Bettersize

BETTER PARTICLE SIZE SOLUTIONS

BeNano Series

Be the Nanoparticle Expert You Need

PARTICLE SIZE

ZETA POTENTIAL

MOLECULAR WEIGHT



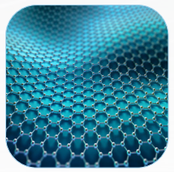
Be the Nanoparticle Expert You Need

The BeNano Series is the latest generation of nanoparticle size and zeta potential analyzers designed by Bettersize Instruments Ltd. Dynamic light scattering (DLS), electrophoretic light scattering (ELS) and static light scattering (SLS) are integrated into the system to provide accurate measurements on particle size, zeta potential and molecular weight.

The BeNano Series 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.



Applications

SECTORS	SAMPLES	SIGNIFICANCE
Nanomaterials 	Silver nanoparticles (AgNPs), quantum dots, titanium dioxide, zinc oxide, synthetic silica, etc.	Nanomaterials have wide applications in emerging technologies such as nanoelectronics, nanophotonics, energy conversion, etc. Many of the physicochemical properties associated to nanomaterials are strongly dependent upon the size and particle-particle interaction. Using the BeNano, researchers could easily carry out the measurements of size and zeta potential.
Proteins & Polypeptides 	Lysozyme, Human serum albumin, Immunoglobulin G (IgG), etc.	For a protein formulation, the subtle changes in size and stability should be detected to ensure the efficacy and safety. Proteins in poor formulations are likely to form aggregates, which will reduce the efficacy of protein drugs and, even worse, cause immunological reactions and toxicity. The BeNano provides rapid access to the characterization of proteins in terms of size and stability information.
Pharmaceuticals 	Fat emulsions, liposomes, vaccines, hydrogels, etc.	In the field of pharmaceuticals, by characterizing size and zeta potential, the BeNano can evaluate the systematic stability and alleviate risks from formulations to accelerate the R&D process. The size and size distribution of drugs and drug delivery system are closely related to the manufacturing process, and impact bioavailability, efficacy, and immune response produced by the final product significantly.
Foods and Beverages 	Soft drinks, dairy products, confectioneries, plant-based products, etc.	Studies on food and beverages can be performed using the BeNano for characterizing size and zeta potential, in order to optimize the stability of dispersion and emulsification, which improves the appearance, taste and mouthfeel, and also prolongs the shelf life of products.

SECTORS	SAMPLES	SIGNIFICANCE
Abrasives 	Nano alumina, nano silicon carbide, nano diamond, cubic boron nitride (CBN), etc.	Nano abrasives is extensively used for high-precision polishing and surface finish of materials such as optical lenses, crystal, gemstones, semiconductors, etc. The stability of polishing slurry is significant for preventing the formation of aggregates that may lead to scratches on workpieces. The BeNano is capable of characterizing the size and zeta potential of slurries even with high concentration.
Paints, Inks & Coatings 	Oil-based and water-based paints, organic pigments, ceramic inks, etc.	Size and size distribution of paint, inks and coatings are the crucial indicators for a long shelf life that ensure their prominent performances. Poor product quality may lead to aggregation, color inconsistencies, and blockages in the channels or nozzles. The utilization of the BeNano benefits the formulation development and improve the performance of the product.
Household Chemicals 	Cosmetics, shampoos, detergents, etc.	The nanomaterials dispersed in sun creams block ultraviolet radiation from the sun. The smaller the particle size, the bigger the surface area and the smoother the cream feels. The surfactants in the detergents may remove oil contamination by forming microemulsion. The decontamination effect depends on the type of surfactants and the size of emulsion droplets. The characterization of nanomaterials is related to all aspects of life.
Academia 	Fundamental and frontier researches related to size, zeta potential, molecular weight, etc.	Measurements of size, zeta potential and molecular weight derived from the BeNano provide a strong tool for academic researches, ranging from verifying theory extrapolations to exploring novel synthetic substances. The accurate and highly reproducible data ensure the authenticity and reliability of the research results.

Nanoparticle Size and Zeta Potential Analyzer

Features and Benefits

High-Performance Hardware

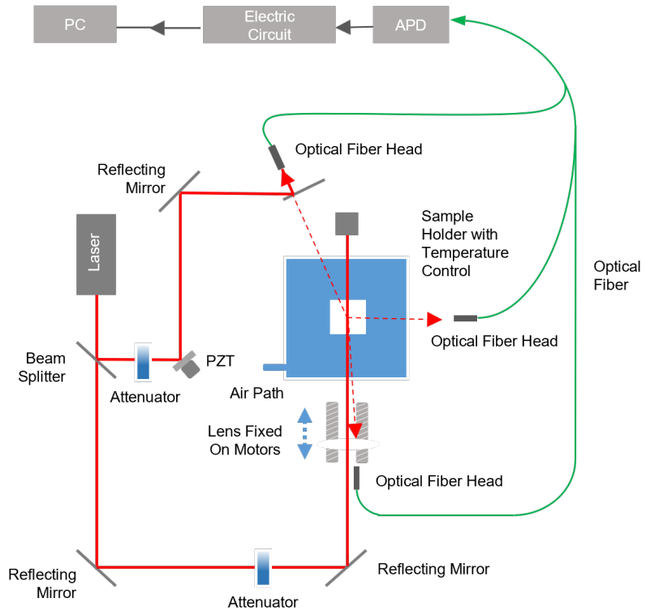
- **Solid-State Laser**
  High-power solid-state laser with high beam quality and long service life
- **APD**
  High sensitivity for low concentration or weak scattering samples
- **Temperature Control System**
  Wide temperature range (-10~110℃) suitable for wide application requirements
- **Intelligent Intensity Adjustment**
  Intelligent adjustment of the intensity according to the scattering capability of the sample
- **Sensitive Optical Fiber Detection System**
  Effectively increase signal-to-noise ratios due to high sensitivity of the optical system
- **Backscattering Detection Optics**
  Applicability for concentrated samples and much higher sensitivity

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 Series

Measurement Parameters

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

Particle Size Measured by DLS

Zeta Potential Measured by ELS

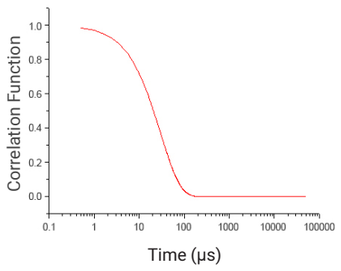
Molecular Weight Measured by SLS

Dynamic Light Scattering (DLS)

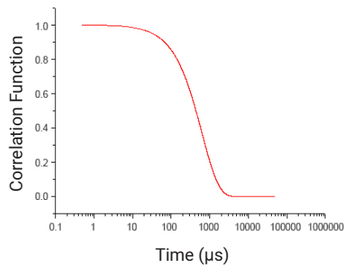
Dynamic light scattering (DLS), also known as photon correlation spectroscopy (PCS) or quasi-elastic light scattering (QELS), is a technology used to detect the fluctuations of the scattering intensities caused by the Brownian motion of particles. In the dispersant, smaller particles move faster, while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

An avalanche photodiode (APD) detector aligned at 90°/173° 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:

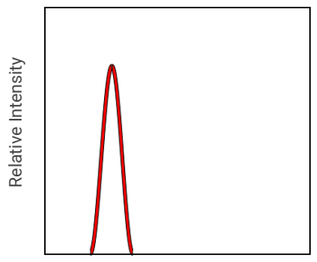
$$D = \frac{k_B T}{3\pi\eta D_H}$$



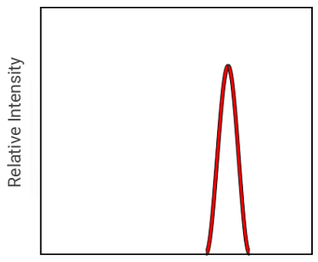
The Correlation Function of Small Particles



The Correlation Function of Large Particles

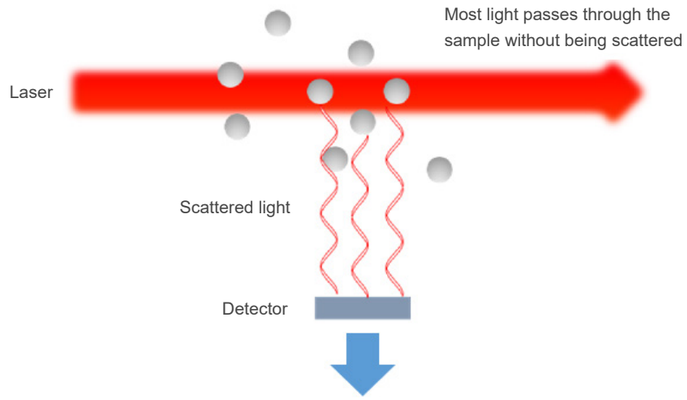


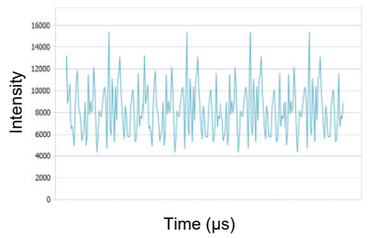
Particle Size Distribution of Small Particles



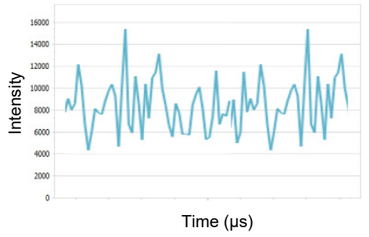
Particle Size Distribution of Large Particles







Intensity Fluctuations of Small Particles



Intensity Fluctuations of Large Particles



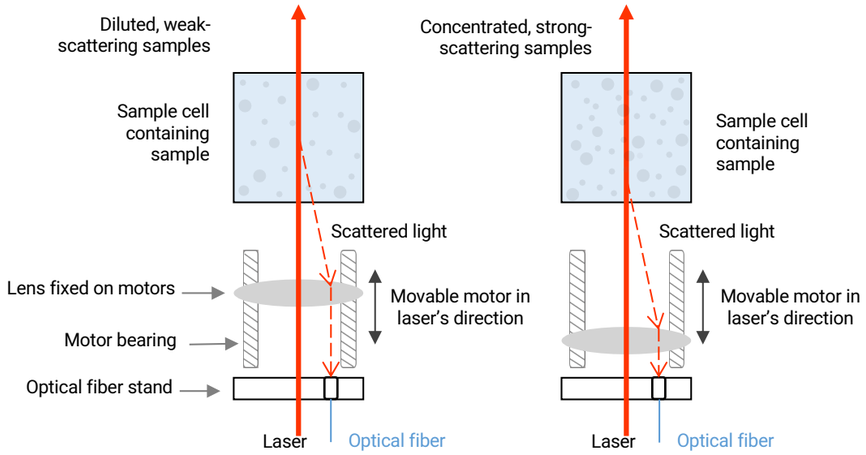
Applications

- 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 polymer

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Backscattering Detection Technology

With Intelligent Search for the Optimal Detection Position



- The detection point is in the middle of the sample cell

As shown in the left graphic, the backscattering volume is so large that the detector receives many scattering signals from the particles and hence increases the sensitivity of the instrument. It has better detection ability for dilute samples, which have smaller sizes and weaker scattering effects. However, the detection is not viable for samples with extremely high concentrations and very strong scattering effects. Even if the sample is barely detected, the result will deviate from the true value.

- The detection point is at the edge of the sample cell

As shown in the right graphic, the detection point is fixed near the wall of the sample cell. The laser beam does not need to penetrate the sample, which can effectively avoid the multiple scattering effect of high concentration samples and ensure the accuracy and repeatability of the particle size results in the high concentration range. However, due to its optical design, the scattering volume is so small that impairs the sensitivity of the instrument, and hence the instrument is not competent to measure small particles, weak-scattering samples or very diluted samples under this condition.

Solution: Intelligent search for the optimal detection position

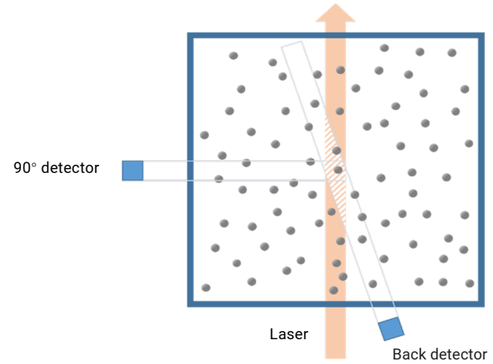
By moving the lens, the detection point can be set at any position from the center to the edge of the sample cell. This allows the detection of different types and concentrations of samples to be considered to the extent possible. In practice, the optimal detection position and laser intensity are determined intelligently for each specific sample according to its sample concentration, size, and scattering ability in order to achieve **the highest measurement accuracy.**

"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."

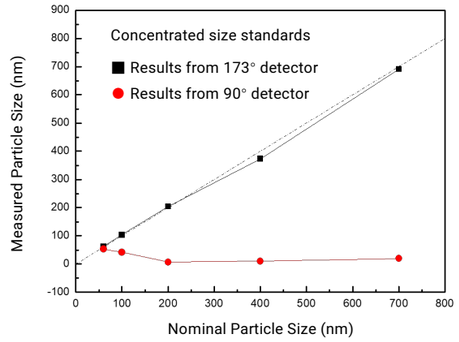
China Agricultural University

Features

- Higher detection sensitivity for samples with very low concentrations down to 0.1 ppm
- Intelligent search for the optimal detection position, which greatly avoids the multiple scattering effect of samples and can detect samples with concentrations of up to 40%
- Effectively limiting the interference of dust



When the sample is detected at 173° at the middle of the cell, the scattered volume is 8-10 times larger than at 90°, leading to much higher sensitivity, and avoiding reflections from the sample cell wall.

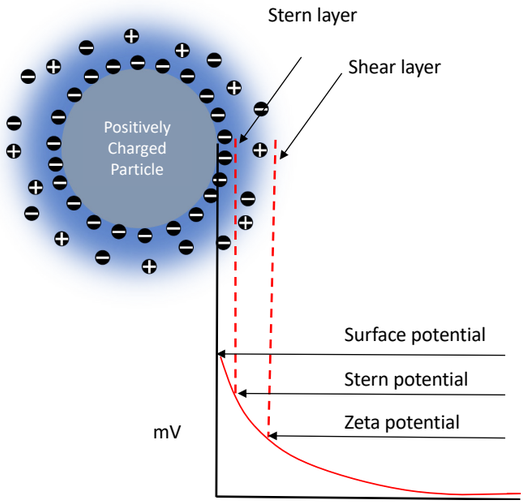


When measuring concentrated size standards, the results obtained from the 173° detector are in much better agreement with the nominal values, compared with the results from the 90° detector.

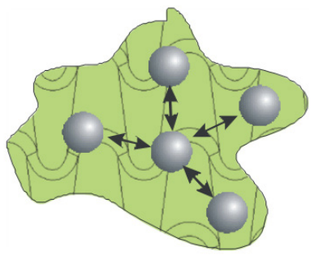


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Electrophoretic Light Scattering (ELS)



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

- Suspension systems such as macromolecules, colloids, emulsions, coal-water slurries, proteins, antigens, antibodies and nanometal/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

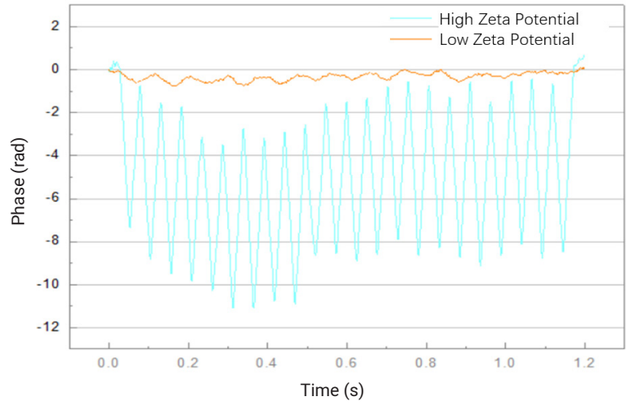
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Phase Analysis Light Scattering (PALS)

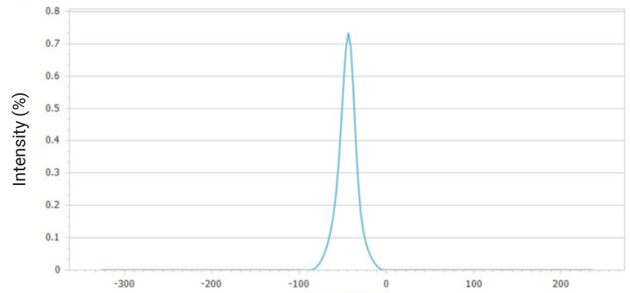
The traditional ELS converts the correlated scattering signals into frequency distribution and then calculates the frequency shift Δf of the scattered light, compared with the reference light. Phase analysis light scattering (PALS), an advanced technology based on the traditional ELS technology, has 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 with time dΦ/dt 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.



Phase Plot of PALS



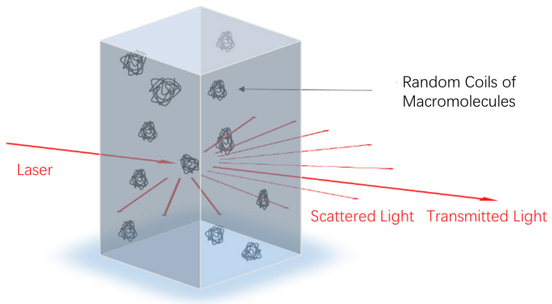
Zeta Potential Distribution

"The results of the BeNano are in line with our R&D goals of liposomes. The particle size perfectly matches the requirements of small unilamellar liposome vesicles SUVs (that have a size range between 20 and 100 nm). The polydispersity index PDI correctly depicts the change in size distribution of our samples. In addition, the temperature control and programmed temperature change are precise and fully meet the requirements of the experiment. "

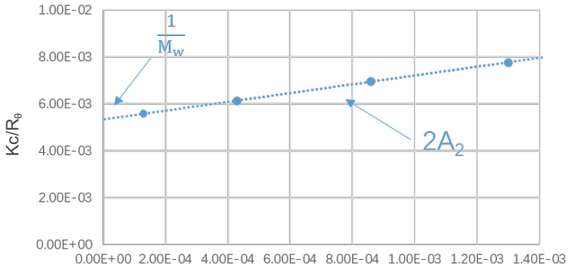
Institute of Chemistry, Chinese Academy of Sciences

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Static Light Scattering (SLS)



Scattered Light of Macromolecules



Debye Plot

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 $(dn/dc)^2$.

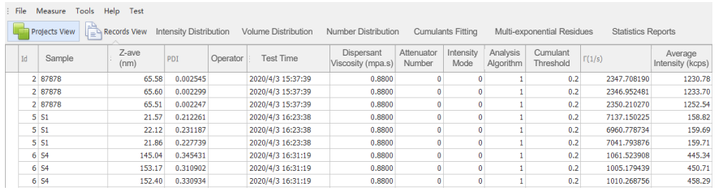
Applications

- 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

"BeNano 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.

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 a user-friendly interface, results previews, and various types of report pages.

Features

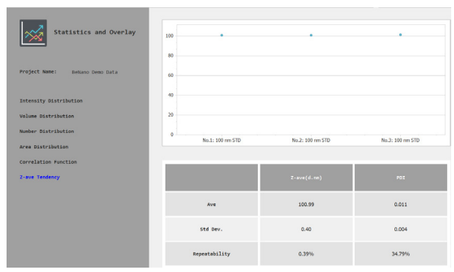
- Standard Operating Procedure (SOP) ensures the completeness and accuracy of parameters during measurements
- Measurement interface shows real-time information and results of various types
- Results and Statistics – automatic calculations of mean and standard deviation
- Statistics and Overlay – comparing 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

Powerful Statistics and Analyzing Tools

- Display the real-time results on the measurement page
- Available mean, standard deviation, and relative standard deviation information
- Able to reanalyze historical data
- More detailed information displayed on the "Statistics and Overlay" page
- Capable of batch-processing multiple results

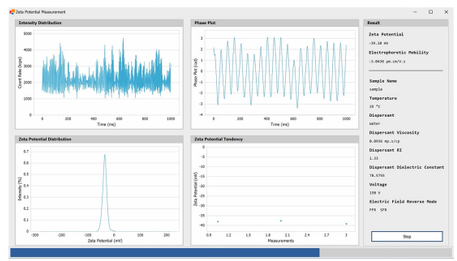
Dynamic Light Scattering

- 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



Electrophoretic Light Scattering

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

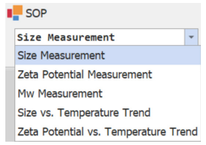


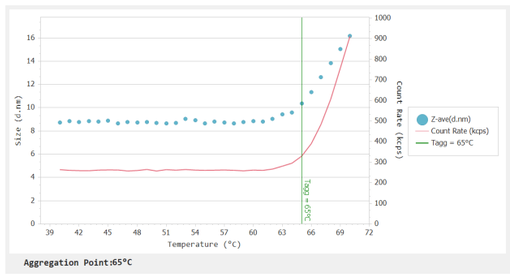
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Temperature Trend Measurement

Temperature trend measurement includes:

- Size vs. Temperature
- Zeta Potential vs. Temperature





Size vs. Temperature trend measurement of the BSA protein

Investigating the particle size and zeta potential of the samples under different temperatures is significant in many applications.

The function of Programmed Temperature Change, ranging from -10°C to 110°C, makes Temperature Trend Measurement available in the BeNano Series.

Benefits

- This feature benefits users who need to study the stability of protein formulations. Generally, the higher the denaturation temperature of the protein, the more stable the formulation.

- Besides, it is useful for users who need to simulate real-time aging using elevated temperatures to manually speed up the aging process.

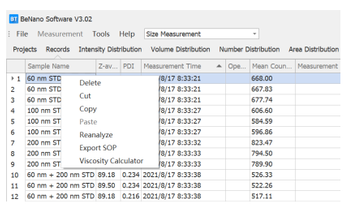
Particle sizes and count rates of PNIPAm hydrogel as a function of temperature

Zeta potentials of PNIPAm hydrogel as a function of temperature

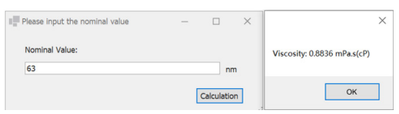
Viscosity Measurement

For the sample of unknown viscosity, the viscosity measurement could be implemented using tracer particles with known sizes (e.g., standard samples with nominal sizes). When the measurement ends, input the accurate size of the tracer particles, and the viscosity of the sample could be determined.

After the measurement, choose and right-click on the corresponding result. Click “Viscosity Calculator” on the pop-up menu.



Through inputting the nominal values of the tracer particles and clicking on “Calculation”, the viscosity of the sample could be finally ascertained.

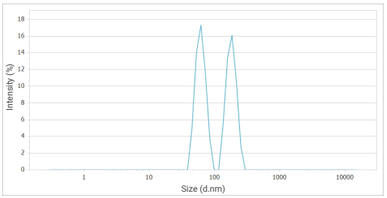


Particle Size Measured by **DLS**

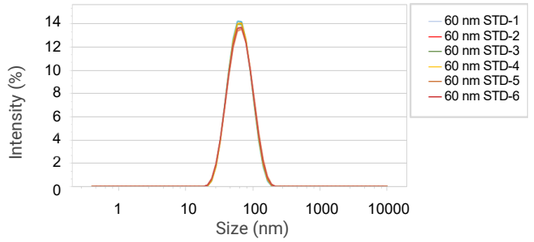
Applications

Resolution

The resolution of the DLS technology depends on the algorithm. Usually, for two narrowly sized-distributed components with a size difference of over 3:1, the algorithm discerns two individual peaks by adjusting the resolution to a higher level. The BeNano Series 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.



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

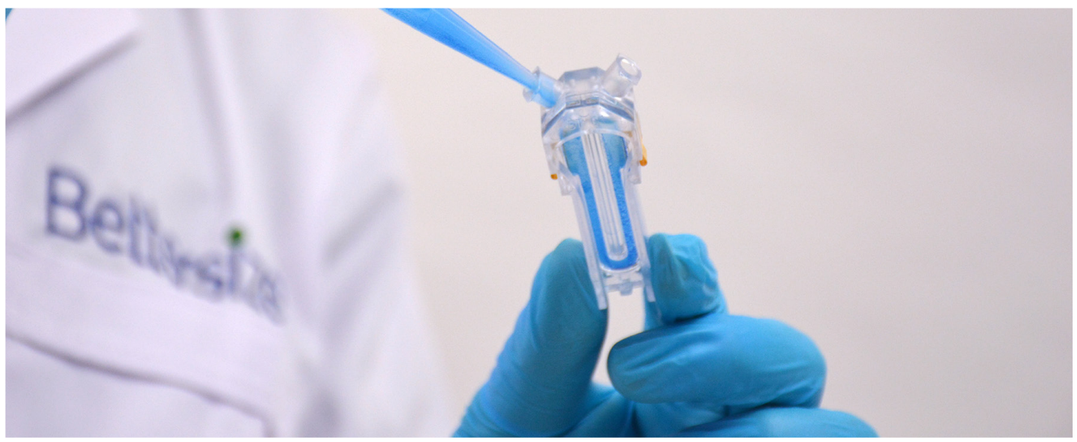


Particle size distribution of a 60 nm polystyrene latex

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

Repeatability

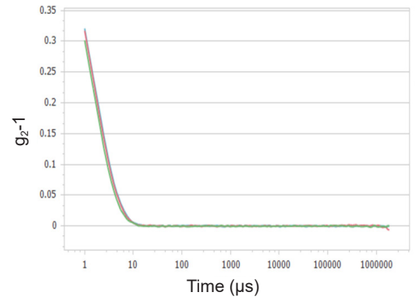
The optical system of the BeNano Series is robust and stable. It has an automatic intensity adjustment and intelligent signal judgment system to ensure high stability and repeatability of the measurements. The figure on the upper right shows the measurement repeatability of the 60 nm polystyrene latex.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

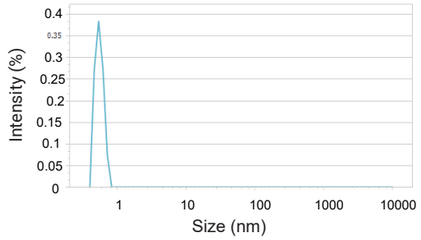


For Small Particles

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

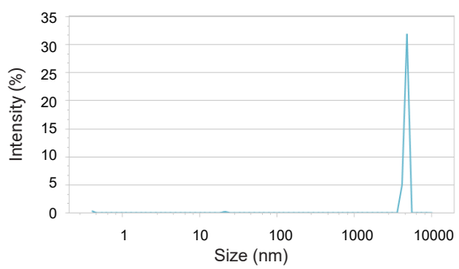
Even for molecules smaller than 1 nm such as vitamin B1 (as shown below), under very diluted conditions of 5% wt, the BeNano Series can effectively detect its scattering intensity and fast decay signals to obtain the particle size and size distribution.

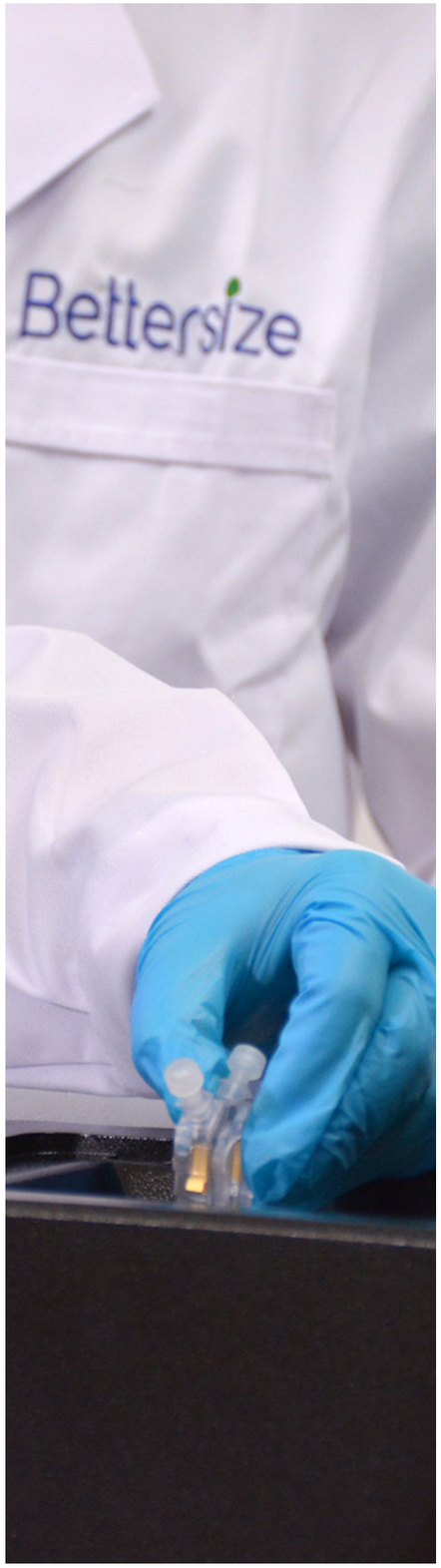




For Large Particles

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 Series 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.

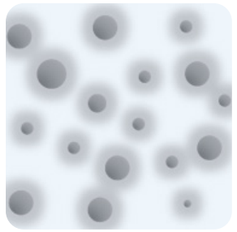




Zeta Potential Measured by **ELS**

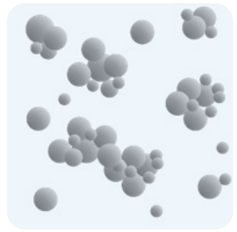
Applications

Particle Stability



High Zeta Potential

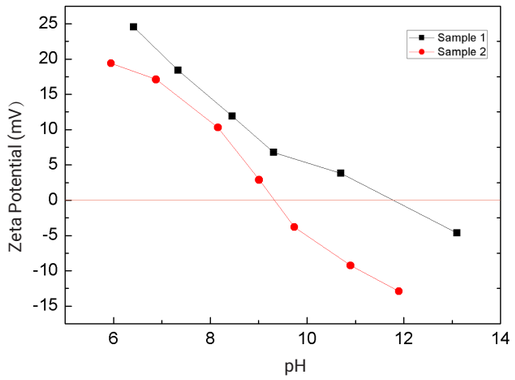
- High repulsion force of particles
- Stable particle system

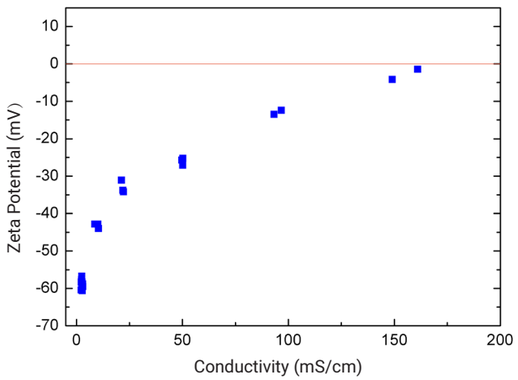


Low or Zero Zeta Potential

- 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 smaller electrophoretic mobility of the particle in the electric field.

Molecular Weight Measured by **SLS**

Applications

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.

Protein Suspensions and Formulations



Formulation 1



Formulation 2

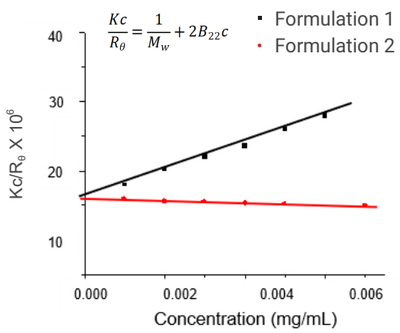
Light scattering technology can provide information of intermolecular forces and stability of a given colloidal particles suspension system. Specifically, the second virial coefficient A_2 (B_{22}) and interaction parameter k_D can be determined by a concentration-dependent SLS measurement and DLS measurement,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

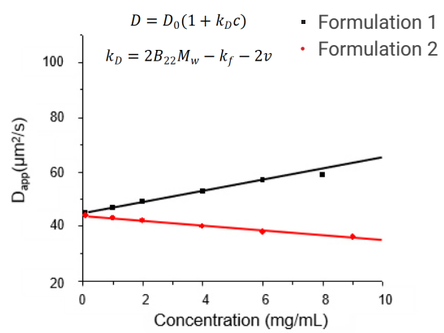
Using quantifiable parameters such as A_2, zeta potential, and k_D, users can access accurate and comparable information regarding the intermolecular forces of the particles.

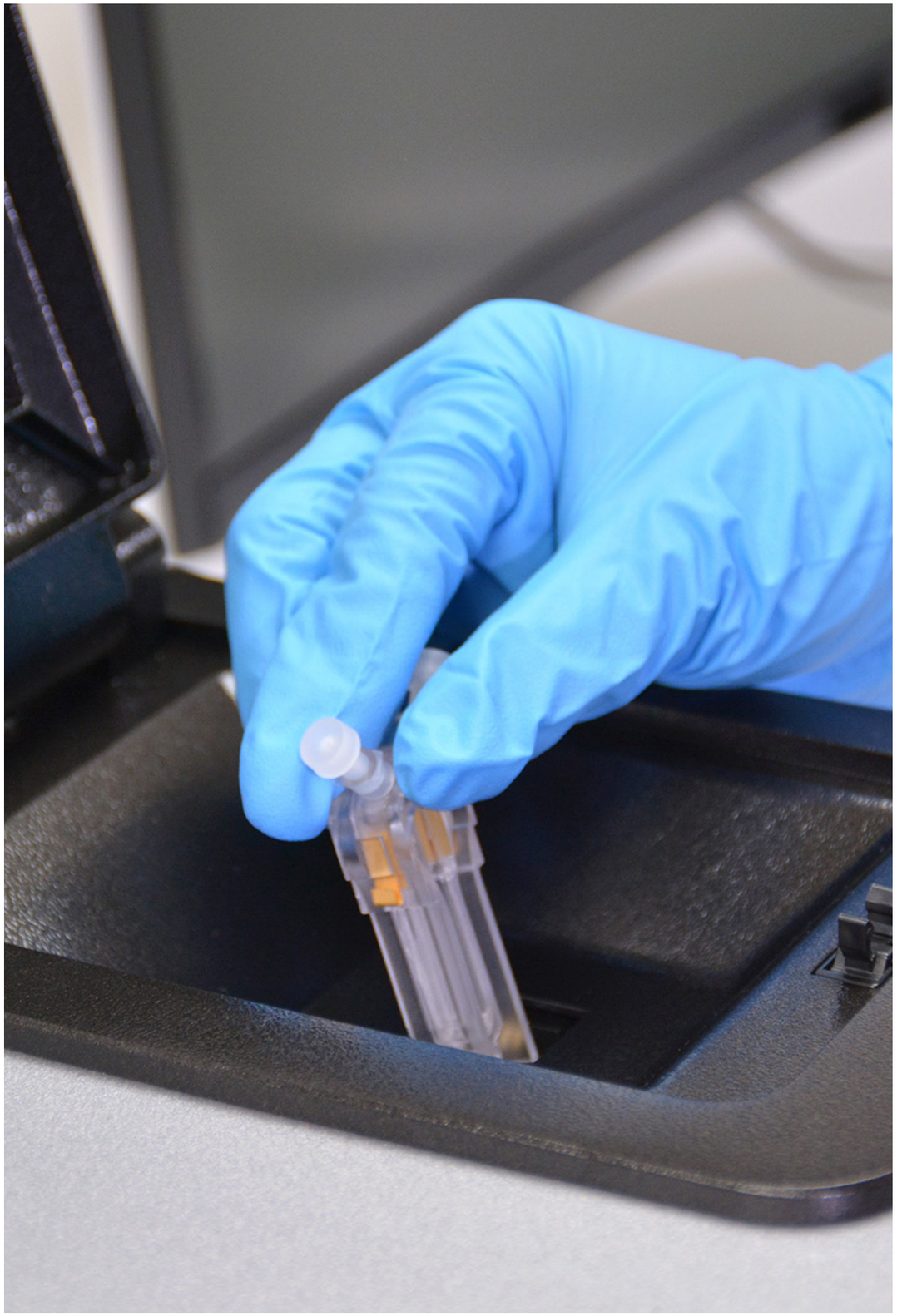
The stability of a protein suspension depends on the functional groups of the protein and the solution environment. By changing the components of the solution environment, a relatively stable protein formulation with fewer protein aggregates and good thermal stability could be obtained. Examining the 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 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 the higher stability of a protein formulation.







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Accessories

Zeta Potential Measurement						
Photo	Type	Description	Material	Sample Volume	Temperature Range	Details
	Folded Capillary Cell	For aqueous samples	PC	0.75 mL	-10 - 70 °C	- 5 cm electrode distance to avoid heating the sample, and provide a more uniform electric field - Avoid cross-contamination - Suitable for high-polarity 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
	Dip Cell	For aqueous and organic samples	PEEK, Platinum	1-1.5 mL	-10 - 70 °C	
Particle Size Measurement						
	Capillary Sizing Cell	For aqueous and organic samples with ultra-micro volume required	Glass	3-5 µL	-10 - 70 °C	- Ease of use: simply dip the cell into the sample and test - Low cost and disposable compared to the 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 effect
	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	40-50 µL	-10 - 70 °C	
	Micro-volume Glass Cuvette	For aqueous samples with micro volume required	Glass	25 µL	-10 - 110 °C	



Function	Parameter	BeNano 180 Zeta Pro	BeNano 180 Zeta	BeNano 90 Zeta	BeNano Zeta	BeNano 180 Pro	BeNano 180	BeNano 90
Size measurement	Size measurement range	0.3 nm - 15 µm*	0.3 nm - 10 µm*	0.3 nm - 15 µm*	N/A	0.3 nm - 15 µm*	0.3 nm -10 µm*	0.3 nm - 15 µm*
	Sample volume	3 µL - 1 mL*	40 µL - 1 mL*	3 µL - 1 mL*	N/A	3 µL - 1 mL*	40 µL - 1 mL*	3 µL - 1 mL*
	Detection angle	90° & 173° & 12°	173° & 12°	90° & 12°	N/A	90° & 173°	173°	90°
	Analysis algorithm	Cumulants, Universal Mode, CONTIN	Cumulants, Universal Mode, CONTIN	Cumulants, Universal Mode, CONTIN	N/A	Cumulants, Universal Mode, CONTIN	Cumulants, Universal Mode, CONTIN	Cumulants, Universal Mode, CONTIN
	Upper limit of concentration range	40% w/v*	40% w/v*	Optical clear†	N/A	40% w/v*	40% w/v*	Optical clear†
	Detection position	Movable position 0 - 5 mm	Movable position 0 - 5 mm	Fixed position 5 mm	N/A	Movable position 0 - 5 mm	Movable position 0 - 5 mm	Fixed position 5 mm
Zeta potential measurement	Detection angle	12°	12°	12°	12°	N/A	N/A	N/A
	Zeta potential measurement range	No actual limitation	No actual limitation	No actual limitation	No actual limitation	N/A	N/A	N/A
	Electrophoretic mobility	> ± 20 µm·cm/V·s	> ± 20 µm·cm/V·s	> ± 20 µm·cm/V·s	> ± 20 µm·cm/V·s	N/A	N/A	N/A
	Conductivity	0 - 260 mS/cm	0 - 260 mS/cm	0 - 260 mS/cm	0 - 260 mS/cm	N/A	N/A	N/A
	Sample volume	0.75 - 1 mL	0.75 - 1 mL	0.75 - 1 mL	0.75 - 1 mL	N/A	N/A	N/A
	Sample size	2 nm - 110 µm	2 nm - 110 µm	2 nm - 110 µm	2 nm - 110 µm	N/A	N/A	N/A
Other measurements	Molecular weight (Mw)	342 Da - 2 x 10^7 Da*	342 Da - 2 x 10^7 Da*	342 Da - 2 x 10^7 Da*	N/A	342 Da - 2 x 10^7 Da*	342 Da - 2 x 10^7 Da*	342 Da - 2 x 10^7 Da*
	Viscosity	0.01 cp - 100 cp*	0.01 cp - 100 cp*	0.01 cp - 100 cp*	N/A	0.01 cp - 100 cp*	0.01 cp - 100 cp*	0.01 cp - 100 cp*
	Interaction parameter K_D	No actual limitation	No actual limitation	No actual limitation	N/A	No actual limitation	No actual limitation	No actual limitation
	Trend measurement	Time and temperature	Time and temperature	Time and temperature	Time and temperature	Time and temperature	Time and temperature	Time and temperature
System parameters	Temperature control range	-10℃ - 110℃, ±0.1℃	-10℃ - 110℃, ±0.1℃	-10℃ - 110℃, ±0.1℃	-10℃ - 110℃, ±0.1℃	-10℃ - 110℃, ±0.1℃	-10℃ - 110℃, ±0.1℃	-10℃ - 110℃, ±0.1℃
	Condensation control	Dry air or nitrogen	Dry air or nitrogen	Dry air or nitrogen	Dry air or nitrogen	Dry air or nitrogen	Dry air or nitrogen	Dry air or nitrogen
	Laser source	50 mW Solid-state laser, 671 nm	50 mW Solid-state laser, 671 nm	50 mW Solid-state laser, 671 nm	50 mW Solid-state laser, 671 nm	50 mW Solid-state laser, 671 nm	50 mW Solid-state laser, 671 nm	50 mW Solid-state laser, 671nm
	Correlator	Up to 4000 channels, 10^{11} linear dynamic range	Up to 4000 channels, 10^{11} linear dynamic range	Up to 4000 channels, 10^{11} linear dynamic range	Up to 4000 channels, 10^{11} linear dynamic range	Up to 4000 channels, 10^{11} linear dynamic range	Up to 4000 channels, 10^{11} linear dynamic range	Up to 4000 channels, 10^{11} linear dynamic range
	Detector	Avalanche photodiode (APD)	Avalanche photodiode (APD)	Avalanche photodiode (APD)	Avalanche photodiode (APD)	Avalanche photodiode (APD)	Avalanche photodiode (APD)	Avalanche photodiode (APD)
	Intensity control	0.0001% - 100%, manual or automatic	0.0001% - 100%, manual or automatic	0.0001% - 100%, manual or automatic	0.0001% - 100%, manual or automatic	0.0001% - 100%, manual or automatic	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)	62.5 x 40 x 24.5 cm (22 kg)	62.5 x 40 x 24.5 cm (22 kg)	62.5 x 40 x 24.5 cm (22 kg)	62.5 x 40 x 24.5 cm (22 kg)	62.5 x 40 x 24.5 cm (22 kg)
	Power supply	AC 100-240 V, 50-60 Hz, 4A	AC 100-240 V, 50-60 Hz, 4A	AC 100-240 V, 50-60 Hz, 4A	AC 100-240 V, 50-60 Hz, 4A	AC 100-240 V, 50-60 Hz, 4A	AC 100-240 V, 50-60 Hz, 4A	AC 100-240 V, 50-60 Hz, 4A
	Conformity to standards	ISO 13321, ISO 22412-2017, ISO 13099-1, ISO 13099-2	ISO 13321, ISO 22412-2017, ISO 13099-1, ISO 13099-2	ISO 13321, ISO 22412-2017, ISO 13099-1, ISO 13099-2	ISO 13321, ISO 22412-2017, ISO 13099-1, ISO 13099-2	ISO 13321, ISO 22412-2017, ISO 13099-1, ISO 13099-2	ISO 13321, ISO 22412-2017, ISO 13099-1, ISO 13099-2	ISO 13321, ISO 22412-2017, ISO 13099-1, ISO 13099-2
Accessories	Disposable micro-volume cuvette	40 - 50 µL	40 - 50 µL	40 - 50 µL	N/A	40 - 50 µL	40 - 50 µL	40 - 50 µL
	Micro-volume glass cuvette	25 µL	N/A	25 µL	N/A	25 µL	N/A	25 µL
	Glass cuvette with round opening	1 mL	1 mL	1 mL	N/A	1 mL	1 mL	1 mL
	Capillary sizing cell	3 - 5 µL	N/A	3 - 5 µL	N/A	3 - 5 µL	N/A	3 - 5 µL
	Dip cell kit	1 - 1.5 mL, zeta potential measurement for organic-based samples	1 - 1.5 mL, zeta potential measurement for organic-based samples	1 - 1.5 mL, zeta potential measurement for organic-based samples	1 - 1.5 mL, zeta potential measurement for organic-based samples	N/A	N/A	N/A

* Dependent on samples and accessories
† Up to 40% w/v using capillary sizing cell

European Representative:

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