Anton Paar Litesizer™ 500 Quick Start Guide

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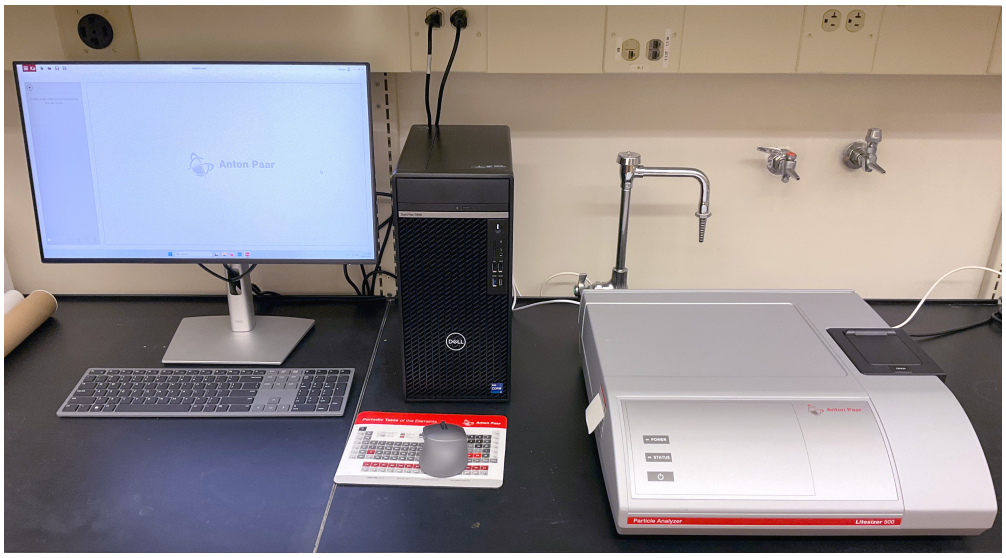

Figure 1: Litesizer 500 setup at the LSU SIF.

The Litesizer 500 instrument is designed for characterizing particles in liquid dispersions using:

- *Dynamic Light Scattering (DLS) for particle size range 0.3 nm – 10 µm*
- *Electrophoretic Light Scattering (ELS) for particle size range 3.8 nm – 100 µm*
- *Static Light Scattering (SLS) for particle size ranging up to 40 nm*
- *sample transmittance*
- *refractive index*

1 Particle size analysis / DLS

1.1 Before the measurement

1. Switch on the instrument at the back left, **at least 10 min before the measurement**.
2. Start up the PC; pw: `anton paar`
3. Open the **Kalliope** software
4. Click the ≡ Ka icon in the top left to open the menu.
5. Under **My Setting** click **Instrument Family** dropdown and select "Litesizer".
6. In the submenu 'Litesizer' select **Instrument** "Litesizer 500", **Accessory** "None".
7. Click the ≡ Ka icon again to close the menu.

1.2 Sample preparation

Concentration If the concentration is too low, not enough light is being scattered. If the concentration is too high, multiple scattering and/or hindered free diffusion of particles may affect the result. For particles < 10 nm there is no real maximum concentration. The lower limit for larger particles is at least 500 particles in the scattering volume[1].

As a guide, the mean detected light intensity should be at least 20,000 counts/s. For automatic measurements, a filter optical density of 0 indicates a low sample concentration.

Solvent (or Dispersant) The solvent or dispersant should be distilled, deionized and/or filtered (pore size of 10 or 20 nm) prior to use. As an additional check, a particle size measurement should be carried out on the solvent alone to ensure that it contains no unwanted particles.

Ultrasonication Ultrasonication should be used carefully, because it may initiate chemical reactions. It can be used to dissolve agglomerates or remove gas bubbles from the sample.

1. Use powder-free latex or nitrile gloves for handling the cuvette.
2. Fill the cuvette with your sample:
   - Place the tip of the pipette at the bottom of the cuvette and fill it from the bottom, while avoiding bubble formation.
   - The measurement is made 6.5 mm from the bottom of the cuvette. The Meniscus must be at least 2 mm above the measurement height (8.5 mm). The sample volume should therefore be 0.85 mL to 3 mL.
   - Check for bubbles and tap the cuvette to dislodge them.
   - Put the lid on the cuvette and ensure the outside is clean and dry.

[1] Approximate scattering volumes are 10^6 µm^3 (10^{-6} mL) for back scattering, 10^4 µm^3 (10^{-8} mL) for side scattering, and 5×10^4 µm^3 (5×10^{-8} mL) for forward scattering.

1.3 Performing the measurement

1. Push the **OPEN** button on the measurement module of the Litesizer, remove the small lid and insert the cuvette firmly as far as it will go. Replace lid *(for standard & quartz cuvettes).*
2. On the Kalliope start-up screen, click on the ⊕ icon to select a new measurement.
3. Select *Particle size* or *Particle size series* under "Measurement modes".
   A **series** allows repeated measurements. This can be useful e. g. for better statistics, or for conducting temperature series, etc.
4. Assign a **Name** to the experiment and enter the **Input parameters**:

   - **General/Measurement Cell:** select the cuvette used in your experiment
   - **General/Measurement angle:**
     - *Automatic* selects optimal mode automatically based on transmittance.
     - *Back scatter* (175°) is mostly suitable for strongly scattering samples, large particles, highly concentrated turbid samples.
     - *Side scatter* (90°) is suitable for weakly scattering samples, transparent samples and small particles. Can be used for 0.3 nm – 1 µm size particles.
     - *Forward scatter* (15°) is suitable for large particles at low concentration (protein aggregates, infusion solutions . . .).
   - **General/Target temperature:** ranges from 0 °C to 70 °C (quartz cuvettes up to 90 °C)
   - **General/Equilibration time:**
     - Use 2 min when measuring close to ambient temperature.
     - Add 1 min for every °C different from ambient temperature (based on 1 mL sample).
     - Use at least 4 min when using Univette cell.
   - **General/Analysis model:**
     - *General* if the sample is not well known, or if a single (broad) peak is expected.
     - *Narrow* if one or more narrow peaks are expected.
     - *Contin* is an alternative algorithm that contains a dienon-negativity parameter and uses a "regularization parameter".
   - **General/Cumulant model:**
     - *ISO 22412* is the default model.
     - *Advanced* use if correlation function shows either an elevated baseline, noise, a second shoulder which is an artifact/is caused by dirt.
   - **Quality/Mode:**
     - *Automatic* time for each run will be 10 s and measurement will continue until either threshold number of counts (10×10^6), or 60 runs are reached.
     - *Quick* number of counts is 3×10^6 , with maximum 30 runs.
     - *Manual* allows setting runs and Time manually.
   - **Filter/Mode:** *Automatic* optimizes optical filter density automatically based on the scattered intensity; *Manual* set density manually.
   - **Focus/Mode:** *Automatic* optimizes focus position automatically; *Manual* set focus position manually between −6 mm to 1 mm, where 0 is the center of the cuvette.

- **Material/Name:** select material from database **(temperature in the measurement must be the same as that in database)**. New materials can be added to database by clicking ≡ Ka icon.
- **Solvent/Name:** select solvent from database **(temperature in the measurement must be the same as that in database)**.
- **User-defined D-Values:** D_p with p indicating the volume fraction of a certain particle size fraction. For example $D_{10} = 200\,\text{nm}$ indicates that 10 % of the total volume of particles has a hydrodynamic diameter $\leq 200\,\text{nm}$.

5. Click the **Start** ▷ button to start the measurement.
6. When finished, the results will be displayed to the right of the graphs.
7. Use the action buttons at the top right to export or recalculate results, if needed.

1.4 Finishing up

1. *For reusable cuvettes:* remove sample from cuvette **straight after measurement**.
2. **Immediately rinse** with the filtered medium or water, and dry the cuvette using clean compressed air/nitrogen. Never allow a sample to dry in the cuvette.
3. Replace the lid in the measurement module and close it.
4. Save the workbook in your folder and indicate the date in the name of a subfolder.
5. Create report (select a template beginning with *LSU* to include the LSU logo).
6. Close the Kalliope software and shutdown the PC.
7. Switch off the Litesizer at the back.

2 Zeta potential analysis / ELS

2.1 Before the measurement

1. Switch on the instrument at the back left, **at least 10 min before the measurement**.
2. Start up the PC; pw: `anton paar`
3. Open the **Kalliope** software
4. Click the ≡ Ka icon in the top left to open the menu.
5. Click **Instrument** and select "Litesizer".
6. Click the ≡ Ka icon again to close the menu.

2.2 Prepare the sample

Concentration Zeta Potential measurements are not sensitive to concentration in opposition to particle size measurements. Concentration must be high enough that sufficient light is scattered. *The detected signal should have at least 20,000 counts/s. If the optical density is 0, then the sample concentration is too low.*

Diluting the sample The sample must be diluted if the particle concentration is too high. By adding more of the solvent that is already in the sample the zeta potential will not be affected ("equilibrium dilution").

If the original solvent is unavailable, it must be extracted from the solution, using sedimentation or centrifugation. This only works well for large particles with sufficient density contrast. For small particles, dialysis is necessary with membranes that are not penetrable by the sample particles.

If the same solvent is unavailable, a solvent with similar properties (viscosity, polarity, pH, electrolyte concentration) to the original should be used.

2.3 Performing the measurement

1. Use powder-free latex or nitrile gloves for handling the Omega cuvette:
    - The Omega cuvettes are made of polycarbonate, and can only be used for aqueous samples.
    - Place the tip of the pipette at the bottom of the cuvette and fill it from the bottom, while avoiding bubble formation.
    - Conditioning of the cuvette reduces electrostatic charges carried by the cuvette walls. Fill a clean and empty measurement cuvette with the dispersion to be measured, let it sit for a few minutes, then discard the dispersion and promptly refill with fresh sample. The measurement is performed on the newly filled cuvette.
    - 700 mL sample is required to ensure both electrodes of the Omega cuvette are in good contact with the sample.
    - Hold the cuvette upside down and gently inject the sample until half full.
    - Once the liquid reaches halfway, carefully turn the cuvette upright and continue injecting the sample until the cuvette is full and both electrodes are covered.

- Check for tiny air bubbles and tap the cuvette to dislodge them.
- Insert the Luer plugs and ensure the outside of the cuvette is clean and dry.

2. Push the **OPEN** button on the measurement module of the Litesizer, remove the small lid and insert the cuvette firmly as far as it will go, with electrodes and sample ports pointing sideways.
3. On the Kalliope start-up screen, click on the ⊕ icon to select a new measurement.
4. Select *Zeta potential* or *Zeta potential series* under "Measurement modes".
   A **series** allows repeated measurements. This can be useful e. g. for better statistics, or for conducting temperature series, etc.
5. Assign a **Name** to the experiment and enter the **Input parameters**:

   - **General/Measurement Cell:** select the cuvette used in your experiment
   - **General/Target temperature:** ranges from 0 °C to 70 °C (Quartz cuvettes up to 90 °C)
   - **General/Equilibrium time:**
     - Set to 2 min when measuring close to ambient temperature.
     - Add 1 min for every °C different from ambient temperature (based on 1 mL sample).
     - Set to at least 4 min when using Univette cell.
   - **General/Approximation:**
     - *Smoluchowski* Sets the Henry factor to 1.5. The Smoluchowski approximation is suitable for water-based samples.
     - *Hueckel* Sets the Henry factor to 1.0. The Hückel approximation is suitable for samples diluted in non-polar solvents.
     - *Other* set the value of the Henry factor manually (must be between $1.0 - 1.5$). This can **possibly improve the quality of the Zeta potential calculation** for measurements in extreme conditions of temperature, ionic strength or particle size. Use the Calculator in Kalliope to calculate the Henry factor for your experimental conditions.
   - **Power adjustment:** *Automatic* increases the voltage until maximum is reached, for which the maximum power is not exceeded. *Manual* set voltage manually between 1 V to 200 V
   - **Quality/Run mode:** *Automatic* will stop experiment when standard deviation reaches threshold value. *Manual* set the number of runs in range of $20 - 1000$.
   - **Solvent:** Select solvent from database. New solvents can be added to database by clicking ≡ Ka icon.

6. Click the **Start** ▷ button to start the measurement.
7. When finished, the results will be displayed to the right of the graphs.
8. Use the action buttons at the top right to export or recalculate results, if needed.

2.4 Finishing up

1. Remove sample from cuvette **straight after measurement**.

2. **Immediately rinse** with the filtered medium or water, and dry the cuvette using clean compressed air/nitrogen. Never allow a sample to dry in the cuvette.
3. Replace the lid in the measurement module and close it.
4. Save the workbook in your folder and indicate the date in the name of a subfolder.
5. Create report (select a template beginning with *LSU* to include the LSU logo).
6. Close the Kalliope software and shutdown the PC.
7. Switch off the Litesizer at the back.

3 Molecular mass measurement / SLS

3.1 Before the measurement

1. Switch on the instrument at the back left, **at least 10 min before the measurement**.
2. Start up the PC; pw: `anton paar`
3. Open the **Kalliope** software
4. Click the ≡ Ka icon in the top left to open the menu.
5. Click **Instrument** and select "Litesizer".
6. Click the ≡ Ka icon again to close the menu.

3.2 Sample preparation

- Use powder-free latex or nitrile gloves for handling the cuvette:
- The solvent/dispersant should be filtered several times using a 0.02 µm or smaller pore size membrane.
- Clean all glassware with a suitable detergent to remove grease and other contaminants. Rinse with water to remove all traces of detergent. Dry in a clean, dust-free drying oven.
- Don't use more solvent than necessary.
- If the same cell is to be used in a series of experiments with the same solvent, rinse it simply with the solvent (no need for washing and drying between measurements).
- Use at least three samples of different concentration for the Debye plot.
- Measure one sample of the solvent alone.
- Also measure a calibration reference.

3.3 Performing the measurement

1. Push the **OPEN** button on the measurement module of the Litesizer, remove the small lid and insert the cuvette firmly as far as it will go, with electrodes and sample ports pointing sideways.
2. On the Kalliope start-up screen, click on the ⊕ icon to select a new measurement.
3. Select *Molecular mass* under "Measurement modes"

4. Assign a **Name** to the experiment and enter the **Input parameters**:

   - **General/Cuvette:** Only Quartz and glass cuvettes can be used.
   - **General/Target temperature:** enter a temperature in the range of 0 °C to 90 °C.
   - **General/Equilibration time:**
     - Use 2 min when measuring close to ambient temperature.
     - Add 1 min for every °C different from ambient temperature (based on 1 mL sample).

- **General/ dn/dc:** Change of refractive index as a function of change in concentration.
- **Quality/Mode:** automatic or manual.
- **Quality/Number of runs:** $1 - 100$.
- **Quality/Time for each run:** must be between 1 s and 30 min.
- **Solvent:** Select solvent from database. New solvents can be added to database by clicking ≡ Ka icon.
- **Reference:** Toluene is generally used as reference. Refractive index and Rayleigh ratio will be automatically imported from the solvent database. New references can be entered in the solvent database (see "Solvent" row above).
- **Shape correction/Shape:** Select a shape correction if the particles do not scatter isotropically. Spherical, spiral, cylindrical, or "no correction" can be selected.
- **Shape/Hydrodynamic radius:** If known, enter. Otherwise it must be measured first.
- **Concentrations:** At least three concentrations are required for a measurement. Concentrations can be selected between 0.001 mg/mL to 500 mg/mL. Measurement will run from highest to lowest concentration, regardless of input order.

5. Click the **Start** ▷ button to start the measurement.
6. When finished, the results will be displayed to the right of the graphs.
7. Use the action buttons at the top right to export or recalculate results, if needed.

3.4 Finishing up

1. Remove sample from cuvette **straight after measurement**.
2. **Immediately rinse** with the filtered medium or water, and dry the cuvette using clean compressed air/nitrogen. Never allow a sample to dry in the cuvette.
3. Replace the lid in the measurement module and close it.
4. Save the workbook in your folder and indicate the date in the name of a subfolder.
5. Create report (select a template beginning with *LSU* to include the LSU LOUISIANA STATE UNIVERSITY logo).
6. Close the Kalliope software and shutdown the PC.
7. Switch off the Litesizer at the back.

4 Transmittance

4.1 Before the measurement

1. Switch on the instrument at the back left, **at least 10 min before the measurement**.
2. Start up the PC; pw: `anton paar`
3. Open the **Kalliope** software
4. Click the ≡ Ka icon in the top left to open the menu.
5. Click **Instrument** and select "Litesizer".
6. Click the ≡ Ka icon again to close the menu.

4.2 Sample preparation

- There are no real restrictions on the type of samples that can undergo transmittance measurements. For aqueous samples, the disposable polystyrene cuvettes can be used. For all other solvents, the quartz cuvettes should be used.
- Along with the sample to be measured, a cuvette with the solvent only should be prepared with the same sample volume, and in the same type of cuvette. This solvent sample can then be used as the reference.
- This measurement can be performed with all Anton Paar cuvettes, except the Omega cuvette Z.

1. Use powder-free latex or nitrile gloves for handling the cuvette.
2. Filling a disposable or quartz cuvette with your sample:
    - Place the tip of the pipette at the bottom of the cuvette and fill it from the bottom, while avoiding bubble formation.
    - The measurement is made 6.5 mm from the bottom of the cuvette. The Meniscus must be at least 2 mm above the measurement height (8.5 mm). The sample volume should therefore be 0.85 mL to 3 mL.
    - Check for bubbles and tap the cuvette to dislodge them.
    - Put the lid on the cuvette and ensure the outside is clean and dry.

4.3 Performing the measurement

1. Push the **OPEN** button on the measurement module of the Litesizer, remove the small lid and insert the cuvette firmly as far as it will go. Replace lid *(for standard & quartz cuvettes).*
2. On the Kalliope start-up screen, click on the ⊕ icon to select a new measurement.
3. Select *Transmittance* or *Transmittance series* under "Measurement modes".
   A **series** allows repeated measurements. This can be useful e. g. for better statistics, or for conducting temperature series, etc.
4. Assign a **Name** to the experiment and enter the **Input parameters**:
    - **General/Target temperature:** ranges from 0 °C to 70 °C (quartz cuvettes up to 90 °C)

- **General/Equilibration time:**
  - Use 2 min when measuring close to ambient temperature.
  - Add 1 min for every °C different from ambient temperature (based on 1 mL sample).
  - Use at least 4 min when using Univette cell.
- **Quality/Time for each run:** Must be between 1 s and 30 min. The recommended initial Time for each run is 10 s.

5. Click the **Start** ▷ button to start the measurement.
6. When finished, the results will be displayed to the right of the graphs.
7. Use the action buttons at the top right to export or recalculate results, if needed.

4.4 Finishing up

1. Remove sample from cuvette **straight after measurement**.
2. **Immediately rinse** with the filtered medium or water, and dry the cuvette using clean compressed air/nitrogen. Never allow a sample to dry in the cuvette.
3. Replace the lid in the measurement module and close it.
4. Save the workbook in your folder and indicate the date in the name of a subfolder.
5. Create report (select a template beginning with *LSU* to include the LSU logo).
6. Close the Kalliope software and shutdown the PC.
7. Switch off the Litesizer at the back.

5 Refractive Index

5.1 Before the measurement

1. Switch on the instrument at the back left, **at least 10 min before the measurement**.
2. Start up the PC; pw: `anton paar`
3. Open the **Kalliope** software
4. Click the ≡ Ka icon in the top left to open the menu.
5. Click **Instrument** and select 'Litesizer'.
6. Click the ≡ Ka icon again to close the menu.

5.2 Sample preparation

- Only quartz cuvettes should be used.
- The solvent should be filtered using a 0.02 µm or smaller pore size filter.
- Prepare three different solvents with the same sample volume and in the same type of cuvette, to perform the instrument calibration:

1. Use powder-free latex or nitrile gloves for handling the cuvette.
2. Fill a quartz cuvette with your sample:
    - Place the tip of the pipette at the bottom of the cuvette and fill it from the bottom, while avoiding bubble formation.
    - The measurement is made 6.5 mm from the bottom of the cuvette. The Meniscus must be at least 2 mm above the measurement height (8.5 mm). The sample volume should therefore be 0.85 mL to 3 mL.
    - Check for bubbles and tap the cuvette to dislodge them.
    - Put the lid on the cuvette and ensure the outside is clean and dry.

5.3 Performing the measurement

1. Push the **OPEN** button on the measurement module of the Litesizer, remove the small lid and insert the cuvette firmly as far as it will go, with electrodes and sample ports pointing sideways.
2. On the Kalliope start-up screen, click on the ⊕ icon to select a new measurement.
3. Select *Refractive index* under "Measurement modes"
4. Assign a **Name** to the experiment and enter the **Input parameters**:
    - **General/Measurement cell:** "Quartz cuvettes" must be selected.
    - **General/Target temperature:** Set a measurement temperature between 0 °C to 90 °C.
    - **General/Equilibration time:**
        - Use 2 min when measuring close to ambient temperature.

  - Add 1 min for every °C different from ambient temperature (based on 1 mL sample).
- **Time for each run:** 2 s are recommended.
- **General/First-Third solvent:** Solvents with known refractive index can be chosen from the drop-down menu and are used as a reference to generate the focus position over refractive index plot.

5. Click the **Start** ▷ button to start the measurement.
6. When finished, the results will be displayed to the right of the graphs.
7. Use the action buttons at the top right to export or recalculate results, if needed.

5.4 Finishing up

1. Remove sample from cuvette **straight after measurement**.
2. **Immediately rinse** with the filtered medium or water, and dry the cuvette using clean compressed air/nitrogen. Never allow a sample to dry in the cuvette.
3. Replace the lid in the measurement module and close it.
4. Save the workbook in your folder and indicate the date in the name of a subfolder.
5. Create report (select a template beginning with *LSU* to include the LSU logo).
6. Close the Kalliope software and shutdown the PC.
7. Switch off the Litesizer at the back.

6 Theory

6.1 Dynamic Light Scattering

Dynamic Light Scattering (DLS) is based on the Brownian motion [5] of particles in a dispersant. Smaller particles move more rapid, than larger particles. The motion causes a phenomenon called Doppler broadening, and the scattered laser light will either be canceled out or interfere constructively, causing intensity fluctuations. Faster motion speeds cause more rapid fluctuations in the measured scattering intensity.

These time-dependent intensity variations can be converted into a translational diffusion coefficient D_τ via a second-order correlation function $g_2(\tau)$ (Equation (1), normalized), where τ is the time between measurement intervals [7]. By incorporating properties of the laser light and the solvent, the particle motion can be linked through the correlation function in Equation (2) directly to the measured fluctuations [3], with the wave length λ, the coherence factor β, the Bragg wave vector q, the viscosity η of the dispersing medium (Pa s), and detector angle θ. It gives access to the measurement of the translational diffusion coefficient D_τ ($m^2\,s^{-1}$).

$$g_2(\tau) = \frac{\langle I(t)I(t+\tau)\rangle}{\langle I(t)\rangle^2} \tag{1}$$

$$\vdots$$

$$g_2(\tau) = 1 + \beta e^{-2D_\tau q^2 \tau}, \tag{2}$$

$$\text{with } q = \frac{4\pi\eta}{\lambda} sin(\theta/2) \tag{3}$$

Using the Stokes–Einstein relation given in Equation (4), the hydrodynamic radius R_h of an equivalent spherical particle can be calculated directly from the measured D_τ. Here, k_B represents the Boltzmann constant ($1.38 \times 10^{-23}\,kg\,m^2\,s^{-2}\,K^{-1}$) and T is the absolute temperature (K).

$$R_h = \frac{k_B T}{6\pi\eta D_\tau} \tag{4}$$

6.2 The electrokinetic or Zeta potential (ζ)

Zeta potential measurements provide information about the stability of a colloidal dispersion. ζ depends not only on the charge of the particles themselves, but also on the solvent in which the particles are dispersed (e. g. pH). Therefore sample manipulation is only recommended for samples that cannot be measured in their original condition; for example, because the sample concentration is not within the required limits. Sample preparation may also be necessary for specific applications or special standardized measurement procedures, but every sample manipulation must be done carefully in order to not falsify the results [1].

With the model of the electrochemical double layer (EDL) the origin of the electrokinetic or Zeta potential can be explained. The layers involved are a stationary layer of negatively charged ions adsorbed to the particle surface (surface charge), electrically screened by a loosely bound layer of hydrated cations, as depicted in Figure 2. The thickness of the EDL is defined by the Debye length in Equation (6).

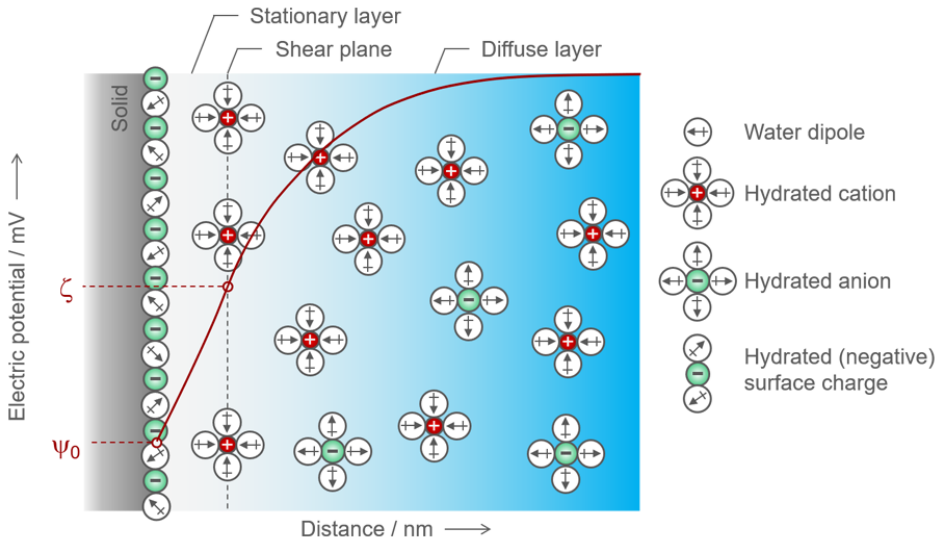

Figure 2: Model of the electrochemical double layer at the solid-liquid interface (Ψ_0 is the surface potential; ζ is the zeta potential). Image from [6].

The Zeta potential of particles in suspension is calculated from the electrophoretic mobility of particles using the Henry equation (5). Herein the crucial parameter is the Henry factor, i. e. Henry function $f(\kappa a)$. There are two limiting cases in electrophoresis measurements. When measuring non-conductive particles the Henry function can be described with the approximation by Smoluchowski, and for conductive particles with the approximations by Hückel [2].

$$\zeta = \frac{3\eta \cdot U_E}{2\varepsilon \cdot f(\kappa a)} \tag{5}$$

Smoluchowski approximation This is mostly used for measuring zeta potential of particles suspended in **aqueous solutions** of moderate electrolyte concentration.

Hückel approximation For particles suspended in **non-polar solvents**, the Hückel approximation should be used.

7 Glossary

Debye length (Debye radius or Debye–Hückel screening length) $1/\kappa$ is a measure of the thickness of the electrical double layer at the surface of the particles. It is calculated by Equation (6). With each Debye length the charges are increasingly electrically screened and the electric potential decreases in magnitude by 1/e. Generally, it is a measure of a charge carrier's net electrostatic effect in a solution and how far its electrostatic effect persists [4].

$$\frac{1}{\kappa} = \sqrt{\frac{\epsilon_f \varepsilon_0 \mathrm{R} T}{2\mathrm{F}^2 I}} \tag{6}$$

with permittivity ϵ_f, dielectric constant ε_0, gas constant R, temperature T, Farraday constant F and ionic strength I.

The Debye length depends on the concentration and type of ions, represented by their charge and valency, v_i^+ (cation) and v_i^- (anion):

$$I = \frac{1}{2}\sum v_k^2 c_{n,k}^{\infty} = \frac{1}{2}\sum v_i^+ c_{n,i}^+ + \frac{1}{2}\sum v_i^- c_{n,i}^- \tag{7}$$

with c representing the concentrations.

dispersity The dispersity (Đ), also known as the polydispersity index (PDI) or heterogeneity index, is a measure of the distribution of molecular mass in a given polymer sample. Đ (PDI) of a polymer is calculated:

$$Đ = M_\mathrm{w} / M_\mathrm{n} \tag{8}$$

where M_w is the weight average molecular weight and M_n is the number average molecular weight. M_n is more sensitive to molecules of low molecular mass, while M_w is more sensitive to molecules of high molecular mass.

DLS Dynamic light scattering

ELS Electrophoretic light scattering

Hydrodynamic radius/diameter It is defined as the radius of a hypothetical sphere that diffuses at the same rate as the particle under investigation. It includes the size of the base particle plus layers of ions, molecules, and covalently bound ligands on the surface that travel with the particle as it moves in solution.

SLS Static light scattering

References

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