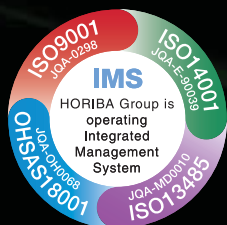# HORIBA
Scientific

Nanoparticle Analyzer
nano partica SZ-100series

Industry's Widest Range and Highest Precision
Measurement Instrument for
Nano-particle Characterization "nano partica SZ-100"

IMS
HORIBA Group is operating Integrated Management System

ISO9001 JQA-0298
ISO14001 JQA-E-90039
OHSAS18001 JQA-OH0068
ISO13485 JQA-MD0010

CE
CE marking comliant

A highly advanced analyzer solves the mysteries of the nano-world. A single device analyzes the three parameters that characterize nanoparticles: particle size, zeta potential, and molecular weight.

Newly developed to satisfy the need for devices to simply and accurately evaluate the size and dispersion stability of nanoparticles, the key to nanotechnology advancement:

nano partica *SZ-100* *Series Nanoparticle Analyzer*

Nanotechnology research and development is a continuously evolving effort to control substances at the atomic and molecular level in order to achieve new and better materials and products.
The miniaturization of components – that is, control at the nanolevel – is necessary to achieve faster, higher-performance devices and functions and to reduce energy consumption. Nanotechnology has come to play a key role in wide-ranging fields that affect our daily lives, including food, cosmetics, and the life sciences.

Clear and simple multi-parameter analysis of nanoparticles!
Three analyzers in a single compact body deliver high-sensitivity, high-accuracy analysis of each measurement parameter.

Particle Size Measurement Range *0.3 nm to 8 µm*

The SZ-100 Series measures particle size and particle distribution width by dynamic light scattering (DLS).
Analysis across a wide range of sample concentrations: Measurement of samples ranging from low ppm-order concentrations to high-concentration samples in double-digit percentages is possible. Accepts commercially available sampling cells. Analysis of small-volume samples is also possible.

Zeta Potential Measurement *−200 to +200 mV*

Analysis of sample volumes as small as 100 µL using HORIBA-developed microelectrophoresis cells. Use the value of zeta potential to predict and control dispersion stability. High zeta potential magnitudes indicate a stable dispersion, useful for formulation work.

Molecular weight *1×10^3 to 2×10^7 Da*

Absolute molecular weight (Mw) and the second virial coefficient (A$_2$) are obtained by performing static light scattering measurement as a function of sample concentration and preparing Debye plots.

The SZ-100 Series applies sophisticated intelligence and learning capability to rapidly determine nanoparticle properties!

● Since the SZ-100 Series analyzer covers a wide sample concentration measurement range, sample dilution and other preprocessing is nearly eliminated.
   The use of a dual optical system enables measurement of high-concentration samples such as slurry and ink pigments as well as low-concentration proteins and polymers.
● A single device analyzes the three parameters that characterize nanoparticles: particle size, zeta potential, and molecular weight.
● HORIBA-developed disposable cells for zeta potential measurement prevent sample contamination.
   Simple analysis by means of ultra micro-volume dedicated cells (volume as low as 100 µL). Suitable for analysis of dilute samples.
● HORIBA-developed electrode for zeta potential cell made from carbon material, the material is not corroded by high salt samples such as saline.

Simple and Convenient Operation

Simply fill the sample cell and place the cell in the analyzer.

A space-saving body design makes the analyzer suitable for installation in any laboratory environment.

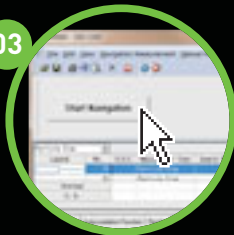Operation Procedure

01

[Sampling]

Fill the sample cell.

02

[Cell Set-Up]

Place the cell in the analyzer.

03

[Start Measurement]

Click the Start button.

04

[Results Display]

The measurement results are displayed.

Maintenance-Free

No maintenance or cleaning of the analyzer is required. After measurement, simply clean or dispose of the cell.
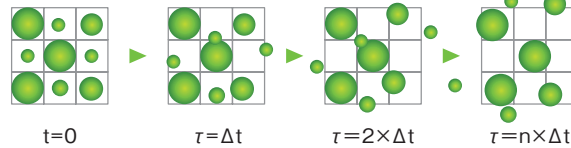
Particle Size Measurement Principle

The SZ-100 uses the technique of dynamic light scattering to determine particle size. Dynamic light scattering is the measurement of fluctuations in scattered light intensity with time. These fluctuations in intensity arise due to the random Brownian motion of the nanoparticles. Therefore, the statistical behavior of these fluctuations in scattered intensity can be related to the diffusion of the particles. Since larger particles diffuse more slowly than small particles one can readily relate particle size to measured fluctuations in light scattering intensity. With modern instruments such as the SZ-100 the technique is rapid and reliable.

Incident light · Particles in Brownian motion · Scattered light · PMT · Amplifier · Digital correlator
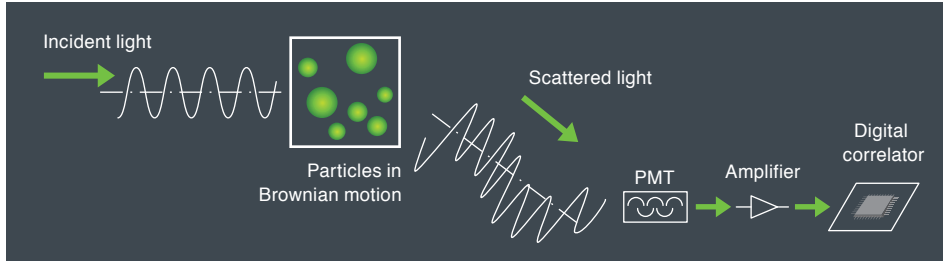
● Graphic Rendering of Diffusing Nanoparticles

$t=0$ · $\tau=\Delta t$ · $\tau=2\times\Delta t$ · $\tau=n\times\Delta t$

● The Relationship Between the Autocorrelation Function and Particle Size

Autocorrelation Function · $G_2(\tau)$ · Large size · Small size + Large size · Small size · Delay time(τ)
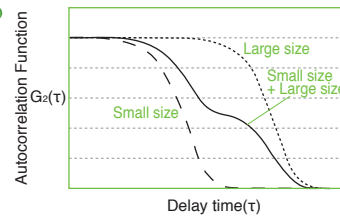
Measurement of the autocorrelation function is done by comparing the scattered light intensity at some reference time t and after some delay time τ. For a very short delay time, the particles have not had a chance to move and therefore the scattered light intensity is unlikely to change much. So, the autocorrelation function has a high value. For a very long delay time, the particles have had a chance to move significantly, and the autocorrelation function has a low value. This low value is related to the time average scattered intensity. The rapidity of this decay from high values to low values corresponds to the speed of particle motion and therefore to the particle size.
The measured autocorrelation function typically has an exponential decay and the diffusion coefficient can be calculated with the following (simplified) relationship

$$G^{(2)}(\tau) = B + Bf \, exp\,(-2D_m q^2 \tau)$$

$G^{(2)}(\tau)$:Measured amplitude autocorrelation function B :So-called baseline f :Instrument constant D_m :Particle diffusion coefficient
q :Scattering vector given by $(4\pi n/\lambda)\sin(\theta/2)$ τ : Delay time

Particle size is calculated from the diffusion coefficient using the Stokes-Einstein equation:

$$D_h = kT/(3\pi\eta D_m)$$

D_h :Particle hydrodynamic size k :Boltzman constant T :Thermodynamic temperature and η :Viscosity
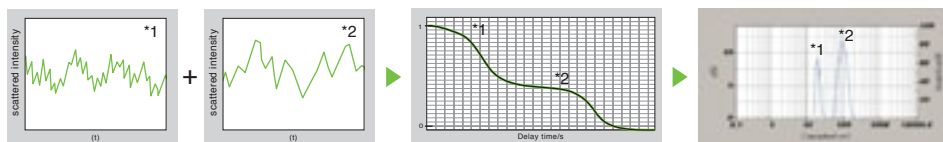
*1 Small particle light fluctuation signal *2 Large particle light fluctuation signal → Autocorrelation function → Particle size distribution

◎ Features of HORIBA's Optical System

❶ High Sensitivity Optical Components

The key to accurately and rapidly evaluating size with dynamic light scattering is to use a high-energy laser light source and a sensitive detector. HORIBA uses a green laser. Scattering intensity is inversely proportional to the fourth power of wavelength. Therefore, the green laser gives more scattering intensity per milliwatt than the more commonly used red laser. Since avalanche photodiodes, APD's, are less sensitive to green light and photomultiplier tubes PMT's, are more sensitive to green light, HORIBA has included the most sensitive PMT detector available. In addition, the dead time of a PMT is shorter than that of an APD and therefore the PMT detector dynamic range is superior.
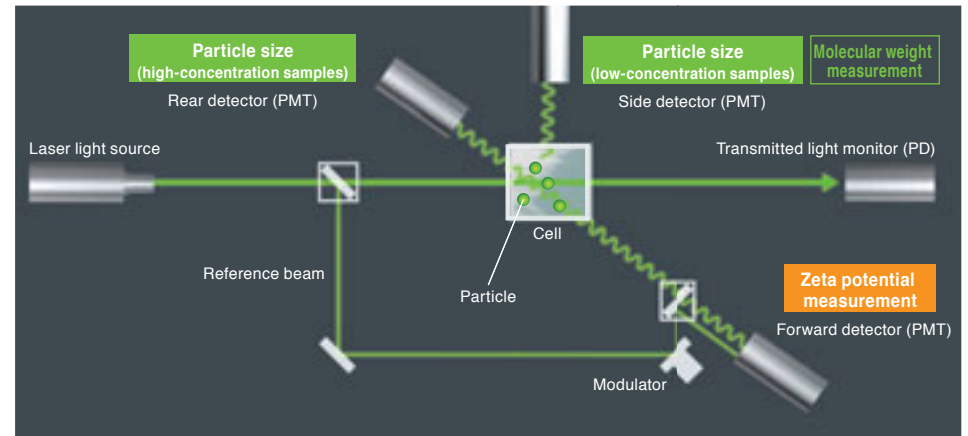
❷ Conformance with Standards

The SZ-100 series conforms to ISO 13321:1996 and JIS Z8826:2005.

❸ Automatic Measurement Optimization

The analyzer features the ability to measure particle size under a number of conditions. In order to eliminate guesswork, measurement conditions can be automatically selected for each sample by using data obtained from that sample.

● **The three angle system of the SZ-100 enables analysis of a wide range of high concentration and dilute samples**

Particle size (high-concentration samples) · Particle size (low-concentration samples) · Molecular weight measurement · Rear detector (PMT) · Side detector (PMT) · Laser light source · Transmitted light monitor (PD) · Cell · Reference beam · Particle · Zeta potential measurement · Forward detector (PMT) · Modulator

● **The optical configurations shown can be automatically selected depending on the concentration of the analyzed sample.**

High Concentration Samples

In order to minimize the effect of multiple scattering the analyzer detects back-scattered light from a scattering volume close to the cell wall.

Side detector · Rear detector · Scattered light · Laser light source · Lens · Cell
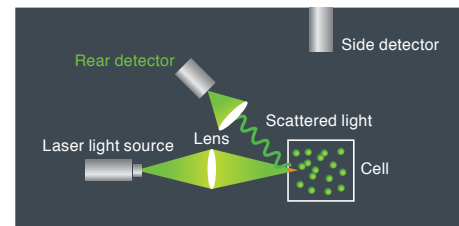
Dilute Samples

In order to minimize the effect of stray light and maximize signal to noise ratio the analyzer detects scattered light at a right angle.

Rear detector · Side detector · Scattered light · Laser light source · Lens · Cell
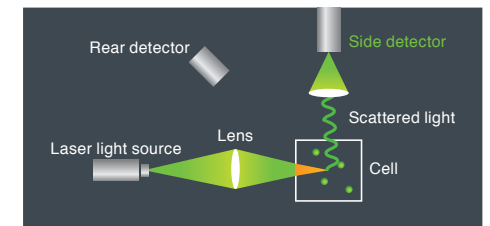
Zeta Potential Measurement Principle
(Laser Doppler Electrophoresis)

Many nanoparticles or colloidal particles have a surface charge when they are in suspension. When an electric field is applied, the particles move due to the interaction between the charged particle and the applied field. The direction and velocity of the motion is a function of particle charge, the suspending medium, and the electric field strength. Particle velocity is then measured by observing the Doppler shift in the scattered light. The particle velocity is proportional to the electrical potential of the particle at the shear plane which is the zeta potential. Thus, this optical measurement of particle motion under an applied field can be used to determine zeta potential.

Particle surface

Shear plane

Zeta potential

mV

Negatively charged particle
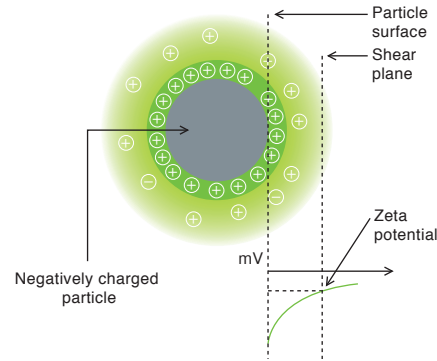
◎ Electrophoresis

Particle motion under an applied electric field is known as electrophoresis. The method used by the SZ-100 is known as laser Doppler electrophoresis. Sample particles are suspended in a solvent of known refractive index, n, viscosity, η, and dielectric constant, ε. The sample is irradiated with laser light of wavelength λ. An electric field with strength E is applied. Due to the electric field, the particles are moving. Since the particles are moving, the scattered light has a frequency (Doppler) shift proportional to the particle charge. The frequency shift of the scattered light at angle θ is measured and the particle velocity V is determined from the frequency shift. Mobility is then readily obtained as the ratio of velocity to electric field strength V/E. Zeta potential is then found from mobility using a model, the most common of which is the Smulo-chowski model.

$$U = \frac{\lambda v_d}{2En\sin(\theta/2)}$$

The following equation is used for the relationship between the calculated electrical mobility and zeta potential.

$$\zeta = \frac{U\eta}{\varepsilon f(\kappa a)}$$

v_o: Laser frequency
$v_o + v_d$: Scattered light frequency

ζ :Zeta potential   U :Electrical mobility   E :Electric field strength   n :Solvent refraction index   ε :Solvent dielectric constant
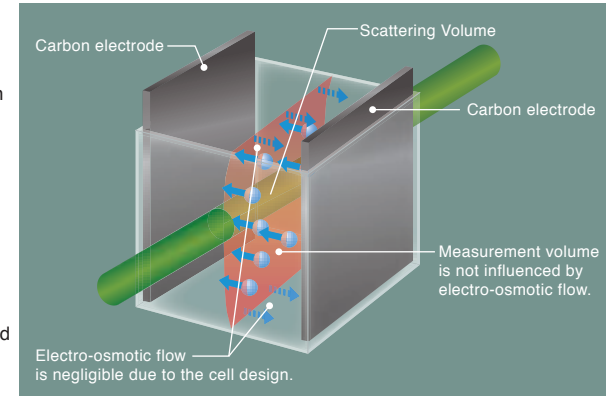η :Solvent viscosity   f(κa) :Henry coefficient
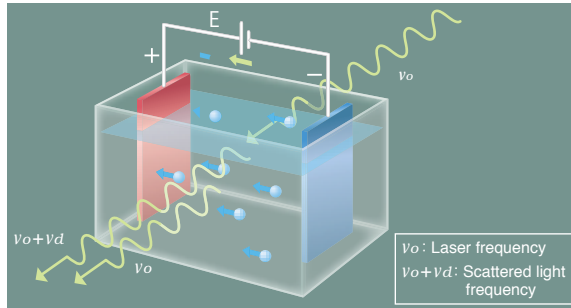
◎ Features

① **Extremely low sample volume makes it possible to measure precious or rare samples.**

② **Modern signal processing electronics efficiently convert optical signals to mobility and zeta potential information. There is no need to manually calculate particle velocity or match speeds.**

③ **Cell design minimizes electro-osmotic flow to enhance sensitivity.**

Particles are not the only objects that acquire a surface charge when in contact with a liquid. Macroscopic objects such as cell or capillary walls do as well. Due to electrostatic attraction, ions with a charge opposite to that of the wall will accumulate close to the wall. And, when an electric field is applied during zeta potential measurement these ions will move in response to the applied field. The moving ions drag the fluid along, creating bulk flow called electro-osmotic flow. This flow will disturb particle motion and distort zeta potential measurements. By eliminating the capillary between the electrodes, the HORIBA zeta potential cell minimizes this effect and maximizes instrument sensitivity.

Carbon electrode

Scattering Volume

Carbon electrode

Measurement volume is not influenced by electro-osmotic flow.

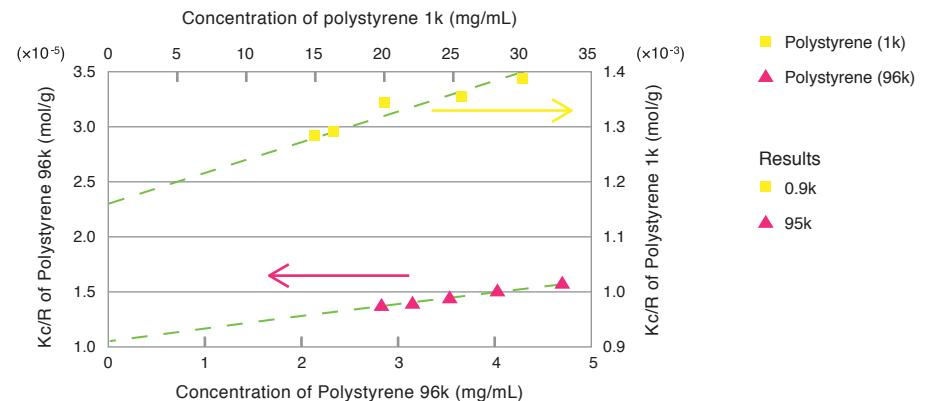Electro-osmotic flow is negligible due to the cell design.

Molecular Weight Measurement Principle

Molecular weight of macromolecules such as polymers, proteins, or starches is determined in two ways with the SZ-100. The first method is the use of the dynamic light scattering size information and the empirical Mark Houwink Sakurada equation. The second method is analysis with a Debye plot. Both of these methods are described below.

The Mark Houwink Sakurada equation relates the diffusion coefficient determined by dynamic light scattering to the molecular weight. All that is required are two empirical constants for the selected polymer-solvent system, an exponent and a prefactor. If the constants are not in the SZ-100 software database, the user can add new constants for rapid analysis. This technique has the advantage that sample concentration need not be well known.

The Debye plot is obtained by first measuring the excess static light scattering intensity of a series of solutions with well known concentration. Here, the excess intensity refers to the increase of the scattered intensity of the solution compared to the pure solvent. Plotting a quantity proportional to the concentration over the excess scattering as a function of concentration yields a straight line. Extrapolating to zero concentration yields the reciprocal of molecular weight. The graph below shows a typical result.

Concentration of polystyrene 1k (mg/mL)

Kc/R of Polystyrene 96k (mol/g)

Kc/R of Polystyrene 1k (mol/g)

Concentration of Polystyrene 96k (mg/mL)

■ Polystyrene (1k)
▲ Polystyrene (96k)

Results
■ 0.9k
▲ 95k

Software

Performance

The operator selects a measurement mode (particle size, zeta potential, or molecular weight), loads the sample when the measurement screen appears, and begins measurement. The SZ-100 Series offers the ultimate in clear, simple operability. 21 CFR Part 11 software is available.

● Quick and Simple Operation

Measurement conditions are readily set manually or with user programmable methods that can be tied to custom buttons. Operators need merely click a button to begin.
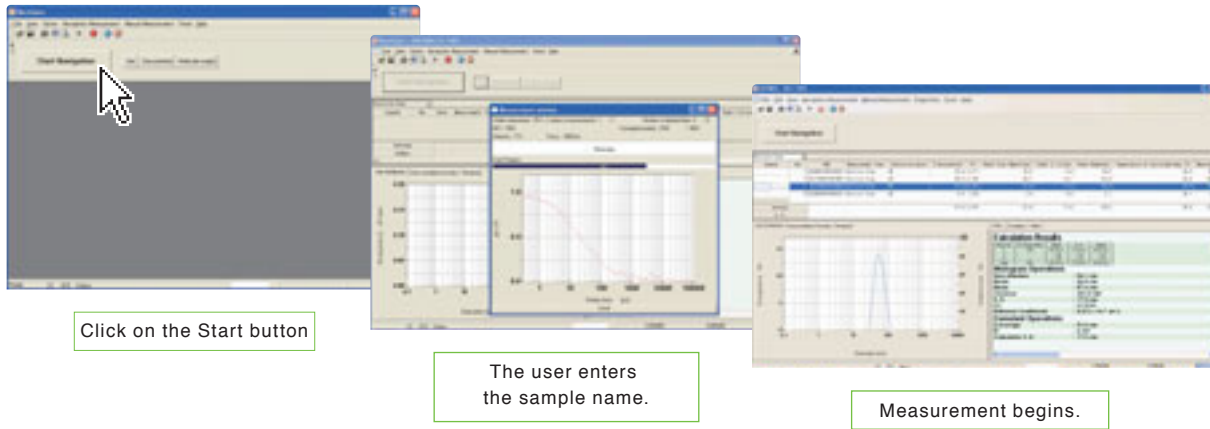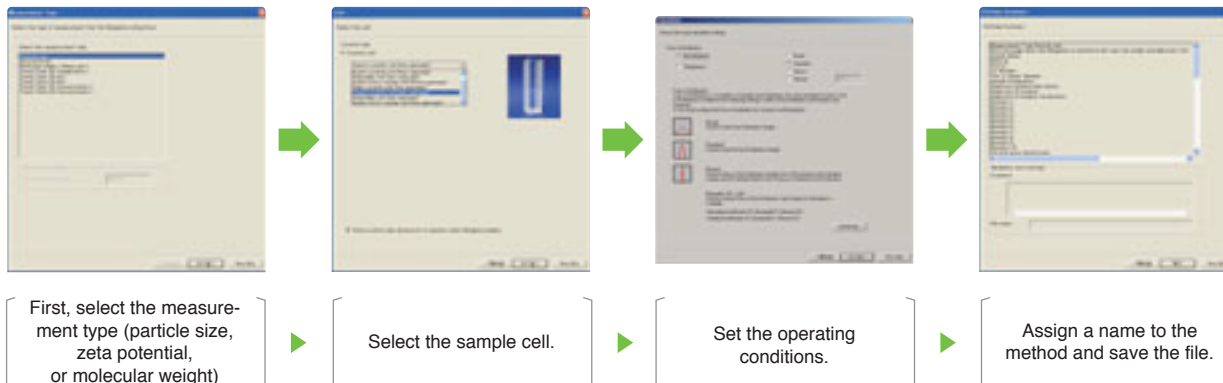
Click on the Start button

The user enters the sample name.

Measurement begins.

● Navigation Creation Is Simple.

Use the software wizard to select analysis conditions. If desired, assign a button for fast analysis in the future.

First, select the measurement type (particle size, zeta potential, or molecular weight)

Select the sample cell.

Set the operating conditions.

Assign a name to the method and save the file.

The software follows a progression of selecting measurement conditions and procedures and creates a navigation file.

● Measurement Accuracy

HORIBA confirms measurement performance prior to product shipment using HORIBA-approved standard samples to confirm accuracy and reproducibility as per the tables below. To ensure high-level, stable performance, HORIBA delivers products manufactured in accordance with rigorous quality control systems worldwide.

Particle size

Particle size measurement accuracy using NIST-traceable polystyrene latex standards particles is as shown below.

Particle size standard value (nm)	Concentration	Standard
100 nm	100 ppm	Measured values for cumulant average size are within ±2%. (This does not include variation in the standard particles themselves.)

Particle size measurement reproducibility is as shown below.

Particle size standard value (nm)	Concentration	Standard
100 nm	100 ppm	The CV value for 6 repeated measurements is less than 2%.
100 nm	10 wt.%	The CV value for 6 repeated measurements is 5% or less.

*Conforms to ISO 13321: 1996, ISO 22412 : 2008 and JIS Z 8826: 2005.

Zeta Potential

Using a HORIBA-designated colloidal silica sample, HORIBA confirms that the measured value is higher than -75 mV and lower than -40 mV. Reproducibility for 6 repeated measurements is within 10% or less in CV value.

Molecular Weight

The measured value is within ±10% of the standard value using a polystyrene standard sample (Nominal molecular weight:96,000).
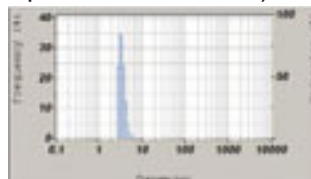
Applications

## ● Biomaterials: Gold colloid particle size measurement results

Au colloids (NIST)	RM8011	RM8012	RM8013
Nominal Size (nm)	10	30	60
NIST reference size by dynamic light scattering (nm)	13.5	26.5	55.3
Size measured with SZ-100 (nm)	11.0	26.6	55.4

RM8011

RM8012

RM8013
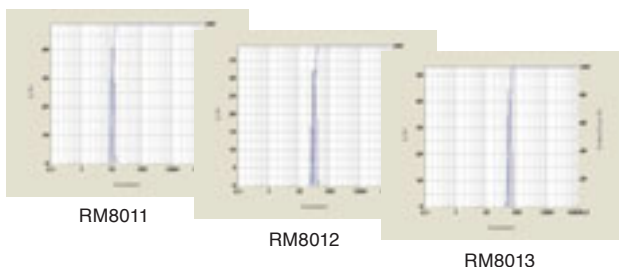
● Gold colloid particle (2nm) size measurement results (with high power laser 532nm 100mW)
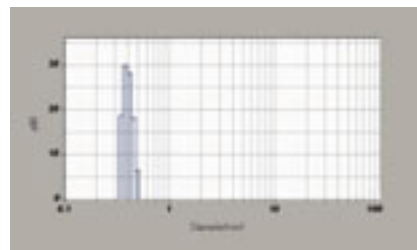

● Lysozyme (from egg white) particle size measurement result (with high power laser 532nm 100mW)
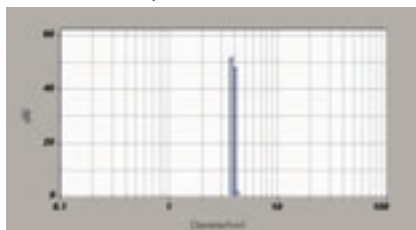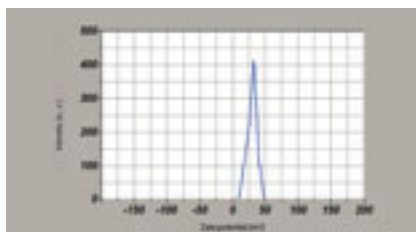

Sample concentration: 0.05mg/mL
Acetic acid buffer: pH=4.3
Average diameter: 4.0 nm

● Thiamin hydrochloride (Vitamin B1 hydrochloride) particle diameter measurement result
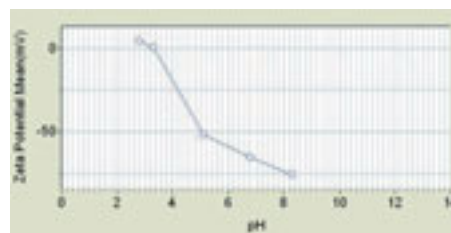

Sample concentration: 300 mg/mL
Average diameter: 0.4 nm

● NIST SRM 1980 α-FeOOH zeta potential measurement result

Sample concentration: 50 ppm, pH = 2.5
Mobility (rated): 2.53 ± 0.12 μm·cm/Vs
Measurement results: Mobility = 2.53 μm·cm/Vs
Zeta potential = 32.9 mV

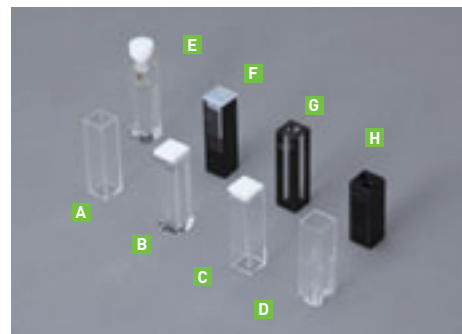## ● Isoelectric point of silica measurement result

Sample concentration: 0.01mol/L
(Adjusted to 10w% with KCl)
Zeta potential = -38.3 mV

Accessories

● Sample Cell Types and Specifications
**We can guide you in selecting the right cell for your application.**

Zeta potential measurement disposable cells
(For zeta potential and particle size measurement, 100 μL, Aqueous)

	Cell Name	Measurement Application	Remarks
A	Disposable cell	Particle size/ Molecular weight	Plastic, 4 surfaces clear, 100 pieces, Full volume 4000 μL (Minimum sample volume 1000 μL)
B	Semi-micro cell	Particle size	Quartz, 4 surfaces clear, Full volume 1600 μL (Minimum sample volume 400 μL)
C	Glass cell	Particle size/ Molecular weight	Glass, 4 surfaces clear, Full volume 4000 μL (Minimum sample volume 1000 μL)
D	Semi-micro disposable cell	Particle size	Plastic, 2 surfaces clear, 100 pieces, Full volume 800 μL (Minimum sample volume 400 μL)
E	Cell with lid	Particle size/ Molecular weight	Quartz, 4 surfaces clear, Full volume 4000 μL (Minimum sample volume 1000 μL)
F	Micro-cell (Side detector only)	Particle size/ Molecular weight	Quartz, 3 surfaces clear, Side detector only, Full volume 30 μL (Minimum sampling volume 12 μL)
G	Sub-micro cell	Particle size/ Molecular weight	Quartz, 4 surfaces clear, Full volume 750 μL (Minimum sampling volume 250 μL)
H	Flow cell	Particle size/ Molecular weight	Quartz, 3 surfaces clear, Full volume 100 μL(Minimum sampling volume 100 μL), 2 connectors with pH controller
I	Zeta potential plastic cell	Zeta potential	For aqueous sample, 20 pieces
J	Zeta potential glass cell	Zeta potential	For organic solvent, 50 replacement gold electrodes, PTFE lid, and 2 caps.

● Autotitrator

This device can be used to automatically prepare plots of zeta potential or particle size as a function of pH. It is an excellent choice for iso-electric point determination.
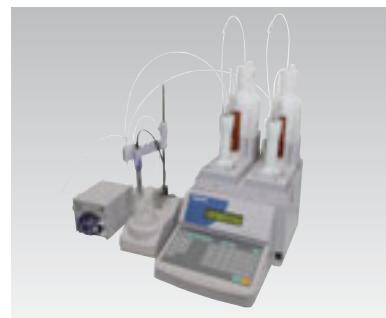
pH Controller Accessory Specifications

- Number of titrant bottles: 2
- Sample flow rate: 30-80 mL/min.
- Sample volume: 50 mL
- pH adjustment range: 1-13
- Power supply: AC 100-120/200-240 V, 50/60 Hz, 45 VA
- Dimensions and weight:
  Body: 468 (D) x 288 (W) x 481 (H) mm, approx. 12 kg
  Stirrer: 225 (D) x 118 (W) x 336 (H) mm, approx. 2.1 kg
  Circulation pump: 202 (D) x 124 (W) x 122 (H) mm, approx. 1.7 kg

pH electrode parts number 3200366539
pH calibration unit parts number 3200043642

SZ-100-S Measurement Specifications

Model	SZ-100-S (particle size and molecular weight measurement only)
Measurement principles	Particle size measurement: Dynamic Light Scattering Molecular weight measurement: Debye plot method (static scattered light intensity)
Measurement range	Particle size: 0.3 nm to 8 μm Molecular weight: 1000 to 2×10^7 Da (Debye plot) 540 to 2×10^7 Da (MHS Equation)[*1]
Maximum sample concentration	40 wt%[*2]
Particle size measurement accuracy	Measurement accuracy of ±2% for NIST traceable polystyrene latex 100 nm spheres (not including variation in the standard particles themselves)
Measurement angles	90° and 173° (automatic or manual selection)
Cells	Cuvettes
Measurement time	Approx. 2 min. under ordinary conditions (from the start of measurement to the display of results for particle size measurement)
Required sample volume	Minimum volume of 12 μL[*3] to 1000 μL (differs depending on cell material)
Usable liquids	Water, ethanol, organic solvents

*1 :Mark-Howink-Sakurada Equation, depending on sample. *2 :Depending on sample. *3 :F Micro-cell.

SZ-100-Z Measurement Specifications
(Particle size and molecular weight measurement specifications are the same as for the SZ-100-S.)

Model	SZ-100-Z (with zeta potential measurement unit)
Measurement principle	Zeta potential measurement: Laser Doppler electrophoresis
Measurement range	-200 to +200 mV
Size range suitable for measurement	Minimum 2.0 nm, Maximum 100 μm[*4]
Measurement conductivity range	0 to 20 S/m[*5]
Maximum sample concentration	40 wt%[*6]
Cells	Dedicated cell with electrodes
Measurement time	Approx. 2 min. under ordinary conditions
Required sample volume	100 μL
Carrier fluids	Water

*4 :Depending on sample. *5 :Recommended sample conductivity range:0 to 2 S/m. *6 :Depending on sample.

Analyzer Specifications (SZ-100-S and SZ-100-Z)

Measuring unit optical system	Light source: Diode pumped frequency doubled laser (532 nm, 10 mW) Detectors: Photomultiplier tubes (PMT)
Laser classification	Class I
Operating temperature and humidity	15-35°C, RH 85% or less (no ncondensing)
Holder temperature control temperature settings	1-90°C (up to 70°C for cells with electrodes and plastic cells)
Purging	Dry gas purge port tube connection is possible.
Power supply	AC 100-240 V, 50/60 Hz, 150 VA
Dimensions	385 (D) x 528 (W) x 273 (H) mm (excluding protrusions)
Weight	25 kg
Personal computer	Windows computer with one available USB port
Interface	USB 2.0 (between measuring unit and PC)
OS	Windows® XP™ 32 bit, Vista™ 32 bit or 7™ 32/64 bit

Class I laser product   CE certification

* Composite photographs are inserted into the PC screens.

Dimensions (mm)

385   273   528
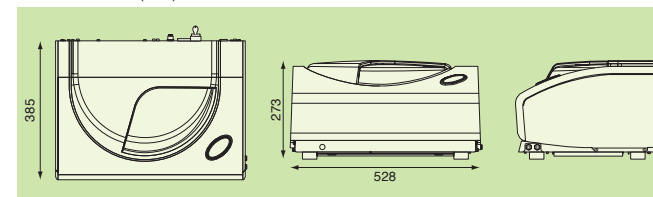
□ Data Processing
Navigation files turn complex parameter input into simple to use operating procedures. / Store 100 data items on a data list. / Display individual data items with a single mouse click. / Perform pH, temperature, and sample concentration trend measurement.

□ Particle Size Measurement
Real-time display of the autocorrelation function / Display of median size, specific surface area, mode size, average size, standard deviation, coefficient of variation, span value, percentage size (max. of 10 items), Z average, polydispersity index, size percentage (max. of 10 items displayed) / Particle distribution graph, autocorrelation function, residual error / Refractive index, viscosity, computing range, and data recalculation after measurement

□ Molecular Weight Measurement
Molecular Weight Measurement
Real-time display of Debye plots / Display of molecular weight and the second virial coefficient / Recalculation of Debye plot graph display data

□ Zeta Potential Measurement
Zeta potential, standard deviation, electrophoretic mobility, and average zeta potential at each peak / Display of zeta potential graphs, mobility graphs, recalculation of data

□ Options
21CFR Part 11 software / Zeta potential measurement organic solvent cells / pH control unit / IQ/OQ/PQ support / High power laser 532nm 100mW

Horiba continues contributing to the preservation of the global environment through analysis and measuring technology.

⚠ **Please read the operation manual before using this product to assure safe and proper handling of the product.**

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