

Application Note

LiQuilaz SO₂, SO₃, and SO₅ New 660 nm Laser Module

Introduction

Particle Measuring Systems switched to the Hitachi 660 nm laser diode (LD) for use in the LiQuilaz and HSLIS product lines due to their much higher reliability and end of life issues with the 780 nm LD. The lifetime of the Hitachi lasers is close to three years and provides greatly improved customer satisfaction. While the switch from the 780 nm to the new Hitachi 660 nm is fairly transparent to most end users, there are some operational changes required due to the wavelength change. A basic understanding of the optical particle counting and how calibrations can provide accurate analysis is useful when making comparisons between the two types of particle counters.

Technical Discussion

Particle Counting Background

The LiQuilaz products are 100% volumetric, which means that they count all the particles that flow through the sample cell. These products also have flow rates from 50 ml/mn to 80 ml/mn. High flow rates combined with 100% counting efficiency results in excellent counting statistics and high precision for ultra pure chemicals with very few particles.

Particles entering the LiQuilaz flow cell intersect the laser beam and scatter light. The amount of light scattered is dependant on the size of the particle. The detector measures the scattered light and the electronics assigns this particle a specific size.

The amount of light scattered is also dependent on other parameters including the contrast in refractive indexes of the medium and the particle, laser power, laser wavelength and optical design of the particle counter. Due to the high dependency on these parameters, absolute sizing results for real world particles in chemicals are not possible. Particle counters do however provide a rapid and extremely sensitive method for accurately detecting changes in particle counts in real world systems.

Resolution

There are some minor particle size resolution differences with the new 660 nm laser module when compared to older 780 nm module. In some cases, depending on the specific particle size selected, the resolution will be slightly poorer and in other cases it will be better. Resolution comparisons can be made through examination of the slope in the scattering diagrams. The steeper slope indicates better resolution (See Figures 1, 2). These differences are normal and they are small; they do not affect the standard operation of the equipment nor do they affect the resolution specification

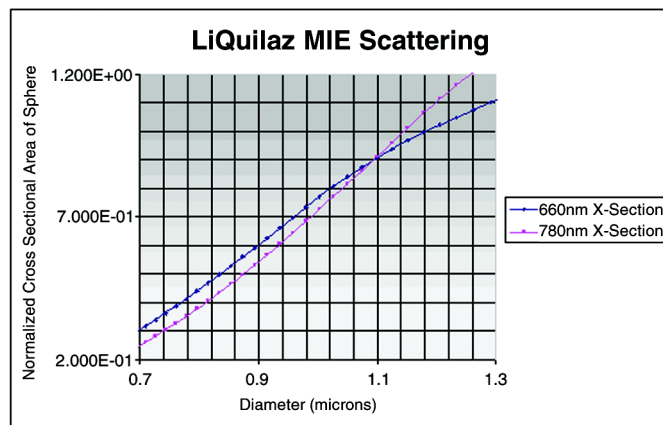


Figure 1. Scattering diagram shows slightly better theoretical resolution above 1 micron for the 780 nm laser diode

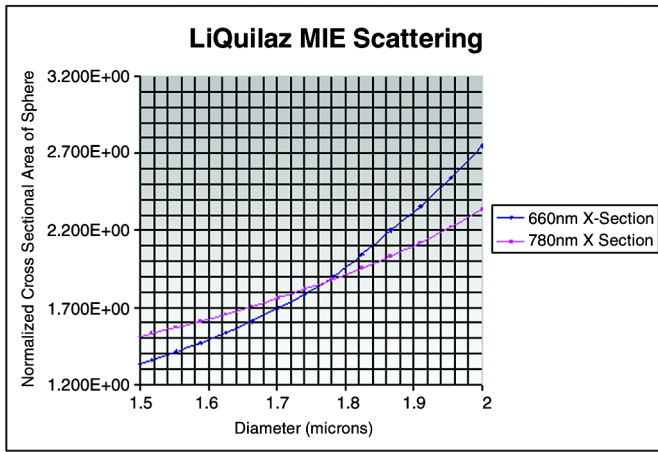


Figure 2. Scattering diagram shows slightly better resolution from 1.5 to 2 microns for the 660nm laser diode

Calibration Background

Particle counters are calibrated using monodisperse polystyrene latex spheres in DI water. Particle standards of a known size are introduced into the particle counter and their voltage response (pulse heights) measured. In order to be acceptable, their pulse heights must fall within certain Software Selectable Threshold (SST) ranges that have been pre-established at Particle Measuring Systems. Calibration curves are then established based on a series of standards and their resulting SST values. The sizing of particles in unknown samples is determined by this calibration. The calibration curves intersect each of the calibration points so there is high accuracy at the chosen calibration sizes. The calibration response between points for the LiQuilaz is a linear or exponential function depending on which produces the best fit.

Calibration Differences

The change in wavelengths from 780 nm to 660 nm results in a different scattering response. Scattering differences between the two wavelengths are dependent on three things: equivalent cross sectional area of the sphere, photodetector response, and laser power setting. When changing to 660 nm, there is a theoretical increase in scattering (up to a factor of two) for the smaller particles, due to the higher equivalent cross section (Figure 3). Particles above one micron have about the same equivalent cross section (Figure 4)

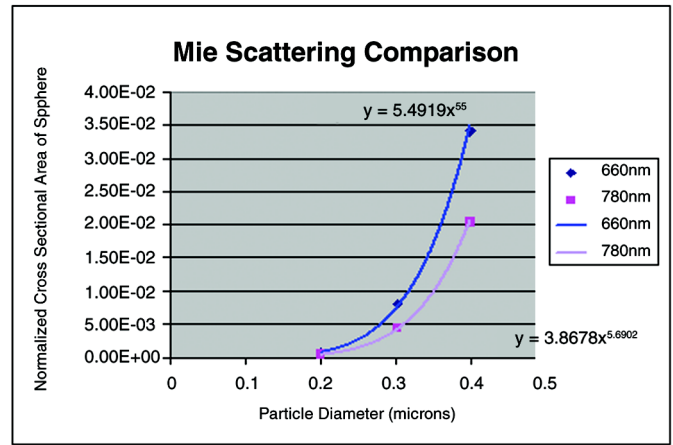


Figure 3. Theoretical Scattering Comparison

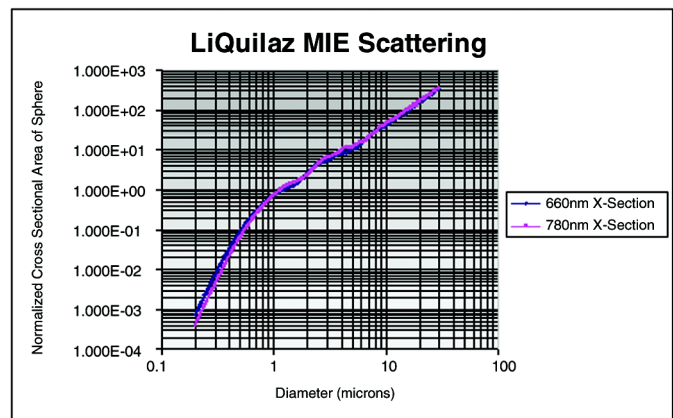


Figure 4. Scattering diagram for 660nm and 780nm laser diode

The scattering increase for the smaller particles is partially offset by a drop of 30% in detector response for all particle sizes (Figure 5). Further optimization of the 660 nm module, through a reduction of laser power of 10%, achieves a very similar scattering response as the 780 nm module (Figures 6) for the smallest particles. Reduction of laser power also has the benefit of improved laser life.

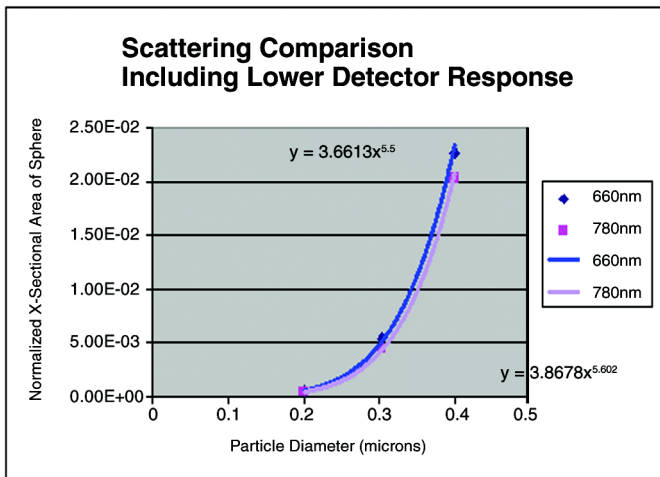


Figure 5. Scattering including detector response

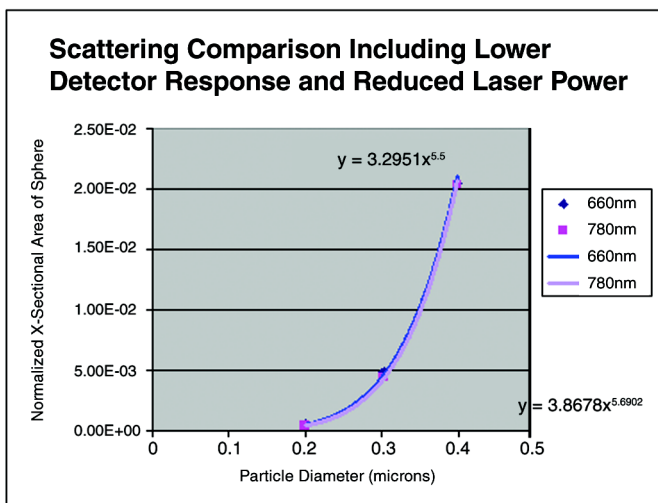


Figure 6. Scattering including detector response and laser power reduction

Different SST ranges and calibration particle sizes have been established for the Hitachi laser. This is necessary to account for the above-mentioned scattering differences.

Conclusion

Particle Measuring Systems switched to the Hitachi 660 nm laser diode due end of life issues with the previous laser diode and to the much higher reliability of the Hitachi 660 nm LD. Changing the LD will mean longer LD life in the LiQuilaz and greater customer satisfaction. The change in the laser wavelength is transparent to users for most applications but requires changes to the SST ranges for some

calibration particle sizes. Resolution differences between the two diodes are minor and do not affect normal operation. The resolution specifications remain the same with the new laser.

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