Designation: E3427 – 24

Standard Guide for Measuring Intensity, Polydispersity, Size, Zeta Potential, Molecular Weight, and Concentration of Nanoparticles in Liquid Suspension Using Laser-Amplified Detection/Power Spectrum Analysis (LAD/PSA) Technology[1]

This standard is issued under the fixed designation E3427; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 The technology, laser-amplified detection/power spectrum analysis (LAD/PSA), is available in three different platforms, which will be designated as Platforms A, B, and C.

1.1.1 *Platform A*—This is a solid-state probe configuration that serves as the optical bench in each of the platforms. It consists of an optical fiber coupler with a y-beam splitter that directs the scattered light signal from the nanoparticles at 180° back to a photodiode detector. The sensing end of the probe can be immersed in a suspension or positioned to measure one drop of a sample on top of the sensing surface.

1.1.2 *Platform B*—The same probe is mounted in a case, positioned horizontally, to detect the signal from either a disposable or permanent cuvette.

1.1.3 *Platform C*—Two probes are mounted in a case, horizontally, at opposite sides of a permanent sample cell. Both size distribution and zeta potential can be measured in this configuration.

1.2 The laser beam travelling through the probe measuring the scattered light from the sample of nanoparticles, in all three platforms, is partially reflected back to the same photodiode detector, and the high optical power of the laser is added to the low optical power of the scattered light signal. The interference (mixing or beating) of those two signals is known as heterodyne beating. The resulting high-power detected signal provides the highest signal-to-noise ratio among dynamic light-scattering (DLS) technologies.

1.3 This combined, amplified, optical signal is converted with a Fast Fourier transform (FFT) into a frequency power spectrum, then into a logarithmic power spectrum that is deconvolved into number and volume size distributions. The mean intensity, polydispersity, number and volume size distributions, concentration, and molecular weight can be reported in all platforms, plus zeta potential on Platform C.

1.4 This technology is capable of measuring nanoparticles in a size range from 2.0 nanometres (nm) to 10 micrometres (µm), at concentrations in a suspending liquid medium up to 40 % cc/mL for all parameters given in 1.3.

1.5 *Units*—The values stated in SI units are to be regarded as the standard. No other units of measurement are included in this standard.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.7 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E1817 Practice for Controlling Quality of Radiological Examination by Using Representative Quality Indicators (RQIs)
E2456 Terminology Relating to Nanotechnology
E2490 Guide for Measurement of Particle Size Distribution of Nanomaterials in Suspension by Photon Correlation Spectroscopy (PCS)
E2834 Guide for Measurement of Particle Size Distribution of Nanomaterials in Suspension by Nanoparticle Tracking Analysis (NTA)
E3247 Test Method for Measuring the Size of Nanoparticles

[1] This guide is under the jurisdiction of ASTM Committee E29 on Particle and Spray Characterization and is the direct responsibility of Subcommittee E29.02 on Non-Sieving Methods.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

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2.2 *ISO Standards:*[3]

ISO 14488 Particulate Material—Sampling and Sample Splitting for the Determination of Particulate Properties

ISO 22412 Particle Size Analysis—Dynamic Light Scattering (DLS)

3. Terminology

3.1 *Definitions*—For definitions of terms pertaining to this guide not otherwise listed in 3.2, reference should be made to ISO 22412, Guides E2490 and E2834, and Test Method E3247.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *deconvolution, n*—iterative computational technique that calculates an estimate of the answer to a problem.

3.2.1.1 *Discussion*—The error between the problem and the estimate is calculated and the estimate is refined. The process is repeated until the error is minimized to a desired minimal value.

3.2.2 *Fast Fourier transform, FFT, n*—algorithm that converts a signal from the amplitude/time domain to the amplitude/frequency domain.

3.2.3 *fiber optic coupler, n*—fiber optic device capable of combining two or more inputs into a single output and also dividing a single input into two or more outputs.

3.2.4 *heterodyne (reference beating), adj*—heterodyne detection is the mixing of scattered light from nanoparticles with a reference light beam from the same source, which is a laser in this technology (refer to heterodyne diagram in Fig. 1).

3.2.4.1 *Discussion*—Sinusoidal electromagnetic waves are generated, as related to dynamic light scattering (DLS), from each nanoparticle in the scattering region of the incident laser signal. The intensity of the scattered light from each nanoparticle is added to the intensity of the laser reference beam of much greater optical power than the optical power of the scattered light from the nanoparticles.

3.2.5 *homodyne (self-beating), adj*—sinusoidal electromagnetic waves are generated, as related to DLS, from all the different pairs of nanoparticles in the scattering region of the incident laser signal representing the sum of the scattered light intensity for each pair added together (refer to homodyne diagram in Fig. 1).

3.2.6 *y-splitter, n*—location in a fiber optic coupler where a single beam is divided into two beams and where two beams are combined into one.

3.3 *Acronyms:*

3.3.1 *CWV*—constant water volume

3.3.2 *DI*—deionized

3.3.3 *DLS*—dynamic light scattering

3.3.4 *FPS*—frequency power spectrum

3.3.5 *IPA*—isopropyl alcohol

3.3.6 *LAD/PSA*—laser-amplified detection/power spectrum analysis

3.3.7 *LI*—loading index

3.3.8 *MI*—mean intensity

3.3.9 *MW*—molecular weight

3.3.10 *NTA*—nanoparticle tracking analysis

3.3.11 *PCS*—photon correlation spectroscopy

3.3.12 *PI*—polydispersity index

3.3.13 *PSA*—power spectrum analysis

3.3.14 *PSD*—power spectrum distribution

3.3.15 *QLS*—quasi-elastic light scattering

3.3.16 *RI*—refractive index

3.3.17 *RRI*—relative refractive index

[3] Available from International Organization for Standardization (ISO), ISO Central Secretariat, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, https://www.iso.org.

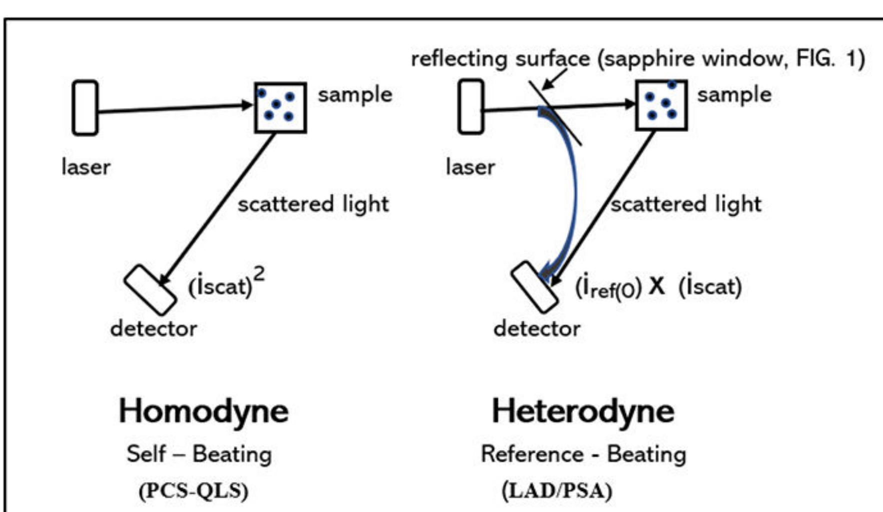

FIG. 1 Comparison Diagrams of Homodyne and Heterodyne Detection