 um*	
Minimum Sample Volume	3 μL*	3 μL*	
Detection Angle	90°	90°	
Analysis Algorithm	Cumulants, Universal Mode, CONTIN	Cumulants, Universal Mode, CONTIN	
Zeta Potential Measurement			
Detection Angle	12°		12°
Zeta Potential Range	No actual limitation		No actual limitation
Electrophoretic Mobility Range	> ±20 μ.cm/V.s		> ±20 μ.cm/V.s
Conductivity Range	260 mS/cm*		260 mS/cm*
Minimum Sample Volume	0.75 mL		0.75 mL
Molecular Weight Measurement			
Molecular Weight Range	342 Da – 2×10^7 Da*	342 Da – 2×10^7 Da*	
Viscosity Measurement			
Viscosity Range	0.01 cp – 100 cp*	0.01 cp – 100 cp*	
Interaction Parameter			
k_D	No actual limitation	No actual limitation	
Trend Measurement			
Mode	Time	Time	
System Parameters			
Temperature Control Range	-10°C - 110°C ± 0.1°C	-10°C - 110°C ± 0.1°C	
Condensation Control	Dry air or nitrogen	Dry air or nitrogen	
Standard Laser Source	50 mW Solid-state laser, 671 nm	50 mW Solid-state laser, 671 nm	
Correlator	Up to 4000 channels	Up to 4000 channels	
Detector	APD (avalanche photodiode)	APD (avalanche photodiode)	
Intensity Control	0.0001% - 100%, manual or automatic	0.0001% - 100%, manual or automatic	
Dimensions (L x W x H)	62.5 x 40 x 24.5 cm (22 kg)	62.5 x 40 x 24.5 cm (22 kg)	
Power Requirements	100 - 240 V, 50/60 Hz	100 - 240 V, 50/60 Hz	
Optional			
Disposable micro volume cuvette (40 μL – 70 μL)	√	√	
Micro-volume glass cuvette (25 μL – 50 μL)	√	√	
Glass cuvette with round opening (1 mL – 1.5 mL)	√	√	
Dip cell kit (1 mL – 1.5 mL, zeta potential measurement for organic samples)	√		√

* Depending on samples and accessories

SERVICES AND SUPPORT

Quality is the core of how Bettersize conducts business, and is constantly verified by our customers and partners around the world. The latest technology and strict quality control system enable our instruments to operate error-free for more than 1,000 days on average.

Over the past decades, Bettersize has provided every customer with product demonstration, installation, product training, software upgrade, spare parts replacement, and maintenance services. We also offer regular workshops and repair services to our business partners and distributors globally.

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BETTER PARTICLE SIZE SOLUTIONS

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