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| **Glossary of Terms**  **MALS = M**ulti **A**ngle **L**ight **S**cattering; terms apply primarily to DAWN instrumentation  **DLS = D**ynamic **L**ight **S**cattering; terms apply primarily to DynaPro or QELS instrumentation | |
| **Term** | **Definition** |
| 2nd Virial Coefficient (A2) | A measure of solvent-solute interaction. Positive for a “good” solvent, negative for a “bad” solvent, zero for a “theta” solvent. Useful in protein crystallography and polymer chemistry. |
| Avogadro's Number (NA) | Appears in the k\* term of the light scattering equation. 6.022x1023; The number of carbon atoms in 12 grams of unbound carbon-12 at its rest-energy electronic state. |
| Band Broadening  (inter-detector) | The change in peak width between detectors caused by dilution of the sample as it moves downstream. Mathematically correctable when using Wyatt’s ASTRA V software! |
| Baseline | MALS – Light scattering intensity from solvent and the electrical detector offset.  DLS - The measured value of the last coefficient in the correlation curve. |
| Beer’s Law | Absorbance = ε L c, where ε is the molar absorptivity, L is the cell path length, and c is the concentration. Used for calculating in-line absolute sample concentration when using a UV detector with a MALS instrument. |
| Berry Formalism | Especially useful for very large sizes, such as samples with RMS radii > 100 nm. Generally more linear than Zimm in this range, therefore a lower polynomial fit can be used. |
| Bovine Serum Albumin  (BSA) | Monomer: Rh ~ 3.4 nm, Mw ~ 67kD, dn/dc is 0.185 in PBS at 690nm.  A good isotropic scatterer and protein standard, often used for MALS normalization and inter-detector alignment with aqueous HPLC. |
| Brownian Motion | The random motion in any liquid or gas due to thermal motion of the particles. |
| Calibration | MALS - Converting detector voltage at 90° to the measured intensity of scattered light. Toluene is recommended for calibration regardless of the solvent used for sample analysis. |
| Conformation | The conformation, or shape, of molecules can be ascertained using MALS data by calculating the slope of log Rz / log Mw  m=1 indicates rod shape; m=0.5-0.6 indicates random coil;  m=1/3 indicates sphere.  Other empirical techniques are available as well, involving DLS data. |
| DAWN in Sixty Seconds (DISS) | A chromatography system using only a guard column in order to run a sample in 1-2 minutes and requiring only 10-20% the sample amount needed for traditional SEC. Bulk average Mw and radius are obtainable (not polydispersity). |
| Debye Formalism | R(θ)/K\*c Useful over wide range of sizes but generally has more curvature than Zimm or Berry and therefore requires a higher order polynomial fit. |
| Debye Plot | Plot (for a single “slice” of in-line MALS data) of the angular dependence of the light scattering intensity and the fit results to the basic light scattering equation. Assesses the quality of fit to the light scattering data and produces Mw & Rz. |
| dn/dc | Also known as the specific refractive index increment. The ratio of the change in refractive index to the change in concentration. To a first approximation dn/dc is the absolute RI difference between solvent & sample, and may be positive, negative, or zero.  dn/dc is wavelength-dependent, although not significantly temperature-dependent nor Mw-dependent above ~3kD. |
| Dt | See “Translational Diffusion Coefficient” |
| Electric Field | The part of a light wave that induces an oscillating dipole in a molecule, resulting in light scattering from the molecule. |
| Excess Rayleigh Ratio | The ratio of scattered to incident light that takes into account the scattering angle, distance, solvent, and volume. In effect, a measure of the light scattered by the solute alone. |
| Field Flow Fractionation  (FFF) | A separation system employing a channel with liquid cross-flow to push larger particles to the margin allowing smaller molecules to elute first. As there is no stationary phase, FFF is often an excellent alternative to liquid chromatography. |
| HPLC (FPLC) (SEC) | High Pressure (or High Performance) Liquid Chromatography. Also known as FPLC, Fast Protein Liquid Chromatography; SEC, Size Exclusion Chromatography; or GPC, Gel Permeation Chromatography. Separates a sample based on hydrodynamic volume by means of flow through a packed column. |
| Hydrodynamic Radius | The radius of a hypothetical sphere with a particular translational diffusion coefficient or intrinsic viscosity. |
| Index of Refraction (Refractive Index) | The interaction of light with matter, related to polarizability (among other properties). A solvent’s refractive index appears in the k\* term of the light scattering equation. |
| Intensity of Light | The power imparted by light on a given area. Proportional to the square of the magnitude of the electric field. |

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| Intrinsic Viscosity | The ratio of specific viscosity and sample concentration. Used to determine the characteristics of macromolecules by quantifying the effect of the macromolecules on the viscosity of the solution. |
| Isotropic Scatterer | A sample that scatters light equally in all directions. For λ=690nm, molecules smaller than 10nm in radius are isotropic scatterers. |
| k\* (Optical Constant) | Optical constant in the MALS equation. (2π2ño2/λo4NA)(dñ/dC)2, where ño is the solvent refractive index, λo is the vacuum wavelength of the incident light, NA is Avogadro’s number, and dñ/dC is the specific refractive index. |
| Lorentz-Lorentz Formula | (R/M) ρ= (ñ2-1)/ (ñ2+2); Describes relationship between the refractive index of the solvent and the solvent density. |
| Mie Model | The fit model used in ASTRA when working with larger, non-dissolving particles. Uses the Mie analysis for a sphere rather than a polynomial to fit the angular light scattering data. |
| Molar Mass (M) | The mass of one mole of a chemical element or chemical compound. Absolute measurements of M can be made four known methods: static light scattering (yields Mw), membrane osmometry (Mn), Analytical Ultracentrifugation (Mz), and Mass Spectroscopy. |
| Molar Mass, Weight Averaged (MW) | The molar mass measurement obtained by static light scattering in flowing mode or in the static “batch” mode.  In the flowing mode Mw = (ΣniMi2)/(ΣniMi) |
| Normalization | MALS - Relating the voltages of all detectors to the calibrated voltage of the 90° detector. Performed with an isotropic scatterer and (if using the flow cell or microcuvette) the solvent to be used for experimentation. |
| Particle Scattering Function P(θ) | The angular variation of scattered light intensity as a function of particle size. |
| Quasi-Elastic Light Scattering (QELS) | Also known as dynamic light scattering or photon correlation spectroscopy, QELS uses the change in scattered light caused by Brownian motion in the sample to measure the translational diffusion Dt of the molecules in solution. Dt yields hydrodynamic radius Rh via the Stokes-Einstein equation. |
| Radius, Hydrodynamic  Rh | The radius of a hypothetical hard sphere with a particular translational diffusion coefficient or intrinsic viscosity. |
| Radius, Root Mean Square (rg) | Measure of molecular size based on the molecule’s mass distribution around its center of mass. Also known as rms radius or (incorrectly) as radius of gyration. |
| Rayleigh Ratio (R(θ)) | The ratio of scattered to incident light intensity, with the scattered intensity being summed over all space.  Rθ=is/Io(r2/(1+cos2θ)). |
| Refraction | The bending of light at an interface between media with different indices of refraction. In a Wyatt MALS flow cell normalization corrects for refraction at the liquid/glass interface, which varies with detector angle. |
| Relative Viscosity | The ratio of viscosity (isothermal) of pure solvent to a solution of known concentration. |
| Specific Refractive Index Increment (dn/dc) | See “dn/dc” |
| Specific Viscosity | The ratio of the viscosities of a polymer solution and pure solvent minus one. Measured at low polymer concentrations and constant temperature. |
| Stretch Factor, k | An arbitrary scaling factor determined by the ASTRA software to plot the values of k\*c and sin2 (θ/2) in the same numerical range for visual presentation in an ASTRA Zimm plot. |
| Stokes-Einstein Equation | Equation for calculating the hydrodynamic radius: Rh=kT/6πDη where Rh is hydrodynamic radius, k is Boltzmann’s constant, T is temperature (Kelvin), and η is the viscosity of the solvent. |
| Toluene | Standard organic solvent used in light scattering calibration due to its large, well-known Rayleigh ratio.  Also used in the making of Trinitrotoluene, TNT. |
| Translational Diffusion Coefficient (Dt) | The rate of the translational movement of molecules due to Brownian motion. Proportional to 1/Rh. |
| Viscosity | The resistance of liquid to flow due to internal friction. |
| Wavelength (λ) | The distance between repeating units in the pattern of a wave of light. Appears in the k\* term of the light scattering equation. |
| Zimm Formalism | K\*c/R(θ) Best for small to mid-sized molecules (RMS radii up to 50nm and higher). More linear than Debye, therefore a lower order polynomial fit can be used. |
| Zimm Plot | A plot combining concentration and angular light scattering data to determine molar mass, rms radius, and 2nd virial coefficient. |